ISSUE STATEMENT

The ASME Code Section III design rules for piping and components have analytical requirements to prevent fatigue failures during service for a 40-year design life. The design analysis procedures for computing a cumulative fatigue usage factor (CUF) incorporate the design cyclic stresses and fatigue design reference curves to safeguard against crack initiation for the materials of construction. There has been extensive technical debate within ASME on the best method for updating the fatigue design curves to explicitly account for environmental factors that can affect the fatigue life and the CUF calculations. As a result, the ASME Code process has not been able to obtain a consensus position on the issue, and comprehensive code revision has been slow in development. The U.S. NRC has published regulatory guidance based on laboratory results obtained by their contractors and collaborators to address environmental effects; the documents include Regulatory Guide 1.207 and NUREG/CR-6909. This guidance has resulted in difficulties in demonstrating acceptable fatigue usage for both new plant design and license renewal approval.

DRIVERS

Regulatory Impact on New Plant Designs and License Renewal Plants

The lack of definite design rules creates uncertainty for both new plants and operating plants where design compliance must be shown for the extended operating period (significant uncertainty for potential 80-year life). To obtain acceptable fatigue usage factors, changes that increase design, construction, and operational costs without meaningful safety benefits may be required for previously certified designs, as well as designs currently under review by the NRC. Affected items in the design may include materials selection, piping thickness, fitting tolerances, and number and locations of piping supports. Additionally, for license renewal, there is uncertainty as to the requirements that may be imposed by NRC, because the scope of locations requiring environmental fatigue analysis is open to interpretation.

Overall Cost to Plant Owners

The impacts on new and license renewal plants will directly affect the overall cost to plant owners in the form of design, re-analysis, and hardware modifications. The application of environmentally assisted fatigue factors results in significantly higher CUFs for both new and existing plants. More detailed calculations are often needed to pass the screening criteria. For some utilities, additional fatigue monitoring may be required in order to demonstrate acceptable usage for the operating life of the plant. For new plants with early design certification, any significant changes to the design would require a re-evaluation of fatigue requirements, which can be costly and may affect license amendments and approval schedules.

Global Interest

Several non-U.S. organizations have been actively following environmentally assisted fatigue issues because 1) regulatory bodies worldwide tend to follow and take action consistent with the U.S. NRC, and 2) the ASME Code is often used as the governing design and operational basis for nuclear power plants. Moreover, several non-U.S. companies have been funding research and development on environmentally assisted fatigue solutions, including EDF, MHI, Rolls Royce, and KHNP.

RESULTS IMPLEMENTATION

Because this issue affects both operating and new plants, several EPRI programs will combine expertise and share final results. While conducting this work and upon its completion, EPRI intends to utilize the ASME Code process to support effective code revisions that resolve the fatigue issue. EPRI may also seek approval directly from the NRC in order to expedite implementation of new guidance for performing fatigue evaluations which include treatment of environmentally assisted fatigue. These actions will include:

- Publication of reports and related documents that form the technical basis of Code modifications in order to obtain code approval and regulatory acceptance.
- Development of EPRI guidance and proposed code cases that provide evaluation procedures for assessing fatigue environmental factors that are accepted by regulatory authorities.
- Promoting an understanding of new procedures to provide for consistency of application by nuclear plant vendors, construction firms, and utilities (new and operating plant owners).
- Supporting ASME Section III and XI code revisions that permanently include Environmentally Assisted Fatigue (EAF) procedures within the body of the code.

Regulatory bodies will participate in the development process and consider Code changes related to environmentally assisted fatigue via their membership in ASME Section III
and XI standards committees. A key objective is for the NRC to evaluate new and revised guidance for performing fatigue evaluations applicable to new plant design and license renewal, potentially endorsing EPRI guidance through a safety evaluation report and/or endorsing code cases through Regulatory Guides 1.84 and 1.147.

