# ATTACHMENT

**Joseph M. Farley Nuclear Plant**
**10 CFR 50.46 ECCS Evaluation Model**
**<u>1996 Annual Report</u>**

**JOSEPH M. FARLEY NUCLEAR PLANT**
**10 CFR 50.46 ECCS EVALUATION MODEL**
**1996 ANNUAL REPORT**

## I. BACKGROUND

Provisions in 10 CFR 50.46 require applicants and holders of operating licenses or construction permits to notify the Nuclear Regulatory Commission (NRC) of errors and changes in the Emergency Core Cooling System (ECCS) Evaluation Models on an annual basis. 10 CFR 50.46 requires that significant errors or changes in the ECCS Evaluation Model be reported to the NRC within 30 days with a proposed schedule for providing a reanalysis or taking other action as may be needed to show compliance with 10 CFR 50.46 requirements. 10 CFR 50.46 defines a significant error or change as one which results in a calculated fuel peak cladding temperature (PCT) different by more than 50°F from the temperature calculated for the limiting transient using the last acceptable model, or as a cumulation of changes and errors such that the sum of the absolute magnitudes of the respective temperature changes is greater than 50°F.

In Reference 1, information was submitted to the NRC regarding modifications to the Westinghouse large-break and small-break Loss-of-Coolant Accident (LOCA) ECCS Evaluation Models as applicable to the Farley Nuclear Plant (FNP) analyses for the calendar year 1995.

The following presents an assessment of the effects of modifications to the Westinghouse ECCS Evaluation Models on the Farley LOCA analysis results since the 1995 annual report (Reference 1) for the calendar year 1996. The 1996 annual report also reflects the recent reanalysis of the Unit 2 large-break LOCA implemented in 1996 (Reference 5). This annual report has been prepared in accordance with the Westinghouse Methodology for Implementation of 10 CFR 50.46 Reporting (WCAP-13451, Reference 2). The results presented in the annual report as an analysis-of-record for the large-break LOCA and small-break LOCA PCTs reflect the use of VANTAGE-5 fuel in both units (Reference 3).

## II. LARGE-BREAK LOCA

Table 1 shows the large-break LOCA PCT rack-ups for both Unit 1 and Unit 2.

### II.A LARGE-BREAK LOCA ANALYSIS-OF-RECORD

The large-break LOCA analyses for Farley Units 1 and 2 were examined to assess the effects of the changes and errors in the Westinghouse large-break LOCA ECCS Evaluation Model on PCT results.

The large-break LOCA analysis-of-record results for Farley Units 1 and 2 were calculated using the 1981 version of the Westinghouse large-break LOCA ECCS Evaluation Model

incorporating the BASH analysis technology (Reference 4). The large-break LOCA analysis for Unit 2 was revised and implemented in 1996 through the Cycle 12 reload safety evaluation process (Reference 5) to support the implementation of ZIRLO™ cladding. As discussed in Reference 5, in order to gain additional PCT margin in the Unit 2 reanalysis, the steam generator tube plugging limit was reduced from 20% to 13% (13% average, 13% peak), administratively, in recognition of the fact that the actual plugging level was not expected to exceed 13% average or peak during Cycle 12 (see Table 1).

The Unit 1 and Unit 2 analyses assumed the following information important to the large-break LOCA in the BASH analysis. The effects of containment mini-purge auto isolation and combined SSE plus LOCA events have been explicitly included in the Unit 2 revised analysis (Reference 5).

| Unit 1 | Unit 2 |
|---|---|
| Core Power = 1.02 x 2652 MWT | Core Power = 1.02 x 2652 MWT |
| 17x17 VANTAGE-5 Fuel Assembly | 17x17 VANTAGE-5 Fuel Assembly |
| $F_Q$ = 2.45 for VANTAGE-5 Fuel<br>$F_Q$ = 2.32 for LOPAR Fuel | $F_Q$ = 2.45 for VANTAGE-5 Fuel<br>$F_Q$ = 2.32 for LOPAR Fuel |
| FΔH = 1.70 for VANTAGE-5 Fuel<br>FΔH = 1.55 for LOPAR Fuel | FΔH = 1.70* for VANTAGE-5 Fuel<br>FΔH = 1.55** for LOPAR Fuel |
| SGTP*** = 20% | SGTP*** = 20% |
| Upflow Configuration | Downflow Configuration |

* The licensed value remained at 1.65 during 1996.

