Material Degradation Management of the Point Lepreau Reactor Coolant System

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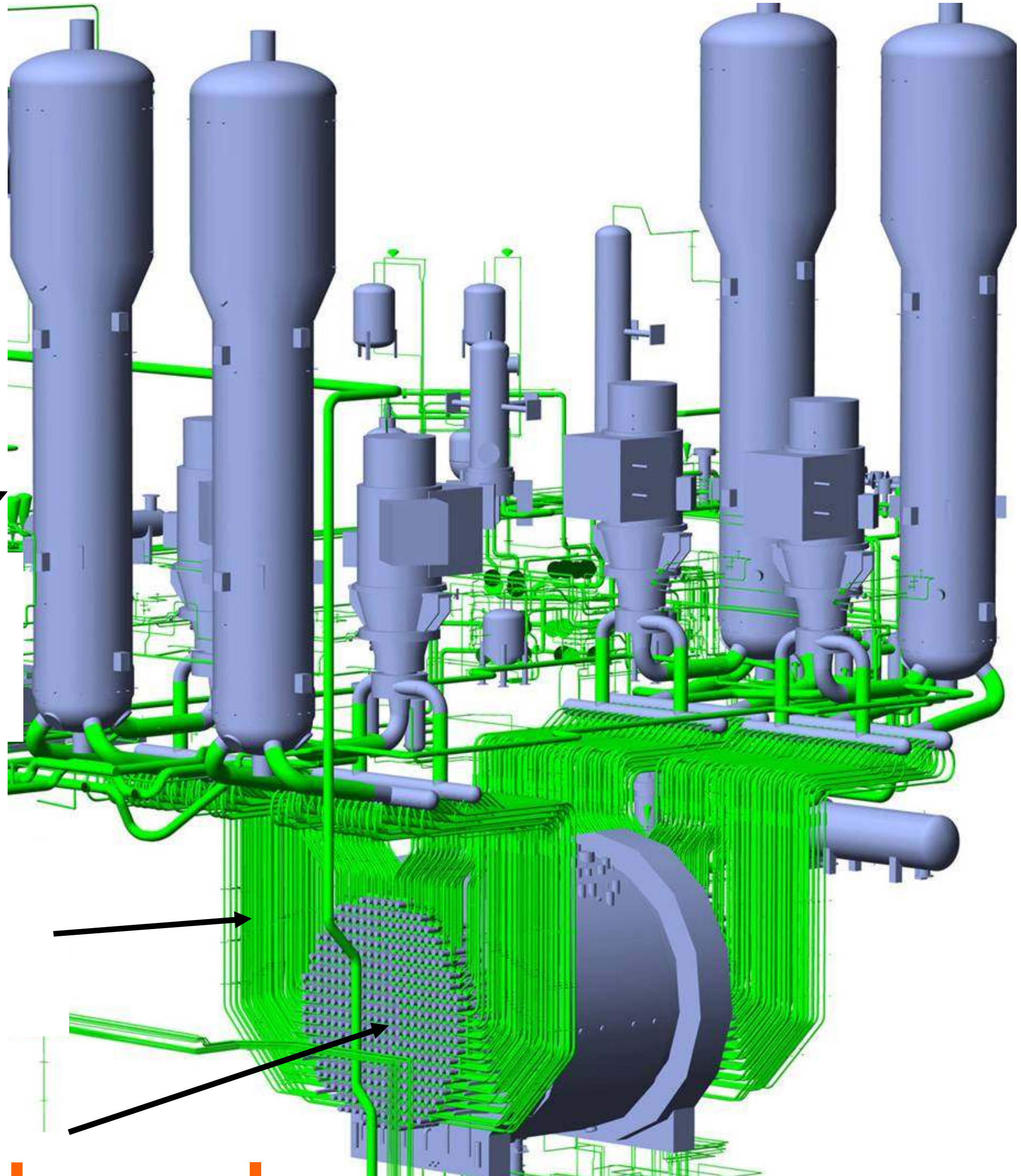
Serious RCS Degradation → Early Refurbishment, 2008



