William S. Orser
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Nuclear Operations

August 13, 1992
NRC-92-0095

U. S. Nuclear Regulatory Commission
Attn: Document Control Desk
Washington, D. C 20555

References: 1) Fermi 2
NRC Docket No. 50-341
NRC License No. NPF-43

2) Detroit Edison Letter, NRC-91-0102, "Proposed License Amendment - Uprated Power Operation", dated September 24, 1991.

Subject: Detroit Edison Response to NRC Plant System Branch (SPLB) Verbal Request for Additional Information on Fermi 2 Power Uprate Submittal (TAC No. 82102)

This letter formally provides the additional information requested by the NRC Plant Systems Branch at the July 30, 1992 meeting held at NRC Headquarters to discuss the use of the SHEX computer code in the Fermi 2 Power Uprate Safety Analysis.

Enclosure 1 to this letter provides a request and response format to the issues discussed at that meeting which were also reviewed in a teleconference between Messrs. T. Colburn and J. Kudrick of the NRC and members of the Fermi 2 licensing staff on August 4, 1992.

Please contact Mr. Terry L. Riley, Supervisor, Nuclear Licensing at (313) 586-1684, to coordinate any further actions on this matter, as needed.

Sincerely,

[signature]

Enclosure

cc: T. G. Colburn
A. B. Davis
M. P. Phillips
S. Stasek

A001

I, WILLIAM S. ORSER, do hereby affirm that the foregoing statements are based on facts and circumstances which are true and accurate to the best of my knowledge and belief.

William S. Orser

WILLIAM S. ORSER
Senior Vice President

On this 13th day of August, 1992, before me personally appeared William S. Orser, being first duly sworn and says that he executed the foregoing as his free act and deed.

Rosalie A. Armetta

Notary Public

ROSALIE A ARMETTA
NOTARY PUBLIC STATE OF MICHIGAN
MONROE COUNTY
MY COMMISSION EXP. NOV. 20,1995

PLANT ANALYSIS SERVICES
San Jose, California

cc: E. C. Eckert
K. M. Fruth
S. K. Rhow
D. J. Robare
C. T. Young
DRF-T23-672

August 6, 1992

To: C. H. Stoll

From: J. E. Torbeck

Subject: Responses to NRC Plant System Branch (SPLB) Request for Additional Information on Fermi-2 Power Uprate

The attached provides the additional information requested by the NRC Plant Systems Branch at the July 30, 1992 meeting held at NRC Headquarters to discuss the use of the SHEX computer code in the Fermi-2 Power Uprate Safety Analysis.

Evidence of verification for the attached is contained in DRF-T23-672.

Note that the discussion on "Service Water Temperature" in Response 3 was provided by Detroit Edison.

Please forward the attached to Detroit Edison.

J. E. Torbeck
Plant Analysis Services

Attachment

Request 1.

Provide a description of the short term analysis which was performed for power uprate and clarify the application of the "short term" (M3CPT) calculation for containment pressure and the "long term" (SHEX) calculation for suppression pool temperature.

Also provide a comparison for the peak pressure numbers using the same (approved) M3CPT code for a direct comparison with those values documented under the LTP. Provide a table of input parameters used for both calculations and justify any differences.

Response 1.

A short-term containment response analysis was performed for the limiting DBA/LOCA which assumes a double-ended guillotine break of a recirculation suction line to demonstrate that operation with power uprate will not result in exceedance of containment design pressure limits. The short-term analysis covers the blowdown period during which the maximum drywell pressure and differential pressure between the drywell and wetwell occur. The analysis was performed at 102% of the uprated power level using the M3CPT computer code (References 1 and 2) which was reviewed and accepted by the NRC (Reference 3) during the Mark I Long Term Program (LTP) for application to Mark I plants including Fermi-2.

The inputs to the M3CPT code which were used for Fermi-2 during the Mark I LTP are compared with those used for Power Uprate in Table 1. Examination of this table shows that the input values used for Power Uprate are essentially the same as the LTP input values except for the reactor parameters associated with Power Uprate and some containment parameters which were updated to be consistent with the Technical Specifications. The differences in the inputs are identified and discussed in Table 2. As shown in this table, the input changes on the RPV conditions due to power uprate caused a 1.8 psi increase in the peak drywell pressure. The differences in other parameters had a minimal impact on the peak drywell pressure. Consequently, the peak drywell pressure calculated at 102% of the uprated power conditions is 49.9 psig, as compared with 48.3 psig calculated at 102% of the current power for the LTP; this is a 1.6 psi increase due to the combined effects.

