July 10, 1985

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Docket No. 50-302

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Mr. Walter S. Wilgus
Vice President, Nuclear Operations
Florida Power Corporation
ATTN: Manager, Nuclear Licensing
& Fuel Management
P. O. Box 14042; M.A.C. H-2
St. Petersburg, Florida 33733

Dear Mr. Wilgus:

SUBJECT: GRANTING OF EXEMPTION FROM 10 CFR 50.44(c)(3)(iii), REACTOR VESSEL HEAD VENT

On July 21, 1983, we issued a temporary exemption to Florida Power Corporation for the installation of a reactor vessel head vent in Crystal River Unit 3 (CR-3). The exemption was based on information presented to the NRC by your letters of October 12, 1982, and April 29, 1983, and on a requirement that confirming integral system tests would be conducted.

By letter dated October 22, 1984, you provided the results of the Once-Through Integral System tests along with a discussion of the applicability of the tests to Crystal River Unit 3. Based upon this information, you requested that the exemption from the subject requirement be made permanent.

We have reviewed your request and found that you have demonstrated that a noncondensible gas bubble in the reactor vessel can be safely removed via the hot leg high point vents; even with a noncondensible gas bubble in the reactor vessel head, natural circulation will be maintained while the plant is cooled and depressurized to the Decay Heat Removal System entry conditions. While a residual gas bubble would still remain in the reactor vessel head following the plant cooldown, the gas bubble would not interfere with the maintenance of core cooling and could be slowly removed thereafter by various means.

We conclude that an exemption to 10 CFR 50.44(c)(3)(iii) can be granted. The Exemption is enclosed; a copy of it is being filed with the Office of the Federal Register for publication. Also enclosed is our Safety Evaluation supporting the Exemption.

Sincerely,
"ORIGINAL SIGNED BY
JOHN F. STOLZ"

John F. Stolz, Chief
Operating Reactors Branch #4
Division of Licensing

Enclosures:
1. Exemption
2. Safety Evaluation

cc w/enclosures:
See next page

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

July 10, 1985

DISTRIBUTION
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DOCKET No. 50-302

MEMORANDUM FOR: Docketing and Service Branch
Office of the Secretary of the Commission

FROM: Office of Nuclear Reactor Regulation

SUBJECT: CRYSTAL RIVER UNIT NO. 3

One signed original of the *Federal Register* Notice identified below is enclosed for your transmittal to the Office of the Federal Register for publication. Additional conformed copies (6) of the Notice are enclosed for your use.

- [ ] Notice of Receipt of Application for Construction Permit(s) and Operating License(s).
- [ ] Notice of Receipt of Partial Application for Construction Permit(s) and Facility License(s): Time for Submission of Views on Antitrust Matters.
- [ ] Notice of Consideration of Issuance of Amendment to Facility Operating License.
- [ ] Notice of Receipt of Application for Facility License(s); Notice of Availability of Applicant's Environmental Report; and Notice of Consideration of Issuance of Facility License(s) and Notice of Opportunity for Hearing.
- [ ] Notice of Availability of NRC Draft/Final Environmental Statement.
- [ ] Notice of Limited Work Authorization.
- [ ] Notice of Availability of Safety Evaluation Report.
- [ ] Notice of Issuance of Construction Permit(s).
- [ ] Notice of Issuance of Facility Operating License(s) or Amendment(s).
- [ ] Order.
- [x] XX Exemption.
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Operating Reactors Branch #4, DL
Office of Nuclear Reactor Regulation

Enclosure:
As stated

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SURNAME	RIngram;cf						
DATE	7/15/85						

OFFICIAL RECORD COPY

Mr. W. S. Wilgus
Florida Power Corporation

Crystal River Unit No. 3 Nuclear
Generating Plant

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Mr. Wilbur Langely, Chairman
Board of County Commissioners
Citrus County
Inverness, Florida 36250

UNITED STATES NUCLEAR REGULATORY COMMISSION

In the Matter of)
FLORIDA POWER CORPORATION, ET AL) Docket No. 50-302
(Crystal River Unit No. 3 Nuclear)
Generating Plant))

EXEMPTION

I.

