INDIAN POINT UNIT NO. 2

EVALUATION OF GL 96-06

FOR

OVERPRESSURIZATION

OF

ISOLATED PIPING SEGMENTS

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SUMMARY

This evaluation was performed to determine if Indian Point Unit No. 2 has isolated piping segments that are susceptible to overpressurization.

The results of the evaluation identified that potential overpressurization conditions will not cause the lines to fail, as all pipelines evaluated remain operable. This conclusion is based on piping design and plant configuration during normal, accident and post accident operating modes. The details of the system and pipe line evaluations considered are documented in this report.

1.0 BACKGROUND

As a result of recent NRC inspection activities, licensee notifications, and event reports, several safety-significant issues have been identified that have generic implications and warrant action to assure that these issues have been adequately addressed and resolved. In particular thermally induced overpressurization of isolated water-filled piping segments in containment could jeopardize the ability of accident-mitigating systems to perform their safety related functions and could also lead to a potential breach of containment integrity. On September 30, 1996 the NRC issued Generic letter 96-06, "Assurance of Equipment Operability and Containment Integrity During Design Basis Accident Conditions. This Generic Letter required that nuclear utilities address the safety-significant issues that could affect containment integrity and equipment operability during accident conditions.

2.0 PURPOSE

The purpose of this evaluation is to determine the number of isolated piping segments that are potentially susceptible to overpressurization during design basis accident conditions. A two step screening process was used to identify those piping segments. An engineering analysis was performed on those piping segments to determine operability.

3.0 SCREENING

3.1 FIRST SCREENING

The first screening contains the total population of lines penetrating containment. This table identifies all lines that contain compressible fluids versus those that are incompressible. All lines containing compressible fluids were eliminated and require no further evaluation since no significant pressures will result due to thermal expansion. See Appendix A, Table A-1 for the list of line numbers included in the first screening.

3.2 SECOND SCREENING

This screening contains a list of all lines that contain incompressible fluids. This list eliminates those isolated piping segments that are not susceptible to overpressurization. These piping segments included those with:

1.) Operating Temperature is higher than potential post-accident temperature.

2.) Line is protected against overpressurization by pressure relief path.
3.) Line inside of Containment is open ended (e.g., Containment Spray Headers).
4.) Line is not water solid.
5.) No safety-related function - no consequences upon failure

See Appendix A, Table A-2. for the list of line numbers included in the second screening.

4.0 Engineering Evaluation of Isolated Piping Segments

After the second screening, nine piping segments remain that need further evaluation. Line numbers for these nine isolated pipe segments are as follows (see Appendix A, Table A-3 for detailed list):

Line #10
Line #33
Line #40
Line #338
Sample Lines # 25, 26, 59, 69, & 474

This segment includes an individual evaluation for each of the nine piping segments that are subject to overpressurization.

4.1 Line Number 10

Line Description

Line #10 is a return line from Loop #2 Hot Leg through MOVs 730 and 731 to the suction header of the RHR pumps. Valves 730 and 731 are normally closed.

Functional Evaluation

An isolated water condition is assumed to exist in this line. Locked open valve 1819 is; however, provided for thermal relief of this line. The path would be from line #337 to line # 60 which is the suction line for the SI pumps.

This relief path (1819); however, will not vent the pipe segment between valves 730 and 731, since these valves are closed, an isolated water condition is assumed to exist between them.

An engineering calculation # FMX-00041 was done to determine what maximum temperature and pressure this line would achieve during a worst case Design Basis Accident. After the maximum pressure is determined a stress evaluation is done using the *Elastic Analysis Method* in Appendix F, of ASME segment III (see Reference 3). Appendix B provides a calculation summary and description.

Conclusion

The results of this calculation show that line #10 would exceed the design pressure for the line, but is within the operability limits set by Appendix F using the Elastic Analysis Method.

4.2 Line Number 33

Line Description

This line provides Primary Water to the cooling spray nozzles of the Pressurizer Relief Tank (PRT). The Primary Water is supplied to the PRT through two phase A containment isolation valves 519 and 552 located outside of containment and valve 560 located inside of containment.

Functional Evaluation

An isolated water condition is assumed to exist in this line. This condition would exist between containment isolation valve 519 and valve 552. These valves are 3" air operated diaphragm valves manufactured by ITT Industries with a 3250L air motor. Based upon best estimate calculations provided by the valve manufacturer (see Reference 2), valve 552 will open and vent to the PRT at a certain internal line pressure. An engineering calculation # FMX-00043 was done to determine what maximum temperature and pressure this line would achieve during a worst case Design Basis Accident

Conclusion

The line pressure for which the valve would lift results in stresses below UFSAR allowable limits. Therefore line overpressurization will not occur because valve 560 would lift and vent any line pressure to the PRT.

4.3 Line Number 40

Line Description

This line is the Reactor Coolant Drain Pump Discharge to the CVCS Waste Hold-Up Tanks. Fluid is pumped to the Hold-Up Tank through valve 1739 inside of containment and two phase A containment isolation valves 1702 and 1705 located outside of containment.

Functional Evaluation

An isolated water condition is assumed to exist in this line. This condition would exist between valve 1739 and containment isolation valve 1702. Valves 1702 and 1705 are 3" air operated diaphragm valves manufactured by ITT Industries with a 3250L air motor. . Based upon best estimate calculations provided by the valve manufacturer (see Reference 2), valves 1702 and 1705 would open and vent to the Hold-Up Tanks at a certain internal line pressure. An engineering calculation # FMX-00043 was done to determine what maximum temperature and pressure this line would achieve during a worst case Design Basis Accident. After the maximum pressure is determined a stress evaluation is done.

