November 5, 2003

Mr. R. T. Ridenoure
Division Manager - Nuclear Operations
Omaha Public Power District
Fort Calhoun Station FC-2-4 Adm.
Post Office Box 550
Fort Calhoun, NE 68023-0550

SUBJECT: FORT CALHOUN STATION, UNIT NO. 1 - ISSUANCE OF AMENDMENT (TAC NO. MB7496)

Dear Mr. Ridenoure:

The Commission has issued the enclosed Amendment No. 222 to Renewed Facility Operating License No. DPR-40 for the Fort Calhoun Station, Unit No. 1 (FCS). The amendment consists of changes to the Technical Specifications (TS) in response to your application dated January 27, 2003, as supplemented by letter dated August 1, 2003.

The amendment authorizes revisions to the Updated Safety Analysis Report (USAR) to incorporate the NRC approval of the GOTHIC 7.0 (GOTHIC) computer program for performing containment analyses. GOTHIC would replace the currently approved CONTRANS code. Omaha Public Power District (OPPD) proposes the use of GOTHIC to verify that the FCS containment pressure is maintained below its design pressure of 60 psig during a loss-of-coolant accident or main steam line break. Upon approval, the licensee will update the FCS USAR Section 14.16, "Containment Pressure Analysis," to reflect the use of the GOTHIC computer program for the peak containment pressure analysis.

In addition, OPPD plans to use GOTHIC to determine the bounding temperature profile associated with environmental equipment qualification for the replacement steam generators effort. GOTHIC will also be used for containment pressure analyses to demonstrate adequate margins of safety during a potential future power uprate at FCS. The staff notes that as part of future licensing submittals, such as the planned replacement of the steam generators and the planned power uprate, the licensee will need to provide a description of the model inputs for the staff to make its final determination that sufficient conservatism has been incorporated into the analysis to provide reasonable assurance that adequate margins to design values are maintained.

A copy of the related Safety Evaluation is also enclosed. The Notice of Issuance will be included in the Commission's next biweekly *Federal Register* notice.

Sincerely,

/RA/

Alan B. Wang, Project Manager, Section 2
Project Directorate IV
Division of Licensing Project Management
Office of Nuclear Reactor Regulation

Docket No. 50-285

Enclosures: 1. Amendment No. 222 to DPR-40
2. Safety Evaluation

cc w/encls: See next page

A copy of the related Safety Evaluation is also enclosed. The Notice of Issuance will be included in the Commission's next biweekly *Federal Register* notice.

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***Date of Safety Evaluation**

ACCESSION NO.: ML033100290 **NRR-058**

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OMAHA PUBLIC POWER DISTRICT

DOCKET NO. 50-285

FORT CALHOUN STATION, UNIT NO. 1

AMENDMENT TO RENEWED FACILITY OPERATING LICENSE

Amendment No. 222
License No. DPR-40

1. The Nuclear Regulatory Commission (the Commission) has found that:

   A. The application for amendment by the Omaha Public Power District (the licensee) dated January 27, 2003, as supplemented by letter dated August 1, 2003, complies with the standards and requirements of the Atomic Energy Act of 1954, as amended (the Act), and the Commission's rules and regulations set forth in 10 CFR Chapter I;

   B. The facility will operate in conformity with the application, the provisions of the Act, and the rules and regulations of the Commission;

   C. There is reasonable assurance (i) that the activities authorized by this amendment can be conducted without endangering the health and safety of the public, and (ii) that such activities will be conducted in compliance with the Commission's regulations;

   D. The issuance of this license amendment will not be inimical to the common defense and security or to the health and safety of the public; and

   E. The issuance of this amendment is in accordance with 10 CFR Part 51 of the Commission's regulations and all applicable requirements have been satisfied.

2. Accordingly, by Amendment No. 222, the license is amended to authorize revision of the Updated Safety Analysis Report (USAR), as set forth in the application for amendment by Omaha Public Power District dated January 27, 2003, and supplement dated August 1, 2003. Omaha Public Power District shall update the USAR to incorporate the NRC approval of the GOTHIC 7.0 computer program for performing containment analyses, as described in the amendment application of January 27, 2003, and supplement dated August 1, 2003, and the staff's Safety Evaluation attached to this amendment.

3. This license amendment is effective as of its date of issuance and shall be implemented within 30 days of the date of issuance. The implementation of the amendment includes the incorporation into the USAR the changes discussed above, as described in the licensee's application dated January 27, 2003, and supplement dated August 1, 2003, and evaluated in the staff's Safety Evaluation attached to this amendment.

FOR THE NUCLEAR REGULATORY COMMISSION

/RA/

Stephen Dembek, Chief, Section 2
Project Directorate IV
Division of Licensing Project Management
Office of Nuclear Reactor Regulation

Date of Issuance: November 5, 2003

SAFETY EVALUATION BY THE OFFICE OF NUCLEAR REACTOR REGULATION

RELATED TO AMENDMENT NO.222 TO RENEWED FACILITY

OPERATING LICENSE NO. DPR-40

OMAHA PUBLIC POWER DISTRICT

FORT CALHOUN STATION, UNIT NO. 1

DOCKET NO. 50-285

1.0 INTRODUCTION

By application dated January 27, 2003, as supplemented by letter dated August 1, 2003, Omaha Public Power District (OPPD) requested the NRC approval of the GOTHIC 7.0 computer program for performing containment analyses for the Fort Calhoun Station, Unit No. 1 (FCS). The requested change would authorize revisions to the FCS Updated Safety Analysis Report (USAR). GOTHIC 7.0 would replace the currently approved CONTRANS code. OPPD proposes the use of GOTHIC 7.0 to verify that the FCS containment pressure is maintained below its design pressure of 60 psig during a loss-of-coolant accident (LOCA) or main steam line break (MSLB). Upon approval, the licensee will update the FCS USAR Section 14.16, "Containment Pressure Analysis," to reflect the use of the GOTHIC 7.0 computer program for the peak containment pressure analysis. In addition, OPPD plans to use GOTHIC 7.0 to determine the bounding temperature profile associated with environmental equipment qualification (EEQ) for the replacement steam generators effort. GOTHIC 7.0 will also be used for containment pressure analyses to demonstrate adequate margins of safety during a potential future power uprate at FCS.

The August 1, 2003, supplemental letter provided additional clarifying information, did not expand the scope of the application as originally noticed, and did not change the staff's original proposed no significant hazards consideration determination as published in the *Federal Register* on March 18, 2003 (68 *FR* 12956).

2.0 REGULATORY EVALUATION

Containment pressure analyses are required for FCS as part of the design basis evaluation (DBE). FCS was licensed for construction prior to May 21, 1971, and at that time the licensee committed to the preliminary General Design Criteria (GDC). The preliminary design criteria which relate to this license amendment request (LAR) are:

1. FCS Design Criterion 10, "Containment." This criterion is similar to 10 CFR Part 50, Appendix A, GDC 16, "Containment Design." FCS Design Criterion 10 states that containment shall be provided. The containment structure shall be designed to sustain

the initial effects of gross equipment failures, such as a large coolant boundary break, without loss of required integrity and, together with other engineered safety features (ESF) as may be necessary, to retain for as long as the situation requires the functional capability to protect the public.

2. FCS Design Criterion 12, "Instrumentation and Control Systems." This criterion is similar to 10 CFR Part 50, Appendix A, GDC 13, "Instrumentation and Control." FCS Design Criterion 12 states that instrumentation and controls shall be provided as required to monitor and maintain variables within prescribed operating ranges.

3. FCS Design Criterion 17, "Monitoring Radioactivity Releases." This criterion is similar to 10 CFR Part 50, Appendix A, GDC 64, "Monitoring Radioactivity Releases." FCS Design Criterion 17 states that a means shall be provided for monitoring the containment atmosphere, the facility effluent discharge paths, and the facility environs for radioactivity that could be released from normal operations, from anticipated transients and from accident conditions.

4. FCS Design Criterion 49, "Containment Design Basis." This criterion is similar to 10 CFR Part 50, Appendix A, GDC 50, "Containment Design Basis." FCS Design Criterion 49 states the containment structure, including access openings and penetrations, and any necessary containment heat removal systems shall be designed so that the containment structure can accommodate, without exceeding the design leakage rate, the pressures and temperatures resulting from the largest credible energy release following a LOCA, including a considerable margin for effects from metal-water or other chemical reactions that could occur as a consequence of failure of emergency core cooling systems.

