FPL

October 15, 2015

L-2015-255
10 CFR 50.90

U. S. Nuclear Regulatory Commission
Document Control Desk
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Subject: St. Lucie Units 1 and 2
Docket Nos. 50-335 and 50-389
License Amendment Request
Containment Vacuum GOTHIC Analyses and Conforming Changes

Pursuant to 10 CFR 50.90, Florida Power & Light Company (FPL) is submitting a request for an amendment to the Technical Specifications (TS) for St. Lucie Units 1 and 2. The proposed amendment would revise the containment vacuum analyses using the GOTHIC computer code and other conforming changes as described in the enclosure.

The enclosure provides a description and assessment of the proposed changes, the existing TS pages marked up to show the proposed changes and the proposed changes to the TS Bases.

This license amendment proposed by FPL has been reviewed by the St. Lucie Plant Onsite Review Group. In accordance with 10 CFR 50.91(b)(1), a copy of the proposed license amendment is being forwarded to the State Designee for the State of Florida.

FPL is requesting that this be processed as a normal amendment request, with approval of the proposed amendment within one year of the submittal date. Once approved, the amendment shall be implemented within 90 days.

If you should have any questions, please contact Mr. Ken Frehafer at (772) 467-7748.

I declare under penalty of perjury that the foregoing is true and correct.

Executed on October 15, 2015

Sincerely,

Christopher R. Costanzo

Christopher R. Costanzo
Site Vice President
St. Lucie Plant

Enclosure

cc: NRC Region II Administrator
St. Lucie Plant NRC Senior Resident Inspector
Ms. Cynthia Becker, Florida Department of Health

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Evaluation of the Proposed Change

St. Lucie Units 1 and 2 Containment Vacuum Analysis Methodology Change and Changes to TS 3.6.1.4, Containment Systems Internal Pressure

1. SUMMARY DESCRIPTION

Pursuant to 10 CFR 50.90, Florida Power & Light Company (FPL) requests to amend Facility Operating License DPR-67 for St. Lucie Unit 1 and NPF-16 for St Lucie Unit 2. The proposed change would revise the Operating Licenses' licensing basis to allow the use of the code "Generation of Thermal-Hydraulic Information for Containments (GOTHIC Version 7.2b(QA))", to model the containment response following the inadvertent actuation of the containment spray system during normal plant operation (referred to as the vacuum analysis). The current vacuum analyses were performed using the A-TEMPT (Unit 1) and WATEMPT (Unit 2) codes which are no longer available for use. GOTHIC is a commercially available code that is supported through EPRI and is used for various applications in the design of nuclear power plants.

Florida Power and Light has identified a need to update the vacuum analyses to incorporate changes in some of the input parameters. The proposed change will also update the St. Lucie Unit 1 and 2 licensing bases to credit the design basis ability of the containment vessel to withstand a higher external pressure differential of 1.04 psi (1.05 psi for Unit 2), and will update Technical Specification 3.6.1.4 for each Unit to revise the allowable containment operating pressure range.

2. DETAILED DESCRIPTION

The St. Lucie containment consists of a free-standing steel containment vessel surrounded by a reinforced concrete shield building. Physically the containment vessel is a right cylinder with a hemispherical dome and ellipsoidal bottom. The cylinder wall of the containment vessel and the shield building are separated by a nominal 4.0 foot annular space. The containment vessel is a low leakage steel shell, designed to confine radioactive materials that could be released by accidental loss of integrity of the reactor coolant pressure boundary. The containment vessel is designed in accordance with the requirements of ASME Code Section III, Class B for Unit 1 and Class MC for Unit 2.

The current licensing basis for the containment vessels conservatively utilizes 0.7 psi as the design for external pressure. External pressure is the difference between the pressure in the shield building annulus and the pressure within the containment vessel. A vacuum relief system is provided to ensure that the design external pressure is not exceeded. The design basis event that challenges the external pressure design basis is the accidental initiation of both containment spray (CS) pumps while all four (4) containment fan coolers (CFCs) are also in operation. The UFSAR analyses for external pressure assume the flow rate per CS pump is 3375 gpm for Unit 1 and 3450 gpm for Unit 2.

For evaluation of a power uprate modification, hydraulic models were developed for the CS system. The hydraulic calculations that were performed using these models indicated that the flow rates that would occur during the vacuum analysis condition would exceed the flow rates listed in the UFSAR. This issue is currently being tracked in the St. Lucie Corrective Action Program (CAP) as a nonconforming condition within the St Lucie IMC-0326 open issues listing.

The current St. Lucie vacuum analyses were performed in accordance with the methodology described in the St Lucie UFSAR Section 6.2.1.2 for Unit 1 and Section 6.2.1.1.3 and Appendix 6.2B for Unit 2. The current analyses used the digital computer codes A-TEMPT for Unit 1 and WATEMPT for Unit 2. The computer codes cited in the Unit 1 and 2 UFSARs are no longer available for use to update the vacuum analyses to reflect the higher CS flow rates.

FPL is requesting NRC approval to

- Update the St. Lucie Units 1 and 2 containment vacuum analyses using the GOTHIC version 7.2b(QA) computer program. The St. Lucie Unit 1 and 2 licensing basis will be updated to credit the design basis ability of the containment vessels to withstand an external pressure of 1.04 psi and 1.05 psi respectively. The revised Unit 1 containment external pressure design was performed in accordance with ASME III 1971 with Addenda through Summer 1972 reconciled to the code of record.

- Update the Technical Specifications (TS) to revise the allowable containment operating pressure range consistent with the analyses.

3. TECHNICAL EVALUATION

3.1 Application of Gothic For Containment Vacuum Analysis

The use of GOTHIC Version 7.2b(QA) to perform the containment vacuum analysis was determined to be an acceptable method based on the following:

The final safety evaluation report for Topical Report BAW-10252(P), Rev. 0, "Analysis of Containment Response to Postulated Pipe Ruptures Using GOTHIC" concluded: The NRC staff finds the described use of GOTHIC for the stated licensing analyses, as presented in Topical Report BAW-10252(P), "Analysis of Containment Response to Postulated Pipe Ruptures Using GOTHIC," and as modified by letter dated March 7, 2005, "Response to a Request for Additional Information Regarding BAW-10252(P), Revision 0, 'Analysis of Containment Response to Postulated Pipe Ruptures Using GOTHIC'," acceptable for the proposed licensing applications.

The capability of the GOTHIC model discussed in the final safety evaluation report for Topical Report BAW-10252(P) made specific reference to, modeling of containment spray, modeling of containment fan coolers, and modeling of flow through valves. These are the key elements used in vacuum analysis.

The containment vacuum analyses involve a similar calculations compared to the containment response to a mainstream line break or reactor coolant system pipe rupture except without the large mass and energy release and at different pressures and temperatures.

ANSI/ANS 56.4 1983 provides guidance that the methods described in 4.2 [methods for evaluation of containment response to a postulated pipe break] are applicable to the minimum pressure (vacuum) analysis.

The developer of the program in, NAI-1688-001, Rev. 0, "Application of GOTHIC for Subatmospheric Conditions" documents that GOTHIC is suitable for use for PWR containment sub-atmospheric/vacuum analyses such as the St. Lucie containments.

3.2 Benchmarking of UFSAR Models With Gothic

The St. Lucie Units 1 and 2 UFSAR vacuum analysis models were benchmarked with GOTHIC to demonstrate that GOTHIC is suitable and conservative for use in containment vacuum assessments.

St. Lucie Unit 1

The key input parameters used for the analysis presented in the UFSAR are listed below.

Parameter	UFSAR
Minimum Containment Volume	2,506,000 ft^3
Maximum Annulus Volume	543,000 ft^3
Spray Data	Flow Rate = 6,750 gpm (total) Effectiveness = 100% Droplet Size (Sauter Mean Diameter) = 989 Micron
Total Maximum Heat Removal Rate for the Containment Fan Coolers	$Q = A \times (T^3 - CCW^3) + B \times (T^2 - CCW^2) +$ $C \times (T - CCW)$ A = 8.86 B = -678.64 C = 108,879.31 T = Containment Temp, °F CCW = CCW Temp, °F Q = Heat removal rate per unit air cooler (Btu/hr)
Maximum In-leakage Rate from Outside Environment into Shield Building	3,160.4 ft^3 in 24 hours at ¼ " w.g.
Vacuum Breaker System Data	Pipe Diameter = 24" Internal Area= 2.8 ft^2 Flow Resistance Coefficients: • $K_{entrance}$= 0.23 • $K_{check\ valve}$= 1.93 • $K_{discharge}$= 1 - 1.20 • $K_{butterfly\ valve}$ = 0.45 (fully open condition)

Parameter	UFSAR
	Delay time to start opening: 1.0 sec Flow Coefficient, Cv, versus disc angle and opening time for the butterfly valve: UFSAR Figure 6.2-54
Minimum RWT Temperature	60°F
Minimum CCW Temperature	60°F
Minimum Initial Containment Pressure	14.7 psia
Maximum Initial Containment Temperature	120°F
Initial Containment Relative Humidity Range	0% to100%
Initial Annulus Pressure	14.7 psia
Initial Annulus Temperature Range	85°F to 110°F
Initial Annulus Relative Humidity	100%
Setpoints for Opening and Closing the Butterfly Valve	- 2.25" w.g. (Open) - 0.25" w.g. (Close)

Summarized below is a comparison of the results of the benchmark study for UFSAR cases A, B and C (i.e., the results as reported in the UFSAR using the UFSAR computer codes versus that predicted by computer code GOTHIC).