Conclusion

The line pressure for which the valves lift results in stresses below UFSAR allowable limits. Therefore line overpressurization will not occur because valves 1702 and 1705 would lift and vent any line pressure to the Hold-Up Tanks.

4.4 Line Number 338

Line Description

This line is the Sump Pump Discharge to the CVCS Waste Hold-Up Tanks. Fluid is pumped to the Hold-Up Tank through valve 1759 inside of containment and two phase A containment isolation valves 1728 and 1723 located outside of containment.

Functional Evaluation

An isolated water condition is assumed to exist in this line. This condition would exist between valve 1759 and containment isolation valve 1728. Valves 1728 and 1723 are 2" air operated diaphragm valves manufactured by ITT Industries with a 3225 air motor. based upon best estimate

calculations provided by the valve manufacturer (see Reference 2), valves 1728 and 1723 will open and vent to the Hold-Up Tanks at a certain internal line pressure. An engineering calculation # FMX-00044 was done to determine what maximum temperature and pressure this line would achieve during a worst case Design Basis Accident. After the maximum pressure is determined a stress evaluation is done. Appendix B provides a calculation summary and description.

Conclusion

The line pressure for which the valves lift results in stresses below UFSAR allowable limits. Therefore line overpressurization will not occur because valves 1728 and 1723 would lift and vent any line pressure to the Hold-Up Tanks.

4.5 Lines # 25, 26, 59, 69, & 474

Line Description

Lines #25 and 26 sample the Pressurizer liquid and steam spaces. Line#59 samples the hot legs from loop 1 & 3 through MOV's 955A & B inside containment and isolation valves 956 E and F outside containment. Line # 69 comes from the accumulator sample lines. This line goes through valves 956 G & H outside of containment. Line # 474 is a pressure transmitter instrument line. Lines #25, 26 and 69 are insulated.

Functional Evaluation

Sample Lines #25, 26, 59, 69, 474 are assumed to experience isolated water conditions. These lines except for line 474 are all identical in size and material and will be analyzed collectively under the same evaluation. Line 474 is smaller in size but has the same material specification.

An engineering calculation # FMX-00042 was performed to determine what maximum temperature and pressure this line would achieve during a worst case Design Basis Accident. After the maximum pressure is determined a stress evaluation is done using the *Elastic Analysis Method* in Appendix F, of ASME segment III (see Reference 3). Appendix B provides a calculation summary and description.

Conclusion

The results of the calculation for these lines show that the stresses would exceed the design pressure for the lines, but is within the operability limits

set by Appendix F using the Elastic Analysis Method. This is one of two methods in Appendix F and is the more conservative of the two. The second method takes the pipe material into the plastic range.

The analysis for line 474 is bounded by the above calculation FMX-00042 done for the sample lines since it is an identical line except that it is smaller in size.

5.0 REFERENCES

1. USNRC Generic Letter 96-06, "Assurance of Equipment Operability and Containment Integrity During Design Basis Accident Conditions," dated September 30, 1996.

2. ITT Industries letter, "Diaphragm Valves," dated January 10, 1997.

3. USNRC Generic Letter 91-18, "Information to Licensees Regarding Two NRC Inspection Manual Sections on Resolution of Degraded and Nonconforming Conditions and on Operability," dated November 7, 1991.

4. Consolidated Edison Company of New York calculation number FMX-00041, "Operability Determination of Overpressurization for RHR Letdown Line #10 Due to Rise in Containment Temperature for a Large Break LOCA."

5. Consolidated Edison Company of New York calculation number FMX-00042, "Operability Determination of Overpressurization for Sample Lines #25, 26, 59, 69 Due to Rise in Containment Temperature for a Large Break LOCA."

6. Consolidated Edison Company of New York calculation number FMX-00043, "Operability Determination of Overpressurization for RCDT Pump Discharge Line #40 and PW to PRT Spray Nozzles Line #33 Due to Rise in Containment Temperature for a Large Break LOCA."

7. Consolidated Edison Company of New York calculation number FMX-00044, "Operability Determination of Overpressurization for Containment Sump Pump Discharge Line #338 Due to Rise in Containment Temperature for a Large Break LOCA."