Response 1 (continued)

The long-term bulk pool temperature response for Fermi-2 with power uprate was also evaluated for the DBA/LOCA. The analysis was performed at 102% of the uprated power and 102% of the current power using the SHEX computer code as discussed in Responses 2 and 3 which follow.

Request 2.

Document the one to one comparison performed between SHEX and HXSIZ performed for the December 1991 meeting. Also, discuss the bases for concluding that HXSIZ was (probably) the code used during the original licensing of Fermi-2.

Response 2.

<u>SHEX Comparison With M3CPT/HXSIZ</u>

The following paragraphs describe information presented in the December, 1991 meeting with the NRC. The purpose of the meeting was to provide information to the NRC regarding the SHEX code, and the equivalence of SHEX to the previously used M3CPT/HXSIZ codes. The information given in the meeting is summarized below, as well as a one-to-one comparison of SHEX and M3CPT/HXSIZ input parameters used for the evaluation.

During the 1970's, the approach used by GE to calculate the long-term containment response consisted of two codes. The M3CPT code was used to calculate the response from the time of LOCA start to the initiation of containment cooling. The HXSIZ code, which has the capability of modeling the heat exchangers used to cool the containment, was used (with M3CPT output values as input) from the time of initiation of containment cooling to beyond the time the peak pool temperature was reached. The approach used by GE in more recent years (1980's and 1990's) has been to use the SHEX code for long term analysis. The SHEX code is primarily based on M3CPT, but has the capability of modeling many more auxiliary systems and represents substantial improvements over HXSIZ.

The M3CPT code is used to model the short-term containment pressure and temperature response. The modeling used is described in References 1 and 2. The code consists of the following key components: Reactor Pressure Vessel, Drywell, Vent System, Suppression Chamber Airspace, and Suppression Pool. The vent clearing and vent flow modeling is detailed and is capable of modeling highly transient phenomena immediately following initiation of LOCA's. The M3CPT code has been qualified extensively against test data and reviewed extensively by the NRC.

Response 2 (continued)

The HXSIZ code was used from the mid to late 1970's to model the long-term containment pressure and temperature response, and is described in Reference 5. This code has been accepted by the NRC for BWR containment analysis (Reference 20 of NUREG-0978, Section 6.2.1.4 of NUREG-0979 and Section 6.2.1.4 of NUREG-0887). The code consists of the following key components: Reactor Pressure Vessel, Drywell, Suppression Chamber Airspace, and Suppression Pool. HXSIZ was applied for times following heat exchanger initiation, using inputs derived from the end conditions of the corresponding M3CPT analysis. The following simplifying assumptions are used: the break flow is equal to the ECCS flow into the vessel, resulting in the RPV water level remaining constant; the vent flow is assumed to be equal to the break flow; the drywell temperature is assumed to be equal to the RPV temperature; the pressure in the suppression chamber airspace is assumed to be equal to the drywell pressure; the suppression chamber airspace temperature is assumed to be equal to the suppression pool temperature, that is, thermodynamic equilibrium is assumed to exist between the suppression chamber airspace and the suppression pool. The HXSIZ code was intended for analysis of a large recirculation line break, and thus is good for only limited applications.

The SHEX code was introduced for several reasons. One reason was to mechanistically model the drywell and suppression chamber airspace responses. Another reason for developing SHEX was to have the capability of analyzing events other than the DBA recirc break LOCA. Some examples of the events that can be modeled with SHEX are: LOCA's of different break sizes and types, RPV isolation, alternate shutdown, SORV transients, RPV controlled depressurization, drywell bypass leakage, and station blackout. The SHEX code also has the ability to incorporate operator actions, such as control of RPV water level and actuation/termination of containment sprays. Thus SHEX can be used to model a wide variety of accidents and transients and is more versatile than HXSIZ.

