Notice of Public Comment Period
Date: February 18, 2019

The U.S. Department of the Interior, Bureau of Safety and Environmental Enforcement (BSEE), is conducting an independent external peer review of a recent study entitled, *TAP 766: Characterizing the Behavior of Inconel Clad A387 Steel (ASTM A387 Grade F22, Class 2) in High Pressure-High Temperature, Corrosive Environments — Material Models for Fatigue and Fracture Properties of Inconel 625 Cladding–Final Report* (April 30, 2018). This peer review will aid BSEE in gathering input from the scientific community on the methodologies and results in this final report. Background information on BSEE's Technology Assessment Project (TAP) 766 study is provided below. More information regarding BSEE's peer review process is available at: https://www.bsee.gov/what-we-do/research/peer-review.

To provide for public involvement in this peer review process, BSEE is announcing and inviting written public comments on the scientific and technical merit of the final TAP 766 report. The final TAP 766 report is available on BSEE's TAP website located at: https://www.bsee.gov/research-record/tap-766-determination-fracture-and-fatigue-fracture-behavior-equipment-constructed-with-cladded-weld-materials.

The 6-week period for submitting written public comments begins on February 18, 2019 and extends through April 1, 2019. Written comments should be submitted on or before April 1, 2019. Relevant public comments within the BSEE Charge for the scope of this peer review (outlined below) and directly addressing the scientific and technical issues in BSEE's 12 Charge Questions (outlined below) will be provided to peer reviewers. BSEE may not be able to fully consider written public comments submitted after the April 1, 2019 due date.

Submit your comments, identified by name, contact (phone and/or e-mail), affiliation, by one of the following methods:

- **Mail:** Mark S. Kozak, Mechanical Engineer
  U.S. Department of the Interior
  Bureau of Safety and Environmental Enforcement
  Emerging Technologies Branch - Systems Reliability (SRS)
  45600 Woodland Road
  Sterling, VA 20166
- **Email:** bsee@endyna.com

Do not submit any information you consider to be Confidential Business Information (CBI) or other information whose disclosure is restricted by statute to BSEE electronically through email. If your comments contain any information that you consider to be CBI or otherwise protected, please contact the BSEE staff listed under **FOR FURTHER INFORMATION CONTACT** to obtain special instructions before submitting your comments.

BSEE Charge for the Scope of this Peer Review
In order to focus the peer review process effectively on BSEE's 12 Charge Questions, BSEE has carefully defined the scope of this peer review for the final report of the BSEE study entitled, *TAP 766: Characterizing the Behavior of Inconel Clad A387 Steel (ASTM A387 Grade F22, Class 2) in High Pressure-High Temperature, Corrosive Environments — Material Models for Fatigue and Fracture Properties of Inconel 625 Cladding–Final Report* (April 30, 2018). Your written comments should stay within the BSEE Scope defined below.

The scope of this peer review is focused only on the scientific and technical merit of the assumptions, inputs, methodologies, modeling, and results for the BSEE study entitled, *TAP 766: Characterizing the Behavior of Inconel Clad A387 Steel (ASTM A387 Grade F22, Class 2) in High Pressure-High Temperature, Corrosive Environments — Material Models for Fatigue and Fracture Properties of Inconel 625 Cladding–Final Report* (April 30, 2018). This peer review is scientific and technical in nature and includes reviewing the methods, assumptions, data quality, the strengths of any inferences made, and the overall strengths and limitations of the study. The scope of the peer review includes the material, fabrication, computations, testing, engineering factors, modeling, results, and final recommendations generated from the TAP 766 study. As such, public comments should focus on the scientific and technical merit of the TAP 766 study and be organized under BSEE's 12 Charge Questions outlined below.

The following are considered **Out-Of-Scope** for this peer review and will not be considered during this peer review process:

- General comments related to high-pressure high-temperature (HPHT) equipment or environments, because: 1) this peer review is focused only on the methods and approach for testing in a sour-gas environment under HPHT conditions that were used in the TAP 766 study referenced above, and 2) this peer review is focused on the standards that were used in the TAP 766 study referenced above (see Tables 3 and 4 in final TAP 766 report).
- Comments on, or suggestions for, alternative fatigue and fracture testing methods, except for comments on any omissions or errors identified in the specific material testing methods used for testing in a sour-gas environment under HPHT conditions in the TAP 766 study referenced above, because this peer review is focused on the research already completed for this TAP 766 study.
- Comments about API RP 17TR8. BSEE has completed a peer review for a previous BSEE study evaluating methods recommended by API RP 17TR8.
- Comments related to BSEE policies, decisions, or current or proposed BSEE regulations.

BSEE Charge Questions

1. Were the objectives of the study clearly defined (Section 1)? If not, what are your recommendations for improving the description of this study's objectives?

2. Were the analyses used for the pre-tested metallurgical analysis (Section 3) appropriately designed, clearly described, and adequately characterized? Were there any apparent strengths, weaknesses, omissions, or errors? Provide an explanation for your answers.

3. Were the analytical methods used for the Engineering Stress-Strain Tensile Testing (Sections 4.1, 5, and 6.1) appropriately designed, clearly described, and adequately characterized? Were there any apparent strengths, weaknesses, omissions, or errors? Provide an explanation for your answers.

- Were the test objects selected for analysis valid test objects to evaluate the material properties?
- Were the assessments of engineering safety factors for the cited methods/standards (Table 4) valid for the expected applications in HPHT corrosive (sour gas) environments?
- Were the computational methods and research design clearly defined, accurate, and appropriate for this material testing method?

- Were the material testing methodology and underlying assumptions clearly defined, accurate, and appropriate?

