BUREAU OF SAFETY AND ENVIRONMENTAL ENFORCEMENT

PEER REVIEW SUMMARY REPORT OF SUBSEA BOLT STUDY: TECHNICAL GAPS IN CURRENT STANDARDS AND REQUIREMENTS

FEBRUARY 13, 2023

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REPORT
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WSP USA ENVIRONMENT & INFRASTRUCTURE, INC.

104 WEST ANAPAMU STREET, SUITE 204A
SANTA BARBARA, CA 09310

T: +1 805-962-0992
F: +1 805-966-1706

WSP.COM

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Prepared by	Dawn L. Johnson, PhD and Nina Woolsey	Dawn L. Johnson, PhD and Nina Woolsey	Dawn L. Johnson, PhD
Signature			
Reviewed by	Carol Turner (WSP), Peer reviewer (Robert Kelly)	Bipin Patel	
Signature	n/a	n/a	
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ACRONYM LIST

ANL	Argonne National Laboratory
ANSI	American National Standards Institute
API	American Petroleum Industry
ASME	American Society of Mechanical Engineers
ASTM	American Society for Testing and Materials
BSEE	Bureau of Safety and Environmental Enforcement
COI	conflict of interest
DOI	Department of Interior
HPHT	high-pressure and high-temperature
NDA	nondisclosure agreement
OMB	Office of Management and Budget
WSP	WSP USA Environment & Infrastructure, Inc.

1 EXECUTIVE SUMMARY

The Bureau of Safety and Environmental Enforcement (BSEE) provides oversight of safety and environmental compliance related to offshore resources. As part of their commitment to safety, BSEE contracted Argonne National Laboratory (ANL) to provide a comprehensive gap analysis of standards relating to subsea bolts and fasteners. Historic failures related to these critical industrial subsea components continues to threaten offshore worker safety and sensitive environmental resources. The study compiled and contrasted relevant standards from several sources. These included the American Petroleum Industry (API), American National Standards Institute (ANSI), American Society of Mechanical Engineers (ASME), and American Society for Testing and Materials (ASTM) as well as about six other sources. The study concluded with identified gaps and recommendations. Conclusions from the gap analysis study are considered "influential" scientific deliverables and require a stringent peer review process.

The peer review process consisted of selecting three reviewers with expertise that aligned with the final report and associated appendices. The panel of peer reviewers were chosen for their diverse perspectives and broad range of technical expertise in mechanical engineering, materials science, oil and gas industrial processes, mechanical testing for material fatigue, corrosion behavior, and high-pressure and high-temperature (HPHT) offshore equipment design. All peer reviewers were vetted to ensure independence and no conflicts of interest.

Reviewers each provided an overall assessment of the study, including answering specific questions regarding the study's methods and assumptions, data analysis, and conclusions. Generally, the reviewers agreed that the study included enough standards to provide a sufficient gap analysis. Most reviewers noted that the study clearly identified limitations and conclusions and recommendations were valid for the scope of work stated. Most comments were positive with only a few minor suggestions including using a broader range of industrial stakeholders upfront (as opposed to the researchers being solely responsible for determining what materials to include), automating the electronic document process to streamline the methods, and using more key search words.

Although the reviewers provided many constructive comments and suggestions, they were not asked to endorse the conclusions or recommendations of this report.

This peer review complied with the BSEE Peer Review Handbook (2017) and the Office of Management and Budget (OMB) Final Information Quality Bulletin for Peer Review (2004; https://georgewbush-whitehouse.archives.gov/omb/memoranda/fy2005/m05-03.html). This peer review was also governed by the Department of Interior (DOI) Information Quality Standards, DOI Department Manual 305 DM 3 (Integrity of Scientific and Scholarly Activities), and Executive Order 12866.

2 BACKGROUND

The Bureau of Safety and Environmental Enforcement (BSEE) provides oversight of safety and environmental compliance related to offshore resources (more information at https://www.bsee.gov/). BSEE uses peer reviews to provide independent scientific reviews of research and studies. The research and studies, along with the peer reviews, help inform regulatory changes and improve the methods and technologies used for managing offshore energy facilities.

Offshore oil and gas drilling and production include operations in harsh conditions including high-pressure high-temperature (HPHT) and highly corrosive environments. BSEE regulations require that offshore oil and gas operators be able to demonstrate that their equipment can perform in HPHT environments. Bolt failures have occurred during oil and gas operations in the Gulf of Mexico in recent history. BSEE is incentivized to avoid incidents such as these and is researching several ways to identify and address root causes of these failures. One of these is a review of a snapshot of relevant bolt standards that apply to subsea equipment and the identification of standard gaps.

BSEE has completed a peer review of the 2018 *Subsea Bolt Study: Technical Gaps in Current Standards and Requirements* final report and associated appendices. The purpose of this peer review was to review and provide feedback on the study and associated methodology, with reviewers providing an overall assessment of the materials and responding to a set of charge questions. This peer review was technical and did not include commenting on any BSEE policies or regulations. Although the reviewers provided many constructive comments and suggestions, they were not asked to endorse the conclusions or recommendations of this study.

As part of the BSEE commitment to offshore safety, a gap analysis study was conducted on standards related to subsea bolts and fasteners. The project was contracted to Argonne National Laboratory (ANL) to conduct a literature review of applicable industry standards, compile/organize identified standards to identify information gaps and provide actionable recommendations. In this study, ANL identified gaps in the bolts standards or requirements that could lead to unsafe conditions in the Outer Continental Shelf. ANL mainly focused on alloy steel threaded fasteners because these have failed in recent history. They reviewed limited historic failure work for bolts subjected to different tensile loadings and extended subsea exposure. Relevant national and international standards were gathered from many organizations, such as the American Petroleum Industry (API), the American National Standards Institute (ANSI), the American Society of Mechanical Engineers (ASME), and the American Society for Testing and Materials (ASTM) among others. These were collected into a database and then researchers searched for themes and patterns and identified gaps in the standards. From these gaps, recommendations were provided.

The peer review was conducted from September 8, 2022, through December 19, 2022, and was managed by WSP USA Environment & Infrastructure, Inc. (WSP). The materials provided to the reviewers are listed in **Appendix 1**. The curricula vitae of the reviewers are provided in **Appendix 2**. The individual reviews are provided in **Appendix 3**.

3 PEER REVIEWERS

Peer reviewers were selected according to their relevant experience and expertise, as well as independence from BSEE or ANL. All peer reviewers were provided the language from the BSEE Peer Review Handbook (2017) and the Office of Management and Budget (OMB) Final Information Quality Bulletin for Peer Review regarding independence and conflict of interest (COI). Each peer reviewer completed a comprehensive COI form to identify any potential or actual conflicts; none were identified. Signed nondisclosure agreements (NDAs) were required before the reviewers received the materials.

3.1 IDENTIFICATION OF PEER REVIEWERS

Identifying and selecting appropriate peer reviewers is the first step in the peer review process. The WSP team reviewed the qualifications requested by BSEE, the materials to be reviewed, discussed the study with BSEE, verified the list of expertise and criteria for potential reviewers with BSEE, and determined where potential conflicts of interest could arise.

The WSP team used all this information to identify the appropriate balance of expertise and experience across the three-person review panel.

3.1.1 EXPERTISE AND BALANCE

Collectively, the expertise identified as necessary for this peer review included:

1. Mechanical engineering, material science, or metallurgical engineering;
2. Oil and gas industry background;
3. Experience with mechanical testing for evaluating material fatigue;
4. Corrosion behavior experience; and
5. Experience with offshore equipment design in high-pressure and high-temperature environments.

Additional criteria for selecting reviewers included:

1. No reviewers with the same affiliation;
2. One reviewer from outside the oil and gas industry;
3. Various perspectives on the issue considered;
4. At least five years of relevant experience; and
5. Publication and/or project experience relevant to the review.

For a peer review to be effective and provide the most comprehensive analysis, the panel must have a good balance of experts who not only cover the range of expertise and technical topics required but also a range of perspectives on the review material.

3.1.2 SELECTING REVIEWERS

Once a potential reviewer was identified, the WSP project manager contacted the individual, engaged in discussion about review expectations, proposed schedule, potential conflicts of interest, and compensation requests. These discussions varied from reviewer to reviewer. Once the reviewer confirmed interest and availability, the WSP project manager confirmed the acceptability of the reviewer with BSEE. The following list shows the various steps and dates for the reviewer selection process.

- Initial contact with reviewers: August 19 – September 7, 2022
- Discussion with reviewers about expectation, schedule, and COIs: August 19 – September 12, 2022

- Finalized reviewer selection and confirmed with BSEE: September 8, 2022
- Provided instructions to reviewers: September 8, 2022
- Receipt of NDAs and COIs and contractual items: September 8 – 23, 2022
- Delivery of review materials: September 8 – 23, 2022

3.2 EVALUATE CANDIDATES AND FINAL SELECTION

3.2.1 INDEPENDENCE

Initial evaluation of the independence of potential peer reviewers was based on current and past affiliations, co-authors on publications, and typical projects and their funding sources. This was further explored with each reviewer upon contact and as part of the COI process.

Discussions were undertaken with each peer reviewer once they acknowledged their interest, so they understood the reports and concerns about conflicts of interest. Potential conflicts of interest included any involvement in or known conflicts of interest with BSEE or Argonne National Laboratory (who authored the report). Finally, each peer reviewer was provided a COI form, based on the standard BSEE template, and were asked to disclose the following potential conflicts:

1. Disclose any potential relevant information regarding your involvement with the research product under review or its authors, developers, directors, or sponsors.

2. Disclose any relevant information related to your professional history.

3. Disclose any relevant information related to your financial interests.

4. Disclose any relevant information related to your public statements.

5. Disclose any relevant information related to your relationships.

6. Disclose any other relevant information regarding why you might be unable to provide impartial review of the research product.

One reviewer had prior interactions with BSEE as part of a National Academy of Science panel and report related to subsea bolts. This was not considered a conflict of interest as the reviewer has no conflicts related to the report subject to this peer review and the prior experience increased his ability to contribute to this review. No other known or potential conflicts of interest were reported.

3.2.2 LOGISTICS

Before the list of peer reviewers was finalized, timeline and availability were confirmed so that the reviewers knew the level of effort required. Any reviewers requesting compensation also provided their cost estimate. The list of confirmed reviewers was given to BSEE for final approval before providing materials to the reviewers.

The Charge Document (provided in **Appendix 1**) was provided to reviewers as part of this step. The Charge Document summarized the project history, the peer review focus, and the charge questions. It also summarized the logistics of the peer review process itself.

3.3 FINAL GROUP OF PEER REVIEWERS

The final selection of peer reviewers included the following three reviewers, with a summary of the expertise category they fulfilled, their current affiliation, and any additional relevant expertise included in **Table 1**. Full resumes for these reviewers can be found in **Appendix 2**. Reviewers were assigned a random number and their responses are provided referencing the assigned number, not by name.

Table 1. Final Group of Selected Reviewers and Relevant Key Expertise

	Brun Hilbert, PhD, PE	***Robert Kelly, PhD***	***Brian Pailes, PhD, PE***
Affiliation	Exponent, Inc.	University of Virginia	Vector Corrosion Services, Inc.
Years of Experience	40	30+	12+
Mechanical Engineering	Yes	-	-
Oil and Gas Industry Background	Yes	-	-
Material Fatigue	Yes	Yes	Yes
Corrosion Behavior	-	Yes	Yes
Offshore Equipment in HPHT Environments	Yes	-	-
General Expertise	Expert in mechanical and petroleum engineering, failure analysis, and hydraulic fracturing	Expertise in corrosion behavior	Expert in metal corrosion, material sampling and cathodic protection

4 OVERALL RESPONSE SUMMARY

Reviewers were asked to provide an overall assessment and respond to specific charge questions for the report and methodology. **Appendix 1** lists all the materials provided to the reviewers. A public comment review was initiated by BSEE on August 25, 2022, with the report posted on social media for one month. No comments were received. A videoconference with the peer reviewers and BSEE staff was completed on October 3, 2022, which allowed reviewers to ask questions about the report. WSP received individual reviewers responses starting October 31, 2022 and ending December 19, 2022.

This section contains an overall summary highlighting the key points for each reviewer. **Appendix C** provides the reviewers full responses with specific recommendations and additional details.

4.1 REVIEW OF THE SUBSEA BOLTS STUDY

4.1.1 REVIEWER 1

The study provided a great gap analysis of standards and serves as a good example to other industries to perform similar studies; however, a wider range of stakeholder input initially could have provided a more thorough review.

4.1.2 REVIEWER 2

The report does an excellent job of comprehensively organizing and linking the range of standards and providing strong support for all recommendations and conclusions. Consequently, the study provides a clear path forward to address standards gaps for a wide range of stakeholders.

4.1.3 REVIEWER 3

The methods, analyses, conclusions, and recommendations are appropriate for the scope of the study. The study was comprehensive, and the next step is to get overall industry feedback.

5 SUMMARIZED INDIVIDUAL RESPONSES

Reviewers were asked to provide an overall assessment and respond to charge questions for each report separately. Reviewers were provided with the Charge Document, which is provided in **Appendix 1**, along with the report. Reviewers had an opportunity to meet with BSEE and ask questions about the reports. Minutes from this meeting are also provided in **Appendix 1**.

This section summarizes the numerical ratings and each individual reviewer's response to each charge question. The summaries are brief synopsis of the typically much longer responses provided in Appendix C. These summaries highlight key points or themes from the reviewer and typically do not provide a great level of detail. **Appendix C** provides the reviewers full responses with specific recommendations and additional details.

5.1 RESPONSES TO THE SUBSEA BOLTS STUDY

As part of the individual responses, reviewers were asked to provide a numerical rating (1 = Unacceptable, 2 = Inadequate, 3 = Mixed, 4 = Good, 5 = Excellent) for most questions. This was only requested when a question was suited to numerical rankings; therefore, some questions do not appear on this table as a numerical rating did not make sense.

Individuals may use slightly different criteria for each level of numerical rating, but the overall pattern shown in **Table 2** clearly indicates that the reviewers overall felt the report was (4) good or (5) excellent, although there were a few areas that were considered (3) mixed by at least one reviewer. Questions were more than one reviewer rated "3" or less are flagged with the reviewers' summaries.

Table 2. Numerical Ratings for Each Question

REVIEWER #	*1*	*2*	*3*
Methods and Assumptions			
Question 2	4	5	5
Question 3	5	5	4
Question 4	5	4	5
Question 7	-	4	5
Question 8	5	4	5
Question 9	5	5	4
Question 10	-	5	-
Question 11	5	4	5
Data Analysis			
Question 12	4	5	4
Question 13	4	5	5
Question 14	5	4	5
Conclusions			
Question 15	4	5	4
Question 16	4	5	5

REVIEWER #	1	2	3
Overall Questions			
Question 19	4	5	4
Question 20	4	5	4
Question 21	5	5	5
Question 25	5	5	4
Question 26	5	5	5

5.1.1 METHODS AND ASSUMPTIONS SUMMARIES

QUESTION 1. ARE APPLICABLE SUBSEA CRITICAL DRILL-THROUGH EQUIPMENT OIL AND GAS AND BOLTING STANDARDS ADDRESSED? ARE THERE ANY OTHER RELEVANT STANDARDS THAT NEED TO BE ADDRESSED FOR THIS STUDY?

Reviewer 1: The standards used in the study were thorough. However, besides the keywords used, a word search using bolt composition materials (*e.g.,* low carbon steel, mild steels, stainless steels or nickel alloys) would provide corrosion specific standards. Also, more discussion may be needed regarding the tools used to tighten subsea bolts.

Reviewer 2: ANL did a comprehensive review of bolting standards while limiting their search to what was relevant.

Reviewer 3: The report appears to include all relevant publicly available data and is a comprehensive gap analysis of the standards.

QUESTION 2. ARE THE METHODS APPROPRIATE? WERE THE METHODS USED VALID FOR THE GOALS OF THIS STUDY PROJECT?

Reviewer 1: The methods used in the study appropriately determined standards gaps. However, perhaps a wider range of users could have been incorporated beforehand to make sure all possible gaps were covered and discussed.

Reviewer 2: The methods were appropriate and valid. Detailed, positive comments regarding the methods can be found in the full reviewer response in Appendix C.

Reviewer 3: The methods appear to be comprehensive and relatively easy to follow and are consistent with the narrative.

QUESTION 3. ARE LIMITATIONS AND UNCERTAINTIES CLEARLY IDENTIFIED AND ADEQUATELY CHARACTERIZED?

Reviewer 1: The authors clearly defined the limits of the study by addressing the extensive range of standards and how the study set limits on what standards were reviewed so that the document did not spiral out of scope.

Reviewer 2: The report clearly identified and described limitations and uncertainties, with none of the uncertainties critically impacting the conclusion.

Reviewer 3: The report clearly identifies limitations and adequately characterizes document sources, their content, and gaps.

QUESTION 4. ARE THE ASSUMPTIONS CLEARLY DEFINED AND APPROPRIATE?

Reviewer 1: The limitation on the literature review was defined and appropriate.

Reviewer 2: The report clearly stated the assumptions.

Reviewer 3: The authors clearly defined objectives and scope of the study and did a good job including relevant industries.

QUESTION 5. ARE THE STRENGTHS OF THE ANALYTICAL METHODS USED IDENTIFIED AND RELEVANT TO THE RESEARCH? ARE THE WEAKNESSES OF THE ANALYTICAL METHODS IDENTIFIED, AND ARE THEY RELEVANT TO THE RESEARCH STUDY?

Reviewer 1: The strengths and weaknesses of analytical methods were clear. However, the reviewer was not clear on the difference between "Yes, Partial" and "No, Incomplete" in Section 7.1 of the report and suggested those should be more clearly defined in the report.

Reviewer 2: No weaknesses of the analytical method were identified.