Response 2 (continued)

The SHEX code consists of mechanistic models similar to those used in M3CPT, which has been reviewed by the NRC. The mechanistic models are used to remove the simplifying assumptions of HXSIZ as described above. Thus, the RPV, break flow, drywell, suppression pool and suppression chamber airspace models used in SHEX are the same or very similar to those used in M3CPT. The vent flow model in SHEX is also similar to that used in M3CPT, except that the vent clearing model is simplified. The SHEX code incorporates a comprehensive modeling of all the auxiliary systems; neither M3CPT nor HXSIZ has this additional capability. In summary, the SHEX code is based on approved methods and provides greater capability for performing long-term containment analyses than M3CPT/HXSIZ. Extensive verification has been performed for SHEX. SHEX has been validated by comparison of results with M3CPT/HXSIZ results, and by other independent evaluations such as checks on calculations (e.g. mass and energy balance, flow rates, heat transfer rates) and checks on system logic.

A comparison of the M3CPT/HXSIZ method and the SHEX code was performed. The important inputs, as presented in Table 3, are identical. The M3CPT/HXSIZ analysis was performed using Power Uprate initial conditions. This was done because the uprated power is the condition of most interest for this comparison. The results of the comparison would also be applicable at a lower power level.

The results of the analysis show that SHEX gives a peak suppression pool temperature of 196.5°F. The M3CPT/HXSIZ codes give a peak suppression pool temperature of 196.1°F. These results are shown in the attached figure. The difference is considered negligible, showing that SHEX is an acceptable alternative to M3CPT/HXSIZ for analyzing the long-term suppression pool temperature response.

<u>HXSIZ Application For Fermi-2 FSAR</u>

It could not be established with certainty that the FSAR long-term containment response analysis was performed with HXSIZ. However, Section 6.2.1.3.6 of the Fermi-2 FSAR gives the following key assumptions used in the post blowdown model:

Response 2 (continued)

a. Drywell and suppression chamber atmosphere are both saturated (100 percent relative humidity).
b. The drywell atmosphere temperature is equal to the temperature of the liquid flowing in from the RPV or to the spray temperature if the spray is activated.
c. Suppression chamber atmosphere temperature is equal to the suppression pool temperature or to the spray temperature if the spray is activated.
d. No credit is taken for heat losses from the primary containment.

Assumptions a, b, c and d agree with HXSIZ modeling. Also, Figure 6.2-12 of the Fermi-2 FSAR shows that the long-term containment analysis was based on the assumption that the suppression chamber pressure is equal to the drywell pressure, which is one of the key assumptions for HXSIZ. In addition, the Fermi-2 FSAR was docketed in April 1975, which is in the time frame when HXSIZ was being used for long-term containment response analyses. Therefore, it is our opinion that HXSIZ was most likely used in generating the long-term containment response of the Fermi-2 FSAR.

Request 3.

Formally provide a comparison of input parameters for the Power Uprate case between SHEX and the UFSAR analysis, discussing significant changes (6) in input parameters and justifying that the changes are conservative or reasonable.

Response 3.

The input parameters used for SHEX for the long-term containment response analysis for Fermi-2 with power uprate are identified in Table 3. These inputs were developed based on the best information currently available regarding the Fermi-2 plant configuration. It has not been possible to determine all the inputs used for the original FSAR long-term containment analysis. However, Table 4 identifies differences in the inputs for the power uprate analysis and the FSAR analysis based on information regarding the inputs for the long-term containment analysis in the FSAR.

The following provides a discussion of these differences.

Service Water Temperature

The original containment analysis used a constant RHR service water (RHRSW) temperature of 90°F which is the maximum design cooling tower outlet temperature. The Technical Specifications prohibits operation with the cooling tower reservoir temperature above 80°F. An energy balance calculation was used to determine the post LOCA RHRSW temperature increase as a function of time from the initial condition of 80°F to the cooling tower maximum design temperature of 90°F. The temperature profile, which is non-linear, was conservatively bounded by a linear profile which was used in the power uprate containment analysis (see Table 4). The following ar all of the important assumptions used in the energy balance.

