ATTACHMENT 3

WCAP-11164, SUPPLEMENT 1, "ADDITIONAL
INFORMATION IN SUPPORT OF THE
TECHNICAL JUSTIFICATION FOR ELIMINATING
LARGE PRIMARY LOOP PIPE RUPTURE
AS THE STRUCTURAL DESIGN BASIS
FOR NORTH ANNA UNITS 1 AND 2"
(NON-PROPRIETARY)

WCAP-11164
Supplement 1

ADDITIONAL INFORMATION IN SUPPORT OF THE TECHNICAL JUSTIFICATION FOR ELIMINATING LARGE PRIMARY LOOP PIPE RUPTURE AS THE STRUCTURAL DESIGN BASIS FOR NORTH ANNA UNITS 1 AND 2

January 1988

S. A. Swamy
J. C. Schmertz
Y. S. Lee
C. B. Bond
C. C. Kim

Verified by: _____
F. J. Witt

Approved by: _____
S. S. Palusamy, Manager
Structural Materials Engineering

Work Performed Under Shop Order VHOJ950

WESTINGHOUSE ELECTRIC CORPORATION
Generation Technology Systems Division
P.O. Box 2728
Pittsburgh, Pennsylvania 15230-2728

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

SECTION 1.0
SUMMARY AND INTRODUCTION

1.1 Summary

Virginia Electric Power Company submitted a leak-before-break analysis for the reactor coolant loops, WCAP-11163, to NRC in support of their snubber reduction program for North Anna Units 1 and 2. After completing their review the NRC transmitted to Virginia Electric Power Company a request for additional information. Virginia Electric Power Company contracted with Westinghouse Electric Corporation to respond to the NRC request including the performance of analyses. This report represents the response.

Additional materials information is provided. Additional leak-before-break analyses were performed using average properties for leak-rate calculations and lower-bound properties for stability calculations. Elastic-plastic fracture mechanics procedures were applied. The margin criteria of 10 on leakage rate, 2 on crack size and 1.4 on load were met as detailed in the NRC request.

It is concluded that leak-before-break conditions are demonstrated for North Anna Units 1 and 2 primary loops using the criteria and recommendations provided by the NRC. The conclusions of WCAP-11163 are unchanged.

1.2 Introduction

Virginia Electric Power Company contracted with Westinghouse Electric Corporation to develop a leak-before-break analysis for the North Anna Units 1 and 2 nuclear power plant for licensing support in their snubber reduction program. The leak-before-break analysis is documented in Westinghouse Proprietary Class 2 Report WCAP-11163 (reference S1.1). WCAP-11164 is the associated Westinghouse Class 3 report. During the regulatory review process, the Nuclear Regulatory Commission (NRC) issued a Request for Additional Information on Elimination of Postulated Primary Loop Pipe Ruptures as a Design Basis. This report addresses the NRC request. The NRC request is given in Appendix A.

Portions of the NRC request are answered as independent items; however, those directly involving the calculational methods are best addressed by presenting a reanalysis reflecting the NRC's request. Specifically, request items 1, 2, and 3 are addressed in separate sections while items 4, 6 and 7, are addressed in the same section. Item 5 is addressed in the concluding discussion. The details included in WCAP-11163 are referenced extensively and, in general, will not be reproduced in this report.

SECTION 2.0
FABRICATION AND WELDING PROCESSES FOR THE PRIMARY LOOP

The primary loop piping of North Anna Units 1 and 2 are made of SA351 CF8A cast stainless steel. The elbows are made of SA351 CF8M cast stainless steel. The piping is centrifugally cast while the fittings are statically cast. The field welds feature a gas tungsten arc weld (GTAW or TIG) root pass followed by shielded metal arc welding (SMAW) to completion. The shop welds are either SMAW or submerged arc (SAW) with a GTAW root pass. Weld repairs on shop welds would be either SMAW or GTAW. The welds have TP 308 stainless steel chemistry. No solution annealing was performed.