5. FCS Design Criterion 52, "Containment Heat Removal Systems." This criterion is similar to 10 CFR Part 50, Appendix A, GDC 38, "Containment Heat Removal." FCS Design Criterion 52 states that where active heat removal systems are needed under accident conditions to prevent exceeding containment design pressure, at least two systems, preferably of different principles, each with full capacity, shall be provided.

This request does not impact the requirements of FCS Design Criterion 12, as no changes to instrumentation or controls were proposed as part of this LAR. This request does not impact the requirements of FCS Design Criterion 17, as no changes to the means used to monitor radioactive releases were proposed as part of this LAR.

The FCS USAR (Section 14.15.8.1 - Radiological Consequences of a LOCA) also states that the containment leak rate is 0.1 percent of the free volume for the first 24 hours, and 0.05 percent of the free volume for the remaining duration of the accident. Therefore, the long-term LOCA analysis should show a reduction in pressure to 50 percent within 24 hours. The long-term pressure analysis to be performed with GOTHIC 7.0 will be used to demonstrate compliance with this FCS requirement.

The staff has previously accepted GOTHIC for similar analyses, "Kewaunee Nuclear Power Plant - Review for Kewaunee Reload Safety Evaluation Methods Topical Report WRSRSEM-NP, Revision 3," September 10, 2001 (ADAMS Accession No. ML012490176).

3.0 EVALUATION

GOTHIC 7.0 would replace the currently approved CONTRANS[1] computer program for performing containment analyses. OPPD proposed to use GOTHIC 7.0 to verify that the FCS containment pressure is maintained below its design pressure of 60 psig during a LOCA or an MSLB, at the containment design temperature of 305°F. In addition, the licensee proposed to update Section 14.16, "Containment Pressure Analysis," of the FCS USAR to reflect the use of the GOTHIC 7.0 computer program for the peak containment pressure analysis.

OPPD also plans to use GOTHIC 7.0 to determine the bounding temperature profile associated with EEQ when replacement steam generators are installed at FCS. GOTHIC 7.0 will also be used for containment pressure analyses to demonstrate adequate margins of safety during a potential future power uprate at FCS.

During its review, the staff noted that the GOTHIC 7.0 model descriptions did not address the long-term LOCA containment pressure response. The long-term pressure response is used to justify a reduction in containment leakage when evaluating the radiological consequences of a LOCA. In response[2] to the staff's request for additional information[3] (RAI), the licensee provided a description of the proposed GOTHIC 7.0 model for the long-term LOCA pressure analysis.

OPPD is a member of the Electric Power Research Institute (EPRI) sponsored GOTHIC Enhancement Project. This Enhancement Project has three key objectives:

(1) Perform maintenance and user support. This includes distributing error notifications and corrections on all versions of the GOTHIC computer code.

(2) Perform extensions of computer code capabilities.

(3) Perform continuous validation of the computer code to experimental data.

OPPD has evaluated all open errors associated with GOTHIC 7.0 and none were identified that would affect a containment pressure analysis. If one occurs in the future, it will be evaluated on a case-by-case basis to determine its impact on any results that the computer code has provided in support of a license amendment.

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[1] Mitchell, R.C., CONTRANS Containment Thermodynamic Analysis, CENPD-140-A, "Description of the CONTRANS Digital Computer Code for Containment Pressure and Temperature Transient Analysis," June 1976, Combustion Engineering, Inc.

[2] Letter (LIC-03-0103) from R.T. Ridenoure, OPPD, to USNRC, Response to Request for Additional Information on License Amendment Request "Containment Pressure Analysis Using the GOTHIC Computer Program," August 1, 2003.

[3] Letter from A.B. Wang, USNRC, to R.T. Ridenoure, OPPD, "Request for Additional Information – Fort Calhoun Station Use of the GOTHIC (Version 7.0) Computer Program (TAC NO. MB7496)," dated June 17, 2003 (ADAMS Accession Number ML031680010).

OPPD has been formally trained in GOTHIC 7.0 by Numerical Applications, Inc., the program developer. The FCS program consists of formal and on-the-job training, the mentoring of inexperienced users whenever they prepare a safety analysis, and the independent review of the safety analysis for completeness and accuracy.

The GOTHIC 7.0 computer program will be maintained consistent with other NRC-approved OPPD methodologies.

The licensee addressed both the limiting LOCA and the limiting MSLB events for the peak containment pressure calculation, based on the current CONTRANS analysis of record (AOR) for these scenarios. For each case, a benchmark study comparing GOTHIC 7.0 to CONTRANS was performed. A GOTHIC 7.0 evaluation model was then developed for each scenario to incorporate modeling features now available to the licensee in GOTHIC 7.0, such as the modeling of containment sprays and additional heat transfer mechanisms, and to include additional conservatism in the calculations.

In response to question 13 of the staff's RAI, the licensee has not requested a review of the following GOTHIC 7.0 models: (1) the jet break-up model, (2) the mist-diffusion layer model, or (3) any model associated with multi-node containment models which would include critical flow models.

A description of the long-term LOCA evaluation model was provided in response to question 5 of the staff's RAI. In addition, the licensee described the changes to the evaluation models for use in performing EEQ calculations in response to question 12 of the staff's RAI.

3.1 LOCA Peak Pressure Analysis

3.1.1 <u>LOCA Peak Pressure Model Description</u>

The licensee benchmarked a GOTHIC 7.0 LOCA model to the current AOR CONTRANS model. Based on this benchmark model, the licensee developed a proposed GOTHIC 7.0 LOCA evaluation model (LEM) for use in future licensing activities. The base GOTHIC 7.0 LOCA model is described below:

- A single, lumped parameter volume was used to represent the containment, to be consistent with the approved CONTRANS methodology. The use of a single, lumped parameter volume for GOTHIC 7.0 licensing calculations is acceptable to the staff.

- The containment initial pressure was conservatively set to three psig based on FCS technical specification (TS) 2.6(2), to be consistent with the AOR. The standard atmospheric pressure at FCS (1000 ft elevation) was assumed to be 14.2 psia. The higher the initial pressure, the higher the moles of the non-condensable gases. The initial pressure contributes to the peak pressure and also degrades condensation on heat conductors and spray droplets, resulting in a conservative pressure calculation.

- The containment initial temperature was conservatively assumed to be at 120°F, to be consistent with the AOR.

- A relative humidity value of 30 percent was assumed, to be consistent with the current AOR.

- Since there is negligible water in the sump during normal operation, prior to the occurrence of an accident, a zero liquid volume fraction was initially assumed.

- The sump liquid to containment atmosphere vapor interface area was conservatively set to 0 ft^2. No heat transfer was assumed to occur between the containment atmosphere and the sump water. Sensitivity studies performed by the licensee that increasing the liquid to vapor interfacial area to as much as 100 ft^2 indicated a negligible impact on the containment peak pressure and temperature calculation. This is a conservative assumption and is acceptable to the staff.

- No heat transfer was assumed to occur between the containment building outer surface and the outside atmosphere. This is a conservative assumption and is acceptable to the staff.

- The licensee assumed the containment is shaped like a cylinder to determine the hydraulic diameter that GOTHIC 7.0 uses to infer the wetted surface area of the containment volume. Sensitivity studies performed by the licensee that varied the hydraulic diameter up to ±40 percent indicated that this had a negligible impact on the peak pressure and temperature calculation. The method used to determine the hydraulic diameter for use in the FCS GOTHIC 7.0 models is acceptable to the staff.

- The containment heat structures used in the GOTHIC 7.0 models explicitly matched the heat structures described in the CONTRANS AOR. The concrete associated with the foundation slab and reactor cavity floor were conservatively excluded from the GOTHIC 7.0 models since they would be exposed to the sump, not to the containment atmosphere, and would not be available as heat sinks during the DBE LOCA. In addition, the surface area to selected heat sinks was conservatively reduced by 10 percent. An air gap between the containment steel liner and the concrete wall was included in the GOTHIC 7.0 models which reduces the effectiveness of the related heat sinks. The effective air gap thickness between the steel liner and the concrete was determined from the thermal conductivity of air and the CONTRANS heat transfer coefficient for the air gap region. The method used to determine the air gap thickness for use in the FCS GOTHIC 7.0 models is acceptable to the staff. The staff concludes that the modeling of the containment heat structures is acceptable for GOTHIC 7.0 licensing calculations as they were developed to produce a conservative containment pressure calculation. While FCS is not considered to be a standard review plan (SRP) plant, the methodology used to model the effectiveness of the containment heat structures (static heat removal mechanisms) is consistent with the guidance in SRP 6.2.1.1.A, "PWR Dry Containment, Including Subatmospheric Containments."