The Florida Power Corporation (the licensee) and eleven other co-owners are the holders of Facility Operating License No. DPR-72 which authorizes operation of the Crystal River Unit No. 3 Nuclear Generating Plant (the facility) at steady-state power levels not in excess of 2544 megawatts thermal. This license provides, among other things, that it is subject to all rules and regulations and Orders of the Nuclear Regulatory Commission (the Commission) now or hereafter in effect.

The facility is a pressurized water reactor at the licensee's site located in Citrus County, Florida.

II.

On December 2, 1981, the Commission published a revised Section 10 CFR 50.44, "Standards for Combustible Gas Control System in Light-Water-Cooled Power Reactors (46 FR 58484). Section 10 CFR 50.44(c)(3)(iii) of the regulation requires:

"To provide improved operation capability to maintain adequate core cooling following an accident, by the end of the first scheduled outage beginning after July 1, 1982, and of sufficient duration to permit required modifications, each light-water nuclear power reactor shall be provided with high point vents for the reactor coolant system, for the reactor vessel head, and for other systems required to maintain adequate core cooling if the accumulation of noncondensible gases would cause the loss of function of these systems."

By letter dated October 12, 1982, the licensee requested an exemption from the requirement of 10 CFR 50.44(c)(3)(iii) to install a reactor vessel head vent. Installation of high point vents at the top of the hot leg U-bends and the pressurizer for CR-3 was accomplished during the 1983 refueling outage. The licensee's justification for the exemption request, contained in the licensee's letter dated January 30, 1981, was based upon the ability to perform a plant depressurization to cold shutdown (following a small-break Loss of Coolant Accident (LOCA)) "even with a gas bubble in the reactor vessel (RV) head, without interrupting natural circulation". In a letter dated April 29, 1983, the licensee committed to implementing procedures and training for use of the high point vents in venting noncondensible gases trapped in the reactor vessel head.

On July 21, 1983, the Commission issued an interim exemption to defer the implementation date for installation of a reactor vessel head vent until December 31, 1985. At that time, the Commission was unable to conclude that noncondensible gases could be safely vented by the hot leg high point vents alone. The primary reason for the Commission's conclusion was the lack of integral system test data which would demonstrate the feasibility of the proposed venting procedure. The interim exemption was granted in order to allow the licensee to perform the necessary integral system testing.

On October 22, 1984, the licensee provided the results of testing performed in the Once-Through Integral System (OTIS) test facility which was performed to demonstrate that a reactor vessel head vent is not necessary to ensure adequate core cooling in the presence of significant quantities of noncondensible gases. Based upon these test results, the licensee requested a permanent exemption from the requirement to install a reactor vessel head vent.

III.

The OTIS facility is an experimental test facility at Babcock & Wilcox's (B&W's) Alliance Research Center in Alliance, Ohio. The OTIS facility was designed to evaluate the thermal/hydraulic conditions in the reactor coolant system and steam generator of a raised-loop B&W reactor, during the natural circulation phases of a small-break LOCA. The OTIS facility is a portion of the Integral Systems Test Program sponsored by the Commission, EPRI, B&W Owners Group and B&W.

The Commission has reviewed the OTIS test results and the licensee's proposed procedures and found that:

- The hot leg vent can be used to remove noncondensible gases from the reactor vessel head during a plant cooldown and depressurization without interrupting natural circulation.

- Even if noncondensible gases in the reactor vessel head expanded into the hot leg U-bend and interrupted natural circulation, feed-and-bleed cooling can be used to assure core cooling. In addition, opening of the hot leg vent will also allow the restoration of natural circulation.
- Venting procedures have been developed to limit gas expansion rates from the reactor vessel head in order to ensure that natural circulation is continuously maintained during a plant cooldown.
- Procedures would specify initiation of feed-and-bleed cooling of the core, should natural circulation become interrupted, while attempting to recover natural circulation by leaving the hot leg vents open.
- The reactor vessel head gas bubble which would remain following plant cooldown to actuation of the decay heat removal system will not interfere with core cooling. The licensee has developed various means to remove this gas bubble in the long term.
- The OTIS tests were performed in a manner which assures that the results bound the expected CR-3 plant performance.