Reviewer 3: The Life Cycle Success Path examples in Appendix B, of the report, were very helpful and the table and charts are comprehensive and user friendly. Perhaps expanding the analysis to include API standards, specifications, and practices would be worthwhile (specifically API Spec 20E and API Spec 20F).

QUESTION 6. ARE THERE GAPS IN THE ANALYTICAL METHODS? ARE THE ANALYTICAL METHODS USED RELEVANT TO DETERMINE SCIENTIFIC FINDINGS AND RECOMMENDATIONS (I.E., EMPIRICAL DATA SUPPORTS THE ANALYTICAL TECHNIQUES OR THEORETICAL DATA)?

Reviewer 1: There are no gaps in the analytical methods to assess the standards.

Reviewer 2: No clear gaps in the analytical methods were observed.

Reviewer 3: The methods provided a comprehensive analysis and satisfied the scope of the study. Utilizing a more efficient method such as feeding electronic documents into a database with automated intelligence or machine learning could perhaps yield better benefits.

QUESTION 7. ARE THE VARIABLES USED IN THE RESEARCH STUDY IDENTIFIED AND CHARACTERIZED?

Reviewer 1: As this study is a literature review, there are not really any variables.

Reviewer 2: The report describes aspects of variability and how it is addressed or if it's not addressed.

Reviewer 3: Yes.

QUESTION 8. ARE THE DATA COLLECTION METHODS AND INPUTS PRESENTED IN A TRANSPARENT MANNER?

Reviewer 1: The researchers are clear in describing document collection, selection, reviews, and limits.

Reviewer 2: The report clearly describes data collection methods and the matrix in Appendix A of the report was very helpful.

Reviewer 3: Yes.

QUESTION 9. WERE THE DATABASE AND PROGRAMS UTILIZED FOR THE STUDY APPROPRIATE, ACCURATE, AND SENSITIVE ENOUGH TO PRODUCE RELEVANT DATA IDENTIFYING BOLTING STANDARDS REQUIREMENT GAPS AND APPLICABLE INDUSTRY STANDARDS?

Reviewer 1: Yes, they are appropriate for this study.

Reviewer 2: Due to the sheer volume of standards, the use of Access and Excel was appropriate.

Reviewer 3: Yes, with the addition of the comment in Question 6.

QUESTION 10. ARE SAFETY FACTORS UTILIZED, AND ARE THEY SUPPORTED AND VALID?

Reviewer 1: Since this is a literature review, there are no safety factors applicable.

Reviewer 2: The report does not widely discuss safety factors but does address them where possible. An in-depth analysis of safety factors would be outside the scope of this study.

Reviewer 3: Safety factors do not seem to be within the scope of work.

QUESTION 11. IS THERE ENOUGH DETAIL PROVIDED ON THE METHODS OR PROCESSES SUCH THAT THE MANUFACTURER CAN REPLICATE THE METHODS OR TECHNIQUES TO ACHIEVE SIMILAR RESULTS?

Reviewer 1: Yes.

Reviewer 2: Assuming the database and related software used in the study would be available to a user, then yes.

Reviewer 3: Yes.

5.1.2 DATA ANALYSIS SUMMARIES

QUESTION 12. WAS THE DATA ANALYSIS APPROPRIATE AND ARE THE RECOMMENDATIONS LOGICAL, AND SUPPORTED BY THE DATA ANALYSIS? THE SCOPE OF THE RECOMMENDATIONS PERTAINS TO ALL SUBMISSIONS, NOT JUST THOSE DERIVED FROM THE STUDY RESULTS.

Reviewer 1: The data analysis was appropriate, but a wider range of users queried initially could have provided more recommendations.

Reviewer 2: The recommendations are strongly supported by the analyses. Detailed, positive comments regarding the recommendations can be found in the full reviewer response in Appendix C.

Reviewer 3: The data analysis was comprehensive. See additional comment in Question 6.

QUESTION 13. ARE THE RESEARCH FINDINGS BASED ON SOUND SCIENCE?

Reviewer 1: While the researchers used sound science and techniques, they may have been limited in the determination of standards gaps by not asking other industry players what they expect in the standards.

Reviewer 2: Yes, the findings are based on sound science as ANL applied a strong understanding of design, mechanics, materials, and environmental effects on durability/safety in service.

Reviewer 3: Yes.

QUESTION 14. ARE THE UNCERTAINTIES AND ACCURACY OF THE DATA APPROPRIATELY INCORPORATED AND REPRESENTED IN THE DELIVERABLES?

Reviewer 1: The researchers addressed the limits on the number of documents reviewed, and it was appropriate for this application.

Reviewer 2: To the extent possible, ANL addresses uncertainties and data accuracy.

Reviewer 3: Yes.

5.1.3 CONCLUSIONS SUMMARIES

QUESTION 15. ARE THE CONCLUSIONS THAT WERE MADE LOGICAL AND APPROPRIATE?

Reviewer 1: For the most part the conclusions are logical; however, statements presented in Section 11.1 and Section 13.6 of the report need clarity. Detailed suggestions can be found in the reviewer's full response in Appendix 3.

Reviewer 2: The conclusions are both logical and appropriate. Detailed, positive comments can be found in the full reviewer response in Appendix 3.

Reviewer 3: Yes.

QUESTION 16. CAN THE CONCLUSIONS BE EFFICIENTLY AND ACCURATELY INTERPRETED, CONSIDERING THE COMPLEXITY OF THE RESEARCH?

Reviewer 1: While the conclusions are straight-forward based on the study results, the report lacks a cohesive conclusion/recommendation section.

Reviewer 2: Despite the complexity of the task, the conclusions are very well organized and will allow efficient interpretation by a wide variety of stakeholders.

Reviewer 3: Yes, the conclusions are clear to industry professionals, with the next step being presentation to industry to fill in any missed gaps.

QUESTION 17. CAN BSEE BE CONFIDENT IN THE CONCLUSIONS DRAWN FROM THE RESEARCH STUDY?

Reviewer 1: BSEE can be confident in the gaps identified; however, there could be additional items missed due to lack of users queried.

Reviewer 2: The BSEE should be very confident in conclusions drawn from the research study as it was well designed, comprehensive, and well executed. The conclusions were strongly supported by relevant science and engineering.

Reviewer 3: Yes.

QUESTION 18. ARE THERE ANY ADDITIONAL CONCLUSIONS DRAWN FROM THE SUBSEA BOLT STUDY OR BOLT STANDARDS GAP ANALYSIS?

Reviewer 1: There could be additional conclusions left out due to lack of users queried initially. Other users in the subsea bolt field could have thought of other items to include.

Reviewer 2: No.

Reviewer 3: The authors identified the significant and relevant gaps based on the study scope. The next step would be to acquire industry feedback, particularly the API.

5.1.4 OVERALL SUMMARIES

QUESTION 19. DID THE RESEARCH MEET THE STATED GOALS AND OBJECTIVES FOR THE SUBSEA BOLT STUDY AND BOLT STANDARDS GAP ANALYSIS?

Reviewer 1: The research did meet its stated goal but was limited to what the researchers thought should be included.

Reviewer 2: The report met the stated goals and objectives of the study and provided clear, well-supported recommendations for standards improvements.

Reviewer 3: Yes, the work achieved stated objectives.

QUESTION 20. WAS THE FINAL RESEARCH REPORT WRITTEN OBJECTIVELY AND TRANSPARENTLY? DID ANY PART OF THE RESEARCH STUDY APPEAR BIASED OR TOO NARROWLY FOCUSED?

Reviewer 1: The identification of missing items may have been too narrow or biased due to it being limited to the researchers' expectations and not that of a wider breadth of industry participants.

Reviewer 2: The final report did not show bias towards any organization, industry or other entity and had transparent objectives.

Reviewer 3: There was no impression of bias, and the report was objective and transparent.

QUESTION 21. WAS THE DECISION-MAKING MADE IN THE RESEARCH PROCESS BASED ON SOUND SCIENCE?

Reviewer 1: Yes.

Reviewer 2: Yes.

Reviewer 3: Yes.

QUESTION 22. ARE THERE ANY APPARENT WEAKNESSES OR GAPS IN THE STUDY THAT NEED TO BE ADDRESSED (E.G., METHODS, RESULTS, DATA, STANDARDS, ETC.)?

Reviewer 1: It would have been helpful to survey others including, industry workers, manufacturers, suppliers, engineers, owners, installers, etc. and see what they expect in the standards. Also, a better discussion on dissimilar metal corrosion is warranted.

Reviewer 2: None.

Reviewer 3: See comments in Question 6, however, the methods used, and conclusions reached were satisfactory for the stated objective.

QUESTION 23. SHOULD OTHER TECHNIQUES OR ANALYTIC PLATFORMS (METHODS) HAVE BEEN CONSIDERED?

Reviewer 1: A survey of other users could have provided the researchers a more complete gap analysis.

Reviewer 2: The techniques and analytic platforms selected were sufficient to do the analysis.

Reviewer 3: See comments in Question 6.

QUESTION 24. ARE THERE ANY ADDITIONAL STUDIES OR SOURCES OF INFORMATION/DATA THAT THE RESEARCH AUTHORS SHOULD HAVE CONSULTED?

Reviewer 1: Surveying a wider breadth of users would provide a more complete study.

Reviewer 2: None that are known.

Reviewer 3: No.

QUESTION 25. TO WHAT EXTENT IS THE SUBJECT MATTER NOVEL OR COMPLEX COMPARED TO OTHERS RESEARCH STUDIES?

Reviewer 1: Even though it was a literature review, it was novel in that it observed a compiled list of standards and took a detailed look at gaps.

Reviewer 2: The research is unique in its breadth and depth of analysis of standards. Considering the vagueness of some of the standards, inconsistent nomenclature, and wide range of technical areas to be reviewed, the study topic is certainly complex.

Reviewer 3: It doesn't appear that there is another comprehensive study such as this one, even though the National Academy made a similar effort.

QUESTION 26. WHAT IS YOUR OVERALL ASSESSMENT OF THE RESEARCH AND STUDY? PROVIDE ADVICE ON THE REASONABLENESS OF JUDGMENTS MADE FROM THE SCIENTIFIC EVIDENCE.

Reviewer 1: The study provided a great gap analysis of standards and serves as a good example to other industries to perform similar studies. Taking the time to compile standards and compare them is extremely valuable.

Reviewer 2: The report does an excellent job of comprehensively organizing and linking the range of standards and providing strong support for all recommendations and conclusions, providing a clear path forward to address standards gaps.

Reviewer 3: The conclusions reached are appropriated based on the analysis performed.

5.1.5 OTHER ADDITIONAL REPORT COMMENTS

Reviewer 1: Several edits and recommendations are provided. Details can be found in the reviewer's full response in Appendix 3.

Reviewer 2: None.

Reviewer 3: The gap analysis will be helpful in the industry. Thanks to BSEE for the opportunity to review.

APPENDICES

APPENDIX 1: MATERIALS PROVIDED

1) Peer Review Charge: Subsea Bolt Study, 7 September 2022
2) Meeting minutes from videoconference with peer reviewers and BSEE staff, October 3, 2022.
3) *Subsea Bolt Study: Technical Gaps in Current Standards and Requirements* dated October 15, 2018; 211 pages including the appendices described in a through e below.
    a. Appendix A of the study entitled *Oil and Gas Standard Subset Matrix;* 16 pages.
    b. Appendix B of the study entitled *Life Cycle Success Path Examples, ASTM A540/540M Success Tree, ASTM A962/A962M Success Tree*; 31 pages.
    c. Appendix C of the study entitled *API Meeting Summary*; 1 page.
    d. Appendix D of the study entitled *Bolt Standards Appearing in Preliminary Database*; 15 pages.
    e. Appendix E of the study entitled *Normative References from Preliminary Database Bolt Standards*; 21 pages.

The report can be viewed online using the BSEE peer review website (https://www.bsee.gov/what-we-do/research/peer-review) under the title "Subsea Bolt Study: Technical Gaps in Current Standards and Requirements." Specifically, the report is available at: https://www.bsee.gov/sites/bsee.gov/files/peer-review//subsea-bolt-standard-gap-analysis-study-report.pdf.

4) The reviewers were also given access to four supporting files (not subject to peer review and not included within this appendix):
    a. BSEE. 2014. QC-Fit Evaluation of Connector and Bolt Failures Summary of Findings. QC-FIT Report #2014-01. Bureau of Safety and Environmental Enforcement Office of Offshore Regulatory Programs.
    b. BSEE. 2016. QC-Fit Evaluation of Fasteners Failures, Addendum. QC-FIT Report # 2016-04. Bureau of Safety and Environmental Enforcement Office of Offshore Regulatory Program.
    c. BSEE. 2017. QC-Fit Evaluation of Fasteners Failures, Addendum II. QC-FIT Report # 006. Bureau of Safety and Environmental Enforcement Office of Offshore Regulatory Program.
    d. National Academies of Sciences, Engineering, and Medicine. 2018. High-Performance Bolting Technology for Offshore Oil and Natural Gas Operations. The National Academies Press: Washington, DC. https://doi.org/10.17226/25032.

More information on BSEE peer reviews can be found at https://www.bsee.gov/what-we-do/research/peer-review.

Peer Review Charge: Subsea Bolt Study
7 September 2022

OBJECTIVE

Wood is requesting experts to perform a peer review for the Bureau of Safety and Environmental Enforcement (BSEE) of the 2018 *Subsea Bolt Study: Technical Gaps in Current Standards and Requirements* (Subsea Bolt Study). The purpose of this peer review is to review and provide feedback on the report and associated methodology. Reviewers should provide an overall assessment of the materials as well as respond to the specific Charge Questions listed below. BSEE uses peer review panels to provide independent scientific review and recommendations regarding research to inform regulatory changes and improve the methods and technologies used for oil spill detection, containment, treatment, recovery, and cleanup.

This peer review is technical and will not focus on editorial style. BSEE will provide the study report for peer review, but it is confidential, and the information contained within it has not been published. Reviewers are not being asked to provide and should not provide advice on BSEE policies and decisions.

SUMMARY

PROJECT HISTORY

The Bureau of Safety and Environmental Enforcement (BSEE) provides oversight of safety and environmental compliance related to offshore resources (more information available at https://www.bsee.gov/). Offshore oil and gas drilling and production include operations in harsh conditions (high pressure, temperature, and highly corrosive). BSEE regulations require that offshore oil and gas operators be able to demonstrate that their equipment can perform in high-pressure, high-temperature environments.

Bolt failures have occurred during oil and gas operations in the Gulf of Mexico in recent history. BSEE is incentivized to avoid incidents such as these and is researching several ways to identify and address root causes of these failures. One of these is the review of a snapshot of relevant bolt standards that apply to subsea equipment and the identification of standard gaps.

PROBLEM STATEMENT, RESEARCH STUDY, AND GOALS

BSEE needs to understand how a time snapshot of the subsea oil and gas bolt standards in its regulatory jurisdiction compares with those in other industries and countries. Argonne National Laboratory (Argonne), in this study, identified gaps in the bolts standards or requirements that could lead to unsafe conditions in the Outer Continental Shelf.

Argonne mainly focused on alloy steel threaded fasteners because these have failed in recent history. They reviewed limited historic failure work for bolts subjected to different tensile

loadings and extended subsea exposure. Argonne collected relevant standards from a multitude of sources including the American Petroleum Industry, American National Standards Institute, American Society of Mechanical Engineers, and American Society for Testing and Materials, and developed a database with these standards. Through this database, they were able to search for themes and patterns and identify gaps in standards. From these gaps, they made recommendations for standards.

Overall, this Subsea Bolts Study reviewed various industry specifications/standards of the alloy material used for bolting application to predict the material performance, including these environmental conditions for offshore oil and gas operations. The Subsea Bolts Study identified gaps in these standards, summarized data, and provided guidance.

CONTRIBUTORS

This work was performed by Argonne National Laboratory (Argonne).

REVIEW MATERIALS PROVIDED

The *Subsea Bolt Study: Technical Gaps in Current Standards and Requirements* (dated October 15, 2018) provided, with 211 total pages, including 5 appendices, 14 tables, and 6 figures.

LOGISTICS

PROCESS

Reviewers must complete the non-disclosure (NDA) and conflict of interest (COI) forms before receiving the review materials. Reviewers may not copy, quote, or otherwise use, disclose, distribute, or publicize the content of the review materials.

Reviewers will consider and evaluate the Subsea Bolts Study. Each reviewer will write up their response to Charge Questions, as well as any other comments, independently of the other reviewers, using the template provided. Comments should be sufficiently clear and detailed to allow readers familiar with the subject to thoroughly understand their relevance to the material provided for review. Reviewers will be able to ask questions on the materials provided for review and request any additional materials if needed. Any requests, questions, or concerns and the completed review shall be provided to Wood, who will coordinate with BSEE.

Reviewers may not be able to answer every question or comment on every aspect of the materials. Reviewers may limit their responses to their areas of expertise; however, please provide an explanation if there is no response to a question.

Reviewers will be available for a teleconference meeting with other reviewers, Wood, and BSEE after receiving the Study. Reviewers will be able to ask questions on the materials provided for review, and BSEE will provide additional technical or background materials as needed.

The Subsea Bolts Study will be published on the BSEE website, and public comments will be sent to the reviewers. Peer reviewers may or may not respond to any of the public comments or use

them to inform their own reviews. Only relevant public comments will be sent to the peer reviewers.

Upon completion of the individual review, the response will be copyedited and formatted and provided to the review for approval, prior to submittal to BSEE. Each response will be assigned a number and the reviewer name removed. The individual response, as well as the curriculum vitae, will be included in the Peer Review Summary Report. BSEE may have questions or requests for clarification upon review of the individual responses.

Once available, the reviewers will be provided the Peer Review Summary Report to review and approve, prior to it being provided to BSEE. Reviewers can submit an invoice (if applicable) once the individual response is accepted by BSEE.