Case	RWT Temp (°F)	CCW Temp (°F)	Cont Temp (°F)	Cont RH (%)	Annulus Temp (°F)	Max $\Delta P_{(Annulus-Cont)}$ (psid)		Max $\Delta P_{(Atm-Annulus)}$ (psid)	
						UFSAR	GOTHIC Benchmark	UFSAR	GOTHIC Benchmark
A	60	60	120	0	110	0.66	0.986	1.17	1.10
B	60	60	120	40	110	0.60	0.584	1.46	1.55
C	60	60	120	100	110	0.27	0.285	2.25	2.33

As shown in the above table, the Max $\Delta P_{(Annulus-Cont)}$ and Max $\Delta P_{(Atm-Annulus)}$ predicted by GOTHIC are in good agreement (i.e., within less than $\pm$ 6%) with the UFSAR values with the exception of the Max $\Delta P_{(Annulus-Cont)}$ for Case A, which differs by +49%. Considering that a lower initial containment RH should lead to greater depressurization in the containment (i.e., Case A compared to Cases B and C, which have higher initial RH values), the GOTHIC results appear more reasonable and conservative than the UFSAR results.

St. Lucie Unit 2

The key input parameters used for the analysis presented in the UFSAR are listed below.

Parameter	UFSAR
Minimum Containment Volume	2,500,000 ft^3
Maximum Annulus Volume	547,000 ft^3
Spray Data	Flow Rate = 6,900 gpm (total) Effectiveness = 100% Droplet Size (Sauter Mean Diameter) = 690 Micron
Total Maximum Heat Removal Rate for the Containment Fan Coolers	11.40 x 10^6 Btu/hr @ 120°F air temperature. 6.053 x 10^6 Btu/hr @ 100°F air temperature. 1.19 x 10^6 Btu/hr @ 70°F air temperature
Maximum In-leakage Rate from Outside Environment into Shield Building	5% of annulus volume per day @ annulus ΔP of 0.25 in w.g pressure differential
Vacuum Breaker System Data	Flow Area= 1.77 ft^2 Loss Coefficients: 1.64 Delay time to start opening: 1.15 sec Note: For the benchmark Gothic case, the butterfly valve was modeled to open instantaneously with no delay.
Minimum RWT Temperature	55°F
Minimum CCW Temperature	60°F
Minimum Initial Containment Pressure	14.4292 psia
Maximum Initial Containment Temperature	90°F
Initial Containment Relative Humidity	20%
Initial Annulus Pressure	14.7 psia

Parameter	UFSAR
Initial Annulus Temperature	56°F
Initial Annulus Relative Humidity	16%
Setpoints for Opening and Closing the Butterfly Valve	- 9.85" ± 0.35" w.g. (Open) - 7.75" w.g. (Close)

Summarized below is a comparison of the results of the benchmark study (i.e., the results as reported in the UFSAR using the UFSAR computer codes versus that predicted by computer code GOTHIC).

RWT Temp (°F)	CCW Temp (°F)	Cont Temp (°F)	Cont RH (%)	Annulus Temp (°F)	Max $\Delta P_{(Annulus - Cont)}$ (psid)		Max $\Delta P_{(Atm - Annulus)}$ (psid)	
					UFSAR	GOTHIC Benchmark	UFSAR	GOTHIC Benchmark
55	60	90	20	56	0.60	0.698	0.615	0.651

As shown in the above table, when compared to the UFSAR, GOTHIC predicts a higher Max $\Delta P_{(Annulus - Cont)}$ and Max $\Delta P_{(Atm - Annulus)}$ by 16% and 6%, respectively.

<u>Conclusion</u>

A-TEMPT, WATEMPT and GOTHIC all use similar calculation techniques to determine the effect of inadvertent actuation of the CS pumps on external pressure. The benchmark study demonstrates that the GOTHIC results are conservative or similar to the results reported in the UFSAR.

3.3 Containment Vacuum Analysis Using Computer Code Gothic

The effect of the higher containment spray flow on the St. Lucie Units 1 and 2 containment vacuum analyses was determined using computer code GOTHIC version 7.2b(QA). The focus of the assessments was to demonstrate that inadvertent actuation of the containment spray system during normal plant operation would not challenge the design differential external pressures of the containment structure. The design basis event that challenges the external pressure design basis assumes the actuation of both CS pumps while all four (4) CFCs are also in operation. Additionally, one of the two independent vacuum relief lines is conservatively assumed to be failed.

<u>St. Lucie Unit 1</u>

The key input parameters used for the updated St. Lucie Unit 1 vacuum analysis are as follows.

Parameter	Updated Values
Minimum Containment Volume	2,498,000 ft^3
Spray Data	Flow Rate = 6,950 gpm (total)
Total Maximum Heat Removal Rate for the Containment Fan Coolers	To be determined using GOTHIC air cooler option benchmarked by vendor performance data
Minimum RWT Temperature	55°F
Minimum Initial Containment Pressure	To be determined by iteration using the structural analysis ΔP Limits
Initial Containment Relative Humidity Range	40% to 100%
Initial Annulus Temperature Range	56°F to 110°F
Initial Annulus Relative Humidity Range	0% to 100%
Setpoints for Opening and Closing the Butterfly Valve	To be determined by iteration using the structural analysis ΔP Limits
Structural Analysis ΔP Limits (Structural Design Bases)	$\Delta P_{Annulus - Cont} < 1.04$ psid (increased from 0.7 psid) $\Delta P_{Atm - Annulus} < 3.0$ psid

The table below summarizes the results of two limiting cases.

Case	Min Cont P (psia)	Cont RH (%)	Annul Temp (°F)	Annul RH (%)	$\Delta P_{Valve\ Open}$ (in w.g.)	$\Delta P_{Valve\ Close}$ (in w.g.)	Max $\Delta P_{(Annulus - Cont)}$ (psid)	Max $\Delta P_{(Atm - Annulus)}$ (psid)
1-1	**14.21**	40	56	0	**-16.0**	**-14.0**	**0.9996**	1.6599
1-2	**14.21**	100	110	0	**-16.0**	**-14.0**	0.7019	**2.5112**

Based on the above results, it is concluded that:

- The maximum allowable initial differential pressure between the containment and annulus is -0.49 psid.
- The maximum allowable negative setpoints for opening/closing the butterfly valve are -16.0 and -14.0 inch w.g., respectively.

- The calculated maximum $\Delta P_{(Annulus\ -\ Cont)}$ is 0.9996 psid (Case 1-1) which is below the allowable value of 1.04 psid.

- The calculated maximum $\Delta P_{(Atm\ -Annulus)}$ is 2.5112 psid (Case 1- 2) which is below the allowable value of 3.0 psid.

The above results are used to establish the normal operation allowable containment internal pressure range at St. Lucie Unit 1, i.e., between -0.490 and +0.500 psig.

St. Lucie Unit 2

The key input parameters used for the revised St. Lucie Unit 2 vacuum analysis are as follows.

Parameter	Updated Values
Minimum Containment Volume	2,493,000 ft^3
Spray Data	Flow Rate = 7,250 gpm (total)
Vacuum Breaker System Data	Flow Area= 1.77 ft^2 Loss Coefficients: 1.64 Delay time to start opening: 1.15 sec Flow Coefficient, Cv, versus disc angle and opening time for the butterfly valve: Assumed same as Unit 1 UFSAR Figure 6.2-54
Minimum Initial Containment Pressure	To be determined by iteration using the structural analysis ΔP Limits
Maximum Containment Temperature	120°F
Initial Containment Relative Humidity Range	40% to 100%
Initial Annulus Temperature Range	56 to 110°F
Initial Annulus Relative Humidity Range	0% to 100%
Setpoints for Opening and Closing the Butterfly Valve	To be determined by iteration using the structural analysis ΔP Limits
Structural Analysis ΔP Limits (Structural Design Bases)	$\Delta P_{Annulus\ -\ Cont} < 1.05$ psid (increased from 0.7 psid) $\Delta P_{Atm\ -\ Annulus} < 3.0$ psid

The table below summarizes the results of two limiting cases.

	Min Cont P	Cont RH	Annul Temp	Annul RH	$\Delta P_{Valve\ Open}$ (in	$\Delta P_{Valve\ Close}$ (in	Max $\Delta P_{(Annulus\ -}$	Max $\Delta P_{(Atm\ -}$

Case	(psia)	(%)	(^oF)	(%)	w.g.)	w.g.)	Cont) (psid)	Annulus) (psid)
1-1	**14.28**	40	56	0	**-14.0**	**-12.0**	**0.9983**	1.6692
1-2	**14.28**	100	110	0	**-14.0**	**-12.0**	0.6483	**2.4538**

Based on the above results, it is concluded that:

- The maximum allowable initial differential pressure between the containment and annulus is -0.42 psid.
- The maximum allowable negative setpoints for opening/closing the butterfly valve are -14.0 and -12.0 inch w.g., respectively.
- The calculated maximum $\Delta P_{(Annulus\ -\ Cont)})$ is 0.9983 psid (Case 1-1) which is below the allowable value of 1.05 psid.
- The calculated maximum $\Delta P_{(Atm\ -Annulus)}$ is 2.4538 psid (Case 1-2) which is below the allowable value of 3.0 psid.