Based on the above discussion, we conclude that an exemption to 10 CFR 50.44(c)(3)(iii) can be granted. Details of the review may be found in the Commission's related Safety Evaluation dated July 10, 1985 , which is available for public inspection at the Commission's Public

Document Room, 1717 H Street, N.W., Washington, D.C., and at the Crystal River Public Library, 668 N.W. First Avenue, Crystal River, Florida.

IV.

Accordingly, the Commission has determined that, pursuant to 10 CFR Part 50.12, an exemption is authorized by law and will not endanger life or property or the common defense and security and is otherwise in the public interest and hereby grants an exemption with respect to the requirements of 10 CFR 50.44(c)(3)(iii), as follows:

The licensee is not required to install a reactor vessel head vent at Crystal River Unit 3.

Pursuant to 10 CFR 51.32, the Commission has determined that the issuance of the exemption will have no significant impact on the environment (50 FR 26422).

This exemption is effective upon issuance.

FOR THE NUCLEAR REGULATORY COMMISSION

Hugh L. Thompson, Jr., Director
Division of Licensing
Office of Nuclear Reactor Regulation

Dated at Bethesda, Maryland
this 10th day of July 1985

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

SAFETY EVALUATION BY THE OFFICE OF NUCLEAR REACTOR REGULATION

EXEMPTION REQUEST FROM THE REACTOR VESSEL HEAD VENT

REQUIREMENT OF 10 CFR 50.44(c)(3)(iii)

FLORIDA POWER CORPORATION, ET AL.

CRYSTAL RIVER UNIT NO. 3 NUCLEAR GENERATING PLANT

DOCKET NO. 50-302

1.0 INTRODUCTION

During the accident at TMI-2, significant quantities of noncondensible gases (hydrogen and fission gases) resulted from fuel cladding oxidation due to low reactor vessel water level and inadequate core cooling conditions. The collection of noncondensibles in the reactor coolant system (RCS) high points and vessel head impaired the ability to achieve natural circulation cooling and hampered efforts to achieve a stable long-term cooling mode.

Based upon its review of the TMI-2 sequence, the NRC staff initiated a wide range of actions designed to improve the capability of power reactors to achieve natural circulation cooling. Included among these items was the requirement of NUREG-0737, Item II.B.1 (Reference 1) that each licensee shall install reactor coolant system and reactor vessel head high point vents. As explained by NUREG-0737, the purpose of the vent system is to enhance core cooling capability, for beyond-design-basis events, by substantially increasing the ability to deal with large quantities of noncondensible gases which could interfere with core cooling.

The requirement for the installation of RCS high point and reactor vessel head vents was subsequently codified in the Commission's regulations at 10 CFR 50.44(c)(3)(iii) on December 2, 1981 as part of the Final Rule, Interim Requirements Related to Hydrogen Control. Consistent with the earlier staff position, the regulation required the installation of the RCS high point vents, including a reactor vessel head vent, in order to provide improved operational capability to maintain adequate core cooling in the event of an accumulation of noncondensible gases in the RCS or reactor vessel head.

On October 12, 1982, the licensee requested (Reference 2) an exemption from the requirement of 10 CFR 50.44(c)(3)(iii) to install a reactor vessel head vent. Installation of high point vents at the top of the hot leg U-bends and the pressurizer for CR-3 was accomplished during the 1983 refueling outage. The case presented by the licensee as justification for the exemption request was based upon the ability to perform a plant depressurization to cold shutdown (following a small-break LOCA) "even with a gas bubble in the reactor vessel (RV) head, without interrupting natural circulation" (see FPC letter to NRC dated January 30, 1981). In a letter dated April 29, 1983 (Reference 3), FPC committed to implementing procedures and training for use of the high point vents in venting noncondensible gases trapped in the reactor vessel head.