SCHEDULE

Task	Estimated Date
Complete non-disclosure and COI Forms	1 week after BSEE approval of list
Attend teleconference with BSEE and other peer reviewers	1 week after reviewers receive package
Provide individual review	60 days after receiving materials (by 11/15/2022)
Verify/approve final individual review (after copyediting and formatting)	7 days after receiving any edits
Review summary report	12/31/2022

ATTRIBUTION AND DISCLOSURE

While each response is coded by number rather than name, the reviewer names, affiliations, curriculum vitae, individual responses, and BSEE comments are included in the Peer Review Summary Report which is typically made available to public on the BSEE website.

ADDITIONAL INFORMATION

Reviewers are not being asked to provide and should not provide advice on BSEE policies and decisions. This peer review must comply with the BSEE Peer Review Handbook (2017) and the Office of Management and Budget (OMB) Final Information Quality Bulletin for Peer Review (2004; https://georgewbush-whitehouse.archives.gov/omb/memoranda/fy2005/m05-03.html). This peer review is also governed by the DOI Information Quality Standards, DOI Department Manual 305 DM 3 (Integrity of Scientific and Scholarly Activities), and Executive Order 12866. This peer review is part of the process to ensure information quality in the products produced by BSEE and DOI.

Conflict of Interest

Reviewers must not have any involvement in or conflict of interest with BSEE, Argonne National Laboratory (Argonne), or an active role in oil and gas industry that could result in a conflict of interest related to subsea bolts and their standards. Each reviewer must be aware of the requirements for independence and lack of conflicts of interest with respect to this peer review. Reviewers should have no financial or other conflicts of interest with the outcome or implications of the review. The following requirements, extracted from the OMB Memorandum on Peer Reviews (2004), are included here.

The National Academy of Sciences defines "conflict of interest" as any financial or other interest that conflicts with the service of an individual on the review panel because it could impair the individual's objectivity or could create an unfair competitive advantage for a person or organization. Agencies shall make a special effort to examine prospective reviewers' potential financial conflicts, including significant investments, consulting arrangements, employer affiliations and grants/contracts. Financial ties of potential reviewers to regulated entities (e.g., businesses), other stakeholders, and regulatory agencies shall be scrutinized when the information being reviewed is likely to be relevant to regulatory policy. The inquiry into potential conflicts goes beyond financial investments and business relationships and includes work as an expert witness, consulting arrangements, honoraria and sources of grants and contracts. To evaluate any real or perceived conflicts of interest with potential reviewers and questions regarding the independence of reviewers, agencies are referred to federal ethics requirements, applicable standards issued by the Office of Government Ethics, and the prevailing practices of the National Academy of Sciences. Specifically, peer reviewers who are federal employees (including special government employees) are subject to federal requirements governing conflicts of interest. With respect to reviewers who are not federal employees, agencies shall adopt or adapt the NAS policy for committee selection with respect to evaluating conflicts of interest. Both the NAS and the federal government recognize that under certain circumstances some conflict may be unavoidable in order to obtain the necessary expertise. To improve the transparency of the process, when an agency determines that it is necessary to use a reviewer with a real or perceived conflict of interest, the agency should consider publicly disclosing those conflicts. In such situations, the agency shall inform potential reviewers of such disclosure at the time they are recruited.

Independence

In its narrowest sense, independence in a reviewer means that the reviewer was not involved in producing the document to be reviewed. However, for peer review of some documents, a broader view of independence is necessary to assure credibility of the process. Reviewers are generally not employed by the agency or office producing the document. A related issue is whether government-funded scientists in universities and consulting firms have sufficient independence from the federal agencies that support their work to be appropriate peer reviewers for those agencies. This concern can be mitigated in situations where an agency awards grants through a competitive process that includes peer review; the agency's potential to influence the scientist's research is limited. As such, when a scientist is awarded a government

research grant through an investigator-initiated, peer reviewed competition, there generally should be no question as to that scientist's ability to offer independent scientific advice to the agency on other projects. This contrasts, for example, to a situation in which a scientist has a consulting or contractual arrangement with the agency or office sponsoring a peer review. Likewise, when the agency and a researcher work together (e.g., through a cooperative agreement) to design or implement a study, there is less independence from the agency. Furthermore, if a scientist has repeatedly served as a reviewer for the same agency, some may question whether that scientist is sufficiently independent from the agency to be employed as a peer reviewer on agency-sponsored projects.

CHARGE QUESTIONS

The Peer Reviewers shall evaluate the following Charge Questions and provide supporting documentation and rationale. The Charge Questions are listed below:

Methods and Assumptions

1. Are applicable subsea critical drill-through equipment oil and gas and bolting standards addressed? Are there any other relevant standards that need to be addressed for this study?
2. Are the methods appropriate? Were the methods used valid for the goals of this study project?
3. Are limitations and uncertainties clearly identified and adequately characterized?
4. Are the assumptions clearly defined and appropriate?
5. Are the strengths of the analytical methods used identified and relevant to the research? Are the weaknesses of the analytical methods identified, and are they relevant to the research study?
6. Are there gaps in the analytical methods? Are the analytical methods used relevant to determine scientific findings and recommendations (i.e., empirical data supports the analytical techniques or theoretical data)?
7. Are the variables used in the research study identified and characterized?
8. Are the data collection methods and inputs presented in a transparent manner?
9. Were the database and programs utilized for the study appropriate, accurate, and sensitive enough to produce relevant data identifying bolting standards requirement gaps and applicable industry standards?
10. Are safety factors utilized, and are they supported and valid?
11. Is there enough detail provided on the methods or processes such that the manufacturer can replicate the methods or techniques to achieve similar results?

Data Analysis

12. Was the data analysis appropriate and are the recommendations logical, supported by the data analysis? The scope of the recommendations pertains to all submissions, not just those derived from the study results.
13. Are the research findings based on sound science?
14. Are the uncertainties and accuracy of the data appropriately incorporated and represented in the deliverables?

Conclusions

15. Are the conclusions that were made logical and appropriate?
16. Can the conclusions be efficiently and accurately interpreted, considering the complexity of the research?
17. Can BSEE be confident in the conclusions drawn from the research study?
18. Are there any additional conclusions drawn from the subsea bolt study or bolt standards gap analysis?

Overall

19. Did the research meet the stated goals and objectives for the subsea bolt study and bolt standards gap analysis?
20. Was the final research report written objectively and transparently? Did any part of the research study appear biased or too narrowly focused?
21. Was the decision-making made in the research process based on sound science?
22. Are there any apparent weaknesses or gaps in the study that need to be addressed (e.g., methods, results, data, standards, etc.)?
23. Should other techniques or analytic platforms (methods) have been considered?
24. Are there any additional studies or sources of information/data that the research authors should have consulted?
25. To what extent is the subject matter novel or complex compared to others research studies?
26. What is your overall assessment of the research and study? Provide advice on the reasonableness of judgments made from the scientific evidence.

Meeting Minutes
Peer Review of the Subsea Bolt Study

MEETING DATE: OCTOBER 3, 2022; 12:00 – 1:00 PM EST
MEETING TYPE: Coordination meeting with reviewers and BSEE

PREPARED BY: Kendra Sultzer, WSP USA Environment & Infrastructure, Inc.

ATTENDEES:

US Bureau of Safety and Environmental Enforcement: Bipin Patel, Ayodele Ike, Dave Villani

WSP USA Environment & Infrastructure Inc.: Dawn Johnson, Carol Turner, Kendra Sultzer

Peer Reviewers: Brun Hilbert, Robert Kelly, Brian Pailes

I. Topics Discussed

A. Introductions

1. BSEE
   a) Bipin – General engineer in Emerging Technology Branch of BSEE, Bipin works for Ayodele, background in materials and metallurgy
   b) Ayodele – Section Chief for Systems Reliability in BSEE, varied engineering background
   c) Dave Villani – Contracting Officer
2. WSP
   a) Dawn – Project manager, has over 10 years of experience with federal peer reviews
   b) Carol – Marine Structural Engineer with 24 years of experience
   c) Kendra – Helping with project management and organization
3. Peer reviewers
   a) Brian Pailes
      (1) Principal engineer at Vector Corrosion Services
      (2) Works with evaluation and rehabilitation of infrastructure due to corrosion and durability, corrosion mitigation and cathodic protection, does a lot of work with submerged steel structures
      (3) PhD in corrosion and Master's in corrosion and cathodic protection
   b) Robert Kelly
      (1) At University of Virginia for 30+ years

      Background in corrosion science and engineering, research on corrosion of metals, methods, corrosion fatigue, hydrogen embrittlement
      (2) Does not know anything about mechanical engineering

c) Brun Hilbert

(1) Works at Exponent, has been there approximately 25 years

(2) Mechanical Engineering background, worked at Exxon for about 12 years, does a lot of bolt failure research at Exponent, Deep Water Horizon and litigation cases where he provided expert testimony, research development and assistance, stress analysis of bolts because of fatigue and overloading

(3) Has met Bipin before because he was on National Academy of Sciences reviewing team for bolt study

B. Overview of Subsea Bolt Study (by BSEE)

1. Background of the history of bolt failure
   a) There were multiple bolt failures in the past in 2001 and 2003. In 2012 and 2014, there were multiple failures within the similar joint configuration. When there is a leak, reporting has to be done to BSEE. BSEE started investigating then.

   b) BSEE decided to make this much more public and investigate more. BSEE decided to put more effort into looking for solutions. 18 bolts and 11 failed in one of the latest failures.

2. Bolt Research conducted by NAS
   a) In 2016, a third bolt failure occurred. National Academy of Science brought in to investigate.

3. The subsea bolts study under review
   a) During this same time, BSEE started a contract with Argonne National Laboratory (ANL) to discover what the gaps were, review the standards. A few gaps were identified. Where are the gaps and missing information that can be extracted from one area to another?

C. Discussion of Study (by Reviewers/BSEE)

1. Robert: Can we get links to those earlier studies mentioned?
   a) Bipin: Yes, they are on the BSEE website. I can email those previous reports to you if needed. You can download the NAS report.

2. Brun: Bipin, do you have the slides from the NAS seminar?
   a) Brian: It looks like they can be found on the BSEE.gov/bolts website in the forum link, available at

   https://www.bsee.gov/what-we-do/offshore-regulatory-programs/emerging-technologies/bolt-and-connector-failures

3. Bipin: There should no longer be the “Draft-Do Not Distribute” message on the study. You can find the public version on the BSEE peer review website, available at

   https://www.bsee.gov/what-we-do/research/peer-review

4. Dawn: Will coordinate with Bipin to either get you links or send you the reports directly.
   a) NAE report

   b) Individual reports for various bolt failures

   c) Public version of report

5. Bipin: We tasked ANL to find out mechanical properties of various steel bolts, coatings, corrosion, heat treatment, and hardness. We asked them to investigate standards relating to all these properties. You cannot use bolts with a zinc coating as of 2017. The industry started ordering new bolts, but this takes 6-9 months from order to delivery. The blowout preventer (BOP) is what blew up with the Deep Water Horizon. Lower marine riser package (LMRP) stacks on top of BOP. These are some of the most important components.
   a) 2016 was a stud failure, but we still define it as a bolt. All the API standards have a "bolt" which is also a screw or stud or fastener.

6. Brun: Deep Water Horizon was not related to bolts. It was related to BOP. 11,000 bolts were recalled – how do you measure the torque? There was a lot of discussion of platings and cathodic protection and embrittlement. Multiple causes and quality assurance issues were the cause.
   a) Robert: What was the cause of the recall?

   b) Brun: Heat treating and plating issues were the cause of the bolt recall.

   c) Bipin: API and operators: when one of units comes out for maintenance, they change the bolts whether or not they have failed or not. There is a 5 year maintenance cycle. They have almost replaced 70% of bolts in rigs in Gulf of Mexico.

7. Robert: In the failures, has fatigue loading been indicated as part of failure mechanism or is it almost all statically driven?
   a) Bipin: It is hydrogen embrittlement. When they test the bolts on the production floor, they work fine. When they put it in the water, it snapped right away for the Blind Shear Ram. The microstructure shows evidence of hydrogen embrittlement. Hydrogen might infiltrate from micro-cracks in thread caused by pressure when cutting the thread.

8. Brian: have the bolt failures all been galvanic systems for cathodic protection or others?
   a) Bipin: Both. It is all galvanic systems. Sacrificial anodes onto the platforms. All of these failures have been underwater.

9. Bipin: Another clarification. There was no testing done for this study.

D. Discussion of Charge Questions (by Reviewers/BSEE)

1. Robert: I was curious about the safety factors. It did not seem like this report delved into safety factors in its analysis. I was trying to figure out how to apply the safety factors question from the methods and assumptions.
   a) Bipin: You can comment based on what the specifications are and if you would like to relate it to it.

   b) Brun: We had some discussions about this with the NAS report. I think there is a suggested safety factor with stress, but we should discuss that more as we get into this. The report is tangentially related to safety issues

2. Robert – question about Question #25. What are they after with this question?
   a) Bipin: Does the study include all of what should be noted?

   b) Dawn: Is it adding new research and results to the industry? It might be a good thing to point out if it has been addressed in other studies (e.g., more recent ones).

E. Public Comments (BSEE)

1. Bipin: Public comments are BSEE's responsibility. Public comments were sent out for 30-day notice. We got reactions on social media, but no one sent comments about it. A lot of people read it but did not go further into it.

II. Action Items

1. Dawn will send along links/files to reviewers that were discussed today and meeting minutes
2. Bipin will send along public comment notes to Dawn

APPENDIX 2: CURRICULA VITAE

Brun Hilbert, PhD, PE, Principal Engineer, Exponent, Inc.

Robert Kelly, PhD, Professor of Materials Science and Engineering, University of Virginia

Brian Pailes, PhD, PE, Principal Engineer, Vector Corrosion Services, Inc.

These will be inserted in the compiled PDF.

Exponent®
Engineering & Scientific Consulting

L. Brun Hilbert, Jr., Ph.D., P.E.

Principal Engineer | Mechanical Engineering
149 Commonwealth Drive | Menlo Park, CA 94025
(650) 688-6934 tel | bhilbert@exponent.com

Professional Profile

Dr. Hilbert has been consulting at Exponent since 1996 in the fields of mechanical and petroleum engineering, with special applications to engineering mechanics and geomechanics. He has worked in the petroleum exploration and production industry for 40 years.

Dr. Hilbert has expertise in mechanical and petroleum engineering. In the area of petroleum engineering, he has expertise in oil and gas well design and integrity, hydraulic fracturing, well production and wellhead equipment, blowouts and well control, drilling mechanics and directional drilling, reservoir geomechanics, reservoir reserves estimation, fixed and floating offshore platforms. He also has experience with natural gas and liquid hydrocarbon storage in solution-mined salt caverns and depleted hydrocarbon formations. In the area of geomechanics, Dr. Hilbert has expertise in evaluating the structural integrity of oil and gas wells in compacting or deforming reservoir rocks, in the stability of underground storage structures and nuclear waste repositories, and he assists clients in failure analysis involving soil-structure interaction, including pipelines. Dr. Hilbert has testifying experience in state and federal courts, intellectual property, and international arbitration, with particular focus on the oil and gas industry.

Prior to joining Exponent, Dr. Hilbert was employed as an Engineering Specialist for Exxon Production Research Company, where he performed research and taught courses in Well Completions and Workovers in the Middle East, Southeast Asia, Australia, and North America.

Academic Credentials & Professional Honors

Ph.D., Materials Science and Mineral Engineering, University of California, Berkeley, 1995

M.S.E., Mechanical Engineering, University of New Orleans, 1981

B.S., Mathematics, University of New Orleans, 1979

National Academy of Engineering Committee on Connector Reliability for Offshore Oil and Natural Gas Operations, 2017-2018

Society of Petroleum Engineers Distinguished Lecturer, 2015-2016

Jane Lewis Fellowship in Geomechanics

Mathematical Association of America Membership Award

Outstanding Instructor, Exxon Production Research Company 1991

Outstanding Instructor, Exxon Company, U.S.A. 1990

Licenses and Certifications

Licensed Professional Mechanical Engineer, California, #M31490

Licensed Professional Engineer, New Mexico, #20939

Licensed Professional Engineer, Texas, #112060, Mechanical and Petroleum Engineering

Prior Experience

Lawrence Berkeley National Laboratory, 1996

University of California at Berkeley, 1992-1996

Exxon Production Research Company, 1981-1992

Professional Affiliations

American Society of Mechanical Engineers

Society of Petroleum Engineers

American Rock Mechanics Association

Publications

Papers and Articles

Hilbert LB and Hallai JF. Natural Gas Production in Extreme Weather (Guest Commentary). Pipeline & Gas Journal. Vol. 248, No, 6, June 7, 2021.

Owens ZC, Smyth BJ, Ames NA, Pye JD, Hilbert LB, Brooks B. Development of a Casing-Integrated Well Control Tool. Offshore Technology Conference. doi:10.4043/28644-MS, April 30, 2018.

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Hilbert LB, Reilly E, Ames N. Underground storage operators must fully understand 2016 PIPES Act. Oil & Gas Journal, July 3, 2017.

Hilbert LB, Saraf VK, Birbiglia DKJ, Shumilak EE, Schutjens PMTM, Hindriks COH, Klever FJ. Modeling horizontal completion deformations in a deepwater unconsolidated sand reservoir. SPE Journal of Drilling & Completion 2011 Mar; (26)2:68-83.

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Hilbert LB, Gwinn RL, Moroney TA, Deitrick GL. Field-scale and wellbore modeling of compaction-induced casing failures. SPE Journal of Drilling & Completion 1999; 14(2):92-101, June.

Guyer RA, McCall KR, Boitnott GN, Hilbert LB Jr, Plona TJ. Quantitative implementation of Preisach-Mayergoyz space to find static and dynamic elastic moduli of rock. Journal of Geophysical Research 1997; 102(B3):5281-5293, March.

Nihei KT, Hilbert Jr LB, Cook NGW, Myer LR. Frictional effects on the compressibility of sandstone. EOS, Transactions of the American Geophysical Union 1996; 77(46).