- The revaporization fraction was set at zero to maximize peak containment pressure. No condensed liquid was assumed to re-enter the containment atmosphere. This is a conservative assumption and is acceptable to the staff.

3.1.2 LOCA Peak Pressure Mass and Energy Releases

Based on the AOR, the limiting LOCA case is the double-ended hot leg slot (DEHSL) break with a single containment spray (CS) pump and a single spray header available for active heat removal. No credit is taken for the containment fan coolers (CFCs).

The steam/water mass and energy calculations were performed using (1) the previously accepted CEFLASH-4A[4] computer program for the blowdown portion of the LOCA (lasting approximately 14 seconds), and (2) the previously accepted CONTRANS computer program for the post-blowdown period. In its response to question 1 of the staff's RAI, the licensee confirmed the AOR for the mass and energy transfer rates used inputs and assumptions that were conservative to maximize the containment pressure and temperature during a LOCA. The AOR was carried out to 600 seconds, which covered the peak pressure period.

A reactor coolant system (RCS) pressure boundary function was developed for use in calculating the break flow velocity. However, the break momentum is dissipated in the single, lumped parameter containment volume and this pressure function should not have a significant impact on the calculated peak containment pressure or temperature. Sensitivity studies, consisting of several iterations to generate this pressure function, performed by the licensee demonstrated that the use of this pressure function in the LOCA GOTHIC 7.0 model had a negligible impact on the peak containment pressure and temperature.

The staff concludes that the LOCA mass and energy release rates are acceptable for the GOTHIC 7.0 licensing calculations as they were developed to produce a conservative containment pressure calculation. While FCS is not considered to be an SRP plant, the methodology used to determine the mass and energy release rates is consistent with the guidance in SRP 6.2.1.3, "Mass and Energy Release Analysis for Postulated Loss-of-Coolant."

3.1.3 Difference Between GOTHIC 7.0 and CONTRANS for LOCA Peak Pressure Analysis

Break Model

In CONTRANS, the break flow can be divided into steam and liquid in a number of ways. The limiting model, with respect to the maximum pressure calculation, is referred to as the instantaneous model. In this analytical model, liquid which separates out from the break flow is added to the containment atmosphere, along with the steam from the break, and some of this liquid will boil off resulting in a higher calculated pressure. In addition, the mass of condensate in the atmosphere was assumed to immediately fall to the sump at the atmospheric temperature.

In GOTHIC 7.0, a user specified break drop size (diameter) is used to model the break liquid in the containment atmosphere. The break drop diameter was assumed to be 100 microns (0.00394 inches), based on the guidance provided by the program developer, Numerical

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[4] CENPD-133 Supplement 5-A, "CEFLASH-4A — A Fortran77 Digital Computer Program for Reactor Blowdown Analysis", dated June 1985.

Applications, Inc. (Section 21.5, "Boundary Conditions," of the GOTHIC 7.0 User Manual). The licensee further addressed the use of this value:

- During a DBE LOCA, the water entering the containment from the RCS is at a temperature above the saturation temperature at the containment pressure. Upon entering the containment the water flashes to steam, fracturing the water jet into fine droplets. Experimental test data[5] have shown that when superheated water flashes to steam, the mean drop diameter is less than 100 microns.

- The GOTHIC 7.0 qualification analyses, presented in the GOTHIC 7.0 code documentation qualification report, were performed using a drop diameter of 100-microns. These qualification analyses showed that GOTHIC 7.0 calculations with the 100-micron assumption agreed with and typically bounded, the measured pressure and temperature response from blowdown tests and measured pressure drops from orifice pressure drop tests.

- A 100 micron drop has a terminal velocity (rainout velocity) of between 1 and 2 ft/sec. This is a realistic terminal velocity and allows for the break drops to be in the containment atmosphere for a realistic time period.

The staff concludes that the break drop size (diameter) used in the FCS GOTHIC 7.0 analyses is acceptable for licensing calculations. This break drop size was also previously found to be acceptable by the staff as part of the Kewaunee review (ADAMS Accession No. ML012490176). The staff finds the break model used in the FCS GOTHIC 7.0 model, in combination with the conservatively calculated mass and energy release rates, acceptable for licensing calculations. The calculated pressure is expected to be less when compared to the CONTRANS model, which bounds the effect of the liquid in the break flow, however the containment pressure calculation will still be conservative.

Engineered Safety Features

Containment Sprays

For the LOCA benchmark model, the CS was modeled as a boundary condition. A drop diameter of 100 microns (0.00394 inches) was used to simulate the CS efficiency used in the CONTRANS computer code. The safety injection refueling water tank (SIRWT), the initial source for the CS, water temperature was set to 105°F to match the CONTRANS model. The CS volumetric flow rate, based on one spray pump and one spray header, was set at 1,885 gpm. It was also assumed that one spray nozzle was missing and five spray nozzles per header were blocked. The CS flow rate also took into account pump degradation, instrumentation uncertainty and the diversion of some flow through the mini-recirculation lines. The CS flow rate was set at 260.69 lbm/sec based on the 105°F SIRWT water temperature. The CS delay time was set to 133 seconds, to be consistent with the AOR.

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[5] "Sprays Formed by Flashing Liquid Jets," by R. Brown and J. L. York, AICHE Journal Vol.8, #2, May 1962, University of Michigan, Ann Arbor, Michigan.

For the LEM, the CS was modeled with the GOTHIC 7.0 spray nozzle model. This model allows for control of the fraction of spray water that become drops, to specify a drop size and to determine spray efficiency. The drop diameter was set to 1,500-microns (0.059055 inches), based on the engineering specifications for the FCS CS nozzle at a flow rate of 1,885 gpm. To account for the effect on non-condensable gases to reduce steam condensation, the licensee included a spray effectiveness multiplier based on the method used in CONTRANS. This added conservatism to the LEM since GOTHIC 7.0 already takes into account the effect of non-condensable gases on the mass and energy transfer at the liquid-vapor interface. The SIRWT temperature was increased to 115°F to account for temperature indication uncertainty and an additional 5°F for conservatism. The CS flow rate was set at 260.1 lbm/sec based on the 115°F SIRWT temperature. The CS delay time was set to 131.1 seconds based on a revised analysis as described in the response to question 4 of the staff’s RAI.

The staff concludes that the modeling of the CS system is acceptable for GOTHIC 7.0 licensing calculations as it was developed to produce a conservative containment pressure calculation. While FCS is not considered to be an SRP plant, the methodology used to model the effectiveness of the CS (active heat removal mechanisms) is consistent with the guidance in SRP 6.2.1.1.A, "PWR Dry Containment, Including Subatmospheric Containments."

Containment Fan Coolers

The CFCs were not credited in either the benchmark model or the LEM.

Safety Injection Tank (SIT) Nitrogen Cover Gas

For the LEM, the nitrogen cover gas in the four SITs was conservatively included in the GOTHIC 7.0 model. In a postulated LOCA, the pressure in the RCS fails below the pressure maintained in the SITs by the nitrogen cover gas and the water is discharged to the RCS. Some of the nitrogen gas would then exit the RCS through the break and enter the containment. If the nitrogen gas enters the containment prior to reaching the peak pressure, then it would increase the peak pressure. The nitrogen gas increases the non-condensable partial pressure by adding to the amount on non-condensables in the containment and the steam condensation is degraded, for example, by degrading spray nozzle efficiency.

The licensee developed a conservative GOTHIC 7.0 boundary condition to model the effects of the nitrogen gas which included the following assumptions:

- The maximum nitrogen gas volume (1,964 ft^3 or 2,667 lbm, total for four SITs) and the maximum gas pressure (301.6 psia, including instrumentation uncertainly) were used.

- The total nitrogen gas volume is assumed to be injected into the containment by the time the containment reached the peak pressure (sensitivity analyses were performed by the licensee to determine a conservative time period for the injection). The rate was determined to be 9.611 lbm/sec over a time period of 277.49 seconds.