SECTION 3.0
MATERIAL PROPERTIES

The material properties presented in tables S3-1 through S3-3 of WCAP-11163 are the ASME Boiler and Pressure Vessel Code Section III minimum properties at the operating temperatures. However, to perform the reanalyses given in the next section, elastic-plastic analyses are required. The material properties at operating temperatures were calculated as follows:

Plant specific material certifications were used to establish the tensile properties for the leak-before-break analyses. Table S3-1 shows the tensile properties at 70°F for SA351 CF8A and SA351 CF8M materials. Table S3-2 shows the tensile properties at 650°F as taken from the material certifications.
[

]^{a,c,e}.

The lower bound properties were used for crack stability analysis and the average properties were used for leak rate calculations. These properties are summarized in table S3-3 for the critical locations discussed in reference S1.1. The lower bound stress-strain curves used in the stability evaluations are given in figures S3-1 through S3-3 obtained using the methodology of reference S3.1.

TABLE S3-1

MECHANICAL PROPERTIES OF THE PRIMARY LOOP MATERIALS FOR
NORTH ANNA UNITS 1 AND 2 AT ROOM TEMPERATURE

PRODUCT FORM	HEAT NR	MATERIAL	0.2% OFFSET YIELD STRESS (PSI)	ULTIMATE STRENGTH (PSI)	% ELONGATION	% REDUCTION IN AREA
27.5 in. ID Cold Leg Pipe	B-2356	A351 CF8A	39,450	81,100	50.0	61.8
	B-2548	A351 CF8A	35,000	78,300	52.0	65.9
	B-2620	A351 CF8A	40,950	79,900	52.0	71.0
	B-2647	A351 CF8A	42,300	83,400	55.0	73.2
	B-2659	A351 CF8A	39,800	77,611	59.0	73.4
	B-2608	A351 CF8A	43,950	84,700	43.0	62.8
	B-2632	A351 CF8A	38,950	80,100	56.0	74.3
	B-2715	A351 CF8A	43,000	83,283	53.0	64.8
	143325	A351 CF8A	50,100	84,250	52.0	N/A
29 in. ID Hot Leg Pipe	B-2641	A351 CF8A	39,950	82,900	53.0	66.8
	B-2764	A351 CF8A	41,958	82,215	50.0	69.0
	B-2744	A351 CF8A	36,960	79,020	49.0	69.7
31 in. ID Cross-over Leg Piping	C-1037A, B,C	A315 CF8A	43,000	85,700	55.5	64.7
	C-1153A	A351 CF8A	39,460	83,310	56.0	70.6
	C-1153B	A351 CF8A	39,460	83,310	56.0	70.6
	C-1632A	A351 CF8A	39,960	83,100	50.0	65.6
31 in. ID x 90D W/Splitter	K0169	A351 CF8M	48,800	80,300	39.4	63.2
	K0222	A351 CF8M	41,100	74,700	50.4	64.2
27.5 in. ID X 35D Elbow	56818	A351 CF8M	41,600	74,700	46.1	65.1
	56824	A351 CF8M	50,500	76,300	43.1	66.9
	56844	A351 CF8M	46,100	76,300	40.1	64.2
31 x 29 in. ID Reducing Elbow	58071	A351 CF8M	50,500	79,700	40.1	63.2
	58090	A351 CF8M	52,800	83,100	37.8	66.0
	58118	A351 CF8M	47,200	76,900	46.8	71.3

TABLE S3-1 (cont.)