Kastenberg WE, Peterson PF, Ahn J, Burch J, Casher G, Chambre PL, Greenspan E, Olander DR, Vujic JL, Bessinger B, Cook NGW, Doyle FM, Hilbert LB Jr. Consideration of autocatalytic criticality of fissile materials in geologic repositories. Nuclear Technology 1996; 115:298-310, September.

McCall KR, Guyer RA, Zhu L, Boitnott GN, Hilbert LB Jr, Plona TJ. Experimental determination of the linear and nonlinear dynamic moduli of rock from quasistatic measurements. Proceedings, 2nd North American Rock Mechanics Symposium: NARMS'96, Aubertin M, Hassani F, Mitri H (eds), Quebec, Canada, 19-21, Balkema, Rotterdam, Netherlands, pp. 147-154, June 1996.

Hilbert LB, Fredrich, JT, Bruno MS, Dietrick GL, de Rouffignac EP. Two-dimensional nonlinear finite element analysis of well damage due to reservoir compaction, well-to-well interactions, and localization on weak layers. Proceedings, 2nd Annual North American Rock Mechanics Symposium, p. 19-21, Montreal, Canada, June 1996.

Bessinger BA, Yi W, Suarez-Rivera R, Nihei K, Hilbert LB, Myer LR. P-Wave amplitude anisotropy in limestones. Proceedings, 7th International Workshop in Seismic Anisotropy, Miami, FL, February 1996.

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Hilbert LB Jr, Yi W, Cook NGW, Cai Y, Liang GP. A new discontinuous finite element method for interaction of many deformable bodies in geomechanics. Proceedings, 8th International Conference on Computational Method and Advances in Geomechancis, pp. 836-931, May 1994.

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Kocian EM, Mefford RN, Hilbert LB, Kalil IA. Compressive loading casing design. Proceedings, 1990 IADC/SPE Drilling Conference, IADC/SPE 19923, Houston, TX, pp. 145-155, February 22-March 2, 1990.

Hilbert LB, Janna WS. The feasibility of electric power generation by the wind on the University of New Orleans Campus. Proceedings, ASME Energy Sources Technology Conference and Exhibition, 82-PET-1, New Orleans, LA, March 1982.

Book Chapters

Hilbert, LB et al., National Academies of Sciences, Engineering, and Medicine. High-Performance Bolting Technology for Offshore Oil and Natural Gas Operations. Washington, DC: The National Academies Press. June 2018. https://doi.org/10.17226/25032

Hilbert LB. Chapter 7. Reservoir Integrity. In: Underground Gas Storage Regulatory Considerations: A Guide for State and Federal Regulatory Agencies. Ground Water Protection Council and Interstate Oil and Gas Compact Commission. May, 2017.

Hilbert LB. Reservoir compaction, subsidence and well damage. In: Numerical Analysis and Modeling in Geomechanics, Chapter 11. John Bull (ed), Spon Press, May 2003.

Other Technical Publications

Saba T, Mohsen MFN, Hilbert LB, Garry MR. Methanol use in hydraulic fracturing fluids. White Paper, August, 29, 2011.

Presentations and Lectures

Hilbert LB, Saba T. Recent developments in hydraulic fracturing. Presented at: A Whole New Ballgame: Oil and Gas in the Trump Administration. A Seminar by Husch Blackwell, LLP. April Denver, CO, 27, 2017.

Hilbert LB. Society of Petroleum Engineers Distinguished Lecture Program: Well design and integrity: Importance, Risk and scientific certainty. Invited Lecture, 2015-2016.

Hilbert LB, Saba T, Murali A. Hydraulic fracturing: An overview of the current environmental and

engineering issues. Exponent Webinar, October 14, 2015.

Hilbert LB, Schell JD, Meyer AA. Considerations of risk in hydraulic fracturing. Invited speaker. ASME Silicon Valley Section Technical Dinner Talk, February 27, 2014.

Hilbert LB, Mosher GE, Schell JD. Hydraulic fracturing: Myths and realities. Exponent Webinar, May 14, 2013.

Hilbert LB, Stewart SE. Hydraulic fracturing: The process. Invited Speaker. Seminar on Fracking Law: From Land Contract Negotiations to Environmental Disputes, National Business Institute Attorney Presentations. Grand Rapids, MI. February 19, 2013.

Hilbert LB (Moderator), et al. Hydraulic fracturing science update and frontiers. Invited Speaker. Seminar presentation: Key Legal Issues and Future Directions in the Environmental Impacts of Shale Development and Hydraulic Fracturing. Sponsored by ALI CLW American Law Institute, November 29, 2012.

Hilbert LB, Hardin WA. Understanding fracing, the potential risks and risk management concerns. Invited Speaker, Shale Gas Drilling Operations (Fracking) Conference, New York, NY, October 3, 2012.

Hilbert LB, Mathieson EL, Osteraas JD. Earthquakes 101: Natural and man-made sources and consequences. Exponent Webinar, January 26, 2012.

Hilbert LB, Saba T, Mohsen F. Hydraulic fracturing: What are the key engineering and environmental issues? Exponent Webinar, May 25, 2011.

Hilbert LB. Unconventional gas resources: Shale gas and hydraulic fracturing. Invited Speaker, Poland - Silicon Valley Technology Symposium, Palo Alto, CA, December 4-7, 2010.

Hilbert LB, Saraf VS. Buckling of multiple concentric casings. Presentation, 2007 West Regional ABAQUS User's Conference, Las Vegas, NV, October 2007.

Hilbert LB. The development and application of user material subroutines for large deformation thermomechanical modeling of Teflon. Presentation, 2006 West Regional ABAQUS User's Conference, Emeryville, CA, October 24-25, 2007.

Hilbert LB. Challenges in constitutive modeling of soft unconsolidated rocks. Presentation, Society of Petroleum Engineers Forum "Challenges in Unconsolidated Reservoirs: Reservoir Performance," Kananaskis, Canada, August 26-31, 2007.

Hilbert LB. Finite element methods in geomechcanics. Invited Lecture, Stanford University, March 2, 2007.

Hilbert LB, Bergström JS. Finite element modeling of a thermoplastic seal at high temperature and pressure. Presentation, 2005 East Regional ABAQUS User's Conference, Westborough, MA, November, 2005.

Hilbert LB. Evaluating pressure integrity of polymer ring seals for threaded connections in HP/HT wells and expandable casing. Presentation, American Society of Mechanical Engineers, North West Houston Sub Section, Houston, TX, September 27, 2003.

Hilbert LB. Analysis of pressure integrity of polymer ring seals. Presentation, American Society of Mechanical Engineers, Silicon Valley Chapter, Mountain View, CA, September 18, 2003.

Hilbert LB. Failure analysis in the petroleum industry. Presentation, Society of Petroleum Engineers, Los

Angeles Basin Section, Long Beach, CA, May 9, 2000.

Hilbert LB. Limitations and unfulfilled expectations of numerical methods in underground design and construction. Presentation, 3rd Geo-Institute Conference, Urbana, IL, June 1999.

Hilbert LB. Landslides! Presentation, Association of Defense Council, South Lake Tahoe, NV, June 1998.

Hilbert LB. Applications of forensics in geotechnical engineering. Presentation, Society of Civil Engineers of California Polytechnic State University, San Luis Obispo, CA, October 1998.

Hilbert LB. On the relationship between the pseudo rigid body and discontinuous deformation analysis. Presentation, Neville G.W. Cook Conference, Berkeley, CA, October 1998.

Hilbert LB. Failure analysis in petroleum engineering. Invited Lecture, Stanford University Petroleum Engineering Seminar, February 1998.

Hilbert LB. Geomechanical modeling of subsidence-induced well failures. Society of Petroleum Engineering, Golden Gate Section, San Francisco, CA, December 1997.

Hilbert LB. Discontinuum mechanics: The Manifold Method and the Finite Element Method. Presentation, Working Forum on the Manifold Method of Material Analysis, U.S. Army Corps of Engineers, Waterways Experiment Station, Timber Cove, CA, October 1995.

Hilbert LB. Computational geomechanics at Lawrence Berkeley National Laboratory. Kiso-Jiban Consultants Co., Tokyo, Japan, September 1995.

Hilbert LB. A finite element method for jointed, fractured and faulted geomaterials. Invited Lecture, Earth Sciences Division Seminar, Lawrence Berkeley National Laboratory, Berkeley, CA, July 1994.

Hilbert LB. Computational discontinuum analysis geoengineering seminar. Invited Lecture, University of California at Berkeley, October 1994.

Hilbert LB. Tubular string design. Invited Lecture, Subsurface Engineering School, Exxon Company U.S.A., Houston, TX, October 1991.

Hilbert LB. Casing and tubing course. Invited Lecture, Esso Production Malaysia Inc., Kerteh, Malaysia, October 1991.

Hilbert LB. Overview of production engineering school. Invited Lecture, Saudi Aramco, Dhahran, Saudi Arabia, August, 1991

Hilbert LB. Casing and tubing school. Invited Lecture, Exxon Production Research Company, Houston, Texas, April 1991.

Hilbert LB. Tubular design in Subsurface Engineering School. Invited Lecture, Exxon Company U.S.A., Houston, TX, June 1990.

Hilbert LB. The Walne 1-34: Exxon's deepest well. Invited Lecture, Exxon Production Research Company Production Seminar, Houston, TX, August 1989.

Hilbert LB. Evaluation methods for premium threaded connections. Invited Lecture, Exxon Production Research Company Production Seminar, Houston, TX, November 1988.

Hilbert LB. Premium tubing connections and analysis. Invited Lecture, Saudi Aramco Mid-Year Technical Review, Dhahran, Saudi Arabia, June 1988.

Hilbert LB. Tubular string design and stability analysis. Invited Lecture, Exxon Production Research Company Production Seminar, Houston, TX, December 1986.

Hilbert LB. Well completions and workovers school. Invited Lecture, Exxon Production Research Company, Houston, Texas; Kerteh, Malaysia; Ras Tanura and Dhahran, Saudi Arabia; Sale, Australia, 1983-1981.

Robert G. Kelly
AT&T Professor of Engineering
Professor of Materials Science and Engineering
rgkelly@virginia.edu (434) 982-5783

Born:
February 1, 1962
Philadelphia, PA

Research and Professional

Education

Ph.D The Johns Hopkins University, Materials Science & Engineering, January 1989
M.S.E. The Johns Hopkins University, Materials Science & Engineering, May 1986
B.E.S. The Johns Hopkins University, satisfied the requirements for degrees in both Biomedical Engineering and Materials Science & Engineering, graduated with departmental and general honors, May 1984.

Professional Experience

Department of Materials Science and Engineering, School of Engineering and Applied Science, University of Virginia, Charlottesville, VA

AT&T Professor of Engineering, 2013-present (renewed after 5-yr review)
Professor, 2004-present
Associate Professor, August, 1997- August, 2004
Assistant Professor, September, 1994 – August, 1997
Institutional Research Assistant Professor, July, 1992 - September, 1994
Research Assistant Professor, July, 1990 - July, 1992

Visiting Research Fellow
Corrosion and Protection Centre, University of Manchester Institute of Science & Technology, Manchester, United Kingdom
September, 1988 - July, 1990

Department of Materials Science and Engineering, College of Engineering, Virginia Polytechnic Institute and State University, Blacksburg, VA

Adjunct Professor, 2017-present

Honors and Awards

2021 W.R. Whitney Award of NACE International
2016 H.H. Uhlig Award of the Corrosion Division of the Electrochemical Society
2013 Selection as AT&T Professor of Engineering Chair, UVA
2012 Sigma Gamma Tau Outstanding Professor of Aerospace Engineering
2011 Selection to University Academy of Teaching at UVa

(including selection to Advisory Board)
2010 Fellow, the Electrochemical Society
2010 Inaugural Best Paper Award in *Corrosion J.*, NACE International
(with J. Scully, N. Taillert, F. Preseul-Moren, M. Goldman)
2009 Distinguished Service Award from NACE International (CESE)
2007 Rodman Scholars Outstanding Professor Award
2007 Fellow, National Association of Corrosion Engineers
2007 Harold S. Morton Award for Undergraduate Teaching (SEAS/UVa)
2006 NASA Engineering and Safety Center Group Achievement Award
2005 UVa MSE Undergraduate Teaching Award
2004 All-University Teaching Award
2004 Rodman Scholars Outstanding Professor Award
2003 Election as Honorary Member, Golden Key International Honour Society
2002 Raouf Lecture, Dept. of Mechanical Engineering, U.S. Naval Academy
2001 Robert T. Foley Award from Natl Capital Section of ECS
2000 UVa MSE Undergraduate Teaching Award
1999 H. H. Uhlig Award (NACE International)
– young educator award
1997 A. B. Campbell Award (NACE International)
– best paper by young author (< 35 y)
1996-97 University Teaching Fellow
1996 Rodman Scholars Award for Excellence in Teaching
1995, 1996, 1997 Local Section of the Electrochemical Society, Gwendolyn Wood Award for best local section while officer
1989-90 NSF/NATO Post-Doctoral Fellowship
1988-89 Academic Year - Fulbright Scholarship
Sigma Xi Scientific Research Honor Society - elected 1988
1987 - Achievement Reward for College Scientists
1986 - Electrochemical Society Energy Summer Research Fellowship
The 1985-86 Carl E. Menneken Fellowship for Scientific Research
1984-86 - NSF Graduate Fellowship
Tau Beta Pi National Engineering Honor Society - elected 1983
ASM Undergraduate Fellow - 1983-84 Academic Year

Graduate Students Directed

Ph.D. (27 graduated, 5 in progress)

Sudesh Kannan (May, 1995)
"Understanding mechanisms of corrosion of carbon steel exposed to black liquor"

Zhihao Fei (with J. Hudson) (December, 1996)
"Spatiotemporal behavior of iron and sulfuric acid electrochemical reaction system"

C. Sean Brossia (January, 1997)
1997 Allan Talbott Gwathmey Award (UVa)

1998 Morris Cohen Award (ECS)
1996 UVa Outstanding GTA Award
"The influence of alloy sulfur on the crevice corrosion behavior of austenitic stainless steels"

Jennifer A. Lillard (with R. Gangloff) (August, 1998)
"Aqueous environmental assisted cracking of a Ni-based superalloy"

Kevin C. Stewart (August, 1999)
"Intermediate attack in crevice corrosion by cathodic focusing"

Kevin R. Cooper (May, 2001) 2002 Morris Cohen Award (ECS)
"Chemistry and electrochemistry of environment-assisted cracking of an al-zn-mg-cu alloy"

Karen Ferrer (May, 2002)
"Determination of the role of bicarbonate in the corrosion of aircraft lap splice joints"

Sherri Wang (with M. Reed, ECE) (May, 2003)
"Nanofabricated devices for studying crevice corrosion"

Feng Gui (January, 2006)
"Development of a Performance Test Protocol for Corrosion Prevention Compounds for Aircraft"

Chris Taylor (with M. Neurock) (January, 2006) Engineering Physics
"First Principles Modeling of the Structure and Reactivity of Water at the Metal/Water Interface"

2006 Allan Talbott Gwathmey Award (UVa)
2008 Morris Cohen Award (ECS)

Brian Ralston (with D. E. Brown, SIE) (August, 2006)
"Modeling the Evolution of Corrosion: A Feature-Based Model for Growth"

Stephen Policastro (May 2008)
"Role of the Electrolyte in Selective Dissolution"

Jason Lee (January, 2011)
"Using Modeling and Microfabrication for Insights into Factors Controlling the Location of Crevice Attack"

Elissa Bumiller (August, 2011)
"Intergranular Corrosion in AA5XXX Aluminum Alloys with Discontinuous Precipitation at the Grain Boundaries"

Michael Francis (May 2012) – coadvised with M. Neurock (ChE)

"Hydrogen Permeation Rates upon First Exposure of Aluminum to Water and Relevance to the Environmental Cracking of Aluminum: a DFT and kMC Study"
2007-08 Va Space Grant Consortium Graduate Research Fellowship

Lei Chen (May, 2012) – coadvised with D. Brown (SIE)

"Image Fusion and An Outlier Detection Framework for Hierarchical Modeling with Application to Corrosion Prediction"

Eric Schindelholz (May, 2014)

"Towards Understanding Surface Wetness and Corrosion Response of Mild Steel in Marine Atmospheres"

2015 Morris Cohen Graduate Student Award, Corrosion Division, The Electrochemical Society

Cindy Shi (May 2015)

"Experimental Evaluation and Modeling of Galvanically-Induced Localized Corrosion of AA7075-T6"
1st Place Mars Fontana Engineering Division Poster, Corrosion '11 Student Poster Session (of > 80 posters presented)

Mary Lyn Lim (May 2016) – coadvised with J. Scully (MSE)

"Intergranular Corrosion Propagation in Sensitized Al-Mg Alloys"

Jayendran Srinivasan (May 2017)

"A Quantitative Framework to Connect the Critical Factors Determining the Stability of Localized Corrosion"
3rd Place, Marcel Pourbaix Prize for Corrosion Science, Student Poster Session, NACE Corrosion Conference 2013, Orlando, FL.
1st Place, Marcel Pourbaix Category for Best Poster in Corrosion Science, Student Poster Session, NACE Corrosion Conference 2014, San Antonio, TX.

