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

SAFETY EVALUATION BY THE OFFICE OF NUCLEAR REACTOR REGULATION

RELATED TO AMENDMENT NO. 157 TO FACILITY OPERATING LICENSE NO. DPR-19

AND AMENDMENT NO. 152 TO FACILITY OPERATING LICENSE NO. DPR-25

COMMONWEALTH EDISON COMPANY

DRESDEN NUCLEAR POWER STATION, UNITS 2 AND 3

DOCKET NOS. 50-237 AND 50-249

1.0 INTRODUCTION

By letter dated February 17, 1997, as supplemented February 27, March 12, March 26, April 2, and April 10, 1997, Commonwealth Edison Company (ComEd, the licensee) submitted a license amendment requesting review and approval of an Unreviewed Safety Question (USQ) associated with the use of containment pressure to compensate for the deficiency in Net Positive Suction Head (NPSH) for the Emergency Core Cooling System (ECCS) pumps following a Design Basis Accident (DBA). In the resolution of the USQ the licensee changed the Updated Final Safety Analysis Report (UFSAR) in the following areas:

1. containment analysis,
2. decay heat model,
3. increase in the suppression pool temperature and the effect on other associated systems following a DBA.
4. ECCS heat exchanger duty and containment cooling service water (CCSW) flow.

In addition, the proposed amendment would change the Technical Specification (TS) allowable water temperature values for the suppression chamber and the ultimate heat sink from 75 degrees Fahrenheit to 95 degrees Fahrenheit. The original licensing basis temperature for both the suppression chamber and ultimate heat sink was 95 degrees Fahrenheit. Both values were changed in the TS in an amendment issued by the NRC on January 28, 1997. The amendment to lower the ultimate heat sink and suppression pool temperature limits in the TS was in response to the resolution of a USQ associated with the operation of Dresden Units following the discovery of a calculational error concerning the head loss across the ECCS suction strainers. The license was amended for both Units 2 and 3, to allow for containment overpressure to compensate for a lack of NPSH for the ECCS pumps.

The proposed amendment will allow for both units to continue power operations when the ultimate heat sink temperature goes above 75 degrees Fahrenheit during warm weather.

The February 27, March 12, March 26, April 2 and April 10, 1997, submittals provided additional clarifying information that did not change the initial proposed no significant hazards consideration determination.

2.0 BACKGROUND

Prior to December 1996, Dresden Station's original design basis as identified in the UFSAR and on vendor drawings included a 1-foot head loss across the ECCS suction strainers located in the suppression pool. This pressure drop is used in the calculations that show that adequate NPSH is available to support the operation of the ECCS pumps during DBA conditions. The design basis for the ECCS has been under review by the licensee. The licensee determined that the 1-foot head loss drop across the suction screen that was previously used was not representative of the actual pressure drop that could exist.

As a part of the design basis review in December 1996, the licensee concluded that the original design basis of Dresden Station assumed an elevated pressure in the containment following a postulated DBA. Many similar vintage Boiling Water Reactors (BWR) were constructed with ECCS designs that use ECCS pumps and pump locations that do not provide as much NPSH margin as later designs. Dresden is an early vintage plant and the design does not include the additional margin that is available in later designs.

The assumption of an elevated post-accident pressure in the suppression chamber was not fully credited in the Dresden, Units 2 and 3, licensing basis, although a limited discussion is included in the UFSAR, Section 6.3.3.4.3. This section of the UFSAR describes an analysis done to verify the NPSH available for the ECCS pumps. The description of the analysis shows that for at least one of the analyzed cases, the presence of a 2-psig pressure in the drywell is adequate to offset the calculated deficiency in the available NPSH. This implies that the overpressure is a required design basis assumption of the facility.

However, the design and licensing bases for the Dresden Station also contain many statements that show that the facility does not require containment pressure to assure adequate NPSH is available to the ECCS pumps, including the TS basis. The licensee concluded that these discrepancies and inconsistencies, when taken together, do not support a clear basis for assuming the availability of the 2-psig pressure following a postulated DBA. Following the discovery of the calculation error, in December 1996, the licensee did a prompt 10 CFR 50.59 evaluation on the change in head loss across the ECCS suction strainers and discovered a USQ existed. In summary, the UFSAR stated that 2-psig of containment pressure will make up for the 3 feet of NPSH deficiency to prevent an ECCS pump cavitation or an ECCS pump cavitation will occur. The new analyses indicated that even with 2-psig of pressure, limited cavitation and reduced ECCS pump flow will occur. This is the reason the licensee concluded that the error in the calculation resulted in a USQ.

The licensee did calculations that included the increased head loss across the ECCS suction strainers. The calculations indicated that to regain NPSH margin, the initial accident analysis assumptions regarding the UHS and suppression pool average water temperature must be reduced. The original TS, in Limiting Condition for Operation (LCO) Sections 3.7.K and 3.8.C, limited these water temperatures to less than or equal to 95 degrees Fahrenheit. The licensee concluded that these temperatures should be limited to less than or equal to 75 degrees Fahrenheit to insure that the DBA analyses are consistent with the existing licensing basis.

The NRC Staff reviewed the proposed license amendment and changes to the TS and on January 28, 1997, approved amending the license for Dresden Station to allow credit for a limited amount of containment overpressure during the first 10 minutes following a DBA. In addition, the TS limits, for both suppression pool and ultimate heat sink temperature limits were reduced from 95 degrees Fahrenheit to 75 degrees Fahrenheit.

The proposed amendment would restore the temperature limits for the suppression pool and the ultimate heat sink to 95 degrees Fahrenheit, the original TS values, to allow the Dresden Station to operate during warm weather conditions. Because of changing the temperature limits more containment pressure is necessary over a longer period to compensate for deficiencies in NPSH for the ECCS pumps following a DBA. The licensee evaluated the necessity for additional containment pressure and determined it was a USQ and requested review and approval pursuant to 10 CFR 50.59 and 10 CFR 50.90.