The above results are used to establish the normal operation allowable containment internal pressure range at St. Lucie Unit 2, i.e., between -0.420 and +0.400 psig.

3.4 Containment Vessel Analysis for Revised External Pressure

St Lucie Unit 1

The containment vessel stress analysis for Unit 1 has been revised to demonstrate the capability of the containment vessel to support a design external pressure of 1.04 psid in accordance with Section III of the ASME code. In order to demonstrate this capability, the analysis of external pressure has been performed in accordance with a later version of the code, ASME III 1971 with Addenda through Summer 1972. The basis for using the later edition follows:

The Inservice Inspection Program for St Lucie Unit 1 invokes ASME Section XI Code, 2001 Ed. with Addenda through 2003 for Inspection and Repairs of the Unit 1 Containment Vessel. IWA-4330 of Section XI allows the vessel to be rerated. IWA-4331(a) states that "Later Editions and Addenda of the Construction Code or a later, different Construction Code, either in its entirety or portions thereof, and Code Cases may be used, provided the requirements of IWA-4221 are met." IWA-4221(c) provides for the use of different Code Editions provided they are reconciled in accordance with IWA-4222 through IWA-4226.

IWA-4222 addresses reconciliation of Code and Owner's requirements and states in IWA-4222(a)(1) that "Only technical requirements that could affect materials, design, fabrication or examination, and affect the pressure boundary need to be reconciled." This reconciliation is addressed by review of requirements in IWA-4223 through IWA-4226 as follows:

IWA-4223 addresses reconciliation of components. Since only the design requirements of the vessel are being changed, and the vessel is not a component, IWA-4223 requirements are not applicable.

IWA-4224 addresses reconciliation of materials. In this case, the vessel material, SA-516 Gr 70, is not changed. As discussed below, no changes were made to this material between the 1968 Section VIII and 1971 Section III with Summer 72 Addenda Codes. Particularly, no changes were made to the curves for external pressure capacity.

IWA-4225 addresses reconciliation of parts, appurtenances, and piping subassemblies and is not applicable to the change in design requirements of the vessel.

IWA-4226 is applicable as design requirements are being changed. Although the current Code of Record for the St. Lucie containment vessel is Section III, 1968 with Winter 1968 Addenda, this Code invokes Section VIII for all aspects of external pressure design. Thus, IWA-4226.3, which governs designs "to all or portions of a different Construction Code" is utilized. Requirements of IWA-4226.3 are addressed as follows:

References to the requirements of Paragraphs IWA-4223, IWA-4224 and IWA-4225 are given in IWA-4226.3. These requirements are either not applicable or are satisfied as previously discussed.

IWA-4226.3(a) requires a reconciliation of material, fabrication and examination requirements to be performed. As previously stated, the SA-516 Gr 70 vessel material is not being changed. Further, review of Subsection NE-2000 in the 1971 Section III with Summer 72 Addenda versus the related paragraphs in Part UG of the 1968 Section VIII Code found no differences affecting vessel external pressure capacity. Review of Subsection NE-4000 fabrication and installation requirements in the 1971 Section III with Summer 72 Addenda versus the related paragraphs in the 1968 Section VIII Code determined that there are no differences in construction requirements affecting vessel external pressure capacity. Review of Subsection NE-5000 examination requirements in the 1971 Section III with Summer 72 Addenda versus the related paragraphs in the 1968 Section VIII Code determined that there are no differences in examination requirements relating to external pressure capacity.

IWA-4226.3(b) requires a reconciliation of differences between the different Code editions. The Summer 1972 Addenda to the ASME Section III, 1971 Ed. identifies the differences for external pressure rules as vessels under external pressure that are not stamped are now required to follow Section III rather than Section VIII rules. This does not impact this stress report as the St. Lucie Unit 1 containment vessel is stamped. Also, for vessels that are being analyzed for external pressure that had previously used the design rules from Paragraph UG-28 of the ASME Section VIII Code, the use of Paragraph NE-3133 is the "new paragraph" to be used. The steps for determining the external pressure capacity in these two sections are the same with the exception of Step 6 in Subparagraph NE-3133.3. The equation in this step has a design margin of 3 rather than a design margin of 4 that is used in Step 6 of Paragraph UG-28 in ASME Section VIII, 1968 Ed.

The use of Subparagraph NE-3133.3 from the Summer 1972 Addenda to ASME Section III, 1971 Ed. results in a higher external pressure capacity rating. Since the external pressure capacity is the only portion of this stress report that had employed the use of Paragraph UG-28 of Section VIII of the ASME Code, 1968 Ed., no other sections need to be reconciled.

<u>St. Lucie Unit 2</u>

The containment stress analysis for Unit 2 has been revised to demonstrate the design capability to support a design external pressure of 1.05 psid in accordance with the original code of record, ASME III 1971 with Addenda through Winter 1972, taking credit for existing margin in the vessel.

The Inservice Inspection Program for St Lucie Unit 2 invokes ASME Section XI Code, 2007 Ed. with Addenda through 2008 for Inspection and Repairs of the Unit 2 Containment Vessel. IWA-4330 of Section XI allows the vessel to be rerated.

4. REGULATORY EVALUATION

4.1 Applicable Regulatory Requirements/Criteria

1) Regulatory Requirements

St. Lucie Unit 1

Technical Specifications and Basis

Technical Specification 3.6.1.4 requires primary containment internal pressure to be maintained between -0.7 and +0.5 psig and is applicable in modes 1 through 4. The regulatory basis for Technical Specification 3.6.1.4 states that lower limitation on containment internal pressure ensures that the containment structure is prevented from exceeding its design negative pressure differential with respect to the annulus atmosphere of 0.70 psi.

Technical Specification 3.6.5.1 requires two vacuum relief lines to be operable in Modes 1 through 4. The regulatory basis of Technical Specification 3.6.5 states, "The vacuum relief valves protect the containment vessel against negative pressure (i.e., a lower pressure inside than outside). Excessive negative pressure inside containment can occur if there is an inadvertent actuation of the containment cooling system or the containment spray system. Multiple equipment failures or human errors are necessary to have inadvertent actuation. The containment pressure vessel contains two 100% vacuum relief lines installed in parallel that protect the containment from excessive external loading. The combined pressure drop at rated flow through either vacuum relief line will not exceed the containment pressure vessel design external pressure differential of 0.7 psid with any prevailing atmospheric pressure."

Design of the vacuum relief lines involves calculating the effect of an inadvertent containment spray actuation that can reduce the atmospheric temperature (and hence pressure) inside containment. Conservative assumptions are used for all the pertinent parameters in the calculation. The resulting containment pressure versus time is calculated, including the effect of the vacuum relief valves opening when their negative pressure setpoint is reached. It is also assumed that one vacuum relief line fails to open.

The containment was designed for an external pressure load equivalent to 0.7 psig. The inadvertent actuation of the containment spray system was analyzed to determine the resulting reduction in containment pressure. This resulted in a differential pressure between the inside containment and the annulus of 0.66 psid, which is less than the design load.

The LCO establishes the minimum equipment required to accomplish the vacuum relief function following the inadvertent actuation of the containment spray system. Two vacuum relief lines are required to be OPERABLE to ensure that at least one is available, assuming one or both valves in the other line fail to open.

In MODES 1, 2, and 3 with pressurizer pressure equal to or greater than 1750 psia, the containment cooling features, such as the containment spray system, are required to be OPERABLE to mitigate the effects of a DBA. Excessive negative pressure inside containment could occur whenever these systems are OPERABLE due to inadvertent actuation of these systems. In MODES 1, 2, 3, and 4, the containment internal pressure is maintained between specified limits. Therefore, the vacuum relief lines are required to be OPERABLE in MODES 1, 2, 3, and 4 to mitigate the effects of inadvertent actuation of the containment spray system or containment cooling system.

The surveillance requirement references the Inservice Testing Program, which establishes the requirement that inservice testing of the ASME Code Class 1, 2, and 3 pumps and valves shall be performed in accordance with Section XI of the ASME Boiler and Pressure Vessel Code and applicable Addenda and approved relief requests. Therefore, the Inservice Testing Program governs surveillance requirement interval. The butterfly valve setpoint is 2.25 +/- 0.25 inches of water gauge differential. The maximum butterfly valve stroke time is within 8 seconds when tested in accordance with the IST Program.

Applicable General Design Criterion

The Construction Permit for the Hutchinson Island (St. Lucie Unit 1) Plant was issued on July 1, 1970 and preceded the publication of the (AEC) "General Design Criteria for Nuclear Power Plants" (10 CFR 50, Appendix A, February 20, 1971). The UFSAR presents responses reflecting the design intent for this nuclear power plant in consideration of the General Design Criteria for Nuclear Power Plants.

UFSAR section 3.1.16 relating to Criterion 16, Containment Design includes the following discussion that would be applicable to the vacuum analysis: The containment vessel, shield building, and the associated engineered safety features systems are designed to safely sustain all internal and external environmental conditions that may reasonably be expected to occur during the life of the plant, including both short and long term effects following a LOCA.

Safety Analysis

UFSAR Table 1.3-1

This table identifies the containment as a steel vessel with cylindrical shell, hemispherical dome, and ellipsoidal bottom, ASME Code, Section III, Class B, surrounded by a reinforced concrete shield building.