Recirculating SGs

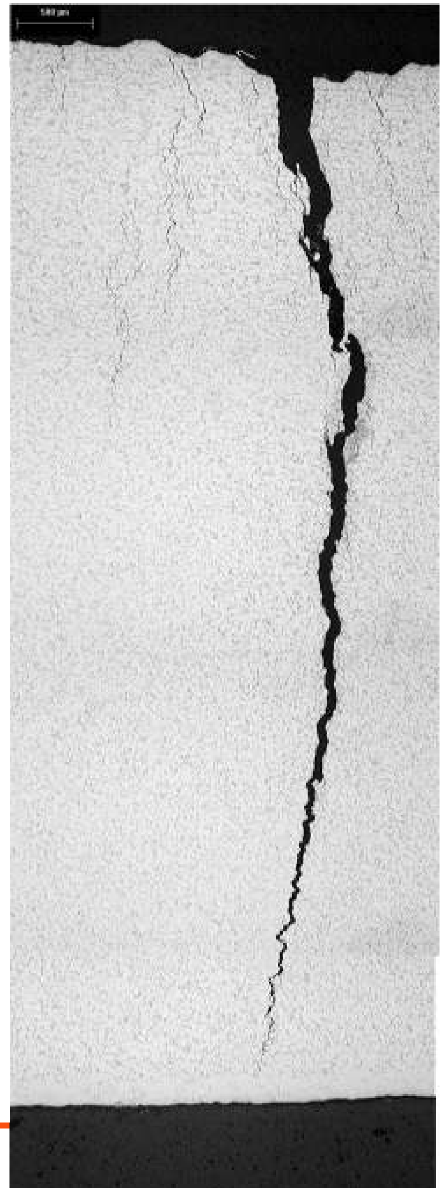
(alloy 800 tubing)

Carbon steel feeder piping

380 Zr alloy fuel channels

Feeder Degradation → Development of Aggressive AMP, 2003

- 18 bends replaced
- 2 forced outages
- Extended 2 planned outages
- Replacement energy ~50M$
- 3% annual O&M budget
- Increased radiation exposure
  - ~30% of total outage exposure
  - Key inspectors reach annual limit
- Increased stakeholder concern about rupture



Successful Feeder AMP…

- Reduced unplanned maintenance
- Incapability factor dropped from 5% to 1%
- Fewer emerging issues, allows focus on improvement initiatives
- Improved stakeholder confidence

→ *Similar approach for whole RCS*

AMP Approach

Based on review of industry best practices

- **Follows general principles common to many industry guidance documents**
  - **Use existing station processes based on INPO AP-913**
  - **Satisfy intent of NEI 03-08**

- **The key to success was a focus on implementation - *making plans easy to use***

Presentation Purpose

Share the most useful and practical features of the Point Lepreau RCS AMP

- *consider the end-user early in the development of AMPs*

Acknowledgements

Practical experience implementing aging management activities:

Southern Nuclear, South Texas Project, Florida Power & Light, Beznau NPP, Biblis NPP, Palo Verde NPP, Ontario Power Generation, Gentilly-2 GS, Bruce Power, Babcock & Wilcox Canada, Dominion Engineering Inc., CNSC, EPRI, Point Lepreau GS, AECL.

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Key Features of the AMP

1. **Improved Integration of Management Activities**
2. **Improved Implementation of Technical Information**
3. **Application of Risk-Based Decision Making**

Focus on implementation – easy to use

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1. Integration of Management Activities – *the need:*

- Manage system-level degradation *(radiation fields, thermal performance...)*
- Manage requirements of system-operating activities *(chemistry control, warm-up procedures...)*
- Formal interfaces, clear responsibilities

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1. Integration of Management Activities

Using an RCS system-level plan

- **modelled after industry-defined mandatory requirement of NEI 03-08, *Guidelines for the Management of Materials Issues***