MECHANICAL PROPERTIES OF THE PRIMARY LOOP MATERIALS FOR
NORTH ANNA UNITS 1 AND 2 AT ROOM TEMPERATURE

PRODUCT FORM	HEAT NR	MATERIAL	0.2% OFFSET YIELD STRESS (PSI)	ULTIMATE STRENGTH (PSI)	% ELONGATION	% REDUCTION IN AREA
31 in. ID x 40D Elbow	57528A	A351 CF8M	42,100	74,100	50.9	66.0
	57604	A351 CF8M	39,900	72,400	56.9	61.3
31 in. ID x 90D Elbow	57412	A351 CF8M	41,000	76,300	49.5	66.9
	57452	A351 CF8M	42,780	75,200	50.5	72.2
	57604	A351 CF8M	39,900	72,400	56.9	61.3
31 in. ID x 90D w/splitter	K0160	A351 CF8M	47,200	80,300	48.4	67.8
27.5 in. ID Cold Leg Pipe	C-2291A &B	A351 CF8A	37,460	80,920	47.0	63.0
	C2152	A351 CF8A	35,090	79,200	50.0	68.5
	C-2230	A351 CF8A	46,200	82,500	54.0	68.6
	C-2246	A351 CF8A	39,960	83,920	53.0	68.8
	C-2205A &B	A351 CF8A	44,955	79,320	51.0	64.2
	147377, PCS1-3	A351 CF8A	51,380	83,400	52.0	N/A
29 in. ID Hot Leg Pipe	C-1638	A351 CF8A	44,455	84,815	47.0	64.7
	C-1804	A351 CF8A	41,960	80,920	50.0	69.0
	C-1751	A351 CF8A	42,600	83,750	50.0	72.5
3/in. ID Crossover Leg Pipe	C-2103	A351 CF8A	40,960	82,320	41.0	71.9
	C-1767A, B,C	A351 CF8A	43,800	83,750	55.5	68.8
	C-1632B	A351 CF8A	39,960	83,100	50.0	65.6
	C-1153C	A351 CF8A	39,460	83,310	56.0	70.6

TABLE S3-1 (cont.)

MECHANICAL PROPERTIES OF THE PRIMARY LOOP MATERIALS FOR
NORTH ANNA UNITS 1 AND 2 AT ROOM TEMPERATURE

PRODUCT FORM	HEAT NR	MATERIAL	0.2% OFFSET YIELD STRESS (PSI)	ULTIMATE STRENGTH (PSI)	% ELONGATION	% REDUCTION IN AREA
27.5 in. ID x 35D	57663	A351 CF8M	54,500	84,800	34.9	57.3
Elbow	57731	A351 CF8M	51,600	81,400	45.0	62.3
	57801	A351 CF8M	48,300	79,700	44.0	71.3
31 x 29 in. ID	58148	A351 CF8M	51,600	85,300	40.7	66.9
Reducing Elbow	58159	A351 CF8M	46,100	83,600	46.2	63.2
31 in. ID x 40D	58090	A351 CF8M	52,800	83,100	37.8	66.0
Elbow	58118	A351 CF8M	47,200	76,900	46.8	71.3
31 in. ID x 90D	58009	A351 CF8M	47,200	78,000	38.4	67.8
Elbow	58037	A351 CF8M	44,900	76,900	51.0	71.3
	58071	A351 CF8M	50,500	79,700	40.1	63.2
31 in. ID x 90D	K0399	A351 CF8M	40,400	72,400	42.1	69.6
W/Splitter	K0134	A351 CF8M	50,000	80,300	45.5	65.1
	K0876	A351 CF8M	41,000	74,700	47.9	67.8

