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AUTH.NAME AUTHOR AFFILIATION
STALL,J.A. Florida Power & Light Co.
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Florida Power & Light Company, 6351 S. Ocean Drive, Jensen Beach, FL 34957

L-98-249
10 CFR 50.90

October 9, 1998

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

Re: St. Lucie Unit 2
Docket No. 50-389
Proposed License Amendment;
Safety Injection Tanks-MODE 4, Supplement

Ref: FPL Letter L-98-115, J.A. Stall to NRC (DCD): Proposed License Amendment, Safety Injection Tanks-MODE 4; May 27,1998.

Florida Power and Light Company (FPL) submitted an application for license amendment (Reference) which will revise Technical Specification (TS) 3.5.1, Emergency Core Cooling Systems (ECCS) - Safety Injection Tanks, by removing the requirement for safety injection tanks (SITs) to be operable in MODE 4. Removal of this requirement is consistent with both the Standard Technical Specifications for Combustion Engineering Plants (NUREG-1432) and the TS for St. Lucie Unit 1, and will minimize the potential for inadvertent safety injection tank discharge during reactor coolant system cooldown/depressurization evolutions.

As a result of discussions held during a telephone conference between FPL and the NRC staff on August 19, 1998, the attachment to this letter is submitted as additional information to support the TS revision described in the reference license amendment request. FPL evaluated the impact on St. Lucie Unit 2 from a loss of coolant accident (LOCA) initiated from Mode 4 conditions and for which safety injection to the reactor coolant system is delayed for up to ten minutes following initiation of the event. The evaluation shows that the core remains protected for the ten minute delay scenario, and also confirms FPL's earlier conclusions which were based on flow from one high pressure safety injection pump at 30 seconds into the event.

Please contact us if there are additional questions about this matter.

Very truly yours,

J. A. Stall
Vice President
St. Lucie Plant

JAS/RLD

140074

A001

Attachment: Mode 4 LOCA Evaluation

cc: Regional Administrator, Region II, USNRC
Senior Resident Inspector, USNRC, St. Lucie Plant
Mr. W.A. Passetti, Florida Department of Health and Rehabilitative Services

MODE 4 LOCA EVALUATION

(Information reformatted and edited from FPL Nuclear Engineering Evaluation
PSL-ENG-SEFJ-98-002, Revision 1, Attachment 3: 9/23/98)

I. General System Response during LOCAs from Shutdown Conditions

A loss of coolant accident (LOCA) initiated from the conditions when the plant is in Mode 4 has been studied for other plants in addressing the risks associated with the lower operating modes (References 1 and 2). For St. Lucie Unit 2 (PSL2), Mode 4 is defined as the mode of operation with the reactor shutdown ($K_{eff} < 0.99$) and the reactor coolant system (RCS) temperature between 200 ^{0}F and 325 ^{0}F. Due to the low amount of stored energy in the system and the fuel, along with low decay heat, the emergency core cooling system (ECCS) requirements in lower modes are less restrictive as compared to Modes 1, 2 and 3 requirements. Previous studies, particularly those applicable to Mode 4 conditions, have shown that the manual initiation of the injection flow with appropriate operator action times (typically 10 minutes is assumed), using only 1 high pressure safety injection (HPSI) pump or 1 low pressure safety injection (LPSI) pump, results in acceptable ECCS performance results. Injection from safety injection tanks (SITs) was not assumed/considered in these studies.

From the viewpoint of inventory loss associated with liquid flashing and mass releases through the break, a Mode 4 LOCA initiated when the RCS pressure is at 2250 psia is generally considered to be more adverse than a LOCA initiated from lower RCS pressure. However, other considerations related to the safety injection (SI) flows, such as the blocking of safety injection actuation signal (SIAS), could result in lower initial pressures being more adverse for LOCA due to the required operator action to initiate safety injection flows. These scenarios are discussed below in describing the effects on system parameters and associated phenomena during Mode 4 LOCAs without the availability of SITs.

