EPRI Research on Flow-Accelerated Corrosion and Erosion in Nuclear Power Plants

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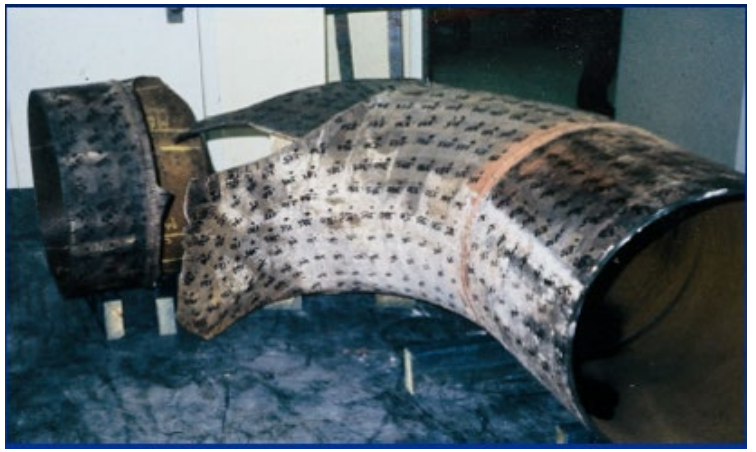
EPRI Recommendations for an Effective FAC Program

- Limited FAC programs in place before the 1986 Surry pipe rupture
- The U.S. NRC required utilities to submit information on their FAC programs, and provided criteria to evaluate them:
  - NRC Generic Letter 89-08 “Erosion-Corrosion-Induced Pipe Wall Thinning”
  - NUREG-1344 “Erosion/Corrosion Induced Pipe Wall Thinning in U.S. Nuclear Power Plants”
- EPRI site visits in the early 1990s identified the need for programmatic recommendations, resulting in NSAC*-202L
  - Provides consistent, industry-wide recommendations
  - Supports the requirements of NRC GL 89-08

