PWROG Project
ISI Interval Extension for Non-Alloy 82/182 RV Nozzle Welds

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Meeting Agenda

• Introduction	1:00
• Review of Project Objectives	1:05
• Recap of June 22nd Meeting	1:15
• Objectives for this Meeting	1:30
• Results of Change-in-Failure Frequency Calculations	1:40
• Results of Pilot Plant Evaluations	2:15
• Proposed Resolution of NRC Concerns Raised at Last Meeting	2:50
• Plant Specific Implementation	3:15
• Summary and Conclusions	3:35
• Future PWROG Actions	3:45
• Additional Questions	3:50
• Adjourn	4:00

Introduction and Review of Project Objectives

- PWROG has a current effort to develop a technical basis to extend the ISI interval for Non-Alloy 82/182 RV nozzles
  - Includes primary inlet, outlet, and SI nozzles
  - Does not include BMI, HV, and CRDM/CEDM nozzles
- Objectives of the PWROG effort include:
  - Develop a technical basis for ISI interval extension for similar metal (Category B-J) and dissimilar metal (Category B-F) welds that do not contain Alloy 82/182
  - Develop a framework for implementing the extended ISI interval
  - Submit topical report for NRC review and approval

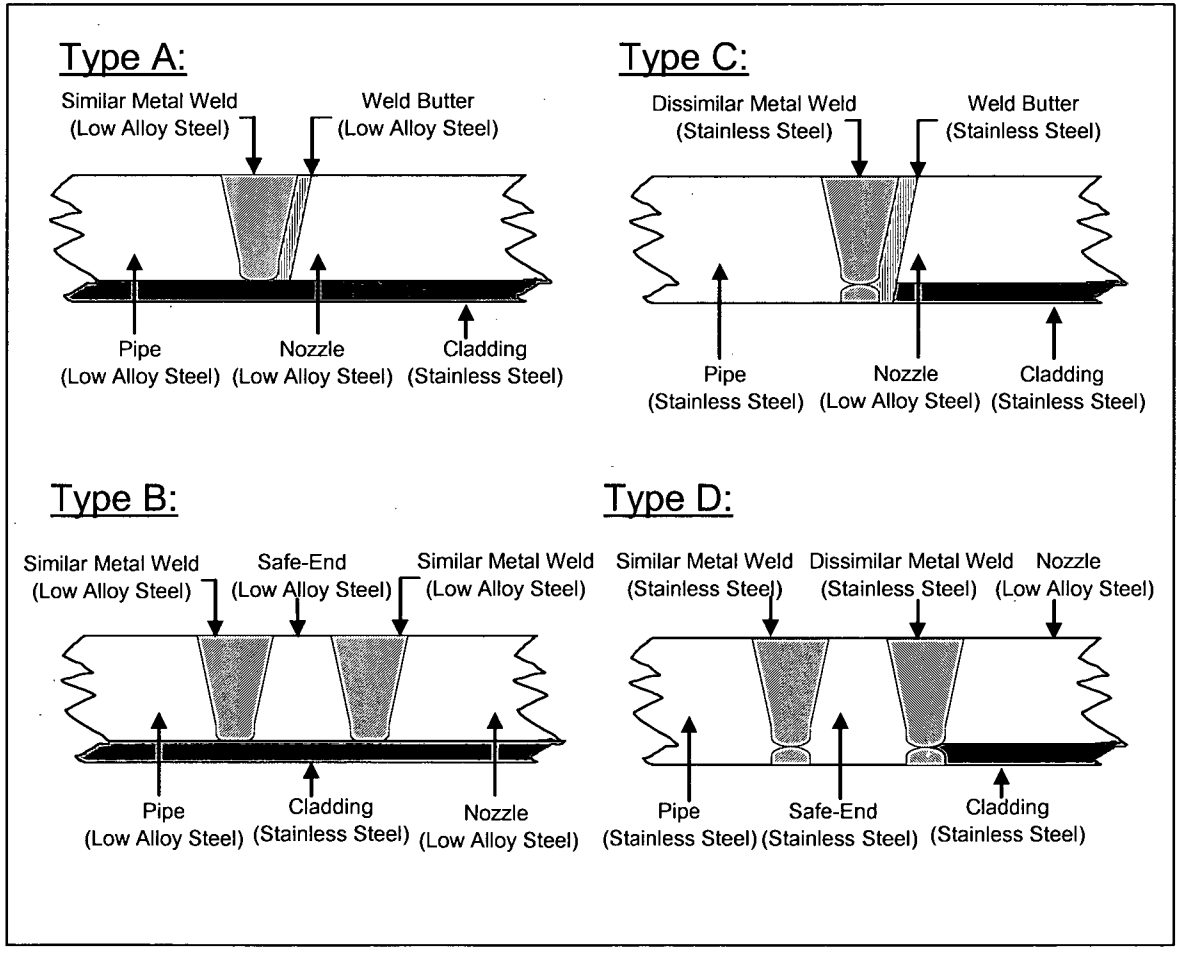
Recap of June 22 Meeting - Background

- Meeting held to inform Staff of PWROG efforts
- Discussed motivation and benefits associated with extending the ISI interval
  - Consistent with extended interval for RV
  - Savings in cost, outage time, and dose
  - May eliminate need to pull core barrel
- Reviewed service experience for these welds
  - Survey conducted of participating PWR plants
  - Very few instances of recordable indications
  - No known reportable indications

Recap of June 22 Meeting – Technical Approach

- Nozzle welds can be categorized into 4 types
  - Similar Metal, with and without a safe-end
  - Dissimilar Metal, with and without a safe-end
- Use Westinghouse SRRA Code to evaluate change in failure frequency associated with extension in ISI interval for each weld type
  - Proposed SRRA inputs and basis discussed
- Compare change-in-risk to R.G. 1.174 criteria
- Evaluate effect on risk-informed ISI program (if applicable)