- A complex analysis would be required to determine the nitrogen gas temperature entering the containment. When the nitrogen gas expands in the SIT following water discharge, its temperature drops to very low values. Then, prior to the nitrogen gas exiting the RCS through the break, it is heated by either the RCS or a combination of the RCS and steam generator (SG), depending on the break location. For the GOTHIC 7.0 model, it was conservatively assumed in the analysis that the nitrogen gas fully mixed with the RCS inventory and reached the saturation temperature of the RCS at the point at which the SITs start discharging their water inventory into the RCS. The nitrogen gas temperature, which corresponds to the saturation temperature of the SIT at a pressure of 301.6 psia, was set to 417.84°F.

The staff concludes that the SIT nitrogen gas model developed for use in the GOTHIC 7.0 licensing analyses is acceptable. The LEM uses a conservative approach in determining the effects of nitrogen on the peak containment pressure and temperature to ensure that the FCS analyses has sufficient margin to the design containment pressure.

3.1.4 Heat Transfer Correlations for LOCA Peak Pressure Analysis

GOTHIC 7.0 provides a variety of heat transfer correlations (HTCs) for its applications. The benchmark model and the LEM used the Tagami[6] correlation, which is appropriate for use during the blowdown portion of a LOCA analysis. The Tagami correlation requires the specification of the time to the first peak pressure (known as the blowdown phase peak) and the accumulated energy into containment during this time phase. These values were 13.317 seconds and 175,649,448 BTU, respectively and were obtained from the CEFLASH-4A blowdown analysis. The staff has determined that the use of the Tagami correlation is acceptable for the GOTHIC 7.0 licensing analyses. While FCS is not considered to be an SRP plant, the use of the Tagami correlation is consistent with the guidance in SRP 6.2.1.1.A, "PWR Dry Containment, Including Subatmospheric Containments." The use of the Tagami correlation in GOTHIC was also previously accepted by the staff as part of the Kewaunee review (ADAMS Accession No. ML012490176).

The benchmark model and the LEM used the Uchida[7] HTC for direct steam condensation after the LOCA blowdown period. The CONTRANS model used the CONTEMPT[8]-like form of the Uchida HTC which is very similar to the form used in GOTHIC 7.0. A comparison of the heat transfer rates indicated the GOTHIC 7.0 model predicted a slightly lower heat transfer rate, about 3 percent, when compared to the Uchida data during the period of interest, when the containment air-to-steam ratio is about 0.73. The staff concludes that the use of the Uchida correlation acceptable for the GOTHIC 7.0 licensing analyses. While FCS is not considered to be an SRP plant, the use of the Uchida correlation is consistent with the guidance in SRP 6.2.1.1.A, "PWR Dry Containment, Including Subatmospheric Containments." The use of the GOTHIC Uchida model was also previously accepted by the staff as part of the Kewaunee

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[6] Tagami, T., *Interim Report on Safety Assessments and Facilities Establishment Project in Japan for Period Ending June 1965 (No. 1)*, unpublished work, 1965.

[7] H. Uchida, A. Oyama, and Y. Toga, "Evaluation of Post-Incident Cooling Systems of Light-Water Power Reactors," Proc. Third International Conference on the Peaceful Uses of Atomic Energy, Volume 13, Session 3.9, United Nations, Geneva (1964).

[8] Hargroves, D.W., L.J. Metcalfe, "CONTEMPT-LT/028 - A Computer Program for Predicting Containment Pressure-Temperature Response to a Loss-of-Coolant Accident," NUREG/CR-0155, March 1979.

6.2.1.1.A, “PWR Dry Containment, Including Subatmospheric Containments.” The use of the GOTHIC 7.0 Uchida model was also previously accepted by the staff as part of the Kewaunee review (ADAMS Accession No. ML012490176).

An exponential-based model is used to transition from the maximum heat transfer rate obtained from the Tagami correlation to the heat transfer rate obtained from the Uchida correlation. In GOTHIC 7.0, the exponential rate was set to -0.025 per unit time. In CONTRANS, the exponential rate was set to -1.0 per unit time, to maximize the calculated pressure, resulting in a more rapid reduction in the heat transfer rate. As a result, there is a small difference in the pressure calculation in the GOTHIC 7.0 benchmark study when compared to the CONTRANS AOR following the first pressure peak at about 14 seconds. The calculated pressure following the first peak showed a larger decrease as a result of the higher heat transfer rates obtained with the GOTHIC 7.0 transition model. The staff performed a scoping study with GOTHIC 7.1 to evaluate the effect of the exponential rate on the calculated peak pressure (Version 7.1 allows the user to control the transition model exponential rate). The results are provided in Figure 1 attached to this safety evaluation. This study confirmed the licensee’s assessment of the exponential rate and indicated that the peak pressure would be about 0.25 psi higher with the more conservative CONTRANS exponential rate. The GOTHIC 7.0 exponential rate was selected to be consistent with ANSI/ANS-56.4-1983[9], and is considered to be a conservative value. The staff concludes that the transition model used in GOTHIC 7.0 is acceptable for licensing analyses. This transition model was also previously determined to be acceptable by the staff as part of the Kewaunee review (ADAMS Accession No. ML012490176).

Natural and forced convection heat transfer correlations are also used to account for heat transfer to the containment heat structures. In the FCS GOTHIC 7.0 models, the characteristic length used to determine if the conditions are laminar or turbulent for natural convection to obtain the heat transfer coefficient, and to obtain the forced convection heat transfer coefficient, is the containment hydraulic diameter. Typically, the characteristic length is related to the specific heat structure, for example the length of the wall. In response to question 11 of the staff's RAI, the licensee addressed the use of the containment hydraulic diameter for the characteristic length. The use of the containment hydraulic diameter is conservative since the heat transfer coefficients are either not dependent on the value or decrease with increasing characteristic length. Sensitivity studies performed by the licensee that varied the hydraulic diameter up to ±40 percent indicated a negligible impact on the peak pressure and temperature calculation. The use of natural and forced convection heat transfer, to supplement the direct condensation heat transfer, is consistent with ANSI/ANS-56.4-1983 and is acceptable to the staff for GOTHIC 7.0 licensing analyses. The use of natural and forced convection heat transfer, to supplement the direct condensation heat transfer, and the use of the containment hydraulic diameter for the characteristic length, were also previously accepted by the staff as part of the Kewaunee review (ADAMS Accession No. ML012490176).

Consistent with ANSI/ANS-56.4-1983, the FCS GOTHIC 7.0 LEM also included containment atmosphere (vapor) to containment heat structure radiation heat transfer. The GOTHIC 7.0

[9] ANSI/ANS-56.4-1983, “American National Standard Pressure and Temperature Transient Analysis for Light Water Reactor Containments,” prepared by the American Nuclear Society.

model is based on a grey gas with grey surrounding walls[10]. For the LOCA scenario, the containment atmosphere remains near saturated conditions and the effect of radiation heat transfer is negligible. The use of radiation heat transfer, to supplement both the direct steam condensation heat transfer and the natural and forced convection heat transfer, is acceptable to the staff for GOTHIC 7.0 licensing analyses.

3.1.5 LOCA Peak Pressure Benchmark Evaluation Model Results

The licensee performed a benchmarked analysis to compare GOTHIC 7.0 to CONTRANS. The comparison is shown in the following table:

Computer Code	Peak Pressure (psig)	Time to Peak Pressure (sec)	Peak Temperature (°F)	Time to Peak Temperature (sec)
GOTHIC 7.0	56.83	288	280.6	282
CONTRANS	58.96	291.82	282.75	291.82

The results of the analysis showed that both GOTHIC 7.0 and CONTRANS predict similar trends, with the peak pressure and temperature occurring at about the same time, about 290 seconds. The differences in the peak values are attributed to modeling differences in the two codes, particularly the modeling of the CS (Section 3.1.3 of this safety evaluation - Engineered Safety Features) and the Uchida HTC (Section 3.1.4 of this safety evaluation). In addition, the treatment of the break flow liquid (Section 3.1.3 of this safety evaluation - Break Model) contributes to the differences. While not quite as conservative as the CONTRANS model, we have found that the GOTHIC 7.0 break model provides similar results (see above table) which are conservative and therefore, is acceptable for licensing calculations.