APPENDIX A

			TOTAL POPULATION OF LINES PENETRATING CONTAINMENT			
				FIRST SCREENING		
					Compressible	Incompressible
Item	Line No.	Penetration No.	Fluid	Function	Fluid	Fluid
1	1	A	Main Steam	28" O.D. MS supply from SG No. 22 into Turbogenerator Building.	X	
2	2	B	Main Steam	28" O.D. MS supply from SG No. 21 into Turbogenerator Building.	X	
3	3	C	Main Steam	28" O.D. MS supply from SG No. 23 into Turbogenerator Building.	X	
4	4	D	Main Steam	28" O.D. MS supply from SG No. 24 into Turbogenerator Building.	X	
5	6	E	Feedwater	18" O.D. Feedwater return to SG No. 21 from Turbogenerator Building.		X
6	5	F	Feedwater	18" O.D. Feedwater return to SG No. 22 from Turbogenerator Building.		X
7	8	G	Feedwater	18" O.D. Feedwater return to SG No. 24 from Turbogenerator Building.		X
8	7	H	Feedwater	18" O.D. Feedwater return to SG No. 23 from Turbogenerator Building.		X
9	9	J	Primary Water	12" O.D. discharge header from RHR Pumps, Nos. 21 and 22, to RHR Heat Exchangers, Nos. 21 and 22.		X
10	10	K	Primary Water	14" O.D. line from Reactor Coolant Loop S/G #22 to RHR Pumps #21,22.		X
11	11a	La	Service Water	10" O.D. line from Service Water Pumps #24,25,26 discharge to Recirc Fan Unit #21		X
12	12a	Ma	Service Water	10" O.D. line from Recirc Fan Unit #23 to Discharge Canal (line 406).		X
13	13	N	Component Cooling Water	6" O.D. line from CCW HXS #21,22 to RCP Seal & Motor Cooling		X
14	15	P	Boric Water	6" O.D. line from Containment Spray Pump #22 to Containment Spray System		X
15	16	Q	Boric Water	6" O.D. line from SI Pumps #21,22,23 to the Cold Legs of S/Gs #22,24.		X

Table **A-1**

16	12b	Mb	Service Water	**10"** O.D. line from Recirc Fan Unit #21 to Discharge Canal (line 406).	X
17	17	R	Seal Water	4" O.D. line from RCP seals to seal water heat exchanger volume control tank.	X
18	18	R	Component Cooling Water	3" O.D. line from Excess Letdown HX #21 to	

35	31	Y	Boric Water	3/4" O.D. line from hot and cold legs of RC loops & Accumulator test tank lines to RWST via line #161.		X
36	32	Y	Nitrogen	3/4" O.D. line from nitrogen line #67 to PRT #21.	X	
37	33	Y	Primary Water	3" O.D. line from Primary Water transfer Pumps to PRT #21.		X
38	34	Y	Station Air	2" O.D. line from Station Air supply header to Containment Building.	X	
39	35	Y	City Water	2" O.D. line from City Water supply header to Containment Building.		X
40	36	Y	Pressurized Air	1 1/2" O.D. line from supply header to liner Weld Channels.	X	
41	37	Y	Pressurized Air	1 1/2" O.D. line from supply header to liner Weld Channels.	X	
42	338	Y	Boric Water	2" O.D. line from sump pumps to Waste Holdup Tank via line #112.		X
43	39	Y	Instrument Air	2" O.D. line from Instrument Air supply header to Containment Building.	X	
44	11d	Ld	Service Water	10" O.D. line from Service Water Pumps #24,25,26 discharge to Recirc Fan Unit #22.		X
45	40	Z	Boric Water	3" O.D. line from Reactor Coolant Drain Pumps to Waste Holdup Tank via line #112.		X
46	41	Z	Seal Water	2" O.D. line from the Charging Pumps via line #212 to RCP #21.		X
47	42	Z	Seal Water	2" O.D. line from the Charging Pumps via line #41 to RCP #22.		X
48	43	Z	Seal Water	2" O.D. line from the Charging Pumps via line #41 to RCP #23.		X
49	44	Z	Seal Water	2" O.D. line from the Charging Pumps via line #41 to RCP #24.		X
50	594	Z	Post Accident Air Sample	3/4" O.D. line Recirc Fan #22 to Sample Vacuum Pump via line #605.	X	
51	45	AA	Generator Blowdown	2" O.D. line from S/G #22 to S/G Blowdown Tank.		X
52	46	BB	Generator Blowdown	2" O.D. line from S/G #21 to S/G Blowdown Tank.		X
53	47	CC	Generator Blowdown	2" O.D. line from S/G #23 to S/G Blowdown Tank.		X
54	48	DD	Generator Blowdown	2" O.D. line from S/G #24 to S/G Blowdown Tank.		X
55	49	EE	Purge Air	36" O.D. from Fan Room to Containment Building.	X	
56	50	FF	Purge Air	36" O.D. from Containment Building to Fan Room.	X	
57	51	GG	Boric Water	8" O.D. from Containment Spray Pumps #21,22 to Containment Spray System.		X