Liquid Flashing due to RCS Depressurization:

A large break LOCA in Mode 4 results in a flow through the break which is initially all liquid. The break flow subsequently changes to two-phase flow and eventually becomes single phase steam flow. The system depressurizes very fast until the pressure reaches the saturation pressure corresponding to the RCS temperature. The depressurization rate slows down as the liquid flashes into a two-phase mixture. The two-phase mixture in the RCS loops flows out through the break until the mixture level drops to the bottom of the hot leg nozzles. The entire remaining liquid inventory resides in the vessel, and continues to boil due to the decay heat from fuel rods and the residual heat from reactor internals. The loss of liquid inventory continues until safety injection begins to flow into the core.

If the LOCA is initiated from an RCS pressure higher than that at which the SIAS can be blocked, safety injection flow would commence at approximately 30 seconds and, for St. Lucie Unit 2, would provide sufficient flow from at least one HPSI pump to prevent core uncovery. If the LOCA, however, is initiated from lower RCS pressures (< 1836 psia), operator action would be required to initiate the safety injection flow from a HPSI or a LPSI pump because the automatic SIAS is typically blocked to prevent unwarranted actuation during the controlled cooldown/depressurization process. For the latter case, ten minutes is traditionally assumed for the operator action.

The maximum RCS temperature in Mode 4 for St. Lucie Unit 2 is < 325 ^{0}F. At this maximum temperature, flashing in the RCS would commence at approximately 100 psia. The RCS depressurization from 100 psia to the containment pressure would take several seconds, and the steam quality and flows in the reactor core during this time would remain well below the threshold for liquid entrainment. Conservative calculations of core conditions during the liquid flashing period show steam qualities well below 5% and steam flows much less than 0.5×10^6 lbm/hr/ft^2, which would result in bubbly to bubbly-slug flow regime in the core (Reference 3). The two-phase mixture level in the core would swell due to the presence of vapor and would help in keeping the core covered. The steam would escape through the loops and out the break. The steam production due to liquid flashing would last only for the initial short duration of RCS depressurization. The steam flow thereafter would correspond to the heating rate from decay heat and reactor internals. This behavior is seen in the studies of Reference 2 where the core remained covered, without safety injection, for up to five minutes for a 2 ft^2 break LOCA.

For automatic initiation of HPSI flow, the HPSI flow would begin injecting well within the first minute. Since the HPSI flow into the vessel (for St. Lucie Unit 2) is much greater than the decay heat boil-off, the core would continue to remain covered for these high pressure LOCA scenarios. Mode 4 LOCAs initiated from lower RCS pressures would result in a negligible change in steam production due to liquid flashing, but would not have an automatic initiation of HPSI flow due to the blocking of SIAS. These LOCAs would require, as stated above, an operator action to initiate safety injection. For St. Lucie Unit 2, ten minutes is a reasonable and conservative operator action time to initiate safety injection during a Mode 4 LOCA. Although partial fuel uncovery may occur, a ten minute delay for safety injection is shown later to reflood the core in sufficient time to limit the cladding temperatures to below the 10 CFR 50.46 limits.

<u>Decay Heat Boil-Off</u>:

For St. Lucie Unit 2, the maximum decay heat boil-off in Mode 4 is calculated to be ~35 lbm/sec, which corresponds to about 250 gpm. The capacity of one HPSI pump at the low RCS pressures encountered during LOCAs of interest is more than 450 gpm (3 injecting loops). This flow is sufficient to make up for the inventory loss due to boil-off. In the absence of HPSI injection, the core would continue to lose inventory and may partially uncover to a maximum depth of about 8 feet during the first 10 minutes for certain larger break sizes ($\geq$2 ft^2 break). Once HPSI flow is initiated, the core mixture level would quickly recover. As discussed later, for all LOCAs of interest, if HPSI flow is initiated within the first 10 minutes, the cladding temperatures would remain below the 10 CFR 50.46 limits.

<u>Loop Seal Clearing</u>:

Loop seal clearing is a phenomenon important for small break LOCAs, typically smaller than about 6 inches in diameter (<0.2 ft^2). For such breaks in Mode 4, the core remains covered for a sufficiently long period of time such that operator action to initiate HPSI flow in ten minutes would adequately mitigate the consequences, and the requirements of ECCS performance analysis (10 CFR 50.46) would be met. Studies done in References 1 and 2 support this conclusion and show that for typical Westinghouse and ABB-CE plants, peak cladding temperatures during Mode 4 LOCAs remain below 2200 ^{0}F. It should be noted that, for PSL2, the top elevation of the loop seal is above the top elevation of the core active fuel, which minimizes concerns involving the impact of the loop seal clearing phenomena on the potential for long term core uncovery.