The licensee concluded that the benchmark comparison showed that the basic LOCA model was suitable for use in developing the LOCA licensing analysis evaluation model. The staff agrees with this assessment.

3.1.6 LOCA Peak Pressure Evaluation Model Results

The licensee performed the LEM analysis with GOTHIC 7.0. The results are shown in the following table:

Computer Code	Peak Pressure (psig)	Time to Peak Pressure (sec)	Peak Temperature (°F)	Time to Peak Temperature (sec)
GOTHIC 7.0	57.81	290	280.9	282

The LEM included the effect of the SIT nitrogen cover gas on the containment pressure and temperature calculation, adding additional conservatism to the results. The staff performed a

[10] McAdams, W.H., *Heat Transmission*, Third Edition, McGraw-Hill, 1954.

scoping study with GOTHIC 7.0 to assess the effect of the SIT nitrogen cover gas. The results, shown in Figure 2 attached to this safety evaluation, indicated that SIT nitrogen cover gas increased the calculated containment pressure by about 0.85 psi. The change in the calculated containment temperature was negligible.

3.1.7 LOCA Peak Pressure Conclusion

The licensee has developed a GOTHIC 7.0 licensing evaluation model, based on a benchmark model comparison to the CONTRANS AOR. The single, lumped parameter volume model is acceptable to the staff, and is consistent with the approach used in the AOR. The modeling of the containment heat structures is acceptable to the staff. The approach is consistent with the CONTRANS AOR and includes additional conservatism for the peak pressure calculation.

The initial containment conditions, the pressure, temperature and relative humidity, have been determined to be conservative for the peak pressure calculation, or consistent with the current AOR, and are acceptable to the staff. The modeling of the ESF, the CS system, has been determined to be conservative for the peak pressure calculation and is acceptable to the staff. The inclusion of the SIT nitrogen cover gas in the LEM added additional conservatism to the peak pressure calculation and is acceptable to the staff.

The LOCA mass and energy release calculation was based on the previously accepted AOR methodology and is acceptable to the staff.

The GOTHIC 7.0 break flow model had been previously accepted by the staff as part of the Kewaunee review (ADAMS Accession No. ML012490176). Based on this previous approval, OPPD has provided justification to demonstrate that the GOTHIC 7.0 break flow model is acceptable for application at FCS. The staff has reviewed the application and concludes that the GOTHIC 7.0 break flow model is acceptable for application at FCS.

The HTCs used in the LEM, the Tagami and Uchida correlations for steam condensation, are acceptable to staff and are consistent with guidance provided in the NRC's SRP and ANSI/ANS-56.4-1983. The augmentation of the steam condensation heat transfer by natural and forced convection heat transfer is consistent with ANSI/ANS-56.4-1983 and is acceptable to the staff. The augmented heat transfer has also been previously accepted by the staff as part of the Kewaunee review (ADAMS Accession No. ML012490176). In addition, based on guidance in ANSI/ANS-56.4-1983, the staff also accepts the radiation augmentation for heat transfer. For the LEM, the effect of radiation heat transfer is negligible.

The staff concludes that the licensee's LEM and the revised peak containment pressure and temperature analysis is acceptable to demonstrate compliance with FCS Design Criteria 10, 49 and 52. The staff concludes that sufficient conservatism has been incorporated in the analysis to provide reasonable assurance that adequate margins to design values are maintained.

3.2 MSLB Peak Pressure Analysis

3.2.1 MSLB Peak Pressure Model Description

The licensee benchmarked a GOTHIC 7.0 MSLB model to the current AOR CONTRANS model. Based on this benchmark model, the licensee developed and proposed a GOTHIC 7.0 MSLB evaluation model (MEM) for use in future licensing activities. The base GOTHIC 7.0 MSLB model description is identical to the LOCA model described in Section 3.1.1 with the following difference:

- The sump liquid to containment atmosphere vapor interface area was conservatively set to 1 ft^2. This effectively prevented steam condensation on the surface of the relatively cool water in the sump during the accident. Sensitivity studies performed by the licensee have shown that increasing the liquid to vapor interfacial area to as much as 100 ft^2 did not impact the containment peak pressure (~ 0.01 psi) or temperature (negligible) calculation.

This is a conservative assumption for the peak pressure evaluation and is acceptable to the staff.

3.2.2 MSLB Peak Pressure Mass and Energy Releases

Based on the AOR, the limiting MSLB case is a 3.33 ft^2 steam line break. This size break ensures a pure steam blowdown from the broken loop. The RCS pumps remain running to maximize primary to secondary heat transfer, and a loss of offsite power was not assumed. The feedwater regulating valve in the ruptured SG was assumed to fail "as-is" and the main feedwater isolation valve (MFIV) was assumed to close in 40 seconds. A leak rate of 2.45 percent of full power flow, about 195 gpm, past the ruptured SG MFIV was also assumed.

The steam/water mass and energy calculations were performed using the previously accepted SGN-III[11] computer program. In response to question 3 of the staff's RAI, the licensee confirmed the AOR for the mass and energy transfer rates used inputs and assumptions that were conservative to maximize the containment pressure and temperature during a MSLB. The AOR was carried out to 300 seconds, which covered the peak pressure period.

An RCS pressure boundary function was developed for use in calculating the break flow velocity. However, the break momentum is dissipated in the single, lumped parameter containment volume and this pressure function should not have a significant impact on the calculated peak containment pressure or temperature. Sensitivity studies performed by the licensee showed that the use of this pressure function in the MSLB GOTHIC 7.0 model had little impact on the containment pressure and temperature response and had no impact on the calculated peak values.

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[11] SGN-III was approved for use by the NRC in NUREG-75/112, "Safety Evaluation Report Related to the Preliminary Design of the Standard Reference System CESSAR System 80," December 1975.

The staff concludes that the MSLB mass and energy release rates are acceptable for GOTHIC 7.0 licensing calculations as they were developed to produce a conservative containment pressure calculation. While FCS is not considered to be an SRP plant, the methodology used to determine the mass and energy release rates is consistent with the guidance in SRP 6.2.1.3, "Mass and Energy Release Analysis for Postulated Loss-of-Coolant."

3.2.3 Difference Between GOTHIC 7.0 and CONTRANS for MSLB Peak Pressure Analysis

Break Model

The break model used for the MSLB is the same as the break model used for the LOCA, as described in Section 3.1.3 of this safety evaluation. In GOTHIC 7.0 a user-specified break drop size (diameter) is used to model the break liquid in the containment atmosphere. The break drop diameter was assumed to be 100 microns (0.00394 inches), based on guidance provided by the program developer, Numerical Applications, Inc. (Section 21.5, "Boundary Conditions," of the GOTHIC 7.0 User Manual.)

The MSLB break is sized to ensure that the blowdown is pure steam and that the effect of the break drop size have a negligible impact on the calculated peak pressure. The licensee performed a sensitivity study by increasing the drop size by two orders of magnitude. The impact on the calculated peak pressure was negligible.

The staff concludes that the break drop size (diameter) used in the FCS GOTHIC 7.0 analyses is acceptable for licensing calculations. This break drop size was also previously determined to be acceptable by the staff as part of the Kewaunee review (ADAMS Accession No. ML012490176). The staff concludes that the break model used in the FCS GOTHIC 7.0 model, in combination with the conservatively calculated mass and energy release rates, is acceptable for licensing calculations.

Engineered Safety Features

Containment Sprays

For the MSLB benchmark model, the CS was modeled as a boundary condition. A drop diameter of 100 microns (0.00394 inches) was used to simulate the CS efficiency used in the CONTRANS computer code. The SIRWT, the initial source for the CS, temperature was set to 105°F to match the CONTRANS model. The CS volumetric flow rate, based on three spray pumps and two spray headers, was set at 5,100 gpm, to be consistent with the AOR. It was also assumed that one spray nozzle was missing and five spray nozzles per header were blocked. The CS flow rate also took into account pump degradation, instrumentation uncertainty and the diversion of some flow through the mini-recirculation lines. The CS flow rate was set at 705.41 lbm/sec based on the 105°F SIRWT temperature. The CS delay time was set to 93.54 seconds, to be consistent with the AOR.

