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50-251 Turkey Point Plant, Unit 4, Florida Power and Light C 05000251
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SUBJECT: Forwards "Containment Leakage Rate Testing," technical evaluation rept.

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June 8, 1981

U.S. Nuclear Regulatory Commission
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Attention: Mr. E. J. Butcher, Jr. (MS 416)
Project Officer

Reference: FRC Project C5257
NRC Contract NRC-03-79-118
NRC TAC No. 08779/08780
FRC Task No. 53/54
Title: Technical Evaluation Report for Turkey Point Units 3 and 4; Containment Leakage Testing

50-V.

Dear Mr. Butcher:

The Technical Evaluation Report (TER) for Turkey Point Units 3 and 4 is hereby forwarded. This report is forwarded in accordance with telephone conversations between Mr. T. J. DelGaizo (FRC) and Mr. P. Hearn (NRC/CSB) on April 21, 1981 and April 27, 1981.

Submission of this TER represents FRC's final action on Tasks 53 and 54.

Very truly yours,

S P Carfagno

S. P. Carfagno
Project Manager

TJD/SPC/bg

Encl.

cc: J. Shapaker
P. Hearn
Y. Huang

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TECHNICAL EVALUATION REPORT

# CONTAINMENT LEAKAGE RATE TESTING

FLORIDA POWER & LIGHT COMPANY
TURKEY POINT UNITS 3 AND 4

NRC DOCKET NO. 50-250, 50-251

NRC TAC NO. 08779, 08780 FRC PROJECT C5257

NRC CONTRACT NO. NRC-03-79-118 FRC TASK 53/54

*Prepared by*

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Washington, D.C. 20555

Lead NRC Engineer: Y. S. Huang

June 5, 1981



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June 5, 1981



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CONTENTS

## 1. BACKGROUND

On August 7, 1975 [1], the NRC requested Florida Power & Light Company (FPL) to review the containment leakage testing programs at Turkey Point Units 3 and 4 and to provide a plan for achieving full compliance with 10CFR50, Appendix J, including appropriate design modifications, changes to Technical Specifications, or requests for exemption from the requirements pursuant to 10CFR50.12, where necessary.

FPL responded on September 12, 1975 [2], stating that the containment leakage testing program at Turkey Point Units 3 and 4 conformed to the requirements of Appendix J except for the frequency and method of testing containment airlocks, the frequency of performing Type B electrical penetration leak tests, and minor differences in terminology between the Technical Specifications and Appendix J. FPL indicated that the minor differences in terminology were eliminated by its proposed Technical Specification change of September 20, 1974 [3].

FPL's letter of July 27, 1977 [4] provided additional information regarding proposed testing of containment airlocks. This letter also indicated that Type B electrical penetrations would be tested every refueling outage, leaving the question of testing of containment airlocks as the only remaining request for exemption from the requirements of Appendix J.

The purpose of this report is to conduct technical evaluations of outstanding issues regarding the implementation of 10CFR50, Appendix J, at Turkey Point Units 3 and 4. Consequently, technical evaluations are provided for FPL's request for exemption from the requirements of Appendix J regarding the testing of containment airlocks as submitted in References 2 and 4, as well as a proposed revision to Technical Specification 4.4.2 submitted in Reference 4.

## 2. EVALUATION CRITERIA

Code of Federal Regulations, Title 10, Part 50 (10CFR50), Appendix J, Containment Leakage Testing, provided the criteria used in conducting the technical evaluations. Where applied to the following evaluations, the criteria are either referenced or briefly stated, where necessary, in support of the results of the evaluations. Furthermore, in recognition of the plant-specific conditions that could lead to requests for exemption not explicitly covered by the regulations, the NRC directed that the technical reviews constantly emphasize the basic intent of Appendix J, that potential containment atmospheric leakage paths be identified, monitored, and maintained below established limits.

# 3. TECHNICAL EVALUATION

## 3.1 REQUESTS FOR EXEMPTION FROM THE REQUIREMENTS OF 10CFR50, APPENDIX J

### 3.1.1 Testing of Containment Airlocks

In Reference 2, FPL requested an exemption from the requirements of 10CFR50, Appendix J with regard to the testing frequency and method of testing containment airlocks. This exemption request would permit continued testing in accordance with Turkey Point Technical Specification 4.4.2.2, which required pressure testing of the personnel and emergency airlocks either annually, if not used, or every 4 months if used periodically. FPL's basis for this request was given as follows:

> Personnel and emergency airlocks are leak tested in accordance with Turkey Point Operating Procedure 13514.1. Leak tightness of the inner door is tested by pressurizing the annulus between the two O-rings. The outer door O-rings are then tested by pressurizing the entire airlock. However, since the inner door opens into containment, both tests tend to unseat the inner door.
>
> Therefore, if the inner door O-rings are to be meaningfully tested, the door must be held shut by a clamping arrangement which takes a minimum of about 12 man-hours to install. A similar arrangement is not required on the outer door because that door opens into the airlock and the test differential pressure is in the direction which seats the door. Thus, a simple positive-pressure test of the personnel and emergency airlocks is not possible because of the design and arrangement of the doors.
>
> Both containments are entered approximately once each week for performance of routine inspections and minor maintenance. If we were to perform the inspection program required by Operating Procedure 13514.1 after each airlock opening, routine entry of the containment would become impractical due to the many man-hours which would be necessary for leak testing. Therefore, in order to continue a viable containment inspection program, and at the same time achieve compliance with the intent of Appendix J, we submitted a proposed Technical Specification change on September 20, 1974, which provided for the performance of an O-ring vacuum test instead of a pressure test. We have designed and built a vacuum test device which could be duplicated and permanently installed on all airlock outer doors and used to

> leak test the doors after each opening. Pending disposition of the proposed change, however, we are currently complying with the existing Technical Specification 4.4.2.2 requirement which requires airlock testing once every 4 months.

In Reference 4, FPL withdrew its request for exemption with regard to the frequency of testing airlocks, but continued to request an exemption in order to use the vacuum testing technique to verify airlock door seals after each opening. In this letter, FPL provided a revised Technical Specification 4.4.2.2 which required airlocks to be tested as follows:

> 4.4.2 LOCAL PENETRATION TESTS
>
> Test Procedure and Frequency
>
> Local leak detection tests of the following components shall be performed at a pressure not less than 50 psig using pressure decay, soap bubble, halogen detection or equivalent methods at the frequency listed, unless otherwise noted:
>
> 2. Personnel and Emergency Airlocks
>
>    a. Within 3 days of every first of a series of openings when containment integrity is required, verify that door seals have not been damaged or seated improperly by vacuum testing the volume between the door seals in accordance with approved plant procedures.
>
>    b. At least once per 6 months, conduct an overall airlock leakage test to verify that the overall airlock leakage rate is within its limit.

FRC Evaluation:

Sections III.B.2 and III.D.2 of Appendix J require that containment airlocks be tested at peak calculated accident pressure (Pa) at 6-month intervals and after each opening in the interim between 6-month tests. These requirements were imposed because airlocks represent potentially large leakage paths which are more subject to human error than other containment penetrations. Type B penetrations (other than airlocks) require testing in accordance with Appendix J at intervals not to exceed 2 years.

Appendix J was published in 1973. A compilation of airlock events from Licensee Event Reports submitted since 1969 shows that airlock testing in accordance with Appendix J has been effective in the prompt identification of airlock leakage, but that rigid adherence to the after-each-opening requirement may not be necessary.

Since 1969, there have been approximately 70 reported airlock leakage tests in which measured leakage exceeded allowable limits. Of these events, 25% were the result of leakage other than from improper seating of airlock door seals. These failures were generally caused by leakage past door-operating mechanism handwheel packing, door-operating cylinder shaft seals, equalizer valves, or test lines. These penetrations resemble other Type B or C containment penetrations except that they may be operated more frequently. Since airlocks are tested at a pressure of Pa every 6 months, these penetrations are tested, at a minimum, four times more frequently than typical Type B or C penetrations. The 6-month test is, therefore, considered to be both justified and adequate for the prompt identification of this leakage.

Improper seating of the airlock door seals, however, is not only the most frequent cause of airlock failures (the remaining 75%), but also represents a potentially large leakage path. While testing at a pressure of Pa after each opening will identify seal leakage, it can also be identified by alternative methods such as pressurizing between double-gasketed door seals (for airlocks designed with this type of seal) or pressurizing the airlock to pressures other than Pa. Furthermore, experience gained in testing airlocks since the issuance of Appendix J indicates that the use of one of these alternative methods may be preferable to the full-pressure test of the entire airlock.

Reactor plants designed prior to the issuance of Appendix J often do not have the capability to test airlocks at Pa without the installation of strongbacks or the performance of mechanical adjustments to the operating mechanism of the inner doors. The reason for this is that the inner doors are designed to seat with accident pressure on the containment side of the door, and therefore, the operating mechanisms were not designed to withstand accident pressure in the opposite direction. When the airlock is pressurized for a local airlock test (i.e., pressurized between the doors), pressure is exerted on the airlock side of the inner door, causing the door to unseat and preventing the performance of a meaningful test. The strongback or mechanical adjustments prevent the unseating of the inner door, allowing the test to proceed. The installation of strongbacks or performance of mechanical adjustments is time consuming (often taking several hours), may result in additional radiation exposure to operating personnel, and may also cause degradation of the operating mechanism of the inner door, with consequential loss of reliability of the airlock. In addition, when conditions require frequent openings over a short period of time, testing at Pa after each opening becomes both impractical (tests often take from 8 hours to several days) and accelerates the rate of exposure of personnel and the degradation of mechanical equipment.