UFSAR 3.8.2.1.2

The structural design conditions for the containment vessel include the following: Maximum external to internal pressure differential is 0.70 psig.

UFSAR 3.8.2.1.4

The design, fabrication, inspection and testing of the containment vessel complies with the requirements of the ASME Boiler and Pressure Vessel Code, Section II Materials; Section III, including all addenda through winter of 1968, Nuclear Vessels, Subsection B "Requirements for Class B Vessels;" Section VIII "Unfired Pressure Vessels," and Section IX "Welding Qualifications."

UFSAR 3.8.2.1.7

Generally speaking, circumferential compression results from external pressure loading. The criteria of Section VIII paragraph UG-28 is used to analyze circumferential buckling. These rules provide a safety factor of 4.0 against shell buckling.

UFSAR Table 3.8-6

This table shows the design external pressure of 0.7 psi.

UFSAR Section 6.2.1.2

Protection of the containment vessel against excessive external pressure is provided by two independent vacuum relief lines each sized to prevent the differential pressure between the containment and the shield building atmosphere from exceeding the design value of 0.70 psi. The containment vessel, which is designed for the specified internal pressure and associated temperature in accordance with ASME Boiler and Pressure Vessel Code, Section III, has an inherent capacity to resist external differential pressure (vacuum). This external pressure is determined by the use of charts provided by the ASME Code. These curves are based on a factor of safety of four; that is, the design external pressure as determined from these charts is one fourth of the collapsing pressure.

The design basis event for the vacuum relief system is the accidental initiation of the containment spray system (both pumps) while all four (4) fan coolers are in operation and the containment is at its maximum normal operating temperature of 120°F. The containment spray pumps are assumed to reach full runout flow (6750 gpm total for both) instantaneously, the initial humidity is assumed to be 40 percent and one (1) vacuum relief subsystem is assumed to fail to operate. The refueling water tank (RWT) water temperature, and therefore the containment spray water temperature, is assumed to be 60°F as is the component cooling water temperature, which is the heat sink for the fan coolers. The shield building annulus initial temperature and humidity are assumed to be 110°F and 100 percent respectively. Containment and annulus initial pressures are 14.7 psia.

At the request of the NRC, three additional cases were evaluated in which the spray temperature is assumed to be 40°F and containment relative humidity is at 0, 40, and 100 percent. The 0 percent initial humidity case is limiting. For these three cases a containment air temperature and annulus air temperature of 90°F and 85°F, respectively, was conservatively assumed. The containment temperature is a function of the component cooling water temperature and the number of fan coolers operating. With a component cooling water temperature of 60°F, the containment air temperature is calculated to be less than 85°F with only one fan cooler in operation. Thus the assumption of 90°F containment air temperature in conjunction with 40°F RWT water and 60°F component cooling water temperature is considered adequately conservative.

For all the cases studied including those postulated by the NRC, the following analytical procedures were used. Calculations were performed with the digital computer code A-TEMPT which considers conditions in the containment and annulus simultaneously. The assumption made in the A-TEMPT program is that perfect mixing of air, water vapor, and evaporating spray droplets exists in the containment air (no temperature stratification) and that the spray droplets attain the temperature of the vapor before they reach the sump. The assumption is also made that once a saturated vapor (100 percent humidity) condition is attained (by either evaporation of drops or containment air cooling), the saturation condition is maintained at all times thereafter at the existing pressure and temperature.

Evaporation of the spray is represented as a mixing of the spray water and its associated energy with the entire air region. The program does not consider any condensation of this water to occur until a 100 percent humidity condition is reached. After this time, spray droplets just transfer heat from the containment air region to the sump. Condensation out of the air to bring it to a saturated air condition at the current pressure and temperature is considered as a separate process.

The vacuum breaker check valve is balanced to open at a 1.1 in wg differential and the butterfly valve is set to open at a differential pressure of 2.25 in. wg. The butterfly valve opens at a constant rate of 12.86^{0}/sec after a conservative 1 second delay assumed for the circuitry. Figure 6.2-54 shows the flow coefficient, Cv, versus disc angle and opening time for this valve.

The heat removal rate for the containment fan coolers is given by:

$Q = A(T^3\text{-}CCW^3) + B\,(T^2\text{-}CCW^2) + C\,(T\text{-}CCW)$

Where: A = 8.86

B = 678.64

C = 108879.31

T = containment air temperature, F

CCW = component cooling water temperature, F

Q = heat removal rate, BTU/hr

The containment sprays are assumed to be 100 percent efficient.

The following is a list of additional conservatisms prevalent in these analyses:

a) There is no single failure spurious signal which can initiate both containment spray subsystems. Initiation of both containment spray subsystems is by coincidence of safety injection actuation signal and high high containment pressure signal which indicates that a major energy source has been introduced into containment and that humidity is rapidly approaching 100 percent.

b) All containment heat sources have been ignored so as to effectively make the containment sprays greater than 100% efficient.

Since the vacuum relief valves also perform a containment isolation function in the event of a LOCA, the automatic butterfly valves have been designed as fail closed. A seismic Class I air accumulator has been provided to ensure a reliable energy source for operation of each valve. Each air accumulator is sized to allow three cycles of operation of its associated air operated valve. The seismic Class I air supply is isolated from the normal non-seismic Class I system. Refer to Table 6.2-2A for a single failure analysis of the containment vacuum relief system.

UFSAR TABLE 6.2-7

Negative pressure differential with relation to shield building annulus opens vacuum relief valves FCV-25 -7 & -8 on high negative pressure differential. The normal operating pressure range is -0.25 to +3.0 inch w.g.

UFSAR TABLE 6.3-6

Containment spray flow rate from both pumps is 6750 GPM.

St. Lucie Unit 2

Technical Specifications and Basis

Technical Specification 3.6.1.4 requires primary containment internal pressure to be maintained between -0.368 and +0.4 psig and is applicable in modes 1 through 4. The regulatory basis for Technical Specification 3.6.1.4 states that lower limitation on containment internal pressure ensures that the containment structure is prevented from exceeding its design negative pressure differential with respect to the annulus atmosphere of 0.70 psi.

Technical Specification 3.6.5.1 requires two vacuum relief lines to be operable in Modes 1 through 4. The regulatory basis of Technical Specification 3.6.5 states that the vacuum relief valves protect the containment vessel against negative pressure (i.e., a lower pressure inside than outside). Excessive negative pressure inside containment can occur if there is an inadvertent actuation of the containment cooling system or the containment spray system. Multiple equipment failures or human errors are necessary to have inadvertent actuation. The containment pressure vessel contains two 100% vacuum relief lines installed in parallel that protect the containment from excessive external loading.

The combined pressure drop at rated flow through either vacuum relief line will not exceed the containment pressure vessel design external pressure differential of 0.7 psid with any prevailing atmospheric pressure.

Design of the vacuum relief lines involves calculating the effect of an inadvertent containment spray actuation that can reduce the atmospheric temperature (and hence pressure) inside containment. Conservative assumptions are used for all the pertinent parameters in the calculation. The resulting containment pressure versus time is calculated, including the effect of the vacuum relief valves opening when their negative pressure setpoint is reached. It is also assumed that one vacuum relief line fails to open.

The containment was designed for an external pressure load equivalent to 0.7 psig. The inadvertent actuation of the containment spray system was analyzed to determine the resulting reduction in containment pressure. This resulted in a differential pressure between the inside containment and the annulus of 0.615 psid, which is less than the design load.

The LCO establishes the minimum equipment required to accomplish the vacuum relief function following the inadvertent actuation of the containment spray system. Two vacuum relief lines are required to be OPERABLE to ensure that at least one is available, assuming one or both valves in the other line fail to open.

In MODES 1, 2, and 3 with pressurizer pressure equal to or greater than 1750 psia, the containment cooling features, such as the containment spray system, are required to be OPERABLE to mitigate the effects of a DBA. Excessive negative pressure inside containment could occur whenever these systems are OPERABLE due to inadvertent actuation of these systems. In MODES 1, 2, 3, and 4, the containment internal pressure is maintained between specified limits. Therefore, the vacuum relief lines are required to be OPERABLE in MODES 1, 2, 3, and 4 to mitigate the effects of inadvertent actuation of the containment spray system or containment cooling system.

The surveillance requirement references the Inservice Testing Program, which establishes the requirement that inservice testing of the ASME Code Class 1, 2, and 3 pumps and valves shall be performed in accordance with Section XI of the ASME Boiler and Pressure Vessel Code and applicable Addenda and approved relief requests. Therefore, the Inservice Testing Program governs surveillance requirement interval. The butterfly valve setpoint is 9.85 +/- 0.35 inches of water gauge differential.

Applicable General Design Criterion

The St. Lucie Unit 2 UFSAR discusses conformance with the NRC "General Design Criteria for Nuclear Power Plants" as specified in Appendix A to 10 CFR 50 effective May 21, 1971 and subsequently amended July 7, 1971 and February 12, 1976. Based on the content herein, the applicant concludes that St. Lucie Unit 2 fully satisfies and is in compliance with the General Design Criteria.