3.0 EVALUATION

3.1 Evaluation of the USQ

The proposed amendment requested review of the USQ to allow credit for a nominal amount of containment overpressure following a DBA. The proposed amendment would also revise the TS, and the TS Bases.

3.2 Containment Pressure and Temperature

The licensee submitted the results and input assumptions of analyses performed with the SHEX-04 computer code to predict the minimum containment pressure and peak suppression pool temperature resulting from a design-basis loss of coolant accident (LOCA). Various cases incorporating different degrees of mixing in the containment atmosphere and the effect of containment sprays were analyzed to determine the most limiting cases, regarding NPSH, for the short- and long-term containment response, and to predict the peak suppression pool temperature.

3.2.1 Minimum Containment Pressure Analyses

The licensee has requested credit for the following amounts of containment overpressure to satisfy pump NPSH requirements:

Time Period (seconds)	Containment Overpressure (psig)
0 - 240	9.5
240 - 480	2.9
480 - 6000	1.9
6000 - Accident end	2.5

The minimum containment pressure analysis conducted by the licensee contains modeling assumptions and input parameters that tend to reduce the predicted post-LOCA containment pressure, thereby providing conservatism in how much overpressure can be credited for NPSH.

The short-term is defined as the time from the start of the LOCA out to 600 seconds. The long-term analysis begins at 600 seconds, the time at which manual operator actions can be credited for throttling ECCS pump flows and initiating containment cooling via drywell/wetwell spray or suppression pool cooling. These analyses varied the degree of thermal mixing between break liquid and containment atmosphere, and also examined different low pressure coolant injection (LPCI) and core spray (CS) pump combinations and pump flows, to determine the case that produced the minimum credible containment pressure. The amount of thermal mixing affects the degree of heat removal from the containment atmosphere, while different combinations of pump flows affect the mass and energy released from the break and how much break flow is available for mixing.

In its February 17, 1997 submittal (Reference 1), the licensee listed the input assumptions and parameters common to the SHEX analyses for minimum containment pressure and peak suppression pool temperature. These are as follows:

- The reactor is assumed to be operating at 102 percent of the rated thermal power, in accordance with Regulatory Guide 1.49
- Use of ANS 5.1-1979 standard, without uncertainty additions, to calculate decay heat
- Vessel blowdown flow rates are based upon the Homogeneous Equilibrium Model
- Feedwater flow continues into the reactor until all feedwater above 180 degrees Fahrenheit is injected
- Thermodynamic equilibrium exists between liquids and gases in the drywell
- The liquid not held up in the drywell is assumed to flow directly to the suppression pool without heat transfer to the drywell fluids

- The vent system flow to the suppression pool consists of a homogeneous mixture of the fluid in the drywell
- The initial suppression pool volume is at the minimum TS level to maximize the calculated suppression pool temperature
- The initial drywell and suppression chamber pressure are at the minimum expected operating values of 1.0 psig and 0 psig, respectively, to minimize containment pressure
- The maximum operating value of the drywell temperature of 150 degrees Fahrenheit and a relative humidity of 100 percent are used to minimize the initial non-condensable gas mass and to minimize the long-term containment pressure for the NPSH evaluation
- The drywell and torus condensation heat transfer coefficients are based on the Uchida correlation with a 1.2 multiplier
- CS and LPCI/containment cooling system pumps have 100 percent of their horsepower rating converted to a pump heat input added either to the reactor vessel input or suppression pool water

The case that predicted the minimum containment pressure for the first 600 seconds assumed a double-ended break of the LPCI recirculation suction line with all 4 LPCI pumps injecting through the break, 2 core spray pumps cooling the core, 60 percent thermal mixing of the break flow with the drywell atmosphere, and the inclusion of passive heat sinks (Case 6a2 as identified in the licensee's February 17, 1997 submittal) (Reference 1).

The minimum pressure predicted from the licensee's short-term analysis is 2.9 psig at 533 seconds. The maximum predicted short-term suppression pool temperature is 148 degrees Fahrenheit at 600 seconds.

The case that predicted the minimum containment pressure for the long-term assumed a double-ended break of the LPCI recirculation suction line with 1 LPCI pump and 1 core spray pump operating, 20 percent thermal mixing of the break flow with the drywell atmosphere, the inclusion of passive heat sinks, and the initiation of drywell/wetwell sprays at 600 seconds and operating continuously for the remainder of the analysis. (Case 2a1 as identified in the licensee's February 17, 1997 submittal) (Reference 1).

The minimum pressure predicted from the long-term analysis is 1.9 psig for the period from 600 seconds to accident termination, and 2.9 psig at the maximum predicted suppression pool temperature for NPSH purposes of 172.1 degrees Fahrenheit.

In a Request for Additional Information (RAI) dated March 21, 1997, the staff asked the licensee if the case of a stuck open relief valve (SORV) had been considered from a minimum pressure perspective. In its response dated March 26, 1997, (Reference 4), the licensee stated an analysis had been previously conducted in connection with the Mark 1 long-term program. The results of these analyses indicate a peak suppression pool temperature of 131 degrees Fahrenheit. Although the containment pressure was not calculated, the containment pressurization for this event would be limited to the gradual heating of the containment airspace. The licensee further indicated that the SORV event without feedwater would require less ECCS flow than the double-ended recirculation line break. Because the recirculation line break results in the highest ECCS flow rates and suppression pool temperatures while developing low amounts of overpressure, the licensee indicated that it represents the limiting case with regard to NPSH.

The staff has reviewed the licensee's minimum containment pressure analysis conducted for the purpose of crediting containment overpressure to help satisfy NPSH requirements for the LPCI and CS pumps. The staff finds that the licensee has used input and modeling assumptions that minimize the containment pressure and has investigated a sufficient number of cases such that the case which produces the minimum credible pressure concurrent with the limiting NPSH condition has been identified. The staff did have concerns with the effect that containment sprays would have on the containment pressure. The licensee has addressed these concerns as discussed below.