4. Were the analytical methods used for the Slow-Strain-Rate Tensile Testing (Sections 4.2, 5, and 6.2) appropriately designed, clearly described, and adequately characterized? Were there any apparent strengths, weaknesses, omissions, or errors? Provide an explanation for your answers.

- Were the test objects selected for analysis valid test objects to evaluate the material properties?
- Were the assessments of engineering safety factors for the cited methods/standards (Table 4) valid for the expected applications in HPHT corrosive (sour gas) environments?
- Were the computational methods and research design clearly defined, accurate, and appropriate for this material testing method?
- Were the material testing methodology and underlying assumptions clearly defined, accurate, and appropriate?

5. Were the analytical methods used for the Bent Beam Stress Corrosion Cracking (SCC) Testing (Sections 4.3, 5, and 6.3) appropriately designed, clearly described, and adequately characterized? Were there any apparent strengths, weaknesses, omissions, or errors? Provide an explanation for your answers.

- Were the test objects selected for analysis valid test objects to evaluate the material properties?
- Were the assessments of engineering safety factors for the cited methods/standards (Table 4) valid for the expected applications in HPHT corrosive (sour gas) environments?
- Were the computational methods and research design clearly defined, accurate, and appropriate for this material testing method?
- Were the material testing methodology and underlying assumptions clearly defined, accurate, and appropriate?

6. Were the analytical methods used for the Fracture Toughness Testing (Sections 4.4, 5, and 6.4) appropriately designed, clearly described, and adequately characterized? Were there any apparent strengths, weaknesses, omissions, or errors? Provide an explanation for your answers.

- Were the test objects selected for analysis valid test objects to evaluate the material properties?
- Were the assessments of engineering safety factors for the cited methods/standards (Table 4) valid for the expected applications in HPHT corrosive (sour gas) environments?
- Were the computational methods and research design clearly defined, accurate, and appropriate for this material testing method?
- Were the material testing methodology and underlying assumptions clearly defined, accurate, and appropriate?

7. Were the analytical methods used for the Fatigue Testing (Sections 4.5, 5, and 6.5) appropriately designed, clearly described, and adequately characterized? Were there any apparent strengths, weaknesses, omissions, or errors? Provide an explanation for your answers.

- Were the test objects selected for analysis valid test objects to evaluate the material properties?
- Were the assessments of engineering safety factors for the cited methods/standards (Table 4) valid for the expected applications in HPHT corrosive (sour gas) environments?
- Were the computational methods and research design clearly defined, accurate, and appropriate for this material testing method?

- Were the material testing methodology and underlying assumptions clearly defined, accurate, and appropriate?

8. Were the analytical methods used for the Fatigue Crack Growth Rate (FCGR) Testing (Sections 4.6, 5, and 6.6) appropriately designed, clearly described, and adequately characterized? Were there any apparent strengths, weaknesses, omissions, or errors? Provide an explanation for your answers.

- Were the test objects selected for analysis valid test objects to evaluate the material properties?
- Were the assessments of engineering safety factors for the cited methods/standards (Table 4) valid for the expected applications in HPHT corrosive (sour gas) environments?
- Were the computational methods and research design clearly defined, accurate, and appropriate for this material testing method?
- Were the material testing methodology and underlying assumptions clearly defined, accurate, and appropriate?

9. Do the FCGR material modeling results (Section 6.6) describe with reasonable accuracy the basis for decisions in the two mathematical models used:

- Were the assumptions clearly defined, accurate, and appropriate for the methods of modeling used for this study?
- Were the limitations and uncertainties clearly identified and adequately characterized for the methods of modeling selected?
- Did the report identify and adequately address the strengths or weakness of the analytical methods used for modeling?

Provide an explanation for your answers for each model used:

1) Paris Law FCGR Material Models
2) Walker Equation FCGR Material Model

10. Were the conclusions based on the TAP 766 study findings in the report (Section 8) logical and appropriate based on the material testing and FCGR material modeling results? Were the other conclusions related to the material testing appropriate? Provide an explanation for your answers.

11. Were the recommendations (Section 9, Appendix A) logical, appropriate, and supported by the conclusions of the material testing results, empirical analysis, and FCGR material modeling results? The scope of the recommendations pertains to all recommendations, not just those derived from the FCGR material modeling results. Provide an explanation for your answers.

12. Are there any additional study findings or conclusions that could be drawn from the material testing and FCGR material modeling results? Provide an explanation for your answers.

Background on TAP 766 Study

BSEE's Technology Assessment Program (TAP) Project 766, awarded in 2015, applied physical material testing with finite element analysis (FEA) modeling to predict material performance in a specified high pressure-high temperature (HPHT), corrosive environment.

Offshore oil and gas drilling and production operations are occasionally conducted in high-pressure (≥15,000 psi) high-temperature (≥350°F) (HPHT), and highly corrosive (H_2S, Cl, S, and CO_2) conditions.

These harsh environments pose operational challenges for equipment currently used by the oil and gas industry. The purpose of TAP 766 was to conduct physical material testing and develop a modeling tool to predict the component failure modes and define fatigue and fracture behavior of a weld-overlay clad material in HPHT, sour gas environments. The objective of the experimental work was to measure the following fatigue and fracture properties of nickel-based Inconel® 625, which had been cladded to a steel alloy ASTM International (ASTM) A387 Grade F22, Class 2 (A387) substrate plate:

- Stress corrosion cracking,
- Fracture toughness,
- Cyclic fatigue, and
- Fatigue crack growth rate (FCGR).

In addition, this study developed fatigue and FCGR models (i.e., mathematical equations) suitable for numerical simulations. Such material models are often required for accurate hand calculations or numerical simulations of equipment to predict response during fatigue or fracture events.

BSEE considers this study to be a highly influential scientific assessment.

FOR FURTHER INFORMATION CONTACT:

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