Fitness for Service for Critical Components in the Energy Industry

Examples of Major Component Fractures

- Establish a technically acceptable, workable framework for assessing Fitness for Service
- Use this Framework to specify methods of assessment for critical components with consideration of the responsible damage mechanism
- Ensure critical review from independent experts
- Application of high-quality engineering methods to decrease risk and increase value for all stakeholders in the energy industry
- Transfer important learnings and/or simplified approaches to the relevant Code or Standard

Key Research Questions

- Why do cracks develop in components designed to conservative construction codes or standards?
- Why do some of these cracks propagate rapidly increasing the risk to catastrophic failure?
- Will the method used to disposition damage ensure safe and reliable operation?
- Can the confidence in run/repair/replace be increased for plants operating in flexible operating modes?

Background

It is apparent that Design Codes which are based on the simplistic approach of *Design by Formula* can NEVER provide knowledge regarding when and how fracture will occur. Indeed, the foreword of the *ASME B&PV Code Section I, Rules for Construction of Power Boilers*, indicates that the rules in isolation cannot prevent failures. This document specifically emphasizes that in addition to the Code requirements, informed engineering assessment should be used when designing boiler components. An excerpt from the foreword to ASME B&PV Code Section I, provided below, states the limitations:

> *"The objective of the rules is to afford reasonably certain protection of life and property and to provide a margin for deterioration in service to give a reasonably long, safe period of usefulness."*

The uncertainties regarding in-service performance have resulted in the development of engineering approaches for assessing the behavior of high energy components including API-579/ASME FFS-1, BS-7910, etc. These methods are based predominantly on information generated over 30 years ago. It is therefore essential to undertake a comprehensive evaluation to assess and reaffirm and/or optimize the relevance of current methodologies and for scenarios of specific concern to the energy industry.

An overriding concern with the present approaches for evaluating component integrity is that the procedures are general in nature. The lack of specific details means that assumptions and interpretations are necessary to facilitate an assessment. Ultimately, the validity of the methodology is critically dependent on the expertise of the responsible engineer(s) or contracted services, the referenced materials property databases and the specific details of the component and/or damage leading to the need for the assessment.

Objective

This project will develop a modern, technically rigorous framework for Fitness for Service (FFS). The materials property data vital to support the process will be established and used to underpin custom methods to assess the integrity of the component for a damage specific scenario. Project partners will identify critical components, damage mechanisms and prioritize the development of the framework on this basis.

Approach

The project will build on existing collaborations to ensure strong engagement of all project participants and relevant stakeholders in the energy industry. Establishing component specific FFS methods will involve the following key stages:

- Establish a project review panel of technical experts;
- Develop the necessary materials property data to underpin the FFS methodology. Data will include new, aged and/or service damaged conditions linked to the specifics of the component and damage mechanism.
- State the requirements regarding installation of instrumentation, the acquisition of data linked to operating scenarios and the analysis of the results to provide sensible inputs for engineering.
- Provide basic guidance and limitations for commercially available inspection techniques to size the length, depth and nature of present defects.
- Recommend how modern computer methods should be used to reduce uncertainty in the local stress state of the component. In general, for high temperature components the relevant stress state will be determined by either an elastic plastic or an inelastic creep analysis.
- Address where, when and how the specific component will fail. This will include consideration of leak or break and seek to ensure designs are damage tolerant.
- Transfer learnings into globally relevant codes and/or standards using simplified, conservative analyses which support the EPRI integrated life management approach.

Research Value

Catastrophic fractures are significant personnel safety hazards and incur very high economic consequences. A validated predictive capability provides an essential engineering tool for FFS because it is impossible to consider every scenario through practical demonstrations. Establishing key links between critical crack size and relevant material property data in the new, aged or damaged condition will reduce the uncertainty in the assessment of component integrity when employing the recommended methods for FFS. If successful, this project will provide a simplified framework for FFS that can be incorporated into common post-construction codes or standards.

Deliverables

The expected list of deliverables will support the adoption of fitness for service methodologies considering relevant details for component-specific and damage-specific characteristics. A reported detailing 'a comprehensive methodology for fitness for service of at-risk plant components' will be published and members will meet 1-2X/year to provide guidance on the project priorities. In addition, the report will contain detailed recommended practices for certain components. The components that will be chosen to be included in the report will be based on project funder feedback and the amount of funding that is available in the project.

Price of Project

The project is $30,000 per year for a total commitment over the 4 years of $120,000. The project qualifies for Self-Directed Funding (SDF) and Tailored Collaboration (TC).

Project Schedule

The current phase of the project will take 48 months.

Who Should Join

The outcomes from the project are critical to all stakeholders in the energy industry. The knowledge created will provide the basis for safe, cost-effective operation of critical equipment and for decisions involving investment in inspections and monitoring. The risk to catastrophic failure is generally greater in older plants or in equipment subjected to cyclic operation. However, all high energy equipment which has not been evaluated using established engineering methods should be considered for analysis.

Contact Information

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