3.2.2 Containment Sprays

According to the current Dresden Emergency Operating Procedures (EOPs), manual initiation of containment sprays would occur at 9 psig containment pressure, and manual shutoff is directed by the EOPs at 2 psig. In a Request for Additional Information (RAI) dated March 21, 1997, the staff asked the licensee about the feasibility of revised spray actuation and termination set points, to increase the margin between the available containment pressure and the NPSH requirements.

Because of concerns with the sprays and the pressure reduction they achieve, by letter dated April 10, 1997, the licensee has committed to change the Dresden Units 2 and 3 EOPs to alert operators to NPSH concerns and to make containment spray operation consistent with the overpressure requirements for NPSH. This will be accomplished by directing operators to terminate containment spray operation at a sufficiently elevated containment pressure such that containment overpressure for NPSH will be present and adequate NPSH margin for ECCS pumps will be ensured. Through training, operators will also be informed of the elevated importance of NPSH, and of the alternate containment spray setpoints. Consideration will also be given to the spray initiation setpoint so that undesirable toggling of the sprays will not occur. The licensee also committed to submit the proposed changes to the BWR Owners Group for evaluation and resolution. The staff concurs with the licensee that the changes to the EOPs increase overall safety.

The licensee's rationale for requiring the BWROG review of the EOP changes is that operating the sprays in accordance with the revised changes to the Dresden Units 2 and 3 EOPs involves increased operator attention and more valve cycling than would be necessary with the current EOPs, based on simulator scenarios. Because the aforementioned changes have a bearing on operator and spray behavior, and may have application to other facilities, an evaluation by the BWROG is necessary.

The licensee commits to have the EOP changes in effect and operators trained prior to implementation of the amendments. The licensee also commits to request to have a final resolution concerning the sprays and EOPs from the BWROG by July 1, 1997.

3.2.3 ANS 5.1-1979 Decay Heat

In resolution of the USQ the licensee has proposed to change the decay heat model described in the UFSAR to ANS 5.1-1979. The original licensing basis calculations for Dresden used the May-Witt decay heat curve, which is recognized by the staff as conservative and which predicts substantially higher values of decay heat than the ANS 5.1-1979 standard. Regarding the licensee's use of the ANS 5.1-1979 standard with no added uncertainty to calculate the decay heat added to the containment post-LOCA, the staff has determined that for containment response analyses, a 2-sigma uncertainty should be added to the decay heat calculated by the standard. The basis for this determination is that the ANS 5.1-1979 standard is a best-estimate model, and thus deviates from the conservative models and methodologies typically required by the staff for design-basis accident analysis. A +2-sigma (i.e. 2 standard deviations) uncertainty corresponds to a 95 percent confidence; i.e. there is a 95 percent statistical confidence that the decay heat calculated by the model will fall within the envelope defined by the calculated decay heat +2-sigma.

Because of the staff's determination concerning use of a +2-sigma uncertainty addition, the licensee has committed to perform new minimum containment pressure and peak suppression pool temperature analyses incorporating a +2-sigma uncertainty addition. By letter dated April 2, 1997, the licensee has committed to provide this analysis within 180 days after issuance of the proposed amendment. This analysis will provide additional justification for use of the ANS 5.1-1979 Decay Heat model. The staff finds that operation of Dresden Units 2 and 3 without the 2-sigma uncertainty addition is acceptable. As discussed in the following section, the staff's basis for operation without an analysis using the 2-sigma uncertainty is a sensitivity study submitted by the licensee (Reference 4) which added 10 percent to the decay heat calculated by ANS 5.1-1979. The study indicates that the addition of 10 percent, which bounds 2-sigma, results in an increase of only approximately 4 degrees Fahrenheit in the peak suppression pool temperature.

3.2.4 Peak Suppression Pool Temperature Analysis

Because of changes in the design heat removal from containment, the proposed increase of the TS maximum ultimate heat sink temperature from 75 degrees Fahrenheit to 95 degrees Fahrenheit, and the proposed increase of the TS maximum suppression pool temperature during normal operation from 75 degrees Fahrenheit to 95 degrees Fahrenheit, the licensee has conducted a re-analysis to determine the peak post-LOCA suppression pool temperature.

A new design value for containment heat removal has been used in the re-analysis. The original rated duty of the LPCI heat exchanger, as described in the Dresden, Units 2 and 3, Updated Final Safety Analysis Report (UFSAR) (Reference 5), was 105 million BTU/hr. As the result of reconstitution of this design-basis value, the licensee established a value 98.5 million BTU/hr. This value of 98.5 assumed a total CCSW flow rate of 7000 GPM. However, the licensee shows that based on recent testing, a total CCSW flow rate of 7000 GPM cannot be achieved.

In addition, a 20 psid differential pressure must be maintained between the tube side and shell side of the heat exchanger to ensure against out leakage of reactor cooling water into the service water system. Because of the reconstituted capacity of the heat exchanger and reduced CCSW flow capability, the total CCSW flow must be throttled to a minimum of 5000 GPM at the nominal total LPCI flow rate of 5000 GPM and peak containment pressure expected during a LOCA, to achieve 20 psid. Incorporating these flows, the revised heat removal rate of the LPCI heat exchanger is 71.0 million BTU/hr. The following assumptions were also made in determining the new value for containment heat removal:

- 95 degrees Fahrenheit service water temperature (consistent with the change affected by this license amendment)
- 165 degrees Fahrenheit suppression pool temperature
- Heat exchanger fouling, in accordance with the guidance of Standard Review Plan (SRP) 6.2.2, "Containment Heat Removal Systems," and consistent with the current licensing basis
- 6 percent of the tubes plugged, consistent with the current licensing basis
- Operation of containment sprays starting at 600 seconds

The licensee presented analyses that varied the degree of thermal mixing in the containment atmosphere and varied the ECCS flow rates. The case that produced the peak suppression pool temperature occurred for a double-ended break of the LPCI recirculation suction line with 2 LPCI pumps and 1 core spray pump operating, and 20 percent thermal mixing of the break flow with the drywell atmosphere (Case 5a1 as identified in the licensee's February 17, 1997 submittal) (Reference 1).