TABLE S3-2

MECHANICAL PROPERTIES OF THE PRIMARY LOOP MATERIALS FOR NORTH ANNA UNITS 1 AND 2 AT 650°F

PRODUCT FORM	HEAT NR	MATERIAL	0.2% OFFSET YIELD STRESS (PSI)	ULTIMATE STRENGTH (PSI)	% ELONGATION	% REDUCTION IN AREA
27.5 in. ID Cold	B-2356	A351 CF8A	23,400	60,000	31.0	53.0
	B-2548	A351 CF8A	21,500	63,000	39.0	57.3
	B-2620	A351 CF8A	24,800	67,000	36.0	54.7
	B-2647	A351 CF8A	22,400	64,250	46.0	59.4
	B-2659	A351 CF8A	20,000	58,500	43.5	59.8
	B-2608	A351 CF8A	23,700	64,500	37.0	58.6
	B-2632	A351 CF8A	20,900	63,750	46.0	68.6
	B-2715	A351 CF8A	21,000	65,000	43.0	65.4
	143325	A351 CF8A	24,450	N/A	N/A	N/A
29 in. ID Hot Leg Pipe	B-2641	A351 CF8A	20,300	62,500	47.5	64.7
	B-2764	A351 CF8A	22,200	64,500	42.0	66.7
	B-2744	A351 CF8A	23,300	64,000	41.5	63.5
31 in. ID Cross-over Leg Piping	C-1037A, B,C	A351 CF8A	27,400	66,000	38.0	58.6
	C-1153A	A351 CF8A	23,700	65,750	38.0	53.8
	C-1153B	A351 CF8A	23,700	66,000	38.0	58.6
	C-1632A	A351 CF8A	24,200	60,000	39.0	51.1
31 in. ID x 90D W/Splitter	K0169	A351 CF8M	30,300	64,000	39.4	62.3
	K0222	A351 CF8M	24,700	57,300	41.0	65.1
27.5 in. ID x 35D Elbow	56818	A351 CF8M	24,700	53,900	54.0	64.2
	56824	A351 CF8M	31,400	66,200	44.7	42.8
	56844	A351 CF8M	25,200	56,100	32.4	47.5
31 in. ID x 40D Elbow	57528A	A351 CF8M	24,730	56,100	44.7	59.3
	57604	A351 CF8M	23,600	56,100	49.8	59.3

TABLE S3-2 (cont.)

MECHANICAL PROPERTIES OF THE PRIMARY LOOP MATERIALS FOR NORTH ANNA UNITS 1 AND 2 AT 650°F

PRODUCT FORM	HEAT NR	MATERIAL	0.2% OFFSET YIELD STRESS (PSI)	ULTIMATE STRENGTH (PSI)	% ELONGATION	% REDUCTION IN AREA
31 in. ID x 90D Elbow	57412	A351 CF8M	25,800	59,500	49.8	59.3
	57452	A351 CF8M	24,700	58,400	46.0	59.3
	57604	A351 CF8M	23,600	56,100	49.8	59.3
31 in. ID x 90D w/splitter	K0160	A351 CF8M	33,700	64,000	36.0	60.3
27.5 in. ID Cold Leg Pipe	C-2291A&	A351 CF8A	23,100	65,000	35.0	32.0
	C-2152	A351 CF8A	19,950	62,250	42.5	34.7
	C-2230	A351 CF8A	23,700	66,250	46.0	60.1
	C-2246	A351 CF8A	26,400	66,250	37.5	51.9
	C-2205A& B	A351 CF8A	22,700	64,000	43.5	57.3
	147377, PCS 1-3	A351 CF8A	25,650	N/A	N/A	N/A
29 in. ID Hot Leg Pipe	C-1638	A351 CF8A	22,300	64,000	39.0	64.7
	C-1804	A351 CF8A	25,500	64,500	42.0	61.8
	C-1751	A351 CF8A	25,000	67,000	37.0	50.6
31 in. ID Crossover Leg Pipe	C-2103	A351 CF8A	23,400	65,000	37.5	60.3
	C-1767A. B,C	A351 CF8A	23,100	63,750	41.0	59.8
	C-1632B	A351 CF8A	24,200	66,000	39.6	51.1
	C-1153C	A351 CF8A	23,700	65,750	38.0	53.8
31 in. ID x 90D w/Splitter	K0399	A351 CF8M	25,800	55,600	28.9	63.2
	K0134	A351 CF8M	31,400	65,900	36.6	63.2
	K0876	A351 CF8M	21,600	55,000	35.6	59.3

N/A = not available

TABLE S3-3
LOWER-BOUND AND AVERAGE MATERIAL PROPERTIES USED IN THE
NORTH ANNA UNITS 1 AND 2 LEAK-BEFORE-BREAK ANALYSIS*

LOCATIONS	MATERIAL	PROPERTY TYPE	TEMPERATURE (°F)	YIELD STRESS (psi)	ULTIMATE STRESS (psi)	MODULUS OF ELASTICITY (psi)
1	SA351 CF8A	Lower Bound	620	[		] a,c,e
		Average	620			
2	SA351 CF8M	Lower Bound	620			
		Average	620			
3,4,5	SA351 CF8M	Lower Bound	556			
		Average	556			

