ATTACHMENT 2 (cont'd)

Computed by: A.M. Wolfe Date: 12-15-90	CAROLINA POWER & LIGHT COMPANY BRUNSWICK - UNIT 2 CALCULATION SHEET	Calculation ID: C-1534A-278
Checked by: Date: 12/15/90		Pg. 1 of Rev. 0
Tag / PID No.:		File:
Project Title:		
Calculation Title: THROUGH WALL LEAK EVALUATION FOR LINE # 2-SW-234-G-157		
Status: Prelim. ☐ Final ☐ Void ☐		

LIST OF EFFECTIVE PAGES

PAGE	REV.
1	0
2	0
3	0
4	0
5	0
6	0
7	0

TABLE OF CONTENTS

FORM NO. 78055 REV. 10/88

ATTACHMENT 2 (cont'd)

Computed by: A.M. Widiff Date: 12-15-90	CAROLINA POWER & LIGHT COMPANY BRUNSWICK - UNIT 2 CALCULATION SHEET	Calculation ID: 2-1534A-278
Checked by: [illegible] Date: 12-15-90		Pg. 2 of / Rev. 0
Tar / PID No.:		File:
Project Title:		
Calculation Title: THROUGH WALL LEAK EVALUATION FOR LINE # 2-SW-234-G-157		
Status: Prelim. ☐ Final ☐ Void ☐		

PURPOSE

EVALUATE "THROUGH-WALL" LEAK DISCOVERED 12-13-90 IN THE DIESEL GENERATOR #4 6"ϕ JACKET WATER SUPPLY PIPING - LINE # 2-SW-234-G-157. THE "THROUGH-WALL" LEAK IS LOCATED IN THE WELD OF THE REDUCED END OF THE 8"x6" REDUCER AT THE INLET JACKET WATER COOLER NOZZLE N-4 ON D.G. # 4. APPROXIMATE LOCATION IS 3'-2" SOUTH OF COLUMN 12D, 3'-2" EAST OF COLUMN W AT ELEV. 23.23. THE PLANT WAS IN OPERATION AT THE TIME THE LEAK WAS DISCOVERED.

REFERENCES

1. USAS B31.1 - 1967 POWER PIPING CODE
2. NRC GENERIC LETTER 90-05 DATED 6-15-90
3. STRESS CALC. DJW 52/552 LTF 9-23-80 (RUN DATE 9-25-80)
4. DWG. F-02250 SHT 52C REV. 0 STRESS ISO
5. DWG. D-02274 SHT 2 REV. 13 FLOW DIAGRAM
6. BSEP SPEC. NO. 248-117 - "SPECIFICATION FOR INSTALLATION OF PIPING SYSTEMS" - REV. 7
7. CP&L DESIGN GUIDE FOR CIVIL/STRUCTURAL OPERABILITY REVIEWS DG II. 20 REV. 1
8. EER NO. 88-0087 REV. 0

FORM NO. 74555 REV. 10/11

ATTACHMENT 2 (cont'd)

Computed by: A.M. WOLFE Date: 12-15-90	CAROLINA POWER & LIGHT COMPANY BRUNSWICK - UNIT 2	Calculation ID: 2-1534A-278
Checked by: Date: 12-15-90	CALCULATION SHEET	Pg. 3 of Rev. 0
Tar / PID No.:		File:
Project Title:		
Calculation Title: THROUGH WALL LEAK EVALUATION FOR LINE # 2-SW-234-G-157		
Status: Prelim. ☐ Final ☐ Void ☐		

PIPE DATA

6" SCH 40 CEMENT-LINED O.D. = 6.625" t = .280"

A-106 GRADE B $S_c = S_h = 15000$ psi

DESIGN TEMPERATURE = 105°F

DESIGN PRESSURE = 150 psig

CALCULATE MINIMUM WALL t_{min}

$$t_{min} = \frac{PD_o}{2(SE + PY)} + A$$ (REF. 1 EQ. 3 - 104.1.2a)

$$= \frac{150(6.625)}{2(15000 \times 1 + 150 \times .4)} + 0$$

$$= 0.033"$$

NOTE: THE ADDITIONAL THICKNESS A FOR CORROSION ALLOWANCE = 0 SINCE THE PIPING IS CEMENT-LINED. HOWEVER SINCE PIPING IS EXPOSED AT THE FLAW LOCATION and IN ORDER TO JUSTIFY CONTINUED PLANT OPERATION, USE A = .020 (1 YEAR STAGNANT). REF. B

