Probability of a Flaw (@specified year/weld): The probability of an unacceptable flaw in the segment's "most likely to fail" weld (or typical weld, if they are viewed as clones) at the current age of the weld (usually the current age of the plant unless the pipe has been repaired or replaced). An unacceptable flaw is defined by the ASME Section XI Code. This has been defined as $a/t > 0.10$ and is obtained from the probabilistic fracture mechanics code (e.g., SRRA).

Probability of Detection: The estimated probability that the inspection method used will be able to detect an unacceptable flaw, given that the flaw is in the weld selected for sample examination. A low assumed probability of detection (POD) results in conservative confidence levels for the sample plans. A POD of 0.2 is considered to be a conservatively low value.

Conditional Probability of Leak/Year/Weld: This input can also be called the conditional leak rate. A failure of a weld may be defined to be a pipe rupture or, more conservatively, as a pipe leak, the leak being a typical precursor to a rupture. In the Perdue Model this is defined as a leak and the same probabilistic fracture mechanics code (e.g., SRRA) that generates the Probability of a Flaw can generate the leak rate conditional on the existence of the unacceptable flaw. This value is an average yearly leakage rate for the remaining life of the plant.

Single Sample Size: Any sample size that is less than or equal to the number of welds (or elements) in the lot can be selected.

Target Leak Rate/Year/Weld: The maximum allowable leak rate per year per weld. This value is required for the calculation of consumer risk. If the application is limited to calculating the probability distributions on number of flaws or leak rates, then this input is not required. Industry experience, currently being captured in industry pipe failure data base efforts, can be used to provide a basis for this value.

Table 3.7-1 provides some suggested target leak rates based on current operating experience (NRC 1997) that can be evaluated in the Perdue model. The values shown are for illustrative purposes and can be further adjusted based on other factors such as type of failure mechanism of concern. Data from SKI (1996) can be used in this assessment along with other data continuing to be captured in ongoing industry efforts.

Table 3.7-1 SUGGESTED TARGET LEAK RATES (PER YEAR/PER WELD) FOR PERDUE MODEL (NRC 1997)			
Material	**Nominal Pipe Size (inches)**		
	≤1	**1 < Diameter < 4**	**≥4**
Stainless Steel	1.0E-5	1.0E-5	1.0E-6
Ferritic Steel	1.0E-5	1.0E-6	5.0E-6

The outputs from the model are:

Target Leak Rate/Year/Lot: This is equal to the number of welds in the lot times the target leak rate/year/weld.

Implied Leak Rate/Year/Lot: For every possible number of flaws in a lot, there is a corresponding failure or leak rate which is closely approximated by the product of the conditional leak rate/weld and the number of indicated flaws.

Binomial Probability of k Flaws: This is the binomial distribution probability of getting a specified number of flaws (k) based on the lot size and the probability of the flaw existing. The sum of the probabilities is also provided.

Pre-ISI (i.e., no ISI) Probability of k Flaws: This is the cumulative probability distribution of the leak rate in the absence of any inspection.

Single Sample Plan (Probability of Detection (POD) equals 1) Probability of k or Less Flaws: This is the likelihood that the sample plan will pass the lot for the true number of flawed welds. The single sample plan rejects the entire lot if one flaw is found. The lot is accepted if no flaws are found.

Single Sample Plan (User Specified POD) Probability of k or Less Flaws: This is the same type of output as discussed in the previous paragraph except that the POD is specified by the user.

Double Sample Plan (Each Sample Size Equals 1) Probability of k or Less Flaws: This is the likelihood that the sample plan will pass the lot for the true number of flawed welds, using a double sampling as illustrated in Figure 3.7-2. For these probabilities, it is assumed that each sample consists of one weld.

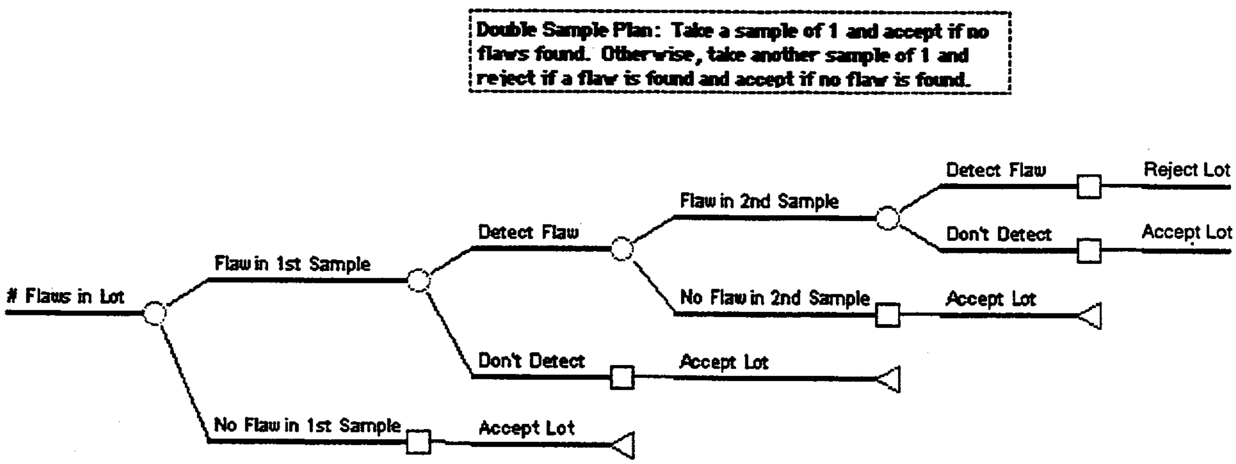


Figure 3.7-2 Decision Tree for a Double Sample of Initial Size=1 (Plan H)
Double Sample Plan: Take a sample of 1 and accept if no flaws found. Otherwise, take another sample of 1 and reject if a flaw is found and accept if no flaw is found.

Double Sample Plan (Each Sample Size Equals 2) probability of k or less flaws: This is the same type of output as discussed for the previous output except that each sample consists of two welds.

Consumer Risk: This is the probability of a leak rate for the lot exceeding the target leak rate for that lot, for each sample plan.

Confidence: This is one minus the consumer risk probability.

Variance: The variance for each plan is determined by using the difference between the mean leak rate and the implied leak rate, and the corresponding binomial probability.

Probability of Sampling 100% of the Lot: This is one minus the probability of accepting the lot calculated for each sample plan.

The model should be used to assist in defending a minimum number of examination locations for the following two situations:

- For highly reliable piping segments (or portions thereof) that have been categorized as high safety significant where examinations may be added, reallocated, or reduced from current ASME Section XI program requirements; a minimum of one location is specified even if the model shows 100% confidence with no ISI.

- For highly reliable piping segments (or portions thereof) that have been categorized as low safety significant where examinations may be reduced from current ASME Section XI program requirements; it is acceptable to define no examinations for these segments as long as a 95% confidence level exists that the piping segment will not exceed its target leak rate.

Use of the model in these two situations will assist in defending that current safety margins are maintained and that defense-in-depth is not compromised by implementation of risk-informed ISI programs for piping versus current ASME Section XI inservice inspection requirements.

Different inputs as may be appropriate for a different segment or lot will produce different outputs for each plan so that a risk profile can be produced on a segment-by-segment basis. These inspection plans are viewed as part of a reliability demonstration process which has the following steps:

- Define appropriate lots for sampling.

- Evaluate the ability of each inspection plan to achieve the target reliability in each lot.

- If a segment is divided into multiple lots, evaluate the ability of the aggregated lot-specific choices to achieve the segment target reliability. This can be estimated by comparing the product of the individual lot confidences for a given segment to a limit value (95%).

A 95% confidence or assurance that the target leak frequency goal will be met was chosen as an acceptable objective for the segment in question. Both the mean leak rate and the estimated confidence level are used in evaluating the inspection plans. The choice of an acceptable plan also considers the projected number of flaws in conjunction with the leak rate statistics and confidence levels.

For Surry Unit 1, the Perdue model was applied to the high safety significant segments, where appropriate, to assist in defining the minimum number of inspection locations that are required for examination in each segment. More than 60 high safety significant pipe segments were evaluated. In addition, the Perdue model was applied to 75 low safety significant pipe segments where current ASME Section XI nondestructive examinations are recommended to be eliminated from the ISI program at Surry Unit 1. These additional evaluations were performed to verify that the current exams could be eliminated in these segments while maintaining a high level of reliability (i.e., insuring that the leak rate post RI-ISI is no greater than current leak rates).

Table 3.7-2 provides an example of the Perdue model for a Surry-1 high head injection piping segment where the cumulative probability distribution on the number of flaws and implied leak rate is tabulated for each of five candidate inspection plans. The mean annual leak rate for the segment, along with its variance, is also provided for each plan. There is a probability of 99.548% that the target leak rate is met for this segment for the Pre-ISI case (i.e., No ISI). The probability of exceeding the target leak rate (i.e., consumer risk) for the Pre-ISI case is 0.452% as compared to 0.308% for the single sample plan with a POD =1.0. The double sample plan with POD=0.2 yields 0.449% and 0.438% for a sample sizes equal one and two, respectively. A low POD value is assumed to provide a conservative upper bound on exceeding the target leak rate. For example, the consumer risk decreases from 0.430% to 0.308% in the single sample plan when the POD is changed from 0.2 to 1.0. The probability of sampling 100% of the lot in the double sampling plan with a sample size equal to one is 0.33% with the POD=0.2 value.

Table 3.7-2
EXAMPLE APPLICATION OF PERDUE MODEL TO A SURRY UNIT 1 HIGH HEAD INJECTION PIPING SEGMENT

	A	B	C	D	H	L	P	T
1	Perdue Model		Release 1.1	Date: 9/25/1997				
2			User Input					
3	Plant		SURRY					
4	Segment # / Loop #		HHI-012A(BUTT WELD)					
5	Number of Welds		38	Must be >= 4 for double sample plan with 2 welds/sample				
6	Prob. of Flaw @ yr 25/weld		2.87E-01					
7	Probability of Detection		0.2	Make 0 <= POD <= 0				
8	Cond. Prob. of Leak /yr/weld		2.06E-05					
9	Single Sample Size		1	Make sample size < "Number of Welds" & <= 10				
10	Target Leak rate /yr/weld		1.00E-05					
11								
12	Target Leak rate /yr/Lot		3.80E-04	(Calculated)				
13								
14	Double Sampling Plans		For 1 & 2 welds in each sample. Accept # = 0 & Cum Reject # = 2. POD = Cell C7					
15	Single Sampling Plan		Accept # = 0,Reject # = 1. Assumes POD = 100% or cell C7 as identified					
16								
17	**Results Summary**		**SURRY**			**HHI-012A(BUTT WELD)**		
18				D	H	L	P	T
19				Pre-ISI (i.e., No ISI)	Double Sample Plan (Each Sample Size = 1)	Double Sample Plan (Each Sample Size = 2)	Single Sample Plan (POD=1)	Single Sample Plan (POD = Cell C7)
20	Consumer Risk (prob. leak rate/yr/lot > target)			0.452%	0.449%	0.438%	0.308%	0.430%
21	Confidence (prob. leak rate/yr/lot < target)			99.548%	99.551%	99.562%	99.692%	99.570%
22	Mean Leak/yr/lot			2.25E-04	2.25E-04	2.25E-04	2.19E-04	2.24E-04
23	Variance (Leak/yr/lot)			3.31E-09	3.31E-09	3.30E-09	3.22E-09	3.30E-09
24	Prob. of Sampling 100% of Lot				3.30E-03	1.54E-02	2.87E-01	5.74E-02
25	Sum of Binomial Prob.		1.00000					
26								
27	**Consumer Risk Table**		**SURRY**			**HHI-012A(BUTT WELD)**		
28	A	B	C	D	H	L	P	T
29	No. of Flaws in Lot (k)	Implied Leak/yr/Lot	Binomial Probability of k Flaws	Probability of k or Less Flaws for the given Sample Plan				
30	0	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
31	1	0.00002	0.00004	0.00004	0.00004	0.00004	0.00006	0.00004
32	2	0.00004	0.00030	0.00034	0.00034	0.00034	0.00045	0.00036
33	3	0.00006	0.00143	0.00177	0.00177	0.00180	0.00230	0.00185
34	4	0.00008	0.00504	0.00681	0.00683	0.00691	0.00863	0.00709
35	5	0.00010	0.01381	0.02063	0.02068	0.02090	0.02546	0.02136
36	6	0.00012	0.03060	0.05123	0.05136	0.05185	0.06161	0.05280
37	7	0.00014	0.05635	0.10758	0.10783	0.10875	0.12609	0.11038
38	8	0.00016	0.08795	0.19553	0.19593	0.19739	0.22349	0.19976
39	9	0.00019	0.11809	0.31361	0.31416	0.31614	0.34991	0.31910
40	10	0.00021	0.13794	0.45155	0.45220	0.45454	0.49249	0.45774
41	11	0.00023	0.14143	0.59297	0.59365	0.59605	0.63345	0.59910
42	12	0.00025	0.12817	0.72114	0.72176	0.72394	0.75647	0.72649

Table 3.7-2 (cont.)
EXAMPLE APPLICATION OF PERDUE MODEL TO A SURRY UNIT 1 HIGH HEAD INJECTION PIPING SEGMENT

	A	B	C	D	H	L	P	T
26								
27	Consumer Risk Table		SURRY			HHI-012A(BUTT WELD)		
43	No. of Flaws in Lot (k)	Implied Leak/yr/Lot	Binomial Probability of k Flaws	Pre-ISI (i.e., No ISI) Probability of k or Less Flaws	Double Sample Plan (Each Sample Size = 1) Prob. of k or Less Flaws	Double Sample Plan (Each Sample Size = 2) Prob. of k or Less Flaws	Single Sample Plan (POD=1) Prob. of k or Less Flaws	Single Sample Plan (POD = Cell C7) Prob. of k or Less Flaws
44	13	0.00027	0.10325	0.82440	0.82490	0.82665	0.85176	0.82854
45	14	0.00029	0.07427	0.89867	0.89903	0.90028	0.91756	0.90152
46	15	0.00031	0.04786	0.94653	0.94676	0.94756	0.95820	0.94829
47	16	0.00033	0.02771	0.97424	0.97438	0.97483	0.98071	0.97522
48	17	0.00035	0.01445	0.98869	0.98876	0.98899	0.99190	0.98918
49	18	0.00037	0.00679	0.99548	0.99551	0.99562	0.99692	0.99570
50	19	0.00039	0.00288	0.99836	0.99837	0.99841	0.99894	0.99844
51	20	0.00041	0.00110	0.99946	0.99946	0.99948	0.99967	0.99949
52	21	0.00043	0.00038	0.99984	0.99984	0.99984	0.99991	0.99985
53	22	0.00045	0.00012	0.99996	0.99996	0.99996	0.99998	0.99996
54	23	0.00047	0.00003	0.99999	0.99999	0.99999	0.99999	0.99999
55	24	0.00049	0.00001	1.00000	1.00000	1.00000	1.00000	1.00000
56	25	0.00052	0.00000	1.00000	1.00000	1.00000	1.00000	1.00000
57	26	0.00054	0.00000	1.00000	1.00000	1.00000	1.00000	1.00000
58	27	0.00056	0.00000	1.00000	1.00000	1.00000	1.00000	1.00000
59	28	0.00058	0.00000	1.00000	1.00000	1.00000	1.00000	1.00000
60	29	0.00060	0.00000	1.00000	1.00000	1.00000	1.00000	1.00000
61	30	0.00062	0.00000	1.00000	1.00000	1.00000	1.00000	1.00000
62	31	0.00064	0.00000	1.00000	1.00000	1.00000	1.00000	1.00000
63	32	0.00066	0.00000	1.00000	1.00000	1.00000	1.00000	1.00000
64	33	0.00068	0.00000	1.00000	1.00000	1.00000	1.00000	1.00000
65	34	0.00070	0.00000	1.00000	1.00000	1.00000	1.00000	1.00000
66	35	0.00072	0.00000	1.00000	1.00000	1.00000	1.00000	1.00000
67	36	0.00074	0.00000	1.00000	1.00000	1.00000	1.00000	1.00000
68	37	0.00076	0.00000	1.00000	1.00000	1.00000	1.00000	1.00000
69	38	0.00078	0.00000	1.00000	1.00000	1.00000	1.00000	1.00000
70	39	0.00080	0.00000	1.00000	1.00000	1.00000	1.00000	1.00000
71	40	0.00082	0.00000	1.00000	1.00000	1.00000	1.00000	1.00000
72	41	0.00085	0.00000	1.00000	1.00000	1.00000	1.00000	1.00000
73	42	0.00087	0.00000	1.00000	1.00000	1.00000	1.00000	1.00000
74	43	0.00089	0.00000	1.00000	1.00000	1.00000	1.00000	1.00000
75	44	0.00091	0.00000	1.00000	1.00000	1.00000	1.00000	1.00000
76	45	0.00093	0.00000	1.00000	1.00000	1.00000	1.00000	1.00000
77	46	0.00095	0.00000	1.00000	1.00000	1.00000	1.00000	1.00000
78	47	0.00097	0.00000	1.00000	1.00000	1.00000	1.00000	1.00000
79	48	0.00099	0.00000	1.00000	1.00000	1.00000	1.00000	1.00000
80	49	0.00101	0.00000	1.00000	1.00000	1.00000	1.00000	1.00000
81	50	0.00103	0.00000	1.00000	1.00000	1.00000	1.00000	1.00000
82	Col. Total		1.00000					

Table 3.7-3 shows a spectrum of statistical evaluations using the Perdue model for segments across several systems of interest for Surry Unit 1 to further illustrate the tool. Large diameter pipes and small diameter pipes are represented for a range of welds contained within those segments. Two low safety-significant segments, where examinations are currently required by ASME Section XI, are also included. These results show that high levels of confidence in meeting the respective target leak rates (see Table 3.7-1) can be achieved in these segments for both the Pre-ISI case and the double sample plan with a sample size of one and a conservative lower bound POD equal to 0.2. Given these results, no further examinations are required for the low safety significant segments. For each high safety-significant segment, one sample is chosen to provide additional assurance that the pressure boundary will be maintained even though the results show that no further examination is required in this highly reliable piping. The location to be examined in each segment is selected by the structural element subpanel using engineering and deterministic insights as discussed in the next section.

Limitations of the Statistical Model

Some limitations have been identified in the statistical model that is used in determining the minimum number of locations to be examined. These limitations have emerged primarily because it had been determined that the piping segments of interest are subject to conditions that may lead to a higher failure potential or importance than was intended for use in the Perdue Model. Also, some piping segments are subject to degradation mechanisms other than those associated with cracking. The Perdue Model should not be used in piping segments where the following conditions may occur:

- Accelerated cracking from high vibratory fatigue, stress-corrosion cracking or other potentially aggressive loading conditions or environments
- Degradation mechanisms associated with wastage, such as flow-assisted corrosion, erosion, or general corrosion
- For socket welds where neither surface nor volumetric examinations are possible
- Where corrective actions or mitigative repairs have been made, such as coatings programs or weld overlays, where the initial conditions of the piping have been altered.

Table 3.7-3
SURRY UNIT 1
SAMPLE RESULTS FROM PERDUE MODEL ANALYSIS

Segment	Nominal Pipe Size (inches)	Number of Welds	Probability of Flaw (a/t = 0.10) at 25 Years	Conditional Probability of Leak (per yr)	Pre-ISI Confidence (%)	Double Sample Plan Confidence (POD = 0.2) (%)	Number of Samples per Segment
ECC-3	6	6	5.38E-02	5.01E-06	100	100	1
ECC-4	6	138	4.99E-02	1.34E-07	100	100	0(1)
HHI-4C	3	9	3.08E-02	1.56E-06	100	100	1
HHI-9	2	82	2.87E-01	2.06E-05	99.99	99.99	1
HHI-12A	2	38	2.87E-01	2.06E-05	99.55	99.55	1
LHI-4	12	2	1.53E-02	6.42E-07	100	100	1
RC-7	36	10	7.66E-04	1.07E-06	99.24	99.24	0(1)
RC-16	6	7	5.38E-02	3.15E-07	100	100	1
RC-58	3	4	3.08E-02	3.40E-07	100	100	1

Note:

(1) Low safety significant segments. Results show high confidence with no subsequent inspections (Pre-ISI column).

For piping segments that have the potential for any of these conditions to occur, a defensible inservice inspection program for these piping segments should be developed based on deterministic information, engineering insights and experience, and industry best practices. Some general guidance for the above situation is provided at the end of Section 3.7.3, and specific examples from the Surry-1 application are provided in Section 3.7.5 for further clarification.

3.7.3 Selection of Actual Inspection Locations

Once the number of locations is determined, the engineering subpanel identifies the specific locations for examination. Figure 3.7-3 displays how this expertise and information is brought together in the structural element selection process.

Simplified P&IDs showing the segment boundaries are reviewed by the team along with piping isometrics, plant and industry operating experience, the previous piping segment evaluations performed to determine the high safety-significant piping segments and system design, fabrication and operating conditions. Based on the postulated failure mechanism and the loading conditions for the piping segment, the areas in which this failure mechanism is most likely to occur are identified considering the following factors:

Configuration Dependent. This factor considers the effect of piping layout and support arrangement. For example, piping with low flexibility for thermal expansion will experience high bending moments which, in turn, can drive crack growth.

Component Dependent. For example, socket welds have low resistance to sustained vibration. Elbows or piping immediately downstream of valves, which add turbulence to the flow, are locations susceptible to erosion-corrosion-wear.

Materials/Chemistry Dependent. Intergranular stress corrosion cracking (IGSCC) and dissimilar metal welds are examples of how materials and chemistry can play a role.

Loads Dependent. An example of this is the number of cycles seen by the piping segment. Another example is piping where inadvertent operation may lead to water hammer events. Seismic events are also included in this category.

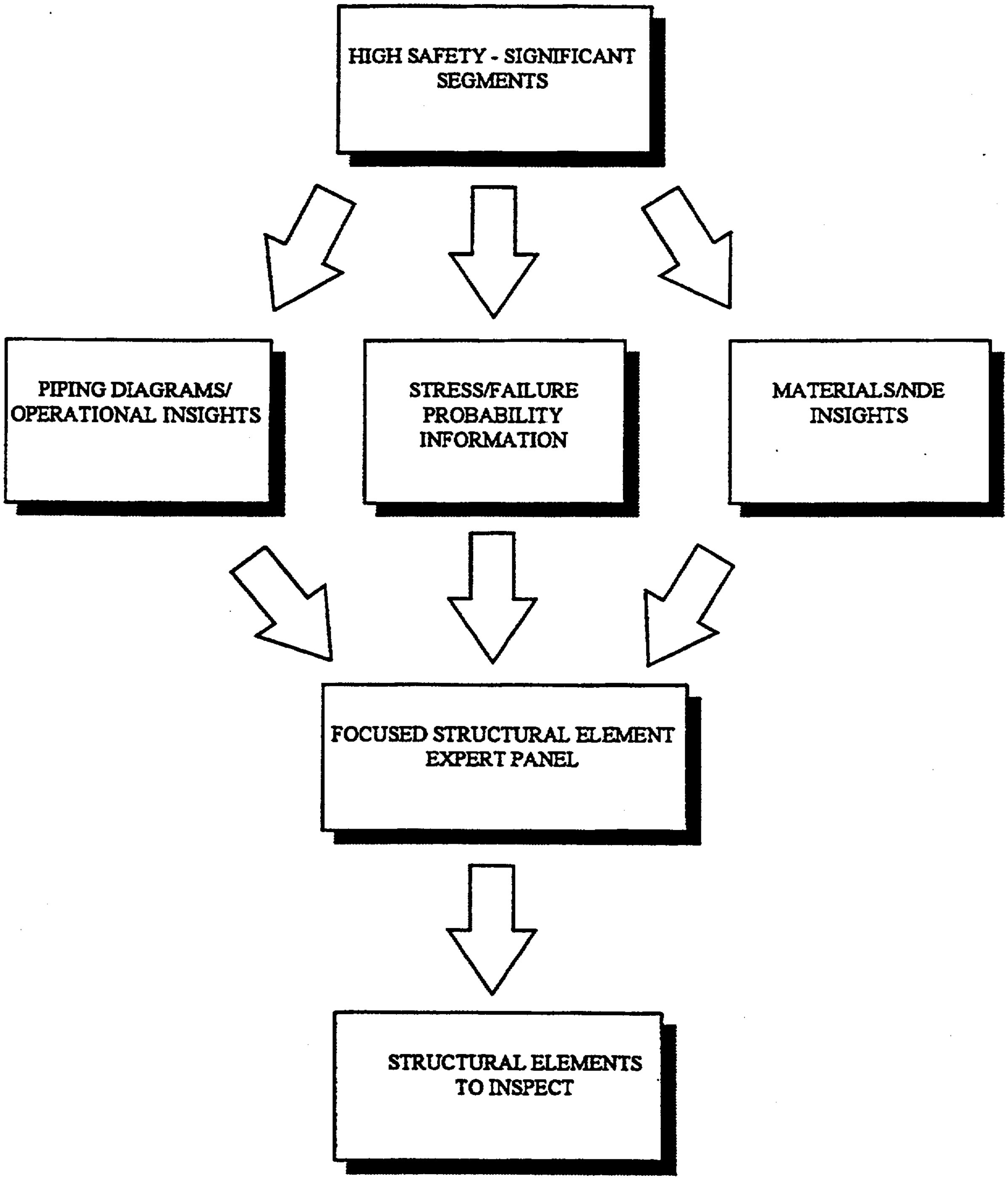


Figure 3.7-3 WOG Structural Element Selection Process

Determination of the inspection location(s) within a piping segment are dependent on these factors. In general,

- Component dependent failure modes are usually localized to a single or small number of locations.

- Materials dependent or operations dependent mechanisms are often present throughout the segment. In such cases, interactions with other effects must be considered for determining the location(s).

- Load dependent failure modes typically involve undetected preexisting flaws or degradation that could fail under high loads. The high loads could arise from dynamic (seismic, water hammer) events, large thermal expansion loads (configuration dependent), or external loading. Locations where such loads could have the greatest impact can often be determined.

Table 3.7-4 provides some additional insights based on postulated failure mechanism that assist in identifying the susceptible areas of piping.

For high safety-significant piping segments where the Perdue statistical model is not applied, the selection of an appropriate number of actual inspection locations will have to be determined using additional rationale beyond the guidance provided above.

- For piping segments subjected to aggressive degradation mechanisms, such as flow-assisted corrosion, that are already addressed in an augmented inspection program, it is recommended that a determination of any potential secondary degradation mechanisms (e.g., thermal fatigue) be made. If it is determined that a secondary mechanism may be of concern, then the examination of at least one location in the segment may be warranted and included in the RI-ISI program. This additional examination(s) beyond the current augmented program should also be considered if the delta risk of RI-ISI versus ASME Section XI ISI is enhanced.

Table 3.7-4
INSIGHTS FOR IDENTIFYING INSPECTION LOCATIONS

Failure Mechanism	General Criteria	Susceptible Areas
Thermal Fatigue	Areas where hot and cold fluid mix, areas of rapid cold or hot water injection, areas of potential leakage past valves separating hot and cold water	Nozzles, branch pipe connections, safe ends, welds, heat-affected zones, base metal, areas of concentrated stress
Corrosion Cracking	Areas exposed to contamination and areas with crevices; high stresses (residual, steady-state, pressure), sensitized material (304 SS) and high coolant conductivity are all required; lack of stress relief or cold springing could also lead to residual stresses	Base metal, welds, and heat-affected zones
Microbiologically influenced corrosion	Areas exposed to organic material or untreated water	Fittings, welds, heat-affected zones, crevices
Vibratory Fatigue	Configurations susceptible to flow induced vibration and flow striping or for vibratory resonance with rotating equipment (pump) frequencies	Welds, branch pipe connections
Stress Corrosion Cracking	Areas of high oxygen and stagnant flow	Austenitic steel welds and heat-affected zones
Flow accelerated corrosion	Areas of low chromium material content, high moisture content, and high pH, high pressure drop or turning losses	
Low cycle fatigue	Areas with high loads due to thermal expansion for heat-up and cool-down thermal cycling.	Equipment nozzles and other anchor points, near snubbers, dissimilar metal joints

- For piping that is highly reliable, but the materials or prior corrective actions negate the applicability of a statistical evaluation, a minimum of one examination location per segment should be performed.

- A segment that is entirely comprised of socket welds and subject to vibration may be appropriately examined using a VT-2 exam that inspects the entire segment for leakage at pressure. Therefore, a minimum number of specific examination locations is not required.

Other situations may exist that warrant considerations beyond the above guidance. However, the engineering subpanel who is selecting the actual inspection locations is always responsible for defending and documenting their rationale for this effort.

Once the initial set of inspection locations is identified, the examinations are performed.

3.7.4 Millstone Unit 3 Examples[1]

Only one segment, ECCS-0, is considered to be high-safety-significant in the emergency core cooling system. The selection of this segment is primarily based on the consequence of failure because the selected element SRRA failure probability was less than 1.0E-08. The subpanel reviewed the structural elements within the segment and concurred that the element location that was selected is considered to have the highest failure potential. The location of concern is the base metal of a 24" pipe at ground surface that may be subjected to cracking because of outside diameter corrosion and external loads. Since the area being examined at this selected element location is base material; not currently addressed in ASME Section XI, Figure 3.7-4 has been developed to identify the area to be inspected by VT-2 and eddy current examination.

QSS-2 is the only segment that is considered to be high-safety-significant in the quench spray system. The selection of this segment is primarily based on consequence of failure. However, the failure probabilities in this segment were based on prior SRRA evaluations of two locations, both of which are less than 1.0E-8. The subpanel reviewed all the elements in the segment and

[1] The Perdue model was unavailable at the time of the Millstone 3 reference plant application. However, these examples highlight how engineering insights are used in selecting actual inspection locations by the engineering subpanel.

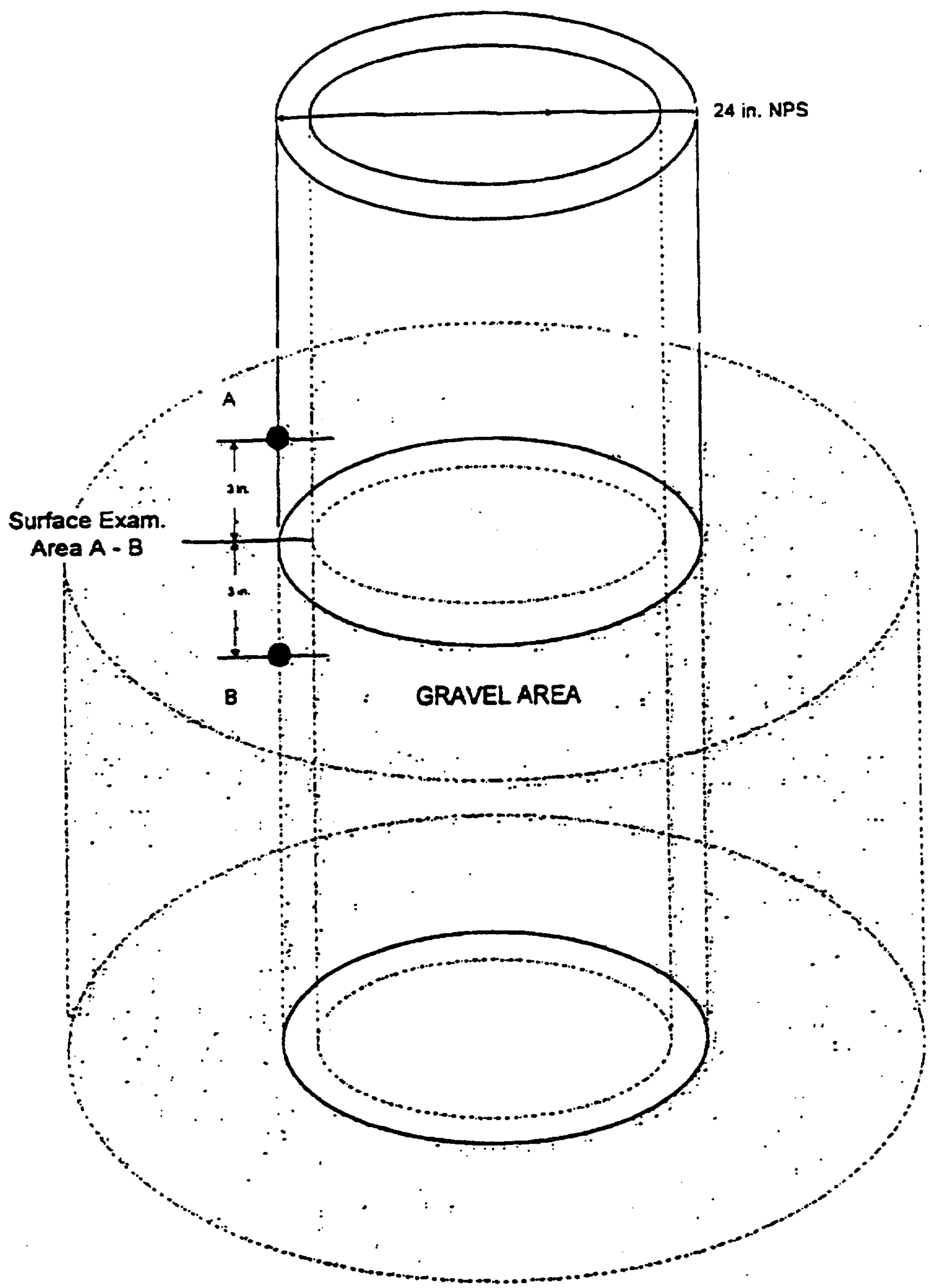


Figure 3.7-4 Millstone Unit 3 Base Metal Examination Location for ECCS-0

concurred that the two selected locations have the highest failure potential. Both locations are pipe-to-elbow welds in the 12" pipe that may be subjected to cracking from vibrational fatigue caused by pump operation. Both UT and VT-2 examinations are recommended for these two locations.

For FWA, five segments were considered to be high safety-significant in this system plus 4 feedwater pipe/elbow to nozzle welds included for plant reliability considerations. The selection of these segments was primarily based on consequence of failure, because the selected element failure probabilities were less than 1.0E-08. The subpanel reviewed all the segment elements and concurred that the element locations selected were considered to have the highest failure probabilities. For the first high safety-significant segment FWA-7, the element location selected was near the turbine driven auxiliary feed pump. The panel agreed that this location on the 2 side of the reducer would act as a sentinel for any vibration related fatigue problems and that the previously specified RT examination should be performed following pump test or system operation. For the remaining 4 high safety-significant segments FWA-12, -14, -16, and -18, a MT examination was added to the specified RT examination because the failure mode was identified to be external loads. Since external loads is a possible combination of several contributors to potential failure and not one single degradation mechanism, the subpanel believed that OD flaws should be examined for at these locations and this was the reason that the MT examination was added. The 4 steam generator inlet feedwater nozzle welds had been included due to plant reliability considerations because of thermal fatigue induced cracking that had been found throughout the industry and at MP3. MP3's nozzles were repaired and modified in 1993 to reduce the potential for fatigue cracking. To monitor the effectiveness of the modifications RT examination of the 2 elbow to nozzle welds and UT examination of the 2 pipe to nozzle welds including additional base material was specified by the subpanel.

Five segments were also considered to be high safety-significant in the SIL system. The selection of these segments was primarily based on consequence of failure, because the selected element failure probabilities were less than 1.0E-08. The subpanel reviewed the element/location selections for each of the selected segments and several changes were made. These changes were based on a detailed review of the piping configurations and fabrication drawings. For SIL-3 a pipe to elbow weld had originally been selected and it was changed to address a unique discontinuity in this piping segment. The subpanel review identified a pipe transition piece welded to a valve where a pipe class change occurred. This pipe class change or thickness change was believed to have a higher potential for failure than the originally selected element location. The subpanel specified that a RT examination method be used at this location so that the area of the valve counterbore region could be examined along with the transition piece to pipe weld. For SIL-5, welds on both sides of a reducer were originally specified for examination. The subpanel decided that after review of these locations that only the 6 side of the reducer needed to be examined. The subpanel believed that since the failure probabilities at these locations were relatively low, less than 1.0E-08, examining both locations was not necessary. The subpanel decided to focus the examination on the higher stressed 6 side of the reducer in order to address the potential thermal fatigue failure mode at this location. Additionally, the weld volume was extended to include 1 of base material adjacent to the weld.

3.7.5 Surry Unit 1 Examples

The Surry expert panel directed the subpanel to select the necessary locations on the high safety-significant segments and some low safety-significant segments for examination, and to determine the appropriate examination methods and extent of examination. The number of locations selected were determined by the perceived failure mechanism importance, the statistical sampling requirements, and the risk change. The subpanel used the following criteria in the selection process.

- Select the locations (100%) where a perceived high failure importance is recognized. These locations generally have an active failure mechanism recognized with a corresponding high failure probability. In some cases where an augmented program was already established, this was maintained. The subpanel in some cases required additions to the augmented inspection programs.

- Select locations as necessary to meet the statistical sampling requirements and change in risk requirements. The subpanel generally examined locations thought to have high loadings, and would generally, in similar multiple loops, spread the examinations in different locations. Additional rationale must be developed when the statistical model cannot be applied to determine the minimum number of examination locations for a given segment.

- The examination requirements and extent of examination followed the guidance found in Table 4.1-1, which is provided later in this report. In some instances, the subpanel required more than what the guidance indicates. Areas of concern associated with socket welds or materials not inspectable by normal NDE methods required departure from the guidance.

Several examples are provided below where additional rationale had to be applied when the Perdue statistical model could not be exercised and when the NDE methods required departure from the guidance in Table 4.1-1.

Segment FW-002 is a non-Code class piping component in the normal feedwater system. The segment is already inspected by the station's augmented erosion/corrosion inspection program (susceptible to that failure mechanism). This program will be maintained on the segment. The subpanel additionally selected a weld for ultrasonic (volumetric) and magnetic particle (surface) examination at a perceived high stress location. The examination would address the secondary failure mechanism of fatigue. This additional sample examination provided additional inspection coverage for risk considerations. Note that the subpanel required a magnetic particle examination. The magnetic particle examination is not a requirement of the guidance in Table 4.1-1 (R1.11). The subpanel wanted to ensure against outside diameter initiating flaws.

Segments CH-008, 009, and 0010, part of the charging system, are small bore, socket welded piping segments which supply seal injection water to the reactor coolant pump seals. The predicted failure mechanism is high cycle fatigue due to pump vibration. The examination technique required by Table 4.1-1 (R1.12) is a VT-2 exam at each refueling outage. Since the VT-2 exam involves inspection of the whole segment for leakage at pressure, tabulation of the exact number of welds per segment and application of the Perdue Model was not deemed necessary. This would be the case for any segment where VT-2 is the appropriate inspection technique. Additional NDE is also directed to this segment by the engineering subpanel that is over and above the guidance in Table 4.1-1.

Service water segments SW-044, 045, 046, 047, and 054 are fabricated of copper/nickel material which is not a material which can be modeled by the SRRA code and statistical model used for

Surry Unit 1. They conduct service water to and from the charging pump intermediate seal coolers. The segments were originally ranked to be low safety significant but were moved up to high by the Expert Panel because of its sensitivity to the possibility of indirect effects. Because the piping is considered highly reliable, the postulated failure mechanism is thermal fatigue by default (actually thermal cycles are practically nonexistent), and the SRRA code could not be used to calculate a failure probability, which is a necessary input to the Perdue Model, the Perdue Model was not used to select examination locations. The subpanel believed that an examination location per segment would be representative of the balance of these highly reliable, low safety significant segments.

Finally, segments RC-041, 042, 043 are Class 1 piping components in the reactor coolant system. The segments provide safety injection water to the three reactor coolant loops when necessary. These segments were identified as being susceptible to thermal striping. The industry has experienced an issue when high pressure and cooler charging water has leaked into the warmer RCS at these locations. The subpanel directed a 100% inspection for this potentially active failure mechanism at the weld connecting the inlet check valve to the reactor coolant piping on all three segments. The statistical model required that one more location be examined on each segment. As the segments were similar in design and function, the subpanel identified welds to be examined at different locations on the three segments. The subpanel required that all selected locations receive an ultrasonic (volumetric) and liquid penetrant (surface) examination, again more than the guidance's requirements.

SECTION 4
INSPECTION PROGRAM REQUIREMENTS

This section contains the minimum Risk-Informed Inservice Inspection (RI-ISI) program requirements for High Safety-Significant (HSS) and Low Safety-Significant (LSS) piping structural elements determined in accordance with the requirements of Section 3.7. Requirements for Nondestructive Examination (NDE), System Pressure Tests, Scheduling, Implementation, Program Monitoring, and Corrective Action Program descriptions are included. Inservice examinations and system pressure tests are to be performed in accordance with this section and the requirements contained in the American Society of Mechanical Engineers (ASME) Boiler & Pressure Vessel Code, Section XI, Edition and Addenda specified in an Owner's current Inservice Inspection Program except where specific references are provided that add supplemental requirements, specify other Code Editions and Addenda, or recommend/require the use of ASME Code Cases.

Examinations and system pressure tests may be performed during either system operation or plant outages, such as refueling outages or maintenance outages. Scheduled examinations are to be completed during each inspection interval. Currently the interval is 10 years. Examinations are distributed across periods such that one third of the examinations are conducted in each period. Alternative examination methods, a combination of methods, or newly developed techniques may be used in lieu of the NDE requirements of Table 4.1-1, as provided in IWA-2240 Alternative Examinations of ASME Section XI.

Experience has shown that when an aggressive mechanism (such as IGSCC, thermal striping, and flow-accelerated corrosion) is discovered, corrective actions and augmented programs are implemented to address the concern. Augmented inspection programs for these situations tend to have intervals less than 10 years.

Through the RI-ISI process, situations may be identified on a plant-specific basis where an aggressive mechanism may potentially occur (e.g., back-leakage of hot water across a check valve into a piping segment containing cooler water, thereby inducing the potential for thermal striping). For these situations, the licensee may choose to either implement examinations more frequently than every 10 years (including the use of thermal monitors) or implement changes to minimize the potential for the identified phenomenon. If the licensee chooses to implement a program that will provide vital information more frequently than every 10 years, then that new information would have to be evaluated at the time that is obtained to determine if a change to the prior RI-ISI results is necessary.

Comparison of results to current ASME Section XI locations are provided with a cost benefit update that now includes the pilot plant work at Surry Unit No. 1.

Examinations Requirements

An attempt should be made to provide a minimum of > 90% coverage criteria (per ASME Code Case N-460) when performing an exam. Volumetrically this is done using ultrasonic (UT) techniques with the >90% requirement being met in all Code required directions (averaged). The examination is considered complete if the >90% coverage is obtained using the specified technique in the plan or combinations of techniques if limitations are encountered. Some limitations will not be known until the examination is performed, since some locations will be examined for the first time by the specified techniques.

When an examination location is selected that does not meet >90% examination coverage, a strategy should to be applied with regard to examination coverage as follows:

1. If >90% coverage is not obtained, the coverage obtained should be documented as well as the reason for the coverage limitation. If the coverage is limited by an obstruction, which is removable, then an evaluation should be performed to either allow removal of the obstruction or justify why the obstruction cannot be removed.

2. If the obstruction is required to remain, then consideration should be given to the structural elements on either side of the selected structural element, which is limited. If either of these structural elements can be examined to the coverage requirements, then an examination should be performed there in addition to the limited coverage exam already performed. This may be the only examination performed in situations where the selected element was selected for statistical sampling alone. Selecting another location would meet the statistical

requirements for the segment, and the original site does not need to be examined. Additionally, the substitution (statistical) would not necessarily be limited to the elements on either side of the element originally selected.

3. If the area or volume of concern still remains insufficiently addressed, consideration should be given to leakage monitoring options such as more frequent pressure testing and VT-2 examinations or operator walkdowns.

4. The coverage obtained, limitations encountered, alternative provisions, and an assessment of how the risk is being addressed should be documented. The information should be formally submitted as a relief request.

It should be noted though that if a current ASME Section XI examination is a partial examination and it continues to be a partial examination in the RI-ISI process, the amount of risk addressed by examination remains the same for that location. If a new location is going to be examined by RI-ISI and it is a partial examination, but it was not previously required to be examined by Section XI, then the new examination would still increase the amount of risk addressed by examination for that location. It is not necessarily true that because you reduce examination totals, that a complete examination must be performed at the RI-ISI selected locations to maintain risk neutrality or improvement in the program. The impact of locations being removed on the overall risk contribution should be assessed (i.e., usually the segment risk contribution is negligible) in an analysis. Additionally the sampling requirements necessary to maintain assurance of structural integrity should be accounted for in the analysis. These type evaluations should be included in how the risk is being addressed in a partial examination situation.

4.1 HIGH SAFETY-SIGNIFICANT LOCATIONS

HSS piping structural elements should be examined in accordance with the requirements of Table 4.1-1 for the areas and/or volumes of concern at each HSS location. The requirements contained in Table 4.1-1 have been taken directly out of ASME Code Case N-577 Risk-Informed Requirements for Class 1, 2, and 3 Piping - Method A Section XI, Division 1. The NDE method for each HSS location is based on the postulated failure modes and the configuration of each piping structural element as described in Table 4.1-1. As an alternative to the requirements in

Table 4.1-1, additional guidance for visual examination methods, examination monitoring techniques, and NDE methods associated with postulated failure modes is provided in Table 4.1-2. This guidance may be used subject to approval by an Authorized Nuclear Inservice Inspector (ANII) under the requirements of Section XI, IWA-2240. All ASME Code Class 1, 2, and 3 HSS locations should continue to receive a visual examination for leakage in accordance with the system pressure test requirements of ASME Section XI.

4.2 LOW SAFETY-SIGNIFICANT LOCATIONS

LSS piping structural elements do not require NDE under a RI-ISI program. When a location is determined to be LSS, it usually has no appreciable consequence or failure importance and thus is assigned a low level examination requirement. This low level requirement consists of a visual examination for leakage that may be conducted during operational walkdowns or in conjunction with system pressure tests performed in accordance with ASME Section XI. LSS locations that are determined to have a high failure importance and a low consequence are usually examined by other Owner controlled programs for the failure mechanism of concern such as Flow Accelerated Corrosion (FAC). These Owner controlled programs shall continue to be implemented based on their own requirements.

4.3 SYSTEM PRESSURE TESTS

System pressure test requirements and VT-2 visual examinations shall continue to be performed on all ASME Code Class 1, 2, and 3 systems regardless of whether the segments contain locations that have been determined to be HSS or LSS. It is recommended that each Owner consider the use of ASME Code Cases N-498-1 Alternative Rules for 10-Year System Hydrostatic Testing for Class 1, 2, and 3 Systems Section XI, Division 1 and N-416-1 Alternative Pressure Test Requirement for Welded Repairs or Installation of Replacement Items by Welding, Class 1, 2, and 3 Section XI, Division 1 to eliminate the need to perform elevated system pressure tests. Use of a RI-ISI program does not require elevated system pressure tests as currently required by ASME Section XI. Use of these ASME Code Cases has been approved by the Nuclear Regulatory Commission (NRC) for many Owners. Both Code Cases are presently being evaluated for industry acceptance by the NRC in Draft Regulatory Guide 1050

Table 4.1-1 EXAMINATION CATEGORY R-A, RISK-INFORMED PIPING EXAMINATIONS							
Item No.	Parts Examined	Examination Requirement/ Fig. No.[2,10]	Examination Method	Acceptance Standard[10]	Extent[3] and Frequency		Deferral of Examination to End of Interval
					1st Interval	Successive[5] Intervals	
R1.10	High Safety-Significant Piping Structural Elements						
R1.11	Elements Subject to Thermal Fatigue	IWB-2500-8(c)[1] IWB-2500-9,10,11 IWC-2500-7(a)[1]	Volumetric	IWB-3514	Element[2,4]	Same as 1st	Not Permissible
R1.12	Elements Subject to High Cycle Mechanical Fatigue	IWB-2500-8(c)[1] IWB-2500-9,10,11 IWC-2500-7(a)[1]	Visual, VT-2[11]	IWB-3142	Each Refueling	Same as 1st	Not Permissible
R1.13	Elements Subject to Corrosive, Erosive, or Cavitation Wastage	Note 8	Volumetric[8] (for Internal Wastage) or Surface (for External Wastage)	IWB-3514 Note 8	Element[2] Element[2]	Same as 1st	Not Permissible
R1.14	Elements Subject to Crevice Corrosion Cracking	Note 7	Volumetric	IWB-3514	Element[2]	Same as 1st	Not Permissible
R1.15	Elements Subject to Primary Water Stress Corrosion Cracking (PWSCC)[6]	Note 7	Visual, VT-2[11]	IWB-3142	Each Refueling	Same as 1st	Not Permissible
R1.16	Elements Subject to Intergranular Stress Corrosion Cracking (IGSCC)	IWB-2500-8(c) IWB-2500-9,10,11	Volumetric	IWB-3514	Element[2]	Same as 1st	Not Permissible
R1.17	Elements Subject to Microbiologically Influenced Corrosion (MIC)	IWB-2500-8(c) IWB-2500-9,10,11	Visual, VT-3 Internal Surfaces or Volumetric[8]	Note 8	Element[2]	Same as 1st	Not Permissible
R1.18	Elements Subject to Flow Accelerated Corrosion (FAC)	Note 9	Note 9	Note 9	Note 9	Note 9	Note 9

Table 4.1-1 (cont.)
EXAMINATION CATEGORY R-A, RISK-INFORMED PIPING EXAMINATIONS

Notes:

(1) The length for the examination volume shall be increased to include 1/2 in. beyond each side of the base metal thickness transition or counterbore.

(2) Includes all examination locations identified in accordance with the risk-informed selection process in Section 3.7.

(3) Includes 100% of the examination location. When the required examination volume or area cannot be examined due to interference by another component or part geometry, limited examinations shall be evaluated by the Expert Panel for acceptability. Areas with acceptable limited examinations, and their bases, shall be documented.

(4) The examination shall include any longitudinal welds at the location selected for examination in Note 2. The longitudinal weld examination requirements shall be met for both transverse and parallel flaws examination volume defined in Note 2.

(5) Initially-selected examination locations are to be examined in the same sequence during successive inspection intervals, to the extent practical.

(6) Applies to mill annealed Alloy 600 nozzle welds and heat affected zone (HAZ) without stress relief.

(7) The examination volume shall include the volume surrounding the weld, weld heat affected zone, and base metal, where applicable, in the crevice region. Examination should focus on detection of cracks initiating and propagating from the inner surface.

(8) The examination volume shall include base metal, welds and weld HAZ in the affected regions of carbon and low alloy steel, and the welds and weld HAZ of austenitic steel. Examinations shall verify the minimum wall thickness required. Acceptance criteria for localized thinning is in course of preparation. The examination method and examination region shall be sufficient to characterize the extent of the element degradation.

(9) In accordance with the Owner's existing FAC program.

(10) Paragraph and Figure numbers refer to the 1989 Edition.

(11) VT-2 examinations may be conducted during a system pressure test or a pressure test specific to that component/element.

Table 4.1-2
GUIDANCE FOR VISUAL EXAMINATION METHODS, EXAMINATION MONITORING TECHNIQUES, AND NDE METHODS ASSOCIATED WITH POSTULATED FAILURE MODES

Potential Piping Inside Surface Initiated Flaws or Relevant Conditions (1)		
Piping Structural Elements	**Postulated Failure Modes**	**Suggested Visual Exam Method, Monitoring Technique, or NDE Method**
Butt Welds (2) *≥ .237 in. Nominal Wall Thickness for Piping ≥ NPS 2*	Cracking *Thermal Fatigue, Mechanical Fatigue, or Corrosion*	Ultrasonic Examination (3) or Continuous Temperature and/or Stress Monitoring *For Thermal Fatigue*
Butt Welds (2) *< .237 in. Nominal Wall Thickness*	Cracking *Thermal Fatigue, Mechanical Fatigue, or Corrosion*	Radiographic Examination (4) or Continuous Temperature and/or Stress Monitoring *For Thermal Fatigue*
Butt Welds (2) *Essentially Limited to RAW Water Cooling Systems*	FAC *Microbiologically Influenced Corrosion, Heat Affected Zone Washout, and General Erosion*	Combinations of Ultrasonic Examination (5), and Radiographic Examination (4)
Branch Connection Welds *Branch Pipe ≤ NPS 2 Connected to Main Run Pipe ≤ NPS 4*	Cracking *Thermal Fatigue, Mechanical Fatigue, Corrosion, or Vibrational Fatigue (6)*	Radiographic Examination (4) or Continuous Temperature and/or Stress Monitoring *For Thermal Fatigue*
Branch Connection Welds *Branch Pipe > NPS 2 Connected to ≥ .237 in. Nominal Wall Thickness Main Run Pipe > NPS 4*	Cracking *Thermal Fatigue Mechanical Fatigue, Corrosion, or Vibrational Fatigue (6)*	Ultrasonic Examination (3) *Main Run Pipe Base Material Adjacent to The Weld* and Radiographic Examination (4) *Weld and Branch Fitting Base Material Adjacent to The Weld to The Extent Possible* or Continuous Temperature and/or Stress Monitoring *For Thermal Fatigue*
Socket Welds *≥.237 in. Nominal Wall Thickness*	Cracking *Thermal Fatigue Mechanical Fatigue, Corrosion, or Vibrational Fatigue (6)* FAC *General Wastage from Flow or Oxidation*	Radiographic Examination (4) Supplemented By Ultrasonic Examination (3) *Pipe Base Material Adjacent to The Weld* or Continuous Temperature and/or Stress Monitoring *For Thermal Fatigue*

Table 4.1-2 (cont.)
GUIDANCE FOR VISUAL EXAMINATION METHODS, EXAMINATION MONITORING TECHNIQUES, AND NDE METHODS ASSOCIATED WITH POSTULATED FAILURE MODES

Potential Piping Inside Surface Initiated Flaws or Relevant Conditions (1)		
Piping Structural Elements	**Postulated Failure Modes**	**Suggested Visual Exam Method, Monitoring Technique, or NDE Method**
Socket Welds *< .237 in. Nominal Wall Thickness*	Cracking *Thermal Fatigue Mechanical Fatigue, Corrosion, or Vibrational Fatigue (6)* FAC *General Wastage from Flow or Oxidation*	Radiographic Examination (4) or Continuous Temperature and/or Stress Monitoring *For Thermal Fatigue*
Pipe Runs or Areas *Base Material and Welds*	FAC *General Wastage from Flow or Oxidation*	Ultrasonic Examination (5), Radiographic Examination (4), or Infra-Red Thermography (7)
Pipe Fittings *Such as Elbows, Tees, Reducers, or Expanders*	FAC *General Wastage from Flow or Oxidation*	Ultrasonic Examination (5), Radiographic Examination (4), or Infra-Red Thermography (7)
Potential Piping Outside Surface Initiated Flaws or Relevant Conditions		
All Piping Structural Elements *Such as Butt Welds, Branch Connection Welds, Socket Welds, Pipe Runs, or Pipe Fittings*	Cracking *Thermal Fatigue Mechanical Fatigue, Corrosion, or Vibrational Fatigue (6)*	Liquid Penetrant Examination or Eddy Current Examination *For Austenitic Stainless Steels, Non-Ferritic High Alloy Materials, and Dissimilar Metal Welds* or Magnetic Particle Examination or Eddy Current Examination *For Carbon Steel, Ferritic Low Alloy Steel Materials and Welds*
All Piping Structural Elements *Such as Butt Welds, Branch Connection Welds, Socket Welds, Pipe Runs, or Pipe Fittings*	Corrosion *General Wastage from Oxidation*	Visual, VT-3 Examination (8)

Table 4.1-2 (cont.)
GUIDANCE FOR VISUAL EXAMINATION METHODS, EXAMINATION MONITORING TECHNIQUES, AND NDE METHODS ASSOCIATED WITH POSTULATED FAILURE MODES

Notes:

(1) Inside surface examinations of piping structural elements subject to cracking may be performed if they become accessible in lieu of the suggested volumetric examinations of this table. Examination methods such as liquid penetrant examination, eddy current examination, or magnetic particle examination for appropriate materials may be used. For piping structural elements subject to FAC, a general VT-3 visual examination may be performed from the inside surface of the piping, but it may necessary to supplement this general visual examination with other examination methods to determine the extent of the erosion or corrosion.