Recap of Nozzle / Weld Types



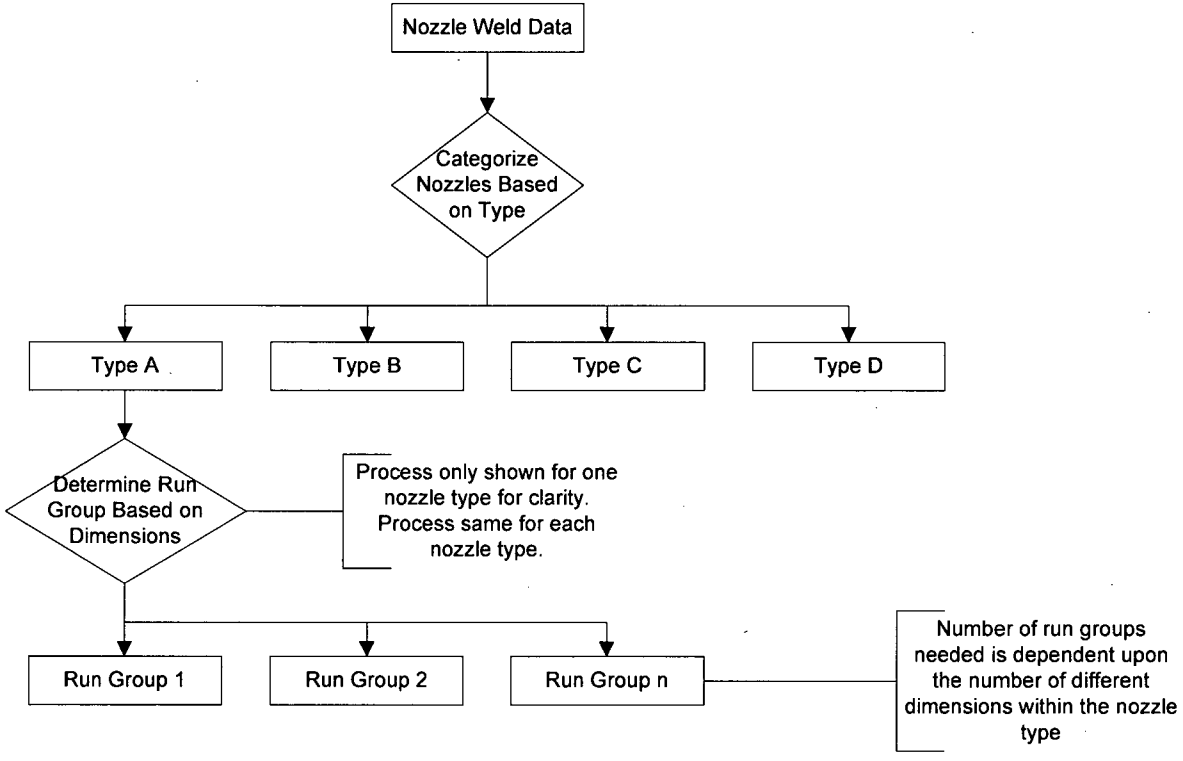
Objectives for this Meeting

- Provide an update on the status of the PWROG effort
- Present the results of the detailed change-in-failure frequency calculations
- Present the results of the pilot plant calculations