On July 21, 1983, the NRC staff issued an interim exemption, until December 31, 1985, to defer the implementation date for installation of a reactor vessel head vent. At that time, the staff was unable to conclude that noncondensible gases could be safely vented by the hot leg high point vents alone. The primary reason for the staff's conclusion was the lack of integral system test data which would demonstrate the feasibility of the proposed venting procedure. The interim exemption was granted in order to allow the licensee, as committed by Reference 3, to perform the necessary integral system testing.

On October 22, 1984, the licensee provided the results of testing performed in the Once-Through Integral System (OTIS) test facility which was performed to demonstrate that a reactor vessel head vent is not necessary to ensure adequate core cooling in the presence of significant quantities of noncondensible gases. Based upon these test results, the licensee requested, in Reference 4, a permanent exemption from the requirement to install a reactor vessel head vent.

This safety evaluation provides our evaluation of the licensee's exemption request. Section 2 provides a discussion of the OTIS test facility and the testing which was performed. The methods employed at CR-3 to vent noncondensible gases from the reactor vessel head are discussed in Section 3. Within Section 4, the relationship of the OTIS test results to CR-3 is provided. Finally, Section 5 presents the conclusion of the NRC staff's review of the licensee's exemption request.

2.0 OTIS FACILITY AND TEST RESULTS

2.1 Facility Description

The OTIS facility is an experimental test facility at B&W's Alliance Research Center in Alliance, Ohio. The OTIS facility was designed to evaluate the thermal/hydraulic conditions in the reactor coolant system and steam generator of a raised-loop B&W reactor, during the natural circulation phases of a small-break LOCA. The OTIS facility is a portion of the Integral Systems Test Program sponsored by the Nuclear Regulatory Commission, EPRI, B&W Owners Group and B&W (Reference 5). A summary of the OTIS facility is provided in the subsequent paragraphs.

The OTIS test facility is a scaled 1x1 (one hot leg, one cold leg) electrically heated loop which simulates the important features of a B&W plant. The loop consists of one 19-tube Once-Through Steam Generator (OTSG), a simulated reactor (consisting of an external downcomer and a reactor vessel), a pressurizer, a single hot leg and a single cold leg. Reactor decay heat following a scram is simulated with electrical heaters which are capable of simulated decay heat levels up to 5% scaled power. Reactor coolant pumps are not simulated in the facility. Other key features simulated are a reactor vessel vent valve, a pressurizer power operated relief valve (PORV), a hot leg vent, high pressure injection, and auxiliary feedwater. The loop was specifically designed to minimize leakage. Guard heaters were employed on the hot leg piping, pressurizer, pressurizer surge line and reactor vessel head to minimize heat loss from the loop.

The four scaling criteria, in order of priority, utilized to configure the OTIS facility were:

- o Full Elevation
- o Post-Small Break LOCA Flow Phenomena
- o Volume
- o Irrecoverable Pressure Loss Characteristics

Use of this scaling philosophy resulted in a full (approximately 95 feet) height facility which has a power to volume scaling of 1:1686. The hot leg diameters were scaled to preserve Froude number. This criterion was chosen to preserve two-phase flow regimes. Flow restrictors were utilized to preserve irrecoverable pressure drop.

The OTIS instrumentation consists of approximately 250 channels of data processed by a high speed data acquisition system. The instrumentation includes pressure and differential pressure measurements; thermocouple and resistance thermocouple measurements of fluid, metal and insulation temperatures; and pitot tubes and flowmeters for measurement of flowrates in the loop. Measurements are also provided for leak, HPI, hot leg vent, PORV, and secondary system feed and steam flows. Noncondensible gas injections are controlled and metered. Noncondensible gas discharges with two-phase primary effluent streams are also measured.

The foregoing is a brief description of the OTIS facility. More detailed information is provided in Reference 6.

2.2 OTIS Test Results

Two tests, OTIS test 240100 and 240200, were funded by the Florida Power Corporation and the Sacramento Municipal Utility District (SMUD) to demonstrate that a reactor vessel head vent is unnecessary to assure adequate core cooling following the release of noncondensible gases into the reactor vessel. The test descriptions and results are presented in References 7 and 8. A summary of the test conduct and results is provided below.