(2) Butt welds include circumferential welds and longitudinal welds. The examination methods suggested for these welds include methods for welds of all materials, dissimilar metal welds, or portions thereof except for those welds that are made from austenitic cast stainless steel materials. Radiographic examination should be used for welds that include austenitic cast stainless steel materials.

(3) An ultrasonic angle beam examination sensitive to flaws initiating at the inside diameter surface of a weld or heat affected zone should be used.

(4) Radiographic examination is a sensitive examination for identifying flaws parallel to the radiation beam used in the technique. The method is good for the detection of pits, slag, and thermal fatigue cracks. Intergranular stress corrosion cracking, stress corrosion cracking, and off angle cracks are not reliably detected with this method. This examination method provides an accurate plan view for the location of flaws that it can detect and is extremely helpful used in conjunction with ultrasonic examination to evaluate localized areas of pitting, flow erosion, or microbiologically influenced corrosion attacks.

(5) An ultrasonic straight beam examination is used here for accurate measurements of material thickness. This method to used to assess erosion/corrosion material loss.

(6) Cracking resulting from vibrational fatigue is not usually detectable by NDE methods prior to leaking. Guidance for assessment of vibrational fatigue conditions may be found in Part 3 of the ASME OM-S/G-1990 GUIDE.

(7) Infra-red thermography may be a useful examination method for overall erosion/corrosion assessments to locate general areas of wall loss in steam or hot fluid systems. This method should be combined with ultrasonic examination or radiographic examination for accurate wall loss measurements.

(8) This general VT-3 visual examination method is good for location of general wastage from oxidation, but if severe oxidation is identified other examination methods may have to be used to quantify the amount of material loss.

which will be Revision 12 to U.S. NRC Regulatory Guide 1.147. Non-Code Class system examination requirements for HSS or LSS locations shall include those system pressure tests and corresponding visual examinations for leakage that are required under an Owner's Current Licensing Basis (CLB) as defined in 10 CFR 54.3. Generally, Non-Code Class systems do not require inservice type system pressure tests.

4.4 COMPARISON OF RESULTS TO CURRENT ASME XI INSPECTION LOCATIONS

This section discusses the comparison of the results of the risk-informed process to the current ASME Section XI piping inspection locations.

4.4.1 Comparison of Examination Locations

Millstone 3 Comparison

Table 4.4-1 provides a comparison of the structural element/location selections by system for the representative WOG plant. The risk-informed ISI program results are compared against the existing ISI program weld selections based on the 1989 Edition of the ASME Code Section XI requirements.

The first column of the table represents the systems that were evaluated under the risk-informed ISI program. This list is also shown in Table 3.2-1 and includes all the ASME Code Class 1, 2, and 3 piping systems of the existing ISI program, piping systems modeled in the PSA, and various balance of plant (non-nuclear Code Class) systems.

The second column of the table identifies the piping segments determined to be high safety-significant by the expert panel previously shown in Table 3.6-13. These high safety-significant piping segments include all the piping structural elements that were evaluated for inclusion in the risk-informed ISI program by the expert panel.

The third column divides the number of the structural elements selected for examination by the expert panel into each of the applicable ASME Code Classifications for each system. This column shows the number of elements that were selected for examination in accordance with the risk-informed ISI program within the ASME Code Class 1, 2, and 3 piping systems, and no exemptions were applied from IWB-1220, IWC-1220, or IWD-1220 of Section XI.

Table 4.4-1 MILLSTONE UNIT 3 PRELIMINARY STRUCTURAL ELEMENT SELECTION RESULTS AND COMPARISON TO ASME SECTION XI 1989 EDITION REQUIREMENTS								
Systems Evaluated	**High Safety-Significant Segments**	**Risk-Informed ISI Program High Safety-Significant Structural Elements**			**ASME Section XI ISI Program 1989 Edition Examination Category Weld Selections**			
		CLASS 1	CLASS 2	CLASS 3	B-F	B-J	C-F-1	C-F-2
BDG (SG Blowdown)	0	-	-	-	-	-	-	-
CCE (CHS Cool)	0	-	-	-	-	-	-	-
CCI (SI Cool)	with SIH	-	-	-	-	-	-	-
CCP (CCW)	4	0	0	5	0	0	0	0
CHS (CVCS)	4	0	6	0	0	9	10	0
CNM (Condensate)	with FWS	-	-	-	-	-	-	-
DTM (Turbine Plant Drains)	with MSS	-	-	-	-	-	-	-
ECCS (1)	1	0	1	0	0	0	0	0
EGF (DG Fuel)	0	-	-	-	-	-	-	-
FWA (Aux Feed)	5	0	8 (2)	1	0	0	0	3
FWS (Feedwater)	0	0	0	0	0	0	0	41
HVK (Control Bld Chill)	0	-	-	-	-	-	-	-
MSS (Main Steam)	0	0	0	0	0	0	0	32
QSS (Quench spray)	1	0	2	0	0	0	64	0

Table 4.4-1 (cont.) MILLSTONE UNIT 3 PRELIMINARY STRUCTURAL ELEMENT SELECTION RESULTS AND COMPARISON TO ASME SECTION XI 1989 EDITION REQUIREMENTS								
Systems Evaluated	**High Safety-Significant Segments**	**Risk-Informed ISI Program High Safety-Significant Structural Elements**			**ASME Section XI ISI Program 1989 Edition Examination Category Weld Selections**			
		CLASS 1	CLASS 2	CLASS 3	B-F	B-J	C-F-1	C-F-2
RCS	55	67(3)	0	0	22	318	0	0
RHS (RHR)	with SIL	-	-	-	-	-	-	-
RSS (Recirc)	1	0	1	0	0	0	23	0
SFC (Fuel Pool)	0	-	-	-	-	-	-	-
SIH (HPI)	4	0	4	0	0	57	28	0
SIL (LPI)	5	0	6	0	0	40	106	0
SWP (SW)	16	0	0	18(3)	0	0	0	0
TOTAL (4)	96	67	28	24	22	424	231	76

Notes:

(1) Section XI weld selections are included in the SIH and SIL systems.

(2) Includes 4 Feedwater Pipe to Nozzle welds that were not determined to be High Safety-Significant.

(3) Eight RCS and 4 Service Water High Safety-Significant elements/segments will require VT-2 exams only.

(4) Total RI-ISI Elements Requiring NDE = 107 Total Section XI Welds = 753 **86% REDUCTION**

No element selections were determined to be applicable outside the existing ASME Code Class boundaries at Millstone Unit 3, but this may not be the case at all plants that apply this process. Section XI currently addresses only weld selections, and under a risk-informed ISI program, this may not always be the case. Since the process identifies the segments of piping that are high safety-significant in relation to their possible failure affecting core damage, the use of existing Section XI exemptions and examination criteria has been shown at Millstone Unit 3 not to be appropriate. Additionally, the following specific information about some of these element selections is provided to show that, under a risk-informed ISI program, the current Section XI requirements may not be applicable to the elements selected for examination:

- for the Chemical and Volume Control System (CHS), six Class 2 elements are shown to have been selected for examination under the risk-informed ISI program. Of these six elements, five are currently exempt from NDE by Section XI because of their pipe sizes under IWC-1220;

- the element selected for examination under the Class 2 column of the Emergency Core Cooling System (ECCS), is not a weld location, but is limited to base metal and is identified in Figure 3.7-4;

- in the Auxiliary Feedwater System (FWA), the Class 3 element that was selected for examination is located on a line that is currently exempt from NDE by pipe size under IWD-1220;

- in the Low Pressure Safety Injection System (SIL), one of the six Class 2 elements selected for examination is also exempt from NDE by pipe size under IWC-1220; and

- for the Service Water System (SWP), selected Class 3 elements, two of the 18 selected are also exempt from NDE by pipe size under IWD-1220.

The fourth column shows the current weld selections under the requirements of the existing Millstone Unit 3 ISI program for Class 1 and 2 piping. These selections are determined under the requirements of Table IWB-2500-1 for Class 1 piping, Examination Categories B-F Pressure Retaining Dissimilar Metal Welds and B-J Pressure Retaining Welds in Piping; and Table IWC-2500-1 for Class 2 piping, Examination Categories C-F-1 Pressure Retaining Welds in

Austenitic Stainless Steel or High Alloy Piping and C-F-2 Pressure Retaining Welds in Carbon or Low Alloy Steel Piping. For Class 3 piping, there are no current requirements to examine welds, but the piping itself receives system pressure tests. For purposes of identifying Class 3 piping subject to examination, the rules of Table IWD-2500-1, Examination Category D-A under the 1992 Edition of ASME Section XI, have been used.

Table 4.4-1 shows that 119 elements were selected for some type of examination under the Millstone Unit 3 risk-informed ISI program. 107 of these elements will receive some type of NDE, Vibration Monitoring, or ID Visual VT3 examination. All the remaining elements in the risk-informed ISI program and those currently included in the Section XI ISI program will continue to receive Visual VT-2 examinations during system pressure tests.

Surry Unit 1 Comparison

Table 4.4-2 for Surry 1 is constructed similar to Table 4.4-1 for Millstone 3 presenting a comparison between a risk-informed program and the current ASME Section XI requirements on piping. An identification of piping segments that are part of plant augmented programs is also included for Surry 1.

As in the Millstone 3 results, Surry 1 will be performing examinations at elements not currently required to be examined by ASME Section XI. Some examples of these additional examinations are provided:

- Several elements currently classified as Non-Code Class will receive examination. These examinations will be in addition to applicable augmented inspection programs that will be continued. Non-Code Class systems or portions of systems that are Non-Code Class identified as having piping segments requiring examination include auxiliary steam, steam generator blowdown, and feedwater. The ASME Section XI Code does not address Non-Code Class systems.

- Several elements currently classified as Class 3 will receive examination. Class 3 systems or portions of systems that are Class 3 identified as having piping segments requiring examination include auxiliary feedwater and component cooling water. The

ASME Section XI Code does not require NDE (volumetric or surface) examinations on Class 3 systems.

- The ASME Section XI Code does not require volumetric and surface examinations of piping less than 3/8 inch wall thickness on Class 2 piping greater than 4 inch nominal pipe size (NPS). The welds are counted for percentage requirements, but not examined by NDE. The risk-informed program will require examination of these welds. Examples where the risk- informed process required examination and the Code did not are the suction lines to the charging pumps (high head safety injection).

Since the risk-informed inspection program will require examinations on a large number of elements constructed to lesser inspection requirements, the program in all cases will determine through an engineering evaluation the root cause of any unacceptable flaw or relevant condition found during examination. The evaluation will include the applicable service conditions and degradation mechanisms to establish that the element(s) will still perform their intended safety function during subsequent operation. Elements not meeting this requirement will be repaired or replaced.

The evaluation will include whether other elements on the segment or segments are subject to the same root cause and degradation mechanism. Additional examinations will be performed on these elements up to a number equivalent to the number of elements required to be inspected on the segment or segments initially. If unacceptable flaws or relevant conditions are again found similar to the initial problem, then the remaining elements identified as susceptible will be examined.

No additional examinations will be performed if there are no additional elements identified as being susceptible to the same service related root cause conditions or no degradation mechanism.

Table 4.4-2 SURRY UNIT 1 STRUCTURAL ELEMENT SELECTION RESULTS AND COMPARISON TO ASME SECTION XI 1989 EDITION REQUIREMENTS										
System	Number of High Safety-Significant Segments (No. in Augmented Program)	Risk-Informed ISI Program High Safety-Significant Structural Elements[a]				ASME Section XI ISI Program 1989 Edition Examination Category Weld Selections				Total Number of Segments Credited in Augmented Programs
		CLASS 1	CLASS 2	CLASS 3	NON-CODE	B-F	B-J	C-F-1	C-F-2	
ACC	0						9			0
AFW[c]	11 (5)		5	3+3[e]					6	16
AS	2				2					0
BD[c]	6 (6)		3		3					12
CC	6			13+4[e]						0
CH	8	12+6[b]+4[e]	1+3[e]				39			3
CN[c]	0									6
CS	0		2[h]					9		2
CW[d]	4									0
ECC	7	12	1				4	24		1
EE	0									0
FC	0									0
FW[c]	13 (13)				7				6	17
HHI[c]	14 (1)		15+2[h]						63	5
LHI[c]	7 (1)		7+3[b]+2[h]						23	1

Table 4.4-2 (cont.)
SURRY UNIT 1 STRUCTURAL ELEMENT SELECTION RESULTS AND COMPARISON TO ASME SECTION XI 1989 EDITION REQUIREMENTS

System	Number of High Safety-Significant Segments (No. in Augmented Program)	Risk-Informed ISI Program High Safety-Significant Structural Elements[a]				ASME Section XI ISI Program 1989 Edition Examination Category Weld Selections				Total Number of Segments Credited in Augmented Programs
		CLASS 1	CLASS 2	CLASS 3	NON-CODE	B-F	B-J	C-F-1	C-F-2	
MS[c]	3 (3)		2+1[g]						18	23
RC	11	20+10[h,i]+3[b]				18	146			3
RH	4	1	4				4	12		0
RS	2		2					4		0
SW[d]	8			5+3[e]						0
VS	2			2						0
TOTAL	108	68	53	33	12	18	202	49	116	89

Summary: Current ASME Section XI selects a total of 385 non-destructive exams while the proposed RI-ISI program selects a total of 136 exams (166 - 30 visual exams), which results in a 65% reduction.

Notes for Table 4.4-2

a. System pressure test requirements and VT-2 visual examinations shall continue to be performed in all ASME Code Class 1, 2, and 3 systems.
b. VT-2 area exam at specific location.
c. Augmented programs for erosion-corrosion and/or high energy line break continue.
d. Pipe coatings program will be maintained.
e. VT-2 for entire segment.
f. UT thickness only.
g. Segment MS-34 has no weld; VT-2 for entire segment.
h. Ten examinations added for change in risk considerations.
i. Six examinations added for defense-in-depth at the reactor vessel outlet nozzle to pipe welds.

4.4.2 Risk/Safety Evaluation

The effect of the RI-ISI program on risk must be estimated in order to ensure that a program that could have an adverse effect on safety is not implemented. The aggregate effects of changes to examination requirements must be evaluated. The assessment should consider changes in ISI effectiveness relative to both the inspection location and the examination method, frequency and level of qualification.

The region in which the piping segment is categorized in the structural element selection matrix (Figure 3.7-1) can be used to guide the evaluation:

- The piping segments in Region 4 should result in a risk neutral impact compared to current ASME Section XI requirements.
- The piping segments in Region 3 should result in a risk neutral impact, particularly if the Owner Defined Program remains the same. However, even if the Owner Defined Program is enhanced, the benefit should be minimal relative to safety, but could be substantial from an plant operation perspective.
- The piping segments in Region 2 should result in a risk neutral impact. The quantitative impact of NDE on these segments is minimal because of the low failure importance within these segments. However, for segments in this region that currently are not examined per current ASME Section XI requirements, the examination of these segments will add defense-in-depth to these high safety-significant locations.
- The piping segments in Region 1 should result in a risk neutral to a beneficial impact on risk. If new susceptible locations are identified, beyond those already examined per ASME Section XI or per an Owner Defined Program, the examination method, frequency, and qualification could have a beneficial impact on risk. An appropriate selection of examination method, frequency and level of qualification could provide a level of improvement in failure probability of the given location depending on the mechanisms and loading conditions that are experienced.

The combined impact of the segments from all four regions is then evaluated to make an overall assessment of RI-ISI program changes on risk. If properly implemented, the RI-ISI should always result in a risk-neutral to risk-reduction compared to the current ASME Section XI program.

If the proposed changes result in a risk impact that is not acceptable, the results from each step of the process should be reviewed to identify where the inclusion of additional piping examinations would decrease the risk impact.

Millstone 3 Plant Evaluation

A comparison of the core damage frequency being addressed by the current ASME Section XI and by the proposed risk-informed ISI program is shown in Figure 4.4-1.

This comparison was based on the core damage frequency being addressed by examination of the 119 structural elements in the risk-informed ISI program and the 753 weld locations that are examined per current ASME Section XI requirements. If a structural element was being inspected in the current ASME Section XI program, then the CDF contribution for the segment containing that structural element was identified and was included in the total CDF being addressed for the system. Similarly, if a structural element is to be inspected in the proposed risk-informed ISI program, then the CDF for the segment containing that structural element was included in the calculation of the total CDF being addressed for the system. Examination of the current ASME Code weld locations addresses a CDF of 1.00E-08/yr (44%) while examination of the risk-informed ISI structural elements addresses a CDF of 2.25E-08/yr (98%) for pressure boundary piping failures (out of a total piping CDF of 2.28E-08/year). Thus, safety is enhanced with far less locations being inspected.

This figure shows the comparison by the systems as defined in the risk-informed program. For example, Table 4.4-1 shows no risk-informed ISI locations for the FWS system, but it shows ISI locations for current ASME Section XI requirements. However, because of the system definition used in the risk-informed ISI program, several locations classified under FWS in ASME Section XI are the same as those classified in the FWA system under the risk-informed ISI program (piping that is common to both the FWA and FWS systems was assigned to the FWA system in the risk-informed program).

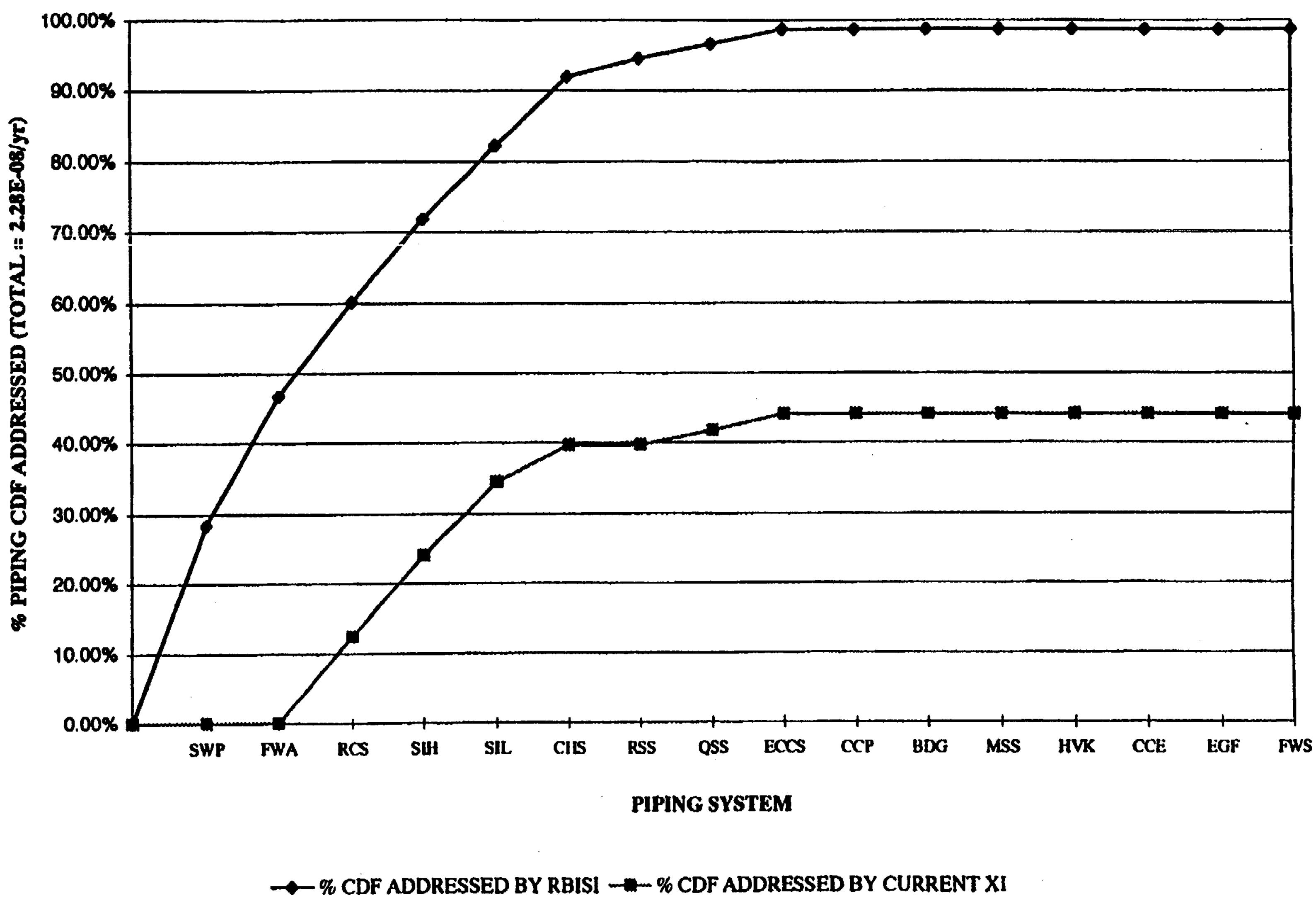


Figure 4.4-1 Millstone Unit 3 Comparison of CDF Results on a Piping System Level

This comparison also assumes 100% effectiveness in detection of precursors to failures for both the Section XI and risk-informed ISI locations in the high safety-significant segments. Credit for leakage testing in finding these precursors by either program in both the high safety-significant and low safety-significant piping segments is not taken in this evaluation.

The total piping core damage frequency is a small fraction of the total plant core damage frequency of 5.87E-05/yr. Examination of the plant piping at the risk-informed locations, however, will verify that the risk of piping pressure boundary failure remains a small contributor to total risk as the unit ages over its licensed life.

Surry Evaluation

A comparison of the Surry results from the proposed risk-informed ISI program and that of the current Section XI ISI program was made to evaluate the change in risk. Two approaches were used to compare the CDF and LERF changes.

The first approach (similar to the Millstone 3 evaluation) assumed that for any segment a) in the current Section XI program (for the Section XI risk calculation) or b) in the proposed RI-ISI program (for that calculation) or, c) in the augmented program, the risk associated with that segment would be addressed completely (with 100% effectiveness). The results from this approach are shown in Figures 4.4-2 and 4.4-3 by system, for CDF and LERF respectively.

As shown by the figures, the RI-ISI program (with augmented) addresses approximately 86% of the CDF risk while the current Section XI (with augmented) addresses about 53%. Similarly, the RI-ISI program (with augmented) addresses approximately 94% of the LERF risk while the current Section XI addresses only 20%. The systems which lead to the improvement which are addressed in the RI-ISI program are blowdown, feedwater, main steam and auxiliary feedwater.

The second approach evaluates the change in risk with the inclusion of the probability of detection as determined by the SRRA model. For this risk comparison between the current Section XI ISI program and the recommended risk-informed ISI program calculations, the following conditions are used:

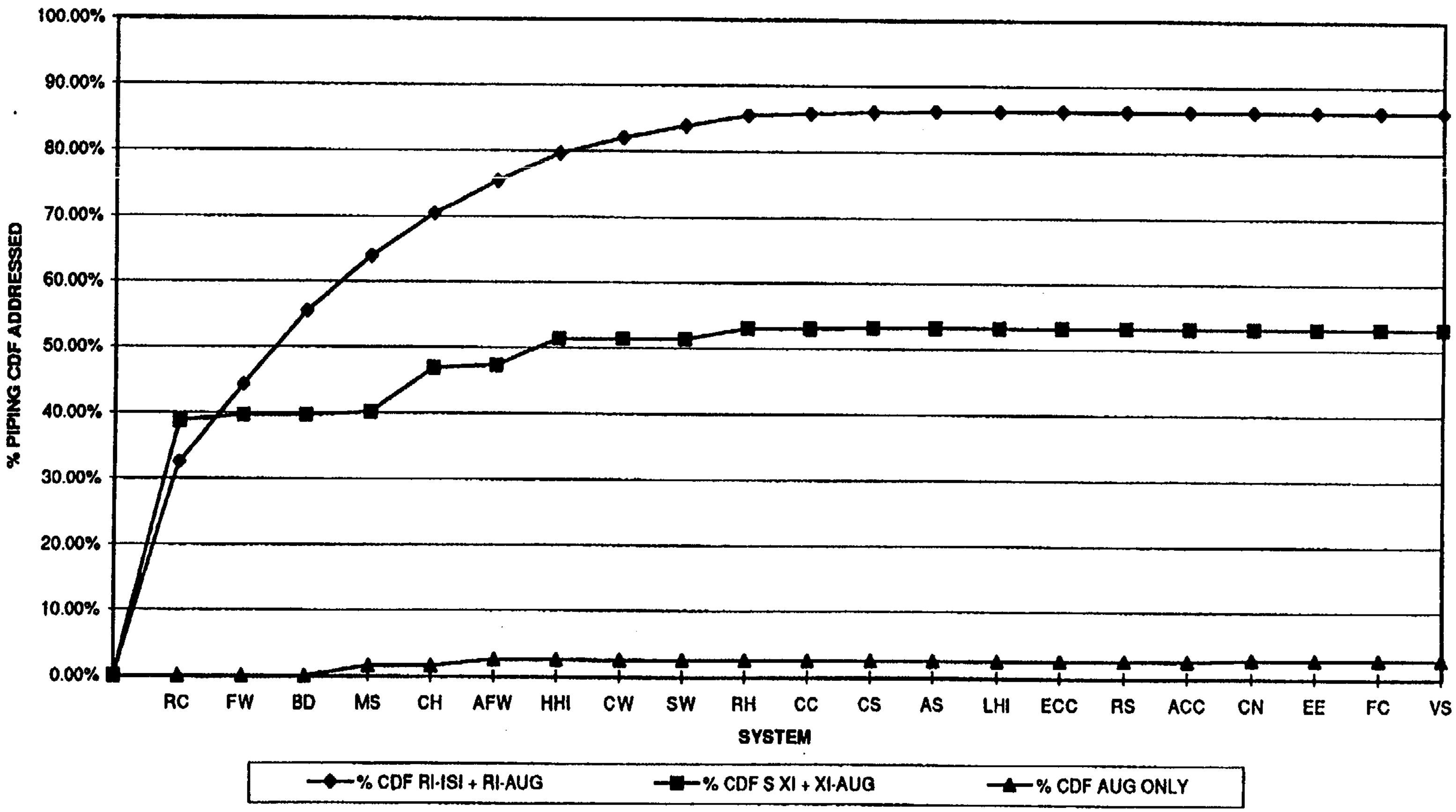


Figure 4.4-2 Surry Unit 1 Comparison of CDF Results on a Piping System Level

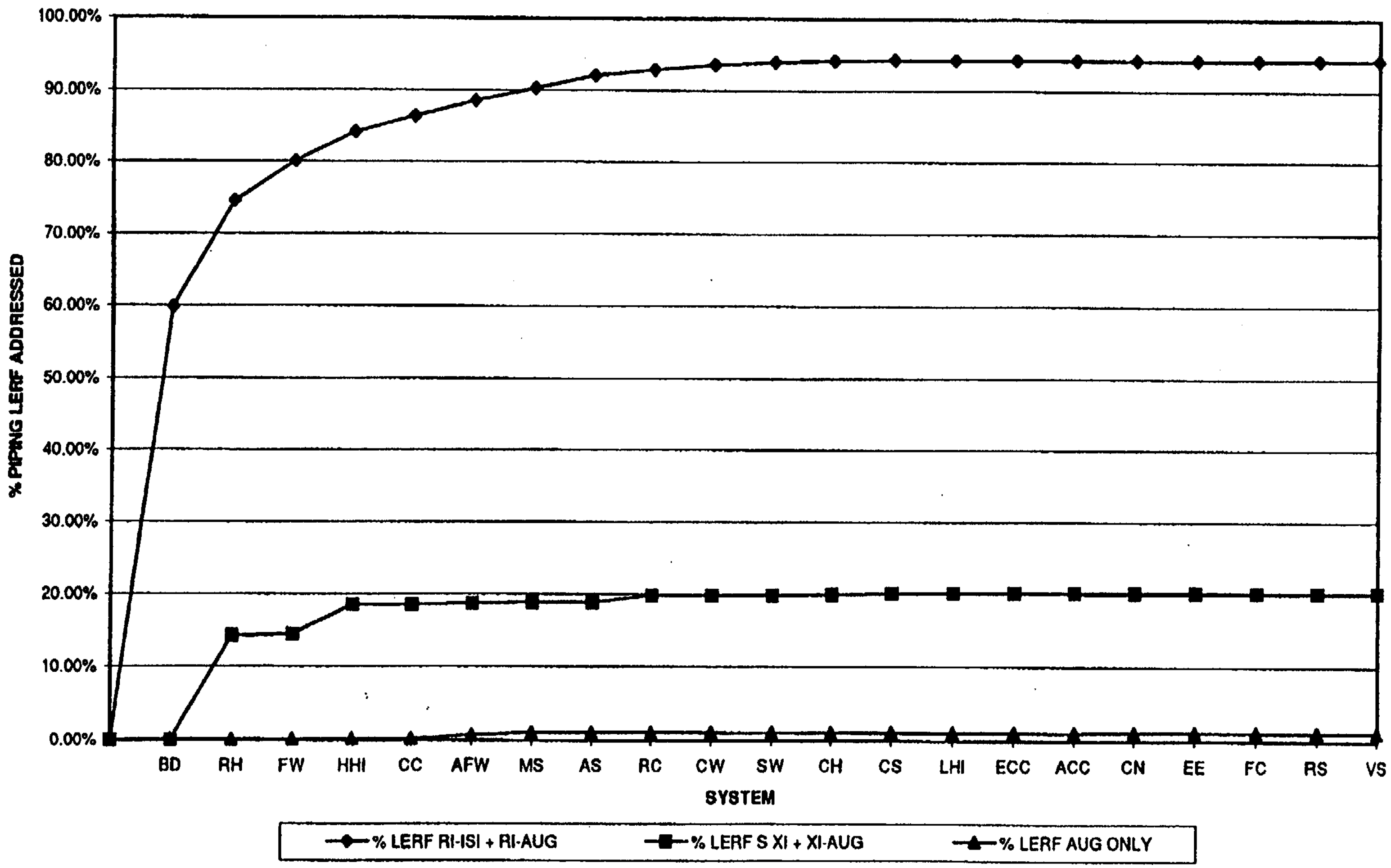


Figure 4.4-3 Surry Unit 1 Comparison of LERF Results on a Piping System Level

- For piping segments that are part of augmented programs (such as erosion-corrosion and stress corrosion cracking), the SRRA failure probabilities with ISI are used (no change from previous calculations).

- For other piping segments, the failure probability with ISI for those being inspected by NDE are used.

- For the RCS piping segments, the failure probability with ISI for those being inspected by NDE and without ISI for those not being inspected was used along with credit for leak detection.

- The risk calculations are performed for all 4 cases (CDF and LERF with and without operator action). The calculations with operator recovery action from the piping failure assumes perfect operators, that is, no human error probabilities will be included.

- For piping segments that are in both the Section XI program and the augmented program, no additional credit is given to the Section XI program in the calculations.

- For piping segments that are in both the RI-ISI program and the augmented program, no additional credit is given to the RI-ISI program in the calculations.

- For selected piping segments that are in both the RI-ISI program and the augmented program in which additional or more stringent examinations are proposed beyond the augmented program, a factor of three improvement (based on work done by Khaleel and Simonen, 1994 which identified an improvement factor based on failure potential) in the failure probability was credited.

- For selected piping segments that are in both the current Section XI program AND an augmented program in which the Section XI proposes that additional or more stringent examinations beyond the augmented program are performed, a factor of three improvement in the failure probability is credited.

Criteria For Evaluation of Results

The suggested criteria for evaluating the results of the study are the following:

1. The total change in piping risk should be risk neutral or a risk reduction in moving from the current Section XI to RI-ISI. If not, the dominant system and piping segment contributors to the RI-ISI risk should be reexamined in an attempt to identify additional examinations which would make the application at least risk neutral. If additional examinations can be proposed, then the change in risk calculations should be revised to credit these additional examinations until at least a risk neutral position is achieved.

2. Once this is achieved, an evaluation of the dominant system contributors to the total risk for the RI-ISI (e.g., system contribution to the total is greater than approximately 10%) should be examined to identify where no improvement has been proposed (i.e., where moving from no ISI or Section XI ISI to RI-ISI, the risk has not changed and it is still a dominant contributor to the total CDF/LERF). If any systems are identified where this is the case, the dominant piping segments in that system should be reevaluated in an attempt to identify additional examinations which would reduce the overall risk for these systems and thus possibly the overall risk.

3. The results should be reviewed to identify any system in which there is a risk increase in moving from the Current Section XI program to the RI-ISI program. The following guidelines are suggested to identify if additional examinations are necessary:

   - If the CDF increase for the system is approximately a) greater than two orders of magnitude below the risk-informed ISI CDF for that system or b) greater than 1E-08, (whichever is higher), then at least one dominant segment in that system should be reevaluated to identify additional examinations

   - If the LERF increase for the system is a) greater than two orders of magnitude below the risk-informed ISI LERF for that system or b) greater than 1E-09 (whichever is higher), then at least one dominant segment in that system should be reevaluated to identify additional examinations

4. If any additional examinations are identified, the change in risk calculations should be revised to credit these additional examinations.

These criteria will provide added assurance that the risk from moving to the RI-ISI program has been addressed. For Surry, this evaluation resulted in the identification of 10 piping segments for which examinations are now required.

The results from the risk comparison for Surry are shown in Table 4.4-3 and Figure 4.4-4. As can be seen from the table and figure, the risk-informed ISI program reduces the risk associated with piping CDF/LERF slightly more than the current Section XI program while reducing the number of examinations required.

Table 4.4-3
SURRY UNIT 1 COMPARISON OF CDF/LERF FOR NO ISI, CURRENT SECTION XI AND RISK-INFORMED ISI PROGRAMS

Case	Piping CDF/LERF Without ISI	Piping CDF/LERF Current Section XI	Piping CDF/LERF Risk-Informed
CDF No Operator Action	6.28E-05	6.09E-05	5.34E-05
CDF with Operator Action	4.05E-06	2.29E-06	1.67E-06
LERF No Operator Action	5.18E-06	5.09E-06	4.63E-06
LERF with Operator Action	4.46E-07	3.63E-07	1.54E-07

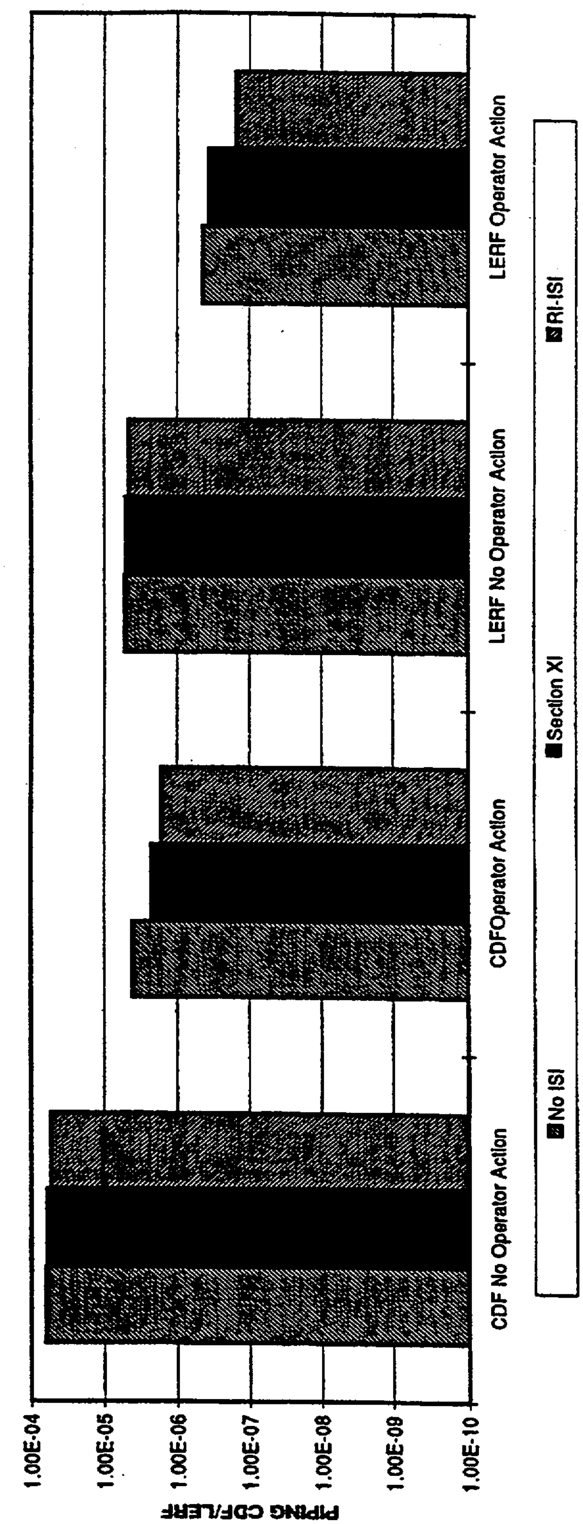


Figure 4.4-4 Surry Unit 1 Comparison of CDF/LERF for No ISI, Current Section XI, and Risk-Informed ISI Program

A comparison between the total piping CDF/LERF and the total plant CDF/LERF reported for Surry in Section 3.1.4 (total plant CDF of 7.2E-05/year and total plant LERF of 1.1E-05/year) was not made because both the piping CDF/LERF and the plant CDF/LERF address large, medium, and small LOCAs, steam line breaks and other events (i.e., there is overlap between the two models).

4.4.3 Cost-Benefit Evaluation

Upon completion of general NRC approval allowing use of risk-informed ISI methodologies contained in this WOG Topical Report for piping, a nuclear utility owner will decide whether to develop their own risk-informed program. The owner will have the option to identify and implement alternative approaches to achieve the same or greater level of safety than is obtained through implementation of ASME Section XI. The choice of alternatives will be first predicated on achieving the same or greater safety (as ASME Section XI), and then on the associated economic and manrem burden associated with the various alternatives.

To support the WOG risk-informed ISI applications, both Northeast Utilities and Virginia Power performed cost-benefit evaluations at the time the respective studies at Millstone Unit 3 and Surry Unit 1 were being completed. Northeast Utilities reviewed prior ISI program information to estimate both the direct and indirect inspection costs and to estimate person-rem savings from implementation of the program. Virginia Power used average NDE examination costs and assumed that similar person-rem savings could be achieved as Northeast Utilities showed for Millstone Unit 3. Virginia Power also estimated how much effort it would take to repeat a risk-informed ISI application for heir other units. A paper by Nitin J. Shah, et al (1997) also captures their cost-benefit study along with lessons learned from performing the pilot study at Surry Unit 1. The next sections summarize the Northeast Utilities and Virginia Power studies to help other utilities in determining the cost-benefit of doing a risk-informed ISI program.

<u>Northeast Utilities Study</u>

Northeast Utilities has provided estimated savings from implementation of a risk-informed inservice inspection program to the piping systems at Millstone Unit 3 in the Supplemental Information enclosed within this topical report. This section builds on this information to provide an indication of the cost-benefit for all WOG member plants.

An estimated savings of $332,000 per outage in direct inspection related costs has been identified for Millstone Unit 3. A savings of 15 person-rem per outage has also been estimated for inspection of Millstone Unit 3 piping using a risk-informed approach.

The Westinghouse Owners Group has established estimated standard cost factors for parameters that are impacted by their programs using a blending of information from the membership. These factors are used in this cost-benefit evaluation, where applicable.

Table 4.4-4 shows net present values of estimated savings from implementation of a risk-informed inspection program for nuclear plant piping systems. As shown in the table, significant savings can be achieved in direct costs. Other indirect cost savings are also expected to be significantly reduced. These indirect cost savings are expected to include:

- Outage critical path reduction (which is becoming more important as utilities continue to reduce outage length)
- Program administration cost reduction
- Insurance premium reduction
- Cost reduction associated with evaluating flaw indications in low safety-significant piping

In addition, a risk-informed ISI program should enhance the finding of precursors to potential failures because inspection resources are focused on locations of highest failure potential in high safety-significant piping segments. The identification of these precursors should help minimize events like leaks, which result in significant business interruption losses. In summary, the development and implementation of a risk-informed ISI program provides the opportunity to significantly reduce burden while maintaining or enhancing safety.

The total effort to perform the risk-informed ISI program for the representative WOG plant exceeded the direct savings that would be gained during one outage at that unit. However, more than half of that cost was associated with learning and adapting the methodology to be applied across all the piping systems at a large nuclear plant, which is a first-of-a-kind application. In addition, there were considerable costs associated with interfacing with ASME, NEI, and the NRC on this project.

Table 4.4-4
ESTIMATED SAVINGS FROM RISK-INFORMED INSPECTION FOR TYPICAL 4-LOOP PLANT* (MILLSTONE 3)

Description	Considerations	Net Present Value of Savings**
Direct Costs		
Actual Inspection Costs	Includes NDE, scaffolding and insulation removal	$1,889,660
ALARA Costs	Assuming approximately 15 REM per outage savings and using $10,000/REM	$846,650
	TOTAL DIRECT COST SAVINGS	$2,736,310
Indirect Costs		
Administrative Costs	Paper work including work orders, surveillances and clearances	Not estimated
Outage Critical Path	Reduction of 1-2 days of outage time anticipated as outages become shorter (NPV savings assumes 0.5 day at $340,000 per day)	$1,314,170
Insurance Premiums		Not estimated
Analysis Costs	From flaw indication evaluations in low safety-significant piping segments	Not estimated
	TOTAL ESTIMATED DIRECT AND INDIRECT SAVINGS	> $4,050,480

* The estimated savings for 2-loop and 3-loop units will obviously be lower than these values depending on the number of piping locations currently being inspected to the requirements of ASME Section XI. The effort to perform a risk-informed ISI program, however, will require less resources relative to the number of piping system segments to be addressed.

** Assumes discount rate of 7.5% and estimated savings at each outage over the remaining 30 years of operating license life.

It is believed by the team members that the risk-informed ISI program can be applied in the future at a cost much less than the direct savings that are gained from piping examinations done in one outage from implementation of the program.

Virginia Power Study

The Surry-1 pilot project endeavored to measure the relative level of safety provided by the risk-informed methodology that should provide a basis for general NRC approval via this Topical report that other utilities will follow.

Preliminary cost figures have been developed from the Surry-1 project, both actual and projected, to better understand the cost of implementing a risk-informed ISI program. A man-week (ManWk) assessment follows:

1) System scope - 2.5 Manweeks
2) Segment identification - 7.5 Manweeks
3) Conditional consequence quantification - 30 Manweeks
4) Failure probability quantification - 46 Manweeks
5) Risk evaluation - 3.0 Manweeks
6) Expert panel categorization - 24 Manweeks
7) Element & NDE selection - 12 Manweeks
8) Administrative - 4.0 Manweeks

Total: 129 Manweeks

A man-week cost was estimated at $2300. The estimate contains direct plus contractor costs brought in to support the project and provide training. The estimated cost to develop a program is approximately $300,000. Additionally, Virginia Power has three other similar units (North Anna 1 & 2 and Surry 2), where some reduction in cost can be obtained due to the similarity. It is estimated that all four units can be completed for approximately $950,000. This cost does not include WOG support funds requested for the Surry-1 pilot. These funds were considered unique to the pilot application (sensitivity studies, software alterations, research, etc.) and would not be required after rulemaking. The SRRA failure probability software was provided to the Surry project at no additional cost.

Program maintenance costs are assumed equivalent to the current program maintenance costs for the purpose of this analysis due to a lack of information and, therefore, are not considered in the evaluation. However, the program is a living program and will require more frequent updates when requirements necessitate it. As such, the maintenance costs will be higher, but probably only marginally.

Again, assuming equivalency in safety, management will want to recover the initial investment costs in the program over time or the process would be rejected rather quickly. The actual projected reduction is estimated at this time to be 65% (see Table 4.4-2), however savings can be plotted over various reduction percentages to ascertain the break-even point. Figures 4.4-5 and 4.4-6 provide some of this information. The plots assume that an average NDE examination costs $4000. One-third of the cost is direct NDE costs and two-thirds is associated with support work (scaffolding, insulation removal and reinstallation, cleaning, etc.). Figure 4.4-6 additionally assumes an exposure reduction at 80% (15 Rem / 4 loop plant, 10 Rem / 3 loop plant) and assumes a cost of $10,000/Rem. The exposure reduction is then reduced linearly with reduction percentage. The plots are based upon current ASME Section XI programs at three Westinghouse PWRs.

By assuming a 65% reduction in examination at an older 3-loop plant, such as Surry-1, due to the risk-informed methodology, then Figure 4.4-5 indicates that the initial $300,000 investment, not considering exposure reduction, would be paid back in just over 3 years. Considering the exposure reduction (Figure 4.4-6) would reduce the time to approximately 2 years. The example of course is simplified and does not consider interest on investments, inflation or tax credits, which would also be considered in an economic evaluation. Larger plants return the initial investment quicker (12-18 months), since given the same reduction percentage, they have more welds in their current ASME Section XI program to be reduced from examination, as demonstrated in the Millstone-3 reference plant study.

Both the Northeast Utilities and Virginia Power cost-benefit studies show that the risk-informed ISI methodology described in this WOG Topical Report provides an opportunity for nuclear utilities to reduce cost while maintaining high levels of safety. The decision to implement such a program should be made with the knowledge that the process involves a significant technical and economic investment.

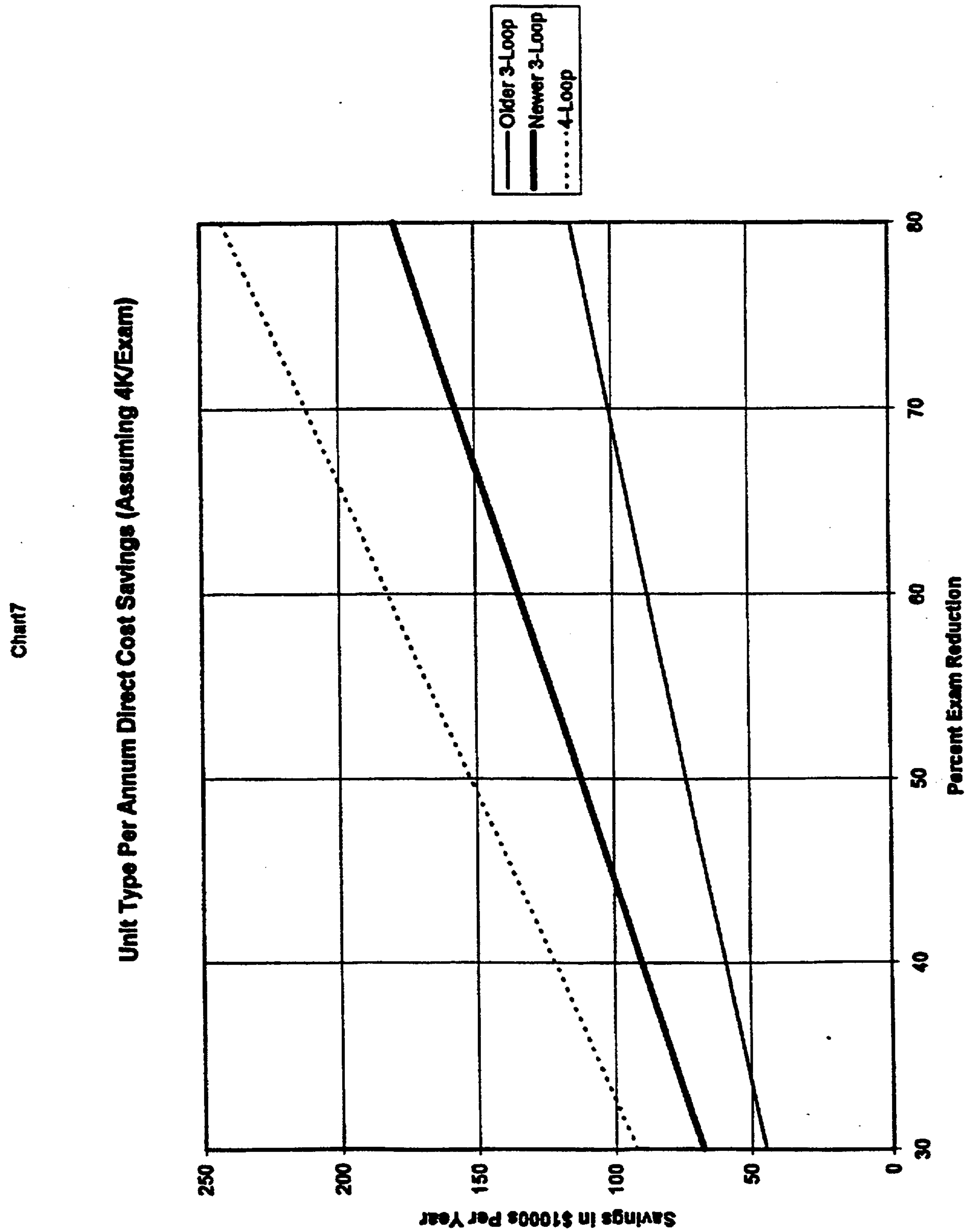


Figure 4.4-5 Unit Type Per Annum Direct Cost Savings (Assuming 4K/Exam)

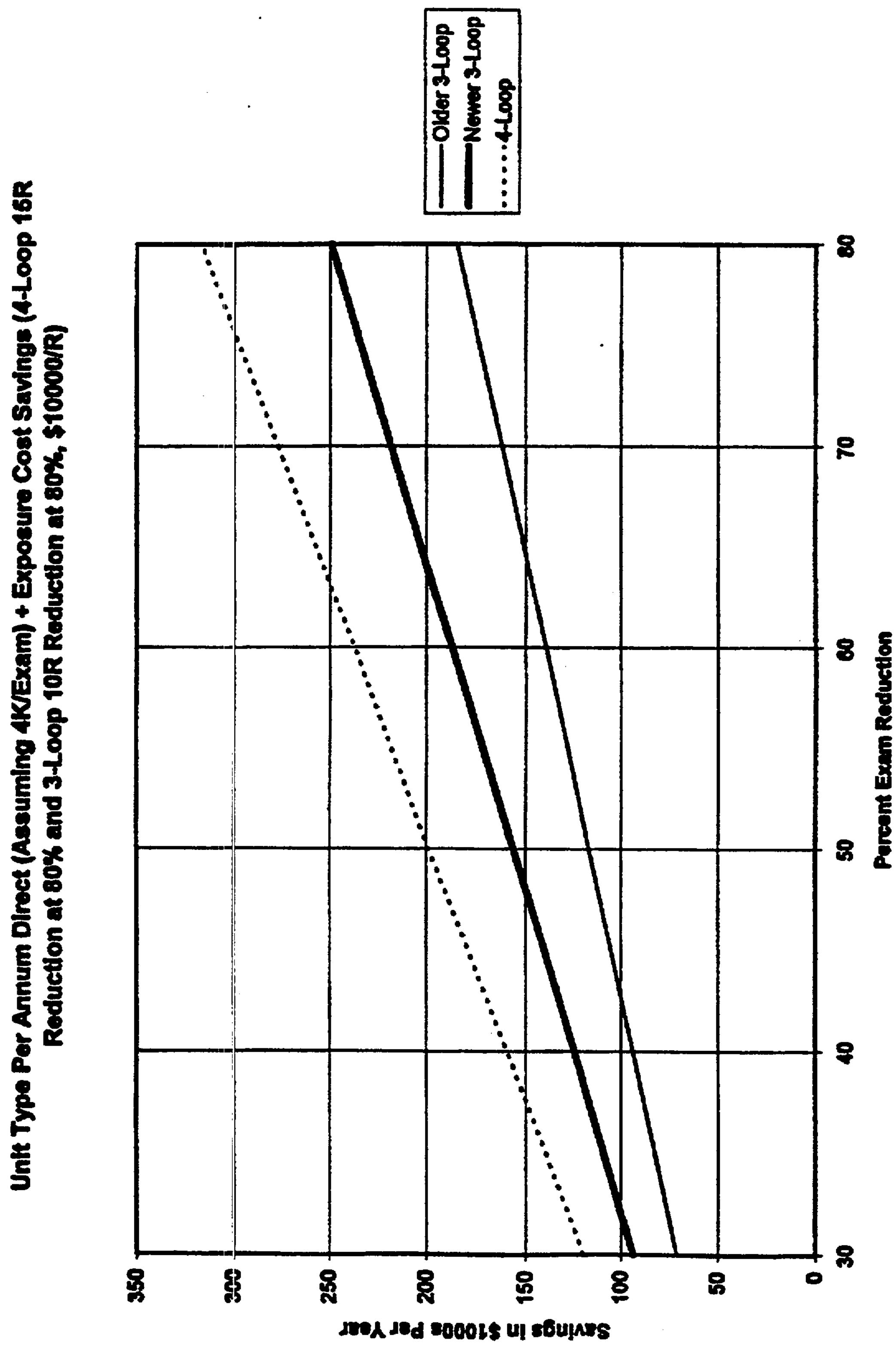


Figure 4.4-6 Unit Type Per Annum Direct (Assuming 4K/Exam) + Exposure Cost Savings (4-Loop 15R Reduction at 90% and 3-Loop 10R Reduction at 90%, $10000/R)

4.5 IMPLEMENTATION AND PROGRAM MONITORING

This subsection provides program requirements and recommendations for the activities associated with implementation, monitoring and corrective action descriptions necessary to support a RI-ISI program.

4.5.1 Implementation

The implementation of a RI-ISI program for piping should be initiated at the start of a plant's 10-year inservice inspection interval consistent with the requirements of the ASME Code Section XI, Edition and Addenda committed to by an Owner in accordance with 10 CFR 50.55a. However, implementation may begin at any point in an existing interval as long as the examinations are scheduled and distributed to be consistent with these requirements and those of this section. The requirements for these intervals are contained in ASME Section XI under IWA-2000 as they apply to Inspection Program B. Documentation of program updates shall be kept and maintained by the Owner on site for audit. Changes arising from the program updates should be evaluated using the change mechanisms described in existing applicable regulations (e.g., 10CFR50.55a, 10CFR50.59, and 10CFR50 Appendix B) to determine if the change to the RI-ISI program should be reported to the NRC. Each 10-year inspection interval is subdivided into inspection periods which end at 3, 7, and 10 years of plant service within each interval. Variations in these inspection program intervals and periods by plus or minus 1 year are allowed under ASME Section XI based on refueling outage situations and may be employed by an Owner who implements a RI-ISI program. These same basic RI-ISI program interval and period requirements shall also be used by Owners who choose to perform on-line NDE, but special considerations may have to be taken in regards to program updates during the performance of corrective actions that result from these examinations. When on-line NDE is performed as part of a RI-ISI program, it is the Owner's responsibility to address the special considerations that may require exceptions to the requirements of ASME Section XI or those in this section.