The maximum predicted suppression pool temperature is 176 degrees Fahrenheit and occurs at approximately 5 hours into the transient. The licensing-basis suppression pool temperature prior to the current re-analysis was 160 degrees Fahrenheit, as stated in the staff's January 28, 1997, license amendment (Reference 6), and was 170 degrees Fahrenheit prior to the staff's January 28, 1997, amendment.

The staff has reviewed the licensee's peak suppression pool temperature analysis and finds that the licensee has used assumptions that maximize the calculated suppression pool temperature. The licensee has also investigated a sufficient number of cases such that the peak temperature case has been identified.

However, the staff notes that the licensee has not incorporated a +2-sigma uncertainty addition on the ANS 5.1-1979 decay heat model. As already discussed in the preceding section, the licensee has committed to re-analyze the peak suppression pool temperature with a 2-sigma uncertainty addition within 180 days of the date of issuance of this license amendment, and to submit this re-analysis for staff review. The licensee has committed to provide the 2-sigma uncertainty addition analysis to provide additional justification for the use of the ANS 5.1-1979 decay heat model.

The staff finds operation without the 2-sigma uncertainty addition acceptable based on a sensitivity study which added 10 percent to the decay heat calculated by ANS 5.1-1979 (Reference 4). The study indicates that the addition of 10 percent, which bounds 2-sigma, results in an increase of only approximately 4 degrees Fahrenheit in the peak suppression pool temperature.

3.2.5 SHEX Benchmark

The licensee benchmarked the current analyses run with the SHEX code against the current licensing-basis containment pressure and temperature response. This benchmarking was performed to assess the differences between the UFSAR and SHEX analytical results produced as a result of the SHEX code and the modeling features inherent in the code. These analyses were provided to the staff in a submittal dated February 27, 1997, (Reference 2).

Two SHEX analyses corresponding to the short and long-term containment pressure and temperature response were conducted and compared against Case C in Section 6.2 of the Dresden, Units 2 and 3, UFSAR. Case C corresponds to a double-ended break of a recirculation suction line, and assumes 1 containment cooling loop with one heat exchanger, and 2 LPCI/2 CCSW pumps for long-term containment cooling.

For the analyses performed using SHEX, the following modeling assumptions and inputs were used, and were chosen to be consistent with Case C in the UFSAR:

- Initial suppression pool temperature of 90 degrees Fahrenheit
- Initial drywell and wetwell pressure of 1.0 psig
- No feedwater addition
- No pump heat addition for pumps taking suction from the suppression pool
- May-Witt decay heat model
- LPCI heat exchanger heat removal rate of 105 million BTU/hr
- 100 percent mixing of drywell break fluid with containment atmosphere

- Mechanistic heat and mass transfer between the suppression pool water and the suppression chamber atmosphere
- A 2 LPCI/containment cooling pump flow of 10,000 GPM and a CS pump flow of 4500 GPM for vessel injection prior to and after 600 seconds
- Use of drywell and suppression chamber sprays initiated at 600 seconds

Regarding the short-term pressure response at 600 seconds, the SHEX analysis predicts a pressure of 10.2 psig, while Case C predicts approximately 11.0 psig. The licensee's analysis stated that any differences in the calculated pressures between the two cases could be attributed to differences in the number of pumps assumed running, since it is uncertain from the description of the UFSAR analysis how many pumps were assumed to be operating.

Regarding the long-term pressure response, the SHEX analysis predicts 4.8 psig, whereas Case C predicts approximately 6.0 psig. The peak long-term pressure predicted by SHEX is 6.4 psig as compared to approximately 6.5 psig for Case C. The licensee attributed these differences to differences in how the SHEX and the Case C analyses model the drywell and wetwell pressures. In SHEX, the drywell and wetwell are modeled separately, whereas the Case C analysis assumes them to be at the same pressure.

The peak long-term containment pressure predicted by SHEX was 162.5 degrees Fahrenheit compared to approximately 162 degrees Fahrenheit for Case C. Because the Case C analysis did not include a plot of the calculated pool temperature but instead provided the drywell temperature, the licensee presented an analysis that used the drywell temperature to predict the stated suppression pool temperature of 162 degrees Fahrenheit. This value compares favorably to the predicted suppression pool temperature in the Quad Cities UFSAR (Dresden's sister plant).

While the benchmark analysis uses assumptions different from those used in pressure and temperature analysis submitted to support this license amendment, the staff notes that the benchmark study is sufficiently consistent with previous licensing-basis analyses such that any differences resulting solely from the computer codes used can be assessed.

The staff has reviewed the licensee's benchmark analysis for the SHEX code, and finds that the analysis adequately assesses any differences between the results produced using SHEX and those produced by a previously approved UFSAR analysis.

3.3 Removal of Local Suppression Pool Temperature Limits Related to Condensation Oscillation Loads

The licensee has proposed to delete the local suppression pool temperature limit, as described in the UFSAR and the Bases for TS 3/4.7. The following paragraphs discuss the initial bases for the limit, and the staff's criteria for removal of the limit.

Dresden is equipped with safety relief valves (SRV) to protect against reactor over-pressurization during operating transients. Steam from an SRV discharge is directed to the suppression pool so that it can be condensed. Because of an extended period of discharge through the SRVs, local temperatures near, the SRV discharge location could lead to condensation instability or "condensation oscillation," which could result in extreme vibratory loadings on containment structures.

Dresden, Units 2 and 3, use "T" quenchers at the discharge of the SRVs and restrictions on bulk pool temperature to avoid the condensation oscillation phenomenon. Section 6.2 of the Dresden UFSAR describes the analyses used to determine the local suppression pool temperature limit that must be met to avoid unstable condensation. These analyses assume an initial suppression pool temperature of 95 degrees Fahrenheit, consistent with the TS change effected by this license amendment. By maintaining the local pool temperature 20 degrees Fahrenheit lower than the saturation temperature of the pool during SRV discharge, condensation oscillation can be avoided.