2.2.1 Test Initialization

Both tests were initialized in a similar manner. The objective of the test initialization is to obtain a hot and noncondensible gas-laden primary system.

The OTIS loop was initially pressurized to 1700 psi with a low, 5 foot, level in the pressurizer. Natural circulation was established with a secondary side steam generator pressure of 1200 psia and a level of 5 feet; core power was set at 1% scaled power. The secondary side conditions were chosen to provide elevated primary system temperatures. Several noncondensible gas additions were made to the reactor vessel head. These gas additions were made to saturate the loop coolant with noncondensible gas and to create a large noncondensible gas bubble in the reactor vessel head.

Following these gas additions, core power was increased to 2% scaled power to achieve the desired loop fluid conditions for testing. As the loop approached a stable natural circulation condition, a final, large gas addition was made at the top of the U-bend in order to interrupt natural circulation. The testing was then initiated from this condition.

2.2.2 Test Conduct and Results

2.2.2.1 OTIS Test 240100 (Reference 7)

The purpose of OTIS test 240100 was to examine the effectiveness of the hot leg high point vent to remove a noncondensible gas bubble from the reactor vessel head during a natural circulation cooldown. Of specific interest was whether, during the primary system depressurization, the gas expanding from the reactor vessel head into the hot leg would be removed from the system, via the hot leg high point vent, and natural circulation would be maintained.

The specific testing procedure utilized for OTIS test 240100 was based upon the SMUD operating procedures. In summary form, the testing procedure was:

- Restore natural circulation by opening the hot leg high point vent.
- Verify natural circulation.
- Depressurize the steam generator secondary side to achieve a cooldown rate of approximately 100°F/hr.

- Depressurize the primary system in steps not to exceed 70 to 100 psi while remaining within the P-T envelope. Basically, this results in maintaining the primary system subcooling between 50 to 100°F.
- Maintain the hot leg high point vent open throughout the plant cooldown.
- Continue the primary system cooldown and depressurization until primary system temperatures and pressure are less than 280°F and 250 psia, respectively. These are typical decay heat removal system actuation conditons.

The relationship of the OTIS procedures to the plant specific CR-3 procedures will be discussed in Section 4.

Within 5 minutes of opening the hot leg high point vent, the noncondensible gas in the hot leg U-bend was removed and natural circulation was restored. Following the recovery of natural circulation, the OTIS test operator proceeded to cool the primary system to achieve 80°F subcooling. A natural circulation cooldown was then performed which lowered the primary system pressures and temperatures from approximately 1750 psia and 545°F to 180 psia and 300°F, respectively. Throughout the cooldown process, natural circulation was continuously maintained. Thus, the test indicates that the hot leg high point vent was effective in removing the noncondensible gas in the reactor vessel head.

2.2.2.2 OTIS Test 240200 (Reference 8)

The purpose of OTIS test 240200 was to demonstrate that, even if natural circulation cooling was interrupted by noncondensibles, an alternate cooling technique, feed and bleed using the HPI and PORV, could be utilized to cool the core.

The specific testing procedure utilized for OTIS test 240200 can be summarized as follows:

- Restore natural circulation by opening the hot leg vent.
- After natural circulation is recovered, close the hot leg vent and proceed with a natural circulation cooldown and depressurization.
- After natural circulation is interrupted by the noncondensible gas in the reactor vessel head expanding and collecting in the hot leg U-bend, open the PORV and actuate HPI and proceed to cool the core with feed and bleed cooling.
- Continue the plant cooldown within the P-T envelope until the system pressure and temperature is lowered to 284 psig and 280°F.