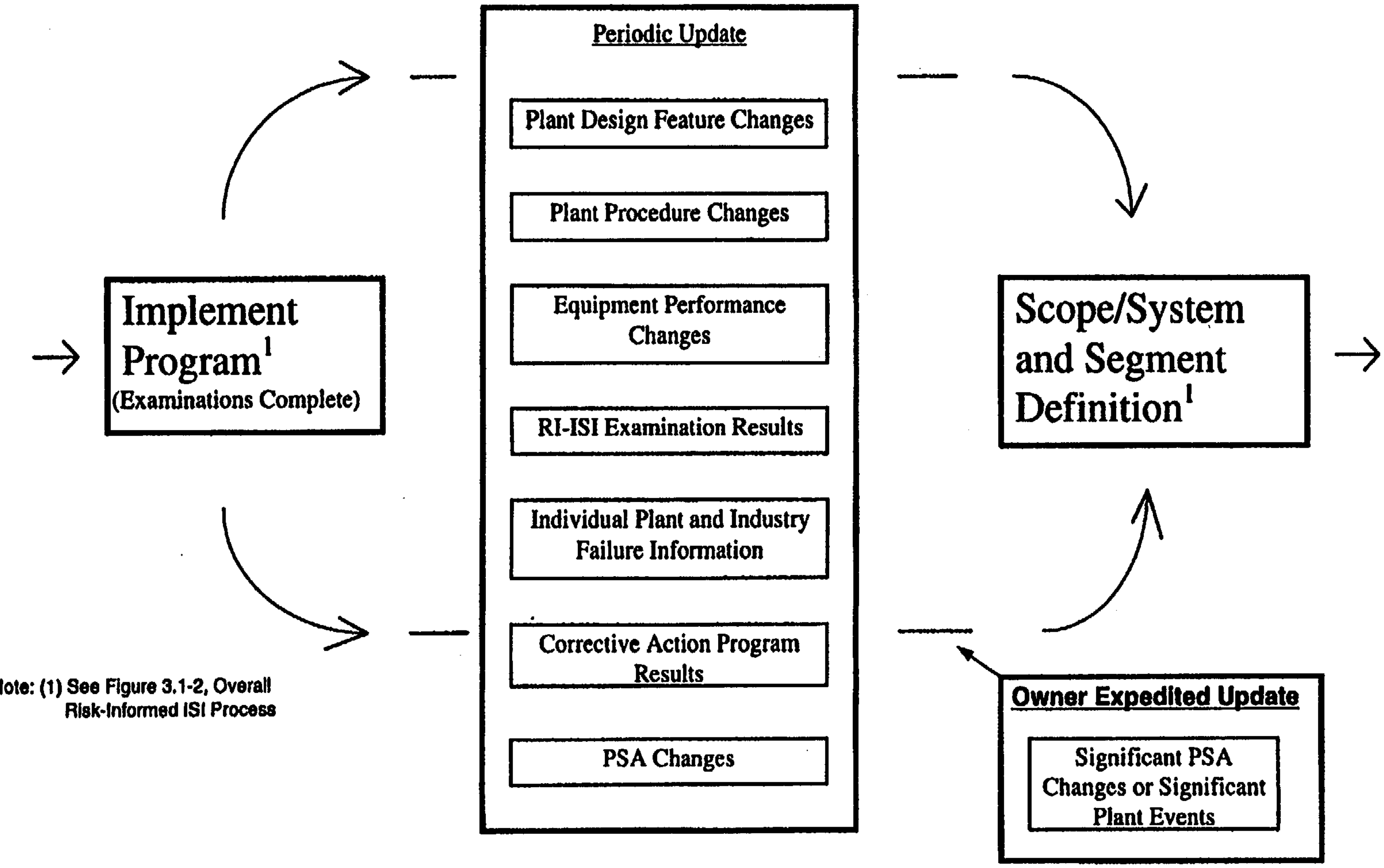
4.5.2 Program Monitoring

RI-ISI programs are living programs and should be monitored continuously. Monitoring of these programs encompasses many facets of feedback or corrective action which includes periodic updates based on inputs and changes resulting from plant design features, plant procedures, equipment performance, examination results, and individual plant and industry failure information. Once the Feedback Process Loop is completed as shown in Figure 4.5-1, all the information is fed back into the Overall Risk-Informed ISI Process of Figure 3.1-2. The periodic update is performed by evaluating the information from the Feedback Process Loop for its applicability to each step in the Overall Risk-Informed ISI Process and begins at the Scope/System and Segment Definition block and ends at the Implement Program block. Changes should be evaluated to determine if the change should be reported to the NRC.

Since the Probabilistic Safety Assessment (PSA) used in the development of any RI-ISI program is a state of knowledge at the time of implementation, any significant changes in these parameters that effect the total plant's Core Damage Frequency (CDF) or Large Early Release Frequency (LERF) by a critical factor should be considered, when identified, as expeditiously as possible. Plant administrative procedures should be in place to input these changes into the PSA and incorporate any relevant results into the RI-ISI program outside of any periodic updates. These expedited program updates should be performed to address significant PSA changes or the occurrence of significant plant events. Significant plant events may include such events as pipe ruptures, earthquakes, or severe operational transients.

- *Periodic Updates.* Updates to a RI-ISI program are performed at least on a period basis to coincide with the inspection program requirements contained in ASME Section XI under Inspection Program B. These updates are required following the completion of all scheduled examinations in each inspection period.

- *Plant Design Feature Changes.* As plant design changes are implemented, changes to the inputs associated with RI-ISI program segment definition and element selections may occur. It is important to address these changes to the inputs used in any engineering assessment or Structural Reliability/Risk Assessment (SRRA) model that may effect resultant failure probabilities in terms of pipe leakage, disabling leakage or full rupture



Note: (1) See Figure 3.1-2, Overall Risk-Informed ISI Process

Figure 4.5-1 Feedback Process Loop

events during RI-ISI program periodic updates. Some examples of these inputs would include the following:

- Material and Configuration Changes
- Welding Techniques/Procedures
- Construction and Preservice Examination Results and
- Stress Data (Operating Modes, Pressure, and Temperature Changes)

In addition, plant design changes could result in significant changes to a plant's CDF or LERF, which in turn could result in a change in consequence for a system's piping segments.

- *Plant Procedure Changes.* Changes to plant procedures that affect system operating parameters or the ability of plant operations personnel to perform actions associated with accident mitigation should be included for review in any RI-ISI program periodic update. Additionally, changes in these procedures which affect component test intervals, valve lineups, or operational modes of equipment shall also be assessed for their impact on changes in postulated failure mechanism initiation or CDF/LERF contribution.

- *Equipment Performance Changes.* Equipment performance changes should be reviewed with system engineers and maintenance personnel to ensure that changes in performance parameters such as valve leakage, increased pump testing or identification of vibration problems is included in the evaluation of the RI-ISI program periodic update. Specific attention should be paid to these conditions if not previously assessed in the qualitative inputs to the element selections of the RI-ISI program.

- *Examination Results.* When scheduled RI-ISI program NDE examinations and system pressure tests (Refer to 4.3) are completed with corresponding VT-2 visual examinations for leakage, and flaws or indications of leakage are identified, the existence of these conditions should be evaluated as part of the RI-ISI program periodic update.

Current ASME Section XI ISI examination reporting requirements do not contain provisions for reporting examination results of ASME Code Class 3 items nor do they address HSS or HSS Non-Code Class items that could be included in a RI-ISI program. In order to compensate for these deficiencies in the current requirements, it is recommended that Owners use Code Case N-532 Alternative Requirements to Repair and Replacement Documentation Requirements and Inservice Summary Report Preparation and Submission as Required by IWA-4000 and IWA-6000 Section XI Division 1 with the supplemental requirements contained in this section.

Code Case N-532 provides for reporting examination and pressure test results on a periodic basis for all ASME Code Class 1, 2, and 3 items consistent with the periodic updates described in this section. When using Code Case N-532 RI-ISI results would be documented on an OWNER'S ACTIVITY REPORT FORM OAR-1 which includes the Abstract Tables contained in the Code Case. Figure 4.5-2 shows a sample Form OAR-1 with these Abstract Tables. Owners should be aware that Code Case N-532 is not generically approved for use by the NRC, but that it has been approved on a plant specific basis and is available to the industry subject to NRC approval. After receiving NRC approval to use Code Case N-532 for a RI-ISI program the following should apply:

A Form OAR-1 per N-532 shall be prepared and certified upon completion of all examinations and system pressure tests each refueling outage. All Form OAR-1s prepared during an inspection period shall be submitted to the NRC following the end of the inspection period. The following tables are part of each Form OAR-1.

N-532, Table 1 – Abstract of examinations and tests shall include all HSS piping items examined by NDE and HSS and LSS system pressure tests performed in accordance with requirements of a RI-ISI program regardless of ASME Code Classification.

N-532, Table 2 – Items with flaws that required evaluation for continued service shall include all HSS piping items subject to NDE in accordance with a RI-ISI program. ASME Section XI requires that analytical evaluation of ASME Code Class 1 and 2 examination results be submitted to the regulatory authority having jurisdiction at the plant site in accordance with IWB-3134(b) and IWC-3125(b). It is recommended that for a RI-ISI program analytical evaluations be submitted to the NRC for review prior to returning the component or system to service. Requirements for analytical evaluation submittals shall be applicable to all HSS piping items subject to NDE regardless of ASME Code Classification. When acceptance criteria for ASME Code Class 3 and HSS Non-Code Class piping items does not exist in ASME Section XI, the Owner shall use the provisions of IWA-3100(b) or any applicable acceptance criteria contained in the Owner's CLB.

FORM OAR-1 OWNER'S ACTIVITY REPORT

Report Number ____________________

Owner ____________________
(Name and Address of Owner)

Plant ____________________
(Name and Address of Plant)

Unit No. __________ (if applicable) Commercial service date __________ Refueling outage no. __________

Current inspection interval ____________________
(1st, 2nd, 3rd, 4th, other)

Current inspection period ____________________
(1st, 2nd, 3rd)

Edition and Addenda of Section XI applicable to the inspection plan ____________________

Date and revision of inspection plan ____________________

Edition and Addenda of Section XI applicable to repairs and replacements, if different than the inspection plan ____________________

CERTIFICATE OF CONFORMANCE

I certify that the statements made in this Owner's Activity Report are correct, and that the examinations, tests, repairs, replacements, evaluations, and corrective measures represented by this report conform to the requirements of Section XI.

Certificate of Authorization No. __________ (if applicable) Expiration Date __________

Signed ____________________ (Owner or Owner's Designee, Title) Date __________

CERTIFICATE OF INSERVICE INSPECTION

I, the undersigned, holding a valid commission issued by the National Board of Boiler and Pressure Vessel Inspectors and the State or Province of __________ and employed by __________ of __________ have inspected the items described in this Owner's Activity Report, during the period __________ to __________, and state that to the best of my knowledge and belief, the Owner has performed all activities represented by this report in accordance with the requirements of Section XI.

By signing this certificate neither the Inspector nor his employer makes any warranty, expressed or implied, concerning the examinations, tests, repairs, replacements, evaluations and corrective measures described this report. Furthermore, neither the Inspector nor his employer shall be liable in any manner for any personal injury or property damage or a loss of any kind arising from or connected with this inspection.

__________ (Inspector's Signature) Commissions __________ (National Board, State, Province, and Endorsements)

Date __________

This form (E00127) may be obtained from the Order Dept., ASME, 22 Law Drive, Box 2300, Fairfield, NJ 07007-2300.

Figure 4.5-2 Sample Form OAR-1 with Abstract Tables 1, 2, and 3

TABLE 1
ABSTRACT OF EXAMINATIONS AND TESTS

Examination Category	Total Examinations Required for The Interval	Total Examinations Credited for This Period	Total Examinations Credited (%) For The Period	Total Examinations Credited (%) To Date for The Interval	Remarks

TABLE 2
ITEMS WITH FLAWS OR RELEVANT CONDITIONS THAT REQUIRED EVALUATION FOR CONTINUED SERVICE

Examination Category	Item Number	Item Description	Flaw Characterization (IWA-3300)	Flaw or Relevant Condition Found During Scheduled Section XI Examination or Test (Yes or No)

TABLE 3
ABSTRACT OF REPAIRS, REPLACEMENTS, OR CORRECTIVE MEASURES REQUIRED FOR CONTINUED SERVICE

Code Class	Repair, Replacement, or Corrective Measure	Item Description	Description of Work	Flaw or Relevant Condition Found During Scheduled Section XI Examination or Test (Yes/No)	Date Complete	Repair/ Replacement Plan Number

Figure 4.5-2 (cont.) Sample Form OAR-1 with Abstract Tables 1, 2, and 3

N-532, Table 3 – Abstract of repairs, replacements, or corrective measures required for continued service shall include all HSS piping items subject to NDE or HSS and LSS items subject to system pressure tests in a RI-ISI Program regardless of ASME Code Classification. A repair or replacement plan and corresponding Form NIS-2A Repair/Replacement Certification Record is not required for HSS or LSS Non-Code Class piping items. Repairs or replacements performed on HSS or LSS Non-Code Class piping items shall be performed in accordance with the Owner's CLB.

Reporting requirements for examination results are shown in Figure 4.5-3.

- *Individual Plant and Industry Failure Information.* Review of individual plant maintenance activities associated with repairs or replacements that are or are not the result of RI-ISI program examinations, including identified flaw evaluations, is an important part of any RI-ISI program periodic update. Evaluating this information as it relates to an Owner's plant provides failure information and trending information that may have a profound effect on the element locations currently being examined under a RI-ISI program. When this review is coupled with industry failure information, a complete update results. Industry failure data is just as important to the overall program as the Owner's information. During the RI-ISI program periodic update individual plant failure information and industry data bases such as the Electric Power Research Institute (EPRI) data base and technical report titled Piping Failures in United States Nuclear Power Plants: 1961 - 1997, presently in draft format at the time of this report, and the Nuclear Performance and Reliability Data System/Equipment Performance and Information Exchange NPRDS/EPIX data base should be reviewed for applicability to the Owner's RI-ISI program.

4.5.3 Use of Corrective Action Programs

Each Owner of a nuclear power plant is responsible to have a corrective action program under the provisions of 10 CFR 50, Appendix B as follows:

"Measures shall be established to assure that conditions adverse to quality, such as failures, malfunctions, deficiencies, deviations, defective material and equipment, and nonconformances

EXAMINATIONS & PRESSURE TESTS
(Complete Per Refueling Outage
RI-ISI Program Requirements)

⇩

SUBMIT ALL ANALYTICAL FLAW EVALUATIONS TO NRC
(Recommended Submittal Prior To Returning
A System Or Component To Service)

⇩

COMPLETE A FORM OAR-1
(With Table Information Required
After Each Refueling Outage)

⇩

SUBMIT COMPLETED FORM OAR-1s
(With Table Information Required
To The NRC Following The End
Of Each Inspection Period)

Figure 4.5-3 Reporting Requirements for Examination Results

are promptly identified and corrected. In the case of significant conditions adverse to quality, the measures shall assure that the cause of the condition is determined and corrective action taken to preclude repetition. The identification of the significant condition adverse to quality, the cause of the condition, and the corrective action shall be documented and reported to appropriate levels of management."

In relation to a RI-ISI program for piping, the following process may be used to meet the intent of 10 CFR 50, Appendix B. Figure 4.5-4 is an example of how a unacceptable flaw, one that has been determined unacceptable through evaluation of examination results and subsequent ASME Section XI analytical evaluation, should be addressed in an acceptable corrective action program using attributes described in this subsection.

- *Identify.* Through the inspection location selection process established under a RI-ISI program, structural element examinations and system pressure tests performed should identify those conditions that would be adverse to quality in relation to identifying precursors to potential or actual leaks, disabling leaks, or pipe ruptures.

- *Characterize.* Depending on the timing of the condition identification and operational mode of the plant, (this may be a more critical situation when on-line NDE is performed) the first issues to be addressed are:

  - the effects on operability of safety-related systems, structures, or components;
  - if regulatory reporting is required (10 CFR 50.72 and 50.73); or
  - the condition results in an immediate plant/personnel safety or operational impact.

If the answer to any of these three considerations is "yes, then the plant's management must be immediately notified through plant established procedures.

- *Evaluate.* Evaluation has two parts: 1) determine the cause and extent of the condition identified, and 2) develop a corrective action plan or plans. Additional examinations shall be considered an acceptable method in providing this cause and extent determination. Under a RI-ISI program, extensive quantitative and qualitative insights

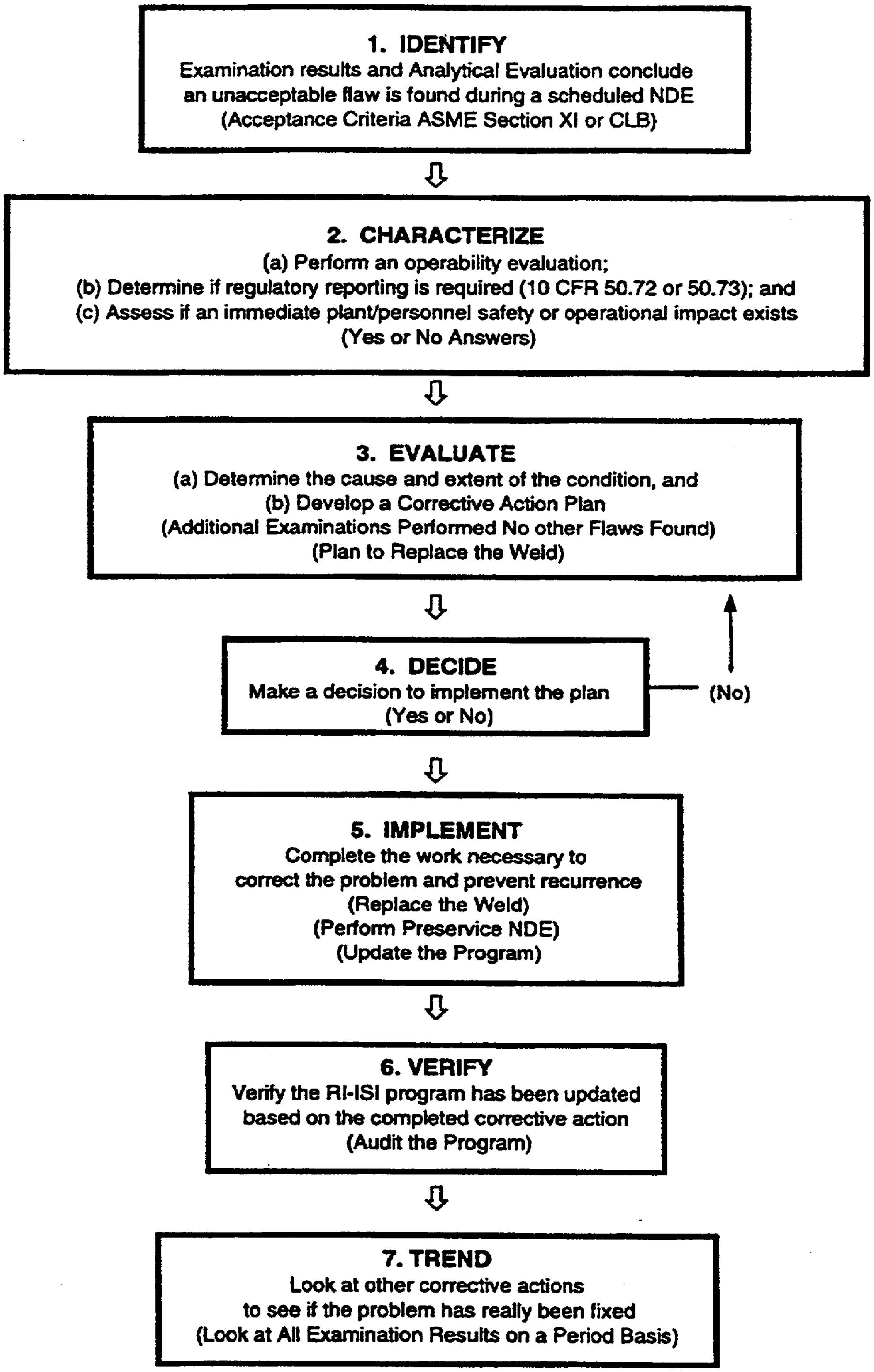


Figure 4.5-4 Corrective Action Program Example

have been used to identify postulated failure modes and elements to be examined. Performance of examinations on selected elements have been grouped into regions of High and Low failure importance and safety significance. These groupings provide the basis for additional examinations to be performed to determine the cause and extent of the condition identified. Acceptable sampling schemes such as those required in ASME Section XI under IWB-2430 shall be used. These additional examinations may be limited by piping segment, materials, service conditions, and failure modes already established in the RI-ISI program. Alternatively, due to the available information used in a RI-ISI program, an engineering evaluation may be used as a substitute for additional examinations to determine the cause and extent of the condition identified. If the engineering evaluation concludes that additional elements are not subjected to the same root cause or that no degradation mechanism exists (such as insignificant indications or conditions that have existed since original fabrication) then no additional examinations may be necessary.

Once the true extent of the condition has been identified and documented by an Owner, then a corrective action plan shall be developed. The plan could include repair, replacement, or monitoring of the condition identified depending on its safety significance. Several options of corrective action may be available to an Owner, but in all cases, needed success criteria must be defined and documented with the corrective action plan. These success criteria include the measurable attributes needed to evaluate the effectiveness of the corrective action in the prevention of a reoccurrence of the identified condition. The success criteria may be as simple as implementation of new element selections based on the new failure information during the next scheduled periodic update of the RI-ISI program and then performance of the examinations to prove that the issue has been corrected. Conversely, this criteria may require a plant design change depending on the condition identified and possible scheduled replacements might have to implemented on a routine basis to prevent the condition from reoccurring.

- *Decide.* A decision should be made by appropriate levels of management on the Owner's implementation of any corrective action plan. Agreement on the adequacy of the success criteria should be reached among the personnel involved and resources allocated to implement the plan. Cost will inevitably play a part in the decision process, but it is more important to fix the problem correctly the first time so as to avoid recurrence in the future.

- *Implement.* Complete the work necessary to both correct the problem and prevent recurrence. In the case of a RI-ISI program, successive examinations may be one way to measure the effectiveness of the corrective action. For example, an Owner could follow the requirements for successive examinations as described in ASME Section XI, IWB-2420. These requirements could be used when flaws or conditions have been accepted by analytical evaluation and measurement of potential service related degradation is essential to avoiding a future failure of a piping structural element.

- *Verify.* The first item that must be verified is whether or not the planned corrective action was implemented. Management should do this as part of their normal daily work activities. In a RI-ISI program this may be as simple as having administrative procedures in place to ensure that the program has been updated as a result of the corrective action plan and checks of the examination data to ensure that the examinations are being performed as scheduled in the program.

  Once it has been determined that corrective actions have been implemented, the planned actions to verify that the desired results are obtained should be conducted. This is done by measuring the success criteria at regularly scheduled intervals in accordance with the corrective action plan. This measurement may indicate that based on the success criteria, the problem was not fixed or only partially fixed. Additional corrective action plans may have to be developed and implemented if this situation occurs.

- *Trend.* The purpose of trending is to identify conditions that are significant based not only on individual issues, but on accumulation of similar issues. Even issues assigned low significance may be deemed of greater significance if there is an increasing number of similar issues. During the RI-ISI program periodic updates a review of occurrences which required corrective actions should be performed by the plant expert panel or the plant ISI subpanel review team to determine if these insights should result in any additional or new examination location changes within the program.

SECTION 5

PLANT-SPECIFIC APPLICATION PROCESS

This section provides the framework for applying the risk-informed methods to a specific plant for piping inservice inspection. The tasks required to develop a comprehensive risk-informed inservice inspection program for piping are provided below. The tasks are:

- Scope Definition
- Segment Definition
- Consequence Evaluation
- Failure Probability Estimation
- Risk Evaluation
- Expert Panel Categorization
- Structural Element Selection
- Inspection Requirements
- Implement Program
- Feedback Loop

Figure 5-1 shows the process. Each task is summarized in the sections below.

Figure 5-2 identifies the skills necessary for a successful program.

5.1 SCOPE DEFINITION

The fluid systems contained in the plant, modeled in the PSA and considered as part of the Maintenance Rule, are identified and compared with the current classifications and required ISI examinations, and with the stress analysis. This review, along with other plant documentation, is used to determine which systems/classes, or portions of systems/classes, should be evaluated as part of the risk-informed ISI process. Given that system boundaries involve system functions and may also involve interfaces between different types of systems, the definition of these boundaries requires a careful, logical approach. All interfaces must be identified to ensure that there is consistency between the defined boundaries, when viewed from the systems on either side of each boundary, and that no safety functions are overlooked.

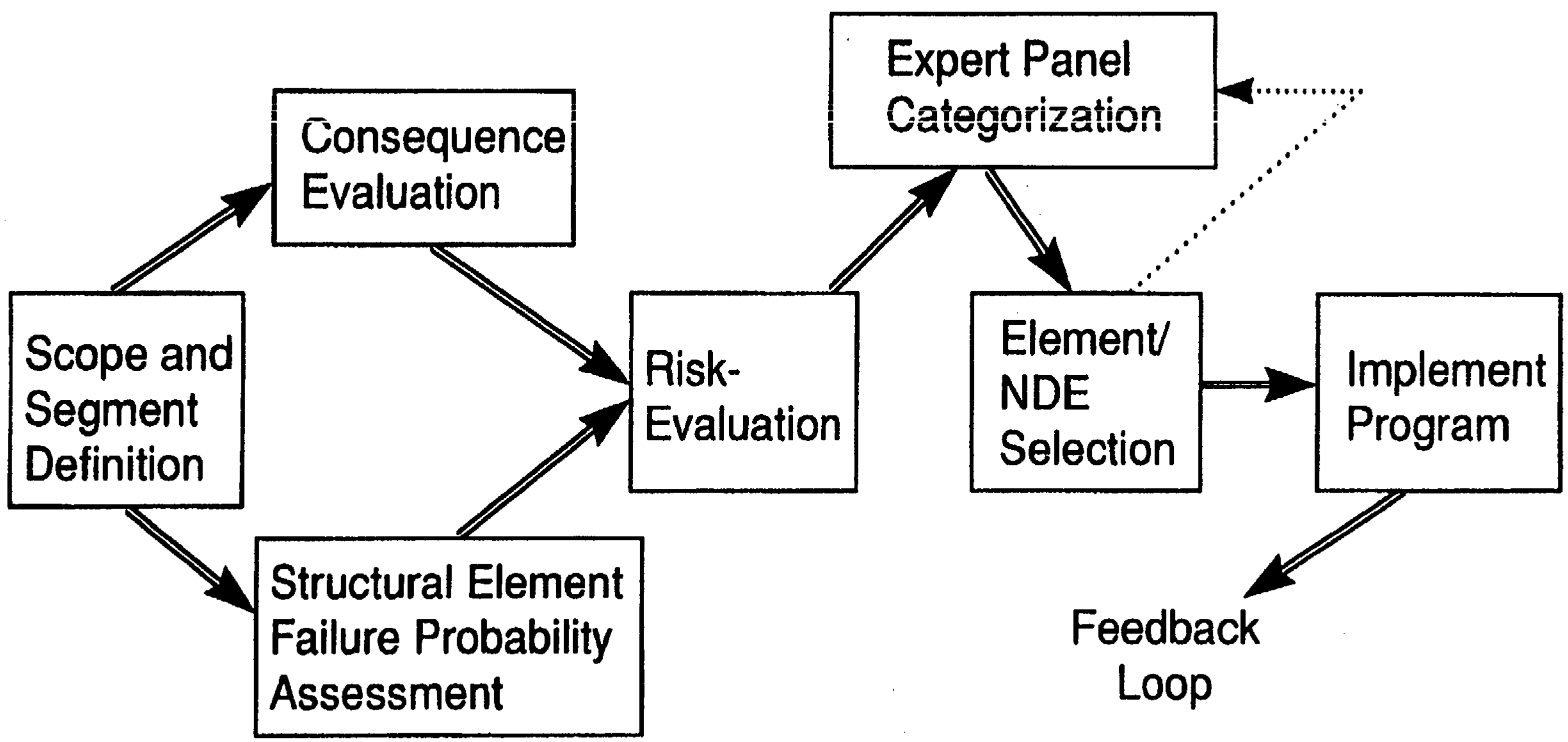


Figure 5-1 WOG Risk-Informed ISI Process

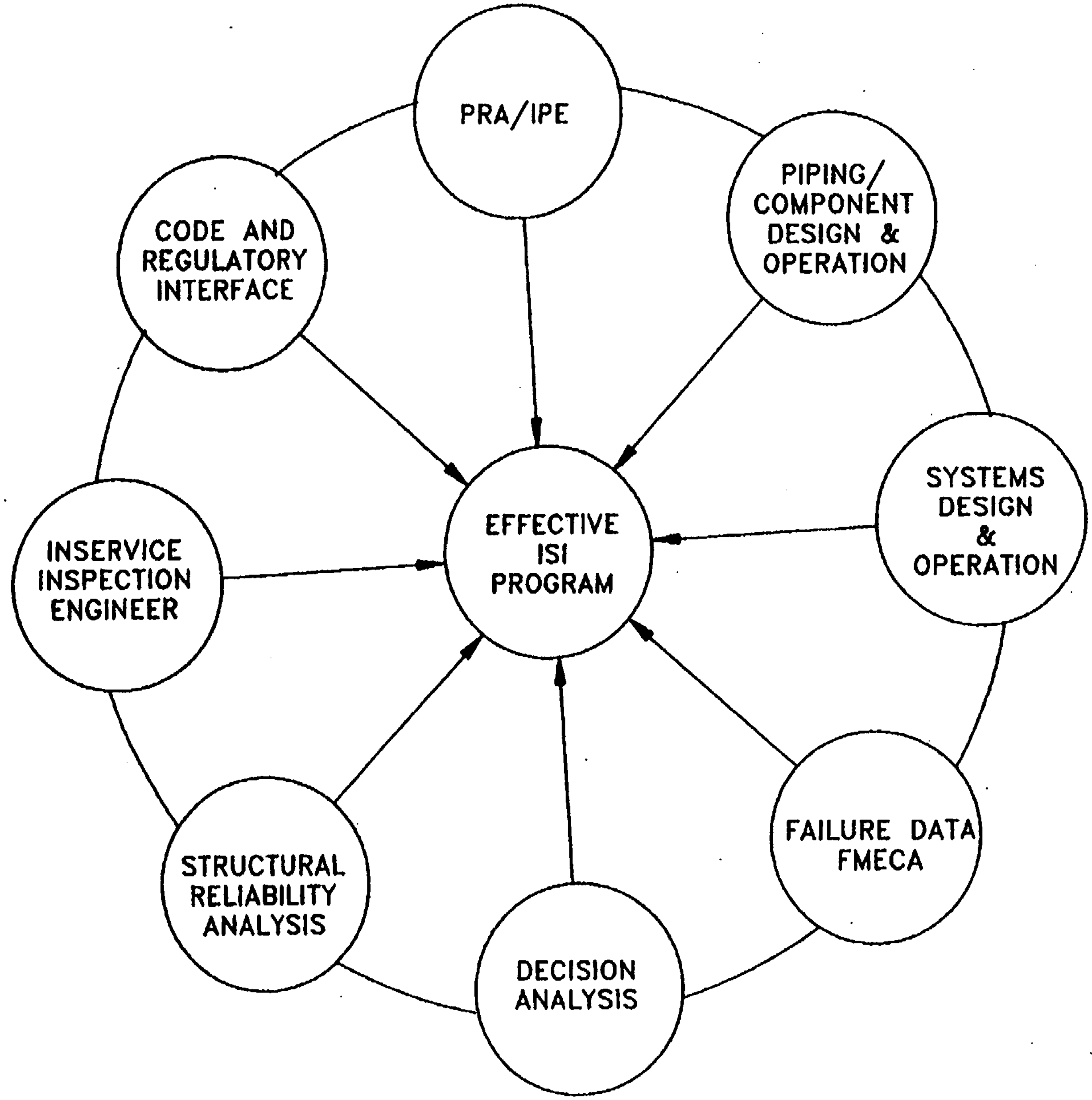


Figure 5-2 Required Skills for Risk-Informed Inspection

5.2 SEGMENT DEFINITION

This task involves the development of piping segments for the process. A piping segment is defined as a portion if piping for which a failure at any point in the segment results in the same consequence (e.g., loss of a system, loss of a pump train, etc.) and includes piping structural elements between major discontinuities such as pumps and valves.

5.3 CONSEQUENCE EVALUATION

The consequences given the failure of a piping segment are identified through PSA insights, engineering evaluations and plant design and operations. Consequences that must be considered include both direct effects (failure of a train in which the piping segment is contained) and indirect effects (such as those due to flooding, pipe whip, or jet impingement).

5.4 FAILURE PROBABILITY ESTIMATION

The overall process of identifying potential failure modes, selecting locations and calculating failure probabilities proceeds by system, and includes preliminary activities for the system as a whole, and detailed assessments and data gathering for each segment. This includes the following steps:

- Gather design basis information
- Review industry experience
- Discuss system operations with system engineer and gain further insights into any potential piping problems
- Determine likely failure mode(s)
- Select candidate location(s)
- Gather detailed data for probability of failure analysis

- Calculate probabilities of failure
- Document locations and probabilities

5.5 RISK EVALUATION

This task is to identify and categorize the components (or pipe segments). The approach calculates the relative importance for each component within the systems of interest. This risk-importance is based on the frequency of core damage (or LERF, if available) resulting from the structural failure of the component in a given segment and the total piping pressure boundary core damage frequency (and LERF, if available). The results are then used to calculate the risk-importance for each segment within the system.

The following outlines the steps of the process:

- Apply PSA to calculate piping pressure boundary core damage frequency (and LERF, if available)
  - Identify impact on PSA model (using EPRI PSA Applications Guide)
  - Identify surrogate component
  - Obtain conditional core damage frequency/probability (LERF)
  - Integrate pressure boundary failure probability/rate
  - Calculate segment piping pressure boundary core damage frequency (and LERF)
  - Calculate total piping pressure boundary core damage frequency (and LERF)
- Calculate importance measures
  - Calculate segment Risk Reduction Worth importance measure
  - Calculate segment Risk Achievement Worth measure
- Evaluate important PSA and failure probability factors through sensitivity studies and uncertainty studies, as appropriate

5.6 EXPERT PANEL CATEGORIZATION

An expert panel (such as the expert panel used for the Maintenance Rule) evaluates the risk-informed results and makes a final review to determine the high safety-significant pipe segments for ISI using the guidance in Section 3.6.3. The expert panel should:

- Consider the PSA and failure probability information and associated uncertainties
- Consider other deterministic considerations
  - Shutdown risk evaluation
  - External events evaluation
  - Other accident scenarios
  - Component operating history
  - Plant operation and maintenance insights
  - Design basis analysis
  - Other deterministic insights
- Conduct expert panel sessions and document results

5.7 STRUCTURAL ELEMENT SELECTION

The selection of inspection locations within each high safety-significant pipe segment is obtained by further review by a subpanel, comprised of materials, ISI and NDE expertise, using the following steps.

- Identify where the segment falls on the structural element matrix.
- Determine the number of inspections required in each segment using the statistical model, if appropriate.
- Verify that the locations with the highest failure potential within a segment are identified for examination.
- Document the results and present to the full expert panel for final review and approval.

The output of this process defines the structural elements selected and the associated examination method and frequency for inspection.

5.8 INSPECTION REQUIREMENTS

The inspection requirements defined in Section 4 should be consulted to define the type of inspection to be performed on the structural elements.

5.9 IMPLEMENTATION, MONITORING AND FEEDBACK

The implementation, monitoring and feedback is discussed in detail in Section 4 and summarized below.

Implementation

Once the risk-informed process is completed, the inspection program can be implemented. The required examinations are scheduled over the 10 year inspection interval in periods. If, during the interval, a reevaluation of the risk-informed process is conducted and scheduled items are no longer required, the items may be eliminated. If items are identified for inclusion in the program, the items should be added and distributed across the remaining periods in the interval. Each subsequent 10 year interval should include, as a minimum, a reevaluation of the risk-informed process.

For examinations that reveal flaws or relevant conditions exceeding ASME acceptance standards, additional examinations should be conducted. The additional examinations should include the same type of piping structural element(s) with the same postulated failure mode(s).

If piping structural elements are accepted for continued service, the areas containing flaws or relevant conditions should be reexamined during the next three inspection periods. If the reexaminations reveal that flaws or relevant conditions remain essentially unchanged for three successive inspection periods, the piping examination schedule may revert to the original schedule.

The examination qualification and methods requirements and personnel qualification requirements should be the same as under the plant's current inservice inspection program.

Feedback

The risk-informed inservice inspection program should be reevaluated periodically as new information becomes available. Such information may result for example from changes to the PSA, from inspection results, from new failure modes experienced by the industry, from replacement activities, from repair activities, or plant design or operational changes. The effect of the new information on the risk-informed process should be determined. Each phase of the risk-informed process should be reevaluated to determine where the new information impacts the process and/or the results. The new information should be included at the appropriate level of the analysis (consequence evaluation, failure probability estimation, etc.) and the analysis should be conducted to identify the changes to the risk-informed inspection program.

5.10 DOCUMENTATION

Each major step of the risk-informed ISI process should be documented for future use in retrievable files. Below is a list of information that may be included by an individual utility in their RI-ISI submittal to NRC. A list of information to be retained onsite for retrieval and potential NRC audit is also provided. The information to be retained is summarized in the previous sub-sections.

Proposed NRC Submittal Contents

- Current Inspection Code
- List of changes to licensing basis (relief requests, FSAR, etc.)
- Process followed (compliance with WCAP, Code Case and note exceptions to methodology)
- Justification for statement that PRA is of sufficient quality
- Summary of results of each step of the process, including summary of risk impact
- How meet RG principles
- RI-ISI Program Plan (summary of changes from current program such as shown in Table 4.4-2)

- Summary of any augmented inspections that would be impacted
- Performance monitoring/feedback/corrective action program changes/commitments
- Future reporting to NRC

Retrievable Onsite Documentation for Potential NRC Audit

- Scope Definition
- Segment definition
- Failure probability assessment
- Consequence evaluation
- PSA Model Runs for program
- Risk evaluation
- Structural element/NDE selection
- Change in risk calculations
- PRA Quality review
- Continual assessment forms as program changes based on inspection results, etc.
- ASME Code required documentation (including inspection personnel qualification, inspection results and flaw evaluations)

SECTION 6
SUMMARY AND CONCLUSIONS

6.1 REPORT SUMMARY AND RELATIONSHIP TO NRC RG-1.174

The risk-informed ISI process for piping is described in Sections 3 and 4. An earlier version of the above process had been applied to Millstone Unit 3, a plant designed to ASME Section III requirements, as a reference plant study and this work was reported in the original version of this Topical Report. The process has since been enhanced through benchmarking efforts in a WOG pilot application at Surry Unit 1, a pre-ASME Section III plant design, as reported in this revision of the Topical Report. While the process has been significantly enhanced to meet NRC regulatory guidance on use of probabilistic risk assessment to improve safety decisionmaking, both of these plant application studies yield consistent results.

This process meets the intent of the framework developed by the NRC and key steps and principles of the general regulatory guide and standard review plan (RG-1.174) as described in Sections 1.4 and 6.2.

6.2 SUMMARY OF RESULTS

After application of the risk evaluation process, including plant expert panel review, 96 pipe segments were shown to be high safety-significant at Millstone-3 and 117 pipe segments are shown to be in this category for Surry-1. In comparing the recommended piping structural elements to be inspected by non-destructive examination (NDE) in the risk-informed ISI program to the current ASME Section XI locations, a greater portion of the risk associated with piping pressure boundary failures can be addressed with the risk-informed program with far fewer examinations being required. At Millstone-3, the risk-informed program recommends 107 NDE examinations versus 753 ASME Section XI required exams, and for Surry-1, 137 NDE exams are suggested versus the 385 required by the ASME Code. Both studies show that examinations can be significantly reduced within the reactor coolant system, and examinations should be reallocated and added to other Class 2 and Class 3 systems, such as service water, auxiliary feedwater, and a few other systems based on the specific plant design. At Surry-1, 12 NDE exams are even recommended in the non-Code class portions of three systems. A significant reduction in radiation exposure is also shown for both units with approximately 60-75 REM being saved each 10-year inspection interval.

This significant reduction in the number of examinations can be achieved while showing a risk reduction in total piping pressure boundary risk in terms of both core damage frequency and large, early release frequency, as demonstrated in detailed calculations performed for Surry-1. Even considering the impact of potential operator actions to recover from piping failure events does not change this positive result. In order to meet defense-in-depth principles and to maintain sufficient safety margins, some current reactor coolant loop piping examinations are kept in place and additional examinations are recommended in 10 low safety-significant segments at Surry-1 to maintain a risk neutral position in the front-line systems, such as containment spray and low head/high head safety injection, and in systems that are dominant contributors to the total piping pressure boundary risk. A statistical model has also been developed and applied to define the minimum number of locations to be examined to insure that an acceptable level of reliability is achieved, consistent with current industry experience, throughout the key piping segments of interest.

Consideration of the key principles, including defense-in-depth and adequate safety margins and uncertainties, have been considered in the risk-informed ISI process through several avenues:

- Piping segments are categorized into two categories (high and low safety significant) and thus require less accuracy than a full ranking.

- The consequence and risk evaluation consider the most bounding situation in terms of assuming no operator action to isolate the piping failure. In addition, conservative assumptions are made to model in the PSA the impact of indirect effects and the piping failures.

- The SRRA model considers uncertainties in inputs by allowing qualitative inputs in terms of ranges and the process allows for sensitivity studies to be conducted with the SRRA model.

- The piping CDF and LERF are determined and an attempt is made to maintain at least an overall risk neutral position.

- Additional piping inspection locations have been added for defense-in-depth in the front-line systems and also in systems that are the dominant contributors to the total piping pressure boundary risk.

- Sensitivity studies, including an uncertainty evaluation, are conducted on key aspects that impact the risk evaluation.

- The expert panel considered other plant deterministic information and tended to make decisions based on conservative assumptions.

- Even if the statistical model says that no inspection is required for a given set of high safety significant segments, a single sample will be inspected to ensure integrity.

- Pressure testing will still be performed for all piping within the scope of the RI-ISI program.

6.3 CONCLUSIONS

Implementation of risk-informed ISI programs using the process and methods provided in this WOG Topical Report will yield significant benefits in terms of enhanced safety, reduced radiation exposure, and reduced cost for nuclear plant piping programs. The studies have been independently performed for both plant applications and show that risk-informed ISI programs have the potential to be implemented at a cost that can be returned in one to two years, depending on the size and age of the unit, following implementation. Given that aging effects are directly evaluated in the process using a structural reliability/risk assessment tool, use of this technology for defining aging management programs and the associated inspection of piping systems as part of license renewal programs could yield additional significant benefits.

While the effort for this application focused on the use of risk-informed methods for the inservice inspection of piping, several insights have been obtained for possible application to other equipment. The process described and the steps can be applied to all types of components, such as vessels, tanks, heat exchangers, snubbers and other equipment addressed by ASME Section XI.

Finally, this report has demonstrated that a risk-informed piping ISI process has been created and can be implemented that satisfies the risk-informed regulation policy promulgated by the NRC. This includes demonstrated satisfaction of the principle elements of "Risk-Informed, Plant Specific Decisionmaking" and compliance with the five "Principles of Risk-Informed Regulation."

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APPENDIX A
PLANT WALKDOWN INFORMATION

The appendix discusses the review of the plant hazards evaluation and the conduct of the plant walkdown to identify potential indirect effects from piping failure.

PRE-WALKDOWN EVALUATION

Millstone 3

The Millstone 3 Hazards Review Program Summary Sheets were reviewed for systems interactions due to postulated pipe breaks. The summary sheets examine the effects of spray wetting, flooding, temperature, pipe whip, jet impingement, rotating machinery, and pressure boundary ejected missiles. Because the risk-informed inspection program is concerned only with the effects due to pipe breaks and leaks, the rotating machinery and pressure boundary missiles evaluations were not reviewed. Note that the pressure boundary missiles are primarily from valves, which are not part of this program. In addition, Section 3.6 of the Millstone FSAR, "Protection Against Dynamic Effects Associated with the Postulated Ruptures of Piping," was reviewed. A summary of the review is provided in Table A-1.

The Hazards Evaluation examined the containment, the ESF building, the auxiliary building, the diesel generator building, the fuel building, the circulating and service water pumphouse, and the hydrogen recombiner building. Because only two cubicles in the circulating and service water pumphouse were mentioned in the Hazards Evaluation, it was decided to include the entire pumphouse in the walkdown. The turbine building was also included because the Hazards Evaluation did not address the building, and because of the amount of the high energy piping in the building.

Surry

The Surry analysis evaluated system interactions due to pipe ruptures. The internal flooding PSA was used in this evaluation to evaluate the potential for flooding and spray. For pipe whip and jet impingement, Chapter 14, Appendix B, of the Surry UFSAR was used which defined high energy lines as piping for which the maximum operating pressure exceeds 275 psig and

Table A-1
HAZARDS REVIEW SUMMARY FOR MILLSTONE 3

Item	Building	Cubicle/Area	Equipment / Pipe Segment	Indirect Effects	Consequences	Walkdown?	Shutdown?	Comments
1	ESF	001, 002, 021, 022	3FWA-004-126-3/128-3	Pipe Whip	Potential loss of "B" electrical division	No	No	Eval concludes no damage
2	ESF	003, 004, 005	FWA, SWP, CCP, RHS piping	Flooding	None	No	Yes	
3	ESF	006, 007, 008, 009, 019, 020	Moderate Energy Cracks	Temperature/ Humidity	Potential loss of equip for 1 RHS or SIH Train (same train/system as break)	No	No	
4	ESF	010	QSS-P1A/B	Flooding	Bounded by 12179-PR-1194	No	No	
5	ESF	011, 012, Rev. 1	FWA*P1B	Water Spray	Loss of Train "B" Equipment in cubicle	Yes	No	Check other equip in cubical
6	ESF	011, 012, Rev. 1	FWA*P1B	Jet Impingement	Cable trays 3TC7520, 3TC7610, TK7520 RHS*P1A cooling	No	Yes	Eval concludes no damage
7	ESF	013, 014	SW & CCW Piping	Flooding	Bounded by 12179-PR-1157	No	No	
8	ESF	013, 014	3FWA-004-126, -128	Pipe Whip	Could cause start of AFW TD pump	No	No	
9	ESF	015, 016, 017, 018	HVQ*ACUS1A/B & HVQ*SCUS2A/B	Water Spray	3EHS*MCC1A4 RHR operation	No	Yes	Eval. concludes no damage
10	AB1	23A, B, E	3CHS-003-8-2	Jet Impingement	3CHS-002-283-2	No	Maybe per T.S.	Letdown line damages seal return line

Table A-1 (cont.)
HAZARDS REVIEW SUMMARY FOR MILLSTONE 3

Item	Building	Cubicle/Area	Equipment / Pipe Segment	Indirect Effects	Consequences	Walkdown?	Shutdown?	Comments
11	AB-1	23C, 23D, 24, 25	30" SW	Flooding	Bounded by 12179-PR-1071	No	No	
12	AB-1	23F	30" SW	Flooding	Bounded by 12179-PR-1071	No	No	
13	AB-1	AB26, 27, 28, 89, 90, 99B, 112	-	-	-	-	-	No piping in risk-informed ISI scope
14	AB-1	33, 34, 35	CHS piping	Flooding	Bounded by 12179-PR-1071	No	No	
15	AB-1	29, 91 Rev. 1	-	-	-	-	-	No piping in risk-informed ISI scope
16	AB-2	86, 87, 88	3CCP*P1C/A	Water Spray	Two CCP Trains	Yes	Yes	Check for CCP pipe shroud
17	AB-2	36	3" CHS Letdown Exchanger Inlet Piping	Pipe Whip	6" CCP inlet or outlet lines	No	Yes	Eval concludes no damage
			3" CHS Letdown Exchanger Inlet Piping	Flooding	Bounded by 12179-PR-1071	No	No	
18	AB-2	38 thru 53, 55 thru 78	CHS piping	Pipe Whip	None - redundant trains in individual cubicles	No	No	
			3" CHS Letdown Exchanger Inlet Piping	Flooding	Bounded by 12179-PR-1071	No	No	
19	AB-2	54, 79, 80, 81	CHS piping	Pipe Whip	Redundant trains in individual cubicles	No	No	

Table A-1 (cont.)
HAZARDS REVIEW SUMMARY FOR MILLSTONE 3

Item	Building	Cubicle/Area	Equipment / Pipe Segment	Indirect Effects	Consequences	Walkdown?	Shutdown?	Comments
20	AB-2	92, 93, 94	CHS alt. mini-flow piping	Jet Impingement	One service water train	No	No	
21	AB-2	30, 31, 32, 95, 96, 97	-	-	-	-	-	No piping in risk-informed ISI scope
22	AB-2	98 Rev. 1	CCP Piping	Flooding	Bounded by 12179-PR-1071	No	Maybe, per TS	
23	EGE	175 - 181 Rev. 1	Service Water	Flooding	Bounded by 12179-PR-1073 Loss of single Generator Train	No	Maybe, per TS	
24	HR	182 - 187 Rev. 1	-	-	-	-	-	No piping in risk-informed ISI scope
25	FB	188, 197, 198	SFC, FPW, CCP Piping	Flooding	Bounded by 12179-PR-1038	No	No	
26	FB	191	CCP, FPW piping	Flooding	Bounded by 12179-PR-1038	No	No	
27	FB	194	SFC pump discharge	Water Spray	Bounded by 12179-NMS-793-DM	No	No	
28	FB	195, 196, 200	SFC piping	Flooding	Bounded by 12179-PR-1038	No	No	
29	CW	201, 202 Rev. 1	SW Pump Discharge Piping	Water Spray	Loss of single electrical train 3EJS*US1A due to spray on 3EHS*MCC1A5 or 3EHS*MCC1B5	Yes	Yes	

Table A-1 (cont.)
HAZARDS REVIEW SUMMARY FOR MILLSTONE 3

Item	Building	Cubicle/Area	Equipment / Pipe Segment	Indirect Effects	Consequences	Walkdown?	Shutdown?	Comments
30	AB-3	99A	SW Piping, 3SWP*P3A suction or discharge	Water Spray	3SWP*P3A suction or discharge spray on 3SWP*P3B	No	Maybe, per TS	SW pumps are drip protected; No consequential damage
31	AB-3	99C, 110, 111	CCP piping	Water Spray	None	No	Maybe per TS	
32	AB-3	99D	CHS piping	Water Spray	None	No	No	
33	AB-3	100, 118 - 121	-	-	-	-	-	No piping in risk-informed ISI scope
34	AB-3	101, 102	CCP piping	Water Spray	None	No	No	
35	AB-3	103 - 109	CCP piping	Water Spray	None	No	No	
36	AB-3	113 - 117	CHS, SWP piping	Water Spray, Flooding	None	No	No	
37	AB-3	Elev. 66'-6"	-	-	-	-	-	Hazards addressed are for fans in systems outside risk-informed ISI scope
38	CS-1	131A - F, 132A - H, 138	Moderate energy cracks in all piping	Flooding	Bounded by 12179-NS(B)-249	No	No	
39	CS-1	133A, 133B, 135, 142A, 144	3RCS-003-171-1	Pipe Whip	Conduit damage resulting in closing letdown and isolation valves	No	Yes	Break postulated to isolate itself due to valve closure
40	CS-1	133C, D Rev. 1	3-CHS-003-662-2	Jet Impingement	Seal Water return line 3-CHS-002-618-2	No	No	

Table A-1 (cont.)
HAZARDS REVIEW SUMMARY FOR MILLSTONE 3

Item	Building	Cubicle/Area	Equipment / Pipe Segment	Indirect Effects	Consequences	Walkdown?	Shutdown?	Comments
41	CS-1	134A - F Rev. 1	3-CHS-025-304-2	Jet Impingement	Seal Water return line 3-CHS-002-618-2	No	No	Note event description for BDG line breaks
42	CS-1	136 Rev. 1	RCS piping	Jet Impingement	Bounded by 12179-NSB-177	No	Yes	
43	CS-2	137 Rev. 2	RCS piping	Pipe Whip/Jet Impinge.	Bounded by 12179-NSB-177	No	Yes	
44	CS-2	139, 146 Rev. 2	RCS piping	Pipe Whip/Jet Impinge.	Bounded by various calcs	No	Yes	
45	CS-2	140 Rev. 2	RCS Piping	Pipe Whip/Jet Impinge.	Bounded by various calcs	No	Yes	
46	CS-2	141 Rev. 1	RCS piping	Pipe Whip/Jet Impinge.	Bounded by various calcs	No	Yes	
47	CS-2	142B - F	FWS, MSS, FWA piping	Pipe Whip/Jet Impinge.	Bounded by various calcs	No	Yes	
48	CS-2	145A - F, 143, 147	Intermediate Break in 30" MSS line at upstream elbow	Axial Jet	Loss of conduits results in loss of radiation monitors, 3RMS*RIY05 & 3RMS*RIY42 and loss of power to 3RMS*RM42	No	No	
			Intermediate Break in 30" MSS line at downstream elbow	Radial Jet	Loss of one MSS line to FWA TD pump	No	Yes	

the maximum temperature equals or exceeds 200°F. Generally, in this analysis, the impact of ruptures in piping operating at these conditions is evaluated by walking down the areas of interest.

Initially, the plant was divided into areas corresponding to the fire areas defined within the plants 10CFR50 Appendix R report. The following areas were reviewed for indirect effects.

- Auxiliary Building
- Main Steam Valve House And Safeguards Area
- Service Building
- Mechanical Equipment Room No. 4 (Charging Pump/SW Pump Room)
- Containment
- Turbine Building
- Mechanical Equipment Room #5
- Emergency Service Water Room

An example of the documentation is provided in Table A-2. It concludes that the component cooling pumps and the charging pumps would be lost if no action was taken to isolate the ruptured line.

WALKDOWN

Millstone 3

The Millstone 3 walkdown was performed and included members from the PRA, piping, and operations groups at Northeast Utilities, and members of risk and structural reliability groups at Westinghouse. The walkdown covered the specific areas listed in Table A-1 in the ESF building and the auxiliary building. The walkdown also included all of the circulating and service water pumphouse and the turbine building. Two of the walkdown worksheets documenting the information gathered are presented in Tables A-3 and A-4.

Item	Building/ Area	Equipment/ Segment	Indirect Effect	Consequences	Walkdown/ Shutdown	Comments
1	AB/17-1A	Low head to high head recirc. lines	Flooding & Spray	1. Loss of CH pump 1A, if isolated 2. Loss of CC and CH pumps if not isolated	Yes/No	During normal operation these headers are isolated. CC pumps are located in the general area of the AB (17-AB)
2	AB/17-1A	Charging pumps & RWST supply lines	Flooding & Spray	Same as item 1.	Yes/No	See comment for item 1
3	AB/17-1B	Low head to high head recirc. lines	Flooding & Spray	1. Loss of CH pump 1B if isolated 2. Loss of CC and CH pumps if not isolated	Yes/No	See comment for item 1
4	AB/17-1B	Charging pumps & RWST supply lines	Flooding & Spray	Same as item 3	Yes/No	See comment for item 1
5	AB/17-1C	Low head to high head recirc. lines	Flooding & Spray	1. Loss of CH pump 1C pump if isolated 2. Loss of CC and CH pumps if not isolated	Yes/No	See comment for item 1
6	AB/17-1C	Charging pumps & RWST supply lines	Flooding & Spray/Jet Impingement	Same as item 5.	Yes/No	The RWST isolation valves are located in this area. CC pumps are located in area 17-AB
7	AB/17-AB	Fire Protection lines	Flooding & Spray	1. None if flooding is terminated 2. Loss of CC and CH pumps if flooding is not terminated	Yes/No	Water spray does not have the potential to disable more than one CC pump due to the small size of the fire protection header and relative location of the pipes and CC pumps

Table A-2
SURRY HAZARD REVIEW SUMMARY FOR THE AUXILIARY BUILDING

Table A-2 (cont.) SURRY HAZARD REVIEW SUMMARY FOR THE AUXILIARY BUILDING						
Item	Building/ Area	Equipment/ Segment	Indirect Effect	Consequences	Walkdown/ Shutdown	Comments
8	AB/17-AB	Charging pumps & RWST supply lines	Flooding & Spray/Jet Impingement	1. None if flooding is terminated 2. Loss of CC and CH pumps if flooding is not terminated	Yes/No	See Comment for item 7.
9	AB/17-AB	4"-SLPD-50 and 6"-SA-21	Spray	1A and 1B CC pumps	Yes/Yes	
10	AB/17-AB	4"-SLPD-50	Jet Impingement	1A/B/C CC pumps and 1C Charging pump	Yes/Yes	This is a conservative estimate
11	AB/17-AB	3"-WGCB-3-601	Pipe Whip	Rupture 2"-CH-90-1503	Yes/Yes	Postulated break is in the horizontal run shown on FP-206AE Sec. 9-9 just to the right of column line TN-5.
12	AB/17-AB	3"-WGCB-1-601	Pipe Whip	Rupture 2"-CH-8-1503	Yes/Yes	Postulated break is in the horizontal run shown on FP-206A quadrant F4 and detached plan A.
13	AB/17-AB	3"-WGCB-2-601	Pipe Whip	Rupture 3"-CC-74-151 and 2-ACC-73-21B	Yes/Yes	Postulated break is in the vertical run shown on FP-206AD.