By letter dated August 29, 1994, from the NRC, to the Boiling Water Reactor Owners Group (Reference 12), the staff transmitted its Safety Evaluation of General Electric (GE) report NEDO-30832 titled "Elimination of Limit on BWR Suppression Pool Temperature," (Reference 13). NEDO-30832 presents a discussion of test data and an analysis which supports deletion of the requirement to maintain the local pool temperature below the saturation temperature of the pool during an SRV discharge.

The staff's evaluation of NEDO-30832 concluded that the local suppression pool temperature limit may be eliminated if suppression pool discharges are delivered to the suppression pool through a "T" or an "X" quencher device, and if the ECCS suction piping is below the quencher elevation. The evaluation also stated that NEDO-30832 was acceptable for reference in future licensing actions when the conditions for its applicability were met.

As stated in the licensee's February 17, 1997 submittal (Reference 1), Dresden, Units 2 and 3, have "T" quenchers installed, and the ECCS pump inlets are located below the elevation of the quenchers. Because Dresden, Units 2 and 3, meet the criteria for removal of local suppression pool temperature limits described in the staff's August 29, 1994 SER, the staff finds removal of local suppression pool temperature limits acceptable.

3.4 <u>LPCI and CS NPSH Calculations</u>

The licensee provided evaluations of post-LOCA NPSH for CS and LPCI pumps. The evaluations were divided into two portions as follows:

Short-Term: 0 to 600 seconds (10 minutes), no operator action credited, vessel injection phase, peak clad temperature (PCT) reached prior to 200 seconds (3.33 minutes)

Long-Term: 600 seconds to completion of the event, operator actions credited, containment cooling phase

Section 6.2.1.3.3 in the UFSAR established the 600 second mark for operator action and the time at which credit for manual initiation of containment cooling can be taken. Therefore, for the long-term case, operator action is credited at the 600 second mark.

3.4.1 Short-Term NPSH Requirements

The bounding NPSH case for LPCI and CS pumps for short-term evaluation was determined to be 4 LPCI and 2 CS pumps at runout conditions, with the LPCI pumps injecting into a broken reactor recirculation suction loop. Only core spray flow is injecting into the reactor. This event was described in Generic Electric (GE) Service Information Letter (SIL) 151 (Reference 7) which postulates a failure of the LPCI Loop Select logic. This SIL focused on the potential for loss of long-term containment cooling due to damage to the LPCI pumps under single failure assumptions. The concern was that operation in cavitation conditions could cause loss of the LPCI pumps and subsequent loss of the containment heat removal function. ComEd evaluated this event in 1976 with a known strainer head loss of 1-foot per 10,000 GPM. The evaluation concluded that a 3-foot deficit existed for the LPCI pumps. The staff found this limited amount of LPCI pump cavitation for a short period acceptable, based on pump test data (Reference 8).

Currently, the known head loss across the clean strainers is 5.8 feet at 10,000 GPM. With the bounding event described above, the licensee determined that a minimum core spray system flow of 11,300 GPM (5650 GPM per pump) is required for the first 200 seconds post accident to ensure the PCT remains below 2200 degrees Fahrenheit. At runout conditions, a CS system flow of 11,600 GPM (5800 GPM per pump) should be available. The licensee stated that the 10 CFR 50.46 analysis assumes a total core spray flow of 11,300 GPM that limits the PCT to 2030 degrees Fahrenheit at approximately 165 to 170 seconds post accident. To ensure total core spray flow meets the total required core spray flow, the licensee has requested that the current licensing basis be changed to account for the increased head loss and the restoration of the suppression pool and ultimate heat sink temperatures. To accomplish this, the licensee requested credit for the following containment overpressure for the specified time periods.

Time Period (seconds)	Containment Overpressure (psig)
0 - 240	9.5
240 - 480	2.9
480 - 600	1.9

The staff notes that some cavitation of the LPCI and CS pumps could occur from 260 to 600 seconds post-LOCA. This cavitation will occur after the PCT has been reached and therefore is not a concern from the PCT standpoint. The staff has reviewed the cavitation of the ECCS pumps, as described in Section 3.5 of this SER and determined that the cavitation is acceptable. The staff has also reviewed the licensee's minimum pressure analysis that shows the existence of 9.5, 2.9, and 1.9 psig containment overpressure, and finds it acceptable, this is discussed in Section 3.2 of this SER.

Based on this information, the following assumptions were made:

- LPCI and CS pump friction losses were developed using clean, commercial steel pipe, and were increased by 15 percent to account for the effects of aging.

- One of the four torus strainers were assumed to be 100 percent blocked while the others remained clean. This is consistent with Dresden's current licensing basis. The strainer closest to the break was assumed blocked. The licensee stated that blocking the strainer closest to the break provided more conservatism than blocking one strainer further from the break.

- A suppression pool pressure of 9.5 psig was assumed to exist for the first 240 seconds, 2.9 psig from 240 to 480 seconds, and 1.9 psig from 480 to 600 seconds. As discussed above, the containment analysis has shown that the suppression pool pressure credited will be present during the first 600 seconds post accident.

- The initial suppression pool temperature is assumed to be 95 degrees Fahrenheit, per Technical Specification 3.7.K.2 that is discussed in Section 3.7 of this SER. The corresponding suppression pool temperatures at 188 and 600 seconds are 137.6 degrees Fahrenheit and 148.7 degrees Fahrenheit, respectively.

- The maximum LPCI and CS flow were assumed to be 5150 GPM (20,600 GPM totals) and 5800 GPM (11,600 GPM totals), respectively at the beginning of the event. This corresponds to NPSH Required (NPSHR) of 31.5 feet and 38.5 feet for LPCI and CS based on the manufacturer's pump curve.

- The minimum suppression pool level, including drawdown of 2.1 feet, was used. This resulted in a static head of 13.3 feet.

