OCT 25 '96 12:12AM

SEJ:96:021(NPP. 38 Page i

Paga

Justification for SPC 1986 LBLOCA Evaluation Model With Interim Adjustment for Non-Physical Behavior

# Table of Contents

Sectio	<u>a</u>	1-1
1.0	INTRODUCTION INTERIM ADJUSTMENT	2-1
2.0	DESCRIPTION OF MODEL AND INTERIM	2.1
3.0	CONSERVATISM  EVALUATION  OP  Description    ADJUSTMENT  3.1  Description of Application Method	3-1 3-1 3-1 3-2 3-2
	3.5 FLECHT/FOR COMPTIENS	4-1
4.0	SUMMARY OF CONSERVATIONS	5-1
5.0	CONCLUSIONS	

OCT 25 '96 12:12AM

SEJ:96:021(NP) P. 39 Page II

# List of Tables

	E E	900
Table	TOT IN PWR Application	2-3
2.1	Ranges of Calculated Parameters at PC1 for PUT to PUT to PUT	3-4
3.1	FCTF Test Conditions	3-4
3.2	FLECHT SEASET/FCTF Test Conditions	

SEJ:96:021(NP) P.40 Page iii

# List of Figures

OCT 25 '96 12:13AM

		Page
		2-4
laure	Build Bate for PWR Application	
2.1	Heat Transfer Versus Reflood Hate to	3-5
	of Predicted Heat Transfer Coefficients to	
3.1	Comparison 01 2932 at 8.0 Feet	
	FCTF Toot Data	
3.2	Comparison of Predicted Hater	
	for FCTF Test 2552 and a sector Coefficients to Data	3-7
	Comperison of Predicted Heat Transfer Country	
3.3	for FCTF Test 3440 at 6.0 Feet	3-8
	Heat Transfer Coefficients to out	
3.4	Comparison of Predicted the Fest	
	for FCTF Test Surger Coefficients to Data	3.9
	Comparison of Predicted Heat Transfer Con	
3.5	for FCTF Test 3941 at 6.0 Feet	3.10
	Readicted Heat Transfer Coefficients to Det	
3.	6 Comparison of Predicted 8.7 Feet	
	for FCTP Test Sort	-601
	Tan 3440 Heat Transfer Coefficients voice	Feet 3-12
3	7 Test State Coefficients versus Reflood Hate at Sta	
2	B Test 3440 Heat Transfer Countries	3-13
	Predicted Heat Transfer Costficients	
:	3.9 Comparison of Place at 8.0 Feet	
	for FCTP Test of Transfer Coefficients to Data	
	Comparison of Predicted Heat Inansis	양양이 가지 않는
	for FCTF Test 0205 at 8.7 Fort	3-15
	Condicted Heat Transfer Coefficients to D	
	3.11 Comparison of Predicts 6.0 Feet	
	for FCTF lest 2200 -	3-16
	Comperison of Predicted Heat Transfer	
	3.12 Compare Test 2230 at 8.7 Feet	od Rete 3.17
	101 1 2230 Heat Transfer Coefficients Versoon	
	3.13 Tests 0205 and 2230 Ho	1 Deto
	at 6.0 Feet Refle	000 Hate 3-18
	Tests 0205 and 2230 Heat Transfer Country	
	3.14 at 8.7 Feet	

# List of Figures (continued)

OCT 25 '96 12:13AM

		Page
Figure	방법 방법 방법 것 같은 것 같이 가지 않는 것 같은 것 같은 것 같이 많은 것 같이 많다.	3-19
3.15	Flooding Rate Effect of FLECHT Heat Transfer	
3.16	Comparison of FLECHT and FCTF Heat Transfer Coefficients at 6.0 Feet	3-20
3.17	Comparison of FLECHT and FCTF (Interim Fix) Heat Transfer Coefficients at 6.0 Feet	3-21

SEJ:96:021(NP) 42 Page 1-1

### Justification for SPC 1986 LBLOCA Evaluation Model With Interim Adjustment for Non-Physical Behavior

- Reference: 1. Letter from R. C. Jones (NRC) to H. D. Curet (SPC), Telecons Concerning Siemens Power Corporation Large Break Loss of Coolent Accident Analysis Methodology, dated October 11, 1996.
  - 2) FLECHT SEASET Program Final Report, NUREG/CR-4167, November 1985.