UFSAR section 3.1.16 relating to Criterion 16, Containment Design, includes the following discussion that would be applicable to the vacuum analysis:

> The containment system is designed to protect the public from the radiological consequences of a LOCA, based on a postulated break of reactor coolant piping up to and including a double ended break of the largest reactor coolant pipe.
>
> The containment vessel, Shield Building, and the associated engineered safety features systems are designed to safely sustain all internal and external environmental conditions that may reasonably be expected to occur during the life of the plant, including both short and long term effects of a design basis accident.

Safety Analysis

UFSAR TABLE 1.3-1

The containment system consists of a steel containment vessel with cylindrical shell, hemispherical dome, and ellipsoidal bottom. – ASME Section III Class MC, surrounded by a reinforced concrete shield building.

UFSAR 3.8.2.2

The following codes, standards and specifications are used in the design, fabrication, erection, and testing of the containment vessel:

American Society of Mechanical Engineers (ASME)

1. ASME Section II, "Material Specifications," 1971 Edition, Winter 1972 Addenda
2. ASME Section III, "Nuclear Power Plant Components," 1971 Edition, Winter 1972 Addenda
3. ASME Section VIII, "Unfired Pressure Vessels," 1971 Edition, Winter 1972 Addenda
4. ASME Section IX, "Welding Qualifications," 1971 Edition, Winter 1972 Addenda

UFSAR 3.8.2.3

A containment vessel of thickness suitable to meet the specified internal, pressure requirements is capable of withstanding an external pressure differential of 0.7 psig in accordance with UG-28 of Section VIII of the ASME Code. Since the ASME Code charts have a safety factor of four, the collapsing pressure for the containment vessel is about four times greater than the design external pressure differential.

> The statement above regarding UG-28 while correct is not consistent with, the design of the Unit 2 containment vessel. For external pressure, the design was not performed in accordance with UG-28 of ASME Section VIII. It was performed in accordance with Section III Article NE-3133 as described in section 3.8.2.4.1 and 3.8.2.5.2 the UFSAR.

Protection of the containment vessel against excessive external pressure is provided by two independent vacuum breaker lines. The arrangement of instrumentation and valving is shown on Figure 9.4-9.

Each vacuum breaker assembly consists of a check valve inside and an automatic air operated butterfly valve outside the containment vessel. Actuation of the butterfly valve is controlled by differential pressure between the containment vessel and the shield building annulus. A transmitter senses the differential pressure and provides a signal to the pilot solenoid on the air operated butterfly valve to open the valve at a differential pressure of -9.85 +/- 0.35 in. wg. and to close the valve at a differential pressure of -7.75 in. wg.

The design criterion used in sizing the vacuum breaker system is to prevent the occurrence of a differential pressure between the inside of the containment and the annulus of less than -0.7 psi, and between the Shield Building annulus and the environment of less than -3 psi due to inadvertent actuation of both containment spray pumps at runout conditions plus four fan coolers. Refer to Subsection 6.2.1.1 for a discussion of the containment vacuum breaker analysis.

UFSAR 3.8.2.3.1.e

The maximum external to internal pressure differential and temperature after cooling of the containment by the containment spray system and actuation of the vacuum breaker system is 0.7 psi at 120 F.

UFSAR 3.8.2.4.1

The design of the containment to guard against buckling is in accordance with ASME Code Section III, NE-3133 design rules with assumptions and boundary conditions inherent in the design rules.

The regions of the shell most likely affected by axial compressive loadings are the top head near the cylinder junction and the bottom tangent line on the cylinder. External pressure for cylinder and head are checked using design rules in NE-3133.3 and NE-3133.4. The cylinder is checked for axial compression using the design rules in NE-3133.6. Seismic and dead loads are considered to cause axial compression.

UFSAR 3.8.2.5.2

The maximum allowable compressive stress used in the design of cylindrical shell subjected to loadings that produce longitudinal compressive stress is in accordance with ASME Code, Section III, Article NE-3133.

Generally speaking, circumferential compression results from external pressure loading. The criteria of ASME Code, Section III, Article NE-3133 is used to analyze circumferential buckling. These rules provide a safety factor of 3.0 against shell buckling.

UFSAR TABLE 3.8-1

Load cases 4, 5, 12, 13 consider a design external pressure of 0.70 PSI.

UFSAR 6.2.1.1.2

Two redundant containment vacuum breakers are provided for protection against loss of containment integrity under external loading conditions. Calculations of containment pressure following an inadvertent operation of the Containment Spray System results in pressures within the containment design differential allowable pressure. Details of this evaluation are provided in Subsection 6.2.1.1.3. The margin, between calculated and design pressure differentials is shown in Table 6.2-3.

UFSAR 6.2.1.1.3

Protection of the containment vessel against excessive external pressure is provided by two independent vacuum relief lines each sized to prevent the differential pressure between the containment and the Shield Building atmosphere from exceeding the design value of 0.70 psi. The vacuum system conforms to the requirements of para. NE-7116 of ASME Section III.

An analysis is made of the design basis accident for a containment differential pressure which is an actuation of the Containment Heat Removal System during normal plant operation. A sensitivity analysis was performed to compare the results of an accident assuming worst case winter conditions as opposed to one with worst case summer conditions. The highest pressure differential occurred under the winter conditions and is presented herein. The containment external pressure analysis was performed using the Ebasco modified version of the WATEMPT computer code (refer to Appendix 6.2B).

Assumptions used in the analysis of an inadvertent Containment Heat Removal System actuation are listed in Table 6.2-11. The calculated external pressure transient is shown as a function of time in Figures 6.2-16 and 17. The containment and Shield Building external pressure and design values and margin are given in Table 6.2-3.

There is no single failure spurious signal which can initiate both containment spray trains. Initiation of both containment spray subsystems is by coincidence of safety injection actuation signal and high-high containment pressure signal which indicates that a major energy source has been introduced into containment and that humidity is rapidly approaching 100 percent.

UFSAR Table 6.2-3

This table identifies that the containment vessel differential design pressure of 0.70 psid, provides a margin of 16.6% to the maximum expected differential pressure from the analysis.

UFSAR Table 6.2.11

This table provides a listing of input parameters for the Cycle 1 analysis of inadvertent spray actuation. The parameters are listed in the technical evaluation above.

UFSAR Appendix 6.2B (Historical)

Many pressurized water reactor (PWR) containment buildings have a multibarrier dry containment system. This consists of a free standing steel containment vessel surrounded by an annular gas space several feet thick (annulus) and a concrete Shield Building. A loss-of-coolant accident (LOCA) causes a pressure buildup in the annulus as a result of containment vessel expansion and heat and mass flow into the Shield Building annulus atmosphere across the primary containment vessel. To limit the pressure rise and to maintain the annulus at a negative gage pressure following the postulated accident, a Shield Building Ventilation System (SBVS) exhausts filtered annulus gas. The WATEMPT computer code determines exhaust rates and sizes the SBVS equipment to maintain a negative annulus pressure following a LOCA inside the primary containment.

The WATEMPT code is primarily an extension of the CONTEMPT code (A Computer Program for Predicting the Containment Pressure - Temperature Response to a Loss-of Coolant Accident). It uses slightly modified CONTEMPT type calculations to determine the containment and annulus, pressure and temperature, initial and transient conditions, and the distribution of heat across the steel containment structure and concrete Shield Building wall.

In the WATEMPT computer code, the containment and the annulus volumes are divided into two regions, the atmospheric region (water vapor and air mixture) and the liquid region. Each individual region is assumed to be completely mixed and in thermal equilibrium. The temperature of the two regions may be different. Mass and energy additions are made to the appropriate region to simulate the various leakage and heat transfer processes. Account is taken of condensation in the vapor region and mass and energy transfers between regions.

The code represents the heat conducting and absorbing materials in the containment by dividing them into segments with appropriate heat transfer coefficients and heat capacities. The steel containment vessel and the concrete Shield Building are the only heat sinks in contact with the Shield Building atmosphere.

Initial temperature distributions in the heat conducting regions are computed from the steady heat conduction equation and the boundary temperatures specified in the input. The containment vessel is represented by several heat conducting sections whose transient thermal behavior can be described by the one-dimensional multi-region transient heat conduction equation. Heat is transferred from the containment vapor region into the annulus atmosphere through these sections. Any additional energy added to the annulus atmosphere from such sources as annulus equipment operation can be inputed by a tabular representation of annulus energy input rates as a function of time.

2) Regulatory Guidance

The applicable safety analysis described in the basis of the standard technical specifications for CE plants (NUREG-1432 Volume 2 Revision 4.0) states in section B3.6.12 Vacuum Relief Valves (Dual):

> Design of the vacuum relief lines involves calculating the effect of an inadvertent containment spray actuation that can reduce the atmospheric temperature (and hence pressure) inside containment. Conservative assumptions are used for all the pertinent parameters in the calculation. For example, the minimum spray water temperature is assumed, as well as maximum initial containment temperature, maximum spray flow, all trains of spray operating, etc. The resulting containment pressure versus time is calculated, including the effect of the vacuum relief valves opening when their negative pressure setpoint is reached. It is also assumed that one vacuum relief line fails to open.

The standard review plan NUREG 0800 Section 3.8.2 Steel Containment, describes that the structural acceptance criteria complies with ASME Section III, Subsection NE, and that these limits apply to buckling criteria.