Typically, loop seal behavior during large breaks has not been found to be important, including breaks initiated from Mode 4 conditions as seen in the assessment studies of Reference 2.

Running of RCPs:

The running of reactor coolant pumps (RCPs) or RCP coastdown when tripped does not have a significant adverse effect on the Mode 4 LOCAs. The running of RCPs would, however, enhance the early depressurization process. For large LOCAs, once steam begins to flow through the break, the RCPs would be ineffective. For smaller break LOCAs, the core would not uncover for times much greater than the assumed delay time for HPSI initiation. The RCPs thus do not significantly impact the results and conclusions of the Mode 4 LOCAs. References 1 and 2 analyses for various break sizes were done with typical LOCA assumptions of loss of offsite power at trip (initiation of break for Mode 4).

For large breaks, early depressurization of the RCS prevents any pressure buildup on the core during the time period prior to HPSI flow initiation by the operator action. If the RCPs continued to run and/or coastdown during the depressurization process, loop inventory would circulate into the core and result in additional heat removal from the core by this liquid inventory which otherwise remains ineffective for core heat removal. However, the head developed by the RCPs in two-phase and single phase steam conditions would be insufficient to create any major flow through the core. The pumps would cavitate and fail in these situations. It should be noted that PSL2 Off-Normal Operating Procedures require RCPs to be turned off when the RCS pressure falls to the range below which RCP seal requirements can not be satisfied (range of 300 to 400 psia for Mode 4 temperatures).

Probabilistic Assessment of LOCAs in Mode 4:

The RCS conditions in Mode 4 are much less severe than those in Mode 1 with respect to the occurrence of a large break LOCA. Additionally, the time spent in Mode 4 is only a few days during a typical operating fuel cycle. Per References 1 and 4, the probability of a LOCA in Mode 4 is lower by a factor of about 20 compared to that in Mode 1, and a double-ended hot or cold leg break in Mode 4 is very unlikely, particularly at low RCS pressures. Therefore, only smaller break sizes have been considered in evaluating LOCAs in Mode 4 (References 1 and 2). The largest RCS pipe size for St. Lucie Unit 2, other than the hot legs and the cold legs, is of area equal to 0.56 ft^2 (surge line, injection nozzle). A conservative break of 2 ft^2 from Mode 4 conditions is analyzed in Reference 2 in assessing the risks during shutdown. The input parameters used in this analysis bound those for St. Lucie Unit 2.

II. Summary of Previous Mode 4 LOCA Studies

Reference 1 Study (Westinghouse):

Calculations were performed by Westinghouse for a break size equivalent to a 6-inch diameter (<0.2 ft^2 area) pipe for a 2-loop, a 3-loop and a 4-loop plant. These calculations utilized limiting peak linear heat rate and safety injection flow rates. The power distribution maximized the power in the upper regions of the core. These assumptions minimize the mixture level swell and maximize the fuel rod heat-up. The scoping analysis performed with Westinghouse TREAT code (Reference 5) identified the limiting plant type, which was then analyzed with NOTRUMP code (References 6 and 7). The peak cladding temperatures were obtained from the LOCTA-IV code (Reference 8). This limiting analysis was expected to bound the various Westinghouse plant designs. The parameters of significance with respect to the mitigation of Mode 4 LOCAs are the RCS volume, power level, peak linear heat rate and the safety injection flow rates. A comparison of these parameters could be used to determine the applicability of these results to a particular plant configuration and mode of operation.