### 1.0 INTRODUCTION

In the Reference 1 letter, the NRC informed SPC of an unacceptable error in the approved 1986 LBLOCA evaluation model. The error is in the FCTF reflood heat transfer correlations over the range of reflood velocities between approximately 1.00 inches/second to 1.77 inches/second. In this range the correlation exhibits the non-physical trend of decreasing heat transfer coefficient with increasing reflood rate. SPC is responding to the NRC staff's position and is continuing to assess the impacts of possible solutions. [

] This

restriction is always conservative with respect to both measured data and the 1986 evaluation model and eliminates the non-physical behavior in the FCTF reflood heat transfer correlations being questioned by the NRC. The following discussions describe the 1986 evaluation model and the non-physical trend. Also included are relevant data points to demonstrate the conservatism of the model compared to the actual FCTF data and the trend of FCTF calculations with FLECHT SEASET test data (Reference 2). This information is provided as requested by the NRC staff in the October 16,1996 meeting with affected licensees and SPC.

P.43

# 2.0 DESCRIPTION OF MODEL AND INTERIM ADJUSTMENT

The heat transfer coefficients calculated by the FCTF heat transfer correlations in the SPC 1986 LBLOCA ECCS evaluation model vary with time during the reflood portion of the LOCA transient. The expected behavior, as stated by the NRC, is that heat transfer coefficients will increase with increasing reflooding rate over the expected range of reflooding rates. PWR FLECHT data show this trend, and FCTF data trends are similar to FLECHT. SPC has found that early in the reflood time period, the predicted heat transfer coefficients using the FCTF that early in the reflood time period, the predicted heat transfer coefficients using the FCTF correlations are calculated to decrease as the reflood rate increases. [

1

[

The range of conditions calculated to occur from the beginning of reflood to the time of calculated peak cladding temperature is important in assessing the conservatism of the model application. For current PWR analyses using the 1986 evaluation model, the ranges of calculated parameters are given in Table 2.1. Conditions which strongly affect PCT are those occurring prior to the calculated time of PCT. I

1

1

Figure 2-1 illustrates FCTF calculated results for conditions typical of a PWR near the time of calculated peak cladding temperature (PCT). The results were calculated at three different times from beginning of reflood for the conditions shown. Heat transfer coefficients versus

flooding rate are shown at 20, 40, and 60 seconds from the beginning of reflood using both the FCTF correlations and the interim model.

# Table 2.1

# Ranges of Calculated Parameters at PCT for PWR Application

	Maximum	Minimum
Parameter		
Pressure (psia)		
Inlet Subcooling (°F)	and the second se	
Maximum Rod Power (kW/ft)		
Minimum Reflood Rate (in/sec)		
Time of PCT from Beginning of He		

P.46

Figure 2.1

Heat Transfer Versus Reflood Rate for PWR Application

1

# 3.0 CONSERVATISM EVALUATION OF 1986 MODEL AND INTERIM ADJUSTMENT

The FCTF correlations were justified by comparison of predicted results to experimental data. The comparisons showed that the carryover rate fractions (CRF), quench times and heat transfer coefficient predictions are conservative or best estimate.

# 3.1 Description of Application Method

The FCTF heat transfer coefficient correlation was designed to predict the total energy (stored energy plus decay heat) which must be removed to quench the rod. As such, it is necessary to know the quench time in order to predict heat transfer coefficients. The FCTF correlations were evaluated against test data using the FCTF quench time correlation and shown to be conservative as presented in the topical report.

# 3.2 Selection of Tests for Comparison

It is appropriate to demonstrate the overall conservatism of the 1986 LBLOCA evaluation model and the interim model. Five high pressure FCTF test results are presented using SPC's LBLOCA methodology. These five tests are the most representative of conditions observed in current SPC's licensing analyses. Table 3-1 shows the test conditions for the five tests.

# 3.3 Evaluation Against High Flooding Rate Tests (1.74-1.77 in/sec)

Heat transfer coefficients are computed at the 6 foot and higher elevations. [

ſ

1

The conservatism of the calculations compared to data for both the correlation and the interim model can also be shown by computing heat transfer coefficients versus reflood rate at specific times for the FCTF tests. [

\_\_\_\_\_1

# 3.4 Evaluation Against Low Flooding Rate Tests (1.15-1.17 in/sec)

The evaluation for the two low flooding rate tests was done in the same manner as for the high flooding rate tests. [

### 3.5 FLECHT/FCTF Comparisons

The non-physical trend in reflood heat transfer coefficients predicted by the FCTF reflood correlations can be characterized as decreasing heat transfer coefficients with increasing reflood rate or, conversely, increasing heat transfer coefficients with decreasing reflood rate. The physical trend for heat transfer versus reflood rate is expected to be a monotonic trend as observed in the FLECHT SEASET data shown in Figure 3-15.