Table A-3
MILLSTONE 3 RISK-INFORMED INSPECTION
INDIRECT EFFECTS WALKDOWN WORKSHEET

Item #: 5 Building: ESF

Cubicle/Area: 011 Elevation: 21" - 6"

Indirect Effect of Concern: Loss of Train A equipment due to any pipe rupture in area (aux. feedwater suction or discharge piping), including a CCP pipe.

Components/Equipment in Cubicle/Area					
System	**Comp. Type**	**Tag No.**	**Train**	**Needed for Safe Shutdown?**	**Support System?**
FWA	Pump	3FWA*P1A	A	Y	N
FWA	Valve	3FWA*HV31D[1]	A	Y	N
FWA	Valve	3FWA*HV31A[1]	A	Y	N
FWA	Valve	3FWA*V4[2]	A	Y	N
FWA	Valve	3FWA*AV61A[3]	A	Y	N
FWA	Valve	3FWA*AV23A[3]	A	Y	N
FWA	Valve	3FWA*HV31CB[4]	B	Y	N
FWA	Valve	3FWA*HV31C[4]	B	Y	N
FWA	Valve	3FWA*AV62B[4]	B	Y	N

1. Located at far side of room from unisolable break
2. Near pump
3. Located at postulated break location
4. Located at far end of room away pump and postulated break

Comments

Cable tray numbers listed in Hazards Evaluation did not match those marked on the overhead trays in the room. Additional checks needed.

Conclusions

Apparent discrepancy with cable tray identifiers noted. Hazards Evaluation concludes pipe break will not target cable trays, but should further investigate effects of losing cable tray. No additional interactions found. Train B valves located away from postulated break locations. Pipe break will only affect FWA Train A. Need to consider the CCP interaction for inclusion in the segments analyzed.

Table A-4
MILLSTONE 3 RISK-INFORMED INSPECTION
INDIRECT EFFECTS WALKDOWN WORKSHEET

Item #: N/A Building: Turbine

Cubicle/Area: Elevation: 14′ - 6"

Indirect Effect of Concern:

Components/Equipment in Cubicle/Area					
System	**Comp. Type**	**Tag No.**	**Train**	**Needed for Safe Shutdown?**	**Support System?**
IAS	Compressor	3IAS-C1A	-	N	Y
IAS	Compressor	3IAS-C1B	-	N	Y
SAS	Compressor	3SAS-C1	-	N	Y

Comments

The three compressors are located side by side near the condensate pump discharge header. A break in the header could potentially fail all three compressors which would cause a reactor trip.

Conclusions

Needs to be considered along with other possible breaks in turbine building.

Surry

The Surry walkdown was performed and included members from the PRA, ISI, structural mechanics and operations groups at Virginia Power and members of the PRA and piping groups at Westinghouse. The walkdown covered the specific areas identified below:

- Main Steam Valve House
- Charging Pump Cubicles
- Service Building
- Turbine Building
- Aux Building Near Elevator and Boric Acid Storage Tanks

An example of the walkdown worksheets documenting the information gathered is shown in Table A-5.

The summary of the indirect effects identified for Surry is provided in section 3.4.2.

INSIGHTS FROM THE WALKDOWN FOR MILLSTONE 3

The following summarizes the insights from the Millstone 3 plant walkdown for the various areas investigated.

Auxiliary Feedwater System

There were numerous valves near the discharge of the motor auxiliary feedwater pump. An AFW piping failure could disable some of these valves, but the effect would still be a loss of one train. Two concerns noted were the spray onto overhead cable trays, and a postulated reactor plant component cooling water (CCP) break which targets the AFW pump and some valve controllers. These sections of piping were not in the original program scope for CCP. Based on the interaction possibility with the AFW system, two CCP segments were added for risk evaluation and the cable trays were investigated for their effects. (Table A-1 Item 5)

Table A-5 SURRY UNIT 1 INDIRECT EFFECTS WALKDOWN WORKSHEET		
Building: 17 (AB)	**Elevation:** 2′-13′	**Cubicle/Section:** 17-1A (Charging Pump 1A Cubicle)
Potential Hazards		**Postulated Effect**
Flooding/Spray Source(s) Charging pump supply and discharge lines.		No concerns were identified during the walkdown.
High Temperature/Humidity Sources (High Energy Lines only) No source was identified.		
Pipe Whip Source(s) (High Energy Lines only) Break in Charging Pump Recirculation line		Failure of 1-CH-MOV-1267A and 1-CH-MOV-1275A. (See note 2 and 3)
Jet Impingement Source(s) (High Energy Lines only) Charging pump discharge line		None was identified.

Comments:

1. Can RWST drain if the recirculation line is broken? No. The recirculation line is not connected to the RWST.
2. Because the Recirculation line is smaller than the postulated targets, the target piping and MOVs are assumed to maintain structural integrity. The operators on the MOVs are assumed to fail such that the MOVs cannot change position (i.e., MOVs are assumed to fail "as is".)
3. The Surry UFSAR does not consider pipe whip in this location because the maximum operating temperature of the fluid is less than 200°F.

Conclusions/Actions:

The walkdown did not identify any indirect effects.

Table A-5 (cont.)
SURRY UNIT 1
INDIRECT EFFECT WALKDOWN WORKSHEET

Building: Aux. Building			**Area/Sec.:** 17-1A (Charging Pump 1A Cubicle)	
Potential Targets in The Area				
System	**Component Type**	**Tag Number**	**Train**	**Needed for Shutdown?**
CH/HHSI	Pump	1-CH-P-1A	A	Yes
SW	Temp. Control Valve	1-SW-TCV-108A	A	Yes
CH/HHSI	MOV	1-CH-MOV-1275A	A	Yes
CH/HHSI	MOV	1-CH-MOV-1287A	A	Yes
CH/HHSI	MOV	1-CH-MOV-1267A	A	Yes
CH/HHSI	MOD	1-VS-MOD-101A	A	Yes
CH/HHSI	MOV	1-CH-MOV-1286A	A	Yes
CH/HHSI	MOV	1-CH-MOV-1267B	A	Yes

Component Cooling Water

It was verified that pipe shrouds had been placed on the discharge piping of CCP pumps 3CCP*P1A and P1C. These shrouds were placed to mitigate the interactions of a break in one train disabling the pump in the other train (as noted in the Hazards Evaluation). No other unique interactions were noted for these areas. (Table A-1 Item 16)

Service Water

There are vital and non-vital motor control centers (MCCs) in the service water pump cubicles. Large drains were noted in each cubicle to prevent flooding problems. The implications of a pipe break spraying on the MCCs was noted for further review. (Table A-1 Item 29) (Note: the expert panel considered this and decided to not take credit for drains and considered this as an indirect effect.)

Turbine Building

The walkdown of the turbine building resulted in several areas needing further consideration for the PSA modeling. The turbine building component cooling water has a small surge tank and virtually any pipe break/leak will eventually fail the system which will lead to reactor trip. The three plant air compressors are located side by side near the condensate pump discharge header. A postulated break in the header could potentially fail all three compressors which would cause a reactor trip. The location of the motor driven and 2 turbine driven pumps makes the system susceptible to losing all pumps due to a pipe break.

It is important to note that the indirect effects discussed here are plant specific. Due to plant layout differences, the contribution of the indirect effects can vary significantly between different plants. It is expected that earlier vintage plants will be impacted more by indirect effects than later vintage plants.

For the reference plant, the most significant indirect effects were associated with Service Water segments SWP-15, SWP-22, and SWP-26 through -29. Segments SWP-15 and SWP-22 are Service Water to the CCE heat-exchangers. It was assumed by the plant expert panel that a pipe failure in either of these segments would result in a loss of both CCE trains due to their close proximity. A loss of all CCE results in a total loss of charging and therefore the segment was determined to be high safety-significant. The indirect effects resulting from these pipe segment failures significantly changed the calculated CDF contributions. Failure of all charging results in a reactor trip as well as failure to provide its accident mitigating functions. However, failure of one train of charging was not considered to result in a reactor trip and the other train is available for accident mitigation. This piping segment would have been categorized low safety-significant due to failure of one train of CCE if indirect effects were not considered. Piping segments SWP-26 through-29 represent Service Water from the pump to the discharge check valve. A failure in any of these segments would flood the entire room resulting in a loss of the Service Water Train involved, including an MCC associated with it. Without considering the indirect effects, any one of the segments would fail one pump in a pump train. These segments were designated as high safety-significant based the importance of Service Water at shutdown. The loss of an operating Service Water train would result in a loss of the operating RHR, a charging train and a Diesel Generator.

All other indirect effects identified in Table 3.4-3 did not contribute to the determination of the segment safety significance category. Segments CCP-13 and CCP-14 disable one train of AFW which was determined to be low safety-significant. Failures in the Auxiliary Feedwater piping segments cause failures of HVAC which did not contribute to the segment categorization. The indirect effect associated piping segments SWP-1 through -4 is room flooding resulting in a loss of the entire pump train and failure of a MCC associated with the Service Water train. However, without considering indirect effects, a failure in these segments would result in failure of a Service Water train because the other pump in the train would back feed through the break. Therefore, if indirect effects were not considered, these segments would still result in a loss of an entire Service Water train, which was determined to be high safety-significant. Segment SWP-13 fails cooling water to the RHR and RSS ventilation units and spray would result in a loss of an MCC which powers valves needed for the train of RSS which is supported by the ventilation unit. This scenario had a low consequence and was determined to be low safety-significant. Segment SWP-20 is similar to segment SWP-13.

With regard to inspection locations, a piping segment location that was important from an indirect effects standpoint would be selected for inspection above other piping segment locations where the direct and/or indirect effect was less severe.

APPENDIX B

SAMPLE EXPERT PANEL WORKSHEETS

Contained in this appendix are sample segment worksheets which were used by the expert panel review for Millstone and Surry. Section 6 of the worksheet contains the final safety-significance category (high or low safety-significant) determined by the expert panel. Below is a brief summary of the segments represented by the worksheets for Millstone and Surry.

Millstone 3

FWS-1: This segment is the main feedwater piping to steam generator A, between motor-operated valve 35A and gate valve FCV 510. A break in this line causes a loss of main feedwater (feedline break), modeled in the PSA as an initiating event. The calculated full break probability is 0 (1.0E-08 was assumed). The RRW value calculated is 1.00 and the RAW value is relatively low. The segment was designated low safety-significant because of the low failure probability and the relatively low consequence.

ECCS-1: This segment is one of the four safety injection lines and it is located between check valves 8818A and 8819A and 8847A (inside containment). A break in this line causes a partial loss of injection, and the eventual loss of the RWST inside containment. The calculated full break probability is 0 (1.0E-08 was assumed). The RRW and RAW values were relatively high, however, the expert panel believed the PSA modeling was too conservative because the RWST inventory would be available for recirculation. The time to switch to recirculation would however be shorter. This segment was designated low safety-significant because of the low failure probability and the expert panel's assessment that the consequence would be lower than calculated.

RCS-7: This segment is the safety injection line from check valve 8948A to the tee on the loop A cold leg. A break in this segment causes a large LOCA, modeled in the PSA as an initiating event. The calculated full break probability is 4.1E-09 (the threshold value of 1.0E-08 was used). The RRW value calculated is 1.00 but the RAW value is relatively high. The segment was designated high safety-significant due to the relatively high RAW value and because of the high consequence of a large LOCA.

RCS-15: This segment is the high pressure safety injection connection from the cold leg tee to check valve 8900B. A break in this segment causes a small LOCA, modeled in the PSA as an initiating event. The calculated full break probability is 1.5E-12 (1.0E-08 was assumed). The RRW value calculated is 1.00 but the RAW value is relatively high. The segment was designated high safety-significant due to the relatively high RAW value and because the pipe failure results in an unisolable break in the RCS.

SIL-9: This segment is from accumulator TK1A to check valve 8956A. A break in this line results in the loss of accumulator TK1A. The calculated full break probability is 0 (1.0E-08 was assumed). The RRW value is 1.00 and the RAW is in a medium range. This segment was designated low safety-significant due to the low failure probability, benign normal operating conditions, and low consequence.

SIH-4: This segment is the High Pressure Safety Injection line from motor operated valves 8821A and 8821B to check valves 8819C, 8819A, 8819D, and 8819B. A break in this segment causes a loss of the RWST outside containment. The calculated full break probability is 0 (the threshold value of 1.0E-08 was used for calculations). The RRW and RAW values are relatively high, therefore the segment was designated high safety-significant.

FWA-12: This segment is the Auxiliary Feedwater line from check valve V12 and V47 to the cavitating venture before Steam Generator D. A break in this line causes an eventual loss of the DOST. The calculated full break probability is 0 (the threshold value of 1.0E-08 was used for calculations). The RRW and RAW values are relatively high, therefore the segment was designated high safety-significant.

SIL-3: This segment is the Low Pressure Safety Injection from motor operated valves 8716A and 8716B to V8735 and motor operated valve 8840. A break in this segment causes a loss of the RWST outside containment. The calculated full break probability is 0 (the threshold valve of 1.0E-08 was used for calculations). The RRW and RAW values are relatively high, therefore the segment was designated high safety-significant.

Surry Examples

ECC-3: This segment is the cold leg loop piping between check valves 1-SI-243 (from low head injection) and 1-SI-237 (from high head injection) and discharge check valve 1-SI-85 (to RCS). A piping failure in this line causes a loss of RWST inside containment (this would only cause a shorter time to switchover of recirculation) and the loss of one injection path to the RCS cold leg because flow restrictors on the injection path limit flow. The PSA model already assumes for LOCA events the loss of one cold leg injection path; therefore, there was no postulated conditional core damage. The failure mechanism postulated was thermal stratification while resulted in relatively low failure probabilities from small leak and large leak. This segment was designated as high safety-significant by the expert panel due to the piping possible being pressurized from the RCS and would also be a common mode failure of one of the low head and high head injection systems flowpath.

FW-12: This segment is the main feedwater piping header to steam generator A. A piping failure in this line is postulated to result in a loss of both main feedwater pumps and cause a loss of main feedwater initiating event. Indirect effects would also result from failure of this line due to spray and flooding and cause a loss of all three Unit 1 AFW pumps, the loss of both Unit 1 containment spray pumps and the loss of three main steam relief valves. These consequences were treated as 1) an initiating event with failure of mitigating equipment and 2) failure of mitigating equipment. The RRW for core damage frequency with operator action was 1.04 (high safety significant) and the RRW for LERF with operation action was 1.008 (high safety significant). The failure mechanism assumed was wastage which resulted in high failure probabilities for small and large leak. The segment is in an augmented program and therefore a factor of 10 reduction is the failure probabilities was assumed. The expert panel concurred that this segment was high safety significant.

HHI-4C: The piping segment is located at the discharge of charging pump A between a check valve and two motor-operated valves. A piping failure in this segment is assessed to result in the loss of RWST outside containment in addition to the loss of the Unit 2's RWST and charging pump cross connects. The postulated indirect consequences are not more severe than the direct impact but was also assessed numerically. With operator action, the segment can be isolated and this results in the loss of one charging pump. The postulated failure mechanism was that a snubber locks up under thermal conditions; yet the failure probability remained relatively low. The expert panel assessed this segment as high safety significant because high head flow would be temporarily interrupted before the operator took action and because of the potential for a common mode failure of all charging pumps.

LHI-4: This segment is one of the low head safety injection system=s suction line from the containment sump to the first motor-operated valve for LHI pump A. A piping failure in this segment is assessed to result in the loss of recirculation from LHI A path. Fatigue was postulated as the failure mechanism and resulted in relatively low failure probabilities. The importance measures indicated this segment as low safety significant. The panel was concerned that this line had a single containment isolation valve and is an extension of the containment sump. The panel designated this segment as high safety significant.

RC-16: This piping segment is the safety injection line from the first isolation check valve to the RCS loop 1 hot leg. This segment was postulated to result in a large, medium or small LOCA depending on the leak size. Thermal striping/stratification and thermal fatigue was the postulated failure mechanism for this segment. This segment was found to be numerically high risk significant (CDF with operator action). The segment provides hot leg safety injection water. The panel noted that the failure mechanism postulated (thermal striping) had occurred in the industry, though on the cold leg safety injection lines. The panel voted unanimously each segment high safety significant.

RC- 58: This piping segment is from PORV block valve to pressurizer PORV. Failure of this segment was postulated to result in a medium or small LOCA depending on leak size. Closure of the block valve would terminate the event and reduce the consequences. The failure mechanism postulated was fatigue. The concern was raised regarding the loss of cold overpressure mitigation capability during shutdown. The panel was concerned with high stress to allowable stress ratios. The panel voted unanimously to make the segment high safety significant.

SW-4: This piping segment is from the discharge of service water pump A through the diesel cooler and shaft bearing oil cooler back to the intake structure. As a direct impact, a rupture in any one of these segments is assessed to result in the loss of one of three SW pumps. As an indirect consequence, failure of any one of these segments is assessed to result in the loss of all SW pumps. The postulated failure mechanism was wastage which results in a high failure probability. The RRW for the CDF with operator action showed this segment to be high safety significant. The expert panel identified that fiberglass failures had occurred at the plant and with a high RRW, the panel identified this segment as high safety significant.

MILLSTONE 3
EXPERT PANEL EVALUATION
SEGMENT RANKING WORKSHEET

Section 1 System & Pipe Segment Identification	
System & Segment Description:	FWS-1 Main Feedwater/Condensate System From motor valve MOV-35A(V14) to gate valve FCV-510(V15)
Location/P&ID Drawing:	E-130C
System Function(s):	Provides feedwater to steam generators

Section 2 Risk Ranking Information		
Failure Effect on System Without Operator Action:	Loss of main feedwater flow to steam generator A	
Failure Effect on System With Operator Action:	Loss of main feedwater flow to steam generator A	
PSA Initiating Events Impact:	Loss of Main Feedwater	
PSA Containment Performance Impact:	None	
Conditional Core Damage Frequency	Without O	With O
Due to Pressure Boundary Failure	1.20E-06	1.20E-06
Total Pressure Boundary Failure Core Damage Frequency (FP*CDFcod)	3.00E-16	3.00E-16
CDF_p Importance Measure Values	RAW 5.38 RRW 1.000	106 1.000
Comments:		

Section 3 Pressure Boundary Failure Probability		
Segment Elements (welds, tees, elbows, etc.):	Pipe to valve V14 weld	
Pressure Boundary Failure Mechanism(s):	Thermal fatigue, erosion/corrosion	
Pressure Boundary Leak Probability:	Small Leak: Full Break :	1.1E-03 0 (use 1.0E-08)
Basis for Pressure Boundary Failure Probability:	High temperature at pipe weld, large nominal pipe size, high normal operating pressure	
Comments:	Break exclusion zone. No E tending LO 040-016 US	

Segment: FWS-1 (Sheet 2)

Section 4 Indirect Effects Evaluation	
Indirect Effect (Spray, flood, pipe whip, jet impingement)	None identified
Pressure Boundary Failure Impact on Other Systems	None identified
Core Damage Frequency Contribution due to Indirect Effects	None

Section 5 Other Considerations		
External Events Evaluation Seismic:	Fire:	External Flood:
Shutdown Risk Evaluation	Feedline break during cooldown. No impact at shutdown.	
Importance to Other Accident Scenarios		
Component Maintenance and Operation Insights:	Review of reports conducted, no major problems found	
Importance to Design Basis Analysis:	Decrease in heat removal by the secondary system, per FSAR Chapter 15.	
Other Deterministic Insights:		

Section 6 Final Risk Category			
Category:	High Safety Significant	Low Safety Significant	X
Basis	Low failure probability, relatively low consequence - loss of MFW		

MILLSTONE 3
EXPERT PANEL EVALUATION
SEGMENT RANKING WORKSHEET

Section 1 System & Pipe Segment Identification	
System & Segment Description:	ECCS-1 Emergency Core Cooling System From CV8819C (V24) and CV8818C (V13) to CV8847C (V985)
Location/P&ID Drawing:	EM-112A, 112B & 113B
System Function(s):	Provides water from the RWST and the containment sump for core cooling during a LOCA

Section 2 Risk Ranking Information		
Failure Effect on System Without Operator Action:	Loss of RWST inside containment	
Failure Effect on System With Operator Action:	Loss of all RHR & HPSI flow	
PSA Initiating Events Impact:	None	
PSA Containment Performance Impact:	None	
Conditional Core Damage Frequency due to Pressure Boundary Failure:	Without OA 4.73E-02* (3.00E-04)	With OA 2.09E-03
Total Segment Pressure Boundary Failure Core Damage Frequency ($FP*CDF_{cond}$):	4.73E-10* (3.00E-12)	2.09E-11
CDF_{pb} Importance Measure Values:	RAW 1.50E+05* (1.32E+4) RRW 1.002* (1.00)	1.83E+05 1.002
Comments: *Based on Expert Panel discussion, the consequence is much less than this – will be requantified (shown in parentheses) – would result in draindown of RWST and earlier transfer to recirc.		

Section 3 Pressure Boundary Failure Probability	
Segment Elements (welds, tees, elbows, etc.):	Weld at V985
Pressure Boundary Failure Mechanism(s):	Thermal fatigue
Pressure Boundary Failure Probability:	Small Leak: 0 (use 1.0E-08 per demand) Full Break: 0 (use 1.0E-08 per demand)
Basis for Pressure Boundary Failure Probability:	High normal operating pressure, Maximum residual stress level, High fatigue transient frequency
Comments:	Valve is located on branch line within 2 feet of run pipe connection; Many nearby branch line snubbers exist which potentially may lockup causing break potential

MILLSTONE 3
EXPERT PANEL EVALUATION
SEGMENT RANKING WORKSHEET

Segment: ECCS - 1 (Sheet 2)

Section 4 Indirect Effects Evaluation	
Indirect Effect: (Spray, flood, pipe whip, jet impingement)	None Identified
Pressure Boundary Failure Impact on Other Systems:	None identified
Core Damage Frequency Contribution due to Indirect Effects:	None

Section 5 Other Considerations		
External Events Evaluation Seismic:	Fire:	External Flood:
Shutdown Risk Evaluation:	Failure results in possible reduced flow for emergency core cooling; loss of RHR flow and LOCA during shutdown if RHR is not isolated	
Importance to Other Accident Scenarios:		
Component Maintenance and Operation Insights:	Review of reports conducted, no major problems found	
Importance to Design Basis Analysis:		
Other Deterministic Insights:		

Section 6 Final Risk Category		
Category:	High Safety Significant	Low Safety Significant X
Basis	Low Failure Probability and lower consequence given draindown of RWST	

Section 1 System & Pipe Segment Identification	
System & Segment Description:	RCS-7 Reactor Coolant System LPSI Connection from Loop A Cold Leg Tee to CV 8948A (V30)
Location/P&ID Drawing:	EM-102A
System Function(s):	Reactor heat removal

Section 2 Risk Ranking Information		
Failure Effect on System Without Operator Action:	Large loss of coolant accident	
Failure Effect on System With Operator Action:	Large loss of coolant accident	
PSA Initiating Events Impact:	Large LOCA initiator	
PSA Containment Performance Impact:	None	
Conditional Core Damage Frequency due to Pressure Boundary Failure	Without OA 9.36E-03	With OA 9.36E-03
Total Segment Pressure Boundary Failure Core Damage Frequency (FP * CDF_{cond})	2.34E-12	2.34E-12
CDF_{pb} Importance Measure Values	RAW 4.12E+05 RRW 1.000	8.22E+05 1.000
Comments		

Section 3 Pressure Boundary Failure Probability	
Segment Elements (welds, tees, elbows, etc.):	10" Pipe weld at connection to RCS cold leg
Pressure Boundary Failure Mechanism(s):	Thermal fatigue
Pressure Boundary Failure Probability:	Small Leak: 1.9E-06 Full Break: 4.1E-09 (Use 1E-08)
Basis for Pressure Boundary Failure Probability:	High temperature at pipe weld, Maximum residual stress level, High steady state stress level
Comments	High usage factor. Branch is on fatigue watch list

MILLSTONE 3
EXPERT PANEL EVALUATION
SEGMENT RANKING WORKSHEET

Segment: RCS-7 (Sheet 2)

Section 4 Indirect Effects Evaluation	
Indirect Effects (spray, flood, pipe whip, jet impingement)	None Identified
Pressure Boundary Failure Impact on Other Systems	None Identified
Core Damage Frequency Contribution due to Indirect Effects	None

Section 5 Other Considerations		
External Events Evaluation Seismic:	Fire:	External Flood:
Shutdown Risk Evaluation	Failure results in Large LOCA at shutdown	
Importance to Other Accident Scenarios		
Component Maintenance and Operation Insights:	Review of reports conducted, no major problems found	
Importance to Design Basis Analysis	Large LOCA, per FSAR Chapter 15	
Other Deterministic Insights		

Section 6 Final Risk Category	
Category: High Safety Significant X	Low Safety Significant
Basis Relatively High RAW Value, High consequence - Large LOCA	

MILLSTONE 3
EXPERT PANEL EVALUATION
SEGMENT RANKING WORKSHEET

Section 1 System & Pipe Segment Identification	
System & Segment Description:	RCS-15 Reactor Coolant System HPSI Connection from Cold Leg Tee to CV 8900B (V70)
Location/P&ID Drawing:	EM-102D
System Function(s):	Reactor heat removal

Section 2 Risk Ranking Information		
Failure Effect on System Without Operator Action:	Small loss of coolant accident	
Failure Effect on System With Operator Action:	Small loss of coolant accident	
PSA Initiating Events Impact:	Small LOCA initiator	
PSA Containment Performance Impact:	None	
Conditional Core Damage Frequency due to Pressure Boundary Failure	Without OA 8.61E-04	With OA 8.61E-04
Total Segment Pressure Boundary Failure Core Damage Frequency (FP * CDF_{cond})	2.15E-13	2.15E-13
CDF_{pb} Importance Measure Values	RAW 3.79E+04 RRW 1.000	7.56E+04 1.000
Comments		

Section 3 Pressure Boundary Failure Probability	
Segment Elements (welds, tees, elbows, etc.):	Weld to V70
Pressure Boundary Failure Mechanism(s):	Thermal fatigue
Pressure Boundary Failure Probability:	Small Leak: 0 (Use 1.0E-08) Full Break: Use 1.0E-08
Basis for Pressure Boundary Failure Probability:	High temperature at pipe weld, High normal operating pressure, Maximum residual stress level
Comments	Area of maximum bending stress. SR EL @ 535/540 & Tee @ 550 are on fatigue watch list

Segment: RCS-15 (Sheet 2)

Section 4 Indirect Effects Evaluation	
Indirect Effects (spray, flood, pipe whip, jet impingement)	None Identified
Pressure Boundary Failure Impact on Other Systems	None Identified
Core Damage Frequency Contribution due to Indirect Effects	None

Section 5 Other Considerations		
External Events Evaluation Seismic:	Fire:	External Flood:
Shutdown Risk Evaluation	Failure results in Small LOCA at shutdown	
Importance to Other Accident Scenarios		
Component Maintenance and Operation Insights:	Review of reports conducted, no major problems found	
Importance to Design Basis Analysis	Small LOCA, per FSAR Chapter 15	
Other Deterministic Insights		

Section 6 Final Risk Category	
Category: High Safety Significant X	Low Safety Significant
Basis Relatively large RAW value, Unisolable break	

MILLSTONE 3
EXPERT PANEL EVALUATION
SEGMENT RANKING WORKSHEET

Section 1 System & Pipe Segment Identification	
System & Segment Description:	SIL-9 Low Pressure Safety Injection SI Accumulator Tank TK1A to CV8956A (V15)
Location/P&ID Drawing:	EM-112B
System Function(s):	Provides borated water to core during design basis accidents

Section 2 Risk Ranking Information		
Failure Effect on System Without Operator Action:	Loss of Accumulator A water flow to cold leg 1	
Failure Effect on System With Operator Action:	Loss of Accumulator A water	
PSA Initiating Events Impact:	None	
PSA Containment Performance Impact:	None	
Conditional Core Damage Frequency due to Pressure Boundary Failure	Without OA 6.61E-04	With OA 6.61E-04
Total Segment Pressure Boundary Failure Core Damage Frequency (FP^*CDF_{cond})	6.61E-12	6.61E-12
CDF_{pb} Importance Measure Values	RAW 2.91E+04 RRW 1.000	5.80E+04 1.001
Comments		

Section 3 Pressure Boundary Failure Probability	
Segment Elements (welds, tees, elbows, etc.):	Valve/pipe weld
Pressure Boundary Failure Mechanism(s):	Thermal fatigue
Pressure Boundary Failure Probability:	Small Leak: 0 (use 1E-08 per demand) Full Break: 0 (use 1E-08 per demand)
Basis for Pressure Boundary Failure Probability:	Maximum Residual Stress
Comments	Location based on potential check valve leakage causing thermal cycling. Choked flow consideration during DBA not considered to be a significant loading concern (thick stainless steel piping).

MILLSTONE 3
EXPERT PANEL EVALUATION
SEGMENT RANKING WORKSHEET

Segment: SIL-9

Section 4 Indirect Effects Evaluation	
Indirect Effects (spray, flood, pipe whip, jet impingement)	None
Pressure Boundary Failure Impact on Other Systems	None
Core Damage Frequency Contribution due to Indirect Effects	None

Section 5 Other Considerations		
External Events Evaluation Seismic: None	Fire:	External Flood:
Shutdown Risk Evaluation	Accumulators isolated during shutdown, do not provide function during shutdown, redundant accumulators available if necessary	
Importance to Other Accident Scenarios		
Component Maintenance and Operation Insights	Review of reports conducted; no major problems found	
Importance to Design Basis Analysis		
Other Deterministic Insights		

Section 6 Final Risk Category	
Category: High Safety Significant	Low Safety Significant X
Basis	Reliable piping, benign normal conditions, minimal consequence.

MILLSTONE 3
EXPERT PANEL EVALUATION
SEGMENT RANKING WORKSHEET

Section 1 System & Pipe Segment Identification	
System & Segment Description:	SIH-4 High Pressure Safety Injection From MOVs 8821A (V15) and 8821B (V19) to CVs 8819C (V24), 8819A (V28), 8819D (V26) & 8819B (V22)
Location/P&ID Drawing:	EM-113B
System Function(s):	Provides emergency core cooling during design basis accidents

Section 2 Risk Ranking Information		
Failure Effect on System Without Operator Action:	Loss of RWST	
Failure Effect on System With Operator Action:	Loss of HPSI flow to all cold legs	
IPE Initiating Events Impact:	None	
IPE Containment Performance Impact:	None	
Conditional Damage Frequency due to Pressure Boundary Failure	Without OA 4.73E-02	With OA 2.99E-03
Total Segment Pressure Boundary Failure Core Damage Frequency (FP * CDFcond)	4.73E-10	2.99E-11
CDFpb Importance Measure Values	RAW 1.50E+05 RRW 1.002	1.23E+04 1.00
Comments		

Section 3 Pressure Boundary Failure Probability	
Segment Elements (welds, tees, elbows, etc.): (V20)	Valve to pipe weld at discharge of MOV8835
Pressure Boundary Failure Mechanism(s):	External loads
Pressure Boundary Failure Probability:	Small Leak: 0 Full Break: 0 (use 1E-08 per demand)
Basis for Pressure Boundary Failure Probability:	Maximum Residual Stress Level, High Steady State Stress Level, High Normal operating pressure
Comments:	Potential for locked snubber or operational vibration

Section 4 Indirect Effects Evaluation	
Indirect Effects (spray, flood, pipe whip, jet impingement)	None
Pressure Boundary Failure Impact on Other Systems	None
Core Damage Frequency Contribution due to Indirect Effects	None

Section 5 Other Considerations		
External Events Evaluation Seismic: None	Fire:	External Flood:
Shutdown Risk Evaluation:	One HPSI required to be available.	
Importance to Other Accident Scenarios		
Component Maintenance and Operation Insights	Review of reports conducted; no major problems found	
Importance to Design Basis Analysis	LOCA mitigation system	
Other Deterministic Insights		

Section 6 Final Risk Category	
Category: High Safety Significant X	Low Safety Significant
Basis	High consequence - loss of RWST, both HPSI pumps injecting to break location.

MILLSTONE 3
EXPERT PANEL EVALUATION
SEGMENT RANKING WORKSHEET

Section 1 System & Pipe Segment Identification	
System & Segment Description:	FWA-12 Auxiliary Feedwater System From V12 and V47 to cavitating venturi (CAV-60D) before SG-D
Location/P&ID Drawing:	EM-130B
System Function(s) provide cooling during startup/cooldown	Supply aux. feedwater to steam generators,

Section 2 Risk Ranking Information		
Failure Effect on System Without Operator Action:	Loss of DWST	
Failure Effect on System With Operator Action Plant	Loss of flow from motor-driven AFW pump A and turbine-driven AFW pump	
IPE Initiating Events Impact:	None	
IPE Containment Performance Impact:	Pipe failure may occur inside containment, steam release	
Conditional Core Damage Frequency due to Pressure Boundary Failure	Without OA 8.34E-02	With OA 2.58E-03
Total Segment Pressure Boundary Failure Core Damage Frequency ($FP*CDF_{cond}$)	8.34E-10	2.58E-11
CDF_{pb} Importance Measure Values	RAW 3.14E+05 RRW 1.003	1.02E+04 1.000
Comments		

Section 3 Pressure Boundary Failure Probability		
Segment Elements (welds, tees, elbows, etc.):	Tee to elbow weld, tee to pipe weld	
Pressure Boundary Failure Mechanism(s):	External loads	
Pressure Boundary Failure Probability:	Small Leak: Full Break:	0 (use 1.0E-08 per demand) 0 (use 1.0E-08 per demand)
Basis for Pressure Boundary Failure Probability	Carbon Steel, Large Initial Flaw, High Steady State Stress	
Comments:	Loads from valve operator or containment during seismic event	

MILLSTONE 3
EXPERT PANEL EVALUATION
SEGMENT RANKING WORKSHEET
SEGMENT: FWA-12

Section 4 Indirect Effects Evaluation	
Indirect Effects (spray, flood, pipe whip, jet impingement)	Loss of cable trays containing HVQ*ACUS1A due to jet impingement within the AFW pump A room
Pressure Boundary Failure Impact on Other Systems	Loss of HVQ*ACUS1A - room cooling to "A" RHR, QSS, SI area
Core Damage Frequency Contribution due to Indirect Effects	

Section 5 Other Considerations		
External Events Evaluation Seismic: None	Fire:	External Flood:
Shutdown Risk Evaluation	FWA provides cooling during plant cooldown/startup, used for safe shutdown after plant transients	
Importance to Other Accident Scenarios		
Component Maintenance and Operation Insights	Review of reports conducted, no major problems found	
Importance to Design Basis Analysis		
Other Deterministic Insights		

Section 6 Final Risk Category	
Category: High Safety Significant X	Low Safety Significant
Basis:	Shorter time to take operator recovery, loss of DWST or loss of motor-driven (A) and turbine-driven AFW pumps (pumps potentially run out)

MILLSTONE 3
EXPERT PANEL EVALUATION
SEGMENT RANKING WORKSHEET

Section 1 System & Pipe Segment Identification	
System & Segment Description: (SIL, RHS)	SIL-3 Low Pressure Safety Injection From MOVs 8716A (V4) and 8716B (V8) to V8735 (V43) and MOV 8840 (V25)
Location/P&ID Drawing:	EM-112A
System Function(s):	Provide emergency cooling and borated water to core during design basis accidents, maintain the core covered, core cooling during shutdown

Section 2 Risk Ranking Information		
Failure Effect on System Without Operator Action:	Loss of RWST	
Failure Effect on System With Operator Action:	Loss of both RHR pump trains	
IPE Initiating Events Impact:	None	
IPE Containment Performance Impact:	None	
Conditional Core Damage Frequency due to Pressure Boundary Failure	Without OA 4.73E-02	With OA 1.96E-02
Total Segment Pressure Boundary Failure Core Damage Frequency ($FP*CDF_{cond}$)	4.73E-10	1.96E-10
CDF_{pb} Importance Measure Values	RAW 1.50E+05 RRW 1.002	8.04E+04 1.001
Comments	Operator would close 8716 valves if break location is known and sufficient time is available	

Section 3 Pressure Boundary Failure Probability	
Segment Elements (welds, tees, elbows, etc.):	Elbow weld at inlet to MOV8840
Pressure Boundary Failure Mechanism(s):	Thermal fatigue (conservative)
Pressure Boundary Failure Probability:	Small Leak: 0 use 1.0E-08 (per demand) Full Break: 0 use 1.0E-08 (per demand)
Basis for Pressure Boundary Failure Probability:	High Steady State Stress Level
Comments	Location based on stress

Section 4 Indirect Effects Evaluation	
Indirect Effects (spray, flood, pipe whip, jet impingement)	None
Pressure Boundary Failure Impact on Other Systems	None
Core Damage Frequency Contribution due to Indirect Effects	None

Section 5 Other Considerations		
External Events Evaluation Seismic: None	Fire:	External Flood:
Shutdown Risk Evaluation	Segment is isolated by closure of 8716A&B for train separation during shutdown (no consequence); Loss of decay heat removal if valves are not closed during shutdown	
Importance to Other Accident Scenarios	Loss of hot leg recirculation (plan not to use this function)	
Component Maintenance and Operation Insights	Review of reports conducted; no major problems found	
Importance to Design Basis Analysis	The RHR pumps provide ECCS during design basis accidents. Need cross-connect during design basis event with single failure to get injection to all cold legs.	
Other Deterministic Insights		

Section 6 Final Risk Category	
Category: High Safety Significant X	Low Safety Significant
Basis	Same consequence as SIL-1 and SIL-2, but doesn't have shutdown risk.

Risk-based Inspection Expert Panel Evaluation Segment Ranking Worksheet

SEGMENT: ECC-003 **PLANT:** Surry Unit 1

Section 1 System and Pipe Segment Identification

System:	Emergency Core Cooling
Segment Description:	Cold leg loop 3 from CV 1-SI-243 and CV 1-SI-237 to CV 1-SI-85.
Drawing Number:	11448-CBM-089B-3 Sh. 4 Rev. 2, 11448-WMKS-0127J3

Section 2 Risk Ranking Information

FAILURE EFFECTS ON SYSTEM

Without Operator Action:	Loss of RWST inside containment; Potential ISLOCA initiating event separated from the RCS by check valves; degradation of the cold leg injection function; only one injection path to a cold leg (hh and LH); flow restrictors on injection paths limit flow.
With Operator Action:	No change.
Initiating Events Impact:	Potential ISLOCA (CV SI-85 fails & pipe breaks)
Containment Performance Impact:	

CONDITIONAL TREATMENT, CDF and LERF IMPORTANCE MEASURE CALCULATIONS

Treatment: None		Without OA	With OA
Conditional Core Damage Frequency due to Pressure Boundary Failure		0.00E+00	0.00E+00
Conditional Large Early Release Frequency due to Pressure Boundary Failure		0.00E+00	0.00E+00

CDF and IMPORTANCE MEASURE CALCULATIONS

		Without OA	With OA
Total Segment Pressure Boundary Failure Core Damage Frequency (FP * CDFcond)		0.00E+00	0.00E+00
CDFpb Importance Measure Values	RAW	1.00E+00	1.00E+00
	RRW	1	1

LERF and IMPORTANCE MEASURE CALCULATIONS

		Without OA	With OA
Total Segment Pressure Boundary Failure Large Early Release Frequency (FP * LERFcond)		0.00E+00	0.00E+00
LERFpb Importance Measure Values	RAW	1.00E+00	1.00E+00
	RRW	1	1

Expert Panel Discussion/Comments:

Risk-based Inspection Expert Panel Evaluation Segment Ranking Worksheet

SEGMENT: ECC-003 **PLANT:** Surry Unit 1

Section 3 Pressure Boundary Failure Probability

Segment Element(s): Weld 1-05

Failure Mechanism(s): Thermal stratification

			Leak Size	Large	Med	Small
Failure Probability:	**Small Leak (w/o ISI):**	8.67E-04	**Large Leak (w/o ISI):**	8.30E-04	0.00E+00	0.00E+00
	Small Leak (with ISI):	9.35E-05	**Large Leak (with ISI):**	2.91E-05	0.00E+00	0.00E+00

Basis for Failure Probability: See failure probability worksheet

Comments: Based upon ECCS inventory and RWST margin assumed small value of 2 gpm.

Section 4 Indirect Effects Evaluation

Indirect Effects: No indirect impact.

Section 5 Other Considerations

External Events Evaluation:

Seismic: Support function in all seismic induced events

Fire: None

Flood: None

Shutdown Risk Evaluation: Alternate decay heat removal/primary if below mid-loop

Importance to Other Accident Scenarios: None

Component Maintenance and Operation Insights: Cold leg injection for LHI & HHI

Importance to Design Basis Analysis: LOCAs, tube rupture, main steam line break, boron dilution, rod ejection as described in UFSAR chapter 14

Other Deterministic Insights: Segment separated by check valve 1-SI-85 from segment RC-43, check valve 1-SI-237 from segment HHI-12D & check valve 1-SI-243 from segment LHI-10

Section 6 Final Risk Category

Risk Category: ◉ HIGH SAFETY SIGNIFICANT ○ LOW SAFETY SIGNIFICANT

Basis for Risk Category: Common mode - failure mechanism
- pressurized with RCS heads
- would see increased sump level

Risk-based Inspection Expert Panel Evaluation Segment Ranking Worksheet

SEGMENT: FW-012 **PLANT:** Surry Unit 1

Section 1 System and Pipe Segment Identification

System:	Feedwater System
Segment Description:	Feedwater header to SG A from 1-FW-FCV-1478 to 1-FW-12 (check valve).
Drawing Number:	11448-CBM-068A-3 SH. 1, 11448-WMKS-1018A3

Section 2 Risk Ranking Information

FAILURE EFFECTS ON SYSTEM

Without Operator Action:	Loss of both MFW pumps.
With Operator Action:	No change.
Initiating Events Impact:	Loss of main feedwater initiating event.
Containment Performance Impact:	

CONDITIONAL TREATMENT, CDF and LERF IMPORTANCE MEASURE CALCULATIONS

Treatment: SYS/JI/S+DC	**Without OA**	**With OA**
Conditional Core Damage Frequency due to Pressure Boundary Failure	1.72E-03	1.72E-03
Conditional Large Early Release Frequency due to Pressure Boundary Failure	1.35E-04	1.35E-04

Treatment: IE/JI/S+DC	**Without OA**	**With OA**
Conditional Core Damage Frequency due to Pressure Boundary Failure	1.49E-04	1.49E-04
Conditional Large Early Release Frequency due to Pressure Boundary Failure	3.62E-06	3.62E-06

CDF and IMPORTANCE MEASURE CALCULATIONS		**Without OA**	**With OA**
Total Segment Pressure Boundary Failure Core Damage Frequency (FP * CDFcond)		1.38E-07	1.38E-07
Measure Values **CDFpb Importance**	**RAW**	3.07E+01	4.61E+02
	RRW	1.00221	1.03533

Risk-based Inspection Expert Panel Evaluation Segment Ranking Worksheet

SEGMENT: FW-012 **PLANT:** Surry Unit 1

LERF and IMPORTANCE MEASURE CALCULATIONS			Without OA	With OA
Total Segment Pressure Boundary Failure Large Early Release Frequency (FP * LERFcond)			3.59E-09	3.59E-09
Measure Values	LERFpb Importance	RAW	2.78E+01	3.12E+02
		RRW	1.00069	1.00811

Expert Panel Discussion/Comments: Failure Effects with Operator Action: Loss of main feedwater; indirect effect of spray and jet impingement assumed instantaneous.

Section 3 Pressure Boundary Failure Probability

Segment Element(s): Pipe to FCV 1478; Drawings: 1018A3

Failure Mechanism(s): Wastage*

			Leak Size	Large	Med	Small
Failure Probability:	**Small Leak (w/o ISI):**	3.60E-01	**Large Leak (w/o ISI):**	3.60E-01	0.00E+00	0.00E+00
	Small Leak (with ISI):	3.60E-02	**Large Leak (with ISI):**	3.60E-02	0.00E+00	0.00E+00

Basis for Failure Probability: See failure probability worksheet

Comments: Based upon condensate automatic make-up capabilities (300,000 gallon tank) to hotwell assumed 500 gpm disabling leak. Leakage could continue for over 8 hours without operator action (1 shift); code allowables used; Segment in augmented program, factor of 10 credit assumed for w/ISI case, SRRA not used

Section 4 Indirect Effects Evaluation

Indirect Effects: Flooding, spray; All three Unit 1 AFW pumps; both Unit 1 CS pumps; Three Main Steam RVs.

Risk-based Inspection Expert Panel Evaluation Segment Ranking Worksheet

SEGMENT: FW-012 **PLANT:** Surry Unit 1

Section 5 Other Considerations

External Events Evaluation:

Seismic:	Not considered significant
Fire:	Backup water supply for fires.
Flood:	None

Shutdown Risk Evaluation:	Alternate decay heat removal
Importance to Other Accident Scenarios:	None
Component Maintenance and Operation Insights:	Fluid contained is condensate. E/C program coverage.
Importance to Design Basis Analysis:	Loss of normal feedwater.
Other Deterministic Insights:	Separated from segment FW-15 by check valve 1-FW-12.

Section 6 Final Risk Category

Risk Category:	◉ HIGH SAFETY SIGNIFICANT	○ LOW SAFETY SIGNIFICANT
Basis for Risk Category:	Total loss of FW, high CDF/LERF with OA RRW	

Risk-based Inspection Expert Panel Evaluation Segment Ranking Worksheet

SEGMENT: HHI-004C **PLANT:** Surry Unit 1

Section 1 System and Pipe Segment Identification

System: High Head Safety Injection

Segment Description: Discharge of charging pump A, between:1-CH-258 (check valve), 1-CH-MOV-1286A, 1-CH-MOV-1287A.

Drawing Number: 11448-MKS-1105B5, 11448-MKS-1105B9

Section 2 Risk Ranking Information

FAILURE EFFECTS ON SYSTEM

Without Operator Action: A: Loss of Unit 1 RWST, loss of Unit 2 RWST cross connect to Unit 1 Charging pumps, and loss of Unit 2 Charging pumps cross connect to Unit 1; N: Loss of VCT and BAT to the charging pumps.

With Operator Action: Closure of CH-MOV-1267A, 1267B, 1275A isolates segment and would result in loss of one charging pump (A) only.

Initiating Events Impact:

Containment Performance Impact:

CONDITIONAL TREATMENT, CDF and LERF IMPORTANCE MEASURE CALCULATIONS

Treatment: SYS/JI/S	Without OA	With OA
Conditional Core Damage Frequency due to Pressure Boundary Failure	1.12E-04	1.12E-04
Conditional Large Early Release Frequency due to Pressure Boundary Failure	2.60E-05	2.60E-05

Treatment: SYS	Without OA	With OA
Conditional Core Damage Frequency due to Pressure Boundary Failure	2.50E-02	0.00E+00
Conditional Large Early Release Frequency due to Pressure Boundary Failure	2.38E-03	2.60E-05

CDF and IMPORTANCE MEASURE CALCULATIONS		Without OA	With OA
Total Segment Pressure Boundary Failure Core Damage Frequency (FP * CDFcond)		4.59E-11	2.97E-13
CDFpb Importance Measure Values	RAW	4.01E+02	2.86E+01
	RRW	1	1

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Risk-based Inspection Expert Panel Evaluation Segment Ranking Worksheet

SEGMENT: HHI-004C **PLANT:** Surry Unit 1

LERF and IMPORTANCE MEASURE CALCULATIONS		**Without OA**	**With OA**
Total Segment Pressure Boundary Failure Large Early Release Frequency (FP * LERFcond)		4.40E-12	1.17E-13
LERFpb Importance Measure Values	**RAW**	4.65E+02	1.18E+02
	RRW	1	1

Expert Panel Discussion/Comments:

Section 3 Pressure Boundary Failure Probability

Segment Element(s): Weld 1-04 3" line

Failure Mechanism(s): Snubber locks up under TC

			Leak Size	Large	Med	Small
Failure Probability:	**Small Leak (w/o ISI):**	3.88E-05	**Large Leak (w/o ISI):**	2.66E-05	0.00E+00	0.00E+00
	Small Leak (with ISI):	2.76E-06	**Large Leak (with ISI):**	9.14E-07	0.00E+00	0.00E+00

Basis for Failure Probability: See failure probability worksheet

Comments: Based upon ECCS inventory and RWST margin assumed small value of 2 gpm.

Section 4 Indirect Effects Evaluation

Indirect Effects: F/S; 1-CH-P-1A; Bounded by direct effect. The indirect impact attributed to the segment is not more severe than the direct impact; indirect consequences of the HHI and LHI piping is also assessed to result; indirect consequences of the HHI and LHI piping is also assessed to result in the unavailability of one charging pump..

Risk-based Inspection Expert Panel Evaluation Segment Ranking Worksheet

SEGMENT: HHI-004C **PLANT:** Surry Unit 1

Section 5 Other Considerations

External Events Evaluation:

Seismic:	Support function in all seismic induced events
Fire:	None
Flood:	None

Shutdown Risk Evaluation:	Alternate decay heat removal/primary if below mid-loop
Importance to Other Accident Scenarios:	None
Component Maintenance and Operation Insights:	No history of problems
Importance to Design Basis Analysis:	Important in LOCAs, tube rupture, main steam line break, boron dilution, and rod ejection.
Other Deterministic Insights:	Separated by check valve 1-CH-258 from segment HHI-004A.

Section 6 Final Risk Category

Risk Category:	◉ HIGH SAFETY SIGNIFICANT	○ LOW SAFETY SIGNIFICANT

Basis for Risk Category:

- High head flow interrupted
- Can mitigate with operator action
- Potential interconnection (common cause) of all charging pumps

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Risk-based Inspection Expert Panel Evaluation Segment Ranking Worksheet

SEGMENT: LHI-004 **PLANT:** Surry Unit 1

Section 1 System and Pipe Segment Identification

System: Low Head Safety Injection

Segment Description: Containment sump to MOV 1860A.

Drawing Number: 11448-WMKS-1106A7, CBM-089B-3 SH. 1, Rev. 5

Section 2 Risk Ranking Information

FAILURE EFFECTS ON SYSTEM

Without Operator Action: Loss of Recirc from LPI Train A.

With Operator Action: No change.

Initiating Events Impact:

Containment Performance Impact:

CONDITIONAL TREATMENT, CDF and LERF IMPORTANCE MEASURE CALCULATIONS

Treatment: SYS

	Without OA	With OA
Conditional Core Damage Frequency due to Pressure Boundary Failure	5.87E-05	5.87E-05
Conditional Large Early Release Frequency due to Pressure Boundary Failure	2.00E-07	2.00E-07

CDF and IMPORTANCE MEASURE CALCULATIONS

			Without OA	With OA
Total Segment Pressure Boundary Failure Core Damage Frequency (FP * CDFcond)			5.59E-11	5.59E-11
Measure Values	CDFpb Importance	RAW	1.94E+00	1.55E+01
		RRW	1	1.00001

LERF and IMPORTANCE MEASURE CALCULATIONS

			Without OA	With OA
Total Segment Pressure Boundary Failure Large Early Release Frequency (FP * LERFcond)			1.90E-13	1.90E-13
Measure Values	LERFpb Importance	RAW	1.04E+00	1.45E+00
		RRW	1	1

Expert Panel Discussion/Comments:

Risk-based Inspection Expert Panel Evaluation Segment Ranking Worksheet

SEGMENT: LHI-004 **PLANT:** Surry Unit 1

Section 3 Pressure Boundary Failure Probability

Segment Element(s): Weld 1-15; Drawing: 1106A7

Failure Mechanism(s): Fatigue*

			Leak Size	Large	Med	Small
Failure Probability:	**Small Leak (w/o ISI):**	2.00E-05	**Large Leak (w/o ISI):**	1.52E-05	0.00E+00	0.00E+00
	Small Leak (with ISI):	7.48E-07	**Large Leak (with ISI):**	1.17E-07	0.00E+00	0.00E+00

Basis for Failure Probability: See failure probability worksheet

Comments: Based upon ECCS inventory and RWST margin assumed small value of 2 gpm; Code allowables used..

Section 4 Indirect Effects Evaluation

Indirect Effects: No indirect impact.

Section 5 Other Considerations

External Events Evaluation:

Seismic: Support function in all seismic induced events

Fire: None

Flood: None

Shutdown Risk Evaluation: Alternate decay heat removal/primary if below mid-loop

Importance to Other Accident Scenarios: None

Component Maintenance and Operation Insights: No history of problems, standby system.

Importance to Design Basis Analysis: Important for large break LOCA

Other Deterministic Insights: None

Section 6 Final Risk Category

Risk Category: ◉ HIGH SAFETY SIGNIFICANT ○ LOW SAFETY SIGNIFICANT

Basis for Risk Category:
- Single containment isolation
- extension of containment sump

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Risk-based Inspection Expert Panel Evaluation Segment Ranking Worksheet

SEGMENT: RC-016 **PLANT:** Surry Unit 1

Section 1 System and Pipe Segment Identification

System: Reactor Coolant

Segment Description: SI from CV 1-SI-91 to RCS Loop 1 hot leg.

Drawing Number: CBM-086A-3 SH. 1, CBM-089B-3 SH. 4, 11448-WMKS-0122H1

Section 2 Risk Ranking Information

FAILURE EFFECTS ON SYSTEM

Without Operator Action: Large loss of coolant accident
Medium loss of coolant accident
Small loss of coolant accident

With Operator Action: No change.

Initiating Events Impact: Large, Medium, or Small LOCA initiator

Containment Performance Impact: Either late containment failure or no containment failure are about equally likely.