Marybeth Parker (May 2018)

"Deconstructing Accelerated Testing Environments for Exfoliation Corrosion of Al-Cu-Li Alloy 2060"
Fred D. Rosi Outstanding Citizen Award for Contributions to the Academic, Educational and Outreach Goals of the MSE Department 2017
NACE Poster Award 2016, 2nd Place, Harvey Herro Category
Virginia Space Grant Consortium Research Fellowship 2015-2017
Rolls-Royce Graduate Fellowship 2012-2016
NACE Graduate Student Book Award 2015

Piyush Khullar (May 2018)

"Cathodic Control of Intergranular Corrosion in Sensitized AA5083 – H131

1st place, Student Poster Session, NACE International Conference: CORROSION 2016, Vancouver, Canada
3rd place, Student Poster Session, NACE International Conference: CORROSION 2015, Dallas, TX
NACE Graduate Student Book Award, NACE International Conference: CORROSION 2015, Dallas, TX

Gilbert Liu (January 2019)

"Combined Experimental and Numerical Approach to Validate the Utility of Laplace's Equation into a Galvanic-Coupling-Induced Localized Corrosion in Atmospheric Condition"
Best Poster Award in 68th International Society of Electrochemistry (ISE) Conference, 2017
Recipient of James G. Simmonds Graduate Fellowship at the University of Virginia, 2017
President of Electrochemical Society (ECS) Student Chapter of UVa, 2017
NACE Graduate Student Book Award, 2015

Ryan Katona (August 2021)

"Anodic and Cathodic Limitations on Localized Corrosion and Stress Corrosion Cracking Propagation of Stainless Steel 304L in Atmospheric Environments"
NACE Graduate Student Book Award, 2021
Doris Kuhlmann-Wilsdorf Outstanding Graduate Student Award, 2021

Pedro Atz Dick (May 2022)

"The Corrosion of Ni-Cr-Mo Alloys in Aprotic Organic Solvents "

Duane Macatangay (May 2022)

"Issues of Localized Corrosion in Additively Manufactured 316L Stainless Steel"

Rebecca Skelton (August 2022)

"¸The Essential Elements of a Model for Localized Corrosion Systems with Complex Geometries: From Prediction to Mitigation Strategies"
2nd place, Student Poster Session, Marcel Pourbaix Corrosion Science Division, NACE International Conference: CORROSION 2019, Nashville, TN

*Utibe-Eno Charles-Granville (expd August 2022)
2022 Fred Rosi Outstanding Citizen Award
*Carolina Vincente Moraes (exptd January 2023)
1st place, Student Poster Session, Marcel Pourbaix Corrosion Science Division, NACE International Conference: CORROSION 2021, virtual
*Armando Shehi (exptd 2026)
*Victor Kontopanos (exptd 2026)
*Timothy Montoya (exptd 2027)

*current

M.S. (21 graduated, 0 in progress)

James Dante (October, 1992)

"Analysis of the adsorbed electrolyte layer formed on a metal surface during atmospheric corrosion"

Elizabeth Nash (August, 1993)

"Measurement of localized corrosion chemistry"

C. Sean Brossia (May, 1994)

"A mechanistic study of iron corrosion in methanol solutions"

Kevin R. Cooper (August, 1995)

"Development of a quantitative test for the exfoliation resistance of aluminum alloy 7075"

Tracy T. Lunt (with J. Hudson) (February, 1997)

"Analysis of electrochemical noise from the corrosion of steels"

Christopher M. Weyant (January, 1999)

"An investigation of the mitigation of atmospheric corrosion by surface active papers"

Karen E. Lewis (May, 1999)

"Determination of the corrosion conditions within aircraft lap-splice joints"

Lisa DeJong (August, 1999)

"Investigations of Crevice Corrosion Scaling Laws Using Microfabrication Techniques and Modeling"

Jackie Williams (December, 2001)

"Mechanistic framework of localized coating failure on copper-containing aluminum alloys AA2024-T3 and AA1100-H14"

Jason Lee (December, 2001)

"Investigations of crevice corrosion using computational modeling and microfabrication techniques"

Wen Gan (January 2005)

"Corrosion Prediction Modeling of Aircraft Lap Joints"

Marco Ciccone (with R. P. Gangloff) (August, 2005)

"Effect of precorrosion-induced crack closure on fatigue crack growth in Al-Zn-Mg-Cu alloys"

Sarah Galyon (August, 2006)

"The Effects of CPC on the Initiation and Growth of Corrosion Fatigue Cracks in AA 7075-T6"

2005 Tri-Services Corrosion Conference Poster Contest Winner (Engineering)

Andrew Hodges (January, 2008)

"The Effect of Crevice Geometry on Crevice Corrosion Stability of 316 Stainless Steel"

Connor Parker (May, 2008)

"Coating Delamination Mechanism and Electrochemical Kinetics of Filiform Corrosion on AA2024-T3"

2007 Harvey Herro Award (3rd Place) at Corrosion '07 Poster Contest

Erica Neiser (January, 2011)

"Atmospheric Corrosion of Silver and Its Relation to Accelerated Corrosion Testing"

2011 DOD Corrosion Bowl for Best Collaborative Research Project (with Ohio State)

Joelle Buczynski (January, 2013)

"Electrochemical Analyses of Etchants Used to Detect Sensitization in Marine-Grade 5XXX Aluminum-Magnesium Alloys"

Mara Shedd (January, 2013)

"Modeling and Measurement of the Maximum Pit Size on Ferrous Alloys Exposed to Atmospheric Conditions"

Lindsey Blohm (May, 2018)

"Galvanic Coupling of AA5xxx-H116 and CDA 706 Utilizing Laboratory, Outdoor, and Accelerated Testing"

Colin Tattersall (August, 2018)

"Modeling and Analysis of Geometrically Complex Corrosion Damage"

Liat Bell (May, 2022)

"Exploration of the Effects of Environmental Factors on the Parameters Needed for the Calculation of the Maximum Pit Size for Stainless Steels 304L and 316L"

Undergraduate Research Assistants (29 graduated, 3 current*)

Patrick Bastek (Chem.E., 1992) — 1992 Sigma Xi Anniversary Award for Undergraduate Research (Engineering)

"Experimental determination of the effect of the surrounding surface area on scratched electrodes"

John Cheng (Appl. Math., 1992)

"Investigation of ion chromatographic techniques for the study of solution chemistry in localized corrosion of aluminum alloys"

Lyndia Brumback (Appl. Math, May, 1993) — 1993 Sigma Xi Anniversary Award for Undergraduate Research (Engineering)

"Investigation of the chemical composition of solutions formed during localized corrosion of aluminum alloys"

Golchereh Salamat (Chem. E., May, 1993) — 1993 SEAS Undergraduate Research and Design Symposium Winner

"Characterization of the solution composition inside dissimilar alloy crevices due to corrosion"

Robert Wilson (Chem. E., Dec, 1993)

"Design and installation of a black liquor corrosion monitoring system"

Daniel Chiang (Chem. E., May, 1994)

"Determination of the effects of chloride and thiosulfate ion concentrations on the pitting of A-282 in synthetic black liquor"

Leigh Ann Pawlick (Mech. E., May, 1995) — 1995 SEAS Undergraduate Research and Design Symposium Finalist

"Study of the corrosive effects of methanolic solutions on metallic materials"

Philip J. Ambrose (Chem.E., May, 1995)

"Black liquor corrosion analysis"

Stephen Garrison (Computer Science, May, 1997)

"Interfacing with invisible corrosion: The development of a graphical user interface for two dimensional modeling of localized corrosion"

Hunter Mayo (Chem. E, May, 1997)

"Study of the anodic and cathodic kinetics of localized corrosion in three corrosion-resistant alloys"

John La Scala (Chem. E, May, 1997)

"An analysis of the ability of surface active papers to mitigate atmospheric corrosion via corrosive gas absorption"

Jackie Williams (Engr. Sci, May, 1999)
"Investigation of the high temperature durability of Peti-5 adhesive through a capillary electrophoresis analysis of corrosive species concentration growth inside composite wing structures"

Jonathan Howse (Computer Science, May, 1999)
"Adding a graphical user interface to an existing crevice corrosion modeling application"

Melissa Snee (Mechanical Engr., May, 1999)
"Improving the safety of riding helmets"

Christian Franck (Mechanical Engr., 2002)
"Quantitative measurements of exfoliation corrosion kinetics at various humidity levels in aluminum alloy 7178-T6"

Jonathan Daniels (Mechanical Engr., 2002)
"A study of the pesticides used at local golf courses: to reduce operating costs and limit pollution"

Marco Ciccone (Chemical Engr., May, 2002) 2003 NACE Fontana Poster Winner
"Effects of quench delay and stabilization treatment on intergranular corrosion resistance fro AA7075, and AA2017"

David Ojumu (Mech Engrg, May 2008)
"Corrosion Protection Compounds: Laboratory Measurements of Field Exposed Samples"

Matthew Kirkham (ChE, May 2009)
"Mid-furnace corrosion in recovery boilers and the abandonment of small communities: the international problem"

Mara Shedd (Chemistry, May 2011)
"The Effect of pH and Phosphate Concentration on Sensitization Detection in Aluminum Alloys"

Bailey E. Risteen (ChE, May 2014)
"Marine aerosol drop size effects on the corrosion behavior of low carbon steel and high purity iron"
URDS winner (2013)

Michael McGrath (ChE, May, 2015)
"Actor-network analysis of corrosion policy oversight office"

John Brownhill (ChE '18)
Ali Alshanoon (SEAS '20)
Cameron Aadahl (ChE 19)
Victor Wang (SEAS '21)
Alex Chmielinski (Chem '19)
Jay Perry (ChE '21)
Alejandro Britos (AE '20)
Michael Beekwilder (ChE '21)
Gabriel Mallari (MAE '22)
*Dani Bilali (SEAS ’24)
*Morgan Small (SE/MSE ’24)
#Emma Laubengayer (MSE ’24)
*Rachel Rosner (ChE/MSE ’24)

Visitors and Postdoctoral Fellows Supervised (16)

Dr. Maria Inman (Ph.D., Univ. of Aukland, NZ), 1994-96
Dr. Jiangnan Yuan (Ph.D., Univ. of Tokyo), 1996-1998
Dr. Oliver Schneider (Ph.D, University of the Saarland), 1998-2001
Dr. Hongwei Wang[1] (Ph.D., Ohio University), 2001-2003
Dr Anna Igual Munoz (Visiting Asst. Prof from University of Valencia, Spain) (2002)
Dr. Francisco J. Presuel-Moreno[1] (Ph.D., Univ. of South Florida), 2002-2005
Research Scientist (2005- 2006)
Dr. Fushuang Cui (Ph.D., Univ. of South Florida), 2003-2005
Dr. Christopher Taylor[2] (Ph.D., Univ. of Virginia), 2006-2007
Dr. Zhuoyuan Chen (PhD, Royal Institute of Technology), 2006-2008
Dr. Yu Cai[2] (Ph.D., Case Western Reserve Univ.), 2005-2011
Dr. Qiaoxia Li (Ph.D., Institute for Metals Research, China), 2008-2010
Dr. Ye Wan (Assoc. Professor, Shenyang Jianzhu University), 2010-2012
Dr. Michael Woldemedhin (Ph.D., Max Planck Institute for Iron and Steel), 2012-2014
Dr. Kateryna Gusieva[1] (PhD, Monash University) 2015-2017
Dr. Gregory Kubacki (PhD, Clemson University) 2018-2019 – now Asst. Prof at Alabama
Dr. Danyil Kovalov (PhD, Karpenko Physico-Mechanical Institute of the NAS of Ukraine) 2020-2022
Dr. Sanjay Choudhary (PhD, Monash University) 2022-present

Key:
*****current
[1]co-advised with J. Scully [2]co-advised with M. Neurock

Bibliography of Books and Refereed Publications

According to Google Scholar (06/06/22)
TOTAL CITATIONS: 7,213
H index: 45

Refereed Journal Articles
Graduate Student co-author, *Undergraduate student co-author*

1. J. J. Sopcisak, M. Ouyang, D. A. Macatangay, B. P. Croom, T. J. Montalbano, D. J. Sprouster, R. G. Kelly, J. R. Trelewicz, R. Srinivasan, S. M. Storck, "Improving the Pitting Corrosion Performance of Additively Manufactured 316L Steel Via Optimized Selective Laser Melting Processing Parameters," *JOM*, vol 74 (4) pp. 1719-1729 (2022). https://doi.org/10.1007/s11837-022-05207-1
2. Utibe-Eno Charles-Granville, Rebecca S Marshall, Carolina V Moraes, Carol F Glover, John R Scully, Robert G Kelly, "Application of Finite Element Modeling to Macro-Galvanic Coupling of AA7050 and SS316: Validation Using the Scanning Vibrating Electrode Technique, J. Electrochem. Soc., 169 031502 (2022). https://doi.org/10.1149/1945-7111/ac55ce
3. D.A. Macatangay, G.W, Kubacki, R.G. Kelly, "Localized Corrosion in Additively Manufactured Stainless Steel and Aluminum Alloys," *JOM*, vol 74 (4) pp. 1651-1658 (2022). https://doi.org/10.1007/s11837-022-05181-8
4. D. Kovalov, C. D. Taylor, H. Heinrich, R. G. Kelly, "Operando electrochemical TEM, ex-situ SEM and atomistic modeling studies of MnS dissolution and its role in triggering pitting corrosion in 304L stainless steel," Corr.Sci., Vol. 199, 1 May 2022, 110184. https://doi.org/10.1016/j.corsci.2022.110184
5. Rebecca Marshall, Ryan Katona, Michael Melia, Robert Kelly, "Pit Stability Predictions of Additively Manufactured SS316 Surfaces Using Finite Element Analysis," J. Electrochem. Soc., 169 021506. https://doi.org/10.1149/1945-7111/ac519d
6. C. Cocke, R.S. Marshall, C. Sprinkle, A. Goff, R.G. Kelly, J.T. Burns, "The Effect of Corrosion Location Relative to Local Stresses on the Fatigue Life of Geometrically Complex, Galvanically Corroded AA7075-T6," Corrosion, 2022, 78(2) pp.152- 162. https://doi.org/10.5006/3908
7. R. G. Kelly, "The Importance of Local Chemistry and Potential in Localized Corrosion and Stress-Corrosion Cracking", Corrosion, 2022 78(2) pp.114-126. https://doi.org/10.5006/4019
8. Utibe-Eno Charles-Granville, Carol F. Glover, John R. Scully, Robert G. Kelly, "Effect of pH and Al Cations on Chromate Inhibition of Galvanic-Induced Corrosion of AA7050-T7451 Macro-Coupled to 316SS", J. Electrochem. Soc., 2021 168 121509. https://doi.org/10.1149/1945-7111/ac412a

9. Duane Macatangay, Jenna Conrades, Keegan Brunner, Robert Kelly, “Applications of Wrought Austenitic Stainless Steel Corrosion Testing to Laser Powder Bed Fusion 316L,” CORROSION (2021) 3885. https://doi.org/10.5006/3885
10. L.M. Blohm, C. Liu, R. G. Kelly, “A Combined Experiment and Modeling Analysis of ASTM G85 WB Accelerated Corrosion Testing of Galvanically Coupled Sensitized AA5456-H116 and CDA 706 Cupronickel,” CORROSION (2021) 77 (10): 1111–1122. https://doi.org/10.5006/3852
11. C. V. Moraes, R. J. Santucci, J. R. Scully, R. G. Kelly, “Finite Element Modeling of Chemical and Electrochemical Protection Mechanisms Offered by Mg-Based Organic Coatings to AA2024-T351,” J. Electrochem. Soc., 2021 168 051505. https://iopscience.iop.org/article/10.1149/1945-7111/abfab8
12. Ryan Katona, Jacob Carpenter, Eric Schindelholz, Rebecca Schaller, Robert Kelly, "Cathodic Kinetics on Platinum and Stainless Steel in NaOH Environments," accepted by J. Electrochem. Soc., 2021 168 071509 https://doi.org/10.1149/1945-7111/ac1318
13. P. J. Steiner, Z. D. Harris, C. V. Moraes, R. G. Kelly, J. T. Burns, “Investigation of IG-SCC growth kinetics in Al-Mg alloys in thin film environments,“ Corrosion, 2021 3833. https://doi.org/10.5006/3833
14. R. M. Katona, J. C. Carpenter, A. W. Knight, R. S. Marshall, B. L. Nation, E.J. Schindelholz, R. F. Schaller, and R. G. Kelly, “ Editors’ Choice—Natural Convection Boundary Layer Thickness at Elevated Chloride Concentrations and Temperatures and the Effects on a Galvanic Couple,” Journal of The Electrochemical Society, 2021, 168031512. https://iopscience.iop.org/article/10.1149/1945-7111/abeb29/pdf
15. R. M. Katona, *A. W. Knight*, C. R. Bryan, E. J. Schindelholz, R. F. Schaller, R. G. Kelly, “Quantitative Assessment of Environmental Phenomena on Maximum Pit Size Predictions in Marine Environments,” *Electrochimica Acta*, (2021) 370, 137696. https://doi.org/10.1016/j.electacta.2020.137696
16. P. Atz Dick, *M. Beekwilder*, R. G. Kelly, “"The Influence of Acidity, Chlorides and a High-Potential Quinone on the Corrosion of Hastelloy C-22 in Nonaqueous Solutions," *Journal of the Electrochemical Society*, (2020) 167, 161503. https://doi.org/10.1149/1945-7111/abcc37
17. Xiangming Sun, Jayendran Srinivasan, Robert G. Kelly, Ravindra Duddu,“Numerical Investigation of Critical Electrochemical Factors for Pitting Corrosion using a Multi-species Reactive Transport Model,” *Corrosion Science*, 2020: 109130. https://doi.org/10.1016/j.corsci.2020.109130
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1. R. G. Kelly, "Ch. 18: Pitting Corrosion," in **Manual on Corrosion Tests and Standards : Applications and Interpretations**, R. Baboian, ed., ASTM, Philadelphia, pp. 166-75 (1995). 2nd edition, 2004
2. R. G. Kelly, C. S. Brossia, "Ch. 35: Organic Liquids," in **Manual on Corrosion Tests and Standards: Applications and Interpretations**, R. Baboian, ed., ASTM, Philadelphia, pp. 372-80 (1995).
3. R. G. Kelly, J. A. Bardwell, "Materials Degradation," in **Encyclopedia of Applied Physics**, vol. 9, G. Trigg, ed., VCH, New York, pp. 349-364 (1994).
4. R. G. Kelly, "Crevice Corrosion," Corrosion, ASM Handbook, vol 13, ASM International, Metals Park, OH, pp. 242-247, 2003.
5. J. R. Scully, R. G. Kelly, "Fundamentals of Aqueous Corrosion, Corrosion, ASM Handbook, vol 13, ASM, Metals Park, OH, pp. 68-86, 2003.
6. Robert G. Kelly, **Crevice corrosion, in** Encyclopedia of Electrochemistry, A. J. Bard, M. Stratmann, Wiley-VCH Verlag GmbH & Co. , vol. 4, 275-307, 2003.