In Figure 3-16, FLECHT SEASET data from three experiments conducted at similar conditions to FCTF Test 3440 (See Table 3-2) are compared with FCTF correlations calculated results to show data trends. [

] However, using the trend of the FLECHT data with reflood rate as

a reference indicates that the [

1

3-17, the FLECHT data are compared with the interim adjustment model heat transfer coefficients [

] The comparison of the FLECHT data in Figure 3-17 and the interim heat transfer coefficients indicates the FCTF correlations with the interim adjustment are more conservative [ ][

#### Table 3.1

# FCTF Test Conditions

Test Number	Refiood Rate (in/sec)	Pressure (psia)	Initial Subcooling (°F)	Peak Initial Temperature (°F)	Pesk Initial LHGR (kW/ft)
0205		and the second of the second			
2230		provide provide and the second second			100
2932	and the second division of the second divisio				
3440	1			a surface and the surface of the particular of t	
3941					

### Table 3.2

# FLECHT SEASET/FCTF Test Conditions

		and the second se			
Test	Pressure (psia)	Tinit (°F)	Power (kW/ft)	Reflood Rate (in/sec)	Subcooling (°F)
FCTF 3440	and the second			and a state of the	
FLECHT SEASET					
FLECHT SEASET					
FLECHT SEASET					

÷.

SEJ:96:021(NP) Page 3-5

#### Figure 3.1

Comparison of Predicted Heat Transfer Coefficients to Data for FCTF Test 2932 at 6.0 Feet .

P.52 SEJ:96:021(NP) Page 3-6

Figure 3.2

Comparison of Predicted Heat Transfer Coefficients for Data for FCTF Test 2932 at 8.7 Feet

P.53

Figure 3.3

Comparison of Predicted Heat Transfer Coefficients to Data for FCTF Test 3440 at 6.0 Feet

### Figure 3.4

1

Comparison of Predicted Heat Transfer Coefficients to Data for FCTF Test 3440 at 8.7 Feet

SEJ:96:021.NP) Pag's 3-9

Figure 3.5

Comparison of Predicted Heat Transfer Coefficients to Data for FCTF Test 3941 at 6.0 Feet ×

SEJ:96:021(NP) Page 3-10

P.56

Figure 3.6

Comparison of Predicted Heat Transfer Coefficients to Data for FCTF Test 3941 at 8.7 Feet

P.57

Figure 3.7

Test 3440 Heat Transfer Coefficients versus Reflood Rate at 6.0 Feet

Figure 3.8

Test 3440 Heat Transfer Coefficients versus Reflood Rate at 8.7 Fest

P.59

Figure 3.9

Comparison of Predicted Heat Transfer Coefficients to Data for FCTF Test 0205 at 6.0 Feet 8

SEJ:96:021(NP) Page 3-14

P.60

Figure 3.10

Comparison of Predicted Heat Transfer Coefficients to Data for FCTF Test 0205 at 8.7 Feet

P.61

#### Figure 3.11

Comparison of Predicted Heat Transfer Coefficients to Data for FCTF Test 2230 at 6.0 Feet

P.62

Figure 3.12

Comparison of Predicted Heat Transfer Coefficients to Data for FCTF Test 2230 at 8.7 Feet

Figure 3.13

Tests 0205 and 2230 Heat Transfer Coefficients versus Reflood Rate at 6.0 Feet

P.64

Figure 3.14

Tests 0205 and 2230 Heat Transfer Coefficients versus Reflood Rate at 8.7 Feet

P.65





Flooding Rate Effect of FLECHT Heat Transfer

.

Figure 3.18

Comparison of FLECHT and FCTF Heat Transfer Coefficients at 6.0 Feet

P.67

Figure 3.17

Comparison of FLECHT and FCTF (Interim Fix) Heat Transfer Coefficients at 6.0 Feet OCT 25 '96 12:20AM

SEJ:96:021(NP) Page 4-1

#### 4.0 SUMMARY OF CONSERVATISMS

The conservatisms in the FCTF heat transfer correlation and the licensing applications are summarized below:

 The FCTF correlations are generally conservative compared to the data. The SER states that the FCTF heat transfer correlation is conservative, or best estimate, for 93 of 112 data points. This statement is based on comparisons calculated with the FCTF quench time correlation.

2.

ĩ

3. [

1

4.

E

1

1

OCT 25 '96 12:20AM

P.69

#### 5.0 CONCLUSIONS

1

The information presented above leads to the following conclusions:

- 1. SPC's 1986 EXEM/PWR LBLOCA ECCS evaluation model as applied in licensing analyses is conservative with respect to the available data.
- 2. The trend of decreasing heat transfer coefficients with increasing reflood rates exists in the methodology but can be eliminated by using SPC's interim adjustment. The interim model is conservative with respect to the correlation.

1

3. [

4.

1