For the MEM, the CS was modeled with the GOTHIC 7.0 spray nozzle model. This model allows for (1) control of the fraction of spray water that becomes drops, (2) to specify a drop size, and (3) to specify a spray efficiency. The drop diameter was set to 1,200 microns (0.04742 inches), based on the engineering specifications for the FCS CS nozzle at a flow rate of 5,000 gpm. To account for the effect on non-condensable gases to reduce steam condensation, the licensee included a spray effectiveness multiplier based on the method used in CONTRANS. This added conservatism to the MEM since GOTHIC 7.0 already takes into account the effect of non-condensable gases on the mass and energy transfer at the liquid-vapor interface. The SIRWT water temperature was increased to 115°F to account for temperature indication uncertainty and an additional 5°F for conservatism. The CS flow rate was set at 690 lbm/sec based on the 115°F SIRWT water temperature. As described in the response to question 9 of the staff's RAI, the CS delay time was set to 104.3 seconds based on a revised analysis.

The staff concludes that the modeling of the CS system is acceptable for GOTHIC 7.0 licensing calculations as it was developed to produce a conservative containment pressure calculation. While FCS is not considered to be an SRP plant, the methodology used to model the effectiveness of the CS (active heat removal mechanisms) is consistent with the guidance in SRP 6.2.1.1.A, "PWR Dry Containment, Including Subatmospheric Containments."

Increasing the SIRWT temperature from 105°F to 115°F does not have an impact on the peak containment pressure and temperature results since the peaks occur prior to CS actuation. This value was used to maintain consistency between the GOTHIC 7.0 LEM and MEM models.

While the CS has no effect on the peak containment pressure, it does provide cooling to the containment and assist the CFCs and various heat sinks in returning the containment environment to pre-accident conditions.

Containment Fan Coolers

The CFCs were modeled using the GOTHIC 7.0 cooler model. The four CFCs were modeled as two coolers.

Cooler #1: This cooler combined fans VA-3A and 3B together. Under design accident conditions, the design flow rate of these fans is 86,000 ft^3/min each. Based on FCS TS 3.6(3)(f), the fans must be shown to be operable to within 10 percent of design flow. Therefore, this cooler uses a combined volumetric flowrate of 154,800 ft^3/min, as a conservative assumption.

Cooler #2: This cooler combined fans VA-7C and 7D together. Under design accident conditions, the design flow rate of these fans is 52,000 ft^3/min each. Based on FCS TS 3.6(3)(f), the fans must be shown to be operable to within 10 percent of design flow. Therefore, this cooler uses a combined volumetric flowrate of 93,600 ft^3/min, as a conservative assumption.

The CFCs were assumed to remove no heat below 120°F since the cooling water was assumed to be at this temperature. Also, since there was no heat removal capacity data available for air/steam temperatures above 288°F, the heat removal rate was assumed to remain constant between 288°F and 500°F. The heat removal capacity was conservatively limited to a combined 200×10^6 BTU/hr. The time delay for CFC actuation was specified as 25.58 seconds, to be consistent with the AOR.

The staff concludes that the modeling of the CFCs is acceptable for GOTHIC 7.0 licensing calculations as it was developed to produce a conservative containment pressure calculation. While FCS is not considered to be an SRP plant, the methodology used to model the effectiveness of the CFCs (active heat removal mechanisms) is consistent with the guidance in SRP 6.2.1.1.A, "PWR Dry Containment, Including Subatmospheric Containments."

Safety Injection Tank Nitrogen Cover Gas

The SITs do not actuate during a MSLB scenario.

3.2.4 Heat Transfer Correlations for MSLB Peak Pressure Analysis

GOTHIC 7.0 provides a variety of HTCs for applications. The benchmark model and the MEM used the Uchida HTC for direct steam condensation. The CONTRANS model used the CONTEMPT-like form of the Uchida HTC which is very similar to the form used in GOTHIC 7.0. A comparison of the heat transfer rate during the period of interest, when the containment air-to-steam ratio is about 0.82, indicated the GOTHIC 7.0 model predicted a slightly lower heat transfer rate, about 3 percent, when compared to the Uchida data. The staff concludes that the use of the GOTHIC 7.0 formulation of the Uchida correlation, while slightly less conservative is acceptable for the licensing analyses because it still provides conservative results for licensing applications. While FCS is not considered to be an SRP plant, the use of the Uchida correlation is consistent with the guidance in SRP 6.2.1.1.A, "PWR Dry Containment, Including Subatmospheric Containments." The GOTHIC Uchida model was also previously accepted by the staff as part of the Kewaunee review (ADAMS Accession No. ML012490176).

As discussed in Section 3.1.4 of this safety evaluation, the use of natural and forced convection heat transfer correlations, to supplement the direct condensation heat transfer, is consistent with ANSI/ANS-56.4-1983 and is acceptable to the staff for GOTHIC 7.0 licensing analyses. The use of natural and forced convection heat transfer, to supplement the direct condensation heat transfer, and the use of the containment hydraulic diameter for the characteristic length, were also previously accepted by the staff as part of the Kewaunee review (ADAMS Accession No. ML012490176).

Consistent with ANSI/ANS-56.4-1983, the FCS GOTHIC 7.0 MEM also included containment atmosphere (vapor) to containment heat structure radiation heat transfer. The use of radiation heat transfer, to supplement both the direct steam condensation heat transfer and the natural and forced convection heat transfer, is acceptable to the staff for GOTHIC 7.0 licensing analyses.

3.2.5 MSLB Peak Pressure Benchmark Evaluation Model Results

The licensee performed a benchmark analysis to compare GOTHIC 7.0 to CONTRANS. The comparison is shown in the following table:

Computer Code	Peak Pressure (psig)	Time to Peak Pressure (sec)	Peak Temperature (°F)	Time to Peak Temperature (sec)
GOTHIC 7.0	58.46	67.01	404	58.01
CONTRANS	59.766	66.99	417.822	64.99

The results of the analysis showed that both GOTHIC 7.0 and CONTRANS predict similar trends. The differences in the peak values are attributed to modeling differences in the two codes, particularly the modeling of the CS (Section 3.2.3 of this safety evaluation - Engineered Safety Features) and the Uchida HTC (Section 3.2.4 of this safety evaluation).

The licensee concluded that the benchmark comparison showed that the basic MSLB model was suitable for use in developing the MSLB licensing analysis evaluation model. The staff agrees with this assessment.

3.2.6 MSLB Peak Pressure Evaluation Model Results

The licensee performed the MEM analysis with GOTHIC 7.0. The results are shown in the following table:

Computer Code	Peak Pressure (psig)	Time to Peak Pressure (sec)	Peak Temperature (°F)	Time to Peak Temperature (sec)
GOTHIC 7.0	56.50	67.01	373.3	47.01

The staff performed a GOTHIC 7.0 scoping study to evaluate the effects of containment atmosphere (vapor) to containment heat structure radiation heat transfer. The pressure response is shown in Figure 3 attached to this safety evaluation and the temperature response is shown in Figure 4 attached to this safety evaluation. The peak pressure is about 1.1 psi higher without radiation, but still within the design base. The peak temperature is about 14°F higher without radiation, but still below the current AOR value.

3.2.7 MSLB Peak Pressure Conclusions

The licensee has developed an MSLB GOTHIC 7.0 licensing evaluation model, based on a benchmark model comparison to the CONTRANS AOR. The single, lumped parameter volume model is acceptable to the staff, and is consistent with the approach used in the AOR. The modeling of the containment heat structures is acceptable to the staff. The approach is consistent with the CONTRANS AOR and includes additional conservatism for the peak pressure calculation.

The initial containment conditions, the pressure, temperature and relative humidity, have been determined to be conservative for the peak pressure calculation, or consistent with the current AOR, and are acceptable to the staff. The modeling of the ESF, the CS system and the CFCs, has been determined to be conservative for the peak pressure calculation and is acceptable to the staff.

The MSLB mass and energy release calculation was based on the previously accepted AOR methodology and is acceptable to the staff.

The GOTHIC 7.0 break flow model has been previously accepted by the staff as part of the Kewaunee review (ADAMS Accession No. ML012490176). Based on this previous approval, OPPD has provided justification to demonstrate that the GOTHIC 7.0 break flow model is acceptable for application at FCS. The staff has reviewed the application and concludes that the GOTHIC 7.0 break flow model is acceptable for application at FCS.