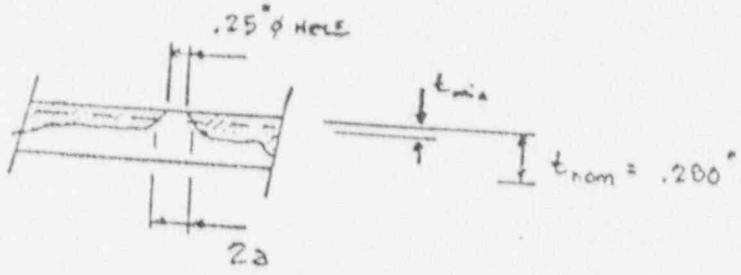
THEREFORE USE $t_{min} = 0.053"$

ATTACHMENT 2 (cont'd)

Computed by: A.M. Wolfe Date: 12-15-90	CAROLINA POWER & LIGHT COMPANY BRUNSWICK - UNIT 2 CALCULATION SHEET	Calculation ID: 2-1534A-2278
Checked by: Date: 12-15-90		Pg. 4 of [illegible] Rev. 0
ar / PID No.:		File:
Project Title:		
Calculation Title: THROUGH WALL LEAKE EVALUATION FOR LINE # 2-SW-234-CC-157		
Status: Prelim. ☐ Final ☐ Voidd ☐		

"THROUGH-WALL FLAW" EVALUATION (REF. 2)

BASED ON A MINIMUM WALL UT READING = .06" (ATT. B), t_{min} IS NOT VIOLATED EXCEPT AT THE .25" ϕ PINHOLE.



FOR A .25" ϕ HOLE and t_{min} = .053", ASSUME 2a = .55"
THEREFORE a = .255"

LENGTH 2a = 0.5" < 3"
< .15πD = .15π(6.625) = 3.12"
THEREFORE "THROUGH-WALL FLAW" APPROACH IS VALID

R = MEAN RADIUS = (6.625 - .28)/2 = 3.1725"

c = a/(πR) = .25/(π × 3.1725) = 0.0250835

T = R/t_m = 3.17225 / .053 = 59.8595

T^2 = 3583.0389

T^3 = 214,475.2998

Computed by: A.M. WOLFE Date: 12-15-90	CAROLINA POWER & LIGHT COMPANY BRUNSWICK - UNIT 2 CALCULATION SHEET	Calculation ID: 2-1536A-278
Checked by: [illegible] Date: 12-15-90		Pg. 5 of / Rev. 0
Tar / PID No.:		File:
Project Title:		
Calculation Title: THROUGH WALL LEAK EVALUATION FOR LINE # 2-SW-234-6-157		
Status: Prelim. ☐ Final ☐ Void ☐		

"THROUGH-WALL FLAW" EVALUATION - CONT'D (REF. 2)

COEFFICIENTS

$$A = -3.20543 + 1.52784r - 0.072698r^2 + 0.0016011r^3 \quad (EQ.4)$$

$$B = 11.36322 - 3.91412r + 0.18619r^2 - 0.004099r^3 \quad (EQ.5)$$

$$C = -3.18009 + 3.84763r - 0.18304r^2 + 0.00403r^3 \quad (EQ.6)$$

THEREFORE: $A = 171.1054$

$B = -434.9383$

$C = 435.6233$

GEOMETRY FACTOR 'F'

$$F = 1 + Ac^{1.5} + Bc^{2.5} + Cc^{3.5} \quad (EQ.2)$$

$$F = 1 + (171.1054)(.0250835)^{1.5} - (434.9383)(.0250835)^{2.5} + [435.6233)(.0250835)^{3.5}$$

$$= 1.0375$$

FORM NO. Y8051 REV. 10/88

ATTACHMENT 2 (cont'd)

Computed by: A.M. Hoyle Date: 12-15-90	CAROLINA POWER & LIGHT COMPANY BRUNSWICK - UNIT 2 CALCULATION SHEET	Calculation ID: 2-1530A-27B
Checked by: [illegible] Date: 12-15-90		Pg. 6 of Rev. 0
Tar / PID No.:		File:
Project Title:		
Calculation Title: THROUGH WALL LEAK EVALUATION FOR LINE # 2-SW-230-6-157		
Status: Prelim. ☐ Final ☐ Void ☐		

"THROUGH-WALL FLAW" EVALUATION - CONT'D (REF. 2)

STRESS INTENSITY FACTOR "K"

$$K = 1.4 \, S \, F \, (\pi a)^{0.5}$$

$$= 1.4 \, (1.907 \text{ ksi}) \, (1.6375) \, (\pi \times .25 \text{ in})^{0.5}$$

$$= 3.87 \text{ ksi (in)}^{0.5} < 35 \text{ ksi (in)}^{0.5} \quad \therefore \text{ ok}$$

WHERE S = STRESS AT THE FLAWED LOCATION RESULTING FROM:

DEADWEIGHT	63 psi	- NODE 12
PRESSURE	776 psi	REF. 3 & 4
THERMAL	0	
* SSE + OBE	1068 psi	
	1.907 ksi	

* $2 \, (OBE_{X+Y} + OBE_{Y+Z})^{1/2}$

NOTE: STRESS LEVELS AT THIS LOCATION ARE LOW DUE TO IT'S PROXIMITY TO THE EXPANSION JOINT.