As with OTIS test 240100, opening of the hot leg high point vent recovered natural circulation within 5 minutes. At that time, the operator closed the hot leg vent and initiated a natural circulation cooldown. Approximately 30 minutes after the start of the plant cooldown, sufficient gas collected in the hot leg U-bend to interrupt natural circulation. The operator then initiated HPI and opened the PORV to establish feed and bleed cooling. This mode of cooling was maintained for approximately an additional four hours. At that time, the loop achieved a quasi-equilibrium condition and the operator was unable to depressurize the plant further. The operator then proceeded to open the hot leg vent, while maintaining feed and bleed cooling, in order to refill the primary loop. Ultimately, the primary loop was refilled; the operator closed the PORV and continued with a natural circulation cooldown, with the hot leg vent open, similar to that performed in OTIS test 240100.

Although the system was unable to be fully cooled and depressurized using feed and bleed cooling, it should be noted that core cooling was maintained throughout the test. Outlet core fluid temperatures were generally maintained between approximately 40 and 85°F subcooled. The test also illustrated that if a natural circulation cooldown was interrupted, via gas accumulation in the hot leg U-bend, natural circulation could be regained by opening the hot leg vent.

3.0 CRYSTAL RIVER 3 VENTING PROCEDURES

In order to ensure adequate core cooling following the generation of a significant amount of noncondensible gases caused by an inadequate core cooling (ICC) event, the licensee has made several changes to the operating procedures. A description of the venting aspects of these procedures and their bases is provided below. Special emphasis is placed on the procedure for a subsequent plant cooldown following an ICC event.

If core conditions during an ICC event become significantly degraded, such that cladding temperatures in excess of 1400°F are inferred from the core exit thermocouples, the CR-3 procedures require that the hot leg vents be opened. These vents are opened to ensure that some of the noncondensible gases which may be created by cladding rupture and/or the zircaloy cladding metal water reaction can be vented from the primary system. The procedures also specify several other actions, such as ensuring HPI flow and depressurizing the steam generators, that the operator should take in order to recover core cooling and mitigate the extent of potential core damage.

Assuming that systems conditions are such that the operator actions specified in the ICC procedure are sufficient to return the core to a coolable condition, the primary system will ultimately refill and natural circulation would be recovered. At that time, the reactor vessel head will be filled with noncondensible gases and the operator will proceed with a natural circulation cooldown.

In order to prevent an interruption of natural circulation due to an accumulation of noncondensible gases in the hot leg U-bends during the subsequent plant cooldown and depressurization, the CR-3 procedures specify that the hot leg vents remain open throughout the natural circulation phase. In addition, the procedure limits the plant cooldown rate to only 10°F/hr and limits the plant depressurization rate by allowing use of only the pressurizer vents.

These actions are specified in order to limit the rate of gas expansion from the reactor vessel head into the hot leg to less than the venting capability of the hot leg vents.

To demonstrate the adequacy of their procedure, the licensee performed calculations which compared the venting rate for the hot leg vents to the expansion rate of gas from the reactor vessel head. These calculations demonstrated that the venting capability from the hot leg vents exceeds the gas expansions rates by factors of 10 or greater.

It should also be noted that the CR-3 procedure specifies operator actions should natural circulation be interrupted. The procedures require that feed and bleed cooling be established while leaving the hot leg high point vents open. In this manner, core cooling will be maintained while the gases in the hot leg U-bends are vented and natural circulation is recovered. Following the recovery of natural circulation, feed and bleed cooling would be terminated and the natural circulation cooldown would be continued.

Once the primary system is depressurized to the decay heat removal system conditions, the plant would be placed in the decay heat removal mode and the hot leg high point vents will be closed. At this time, the plant will be in a cold shutdown condition with a noncondensible gas bubble still remaining in the reactor vessel upper head. The licensee outlined several methods for removing the gas bubble from the reactor vessel head, depending on plant status and equipment availability. The methods outlined rely on degassing the primary system fluid and thereby allow the reactor vessel head bubble to be absorbed by the primary system fluid. The specific means to degas the primary system include (1) use of the pressurizer spray and pressurizer vent, (2) use of the pressurizer heaters and pressurizer vent, and (3) use of the makeup and purification system. As the gas bubble will not interfere with core cooling, we find this approach acceptable.