58	52	JJ	Component Cooling Water	16" O.D. from the RHR Hx #22 to CCW Pumps.		X
59	53	KK	Component Cooling Water	16" O.D. from CCW Pumps to RHR Hx #22.		X
60	56	NN	Boric Water	6" O.D. from SI Pumps # 21,22, 23 to the Hot Legs of S/Gs # 21,23.		X
61	57	OO	Water	18" O.D. line from Containment Sump to RHR Pumps.		X
62	60	QQ	Borated Water	8" O.D. from RHR Hx #21 to SI Pumps # 21,22,23.		X
63	58	PP	Containment Air	10" O.D. line from Containment Building to Fan Room.	X	
64	65	RR	Air	1" O.D. line from Radiation Monitor to Containment Building	X	
65	66	RR	Air	1" O.D. line from Containment Building to Radiation Monitor.	X	
66	529	RR	Spare		*	
67	68	RR	Nitrogen	1" O.D. line from Nitrogen Manifold to Accumulator Tanks.	X	
68	69	RR	Sampling	3/8" O.D. line from Accumulator Tanks to Sampling System.		X
69	474	RR	Instrument Line	1" O.D. line from the Pressurizer to PT-4588.		X
70	368	RR	Containment Air	3/4" O.D. line from inside Containmnet Building to a condensate pot & PT-948A, PT-949A.	X	
71	788	RR	Sampling Waste	3/4" O.D. line from the HRSS Collection Tank to the Containment Sump Pit.		X
72	LIS-1321	RR	Instrument Filled Capillary Tubing	3/4" O.D. line from Reactor Head Level Pot to Hydraulic Isolator Rack (Trench Area)		X
73	LIS-1322	RR	Instrument Filled Capillary Tubing	3/4" O.D. line from Reactor Head Level Pot to Hydraulic Isolator Rack (Trench Area)		X
74	25	W	Sampling	3/8" O.D. line from the Pressurizer Steam Space to the Sampling System.		X
75	26	W	Sampling	3/8" O.D. line from the Pressurizer LIquid Space to the Sampling System.		X
76	59	W	Sampling	3/8" O.D. line from Reactor Coolant Loop of S/Gs #22,23 to the Sampling System.		X
77	364	W	Sampling	1/2" O.D. line from Blowdown Line S/G #21 to Sampling System.		X
78	365	W	Sampling	1/2" O.D. line from Blowdown Line S/G #22 to Sampling System.		X
79	366	W	Sampling	1/2" O.D. line from Blowdown Line S/G #23 to Sampling System.		X

80	367	W	Sampling	1/2" O.D. line from Blowdown Line S/G #24 to Sampling System.		X
81	54	LL	Cooling Water	3" O.D. line from the Recirc Aux Cooling Pumps to the SI System Recirculation Pumps.		X
82	55	LL	Cooling Water	3" O.D. line from the SI System Recirculation Pumps to line #52.		X
83	369	LL	Containment Air Test	3/4" O.D. line from Containment Building to Condensate Pot.	X	
84	608	LL	Post Accident Air Sample	3/4" O.D. line from the Recirc Fan #21 to Sampling Vacuum Pump Line # 605.	X	
85	629	LL	Post Accident Venting System	3" O.D. line from manually operated Containment Isolation Valves to Fan Cooler Filter Unit #22.	X	
86	LIS-1311	LL	Instrument Filled Capillary Tubing	1" O.D. line from Reactor Head Level Pot to the Hydraulic Isolation Rack in the Trench Area.		X
87	LIS-1312	LL	Instrument Filled Capillary Tubing	1" O.D. line from Reactor Bottom Level Pot to the Hydraulic Isolation Rack in the Trench Area.		X
88	495	SS	Service Water	2" O.D. line from Recirc Fan #24 Motor Cooler to Line # 494.		X
89	496	SS	Service Water	2" O.D. line from Recirc Fan #23 Motor Cooler to Line # 494.		X
90	497	SS	Service Water	2" O.D. line from Recirc Fan #21 Motor Cooler to Line # 494.		X
91	498	SS	Service Water	2" O.D. line from Recirc Fan #22 Motor Cooler to Line # 494.		X
92	499	SS	Service Water	2" O.D. line from Recirc Fan #25 Motor Cooler to Line # 494.		X
93	575	SS	Hydrogen	2" O.D. line from Hydrogen Gas Stand #21 to Containment Building Hydrogen Recombiner #21.	X	
94	576	SS	Hydrogen	3/4" O.D. line from Hydrogen Gas Stand #21 to Containment Building Hydrogen Recombiner #21.	X	
95	573	TT	Hydrogen	2" O.D. line from Hydrogen Gas Stand #22 Section B to Containment Building Hydrogen Recombiner #22.	X	

Table A-1

96	574	TT	Hydrogen	3/4" O.D. line from Hydrogen Gas Stand #22 Section B to Containment Building Hydrogen Recombiner #22.	X	
97	595	TT	Sampling	3/8" O.D. line from the Recirculation Pumps #21,22 to line #59.		X
98	606	TT	Post Accident Air Sample	3/4" O.D. line from Recirculation Fan Unit #24 to Sample Vacuum Pump via line #605.	X	
99		UU	Containment Air Test	6" O.D. line from Air Compressors to Containment Building.	X	
100		VV	Containment Air Test	6" O.D. line from Containment Building to Pipe Trench Atmosphere..	X	
101	14	OO	Component Cooling Water	6" O.D. line from RCS Pumps Motor cooling and seals to CCW Pumps #21,22,23 via line #52.		X
102	14a	OO	Component Cooling Water	3" O.D. line from RCS Pumps Motor cooling and seals to CCW Pumps #21,22,23 via line #52.		X
103	571	OO	Oxygen	1" O.D. line from the Oxygen Gas Stand Fan House to Containment Building.	X	
104	370	OO	Containment Air (test)	3/4" O.D. line from inside Containment Building to Condensate Pot.	X	
105	572	OO	Post Accident Air Sample	3/4" O.D. line from the Sample Vacuum Pump via Line #557 to Containment Building Atmosphere.	X	
106	605	OO	Service Water	3/4" O.D. line from the Recirc Fan Unit #25 to the Vacuum Sample Pump header.	X	
107	12e	Me	Service Water	10" O.D. line from the Recirc Fan #25 to Discharge Canal (line #406).		X
	Notes					
	Asterisk (*) Indicates that this is an inactive spare line.					