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1. R. G. Kelly, G. S. Frankel, P. M. Natishan, R. C. Newman, *Critical Factors in Localized Corrosion IIII*, PV 98-17, The Electrochemical Society, Inc., Pennington, NJ (1999). A 725-page conference proceedings.
2. M. Seo, B . Macdougall, H. Takahashi, R. G. Kelly, *Passivity and Localized Corrosion*, PV 99-27, The Electrochemical Society, Inc., Pennington, NJ (1999). A 729-page conference proceedings.
3. R. G. Buchheit, R. G. Kelly, N. A. Missert, B. A. Shaw, *Corrosion and Protection of Light Metal Alloys*, PV 2003-23, The Electrochemical Society, Inc., Pennington, NJ (2003). A 416-page conference proceedings.
4. Kelly, R. G.; Tribollet, B.; Presuel-Moreno, F. J **,** *Modeling and Simulation of Dissolution and Corrosion Processes.* ECS Trans., 2008; 11(12)., Electrochemical Society, Pennington, NJ (2008), 53 pp.

Invited Presentations and Lectures

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1. R. G. Kelly, "An Evaluation of the Susceptibility of Laser Surface-Melted Aluminum Bronze to Dealloying via an Accelerated Electrochemical Test," David Taylor Naval Ship R & D Center Summer Student Symp., Annapolis, MD, August 22, 1983.

2. R. G. Kelly, "An Evaluation of the Susceptibility of Laser Surface-Melted Aluminum Bronze to Dealloying via an Accelerated Electrochemical Test," Baltimore Chapter of ASM, January 11, 1984.

3. R. G. Kelly, "Determination of the Rate-Limiting Mechanism of Li/Iodine(P2VP) Batteries," University of Minnesota, February 21, 1986.

4. R. G. Kelly, P.J. Moran, "Determination of the Rate-Limiting Mechanism of Li/I_2e(P2VP) Batteries," Sandia National Laboratories, Albuquerque, NM, September 23, 1986.

5. R. G. Kelly, P. J. Moran, "Corrosion and Passivity of Metals in Non-Aqueous and Mixed Solvents," Sandia National Laboratories, Albuquerque, NM, September 23, 1986.

6. R. G. Kelly, P. J. Moran, "Corrosion and Passivity of Metals in Non-Aqueous and Mixed Solvents," Dept. of Chemistry, Tel Aviv University, Tel Aviv, Israel, January 12, 1987.

7. R. G. Kelly, "The Passivity of Iron in Non-Aqueous and Mixed Solvents," Sandia National Laboratories, Albuquerque, NM, January 5, 1990.

8. R. G. Kelly, "The Passivity of Iron in Non-Aqueous and Mixed Solvents," Naval Research Laboratory, January 16, 1990.

9. R. G. Kelly, "The Passivity of Iron in Non-Aqueous and Mixed Solvents," Argonne National Laboratories, January 23, 1990.

10. R. G. Kelly, "Brittle Fracture of an Ag/Au Alloy Induced by a Surface Film," Department of Materials Science & Engineering, University of Florida, June 28, 1991.

11. B. K. Nash, J. Cheng, R. G. Kelly, "Advanced Solution Analysis Techniques Applied to Alloy Dissolution Studies," Research in Progress Symp., Corrosion '92, NACE, Nashville, TN, April 28, 1992.

12. B. K. Nash, R. G. Kelly, "The Characterization of the Crevice Solution Chemistry in 304 Stainless Steel," Advances in Corrosion and Protection, University of Manchester Institute of Science and Technology, Manchester, England, July, 1992.

13. R. G. Kelly, "Advanced Solution Analysis Techniques in Corrosion Science," National Capital Section of the Electrochemical Society, College Park, MD, April 8, 1993.

14. R. G. Kelly, "Analytical Probes of Dissolution of Materials," 2nd Intl. Symp. on Electrochemical Processing of Tailored Materials, Honolulu, HI, May, 1993.

15. G. Salamat, R. G. Kelly, "Analysis of Dissimilar Metal Crevice Corrosion of Stainless Steels," Symp. on Compatibility of Biomedical Implants, P. Kovacs, N. S. Istephanos, eds., The Electrochemical Society, San Francisco, May, 1994.

16. R. G. Kelly, "Probing the Chemical Composition of Occluded Corrosion Sites," 1994 Gordon Research Conference on Corrosion, Colby Sawyer College, NH, July, 1994.

17. R. G. Kelly, "Probing the Chemistry Inside Localized Corrosion Sites," Center for Nuclear Waste Regulatory Analyses, Southwest Research Institute, San Antonio, January 11, 1995.

18. R. G. Kelly, "Control of Localized Corrosion by Occluded Site Solutions," Department of Materials Science and Engineering Seminar Series, McMaster University, June 23, 1995.

19. “The Role of Ion Analysis in Understanding Corrosion Problems,” Richmond Chromatography Discussion Group, March 25, 1996.

20. R. G. Kelly, K. C. Stewart, “Spatiotemporal Modeling and Measurement of the Crevice Environment”, in Symp. on Prediction of Passivity Breakdown and Localized Corrosion: Experimental and Modeling Approaches, 190th Meeting of the Electrochemical Society, San Antonio, TX, Oct. 6-11, 1996.

21. “An Analysis of Fuselage Lap Splice Joint Corrosion," Materials Directorate, Wright-Patterson Air Force Base, July 22, 1996.

22. “Measurement and Modeling of the Factors Controlling Localized Corrosion,” Department of Chemical Engineering, University of Virginia, October 17, 1996.

23. R. G. Kelly, “Applications of Advanced Solution Analysis Techniques to Corrosion Science and Engineering,” Research Topical Symposium on Advanced Monitoring and Analytical Techniques, Corrosion ‘97, NACE, Houston, March, 1997.

24. “Determining the Chemical Composition of Occluded Sites,” Internatl. Symp. on Pits and Pores: Formation, Properties and Significance for Advanced Luminescent Materials, 191st Meeting of the Electrochemical Society, Montreal, May 5, 1997.

25. “Accelerated Corrosion Inside Occluded Spaces,” Lucent Technology Seminar Series, Lucent Technologies, Murray Hill, NJ, June 10, 1997.

26. “Microinstruments for Corrosion Monitoring,” Shell Westhollow Research Center, Houtson, October 13, 1997.

27. “Design, Manufacture, and Performance of Embeddable Microinstruments for Electrochemical Measurements,” Corrosion Prevention ‘97, NACE - Canada, Toronto, Nov, 10, 1997.

28. "Corrosion Conditions Inside Occluded Regions on Aircraft,” Research in Progress, Corrosion ‘98, San Diego, March 25, 1998.

29. "Control of Crevice Corrosion Morphology,” Gordon Conference on Aqueous Corrosion, Colby-Sawyer College, July 8, 1998.

30. “Computational Study of the Factors that Control Crevice Corrosion Morphology,” Sandia National Laboratory, August 6, 1998.

31. "Effects of Subcrevices in Crevice Corrosion: Computational Modeling Results," L. A. DeJong, J. M. Howse, R. G. Kelly, Corrosion '99.

32. "The Effects of the UTF and Teaching Portfolio on Teaching Effectiveness," R. G. Kelly, UVa Fall Teaching Workshop, September 1, 1998.

33. "Corrosion Microinstruments," TRB Meeting, Washington, DC, January 14, 1999.

34. "Embeddable Corrosion Sensors, SPIE Conf. Proc., Newport Beach, CA, (1999).

35. "Modeling and Measurement of Occluded Crevice Corrosion," Materials Science Seminar Series, Virginia Tech, September 10, 1999.

36. "The Effect of Boundary Conditions on Localized Corrosion Computations," 1999 DoE Corrosion Contractors Meeting, Univ. of Illinois, Urbana, IL, September 18, 1999.

37. "Towards Understanding and Mitigating Crevice Corrosion in Aging Aircraft", Chemical Engineering Dept., University of Oklahoma, March 1, 2000.

38. "Progress Towards Understanding Crevice Corrosion" Chemical Engineering Dept., Case Western Reserve University, March 23, 2000.

39. "Recent Computational and Experimental Investigations of Crevice Corrosion, " Symposium H, MRS Spring Meeting, San Francisco, April, 2000.

40. "Computational Studies of Crevice Corrosion " School of Chemistry, Tel Aviv University, Tel Aviv, Israel, January 10, 2001.

41. "Local Probes of Corrosion and Coating Failure on Al Alloys," University of Western Ontario, New London, Ontario, October 5, 2001.

42. "Localized Failure of Organic Coatings," The State Key Laboratory on Marine Corrosion and Protection,Qingdao Corrosion and Protection Laboratory, Luoyang Ship Materials Research Institute, China, Aug 13, 2001.

43. "Embeddable Microinstruments for Measurement of Corrosivity in Reinforced Concrete," The State Key Laboratory on Marine Corrosion and Protection,Qingdao Corrosion and Protection Laboratory, Luoyang Ship Materials Research Institute, China, Aug 14, 2001.

44. "Corrosion Effects on Structural Integrity", 5th Annual Raouf Lecture, Mech Engr, U.S. Naval Academy, 2/22/02

45. "The Influence of the Carbon Dioxide System on Corrosion Morphology," Corrosion '02, Denver, April 2002.

46. “The Role of ESI in Structural Integrity,” Corrosion/Fatigue Structural Demonstration Review, WPAFB, June 1, 2001.

47. “Linking Corrosion Phenomena Prediction to Corrosion Science and Engineering Fundamentals, Materials Lab, Air Force Research Laboratory, Wright-Patterson AFB, July 12, 2002.

48. “Linking Corrosion Phenomena Prediction to Corrosion Science and Engineering Fundamentals,” Gordon Conference on Aqueous Corrosion, July, 2002.

49. ”Use of the Autocorrelation Function to Describe Corrosion Topography,” *Critical Factors in Localized Corrosion IV: A Symposium in Honor of the 65th Birthday of Hans Bohni,* October, 2002.

50. “Computational Studies of Localized Corrosion Linking Fundamental Corrosion Science to Technological Applications,” Topical Day on “Numerical simulation of localised corrosion,” SCK•CEN, Belgium, 15-16th of October, 2002.

51. “Measurement and Modeling of Crack Conditions During the Environment-Assisted Cracking of an Al-Zn-Mg-Cu Alloy,” Environment-Induced Cracking of Metals, Second International Conference - September 19 - 23, 2004, Banff, Canada.

52. "The Challenges in Predicting Long-term Performance of Materials: Aging Aircraft and Nuclear Waste Storage", Center for Materials Science Seminar Series, Norfolk State University, December 1, 2004.

53. “*Ab Initio* Calculations of the Electrochemistry and Hydrogen Uptake on Ni(100),” with C.D. Taylor, M. Neurock, Corrosion ’05, Research in Progress, Houston, April, 2005.

54. “Localized Chemical Environments and the Implications on Fatigue in Aircraft Structures,” International Congress of Fracture XI, Turin, Italy, March, 2005.

55. “First principles modeling of the initial stages of oxide formation and hydrogen uptake on Ni (111),” Workshop on Effects of Pb and S on the Performance of Secondary Side Tubing of Steam Generators in PWRs, Argonne National Laboratory, May 24-27, 2005.

56. C. D. Taylor, R. G. Kelly, M. Neurock. “Recent Ab Initio Calculations of the Electrochemical Interface and Their Application to Corrosion and SCC in Supercritical Water,” SCWR Review Workshop, Lockheed-Martin Corp., March 7, 2006.

57. J. H. Payer, R. G. Kelly, “Localized Corrosion Data and Analyses from the Materials Performance Thrust of the OCWRM Science and Technology Program,” Nuclear Waste Technical Review Board Workshop on Localized Corrosion, Las Vegas, NV, September 25-26, 2006.

58. R. G. Kelly, “Computational Modeling of Corrosion,” International Workshop on Future Perspectives on Corrosion Research, Ringberg Castle, Tegernsee, Germany, December 13-16, 2006.

59. Panel Member: *"Corrosion Education throughout the World"* Moderator: Gerald Frankel (Ohio State University) Panelists: Bob Cottis (UMIST, UK), V.S. Raja (Indian Institute of Technology, Bombay), Ricardo Carranza (Instituto Sabato - UNSAM - CNEA - Argentina), **Robert Kelly** (University of Virginia), and En-Hou Han (Institute of Metals Research, China), 17th International Corrosion Congress, Las Vegas, NV, Oct. 6-10, 2008.

60. R. G. Kelly, “Atmospheric Corrosion and Crevice Corrosion Research at UVa,” National Institute of Materials Science, Tsukuba, Japan, December 10, 2008.

61. E.B. Neiser, R. G. Kelly, “Factors Controlling the Atmospheric Corrosion of Silver in Natural and Accelerated Test Environments”, 8th Spring Meeting of the International Society of Electrochemistry, Columbus, OH, May, 2010.

62. “Improving Accelerated Testing via Understanding the Kinetics of Silver Oxidation and Corrosion,” Chemistry Department Seminar, Univ. of Western Ontario, June 22, 2010.

63. Development of Intergranular Corrosion Model, Dept. of MSE, Va. Tech, Blacksburg, VA, Sept 16, 2011

64. Development of Intergranular Corrosion Model, Solid Mechanics and Materials Seminar, Brown University, Providence, RI, November 14, 2011

65. Aluminum Corrosion Research at UVa, UTC Aluminum Corrosion Workshop, United Technologies, Hartford, CT, September 28, 2011

66. “Future of Corrosion Science,” Gordon Research Seminar on Aqueous Corrosion, Colby Sawyer College, July 7, 2012.

67. “Integrated Modeling of Intergranular Corrosion and Stress Corrosion Damage Evolution on 5XXX (Al-Mg) Alloys,” Gordon Conference on Aqueous Corrosion, Colby Sawyer College, July 9, 2012.

68. “Atmospheric Localized Corrosion: Measurement, Mechanisms, and Modeling,” Gordon Conference on Aqueous Corrosion, Colby Sawyer College, July 10-15, 2016.

69. “The Use of the Galvele Pit Stability Product in the Modeling of Localized Corrosion Stability in Stainless Steels,” TEG 407X Mechanisms of Localized Corrosion: In Memoriam of Prof. J. R. Galvele, March 9, 2016, NACE 2016, Vancouver, BC, Canada

70. “Prediction of Maximum Pit Size from Atmospheric Exposure of Metallic Materials,” UFD Expert Panel on CISCC of Interim Storage Containers for Spent Nuclear Fuel, Sandia National Lab, Albuquerque, March 24-25, 2016.

71. “Complementary Experimental and Modeling Approaches to Elucidate Critical Conditions for Pit Stability and Repassivation,” C04-1287: Pits & Pores 7: Nanomaterials – Fabrication Processes, Properties, and Applications, PRiME 2016/230th ECS Meeting, Honolulu, October 4, 2016.

72. “Understanding the Role of Al^{3+} in Accelerated Testing and Its Impact on the Protective Oxide Film of AA2060,” C02-1162, in C02: Oxide Films: A Symposium in Honor of Masahiro Seo, PRiME 2016/230th ECS Meeting, Honolulu, October 4, 2016.

73. “Modeling of Localized Corrosion under Atmospheric Conditions: Cathodic Limitations,” (Keynote), 68th Annual Meeting of the International Society of Electrochemistry in Providence, RI, USA (August 29, 2017).

74. “Accelerated Sensitization in Laser Additively Manufactured 316L,” Corrosion of Additively Manufactured Metals Symposium, MS&T 2018, Columbus, OH (October 17, 2018)

75. “Measurement and Modeling of Damage from Atmospheric Galvanic Corrosion and Its Mitigation,” CAMBR, Western University, London, Ontario, December 5, 2018.

76. “Electrochemical Characterization of Additively Manufactured Al-10Si-Mg in Standardized Test Solutions,” Corrosion of Additively Manufactured Metals Symposium, MS&T 2019, Columbus, OH (October 2, 2019).

77. “Modeling of Localized Corrosion Under Atmospheric Conditions in the Presence of Galvanic Coupling,” Advances in Corrosion Science and Corrosion Engineering, Australian Corrosion Association, Melbourne, AU (July 24, 2019).

78. “Overcoming "Explain Everything, Predict Nothing": The Challenge to Corrosion Science,” 2020 Gordon Research Conference on Aqueous Corrosion, July, 2020 (cancelled by pandemic)

79. “Computational and Experimental Studies of Localized Corrosion on Engineering Structures,” Dept. of Materials Sci. & Engineering, Texas A&M University, September 14, 2020.

80. “Sensor Design, Construction and Validation for *in-Situ* Water Layer Thickness Determination during Accelerated Corrosion Testing,“ PRIME 2020, Symposium C06 (Keynote), The Electrochemical Society.

81. “OK, Now What? Facing the Failures and Building on the Successes of Corrosion Science,” 2022 Gordon Research Conference on Aqueous Corrosion, July, 2022.

Unrefereed Conference Proceedings and Other Unrefereed Technical Publications

1. R. G. Kelly, J. R. Scully, "An Evaluation of the Susceptibility of Laser Surface-Melted Aluminum Bronze to Dealloying via an Accelerated Electrochemical Test," NSRDC TM-28-83-189, David Taylor Naval Ship R & D Center, Annapolis, MD (1983).

2. J. R. Scully, R. G. Kelly, "Corrosion Characteristics of Rapidly Solidified Cu-based Alloys," NSRDC TM-28-83-190, David Taylor Naval Ship R & D Center, Annapolis, MD (1983).