1. The maximum Technical Specification reservoir temperature of 80°F was used as an initial condition.

2. The maximum design cooling tower outlet temperature of 90°F was used.

Response 3 (continued)

3. The minimum Technical Specification RHR reservoir water level was used. This is conservative because it minimizes the heat capacity of the reservoir and maximizes the reservoir heatup.

4. Evaporative and drift losses were used to reduce reservoir inventory during the heatup period.

5. Complete mixing is assumed in the reservoir. This is conservative because hot water is discharged into the cooling towers and is sprayed down to the surface of the reservoir. Cooler water is drawn from the bottom of the reservoir where the pump suctions are located. No credit was taken for temperature stratification which would have lowered the reservoir discharge temperature profile.

This time variant service water temperature will result in a more realistic suppression pool temperature response than the 90°F service water temperature used for the FSAR analysis.

<u>Suppression Pool Volume</u>

The initial suppression pool volume used for the power uprate long-term containment analysis was set at 117,161 ft3 which is less than the pool volume of 121,080 ft3 used for the FSAR analysis. 121,080 ft3 corresponds to the T/S minimum value. This lower pool volume of 117,161 ft3 used for the Power Uprate analysis adds conservatism to the calculated pool temperature, since a lower initial pool volume results in higher calculated values for pool temperature.

<u>Initial Pool Temperature</u>

The initial pool temperature for the Power Uprate containment analysis was set at 95°F which is the T/S limit for normal operation. This compares to the nominal value of 90°F which was used for the FSAR analysis. This increase in initial pool temperature results in higher calculated pool temperatures.

Response 3 (continued)

Feedwater Addition

All water in the feedwater system which could contribute to higher calculated pool temperatures was added to the RPV and containment system for the Power Uprate analysis. This was achieved by adding all feedwater which is in the feedwater system during normal operation which has a temperature greater than the maximum expected pool temperature. This translates to all feedwater through feedwater heaters numbered 6, 5, 4 and 3.

In addition, a conservative calculation of the energy in the feedwater piping is added to the RPV/containment system. This water mass and energy addition assures that the pool temperature calculation conservatively reflect the effect of feedwater addition on suppression pool temperature.

It is not certain what feedwater addition was considered for the long-term FSAR analysis, but it is most likely that it did not include any feedwater.

The Power Uprate analysis assumption for feedwater addition will result in a higher calculated value for pool temperature than the FSAR assumption.

Initiation Time for Containment Cooling

The FSAR analysis assumed pool cooling was initiated at 10 minutes after the initiation of the DBA. The Power Uprate long-term containment response analysis has assumed more conservatively that the containment cooling is initiated at 20 minutes which will result in a higher pool temperature than that obtained with the FSAR initiation time.

Response 3 (continued)

Decay Heat

The FSAR identified decay heat values used for the long-term containment analysis which correspond to the May-Witt decay heat model values after 60 seconds. For the power uprate analysis a more realistic decay heat has been included. This decay heat which is based on the ANS 5.1 model (Reference 6) is described in Appendix B of Reference 7. This decay heat includes contributions due to fission heat induced by delayed neutrons, decay heat from fission products, decay heat from actinides (heavy elements) and decay heat from irradiated structural materials. For conservatism additional margin which corresponds to two standard deviations (10%) was added on the decay heat as described in Reference 7, Appendix B, for the Fermi-2 long-term containment power uprate analysis. This decay heat will result in a more realistic pool temperature than that used in the FSAR, but it is still conservative.

Request 4.

Summarize the reasoning for the conclusion that the use of SHEX and M3CPT for power uprate calculations are conservative and reasonable.

Response 4.

M3CPT Short-Term Analysis

The M3CPT computer code was used to calculate the short-term containment response for Fermi-2 with power uprate. This analysis was done to determine the impact of power uprate on the peak drywell pressure which occurs during the RPV blowdown phase of the recirculation suction line break DBA. M3CPT was reviewed and accepted by the NRC for calculation of the containment pressure and temperature response for Mark I plants during the Mark I Containment Long Term Program (LTP). As described in Response 1 the power uprate analysis using M3CPT was performed with essentially the same inputs for the containment parameters as those used for the LTP analysis. The RPV conditions were changed to reflect the power uprate conditions. As a result of these changes the calculated peak drywell pressure increased by 1.6 psi to 49.9 psig from 48.3 psig calculated for Fermi-2 during the LTP.