TOTAL POPULATION OF LINES CONTAINING INCOMPRESSIBLE FLUIDS THAT PENETRATE CONTAINMENT

SECOND SCREENING

Item	Line No.	Penetration No.	Fluid	Function	Evaluation Required	Remarks see notes
1	6	E	Feedwater	18" O.D. Feedwater return to SG No. 21 from Turbogenerator Building.	No	1,2,4
2	5	F	Feedwater	18" O.D. Feedwater return to SG No. 22 from Turbogenerator Building.	No	1,2,4
3	8	G	Feedwater	18" O.D. Feedwater return to SG No. 24 from Turbogenerator Building.	No	1,2,4
4	7	H	Feedwater	18" O.D. Feedwater return to SG No. 23 from Turbogenerator Building.	No	1,2,4
5	9	J	Primary Water	12" O.D. discharge header from RHR Pumps, Nos. 21 and 22, to RHR Heat Exchangers, Nos. 21 and 22.	No	2
6	10	K	Primary Water	14" O.D. line from Reactor Coolant Loop S/G #22 to RHR Pumps #21,22.	Yes	
7	11a	La	Service Water	10" O.D. line from Service Water Pumps #24,25,26 discharge to Recirc Fan Unit #21	No	2
8	12a	Ma	Service Water	10" O.D. line from Recirc Fan Unit #23 to Discharge Canal (line 406).	No	2
9	13	N	Component Cooling Water	6" O.D. line from CCW HXS #21,22 to RCP Seal & Motor Cooling	No	2
10	15	P	Boric Water	6" O.D. line from Containment Spray Pump #22 to Containment Spray System	No	2,3
11	16	Q	Boric Water	6" O.D. line from SI Pumps #21,22,23 to the Cold Legs of S/Gs #22,24.	No	2
12	12b	Mb	Service Water	10" O.D. line from Recirc Fan Unit #21 to Discharge Canal (line 406).	No	2
13	17	R	Seal Water	4" O.D. line from RCP seals to seal water heat exchanger volume control tank.	No	2
14	18	R	Component Cooling Water	3" O.D. line from Excess Letdown HX #21 to CCW Pumps #21,22,23 via line #14,52.	No	2
15	19	R	Charging Water	3" O.D. line from Charging Pumps to Regenerative Heat Exchanger.	No	2
16	22	U	Component Cooling Water	3" O.D. from CCW HX #21,22 via line #13 to Letdown Excess HX #21.	No	2
17	12d	Md	Service Water	10" O.D. from Recirc Fan #22 to Discharge Canal (line 406).	No	2
18	21	T	Condensate	3" O.D. line from the Turbine area to the Containment Building.	No	2,4

19	27	X	Letdown Primary Water	2" O.D. line from the Regenerative HX #21 to the Non-Regenerative HX #21.	No	2
20	11c	Lc	Service Water	10" O.D. line from Service Water Pumps #24,25,26 discharge to Recirc Fan Unit #24	No	2
21	12c	Mc	Service Water	10" O.D. from Recirc Fan #24 to Discharge Canal (line 406).	No	2
22	11b	Lb	Service Water	10" O.D. line from Service Water Pumps #24,25,26 discharge to Recirc Fan Unit #23.	No	2
23	11e	Le	Service Water	10" O.D. line from Service Water Pumps #24,25,26 discharge to Recirc Fan Unit #25.	No	2
24	31	Y	Boric Water	3/4" O.D. line from hot and cold legs of RC loops & Accumulator test tank lines to RWST via line #161.	No	2
25	33	Y	Primary Water	3" O.D. line from Primary Water transfer Pumps to PRT #21.	Yes	
26	35	Y	City Water	2" O.D. line from City Water supply header to Containment Building.	No	5
27	338	Y	Boric Water	2" O.D. line from sump pumps to Waste Holdup Tank via line #112.	Yes	
28	11d	Ld	Service Water	10" O.D. line from Service Water Pumps #24,25,26 discharge to Recirc Fan Unit #22.	No	2
29	40	Z	Boric Water	3" O.D. line from Reactor Coolant Drain Pumps to Waste Holdup Tank via line #112.	Yes	
30	41	Z	Seal Water	2" O.D. line from the Charging Pumps via line #212 to RCP #21.	No	2
31	42	Z	Seal Water	2" O.D. line from the Charging Pumps via line #41 to RCP #22.	No	2
32	43	Z	Seal Water	2" O.D. line from the Charging Pumps via line #41 to RCP #23.	No	2
33	44	Z	Seal Water	2" O.D. line from the Charging Pumps via line #41 to RCP #24.	No	2
34	45	AA	Generator Blowdown	2" O.D. line from S/G #22 to S/G Blowdown Tank.	No	1,4
35	46	BB	Generator Blowdown	2" O.D. line from S/G #21 to S/G Blowdown Tank.	No	1,4
36	47	CC	Generator Blowdown	2" O.D. line from S/G #23 to S/G Blowdown Tank.	No	1,4
37	48	DD	Generator Blowdown	2" O.D. line from S/G #24 to S/G Blowdown Tank.	No	1,4
38	51	GG	Boric Water	8" O.D. from Containment Spray Pumps #21,22 to Containment Spray System.	No	3,4
39	52	JJ	Component Cooling Water	16" O.D. from the RHR Hx #22 to CCW Pumps.	No	2
40	53	KK	Component Cooling Water	16" O.D. from CCW Pumps to RHR Hx #22.	No	2
41	56	NN	Boric Water	6" O.D. from SI Pumps # 21,22, 23 to the Hot Legs of S/Gs # 21,23.	No	2
42	57	OO	Water	18" O.D. line from Containment Sump to RHR Pumps.	No	3
43	60	QQ	Borated Water	8" O.D. from RHR Hx #21 to SI Pumps # 21,22,23.	No	2
44	69	RR	Sampling	3/8" O.D. line from Accumulator Tanks to Sampling System.	Yes	
45	474	RR	Instrument Line	1" O.D. line from the Pressurizer to PT-4588.	Yes	