ORM NO. 7FB033 REV. 10/15		
Computed by: R.M. Wolfe Date: 12-15-90	CAROLINA POWER & LIGHT COMPANY BRUNSWICK - UNIT 2 CALCULATION SHEET	Calculation ID: 2-1534A-27B
Checked by: Date: 12-17-90		Pg. 7 of Rev. 0
Tar / PID Nbr.:		File:
Project Title:		
Calculation Title: THROUGH WALL LEAK EVALUATION FOR LINE # 2-SW-234-6-147		
Status: Prelim. ☐ Final ☐ Void ☐		

CONCLUSION

THE STRUCTURAL INTEGRITY OF FLAWED PIPING HAS BEEN REVIEWED and FOUND ACCEPTABLE USING THE "THROUGH-WALL FLAW" APPROACH OF NRC GENERIC LETTER # 90-05 DATED 6-15-90.

A PERMANENT CODE REPAIR IS REQUIRED DURING THE NEXT SCHEDULED OUTAGE EXCEEDING 30 DAYS OR THE NEXT REFUELING OUTAGE. HOWEVER THIS REPAIR SHOULD BE MADE AS SOON AS DIESEL GENERATOR #4 CAN BE TAKEN OUT OF SERVICE.

EER No. 90-0354
Rev. No. 0
Page No. 32

ATTACHMENT 2 (cont'd)

DESIGN VERIFICATION RECORD

ATTACHMENT A
2.153.A.279 R/0

I. Instructions to Verification Personnel

Plant : BRUNSWICK. 2 Project No.: 1539A File No. 4060

Document Number	Revision	Document Title
2.153.A.279	0	THROUGH WALL LEAK EVALUATION FOR
N/A		LINE # 2.5W.234.G.157

Design in verification should be done in accordance with ANSI N45.2.11, Section 6, as amended by Regulatory Guide 1.64, Rev.2.

Verification Methods to be used:
- X Design Review
- ____ Alternate or Simplified Calculations
- ____ Qualification Testing

Documents "Q" Level:
- X Q (Class A)
- ____ Seismic (ClassB)
- ____ FP-Q (Class D)
- ____ Other

Special Instructions:

NONE

Discipline Project Engineer [signature] Date 12-15-90

II. Verification Documentation:

Method Used:
- X Design Review (Attach any documentation)
- ____ Alternate or Simplified Calculations (Attach Calculations)
- ____ Qualification Testing

Design Document Acceptable: Yes X No ____
If not acceptable, give reasons or provide comments on the reverse side of this form:

Verification Check Completed By (Signature): [signature] Date 12-15-90
Acknowledgement of Verification: (DPE): [signature] Date 12-15-90

III. Resolution of Comments:

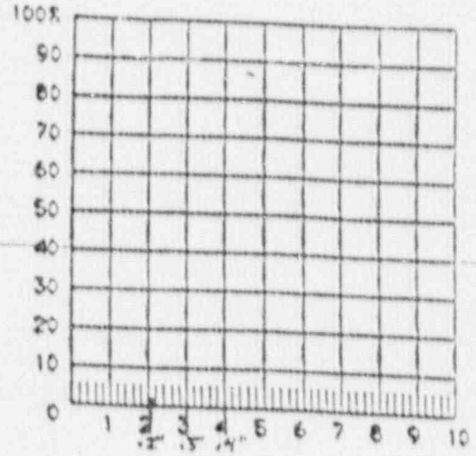
Comments Resolved (See Reverse Side):
(RE) N/A
Action taken makes Design Documents Acceptable
(DPE) _____ Date _____ Verifier _____ Date _____

ATTACHMENT 4
RELIEF REQUEST NO.

THICKNESS CALIBRATION SHEET

PLANT/UNIT: BSEP
COMPONENT: Service Water
PROCEDURE #: NDEP 408 REV. 6
CALIBRATION BLOCK #1 #EBOC3613 BLOCK THICKNESS .405", .305", .205"
#2 N/A BLOCK THICKNESS N/A
INSTRUMENT: USK-7
CAL. DUE DATE: 1/8/90
SERIAL NUMBER: 27276-3776
SWEEP: 5.02
DELAY: 7.47
RANGE: .5"

TRANSDUCER FREQUENCY: 5 MHz
TRANSDUCER SERIAL NO.: L08561
TRANSDUCER BRAND: Aerotech
TRANSDUCER SIZE: .25"
TRANSDUCER ELEMENT: SINGLE OR (DUAL)



EACH MAJOR SCREEN DIVISION .10"