demonstrating the evaluation of effects on RI-ISI programs
- Present proposed resolution of NRC comments from last meeting
- Discuss plant specific implementation plan and future PWROG actions
- Obtain NRC feedback

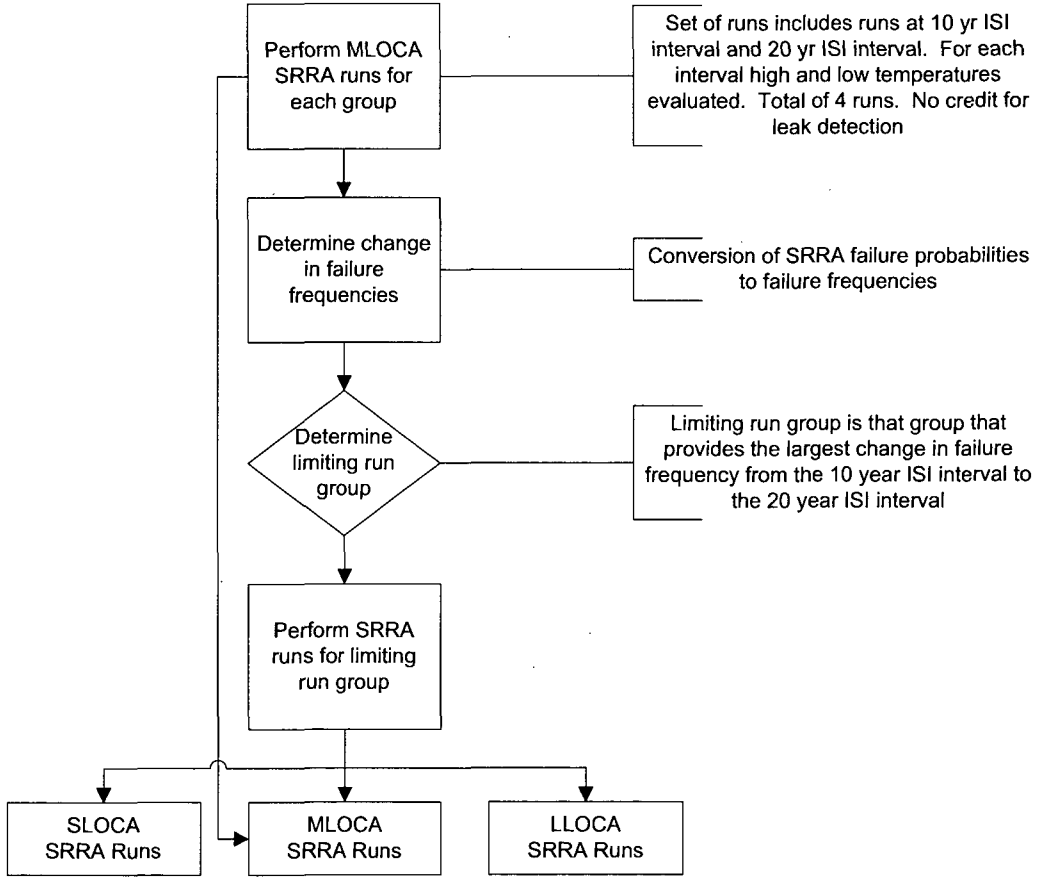
Change-in-Failure Frequency Calculations