CONDITIONAL TREATMENT, CDF and LERF IMPORTANCE MEASURE CALCULATIONS

Treatment: IE-L

	Without OA	With OA
Conditional Core Damage Frequency due to Pressure Boundary Failure	9.40E-03	9.40E-03
Conditional Large Early Release Frequency due to Pressure Boundary Failure	3.77E-05	3.77E-05

Treatment: IE-M

	Without OA	With OA
Conditional Core Damage Frequency due to Pressure Boundary Failure	5.36E-03	5.36E-03
Conditional Large Early Release Frequency due to Pressure Boundary Failure	5.53E-06	5.53E-06

Treatment: IE-S

	Without OA	With OA
Conditional Core Damage Frequency due to Pressure Boundary Failure	6.41E-04	6.41E-04
Conditional Large Early Release Frequency due to Pressure Boundary Failure	1.65E-06	1.65E-06

Risk-based Inspection Expert Panel Evaluation Segment Ranking Worksheet

SEGMENT: RC-016 **PLANT:** Surry Unit 1

CDF and IMPORTANCE MEASURE CALCULATIONS		**Without OA**	**With OA**
Total Segment Pressure Boundary Failure Core Damage Frequency (FP * CDFcond)		1.23E-07	1.23E-07
Measure Values — **CDFpb Importance**	**RAW**	2.46E+02	3.80E+03
	RRW	1.00197	1.03132

LERF and IMPORTANCE MEASURE CALCULATIONS		**Without OA**	**With OA**
Total Segment Pressure Boundary Failure Large Early Release Frequency (FP * LERFcond)		3.52E-10	3.52E-10
Measure Values — **LERFpb Importance**	**RAW**	9.66E+00	1.02E+02
	RRW	1.00007	1.00079

Expert Panel Discussion/Comments:

Section 3 Pressure Boundary Failure Probability

Segment Element(s): ID root of welds 1-08, 2-08; Drawings: 122H1, 122K1

Failure Mechanism(s): Striping/stratification, Thermal fatigue

			Leak Size	Large	Med	Small
Failure Probability:	**Small Leak (w/o ISI):**	5.31E-04	**Large Leak (w/o ISI):**	3.09E-04	3.34E-04	3.59E-04
	Small Leak (with ISI):	1.69E-05	**Large Leak (with ISI):**	5.52E-06	6.35E-06	7.00E-06

Basis for Failure Probability: See failure probability worksheet

Comments: Large LOCA = 5001GPM, Medium LOCA = 1501 GPM, Small LOCA = 100 GPM/BASIS: LARGE LOCA NUREG/CR-4550 PAGES 3-2, 3-3

Section 4 Indirect Effects Evaluation

Indirect Effects: No indirect impact.

Risk-based Inspection Expert Panel Evaluation Segment Ranking Worksheet

SEGMENT: RC-016 **PLANT:** Surry Unit 1

Section 5 Other Considerations

External Events Evaluation:

Seismic:	Contributes about 7% to small and medium break LOCA seismic CDF. Minimal contribution to large break LOCA seismic CDF.
Fire:	Not considered a significant contributor to external fire events.
Flood:	Not considered a significant contributor to external flood events.

Shutdown Risk Evaluation:	Shutdown LOCA less likely than at power LOCA since pressure reduced.
Importance to Other Accident Scenarios:	None
Component Maintenance and Operation Insights:	Temperature average between 547 and 573 degrees F. at 2235 psig. during normal operation. Chemistry controlled to reduce corrosion potential.
Importance to Design Basis Analysis:	LOCA described in UFSAR chapter 14. Second barrier provided in defense of fission product release.
Other Deterministic Insights:	Segment separated by check valve 1-SI-91 from segment ECCS-005

Section 6 Final Risk Category

Risk Category:	◉ HIGH SAFETY SIGNIFICANT	○ LOW SAFETY SIGNIFICANT
Basis for Risk Category:	No credit for thermal monitoring.	

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Risk-based Inspection Expert Panel Evaluation Segment Ranking Worksheet

SEGMENT: RC-058 **PLANT:** Surry Unit 1

Section 1 System and Pipe Segment Identification

ystem:	Reactor Coolant
egment Description:	From block valve 1-RC-MOV-1535 to PORV 1-RC-PCV-1456.
rawing Number:	CBM-086B-3 SH. 1, 11448-WMKS-0124A1-1

Section 2 Risk Ranking Information

FAILURE EFFECTS ON SYSTEM

Without Operator Action:	Medium loss of coolant accident Small loss of coolant accident
With Operator Action:	Closure of MOV-1535 terminates LOCA, therefore none.
Initiating Events Impact:	Medium, or Small LOCA initiator
Containment Performance Impact:	Either late containment failure or no containment failure are about equally likely.

ONDITIONAL TREATMENT, CDF and LERF IMPORTANCE MEASURE CALCULATIONS

Treatment: IE-M	Without OA	With OA
Conditional Core Damage Frequency due to Pressure Boundary Failure	5.36E-03	0.00E+00
Conditional Large Early Release Frequency due to Pressure Boundary Failure	5.53E-06	0.00E+00

Treatment: IE-S	Without OA	With OA
Conditional Core Damage Frequency due to Pressure Boundary Failure	6.41E-04	0.00E+00
Conditional Large Early Release Frequency due to Pressure Boundary Failure	1.65E-06	0.00E+00

CDF and IMPORTANCE MEASURE CALCULATIONS		Without OA	With OA
Total Segment Pressure Boundary Failure Core Damage Frequency (FP * CDFcond)		6.84E-09	0.00E+00
Measure Values **CDFpb Importance**	**RAW**	9.66E+01	1.00E+00
	RRW	1.00011	1

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Risk-based Inspection Expert Panel Evaluation Segment Ranking Worksheet

SEGMENT: RC-058 **PLANT:** Surry Unit 1

LERF and IMPORTANCE MEASURE CALCULATIONS		Without OA	With OA
Total Segment Pressure Boundary Failure Large Early Release Frequency (FP * LERFcond)		8.18E-12	0.00E+00
Measure Values LERFpb Importance	RAW	2.39E+00	1.00E+00
	RRW	1	1

Expert Panel Discussion/Comments:

Section 3 Pressure Boundary Failure Probability

Segment Element(s): Pipe to valve, pipe to reducer; Drawings: 0124A1-1

Failure Mechanism(s): Fatigue

			Leak Size	Large	Med	Small
Failure Probability:	**Small Leak (w/o ISI):**	4.15E-05	**Large Leak (w/o ISI):**	0.00E+00	4.56E-05	4.56E-05
	Small Leak (with ISI):	3.20E-05	**Large Leak (with ISI):**	0.00E+00	2.81E-05	2.81E-05

Basis for Failure Probability: See failure probability worksheet

Comments: Medium LOCA = 1501GPM, Small LOCA = 100 GPM/BASIS: NUREG/CR-4550 PAGES 3-2, 3-3; 20% snubber failure probability used due to large number of snubbers; use values/note for no leak detection Large Leak probability should be used, also for small leak

Section 4 Indirect Effects Evaluation

Indirect Effects: No indirect impact.

Risk-based Inspection Expert Panel Evaluation Segment Ranking Worksheet

SEGMENT: RC-058 **PLANT:** Surry Unit 1

Section 5 Other Considerations

External Events Evaluation:

Seismic: Contributes about 7% to small and medium break LOCA seismic CDF. Minimal contribution to large break LOCA seismic CDF.

Fire: Not considered a significant contributor to external fire events.

Flood: Not considered a significant contributor to external flood events.

Shutdown Risk Evaluation: Shutdown LOCA less likely than at power LOCA since pressure reduced.

Importance to Other Accident Scenarios: None

Component Maintenance and Operation Insights: Temperature average between 547 and 573 degrees F. at 2235 psig. during normal operation. Chemistry controlled to reduce corrosion potential.

Importance to Design Basis Analysis: LOCA described in UFSAR chapter 14. Second barrier provided in defense of fission product release.

Other Deterministic Insights: None

Section 6 Final Risk Category

Risk Category: ⦿ HIGH SAFETY SIGNIFICANT ○ LOW SAFETY SIGNIFICANT

Basis for Risk Category: 3x2 reducer at PCV-1456 is high stress location (large fraction of code allowable)

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Risk-based Inspection Expert Panel Evaluation Segment Ranking Worksheet

SEGMENT: SW-004 **PLANT:** Surry Unit 1

Section 1 System and Pipe Segment Identification

System: Service Water

Segment Description: From 1-SW-P-1A discharge through diesel cooler and shaft bearing oil cooler to intake structure.

Drawing Number: CBM-071A-3 SH.1

Section 2 Risk Ranking Information

FAILURE EFFECTS ON SYSTEM

Without Operator Action: Loss of pump 1-SW-P-1A

With Operator Action: No change.

Initiating Events Impact:

Containment Performance Impact:

CONDITIONAL TREATMENT, CDF and LERF IMPORTANCE MEASURE CALCULATIONS

Treatment: SYS/S	Without OA	With OA
Conditional Core Damage Frequency due to Pressure Boundary Failure	3.69E-04	3.69E-04
Conditional Large Early Release Frequency due to Pressure Boundary Failure	9.50E-06	9.50E-06

Treatment: SYS	Without OA	With OA
Conditional Core Damage Frequency due to Pressure Boundary Failure	3.69E-04	3.69E-04
Conditional Large Early Release Frequency due to Pressure Boundary Failure	9.50E-06	9.50E-06

CDF and IMPORTANCE MEASURE CALCULATIONS		Without OA	With OA
Total Segment Pressure Boundary Failure Core Damage Frequency (FP * CDFcond)		2.35E-08	2.35E-08
CDFpb Importance Measure Values	RAW	1.28E+01	1.83E+02
	RRW	1.00038	1.00584

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Risk-based Inspection Expert Panel Evaluation Segment Ranking Worksheet

SEGMENT: SW-004 **PLANT:** Surry Unit 1

LERF and IMPORTANCE MEASURE CALCULATIONS		**Without OA**	**With OA**
Total Segment Pressure Boundary Failure Large Early Release Frequency (FP * LERFcond)		6.07E-10	6.07E-10
Measure Values — **LERFpb Importance**	**RAW**	4.67E+00	4.36E+01
	RRW	1.00012	1.00136

Expert Panel Discussion/Comments:

Section 3 Pressure Boundary Failure Probability

Segment Element(s): 163L - CLASS PIPE - WELD AT REDUCER ON 2" SIDE

Failure Mechanism(s): Wastage/Pitting

			Leak Size	Large	Med	Small
Failure Probability:	**Small Leak (w/o ISI):**	1.00E-02	**Large Leak (w/o ISI):**	1.00E-02	0.00E+00	0.00E+00
	Small Leak (with ISI):	1.00E-02	**Large Leak (with ISI):**	1.00E-02	0.00E+00	0.00E+00

Basis for Failure Probability: See failure probability worksheet

Comments: 10GPM/BASED UPON 10% OF 2" PIPE FLOW; NO SNUBBERS; FIBERGLASS PIPING FAILURE PROBABILITY SET AT 1 X 10E-2 FOR SMALL LEAK AND LARGE LEAK

Section 4 Indirect Effects Evaluation

Indirect Effects: Loss of SW pumps.

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Risk-based Inspection Expert Panel Evaluation Segment Ranking Worksheet

SEGMENT: SW-004 **PLANT:** Surry Unit 1

Section 5 Other Considerations

External Events Evaluation:

Seismic: Provides heat sink for seismic LOCA.

Fire: Not considered a significant contributor to external fire events.

Flood: Not considered a significant contributor to external flood events.

Shutdown Risk Evaluation: Primary heat sink for decay heat removal during shutdown. Alternate long term decay heat removal.

Importance to Other Accident Scenarios: Provides heat sink for spent fuel pit cooling.

Component Maintenance and Operation Insights: Contains river water from James River. Flows only during accident with loss of off-site power and during quarterly pump testing.

Importance to Design Basis Analysis: Large break LOCA long term heat removal described in UFSAR chapter 14.

Other Deterministic Insights: None.

Section 6 Final Risk Category

Risk Category: ◉ HIGH SAFETY SIGNIFICANT ○ LOW SAFETY SIGNIFICANT

Basis for Risk Category: High CDF w/OA RRW, fiberglass failures experienced at plant.

APPENDIX C

SAMPLE FAILURE PROBABILITY WORKSHEETS

This appendix contains sample SRRA code input worksheets and the code output for Millstone 3 and Surry. Supplement 1 discusses the SRRA code and its input and output parameters in detail.

Millstone 3

The piping segments presented are the same as those in Appendix B. The piping segments are ECCS-1 (Tables C-1 through C-3), FWS-1 (Tables C-4 through C-6), RCS-7 (Tables C-7 through C-9), RCS-15 (Tables C-10 through C-12), and SIL-9 (Tables C-13 through C-15). For a given segment, the input worksheet is shown first, followed by the small leak probability calculation output then the full break output. For the cases in which 0 failures are predicted, the values in parentheses on the worksheets are those calculated assuming one half failure in 5000 trails, corrected for importance sampling.

Note: The failure probability worksheets and results for Millstone 3 are likely to change because of the modifications made to the SRRA model as described in Supplement 1.

Surry

The piping segments presented are the same as those in Appendix B. The piping segments are ECC-03 (Tables C-16 through C-18), FW-12 (Tables C-19 through C-21), LHI-4 (Tables C-22 through C-24), HHI-4C (Tables C-25 through C-27), RC-16 (Tables C-28 through C-30), RC-58 (Tables C-31 through C-33), and SW-04 (Tables C-34 through C-36). Similar to Millstone, the input worksheet is shown along with the small leak probability calculation output and the large leak probability calculation.

Table C-1					
ECCS-1					
Piping Structural Reliability Estimates for Millstone Unit No. 3					
System: ECCS		Segment: 1			Sheet of
P&ID No.: EM-112A, B & 113B		Data Point: 165 of X7003B			
Pipe Stress Calculation Number: X7003B 831, X10705		PSI/Const. Method: VT-2, PT, UT/Hydro, RT			
Piping Stress Isometric No.: SIL-6, 159 & 165		Proposed ISI Method: VT-2, UT			
Piping Component/Segment Element (weld, tee, elbow, etc.): Weld at valve V985					
No.	**Input Parameter Description**	**Check Input Choice (for Table 1 Value)**			**Set Value***
1	Type of Piping Material	304 SS	316 SS	Carbon Steel	---
2	Temperature at Pipe Weld	Low (150)	Medium (350)	High (550)	350
3	Nominal Pipe Size	Small (2)	Medium (5)	Large (16)	6
4	Pipe Wall Thickness	Thin (.06)	Normal (.14)	Thick (.22)	.12
5	Normal Operating Pressure	Low (0.5)	Medium (1.3)	High (2.1)	2.5
6	Residual Stress Level	None (0.0)	Moderate (0.1)	Maximum (0.2)	.2
7	Initial Flaw Size	Small (.05)	Medium (.11)	Large (.17)	.05
8	Steady-State Stress Level	Low (.05)	Medium (.11)	High (.17)	.17
9	Stress Corrosion Potential	None (0.0)	Moderate (0.5)	Maximum (1.0)	0
10	Material Wastage Potential	None (0.0)	Moderate (0.5)	Maximum (1.0)	0
11	High Cycle Fatigue Loads	None (0.0)	Moderate (.08)	Maximum (.16)	0
12	Fatigue Transient Loads	Low (.10)	Medium (.22)	High (.34)	.28
13	Fatigue Transient Frequency	Low (5)	Medium (13)	High (21)	17
14	Design-Limiting Stress (Break Only)	Low (.10)	Medium (.26)	High (.42)	.22
15	Optional Crack Inspection Interval	Low (6)	Medium (10)	High (14)	10
16	Optional crack Inspection Accuracy	High (.16)	Medium (.24)	Low (.32)	.24
*For optional numeric input, use a value (and associated units) from the standard range given in Table 1.					
Small Leak Probability, No ISI: 0 (6.4E-09)		Optional Leak Probability With ISI: 0 (6.4E-09)			
Full Break Probability, No ISI: 0 (2.3E-12)		Optional Break Probability With ISI: 0 (2.3E-12)			
Comments: Valve is located on branch line within 2 ft. of run pipe connection. Many nearby branch line snubbers exist which potentially may lockup causing break potential.					

Table C-2

ECCS-1 SMALL LEAK PROBABILITY

```
                  STRUCTURAL RELIABILITY AND RISK ASSESSMENT (SRRA)
WESTINGHOUSE         PROBABILITY OF FAILURE PROGRAM SPFMPROF     ESBU-NTD
========================================================================
     INPUT VARIABLES FOR CASE 34: 316 STAINLESS STEEL PIPE WELD LEAK

      NCYCLE =     40           NFAILS =  1000           NTRIAL =  5000
      NOVARS =     29           NUMSET =     6           NUMISI =     5
      NUMSSC =      7           NUMTRC =     7           NUMFMD =     4
```

VARIABLE NO.	NAME	DISTRIBUTION TYPE	LOG	MEDIAN VALUE	DEVIATION OR FACTOR	SHIFT MV/SD	USAGE NO.	SUB
1	PIPE-DIA	NORMAL	NO	6.0000D+00	3.0000D-02	.00	1	SET
2	WALL/DIA	NORMAL	NO	1.1000D-01	3.3000D-03	.00	2	SET
3	SRESIDUAL	NORMAL	YES	1.2357D+01	1.4125D+00	1.00	3	SET
4	INT%DEPTH	NORMAL	YES	5.0000D+00	1.4125D+00	1.00	4	SET
5	L/D-RATIO	NORMAL	YES	6.0000D+00	1.4125D+00	1.00	5	SET
6	PROB/VOL	- CONSTANT -		1.0000D-04			6	SET
7	FIRST-ISI	- CONSTANT -		5.0000D+00			1	ISI
8	FREQ-ISI	- CONSTANT -		1.0000D+01			2	ISI
9	EPST-PND	- CONSTANT -		1.0000D-03			3	ISI
10	ASTAR-PND	- CONSTANT -		-4.8000D-01			4	ISI
11	ANUU-PND	- CONSTANT -		1.6000D+00			5	ISI
12	HOURS/CY	NORMAL	YES	7.4473D+03	1.0500D+00	1.00	1	SSC
13	PRESSURE	NORMAL	NO	2.5000D+00	1.5000D-02	.00	2	SSC
14	STRESS-SS	NORMAL	YES	1.0503D+01	1.2589D+00	.00	3	SSC
15	SCC-COEFF	NORMAL	YES	3.2310D-12	2.3714D+00	1.00	4	SSC
16	SCC-EXPNT	- CONSTANT -		2.1610D+00			5	SSC
17	SCC-TIMEI	- CONSTANT -		1.0000D+00			6	SSC
18	ECW-RATE	NORMAL	YES	1.2740D-11	2.3714D+00	.00	7	SSC
19	NOFTRS/HR	- CONSTANT -		6.0000D+01			1	TRC
20	STRESS-FT	NORMAL	YES	6.1783D-02	1.4125D+00	.00	2	TRC
21	NOSTRS/CY	- CONSTANT -		1.5000D+01			3	TRC
22	STRESS-ST	NORMAL	YES	1.7917D+01	1.2589D+00	.00	4	TRC
23	FCG-COEFF	NORMAL	YES	9.1401D-12	2.8508D+00	1.00	5	TRC
24	FCG-EXPNT	- CONSTANT -		4.0000D+00			6	TRC
25	FCG-THOLD	- CONSTANT -		4.6000D+00			7	TRC
26	LIMIT-DSL	NORMAL	NO	-9.7000D-01	1.0000D-02	.00	1	FMD
27	LIMIT-PBS	- CONSTANT -		0.0000D+00			2	FMD
28	STRESS-DL	- CONSTANT -		0.0000D+00			3	FMD
29	FREQ-DLTR	- CONSTANT -		0.0000D+00			4	FMD

PROBABILITIES OF FAILURE MODE: EXCEED LIMITING DEPTH FOR SMALL LEAK

NUMBER FAILED = 0 NUMBER OF TRIALS = 5000

END OF CYCLE	FAILURE PROBABILITY WITHOUT FOR PERIOD	CUM. TOTAL	AND WITH IN-SERVICE INSPECTION FOR PERIOD	CUM. TOTAL
.0	6.37720D-09	6.37720D-09	6.37720D-09	6.37720D-09
40.0	0.00000D+00	6.37720D-09	0.00000D+00	6.37720D-09

Table C-3

ECCS-1 FULL BREAK PROBABILITY

STRUCTURAL RELIABILITY AND RISK ASSESSMENT (SRRA)

WESTINGHOUSE PROBABILITY OF FAILURE PROGRAM SPFMPROF ESBU.-NTD

INPUT VARIABLES FOR CASE 35: 316 STAINLESS STEEL PIPE WELD BREAK

NCYCLE =	40	NFAILS =	1000	NTRIAL =	5000
NOVARS =	29	NUMSET =	6	NUMISI =	5
NUMSSC =	7	NUMTRC =	7	NUMFMD =	4

VARIABLE NO.	NAME	DISTRIBUTION TYPE	LOG	MEDIAN VALUE	DEVIATION OR FACTOR	SHIFT MV/SD	USAGE NO.	SUB
1	PIPE-DIA	NORMAL	NO	6.0000D+00	3.0000D-02	.00	1	SET
2	WALL/DIA	NORMAL	NO	1.1000D-01	3.3000D-03	.00	2	SET
3	SRESIDUAL	NORMAL	YES	1.2357D+01	1.4125D+00	1.00	3	SET
4	INT%DEPTH	NORMAL	YES	5.0000D+00	1.4125D+00	1.00	4	SET
5	L/D-RATIO	NORMAL	YES	6.0000D+00	1.4125D+00	1.00	5	SET
6	PROB/VOL	- CONSTANT -		1.0000D-04			6	SET
7	FIRST-ISI	- CONSTANT -		5.0000D+00			1	ISI
8	FREQ-ISI	- CONSTANT -		1.0000D+01			2	ISI
9	EPST-PND	- CONSTANT -		1.0000D-03			3	ISI
10	ASTAR-PND	- CONSTANT -		-4.8000D-01			4	ISI
11	ANUU-PND	- CONSTANT -		1.6000D+00			5	ISI
12	HOURS/CY	NORMAL	YES	7.4473D+03	1.0500D+00	1.00	1	SSC
13	PRESSURE	NORMAL	NO	2.5000D+00	1.5000D-02	.00	2	SSC
14	STRESS-SS	NORMAL	YES	1.0503D+01	1.2589D+00	.00	3	SSC
15	SCC-COEFF	NORMAL	YES	3.2310D-12	2.3714D+00	1.00	4	SSC
16	SCC-EXPNT	- CONSTANT -		2.1610D+00			5	SSC
17	SCC-TIMEI	- CONSTANT -		1.0000D+00			6	SSC
18	ECW-RATE	NORMAL	YES	1.2740D-11	2.3714D+00	.00	7	SSC
19	NOFTRS/HR	- CONSTANT -		6.0000D+01			1	TRC
20	STRESS-FT	NORMAL	YES	6.1783D-02	1.4125D+00	.00	2	TRC
21	NOSTRS/CY	- CONSTANT -		1.5000D+01			3	TRC
22	STRESS-ST	NORMAL	YES	1.7917D+01	1.2589D+00	.00	4	TRC
23	FCG-COEFF	NORMAL	YES	9.1401D-12	2.8508D+00	1.00	5	TRC
24	FCG-EXPNT	- CONSTANT -		4.0000D+00			6	TRC
25	FCG-THOLD	- CONSTANT -		4.6000D+00			7	TRC
26	LIMIT-DSL	- CONSTANT -		0.0000D+00			1	FMD
27	LIMIT-PBS	NORMAL	NO	6.1783D+01	3.2000D+00	-1.00	2	FMD
28	STRESS-DL	NORMAL	YES	1.4210D+01	1.4125D+00	1.00	3	FMD
29	FREQ-DLTR	- CONSTANT -		1.0000D-03			4	FMD

PROBABILITIES OF FAILURE MODE: EXCEED FLOW STRESS LIMIT FOR FULL BREAK

NUMBER FAILED = 0 NUMBER OF TRIALS = 5000

END OF CYCLE	FAILURE PROBABILITY WITHOUT FOR PERIOD	CUM. TOTAL	AND WITH IN-SERVICE INSPECTION FOR PERIOD	CUM. TOTAL
.0	2.34604D-12	2.34604D-12	2.34604D-12	2.34604D-12
40.0	0.00000D+00	2.34604D-12	0.00000D+00	2.34604D-12

Table C-4 FWS-1					
Piping Structural Reliability Estimates for Millstone Unit No. 3					
System: FWS		Segment: 1			Sheet of
P&ID No.: EM-130C		Data Point: 410			
Pipe Stress Calculation Number: X1709		PSI/Const. Method: VT-2/Hydro, RT			
Piping Stress Isometric No.: C.I. FWS-11		Proposed ISI Method: VT-2, UT			
Piping Component/Segment Element (weld, tee, elbow, etc.): Pipe to valve (V14) weld					
No.	**Input Parameter Description**	**Check Input Choice (for Table 1 Value)**			**Set Value***
1	Type of Piping Material	304 SS	316 SS	Carbon Steel	---
2	Temperature at Pipe Weld	Low (150)	Medium (350)	High (550)	446
3	Nominal Pipe Size	Small (2)	Medium (5)	Large (16)	18
4	Pipe Wall Thickness	Thin (.06)	Normal (.14)	Thick (.22)	.06
5	Normal Operating Pressure	Low (0.5)	Medium (1.3)	High (2.1)	1.8
6	Residual Stress Level	None (0.0)	Moderate (0.1)	Maximum (0.2)	0.1
7	Initial Flaw Size	Small (.05)	Medium (.11)	Large (.17)	.05
8	Steady-State Stress Level	Low (.05)	Medium (.11)	High (.17)	.08
9	Stress Corrosion Potential	None (0.0)	Moderate (0.5)	Maximum (1.0)	0
10	Material Wastage Potential	None (0.0)	Moderate (0.5)	Maximum (1.0)	0.5
11	High Cycle Fatigue Loads	None (0.0)	Moderate (.08)	Maximum (.16)	0
12	Fatigue Transient Loads	Low (.10)	Medium (.22)	High (.34)	0.1
13	Fatigue Transient Frequency	Low (5)	Medium (13)	High (21)	13
14	Design-Limiting Stress (Break Only)	Low (.10)	Medium (.26)	High (.42)	.16
15	Optional Crack Inspection Interval	Low (6)	Medium (10)	High (14)	10
16	Optional crack Inspection Accuracy	High (.16)	Medium (.24)	Low (.32)	.24
*For optional numeric input, use a value (and associated units) from the standard range given in Table 1.					
Small Leak Probability, No ISI: 1.09E-3		Optional Leak Probability With ISI: 6.21E-06			
Full Break Probability, No ISI: 0 (3.5E-11)		Optional Break Probability With ISI: 0 (3.5E-11)			
Comments: Break exclusion zone. No EC trending, LOC 040-016 US.					

Table C-5

FWS-1 SMALL LEAK PROBABILITY

WESTINGHOUSE — STRUCTURAL RELIABILITY AND RISK ASSESSMENT (SRRA) PROBABILITY OF FAILURE PROGRAM SPFMPROF — ESBU-NTD

INPUT VARIABLES FOR CASE 2: CARBON STEEL PIPE WELD SMALL LEAK

NCYCLE =	40	NFAILS =	1000	NTRIAL =	5000
NOVARS =	29	NUMSET =	6	NUMISI =	5
NUMSSC =	7	NUMTRC =	7	NUMFMD =	4

VARIABLE NO.	NAME	DISTRIBUTION TYPE	LOG	MEDIAN VALUE	DEVIATION OR FACTOR	SHIFT MV/SD	USAGE NO.	SUB
1	PIPE-DIA	NORMAL	NO	1.8000D+01	9.0000D-02	.00	1	SET
2	WALL/DIA	NORMAL	NO	6.0000D-02	1.8000D-03	.00	2	SET
3	SRESIDUAL	NORMAL	YES	6.4337D+00	1.4125D+00	.00	3	SET
4	INT%DEPTH	NORMAL	YES	5.0000D+00	1.4125D+00	1.00	4	SET
5	L/D-RATIO	NORMAL	YES	6.0000D+00	1.4125D+00	1.00	5	SET
6	PROB/VOL	- CONSTANT -		1.0000D-04			6	SET
7	FIRST-ISI	- CONSTANT -		5.0000D+00			1	ISI
8	FREQ-ISI	- CONSTANT -		1.0000D+01			2	ISI
9	EPST-PND	- CONSTANT -		5.0000D-03			3	ISI
10	ASTAR-PND	- CONSTANT -		-2.4000D-01			4	ISI
11	ANUU-PND	- CONSTANT -		3.0000D+00			5	ISI
12	HOURS/CY	NORMAL	YES	7.4473D+03	1.0500D+00	1.00	1	SSC
13	PRESSURE	NORMAL	NO	1.8000D+00	1.5000D-02	.00	2	SSC
14	STRESS-SS	NORMAL	YES	5.1470D+00	1.2589D+00	.00	3	SSC
15	SCC-COEFF	NORMAL	YES	3.5900D-13	2.3714D+00	.00	4	SSC
16	SCC-EXPNT	- CONSTANT -		2.1610D+00			5	SSC
17	SCC-TIMEI	- CONSTANT -		1.0000D+00			6	SSC
18	ECW-RATE	NORMAL	YES	6.3700D-07	2.3714D+00	.00	7	SSC
19	NOFTRS/HR	- CONSTANT -		6.0000D+01			1	TRC
20	STRESS-FT	NORMAL	YES	6.4337D-02	1.4125D+00	.00	2	TRC
21	NOSTRS/CY	- CONSTANT -		1.3000D+01			3	TRC
22	STRESS-ST	NORMAL	YES	6.4337D+00	1.2589D+00	1.00	4	TRC
23	FCG-COEFF	NORMAL	YES	1.2017D-11	2.8508D+00	1.00	5	TRC
24	FCG-EXPNT	- CONSTANT -		3.7000D+00			6	TRC
25	FCG-THOLD	- CONSTANT -		3.5000D+00			7	TRC
26	LIMIT-DSL	NORMAL	NO	-9.7000D-01	1.0000D-02	.00	1	FMD
27	LIMIT-PBS	- CONSTANT -		0.0000D+00			2	FMD
28	STRESS-DL	- CONSTANT -		0.0000D+00			3	FMD
29	FREQ-DLTR	- CONSTANT -		0.0000D+00			4	FMD

PROBABILITIES OF FAILURE MODE: EXCEED LIMITING DEPTH FOR SMALL LEAK

NUMBER FAILED = 316 NUMBER OF TRIALS = 5000

END OF CYCLE	FAILURE PROBABILITY WITHOUT FOR PERIOD	CUM. TOTAL	AND WITH IN-SERVICE INSPECTION FOR PERIOD	CUM. TOTAL
6.0	1.41843D-08	1.41843D-08	7.09612D-11	7.09612D-11
7.0	8.24432D-07	8.38616D-07	4.34590D-09	4.41686D-09
8.0	4.48267D-07	1.28688D-06	2.25107D-09	6.66793D-09
9.0	1.86245D-05	1.99114D-05	5.15727D-07	5.22395D-07
10.0	1.62683D-07	2.00740D-05	1.18905D-09	5.23584D-07
11.0	2.59319D-05	4.60059D-05	9.03992D-07	1.42758D-06

Table C-5 (cont.)

FWS-1 SMALL LEAK PROBABILITY

12.0	8.95441D-07	4.69014D-05	3.93405D-08	1.46692D-06
14.0	3.21027D-06	5.01116D-05	1.22563D-06	2.69255D-06
15.0	2.74723D-08	5.01391D-05	6.15578D-09	2.69871D-06
16.0	2.95454D-06	5.30936D-05	6.75335D-09	2.70546D-06
17.0	1.58686D-05	6.89622D-05	5.10427D-08	2.75650D-06
18.0	5.31092D-07	6.94933D-05	1.32861D-09	2.75783D-06
19.0	6.22227D-05	1.31716D-04	1.89205D-07	2.94704D-06
20.0	1.34045D-05	1.45121D-04	1.82564D-08	2.96529D-06
21.0	8.13526D-06	1.53256D-04	2.86175D-08	2.99391D-06
22.0	6.98358D-06	1.60239D-04	4.41429D-08	3.03805D-06
23.0	1.05365D-04	2.65604D-04	1.05385D-06	4.09190D-06
24.0	1.05498D-04	3.71102D-04	4.55720D-07	4.54762D-06
25.0	8.28412D-05	4.53943D-04	1.51379D-06	6.06141D-06
26.0	1.63160D-05	4.70259D-04	7.16360D-10	6.06212D-06
27.0	2.23614D-04	6.93873D-04	3.49592D-08	6.09708D-06
28.0	1.09478D-04	8.03351D-04	2.32728D-08	6.12036D-06
29.0	1.08010D-05	8.14152D-04	9.21074D-10	6.12128D-06
30.0	1.78803D-05	8.32032D-04	3.64537D-09	6.12492D-06
31.0	4.47131D-06	8.36503D-04	9.58423D-10	6.12588D-06
32.0	7.85007D-05	9.15004D-04	4.43658D-08	6.17025D-06
33.0	9.77842D-06	9.24782D-04	4.74730D-09	6.17499D-06
34.0	1.75473D-05	9.42330D-04	1.57386D-08	6.19073D-06
35.0	2.58613D-05	9.68191D-04	1.96033D-08	6.21034D-06
36.0	3.97057D-05	1.00790D-03	2.22109D-10	6.21056D-06
37.0	4.21448D-05	1.05004D-03	1.58531D-10	6.21072D-06
38.0	7.24170D-06	1.05728D-03	5.41483D-11	6.21077D-06
39.0	1.53097D-05	1.07259D-03	1.93248D-10	6.21096D-06
40.0	1.44083D-05	1.08700D-03	2.48961D-10	6.21121D-06
	DEVIATION ON CUMULATIVE TOTALS =		5.91907D-05	4.62194D-06

Table C-6

FWS-1 FULL BREAK PROBABILITY

WESTINGHOUSE — STRUCTURAL RELIABILITY AND RISK ASSESSMENT (SRRA) PROBABILITY OF FAILURE PROGRAM SPFMPROF — ESBU-NTD

INPUT VARIABLES FOR CASE 3: CARBON STEEL PIPE WELD FULL BREAK

NCYCLE =	40	NFAILS =	1000	NTRIAL =	5000
NOVARS =	29	NUMSET =	6	NUMISI =	5
NUMSSC =	7	NUMTRC =	7	NUMFMD =	4

VARIABLE NO.	NAME	DISTRIBUTION TYPE	LOG	MEDIAN VALUE	DEVIATION OR FACTOR	SHIFT MV/SD	USAGE NO.	SUB
1	PIPE-DIA	NORMAL	NO	1.8000D+01	9.0000D-02	.00	1	SET
2	WALL/DIA	NORMAL	NO	6.0000D-02	1.8000D-03	.00	2	SET
3	SRESIDUAL	NORMAL	YES	6.4337D+00	1.4125D+00	.00	3	SET
4	INT%DEPTH	NORMAL	YES	5.0000D+00	1.4125D+00	1.00	4	SET
5	L/D-RATIO	NORMAL	YES	6.0000D+00	1.4125D+00	1.00	5	SET
6	PROB/VOL	- CONSTANT -		1.0000D-04			6	SET
7	FIRST-ISI	- CONSTANT -		5.0000D+00			1	ISI
8	FREQ-ISI	- CONSTANT -		1.0000D+01			2	ISI
9	EPST-PND	- CONSTANT -		5.0000D-03			3	ISI
10	ASTAR-PND	- CONSTANT -		-2.4000D-01			4	ISI
11	ANUU-PND	- CONSTANT -		3.0000D+00			5	ISI
12	HOURS/CY	NORMAL	YES	7.4473D+03	1.0500D+00	1.00	1	SSC
13	PRESSURE	NORMAL	NO	1.8000D+00	1.5000D-02	.00	2	SSC
14	STRESS-SS	NORMAL	YES	5.1470D+00	1.2589D+00	.00	3	SSC
15	SCC-COEFF	NORMAL	YES	3.5900D-13	2.3714D+00	.00	4	SSC
16	SCC-EXPNT	- CONSTANT -		2.1610D+00			5	SSC
17	SCC-TIMEI	- CONSTANT -		1.0000D+00			6	SSC
18	ECW-RATE	NORMAL	YES	6.3700D-07	2.3714D+00	.00	7	SSC
19	NOFTRS/HR	- CONSTANT -		6.0000D+01			1	TRC
20	STRESS-FT	NORMAL	YES	6.4337D-02	1.4125D+00	.00	2	TRC
21	NOSTRS/CY	- CONSTANT -		1.3000D+01			3	TRC
22	STRESS-ST	NORMAL	YES	6.4337D+00	1.2589D+00	1.00	4	TRC
23	FCG-COEFF	NORMAL	YES	1.2017D-11	2.8508D+00	1.00	5	TRC
24	FCG-EXPNT	- CONSTANT -		3.7000D+00			6	TRC
25	FCG-THOLD	- CONSTANT -		3.5000D+00			7	TRC
26	LIMIT-DSL	- CONSTANT -		0.0000D+00			1	FMD
27	LIMIT-PBS	NORMAL	NO	6.4337D+01	3.2000D+00	-1.00	2	FMD
28	STRESS-DL	NORMAL	YES	1.0294D+01	1.4125D+00	1.00	3	FMD
29	FREQ-DLTR	- CONSTANT -		1.0000D-03			4	FMD

PROBABILITIES OF FAILURE MODE: EXCEED FLOW STRESS LIMIT FOR FULL BREAK

NUMBER FAILED = 0 NUMBER OF TRIALS = 5000

END OF CYCLE	FAILURE PROBABILITY WITHOUT: FOR PERIOD	CUM. TOTAL	AND WITH IN-SERVICE INSPECTION: FOR PERIOD	CUM. TOTAL
.0	3.50552D-11	3.50552D-11	3.50552D-11	3.50552D-11
40.0	0.00000D+00	3.50552D-11	0.00000D+00	3.50552D-11

Table C-7 RCS-7					
Piping Structural Reliability Estimates for Millstone Unit No. 3					
System: Reactor Coolant System		Segment: RCS-7			Sheet of
P&ID No.: 12179-EM-102A R10		Data Point: 1021			
Pipe Stress Calculation Number: X7001B		PSI/Const. Method: VT-2, PT, UT/Hydro, PT,RT			
Piping Stress Isometric No.:		Proposed ISI Method: VT-2, UT			
Piping Component/Segment Element (weld, tee, elbow, etc.): Pipe weld at conn RCL					
No.	**Input Parameter Description**	**Check Input Choice (for Table 1 Value)**			**Set Value***
1	Type of Piping Material	304 SS	316 SS	Carbon Steel	---
2	Temperature at Pipe Weld	Low (150)	Medium (350)	High (550)	600
3	Nominal Pipe Size	Small (2)	Medium (5)	Large (16)	10
4	Pipe Wall Thickness	Thin (.06)	Normal (.14)	Thick (.22)	.1
5	Normal Operating Pressure	Low (0.5)	Medium (1.3)	High (2.1)	2.5
6	Residual Stress Level	None (0.0)	Moderate (0.1)	Maximum (0.2)	.2
7	Initial Flaw Size	Small (.05)	Medium (.11)	Large (.17)	.05
8	Steady-State Stress Level	Low (.05)	Medium (.11)	High (.17)	.14
9	Stress Corrosion Potential	None (0.0)	Moderate (0.5)	Maximum (1.0)	0
10	Material Wastage Potential	None (0.0)	Moderate (0.5)	Maximum (1.0)	0
11	High Cycle Fatigue Loads	None (0.0)	Moderate (.08)	Maximum (.16)	.08
12	Fatigue Transient Loads	Low (.10)	Medium (.22)	High (.34)	.25
13	Fatigue Transient Frequency	Low (5)	Medium (13)	High (21)	5
14	Design-Limiting Stress (Break Only)	Low (.10)	Medium (.26)	High (.42)	.22
15	Optional Crack Inspection Interval	Low (6)	Medium (10)	High (14)	10
16	Optional crack Inspection Accuracy	High (.16)	Medium (.24)	Low (.32)	.24
*For optional numeric input, use a value (and associated units) from the standard range given in Table 1.					
Small Leak Probability, No ISI: 1.85E-06		Optional Leak Probability With ISI: 1.30E-06			
Full Break Probability, No ISI: 4.15E-09		Optional Break Probability With ISI: 3.44E-09			
Comments: High usage factor. Branch is on Fatigue watch list.					

Table C-8

RCS-7 SMALL LEAK PROBABILITY

WESTINGHOUSE — STRUCTURAL RELIABILITY AND RISK ASSESSMENT (SRRA) PROBABILITY OF FAILURE PROGRAM SPFMPROF — ESBU-NTD

INPUT VARIABLES FOR CASE 53: 316 STAINLESS STEEL PIPE WELD LEAK

NCYCLE =	40	NFAILS =	1000	NTRIAL =	5000
NOVARS =	29	NUMSET =	6	NUMISI =	5
NUMSSC =	7	NUMTRC =	7	NUMFMD =	4

VARIABLE NO.	NAME	DISTRIBUTION TYPE	LOG	MEDIAN VALUE	DEVIATION OR FACTOR	SHIFT MV/SD	USAGE NO.	SUB
1	PIPE-DIA	NORMAL	NO	1.0000D+01	5.0000D-02	.00	1	SET
2	WALL/DIA	NORMAL	NO	9.0000D-02	2.7000D-03	.00	2	SET
3	SRESIDUAL	NORMAL	YES	1.0318D+01	1.4125D+00	1.00	3	SET
4	INT%DEPTH	NORMAL	YES	5.0000D+00	1.4125D+00	1.00	4	SET
5	L/D-RATIO	NORMAL	YES	6.0000D+00	1.4125D+00	1.00	5	SET
6	PROB/VOL	- CONSTANT -		1.0000D-04			6	SET
7	FIRST-ISI	- CONSTANT -		5.0000D+00			1	ISI
8	FREQ-ISI	- CONSTANT -		1.0000D+01			2	ISI
9	EPST-PND	- CONSTANT -		1.0000D-03			3	ISI
10	ASTAR-PND	- CONSTANT -		-4.8000D-01			4	ISI
11	ANUU-PND	- CONSTANT -		1.6000D+00			5	ISI
12	HOURS/CY	NORMAL	YES	7.4473D+03	1.0500D+00	1.00	1	SSC
13	PRESSURE	NORMAL	NO	2.7000D+00	1.5000D-02	.00	2	SSC
14	STRESS-SS	NORMAL	YES	7.7003D+00	1.2589D+00	.00	3	SSC
15	SCC-COEFF	NORMAL	YES	3.2310D-12	2.3714D+00	1.00	4	SSC
16	SCC-EXPNT	- CONSTANT -		2.1610D+00			5	SSC
17	SCC-TIMEI	- CONSTANT -		1.0000D+00			6	SSC
18	ECW-RATE	NORMAL	YES	1.2740D-11	2.3714D+00	.00	7	SSC
19	NOFTRS/HR	- CONSTANT -		6.0000D+01			1	TRC
20	STRESS-FT	NORMAL	YES	4.1068D+00	1.4125D+00	.00	2	TRC
21	NOSTRS/CY	- CONSTANT -		5.0000D+00			3	TRC
22	STRESS-ST	NORMAL	YES	1.2834D+01	1.2589D+00	.00	4	TRC
23	FCG-COEFF	NORMAL	YES	9.1401D-12	2.8508D+00	1.00	5	TRC
24	FCG-EXPNT	- CONSTANT -		4.0000D+00			6	TRC
25	FCG-THOLD	- CONSTANT -		4.6000D+00			7	TRC
26	LIMIT-DSL	NORMAL	NO	-9.7000D-01	1.0000D-02	.00	1	FMD
27	LIMIT-PBS	- CONSTANT -		0.0000D+00			2	FMD
28	STRESS-DL	- CONSTANT -		0.0000D+00			3	FMD
29	FREQ-DLTR	- CONSTANT -		0.0000D+00			4	FMD

PROBABILITIES OF FAILURE MODE: EXCEED LIMITING DEPTH FOR SMALL LEAK

NUMBER FAILED = 38 NUMBER OF TRIALS = 5000

END OF CYCLE	FAILURE PROBABILITY WITHOUT: FOR PERIOD	CUM. TOTAL	AND WITH IN-SERVICE INSPECTION: FOR PERIOD	CUM. TOTAL
2.0	8.94271D-10	8.94271D-10	8.94271D-10	8.94271D-10
3.0	1.01876D-08	1.10818D-08	1.01876D-08	1.10818D-08
4.0	5.04658D-08	6.15476D-08	5.04658D-08	6.15476D-08
5.0	9.95457D-08	1.61093D-07	9.95457D-08	1.61093D-07
6.0	3.65580D-08	1.97651D-07	7.38916D-09	1.68482D-07
7.0	1.34157D-09	1.98993D-07	8.06409D-10	1.69289D-07

Table C-8 (cont.)

RCS-7 SMALL LEAK PROBABILITY

8.0	2.70362D-09	2.01697D-07	2.26866D-09	1.71558D-07
9.0	2.09142D-10	2.01906D-07	1.21163D-10	1.71679D-07
10.0	4.51808D-07	6.53714D-07	4.44936D-07	6.16614D-07
11.0	2.28950D-07	8.82664D-07	2.25890D-07	8.42504D-07
12.0	1.13720D-08	8.94036D-07	1.11866D-08	8.53691D-07
14.0	5.01018D-08	9.44137D-07	4.95022D-08	9.03193D-07
18.0	3.38555D-08	9.77993D-07	1.21196D-08	9.15312D-07
19.0	1.49986D-09	9.79493D-07	8.09079D-10	9.16122D-07
21.0	5.88162D-09	9.85374D-07	4.88857D-09	9.21010D-07
26.0	3.87838D-07	1.37321D-06	7.42869D-08	9.95297D-07
28.0	2.32675D-08	1.39648D-06	2.60714D-09	9.97904D-07
35.0	3.64726D-07	1.76121D-06	2.94839D-07	1.29274D-06
36.0	8.99882D-08	1.85119D-06	4.59765D-09	1.29734D-06
40.0	0.00000D+00	1.85119D-06	0.00000D+00	1.29734D-06
	DEVIATION ON CUMULATIVE TOTALS =		2.99190D-07	2.50752D-07

Table C-9

RCS-7 FULL BREAK PROBABILITY

WESTINGHOUSE — STRUCTURAL RELIABILITY AND RISK ASSESSMENT (SRRA) PROBABILITY OF FAILURE PROGRAM SPFMPROF — ESBU-NTD

INPUT VARIABLES FOR CASE 54: 316 STAINLESS STEEL PIPE WELD BREAK

NCYCLE =	40	NFAILS =	1000	NTRIAL =	5000
NOVARS =	29	NUMSET =	6	NUMISI =	5
NUMSSC =	7	NUMTRC =	7	NUMFMD =	4

VARIABLE NO.	NAME	DISTRIBUTION TYPE	LOG	MEDIAN VALUE	DEVIATION OR FACTOR	SHIFT MV/SD	USAGE NO.	SUB
1	PIPE-DIA	NORMAL	NO	1.0000D+01	5.0000D-02	.00	1	SET
2	WALL/DIA	NORMAL	NO	9.0000D-02	2.7000D-03	.00	2	SET
3	SRESIDUAL	NORMAL	YES	1.0318D+01	1.4125D+00	1.00	3	SET
4	INT%DEPTH	NORMAL	YES	5.0000D+00	1.4125D+00	1.00	4	SET
5	L/D-RATIO	NORMAL	YES	6.0000D+00	1.4125D+00	1.00	5	SET
6	PROB/VOL	- CONSTANT -		1.0000D-04			6	SET
7	FIRST-ISI	- CONSTANT -		5.0000D+00			1	ISI
8	FREQ-ISI	- CONSTANT -		1.0000D+01			2	ISI
9	EPST-PND	- CONSTANT -		1.0000D-03			3	ISI
10	ASTAR-PND	- CONSTANT -		-4.8000D-01			4	ISI
11	ANUU-PND	- CONSTANT -		1.6000D+00			5	ISI
12	HOURS/CY	NORMAL	YES	7.4473D+03	1.0500D+00	1.00	1	SSC
13	PRESSURE	NORMAL	NO	2.7000D+00	1.5000D-02	.00	2	SSC
14	STRESS-SS	NORMAL	YES	7.7003D+00	1.2589D+00	.00	3	SSC
15	SCC-COEFF	NORMAL	YES	3.2310D-12	2.3714D+00	1.00	4	SSC
16	SCC-EXPNT	- CONSTANT -		2.1610D+00			5	SSC
17	SCC-TIMEI	- CONSTANT -		1.0000D+00			6	SSC
18	ECW-RATE	NORMAL	YES	1.2740D-11	2.3714D+00	.00	7	SSC
19	NOFTRS/HR	- CONSTANT -		6.0000D+01			1	TRC
20	STRESS-FT	NORMAL	YES	4.1068D+00	1.4125D+00	.00	2	TRC
21	NOSTRS/CY	- CONSTANT -		5.0000D+00			3	TRC
22	STRESS-ST	NORMAL	YES	1.2834D+01	1.2589D+00	.00	4	TRC
23	FCG-COEFF	NORMAL	YES	9.1401D-12	2.8508D+00	1.00	5	TRC
24	FCG-EXPNT	- CONSTANT -		4.0000D+00			6	TRC
25	FCG-THOLD	- CONSTANT -		4.6000D+00			7	TRC
26	LIMIT-DSL	- CONSTANT -		0.0000D+00			1	FMD
27	LIMIT-PBS	NORMAL	NO	5.1336D+01	3.2000D+00	-1.00	2	FMD
28	STRESS-DL	NORMAL	YES	1.1807D+01	1.4125D+00	1.00	3	FMD
29	FREQ-DLTR	- CONSTANT -		1.0000D-03			4	FMD

PROBABILITIES OF FAILURE MODE: EXCEED FLOW STRESS LIMIT FOR FULL BREAK

NUMBER FAILED = 40 NUMBER OF TRIALS = 5000

END OF CYCLE	FAILURE PROBABILITY WITHOUT FOR PERIOD	CUM. TOTAL	AND WITH IN-SERVICE INSPECTION FOR PERIOD	CUM. TOTAL
3.0	3.32838D-12	3.32838D-12	3.32838D-12	3.32838D-12
4.0	4.56267D-14	3.37400D-12	4.56267D-14	3.37400D-12
5.0	1.11528D-09	1.11865D-09	1.11528D-09	1.11865D-09
6.0	1.80913D-12	1.12046D-09	8.92447D-14	1.11874D-09
7.0	5.08248D-10	1.62871D-09	1.35968D-10	1.25471D-09
8.0	8.65115D-13	1.62957D-09	2.01630D-13	1.25491D-09

Table C-9 (cont.)

RCS-7 FULL BREAK PROBABILITY

9.0	3.43633D-12	1.63301D-09	2.85746D-12	1.25777D-09
10.0	1.16420D-11	1.64465D-09	9.38850D-12	1.26716D-09
11.0	3.90819D-10	2.03547D-09	3.83862D-10	1.65102D-09
13.0	9.94750D-11	2.13495D-09	9.90966D-11	1.75011D-09
14.0	1.13095D-12	2.13608D-09	1.00875D-12	1.75112D-09
15.0	2.06633D-12	2.13814D-09	2.05977D-12	1.75318D-09
17.0	1.40478D-12	2.13955D-09	6.68420D-14	1.75325D-09
19.0	3.61956D-11	2.17574D-09	8.23173D-12	1.76148D-09
20.0	2.13062D-11	2.19705D-09	8.09302D-12	1.76957D-09
22.0	3.36388D-12	2.20041D-09	1.92871D-12	1.77150D-09
24.0	1.90910D-09	4.10951D-09	1.66636D-09	3.43786D-09
26.0	3.11303D-11	4.14064D-09	1.30261D-12	3.43917D-09
30.0	8.01516D-12	4.14866D-09	1.98107D-12	3.44115D-09
40.0	0.00000D+00	4.14866D-09	0.00000D+00	3.44115D-09
	DEVIATION ON CUMULATIVE TOTALS =		6.53396D-10	5.95488D-10

Table C-10

RCS-15

Piping Structural Reliability Estimates for Millstone Unit No. 3

System: Reactor Coolant System		Segment: RCS-15		Sheet of
P&ID No.: 12179-EM-102D R4		Data Point: 530		
Pipe Stress Calculation Number: X10702		PSI/Const. Method: VT-2, PT/Hydro, PT, RT		
Piping Stress Isometric No.:		Proposed ISI Method: VT-2, RT		

Piping Component/Segment Element (weld, tee, elbow, etc.): Weld to V70

No.	Input Parameter Description	Check Input Choice (for Table 1 Value)			Set Value*
1	Type of Piping Material	304 SS	316 SS	Carbon Steel	---
2	Temperature at Pipe Weld	Low (150)	Medium (350)	High (550)	600
3	Nominal Pipe Size	Small (2)	Medium (5)	Large (16)	1.5
4	Pipe Wall Thickness	Thin (.06)	Normal (.14)	Thick (.22)	.14
5	Normal Operating Pressure	Low (0.5)	Medium (1.3)	High (2.1)	2.5
6	Residual Stress Level	None (0.0)	Moderate (0.1)	Maximum (0.2)	.2
7	Initial Flaw Size	Small (.05)	Medium (.11)	Large (.17)	.05
8	Steady-State Stress Level	Low (.05)	Medium (.11)	High (.17)	.11
9	Stress Corrosion Potential	None (0.0)	Moderate (0.5)	Maximum (1.0)	0
10	Material Wastage Potential	None (0.0)	Moderate (0.5)	Maximum (1.0)	0
11	High Cycle Fatigue Loads	None (0.0)	Moderate (.08)	Maximum (.16)	0
12	Fatigue Transient Loads	Low (.10)	Medium (.22)	High (.34)	.16
13	Fatigue Transient Frequency	Low (5)	Medium (13)	High (21)	5
14	Design-Limiting Stress (Break Only)	Low (.10)	Medium (.26)	High (.42)	.22
15	Optional Crack Inspection Interval	Low (6)	Medium (10)	High (14)	10
16	Optional crack Inspection Accuracy	High (.16)	Medium (.24)	Low (.32)	.16

*For optional numeric input, use a value (and associated units) from the standard range given in Table 1.

Small Leak Probability, No ISI: 0 (1.7E-10)	Optional Leak Probability With ISI: 0 (1.7E-10)
Full Break Probability, No ISI: 1.47E-12	Optional Break Probability With ISI: 1.47E-12

Comments: Area of maximum bending stress. SR el at 535/540 & tee at 550 are on fatigue watch list.