ANSI/ANS 56.4-1983 Section 4.4 states the following: The minimum dry primary containment pressure analysis shall be performed to determine the worst-case negative pressure differential across the dry primary containment structure. The results of this analysis are required to verify the adequacy of the dry primary containment structural design for negative pressure differentials (that is, environment pressure exceeds the dry primary containment atmosphere region pressure). Typically, this case results from assuming the inadvertent actuation of the dry primary containment spray system. The methods described in 4.2 [methods for evaluation of containment response to a postulated pipe break] are applicable to this analysis. However, consideration shall be given, but not limited, to the following initial and boundary conditions and their values chosen to yield a conservatively low estimate of the containment pressure: For inadvertent spray actuation transients, the upper bound initial dry primary containment atmosphere temperature and lower bound initial dry primary containment atmosphere pressure shall be used. For dry primary containments which employ vacuum breaking devices to mitigate negative pressure transients, the initial relative humidity shall be assumed to be at its lowest credible value. Otherwise, the initial relative humidity shall be chosen from the range of credible values to produce the lowest dry primary containment atmosphere pressure.

3) Evaluation of Compliance with Regulatory Requirements

Change to the Analysis Methodology for Inadvertent Containment Spray Initiation

The use of GOTHIC Version 7.2b(QA) to perform the containment vacuum analysis is acceptable for providing a best estimate value for containment response based on the following:

The NRC Final Safety Evaluation for Topical Report BAW-10252(P), R0, "Analysis of Containment Response to Postulated Pipe Ruptures Using GOTHIC" concluded: The NRC staff finds the described use of GOTHIC for the stated licensing analyses, as presented in Topical Report BAW-10252(P), Analysis of Containment Response to Postulated Pipe Ruptures Using GOTHIC, and as modified by letter dated March 7, 2005, "Response to a Request for Additional Information Regarding BAW-10252(P), Revision 0, 'Analysis of Containment Response to Postulated Pipe Ruptures Using GOTHIC'," acceptable for the proposed licensing applications.

The capability of the GOTHIC model discussed in the NRC final safety evaluation report made specific reference to, modeling of containment spray, modeling of containment fan coolers, and modeling of flow through valves. These are the key elements used in vacuum analysis.

The NRC final safety evaluation report additionally states that the Framatome methodologies for the use of GOTHIC to perform licensing analyses of a large, dry, PWR containment to (1) evaluate the containment atmosphere's peak pressure and temperature response to large pipe breaks in high energy piping systems, and (2) evaluate the long-term containment response following a design-basis LOCA, are based on the guidance provided in SRP Sections 6.2.1, 6.2.1.1.A, 6.2.1.3, 6.2.1.4, and 6.2.2, and in ANSI/ANS-56.4-1983.

ANSI/ANS 56.4 -1983 states that the minimum dry primary containment pressure analysis shall be performed to determine the worst-case negative pressure differential across the dry primary containment structure. The results of this analysis are required to verify the adequacy of the dry primary containment structural design for negative pressure differentials (that is, environment pressure exceeds the dry primary containment atmosphere region pressure). Typically, this case results from assuming the inadvertent actuation of the dry primary containment spray system. The methods described in 4.2 [methods for evaluation of containment response to a postulated pipe break] are applicable to this analysis. However, consideration shall be given, but not limited, to the following initial and boundary conditions and their values chosen to yield a conservatively low estimate of the containment pressure: For inadvertent spray actuation transients, the upper bound initial dry primary containment atmosphere temperature and lower bound initial dry primary containment atmosphere pressure shall be used. For dry primary containments which employ vacuum breaking devices to mitigate negative pressure transients, the initial relative humidity shall be assumed to be at its lowest credible value. Otherwise, the initial relative humidity shall be chosen from the range of credible values to produce the lowest dry primary containment atmosphere pressure.

The guidance above states that the methods for evaluation of containment response to a postulated pipe break are also applicable to the analysis of inadvertent containment spray initiation. Based on conclusions in the safety evaluation report for Topical Report BAW-10252(P), that GOTHIC would be an acceptable method for evaluation the containment response to a postulated pipe rupture, GOTHIC would also be expected to be an acceptable method for performing the vacuum (inadvertent spray actuation) analysis.

Supporting the conclusion above, NAI Report NAI-1688-001, Rev. 0, "Application of GOTHIC for Subatmospheric Conditions", documents that GOTHIC is suitable for use for PWR containment sub-atmospheric/vacuum analyses such as the St. Lucie containments.

The benchmarking data presented in the technical evaluation demonstrates reasonableness of the results of the GOTHIC analysis in comparison to the existing analysis.

In conclusion, the use of GOTHIC to perform the containment vacuum analysis is consistent with industry guidance and supported by the developer of the program. The NRC has accepted the use of the GOTHIC program for related analyses, i.e. containment response to postulated pipe ruptures. Benchmarking of the GOTHIC code against the existing analysis demonstrates the ability of the program to produce reasonable and conservative results.

Change to Containment Design External Pressure

For Unit 1, an analysis of the containment vessel for external pressure in accordance with the requirements of the ASME Code Section III 1971 with Addenda through Summer 1972 was performed. This analysis determined that the containment vessel was capable of supporting a design external pressure load of 1.04 psi. The original code of record is ASME Section III 1968 edition with addenda through Winter 1968. The methodology used in the 1968 code provides a factor of safety of four to the buckling pressure. The 1971 code with Addenda through Summer 1972 provides a factor of safety of three to the buckling pressure. The later code used for the external pressure calculation has a lower factor of safety relative to the bucking pressure than the original code of record; however, the later code and subsequent versions of the code with the factor of safety of three to the buckling pressure have been accepted by the NRC for the analysis of external pressure loads on containment vessels of other facilities including St. Lucie Unit 2. Although the factor of safety is lower than that in the original code of record, there is substantial margin to the buckling pressure using a methodology that has been previously accepted. The later code can be used for rerating the containment vessel in accordance with the rules of the ASME Boiler and Pressure Vessel Code Section XI, paragraph IWA-4330.

For Unit 2 an analysis of the containment vessel for external pressure in accordance with the requirements of the original code of record, ASME Code Section III 1971 with Addenda through Winter 1972 was performed. This analysis determined that the containment vessel was capable of supporting a design external pressure load of 1.05 psi.

In conclusion, the revised analyses of the containment vessels demonstrates that stresses remain within the allowable for ASME Section III and the maximum calculated external pressure will be less than 1/3 of the bucking pressure. From these analyses it can be concluded that the containment vessel structure will not be subject to detrimental loading or buckling from the licensing basis external pressure event.

Change to Technical Specification 3.6.1.4 – Containment Internal Pressure

Analyses performed using the GOTHIC version 7.2b(QA) computer program determined that the maximum external pressure that would result from an inadvertent actuation of the containment spray and cooling systems would be 1.000 psi for Unit 1, and 0.998 psi for Unit 2. The analysis included conservative assumptions for all inputs including all trains of containment spray and containment cooling operating, only one vacuum relief line functioning, maximum containment spray flow of 6950 gpm for Unit 1 and 7250 gpm for Unit 2, maximum containment temperature, and minimum cooling water temperature. The analysis determined the required opening setpoint for the vacuum relief valves was -16.0 inch w.g. for Unit 1 and -14.0 inch w.g. for Unit 2 between the containment and the annulus. The containment pressure was maintained at -0.490 psig for Unit 1 and -0.420 psig for Unit 2 at the initiation of the event. These values will be used to establish the allowable containment pressure for Technical Specification 3.6.1.4.

In conclusion, the proposed technical specification changes are consistent with the analysis inputs for inadvertent containment spray initiation.

4.2 Precedent

No precedent was identified for the use of the GOTHIC program to perform the containment vacuum analysis; therefore no precedent is presented in this Amendment Request.

4.3 No Significant Hazards Consideration Determination

The proposed license amendment involves the following changes:

- Revise the analysis of inadvertent containment spray initiation using the GOTHIC version 7.2b(QA) computer program. The St. Lucie Unit 1 and 2 licensing basis will be revised to include the design basis ability of the containment vessels to withstand a differential pressure from annular space between the shield building and containment vessel to the inside of the containment vessel of 1.04 psi for Unit 1 and 1.05 psi for Unit 2.
- Update Technical Specification 3.6.1.4. to revise the allowable containment internal pressure operating range consistent with the revised analysis for inadvertent containment spray actuation. For Unit 1, the allowable pressure will be -0.490 to 0.5 psig. For Unit 2, the allowable pressure will be -0.420 to 0.400 psig.

Florida Power and Light has evaluated whether or not a significant hazards consideration is involved with the proposed amendments by focusing on the three standards set forth in 10 CFR 50.92, "Issuance of amendment," as discussed below:

1) Does the proposed amendment involve a significant increase in the probability or consequences of an accident previously evaluated?

   Response: No

   This proposed amendment is related to the analysis of the maximum external pressure that the reactor containment building will experience. A proposed change to the Technical Specifications will limit the allowable external pressure during operation to a value consistent with that considered in the analysis. The analysis is being revised to consider containment spray pump flow higher than previously considered. Containment spray pumps cool and depressurize the containment building; therefore, higher flow impacts the analysis of external pressure on the containment building. The proposed amendment is for the use of a different analysis methodology using the GOTHIC computer code instead of the A-TEMPT and WATEMPT codes that were originally used for the Unit 1 and Unit 2 analyses respectively. The original codes are not currently available. The GOTHIC code is an accepted code for similar analysis. The analysis performed demonstrates that in the postulated event of an inadvertent start of two containment spray pumps, the loading the reactor containment building will experience is within the design of the structure. With this load, the stresses experienced by the reactor containment building remain below the code allowable stresses.