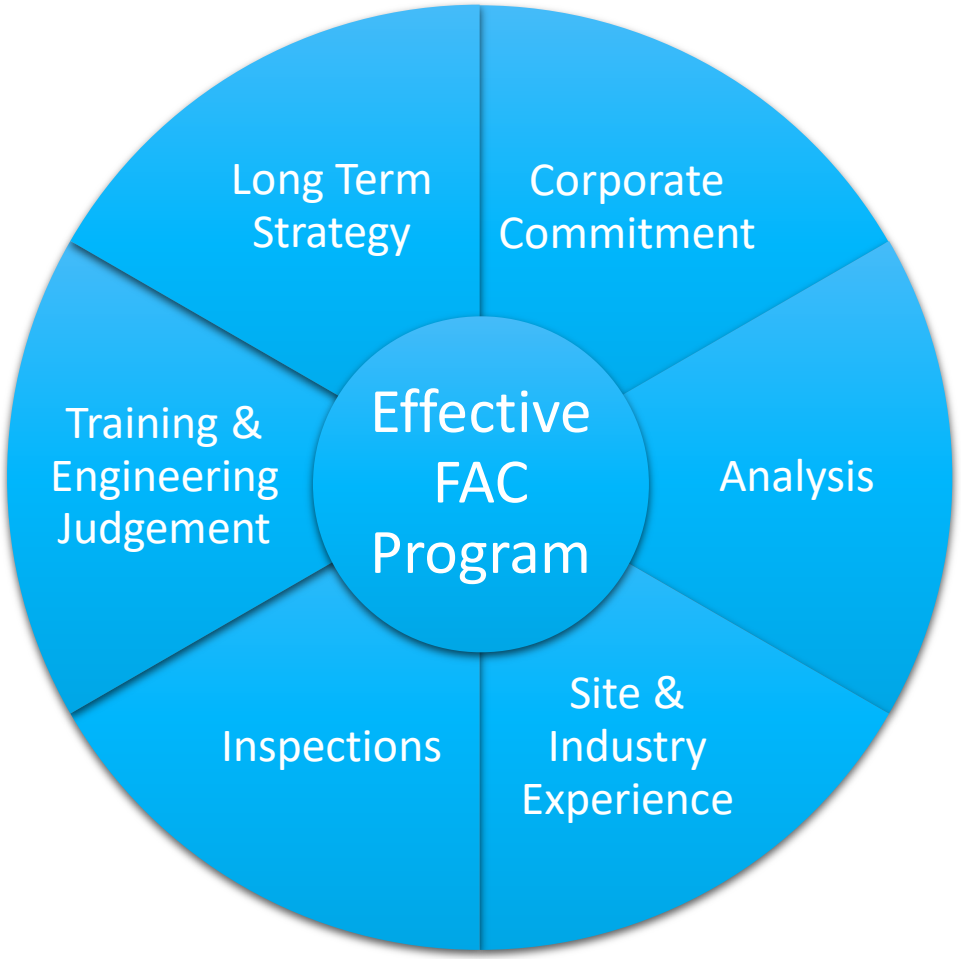


Nuclear Safety Analysis Center (NSAC) operated by EPRI

What's inside NSAC-202L?

1 - Introduction
2 - Elements of an Effective FAC Program
3 - Procedures and Documentation
4 - Recommendations for FAC Tasks
5 - Development of a Long-Term Strategy
6 - References

A - Recommendations for Small-bore Piping
B - Recommended Program for Vessels and Equipment
C - Most Significant FAC Experience Events
D - Historical Background
E – CHUG Position Papers



Recommendations for an Effective Flow-Accelerated Corrosion Program (NSAC-202L-R4). EPRI, Palo Alto, CA: 2013. 3002000563.

Background

- Recommendations are periodically reviewed to determine whether revision is warranted.
- Potential changes may result from:
  - Operating experience
  - R&D results
  - Regulatory actions
  - Member comments
  - Industry changes
  - Technology improvements

Revision 0 – November 1993
Revision 1 – November 1996
Revision 2 – April 1999
Revision 3 – May 2006
Revision 4 – November 2013

- An industry meeting to determine whether a revision is warranted was held in June 2024.

Revision of the guidance will begin in 2025

Managing FAC Beyond 80 Years

- Evaluate the exclusion criterion for low operating time.

> • Systems or portions of systems with no flow, or those that operate less than 2% of plant operating time (low operating time); or single-phase systems that operate with temperature > 200°F (93°C) less than 2% of the plant operating time. Caution—if the actual operating conditions of the system cannot be confirmed (e.g., leaking valve, time of system operation cannot be confirmed), or if the service is especially severe (e.g., flashing flow), that system should not be excluded from evaluation based on operating time alone. A further caution—some lines that operate less than 2% of the time have experienced damage caused by FAC. These lines include Feedwater Recirculation, startup condensate lines, High Pressure Coolant Injection (HPCI), by-pass lines to the condenser, and Reactor Coolant Inventory Control (RCIC). Such lines should be excluded only if no wear has been observed and continued operation under existing parameters is assured. Balancing lines between normally flowing lines should not be excluded based on this criterion.

Recent OE may result in an addition exception.

Application of AI and Machine Learning

- EPRI report 3002023922 trained model using 27,000 measurements from 48 units.
- Initial results on a component basis showed apparent statistical improvements
- Significant benefits are not observed for quantitative modeling when using standard FAC metrics
- Risk ranking of susceptible-not-modeled (SNM) was improved upon based on measured wear rate.