3. J. R. Scully, R. G. Kelly, "Intergranular Corrosion of Ferralium 255 Duplex Stainless Steel Simulated Weldments," NSRDC SME-84-54, David Taylor Naval Ship R & D Center, Annapolis, MD (1984).

4. R. G. Kelly, "A Low-Power, Low-Cost, High-Frequency Galvanostat and Application to Li/I2 Batteries," *J. Electrochemical Soc.*, 134, pp. 55C-56C (1987).

5. B. K. Nash, R. G. Kelly, "The Use of Ion Chromatography for the Study of Localized Corrosion," *Critical Issues in Localized Corrosion*, G. Frankel, R. C. Newman, eds., PV 92-9, The Electrochemical Society, Pennington, NJ, pp. 420-426 (1992).

6. J. F. Dante, R. G. Kelly, "The Composition of the Absorbed Electrolyte Layer During Atmospheric Corrosion," *2nd Intl. Symp. on Corrosion and Reliability of Electronic Materials and Devices*, J.D. Sinclair, R. B. Comizzoli, ed., PV 93-1, The Electrochemical Society, Pennington, NJ, pp. 374-87 (1993).

7. R. G. Kelly, P. J. Moran, J. R. Scully, G. E. Stoner, W. J. Eggers, "Electrochemical Techniques in Corrosion Engineering: A Short Course," Center for Electrochemical Sciences and Engineering, (1993).

8. G. Salamat, R. G. Kelly, "Analysis of Dissimilar Metal Crevice Corrosion of Stainless Steels," *Compatibility of Biomedical Implants*, P. Kovacs, N. S. Istephanos, eds., PV 94-15, The Electrochemical Society, Pennington, NJ, pp. 354-67 (1994). (*invited paper*)

9. C. S. Brossia, R. G. Kelly, "On the Role of Alloy Sulfur in the Initiation of Crevice Corrosion in Stainless Steel," *Proc. of the Symp. on Critical Factors in Localized Corrosion II*, P. M. Natishan, R. G. Kelly, G. S. Frankel, R. C. Newman, eds., PV 95-15, The Electrochemical Soc., Pennington, NJ, pp. 201-217 (1996).

10. M. E. Inman, R. G. Kelly, S. A. Willard, R. S. Piascik, "Coordinated Metallographic, Chemical and Electrochemical Analyses of Fuselage Lap Splice Corrosion," *Proc. of the ASIP Conference*, Atlanta, November, 1996.
11. R. G. Kelly, "New Developments in the Measurement and Modeling of Localized Corrosion Sites," *Interface*, June, 1997. *Invited paper.*

12. R. G. Kelly, "Applications of Advanced Solution Analysis Techniques to Corrosion Science and Engineering," Research Topical Symposium on Advanced Monitoring and Analytical Techniques, NACE, Houston, March, 1997. *Invited paper*.

13. R. G. Kelly, J. Yuan, S. H. Jones, J. H. Aylor, W. Wang, A. P. Batson, A. Wintenberg, G.G. Clemena, "Corrosion Monitoring in Concrete by Embeddable Microinstruments," *ASTM Conference on Understanding Corrosion Mechanisms of Metals in Concrete - A Key to Improving Infrastructure Durability*, Boston, MA, July, 1997.

14. R. G. Kelly, P. M. Natishan, "Successful Local Sections," Interface, Spring, 1999, p. 40.

15. Karen S. Lewis, Robert G. Kelly, and Robert S. Piascik. (1999). "Determination of the Corrosive Conditions Present within Aircraft Lap-Splice Joints". The 2nd Joint NASA/FAA/DoD Conference on Aging Aircraft, Hampton, VA.

16. L. A. DeJong, R. G. Kelly, "The Demonstration of the Microfabrication of Rigorously Defined Crevices for the Investigation of Crevice Corrosion Scaling Laws," in *Critical Factors in Localized Corrosion IIII*, R. G. Kelly, G. S. Frankel, P. M. Natishan, R. C. Newman, eds., PV 98-17, The Electrochemical Society, Inc., Pennington, NJ, pp. 678-89 (1999).

17. R. G. Kelly, K. C. Stewart, "Combining the Ohmic Drop and Critical Crevice Solution Approaches to Rationalize Intermediate Attack in Crevice Corrosion," in ***Passivity of Metals and Semiconductors VIII*** , M. B. Ives, B. R. MacDougall, J. A. Bardwell, eds. PV 99-42, The Electrochemical Society, Princeton, p. 546-554 (1999).

18. M. M. Altynova, R. G. Kelly, J. R. Scully, X. Zheng, G. R. Cooke, D. T. Peeler, "Lap Joint Corrosion Prediction Model," Aging Aircraft 2000, St. Louis, MO, 20 pgs.

19. L. B. Simon, G. Skennerton, J. L. Elster, J. P. Wikswo, R. G. Kelly, "Quantification of Corrosion Rates in Aircraft Lapjoints Treated with Corrosion Prevention Compounds (CPC)," Aging Aircraft 2000, St. Louis, MO, 16 pgs.

20. R. G. Kelly, J. R. Scully, M. M. Altynova, D. T. Peeler, "Combining Probabalistic and Database Approaches to the Prediction of Corrosion Damage in Aging Aircraft," Aging Aircraft 2001, DoD, Orlando, 2001, 11 pgs.

21. Feng Gui, K. R. Cooper, L. B. Simon, R. G. Kelly, "Laboratory Evaluations of Corrosion Prevention Compounds" Aging Aircraft 2001, DoD, Orlando, 2001, 12 pgs.

22. O. M. Schneider, J. M. Williams, R. G. Kelly, "Phenomenology of Localized Coating Failure on AA1100-H14" Tri-Services Corrosion Conference, San Antonio, January, 2002, 14 pgs.

23. W. Gan, H. Wang, R. G. Kelly, "Initial Studies of Controlled Release of Chemical Species from Functional Coatings," Tri-Services Corrosion Conference, San Antonio, January, 2002, 7 pgs.

24. K. R. Cooper, C. Franck, R. G. Kelly, "Development of an Exfoliation Test Procedure for USAF Aging Aircraft Program," Tri-Services Corrosion Conference, San Antonio, January, 2002, 10 pgs.

25. K. R. Cooper, R. G. Kelly, "Crack Tip Chemistry and Electrochemistry of Environmental Cracks in AA 7050," Proc. of James Staley Symposium, TMS Meeting, Indianapolis, November, 2001, 10 pgs.

26. L. B. Simon, R. G. Kelly, F. Gui, J. M. Williams, K. Furrow, "Performance Assessment of Corrosion Prevention Compounds Using Laboratory Tests,"6th Joint FAA/DOD/NASA on Aging Aircraft 2002, September16-19, 2002, 12 pp.

27. R. G. Kelly, K. S. Ferrer, "Use of the Autocorrelation Function to Describe Corrosion Topography," Critical Factors in Localized Corrosion IV -- *A Symposium in Honor of the 65th Birthday of Hans Bohni* -- S. Virtanen, P. Schmuki, and G. S. Frankel, eds., PV 2002-24, The Electrochemical Society, Pennington, NJ (2002) pp. 457-474.

28. R. G. Kelly, K. S. Ferrer, "The Impact of the Carbon Dioxide System on the Cathodic Kinetics Within Aircraft Lap Splice Joints," Factors in Localized Corrosion IV -- *A Symposium in Honor of the 65th Birthday of Hans Bohni* -- S. Virtanen, P. Schmuki, and G. S. Frankel, eds., PV 2002-24, The Electrochemical Society, Pennington, NJ (2002) pp. 176-186.

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101. First Principles Calculations of the Energetics of Water and Oxygen Interacting with Aluminum, M. F.Francis, R. Kelly and M. Neurock, Aging Aircraft 2008, NASA/DOD/JCAA, Phoenix, AZ, April 21-24, 2008.

102. Role of Reactive Species in Atmospheric Corrosion of Silver, D. Liang, G. Ma, B. Wyslouzil, H. C. Allen, G. S. Frankel, J. D. Fuentes, Z. Y. Chen, W. C. Keene, R. G. Kelly, Research in Progress Symposium, Corrosion '08, New Orleans, March 16-20, 2008.

103. Ryan Dunn, Robert Kelly, Elissa Bumiller, "Development of A Degree of Sensitization Probe (DoS) for 5XXX Aluminum Alloys," ShipTech 2010, Biloxi, Mississippi, March, 2010.

104. M. E. Shedd, R. G. Kelly, "The Effect of pH and Phosphate Concentration on Sensitization Detection in Aluminum Alloys," 8th Spring Meeting of the International Society of Electrochemistry, Columbus, OH, May, 2010.

105. Q. Li, J. R. Maben, W. C. Keene, R. G. Kelly, "Chemical Characteristics of Material Surfaces Exposed to Ambient Coastal Marine Atmospheres" 8th Spring Meeting of the International Society of Electrochemistry, Columbus, OH, May, 2010.

106. E. Schindelholz, R. G. Kelly, "Application of Inkjet Printing for Salt Deposition Prior to Atmospheric Corrosion Testing." 8th Spring Meeting of the International Society of Electrochemistry, Columbus, OH, May, 2010.

107. M. Shedd and R. G. Kelly, "Modeling and Measurement of Maximum Pit Size during Atmospheric Exposure of Stainless Steels," Symposium D3 - Corrosion Issues in Nuclear Waste Storage: A Symposium in Honor of the 65th Birthday of

David Shoesmith, 218th ECS Meeting - Las Vegas, NV. October 10 - October 15, 2010.

108. E. Rouya, R. G. Kelly, M. Reed, and G. Zangari. “Electrocatalysis and Surface Characterization of Nanoporous Gold,” Symposium B3 - Electrochemistry of Novel Materials for Energy Storage and Conversion, 218th ECS Meeting - Las Vegas, NV. October 10 - October 15, 2010.

109. L. Chen, X. Wang, R. G. Kelly, and D. Brown, “Integrated Effects of Grain Boundary Characteristics on the Behavior of Intergranular Corrosion in 5XXX-Series Alloys,” Symposium D4 - Corrosion Modelling, 218th ECS Meeting - Las Vegas, NV. October 10 - October 15, 2010.

110. M. E. Shedd, R. G. Kelly, “Modeling and Measurement of Boundary Conditions for Pit Size on Stainless Steels Exposed to Atmospheric Environments,”: Research in Progress Symposium, Corrosion ’11,, Houston, TX, March 2011.

111. Joelle Buczynski, Robert G. Kelly, “Characterization of the β-phase (Al_3Mg_2) in 5XXX Aluminum Alloys, Poster Session, Corrosion ’11, Houston, TX, March 2011.

112. Cindy Shi, Robert G. Kelly, “Experimental Evaluation and Modeling of Galvanic Interactions between AA7075-T6 and Noble Materials,” Corrosion ’11, Houston, TX, March 2011.

220th ECS Meeting & Electrochemical Energy Summit in Boston, Massachusetts (October 9-14, 2011):

113. E. Schindelholz, R. Kelly, I. Cole, and T. Muster, # 2574: "Time of Wetness: Sensing Accuracy and Comparability", Symposium J1 - Sensors, Actuators, and Microsystems General Session.

114. Y. Shi and R. Kelly, Presentation # 1722: "Experimental Evaluation and Modeling of Galvanic Interactions between AA7075-T6 and Noble Materials", Symposium D4 - Critical Factors in Localized Corrosion 7.

115. M. Lim, R. Matthews, R. Tryon, S. Jain, R. Kelly, and J. Scully, Presentation # 1724: "Experiments and Modeling of Intergranular Corrosion Penetration in AA5083 as a Function of Electrochemical and Metallurgical Conditions," Symposium D4 - Critical Factors in Localized Corrosion 7.

116. L. Chen, D. Brown, and R. Kelly, Presentation # 1725: "Statistical Modeling of Intergranular Corrosion Based on Grain Boundary Characteristics in 5XXX-Series Alloys," Symposium D4 - Critical Factors in Localized Corrosion 7.

117. M. Shedd and R. Kelly, Presentation # 1691: "Modeling and Measurement of Boundary Conditions for Pit Size on Stainless Steels under Atmospheric Exposure Conditions," Symposium D4 - Critical Factors in Localized Corrosion 7.

118. J. Lee and R. Kelly, Presentation # 1686: "Factors Controlling the Location of Crevice Attack in Austenitic Stainless Steels, Symposium D4 - Critical Factors in Localized Corrosion 7.

119. J. Buczynski and R. Kelly, Presentation # 1673: "Electrochemical Characterization of the β-phase (Al_3Mg_2) in 5XXX Aluminum Alloys," Symposium D3 - Corrosion on Land, Sea, and Air.

120. Y. Wan, E. Neiser, and R. Kelly, Presentation # 1672: "Accelerated Corrosion Tests for Silver and their Correlation to Field Exposures," Symposium D3 - Corrosion on Land, Sea, and Air.

121. D. Mizuno and R. Kelly, Presentation # 1674: "Modeling and Measurement of Atmospheric Galvanic Corrosion of AA5083-H131 in Contact with 4340 Steel," Symposium D3 - Corrosion on Land, Sea, and Air.

Corrosion '12, Salt Lake City, UT, March 12-14, 2012

122. Mary Lyn C. Lim, Robert Matthews, Mike Oja, Robert Tryon,Robert G. Kelly, John R. Scully, Modeling of Intergranular Corrosion Penetration in AA5083 as a Function of Electrochemical and Metallurgical Conditions, Research in Progress Symposium.

123. Daisuke Mizuno, Robert G. Kelly, Measurement and Modeling of the Role of Sensitization on the Galvanic Interactions Between 4340 Steel and AA5083 under Thin Film Conditions, Research in Progress Symposium.

124. Y. Wan,R. G. Kelly, The Effects of Ozone, UV Light, and Method of Salt Deposition on the Corrosion of Silver and Steel in Accelerated Test Chambers, Research in Progress Symposium.

Patents and formal copyrights awarded or pending

Robert G. Kelly, Robert A. Ross, Josef K. Hudson, Stephen H. Jones, "Embeddable Corrosion Monitoring Instrument for Steel Reinforced Structures," U.S. and China Patents 09/899,908 (2000). Received Notice of Allowance, issuance by 12/26/03.

Kevin Cooper, Fritz Friedersdorf, Keith Furrow, Jackie Williams, Amanda Owen, Robert Kelly, "A Corrosion Inhibitor Derived from Tobacco" U.S. Provisional Application 60/ 428,740 (2002).

Professional Service

University

Organizational Excellence Leadership Council (2016- present)
Search Committee, Asst Director for Center for Teaching Excellence (2016)
Mentor, Excellence in Diversity Program, Mentor for Amalia R. Miller (2004-05), Malek Abdessallm (2004-05), Chris Deppman (2009-10)

Mentor, University Academy of Teaching, Gary Koenig (2011-12)
University Teaching Fellow Mentor for M. Begley (2002-03), A. Ghosh (2008-09)
University Committee on Information Technology (2004)
Provost's On-Line Course Evaluation Advisory Committee (2003-05)
Presentation on use of Socratic Method in TRC/SEAS GTA Course (Fall, 2001, 2002, 2014-18)
Conducted workshop on graduate student advising at request of TRC (March 1, 1999)
Selection Committee:
University Teaching Fellows (1998-2011)
Faculty Senate Dissertation Year Fellows (2006-present)
University Teaching + Technology Fellows (1999)
Judging for Fall Undergraduate Research Symposium
Coached preparers of Teaching Portfolios via TRC.
Denise Newman (Psychology, 2001)
Melinda Schmidt (PhD student in Psychology, 2003)
Mark Kirk (Asst Prof, Medical Toxicology, 2003)

School of Engineering and Applied Science (SEAS)
Promotion and Tenure Committee (2009-10, 2015-18)
Chair, 2015-16, 2016-17, 2017-18
Search Chair, Associate Dean for Advancement (2016-17)
Rolls Royce Faculty Search Committee (2009-2011)
Lead, Research Distinctiveness Module, SEAS 2010 Strategic Planning Ctte
Conducted workshop on graduate student advising at request of Dean (2006)
Co-Chair, Rankings and Recognition Committee (2004-2006)
TCC Faculty Search Committee (2002)
Director, Rodman Scholars Program (1999- 2004)
Faculty Advisor, Tau Beta Pi Chapter (1997-2000)
CHEM 151-152 Advisory Committee (1995-1999)
Committee for the Evaluation of Rodman Core Courses (1995)
Rodman Scholars Committee (1994 - 1999)
ENGR 160 Advisory Committee (1996 - 1998)
SEAS Undergraduate Curriculum Committee (1996-1998)
Chair, Physics Task Force (1997)
Participated in the SEAS Common Reading Experience (1995 - present)
Judge, 1994 Undergraduate Research & Design Symposium

Department of Materials Science and Engineering
Associate Chair (Finance (2016-present)
Strategic Planning Committee (2020-present)
Planning Committee, Chair (2008-2010)
Graduate Recruiting Committee, Chair (2004-present)
Award Committee, Chair (2004-2005)
EP Materials Comprehensive Examination Preparation (2000-2009)
Building Committee (2002-2004)

MURI Hiring Committee (2001)
Mechanical Properties Hiring Committee (2000)
Computational Materials Hiring Committee (2001)
Student Recruiting Committee, Chair (1997-2002)
Undergraduate MSE Option Committee
Represented Materials Science and Engineering at various SEAS Open Houses and other functions

The Electrochemical Society (ECS)
Editor, *Interface* (2018-present)
Audit Committee (2011-12)
Finance Committee (2009-2010)
Individual Membership Committee (2007-2008)
Ways and Means Committee (2003-2005)
Representative to Federation of Materials Societies (2003-2005)
Honors and Awards Committee (1999-2003)
2001, 2003 Olin Palladium Award Committees (Chair)
2000-2012 H. H. Uhlig Award Committee (Chair, 2007-2012)
Morris Cohen Award Committee (1999-2000)
National Meetings Committee of the Electrochemical Society 1996 - 98

Executive Committee, Corrosion Division
Past Chair (2006 – 2008)
Chair (2004-2006)
Vice-Chair (2002-2004)
Secretary/Treasurer (2000-2002)
Member at Large (1998-2000)
Newsletter Editor (1998-2000)
Advisory Board of *Interface* (1998-2003)

Executive Committee, National Capital Section of the Electrochemical Society, 1993- 1998
Secretary, Program Chairman, Science Fair Chairman, Chairman, Past Chairman

Meeting Organization (selected):
Co-organizer, Modeling and Simulation of Dissolution and Corrosion Processes—R. G. Kelly, J. Meyers, F. Presuel-Moreno and B. Tribollet (2007).