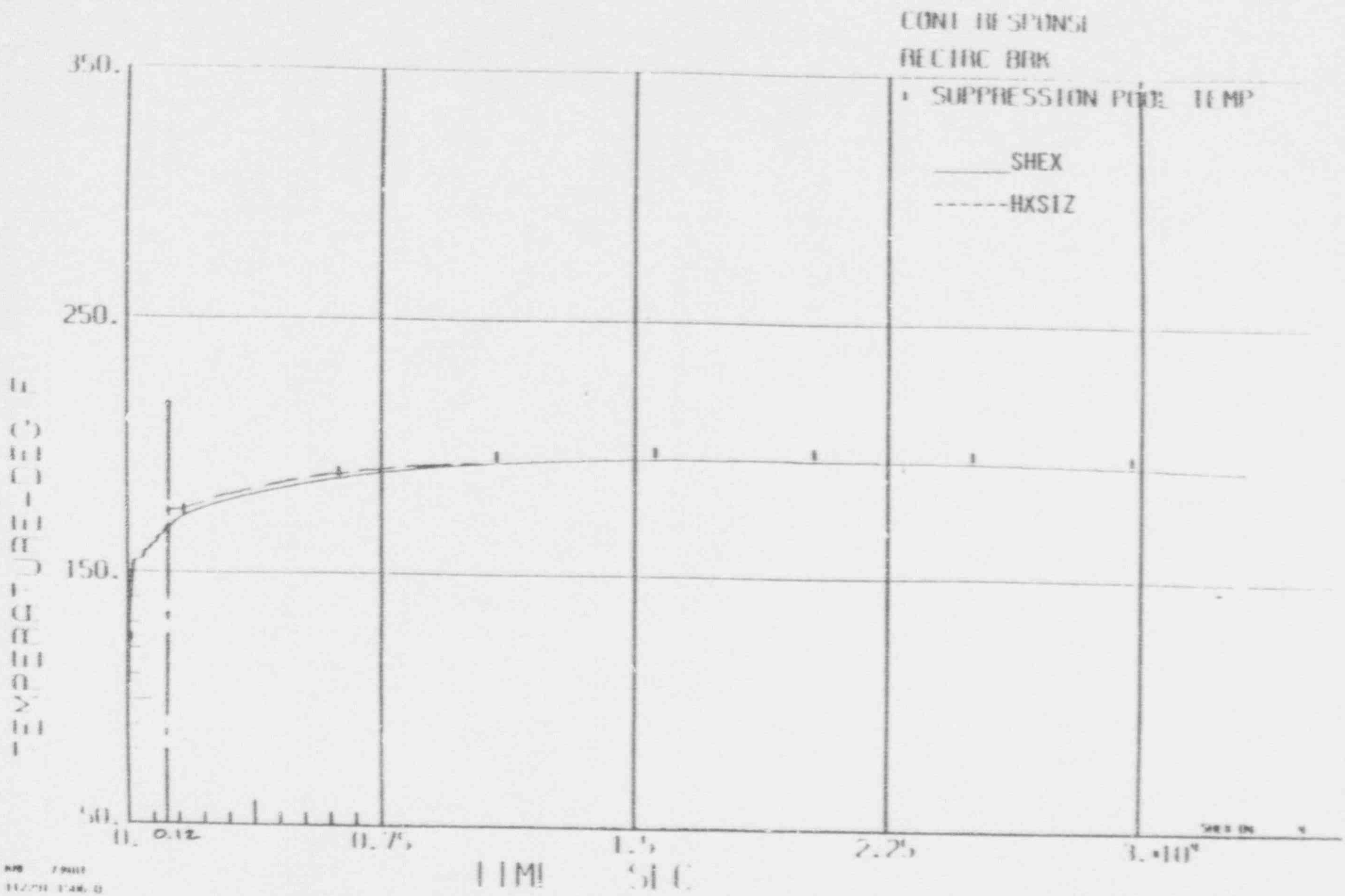
In summary, the short term analysis using M3CPT, which was reviewed and approved for use in the LTP, was redone with the uprated power. The 49.9 psig peak drywell pressure for power uprate is well below the UFSAR value of 56.6 psig and the design value of 62 psig.