PROJECT PLAN

The work is divided into short-term and long-term solutions. Short-term activities are focused on limiting the scope of locations that require EAF analysis and providing guidance for performing EAF analyses consistent with current ASME and NRC requirements. Long-term activities include seeking a technical basis for significant changes to the current ASME and NRC requirements and implementing those changes. Both efforts are driven by the knowledge gap prioritization and roadmap described in the 2011 Technical Report Environmentally Assisted Fatigue Gap Analysis and Roadmap for Future Research -- Gap Analysis Report (Product ID 1023012) and the 2012 Technical Report Environmentally Assisted Fatigue Gap Analysis and Roadmap for Future Research -- Roadmap (Product ID 1026724).

Short-Term Activities

EPRI will engage the ASME Code working groups to develop new procedures that incorporate environmental factors for fatigue where required. The basic strategy is to first develop Code Cases that can be adopted by licensees, followed by code revisions. An EPRI-led expert panel was used to identify and prioritize EAF knowledge gaps. Members of this panel have participated in a voluntary effort to test current ASME code cases with guidance for performing environmental fatigue evaluations and provide comments and lessons learned. This effort provided input to update EPRI guidance for performing environmental fatigue evaluations as well as significant comments and recommended changes to the code cases.

EPRI Technical Report, Guidelines for Addressing Environmental Effects in Fatigue Usage Calculations (1025823) was published in 2012. EPRI has also documented a methodology for identifying the most limiting locations for EAF; a technical report was published in 2012 summarizing the results (Technical Report 1024995).

In 2013, efforts were undertaken to evaluate and reduce sources of excessive conservatism in EAF calculations. Reports documenting these results will be produced and, where appropriate, submitted to the NRC for approval. The U.S. NRC is expected to issue Revision 1 to NUREG/CR-6909 and Regulatory Guide 1.207 for comment in 2014. EPRI will coordinate industry review of these documents and follow their final publication.

Long-Term Activities

Final approval of code cases and proposed revisions to the code will require cooperation among ASME, industry participants, and the NRC. Further research is necessary to close the gap between predicted environmental effects on fatigue life and industry operating experience. Industry operating experience includes fatigue failures due to loads and transients that were not accounted for in the design; the industry has not identified failures due to lack of margin applied to the analyzed loads and transients. Long term research will address fatigue usage (cycling occurring prior to crack initiation), fatigue crack growth (crack extension after a fatigue crack initiates), and fatigue testing (of specimens and/or components) to provide the additional data needed to close the gap. The experimental effort will begin in the 4th quarter of 2013 with research focused on addressing high priority knowledge gaps and providing the inputs to subsequent testing on component-type specimens.

RISKS

• Existing data and information on environmentally assisted fatigue may be insufficient to support improvements to the ASME Code. Development of additional environmental fatigue data will take time and delay changes to the current guidance.
• Additional environmental fatigue data may not support the hypothesis that the current EAF methodology is overly conservative.
• The ASME Code committees may not approve code cases or code changes based on EPRI recommendations.
• NRC may not agree to the proposed EPRI guidance, code cases, or revised ASME Code procedures.
**RECORD OF REVISION**

This record of revision will provide a high level summary of the major changes in the document and identify the Roadmap Owner.

<table>
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<tr>
<th>REVISION</th>
<th>DESCRIPTION OF CHANGE</th>
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| 0 | **Original Issue:** August 2011  
**Roadmap Owner:** Letitia Midmore |
| 1 | **Revision Issued:** August 2012  
**Roadmap Owner:** Shannon Chu and Jean Smith  
**Changes:** Project plan updated to remove discussion of a completed project and reframe the descriptions in terms of short-term and long-term activities. |
| 2 | **Revision Issued:** August 2013  
**Roadmap Owner:** Jean Smith  
**Changes:** Updated flow chart to remove an unnecessary milestone and to revise the start date of EAF specimen testing and the end date of NRC revision of documents. |
| 3 | **Revision 3:** January 2014  
**Roadmap Owner:** Jean Smith  
**Changes:** Numerous editorial changes were made to the project plan to reflect the completion of work activities and to show proposed work. The flowchart reflects completed milestones and the initiation of laboratory efforts. |