The HTC used in the MEM, the Uchida correlation for steam condensation, is acceptable to the staff and is consistent with guidance provided in the NRC's SRP and ANSI/ANS-56.4-1983. The augmentation of the steam condensation heat transfer by natural and forced convection heat transfer is consistent with ANSI/ANS-56.4-1983 and is acceptable to the staff. The augmented heat transfer has also been previously accepted by the staff as part of the Kewaunee review (ADAMS Accession No. ML012490176). In addition, based on guidance in ANSI/ANS-56.4-1983, the staff also accepts the radiation augmentation for heat transfer in combination with the selection of the MSLB break size to ensure a pure steam blowdown.

The staff concludes that the licensee's MEM and the revised peak containment pressure and temperature analysis is acceptable to demonstrate compliance with FCS Design Criteria 10, 49 and 52. Therefore, the staff concludes that sufficient conservatism has been incorporated in the analysis to provide reasonable assurance that adequate margins to design values are maintained.

3.3 LOCA Long-Term Evaluation Model

3.3.1 LOCA Long-Term Evaluation Model Description

The licensee agreed with the staff that the long-term containment response analysis is required. The licensee plans to extend the analysis to include the post-recirculation actuation signal (RAS) period as part of the future licensing submittals. The planned replacement of the steam generators and the planned power uprate are examples of where this reanalysis would be necessary. The containment response analysis should provide the trends for key parameters, such as the containment pressure and temperature for a design basis accident (DBA). The licensee's plan was provided in response to question 5 of the staff's RAI.

The full analysis should cover the duration referred to as the short-term and the long-term periods. These distinctions are made with reference to the RAS. The short-term analysis is concluded upon receipt of the RAS and the long-term analysis continues after RAS for a specified period of time after the occurrence of the DBA.

The peak pressure and temperature generally occur early in the accident (on the order of a few minutes) during the short-term period. The licensee stated that the full analysis should run long enough to return the containment pressure and temperature to their original values prior to the initiation of the event. This duration, for a LOCA, may be up to two weeks.

The analysis used to obtain the break mass and energy transfer rates to the containment for the short-term, up to the initiation of RAS, is based on computer codes capable of analyzing the RCS response to large break LOCAs. During this period, the safety injection into the RCS is from the SIRWT and the safety injection has a fixed enthalpy (constant temperature source). In the post-RAS period, the ESF (CS and high pressure safety injection (HPSI) system) pumps take their suction from the containment sump after being switched from the SWIRT. Since the RCS break discharges to the containment sump, the enthalpy of the safety injection would be a function of time (changing sump temperature). The containment sump is cooled by the shutdown cooling heat exchangers (SDC-HX) after the RAS occurs to provide sufficient net positive suction head (NPSH) for the safety injection pumps as well as sufficient cooling to remove the stored energy in the RCS metal (sensible heat) and the core decay heat.

The model for the long-term containment pressure analysis should have sufficient details to produce the containment pressure and temperature trend for the specified time period. The modeling details should primarily address two aspects: (1) the break mass and energy transfer rates from the RCS to the containment, and (2) the cooling mechanism for the containment sump.

Conservative inputs and assumptions should be used to model the mass and energy releases into the containment during the long-term analysis and to model the ESF. In addition, the heat transfer coefficients for the passive containment heat structures should be conservatively low for the containment pressure and temperature calculation.

The licensee plans to extend the short-term analysis to include the long-term containment response by adding two major modifications to the LEM model. These are the extension of the break mass and energy transfer to the containment during the long-term period and the cooling of the containment sump by the SDC-HX.

The calculation of the mass and energy transfer rates using RCS codes must include the proper forcing function for the safety injection enthalpy from the containment sump. The sump enthalpy is a function of the RCS mass and energy transfer and the SDC-HX cooldown rate. This would require a time consuming iteration between the RCS and the containment codes to calculate the containment pressure and temperature if RCS codes were used to develop the mass and energy releases into the containment.

The long-term response is based on a mass and energy balance around the reactor vessel and does not require the special models needed in RCS codes for LOCA analyses, such as blowdown, refill, and reflood. The long-term analysis is much less demanding than the short-term analysis for the break mass and energy release rates and the long-term analysis has been previously performed with containment codes. The CONTRANS stand-alone containment model has been previously accepted by the staff for long-term analyses. The COPPATA[12] code has also been previously accepted by the staff for long-term analyses. The staff has also used

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[12] Bechtel Standard Computer Program, NE100, COPATTA, Containment Temperature and Pressure Transient Analysis," User and Theory Manuals.

the CONTAIN[13] code to perform its independent assessment of the licensee's methods for similar analyses.

The GOTHIC 7.0 code has the necessary features to model the RCS long-term mass and energy transfer rates. This will be accomplished by modeling the RCS primary system as follows:

- A lumped parameter volume will be used to represent the reactor vessel and the primary system piping. Thermal conductors will be added to this volume to represent the RCS metal sensible heat, including the SG tubes, the RCS pipe runs, the vessel internals, etc.

- Thermal conductors may be used to represent the fuel rods producing the decay heat. An alternative to this approach may be to account for the mass of uranium and zircaloy and include the decay heat as a forcing function using a GOTHIC heater component. The decay heat generation table will conservatively model the decay heat, based on one of the currently used standards, ANS-1971 or ANS-1979, or based on SRP 9.2.5, "Ultimate Heat Sink," Branch Technical Position ASB 9-2, "Residual Decay Energy for Light-water Reactors for Long-term Cooling."

- The HPSI pumps will be modeled by providing the safety injection flow rate versus RCS pressure as a GOTHIC forcing function to a coupled boundary condition. The suction will be from the containment sump and going to the new RCS volume.

To model the post-RAS CS, a coupled boundary condition will be provided from the containment sump to the containment spray. The SDC-HX will be added to the LEM to cool the containment sump.

3.3.2 LOCA Long-Term Model

Based on the staff's acceptance of similar modeling methods, the staff concludes that the licensee may use GOTHIC 7.0 for future licensing submittals for the long-term FCS LOCA containment pressure and temperature analysis to demonstrate compliance with FCS Design Criterion 52 and to justify a reduction in containment leakage when evaluating the radiological consequences of a LOCA. However, as part of future licensing submittals, such as the planned replacement of the steam generators and the planned power uprate, the licensee will need to provide a description of the model inputs for the staff to make its final determination that sufficient conservatism has been incorporated into the analysis to provide reasonable assurance that adequate margins to design values are maintained.

In response to question 2 of the staff's RAI, the licensee stated that the currently approved CONTRANS AOR long-term pressure response will be maintained in the USAR to demonstrate compliance with FCS Design Criterion 52 and to justify a reduction in containment leakage when evaluating the radiological consequences of a LOCA. This is acceptable to the staff.

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[13] Murata, K.K. et al., "Code Manual for CONTAIN 2.0: A Computer Code for Nuclear Reactor Containment Analysis," NUREG/CR-6533, USNRC, December 1997.

3.4 Environmental Equipment Qualification Model

In response to question 12 of the staff's RAI, the licensee identified the changes to the evaluation models for EEQ analyses. To be consistent with NUREG-0588[14] and SRP 6.2.1.5, the models will include an eight percent credit for vaporization and the heat transfer rate from the Tagami and Uchida correlations will be increased by a factor of four to evaluate electrical components. This is acceptable to the staff.

The current EEQ AOR, based on CONTRANS, is being maintained in the USAR. This is acceptable to the staff.

3.5 Conclusions

The staff concludes that the licensee's GOTHIC 7.0 LOCA and MSLB evaluation models and the revised peak containment pressure and temperature analyses are acceptable to demonstrate compliance with FCS Design Criteria 10, 49 and 52. The staff concludes that sufficient conservatism has been incorporated in the analyses to provide reasonable assurance that adequate margins to design values are maintained. Therefore, the proposed change to USAR Section 14.16 to incorporate the use of the GOTHIC 7.0 computer program for the containment peak pressure evaluation is acceptable to the staff.