46	788	RR	Sampling Waste	3/4" O.D. line from the HRSS Collection Tank to the Containment Sump Pit.	Yes	3
47	LIS-1321	RR	Instrument Filled Capillary Tubing	3/4" O.D. line from Reactor Head Level Pot to Hydraulic Isolator Rack (Trench Area)	Yes	2
48	LIS-1322	RR	Instrument Filled Capillary Tubing	3/4" O.D. line from Reactor Head Level Pot to Hydraulic Isolator Rack (Trench Area)	Yes	2
49	25	W	Sampling	3/8" O.D. line from the Pressurizer Steam Space to the Sampling System.	Yes	
50	26	W	Sampling	3/8" O.D. line from the Pressurizer LIquid Space to the Sampling System.	Yes	
51	59	W	Sampling	3/8" O.D. line from Reactor Coolant Loop of S/Gs #22,23 to the Sampling System.	Yes	
52	364	W	Sampling	1/2" O.D. line from Blowdown Line S/G #21 to Sampling System.	No	1
53	365	W	Sampling	1/2" O.D. line from Blowdown Line S/G #22 to Sampling System.	No	1
54	366	W	Sampling	1/2" O.D. line from Blowdown Line S/G #23 to Sampling System.	No	1
55	367	W	Sampling	1/2" O.D. line from Blowdown Line S/G #24 to Sampling System.	No	1
56	54	LL	Cooling Water	3" O.D. line from the Recirc Aux Cooling Pumps to the SI System Recirculation Pumps.	No	2
57	55	LL	Cooling Water	3" O.D. line from the SI System Recirculation Pumps to line #52.	No	2
58	LIS-1311	LL	Instrument Filled Capillary Tubing	1" O.D. line from Reactor Head Level Pot to the Hydraulic Isolation Rack in the Trench Area.	Yes	2
59	LIS-1312	LL	Instrument Filled Capillary Tubing	1" O.D. line from Reactor Bottom Level Pot to the Hydraulic Isolation Rack in the Trench Area.	Yes	2
60	495	SS	Service Water	2" O.D. line from Recirc Fan #24 Motor Cooler to Line # 494.	No	2
61	496	SS	Service Water	2" O.D. line from Recirc Fan #23 Motor Cooler to Line # 494.	No	2
62	497	SS	Service Water	2" O.D. line from Recirc Fan #21 Motor Cooler to Line # 494.	No	2
63	498	SS	Service Water	2" O.D. line from Recirc Fan #22 Motor Cooler to Line # 494.	No	2
64	499	SS	Service Water	2" O.D. line from Recirc Fan #25 Motor Cooler to Line # 494.	No	2

65	595	TT	Sampling	3/8" O.D. line from the Recirculation Pumps #21,22 to line #59.	No	3
66	14	OO	Component Cooling Water	6" O.D. line from RCS Pumps Motor cooling and seals to CCW Pumps #21,22,23 via line #52.	No	2
67	14a	OO	Component Cooling Water	3" O.D. line from RCS Pumps Motor cooling and seals to CCW Pumps #21,22,23 via line #52.	No	2
68	12e	Me	Service Water	10" O.D. line from the Recirc Fan #25 to Discharge Canal (line #406).	No	2
	Notes					
	1.) Operating Temperature is higher than potential post-accident temperature.					
	2.) Line is protected against overpressurization by pressure relief path.					
	3.) Line inside of Containment is open ended (e.g., Containment Spray Headers).					
	4.) Line is not water solid.					
	5.) No safety-related function - no consequences upon failure					

TOTAL POPULATION OF LINES CONTAINING INCOMPRESSIBLE FLUIDS THAT PENETRATE CONTAINMENT AND REQUIRE EVALUATION

Item	Line No.	Penetration No.	Fluid	Function
1	10	K	Primary Water	14" O.D. line from Reactor Coolant Loop S/G #22 to RHR Pumps #21,22.
2	33	Y	Primary Water	3" O.D. line from Primary Water transfer Pumps to PRT #21.
3	338	Y	Boric Water	2" O.D. line from sump pumps to Waste Holdup Tank via line #112.
4	40	Z	Boric Water	3" O.D. line from Reactor Coolant Drain Pumps to Waste Holdup Tank via line #112.
5	69	RR	Sampling	3/8" O.D. line from Accumulator Tanks to Sampling System.
6	474	RR	Instrument Line	1" O.D. line from the Pressurizer to PT-4588.
7	25	W	Sampling	3/8" O.D. line from the Pressurizer Steam Space to the Sampling System.
8	26	W	Sampling	3/8" O.D. line from the Pressurizer Liquid Space to the Sampling System.
9	59	W	Sampling	3/8" O.D. line from Reactor Coolant Loop of S/Gs #22,23 to the Sampling System.