The initial conditions of 350 ^{0}F and 465 psia with a decay heat corresponding to 4 hours after shutdown were modeled consistently for all cases. The auxiliary feedwater flow was not modeled as steam generators were detemined to have a minor impact on these transients. The decay heat was based on 120% of the 1971 ANS Standard value, assuming prior long term operation at 102% of the core rated power level. The important input parameters are given below for comparison:

	2-Loop	3-Loop	4-Loop	PSL2
RCS Volume/MWt (ft^3/MWt)	3.41	3.57	3.57	3.99
Core Power (MWt)	1876	2775	3588	2754
Peak Linear Hear Rate (kW/ft)	17.153	13.263	16.755	13
RCS Pressure (psia)	465	465	465	1836 (*Note 1*)
RCS Temperature (^{0}F)	350	350	350	325
Shutdown Time (hours)	4	4	4	2.5
Maximum SI Flow (lbm/sec)	40.9	46.2	56.8	60.1
SI/MWt (lbm/sec/MWt)	0.0218	0.0166	0.0158	0.0218

Note 1: *1836 psia is the highest RCS pressure at which the automatic SIAS can be blocked. RCS pressures in Mode 4 are typically less than 500 psia.*

The RCS inventory is minimum for a typical 2-loop plant as compared to other Westinghouse plant designs. St. Lucie Unit 2 has a vessel inventory which is at least 10% greater than a typical Westinghouse 3-loop plant. Although the decay heat at 2.5 hours after shutdown (conservative time for St. Lucie Unit 2 to reach Mode 4) is about 12% higher than that at 4 hours after shutdown, the overall Mode 4 LOCA consequences for St. Lucie Unit 2 would remain bounded by the above 4-loop plant results because the power level and the peak linear heat rate used have substantial margin compared to St. Lucie Unit 2 parameters. Also, the HPSI flow injection is higher resulting in a larger SI/MWt ratio for St. Lucie Unit 2.

The results of the TREAT analysis concluded that 2-loop designs lead to worse clad temperatures than the 3-loop and 4-loop designs as shown below:

	2-Loop	3-Loop	4-Loop
Peak Cladding Temperature (^{0}F)	1363	1143	990

The 2-loop plant analysis performed with NOTRUMP showed similar plant response but with significant improvement in the core mixture level and the corresponding fuel rod heatup. The peak cladding temperature for 2-loop plant with NOTRUMP calculation remained below 500 ^{0}F.

Both TREAT and NOTRUMP calculations produced plant responses which were expected of such transients initiated from lower operating mode conditions. There was a rapid initial depressurization, which slowed at the onset of liquid flashing. The break flow transitioned from liquid to two-phase fluid at this time. The loop seals in all cases cleared early (replugged only momentarily for 2-loop plant). Only a brief core uncovery (depth of <1 ft) occurred prior to the venting of steam through the loop seal. Subsequent to core recovery following the clearing of loop seal, the mixture level in the core decreased gradually due to the liquid inventory boil-off. The initiation of safety injection flow at 10 minutes prevented any major rod heat-up. The degree of core uncovery was dependent on the amount of injection flow. One HPSI pump flow was determined to be sufficient to provide timely core recovery without causing any major fuel rod heat up that would exceed the 10 CFR 50.46 cladding temperature limits.

Reference 2 Study (ABB-CE):

Calculations were performed by ABB-Combustion Engineering (ABB-CE) to evaluate the impact of unavailability of HPSI pumps for 10 minutes on the LOCA events initiated from low pressure, low temperature conditions. SITs were considered isolated in these shutdown operating modes. Conservative plant parameters were used which bound the St. Lucie Unit 2 plant configuration. Analyses of the postulated LOCA transients were performed using realistic computer codes and methods.

The shutdown LOCA transient would be significantly less dynamic than the full power design basis LOCA transient. Significant mitigating factors during shutdown LOCAs are 1) low initial temperature which would lead to a low amount of initial stored energy and subsequent flashing rate, and 2) low decay heat which would reduce the core boil-off rate. Other conditions, such as low RCS pressure and short time window in these shutdown modes, would result in a reduction in the probability of LOCAs. The implication is that the probability of a LOCA under low temperature and pressure conditions is very low during such a short time window compared to the design basis LOCA in Mode 1. The evaluation of Mode 4 LOCA was performed due to the operator action required to establish safety injection flow to mitigate the accident consequences in the lower Modes.