The probability of occurrence of an event that would expose the containment building to external pressure is not increased by the change in the analysis methodology used. The probability of the initiating event, inadvertent start of both containment spray pumps, is unchanged.

The consequences of an event where the containment building is exposed to external pressure will not be increased as the resulting external pressure on the containment vessel remains within the design, which provides a large margin to the buckling pressure.

Therefore, the proposed amendment does not involve a significant increase in the probability or consequences of an accident previously evaluated.

2) Does the proposed amendment create the possibility of a new or different kind of accident from any accident previously evaluated?

Response: No

This proposed amendment changes the methodology for analyzing an event that results in exposing the reactor containment vessel to external pressure. A proposed change to the Technical Specifications will limit the external pressure during operation to a value consistent with the initial condition considered in the analysis. The potential for a new or different kind of accident is not created by the use of a different analysis methodology for a previously defined event. Therefore, the proposed change does not create the possibility of a new or different kind of accident from any accident previously evaluated.

3) Does the proposed amendment involve a significant reduction in a margin of safety?

Response: No

This proposed amendment changes the methodology for analyzing an event that results in exposing the reactor containment building to external pressure. A proposed change to the Technical Specifications will limit the allowable external pressure during operation to a value consistent with the starting point considered in the analysis. The technical evaluation demonstrates that the use of the GOTHIC computer code to determine maximum containment external pressure will result in realistic results similar to the original analysis with the A-TEMPT and WATEMPT codes. The margin of safety in this analysis is maintained by assuring the resulting external pressure acting on the reactor containment vessel maintains significant margin to the buckling pressure in accordance with Section III of the ASME code. For Unit 2, the original code of record limited the maximum external pressure to 1/3 of the expected buckling pressure. The analysis of the increased external pressure for Unit 2 has been performed in accordance with the original code of record. The original code of record for Unit 1 was under development at the time and made reference to ASME Section VIII for the analysis of external pressure. The rules of ASME Section VIII at that time limited the maximum external pressure to ¼ of the expected buckling pressure. In order to increase the allowable external pressure, the analysis of external pressure was performed using a later version of the ASME code which allows a maximum external pressure of 1/3 of the buckling pressure. The later version of the code used for Unit 1 uses a methodology for determining the maximum external pressure consistent with the code used for Unit 2.

Although the margin between the allowable external pressure and the expected buckling pressure for Unit 1 will be changed from a factor of 4 to a factor of 3, substantial margin is maintained in accordance with more current versions of ASME III. The proposed change does not involve a significant reduction in a margin of safety.

Based on the above, Florida Power and Light concludes that the proposed amendments do not involve a significant hazards consideration under the standards set forth in 10 CFR 50.92, and, accordingly, a finding of "no significant hazards consideration" is justified.

4.4 Conclusions

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

5. ENVIRONMENTAL CONSIDERATION

10 CFR 51.22(c)(9) provides criteria for and identification of licensing and regulatory actions eligible for categorical exclusion from performing an environmental assessment. A proposed amendment of an operating license for a facility requires no environmental assessment, if the operation of the facility in accordance with the proposed amendment does not: (1) involve a significant hazards consideration, (2) result in a significant change in the types or significant increase in the amounts of any effluents that may be released offsite, and (3) result in a significant increase in individual or cumulative occupational radiation exposure.

FPL has reviewed this LAR and determined that the proposed amendment meets the eligibility criteria for categorical exclusion set forth in 10 CFR 51.22(c)(9). Pursuant to 10 CFR 51.22(b), no environmental impact statement or environmental assessment needs to be prepared in connection with the issuance of this amendment. The basis for this determination follows.

Basis

This change meets the eligibility criteria for categorical exclusion set forth in

10CFR 51.22(c)(9) for the following reasons:

1. As demonstrated in the 10 CFR 50.92 evaluation, the proposed amendment does not

involve a significant hazards consideration.

2. The proposed amendment does not result in a significant change in the types or increase in the amounts of any effluents that may be released offsite. The proposed change provides a revised evaluation methodology and Technical Specification changes which assure that the containment vessel will not be subjected to an external pressure condition which will lead to failure during the postulated design basis external pressure event. Thus, the proposed amendment will not result in a significant change in the types or increase in the amounts of any effluents that may be released offsite.

3. The proposed amendment does not result in a significant increase in individual or cumulative occupational radiation exposure. The proposed change provides a revised evaluation methodology and Technical Specification changes which assure that the containment vessel will not be subjected to an external pressure condition which will lead to failure during the postulated design basis external pressure event. Hence, the proposed amendment does not result in a significant increase in individual or cumulative occupational radiation exposure.

6. REFERENCES

1. St. Lucie Unit 1 UFSAR, Amendment 26

2. St. Lucie Unit 1 Technical Specifications Amendment 227

3. ST. Lucie Unit 2 UFSAR, Amendment 22

4. St. Lucie Unit 2 Technical Specifications Amendment 177

5. Technical Specification Bases Section 3-4.6 Rev. 10- Unit 1

6. Technical Specification Bases Section 3-4.6 Rev. 13- Unit 2

7. NUREG-1432 Volume 2, Revision 4.0, Standard Technical Specifications Combustion Engineering Plants Bases

8. ANSI/ANS-56.4-1983 Pressure and Temperature Transient Analysis for Light Water Reactor Containments

9. NAI Report NAI-1688-001, Rev. 0, "Application of GOTHIC for Subatmospheric Conditions".

10. NUREG 0800 Rev. 3 Section 3.8.2, Steel Containment

CONTAINMENT SYSTEMS

INTERNAL PRESSURE

LIMITING CONDITION FOR OPERATION

3.6.1.4 Primary containment internal pressure shall be maintained between ~~-0.7~~ -0.490 and +0.5 psig.

APPLICABILITY: MODES 1, 2, 3 and 4.

ACTION:

With the containment internal pressure outside of the limits above, restore the internal pressure to within the limits within 1 hour or be in at least HOT STANDBY within the next 6 hours and in COLD SHUTDOWN within the following 30 hours.

SURVEILLANCE REQUIREMENTS

4.6.1.4 The primary containment internal pressure shall be determined to be within the limits in accordance with the Surveillance Frequency Control Program.

CONTAINMENT SYSTEMS

INTERNAL PRESSURE

LIMITING CONDITION FOR OPERATION

3.6.1.4 Primary containment internal pressure shall be maintained between ~~-0.368~~ and +0.400 psig.

-0.420

APPLICABILITY: MODES 1, 2, 3, and 4.

ACTION:

With the containment internal pressure outside of the limits above, restore the internal pressure to within the limits within 1 hour or be in at least HOT STANDBY within the next 6 hours and in COLD SHUTDOWN within the following 30 hours.

SURVEILLANCE REQUIREMENTS

4.6.1.4 The primary containment internal pressure shall be determined to be within the limits in accordance with the Surveillance Frequency Control Program.

3/4.6 CONTAINMENT SYSTEMS (continued)

BASES (continued)

3/4.6.1 CONTAINMENT VESSEL (continued)

3/4.6.1.4 INTERNAL PRESSURE

1.04

The limitations on containment internal pressure ensure that 1) the containment structural is prevented from exceeding its design negative pressure differential with respect to the annulus atmosphere of ~~0.70~~ psi and 2) the containment peak pressure does not exceed the design pressure of 44 psig during loss of coolant accident conditions.

The maximum peak pressure obtained from a loss of coolant accident is 42.77 psig. The limit of 0.5 psig for initial positive containment pressure will limit the maximum peak pressure to less than 44.0 psig which is the design pressure and is consistent with the accident analyses.

3/4.6.1.5 AIR TEMPERATURE

The limitation on containment air temperature ensures that the peak containment vessel temperature does not exceed the containment vessel design temperature of 264°F during steam line break and LOCA conditions. The containment temperature limit is consistent with the accident analyses.

3/4.6.1.6 CONTAINMENT VESSEL STRUCTURAL INTEGRITY

The limitation ensures that the structural integrity of the containment steel vessel will be maintained comparable to the original design standards for the life of the facility. Structural integrity is required to ensure that the vessel will withstand the maximum pressure of 42.77 psig in the event of the limiting design basis loss of coolant accident. A visual inspection in accordance with the Containment Leakage Rate Testing Program is sufficient to demonstrate this capability.

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3/4.6 CONTAINMENT SYSTEMS (continued)

BASES (continued)

3/4.6.4 DELETED

3/4.6.5 VACUUM RELIEF VALVES

BACKGROUND: The vacuum relief valves protect the containment vessel against negative pressure (i.e., a lower pressure inside than outside). Excessive negative pressure inside containment can occur if there is an inadvertent actuation of the containment cooling system or the containment spray system. Multiple equipment failures or human errors are necessary to have inadvertent actuation.

The containment pressure vessel contains two 100% vacuum relief lines installed in parallel that protect the containment from excessive external loading. The vacuum relief lines are 24-inch penetrations that connect the shield building annulus to the containment. Each vacuum relief line is isolated by a pneumatically operated butterfly valve in series with a check valve located on the containment side of the penetration.

A separate pressure controller that senses the differential pressure between the containment and the annulus actuates each butterfly valve. Each butterfly valve is provided with an air accumulator that allows the valve to open following a loss of instrument air. The combined pressure drop at rated flow through either vacuum relief line will not exceed the containment pressure vessel design external pressure differential of ~~0.7~~ psid with any prevailing atmospheric pressure.