RCS Aging Management Plan

using NEI 03-08 Guidelines

Major Component Plans

- **Feeder Piping**
- **Fuel Channels**
- **Steam Generators**

Multi-System Programs

- **Periodic Inspection**
- **Fatigue**
- **Chemistry Control**
- **NDE, FAC, Vessels, Welds, Supports, etc.**

2. *Improved Implementation of Technical Information* *- the need:*

- AMPs not always used
  - Too lengthy
  - Include superfluous information
  - Practical information not included
- Key R&D results not always used in AMPs
  - Not communicated in a practical way

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Consistent, Easy-to-Use Plan Format

- **Follows existing station processes, based on INPO AP-913**
- **< 40 pages**
- **Information in easy look-up tables**
- **Contains practical information, e.g.**
  - ***Mandatory maintenance & regulatory commitments***
  - ***Clear acceptance criteria***
  - ***Maintenance activity scope, schedule***
  - ***Response plans***

Link between Degradation and Management Activity – from Feeder AMP

Degrad-ation Mechanism	Primary Strategy to Manage Degradation		
	Affected Components	**Management Option**	**Management Activities**
Flow Accelerated Corrosion	All outlet locations, especially tight radius bends & adjacent to Grayloc Hub	Inspection	Wall thickness measurements
		Repair	Replace components projected to thin below minimum acceptable thickness
		Chemistry Control	Control pHa to lower end of specification (10.2-10.4) to minimize FAC rate

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Key Factors Affecting Feeder Cracking

Primary Factors	Secondary Factors
Stress	
Residual Stress: Based on physical evidence from spare bends and cracked feeders.	**Operating Stress**: postulated to increase susceptibility. No physical evidence.
Material	
Cold Work/Hardness: associated with observed cracks.	**Ovality and Impurities**: Postulated, based on operating experience and literature.
Environmental	
Temperature: Cracks only in outlet feeders where temp is 40°C higher than in inlets. Consistent with proposed mechanism.	**FAC-generated hydrogen**: Consistent with all crack locations **Oxidizing Species and Impurities**: Based on literature and test results

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Response Plan to Feeder Crack Inspection Findings

Cracked Feeders in 2007	Max. Crack Length	Condition Assessment Valid	Impact on Inspection and Maintenance Strategy
Reportable Cracks in Outlet Tight Radius Bends:			
0-6	~25mm	Yes	No supplementary activities or changes to the plan required.
>0	>30mm	Review required	Characterize indications after feeders are removed. Depending on the severity ofcracking, re-assess the validity of the condition assessment prior to reactor restart.
Reportable Cracks in Inlet Bends:			
>0	N/A	No	Expand scope to all inlet 1st & 2nd bends; perform operational assessment prior to reactor restart.

3. Application of Risk-Based Decision Making - the need

- **means to allocate resources for maximum benefit**
  - **for activities in a single plan**
  - **to allocate resources between plans**

Concept of risk-reduction

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Concept of Risk Reduction considers:

- Reduction in risk of degradation by the management activity
- Consequential costs of the management activity ($cost, worker hazards, risk of additional damage…)
- Likelihood that the activity will be successful

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Evaluating risk reduction provided by management activities

- **Risk Management Index**
  - *- qualitative comparison*
- **Calculated Change in Severe Core Damage Frequency, PSE**
  - *- quantitative comparison*