CALIBRATION VER. / CHECK	
INITIAL	TIME
CH	0015
CH	0100
CH	0200
CH	0245

COMMENTS: DG # 1, 2, 3, 4 - Service Water Inlets

EXAMINERS 1 [signature] DATE 12/26/89 LEVEL II
2 N/A DATE N/A LEVEL N/A
REVIEWERS 1 [signature] DATE 12-30-89
2 _____ DATE _____
3 _____ DATE _____

ADDITIONAL SHEETS: (YES) NO

APPENDIX A

WALL THICKNESS MEASUREMENT RECORD SHEET

PLANT: Brunswick UNIT: 1

Page ___ of ___

COMPONENT: DG #4 Inlet NOM. SIZE O.D.: 8" NOM. WALL: 0.332 MIN. WALL: 0.043 ZONE: N/A

LINEAR SPACING: N/A RADIAL SPACING: 1" STARTING AT: 1" US from ℄ ENDING AT: 1" DS. from ℄

LINEAR INCREMENT | RADIAL INCREMENT

		A	B*	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	S	T
1" US from ℄	1	.29"	.10"	.25"	.30"	.33"	.34"	.33"	.31"	.31"	.31"	.31"	.30"	.29"	.31"	.32"	.32"	.31"	.32"	.33"	.33"
Toe	2	.31"	.18"	.34"	.32"	.33"	.34"	.32"	.30"	.30"	.30"	.30"	.30"	.30"	.30"	.32"	.32"	.32"	.31"	.33"	.34"
℄	3	.40"	.39"	.37"	.38"	.36"	.27"	.38"	.40"	.38"	.36"	.37"	.38"	.38"	.38"	.40"	.40"	.37"	.38"	.38"	.41"
Toe	4	.31"	.32"	.30"	.31"	.32"	.32"	.33"	.35"	.35"	.36"	.36"	.36"	.36"	.36"	.36"	.36"	.36"	.36"	.36"	.35"
1" DS from ℄	5	.32"	.32"	.30"	.31"	.32"	.32"	.33"	.34"	.35"	.35"	.35"	.35"	.35"	.35"	.35"	.36"	.36"	.36"	.35"	.35"
														Readings taken Approx .25" either sides of B1							
		U	V	W	X	Y	Z	AA													
1" US from ℄	1	.32"	.33"	.33"	.33"	.33"	.34"	.34"						B1							
Toe	2	.33"	.32"	.32"	.32"	.33"	.33"	.33"						.15"							
℄	3	.40"	.41"	.39"	.39"	.38"	.39"	.38"					.16"	.10"	.15"						
Toe	4	.36"	.36"	.34"	.34"	.32"	.31"	.31"						.36"							
1" DS from ℄	5	.36"	.35"	.34"	.33"	.32"	.32"	.32"													

Elbow

LOWEST MEASUREMENT: .10" AT LOCATION: (LIN. 1 RAD. B) COMMENTS: A is at Datum 0 - Outside Radius at Elbow

PERFORMED BY: [signature] DATE: 12/20/90

[signature] 12-20-90

APPENDIX A

WALL THICKNESS MEASUREMENT RECORD SHEET

PLANT: Brunswick UNIT: 1 Page ___ of ___

COMPONENT: DG #1 Inlet NOM. SIZE O.D.: 8" NOM. WALL: 0.332 MIN. WALL: 0.043 ZONE: N/A

LINEAR SPACING: N/A RADIAL SPACING: 22½° STARTING AT: 1" DS from ℄ ENDING AT: 1" DS from ℄

LINEAR INCREMENT	RADIAL INCREMENT	A	B	C	D	E	F	G	H*	I	J	K	L	M	N	O	P	Q	R	S	T
1" US from ℄	1	.38"	.37"	.36"	.36"	.35"	.35"	.35"	.35"	.32"	.32"	.30"	.32"	.33"	.33"	.33"	.32"	.33"	.34"	.34"	.34"
Toe	2	.34"	.34"	.33"	.34"	.32"	.33"	.34"	.10"	.25"	.32"	.29"	.30"	.32"	.32"	.25"	.32"	.33"	.33"	.35"	.34"
℄ -	3	.37"	.35"	.33"	.32"	.32"	.34"	.34"	.11"	.30"	.34"	.33"	.36"	.37"	.34"	.35"	.39"	.39"	.36"	.32"	.35"
Toe	4	.32"	.32"	.32"	.32"	.32"	.34"	.34"	.32"	.30"	.35"	.34"	.35"	.34"	.34"	.35"	.36"	.32"	.35"	.35"	.35"
1" DS from ℄	5	.34"	.32"	.32"	.32"	.33"	.34"	.35"	.18"	.28"	.35"	.35"	.34"	.34"	.35"	.35"	.36"	.32"	.35"	.35"	.36"	.36"
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		U	V	W	X	Y	Z	AA	BB	—	—	—	—	—	—	—	—	* H2	—	—	—
1" US from ℄	1	.35"	.35"	.35"	.35"	.35"	.39"	.39"	.40"	—	—	—	—	—	—	—	—	16"	—	—	—
Toe	2	.34"	.35"	.32"	.32"	.32"	.34"	.36"	.34"	—	—	—	—	—	—	—	.22"	.10"	.14"	—	—
℄ -	3	.35"	.39"	.37"	.34"	.36"	.34"	.36"	.34"	—	—	—	—	—	—	—	—	.22"	—	—	—
Toe	4	.35"	.35"	.35"	.32"	.34"	.32"	.33"	.32"	—	—	—	—	—	—	—	—	—	—	—	—
1" DS from ℄	5	.36"	.37"	.36"	.35"	.35"	.33"	.33"	.33"	—	—	—	—	—	—	—	—	—	—	—	—
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Elbow