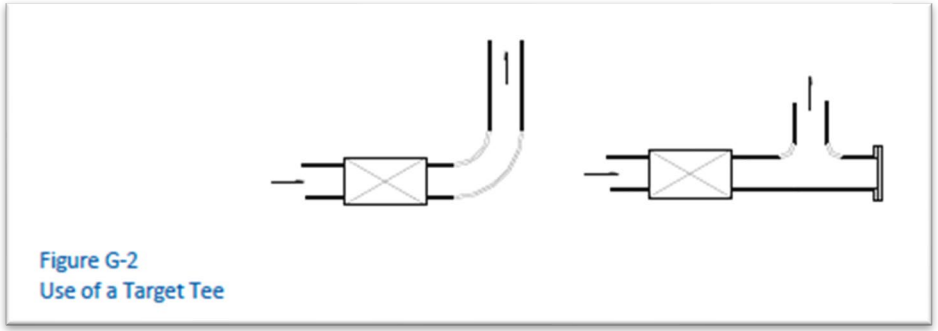
Future Work

- The quantitative model can be refined to:
  - Better represent known effects of factors
  - Provide results for each operating cycle
  - Provide results for lifetime wear
  - Use only validated databases
  - Account for plant type (PWR, BWR, CANDU)
- SNM risk ranking can be improved by:
  - Identifying high and low priority data to prioritize components with high consequence of failure
  - Screening out data on the low end of the wear rate range in which measurement error has a larger impact than actual wear
  - Training with a larger dataset until the learning curves plateau

Erosion

Erosive Mechanisms

- Guidance in EPRI 3002023786, "*Recommendations for an Effective Program Against Erosive Attack*," is used to manage erosion mechanisms.
- Published April 2023.
- Key elements are similar to FAC Programs
  - Corporate Commitment
  - Analysis
  - Operating Experience
  - Inspections
  - Training and Engineering Judgment
  - Long-Term Strategy



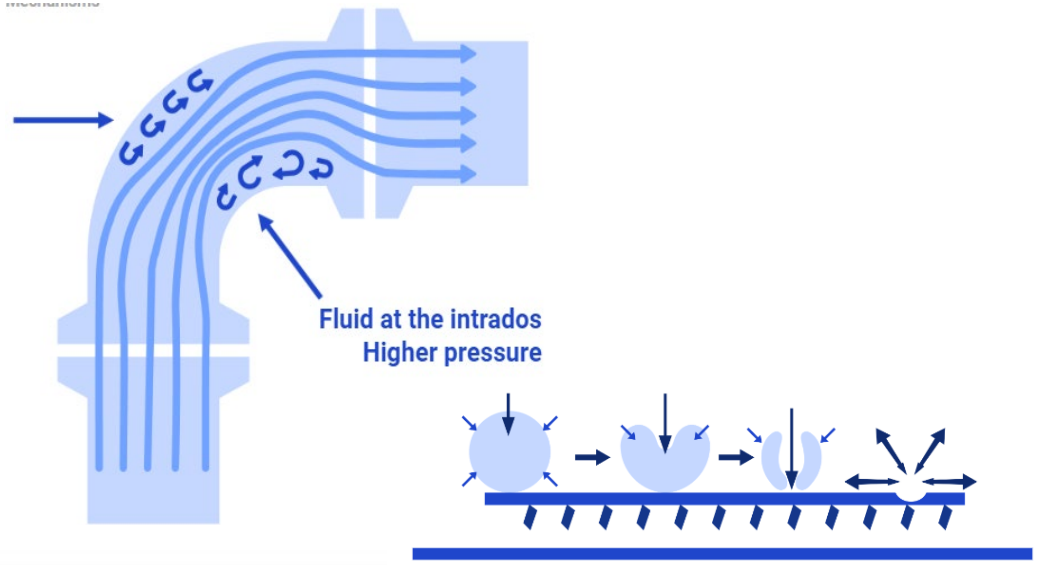
Erosion has been increasing in importance relative to FAC

Erosion Research

- *Erosion State-of-the-Fleet Assessments*
  - *Utility assessments were important for the development and improvement of NSAC-202L*
  - *Self-assessment guidance similar to CHUG Position Paper 7 will be developed.*
  - *Learnings will be distributed similar to State-of-the-Fleet Assessment of FAC Program Effectiveness* (3002015065)

Computer Based Training Module: Erosion in Piping Systems and Components

- Product ID 3002029269
- This two-hour course presents a series of 8 modules related to erosion in piping systems



Conclusions

- Guidance in EPRI 3002000563, "*Recommendations for an Effective Flow-Accelerated Corrosion Program (NSAC-202L-R4),*" can continue to be used to manage FAC.
- Guidance in EPRI 3002023786, "*Recommendations for an Effective Program Against Erosive Attack*, Revision 1" can continue to be used to manage erosion mechanisms.
- Recommendations are periodically reviewed to determine whether revision is warranted based on operating experience, R&D results, regulatory actions, and other industry changes.

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