For these reasons, the intent of Appendix J is satisfied, and the undesirable effects of testing after each opening are reduced if a satisfactory test of the airlock door seals is performed within 3 days of each opening or every 3 days during periods of frequent openings, whenever containment integrity is required. The test of the airlock door seals may be performed by pressurizing the space between the double-gasketed seals (if so equipped) or by pressurizing the entire airlock to a pressure less than Pa that does not require the installation of strongbacks or performance of other mechanical adjustments. If the reduced pressure airlock test is to be employed, the results of the leakage test must be conservatively extrapolated to equivalent Pa test results.

In view of the foregoing discussion, FPL's proposed Technical Specification 4.4.2.2 is acceptable. Furthermore, no exemption from the requirements of Appendix J is necessary because FPL's proposed testing is within the revised version of Section III.D.2 (effective October 22, 1980). FPL should ensure that its airlock testing program is in complete conformance with the revised rule.

With regard to the extrapolation of the reduced pressure test to equivalent Pa test results, comments on FPL's proposed extrapolation method submitted on November 26, 1980 [5] are contained in Appendix A to this report.

## 3.2 PROPOSED TECHNICAL SPECIFICATION CHANGE

In Reference 4, FPL proposed to revise Specification 4.4.2 to incorporate its proposed exemption from Appendix J with regard to the testing of containment airlocks. In addition, this specification provided for testing at Pa using pressure decay, soap bubble, halogen detection, or equivalent methods of the following components:

Containment purge valves - each refueling
Equipment access openings - annually and after use
Fuel transfer tube flange - each refueling
Electrical penetrations - each refueling.

The proposed specification also required that repairs and tests be made whenever the sum of the local leak rate tests, including isolation valves, exceeds 60% of the total containment allowable leak rate.

FRC Evaluation:

In Section 3.1 of this report, FRC found FPL's proposal for testing of containment airlocks to be acceptable, provided that the results of the vacuum testing between airlock door seals are conservatively extrapolated to Pa results. The remainder of the proposed specification conforms to Section III.B of Appendix J. Consequently, Proposed Specification 4.4.2 is acceptable in meeting the requirements and intent of Appendix J.

## 4. CONCLUSIONS

FPL's request for exemption from the requirements of Appendix J regarding testing of containment airlocks as submitted in References 2 and 4 and FPL's proposed change to Technical Specification 4.4.2 as submitted in Reference 4 were technically evaluated. The conclusions of these evaluations are as follows:

- FPL's proposal to verify that airlock door seals have not been damaged or seated improperly by vacuum testing the volume between the seals within 3 days of every first of a series of openings, when containment integrity is required in the interim between full-pressure 6-month, tests is acceptable. No exemption is required because of the revision to Section III.D.2, effective October 22, 1980.

- FPL's proposed change to Technical Specification 4.4.2 is acceptable since it conforms to the requirements of Appendix J.

## 5. REFERENCES

1. K. R. Goller (NRC)
   Letter to FPL
   August 7, 1975.

2. R. E. Uhrig (FPL)
   Letter to K. R. Goller (NRC)
   September 12, 1975.

3. R. E. Uhrig (FPL)
   Letter to E. G. Case (NRC)
   September 20, 1974.

4. R. E. Uhrig (FPL)
   Letter to V. Stello (NRC)
   July 27, 1977.

5. R. E. Uhrig (FPL)
   Letter to S. A. Varga (NRC)
   November 26, 1980.

## APPENDIX A - EXTRAPOLATION OF REDUCED PRESSURE LEAKAGE MEASUREMENTS TO EQUIVALENT FULL PRESSURE LEAKAGE

### 1. FPL's CORRELATION

In Reference 5, FPL provided the following information:

"The test will begin at a absolute pressure of 12.92" Hg (17" Hg vacuum) and alarm if pressure increases to 14.42" Hg (15.5" Hg vacuum).