SHEX Long-Term Analysis

The SHEX code was used to calculate the long-term containment response for Fermi-2 with power uprate. The primary purpose of this analysis was to determine the impact of power uprate on the calculated peak suppression pool temperature following a DBA LOCA. SHEX is a computer code which has been used by GENE for over 10 years to perform containment long-term analyses which have been submitted and accepted by the NRC. The key models in SHEX are based on M3CPT models which have been reviewed by the NRC. To establish confidence in the use of SHEX for this analysis a direct comparison of the peak pool temperature calculated with SHEX and M3CPT/HXSIZ was performed using Fermi-2 inputs at the uprated power as described in Response 2. This showed excellent agreement. SHEX gave 196.5°F and M3CPT/HXSIZ gave 196.1°F. This comparison is useful as noted in Response 2 in that HXSIZ is the method which is believed to have been used for the original Fermi-2 SAR long-term analysis and HXSIZ has been reviewed and accepted by the NRC.

The inputs for the long-term containment analysis with SHEX were based on power uprate conditions. The inputs were selected to provide an up-to-date representation of the Fermi-2 plant with power uprate and to retain conservatism in all key inputs as described in Response 3. Response 3 identified differences in the inputs for the power uprate analysis compared to the original SAR analysis and justifies the differences. The SHEX analysis was also performed at 102% of the current power with all inputs the same as those for the power uprate case except for those which are sensitive to power. This analysis gave a peak pool temperature of 193.6°F compared to 196.5°F at 102% of the uprated power. This shows that the effect of the power uprate, alone, is to increase the peak pool temperature by 2.9°F.

In summary, SHEX evolved from two previously approved codes (M3CPT/HXSIZ) and has been shown to give equivalent pool temperature response to the predecessor HXSIZ code. The long-term analysis for Fermi-2 with power uprate was performed with the SHEX computer code using conservative inputs and yielded a peak post DBA-LOCA pool temperature of 196.5°F. This temperature shows margin remains to the controlling limit of 198°F which comes from NPSH requirement for pumps taking suction from the suppression pool with no credit for containment pressure per Reg. Guide 1.1.



CONT RESPONSE
RECIRC BRK
SUPPRESSION POOL TEMP
SHEX
HXSIZ
350.
250.
150.
50.
0.
0.12
0.75
1.5
2.25
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TIME SEC
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TABLE 1

M^{3}CPT INPUT VALUES USED IN FERMI-2 LTP AND POWER UPRATE ANALYSIS

INPUT PARAMETER	LTP VALUE	POWER UPRATE VALUE
Core Thermal Power (MWt)	3358	3499
RPV Dome Pressure (psia)	1020	1063
Core Inlet Enthalpy (Btu/lbm)	525.7	531.1
Initial Liquid Mass in RPV (lbm)	640500	640500
Feedwater Addition to RPV	0.	0.
Drywell Volume (ft^3)	163730	163730
Initial Drywell Pressure (psig)	0.75	0.75
Initial Drywell Rel. Humidity (%)	20	20
Initial Drywell Temperature	135	145
Vent Flow Area (ft^2)	240.9	240.9
Vent Flow Loss Coefficient	5.51	5.51
Vent Submergence (ft)	3.33	3.33
Suppression Pool Volume (ft^3)	121080	124220
Wetwell Airspace Volume (ft^3)	130900	127760
Suppression Pool Temperature (F)	70	95
Wetwell Airspace Pressure (psig)	0.75	0.75

TABLE 2.

COMPARISON OF M3CPT INPUT VALUES BETWEEN LTP AND POWER UPRATE FOR FERMI-2

(LTP Peak DW Pressure = 48.3 psig; Power Uprate Peak DW Pressure = 49.9 psig)