* Readings taken Approx. .25" within 5.2" of H2

LOWEST MEASUREMENT: .10" AT LOCATION: ELM. 2 RAD. H) COMMENTS: A is at Datum 0 - outside Radius of Elbow

PERFORMED BY: [signature] DATE: 12/20/90

Reviewed: N.K. 12-20-90

APPENDIX A

WALL THICKNESS MEASUREMENT RECORD SHEET

PLANT: Brunswick UNIT: 1

COMPONENT: DG #1 Inlet NOM. SIZE O.D.: 6" NOM. WALL: 0.280 MIN. WALL: 0.033 Page ___ of ___ ZONE: N/A

LINEAR SPACING: N/A RADIAL SPACING: Circle N/A STARTING AT: 1" DS from ℄ ENDING AT: 1" DS from ℄

1"

	LINEAR INCREMENT	RADIAL INCREMENT	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	S	T	U
1" US from ℄	1		.26"	.29"	.29"	.27"	.27"	.28"	.29"	.28"	.27"	.27"	.27"	.30"	.30"	.30"	.29"	.29"	.30"	.29"	.28"	.27"	.25"
Toe	2		.26"	.29"	.29"	.27"	.27"	.28"	.29"	.27"	.27"	.26"	.26"	.30"	.30"	.31"	.29"	.29"	.31"	.31"	.28"	.26"	.25"
℄	3		.34"	.38"	.37"	.38"	.39"	.40"	.32"	.30"	.30"	.28"	.30"	.31"	.34"	.32"	.31"	.33"	.32"	.30"	.29"	.34"	.33"
Toe	4		.42"	.41"	.40"	.39"	.39"	.41"	.39"	.38"	.34"	.35"	.38"	.38"	.38"	.40"	.38"	.38"	.38"	.39"	.40"	.41"	.42"
1" DS from ℄	5		.42"	.42"	.40"	.40"	.40"	.42"	.39"	.39"	.37"	.38"	.39"	.40"	.40"	.40"	.40"	.40"	.39"	.39"	.42"	.42"	.42"
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Flow

LOWEST MEASUREMENT: .25" AT LOCATION: (LIN. 1,2 RAD. U) COMMENTS: A is at Datum 0 — Outside Radius of Elbow (DS Elbow)

PERFORMED BY: [signature] DATE: 12/20/90

A.K. Ford 12-20-90

APPENDIX A

WALL THICKNESS MEASUREMENT RECORD SHEET

PLANT: Brunswick UNIT: 1

Page ___ of ___

COMPONENT: DG # 2 Inlet NOM. SIZE O.D.: 8" NOM. WALL: 0.332 MIN. WALL: 0.043 ZONE: N/A

LINEAR SPACING: N/A RADIAL SPACING: 1" STARTING AT: 1" DS from ℄ ENDING AT: 1" DS from ℄

	LINEAR INCREMENT	RADIAL INCREMENT	A	B	* C	D	E	F	G	** H	I	J	K	L	M	N	O	P	Q	R	S	T
1" US from ℄	1		.31"	.28"	.27"	.31"	.31"	.32"	.32"	.32"	.32"	.33"	.31"	.33"	.36"	.35"	.34"	.33"	.34"	.34"	.34"	.35"
Toe	2		.30"	.23"	.22"	.29"	.28"	.26"	.28"	.18"	.32"	.31"	.31"	.32"	.35"	.29"	.34"	.32"	.34"	.34"	.34"	.35"
℄	3		.31"	.29"	.28"	.32"	.32"	.32"	.32"	.33"	.35"	.37"	.36"	.38"	.38"	.38"	.37"	.37"	.37"	.36"	.36"	.36"
Toe	4		.31"	.33"	.31"	.32"	.33"	.33"	.34"	.34"	.36"	.36"	.37"	.38"	.38"	.38"	.38"	.38"	.38"	.36"	.36"	.36"
1" DS from ℄	5		.31"	.31"	.31"	.32"	.32"	.33"	.35"	.35"	.36"	.37"	.38"	.38"	.38"	.38"	.38"	.38"	.38"	.37"	.36"	.36"	.36"
			U	V	W	X	Y	Z	AA													
1" US from ℄	1		.34"	.34"	.34"	.34"	.34"	.34"	.33"													
Toe	2		.32"	.33"	.32"	.32"	.34"	.35"	.33"													
℄	3		.34"	.33"	.35"	.34"	.33"	.34"	.32"			.20"	.22"	.24"		.24"	.18"	.30"				
Toe	4		.34"	.35"	.33"	.34"	.32"	.32"	.31"				.24"				.20"					
1" DS from ℄	5		.35"	.35"	.33"	.32"	.32"	.32"	.31"													