To determine the leak rate at 50 psig (64.7 psia), the design basis accident pressure, the following derivation was used:

Flow for a compressible fluid may be calculated as follows:

$$F = K\,Y\sqrt{\Delta P} \qquad (1)$$

where
- $F$ = Flow or leakage
- $K$ = Coefficient of resistance
- $Y$ = Expansion factor
- $\Delta P$ = Pressure drop across seal

The maximum valve for Y is 1.0 and calculates the leakage for a non-compressible fluid. The coefficient of resistance is constant for each seal tested. Therefore:

$$F = K\sqrt{\Delta P} \qquad \text{or} \qquad L = K\sqrt{\Delta P}$$

A ratio between the leak rate at $L_{50}$ and $L_{test}$ becomes:

$$\frac{L_{50}}{L_{test}} = \frac{K\sqrt{P_{64.7} - P_{14.7}}}{K\sqrt{P_{14.7} - P_{test}}}$$

$$L_{50} = L_{test}\left[\frac{\sqrt{P_{64.7} - P_{14.7}}}{\sqrt{P_{14.7} - P_{test}}}\right]$$

where $P_{64.7}$ = 131.73" Hg

$P_{14.7}$ = 29.92" Hg

$$L_{50} = L_{test}\left[\frac{\sqrt{131.73 - 29.92}}{\sqrt{29.92 - P_{test}}}\right]$$

---

[1]Chemical Engineer's Handbook, McGraw-Hill, Inc., 1963, Section 5 (Fluid Mechanics, Flow Measurement), Pages 5-8 & 5-9

$$L_{50} = \sqrt{102.52\left[\frac{L_{test}}{29.92 - P_{test}}\right]}$$

$$\therefore L_{50} = 10.13 \sqrt{\left[\frac{L_{test}}{29.92 - P_{test}}\right]} \text{ with pressures in inches of Hg"}$$

By substituting 12.92 in. Hg for $P_{test}$, this formula yields the following correlation:

$$\frac{L_{50}}{L_{test}} = 2.45$$

EVALUATION:

The Licensee dropped the value of Y from the formula $F = KY\sqrt{\Delta P}$ because the maximum value of Y is 1.0. If the value of Y is retained, the correlation would be:

$$\frac{L_{50}}{L_{test}} = \frac{KY_{50}\sqrt{P_{64.7} - P_{14.7}}}{KY_{test}\sqrt{P_{14.7} - P_{test}}}$$

Although the maximum value of Y is 1.0, it does not follow that the ratio of $Y_{50}$ to $Y_{test}$ is necessarily $\leq 1.0$. Consequently, the Licensee's correlation is not necessarily conservative.

2. VISCOUS FLOW

For viscous flow, mass flow rate ($\dot{m}$) is proportional to the difference of the square of inlet pressure and the square of outlet pressure:

$$\dot{m}_{50} = (64.7^2 - 14.7^2) \times \text{const.}$$

$$\dot{m}_{test} = (14.7^2 - P_{test}^2) \times \text{const.}$$

$$L_{50} \sim F_{50} = \frac{\dot{m}_{50}}{P_{50}} = \frac{64.7^2 - 14.7^2}{64.7} \times \text{const.}$$

$$L_{test} \sim F_{test} = \frac{\dot{m}_{test}}{P_{test}} = \frac{14.7^2 - P_{test}^2}{14.7} \times \text{const}$$

$$\therefore \frac{L_{50}}{L_{test}} = \frac{64.7^2 - 14.7^2}{64.7} \times \frac{14.7}{14.7^2 - P_{test}^2}$$

Using in. Hg units: $64.7 = 131.73$

$14.7 = 29.92$

$P_{test} = 12.92$

then $\frac{L_{50}}{L_{test}} = 5.13$

3. CHOKED FLOW

For choked flow, $P_{orifice} \sim P_{source}$. Therefore, apart from Reynold's Number effects, mass flow rate ~ $P_{source,\ abs}$.

F = volumetric flow rate (at source density) is independent of $P_{outlet}$. Therefore, since volumetric flow rate is proportional to the percent of mass per unit time (denoted by L),

$$\frac{L_{50}}{L_{test}} = \frac{P_{64.7}}{P_{test}} = \frac{131.73 \text{ in. Hg}}{29.92 \text{ in. Hg}} = 10.2$$

CONCLUSION:

The above analysis yields the following results for the correlation of $L_{50}/L_{test}$:

| FPL's $\sqrt{\Delta P}$ Method | Viscous Flow | Choked Flow |
|---|---|---|
| 2.45 | 5.13 | 10.2 |

Since the choked flow correlation is the most conservative, this correlation should be used.

It should be noted that FPL stated in Reference 5 that the allowable local leakage rate at Turkey Point is 0.25% wt/day or 45,000 cc/min. At the same time, FPL calculated airlock leakage rates (including instrument errors) which will cause an alarm to sound after an elapsed time of 1 minute as follows:

$$L_{test} = 31.93 \text{ cc/min (personnel airlock)}$$
$$L_{test} = 7.98 \text{ cc/min (emergency airlock)}.$$

It can be seen that even using the most conservative correlation (choked flow), the alarm will detect leakage which is a very small percentage of total allowable local leakage (less than 1%).