- Geometries and operating conditions reviewed for all plants participating in PWROG effort
- Sensitivity runs performed to determine limiting configurations / conditions for each weld/nozzle type
- Full set of runs performed for limiting configuration
  - Seismic Loading
  - Elevated fatigue stress due to snubber lock-up
  - Seismic loading with failure of snubbers to restrain motion
- Bounding change-in-failure frequency values determined for 40 and 60 years of operation and three LOCA leak rates (break sizes)

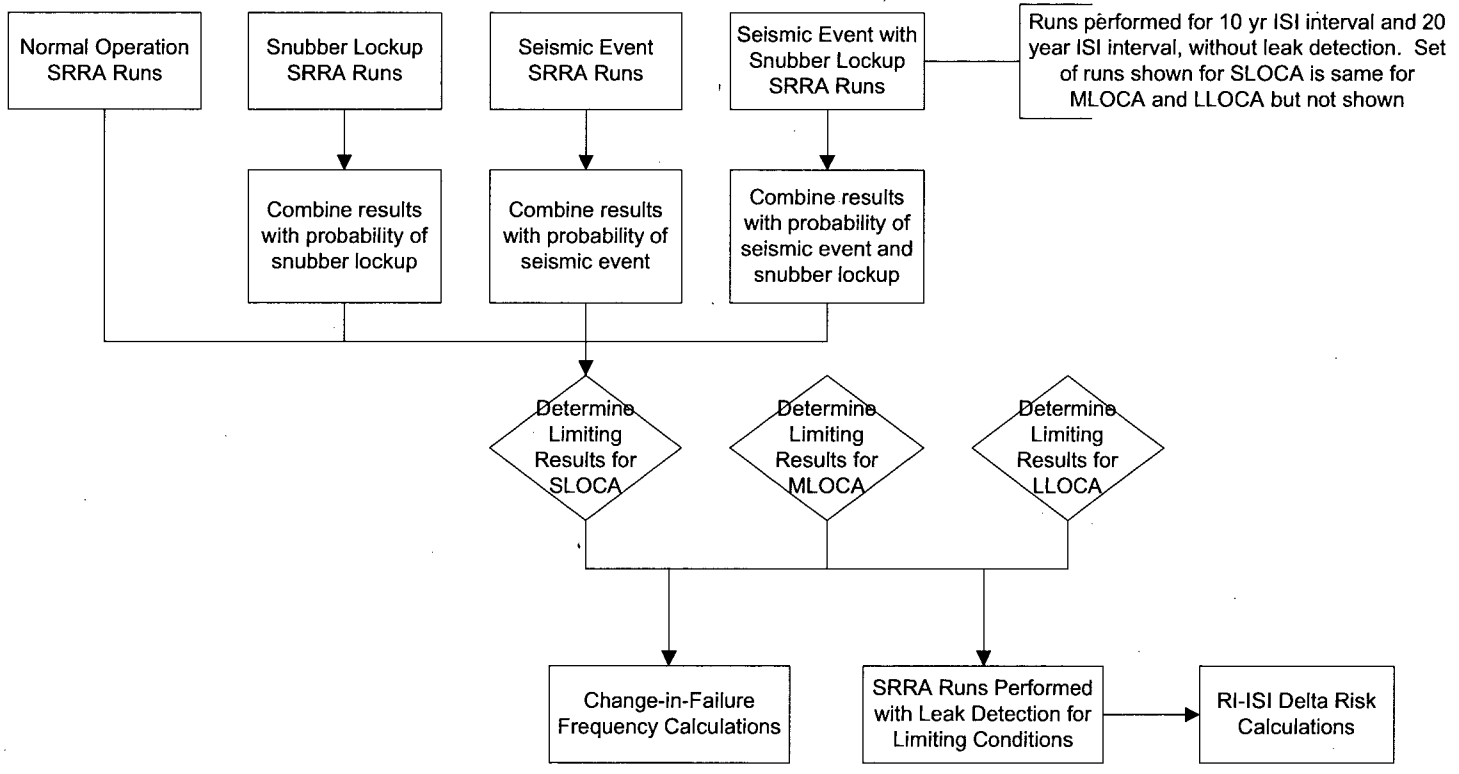
Change-in-Failure Frequency Calculations – Process