** The licensed value was reduced to 1.30 during 1996.

*** SGTP = Steam generator tube plugging limit assumed in the LOCA analysis. The limit was reduced administratively to 10% in 1995 (Unit 1) and 13% in 1996 (Unit 2) in order to gain PCT margin (see Table l).

For Farley Units 1 and 2, the limiting size break analysis-of-record is a double-ended guillotine rupture of the cold leg piping with a discharge coefficient of $C_D = 0.4$. The limiting PCTs determined for the Unit 1 and Unit 2 large-break are shown in Table 1. The Unit 1 analysis-of-record limiting PCT value includes 3°F for containment mini-purge automatic isolation, 8°F for increased Tavg temperature uncertainty, and 6°F for combined safe shutdown earthquake (SSE)

and LOCA events. It is noted that the 50°F transition core penalty has been removed by the Unit 1 Cycle 14 reload safety evaluation (Reference 6) since there are no LOPAR fuel assemblies loaded in the Unit 1 Cycle 14 core. Although there are still 28 LOPAR fuel assemblies in the Unit 2 core, the transition core penalty was also removed for Unit 2 by taking credit for reduced powers in the VANTAGE-5 assemblies that are adjacent to LOPAR assemblies (see Reference 5). In addition, both units contain 1.5X IFBAs with 100 psi backfill pressure, which has been shown to introduce a 7°F PCT penalty for Unit 1 (Reference 6) and a 15°F PCT penalty for Unit 2 (Reference 5).

## II.B 1996 10 CFR 50.46 LOCA MODEL ASSESSMENTS

The following changes and errors in the Westinghouse ECCS Evaluation Model would affect the 1981 Evaluation Model with BASH results obtained for the Farley analysis.

### II.B.1 Prior Reported Assessments

The prior large-break LOCA PCT assessments given in Table 1 were submitted to the NRC in March 1996 as part of the 1995 Annual Report (Reference 1). It is noted in Table 1 that the previous changes and errors were corrected in the recent reanalysis of the large-break LOCA for Unit 2 (Reference 5).

### II.B.2 Translation of Fluid Conditions from SATAN to LOCTA

An error was discovered in the coding related to the translation of fluid conditions between the SATAN blowdown hydraulics code and the LOCTA code used for subchannel analysis of the fuel rods. In performing axial interpolations to translate the SATAN fluid conditions onto the mesh nodalization used by the LOCTA code, the length of the lower core channel fluid connection to the lower plenum node was incorrectly calculated. The generic effect results in a 15°F PCT penalty for both Unit 1 and Unit 2.

## II.C 10 CFR 50.59 SAFETY EVALUATIONS FOR NON-MODEL IMPACTS

As reported in Reference 1 and as noted in Table 1, the accumulator water temperature was increased from 90°F to 120°F for Unit 1 through the Cycle 14 reload safety evaluation process (Reference 6). For Unit 2, the accumulator temperature of 120°F was explicitly used in the reanalysis (Reference 5).

## II.D TOTAL RESULTANT LARGE-BREAK LOCA PCT

As discussed above, the changes and errors to the Westinghouse large-break LOCA ECCS Evaluation Model could affect the large-break LOCA analysis results by altering the PCT. As shown in Table 1, the large-break LOCA analysis PCT results for both units are below the 10 CFR 50.46 limit of 2200°F.

## II.E LARGE-BREAK LOCA CONCLUSIONS

An evaluation of the effects of changes and errors in the Westinghouse large-break BASH ECCS Evaluation Model was performed on the large-break LOCA applicable to the Farley reference analysis. When the effects of the large-break ECCS Evaluation Model changes and errors were combined with those of plant changes and the large-break LOCA analysis-of-record results, it was determined that Farley Units 1 and 2 were in compliance with the requirements of 10 CFR 50.46.

## III. SMALL-BREAK LOCA

Table 2 shows the small-break LOCA PCT rack-ups for both Unit 1 and Unit 2.