Flow

Readings taken approx. .25" either sides of C2, H2

(*) C2 .25"

(**) H2 NR

LOWEST MEASUREMENT: .18" AT LOCATION: ELIN. 2 AZIMUTH H) COMMENTS: A is at Datum 0 - Outside Radius at Elbow

RECORDED BY: [signature] DATE: 12/20/90

A.K. Jr. 12.20.90

APPENDIX A

WALL THICKNESS MEASUREMENT RECORD SHEET

PLANT: Brunswick UNIT: 1

COMPONENT: DG #3 Inlet NOM. SIZE O.D.: 8" NOM. WALL: 0.332 MIN. WALL: 0.245 Page ___ of ___ ZONE: ___

LINEAR SPACING: N/A RADIAL SPACING: 1" STARTING AT: 1" US from ℄ ENDING AT: 1" DS from ℄

Elbow

LINEAR INCREMENT	RADIAL INCREMENT	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	S	T
1" US from ℄	1	.32"	.33"	.33"	.32"	.32"	.32"	.32"	.34"	.36"	.34"	.34"	.35"	.34"	.35"	.36"	.34"	.35"	.34"	.34"	.33"
Toe	2	.31"	.32"	.32"	.32"	.31"	.31"	.32"	.33"	.34"	.32"	.32"	.33"	.33"	.34"	.35"	.34"	.33"	.34"	.34"	.34"
℄	3	.36"	.38"	.37"	.38"	.36"	.37"	.36"	.38"	.38"	.38"	.38"	.38"	.37"	.36"	.37"	.37"	.38"	.39"	.38"	.39"
Toe	4	.32"	.32"	.33"	.34"	.32"	.34"	.34"	.36"	.35"	.35"	.35"	.36"	.35"	.34"	.35"	.36"	.37"	.36"	.37"	.36"
1" DS from ℄	5	.32"	.32"	.34"	.34"	.34"	.35"	.35"	.35"	.36"	.36"	.36"	.36"	.36"	.36"	.36"	.36"	.37"	.37"	.37"	.37"
		—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
		—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
		—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
		U	V	W	X	Y	Z	AA	—	—	—	—	—	—	—	—	—	—	—	—	—
1" US from ℄	1	.34"	.35"	.34"	.33"	.32"	.32"	.32"	—	—	—	—	—	—	—	—	—	—	—	—	—
Toe	2	.34"	.34"	.33"	.32"	.32"	.31"	.32"	—	—	—	—	—	—	—	—	—	—	—	—	—
℄	3	.38"	.37"	.37"	.36"	.38"	.35"	.35"	—	—	—	—	—	—	—	—	—	—	—	—	—
Toe	4	.35"	.34"	.34"	.32"	.33"	.33"	.32"	—	—	—	—	—	—	—	—	—	—	—	—	—
1" DS from ℄	5	.36"	.35"	.35"	.34"	.33"	.33"	.33"	—	—	—	—	—	—	—	—	—	—	—	—	—
		—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
		—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
		—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
		—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
		—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—

LOWEST MEASUREMENT: .31" AT LOCATION: ELEV. 2 RAD. 2 (A, E, F,) COMMENTS: A is at Datum 0 - Outside Radius of Elbow

PERFORMED BY: [signature] DATE: 12/20/90

AVS 12.20.90

ATTACHMENT 5
RELIEF REQUEST NO.

EER No. 88-0087
Rev. No. 0
Page No. 14 of 17

CAROLINA POWER & LIGHT COMPANY

METALLURGY UNIT MEMORANDUM

To: Harry Mayes Date: DEC 2 1987

Investigators: Ahmad Moccari MSL No.: 10-108

Reviewed by: D. A. Mauney

Approved by: Metallurgy Unit Supervisor

Distribution: Dennis Sullivan
File/Metallurgy Unit

Subject: BSEP Unit 1--Life Prediction of Service Water Pipe

Objective

The objective of this project was to determine the cause of pipe joint leaks in concrete-lined service water piping. Also, evaluate the corrosion rate of the pipe that is in service.