Based on the above assumptions, the licensee evaluated the minimum suppression pool pressure (i.e., containment pressure) required for pump protection, assuming NPSH Available (NPSHA) was equal to NPSHR using the following equation.

$$P_{t,min}=\frac{(NPSHR-Z+h_{total})}{144xV}+P_V$$

where: P_t = suppression pool pressure in psia
P_v = saturation pressure in psia
V = specific volume in ft^3/lb
h_{total} = head loss across a strainer in feet plus suction friction losses in feet
Z = static head of water above a pump inlet in feet

The licensee's analysis, DRE97-0012 (Reference 9) showed that with all six ECCS pumps running and 9.5 psig minimum suppression pool pressure for the first 240 seconds, no NPSH deficit exists for the LPCI and CS at the 240-second mark. The licensee stated that under these worst case conditions, the CS and LPCI pumps would be cavitating from 260 to 600 seconds. However, the licensee does not have credit for containment overpressure greater than 2.9 psig after 241 seconds and therefore, the licensee's analysis shows that the LPCI and CS pumps would be cavitating from 241 to 600 seconds. Based on the credited containment overpressure of 1.9 psig, the staff calculated that the maximum deficit of 6.3 feet for LPCI and 12.5 feet for CS occurs at 600 seconds. These results are based on maximum flow conditions. The staff also notes that the margin deficits shown in the licensee's analysis are based on the minimum containment pressure curve, not the credited containment overpressure. Thus, the margin deficits discussed above are slightly larger than the deficits shown in the licensee's calculation.

As stated before, the PCT occurs at approximately 165 to 170 seconds after the design basis LOCA; CS flow of at least 5650 GPM is limiting at this point. Since potential cavitation does not occur until the 260-second mark, a CS flow of at least 5650 GPM is expected to exist. The PCT will begin to decrease at approximately 170 seconds, and therefore, the CS flow and NPSHA at the 600-second mark are bounded by the PCT analysis. The staff notes that additional margin is accounted for in this analysis based on the following:

1. The limiting CS flow of 5650 GPM per pump is for a PCT of 2030 degrees Fahrenheit that is lower than the allowable PCT of 2200 degrees Fahrenheit.

2. The licensee used LPCI and CS pump friction losses developed based on clean, commercial steel pipe, and increased by 15 percent to account for the effects of aging.

3. The strainer closest to the break was assumed blocked. The blocking of the strainer closest to the break provides more conservatism than blocking one strainer further from the break.

Based on the above analysis, the staff finds that with credit for containment overpressure of 9.5 psig for the first 240 seconds, 2.9 psig from 240 to 480 seconds, and 1.9 psig from 480 to 600 seconds, with some pump cavitation, NPSH for the ECCS pumps will be available to meet the short term worst case scenario. This 4LPCI/2CS pump case is shown on Figure 2 from the licensee's supplemented submittal dated March 26, 1997. The licensee intends to add this figure to the Dresden UFSAR. The staff concludes that this is acceptable.

3.4.2 Long-Term NPSH Requirements

The bounding NPSH case for LPCI and CS pumps for the long-term evaluation was determined to be a DBA LOCA. The evaluation done was time and temperature dependent beginning at 600 seconds post DBA. The maximum suppression pool temperature of 172.1 degrees Fahrenheit, for the worst case NPSH, was reached at the 18813-second mark. The effects of throttled LPCI pumps and different pump combinations, i.e., 4LPCI/3CS and 3LPCI/2CS etc., were examined.

Under this bounding event, the licensee evaluated the long-term NPSH requirements for LPCI and CS crediting operator actions and accounting for the new head loss of 5.8 feet at 10,000 GPM. To assure total core spray and LPCI flows meet the total required flow, the licensee has requested that the current licensing basis be changed to account for the increased head loss and the restoration of the suppression pool and ultimate heat sink temperatures. To accomplish this, the licensee requested credit for the following overpressure for the specified times.

Time (seconds)	Containment Overpressure (psig)
600 - 6000	1.9
6000 - Accident End	2.5

The staff has reviewed the licensee's minimum pressure analysis that shows the existence of 1.9 and 2.5 psig containment overpressure, and finds it acceptable, this is discussed in Section 3.2 of this SER. Based on this information, the following assumptions were made:

- LPCI and CS pump friction losses were developed using clean, commercial steel pipe, and were increased by 15 percent to account for the effects of aging.

- One of the four torus strainers were assumed to be 100 percent blocked while the others remained clean. This is consistent with Dresden's current licensing basis. The strainer closest to the break was assumed blocked. The licensee stated that blocking the strainer closest to the break provided more conservatism than blocking one strainer further from the break.

- Operator action will be taken at the 600-second mark to reduce LPCI and CS to their nominal rated flows of 5000 GPM and 4500 GPM, respectively.

- The minimum suppression pool level, including drawdown of 2.1 feet and a recovery of 1.1 feet, was used. This resulted in a static head of 14.4 feet.

- A suppression pool pressure of 1.9 psig was assumed to exist from 600 to 6000 seconds and 2.5 psig from 6000 seconds to the end of the accident. As discussed above, the containment analysis has shown that the suppression pool pressure credited will be present following the first 600 seconds post accident.

Based on the above assumptions, the licensee evaluated the minimum suppression pool pressure (i.e., containment pressure) required for pump protection, assuming NPSH Available (NPSHA) was equal to NPSHR using the equation described above. The licensee's analysis, DRE97-0010 (Reference 10) showed that with all six ECCS pumps running at their nominal flows and 1.9 psig and 2.5 psig minimum suppression pool pressure, a limited amount of NPSH deficit exists for the LPCI and CS. However, operator actions to further reduce LPCI flow are sufficient to maintain the long-term NPSH requirements, i.e., 4 LPCI at 2500 GPM and 2 CS at 4500 GPM. The worst case pump combination from the long-term NPSH standpoint was the 3LPCI/2CS case. In this case, with the credited containment overpressure and nominal pump flow rates, limited NPSH deficit also exists and requires operator actions to reduce the flow rates of the 3 available LPCI pumps. As described in the licensee's analysis, DRE97-0010, the operators would throttle LPCI flow to 2500 GPM for two pumps and 5000 GPM for the remaining LPCI pump. At these throttled flows and pump combination, the NPSH deficit would no longer exist. The staff notes that this 3LPCI/2CS pump case is the most limiting regarding NPSH requirements for the long-term case. This throttled 3LPCI/2CS pump case is shown on Figure 2 from the licensee's supplemental submittal dated March 26, 1997. The licensee intends to add this figure to the Dresden UFSAR.