## III.A SMALL-BREAK LOCA ANALYSIS-OF-RECORD

The small-break LOCA analyses for Farley Units 1 and 2 were also examined to assess the effects of the changes and errors to the Westinghouse small-break LOCA ECCS Evaluation Models on PCT results. The small-break LOCA ECCS analysis results were calculated using the NOTRUMP small-break LOCA ECCS Evaluation Model (Reference 7).

The Unit 1 and Unit 2 analyses assumed the following information important to the small-break LOCA analyses:

| Unit 1 | Unit 2 |
|---|---|
| Core Power = 1.02 X 2775 MWT | Core Power = 1.02 x 2775 MWT |
| 17x17 VANTAGE-5 Fuel Assembly | 17x17 VANTAGE-5 Fuel Assembly |
| $F_Q = 2.50$ | $F_Q = 2.50$ |
| $F\Delta H = 1.70$ | $F\Delta H = 1.70$ |
| Upflow Configuration | Downflow Configuration |

For Farley Units 1 and 2, the limiting size break analysis-of-record for the VANTAGE-5 fuel analysis is a 3-inch diameter break in the cold leg. The limiting PCTs determined for the Unit 1 and Unit 2 17x17 VANTAGE-5 small-break are shown in Table 2. Both the Unit 1 and Unit 2 analysis-of-record limiting PCT values include a 20°F penalty due to the increased Tavg temperature uncertainty.

## III.B 1996 10 CFR 50.46 LOCA MODEL ASSESSMENTS

The following changes and errors in the Westinghouse ECCS Evaluation Models would affect the NOTRUMP small-break LOCA analysis results obtained for the Farley VANTAGE-5 fuel analysis. Information provided herein in items III.B.2, III.B.3, and III.B.4 were previously submitted to the NRC in August 1996 and January 1997 (References 8 and 9). However, they are repeated herein for completeness.

### III.B.1 Prior Reported Assessments

The prior small-break LOCA PCT assessments shown in Table 2 were submitted to the NRC in Reference 1.

### III.B.2 SBLOCTA Fuel Rod Initialization

As reported in Reference 8, an error was discovered in the SBLOCTA code related to adjustments which are made as part of the fuel rod initialization process which is used to obtain agreement between the SBLOCTA model and the fuel data supplied from the thermal-hydraulic design calculations at full power, steady-state conditions. Additionally, updates were made to the fuel rod clad creep and strain model to correct logic errors that could occur in certain transient conditions. The generic effect resulted in a 10°F PCT penalty for both Unit 1 and Unit 2 (see Reference 8).

A Burst and Blockage/Time in Life penalty change has also been appropriately assessed (a 10°F penalty increase for Unit 1 and a 7°F penalty increase for Unit 2) for the SBLOCTA fuel rod initialization error (see Reference 8).

### III.B.3 NOTRUMP Input Error

#### III.B.3.a *AFW Flow Reduction From 1050 gpm to 650 gpm*

During the recent power uprate SBLOCA analysis, an inadvertent input error concerning the total Auxiliary Feedwater (AFW) flow assumption was discovered and reported in Reference 8. The original analysis-of-record used 1050 gpm for a total AFW flow from the combination of one motor-driven AFW pump (MDAFWP) and the turbine-driven AFW pump (TDAFWP) to the steam generators. The correct flow rate should be 696 gpm. A conservative evaluation of the impact on the current SBLOCA PCT using 650 gpm for total AFW flow has resulted in a 25°F penalty for both Unit 1 and Unit 2 (see Reference 8).

A Burst and Blockage/Time in Life penalty change has been assessed (a 27°F penalty increase for Unit 1 and a 15°F penalty increase for Unit 2) for the AFW flow reduction to 650 gpm (see Reference 8).

Note the further reduction in AFW flow discussed in III.B.3.b below.

**III.B.3.b** ***AFW Flow Reduction From 650 gpm to 295 gpm***

During the recent power uprate SBLOCA analysis and subsequent to the discovery of the error discussed in III.B.3.b, an inadvertent input error concerning the total Auxiliary Feedwater (AFW) flow assumption was discovered and reported in Reference 9. The original analysis-of-record used 1050 gpm for total AFW flow from the combination of one motor-driven AFW pump (MDAFWP) and the turbine-driven AFW pump (TDAFWP) to the steam generators. As discussed above, a more detailed analysis performed as part of the power uprate program indicated only 696 gpm would be available. Subsequent to that evaluation and through further investigation through the power uprate program, it was discovered that credit could not be taken for the TDAFWP. The correct flow rate should be 295 gpm. A conservative evaluation of the impact on the current SBLOCA PCT using 295 gpm for total AFW flow has resulted in a 50°F penalty for both Unit 1 and Unit 2 (see Reference 9).