1.04

APPLICABLE SAFETY ANALYSES: Design of the vacuum relief lines involves calculating the effect of an inadvertent containment spray actuation that can reduce the atmospheric temperature (and hence pressure) inside containment. Conservative assumptions are used for all the pertinent parameters in the calculation. The resulting containment pressure versus time is calculated, including the effect of the vacuum relief valves opening when their negative pressure setpoint is reached. It is also assumed that one vacuum relief line fails to open.

The containment was designed for an external pressure load equivalent to ~~0.7~~ psig. The inadvertent actuation of the containment spray system was

1.04

analyzed to determine the resulting reduction in containment pressure. This resulted in a differential pressure between the inside containment and the annulus of ~~0.66~~ psid, which is less than the design load.

1.00

3/4.6 **CONTAINMENT SYSTEMS** (continued)

BASES (continued)

3/4.6.5 **VACUUM RELIEF VALVES** (continued)

ACTIONS: With one of the required vacuum relief lines inoperable, the inoperable line must be restored to OPERABLE status within 72 hours. The specified time period is consistent with other LCOs for the loss of one train of a system required to mitigate the consequences of a LOCA or other DBA. If the vacuum relief line cannot be restored to OPERABLE status within the required ACTION time, the plant must be brought to a MODE in which the LCO does not apply. To achieve this status, the plant must be brought to at least MODE 3 within the next 6 hours and to MODE 5 within the following 30 hours. The allowed ACTION times are reasonable, based on operating experience, to reach the required plant conditions from full power conditions in an orderly manner and without challenging plant systems.

SURVEILLANCE REQUIREMENTS: This SR references the Inservice Testing Program, which establishes the requirement that inservice testing of the ASME Code Class 1, 2, and 3 pumps and valves shall be performed in accordance with Section XI of the ASME Boiler and Pressure Vessel Code and applicable Addenda and approved relief requests. Therefore, the Inservice Testing Program governs SR interval. The butterfly valve setpoint is ~~2.25±0.25~~ inches of water gauge differential. The maximum butterfly valve stroke time is within 8 seconds when tested in accordance with the IST Program.

less than or equal to 16

3/4.6 CONTAINMENT SYSTEMS (continued)

<u>BASES</u> (continued)

3/4.6.1 CONTAINMENT VESSEL (continued)

3/4.6.1.3 CONTAINMENT AIR LOCKS

The limitations on closure and leak rate for the containment air locks are required to meet the restrictions on CONTAINMENT INTEGRITY and containment leak rate. Surveillance testing of the air lock seals provides assurance that the overall air lock leakage will not become excessive due to seal damage during the intervals between air lock leakage tests.

3/4.6.1.4 INTERNAL PRESSURE

The limitations on containment internal pressure ensure that (1) the containment structure is prevented from exceeding its design negative pressure differential with respect to the annulus atmosphere of ~~0.7~~ 1.05 psi and (2) the containment peak pressure does not exceed the design pressure of 44 psig during loss of coolant accident conditions.

The maximum peak pressure expected to be obtained from a loss of coolant accident is 43.48 psig. The limit of 0.4 psig for initial positive containment pressure will limit the maximum peak pressure to less than the design pressure of 44 psig and is consistent with the safety analyses.

3/4.6.1.5 AIR TEMPERATURE

The limitation on containment average air temperature ensures that the peak containment vessel temperature does not exceed the containment vessel design temperature of 264°F during steam line break and loss of coolant accident conditions and is consistent with the safety analyses.

3/4.6.1.6 CONTAINMENT VESSEL STRUCTURAL INTEGRITY

The limitation ensures that the structural integrity of the containment steel vessel will be maintained comparable to the original design standards for the life of the facility. Structural integrity is required to ensure that the vessel will withstand the maximum pressure of 43.48 psig in the event of the limiting design basis loss of coolant accident. A visual inspection in accordance with the Containment Leakage Rate Testing Program is sufficient to demonstrate this capability.

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3/4.6 CONTAINMENT SYSTEMS (continued)

BASES (continued)

3/4.6.4 DELETED

3/4.6.5 VACUUM RELIEF VALVES

BACKGROUND: The vacuum relief valves protect the containment vessel against negative pressure (i.e., a lower pressure inside than outside). Excessive negative pressure inside containment can occur if there is an inadvertent actuation of the containment cooling system or the containment spray system. Multiple equipment failures or human errors are necessary to have inadvertent actuation.

The containment pressure vessel contains two 100% vacuum relief lines installed in parallel that protect the containment from excessive external loading. The vacuum relief lines are 24-inch penetrations that connect the shield building annulus to the containment. Each vacuum relief line is isolated by a pneumatically operated butterfly valve in series with a check valve located on the containment side of the penetration.

A separate pressure controller that senses the differential pressure between the containment and the annulus actuates each butterfly valve. Each butterfly valve is provided with an air accumulator that allows the valve to open following a loss of instrument air. The combined pressure drop at rated flow through either vacuum relief line will not exceed the containment pressure vessel design external pressure differential of ~~0.7~~ 1.05 psid with any prevailing atmospheric pressure.

APPLICABLE SAFETY ANALYSES: Design of the vacuum relief lines involves calculating the effect of an inadvertent containment spray actuation that can reduce the atmospheric temperature (and hence pressure) inside containment. Conservative assumptions are used for all the pertinent parameters in the calculation. The resulting containment pressure versus time is calculated, including the effect of the vacuum relief valves opening when their negative pressure setpoint is reached. It is also assumed that one vacuum relief line fails to open.

The containment was designed for an external pressure load equivalent to ~~0.7~~ 1.05 psig. The inadvertent actuation of the containment spray system was analyzed to determine the resulting reduction in containment pressure. This resulted in a differential pressure between the inside containment and the annulus of ~~0.615~~ 0.998 psid, which is less than the design load.

3/4.6 CONTAINMENT SYSTEMS (continued)

BASES (continued)

3/4.6.5 VACUUM RELIEF VALVES (continued)

SURVEILLANCE REQUIREMENTS: This SR references the Inservice Testing Program, which establishes the requirement that inservice testing of the ASME Code Class 1, 2, and 3 pumps and valves shall be performed in accordance with Section XI of the ASME Boiler and Pressure Vessel Code and applicable Addenda and approved relief requests. Therefore, the Inservice Testing Program governs SR interval. The butterfly valve setpoint is ~~9.85±0.35~~ less than or equal to 14 inches of water gauge differential.

3/4.6.6 SECONDARY CONTAINMENT

3/4.6.6.1 SHIELD BUILDING VENTILATION SYSTEM

The OPERABILITY of the shield building ventilation systems ensures that containment vessel leakage occurring during LOCA conditions into the annulus will be filtered through the HEPA filters and charcoal adsorber trains prior to discharge to the atmosphere and also reduces radioactive effluent releases to the environment during a fuel handling accident involving a recently irradiated fuel assembly in the spent fuel storage building. This requirement is necessary to meet the assumptions used in the safety analyses and limit the site boundary radiation doses to within the limits of 10 CFR 50.67 during LOCA conditions.

The fuel handling accident analysis assumes a minimum post reactor shutdown decay time of 72 hours. Therefore, recently irradiated fuel is defined as fuel that has occupied part of a critical reactor core within the previous 72 hours. This represents the applicability bases for fuel handling accidents. Containment closure will have administrative controls in place to assure that a single normal or contingency method to promptly close the primary or secondary containment penetrations will be available. These prompt methods need not completely block the penetrations nor be capable of resisting pressure, but are to enable the ventilation systems to draw the release from the postulated fuel handling accident in the proper direction such that it can be treated and monitored.

The Surveillance Frequency is controlled under the Surveillance Frequency Control Program.

With respect to Surveillance 4.6.6.1.b, this SR verifies that the required Shield Building Ventilation System filter testing is performed in accordance with the Ventilation Filter Testing Program (VFTP).

CONTAINMENT SYSTEMS

INTERNAL PRESSURE

LIMITING CONDITION FOR OPERATION

3.6.1.4 Primary containment internal pressure shall be maintained between -0.490 and +0.5 psig.

APPLICABILITY: MODES 1, 2, 3 and 4.

ACTION:

With the containment internal pressure outside of the limits above, restore the internal pressure to within the limits within 1 hour or be in at least HOT STANDBY within the next 6 hours and in COLD SHUTDOWN within the following 30 hours.

SURVEILLANCE REQUIREMENTS

4.6.1.4 The primary containment internal pressure shall be determined to be within the limits in accordance with the Surveillance Frequency Control Program.

CONTAINMENT SYSTEMS

INTERNAL PRESSURE

LIMITING CONDITION FOR OPERATION

3.6.1.4 Primary containment internal pressure shall be maintained between -0.420 and +0.400 psig.

APPLICABILITY: MODES 1, 2, 3, and 4.

ACTION:

With the containment internal pressure outside of the limits above, restore the internal pressure to within the limits within 1 hour or be in at least HOT STANDBY within the next 6 hours and in COLD SHUTDOWN within the following 30 hours.

SURVEILLANCE REQUIREMENTS

4.6.1.4 The primary containment internal pressure shall be determined to be within the limits in accordance with the Surveillance Frequency Control Program.