Background

Service water pipe at BSEP Unit 1 was leaking at several locations at the joints . Plant personnel decided to replace several hundred feet of the pi 0/30 copper-nickel alloy. The piping is 16-inch cement-lined Carbon 106 Grade B with a wall thickness of 3/4 inch. After this first r nt, they observed more leakage in old sections of the pipe. An estimate revealed that further replacement of the old pipe with 70/30 copper-nickel alloy will be very costly. In view of this situation, Metallurgy Unit assistance was requested to identify the problem, estimate the remaining life, and find alternative solutions.

Date: ~~DEC 2 1987~~ MSL No.: 10-108

Laboratory Examinations

Several sections of cement-lined pipe were sent to the Metallurgy Unit laboratories for detail examinations. The sections were photographed, radiographed, dimensioned, and then some samples were metallographically prepared for optical examination. Some chips were machined for carbon analysis of the base pipe material and the backing ring metal. Also, corrosion rate of carbon steel exposed to the service water was measured electrochemically and gravimetrically.

Results

The as-received appearance, wall thickness measurements, and radiography revealed poor joint preparation is the primary cause of the leakage. These conditions can be described as follows:

1. Presence of a crevice between the base pipe and backing ring, Figure 1.

2. Using porous cement for lining (coating) the joints after they were welded.

3. Damage in the original cement lining adjacent to the joint due to the heat release during and after welding.

4. Improper application of the cement at the joints creating rough surfaces causing more severe turbulent flow at the joints resulting in a liner leakage problem in this area.

Leakage was found at the elbow apparently due to solid object impingement. As long as the sharp angle elbow and high flow rate exists, this problem will be difficult to eliminate.

Metallographical examination and carbon analysis of the basse pipe and backing ring materials showed a microstructure typical of carbon steel and a carbon level in the range specified for Carbon Steel A 106 Grade B.

A corrosion rate of 15-20 mpy was measured electrochemically and confirmed by immersion test. This rate was measured under stagnant conditions which simulates a crevice condition under the cement lining. If the cement lining is damaged and water at the flow rate of 10 feet per second (10 feet per second was given by plant personnel) interact with the pipe material, the corrosion rate would be estimated to increase by a factor of 2 (corrosion rate would be 30/40 mpy). These observations imply that the remaining life of the pipe depends very much on the present wall thickness and the integrity of the cement coating.

Conclusions

1. Leakage at the joint is due to the improper condition of the cement lining.

2. Leakage at the elbow is due to solid object impingement.

3. Under stagnant conditions, a corrosion rate of 15/20 mpy was measured which should model the corrosion rate under the joint concrete lining. Local thickness should of course be accounted for when estimating remaining life.

Recommendations

1. Remove cement lining at the joint, clean the rust, and cover it with nonporous cement possibly coated with sealant. Use an application technique that leaves a smooth surface not raised above the original surface of the pipe lining.