**III.B.4 <u>NOTRUMP Evaluation</u>**

In order to offset the increase in PCT resulting from the error discussed in III.B.3.b above, credit was taken for plant-specific high head safety injection (HHSI) flows as opposed to the very conservative flows used in an existing evaluation for a safety injection line imbalance at Farley Units 1 and 2 (see Reference 9). When the plant-specific degraded flows are used, a 73°F PCT benefit results, which is used to offset the reduced auxiliary feedwater flow penalty as discussed in Reference 9.

Associated with the above NOTRUMP input error (in III.B.3.b) and NOTRUMP evaluation is a change in the current Burst and Blockage/Time in Life penalty (a 25°F penalty decrease for Unit 1 and a 14°F penalty decrease for Unit 2) (see Reference 9).

**III.C <u>10 CFR 50.59 SAFETY EVALUATIONS FOR NON-MODEL IMPACTS</u>**

There have been no non-zero non-model PCT assessments under 10 CFR 50.59 made against the reference VANTAGE-5 LOCA analysis results to date. It should be noted that the effects of all of the applicable previous evaluations for both Farley Units 1 and 2 were incorporated into the VANTAGE-5 analysis.

**III.D <u>TOTAL RESULTANT SMALL-BREAK LOCA PCT</u>**

As discussed above, the changes and errors in the Westinghouse small-break LOCA ECCS Evaluation Model could affect the small-break LOCA analysis results by altering the PCT as shown in Table 2.

## III.E SMALL-BREAK LOCA CONCLUSIONS

An evaluation of the effects of changes and errors to the Westinghouse ECCS Evaluation Model was performed for the small-break LOCA analysis results. When the effects of the small-break ECCS Evaluation Model changes and errors were combined with those of plant changes and the small-break LOCA analysis-of-record results, it was determined that compliance with the requirements of 10 CFR 50.46 would be maintained for both Units 1 and 2.

## IV. REFERENCES

1. Letter from D. N. Morey to USNRC, "Joseph M. Farley Nuclear Plant 10 CFR 50.46 Annual ECCS Evaluation Model Changes Report for 1995," March 25, 1996.

2. WCAP-13451, "Westinghouse Methodology for Implementation of 10 CFR 50.46 Reporting," dated October 1992.

3. NRC Safety Evaluation Report, "Issuance of Amendme . No. 92 to Facility Operating License No. NPF-2 and Amendment No. 85 to Facility Operating License No. NPF-8 Regarding the Use of VANTAGE-5 Fuel in Both Units and Allowing Removal and Replacement of the Resistance Temperature Detector Bypass Manifold System in Unit 2 - Joseph M. Farley Nuclear Plant, Units 1 and 2 (TAC Nos. M81025 and M81026)," March 11, 1992.

4. "The 1981 Version of the Westinghouse ECCS Evaluation Model Using the BASH Code," WCAP-10266-P-A, Rev. 2 (Proprietary), Young, M. Y., et. al, March 1987.

5. Joseph M. Farley Nuclear Plant Unit 2 Cycle 12 Reload Safety Evaluation (10 CFR 50.59 Evaluation), letter CAF-NF-1564 dated October 2, 1996.

6. Joseph M. Farley Nuclear Plant Unit 1 Cycle 14 Reload Safety Evaluation (10 CFR 50.59 Evaluation), letter CAF-NF-1479 dated September 1, 1995.

7. "Westinghouse Small-break ECCS Evaluation Model Using the NOTRUMP Code," WCAP-10054-P-A (Proprietary), WCAP-10081-A (Non-Proprietary), Lee, N., et. al, August 1985.

8. Letter from D. N. Morey to USNRC, "Joseph M. Farley Nuclear Plant, Peak Clad Temperature (PCT) Calculation," August 12, 1996.

9. Letter from D. N. Morey to USNRC, "Joseph M. Farley Nuclear Plant, Peak Clad Temperature (PCT) Calculation," January 8, 1997.