*Poisson's ratio used is 0.3

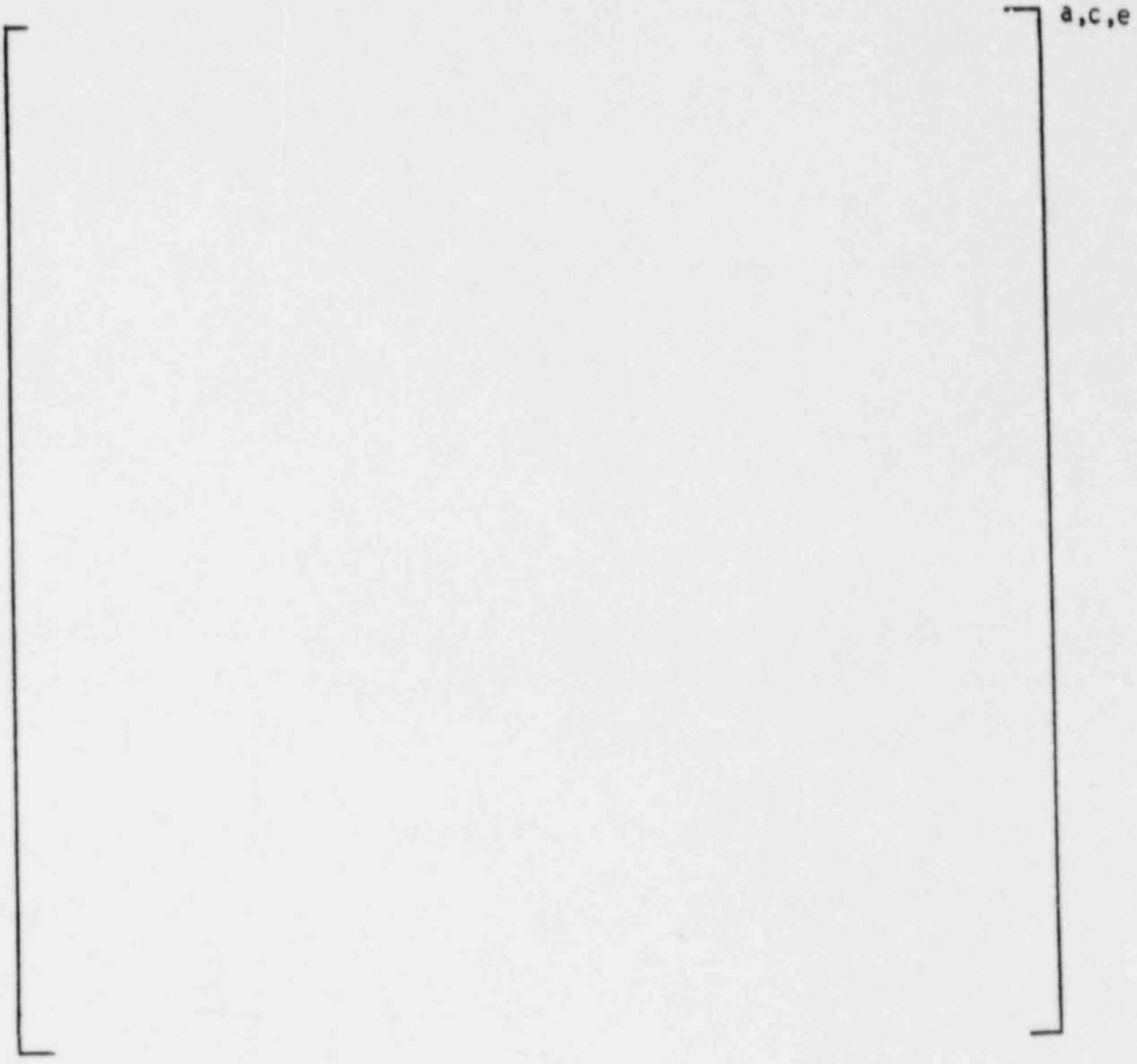

Figure S3-1: Lower Bound Stress-Strain Curve for SA351 CFBA at 620°F