Based on the above analysis, the staff finds that with credit for containment overpressure of 1.9 psig from 600 to 6000 seconds and 2.5 psig from 6000 to end of the accident, NPSH for the ECCS pumps will be available to meet the long-term worst case scenario. The staff concludes that this is acceptable.

3.5 LPCI and Core Spray Pump Cavitation

The NRC staff issued a TS amendment dated January 28, 1997, which contained the staff's safety evaluation (SE) of an unreviewed safety question related to Emergency Core Cooling System (ECCS) suction strainer pressure drop for Dresden, Units 2 and 3. This SE addressed the performance of the LPCI and Core Spray (CS) pumps under cavitating flow conditions similar to that currently being proposed by the licensee, except that the period of time which these pumps are expected to cavitate and the cavitating pump flow for the limiting LOCA conditions is less than previously analyzed. In the previous analysis, the licensee assumed cavitation for the entire first 600 second (ten-minute) period, whereas in the current analysis, the pumps are assumed to begin cavitating after 260 seconds and continue cavitating until 600 seconds (a total of 340 seconds) following the beginning of the limiting LOCA. Prior to 260 seconds following the beginning of the LOCA, with the credited containment overpressure conditions, the ECCS pumps will have adequate net positive suction head (NPSH) pressure and will not cavitate. After 600 seconds, the licensee assumes operator action to throttle the discharge of the CS and LPCI pumps and reduce the required NPSH to less than that available such that the pumps would remain operable for long term post-LOCA operation.

In the previous analysis, the licensee determined that the CS pumps were more limiting for NPSH than were the LPCI pumps for the limiting LOCA and that for the maximum CS pump cavitation which would occur, the CS pumps would each conservatively discharge 5300 gpm. For the current analysis, the licensee determined that the CS pumps are still more limiting than the LPCI pumps for NPSH and that the CS pumps would each discharge 5800 gpm when adequate NPSH exists (i.e., prior to 260 seconds). The staff has determined that with this flow continuing after 260 seconds, the peak NPSH deficit would occur at 600 seconds and would equal -12.5 feet. Therefore, the actual cavitating pump flow would be less than 5800 gpm under these conditions. However, the staff agrees that the CS pump flow would be significantly greater than the minimum flow of 4500 gpm per CS pump assumed in the licensee's analysis during this time period. As discussed in the NRC staff evaluation dated January 28, 1997, the CS and LPCI pumps have been shown to be capable of operating under maximum cavitating conditions for periods of time significantly greater than the 340-second period required in the licensee's analysis. Therefore, the conclusions contained in the NRC staff evaluation dated January 28, 1997, remain applicable to the licensee's current analysis. The staff finds that the licensee has performed an adequate assessment of the CS and LPCI pump performance during the limiting accident conditions.

3.6 UFSAR Suppression Pool Temperature Change At New Thermal Conditions

3.6.1 Torus Attached Piping

The licensee has performed an evaluation of the increased thermal loads placed on the torus attached piping as a result of increasing the long term suppression pool temperature from the original analysis peak value of 165 degrees Fahrenheit to 176 degrees Fahrenheit. This information was provided by letter dated April 10, 1997. The evaluation and all supporting calculations demonstrated that all piping systems and supports will remain within UFSAR allowable limits for Dresden, Unit 2. The evaluation of the torus attached piping is currently being performed for Dresden, Unit 3. Dresden, Unit 3, shut down for a refueling outage on March 29, 1997. This commitment has been reflected as a license condition in Appendix B. The licensee has committed to complete the torus attached piping analysis and assure all torus attached piping systems and supports will remain within UFSAR allowable limits prior to restart of Unit 3 from the current refueling outage. The staff finds this acceptable.

3.6.2 Equipment Qualification

In resolution of the USQ the licensee has evaluated how the increase in suppression pool temperature will affect the qualification of equipment in the Reactor Building Corner Rooms, Torus Area, and the Reactor Building General Area. By letter dated March 26, 1997, the licensee stated that the reevaluation has been completed and all equipment remains in compliance with 10 CFR 50.49. The staff finds this acceptable.

3.6.3 Electrical Loading With ECCS Pumps At Runout Flows

As part of the resolution of the USQ the licensee evaluated the impact of the higher than rated pump flow on the brake horsepower requirements for the Core Spray and LPCI motors has been reviewed. The conclusion in the UFSAR Section 8 that the loading on the emergency diesel generator is within its capacity has not changed. The staff finds this acceptable.

3.7 Changes to the Temperature Technical Specifications

Changes to the following TS Limiting Conditions for Operation (LCO), Surveillance Requirements (SR), and Action statements related to the suppression pool and service water temperatures have been proposed. These changes would restore (raise) the TS values for these temperatures to the values they were before they were lowered via an amendment issued January 28, 1997. The staff's January 28, 1997, amendment (Reference 6) lowered these TS values to limit the post-LOCA suppression pool temperature rise for ECCS pump NPSH considerations.

Current TS LCO 3.7.K.2 specifies a maximum suppression pool temperature of 75 degrees Fahrenheit during Operational Modes 1 and 2. The licensee has proposed restoring this temperature to 95 degrees Fahrenheit.

Current TS LCO 3.7.K.2.a specifies a maximum suppression pool temperature of 85 degrees Fahrenheit during testing which adds heat to the suppression pool. The licensee has proposed restoring this temperature to 105 degrees Fahrenheit.

Current TS LCO 3.7.K.2.b specifies a maximum suppression pool temperature of 100 degrees Fahrenheit during operation at a power less than or equal to 1 percent of rated thermal power. The licensee has proposed restoring this temperature to 110 degrees Fahrenheit.

