TABULAR SUMMARY OF PERSPECTIVES AND COMPARISON WITH INDUSTRY POSITIONS

<table>
<tr><th>Issue</th><th>Industry Position</th><th>Experts Opinion</th><th>Staff Assessment</th></tr>
<tr><td>1. CRDM Critical Circumferential Through-Wall Crack Length</td><td>273 degrees around the circumference at 3 times the operating pressure.</td><td>271 to 277 degrees at 3 times operating pressure.
225 to 90 degrees for combined through-wall and surface flaw geometries.
Further work is needed to evaluate time estimates for single or linked flaws to reach a critical length in the environment of the annular gap.</td><td rowspan="2">Based on the information presented by the industry and the independent experts opinion on issues 1- 5, the staff believes that:
• Detectable leakage can occur at crack lengths smaller than a critical crack length.
• The average time between plant outages is potentially less than the time required for a crack to reach a critical size.
• The remaining lifetime of a 165° through-wall crack ranges between 1.5 - 6 years
• Additional confirmatory work will be needed.</td></tr>
<tr><td>2. Crack Growth Rate</td><td>Relief of residual stress due to opening of the crack retards or terminate further crack growth.
6 years is required for crack to grow through wall.
A circumferential crack is unlikely to propagate through the wall and grow along the nozzle-weld contour.</td><td>Restrained bending condition limits crack growth. Weld residual stresses will be the primary driving force. Rates of residual stress relaxation expected to accompany crack growth are unknown.
The CGR can be accelerated in acidic or basic solution, and presence of sufficient stress.
Above certain crack opening, the environment seen by the crack would be controlled by the primary coolant chemistry.
Simple fracture mechanics models may underestimate crack growth if multiple cracks initiate and link.</td></tr>
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3. Susceptibility Ranking and Activation Energies	Primarily based on time and temperature. The activation energy (Kcal/mole °C) crack initiation ~ 40 - 50 crack growth ~ 30 -35	The proposed ranking in terms of susceptibility based on operating temperature is reasonable. Activation energy is appropriate.	
4. CRDM Crack Leakage	Annular average interference gap will contribute to leakage if the crack length in the tube is greater than some value.	Leak rate analyses, which consider crack-opening displacement, surface roughness, number of turns, and actual flow path to thickness length indicate that a detectable leakage would occur from the crack. Thermal expansion between the penetration and the RPV head creates an annular gap for leakage. Ovalization of the nozzle head penetration will affect the dimensions of this gap. An interference fit may occur at operating temperature, hence significantly blocking leakage; but could provide detachment restraint.	

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5. Plugging of Leakage Path	Boric acid plugging the crack is unlikely. System pressure will sweep out deposited boric acid.	For a 180-degree crack, and for water quality < 100%, boric acid stays in solution. No concern of boric acid plugging the crack. Plugging from other corrosion products needs to be evaluated.	
6. Adequacy of Visual Inspection to Detect CRDM Cracking	VT-2 can distinguish between boron deposits from CRDM cracks and other non-relevant deposits.	Boric acid deposits from prior leaks from other sources could challenge the ability to detect leaks from the VHP crevice if the vessel head has not been cleaned. Requires adequate access to inner rows of CRDMs and good illumination. If only a small amount of leakage escapes the crevice there is less confidence in the visual examination.	NRC Bulletin 2001-01 indicates the need for use of qualified inspection techniques for certain categories of plants.

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7. CRDM Crack Detection (Eddy Current , Ultrasonic, and Penetrant Testings)		ET is adequate for detecting and length sizing through-wall cracking initiated from the ID of the nozzle. UT can be used to confirm length measurements and provide depth estimates. Adaptive scanning is needed to accommodate the complex shape of ***J***-groove. UT using time-of-flight diffraction should work for OD PWSCC.	
8. Can OD PWSCC in CRDM Nozzle Grow Through-Wall without Leaking?	System pressure will prevent blockage of the crevice	Requires blockage of the crevice immediately after sufficient concentration of lithium hydroxide and boric acid is formed and enough steam or water is also trapped to provide the environment in which cracking can occur in the outer surface of the CRDM nozzle.	Expert analyses and opinions suggest that the concentration mechanism for boric acid is not probable and boric acid should remain in solution in the crack plane. However, the possibility of prohibiting leakage still exists due to potential for interference fits at temperature and the possibility of plugging from other corrosion products (see Issue 5).

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9. CRDM Sampling Inspection	Being evaluated	Considerations include: • Technical and statistical basis for the sampling plan • Residual stresses and weld repair effects (e.g highest residual stresses are associated with the outermost penetrations.) • Sporadic instances of cracking can be expected to occur.	Recognizing the risk perspective (Issue 11), and the required time to inspect ~ 70 CRDMs per plant, a sampling inspection would be considered. However, statistical analysis and operating experience do not support sampling inspection.
10. Leak Detection Equipment	Industry is looking into availability and efficacy of several detection technology.	Equipment capable of detecting small leakage are available • 0.5 gpm–acoustic emission • <0.2 gpm visual • 0.026 gpm humidity • 0.0044 gpm N_2-13	Techniques are available, but not for near term implementation. Potential implementation would be driven by the need for qualification and the associated costs to the industry.

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11. Risk Implications	Under development	Existing PRAs do not explicitly address these types of initiating events, but combine them with other possible RCS breaks of similar size. The estimation of event frequency, and the probability of recovery actions given the break location, were hampered by a lack of relevant information. Accordingly, the staff focused on the CCDP, basically an estimate of the emergency core cooling system failure probability, given one or more CRDM failures. The major contribution to the CCDP would be from the resulting small to medium break LOCA. Additional considerations include the potential for damage of other rod assemblies, clogging the sump by dislodged insulation, and design, configuration, and alignment of engineered safety features (ESF). NRC is in need of additional plant-specific information from the industry to enable more accurate determinations in this regard.	Staff concurs with expert group evaluation. NRC is in need of additional plant-specific information from the industry to enable more accurate determinations in this regard.