Per Reference 2, the largest potential pipe break based on the evaluation of mechanistic breaks at low temperature/pressure conditions would result in what is termed as a significant leak in the RCS piping. However, a break size of up to 2 ft^2 was analyzed in the Reference 2 study. This maximum break size envelopes the largest RCS piping, excluding the hot and cold legs. Since forced circulation through the core would enhance core cooling, RCPs were conservatively tripped at the start of the transient.

The analysis was performed with the realistic evaluation model (REM) for small break LOCA that was submitted to the NRC for review in 1988. This evaluation model includes the REM version of the CEFLASH-4AS computer code and REM version of the PARCH computer code (References 9 through 13). A calculational uncertainty of 150 ^{0}F, determined for the licensing application of the REM model, was applied to the shutdown LOCA analysis. Although the largest break size analyzed for design basis LOCA using the REM version of the CEFLASH-4AS code is 0.5 ft^2, the REM methodology in terms of the applicability of the drift flux and phase separation models was considered applicable to breaks up to 3.0 ft^2 for LOCA scenarios from shutdown conditions due to the similar relative velocities of the liquid and steam phases.

Break sizes of 0.56 ft^2, 1.0 ft^2 and 2.0 ft^2 were analyzed for the reference plant using the REM version of the above stated evaluation model. The breaks in the top of the cold legs were modeled to maximize the depressurization rate and the inventory flashing rate, which would accelerate the core uncovery. The important input parameters are given below for comparison:

	Reference Plant	PSL2
Core Power, 102% (MWt)	2754	2754
Peak Linear Hear Rate (kW/ft)	15.5	13
RCS Pressure (psia)	300	1836 (*Note 1*)
RCS Temperature (^{0}F)	300	325
Shutdown Time (hours)	2.5	2.5
Fuel Type	14 x 14	16 x 16
Downcomer + RV Volume Below Core (ft^3)	~2000	~2000

Note 1: *1836 psia is the highest RCS pressure at which the automatic SIAS can be blocked. RCS pressures in Mode 4 are typically less than 500 psia.*

The primary system depressurized rapidly for all the break sizes. The depressurization proceeded at different rates for different break sizes at the onset of steam production and volume expansion in the primary system when the break flow became two-phase. The inventory loss was rapid at the beginning and significantly decreased as the break flow transitioned to two-phase flow and eventually to steam. The amount of inventory remaining in the system (primarily in the reactor vessel) at the time of transition of the break flow to steam was less for larger breaks. The mixture level remained at the hot leg elevation for several minutes when steam produced in the core flowed down the hot leg countercurrent to the draining liquid. In the absence of injection flow, the core started to uncover and the extent of core uncovery was different for the various break sizes. As the core uncovered, the cladding heat-up began first at elevations near the top of the core and progressed downward to the hot spot elevation (~ 10% of the active core height below the top of the core).

For the worst case (2 ft^2 break), core uncovery began at approximately five minutes into the event and reached a maximum depth of about 8 feet within ten minutes. The initiation of safety injection at ten minutes resulted in reflooding the core and the PCT remained under 1400 ^{0}F. For the other break sizes (0.56 ft^2 and 1.0 ft^2), core uncovery did not occur in the absence of safety injection flow until well beyond ten minutes. The initiation of HPSI flow in ten minutes for these events, therefore, would result in the core remaining covered throughout the transient period.

For St. Lucie Unit 2, the largest RCS pipe size excluding the hot and cold legs has 0.56 ft^2 area. A break size of 2 ft^2 thus conservatively bounds the largest probable Mode 4 LOCA size. It is therefore concluded that Mode 4 LOCAs, without crediting the SITs, would result in the cladding temperatures below the 10 CFR 50.46 limit of 2200 ^{0}F, when considering the initiation of the HPSI flow in ten minutes.

III. Mode 4 LOCA for St. Lucie Unit 2 (Without SITs)

LOCAs Initiated from 2250 psia:

The calculations performed in Reference 2 for a reference plant and for a 2 ft^2 break show that the core remains protected if safety injection is initiated from one HPSI pump in ten minutes. Although the Reference 2 calculation is performed with a lower initial pressure, the system dynamics in terms of core mixture level for PSL2 is expected to be very similar.