Table C-11

RCS-15 SMALL LEAK PROBABILITY

STRUCTURAL RELIABILITY AND RISK ASSESSMENT (SRRA)

WESTINGHOUSE PROBABILITY OF FAILURE PROGRAM SPFMPROF ESBU.-NTD

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INPUT VARIABLES FOR CASE 67: 316 STAINLESS STEEL PIPE WELD LEAK

NCYCLE =	40	NFAILS =	1000	NTRIAL =	5000
NOVARS =	29	NUMSET =	6	NUMISI =	5
NUMSSC =	7	NUMTRC =	7	NUMFMD =	4

VARIABLE NO.	NAME	DISTRIBUTION TYPE	LOG	MEDIAN VALUE	DEVIATION OR FACTOR	SHIFT MV/SD	USAGE NO.	SUB
1	PIPE-DIA	NORMAL	NO	1.5000D+00	7.5000D-03	.00	1	SET
2	WALL/DIA	NORMAL	NO	1.5000D-01	4.5000D-03	.00	2	SET
3	SRESIDUAL	NORMAL	YES	1.0318D+01	1.4125D+00	1.00	3	SET
4	INT%DEPTH	NORMAL	YES	5.0000D+00	1.4125D+00	1.00	4	SET
5	L/D-RATIO	NORMAL	YES	6.0000D+00	1.4125D+00	1.00	5	SET
6	PROB/VOL	- CONSTANT -		1.0000D-04			6	SET
7	FIRST-ISI	- CONSTANT -		5.0000D+00			1	ISI
8	FREQ-ISI	- CONSTANT -		1.0000D+01			2	ISI
9	EPST-PND	- CONSTANT -		1.0000D-03			3	ISI
10	ASTAR-PND	- CONSTANT -		-3.2000D-01			4	ISI
11	ANUU-PND	- CONSTANT -		1.6000D+00			5	ISI
12	HOURS/CY	NORMAL	YES	7.4473D+03	1.0500D+00	1.00	1	SSC
13	PRESSURE	NORMAL	NO	2.7250D+00	1.5000D-02	.00	2	SSC
14	STRESS-SS	NORMAL	YES	5.6469D+00	1.2589D+00	.00	3	SSC
15	SCC-COEFF	NORMAL	YES	3.2310D-12	2.3714D+00	1.00	4	SSC
16	SCC-EXPNT	- CONSTANT -		2.1610D+00			5	SSC
17	SCC-TIMEI	- CONSTANT -		1.0000D+00			6	SSC
18	ECW-RATE	NORMAL	YES	1.2740D-11	2.3714D+00	.00	7	SSC
19	NOFTRS/HR	- CONSTANT -		6.0000D+01			1	TRC
20	STRESS-FT	NORMAL	YES	5.1336D-02	1.4125D+00	.00	2	TRC
21	NOSTRS/CY	- CONSTANT -		5.0000D+00			3	TRC
22	STRESS-ST	NORMAL	YES	8.7271D+00	1.2589D+00	.00	4	TRC
23	FCG-COEFF	NORMAL	YES	9.1401D-12	2.8508D+00	1.00	5	TRC
24	FCG-EXPNT	- CONSTANT -		4.0000D+00			6	TRC
25	FCG-THOLD	- CONSTANT -		4.6000D+00			7	TRC
26	LIMIT-DSL	NORMAL	NO	-9.7000D-01	1.0000D-02	.00	1	FMD
27	LIMIT-PBS	- CONSTANT -		0.0000D+00			2	FMD
28	STRESS-DL	- CONSTANT -		0.0000D+00			3	FMD
29	FREQ-DLTR	- CONSTANT -		0.0000D+00			4	FMD

PROBABILITIES OF FAILURE MODE: EXCEED LIMITING DEPTH FOR SMALL LEAK

NUMBER FAILED = 0 NUMBER OF TRIALS = 5000

END OF CYCLE	FAILURE PROBABILITY WITHOUT FOR PERIOD	CUM. TOTAL	AND WITH IN-SERVICE INSPECTION FOR PERIOD	CUM. TOTAL
.0	1.66284D-10	1.66284D-10	1.66284D-10	1.66284D-10
40.0	0.00000D+00	1.66284D-10	0.00000D+00	1.66284D-10

Table C-12

RCS-15 FULL BREAK PROBABILITY

```
                    STRUCTURAL RELIABILITY AND RISK ASSESSMENT (SRRA)
WESTINGHOUSE           PROBABILITY OF FAILURE PROGRAM SPFMPROF          ESBU-NTD
=============================================================================
    INPUT VARIABLES FOR CASE 68: 316 STAINLESS STEEL PIPE WELD BREAK

    NCYCLE =     40           NFAILS =  1000            NTRIAL =  5000
    NOVARS =     29           NUMSET =     6            NUMISI =     5
    NUMSSC =      7           NUMTRC =     7            NUMFMD =     4
```

VARIABLE NO.	NAME	DISTRIBUTION TYPE	LOG	MEDIAN VALUE	DEVIATION OR FACTOR	SHIFT MV/SD	USAGE NO.	SUB
1	PIPE-DIA	NORMAL	NO	1.5000D+00	7.5000D-03	.00	1	SET
2	WALL/DIA	NORMAL	NO	1.5000D-01	4.5000D-03	.00	2	SET
3	SRESIDUAL	NORMAL	YES	1.0318D+01	1.4125D+00	1.00	3	SET
4	INT%DEPTH	NORMAL	YES	5.0000D+00	1.4125D+00	1.00	4	SET
5	L/D-RATIO	NORMAL	YES	6.0000D+00	1.4125D+00	1.00	5	SET
6	PROB/VOL	- CONSTANT -		1.0000D-04			6	SET
7	FIRST-ISI	- CONSTANT -		5.0000D+00			1	ISI
8	FREQ-ISI	- CONSTANT -		1.0000D+01			2	ISI
9	EPST-PND	- CONSTANT -		1.0000D-03			3	ISI
10	ASTAR-PND	- CONSTANT -		-3.2000D-01			4	ISI
11	ANUU-PND	- CONSTANT -		1.6000D+00			5	ISI
12	HOURS/CY	NORMAL	YES	7.4473D+03	1.0500D+00	1.00	1	SSC
13	PRESSURE	NORMAL	NO	2.7250D+00	1.5000D-02	.00	2	SSC
14	STRESS-SS	NORMAL	YES	5.6469D+00	1.2589D+00	.00	3	SSC
15	SCC-COEFF	NORMAL	YES	3.2310D-12	2.3714D+00	1.00	4	SSC
16	SCC-EXPNT	- CONSTANT -		2.1610D+00			5	SSC
17	SCC-TIMEI	- CONSTANT -		1.0000D+00			6	SSC
18	ECW-RATE	NORMAL	YES	1.2740D-11	2.3714D+00	.00	7	SSC
19	NOFTRS/HR	- CONSTANT -		6.0000D+01			1	TRC
20	STRESS-FT	NORMAL	YES	5.1336D-02	1.4125D+00	.00	2	TRC
21	NOSTRS/CY	- CONSTANT -		5.0000D+00			3	TRC
22	STRESS-ST	NORMAL	YES	8.7271D+00	1.2589D+00	.00	4	TRC
23	FCG-COEFF	NORMAL	YES	9.1401D-12	2.8508D+00	1.00	5	TRC
24	FCG-EXPNT	- CONSTANT -		4.0000D+00			6	TRC
25	FCG-THOLD	- CONSTANT -		4.6000D+00			7	TRC
26	LIMIT-DSL	- CONSTANT -		0.0000D+00			1	FMD
27	LIMIT-PBS	NORMAL	NO	5.1336D+01	3.2000D+00	-1.00	2	FMD
28	STRESS-DL	NORMAL	YES	1.1294D+01	1.4125D+00	1.00	3	FMD
29	FREQ-DLTR	- CONSTANT -		1.0000D-03			4	FMD

PROBABILITIES OF FAILURE MODE: EXCEED FLOW STRESS LIMIT FOR FULL BREAK

NUMBER FAILED = 1 NUMBER OF TRIALS = 5000

END OF CYCLE	FAILURE PROBABILITY WITHOUT FOR PERIOD	CUM. TOTAL	AND WITH IN-SERVICE INSPECTION FOR PERIOD	CUM. TOTAL
1.0	1.46947D-12	1.46947D-12	1.46947D-12	1.46947D-12
40.0	0.00000D+00	1.46947D-12	0.00000D+00	1.46947D-12
DEVIATION ON CUMULATIVE TOTALS =			1.46947D-12	1.46947D-12

Table C-13 SIL-9					
Piping Structural Reliability Estimates for Millstone Unit No. 3					
System: Low Pressure Safety Injection		Segment: SIL-9			Sheet of
P&ID No.: EM-112B		Data Point: 95			
Pipe Stress Calculation Number: 7001B		PSI/Const. Method: VT-2, UT, PT/Hydro, RT			
Piping Stress Isometric No.:		Proposed ISI Method: VT-2, UT			
Piping Component/Segment Element (weld, tee, elbow, etc.): Valve/pipe weld					
No.	**Input Parameter Description**	**Check Input Choice (for Table 1 Value)**			**Set Value***
1	Type of Piping Material	304 SS	316 SS	Carbon Steel	---
2	Temperature at Pipe Weld	Low (150)	Medium (350)	High (550)	350
3	Nominal Pipe Size	Small (2)	Medium (5)	Large (16)	10
4	Pipe Wall Thickness	Thin (.06)	Normal (.14)	Thick (.22)	.1
5	Normal Operating Pressure	Low (0.5)	Medium (1.3)	High (2.1)	.7
6	Residual Stress Level	None (0.0)	Moderate (0.1)	Maximum (0.2)	.2
7	Initial Flaw Size	Small (.05)	Medium (.11)	Large (.17)	.05
8	Steady-State Stress Level	Low (.05)	Medium (.11)	High (.17)	.11
9	Stress Corrosion Potential	None (0.0)	Moderate (0.5)	Maximum (1.0)	0
10	Material Wastage Potential	None (0.0)	Moderate (0.5)	Maximum (1.0)	0
11	High Cycle Fatigue Loads	None (0.0)	Moderate (.08)	Maximum (.16)	0
12	Fatigue Transient Loads	Low (.10)	Medium (.22)	High (.34)	.1
13	Fatigue Transient Frequency	Low (5)	Medium (13)	High (21)	5
14	Design-Limiting Stress (Break Only)	Low (.10)	Medium (.26)	High (.42)	.09
15	Optional Crack Inspection Interval	Low (6)	Medium (10)	High (14)	10
16	Optional crack Inspection Accuracy	High (.16)	Medium (.24)	Low (.32)	.16
*For optional numeric input, use a value (and associated units) from the standard range given in Table 1.					
Small Leak Probability, No ISI: 0 (2.5E-08)		Optional Leak Probability With ISI: 0 (2.5E-08)			
Full Break Probability, No ISI: 0 (9.2E-12)		Optional Break Probability With ISI: 0 (9.2E-12)			
Comments: Location based on potential check valve leakage causing thermal cycling.					

Table C-14

SIL-9 SMALL LEAK PROBABILITY

WESTINGHOUSE — STRUCTURAL RELIABILITY AND RISK ASSESSMENT (SRRA) PROBABILITY OF FAILURE PROGRAM SPFMPROF — ESBU-NTD

==

INPUT VARIABLES FOR CASE 18: 316 STAINLESS STEEL PIPE WELD LEAK

NCYCLE =	40	NFAILS =	1000	NTRIAL =	5000
NOVARS =	29	NUMSET =	6	NUMISI =	5
NUMSSC =	7	NUMTRC =	7	NUMFMD =	4

VARIABLE NO.	NAME	DISTRIBUTION TYPE	LOG	MEDIAN VALUE	DEVIATION OR FACTOR	SHIFT MV/SD	USAGE NO.	SUB
1	PIPE-DIA	NORMAL	NO	1.0000D+01	5.0000D-02	.00	1	SET
2	WALL/DIA	NORMAL	NO	1.0000D-01	3.0000D-03	.00	2	SET
3	SRESIDUAL	NORMAL	YES	1.2357D+01	1.4125D+00	1.00	3	SET
4	INT%DEPTH	NORMAL	YES	5.0000D+00	1.4125D+00	1.00	4	SET
5	L/D-RATIO	NORMAL	YES	6.0000D+00	1.4125D+00	1.00	5	SET
6	PROB/VOL	- CONSTANT -		1.0000D-04			6	SET
7	FIRST-ISI	- CONSTANT -		5.0000D+00			1	ISI
8	FREQ-ISI	- CONSTANT -		1.0000D+01			2	ISI
9	EPST-PND	- CONSTANT -		1.0000D-03			3	ISI
10	ASTAR-PND	- CONSTANT -		-3.2000D-01			4	ISI
11	ANUU-PND	- CONSTANT -		1.6000D+00			5	ISI
12	HOURS/CY	NORMAL	YES	7.4473D+03	1.0500D+00	1.00	1	SSC
13	PRESSURE	NORMAL	NO	7.0000D-01	1.5000D-02	.00	2	SSC
14	STRESS-SS	NORMAL	YES	6.1783D+00	1.2589D+00	.00	3	SSC
15	SCC-COEFF	NORMAL	YES	3.2310D-12	2.3714D+00	1.00	4	SSC
16	SCC-EXPNT	- CONSTANT -		2.1610D+00			5	SSC
17	SCC-TIMEI	- CONSTANT -		1.0000D+00			6	SSC
18	ECW-RATE	NORMAL	YES	1.2740D-11	2.3714D+00	.00	7	SSC
19	NOFTRS/HR	- CONSTANT -		6.0000D+01			1	TRC
20	STRESS-FT	NORMAL	YES	6.1783D-02	1.4125D+00	.00	2	TRC
21	NOSTRS/CY	- CONSTANT -		5.0000D+00			3	TRC
22	STRESS-ST	NORMAL	YES	6.1783D+00	1.2589D+00	.00	4	TRC
23	FCG-COEFF	NORMAL	YES	9.1401D-12	2.8508D+00	1.00	5	TRC
24	FCG-EXPNT	- CONSTANT -		4.0000D+00			6	TRC
25	FCG-THOLD	- CONSTANT -		4.6000D+00			7	TRC
26	LIMIT-DSL	NORMAL	NO	-9.7000D-01	1.0000D-02	.00	1	FMD
27	LIMIT-PBS	- CONSTANT -		0.0000D+00			2	FMD
28	STRESS-DL	- CONSTANT -		0.0000D+00			3	FMD
29	FREQ-DLTR	- CONSTANT -		0.0000D+00			4	FMD

PROBABILITIES OF FAILURE MODE: EXCEED LIMITING DEPTH FOR SMALL LEAK

NUMBER FAILED = 0 NUMBER OF TRIALS = 5000

END OF CYCLE	FAILURE PROBABILITY WITHOUT FOR PERIOD	CUM. TOTAL	AND WITH IN-SERVICE INSPECTION FOR PERIOD	CUM. TOTAL
.0	2.50257D-08	2.50257D-08	2.50257D-08	2.50257D-08
40.0	0.00000D+00	2.50257D-08	0.00000D+00	2.50257D-08

Table C-15

SIL-9 FULL BREAK PROBABILITY

```
                         STRUCTURAL RELIABILITY AND RISK ASSESSMENT (SRRA)
WESTINGHOUSE               PROBABILITY OF FAILURE PROGRAM SPFMPROF           ESBU-NTD
=================================================================================
     INPUT VARIABLES FOR CASE 17: 316 STAINLESS STEEL PIPE WELD BREAK

     NCYCLE =     40            NFAILS =  1000            NTRIAL =  5000
     NOVARS =     29            NUMSET =     6            NUMISI =     5
     NUMSSC =      7            NUMTRC =     7            NUMFMD =     4
```

VARIABLE NO.	NAME	DISTRIBUTION TYPE	LOG	MEDIAN VALUE	DEVIATION OR FACTOR	SHIFT MV/SD	USAGE NO.	SUB
1	PIPE-DIA	NORMAL	NO	1.0000D+01	5.0000D-02	.00	1	SET
2	WALL/DIA	NORMAL	NO	1.0000D-01	3.0000D-03	.00	2	SET
3	SRESIDUAL	NORMAL	YES	1.2357D+01	1.4125D+00	1.00	3	SET
4	INT%DEPTH	NORMAL	YES	5.0000D+00	1.4125D+00	1.00	4	SET
5	L/D-RATIO	NORMAL	YES	6.0000D+00	1.4125D+00	1.00	5	SET
6	PROB/VOL	- CONSTANT -		1.0000D-04			6	SET
7	FIRST-ISI	- CONSTANT -		5.0000D+00			1	ISI
8	FREQ-ISI	- CONSTANT -		1.0000D+01			2	ISI
9	EPST-PND	- CONSTANT -		1.0000D-03			3	ISI
10	ASTAR-PND	- CONSTANT -		-3.2000D-01			4	ISI
11	ANUU-PND	- CONSTANT -		1.6000D+00			5	ISI
12	HOURS/CY	NORMAL	YES	7.4473D+03	1.0500D+00	1.00	1	SSC
13	PRESSURE	NORMAL	NO	7.0000D-01	1.5000D-02	.00	2	SSC
14	STRESS-SS	NORMAL	YES	6.1783D+00	1.2589D+00	.00	3	SSC
15	SCC-COEFF	NORMAL	YES	3.2310D-12	2.3714D+00	1.00	4	SSC
16	SCC-EXPNT	- CONSTANT -		2.1610D+00			5	SSC
17	SCC-TIMEI	- CONSTANT -		1.0000D+00			6	SSC
18	ECW-RATE	NORMAL	YES	1.2740D-11	2.3714D+00	.00	7	SSC
19	NOFTRS/HR	- CONSTANT -		6.0000D+01			1	TRC
20	STRESS-FT	NORMAL	YES	6.1783D-02	1.4125D+00	.00	2	TRC
21	NOSTRS/CY	- CONSTANT -		5.0000D+00			3	TRC
22	STRESS-ST	NORMAL	YES	6.1783D+00	1.2589D+00	.00	4	TRC
23	FCG-COEFF	NORMAL	YES	9.1401D-12	2.8508D+00	1.00	5	TRC
24	FCG-EXPNT	- CONSTANT -		4.0000D+00			6	TRC
25	FCG-THOLD	- CONSTANT -		4.6000D+00			7	TRC
26	LIMIT-DSL	- CONSTANT -		0.0000D+00			1	FMD
27	LIMIT-PBS	NORMAL	NO	6.1783D+01	3.2000D+00	-1.00	2	FMD
28	STRESS-DL	NORMAL	YES	5.5605D+00	1.4125D+00	1.00	3	FMD
29	FREQ-DLTR	- CONSTANT -		1.0000D-03			4	FMD

PROBABILITIES OF FAILURE MODE: EXCEED FLOW STRESS LIMIT FOR FULL BREAK

NUMBER FAILED = 0 NUMBER OF TRIALS = 5000

END OF CYCLE	FAILURE PROBABILITY WITHOUT FOR PERIOD	CUM. TOTAL	AND WITH IN-SERVICE INSPECTION FOR PERIOD	CUM. TOTAL
.0	9.20644D-12	9.20644D-12	9.20644D-12	9.20644D-12
40.0	0.00000D+00	9.20644D-12	0.00000D+00	9.20644D-12

Table C-16

PIPING SEGMENT ECC-03 FAILURE PROBABILITY WORKSHEET

Surry Unit 1

System: ECC **Segment:** ECCS-001,002,003 **Failure Mode(s):** Thermal Stratification/a **Location:** Welds 1-04; 1-05- 1-05 Drawings 127J1; 127J2; 127J3

No.	Input Parameter Description	Circle Choice or Set Value			Set Value	Basis
1	Type of Piping Material	304SS	316SS	Carbon Steel		Drawing/Spec.
2	Crack inspection Interval (optional)	Low(6)	Medium(10)	High(14)		Section XI
3	Crack inspection Accuracy (optional)	High(.16)	Medium(.24)	Low(.32)		UT
4	Temperature at Pipe Weld	Low(150)	Medium(350)	High(550)	170	Line List
5	Nominal Pipe Size	Small(2)	Medium(5)	Large(16)	6	Drawing
6	Thickness to O.D. Ratio	Thin(.05)	Normal(.13)	Thick(.21)	.085	Calc.
7	Normal Operating Pressure	Low(0.5)	Medium(1.3)	High(2.1)	2.52	Line List
8	Residual Stress Level	None(0.0)	Moderate(10)	Maximum(20)		Thick Wall
9	Initial Flaw Conditions	One Flaw	X-Ray NDE	No X-Ray	.15	Spec.
10	DW & Thermal Stress Level	Low(.05)	Medium(.11)	High(.17)		Calc.
11	Stress Corrosion Potential	None(0.0)	Moderate(0.5)	Maximum(1.0)		Judgment
12	Material Wastage Potential	None(0.0)	Moderate(0.5)	Maximum(1.0)		Judgment
13	Vibratory Stress Range	None(0.0)	Moderate(1.5)	Maximum(3.0)		Judgment
14	Fatigue Stress Range	Low(.30)	Medium(.50)	High(.70)	.6	Stratification
15	Low Cycle Fatigue Frequency	Low(10)	Medium(20)	High(30)		Stratification
16	Design Limiting Stress (LL/Break Only)	Low(.10)	Medium(.26)	High(.42)	.214	Calc.
17	System Disabling Leak (Large Leak Only)	None(0)	Medium(300)	High(600)	2	Assumed Small
18	Min. Detectable Leak (LL/Break Only)	None(0)	Medium(5)	High(10)	1	T.S. Limit

<u>No Leak Detection</u>
Small Leak Prob., No ISI: 8.6721E-4 Small Leak Prob., With ISI: 9.3484E-5
Large Leak Prob., No ISI: 8.2946E-4 Large Leak Prob., With ISI: 2.9107E-5 (N/A if not applicable)
Break Prob., No ISI: N/A Break Prob., With ISI: N/A (N/A if not applicable)

<u>No Leak Detection</u>(Snubber locking up under Thermal Conditions, Item 14 set at N/A .)(Snubber failure probability set at N/A .)(N/A if not applicable)
Small Leak Prob., No ISI: Small Leak Prob., With ISI: (N/A if not applicable)
Large Leak Prob., No ISI: Large Leak Prob., With ISI: (N/A if not applicable)
Break Prob., No ISI: Break Prob., With ISI: (N/A if not applicable)

<u>No Leak Detection</u>(Snubber not locking up under Seismic Conditions, Item 16 set at N/A .)(Snubber failure probability set at N/A .)(N/A if not applicable)
Large Leak Prob., No ISI: Large Leak Prob., With ISI: (N/A if not applicable)
Break Prob., No ISI: Break Prob., With ISI: (N/A if not applicable)

<u>Leak Detection (with Snubber failure if most limiting)</u>
Large Leak Prob., No ISI: 1.7060E-4 Large Leak Prob., With ISI: 3.9150E-5 (N/A if not applicable)
Break Prob., No ISI: N/A Break Prob., With ISI: N/A (N/A if not applicable)

<u>Comments:</u>
Assumed some check valve back leakage.
No snubbers.

Table C-17

PIPING SEGMENT ECC-03 SMALL LEAK FAILURE PROBABILITY

SRRA MODEL OUTPUT

Output Print File S6PROFSL.P74 Opened at 12:39 on 04-06-1997

Type of Piping Steel Material	316 St
Pipe Weld Failure Mode	Small Leak
Years Between Inspections	10.0
Wall Fraction for 50% Detection	0.240
Degrees (F) at Pipe Weld	170.0
Nominal Pipe Size (NPS, inch)	6.0
Thickness / Outside Diameter	0.0850
Operating Pressure (ksi)	2.52
Uniform Residual Stress (ksi)	20.0
Flaw Factor (<0 for 1 Flaw)	1.00
DW & Thermal Stress / Flow Stress	0.15
SCC Rate / Rate for BWR Sens. SS	0.00
Factor on Wastage of .0095 in/yr	0.00
P-P Vib. Stress (ksi for NPS of 1)	0.0
Cyclic Stress Range / Flow Stress	0.600
Fatigue Cycles per Year	30.0
Design-Limit Stress / Flow Stress	0.214
System Disabling Leak Rate (GPM)	2.0
Minimum Detectable Leak Rate (GPM)	0.0
Value of Weld Metal Flow Stress in Ksi	69.30

WESTINGHOUSE STRUCTURAL RELIABILITY AND RISK ASSESSMENT (SRRA) PROBABILITY OF FAILURE PROGRAM LEAKPROF ESBU-NSD

INPUT VARIABLES FOR CASE 74: 316 St Steel Pipe Segment ECCS-1;2;3

NCYCLE =	40	NFAILS =	400	NTRIAL =	40000
NOVARS =	28	NUMSET =	6	NUMISI =	5
NUMSSC =	6	NUMTRC =	6	NUMFMD =	5

VARIABLE NO.	NAME	DISTRIBUTION TYPE	LOG	MEDIAN VALUE	DEVIATION OR FACTOR	SHIFT MV/SD	USAGE NO.	SUB
1	PIPE-ODIA	NORMAL	NO	6.6250D+00	2.4000D-02	.00	1	SET
2	WALL/ODIA	NORMAL	NO	8.5000D-02	2.6350D-03	.00	2	SET
3	SRESIDUAL	NORMAL	YES	2.0000D+01	1.4142D+00	.00	3	SET
4	INT%DEPTH	NORMAL	YES	1.7036D+01	1.3000D+00	2.00	4	SET
5	L/D-RATIO	NORMAL	YES	6.0000D+00	1.7126D+00	1.00	5	SET
6	FLAWS/IN	- CONSTANT -		3.1824D-03			6	SET
7	FIRST-ISI	- CONSTANT -		5.0000D+00			1	ISI
8	FREQ-ISI	- CONSTANT -		1.0000D+01			2	ISI
9	EPST-PND	- CONSTANT -		1.0000D-03			3	ISI
10	ASTAR-PND	- CONSTANT -		-2.4000D-01			4	ISI
11	ANUU-PND	- CONSTANT -		1.6000D+00			5	ISI
12	HOURS/YR	NORMAL	YES	7.4473D+03	1.0500D+00	.00	1	SSC
13	PRESSURE	NORMAL	YES	2.5200D+00	1.0323D+00	.00	2	SSC
14	SIG-DW&TH	NORMAL	YES	1.0396D+01	1.2599D+00	.00	3	SSC
15	SCC-COEFF	NORMAL	YES	3.2310D-12	2.3714D+00	.00	4	SSC
16	SCC-EXPNT	- CONSTANT -		2.1610D+00			5	SSC
17	WASTAGE	NORMAL	YES	1.2740D-12	2.3714D+00	.00	6	SSC
18	DSIG-VIBR	NORMAL	YES	3.6957D-04	1.3465D+00	.00	1	TRC
19	CYCLES/YR	- CONSTANT -		3.0000D+01			2	TRC
20	DSIG-FATG	NORMAL	YES	4.1583D+01	1.4142D+00	.00	3	TRC
21	FCG-COEFF	NORMAL	YES	9.1401D-12	2.8508D+00	1.00	4	TRC
22	FCG-EXPNT	- CONSTANT -		4.0000D+00			5	TRC
23	FCG-THOLD	- CONSTANT -		1.5000D+00			6	TRC
24	LDEPTH-SL	- CONSTANT -		-9.9900D-01			1	FMD
25	SIG-FLOW	NORMAL	NO	6.9305D+01	3.2000D+00	.00	2	FMD

Table C-17 (cont.)

PIPING SEGMENT ECC-03 SMALL LEAK FAILURE PROBABILITY

SRRA MODEL OUTPUT

26	STRESS-DL	- CONSTANT -	0.0000D+00	3	FMD
27	B-SDLEAK	- CONSTANT -	0.0000D+00	4	FMD
28	B-MDLEAK	- CONSTANT -	0.0000D+00	5	FMD

PROBABILITIES OF FAILURE MODE: THROUGH-WALL CRACK DEPTH FOR SMALL LEAK

NUMBER FAILED = 400 NUMBER OF TRIALS = 1434

END OF YEAR	FAILURE PROBABILITY WITHOUT FOR PERIOD	CUM. TOTAL	AND WITH IN-SERVICE INSPECTIONS FOR PERIOD	CUM. TOTAL
1.0	3.33174D-07	3.33174D-07	3.33174D-07	3.33174D-07
2.0	2.03029D-06	2.36346D-06	2.03029D-06	2.36346D-06
3.0	4.10166D-06	6.46512D-06	4.10166D-06	6.46512D-06
4.0	9.73175D-06	1.61969D-05	9.73175D-06	1.61969D-05
5.0	6.27881D-06	2.24757D-05	6.27881D-06	2.24757D-05
6.0	3.95266D-06	2.64283D-05	1.62860D-08	2.24920D-05
7.0	4.15186D-05	6.79470D-05	1.02527D-06	2.35172D-05
8.0	8.23812D-06	7.61851D-05	6.65005D-07	2.41822D-05
9.0	1.76040D-05	9.37891D-05	2.78993D-06	2.69722D-05
10.0	1.28268D-05	1.06616D-04	1.81927D-06	2.87914D-05
11.0	9.21463D-06	1.15831D-04	1.58895D-06	3.03804D-05
12.0	1.78327D-06	1.17614D-04	3.21503D-07	3.07019D-05
13.0	4.69119D-05	1.64526D-04	1.94242D-05	5.01261D-05
14.0	1.09636D-05	1.75489D-04	1.66996D-06	5.17960D-05
15.0	3.15074D-06	1.78640D-04	4.52273D-07	5.22483D-05
16.0	6.41339D-06	1.85053D-04	4.70735D-09	5.22530D-05
17.0	9.60630D-06	1.94660D-04	1.55363D-08	5.22685D-05
18.0	2.02292D-05	2.14889D-04	4.78133D-08	5.23163D-05
19.0	3.19268D-06	2.18082D-04	2.35846D-08	5.23399D-05
20.0	2.82963D-05	2.46378D-04	2.15177D-07	5.25551D-05
21.0	7.09890D-05	3.17367D-04	4.98744D-06	5.75426D-05
22.0	3.46832D-05	3.52050D-04	2.11425D-06	5.96568D-05
23.0	5.00152D-06	3.57052D-04	7.55603D-08	5.97324D-05
24.0	1.91289D-04	5.48341D-04	3.01475D-05	8.98799D-05
25.0	1.17773D-05	5.60118D-04	2.50270D-07	9.01302D-05
26.0	1.03270D-05	5.70445D-04	1.07175D-09	9.01312D-05
27.0	2.66519D-05	5.97097D-04	2.41576D-09	9.01337D-05
28.0	3.00766D-05	6.27174D-04	2.26497D-08	9.01563D-05
29.0	1.16294D-05	6.38803D-04	3.81798D-09	9.01601D-05
30.0	1.07793D-05	6.49582D-04	1.77431D-08	9.01779D-05
31.0	1.25231D-05	6.62106D-04	5.14971D-08	9.02294D-05
32.0	1.35489D-04	7.97595D-04	3.17955D-06	9.34089D-05
33.0	7.24468D-06	8.04839D-04	1.68088D-08	9.34257D-05
34.0	1.45223D-05	8.19362D-04	5.00140D-08	9.34757D-05
35.0	2.91615D-06	8.22278D-04	7.79099D-09	9.34835D-05
36.0	3.79121D-06	8.26069D-04	2.85712D-12	9.34835D-05
37.0	1.21935D-05	8.38263D-04	2.78377D-10	9.34838D-05
38.0	1.63821D-05	8.54645D-04	2.95726D-10	9.34841D-05
39.0	9.24489D-06	8.63890D-04	1.65187D-10	9.34843D-05
40.0	3.32089D-06	8.67211D-04	6.68250D-10	9.34849D-05
DEVIATION ON CUMULATIVE TOTALS =			3.68325D-05	1.40257D-05

Table C-18

PIPING SEGMENT ECC-03 LARGE LEAK FAILURE PROBABILITY

SRRA MODEL OUTPUT

Output Print File S6PROFLL.P75 Opened at 12:41 on 04-06-1997

Type of Piping Steel Material	316 St
Pipe Weld Failure Mode	Large Leak
Years Between Inspections	10.0
Wall Fraction for 50% Detection	0.240
Degrees (F) at Pipe Weld	170.0
Nominal Pipe Size (NPS, inch)	6.0
Thickness / Outside Diameter	0.0850
Operating Pressure (ksi)	2.52
Uniform Residual Stress (ksi)	20.0
Flaw Factor (<0 for 1 Flaw)	1.00
DW & Thermal Stress / Flow Stress	0.15
SCC Rate / Rate for BWR Sens. SS	0.00
Factor on Wastage of .0095 in/yr	0.00
P-P Vib. Stress (ksi for NPS of 1)	0.0
Cyclic Stress Range / Flow Stress	0.600
Fatigue Cycles per Year	30.0
Design-Limit Stress / Flow Stress	0.214
System Disabling Leak Rate (GPM)	2.0
Minimum Detectable Leak Rate (GPM)	0.0
Value of Weld Metal Flow Stress in Ksi	69.30

WESTINGHOUSE STRUCTURAL RELIABILITY AND RISK ASSESSMENT (SRRA) PROBABILITY OF FAILURE PROGRAM LEAKPROF ESBU-NSD

INPUT VARIABLES FOR CASE 75: 316 St Steel Pipe Segment ECCS-1;2;3

NCYCLE = 40 NFAILS = 400 NTRIAL = 50000
NOVARS = 28 NUMSET = 6 NUMISI = 5
NUMSSC = 6 NUMTRC = 6 NUMFMD = 5

VARIABLE NO.	NAME	DISTRIBUTION TYPE	LOG	MEDIAN VALUE	DEVIATION OR FACTOR	SHIFT MV/SD	USAGE NO.	SUB
1	PIPE-ODIA	NORMAL	NO	6.6250D+00	2.4000D-02	.00	1	SET
2	WALL/ODIA	NORMAL	NO	8.5000D-02	2.6350D-03	.00	2	SET
3	SRESIDUAL	NORMAL	YES	2.0000D+01	1.4142D+00	.00	3	SET
4	INT%DEPTH	NORMAL	YES	1.7036D+01	1.3000D+00	2.00	4	SET
5	L/D-RATIO	NORMAL	YES	6.0000D+00	1.7126D+00	2.00	5	SET
6	FLAWS/IN	- CONSTANT -		3.1824D-03			6	SET
7	FIRST-ISI	- CONSTANT -		5.0000D+00			1	ISI
8	FREQ-ISI	- CONSTANT -		1.0000D+01			2	ISI
9	EPST-PND	- CONSTANT -		1.0000D-03			3	ISI
10	ASTAR-PND	- CONSTANT -		-2.4000D-01			4	ISI
11	ANUU-PND	- CONSTANT -		1.6000D+00			5	ISI
12	HOURS/YR	NORMAL	YES	7.4473D+03	1.0500D+00	.00	1	SSC
13	PRESSURE	NORMAL	YES	2.5200D+00	1.0323D+00	.00	2	SSC
14	SIG-DW&TH	NORMAL	YES	1.0396D+01	1.2599D+00	.00	3	SSC
15	SCC-COEFF	NORMAL	YES	3.2310D-12	2.3714D+00	.00	4	SSC
16	SCC-EXPNT	- CONSTANT -		2.1610D+00			5	SSC
17	WASTAGE	NORMAL	YES	1.2740D-12	2.3714D+00	.00	6	SSC
18	DSIG-VIBR	NORMAL	YES	3.6957D-04	1.3465D+00	.00	1	TRC
19	CYCLES/YR	- CONSTANT -		3.0000D+01			2	TRC
20	DSIG-FATG	NORMAL	YES	4.1583D+01	1.4142D+00	.00	3	TRC
21	FCG-COEFF	NORMAL	YES	9.1401D-12	2.8508D+00	1.00	4	TRC
22	FCG-EXPNT	- CONSTANT -		4.0000D+00			5	TRC
23	FCG-THOLD	- CONSTANT -		1.5000D+00			6	TRC
24	LDEPTH-SL	- CONSTANT -		0.0000D+00			1	FMD
25	SIG-FLOW	NORMAL	NO	6.9305D+01	3.2000D+00	.00	2	FMD

Table C-18 (cont.)

PIPING SEGMENT ECC-03 LARGE LEAK FAILURE PROBABILITY

SRRA MODEL OUTPUT

26	STRESS-DL	NORMAL YES	1.4831D+01	1.4142D+00	.00	3	FMD
27	B-SDLEAK	- CONSTANT -	2.2905D+00			4	FMD
28	B-MDLEAK	- CONSTANT -	2.0813D+01			5	FMD

PROBABILITIES OF FAILURE MODE: EXCEED DISABLING LEAK RATE OR BREAK

NUMBER FAILED = 400 NUMBER OF TRIALS = 1080

END OF YEAR	FAILURE PROBABILITY WITHOUT FOR PERIOD	CUM. TOTAL	AND WITH IN-SERVICE INSPECTIONS FOR PERIOD	CUM. TOTAL
1.0	6.85050D-10	6.85050D-10	6.85050D-10	6.85050D-10
2.0	4.82361D-07	4.83046D-07	4.82361D-07	4.83046D-07
3.0	1.11163D-06	1.59468D-06	1.11163D-06	1.59468D-06
4.0	1.35354D-06	2.94822D-06	1.35354D-06	2.94822D-06
5.0	5.35139D-06	8.29961D-06	5.35139D-06	8.29961D-06
6.0	1.01833D-05	1.84829D-05	3.86722D-08	8.33828D-06
7.0	5.49637D-06	2.39793D-05	4.59385D-08	8.38422D-06
8.0	2.44516D-06	2.64244D-05	1.80675D-07	8.56489D-06
9.0	1.51599D-05	4.15843D-05	1.53256D-06	1.00975D-05
10.0	3.02920D-06	4.46135D-05	1.93047D-07	1.02905D-05
11.0	3.71388D-05	8.17523D-05	7.63772D-06	1.79282D-05
12.0	5.32324D-06	8.70756D-05	6.81228D-07	1.86094D-05
13.0	1.59366D-06	8.86692D-05	2.23921D-07	1.88334D-05
14.0	8.74582D-07	8.95438D-05	2.18981D-07	1.90523D-05
15.0	4.75332D-06	9.42971D-05	7.77180D-07	1.98295D-05
16.0	1.87714D-06	9.61743D-05	2.49049D-09	1.98320D-05
17.0	1.82364D-06	9.79979D-05	2.35864D-09	1.98344D-05
18.0	9.00252D-05	1.88023D-04	3.14905D-07	2.01493D-05
19.0	5.02576D-06	1.93049D-04	1.64228D-08	2.01657D-05
20.0	6.48377D-06	1.99533D-04	2.00995D-07	2.03667D-05
21.0	5.90433D-06	2.05437D-04	3.37695D-08	2.04005D-05
22.0	3.76407D-05	2.43078D-04	9.45213D-07	2.13457D-05
23.0	2.79445D-06	2.45872D-04	1.29279D-07	2.14750D-05
24.0	3.21681D-07	2.46194D-04	8.29237D-09	2.14832D-05
25.0	2.80427D-05	2.74237D-04	8.86767D-07	2.23700D-05
26.0	1.20452D-05	2.86282D-04	4.29405D-09	2.23743D-05
27.0	6.67115D-06	2.92953D-04	2.90591D-09	2.23772D-05
28.0	1.68871D-05	3.09840D-04	6.63992D-09	2.23839D-05
29.0	1.87029D-05	3.28543D-04	3.59089D-08	2.24198D-05
30.0	1.05176D-04	4.33719D-04	1.47313D-07	2.25671D-05
31.0	3.32383D-07	4.34051D-04	1.85115D-10	2.25673D-05
32.0	1.92613D-05	4.53312D-04	6.41891D-08	2.26315D-05
33.0	4.28478D-06	4.57597D-04	6.01387D-09	2.26375D-05
34.0	7.43054D-07	4.58340D-04	2.48666D-09	2.26400D-05
35.0	2.69008D-04	7.27348D-04	6.46442D-06	2.91044D-05
36.0	9.34558D-06	7.36694D-04	1.61980D-10	2.91045D-05
37.0	8.55671D-05	8.22261D-04	2.67804D-09	2.91072D-05
38.0	3.05548D-06	8.25316D-04	3.92740D-10	2.91076D-05
39.0	4.14694D-06	8.29463D-04	1.53305D-10	2.91078D-05
40.0	0.00000D+00	8.29463D-04	0.00000D+00	2.91078D-05

DEVIATION ON CUMULATIVE TOTALS = 3.29239D-05 7.72206D-06

Table C-19

PIPING SEGMENT FW-12 FAILURE PROBABILITY WORKSHEET

Surry Unit 1

System: FW Segment: FW-012, 013, 014 Failure Mode(s): Wastage Location: Pipe to FCV 1478, 1488, 1498 Drawing 1018 A3

No.	Input Parameter Description	Circle Choice or Set Value			Set Value	Basis
1	Type of Piping Material	304SS	316SS	Carbon Steel		Drawing/Spec
2	Crack Inspection Interval (optional)	Low(6)	Medium(10)	High(14)		Section XI
3	Crack Inspection Accuracy (optional)	High(.16)	Medium(.24)	Low(.32)		UT
4	Temperature at Pipe Weld	Low(150)	Medium(350)	High(550)		Line List
5	Nominal Pipe Size	Small(2)	Medium(5)	Large(16)	435	Drawing
6	Thickness to O.D. Ratio	Thin(.05)	Normal(.13)	Thick(.21)	14	Calc.
7	~~Normal Operating Pressure~~	~~Low(0.5)~~	~~Medium(1.3)~~	~~High(2.1)~~	.054	Line List
8	Residual Stress Level	None(0.0)	Moderate(10)	Maximum(20)	.9	Stress Relieved
9	Initial Flaw Conditions	One Flaw	X-Ray NDE	No X-Ray		Spec.
10	DW & Thermal Stress Level	Low(.05)	Medium(.11)	High(.17)	.283	Code Allowables
11	Stress Corrosion Potential	None(0.0)	Moderate(0.5)	Maximum(1.0)		Judgment
12	Material Wastage Potential	None(0.0)	Moderate(0.5)	Maximum(1.0)	1.5	Some Wastage
13	Vibratory Stress Range	None(0.0)	Moderate(1.5)	Maximum(3.0)		Judgment
14	Fatigue Stress Range	Low(.30)	Medium(.50)	High(.70)		Judgment
15	Low Cycle Fatigue Frequency	Low(10)	Medium(20)	High(30)		Judgment
16	Design Limiting Stress (LL/Break Only)	Low(.10)	Medium(.26)	High(.42)	.21	Code Allowables
17	System Disabling Leak (Large Leak Only)	None(0)	Medium(300)	High(600)	500	Condensate Makeup
18	Min. Detectable Leak (LL/Break Only)	None(0)	Medium(5)	High(10)	1	Accessible Area

<u>No Leak Detection</u>
Small Leak Prob., No ISI: 3.6003E-1 Small Leak Prob., With ISI: 4.0763E-3
*Large Leak Prob., No ISI: 3.6003E-1 Large Leak Prob., With ISI: 4.0763E-3 (N/A if not applicable)
Break Prob., No ISI: N/A Break Prob., With ISI: N/A (N/A if not applicable)

<u>No Leak Detection</u>(Snubber locking up under Thermal Conditions, Item 14 set at .7 .)(Snubber failure probability set at 10% .)(N/A if not applicable)
Small Leak Prob., No ISI: 3.6068E-2 Small Leak Prob., With ISI: 4.0739E-4 (N/A if not applicable)
Large Leak Prob., No ISI: 3.6068E-2 Large Leak Prob., With ISI: 4.0739E-4 (N/A if not applicable)
Break Prob., No ISI: N/A Break Prob., With ISI: N/A (N/A if not applicable)

<u>No Leak Detection</u>(Snubber not locking up under Seismic Conditions, Item 16 set at .5 .)(Snubber failure probability set at 10% .)(N/A if not applicable)
Large Leak Prob., No ISI: 3.6003E-2 Large Leak Prob., With ISI: 4.0763E-4 (N/A if not applicable)
Break Prob., No ISI: N/A Break Prob., With ISI: N/A (N/A if not applicable)

<u>Leak Detection (with Snubber failure if most limiting)</u>
*Large Leak Prob., No ISI: 3.6003E-1 Large Leak Prob., With ISI: 4.0763E-3 (N/A if not applicable)
Break Prob., No ISI: N/A Break Prob., With ISI: N/A (N/A if not applicable)

<u>Comments:</u>
Code Allowables used.

Table C-20

PIPING SEGMENT FW-12 SMALL LEAK FAILURE PROBABILITY

SRRA MODEL OUTPUT

Output Print File CSPROFSL.P32 Opened at 09:02 on 04-06-1997

Type of Piping Steel Material	Carbon
Pipe Weld Failure Mode	Small Leak
Years Between Inspections	10.0
Wall Fraction for 50% Detection	0.240
Degrees (F) at Pipe Weld	435.0
Nominal Pipe Size (NPS, inch)	14.0
Thickness / Outside Diameter	0.0540
Operating Pressure (ksi)	0.90
Uniform Residual Stress (ksi)	0.0
Flaw Factor (<0 for 1 Flaw)	12.80
DW & Thermal Stress / Flow Stress	0.28
SCC Rate / Rate for BWR Sens. SS	0.00
Factor on Wastage of .0095 in/yr	1.50
P-P Vib. Stress (ksi for NPS of 1)	0.0
Cyclic Stress Range / Flow Stress	0.500
Fatigue Cycles per Year	10.0
Design-Limit Stress / Flow Stress	0.210
System Disabling Leak Rate (GPM)	500.0
Minimum Detectable Leak Rate (GPM)	0.0
Value of Weld Metal Flow Stress in Ksi	64.80

WESTINGHOUSE — STRUCTURAL RELIABILITY AND RISK ASSESSMENT (SRRA) PROBABILITY OF FAILURE PROGRAM LEAKPROF — ESBU-NSD

INPUT VARIABLES FOR CASE 32: Carbon Steel Pipe Segment FW-12;13;14

NCYCLE =	40	NFAILS =	400	NTRIAL =	10000
NOVARS =	28	NUMSET =	6	NUMISI =	5
NUMSSC =	6	NUMTRC =	6	NUMFMD =	5

VARIABLE NO.	NAME	DISTRIBUTION TYPE	LOG	MEDIAN VALUE	DEVIATION OR FACTOR	SHIFT MV/SD	USAGE NO.	SUB
1	PIPE-ODIA	NORMAL	NO	1.4000D+01	3.2000D-02	.00	1	SET
2	WALL/ODIA	NORMAL	NO	5.4000D-02	1.6740D-03	.00	2	SET
3	SRESIDUAL	NORMAL	YES	1.0000D-03	1.4142D+00	.00	3	SET
4	INT%DEPTH	NORMAL	YES	7.9536D+00	1.5516D+00	.00	4	SET
5	L/D-RATIO	NORMAL	YES	6.0000D+00	1.7126D+00	.00	5	SET
6	FLAWS/IN	- CONSTANT -		3.2504D-02			6	SET
7	FIRST-ISI	- CONSTANT -		5.0000D+00			1	ISI
8	FREQ-ISI	- CONSTANT -		1.0000D+01			2	ISI
9	EPST-PND	- CONSTANT -		5.0000D-03			3	ISI
10	ASTAR-PND	- CONSTANT -		-2.4000D-01			4	ISI
11	ANUU-PND	- CONSTANT -		3.0000D+00			5	ISI
12	HOURS/YR	NORMAL	YES	7.4473D+03	1.0500D+00	.00	1	SSC
13	PRESSURE	NORMAL	YES	9.0000D-01	1.0323D+00	.00	2	SSC
14	SIG-DW&TH	NORMAL	YES	1.8337D+01	1.2599D+00	.00	3	SSC
15	SCC-COEFF	NORMAL	YES	3.5900D-14	2.3714D+00	.00	4	SSC
16	SCC-EXPNT	- CONSTANT -		2.1610D+00			5	SSC
17	WASTAGE	NORMAL	YES	1.9110D-06	2.3714D+00	.00	6	SSC
18	DSIG-VIBR	NORMAL	YES	1.6667D-04	1.3465D+00	.00	1	TRC
19	CYCLES/YR	- CONSTANT -		1.0000D+01			2	TRC
20	DSIG-FATG	NORMAL	YES	3.2398D+01	1.4142D+00	.00	3	TRC
21	FCG-COEFF	NORMAL	YES	6.7931D-13	1.7194D+00	.00	4	TRC
22	FCG-EXPNT	- CONSTANT -		5.9500D+00			5	TRC
23	FCG-THOLD	- CONSTANT -		1.9000D+01			6	TRC
24	LDEPTH-SL	- CONSTANT -		-9.9900D-01			1	FMD
25	SIG-FLOW	NORMAL	NO	6.4797D+01	3.2000D+00	.00	2	FMD

Table C-20 (cont.)

PIPING SEGMENT FW-12 SMALL LEAK FAILURE PROBABILITY

SRRA MODEL OUTPUT

26	STRESS-DL	NORMAL	YES	1.3607D+01	1.4142D+00	.00	3	FMD
27	B-SDLEAK	- CONSTANT -		4.3982D+01			4	FMD
28	B-MDLEAK	- CONSTANT -		4.3982D+01			5	FMD

PROBABILITIES OF FAILURE MODE: SMALL OR LARGE LEAK OR BREAK BY WASTAGE

NUMBER FAILED = 400 NUMBER OF TRIALS = 1111

END OF YEAR	FAILURE PROBABILITY WITHOUT FOR PERIOD	CUM. TOTAL	AND WITH IN-SERVICE INSPECTIONS FOR PERIOD	CUM. TOTAL
2.0	9.00090D-04	9.00090D-04	9.00090D-04	9.00090D-04
3.0	9.00090D-04	1.80018D-03	9.00090D-04	1.80018D-03
4.0	9.00090D-04	2.70027D-03	9.00090D-04	2.70027D-03
6.0	2.70027D-03	5.40054D-03	1.35015D-05	2.71377D-03
7.0	4.50045D-03	9.90099D-03	2.25053D-05	2.73628D-03
8.0	3.60036D-03	1.35014D-02	1.80347D-05	2.75431D-03
9.0	6.30063D-03	1.98020D-02	3.20940D-05	2.78641D-03
10.0	5.40054D-03	2.52025D-02	2.95670D-05	2.81597D-03
11.0	7.20072D-03	3.24032D-02	4.80018D-05	2.86397D-03
12.0	6.30063D-03	3.87039D-02	5.77420D-05	2.92172D-03
13.0	4.50045D-03	4.32043D-02	8.24102D-05	3.00413D-03
14.0	3.60036D-03	4.68047D-02	1.11338D-04	3.11546D-03
15.0	1.08011D-02	5.76058D-02	7.06374D-04	3.82184D-03
16.0	1.08011D-02	6.84068D-02	5.97774D-06	3.82782D-03
17.0	9.90099D-03	7.83078D-02	8.39504D-06	3.83621D-03
18.0	1.53015D-02	9.36094D-02	1.86417D-05	3.85485D-03
19.0	6.30063D-03	9.99100D-02	9.40229D-06	3.86425D-03
20.0	6.30063D-03	1.06211D-01	1.25075D-05	3.87676D-03
21.0	1.08011D-02	1.17012D-01	2.56855D-05	3.90245D-03
22.0	1.53015D-02	1.32313D-01	4.27736D-05	3.94522D-03
23.0	1.08011D-02	1.43114D-01	3.39219D-05	3.97914D-03
24.0	1.08011D-02	1.53915D-01	3.48654D-05	4.01401D-03
25.0	1.53015D-02	1.69217D-01	5.80230D-05	4.07203D-03
26.0	1.53015D-02	1.84518D-01	2.93011D-07	4.07232D-03
27.0	1.17012D-02	1.96220D-01	2.59212D-07	4.07258D-03
28.0	1.71017D-02	2.13321D-01	3.85467D-07	4.07297D-03
29.0	8.10081D-03	2.21422D-01	1.98333D-07	4.07317D-03
30.0	1.17012D-02	2.33123D-01	3.10748D-07	4.07348D-03
31.0	9.90099D-03	2.43024D-01	2.85966D-07	4.07376D-03
32.0	1.44014D-02	2.57426D-01	4.77358D-07	4.07424D-03
33.0	1.17012D-02	2.69127D-01	4.43106D-07	4.07469D-03
34.0	1.53015D-02	2.84428D-01	6.72403D-07	4.07536D-03
35.0	1.80018D-02	3.02430D-01	9.64182D-07	4.07632D-03
36.0	1.26013D-02	3.15032D-01	4.13114D-09	4.07633D-03
37.0	7.20072D-03	3.22232D-01	2.97484D-09	4.07633D-03
38.0	1.26013D-02	3.34833D-01	6.19516D-09	4.07633D-03
39.0	1.53015D-02	3.50135D-01	9.67723D-09	4.07634D-03
40.0	9.90099D-03	3.60036D-01	7.49518D-09	4.07635D-03

DEVIATION ON CUMULATIVE TOTALS = 1.44075D-02 1.91244D-03

Table C-21

PIPING SEGMENT FW-12 LARGE LEAK FAILURE PROBABILITY

SRRA MODEL OUTPUT

Output Print File CSPROFLL.P33 Opened at 09:04 on 04-06-1997

Type of Piping Steel Material	Carbon
Pipe Weld Failure Mode	Large Leak
Years Between Inspections	10.0
Wall Fraction for 50% Detection	0.240
Degrees (F) at Pipe Weld	435.0
Nominal Pipe Size (NPS, inch)	14.0
Thickness / Outside Diameter	0.0540
Operating Pressure (ksi)	0.90
Uniform Residual Stress (ksi)	0.0
Flaw Factor (<0 for 1 Flaw)	12.80
DW & Thermal Stress / Flow Stress	0.28
SCC Rate / Rate for BWR Sens. SS	0.00
Factor on Wastage of .0095 in/yr	1.50
P-P Vib. Stress (ksi for NPS of 1)	0.0
Cyclic Stress Range / Flow Stress	0.500
Fatigue Cycles per Year	10.0
Design-Limit Stress / Flow Stress	0.210
System Disabling Leak Rate (GPM)	500.0
Minimum Detectable Leak Rate (GPM)	0.0
Value of Weld Metal Flow Stress in Ksi	64.80

WESTINGHOUSE — STRUCTURAL RELIABILITY AND RISK ASSESSMENT (SRRA) PROBABILITY OF FAILURE PROGRAM LEAKPROF — ESBU-NSD

INPUT VARIABLES FOR CASE 33: Carbon Steel Pipe Segment FW-12;13;14

NCYCLE =	40	NFAILS =	400	NTRIAL =	10000
NOVARS =	28	NUMSET =	6	NUMISI =	5
NUMSSC =	6	NUMTRC =	6	NUMFMD =	5

VARIABLE NO.	VARIABLE NAME	DISTRIBUTION TYPE	DISTRIBUTION LOG	MEDIAN VALUE	DEVIATION OR FACTOR	SHIFT MV/SD	USAGE NO.	USAGE SUB
1	PIPE-ODIA	NORMAL	NO	1.4000D+01	3.2000D-02	.00	1	SET
2	WALL/ODIA	NORMAL	NO	5.4000D-02	1.6740D-03	.00	2	SET
3	SRESIDUAL	NORMAL	YES	1.0000D-03	1.4142D+00	.00	3	SET
4	INT%DEPTH	NORMAL	YES	7.9536D+00	1.5516D+00	.00	4	SET
5	L/D-RATIO	NORMAL	YES	6.0000D+00	1.7126D+00	.00	5	SET
6	FLAWS/IN	- CONSTANT -		3.2504D-02			6	SET
7	FIRST-ISI	- CONSTANT -		5.0000D+00			1	ISI
8	FREQ-ISI	- CONSTANT -		1.0000D+01			2	ISI
9	EPST-PND	- CONSTANT -		5.0000D-03			3	ISI
10	ASTAR-PND	- CONSTANT -		-2.4000D-01			4	ISI
11	ANUU-PND	- CONSTANT -		3.0000D+00			5	ISI
12	HOURS/YR	NORMAL	YES	7.4473D+03	1.0500D+00	.00	1	SSC
13	PRESSURE	NORMAL	YES	9.0000D-01	1.0323D+00	.00	2	SSC
14	SIG-DW&TH	NORMAL	YES	1.8337D+01	1.2599D+00	.00	3	SSC
15	SCC-COEFF	NORMAL	YES	3.5900D-14	2.3714D+00	.00	4	SSC
16	SCC-EXPNT	- CONSTANT -		2.1610D+00			5	SSC
17	WASTAGE	NORMAL	YES	1.9110D-06	2.3714D+00	.00	6	SSC
18	DSIG-VIBR	NORMAL	YES	1.6667D-04	1.3465D+00	.00	1	TRC
19	CYCLES/YR	- CONSTANT -		1.0000D+01			2	TRC
20	DSIG-FATG	NORMAL	YES	3.2398D+01	1.4142D+00	.00	3	TRC
21	FCG-COEFF	NORMAL	YES	6.7931D-13	1.7194D+00	.00	4	TRC
22	FCG-EXPNT	- CONSTANT -		5.9500D+00			5	TRC
23	FCG-THOLD	- CONSTANT -		1.9000D+01			6	TRC
24	LDEPTH-SL	- CONSTANT -		-9.9900D-01			1	FMD
25	SIG-FLOW	NORMAL	NO	6.4797D+01	3.2000D+00	.00	2	FMD

Table C-21 (cont.)