Change-in-Failure Frequency Calculations – Process (cont.)



Change-in-Failure Frequency Calculations – Process (cont.)



Change-in-Failure Frequency Calculations – Results

Type A – B&W Similar Metal Bounding Change in Failure Frequencies / year			
	LOCA Size	**Without Leak Detection**	**With Leak Detection**
Outlet Nozzle – 40 Year Results	SLOCA	1.36E-09	5.65E-11
	MLOCA	3.77E-11	1.75E-11
	LLOCA	1.74E-11	4.60E-12
Inlet Nozzle – 40 Year Results	SLOCA	7.88E-10	3.06E-11
	MLOCA	1.66E-11	3.36E-12
	LLOCA	1.76E-11	3.10E-12

Type B – CE Similar Metal Bounding Change in Failure Frequencies / year			
	LOCA Size	**Without Leak Detection**	**With Leak Detection**
Outlet Nozzle – 40 Year Results	SLOCA	1.23E-09	5.66E-11
	MLOCA	4.13E-11	2.19E-11
	LLOCA	4.13E-11	2.19E-11
Inlet Nozzle – 40 Year Results	SLOCA	1.29E-09	9.72E-11
	MLOCA	4.02E-11	1.49E-11
	LLOCA	1.99E-11	3.28E-12

Change-in-Failure Frequency Calculations – Results (cont.)

Type C – Westinghouse Dissimilar Metal – No Safe-End Bounding Change in Failure Frequencies / year			
	LOCA Size	**Without Leak Detection**	**With Leak Detection**
Outlet Nozzle – 40 Year Results	SLOCA	6.79E-08	4.58E-09
	MLOCA	6.78E-08	3.20E-09
	LLOCA	1.94E-07	3.20E-09
Inlet Nozzle – 40 Year Results	SLOCA	7.54E-08	3.56E-09
	MLOCA	7.27E-08	1.53E-09
	LLOCA	8.15E-08	1.40E-09

Type D – Westinghouse Dissimilar Metal – Safe-End Bounding Change in Failure Frequencies / year			
	LOCA Size	**Without Leak Detection**	**With Leak Detection**
Outlet Nozzle – 40 Year Results	SLOCA	6.09E-08	9.45E-09
	MLOCA	7.09E-08	8.06E-09
	LLOCA	7.03E-08	8.03E-09
Inlet Nozzle – 40 Year Results	SLOCA	9.80E-08	3.98E-08
	MLOCA	8.09E-08	3.20E-08
	LLOCA	8.05E-08	3.20E-08

Pilot Plant Evaluations

- Two pilot plants evaluated for acceptability of extension in ISI interval and effects on piping risk-informed inservice inspection program:
  - Three Mile Island Unit 1 – EPRI Piping RI-ISI Program – Type A
  - Beaver Valley Unit 1 – PWROG Piping RI-ISI Program – Type C
- Both plants have been evaluated for implementation of the RV ISI interval extension
  - Three Mile Island Unit 1 – Individual plant submittal
  - Beaver Valley Unit 1 – WCAP-16168 pilot plant
- Effect on RI-ISI program is in the ΔRisk Evaluation