The staff concludes that the licensee's plan to use GOTHIC 7.0 for the long-term FCS LOCA containment pressure and temperature analysis is acceptable to demonstrate compliance with FCS Design Criterion 52 and to justify a reduction in containment leakage when evaluating the radiological consequences of a LOCA. However, as part of future licensing submittals, such as the planned replacement of the steam generators and the planned power uprate, the licensee will need to provide a description of the model inputs for the staff to make its final determination that sufficient conservatism has been incorporated into the analysis to provide reasonable assurance that adequate margins to design values are maintained. Maintaining the currently approved CONTRANS AOR long-term pressure response in the USAR to demonstrate compliance with FCS Design Criterion 52 and to justify a reduction in containment leakage when evaluating the radiological consequences of a LOCA, is acceptable to the staff.

The staff concludes that the licensee's plan to use GOTHIC 7.0 for EEQ analyses is acceptable. Maintaining the current approved CONTRANS EEQ AOR in the USAR is acceptable to the staff.

4.0 STATE CONSULTATION

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

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[14] NUREG-0588, "Interim Staff Position on Environmental Qualification of Safety-Related Electrical Equipment."

5.0 ENVIRONMENTAL CONSIDERATION

The amendment changes a requirement with respect to installation or use of a facility component located within the restricted area as defined in 10 CFR Part 20. The NRC staff has determined that the amendment involves no significant increase in the amounts, and no significant change in the types, of any effluents that may be released offsite, and that there is no significant increase in individual or cumulative occupational radiation exposure. The Commission has previously issued a proposed finding that the amendment involves no significant hazards consideration and there has been no public comment on such finding (68 FR 12956). Accordingly, the amendment meets the eligibility criteria for categorical exclusion set forth in 10 CFR 51.22(c)(9). Pursuant to 10 CFR 51.22(b) no environmental impact statement or environmental assessment need be prepared in connection with the issuance of the amendment.

6.0 CONCLUSION

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

Attachments: Figures 1 through 4

Principal Contributor: E. Throm

Date: November 5, 2003

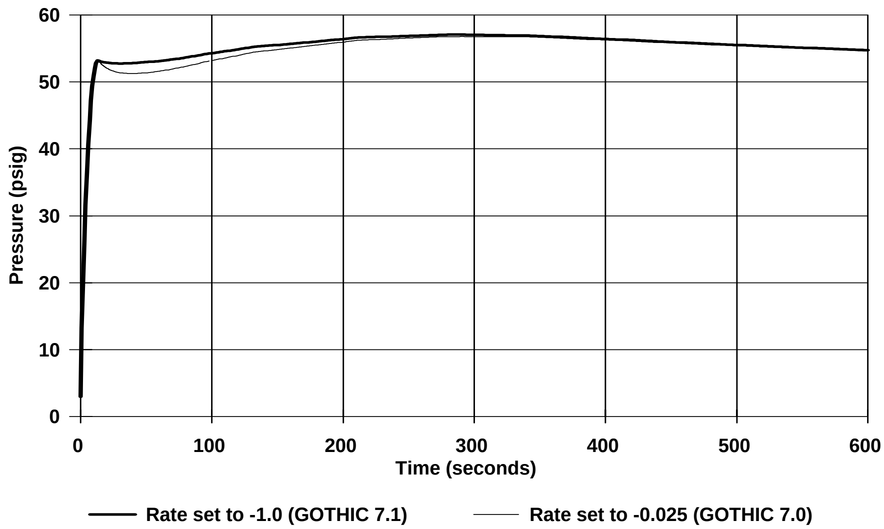

Figure 1 Staff scoping study - Effect of Tagami to Uchida transition rate on LOCA pressure calculation

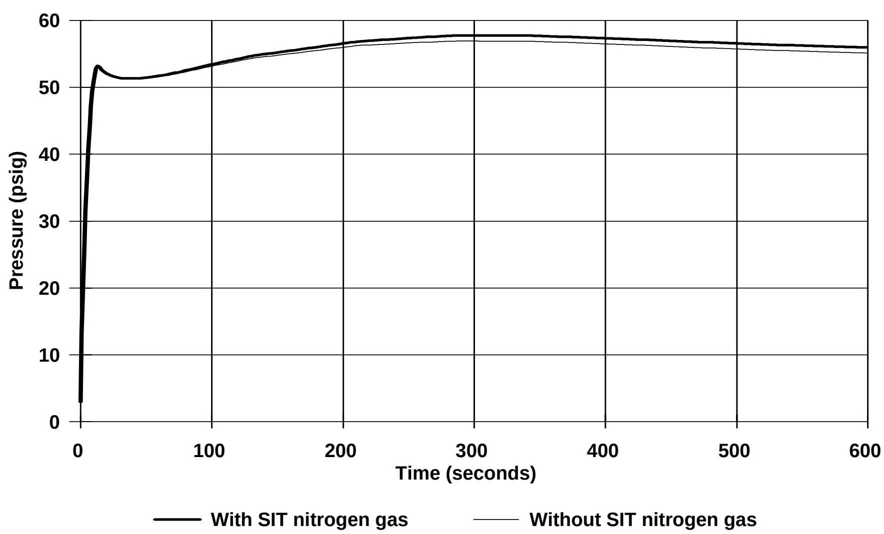

Figure 2 Staff scoping study - Effect of SIT nitrogen gas on LOCA pressure calculation (GOTHIC 7.0)

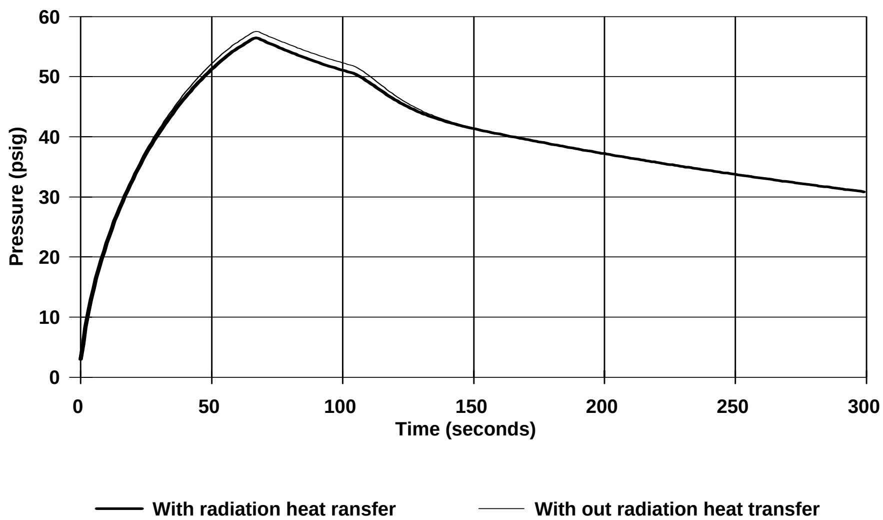

Figure 3 Staff scoping study - Effect of radiation heat transfer on MSLB calculated pressure (GOTHIC 7.0)

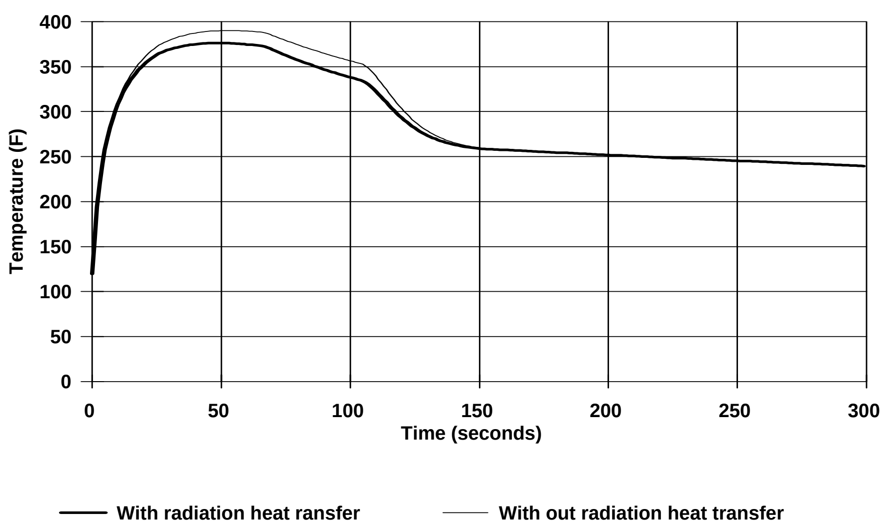

Figure 4 Staff scoping study - Effect of radiation heat transfer on MSLB calculated temperature (GOTHIC 7.0)