Current TS LCO 3.7.K.2.c specifies a maximum suppression pool temperature of 110 degrees Fahrenheit with the main steam isolation valves closed following a plant trip. The licensee has proposed restoring this temperature to 120 degrees Fahrenheit.

Current TS LCO 3.8.C.2 specifies an average ultimate heat sink water temperature of 75 degrees Fahrenheit. The licensee has proposed restoring this value to 95 degrees Fahrenheit.

Any changes to the SRs and Action statements that correspond to the LCOs being changed are editorial in nature and consist of changing the temperatures in the statements to make them consistent with the LCCs. The actual actions and surveillance requirements and/or frequencies will not be changed.

The Bases for TS 3.7.K.2 will also be changed to reflect that there is a dependency on containment overpressure are to ensure that adequate NPSH is available to the ECCS pumps. The Bases will also indicate that even with overpressure, the NPSH available may be less than that required by the pumps.

The staff has found a limited amount of pump cavitation acceptable, as discussed in Section 3.5 of this evaluation.

Because the supporting analyses for this amendment request, which use the revised suppression pool and ultimate heat sink temperatures, have been found acceptable subject to the considerations mentioned previously in this evaluation, the proposed changes in these temperatures are acceptable.

3.8 Bulletin 96-03

The staff issued NRC Bulletin 96-03, "Potential Plugging of Emergency Core Cooling Suction Strainers by Debris in Boiling Water Reactors," (Reference 11) identifying that the buildup of debris from thermal insulation, corrosion products, and other particulate on ECCS pump strainers is highly likely to occur, creating the potential for a common-cause failure of the ECCS, which could prevent the ECCS from providing long-term cooling following a LOCA. The staff has requested that all BWR licensees take appropriate measures to ensure the capability of the ECCS to perform its safety function following a LOCA. NRC Bulletin 96-03 also requested that all licensee's implement these actions by the end of the first refueling outage starting after January 1, 1997.

This time frame for implementation was considered appropriate by the staff based on recent cleaning of suppression pools, operator training and appropriate emergency operating procedures, alternate water sources, and a low probability of the initiating event. For Dresden, consideration of containment overpressure of 9.5 psig for the first 240 seconds restores the ECCS capability to meet the requirements of 10 CFR 50.46(a)(1)(i) with the original licensing basis. The staff notes that this conclusion is based on the licensee's analysis of only one strainer completely blocked and does not take into account the potential for additional blockages as identified in NRC Bulletin 96-03. Appropriate corrective actions, if any, resulting from the licensee's evaluation of NRC Bulletin 96-03 will be implemented in accordance with 10 CFR 50 Appendix B. This action will resolve the staff's outstanding questions concerning ECCS performance and will provide long-term assurance that the requirements of 10 CFR 50.46 are met. The resolution of NRC Bulletin 96-03 will be addressed in a separate letter.

4.0 SUMMARY

Based on the preceding evaluation, the staff finds that the use of a limited amount of containment overpressure for NPSH purposes acceptable. The licensee has committed to change the EOPs to alert operators to NPSH concerns and to make containment spray operation consistent with the overpressure requirements for NPSH. This will be accomplished by directing operators to terminate containment spray operation at a sufficiently elevated containment pressure such that containment overpressure for NPSH will be present and adequate NPSH margin for ECCS pumps will be ensured. Consideration will also be given to the spray initiation setpoint so that undesirable toggling of the sprays will not occur. Finally, the licensee has committed to submit the proposed changes to the BWR Owners Group for evaluation and resolution.

The staff further notes that the operators will receive simulator training on the EOP changes prior to the changes being implemented. The licensee commits to have the EOP changes in effect prior to implementation of the amendments, and commits to have a final resolution concerning the sprays and EOPs, including the BWROG evaluation, by July 1, 1997.

The staff finds operation with the peak pool temperature of 176 degrees Fahrenheit, calculated without the 2-sigma uncertainty addition, acceptable, based on a sensitivity study conducted with 10 percent added to the decay heat calculated by ANS 5.1-1979. The study indicates that the addition of 10 percent, which bounds 2-sigma, results in an increase of approximately 4 degrees Fahrenheit in the peak suppression pool temperature. The licensee commits to perform containment minimum pressure and temperature re-analyses with a +2-sigma adder within 180 days of the date of issuance of these license amendment, and to submit this re-analyses for staff review. The reanalysis will provide additional justification for the use of the ANS 5.1-1979 decay heat model.

The staff finds restoration of the TS maximum suppression pool and TS ultimate heat sink temperatures from 75 to 95 degrees Fahrenheit acceptable. This is based on the staff's finding that the analyses in which these temperatures have been used are acceptable.

In addition, the staff finds it acceptable for the licensee to change the UFSAR to reflect the new NPSH and containment pressure/temperature conditions addressed by this safety evaluation.

Finally, the staff finds the removal of local suppression pool temperature limits, as they relate to condensation oscillation phenomena, acceptable. This is based on a previous staff evaluation for BWRs, which found removal of the limits acceptable provided that the plant met certain criteria.

5.0 STATE CONSULTATION

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

6.0 ENVIRONMENTAL CONSIDERATION

The amendments change a requirement with respect to the installation or use of a facility component found within the restricted area as defined in 10 CFR Part 20 and change surveillance requirements. The NRC staff has determined that the amendments involve 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 amendments involve no significant hazards consideration, and there has been no public comment on such finding (62 FR 8998). Accordingly, the amendments meet 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 amendments.

7.0 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 amendments will not be inimical to the common defense and security or to the health and safety of the public.

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Date: April 30, 1997

8.0 REFERENCES

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12. Holahan, G. M., USNRC to R. P. Pinelli, Boiling Water Reactors Owners Group, "Transmittal of the Safety Evaluation of General Electric Company Topical Reports; NEDO-30832," entitled, "Elimination of Limit on BWR Suppression Pool Temperature for SRV Discharge With Quenchers" and NEDO-31695 entitled, "BWR Suppression Pool Temperature Technical Specification Limits," August 29, 1994.

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