2. Replace the pipe with carbon steel cladded with 70/30 copper-nickel alloy.

3. Replace the pipe with 70/30 copper-nickel alloy.

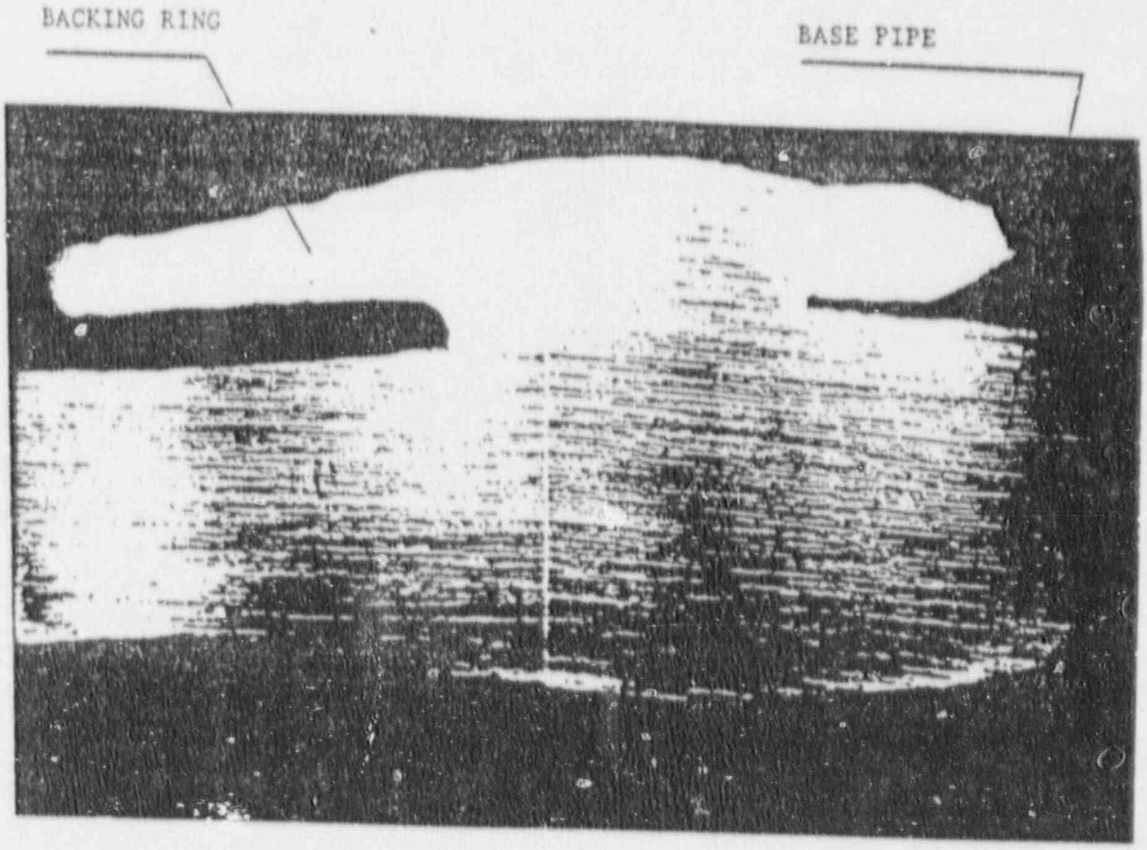

Fig. 1-Photograph showing the crevice between the base pipe and backing ring.

2. Replace the pipe with carbon steel cladded with 70/30 copper-nickel alloy.

3. Replace the pipe with 70/30 copper-nickel alloy.

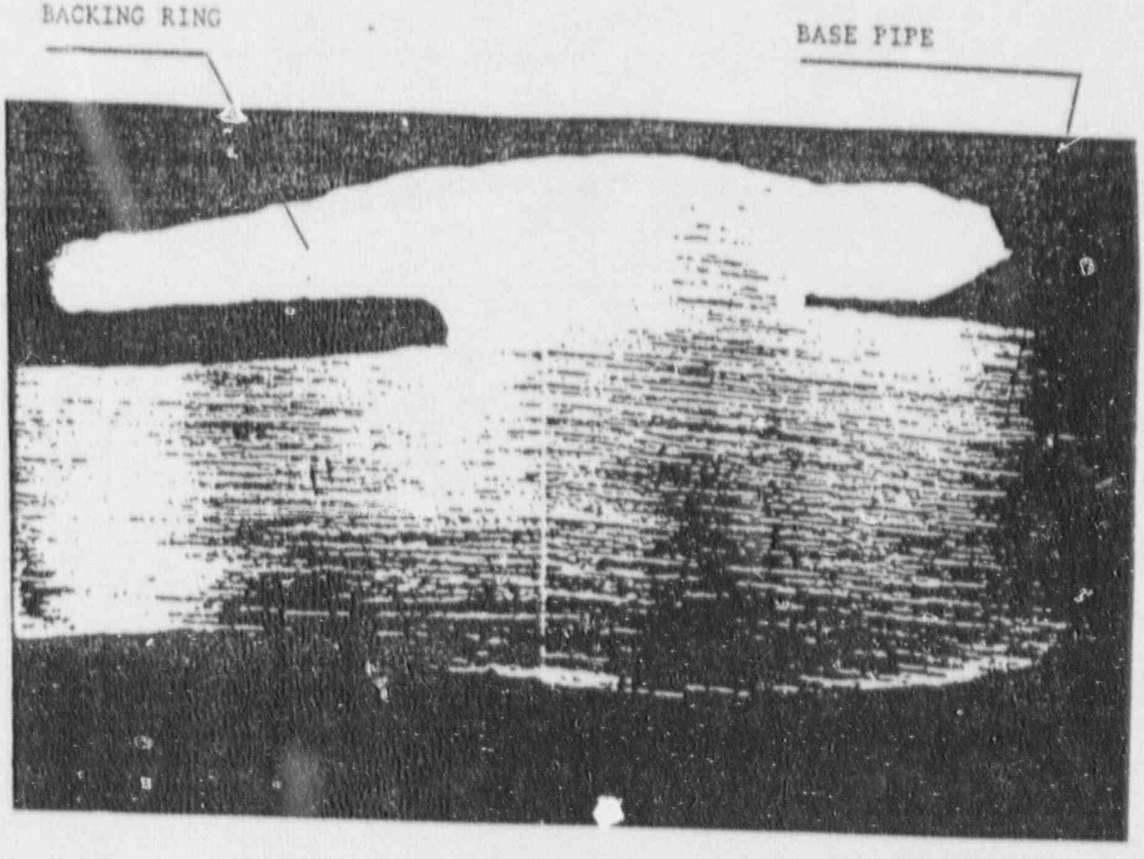

Fig. 1-Photograph showing the crevice between the base pipe and backing ring.