PIPING SEGMENT FW-12 LARGE LEAK FAILURE PROBABILITY

SRRA MODEL OUTPUT

26	STRESS-DL	NORMAL	YES	1.3607D+01	1.4142D+00	.00	3 FMD
27	B-SDLEAK	- CONSTANT -		1.5640D+01			4 FMD
28	B-MDLEAK	- CONSTANT -		4.3982D+01			5 FMD

PROBABILITIES OF FAILURE MODE: SMALL OR LARGE LEAK OR BREAK BY WASTAGE

NUMBER FAILED = 400 NUMBER OF TRIALS = 1111

END OF YEAR	FAILURE PROBABILITY WITHOUT FOR PERIOD	CUM. TOTAL	AND WITH IN-SERVICE INSPECTIONS FOR PERIOD	CUM. TOTAL
2.0	9.00090D-04	9.00090D-04	9.00090D-04	9.00090D-04
3.0	9.00090D-04	1.80018D-03	9.00090D-04	1.80018D-03
4.0	9.00090D-04	2.70027D-03	9.00090D-04	2.70027D-03
6.0	2.70027D-03	5.40054D-03	1.35015D-05	2.71377D-03
7.0	4.50045D-03	9.90099D-03	2.25053D-05	2.73628D-03
8.0	3.60036D-03	1.35014D-02	1.80347D-05	2.75431D-03
9.0	6.30063D-03	1.98020D-02	3.20940D-05	2.78641D-03
10.0	5.40054D-03	2.52025D-02	2.95670D-05	2.81597D-03
11.0	7.20072D-03	3.24032D-02	4.80018D-05	2.86397D-03
12.0	6.30063D-03	3.87039D-02	5.77420D-05	2.92172D-03
13.0	4.50045D-03	4.32043D-02	8.24102D-05	3.00413D-03
14.0	3.60036D-03	4.68047D-02	1.11338D-04	3.11546D-03
15.0	1.08011D-02	5.76058D-02	7.06374D-04	3.82184D-03
16.0	1.08011D-02	6.84068D-02	5.97774D-06	3.82782D-03
17.0	9.90099D-03	7.83078D-02	8.39504D-06	3.83621D-03
18.0	1.53015D-02	9.36094D-02	1.86417D-05	3.85485D-03
19.0	6.30063D-03	9.99100D-02	9.40229D-06	3.86425D-03
20.0	6.30063D-03	1.06211D-01	1.25075D-05	3.87676D-03
21.0	1.08011D-02	1.17012D-01	2.56855D-05	3.90245D-03
22.0	1.53015D-02	1.32313D-01	4.27736D-05	3.94522D-03
23.0	1.08011D-02	1.43114D-01	3.39219D-05	3.97914D-03
24.0	1.08011D-02	1.53915D-01	3.48654D-05	4.01401D-03
25.0	1.53015D-02	1.69217D-01	5.80230D-05	4.07203D-03
26.0	1.53015D-02	1.84518D-01	2.93011D-07	4.07232D-03
27.0	1.17012D-02	1.96220D-01	2.59212D-07	4.07258D-03
28.0	1.71017D-02	2.13321D-01	3.85467D-07	4.07297D-03
29.0	8.10081D-03	2.21422D-01	1.98333D-07	4.07317D-03
30.0	1.17012D-02	2.33123D-01	3.10748D-07	4.07348D-03
31.0	9.90099D-03	2.43024D-01	2.85966D-07	4.07376D-03
32.0	1.44014D-02	2.57426D-01	4.77358D-07	4.07424D-03
33.0	1.17012D-02	2.69127D-01	4.43106D-07	4.07469D-03
34.0	1.53015D-02	2.84428D-01	6.72403D-07	4.07536D-03
35.0	1.80018D-02	3.02430D-01	9.64182D-07	4.07632D-03
36.0	1.26013D-02	3.15032D-01	4.13114D-09	4.07633D-03
37.0	7.20072D-03	3.22232D-01	2.97484D-09	4.07633D-03
38.0	1.26013D-02	3.34833D-01	6.19516D-09	4.07633D-03
39.0	1.53015D-02	3.50135D-01	9.67723D-09	4.07634D-03
40.0	9.90099D-03	3.60036D-01	7.49518D-09	4.07635D-03

DEVIATION ON CUMULATIVE TOTALS = 1.44075D-02 1.91244D-03

Table C-22

PIPING SEGMENT HHI-4C FAILURE PROBABILITY WORKSHEET

Surry Unit 1

System: HHI Segment: HHI-4C, 5C, 6C Failure Mode(s): Snubber Lock-up under Thermal Conditions Location: 4C - 1-04; 5C - 2-AM-A; 6C - 2-AV-A Drawings wmks: 1105B5; 1105B9

No.	Input Parameter Description	Circle Choice or Set Value			Set Value	Basis
1	Type of Piping Material	304SS	316SS	Carbon Steel		Drawing/Spec.
2	Crack Inspection Interval (optional)	Low(6)	Medium(10)	High(14)		Section XI
3	Crack Inspection Accuracy (optional)	High(.16)	Medium(.24)	Low(.32)		UT
4	Temperature at Pipe Weld	Low(150)	Medium(350)	High(550)	170	Line List
5	Nominal Pipe Size	Small(2)	Medium(5)	Large(16)	3	Drawing
6	Thickness to O.D. Ratio	Thin(.05)	Normal(.13)	Thick(.21)	.125	Calc.
7	Normal Operating Pressure	Low(0.5)	Medium(1.3)	High(2.1)	2.52	Line List
8	Residual Stress Level	None(0.0)	Moderate(10)	Maximum(20)		Judgment
9	Initial Flaw Conditions	One Flaw	X-Ray NDE	No X-Ray		Spec.
10	DW & Thermal Stress Level	Low(.05)	Medium(.11)	High(.17)	.132	Calc.
11	Stress Corrosion Potential	None(0.0)	Moderate(0.5)	Maximum(1.0)		Judgment
12	Material Wastage Potential	None(0.0)	Moderate(0.5)	Maximum(1.0)		Judgment
13	Vibratory Stress Range	None(0.0)	Moderate(1.5)	Maximum(3.0)		Judgment
14	Fatigue Stress Range	Low(.30)	Medium(.50)	High(.70)		Judgment
15	Low Cycle Fatigue Frequency	Low(10)	Medium(20)	High(30)		Judgment
16	Design Limiting Stress (LL/Break Only)	Low(.10)	Medium(.26)	High(.42)	.156	Calc.
17	System Disabling Leak (Large Leak Only)	None(0)	Medium(300)	High(600)	2	RWST Margin Small
18	Min. Detectable Leak (LL/Break Only)	None(0)	Medium(5)	High(10)	1	Accessible

No Leak Detection
Small Leak Prob., No ISI: 3.8711E-6 Small Leak Prob., With ISI: 1.4437E-7
Large Leak Prob., No ISI: 3.3010E-6 Large Leak Prob., With ISI: 7.1812E-8 (N/A if not applicable)
Break Prob., No ISI: N/A Break Prob., With ISI: N/A (N/A if not applicable)

No Leak Detection(Snubber locking up under Thermal Conditions, Item 14 set at .7 .)(Snubber failure probability set at 10% .)(N/A if not applicable)
Small Leak Prob., No ISI: 3.8839E-5 Small Leak Prob., With ISI: 2.7580E-6 (N/A if not applicable)
Large Leak Prob., No ISI: 2.6592E-5 Large Leak Prob., With ISI: 9.1390E-7 (N/A if not applicable)
Break Prob., No ISI: N/A Break Prob., With ISI: N/A (N/A if not applicable)

No Leak Detection(Snubber not locking up under Seismic Conditions, Item 16 set at .5 .)(Snubber failure probability set at 10% .)(N/A if not applicable)
*Large Leak Prob., No ISI: 1.5955E-5 Large Leak Prob., With ISI: 1.5501E-5 (N/A if not applicable)
Break Prob., No ISI: N/A Break Prob., With ISI: N/A (N/A if not applicable)

Leak Detection (withSnubber failure if most limiting)
*Large Leak Prob., No ISI: 1.0049E-5 Large Leak Prob., With ISI: 2.1156E-6 (N/A if not applicable) - Used Thermal Condition - set 14 to 0.7;
Break Prob., No ISI: N/A Break Prob., With ISI: N/A (N/A if not applicable) Apply 10%snubber failure probability

Comments:

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Table C-23

PIPING SEGMENT HHI-4C SMALL LEAK FAILURE PROBABILITY

SRRA MODEL OUTPUT

Output Print File S4PROFSL.P33 Opened at 14:01 on 03-30-1997

Type of Piping Steel Material	304 St
Pipe Weld Failure Mode	Small Leak
Years Between Inspections	10.0
Wall Fraction for 50% Detection	0.240
Degrees (F) at Pipe Weld	170.0
Nominal Pipe Size (NPS, inch)	3.0
Thickness / Outside Diameter	0.1250
Operating Pressure (ksi)	2.52
Uniform Residual Stress (ksi)	10.0
Flaw Factor (<0 for 1 Flaw)	1.00
DW & Thermal Stress / Flow Stress	0.13
SCC Rate / Rate for BWR Sens. SS	0.00
Factor on Wastage of .0095 in/yr	0.00
P-P Vib. Stress (ksi for NPS of 1)	0.8
Cyclic Stress Range / Flow Stress	0.300
Fatigue Cycles per Year	10.0
Design-Limit Stress / Flow Stress	0.156
System Disabling Leak Rate (GPM)	2.0
Minimum Detectable Leak Rate (GPM)	0.0
Value of Weld Metal Flow Stress in Ksi	69.30

WESTINGHOUSE — STRUCTURAL RELIABILITY AND RISK ASSESSMENT (SRRA) PROBABILITY OF FAILURE PROGRAM LEAKPROF — ESBU-NSD

INPUT VARIABLES FOR CASE 33: 304 St Steel Pipe Segment HHI-4C;5C;6C

NCYCLE =	40	NFAILS =	400	NTRIAL =	40000
NOVARS =	28	NUMSET =	6	NUMISI =	5
NUMSSC =	6	NUMTRC =	6	NUMFMD =	5

VARIABLE NO.	NAME	DISTRIBUTION TYPE	LOG	MEDIAN VALUE	DEVIATION OR FACTOR	SHIFT MV/SD	USAGE NO.	SUB
1	PIPE-ODIA	NORMAL	NO	3.5000D+00	1.6000D-02	.00	1	SET
2	WALL/ODIA	NORMAL	NO	1.2500D-01	3.8750D-03	.00	2	SET
3	SRESIDUAL	NORMAL	YES	1.0000D+01	1.4142D+00	.00	3	SET
4	INT%DEPTH	NORMAL	YES	2.2310D+01	1.2544D+00	2.00	4	SET
5	L/D-RATIO	NORMAL	YES	6.0000D+00	1.7126D+00	1.00	5	SET
6	FLAWS/IN	- CONSTANT -		3.7371D-03			6	SET
7	FIRST-ISI	- CONSTANT -		5.0000D+00			1	ISI
8	FREQ-ISI	- CONSTANT -		1.0000D+01			2	ISI
9	EPST-PND	- CONSTANT -		1.0000D-03			3	ISI
10	ASTAR-PND	- CONSTANT -		-2.4000D-01			4	ISI
11	ANUU-PND	- CONSTANT -		1.6000D+00			5	ISI
12	HOURS/YR	NORMAL	YES	7.4473D+03	1.0500D+00	.00	1	SSC
13	PRESSURE	NORMAL	YES	2.5200D+00	1.0323D+00	.00	2	SSC
14	SIG-DW&TH	NORMAL	YES	9.1482D+00	1.2599D+00	.00	3	SSC
15	SCC-COEFF	NORMAL	YES	3.5900D-11	2.3714D+00	.00	4	SSC
16	SCC-EXPNT	- CONSTANT -		2.1610D+00			5	SSC
17	WASTAGE	NORMAL	YES	1.2740D-12	2.3714D+00	.00	6	SSC
18	DSIG-VIBR	NORMAL	YES	5.0366D-01	1.3465D+00	.00	1	TRC
19	CYCLES/YR	- CONSTANT -		1.0000D+01			2	TRC
20	DSIG-FATG	NORMAL	YES	2.0791D+01	1.4142D+00	.00	3	TRC
21	FCG-COEFF	NORMAL	YES	9.1401D-12	2.8508D+00	1.00	4	TRC
22	FCG-EXPNT	- CONSTANT -		4.0000D+00			5	TRC
23	FCG-THOLD	- CONSTANT -		1.5000D+00			6	TRC
24	LDEPTH-SL	- CONSTANT -		-9.9900D-01			1	FMD
25	SIG-FLOW	NORMAL	NO	6.9305D+01	3.2000D+00	.00	2	FMD

Table C-23 (cont.)

PIPING SEGMENT HHI-4C SMALL LEAK FAILURE PROBABILITY

SRRA MODEL OUTPUT

26	STRESS-DL	- CONSTANT -	0.0000D+00	3	FMD
27	B-SDLEAK	- CONSTANT -	0.0000D+00	4	FMD
28	B-MDLEAK	- CONSTANT -	0.0000D+00	5	FMD

PROBABILITIES OF FAILURE MODE: THROUGH-WALL CRACK DEPTH FOR SMALL LEAK

NUMBER FAILED = 400 NUMBER OF TRIALS = 20149

END OF YEAR	FAILURE PROBABILITY WITHOUT FOR PERIOD	CUM. TOTAL	AND WITH IN-SERVICE FOR PERIOD	INSPECTIONS CUM. TOTAL
1.0	7.79489D-09	7.79489D-09	7.79489D-09	7.79489D-09
2.0	9.46470D-09	1.72596D-08	9.46470D-09	1.72596D-08
3.0	3.13208D-11	1.72909D-08	3.13208D-11	1.72909D-08
4.0	3.78483D-10	1.76694D-08	3.78483D-10	1.76694D-08
5.0	8.63668D-08	1.04036D-07	8.63668D-08	1.04036D-07
6.0	1.46871D-08	1.18723D-07	5.86592D-11	1.04095D-07
7.0	2.80665D-08	1.46790D-07	5.87488D-10	1.04682D-07
8.0	1.58935D-09	1.48379D-07	1.00813D-11	1.04692D-07
9.0	1.57488D-08	1.64128D-07	2.59319D-10	1.04952D-07
10.0	8.30398D-09	1.72432D-07	1.31959D-10	1.05084D-07
11.0	6.77961D-08	2.40228D-07	3.15093D-09	1.08235D-07
12.0	2.99759D-09	2.43226D-07	1.38613D-10	1.08373D-07
13.0	6.69150D-08	3.10141D-07	1.84343D-08	1.26807D-07
14.0	5.88476D-09	3.16025D-07	2.34647D-10	1.27042D-07
15.0	9.38809D-08	4.09906D-07	1.24159D-08	1.39458D-07
16.0	5.27049D-08	4.62611D-07	1.27105D-11	1.39471D-07
17.0	4.44965D-08	5.07108D-07	4.34416D-11	1.39514D-07
18.0	4.55557D-08	5.52663D-07	8.66326D-12	1.39523D-07
19.0	4.81838D-08	6.00847D-07	7.22501D-11	1.39595D-07
20.0	9.55378D-08	6.96385D-07	1.03817D-09	1.40633D-07
21.0	3.44537D-09	6.99830D-07	2.80123D-12	1.40636D-07
22.0	1.60112D-07	8.59943D-07	7.51578D-10	1.41388D-07
23.0	1.15915D-07	9.75858D-07	5.23298D-10	1.41911D-07
24.0	1.40958D-07	1.11682D-06	2.09795D-09	1.44009D-07
25.0	6.55326D-08	1.18235D-06	1.81833D-10	1.44191D-07
26.0	1.74409D-07	1.35676D-06	5.09877D-12	1.44196D-07
27.0	3.60366D-07	1.71712D-06	1.85859D-11	1.44214D-07
28.0	2.89741D-07	2.00686D-06	6.00553D-11	1.44274D-07
29.0	3.11527D-08	2.03802D-06	3.80827D-13	1.44275D-07
30.0	1.73714D-07	2.21173D-06	1.32070D-11	1.44288D-07
31.0	2.68902D-08	2.23862D-06	1.75926D-12	1.44290D-07
32.0	5.69752D-08	2.29560D-06	1.90512D-12	1.44292D-07
33.0	1.45119D-07	2.44072D-06	6.53594D-11	1.44357D-07
34.0	3.58230D-08	2.47654D-06	2.42113D-12	1.44360D-07
35.0	2.00928D-07	2.67747D-06	1.64363D-11	1.44376D-07
36.0	4.85664D-07	3.16313D-06	1.47700D-12	1.44377D-07
37.0	6.99600D-08	3.23309D-06	1.34318D-14	1.44377D-07
38.0	1.76823D-07	3.40991D-06	7.48626D-14	1.44378D-07
39.0	2.99860D-07	3.70977D-06	8.16170D-13	1.44378D-07
40.0	1.61404D-07	3.87118D-06	5.55890D-13	1.44379D-07
DEVIATION ON CUMULATIVE TOTALS =			1.91633D-07	3.73674D-08

Table C-24

PIPING SEGMENT HHI-4C LARGE LEAK FAILURE PROBABILITY
SRRA MODEL OUTPUT

Output Print File S4PROFLL.P34 Opened at 14:03 on 03-30-1997

Type of Piping Steel Material	304 St
Pipe Weld Failure Mode	Large Leak
Years Between Inspections	10.0
Wall Fraction for 50% Detection	0.240
Degrees (F) at Pipe Weld	170.0
Nominal Pipe Size (NPS, inch)	3.0
Thickness / Outside Diameter	0.1250
Operating Pressure (ksi)	2.52
Uniform Residual Stress (ksi)	10.0
Flaw Factor (<0 for 1 Flaw)	1.00
DW & Thermal Stress / Flow Stress	0.13
SCC Rate / Rate for BWR Sens. SS	0.00
Factor on Wastage of .0095 in/yr	0.00
P-P Vib. Stress (ksi for NPS of 1)	0.8
Cyclic Stress Range / Flow Stress	0.300
Fatigue Cycles per Year	10.0
Design-Limit Stress / Flow Stress	0.156
System Disabling Leak Rate (GPM)	2.0
Minimum Detectable Leak Rate (GPM)	0.0
Value of Weld Metal Flow Stress in Ksi	69.30

WESTINGHOUSE — STRUCTURAL RELIABILITY AND RISK ASSESSMENT (SRRA) PROBABILITY OF FAILURE PROGRAM LEAKPROF — ESBU-NSD

INPUT VARIABLES FOR CASE 34: 304 St Steel Pipe Segment HHI-4C;5C;6C

NCYCLE =	40	NFAILS =	400	NTRIAL =	50000
NOVARS =	28	NUMSET =	6	NUMISI =	5
NUMSSC =	6	NUMTRC =	6	NUMFMD =	5

VARIABLE NO.	NAME	DISTRIBUTION TYPE	LOG	MEDIAN VALUE	DEVIATION OR FACTOR	SHIFT MV/SD	USAGE NO.	SUB
1	PIPE-ODIA	NORMAL	NO	3.5000D+00	1.6000D-02	.00	1	SET
2	WALL/ODIA	NORMAL	NO	1.2500D-01	3.8750D-03	.00	2	SET
3	SRESIDUAL	NORMAL	YES	1.0000D+01	1.4142D+00	.00	3	SET
4	INT%DEPTH	NORMAL	YES	2.2310D+01	1.2544D+00	2.00	4	SET
5	L/D-RATIO	NORMAL	YES	6.0000D+00	1.7126D+00	2.00	5	SET
6	FLAWS/IN	- CONSTANT -		3.7371D-03			6	SET
7	FIRST-ISI	- CONSTANT -		5.0000D+00			1	ISI
8	FREQ-ISI	- CONSTANT -		1.0000D+01			2	ISI
9	EPST-PND	- CONSTANT -		1.0000D-03			3	ISI
10	ASTAR-PND	- CONSTANT -		-2.4000D-01			4	ISI
11	ANUU-PND	- CONSTANT -		1.6000D+00			5	ISI
12	HOURS/YR	NORMAL	YES	7.4473D+03	1.0500D+00	.00	1	SSC
13	PRESSURE	NORMAL	YES	2.5200D+00	1.0323D+00	.00	2	SSC
14	SIG-DW&TH	NORMAL	YES	9.1482D+00	1.2599D+00	.00	3	SSC
15	SCC-COEFF	NORMAL	YES	3.5900D-11	2.3714D+00	.00	4	SSC
16	SCC-EXPNT	- CONSTANT -		2.1610D+00			5	SSC
17	WASTAGE	NORMAL	YES	1.2740D-12	2.3714D+00	.00	6	SSC
18	DSIG-VIBR	NORMAL	YES	5.0366D-01	1.3465D+00	.00	1	TRC
19	CYCLES/YR	- CONSTANT -		1.0000D+01			2	TRC
20	DSIG-FATG	NORMAL	YES	2.0791D+01	1.4142D+00	.00	3	TRC
21	FCG-COEFF	NORMAL	YES	9.1401D-12	2.8508D+00	1.00	4	TRC
22	FCG-EXPNT	- CONSTANT -		4.0000D+00			5	TRC
23	FCG-THOLD	- CONSTANT -		1.5000D+00			6	TRC
24	LDEPTH-SL	- CONSTANT -		0.0000D+00			1	FMD
25	SIG-FLOW	NORMAL	NO	6.9305D+01	3.2000D+00	.00	2	FMD

Table C-24 (cont.)
PIPING SEGMENT HHI-4C LARGE LEAK FAILURE PROBABILITY
SRRA MODEL OUTPUT

26	STRESS-DL	NORMAL	YES	1.0812D+01	1.4142D+00	.00	3	FMD
27	B-SDLEAK	- CONSTANT -		2.1472D+00			4	FMD
28	B-MDLEAK	- CONSTANT -		1.0996D+01			5	FMD

PROBABILITIES OF FAILURE MODE: EXCEED DISABLING LEAK RATE OR BREAK

NUMBER FAILED = 400 NUMBER OF TRIALS = 12856

END OF YEAR	FAILURE PROBABILITY WITHOUT FOR PERIOD	CUM. TOTAL	AND WITH IN-SERVICE INSPECTIONS FOR PERIOD	CUM. TOTAL
1.0	5.82716D-09	5.82716D-09	5.82716D-09	5.82716D-09
2.0	5.40650D-10	6.36781D-09	5.40650D-10	6.36781D-09
3.0	2.17075D-08	2.80753D-08	2.17075D-08	2.80753D-08
4.0	3.41189D-09	3.14872D-08	3.41189D-09	3.14872D-08
5.0	1.95021D-08	5.09893D-08	1.95021D-08	5.09893D-08
6.0	2.98215D-09	5.39714D-08	1.35074D-11	5.10028D-08
7.0	2.20484D-09	5.61763D-08	1.24969D-11	5.10153D-08
8.0	7.77410D-09	6.39504D-08	8.08788D-11	5.10962D-08
9.0	7.49491D-08	1.38900D-07	3.32346D-09	5.44196D-08
10.0	1.26132D-07	2.65032D-07	3.42091D-09	5.78405D-08
11.0	1.07364D-07	3.72396D-07	9.25053D-09	6.70911D-08
12..0	1.28547D-09	3.73682D-07	7.19833D-11	6.71630D-08
13.0	2.41892D-09	3.76100D-07	2.20141D-10	6.73832D-08
14.0	2.09598D-08	3.97060D-07	2.37549D-09	6.97587D-08
15.0	4.78265D-09	4.01843D-07	3.73470D-10	7.01321D-08
16.0	1.32994D-08	4.15142D-07	2.71688D-12	7.01349D-08
17.0	2.91318D-09	4.18055D-07	1.50510D-12	7.01364D-08
18.0	1.10658D-09	4.19162D-07	4.37912D-12	7.01407D-08
19.0	6.24337D-09	4.25405D-07	2.28004D-11	7.01635D-08
20.0	1.33228D-08	4.38728D-07	3.92645D-11	7.02028D-08
21.0	3.01319D-08	4.68860D-07	6.22060D-11	7.02650D-08
22.0	3.93092D-09	4.72791D-07	3.83968D-12	7.02689D-08
23.0	5.30892D-08	5.25880D-07	7.86797D-10	7.10557D-08
24.0	2.06607D-08	5.46541D-07	3.00792D-10	7.13564D-08
25.0	7.11882D-09	5.53660D-07	1.46774D-10	7.15032D-08
26.0	2.98475D-08	5.83507D-07	2.80055D-13	7.15035D-08
27.0	4.16055D-07	9.99563D-07	9.93567D-13	7.15045D-08
28.0	1.13945D-08	1.01096D-06	1.66484D-13	7.15047D-08
29.0	2.81386D-07	1.29234D-06	3.63781D-11	7.15410D-08
30.0	2.93171D-07	1.58551D-06	1.60880D-10	7.17019D-08
31.0	3.64955D-08	1.62201D-06	2.05368D-12	7.17040D-08
32.0	4.43675D-07	2.06569D-06	6.27477D-11	7.17667D-08
33.0	1.80622D-08	2.08375D-06	3.15045D-12	7.17699D-08
34.0	1.90696D-08	2.10282D-06	3.09455D-13	7.17702D-08
35.0	2.98955D-08	2.13271D-06	3.51307D-11	7.18053D-08
36.0	1.52949D-07	2.28566D-06	1.46158D-12	7.18068D-08
37.0	2.87227D-08	2.31438D-06	5.27857D-14	7.18068D-08
38.0	3.60078D-08	2.35039D-06	6.09466D-14	7.18069D-08
39.0	1.41005D-07	2.49140D-06	1.74272D-13	7.18071D-08
40.0	8.09670D-07	3.30107D-06	5.18944D-12	7.18122D-08
DEVIATION ON CUMULATIVE TOTALS =			1.62472D-07	2.43370D-08

Table C-25

PIPING SEGMENT LHI-04 FAILURE PROBABILITY WORKSHEET

Surry Unit 1

System: LHI **Segment:** LHI,003,004,005,006 **Failure Mode(s):** Fatigue **Location:** Welds: 3) 1-13; 4) 1-15; 5) 1-12; 6) 1-16 Drawings wmks 1106A7

No.	Input Parameter Description	Circle Choice or Set Value			Set Value	Basis
1	Type of Piping Material	304SS	316SS	Carbon Steel		Drawing/Spec
2	Crack Inspection Interval (optional)	Low(6)	Medium(10)	High(14)		Section XI
3	Crack Inspection Accuracy (optional)	High(.16)	Medium(.24)	Low(.32)		UT
4	Temperature at Pipe Weld	Low(150)	Medium(350)	High(550)	170	Line List
5	Nominal Pipe Size	Small(2)	Medium(5)	Large(16)	12	Drawing
6	Thickness to O.D. Ratio	Thin(.05)	Normal(.13)	Thick(.21)	.0294	Calc.
7	Normal Operating Pressure	Low(0.5)	Medium(1.3)	High(2.1)	.10	Line List
8	Residual Stress Level	None(0.0)	Moderate(10)	Maximum(20)		Judgment
9	Initial Flaw Conditions	One Flaw	X-Ray NDE	No X-Ray		Spec.
10	DW & Thermal Stress Level	Low(.05)	Medium(.11)	High(.17)	.1	Code Allowable
11	Stress Corrosion Potential	None(0.0)	Moderate(0.5)	Maximum(1.0)		Judgment
12	Material Wastage Potential	None(0.0)	Moderate(0.5)	Maximum(1.0)		Judgment
13	Vibratory Stress Range	None(0.0)	Moderate(1.5)	Maximum(3.0)		Judgment
14	Fatigue Stress Range	Low(.30)	Medium(.50)	High(.70)		Judgment
15	Low Cycle Fatigue Frequency	Low(10)	Medium(20)	High(30)		Judgment
16	Design Limiting Stress (LL/Break Only)	Low(.10)	Medium(.26)	High(.42)	.111	Code Allowable
17	System Disabling Leak (Large Leak Only)	None(0)	Medium(300)	High(600)	2	Assumed Small
18	Min. Detectable Leak (LL/Break Only)	None(0)	Medium(5)	High(10)	None	Not used in testing

No Leak Detection

Small Leak Prob., No ISI: 2.0050E-5 Small Leak Prob., With ISI: 7.4804E-7

Large Leak Prob., No ISI: 1.5218E-5 Large Leak Prob., With ISI: 1.1679E-7 (N/A if not applicable)

Break Prob., No ISI: N/A Break Prob., With ISI: N/A (N/A if not applicable)

No Leak Detection(Snubber locking up under Thermal Conditions, Item 14 set at N/A .)(Snubber failure probability set at N/A .)(N/A if not applicable)

Small Leak Prob., No ISI: Small Leak Prob., With ISI: (N/A if not applicable)

Large Leak Prob., No ISI: Large Leak Prob., With ISI: (N/A if not applicable)

Break Prob., No ISI: Break Prob., With ISI: (N/A if not applicable)

No Leak Detection(Snubber not locking up under Seismic Conditions, Item 16 set at N/A .)(Snubber failure probability set at N/A .)(N/A if not applicable)

Large Leak Prob., No ISI: Large Leak Prob., With ISI: (N/A if not applicable)

Break Prob., No ISI: Break Prob., With ISI: (N/A if not applicable)

Leak Detection (with Snubber failure if most limiting)

Large Leak Prob., No ISI: N/A Large Leak Prob., With ISI: N/A (N/A if not applicable)

Break Prob., No ISI: N/A Break Prob., With ISI: N/A (N/A if not applicable)

Comments:

Code Allowables used.

Table C-26

PIPING SEGMENT LHI-04 SMALL LEAK FAILURE PROBABILITY SRRA MODEL OUTPUT

Output Print File S4PROFSL.P52 Opened at 11:19 on 04-07-1997

Type of Piping Steel Material	304 St
Pipe Weld Failure Mode	Small Leak
Years Between Inspections	10.0
Wall Fraction for 50% Detection	0.240
Degrees (F) at Pipe Weld	170.0
Nominal Pipe Size (NPS, inch)	12.0
Thickness / Outside Diameter	0.0294
Operating Pressure (ksi)	0.10
Uniform Residual Stress (ksi)	10.0
Flaw Factor (<0 for 1 Flaw)	1.00
DW & Thermal Stress / Flow Stress	0.10
SCC Rate / Rate for BWR Sens. SS	0.00
Factor on Wastage of .0095 in/yr	0.00
P-P Vib. Stress (ksi for NPS of 1)	0.0
Cyclic Stress Range / Flow Stress	0.300
Fatigue Cycles per Year	10.0
Design-Limit Stress / Flow Stress	0.111
System Disabling Leak Rate (GPM)	2.0
Minimum Detectable Leak Rate (GPM)	0.0
Value of Weld Metal Flow Stress in Ksi	69.30

WESTINGHOUSE — STRUCTURAL RELIABILITY AND RISK ASSESSMENT (SRRA) PROBABILITY OF FAILURE PROGRAM LEAKPROF — ESBU-NSD

INPUT VARIABLES FOR CASE **: 304 St Steel Pipe Segment LHI-3;4;5;6

NCYCLE =	40	NFAILS =	400	NTRIAL =	40000
NOVARS =	28	NUMSET =	6	NUMISI =	5
NUMSSC =	6	NUMTRC =	6	NUMFMD =	5

VARIABLE NO.	VARIABLE NAME	DISTRIBUTION TYPE	LOG	MEDIAN VALUE	DEVIATION OR FACTOR	SHIFT MV/SD	USAGE NO.	USAGE SUB
1	PIPE-ODIA	NORMAL	NO	1.2750D+01	3.2000D-02	.00	1	SET
2	WALL/ODIA	NORMAL	NO	2.9400D-02	9.1140D-04	.00	2	SET
3	SRESIDUAL	NORMAL	YES	1.0000D+01	1.4142D+00	.00	3	SET
4	INT%DEPTH	NORMAL	YES	2.6249D+01	1.2312D+00	2.00	4	SET
5	L/D-RATIO	NORMAL	YES	6.0000D+00	1.7126D+00	1.00	5	SET
6	FLAWS/IN	- CONSTANT -		4.0489D-03			6	SET
7	FIRST-ISI	- CONSTANT -		5.0000D+00			1	ISI
8	FREQ-ISI	- CONSTANT -		1.0000D+01			2	ISI
9	EPST-PND	- CONSTANT -		1.0000D-03			3	ISI
10	ASTAR-PND	- CONSTANT -		-2.4000D-01			4	ISI
11	ANUU-PND	- CONSTANT -		1.6000D+00			5	ISI
12	HOURS/YR	NORMAL	YES	7.4473D+03	1.0500D+00	.00	1	SSC
13	PRESSURE	NORMAL	YES	1.0000D-01	1.0323D+00	.00	2	SSC
14	SIG-DW&TH	NORMAL	YES	6.9305D+00	1.2599D+00	.00	3	SSC
15	SCC-COEFF	NORMAL	YES	3.5900D-11	2.3714D+00	.00	4	SSC
16	SCC-EXPNT	- CONSTANT -		2.1610D+00			5	SSC
17	WASTAGE	NORMAL	YES	1.2740D-12	2.3714D+00	.00	6	SSC
18	DSIG-VIBR	NORMAL	YES	1.6667D-04	1.3465D+00	.00	1	TRC
19	CYCLES/YR	- CONSTANT -		1.0000D+01			2	TRC
20	DSIG-FATG	NORMAL	YES	2.0791D+01	1.4142D+00	.00	3	TRC
21	FCG-COEFF	NORMAL	YES	9.1401D-12	2.8508D+00	1.00	4	TRC
22	FCG-EXPNT	- CONSTANT -		4.0000D+00			5	TRC
23	FCG-THOLD	- CONSTANT -		1.5000D+00			6	TRC
24	LDEPTH-SL	- CONSTANT -		-9.9900D-01			1	FMD
25	SIG-FLOW	NORMAL	NO	6.9305D+01	3.2000D+00	.00	2	FMD

Table C-26 (cont.)
PIPING SEGMENT LHI-04 SMALL LEAK FAILURE PROBABILITY
SRRA MODEL OUTPUT

26	STRESS-DL	- CONSTANT -	0.0000D+00	3	FMD
27	B-SDLEAK	- CONSTANT -	0.0000D+00	4	FMD
28	B-MDLEAK	- CONSTANT -	0.0000D+00	5	FMD

PROBABILITIES OF FAILURE MODE: THROUGH-WALL CRACK DEPTH FOR SMALL LEAK

NUMBER FAILED = 400 NUMBER OF TRIALS = 18634

END OF YEAR	FAILURE PROBABILITY WITHOUT FOR PERIOD	CUM. TOTAL	AND WITH IN-SERVICE FOR PERIOD	INSPECTIONS CUM. TOTAL
2.0	1.45468D-08	1.45468D-08	1.45468D-08	1.45468D-08
3.0	9.60939D-10	1.55077D-08	9.60939D-10	1.55077D-08
4.0	4.68097D-07	4.83605D-07	4.68097D-07	4.83605D-07
5.0	6.12827D-08	5.44888D-07	6.12827D-08	5.44888D-07
6.0	1.75877D-07	7.20765D-07	5.03385D-10	5.45391D-07
7.0	7.07888D-08	7.91554D-07	4.56368D-10	5.45847D-07
8.0	4.36571D-08	8.35211D-07	3.16315D-10	5.46164D-07
9.0	2.33301D-07	1.06851D-06	4.79062D-09	5.50954D-07
10.0	8.30516D-08	1.15156D-06	1.09621D-09	5.52051D-07
11.0	3.45188D-07	1.49675D-06	5.25852D-08	6.04636D-07
12.0	5.11694D-07	2.00845D-06	3.36194D-08	6.38255D-07
13.0	3.83721D-07	2.39217D-06	2.68504D-08	6.65106D-07
14.0	9.73126D-08	2.48948D-06	9.45615D-09	6.74562D-07
15.0	4.81176D-07	2.97066D-06	1.89192D-08	6.93481D-07
16.0	8.98940D-08	3.06055D-06	1.27178D-11	6.93494D-07
17.0	1.11501D-06	4.17556D-06	7.35594D-10	6.94229D-07
18.0	2.40247D-07	4.41581D-06	1.85449D-10	6.94415D-07
19.0	6.92592D-07	5.10840D-06	1.65287D-09	6.96068D-07
20.0	3.95971D-07	5.50437D-06	1.91372D-10	6.96259D-07
21.0	9.86178D-07	6.49055D-06	2.13247D-09	6.98392D-07
22.0	7.60547D-07	7.25109D-06	8.78818D-10	6.99270D-07
23.0	1.16786D-06	8.41896D-06	1.10003D-08	7.10271D-07
24.0	1.63321D-06	1.00522D-05	3.72827D-08	7.47553D-07
25.0	3.65624D-07	1.04178D-05	2.49567D-10	7.47803D-07
26.0	3.27005D-07	1.07448D-05	3.15683D-12	7.47806D-07
27.0	2.34827D-07	1.09796D-05	9.48577D-13	7.47807D-07
28.0	5.83098D-07	1.15627D-05	1.72205D-12	7.47809D-07
29.0	3.45369D-07	1.19081D-05	5.09393D-11	7.47860D-07
30.0	2.40198D-07	1.21483D-05	3.55000D-12	7.47863D-07
31.0	5.02699D-07	1.26510D-05	9.06996D-12	7.47872D-07
32.0	3.38754D-07	1.29897D-05	3.10176D-11	7.47903D-07
33.0	5.71615D-07	1.35614D-05	5.57266D-11	7.47959D-07
34.0	3.02256D-07	1.38636D-05	6.36701D-11	7.48023D-07
35.0	2.10327D-07	1.40739D-05	3.20227D-12	7.48026D-07
36.0	2.81382D-06	1.68878D-05	1.75648D-11	7.48043D-07
37.0	1.12904D-06	1.80168D-05	1.30517D-12	7.48045D-07
38.0	2.42155D-07	1.82589D-05	2.08426D-14	7.48045D-07
39.0	7.07655D-07	1.89666D-05	3.42589D-12	7.48048D-07
40.0	1.08366D-06	2.00503D-05	5.46998D-13	7.48049D-07

DEVIATION ON CUMULATIVE TOTALS = 9.91721D-07 1.93568D-07

Table C-27
PIPING SEGMENT LHI-04 LARGE LEAK FAILURE PROBABILITY
SRRA MODEL OUTPUT

Output Print File S4PROFLL.P53 Opened at 11:22 on 04-07-1997

Type of Piping Steel Material	304 St
Pipe Weld Failure Mode	Large Leak
Years Between Inspections	10.0
Wall Fraction for 50% Detection	0.240
Degrees (F) at Pipe Weld	170.0
Nominal Pipe Size (NPS, inch)	12.0
Thickness / Outside Diameter	0.0294
Operating Pressure (ksi)	0.10
Uniform Residual Stress (ksi)	10.0
Flaw Factor (<0 for 1 Flaw)	1.00
DW & Thermal Stress / Flow Stress	0.10
SCC Rate / Rate for BWR Sens. SS	0.00
Factor on Wastage of .0095 in/yr	0.00
P-P Vib. Stress (ksi for NPS of 1)	0.0
Cyclic Stress Range / Flow Stress	0.300
Fatigue Cycles per Year	10.0
Design-Limit Stress / Flow Stress	0.111
System Disabling Leak Rate (GPM)	2.0
Minimum Detectable Leak Rate (GPM)	0.0
Value of Weld Metal Flow Stress in Ksi	69.30

STRUCTURAL RELIABILITY AND RISK ASSESSMENT (SRRA)
WESTINGHOUSE PROBABILITY OF FAILURE PROGRAM LEAKPROF ESBU-NSD

INPUT VARIABLES FOR CASE **: 304 St Steel Pipe Segment LHI-3;4;5;6

NCYCLE =	40	NFAILS =	400	NTRIAL =	50000
NOVARS =	28	NUMSET =	6	NUMISI =	5
NUMSSC =	6	NUMTRC =	6	NUMFMD =	5

VARIABLE NO.	NAME	DISTRIBUTION TYPE	LOG	MEDIAN VALUE	DEVIATION OR FACTOR	SHIFT MV/SD	USAGE NO.	SUB
1	PIPE-ODIA	NORMAL	NO	1.2750D+01	3.2000D-02	.00	1	SET
2	WALL/ODIA	NORMAL	NO	2.9400D-02	9.1140D-04	.00	2	SET
3	SRESIDUAL	NORMAL	YES	1.0000D+01	1.4142D+00	.00	3	SET
4	INT%DEPTH	NORMAL	YES	2.6249D+01	1.2312D+00	2.00	4	SET
5	L/D-RATIO	NORMAL	YES	6.0000D+00	1.7126D+00	2.00	5	SET
6	FLAWS/IN	- CONSTANT -		4.0489D-03			6	SET
7	FIRST-ISI	- CONSTANT -		5.0000D+00			1	ISI
8	FREQ-ISI	- CONSTANT -		1.0000D+01			2	ISI
9	EPST-PND	- CONSTANT -		1.0000D-03			3	ISI
10	ASTAR-PND	- CONSTANT -		-2.4000D-01			4	ISI
11	ANUU-PND	- CONSTANT -		1.6000D+00			5	ISI
12	HOURS/YR	NORMAL	YES	7.4473D+03	1.0500D+00	.00	1	SSC
13	PRESSURE	NORMAL	YES	1.0000D-01	1.0323D+00	.00	2	SSC
14	SIG-DW&TH	NORMAL	YES	6.9305D+00	1.2599D+00	.00	3	SSC
15	SCC-COEFF	NORMAL	YES	3.5900D-11	2.3714D+00	.00	4	SSC
16	SCC-EXPNT	- CONSTANT -		2.1610D+00			5	SSC
17	WASTAGE	NORMAL	YES	1.2740D-12	2.3714D+00	.00	6	SSC
18	DSIG-VIBR	NORMAL	YES	1.6667D-04	1.3465D+00	.00	1	TRC
19	CYCLES/YR	- CONSTANT -		1.0000D+01			2	TRC
20	DSIG-FATG	NORMAL	YES	2.0791D+01	1.4142D+00	.00	3	TRC
21	FCG-COEFF	NORMAL	YES	9.1401D-12	2.8508D+00	1.00	4	TRC
22	FCG-EXPNT	- CONSTANT -		4.0000D+00			5	TRC
23	FCG-THOLD	- CONSTANT -		1.5000D+00			6	TRC
24	LDEPTH-SL	- CONSTANT -		0.0000D+00			1	FMD
25	SIG-FLOW	NORMAL	NO	6.9305D+01	3.2000D+00	.00	2	FMD

Table C-27 (cont.)
PIPING SEGMENT LHI-04 LARGE LEAK FAILURE PROBABILITY
SRRA MODEL OUTPUT

26	STRESS-DL	NORMAL	YES	7.6928D+00	1.4142D+00	.00	3	FMD
27	B-SDLEAK	- CONSTANT -		1.0546D+01			4	FMD
28	B-MDLEAK	- CONSTANT -		4.0055D+01			5	FMD

PROBABILITIES OF FAILURE MODE: EXCEED DISABLING LEAK RATE OR BREAK

NUMBER FAILED = 400 NUMBER OF TRIALS = 30280

END OF YEAR	FAILURE PROBABILITY WITHOUT FOR PERIOD	CUM. TOTAL	AND WITH IN-SERVICE INSPECTIONS FOR PERIOD	CUM. TOTAL
1.0	2.76955D-13	2.76955D-13	2.76955D-13	2.76955D-13
2.0	1.84989D-11	1.87758D-11	1.84989D-11	1.87758D-11
3.0	1.83449D-09	1.85326D-09	1.83449D-09	1.85326D-09
4.0	8.59677D-08	8.78210D-08	8.59677D-08	8.78210D-08
5.0	4.19350D-09	9.20145D-08	4.19350D-09	9.20145D-08
6.0	1.17526D-08	1.03767D-07	1.90456D-11	9.20335D-08
7.0	4.54052D-08	1.49172D-07	7.36206D-11	9.21071D-08
8.0	6.93727D-10	1.49866D-07	3.52033D-12	9.21107D-08
9.0	1.20927D-08	1.61959D-07	2.60716D-11	9.21367D-08
10.0	1.80472D-07	3.42431D-07	1.96590D-09	9.41026D-08
11.0	1.03478D-07	4.45909D-07	4.53304D-09	9.86357D-08
12.0	2.54853D-07	7.00761D-07	1.10643D-08	1.09700D-07
13.0	9.21467D-08	7.92908D-07	8.22837D-10	1.10523D-07
14.0	2.49914D-08	8.17900D-07	3.96435D-10	1.10919D-07
15.0	1.29152D-07	9.47051D-07	3.49984D-09	1.14419D-07
16.0	2.28668D-07	1.17572D-06	4.84983D-12	1.14424D-07
17.0	2.56427D-08	1.20136D-06	2.58860D-12	1.14427D-07
18.0	3.83321D-08	1.23969D-06	3.01561D-12	1.14430D-07
19.0	2.17753D-06	3.41722D-06	8.06941D-10	1.15237D-07
20.0	9.52658D-09	3.42675D-06	1.09011D-12	1.15238D-07
21.0	1.20682D-07	3.54743D-06	2.09011D-11	1.15259D-07
22.0	7.15812D-08	3.61901D-06	2.18645D-11	1.15280D-07
23.0	8.98377D-08	3.70885D-06	1.04829D-10	1.15385D-07
24.0	5.94033D-09	3.71479D-06	1.30089D-12	1.15387D-07
25.0	1.53423D-06	5.24902D-06	1.37853D-09	1.16765D-07
26.0	9.41368D-08	5.34316D-06	1.24883D-13	1.16765D-07
27.0	9.55581D-08	5.43872D-06	4.07495D-13	1.16766D-07
28.0	1.20868D-08	5.45080D-06	2.80659D-14	1.16766D-07
29.0	5.42698D-08	5.50507D-06	1.44749D-13	1.16766D-07
30.0	1.80875D-07	5.68595D-06	6.39415D-13	1.16766D-07
31.0	8.68635D-07	6.55458D-06	3.43403D-13	1.16767D-07
32.0	2.64816D-08	6.58106D-06	3.88684D-12	1.16771D-07
33.0	8.24575D-10	6.58189D-06	4.93642D-14	1.16771D-07
34.0	7.73052D-06	1.43124D-05	8.74417D-13	1.16772D-07
35.0	3.27432D-08	1.43452D-05	2.14956D-11	1.16793D-07
36.0	6.20221D-08	1.44072D-05	3.11588D-15	1.16793D-07
37.0	2.13319D-08	1.44285D-05	1.72015D-15	1.16793D-07
38.0	9.22975D-08	1.45208D-05	6.88458D-14	1.16793D-07
39.0	2.96237D-07	1.48170D-05	2.90554D-15	1.16793D-07
40.0	4.01302D-07	1.52183D-05	4.76037D-15	1.16793D-07

DEVIATION ON CUMULATIVE TOTALS = 7.55887D-07 6.66573D-08

Table C-28

PIPING SEGMENT RC-16 FAILURE PROBABILITY WORKSHEET

Surry Unit 1

System: RC Segment: RC-016, 017 Failure Mode(s): Striping; Some Stratification; Thermal Fatigue Location: ID Root of Welds I-08, 2-08; Drawings 122HI, 122KI

No.	Input Parameter Description	Circle Choice or Set Value			Set Value	Basis
1	Type of Piping Material	304SS	316SS	Carbon Steel		Drawing/Spec.
2	Crack Inspection Interval (optional)	Low(6)	Medium(10)	High(14)		Section XI
3	Crack Inspection Accuracy (optional)	High(.16)	Medium(.24)	Low(.32)		UT
4	Temperature at Pipe Weld	Low(150)	Medium(350)	High(550)	606	Line List
5	Nominal Pipe Size	Small(2)	Medium(5)	Large(16)	6	Drawing
6	Thickness to O.D. Ratio	Thin(.05)	Normal(.13)	Thick(.21)	.085	Calc.
7	Normal Operating Pressure	Low(0.5)	Medium(1.3)	High(2.1)	2.52	Line List
8	Residual Stress Level	None(0.0)	Moderate(10)	Maximum(20)		Judgment
9	Initial Flaw Conditions	One Flaw	X-Ray NDE	No X-Ray		Striping
10	DW & Thermal Stress Level	Low(.05)	Medium(.11)	High(.17)	.186	Calc.
11	Stress Corrosion Potential	None(0.0)	Moderate(0.5)	Maximum(1.0)		Judgment
12	Material Wastage Potential	None(0.0)	Moderate(0.5)	Maximum(1.0)		Judgment, material
13	Vibratory Stress Range	None(0.0)	Moderate(1.5)	Maximum(3.0)		Judgment, not near pump
14	Fatigue Stress Range	Low(.30)	Medium(.50)	High(.70)	.6	Strat. (Some)
15	Low Cycle Fatigue Frequency	Low(10)	Medium(20)	High(30)		Small Changes Annually
16	Design Limiting Stress (LL/Break Only)	Low(.10)	Medium(.26)	High(.42)	.132	Calc.
17	System Disabling Leak (Large Leak Only)	None(0)	Medium(300)	High(600)	5001	Large LOCA
18	Min. Detectable Leak (LL/Break Only)	None(0)	Medium(5)	High(10)	1	T.S. Limit

No Leak Detection

*Small Leak Prob., No ISI: 5.3143E-4 Small Leak Prob., With ISI: 1.6947E-5
*Large Leak Prob., No ISI: 3.089E-4 Large Leak Prob., With ISI: 5.5208E-6 (N/A if not applicable)
Break Prob., No ISI: N/A Break Prob., With ISI: N/A (N/A if not applicable)

No Leak Detection(Snubber locking up under Thermal Conditions, Item 14 set at N/A .)(Snubber failure probability set at N/A .)(N/A if not applicable)
Small Leak Prob., No ISI: Small Leak Prob., With ISI: (N/A if not applicable)
Large Leak Prob., No ISI: Large Leak Prob., With ISI: (N/A if not applicable)
Break Prob., No ISI: Break Prob., With ISI: (N/A if not applicable)

No Leak Detection(Snubber not locking up under Seismic Conditions, Item 16 set at N/A .)(Snubber failure probability set at N/A .)(N/A if not applicable)
Large Leak Prob., No ISI: Large Leak Prob., With ISI: (N/A if not applicable)
Break Prob., No ISI: Break Prob., With ISI: (N/A if not applicable)

Leak Detection (with Snubber failure if most limiting)
*Large Leak Prob., No ISI: 2.2022E-5 Large Leak Prob., With ISI: 2.3951E-7 (N/A if not applicable)
Break Prob., No ISI: N/A Break Prob., With ISI: N/A (N/A if not applicable)

Comments:

* Use Values

Table C-29
PIPING SEGMENT RC-16 SMALL LEAK FAILURE PROBABILITY SRRA MODEL OUTPUT

Output Print File S6PROFSL.P01 Opened at 12:46 on 01-16-1997

Type of Piping Steel Material	316 St
Pipe Weld Failure Mode	Small Leak
Years Between Inspections	10.0
Wall Fraction for 50% Detection	0.240
Degrees (F) at Pipe Weld	606.0
Nominal Pipe Size (NPS, inch)	6.0
Thickness / Outside Diameter	0.0850
Operating Pressure (ksi)	2.52
Uniform Residual Stress (ksi)	10.0
Flaw Factor (<0 for 1 Flaw)	-10.80
DW & Thermal Stress / Flow Stress	0.19
SCC Rate / Rate for BWR Sens. SS	0.00
Factor on Wastage of 0.095 in/yr	0.00
P-P Vib. Stress (ksi for NPS of 1)	0.0
Cyclic Stress Range / Flow Stress	0.600
Fatigue Cycles per Year	10.0
Design-Limit Stress / Flow Stress	0.132
System Disabling Leak Rate (GPM)	5001.0
Minimum Detectable Leak Rate (GPM)	0.0
Value of Weld Metal Flow Stress in Ksi	51.08

STRUCTURAL RELIABILITY AND RISK ASSESSMENT (SRRA)
WESTINGHOUSE PROBABILITY OF FAILURE PROGRAM LEAKPROF ESBU-SMPI

==

INPUT VARIABLES FOR CASE 1: 316 St Steel Pipe Segment RC016017

NCYCLE =	40	NFAILS =	400	NTRIAL =	40000
NOVARS =	28	NUMSET =	6	NUMISI =	5
NUMSSC =	6	NUMTRC =	6	NUMFMD =	5

VARIABLE NO.	NAME	DISTRIBUTION TYPE	LOG	MEDIAN VALUE	DEVIATION OR FACTOR	SHIFT MV/SD	USAGE NO.	SUB
1	PIPE-ODIA	NORMAL	NO	6.6250D+00	2.4000D-02	.00	1	SET
2	WALL/ODIA	NORMAL	NO	8.5000D-02	2.6350D-03	.00	2	SET
3	SRESIDUAL	NORMAL	NO	1.0000D+00	1.4600D+01	.00	3	SET
4	INT%DEPTH	NORMAL	YES	1.7036D+01	1.3000D+00	2.00	4	SET
5	L/D-RATIO	NORMAL	YES	6.0000D+00	1.7126D+00	1.00	5	SET
6	FLAWS/IN	- CONSTANT -		-3.4370D-02			6	SET
7	FIRST-ISI	- CONSTANT -		5.0000D+00			1	ISI
8	FREQ-ISI	- CONSTANT -		1.0000D+01			2	ISI
9	EPST-PND	- CONSTANT -		1.0000D-03			3	ISI
10	ASTAR-PND	- CONSTANT -		-2.4000D-01			4	ISI
11	ANUU-PND	- CONSTANT -		1.6000D+00			5	ISI
12	HOURS/YR	NORMAL	YES	7.4473D+03	1.0500D+00	.00	1	SSC
13	PRESSURE	NORMAL	YES	2.5200D+00	1.0323D+00	.00	2	SSC
14	SIG-DW&TH	NORMAL	YES	9.5018D+00	1.2599D+00	.00	3	SSC
15	SCC-COEFF	NORMAL	YES	3.2310D-12	2.3714D+00	.00	4	SSC
16	SCC-EXPNT	- CONSTANT -		2.1610D+00			5	SSC
17	WASTAGE	NORMAL	YES	1.2740D-12	2.3714D+00	.00	6	SSC
18	DSIG-VIBR	NORMAL	YES	3.6957D-04	1.3465D+00	.00	1	TRC
19	CYCLES/YR	- CONSTANT -		1.0000D+01			2	TRC
20	DSIG-FATG	NORMAL	YES	3.0651D+01	1.4142D+00	.00	3	TRC
21	FCG-COEFF	NORMAL	YES	9.1401D-12	2.8508D+00	1.00	4	TRC
22	FCG-EXPNT	- CONSTANT -		4.0000D+00			5	TRC
23	FCG-THOLD	- CONSTANT -		1.5000D+00			6	TRC
24	LDEPTH-SL	- CONSTANT -		-9.9900D-01			1	FMD
25	SIG-FLOW	NORMAL	NO	5.1085D+01	3.2000D+00	.00	2	FMD