4.0 APPLICABILITY OF OTIS TEST RESULTS TO CR-3

Application of smaller scaled integral system test results to infer expected full scale plant performance should be performed with caution. Typically, the results of scaled tests are used to verify computer codes. These verified codes are then used to calculate plant performance with increased confidence. In this case, the licensee views the OTIS tests as "proof of principle" tests related to the ability of the hot leg high point vents to vent noncondensible gases from the reactor vessel head during a plant cooldown and depressurization following an ICC condition. This approach requires a careful review of OTIS scaling to assure that the facility properly simulates expected plant thermohydraulic performance. In addition, test conduct must be examined to assure that the impact of plant procedures on the system response is properly reflected.

4.1 OTIS Scaling

As described in Section 2, the OTIS facility is a 1x1, full height, full pressure simulation of a 205 FA plant. The facility scale factor is 1:1686 with respect to power-to-volume scaling. As such, the facility has several atypicalities, such as excessive metal mass, which are expected in smaller scaled facilities. The hot leg vents were simulated using a scaling factor of 1:1686 with an adjustment for the scaled power level of 3600 Mwt, used as the basis for overall OTIS scaling, and the CR-3 power level of 2544 Mwt. Using these scaling factors, an ideal scaled vent area of 1.93 cm^2 was derived. The actual scaled vent area chosen was 2.11 cm^2 in order to arrive at a vent area intermediate to that for the CR-3 and the Rancho Seco plants. In addition, the OTIS tests were performed using nitrogen as the noncondensible gas.

The licensee has evaluated the scaling compromises utilized in the OTIS tests. The licensee has concluded that the rate of evolution of gases from the reactor vessel (RV) head and from the coolant depends primarily upon the head volume and on rates of system pressure and temperature reductions. The rate of venting depends upon vent areas and on system conditions. Therefore, the licensee concluded that the overall geometrical scaling used for OTIS is less significant than the system fluid conditions.

Relative to the use of nitrogen versus hydrogen, which is expected to be the predominant gas species following an ICC event, the licensee has concluded that this should result in a conservative test simulation. The licensee has examined the use of nitrogen gas on both the expansion rate from the RV head and on the venting rate of the hot leg vent. Based on relative densities between nitrogen and hydrogen, the licensee concluded that the relatively dense nitrogen would tend to more readily gravitate towards the lower voided elevation in the RV head and would be more readily swept out of the RV head. With vapor in the hot leg U-bend, the relatively dense nitrogen would tend to be segregated towards the lower elevation and be less readily vented. Thus it was concluded that the use of nitrogen would conservatively simulate expected plant performance with hydrogen gas trapped within the RV head.

We have reviewed the licensee's conclusions relative to OTIS scaling and generally agree with their assessment. However, we do not totally agree with the scaling rationale utilized to size the hot leg vent in the OTIS facility. As stated in Reference 6, the core vessel portion of the reactor vessel contained excess volume. As a result, non-flow lengths, specifically the reactor vessel head, were shortened in order to maintain overall reactor vessel power-to-volume scaling. Thus, the OTIS head volume is undersized. If the scale factor is chosen based upon the hot leg venting areas in OTIS and CR-3, i.e.

$$\text{Scale Factor} = \frac{\text{CR-3 Vent Area}}{\text{OTIS Vent Area}}$$

we get a scale factor of 1140. Applying this scale factor to the reactor vessel head, it is found that the OTIS head volume is only 61% of the "ideal" scaled CR-3 head volume. As a result, given similar depressurization rates, it appears that the OTIS tests may underestimate the gas expansion rate from the reactor vessel head.

While we have concerns with respect to the scaling of the hot leg vent, we also note that the use of nitrogen gas tends to compensate for this effect. If only the gas was to be vented through the hot leg vent, the volumetric venting rate would be approximately 3.7 times less for nitrogen than for hydrogen. As a result, it appears that the overall relationship between the hot leg venting rate and gas expansion rate is conservatively simulated.

In addition, as will be discussed further below, the depressurization rates utilized in the OTIS tests were significantly greater than those calculated for CR-3. As a result, we have concluded that the OTIS test conservatively reflects the expected CR-3 performance.