For large LOCAs initiated from high RCS pressures (~2250 psia), injection from at least one HPSI pump would commence very early (~ 30 seconds) due to rapid system depressurization and availability of automatic SIAS. Initial flashing and decay heat boil-off would not lead to any significant core uncovery. The total boil-off in the core is less than the liquid inventory above the top of the core. The total boil-off accounts for the stored heat release from the fuel and reactor internals in the core region. The heat release from the reactor vessel is insignificant during this period compared to the conservative heat release considered from fuel and internals. During this period, the flow regime in the core would be of the bubbly-slug type with low steam qualities. The swelling due to the creation of voids would help keep the mixture level above the top of the core, minimizing core uncovery concerns. The smaller break sizes are less severe from a core uncovery viewpoint during the early period of the transient. The mixture level would remain above the top of the core for smaller breaks. The automatic initiation of HPSI flow, which for St. Lucie Unit 2 exceeds the core decay heat boil-off rate, would maintain the core covered throughout the period of interest. The SITs are therefore not needed to mitigate the consequences of a LOCA initiated from high pressures in Mode 4 resulting in automatic initiation of safety injection flow from at least one HPSI pump.

LOCAs Initiated from Lower Pressures:

The major difference between the evaluation of a high pressure and a low pressure LOCA in Mode 4 is the time of actuation of HPSI flow. For St. Lucie Unit 2, HPSI flow initiation during a LOCA from initial RCS pressures below ~1836 psia is by operator action, since the SIAS may be blocked at these conditions. The probability of a LOCA in this mode of operation at low pressures/temperatures, however, is much less than that at higher pressures and significantly lower (by a factor of 20) than that from Mode 1 conditions. Additionally, the time spent at these conditions (in Mode 4) is significantly less than that in Mode 1. A double-ended hot or cold leg break in Mode 4 is thus very unlikely at low RCS pressures. Therefore, only smaller break sizes have been considered in evaluating LOCAs in Mode 4. The LOCA studies documented in Reference 2, which bound St. Lucie Unit 2 plant parameters, cover break sizes from 0.56 ft^2 to 2 ft^2, and based on the study performed in Reference 1, smaller sized breaks would not produce more adverse consequences.

Large Breaks (> 0.56 ft^2): For breaks up to 2ft^2, Reference 2 used a peak linear heat rate more adverse than St. Lucie Unit 2, and heat-up of the core using the ABB-CE REM version of the PARCH code resulted in calculated cladding temperatures which have significant margin to 2200 ^{0}F when considering a ten minute operator action time to initiate the HPSI flow. These calculations used 300 ^{0}F as the initial RCS temperature at 2.5 hours after shutdown. A time of 2.5 hours after shutdown is applicable for St. Lucie Unit 2 to cooldown from ~575 ^{0}F to 325 ^{0}F using the maximum permissible cooldown rate. The difference in the initial RCS temperature (300 ^{0}F vs 325 ^{0}F) is not expected to have a significant impact on the transient and liquid flashing would commence only slightly earlier (at higher RCS pressure by ~25 psia) due to the rapid system depressurization during the transient. A higher initial RCS pressure (1836 psia) would have a minor impact on the initial stored energy in the RCS and would result in no significant effect on the consequences. Therefore, LOCAs initiated from Mode 4 conditions with break sizes up to 2 ft^2 would not violate 10 CFR 50.46 PCT limits for St. Lucie Unit 2.

Smaller Breaks (< 0.56 ft^2): Breaks smaller than 0.56 ft^2 have been analyzed in Reference 1 using plant parameters which would bound the Westinghouse 2, 3 and 4 loop plants. Mode 4 LOCA is governed by a few important plant parameters, which could be used to define the consequences of such events. These generic calculations thus could be applied to ABB-CE plants when used appropriately with correct scaling of parameters of interest. The calculations for 2-loop plants have shown the worst consequences of the 3 plant designs. It is shown that for the limiting 2-loop plant, a ten minute operator action time is sufficient to limit the PCT to well below 2200 ^{0}F (the calculated PCT for 2-loop plant with NOTRUMP calculation remained below 500 ^{0}F). St. Lucie Unit 2 parameters are better represented by those used in 4-loop plant analysis, which is shown to have a large margin to the PCT limit as compared to the 2-loop plant calculations. In addition, the loop seal behavior for St. Lucie Unit 2 would not create long-term adverse core uncovery conditions because the plant configuration is such that the elevation of the top of the crossover leg (loop seal) is higher than the elevation of the top of core active fuel.