Three Mile Island Unit 1 – Change-in-Risk Regulatory Evaluation

- Bounding Change-in-Failure Frequencies combined with TMI-1 CCDP and CLERP values for all LOCA sizes
  - 40 year values used
  - No credit for leak detection
- ΔCDF and ΔLERF values summed for each LOCA size and multiplied by total number of nozzles (details on next slide)
  - ΔCDF = 1.94E-11 / year
  - ΔLERF = 2.15E-12 / year
- ΔCDF and ΔLERF values meet guidelines of R.G. 1.174 for an acceptably small change-in-risk

TMI Unit 1 – Change-in-Risk Regulatory Evaluation – Results

Change-in-Risk Calculations – Three Mile Island Unit 1					
Break Size	**Bounding Change in Failure Frequency (No Leak Detection)**	**CCDP**	**ΔCDF**	**CLERP**	**ΔLERF**
Outlet Nozzle					
SLOCA	1.36E-09	1.83E-03	2.49E-12	2.53E-04	3.44E-13
MLOCA	3.77E-11	2.23E-03	8.41E-14	2.55E-04	9.61E-15
LLOCA	1.74E-11	3.93E-02	6.84E-13	8.06E-04	1.40E-14
# of Outlet Nozzles	2	Total ΔCDF	6.51E-12	Total ΔLERF	7.35E-13
Inlet Nozzle					
SLOCA	7.88E-10	1.83E-03	2.36E-12	2.53E-04	3.26E-13
MLOCA	1.66E-11	2.23E-03	8.96E-14	2.55E-04	1.03E-14
LLOCA	1.76E-11	3.93E-02	7.82E-13	8.06E-04	1.60E-14
# of Inlet Nozzles	4	Total ΔCDF	1.29E-11	Total ΔLERF	1.41E-12
All Nozzles					
Total Change-in-Risk Results		Total ΔCDF	1.94E-11	Total ΔLERF	2.15E-12

TMI Unit 1 – ΔRisk Evaluation Process for RI-ISI Program

- EPRI RI-ISI Method allows 4 different change-in-risk methods
  - Qualitative
  - Bounding without credit for increase in POD
  - Bounding with credit for increase in POD
  - Markov Method
- TMI-1 RI-ISI program used the Markov Method
- Two methods evaluated for effect of interval extension
  - Markov Method
  - Additive with Bounding change-in-failure frequencies

TMI Unit 1 – RI-ISI Program ΔRisk Evaluation – Markov Model

- 10-yr and 20-yr ISI effectiveness factors calculated for RV nozzle welds
- Change-in-risk for ISI interval extension calculated using difference in effectiveness factors
- Change-in-risk for ISI interval extension added to RC system change-in-risk for RI-ISI (details on next slide)
  - ΔCDF = 7.58E-09 / year
  - ΔLERF = 1.24E-09 / year
- RC system change-in-risk values satisfy requirements of EPRI RI-ISI TR (ΔCDF≤1E-7/yr, ΔLERF≤1E-8/yr)

TMI Unit 1 – RI-ISI Program ΔRisk Evaluation – Markov Model – Results

$\Delta CDF = \lambda_f P_I \langle R \mid F \rangle (\Delta I) CCDP$ (per nozzle)	1.40E-10 / yr
$\Delta LERF = \lambda_f P_I \langle R \mid F \rangle (\Delta I) CLERP$ (per nozzle)	1.94E-11 / yr
Number of RV Nozzles	6
Total Nozzle ΔCDF	8.41E-10 / yr
Total Nozzle ΔLERF	1.16E-10 / yr
RC System ΔCDF from RI-ISI	6.74E-09 / yr
RC System ΔLERF from RI-ISI	1.12E-09 / yr
New RC System ΔCDF	7.58E-09 / yr
New RC System ΔLERF	1.24E-09 / yr

TMI Unit 1 – RI-ISI Program ΔRisk Evaluation – Additive Method

- ΔCDF and ΔLERF determined for all nozzles
  - Similar to regulatory change-in-risk evaluation
  - Credit for leak detection
- Total ΔRisk for nozzle ISI interval extension added to RC system and total plant ΔRisk from RI-ISI program element selection (details on next slide)
  - ΔCDF = 6.74E-09 / year
  - ΔLERF = 1.12E-09 / year
- RC system ΔRisk values satisfy requirements of EPRI Piping RI-ISI program topical report