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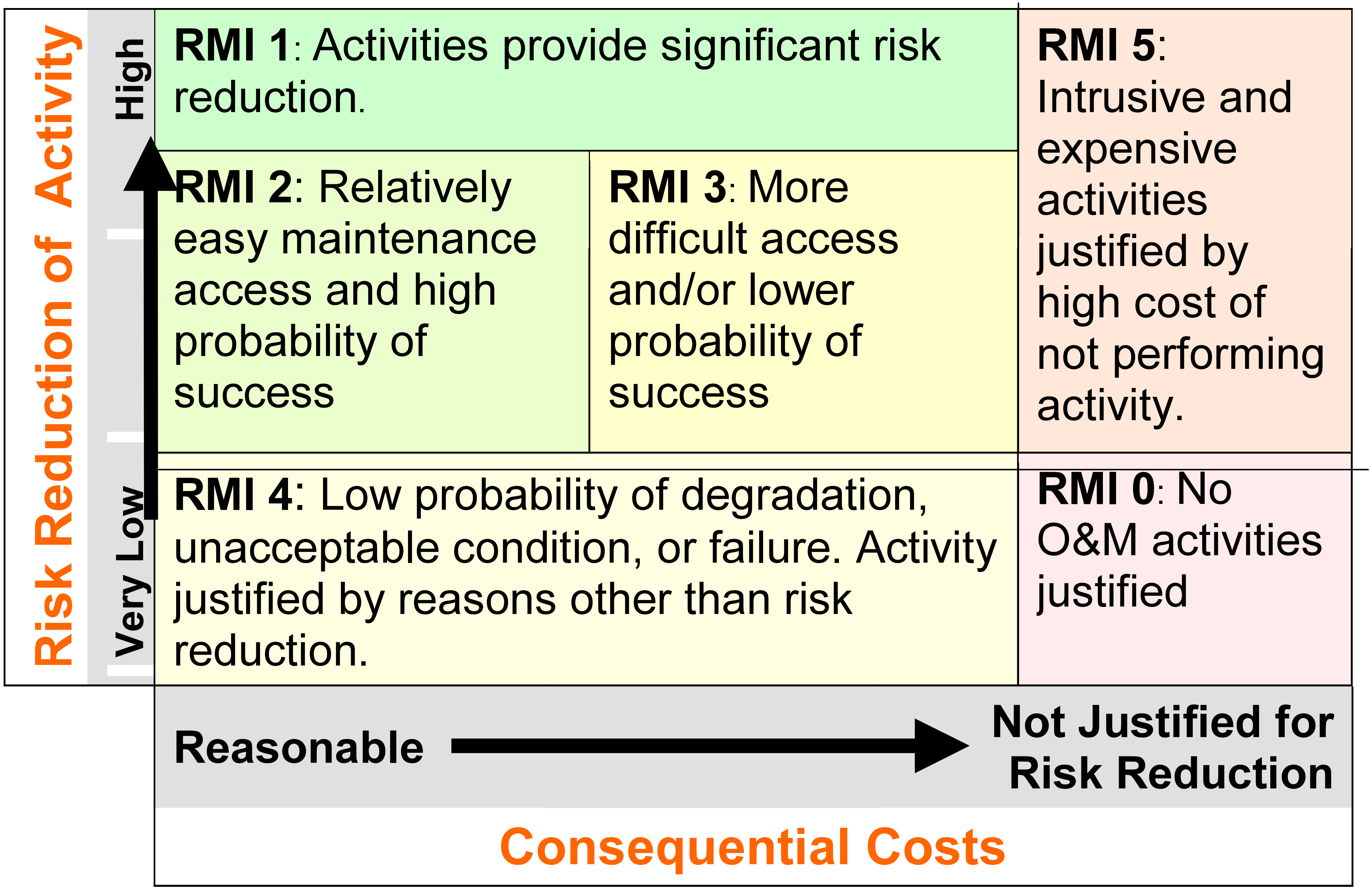
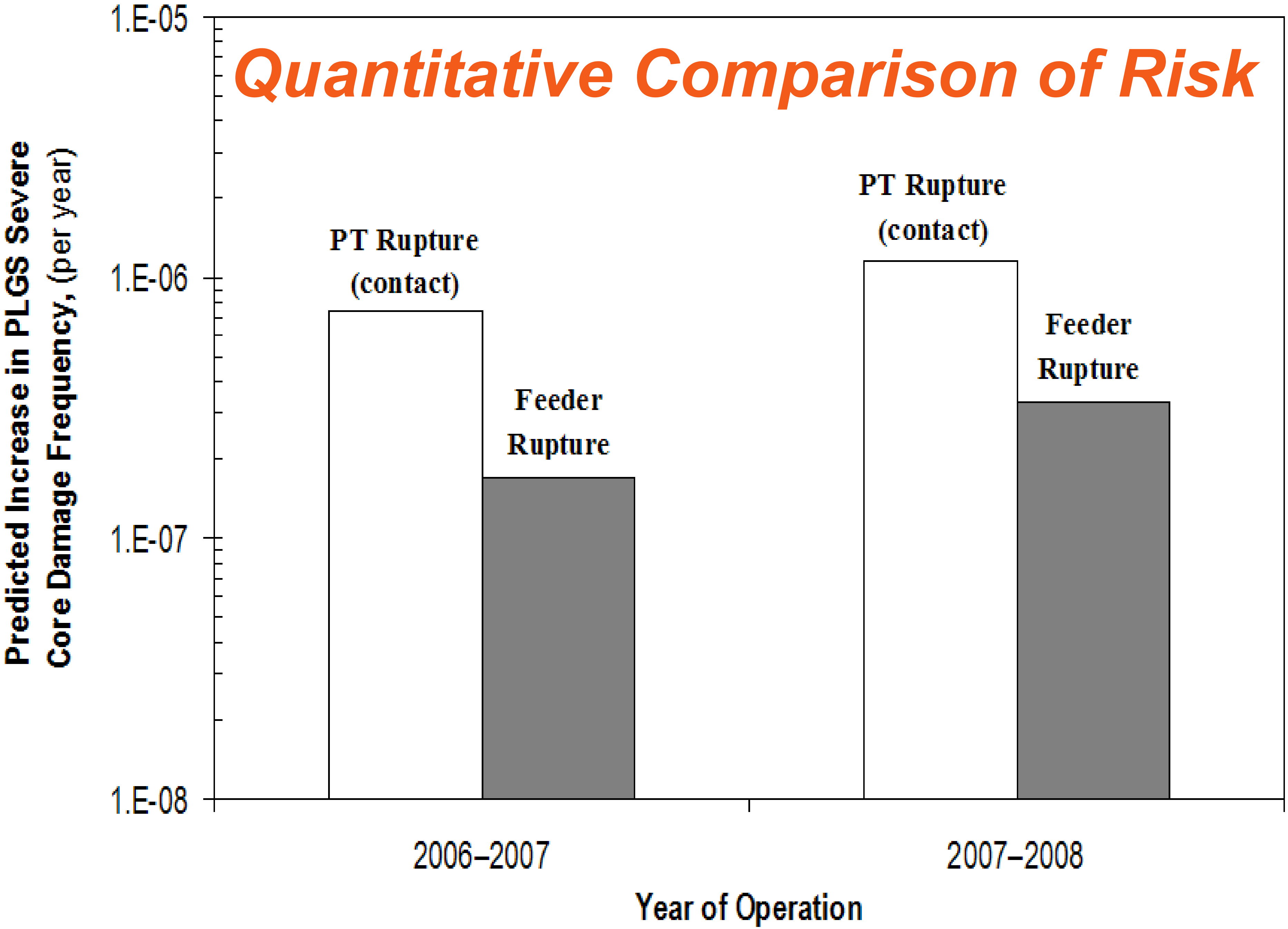


Risk Management Index



Quantitative Comparison of Risk
1.E-05
1.E-06
1.E-07
1.E-08
Predicted Increase in PLGS Severe Core Damage Frequency, (per year)
PT Rupture (contact)
Feeder Rupture
PT Rupture (contact)
Feeder Rupture
2006–2007
2007–2008
Year of Operation

3. Concluding Remarks

Tangible benefits of program since 2003:

- less unplanned maintenance
- fewer emerging issues
- improved stakeholder confidence

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3. Concluding Remarks

Success attributed to:

- **considering the challenges that station engineers face in using these plans, early in their development**

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