INPUT PARAMETER	LTP VALUES	POWER UP. VALUES	REASON FOR DIFFERENCE	IMPACT ON PEAK DRYWELL PRESSURE
Core Thermal Power (MWt)	3358 (102 % Current Rated)	3499 (102 % of Uprated)	Power uprate	Increase by 1.8 psi due to these input changes
RPV Dome Pressure (psia)	1020	1063	Power Uprate	
Core Inlet Enthalpy (Btu/lbm)	525.7	531.1	Power Uprate	
Drywell Initial Temperature (°F)	135	145	Tech. Spec limit for DW temp. was changed to 145°F	0.2 psi lower with 145 F
Suppression Pool Initial Temp. (°F)	70	95	Tech. Spec limit is used.	Negligible impact on short-term pressure response
Suppression Pool Volume (ft^3)	121080	124220	Change to upper limit on pool volume.	Negligible impact because submergence is not changed
Wetwell Airspace Volume (ft^3) (total wetwell vol. minus sup. pool vol.)	130900	127760	Tech Spec upper limit for pool vol. is used.	Higher drywell press. with smaller airspace volume, but negligible impact with such small diff.

* A Tech Spec amendment was approved to increase the drywell temperature limit to 145°F from the original value of 135°F. (See Reference 4.)

TABLE 3

COMPARISON OF SHEX AND M3CPT/HXSIZ INPUT VALUES
FOR FERMI-2 POWER UPRATE ANALYSIS

INPUT PARAMETER	SHEX VALUE	M3CPT/ HXSIZ VALUE
Core Thermal Power (MWt)	3499 (102% of Uprated	3499 (102% of Uprated)
Vessel Dome Pressure (psia)	1063	1063
Feedwater Addition (lbm)	607638	607638
Decay Heat	ANS/5.1+2σ	ANS/5.1+2σ
Drywell Free Volume (ft^3)	163730	163730
Suppression Pool Volume (ft^3)	117161	117161
Initial Supp. Pool Temp. (°F)	95	95
Initial Wetwell Air Temp. (°F)	95	95
Initial Wetwell Relative Humidity (%)	100	100
Wetwell Airspace Free Volume (ft^3)	134819	134819
RHR HXR K (Btu/sec-°F)	321	321
RHR Service Water Temperature (°F)	80-90	80-90
RHR Pump Heat (Hp)	2100	2100
LPCS Pump Heat (Hp)	1600	1600
Time to Turn on RHR (minutes)	20	20
Initial Drywell Relative Humidity (%)	20	20
Initial Drywell Pressure (psia)	15.45	15.45
Initial Drywell Temperature (°F)	145	145
Initial Wetwell Pressure (psia)	15.45	15.45

TABLE 4.

Differences in Inputs for Fermi-2 Containment Long-Term Analysis
SHEX vs USAR

	SHEX Analysis	USAR Analysis
Service Water Temp	Ramped linearly from 80°F to 90°F over 8 hrs. (80°F MAX T.S. limit)	90°F (Cooling tower design)
Suppression Pool Volume	117161 ft³ (< T.S. min. limit for conservatism)	121080 ft³ (T.S. min. limit)
Initial Pool Temperature	95°F (T.S. max limit)	90°F (Nominal value)
Feedwater Addition	All feedwater which can contribute to increased max pool temperature	None
HX Initiation Time	20 minutes	10 minutes
Decay Heat	ANS 5.1 + margin	May-Witt

References:

1. General Electric Co., "The GE Pressure Suppression Containment System Analytical Model", NEDO-10320, April 1971; Supplement 1, May 1971; Supplement 2, June 1973.

2. General Electric Co., "The General Electric Mark III Pressure Suppression Containment System Analytical Model", NEDO-20533, June 1974.

3. U. S. Nuclear Regulatory Commission, "Mark I Containment Long-Term Program Safety Evaluation Report," NUREG-0661, July 1980.

4. T. R. Quay (NRC) to B. R. Sylvia (DECo), "Amendment No. 20 to Facility Operating License No. NPF-43: Drywell Air Temperature Limit (TAC No. 65174)," Docket No. 50-341, June 23, 1988.

5. General Electric Co., "The General Electric Mark III Pressure Suppression Containment System Analytical Model Supplement 1," NEDO-20533-1, September 1975.

6. "Decay Heat Power In Light Water Reactors" ANSI/ANS 5.1 - 1979, Approved by American National Standards Initiative, August 29, 1979.

7. General Electric Co., "The GESTR-LOCA and SAFER Models for the Evaluation of the Loss-of-Coolant Accident", NEDO-23785-1-A Volume III, October 1984.