TMI Unit 1 – RI-ISI Program ΔRisk Evaluation – Additive Method – Results

	ΔCDF / yr	ΔLERF / yr
Nozzle Change-in-Risk Results	4.31E-13	5.96E-14
RC System Change-in-Risk	6.74E-09	1.12E-09
New RC System Change-in-Risk	6.74E-09	1.12E-09
Plant Change-in-Risk	4.08E-08	5.36E-09
New RC Plant Change-in-Risk	4.08E-08	5.36E-09

Beaver Valley Unit 1 – Change-in-Risk Regulatory Evaluation

- Bounding Change-in-Failure Frequencies combined with BV1 CCDP and CLERP values for all LOCA sizes
  - 40 year values used
  - No credit for leak detection
- ΔCDF and ΔLERF values summed for each LOCA size and multiplied by total number of nozzles (details on next slide)
  - ΔCDF = 2.53E-09 / year
  - ΔLERF = 6.37E-14 / year
- ΔCDF and ΔLERF values meet guidelines of R.G. 1.174 for an acceptably small change-in-risk

Beaver Valley Unit 1 – Change-in-Risk Regulatory Evaluation – Results

Change-in-Risk Calculations – Beaver Valley Unit 1					
Break Size	**Bounding Change in Failure Frequency (No Leak Detection) / year**	**CCDP**	**ΔCDF / year**	**CLERP**	**ΔLERF / year**
Outlet Nozzles					
SLOCA	6.79E-08	1.38E-05	9.37E-13	7.61E-12	5.16E-19
MLOCA	6.78E-08	1.68E-03	1.14E-10	4.70E-08	3.18E-15
LLOCA	1.94E-07	2.15E-03	4.18E-10	5.30E-08	1.03E-14
# of Outlet Nozzles	3	Total ΔCDF	1.60E-09	Total ΔLERF	4.05E-14
Inlet Nozzles					
SLOCA	7.54E-08	1.93E-04	1.46E-11	2.90E-10	2.19E-17
MLOCA	7.27E-08	1.68E-03	1.22E-10	4.70E-08	3.42E-15
LLOCA	8.15E-08	2.15E-03	1.75E-10	5.30E-08	4.32E-15
# of Inlet Nozzles	3	Total ΔCDF	9.36E-10	Total ΔLERF	2.33E-14
All Nozzles					
Total Change-in-Risk Results		**Total ΔCDF**	2.53E-09	**Total ΔLERF**	6.37E-14

Beaver Valley Unit 1 – ΔRisk Evaluation Process for RI-ISI Program

- ΔCDF and ΔLERF determined for all nozzles
  - Similar to regulatory change-in-risk evaluation
  - Credit for leak detection
- Total change-in-risk for nozzle ISI interval extension added to RC system and total plant ΔRisk from RI-ISI program element selection.
- Total change-in-risk compared to plant and system criteria for acceptable ΔRisk

Beaver Valley Unit 1 – RI-ISI Program ΔRisk Evaluation – Results

Effect on Beaver Valley RI-ISI Program				
	Beaver Valley Unit 1 with Operator Action		Beaver Valley Unit 1 without Operator Action	
	ΔCDF / yr	ΔLERF / yr	ΔCDF / yr	ΔLERF / yr
RC System (Existing RI-ISI Program)	-2.58E-13	4.52E-19	-2.58E-13	4.52E-19
Additional Risk from ISI Int. Extension	5.58E-11	1.40E-15	5.58E-11	1.40E-15
Total RC System Change-in-Risk	5.55E-11	1.40E-15	5.55E-11	1.40E-15
Acceptable System Change-in-Risk	0.0E+00	1.0E-09	0.0E+00	1.0E-09
Total Plant (Existing RI-ISI Program)	-3.94E-11	-7.88E-13	-2.02E-10	-9.36E-13
Additional Risk from ISI Int. Extension	5.58E-11	1.40E-15	5.58E-11	1.40E-15
Total Plant Change-in-Risk	1.64E-11	-7.87E-13	-1.46E-10	-9.35E-13
Acceptable Total Change-in-Risk	0.0E+00	0.0E+00	0.0E+00	0.0E+00