## TABLE 1

### JOSEPH M. FARLEY NUCLEAR PLANT
### TOTAL RESULTANT LARGE-BREAK LOCA PCT (°F)

| | Unit 1, °F | Unit 2, °F |
|---|---|---|
| **A. ANALYSIS-OF-RECORD (VANTAGE-5)** | | |
| 1. ECCS Analysis | 1896* | 2042** |
| 2. Containment Mini-Purge Auto Isolation | 3 | 0** |
| 3. Tavg Temperature Uncertainty | 8 | 8** |
| 4. Combined SSE and LOCA Events | 6 | 0** |
| 5. Transition Core Penalty | 0[(a)] | 0[(b)]** |
| 6. SG Tube Plugging Margin | -40[(c)] | -28[(d)]** |
| 7. 1.5X IFBA | 7 | 15 |
| Total Analysis-of-Record PCT = | 1880* | 2037** |
| **B. 1996 10 CFR 50.46 MODEL ASSESSMENTS** | | |
| 1. Prior Reported Assessments | -6 | 0 |
| 2. Translation of Fluid Conditions from SATAN to LOCTA | 15 | 15 |
| **C. 10 CFR 50.59 PLANT MODIFICATIONS** | | |
| 1. Increased Accumulator Water Temperature | 48 | 0** |
| **D. TOTAL RESULTANT LARGE-BREAK LOCA PCT** | 1937 | 2052 |

(a) The Unit 1 Transition Core Penalty has been removed since the core contains all VANTAGE-5 fuel.

(b) The Unit 2 Transition Core Penalty has been removed by taking credit for reduced powers in the VANTAGE-5 assemblies that are adjacent to the LOPAR assemblies (see Reference 5).

(c) To gain additional PCT margin, the steam generator tube plugging limit was reduced from 20% to 10% (Reference 6).

(d) To gain additional PCT margin, the steam generator tube plugging limit was reduced from 20% to 13% (Reference 5).

* The PCT values are rounded up to the next highest integer number to avoid reporting in decimal points.

** The Unit 2 results correspond to the revised LOCA analysis performed to support the use of ZIRLO™ and a revised flooding rate (Reference 5).

## TABLE 2

JOSEPH M. FARLEY NUCLEAR PLANT
TOTAL RESULTANT SMALL-BREAK LOCA PCT (°F)

| | | Unit 1, °F | Unit 2, °F |
|---|---|---|---|
| A. | ANALYSIS-OF-RECORD (VANTAGE-5) | | |
| | 1. ECCS Analysis | 1785* | 1763* |
| | 2. Tavg Temperature Uncertainty | 20 | 20 |
| | Total Analysis-of-Record PCT = | 1805 | 1783 |
| B. | 1996 10 CFR 50.46 MODEL ASSESSMENTS | | |
| | 1. Prior Reported Assessments | 208* | 84* |
| | 2. SBLOCTA Fuel Rod Initialization | 10** | 10** |
| | 3. AFW Flow Reduction from 1050 gpm to 650 gpm | 25** | 25** |
| | 4. AFW Flow Reduction from 650 gpm to 295 gpm | 50** | 50** |
| | 5. Evaluation for Plant-Specific HHSI Flows | -73** | 73** |
| | 6. Change in Burst and Blockage/Time in Life | 12*** | 8*** |
| C. | 10 CFR 50.59 PLANT MODIFICATIONS | | |
| | None | 0 | 0 |
| D. | TOTAL RESULTANT SMALL-BREAK LOCA PCT | 2037 | 1887 |

* Reported to the NRC under 10 CFR 50.46 in Reference 1.

** Reported to the NRC under significant reporting requirements of 10 CFR 50.46 in August 1996 (Reference 8) and January 1997 (Reference 9). These are repeated here for completeness.

*** For Burst and Blockage/Time in Life, penalties of 84°F for Unit 1 and 23°F for Unit 2 were included in B.1 above as previously reported to the NRC in Reference 1. Item B.6 is the sum of the changes in the Burst and Blockage/Time in Life penalty due to items B.2, B.3, B.4, and B.5 since the Burst and Blockage/Time in Life penalty is a function of PCT. Thus, the total penalties for change in Burst and Blockage/Time in Life are 96°F for Unit 1 and 31°F for Unit 2.