APPENDIX B

Calculation Description & Summary

OBJECTIVE OF CALCULATION

To determine if pressure stresses caused by the thermal expansion of water due to rise in containment temperature in isolated piping sections will exceed FSAR criteria in Table 1.11-2 or operability stress criteria shown in Appendix F of ASME Section III for Elastic Analysis after the occurrence of a Design Basis Accident.

CALCULATION METHOD/ASSUMPTIONS

1. The line is considered to be completely air free and full of standing water. (overly conservative)
2. A heat transfer analysis is performed to find the rise in water temperature inside the pipe due to the changing temperature of the containment atmosphere. This analysis is done in accordance with: "STANDARDS OF TUBULAR EXCHANGERS MANUFACTURERS ASSOCIATION", 5TH Edition, 1968.
3. The consequent rise in pressure is found using the bulk modulus of water according to "MARKS' STANDARD HANDBOOK FOR MECHANICAL ENGINEERS.", 9th edition.
4. The pressure calculated in item 3. above is used in the equations for both longitudinal and hoop stresses due to occasional loads, from ASME B31.1, 1989 Edition. The criteria shown in Table 1.11-2 of the FSAR is applied to the results. If the stresses in the pipe exceed FSAR criteria then an operability analysis is done using appendix F, section III of the code. For an operability evaluation, the use of criterea from the later code (Appendix F) is justified as per GL 91-18 untill the next refueling outage. The allowable stresses for design are per FSAR.

DESIGN BASIS AND REFERENCES

A large break LOCA design basis is applicable for this calculation.

1. Standards of Tubular Exchangers Manufacturers Assoc., TEMA 5th Edition.
2. Marks' Standard Handbook for Mechanical Engineers, Marks, 9th Edition.
3. ASME B31.1, 1989 Edition.
4. Principles of Heat Transfer, Kreith, 5th Edition.
5. ASME Section III, 1989 Edition.
6. Thermodynamic Properties of Steam, Keenan & Keyes, 1st Edition
7. 1980 Annual Book of ASTM Standards, part 1, ASTM
8. Ladish Fitting Catalog #55, 1955

SYMBOLS

A_i Effective inside heat transfer surface area, ft^2
A_o Effective outside heat transfer surface area, ft^2
c_p Specific heat at constant pressure, Btu/lbm. °F
D_i Inside diameter, in
D_o Outside diameter, in
Es Bulk modulus of elasticity for an isentropic process, lb/in^2
h_i Inside Convective film coefficient, Btu/hr.ft^2.°F
h_o Outside Convective film coefficient, Btu/hr.ft^2.°F
k_w Thermal Conductivity, Btu/hr.ft^2.°F
L Length , ft
M_A Dead weight and thermal load, lbf-in
M_B Seismic load, lbf-in

m Mass, lbm
P Pressure, lbf/in^2
P_D Design pressure, lbf/in^2
P_m Primary membrane stress intensity, lbf/in^2
r_i Inside fouling resistance, hr.ft^2.°F/Btu
r_I Insulation resistance, hr.ft^2.°F/Btu
r_o Outside fouling resistance, hr.ft^2.°F/Btu
r_w Conductive resistance, hr.ft^2.°F/Btu
S_m Membrane stress, psi
S_u Tensile strength, psi
S_y Yield strength, psi
SE Allowable stress, ksi
t time, seconds
$tmin$ Minimum wall thickness, in
t_n Nominal thickness, in
T_o Outside temperature, °F
T_w Water Temperature, °F
U Overall heat transfer coefficient, Btu/hr.ft^2.°F
Q Heat transfered. Btu/hr
v Specific volume, lbm/ft^3
$vsat$ Specific volume at saturation , lbm/ft^3
V_w Volume of water, ft^3
V_p Volume of pipe using inside diameter, ft^3
W Weight of pipe /ft.
x_w Wall thickness, in
Z Section modulus, in^3

Greek letters

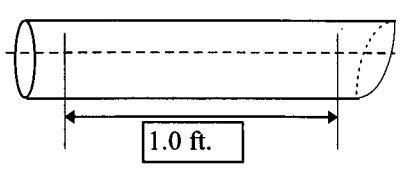
α Coefficient of linear expansion, ft/ °F
Δ Difference
ρ Density, lbm/ ft^3

I-Temperature of Containment Atmosphere as a Function of Time-Exhibit A

The containment temperature profile was taken from figure 14.3-104J of the FSAR ,Chapter 14 (Rev.13). This is a curve for containment temperature as a function of time after a double-ended pump suction break with minimum safeguards. This figure was recently corrected by Westinghouse. The corrected figure was used to find $T_o(t)$. (The corrected figure shows containment temperature reaching higher temperatures than the current FSAR curve).

II-Heat Transfer to the Pipe

Consider a one foot section of pipe:



An integrated heat transfer approach was used using the containment temperature profile as a driver. The heat inputed into the pipe was calculated at each time interval. The time intervals chosen followed the logorithmic scale shown on the absisca of Exhibit A . The rate of temperature rise in the pipe was also calculated at each interval and this gave us the temperature of the water in the pipe at each time interval.