Beaver Valley Unit 1 – RI-ISI Program ΔRisk Evaluation

- For its first risk-informed application, NRC requested the PWROG method for piping ISI to be risk neutral.
  - For the pilot plant application in WCAP-14572, Revision 1-NP-A, risk neutral was conservatively set as ΔRisk ≤ 0.0.
  - However, this was not required in the subsequent versions of Regulatory Guides 1.174 and 1.178 for RI applications.
- Later NRC approved RI-ISI applications/methodologies defined risk neutral to be consistent with current calculation capabilities as ΔCDF≤1E-7/yr and ΔLERF≤1E-8/yr per system.
- Beaver Valley Unit 1 satisfies these ΔRisk requirements with no additional examinations that would increase man-REM exposure levels.

Proposed Resolution of NRC Concerns Raised at Last Meeting

- Embedded Flaws / Flaw Distributions
- Inspection Scheduling / Distribution
- Probability of Detection
- Cast Austenitic Stainless Steel

Embedded Flaws \ Flaw Distribution

- SRRA Code considers surface flaws only
- Based on flaw density and weld sizes, one surface flaw considered per each weld
- Deterministic analyses, performed in accordance with ASME Section XI, Nonmandatory Appendices A and C, have shown that growth of embedded flaws is insignificant
- ISI results should be reviewed to confirm that no more than 1 surface flaw is present in each weld

Inspection Scheduling / Distribution

- RV ISI interval extension plans were provided to NRC by PWROG (OG-06-356 & OG-09-454)
- RV nozzle exams will be performed at same time as RV ISI
- 31 Plants with Alloy 82/182 welds can not use ISI interval extension for nozzles
- Separate implementation plan is not needed to ensure a uniform distribution of RV nozzle inspections requested by NRC

Probability of Detection (POD)

- POD used in SRRA calculations for RV nozzle welds is consistent with that used for PWROG RI-ISI applications for ultrasonic (UT)
- Lower POD = Lower ΔRisk, Higher POD = Higher ΔRisk for regulatory evaluations (R.G. 1.174)
- For piping RI-ISI program ΔRisk evaluations, POD should be consistent
- WCAP will include results of sensitivity studies

Cast Austenitic Stainless Steel (CASS)

- Only applicable to Type C and D nozzles
- No specific considerations made for CASS materials in SRRA runs for failure probabilities without ISI
- Low POD issues exist for CASS regardless of inspection interval (ASME XI 10 years or PWROG 20 years)
- Assuming a higher POD results in a larger calculated change-in-failure frequency and ΔRisk
- Deterministic analyses show that even large flaws are unlikely to grow to critical dimensions in 20+ years

Plant Specific Implementation Plan

- No plant specific SRRA calculations – Bounding change-in-failure frequency values would be used instead
- Plant specific CCDP and CLERP values would be used
- ISI results should be reviewed to confirm that no more than 1 surface flaw is present in each weld
- Plants would provide results of risk calculations similar to those shown for pilot plants
- Submit relief request, revise existing relief request, or implement through update to RI-ISI program

Summary and Conclusions

- Bounding change-in-failure frequencies have been calculated for each nozzle / weld type and LOCA sizes for both 40 and 60 years of operation
- Pilot plant calculations show that R.G. 1.174 change-in-risk guidelines are satisfied
- Piping RI-ISI program requirements may require additional piping inspections to meet respective ΔRisk requirements
- NRC comments from last meeting have been considered and accounted for in pilot plant applications
- Proposed plant-specific implementation plan is simple and straight-forward for PWROG utilities to use and NRC to review