Table C-29 (cont.)
PIPING SEGMENT RC-16 SMALL LEAK FAILURE PROBABILITY
SRRA MODEL OUTPUT

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26  STRESS-DL   - CONSTANT -    0.0000D+00                3  FMD
27  B-SDLEAK    - CONSTANT -    0.0000D+00                4  FMD
28  B-MDLEAK    - CONSTANT -    0.0000D+00                5  FMD
```

PROBABILITIES OF FAILURE MODE: THROUGH-WALL CRACK DEPTH FOR SMALL LEAK

NUMBER FAILED = 400 NUMBER OF TRIALS = 10023

END OF YEAR	FAILURE PROBABILITY WITHOUT FOR PERIOD	CUM. TOTAL	AND WITH IN-SERVICE INSPECTIONS FOR PERIOD	CUM. TOTAL
1.0	7.06487D-08	7.06487D-08	7.06487D-08	7.06487D-08
2.0	1.13614D-07	1.84263D-07	1.13614D-07	1.84263D-07
3.0	2.61393D-06	2.79819D-06	2.61393D-06	2.79819D-06
4.0	3.41953D-06	6.21772D-06	3.41953D-06	6.21772D-06
5.0	1.46373D-06	7.68145D-06	1.46373D-06	7.68145D-06
6.0	8.54034D-06	1.62218D-05	2.90948D-08	7.71055D-06
7.0	1.53790D-06	1.77597D-05	2.84612D-08	7.73901D-06
8.0	5.13029D-06	2.28900D-05	2.25817D-07	7.96482D-06
9.0	3.34913D-05	5.63813D-05	2.71911D-06	1.06839D-05
10.0	1.34063D-05	6.97876D-05	1.64706D-06	1.23310D-05
11.0	2.12286D-06	7.19104D-05	1.52146D-07	1.24831D-05
12.0	6.37091D-06	7.82813D-05	5.04352D-07	1.29875D-05
13.0	2.03347D-06	8.03148D-05	2.12273D-07	1.31998D-05
14.0	6.00747D-06	8.63223D-05	7.58031D-07	1.39578D-05
15.0	2.23316D-06	8.85554D-05	4.09244D-07	1.43670D-05
16.0	2.09041D-06	9.06459D-05	7.82116D-10	1.43678D-05
17.0	1.11525D-05	1.01798D-04	5.67209D-09	1.43735D-05
18.0	2.59331D-05	1.27731D-04	1.11759D-07	1.44853D-05
19.0	3.55314D-06	1.31285D-04	7.64279D-09	1.44929D-05
20.0	2.14520D-05	1.52737D-04	1.49909D-07	1.46428D-05
21.0	1.19558D-05	1.64692D-04	4.70574D-07	1.51134D-05
22.0	1.09761D-05	1.75668D-04	1.06634D-07	1.52200D-05
23.0	8.60885D-06	1.84277D-04	3.46454D-07	1.55665D-05
24.0	1.26317D-05	1.96909D-04	4.64703D-07	1.60312D-05
25.0	2.12868D-05	2.18196D-04	6.70642D-07	1.67018D-05
26.0	1.75070D-05	2.35703D-04	2.19842D-09	1.67040D-05
27.0	1.71112D-05	2.52814D-04	9.58261D-09	1.67136D-05
28.0	1.20523D-05	2.64866D-04	4.92245D-09	1.67185D-05
29.0	6.37933D-06	2.71246D-04	3.98305D-09	1.67225D-05
30.0	3.94675D-06	2.75192D-04	4.90611D-09	1.67274D-05
31.0	2.80601D-05	3.03252D-04	3.80871D-08	1.67655D-05
32.0	3.82401D-06	3.07076D-04	5.28790D-09	1.67708D-05
33.0	1.34925D-05	3.20569D-04	2.60070D-08	1.67968D-05
34.0	6.70825D-06	3.27277D-04	1.99906D-08	1.68168D-05
35.0	1.75079D-05	3.44785D-04	9.03759D-08	1.69072D-05
36.0	3.64864D-05	3.81271D-04	3.11328D-10	1.69075D-05
37.0	2.38315D-05	4.05103D-04	2.34054D-10	1.69077D-05
38.0	1.68424D-06	4.06787D-04	5.27691D-11	1.69078D-05
39.0	1.05336D-04	5.12123D-04	3.72499D-08	1.69450D-05
40.0	1.93159D-05	5.31439D-04	2.00214D-09	1.69470D-05
DEVIATION ON CUMULATIVE TOTALS =			2.60376D-05	4.74229D-06

Table C-30
PIPING SEGMENT RC-16 LARGE LEAK FAILURE PROBABILITY SRRA MODEL OUTPUT

Output Print File S6PROFLL.P02 Opened at 12:49 on 01-16-1997

Type of Piping Steel Material	316 St
Pipe Weld Failure Mode	Large Leak
Years Between Inspections	10.0
Wall Fraction for 50% Detection	0.240
Degrees (F) at Pipe Weld	606.0
Nominal Pipe Size (NPS, inch)	6.0
Thickness / Outside Diameter	0.0850
Operating Pressure (ksi)	2.52
Uniform Residual Stress (ksi)	10.0
Flaw Factor (<0 for 1 Flaw)	-10.80
DW & Thermal Stress / Flow Stress	0.19
SCC Rate / Rate for BWR Sens. SS	0.00
Factor on Wastage of 0.095 in/yr	0.00
P-P Vib. Stress (ksi for NPS of 1)	0.0
Cyclic Stress Range / Flow Stress	0.600
Fatigue Cycles per Year	10.0
Design-Limit Stress / Flow Stress	0.132
System Disabling Leak Rate (GPM)	5001.0
Minimum Detectable Leak Rate (GPM)	0.0
Value of Weld Metal Flow Stress in Ksi	51.08

STRUCTURAL RELIABILITY AND RISK ASSESSMENT (SRRA)
WESTINGHOUSE PROBABILITY OF FAILURE PROGRAM LEAKPROF ESBU-SMP
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INPUT VARIABLES FOR CASE 2: 316 St Steel Pipe Segment RC016017

NCYCLE = 40 NFAILS = 400 NTRIAL = 50000
NOVARS = 28 NUMSET = 6 NUMISI = 5
NUMSSC = 6 NUMTRC = 6 NUMFMD = 5

VARIABLE NO.	NAME	DISTRIBUTION TYPE	LOG	MEDIAN VALUE	DEVIATION OR FACTOR	SHIFT MV/SD	USAGE NO.	SUB
1	PIPE-ODIA	NORMAL	NO	6.6250D+00	2.4000D-02	.00	1	SET
2	WALL/ODIA	NORMAL	NO	8.5000D-02	2.6350D-03	.00	2	SET
3	SRESIDUAL	NORMAL	NO	1.0000D+00	1.4600D+01	.00	3	SET
4	INT%DEPTH	NORMAL	YES	1.7036D+01	1.3000D+00	2.00	4	SET
5	L/D-RATIO	NORMAL	YES	6.0000D+00	1.7126D+00	2.00	5	SET
6	FLAWS/IN	- CONSTANT -		-3.4370D-02			6	SET
7	FIRST-ISI	- CONSTANT -		5.0000D+00			1	ISI
8	FREQ-ISI	- CONSTANT -		1.0000D+01			2	ISI
9	EPST-PND	- CONSTANT -		1.0000D-03			3	ISI
10	ASTAR-PND	- CONSTANT -		-2.4000D-01			4	ISI
11	ANUU-PND	- CONSTANT -		1.6000D+00			5	ISI
12	HOURS/YR	NORMAL	YES	7.4473D+03	1.0500D+00	.00	1	SSC
13	PRESSURE	NORMAL	YES	2.5200D+00	1.0323D+00	.00	2	SSC
14	SIG-DW&TH	NORMAL	YES	9.5018D+00	1.2599D+00	.00	3	SSC
15	SCC-COEFF	NORMAL	YES	3.2310D-12	2.3714D+00	.00	4	SSC
16	SCC-EXPNT	- CONSTANT -		2.1610D+00			5	SSC
17	WASTAGE	NORMAL	YES	1.2740D-12	2.3714D+00	.00	6	SSC
18	DSIG-VIBR	NORMAL	YES	3.6957D-04	1.3465D+00	.00	1	TRC
19	CYCLES/YR	- CONSTANT -		1.0000D+01			2	TRC
20	DSIG-FATG	NORMAL	YES	3.0651D+01	1.4142D+00	.00	3	TRC
21	FCG-COEFF	NORMAL	YES	9.1401D-12	2.8508D+00	1.00	4	TRC
22	FCG-EXPNT	- CONSTANT -		4.0000D+00			5	TRC
23	FCG-THOLD	- CONSTANT -		1.5000D+00			6	TRC
24	LDEPTH-SL	- CONSTANT -		0.0000D+00			1	FMD
25	SIG-FLOW	NORMAL	NO	5.1085D+01	3.2000D+00	.00	2	FMD

Table C-30 (cont.)
PIPING SEGMENT RC-16 LARGE LEAK FAILURE PROBABILITY
SRRA MODEL OUTPUT

26	STRESS-DL	NORMAL	YES	6.7432D+00	1.4142D+00	.00	3	FMD
27	B-SDLEAK	- CONSTANT -		1.1628D+01			4	FMD
28	B-MDLEAK	- CONSTANT -		2.0813D+01			5	FMD

PROBABILITIES OF FAILURE MODE: EXCEED DISABLING LEAK RATE OR BREAK

NUMBER FAILED = 400 NUMBER OF TRIALS = 9217

END OF YEAR	FAILURE PROBABILITY WITHOUT FOR PERIOD	CUM. TOTAL	AND WITH IN-SERVICE INSPECTIONS FOR PERIOD	CUM. TOTAL
1.0	9.44497D-10	9.44497D-10	9.44497D-10	9.44497D-10
2.0	3.48526D-11	9.79350D-10	3.48526D-11	9.79350D-10
3.0	1.18242D-08	1.28035D-08	1.18242D-08	1.28035D-08
4.0	1.00948D-06	1.02229D-06	1.00948D-06	1.02229D-06
5.0	2.44977D-07	1.26727D-06	2.44977D-07	1.26727D-06
6.0	1.58724D-07	1.42599D-06	2.57772D-10	1.26752D-06
7.0	3.85839D-06	5.28438D-06	8.97329D-09	1.27650D-06
8.0	8.89986D-07	6.17437D-06	4.04945D-09	1.28055D-06
9.0	4.62292D-08	6.22060D-06	1.42977D-09	1.28198D-06
10.0	6.94966D-07	6.91557D-06	3.24458D-08	1.31442D-06
11.0	8.95701D-08	7.00514D-06	2.48158D-08	1.33924D-06
12.0	3.09731D-06	1.01024D-05	3.86141D-07	1.72538D-06
13.0	1.17576D-06	1.12782D-05	9.39159D-08	1.81929D-06
14.0	2.21441D-07	1.14996D-05	9.58465D-09	1.82888D-06
15.0	5.23163D-08	1.15520D-05	2.13572D-09	1.83101D-06
16.0	6.29774D-06	1.78497D-05	9.89622D-10	1.83200D-06
17.0	2.06051D-06	1.99102D-05	3.46617D-10	1.83235D-06
18.0	3.60261D-07	2.02705D-05	7.92292D-11	1.83243D-06
19.0	2.01625D-06	2.22867D-05	8.18443D-10	1.83325D-06
20.0	5.54292D-06	2.78296D-05	1.33679D-09	1.83458D-06
21.0	5.73822D-06	3.35679D-05	2.19211D-09	1.83678D-06
22.0	1.08762D-06	3.46555D-05	1.90695D-09	1.83868D-06
23.0	2.11715D-06	3.67726D-05	3.34736D-08	1.87216D-06
24.0	6.39419D-06	4.31668D-05	3.51954D-08	1.90735D-06
25.0	2.98934D-05	7.30602D-05	3.58711D-06	5.49446D-06
26.0	4.35838D-06	7.74186D-05	4.36037D-10	5.49490D-06
27.0	1.70956D-04	2.48375D-04	2.15406D-08	5.51644D-06
28.0	2.65279D-06	2.51028D-04	1.95007D-11	5.51646D-06
29.0	2.83421D-06	2.53862D-04	1.35764D-10	5.51660D-06
30.0	8.09219D-07	2.54671D-04	4.14062D-11	5.51664D-06
31.0	8.87661D-06	2.63548D-04	5.05762D-10	5.51714D-06
32.0	4.65187D-06	2.68200D-04	8.63523D-10	5.51801D-06
33.0	4.20967D-06	2.72409D-04	8.49243D-10	5.51886D-06
34.0	2.11216D-06	2.74522D-04	1.23110D-09	5.52009D-06
35.0	3.21523D-06	2.77737D-04	4.23344D-10	5.52051D-06
36.0	7.99189D-06	2.85729D-04	8.18598D-12	5.52052D-06
37.0	1.84814D-06	2.87577D-04	2.68455D-12	5.52052D-06
38.0	9.93023D-06	2.97507D-04	2.02537D-10	5.52072D-06
39.0	1.34510D-06	2.98852D-04	2.53457D-11	5.52075D-06
40.0	1.00560D-05	3.08908D-04	5.34335D-11	5.52080D-06

DEVIATION ON CUMULATIVE TOTALS = 1.51074D-05 2.06415D-06

Table C-31
PIPING SEGMENT RC-58 FAILURE PROBABILITY WORKSHEET

Surry Unit 1

System: RC Segment: RC-057,058,059 Failure Mode(s): Fatigue Location: Pipe to Valve; Pipe to Reducer Drawing 0124 A1-1

No.	Input Parameter Description	Circle Choice or Set Value			Set Value	Basis
1	Type of Piping Material	304SS	316SS	Carbon Steel		Drawing/Spec.
2	Crack Inspection Interval (optional)	Low(6)	Medium(10)	High(14)		Section XI
3	Crack Inspection Accuracy (optional)	High(.16)	Medium(.24)	Low(.32)		UT
4	Temperature at Pipe Weld	Low(150)	Medium(350)	High(550)	650	Line List[1]
5	Nominal Pipe Size	Small(2)	Medium(5)	Large(16)	3	Drawing[1]
6	Thickness to O.D. Ratio	Thin(.05)	Normal(.13)	Thick(.21)	.125	Calc.
7	Normal Operating Pressure	Low(0.5)	Medium(1.3)	High(2.1)	2.235	Line List
8	Residual Stress Level	None(0.0)	Moderate(10)	Maximum(20)		Judgment
9	Initial Flaw Conditions	One Flaw	X-Ray NDE	No X-Ray		Spec.
10	DW & Thermal Stress Level	Low(.05)	Medium(.11)	High(.17)	.342	Calc.
11	Stress Corrosion Potential	None(0.0)	Moderate(0.5)	Maximum(1.0)		Judgment
12	Material Wastage Potential	None(0.0)	Moderate(0.5)	Maximum(1.0)		Judgment/Material
13	Vibratory Stress Range	None(0.0)	Moderate(1.5)	Maximum(3.0)		Transients Experienced
14	Fatigue Stress Range	Low(.30)	Medium(.50)	High(.70)		Judgment
15	Low Cycle Fatigue Frequency	Low(10)	Medium(20)	High(30)		Small Changes Annually
16	Design Limiting Stress (LL/Break Only)	Low(.10)	Medium(.26)	High(.42)	.253	Calc.
17	System Disabling Leak (Large Leak Only)	None(0)	Medium(300)	High(600)	.501	Medium LOCA
18	Min. Detectable Leak (LL/Break Only)	None(0)	Medium(5)	High(10)	1	T.S. Limit

[1] .4375" thick sh 160

*__No Leak Detection__
Small Leak Prob., No ISI: 4.1474E-5 Small Leak Prob., With ISI: 3.202E-5
*Large Leak Prob., No ISI: 4.5569E-5 Large Leak Prob., With ISI: 2.8049E-5 (N/A if not applicable)
Break Prob., No ISI: N/A Break Prob., With ISI: N/A (N/A if not applicable)

__No Leak Detection__(Snubber locking up under Thermal Conditions, Item 14 set at .7 .)(Snubber failure probability set at 20% .)(N/A if not applicable)
Small Leak Prob., No ISI: 1.7076E-5 Small Leak Prob., With ISI: 5.78E-6 (N/A if not applicable)
Large Leak Prob., No ISI: 1.3248E-5 Large Leak Prob., With ISI: 5.94262E-6 (N/A if not applicable)
Break Prob., No ISI: N/A Break Prob., With ISI: N/A (N/A if not applicable)

__No Leak Detection__(Snubber not locking up under Seismic Conditions, Item 16 set at .5 .)(Snubber failure probability set at 20% .)(N/A if not applicable)
Large Leak Prob., No ISI: 3.2683E-5 Large Leak Prob., With ISI: 3.16298E-5 (N/A if not applicable)
Break Prob., No ISI: N/A Break Prob., With ISI: N/A (N/A if not applicable)

*__Leak Detection (with Snubber failure if most limiting)__
* Large Leak Prob., No ISI: 3.7727E-6 Large Leak Prob., With ISI: 2.3223E-6 (N/A if not applicable) (nonsnubber failure most limiting
Break Prob., No ISI: N/A Break Prob., With ISI: N/A (N/A if not applicable)

__Comments:__
Note: 20% snubber failure probability used due to large number of snubbers.
* use values/note for no leak detection LL probability should be used

Table C-32

PIPING SEGMENT RC-58 SMALL LEAK FAILURE PROBABILITY SRRA MODEL OUTPUT

Output Print File S6PROFSL.P16 Opened at 22:15 on 01-16-1997

Type of Piping Steel Material	316 St
Pipe Weld Failure Mode	Small Leak
Years Between Inspections	10.0
Wall Fraction for 50% Detection	0.240
Degrees (F) at Pipe Weld	650.0
Nominal Pipe Size (NPS, inch)	3.0
Thickness / Outside Diameter	0.1250
Operating Pressure (ksi)	2.24
Uniform Residual Stress (ksi)	10.0
Flaw Factor (<0 for 1 Flaw)	1.00
DW & Thermal Stress / Flow Stress	0.34
SCC Rate / Rate for BWR Sens. SS	0.00
Factor on Wastage of 0.095 in/yr	0.00
P-P Vib. Stress (ksi for NPS of 1)	1.5
Cyclic Stress Range / Flow Stress	0.500
Fatigue Cycles per Year	10.0
Design-Limit Stress / Flow Stress	0.253
System Disabling Leak Rate (GPM)	1501.0
Minimum Detectable Leak Rate (GPM)	0.0
Value of Weld Metal Flow Stress in Ksi	49.25

WESTINGHOUSE — STRUCTURAL RELIABILITY AND RISK ASSESSMENT (SRRA) PROBABILITY OF FAILURE PROGRAM LEAKPROF — ESBU-SMP

INPUT VARIABLES FOR CASE 16: 316 St Steel Pipe Segment RC057058059

NCYCLE =	40	NFAILS =	400	NTRIAL =	40000
NOVARS =	28	NUMSET =	6	NUMISI =	5
NUMSSC =	6	NUMTRC =	6	NUMFMD =	5

VARIABLE NO.	NAME	DISTRIBUTION TYPE	LOG	MEDIAN VALUE	DEVIATION OR FACTOR	SHIFT MV/SD	USAGE NO.	SUB
1	PIPE-ODIA	NORMAL	NO	3.5000D+00	1.6000D-02	.00	1	SET
2	WALL/ODIA	NORMAL	NO	1.2500D-01	3.8750D-03	.00	2	SET
3	SRESIDUAL	NORMAL	NO	1.0000D+00	1.4600D+01	.00	3	SET
4	INT%DEPTH	NORMAL	YES	2.2310D+01	1.2544D+00	2.00	4	SET
5	L/D-RATIO	NORMAL	YES	6.0000D+00	1.7126D+00	1.00	5	SET
6	FLAWS/IN	- CONSTANT -		3.7371D-03			6	SET
7	FIRST-ISI	- CONSTANT -		5.0000D+00			1	ISI
8	FREQ-ISI	- CONSTANT -		1.0000D+01			2	ISI
9	EPST-PND	- CONSTANT -		1.0000D-03			3	ISI
10	ASTAR-PND	- CONSTANT -		-2.4000D-01			4	ISI
11	ANUU-PND	- CONSTANT -		1.6000D+00			5	ISI
12	HOURS/YR	NORMAL	YES	7.4473D+03	1.0500D+00	.00	1	SSC
13	PRESSURE	NORMAL	YES	2.2350D+00	1.0323D+00	.00	2	SSC
14	SIG-DW&TH	NORMAL	YES	1.6842D+01	1.2599D+00	.00	3	SSC
15	SCC-COEFF	NORMAL	YES	3.2310D-12	2.3714D+00	.00	4	SSC
16	SCC-EXPNT	- CONSTANT -		2.1610D+00			5	SSC
17	WASTAGE	NORMAL	YES	1.2740D-12	2.3714D+00	.00	6	SSC
18	DSIG-VIBR	NORMAL	YES	1.0073D+00	1.3465D+00	.00	1	TRC
19	CYCLES/YR	- CONSTANT -		1.0000D+01			2	TRC
20	DSIG-FATG	NORMAL	YES	2.4623D+01	1.4142D+00	.00	3	TRC
21	FCG-COEFF	NORMAL	YES	9.1401D-12	2.8508D+00	1.00	4	TRC
22	FCG-EXPNT	- CONSTANT -		4.0000D+00			5	TRC
23	FCG-THOLD	- CONSTANT -		1.5000D+00			6	TRC
24	LDEPTH-SL	- CONSTANT -		-9.9900D-01			1	FMD
25	SIG-FLOW	NORMAL	NO	4.9246D+01	3.2000D+00	.00	2	FMD

Table C-32 (cont.)
PIPING SEGMENT RC-58 SMALL LEAK FAILURE PROBABILITY
SRRA MODEL OUTPUT

26	STRESS-DL	- CONSTANT -	0.0000D+00	3	FMD
27	B-SDLEAK	- CONSTANT -	0.0000D+00	4	FMD
28	B-MDLEAK	- CONSTANT -	0.0000D+00	5	FMD

PROBABILITIES OF FAILURE MODE: THROUGH-WALL CRACK DEPTH FOR SMALL LEAK

NUMBER FAILED = 400 NUMBER OF TRIALS = 5457

END OF YEAR	FAILURE PROBABILITY WITHOUT FOR PERIOD	CUM. TOTAL	AND WITH IN-SERVICE INSPECTIONS FOR PERIOD	CUM. TOTAL
1.0	3.05735D-05	3.05735D-05	3.05735D-05	3.05735D-05
2.0	1.93275D-07	3.07667D-05	1.93275D-07	3.07667D-05
3.0	2.97649D-08	3.07965D-05	2.97649D-08	3.07965D-05
4.0	2.64509D-07	3.10610D-05	2.64509D-07	3.10610D-05
5.0	6.27345D-08	3.11237D-05	6.27345D-08	3.11237D-05
6.0	6.64182D-08	3.11902D-05	1.15932D-08	3.11353D-05
7.0	9.62364D-09	3.11998D-05	1.28965D-09	3.11366D-05
8.0	2.18647D-07	3.14184D-05	1.54370D-08	3.11521D-05
9.0	1.53169D-07	3.15716D-05	1.24834D-08	3.11645D-05
10.0	2.23454D-07	3.17950D-05	1.40678D-08	3.11786D-05
11.0	1.62505D-08	3.18113D-05	7.13916D-10	3.11793D-05
12.0	6.76120D-07	3.24874D-05	1.37749D-07	3.13171D-05
13.0	8.02740D-07	3.32902D-05	1.74791D-07	3.14919D-05
14.0	9.43936D-08	3.33846D-05	8.65672D-09	3.15005D-05
15.0	1.81334D-06	3.51979D-05	5.00325D-07	3.20008D-05
16.0	4.43455D-08	3.52422D-05	9.34692D-11	3.20009D-05
17.0	2.22844D-08	3.52645D-05	8.36751D-12	3.20009D-05
18.0	3.06251D-09	3.52676D-05	2.53614D-12	3.20009D-05
19.0	2.76890D-08	3.52953D-05	1.78585D-11	3.20010D-05
20.0	5.10872D-08	3.53464D-05	4.84685D-11	3.20010D-05
21.0	4.08811D-07	3.57552D-05	1.16623D-08	3.20127D-05
22.0	1.81130D-07	3.59363D-05	3.89584D-10	3.20131D-05
23.0	2.19679D-07	3.61560D-05	9.84884D-10	3.20141D-05
24.0	1.97957D-07	3.63539D-05	5.07247D-10	3.20146D-05
25.0	1.84426D-08	3.63724D-05	6.08195D-11	3.20146D-05
26.0	2.67152D-07	3.66395D-05	4.68987D-10	3.20151D-05
27.0	1.30366D-07	3.67699D-05	6.13693D-13	3.20151D-05
28.0	2.77886D-07	3.70478D-05	3.22988D-12	3.20151D-05
29.0	7.28714D-07	3.77765D-05	3.17546D-10	3.20154D-05
30.0	1.28955D-07	3.79055D-05	6.69171D-11	3.20155D-05
31.0	5.74814D-07	3.84803D-05	4.33284D-10	3.20159D-05
32.0	6.17462D-08	3.85420D-05	2.72044D-11	3.20159D-05
33.0	1.62001D-06	4.01620D-05	3.65206D-09	3.20196D-05
34.0	3.54851D-08	4.01975D-05	6.32502D-13	3.20196D-05
35.0	2.85635D-07	4.04831D-05	1.22371D-09	3.20208D-05
36.0	9.36552D-08	4.05768D-05	7.73760D-12	3.20208D-05
37.0	4.11905D-07	4.09887D-05	5.75641D-12	3.20208D-05
38.0	1.98323D-07	4.11870D-05	7.31900D-12	3.20208D-05
39.0	1.51868D-08	4.12022D-05	5.49533D-13	3.20208D-05
40.0	2.72315D-07	4.14745D-05	1.99024D-12	3.20208D-05
DEVIATION ON CUMULATIVE TOTALS =			1.99646D-06	1.76997D-06

Table C-33
PIPING SEGMENT RC-58 LARGE LEAK FAILURE PROBABILITY
SRRA MODEL OUTPUT

Output Print File S6PROFLL.P17 Opened at 22:17 on 01-16-1997

Type of Piping Steel Material	316 St
Pipe Weld Failure Mode	Large Leak
Years Between Inspections	10.0
Wall Fraction for 50% Detection	0.240
Degrees (F) at Pipe Weld	650.0
Nominal Pipe Size (NPS, inch)	3.0
Thickness / Outside Diameter	0.1250
Operating Pressure (ksi)	2.24
Uniform Residual Stress (ksi)	10.0
Flaw Factor (<0 for 1 Flaw)	1.00
DW & Thermal Stress / Flow Stress	0.34
SCC Rate / Rate for BWR Sens. SS	0.00
Factor on Wastage of 0.095 in/yr	0.00
P-P Vib. Stress (ksi for NPS of 1)	1.5
Cyclic Stress Range / Flow Stress	0.500
Fatigue Cycles per Year	10.0
Design-Limit Stress / Flow Stress	0.253
System Disabling Leak Rate (GPM)	1501.0
Minimum Detectable Leak Rate (GPM)	0.0
Value of Weld Metal Flow Stress in Ksi	49.25

STRUCTURAL RELIABILITY AND RISK ASSESSMENT (SRRA)
WESTINGHOUSE PROBABILITY OF FAILURE PROGRAM LEAKPROF ESBU-SMF

INPUT VARIABLES FOR CASE 17: 316 St Steel Pipe Segment RC057058059

NCYCLE =	40	NFAILS =	400	NTRIAL =	50000
NOVARS =	28	NUMSET =	6	NUMISI =	5
NUMSSC =	6	NUMTRC =	6	NUMFMD =	5

VARIABLE NO.	NAME	DISTRIBUTION TYPE	LOG	MEDIAN VALUE	DEVIATION OR FACTOR	SHIFT MV/SD	USAGE NO.	SUB
1	PIPE-ODIA	NORMAL	NO	3.5000D+00	1.6000D-02	.00	1	SET
2	WALL/ODIA	NORMAL	NO	1.2500D-01	3.8750D-03	.00	2	SET
3	SRESIDUAL	NORMAL	NO	1.0000D+00	1.4600D+01	.00	3	SET
4	INT%DEPTH	NORMAL	YES	2.2310D+01	1.2544D+00	2.00	4	SET
5	L/D-RATIO	NORMAL	YES	6.0000D+00	1.7126D+00	2.00	5	SET
6	FLAWS/IN	- CONSTANT -		3.7371D-03			6	SET
7	FIRST-ISI	- CONSTANT -		5.0000D+00			1	ISI
8	FREQ-ISI	- CONSTANT -		1.0000D+01			2	ISI
9	EPST-PND	- CONSTANT -		1.0000D-03			3	ISI
10	ASTAR-PND	- CONSTANT -		-2.4000D-01			4	ISI
11	ANUU-PND	- CONSTANT -		1.6000D+00			5	ISI
12	HOURS/YR	NORMAL	YES	7.4473D+03	1.0500D+00	.00	1	SSC
13	PRESSURE	NORMAL	YES	2.2350D+00	1.0323D+00	.00	2	SSC
14	SIG-DW&TH	NORMAL	YES	1.6842D+01	1.2599D+00	.00	3	SSC
15	SCC-COEFF	NORMAL	YES	3.2310D-12	2.3714D+00	.00	4	SSC
16	SCC-EXPNT	- CONSTANT -		2.1610D+00			5	SSC
17	WASTAGE	NORMAL	YES	1.2740D-12	2.3714D+00	.00	6	SSC
18	DSIG-VIBR	NORMAL	YES	1.0073D+00	1.3465D+00	.00	1	TRC
19	CYCLES/YR	- CONSTANT -		1.0000D+01			2	TRC
20	DSIG-FATG	NORMAL	YES	2.4623D+01	1.4142D+00	.00	3	TRC
21	FCG-COEFF	NORMAL	YES	9.1401D-12	2.8508D+00	1.00	4	TRC
22	FCG-EXPNT	- CONSTANT -		4.0000D+00			5	TRC
23	FCG-THOLD	- CONSTANT -		1.5000D+00			6	TRC
24	LDEPTH-SL	- CONSTANT -		0.0000D+00			1	FMD
25	SIG-FLOW	NORMAL	NO	4.9246D+01	3.2000D+00	.00	2	FMD

Table C-33 (cont.)
PIPING SEGMENT RC-58 LARGE LEAK FAILURE PROBABILITY
SRRA MODEL OUTPUT

26	STRESS-DL	NORMAL	YES	1.2459D+01	1.4142D+00	.00	3	FMD
27	B-SDLEAK	- CONSTANT -		4.4079D+00			4	FMD
28	B-MDLEAK	- CONSTANT -		1.0996D+01			5	FMD

PROBABILITIES OF FAILURE MODE: EXCEED DISABLING LEAK RATE OR BREAK

NUMBER FAILED = 400 NUMBER OF TRIALS = 3687

END OF YEAR	FAILURE PROBABILITY WITHOUT FOR PERIOD	CUM. TOTAL	AND WITH IN-SERVICE INSPECTIONS FOR PERIOD	CUM. TOTAL
1.0	3.33516D-06	3.33516D-06	3.33516D-06	3.33516D-06
2.0	2.44084D-05	2.77435D-05	2.44084D-05	2.77435D-05
3.0	4.92446D-08	2.77928D-05	4.92446D-08	2.77928D-05
4.0	1.34994D-09	2.77941D-05	1.34994D-09	2.77941D-05
5.0	7.59701D-08	2.78701D-05	7.59701D-08	2.78701D-05
6.0	1.47989D-07	2.80181D-05	5.48406D-10	2.78706D-05
7.0	1.20917D-07	2.81390D-05	5.06341D-09	2.78757D-05
8.0	5.97074D-09	2.81450D-05	5.85096D-10	2.78763D-05
9.0	6.43262D-08	2.82093D-05	2.80123D-09	2.78791D-05
10.0	4.57226D-09	2.82139D-05	4.28518D-10	2.78795D-05
11.0	3.02325D-09	2.82169D-05	1.22178D-10	2.78796D-05
12.0	4.67067D-08	2.82636D-05	4.96029D-09	2.78846D-05
13.0	1.22481D-09	2.82648D-05	6.33701D-11	2.78846D-05
14.0	2.77235D-08	2.82925D-05	9.21454D-10	2.78856D-05
15.0	1.27653D-07	2.84202D-05	1.30684D-08	2.78986D-05
16.0	2.11578D-08	2.84413D-05	4.45061D-12	2.78986D-05
17.0	8.57868D-08	2.85271D-05	1.52941D-10	2.78988D-05
18.0	1.64121D-07	2.86912D-05	1.25991D-09	2.79001D-05
19.0	4.39086D-07	2.91303D-05	2.72077D-10	2.79003D-05
20.0	4.62152D-08	2.91765D-05	2.92562D-10	2.79006D-05
21.0	2.42487D-09	2.91790D-05	9.98393D-12	2.79006D-05
22.0	1.79865D-07	2.93588D-05	7.35547D-10	2.79014D-05
23.0	5.85201D-08	2.94174D-05	2.49486D-10	2.79016D-05
24.0	7.95809D-08	2.94969D-05	5.56451D-10	2.79022D-05
25.0	1.94796D-07	2.96917D-05	5.68400D-09	2.79079D-05
26.0	5.21654D-08	2.97439D-05	5.10303D-13	2.79079D-05
27.0	4.07707D-07	3.01516D-05	1.40309D-09	2.79093D-05
28.0	1.03591D-07	3.02552D-05	7.86864D-12	2.79093D-05
29.0	4.99632D-09	3.02602D-05	4.62066D-13	2.79093D-05
30.0	8.21625D-08	3.03424D-05	1.96166D-10	2.79095D-05
31.0	4.46089D-08	3.03870D-05	1.30322D-11	2.79095D-05
32.0	1.09754D-07	3.04967D-05	1.23450D-10	2.79096D-05
33.0	5.70996D-07	3.10677D-05	1.38261D-08	2.79234D-05
34.0	1.31202D-05	4.41879D-05	1.22141D-07	2.80456D-05
35.0	5.46170D-07	4.47341D-05	2.52405D-09	2.80481D-05
36.0	6.52487D-08	4.47993D-05	4.53101D-12	2.80481D-05
37.0	8.26857D-08	4.48820D-05	1.39712D-11	2.80481D-05
38.0	4.18999D-07	4.53010D-05	1.05253D-09	2.80492D-05
39.0	2.05933D-07	4.55069D-05	1.53907D-11	2.80492D-05
40.0	6.26695D-08	4.55696D-05	8.70250D-11	2.80493D-05
DEVIATION ON CUMULATIVE TOTALS =			2.15163D-06	1.72711D-06

Table C-34

PIPING SEGMENT SW-04 FAILURE PROBABILITY WORKSHEET

Surry Unit 1

System: SW Segment: SW-004, 005, 006 Failure Mode(s): Wastage/Pitting Location: 163L Class Pipe - Weld at Reducer on 2" side

No.	Input Parameter Description	Circle Choice or Set Value			Set Value	Basis
1	Type of Piping Material	304SS	316SS	Carbon Steel		163L - Drawing/Spec
2	Crack Inspection Interval (optional)	Low(6)	Medium(10)	High(14)		Section XI
3	Crack Inspection Accuracy (optional)	High(.16)	Medium(.24)	Low(.32)		RT
4	Temperature at Pipe Weld	Low(150)	Medium(350)	High(550)	95	Line List
5	Nominal Pipe Size	Small(2)	Medium(5)	Large(16)	2	Drawing
6	Thickness to O.D. Ratio	Thin(.05)	Normal(.13)	Thick(.21)	.06	Calc.
7	Normal Operating Pressure	Low(0.5)	Medium(1.3)	High(2.1)	.025	Line List
8	Residual Stress Level	None(0.0)	Moderate(10)	Maximum(20)	5	Judgment - fillet
9	Initial Flaw Conditions	One Flaw	X-Ray NDE	No X-Ray		Spec.
10	DW & Thermal Stress Level	Low(.05)	Medium(.11)	High(.17)	.038	Calc.
11	Stress Corrosion Potential	None(0.0)	Moderate(0.5)	Maximum(1.0)		Judgment
12	Material Wastage Potential	None(0.0)	Moderate(0.5)	Maximum(1.0)	1.0	Judgment
13	Vibratory Stress Range	None(0.0)	Moderate(1.5)	Maximum(3.0)		Judgment
14	Fatigue Stress Range	Low(.30)	Medium(.50)	High(.70)		Judgment
15	Low Cycle Fatigue Frequency	Low(10)	Medium(20)	High(30)		Judgment
16	Design Limiting Stress (LL/Break Only)	Low(.10)	Medium(.26)	High(.42)	.017	Calc.
17	System Disabling Leak (Large Leak Only)	None(0)	Medium(300)	High(600)	10	10% of 2" pipe flow
18	Min. Detectable Leak (LL/Break Only)	None(0)	Medium(5)	High(10)	1	1 gpm - Pump PT accessible

No Leak Detection

Small Leak Prob., No ISI: 3.4793E-4 Small Leak Prob., With ISI: 9.7512E-6

Large Leak Prob., No ISI: 9.3320E-5 Large Leak Prob., With ISI: 7.0519E-7 (N/A if not applicable)

Break Prob., No ISI: N/A Break Prob., With ISI: N/A (N/A if not applicable)

No Leak Detection(Snubber locking up under Thermal Conditions, Item 14 set at N/A .)(Snubber failure probability set at N/A .)(N/A if not applicable)

Small Leak Prob., No ISI: ______ Small Leak Prob., With ISI: ______ (N/A if not applicable)

Large Leak Prob., No ISI: ______ Large Leak Prob., With ISI: ______ (N/A if not applicable)

Break Prob., No ISI: ______ Break Prob., With ISI: ______ (N/A if not applicable)

No Leak Detection(Snubber not locking up under Seismic Conditions, Item 16 set at N/A .)(Snubber failure probability set at N/A .)(N/A if not applicable)

Large Leak Prob., No ISI: ______ Large Leak Prob., With ISI: ______ (N/A if not applicable)

Break Prob., No ISI: ______ Break Prob., With ISI: ______ (N/A if not applicable)

Leak Detection (with Snubber failure if most limiting)

Large Leak Prob., No ISI: 1.0665E-5 Large Leak Prob., With ISI: 2.9987E-7 (N/A if not applicable)

Break Prob., No ISI: N/A Break Prob., With ISI: N/A (N/A if not applicable)

Comments:

No Snubbers.

Fiberglass piping failure probability set at 1E-2 for small leak and large leak (based upon fatigue).

Table C-35

PIPING SEGMENT SW-04 SMALL LEAK FAILURE PROBABILITY
SRRA MODEL OUTPUT

Output Print File S6PROFSL.P03 Opened at 14:18 on 04-02-1997

Type of Piping Steel Material	316 St
Pipe Weld Failure Mode	Small Leak
Years Between Inspections	10.0
Wall Fraction for 50% Detection	0.160
Degrees (F) at Pipe Weld	95.0
Nominal Pipe Size (NPS, inch)	2.0
Thickness / Outside Diameter	0.0600
Operating Pressure (ksi)	0.25
Uniform Residual Stress (ksi)	5.0
Flaw Factor (<0 for 1 Flaw)	12.80
DW & Thermal Stress / Flow Stress	0.04
SCC Rate / Rate for BWR Sens. SS	0.00
Factor on Wastage of .0095 in/yr	1.00
P-P Vib. Stress (ksi for NPS of 1)	0.0
Cyclic Stress Range / Flow Stress	0.300
Fatigue Cycles per Year	20.0
Design-Limit Stress / Flow Stress	0.017
System Disabling Leak Rate (GPM)	10.0
Minimum Detectable Leak Rate (GPM)	0.0
Value of Weld Metal Flow Stress in Ksi	72.44

WESTINGHOUSE — STRUCTURAL RELIABILITY AND RISK ASSESSMENT (SRRA) PROBABILITY OF FAILURE PROGRAM LEAKPROF — ESBU-NSD

INPUT VARIABLES FOR CASE 3: 316 St Steel Pipe Segment SW-4;5;6

NCYCLE = 40 NFAILS = 400 NTRIAL = 40000
NOVARS = 28 NUMSET = 6 NUMISI = 5
NUMSSC = 6 NUMTRC = 6 NUMFMD = 5

VARIABLE NO.	NAME	DISTRIBUTION TYPE	LOG	MEDIAN VALUE	DEVIATION OR FACTOR	SHIFT MV/SD	USAGE NO.	SUB
1	PIPE-ODIA	NORMAL	NO	2.3750D+00	1.6000D-02	.00	1	SET
2	WALL/ODIA	NORMAL	NO	6.0000D-02	1.8600D-03	.00	2	SET
3	SRESIDUAL	NORMAL	YES	5.0000D+00	1.4142D+00	.00	3	SET
4	INT%DEPTH	NORMAL	YES	3.9953D+01	1.1840D+00	2.00	4	SET
5	L/D-RATIO	NORMAL	YES	6.0000D+00	1.7126D+00	1.00	5	SET
6	FLAWS/IN	- CONSTANT -		6.9762D-02			6	SET
7	FIRST-ISI	- CONSTANT -		5.0000D+00			1	ISI
8	FREQ-ISI	- CONSTANT -		1.0000D+01			2	ISI
9	EPST-PND	- CONSTANT -		1.0000D-03			3	ISI
10	ASTAR-PND	- CONSTANT -		-1.6000D-01			4	ISI
11	ANUU-PND	- CONSTANT -		1.6000D+00			5	ISI
12	HOURS/YR	NORMAL	YES	7.4473D+03	1.0500D+00	.00	1	SSC
13	PRESSURE	NORMAL	YES	2.5000D-01	1.0323D+00	.00	2	SSC
14	SIG-DW&TH	NORMAL	YES	2.7527D+00	1.2599D+00	.00	3	SSC
15	SCC-COEFF	NORMAL	YES	3.2310D-12	2.3714D+00	.00	4	SSC
16	SCC-EXPNT	- CONSTANT -		2.1610D+00			5	SSC
17	WASTAGE	NORMAL	YES	1.2740D-09	2.3714D+00	.00	6	SSC
18	DSIG-VIBR	NORMAL	YES	8.1948D-04	1.3465D+00	.00	1	TRC
19	CYCLES/YR	- CONSTANT -		2.0000D+01			2	TRC
20	DSIG-FATG	NORMAL	YES	2.1732D+01	1.4142D+00	.00	3	TRC
21	FCG-COEFF	NORMAL	YES	9.1401D-12	2.8508D+00	1.00	4	TRC
22	FCG-EXPNT	- CONSTANT -		4.0000D+00			5	TRC
23	FCG-THOLD	- CONSTANT -		1.5000D+00			6	TRC
24	LDEPTH-SL	- CONSTANT -		-9.9900D-01			1	FMD
25	SIG-FLOW	NORMAL	NO	7.2439D+01	3.2000D+00	.00	2	FMD

Table C-35 (cont.)
PIPING SEGMENT SW-04 SMALL LEAK FAILURE PROBABILITY
SRRA MODEL OUTPUT

```
26  STRESS-DL   - CONSTANT -   0.0000D+00      3  FMD
27  B-SDLEAK    - CONSTANT -   0.0000D+00      4  FMD
28  B-MDLEAK    - CONSTANT -   0.0000D+00      5  FMD
```

PROBABILITIES OF FAILURE MODE: THROUGH-WALL CRACK DEPTH FOR SMALL LEAK

NUMBER FAILED = 400 NUMBER OF TRIALS = 6231

END OF YEAR	FAILURE PROBABILITY WITHOUT FOR PERIOD	CUM. TOTAL	AND WITH IN-SERVICE INSPECTIONS FOR PERIOD	CUM. TOTAL
1.0	1.68675D-07	1.68675D-07	1.68675D-07	1.68675D-07
2.0	8.09942D-08	2.49670D-07	8.09942D-08	2.49670D-07
3.0	4.36649D-06	4.61616D-06	4.36649D-06	4.61616D-06
4.0	1.68354D-06	6.29970D-06	1.68354D-06	6.29970D-06
5.0	5.99626D-07	6.89932D-06	5.99626D-07	6.89932D-06
6.0	3.22421D-06	1.01235D-05	8.01170D-09	6.90733D-06
7.0	1.11108D-06	1.12346D-05	1.95106D-09	6.90928D-06
8.0	1.90092D-06	1.31355D-05	2.64217D-09	6.91193D-06
9.0	1.61321D-05	2.92677D-05	8.44600D-07	7.75653D-06
10.0	1.51785D-05	4.44462D-05	1.77084D-06	9.52737D-06
11.0	6.14651D-07	4.50608D-05	8.68505D-10	9.52824D-06
12.0	3.94516D-06	4.90060D-05	7.54126D-08	9.60365D-06
13.0	2.12864D-05	7.02924D-05	1.30008D-07	9.73366D-06
14.0	2.12798D-06	7.24204D-05	4.30191D-09	9.73796D-06
15.0	3.12126D-07	7.27325D-05	3.88657D-09	9.74185D-06
16.0	2.23936D-05	9.51261D-05	1.08247D-09	9.74293D-06
17.0	5.83434D-06	1.00960D-04	1.42498D-10	9.74307D-06
18.0	1.21247D-05	1.13085D-04	2.97019D-09	9.74604D-06
19.0	3.79691D-06	1.16882D-04	2.48304D-11	9.74607D-06
20.0	5.06567D-06	1.21948D-04	3.24158D-11	9.74610D-06
21.0	2.63866D-06	1.24586D-04	3.59468D-11	9.74613D-06
22.0	2.88784D-06	1.27474D-04	1.47138D-11	9.74615D-06
23.0	6.72631D-06	1.34201D-04	6.16649D-11	9.74621D-06
24.0	3.00307D-06	1.37204D-04	1.11170D-10	9.74632D-06
25.0	8.99674D-06	1.46200D-04	7.43563D-10	9.74707D-06
26.0	9.46188D-06	1.55662D-04	1.84386D-12	9.74707D-06
27.0	6.91703D-06	1.62579D-04	8.25949D-12	9.74708D-06
28.0	4.62285D-06	1.67202D-04	9.75302D-13	9.74708D-06
29.0	8.75900D-05	2.54792D-04	4.16906D-09	9.75125D-06
30.0	2.80004D-06	2.57592D-04	4.11208D-12	9.75125D-06
31.0	3.02396D-06	2.60616D-04	2.67371D-14	9.75125D-06
32.0	1.15533D-05	2.72169D-04	1.51220D-11	9.75126D-06
33.0	2.56739D-06	2.74737D-04	3.38600D-14	9.75126D-06
34.0	1.54113D-06	2.76278D-04	2.55637D-13	9.75126D-06
35.0	3.71838D-07	2.76650D-04	5.85880D-16	9.75126D-06
36.0	1.09185D-05	2.87568D-04	1.07253D-15	9.75126D-06
37.0	1.08667D-05	2.98435D-04	1.02031D-15	9.75126D-06
38.0	2.36529D-05	3.22088D-04	2.61787D-12	9.75127D-06
39.0	1.41398D-05	3.36228D-04	3.77205D-14	9.75127D-06
40.0	1.17076D-05	3.47935D-04	4.95532D-14	9.75127D-06

DEVIATION ON CUMULATIVE TOTALS = 1.68305D-05 2.91000D-06

Table C-36
PIPING SEGMENT SW-04 LARGE LEAK FAILURE PROBABILITY
SRRA MODEL OUTPUT

Output Print File S6PROFLL.P04 Opened at 14:21 on 04-02-1997

Type of Piping Steel Material	316 St
Pipe Weld Failure Mode	Large Leak
Years Between Inspections	10.0
Wall Fraction for 50% Detection	0.160
Degrees (F) at Pipe Weld	95.0
Nominal Pipe Size (NPS, inch)	2.0
Thickness / Outside Diameter	0.0600
Operating Pressure (ksi)	0.25
Uniform Residual Stress (ksi)	5.0
Flaw Factor (<0 for 1 Flaw)	12.80
DW & Thermal Stress / Flow Stress	0.04
SCC Rate / Rate for BWR Sens. SS	0.00
Factor on Wastage of .0095 in/yr	1.00
P-P Vib. Stress (ksi for NPS of 1)	0.0
Cyclic Stress Range / Flow Stress	0.300
Fatigue Cycles per Year	20.0
Design-Limit Stress / Flow Stress	0.017
System Disabling Leak Rate (GPM)	10.0
Minimum Detectable Leak Rate (GPM)	0.0
Value of Weld Metal Flow Stress in Ksi	72.44

WESTINGHOUSE STRUCTURAL RELIABILITY AND RISK ASSESSMENT (SRRA) PROBABILITY OF FAILURE PROGRAM LEAKPROF ESBU-NSD

INPUT VARIABLES FOR CASE 4: 316 St Steel Pipe Segment SW-4;5;6

NCYCLE =	40	NFAILS =	400	NTRIAL =	50000
NOVARS =	28	NUMSET =	6	NUMISI =	5
NUMSSC =	6	NUMTRC =	6	NUMFMD =	5

VARIABLE NO.	NAME	DISTRIBUTION TYPE	LOG	MEDIAN VALUE	DEVIATION OR FACTOR	SHIFT MV/SD	USAGE NO.	SUB
1	PIPE-ODIA	NORMAL	NO	2.3750D+00	1.6000D-02	.00	1	SET
2	WALL/ODIA	NORMAL	NO	6.0000D-02	1.8600D-03	.00	2	SET
3	SRESIDUAL	NORMAL	YES	5.0000D+00	1.4142D+00	.00	3	SET
4	INT%DEPTH	NORMAL	YES	3.9953D+01	1.1840D+00	2.00	4	SET
5	L/D-RATIO	NORMAL	YES	6.0000D+00	1.7126D+00	2.00	5	SET
6	FLAWS/IN	- CONSTANT -		6.9762D-02			6	SET
7	FIRST-ISI	- CONSTANT -		5.0000D+00			1	ISI
8	FREQ-ISI	- CONSTANT -		1.0000D+01			2	ISI
9	EPST-PND	- CONSTANT -		1.0000D-03			3	ISI
10	ASTAR-PND	- CONSTANT -		-1.6000D-01			4	ISI
11	ANUU-PND	- CONSTANT -		1.6000D+00			5	ISI
12	HOURS/YR	NORMAL	YES	7.4473D+03	1.0500D+00	.00	1	SSC
13	PRESSURE	NORMAL	YES	2.5000D-01	1.0323D+00	.00	2	SSC
14	SIG-DW&TH	NORMAL	YES	2.7527D+00	1.2599D+00	.00	3	SSC
15	SCC-COEFF	NORMAL	YES	3.2310D-12	2.3714D+00	.00	4	SSC
16	SCC-EXPNT	- CONSTANT -		2.1610D+00			5	SSC
17	WASTAGE	NORMAL	YES	1.2740D-09	2.3714D+00	.00	6	SSC
18	DSIG-VIBR	NORMAL	YES	8.1948D-04	1.3465D+00	.00	1	TRC
19	CYCLES/YR	- CONSTANT -		2.0000D+01			2	TRC
20	DSIG-FATG	NORMAL	YES	2.1732D+01	1.4142D+00	.00	3	TRC
21	FCG-COEFF	NORMAL	YES	9.1401D-12	2.8508D+00	1.00	4	TRC
22	FCG-EXPNT	- CONSTANT -		4.0000D+00			5	TRC
23	FCG-THOLD	- CONSTANT -		1.5000D+00			6	TRC
24	LDEPTH-SL	- CONSTANT -		0.0000D+00			1	FMD
25	SIG-FLOW	NORMAL	NO	7.2439D+01	3.2000D+00	.00	2	FMD

Table C-36 (cont.)
PIPING SEGMENT SW-04 LARGE LEAK FAILURE PROBABILITY SRRA MODEL OUTPUT

26	STRESS-DL	NORMAL	YES	1.2315D+00	1.4142D+00	.00	3	FMD
27	B-SDLEAK	- CONSTANT -		7.4613D+00			4	FMD
28	B-MDLEAK	- CONSTANT -		7.4613D+00			5	FMD

PROBABILITIES OF FAILURE MODE: EXCEED DISABLING LEAK RATE OR BREAK

NUMBER FAILED = 400 NUMBER OF TRIALS = 14500

END OF YEAR	FAILURE PROBABILITY WITHOUT FOR PERIOD	CUM. TOTAL	AND WITH IN-SERVICE INSPECTIONS FOR PERIOD	CUM. TOTAL
1.0	4.47159D-12	4.47159D-12	4.47159D-12	4.47159D-12
2.0	4.53694D-11	4.98410D-11	4.53694D-11	4.98410D-11
3.0	3.58988D-07	3.59038D-07	3.58988D-07	3.59038D-07
4.0	1.02973D-09	3.60068D-07	1.02973D-09	3.60068D-07
5.0	3.39609D-07	6.99677D-07	3.39609D-07	6.99677D-07
6.0	1.20387D-06	1.90354D-06	1.22417D-09	7.00901D-07
7.0	7.71967D-07	2.67551D-06	8.03318D-10	7.01704D-07
8.0	1.43489D-07	2.81900D-06	1.46276D-10	7.01850D-07
9.0	5.83709D-07	3.40271D-06	5.94038D-10	7.02445D-07
10.0	5.42957D-07	3.94567D-06	5.70273D-10	7.03015D-07
11.0	9.71261D-07	4.91693D-06	9.87671D-10	7.04002D-07
12.0	2.05344D-07	5.12227D-06	2.09279D-10	7.04212D-07
13.0	8.96293D-09	5.13123D-06	1.06631D-11	7.04222D-07
14.0	5.59281D-07	5.69052D-06	8.01195D-10	7.05024D-07
15.0	1.16427D-07	5.80694D-06	1.32938D-10	7.05157D-07
16.0	1.01018D-08	5.81704D-06	1.47107D-14	7.05157D-07
17.0	1.38847D-07	5.95589D-06	2.59078D-13	7.05157D-07
18.0	2.49703D-07	6.20559D-06	2.82860D-13	7.05157D-07
19.0	5.91051D-06	1.21161D-05	2.45604D-11	7.05182D-07
20.0	2.98392D-07	1.24145D-05	7.78344D-13	7.05182D-07
21.0	6.20886D-08	1.24766D-05	8.56556D-14	7.05183D-07
22.0	1.55247D-07	1.26318D-05	2.09962D-13	7.05183D-07
23.0	9.35290D-08	1.27254D-05	1.34603D-13	7.05183D-07
24.0	5.27082D-07	1.32524D-05	1.45966D-12	7.05184D-07
25.0	1.57152D-06	1.48240D-05	6.62705D-12	7.05191D-07
26.0	6.23501D-06	2.10590D-05	1.26675D-13	7.05191D-07
27.0	1.17898D-06	2.22380D-05	5.37125D-15	7.05191D-07
28.0	2.21778D-06	2.44557D-05	4.44289D-15	7.05191D-07
29.0	6.47595D-07	2.51033D-05	1.38936D-15	7.05191D-07
30.0	3.23230D-06	2.83356D-05	5.91452D-13	7.05192D-07
31.0	1.35281D-06	2.96884D-05	6.84518D-15	7.05192D-07
32.0	2.72396D-06	3.24124D-05	4.66115D-14	7.05192D-07
33.0	2.03292D-07	3.26157D-05	4.56785D-16	7.05192D-07
34.0	3.14936D-07	3.29306D-05	8.71897D-16	7.05192D-07
35.0	4.92516D-07	3.34232D-05	2.70981D-15	7.05192D-07
36.0	4.62389D-07	3.38855D-05	1.71744D-18	7.05192D-07
37.0	3.04058D-07	3.41896D-05	5.80665D-19	7.05192D-07
38.0	5.20779D-05	8.62675D-05	7.85445D-14	7.05192D-07
39.0	5.46281D-06	9.17303D-05	2.42959D-16	7.05192D-07
40.0	1.59019D-06	9.33205D-05	2.25975D-17	7.05192D-07

DEVIATION ON CUMULATIVE TOTALS = 4.60138D-06 4.05585D-07

APPENDIX D
SRRA CODE DESCRIPTION

Information now contained in WCAP-14572, Revision 1-NP-A, Supplement 1.

APPENDIX E
BENCHMARKING OF SRRA CODE

Information now contained in WCAP-14572, Revision 1-NP-A, Supplement 1.

APPENDIX F
RELATED WOG AND ACRS CORRESPONDENCE

Note: The WOG letters provided in this appendix contain the changes suggested to be made to the WCAP based on NRC staff review of the submitted WOG Topical Report. These recommended changes have been incorporated into the accepted version of the report. One WOG letter is referenced in the NRC's SER, while the other letter is referenced in an NRC Advisory Committee on Reactor Safeguards (ACRS) letter also included in this appendix. The ACRS letter contains the review and recommendations of the ACRS based on their review of the submitted WOG Topical Report.