Basic heat transfer relationship: $Q = A_o U \Delta T$,.....Ref.1, p.122

where $\Delta T = T_o(t) - T_w(t)$, and

$U = 1/[1/h_o + r_o + r_w + r_I + r_i(A_o/A_i) + 1/h_i(Ao/Ai)]$

k_w *was allowed to vary with temperature* ....Ref. 2, p.4-81

$r_w(0) = x_w/k_w ln(A_o/A_i)$, & $rI = x_I/k_I ln(D_{Io}/D_{Ii})$, *(If insulated)*

Heat transfer surface Area, $A_o = \pi D_o.L$ / *or* $= \pi D_{Io}.L$ *(If insulated)*

The diameter and the length of the pipe was allowed to vary with temperature. This was done by using the the coefficient of thermal expansion for this type of material. The diameter and the length of an initial one foot section of pipe are therefore dependant on the temperature of containment atmosphere which is a function of time. Therefore:

$D_o(t) \doteq D_o(0).[1+\alpha.[T_o(t) - T_o(0)]]$,...Ref. 2, p.4-2.

$L(t) = L(0)[1+\alpha.[T_o(t) - T_o(0)]]$,... Ref. 2, p.4-2

$\alpha = 9.29E\text{-}6\ ft/^oF$,...Ref 5. Appendix I, Table I-5.0

So, the heat transfered to the pipe as a function time:
$Q(t) = (U(t))(A_o(t))(\Delta T(t))$
and this is done at every time interval. We will then have integrated results of $Q(t)$ over 1E6 seconds.

Temperature Rise in Pipe

Using the heat $Q(t)$ that was calculated at every time interval, we now calculate the rate of temperature rise in the pipe for that time interval. Notice that this rate of temperature change is time dependent and is different for every time interval

$dT/dt = Q(t)/[m.c_p.(60sec/min)]$, in, $^oF/min$

Temperature of water in pipe

The temperature of the water inside the pipe is now calculated at every time interval using the rate of temperature rise that we had just calculated, so:

$$T_w(t+\Delta T) = T_w(t_1) + \frac{\Delta T_w}{\Delta t}(t)[\Delta t/60]$$

Column 3of Exhibit B shows the integrated results of $T_w(t)$ as a function of time.

Specific Volume in the pipe

Now that we have a temperature profile for the water in the pipe, column 18 (*vsat(t)*) of Exhibit B has the corresponding specific volume at saturation profile....Ref 6, p.28, Table 1

III-Pressure in the Pipe

The pressure of the water in the pipe is now calculated using the bulk modulus method.The bulk modulus of elasticity is the ratio of the pressure stress to the volumetric strain. For ideal gases $E_s = kp$ for an isentropic process where k is the ratio of the specific heats. For liquids, a mean value is used by integrating the equation over a finite interval: Integration limits were found using Table 4 of Ref. 6 p.74 for water as a comperessed liquid

$E_s = - v_1 (\Delta p/\Delta v)$,....Ref. 2, p.3-36

For pressures above 6000 psia the bulk modulus was extrapolated from the data in Ref. 6 Table 4 p.74.
See Exhibit C.

In order to find the pressure in the pipe the actual specific volume of the water at a specific time interval must be found and is subtracted from the specific volume at saturation at that same time interval. Since the water expands more than the pipe the difference in volume results in a pressure difference that is proportional to the bulk modulus at that time interval.

Interior Volume of Pipe at time t for a one foot section

$$V_p(t) = \frac{\pi (D_i(t))^2}{4} \cdot L(t)$$

This is equal to the volume of water at time *t*. Dividing this volume by the mass gives us the specific volume at time *t*.

$v(t) = V_p(t)/m$

Change in pressure at time t

$\Delta P(t) = E_s(t)[v(t) - vsat(t)]/v(t)$...Ref 2, p.3-36

IV-Stress Analysis

Maximum Allowable Hoop Stress

FSAR criteria for hoop stress:

$P_m < or = 1.2\,S$ ...from FSAR table 1.11-2

If calculated thermal stresses in the pipe exceed FSAR criterea then an operability analysis is performed in accordance with the requirments of GL91-18, section 6.13. GL 91-18 provides requirements for piping and supports which in turn endorses the use of appendix F. This criterea is intended to qualify ASME Class 1 & 2 piping. Use of this criterea for IP2 can only be considered for operability
For operability from appendix F of Section III, F-1331.1 Elastic Analysis:

$P_m < or = 2.4\,S_m$ & $< or = 0.7\,S_u$, Lowest of the two conditions applies ,...Ref 5, Appendix F, p.561

Note: S_m is for class 1 only. For material not specified as class 1 substitute S from B31.1 for S_m

Maximum Allowable Pressure

$P = \frac{2 P_m t}{D_o - 2yt}$,....Ref 3, p.31

This is our maximum allowable pressure in the pipe.

Longitudinal Stress

Two conditions must be satisfied:

(1) $\frac{P D_o}{} < or = P_m$, ;

(2) $\frac{P D_o}{4 t_n} + \frac{0.75 i M_A}{Z} + \frac{0.75 i M_B}{Z}$, <or $=KS_h$....Ref 3, p.30

FSAR criteria states that equation (2) must be less than 1.2S (S is allowable stresses out of B31.1). If Pipe does not meet this criteria then operability under Appendix F requires that $Ks_h = 2 S_y$ (from Appendix F)

S_y = *yield stress*

$i = 1.3$,...Ref 3, p.224, note 11.

$M_A = \frac{WL^2}{8}$, *where W = weight of pipe per foot.*

From FSAR (1.11.4.16.1); $0.75 I M_A/Z = 3000 psi$