While we believe the OTIS tests are sufficient for examining the effectiveness of venting trapped noncondensible gases from the reactor vessel via the hot leg vents, we also recognize that the OTIS facility is only a 1x1 representation of a B&W plant. To confirm that multiloop behavior does not affect this mode of gas removal, tests are currently scheduled in the MIST facility. The MIST facility is a 2x4 representation of a B&W 177 FA lowered loop plant. These tests should be performed in 1986.

4.2 Test Conduct

Specific test conduct for the OTIS tests are described in Section 2; the applicable CR-3 procedures are discussed in Section 3. As is readily apparent, the OTIS tests do not represent the specific CR-3 procedures. The licensee has reviewed the specific OTIS test conduct and has concluded that the OTIS tests conservatively reflect the CR-3 procedures. Specifically, the OTIS tests had peak depressurization and cooldown rates of 2500 psi/hr and about 100°F/hr, respectively. Calculated performance for CR-3 obtains a maximum depressurization rate of 1150 psi/hr, while test procedures limit the cooldown rate to 10°F/hr. As a result, the gas expansion rates on a scaled basis, from the reactor vessel head, should exceed those expected for CR-3. Therefore, the licensee concluded that since OTIS test 240100 did not interrupt natural circulation, neither should CR-3.

We have reviewed the OTIS test conduct versus the CR-3 procedures and agree with the licensee's conclusions. We have also performed independent calculations to examine our concerns with respect to the scaling of the hot leg high point vent. These calculations indicate that gas expansion rates experienced in OTIS exceeded the CR-3 venting rate even when a scaling factor based on equivalent hot leg venting areas is utilized. Thus, we also conclude that the OTIS test results should bound expected CR-3 performance.

5.0 CONCLUSIONS

Based upon the foregoing, we have concluded:

- OTIS test 240100 demonstrates that the hot leg vent can be utilized to remove noncondensible gases from the reactor vessel head, during a plant cooldown and depressurization without interrupting natural circulation.

- OTIS test 240200 demonstrates that even if noncondensible gases in the reactor vessel head expanded into the hot leg U-bend and interrupted natural circulation, feed and bleed cooling can be used to assure core cooling. In addition, opening of the hot leg vent will also allow the restoration of natural circulation.

- The CR-3 venting procedures have been developed to limit gas expansion rates from the reactor vessel head in order to ensure that natural circulation is continuously maintained during a plant cooldown.

- In addition, the CR-3 procedures specify initiation of feed and bleed cooling of the core, should natural circulation become interrupted, while attempting to recover natural circulation by leaving the hot leg vents open.

- The reactor vessel head gas bubble which would remain following the plant cooldown to the decay heat removal system will not interfere with core cooling. The licensee has developed various means to remove this gas bubble in the longer term if it should be desirable.

- The OTIS tests were performed in a manner which assures that the results bound the expected CR-3 plant performance.

Based upon the above, we conclude that FPC may be granted a permanent exemption from the requirement of 10 CFR 50.44 (c)(3)(iii) to install a reactor vessel head vent at CR-3.

Principal Contributor

R. Jones

Dated July 10, 1985

6.0 REFERENCES

1. NUREG-0737, Clarification of TMI Action Plan, Item II.B.1.

2. Florida Power Corporation letter dated October 12, 1982, to J. F. Stolz.

3. Florida Power Corporation letter dated April 29, 1983, to D. G. Eisenhut.

4. Florida Power Corporation letter dated October 22, 1984 to J. F. Stolz.

5. NRC-04-83-168/RP2399-1, "Contract Among the Babcock and Wilcox Company and Electric Power Research Institute and the U.S. Nuclear Regulatory Commission."

6. Once-Through Integral System Test Program, OTIS Loop Functional Specification, RDD: 84:4091-24:01; prepared by the Babcock and Wilcox Company (provided with Reference 4)

7. OTIS HOT Leg High Point Vent Test #240100, B&W Document No. 12-1152307-00, July 1984 (provided with Reference 4).

8. OTIS Hot Leg High Point Vent Test #240200, B&W Document No. 12-1152308-00, July 1984 (provided with Reference 4).