The core mixture level in the Reference 1, 4-loop plant analysis remained above the top of the core for the ten minute period of interest. The 4-loop plant parameters are expected to bound St. Lucie Unit 2 conditions as discussed earlier. Since the HPSI flow for St. Lucie Unit 2 is higher than that used in the Reference 1 study, the inventory recovery would be faster. The small break LOCAs for St. Lucie Unit 2 thus would not violate 10 CFR 50.46 PCT limits.

IV. Conclusions

As described above, the probability of LOCAs in Mode 4 is less than that in Mode 1 by a factor of at least 20 and a double-ended hot or cold leg break in Mode 4 is very unlikely. Therefore, only smaller break sizes have been considered in evaluating LOCAs in Mode 4. The evaluation shows that such events can be mitigated by the safety injection system alone without crediting the SITs. This conclusion is based on the fact that the SITs were considered to be unavailable in the scenarios evaluated. Break sizes corresponding to the largest RCS penetration (excluding hot and cold legs) are not expected to result in core uncovery. The bounding break scenarios evaluated could result in partial fuel uncovery, but the cladding temperatures would remain well below the 10 CFR 50.46 limit of 2200 ^{0}F even after assuming a ten minute delay time for initiating HPSI flow.

V. References

1. WCAP-12476, "Evaluation of LOCA During Mode 3 and Mode 4 Operation for Westinghouse NSSS," November, 1991

2. CE NPSD-668, "Activities for Assessment of and Recommendations for Shutdown Cooling System Relief Valves," CEOG Task 619, Prepared for the C-E Owners Group, September, 1991

3. Hsu, Y. and Graham, R. W., "Transport Processes in Boiling and Two-Phase Systems Including Near-Critical Fluids," Hemisphere Publishing Corporation, McGraw-Hill Book Company, 1976 (Pages166-167)

4. NUREG/CR-6144, Vol. 2 Part 1A, "Evaluation of Potential Severe Accidents During Low Power and Shutdown Operations at Surry, Unit 1," Main Report (Chapters 1-6), Brookhaven National Laboratory, 1994

5. WCAP-11297 (Nonproprietary), "Comparison of the TREAT and NOTRUMP Small Break LOCA Transient Results," September 1986

6. WCAP-10080-A, "NOTRUMP, A Nodal Transient Small Break and General Network Code," August 1985

7. WCAP-10081-A, "Westinghouse Small Break ECCS Evaluation Model Using the NOTRUMP Code," August 1985

8. WCAP-8305 (Non-Proprietary), "LOCTA-IV Program: Loss-of-Coolant Transient Analysis," June 1974

9. CEN-373-P, Volume 1, "Realistic Small Break LOCA Evaluation Model, Calculational Models," April 1988; Volume 2, "Application of Evaluation Model," December 1988; Volume 2 Supplement 1-P, "Application of Evaluation Model to Calvert Cliffs Units 1&2," September 1989; Volume 3, "Computer Program Input and Output Description," December 1988.

10. Letter LD-88-030, "Submittal of Realistic SBLOCA Evaluation Model," A. E. Scherer (ABB CE) to J. A. Norberg (NRC), April 27, 1988

11. Letter LD-88-155, "Submittal of Volumes 2 and 3 of Combustion Engineering's Realistic Small Break Loss-Of-Coolant-Accident Evaluation Model," A. E. Scherer (ABB CE) to J. A. Norberg (NRC), December 9, 1988

12. Letter LD-89-001, "Addendum to Volume 3 of Combustion Engineering's Realistic Small Break Loss-of-Coolant-Accident Evaluation Model," A. E. Scherer (ABB CE) to J. A. Norberg (NRC), January 11, 1989

13. Letter LD-89-099, "Supplement 1 to Volume 2 of Combustion Engineering's Realistic Small Break LOCA Evaluation Model," A. E. Scherer (ABB CE) to J. A. Norberg (NRC), August 28, 1989