Co-chair, Critical Factors in Localized Corrosion IV A Symposium in Honor of the 65th Birthday of Hans Bohni, Session on Propagation of Localized Corrosion Processes, Fall, 2002

Co-organized "Passivity and Localized Corrosion, An International Symposium in Honor of Prof. Norio Sato (1999).

M. Seo, B. Macdougall, H. Takahashi, R. G. Kelly, *Passivity and Localized Corrosion*, PV 99-27, The Electrochemical Society, Inc., Pennington, NJ (1999). A 729-page conference proceedings

Lead organizer, "Critical Factors in Localized Corrosion III, A Symposium in Honor of the 70th Birthday of Jerome Kruger (1998)

R. G. Kelly, G. S. Frankel, P. M. Natishan, R. C. Newman, *Critical Factors in Localized Corrosion III*, PV 98-17, The Electrochemical Society, Inc., Pennington, NJ (1998). A 725-page conference proceedings.

Vice-chairman and co-organizer of Stress-Corrosion Cracking Symposium, 1990

Chairman of a session of the Symposium on Critical Issues in Localized Corrosion, 1991

Chairman of a session of the General Corrosion Symposium, 1991, 1992

Chairman and organizer of Corrosion in Batteries and Fuel Cells Symposium, 1993

Chairman and co-organizer of Critical Factors in Localized Corrosion II Symposium, 1995

Session Chair, Symposium on Prediction of Passivity Breakdown and Localized Corrosion: Experimental and Modeling Approaches, 1996.

The National Association of Corrosion Engineers (NACE)

Session Organizer, NACE Research in Progress Symposium, 1994, 1995, 1997
Vice Chair, NACE Research in Progress Symposium, 1999
H.H. Uhlig Educator Award Subcommitte (2001-present)
A. B. Campbell Awards Subcommittee (1998-2002)
Chair, Research in Progress Symposium, Corrosion '00, Orlando, March, 2000.
Session Chair, "Advanced Methods Applied to Corrosion Measurements," Research in Progress Symposium, Corrosion '00, Orlando, FL, March, 2000.

Materials Research Society

Session Chair, Localized Corrosion, Symposium H, MRS Spring Meeting, San Francisco, April, 2000.

Scientific Committee, 14th International Aluminium Conference, 13-15, November, 2019, Tokyo, Japan. (2018-present)

Tau Beta Pi

Faculty advisor for University of Virginia Chapter (1999)

Consulting

Newport News Shipbuilding and Drydock Company, 1991

ARCO Oil and Gas, 1991
Innovative Solutions for Advanced Technology, 1991
Valence Technology, 1992
Siemens Automotive, 1992
Waters Corporation, 1994-98
Optimetrics, 1995
Bettis Atomic Power Laboratory, 1995
Knolls Atomic Power Laboratory, 1995
MetalSpray, 1995-6
Trident Engineering Associates, 1995
Wright Patterson AFB, 1996
Faraday Technology, 1996
Luna Innovations/F&S, Inc., 1997- 1999, 2017-2019
NCI Information Systems, 1997-2000
Metal Container Corp., 1999
S&K Technologies, Inc., 2000 – 2006
Swales Aerospace (for NASA Engineering Safety Center), 2004-06
CCI, Inc, 2006-2007
Valdez International, 2006-08
Scribner Associates, 2007
Advanced Energy Industries, Inc., 2007
ElectaWatch, 2009-present
Encell, 2010-2013
Eastman Chemical, 2011-2012
PPA Architects, 2011-2012
AMA Corporation (for NASA Engineering Safety Center), 2012-present
Alcoa, 2011
Metna, 2015
VEXTEC, 2012, 2014-present
SAF Engineering, 2011-2016
Sandia National Labortatories, 2016
PPG, 2016
GE India Corporation 2015 – 2017
Global Technologies, 2018-present
EngeniusMicro, 2020-present
Aerospace Corporation, 2019-present
Halliburton, 2019-2020
K&L Gates, 2018-2020

Other significant professional activities

External Review Panel, Total Performance Assessment Code ver 3.2, Center for Nuclear Waste and Regulatory Analyses, San Antonio, 1999.

External Review Panel, Applied Science Department, Brookhaven National Laboratory, 1999.

Waste Package Materials Performance Peer Review Panel, Dept. of Energy, 2001-2002.

Organizer, Advanced Modeling of Corrosion Damage Evolution, Office of Naval Research, Airlie Conference Center, Warrenton, VA, June 14-15, 2005

Technical Assistance to *Columbia* Accident Investigation Board, 2003.

Technical Assistance to the 9/11 Pentagon Memorial design team, 2003-2010.

Technical Assistance to the International Space Station, 2004-06, 2012-14.

Reviewer
Editor, *Interface* (member journal of the Electrochemical Society (2018-present)
Editorial Board, *J. Applied Electrochemistry* (2016-present)
U.S. Editor, *Corrosion Science, Engineering, and Technology (IOM, UK)* (2003- 2010)
Editorial Board, *J. Corrosion Science and Engineering* (1998- 2005)
Editorial Board, *Corrosion Reviews* (2011-present)

Reviewer for *J. Electrochemical Society, Corrosion, Corrosion Science,* ASTM, National Science Foundation, Department of Energy, *J. Chromatography, The Physical Review, Metallurgical Transactions, Electrochimica Acta, Nature* among others.

TEACHING

Undergraduate

Average Instructor Evaluation Relative to Mean (1992-2018): +0.36 on a 5-point scale

Courses Taught:
ENGR 202 "Engineering Thermodynamics"
ME 339 "Engineering Materials"
ME 352 "Engineering Materials" – co-taught with Shiflet, Gangloff, Wadley
ENGR 291R "Conservation Principles II"
MSE 301 “Corrosion”
MSE 301L "Corrosion Laboratory"
MSE 209/MSE 2090 "Introduction to Materials Science"
ENGR 141R "Synthesis and Design I"
MAE/MSE 3610 “Aerospace Materials”
MSE/EVSC 2010 “Materials That Shape Our Civilization”

Graduate

Average Instructor Evaluation Relative to Mean: +0.42 on a 5-point scale

MSE 793/CHE 898 "Dynamic Behavior of Corrosion and Electrocatalytic Processes," - with J. Hudson (ChE).
MSE 606 "Structure and Properties of Metals II"

Continuing Education

"Electrochemical Techniques in Corrosion Engineering"
Summers, 1991 - 2002

Coordinated and co-taught a five-day short course aimed at developing the skills of practicing engineers in the application of modern corrosion measurement techniques. Between 30 and 40 engineers participate each year. The course is held on the campus of the School of Engineering and Applied Science of the University of Virginia. The course is co-sponsored by the Center for Electrochemical Science and Engineering, the Old Dominion section of NACE, and EG&G Princeton Applied Research.

Curriculum Development

- Development of new or completely revamped courses across the range of academic levels
  - ENGR 141R: *Synthesis and Design I* (revamped) - an introduction to engineering, analysis, and software tools for freshmen engineering honors students; one semester project involved the design of a mobile environmentally friendly brick kiln that can be used for education at secondary schools.
  - MSE 291R: *Conservation Principles II* (new) - an integrated course teaching the common base for and material of statics, dynamics, and thermodynamics to sophomore engineering honors students.
  - MSE 301 & 301L: *Corrosion* and *Corrosion Laboratory* (new) – coupled junior-level lecture and laboratory courses introducing the principles of the degradation of materials by the environment; used examples from research and consulting to illustrate important design considerations.
  - MSE 606:*Structures and Properties of Materials II* (revamped) – second-semester course providing intensive introduction to materials science for beginning graduate students with undergraduate degrees in physics, chemistry, or engineering; brought in examples of everyday uses of electrical, optical, and mechanical properties.
  - MSE/EVSC 2010: *Materials That Shape Our Civilization*: completely revamped course from a historical survey of the importance of materials to one focusing on the effects of materials on sustainability in terms of greenhouse gas generation as well as means to mitigate those effects.
- Primary author of a 420-page book (*Electrochemical Techniques in Corrosion Engineering, Marcel Dekker, 2002)* based on an intensive, one-week short course offered at UVa each summer for 13 years aimed giving working engineers practical skills to evaluate corrosion problems and develop mitigation strategies.

VCS, Inc.
Tax ID# 46-5106848
8413 Laurel Fair Circle. Suite 200B
Tampa, FL 33610

Brian Pailes, Ph.D., P.E.
Principal Engineer
(813) 777-6946 Mobile
brianp@VCServices.com

EDUCATION

Doctorate of Philosophy in Civil Engineering (Structures), Rutgers University, 2014
Master of Science in Civil Engineering (Structures), University of Virginia, 2009
Bachelor of Science in Civil Engineering, Northeastern University, 2007

CERTIFICATIONS, REGISTRATIONS & PROFESSIONAL ASSOCIATIONS

Professional Engineer
Florida #81340, Louisiana #41478, Minnesota #56551, Mississippi #29931, New Jersey #24GE05566500, New York #097707, Rhode Island #12801, Texas #131712, Washington DC #920607
Authorized to work in Canada – Work Permit
Graduate Certificate in Geophysics at Rutgers University
OSHA 510 - 30 Hour Safety Certification
MSHA Part 48 – 24 Hour Minor Training
NACE Cathodic Protection Specialist (CP-4) #59110
American Concrete Institute – Member
Precast Concrete Institute – Member
American Society of Civil Engineers – Member
Chi Epsilon – Member

EMPLOYMENT HISTORY

(2018 – Present) Principal Engineer – VCS, Inc., Tampa, FL
(2016 – 2018) Senior Project Manager – VCS, Inc., Tampa, FL
(2014 – 2016) Project Manager – VCS, Inc., Tampa, FL
(2010 – 2014) Graduate Research Assistant – Rutgers University, Piscataway, NJ
(2010 – 2014) Consulting Engineer – Transportation Infrastructure Systems, Piscataway, NJ
(2009 – 2010) Research Faculty – Virginia Polytechnic Institute and State University, Blacksburg, VA
(2008 – 2009) Graduate Researcher – Virginia Transportation Research Council, Charlottesville, VA
(2007 – 2008) Graduate Teaching Assistant – University of Virginia, Charlottesville, VA
(2005 – 2006) Co-op Student Employee – Simpson Gumpertz and Heger, Waltham, MA
(2004 – 2004) Co-op Student Employee – Parsons Brinckerhoff, Boston, MA

PROFESSIONAL CREDENTIALS

- Active Technical Committee Member of the Transportation Research Board Corrosion Committee AHD45
- Active Technical Committee Member of the American Society of Nondestructive Testing Infrastructure Committee
- Vice Chairman of the NACE Standards Committee - SC 12 - Concrete Infrastructure

PROFESSIONAL EXPERTISE

- Investigation and inspection of reinforced concrete to identify corrosion of embedded metals.
- Non-destructive testing (NDT) of reinforced concrete to identify deterioration and damage.
    - Ground penetrating radar

    - Corrosion potential measurements
    - Electrical resistivity
    - Impact Echo
    - Chain drag/hammer sounding
- Material sampling and testing of reinforced concrete
    - Chloride concentration
    - Carbonation depth
    - Strength and modulus evaluation
    - Permeability
- Remote Monitoring
    - Installation and programing of remote monitoring units
    - Monitoring cathodic protection system and health and safety of construction sites
- Cathodic Protection
    - Design and installation of galvanic and impressed current cathodic protection systems on a variety of reinforced concrete infrastructure.

PROJECT EXPERIENCE

Bridges

- (2021) Chatham Bridge, Fredericksburg, VA – QA/QC of the installation of thermal spray metalizing of substructure elements
- (2021) Goochland Cathodic Protection Installation, Goochland, VA – QA/QC of the installation of thermal spray metalizing of pier caps and installation of impressed current cathodic protection
- (2020) Arlington Memorial Bridge, Washington, DC – QA/QC and monitoring of hybrid cathodic protection system.
- (2020) Bridge 9123, Jordan, MN – Condition investigation of bridge repairs to determine effectiveness of galvanic cathodic protection system
- (2019) Winona County Metallizing, Rochester, MN – QA/QC and monitoring of thermally spray coated (TSC) zinc cathodic protection system
- (2019) Mineral King Bridge, Fresno, CA – Reinforced concrete deterioration assessment of historic spandrel arch bridge.
- (2019) Rainbow Bridge, Niagara Falls, NY – Corrosion assessment of reinforced concrete bridge deck and substructure.
- (2019) Schuylkill River Bridge, Berks County, PA – Materials testing of reinforced concrete arch, piers and deck
- (2019) Brooklyn Queens Expressway, New York, NY – Service life modeling of concrete deterioration.
- (2019) 21st Avenue over McPherson Bayou, St Pete Beach, FL – Design of cathodic protection jackets for piles.
- (2019) KAM Highway Bridge, Oahu, HI – Design of galvanic cathodic protection system for reinforced concrete arch bridge.
- (2018) Stan Gober Memorial Bridge, Naples, FL – Corrosion assessment of a reinforced concrete bridge for service life extension.
- (2018) SW-SE Freeway, Washington, D.C. – Evaluation and development of 50-year service life extension for three multi-span bridges.
- (2018) Whirlpool Bridge, Niagara Falls, NY – Evaluation of corrosion activity in reinforced concrete elements.
- (2017) I-395 over the Potomac River, Washington, DC – Corrosion assessment of a reinforced concrete bridge and development of rehabilitation solutions.
- (2016) 16th St. NW Bridge, Washington, DC – Corrosion assessment of historic reinforced concrete arch bridge.

- (2016) Siesta Key Bridge, Sarasota, FL – Design and installation of cathodic protection remote monitoring station.
- (2016) Main St. Bridge, Daytona Beach, FL – Verification and commissioning of galvanic jacket installation to reinforced concrete piles.
- (2016) Welsh Causeway, Madeira Beach, FL – Verification and commissioning of galvanic jacket installation to reinforced concrete piles.
- (2015) Route 105 Fort Eustis Blvd., Newport News, VA – Corrosion assessment of bridge substructure for reuse in rehabilitation.
- (2015) Ohio State Route 296, Urbana, OH – Verification of proper installation of embedded zinc galvanic anodes
- (2015) Maydell Drive, Tampa, FL – Evaluation of substructure bents for corrosion deterioration.
- (2014 – 2015) Pulaski Skyway, Newark, NJ – Evaluation of reinforced concrete pier for concrete deterioration and reinforcing section loss.
- (2011) Admiral Clarey Bridge, Pearl Harbor, HI – NDT investigation of protective jackets around precast piles for corrosion protection.
- (2011) State Route 15 over Interstate 66, Haymarket, VA – Condition assessment of reinforced concrete deck using NDT and material sampling.
- (2009 – 2014) Long Term Bridge Performance Program – Conducted non-destructive and materials evaluation of bridges throughout the United States.
- (2008) Hampton Roads Bridge and Tunnel – Conducted an evaluation of piles which had fiberglass and concrete jackets.

Parking Structures

- (2020) Daniel K. Inouye International Airport Car Rental Garage, Honolulu, HI – Design of a galvanic cathodic protection system to protect reinforced concrete footers
- (2020) St. Clair County Court House Parking Garage, Belleville, IL – Corrosion assessment of subgrade parking facility, design of a hybrid cathodic protection system and QA/QC for system installation.
- (2019) United States Postal Service Headquarters Garage, Washington, DC – Corrosion assessment of subgrade parking facility and design of hybrid cathodic protection system.
- (2019) Indianapolis Airport Parking Garage, Indianapolis, IN – Technical support for the installation of galvanic cathodic protection.
- (2015) Camelback Parking Garage, Phoenix, AZ – Corrosion assessment of subterranean parking garage.
- (2014) University of Iowa Children's Hospital Parking Garage Ramp 2, Iowa City, IA – Identification of consolidation issues in post-tensioned beams and slab.

Ports

- (2020) Port of Corpus Christi, Corpus Christi, TX – Design, installation QA/QC, and monitoring of a hybrid cathodic protection system for Oil Docks 4 and 7.
- (2020) Port Everglades, Fort Lauderdale, FL – Design and QA/QC of a galvanic cathodic protection system for a steel sheet-pile bulkhead wall.
- (2019) Antigua Cruise Ship Pier, Antigua – Design of galvanic cathodic protection for steel sheet-pile bulkhead wall.
- (2019) Dominion Terminal Pier XI, Newport News, VA – Corrosion evaluation and rehabilitation recommendations for coal loading pier.
- (2019) Port Manatee, Port Manatee, FL – Stray current evaluation for steel sheet-pile bulkhead wall.
- (2019) Port of Pascagoula, Pascagoula, MS – Design of an impressed current cathodic protection system for a steel sheet-pile bulkhead wall.

- (2019) Port of Port Arthur, Port Arthur, TX – Evaluation of existing impressed current cathodic protection system on Berth 3 and 4 and design of new impressed current cathodic protection system.
- (2019) Port of Port Arthur, Port Arthur, TX – Review of impressed current cathodic protection system design for Berth 5
- (2018) Port of Port Arthur, Port Arthur, TX – Corrosion study of bulkhead wall for Berth 3 and 4
- (2017) Port of Houston Barbours Cut, Houston, TX – Verification and commissioning of galvanic jacket installation to reinforced concrete piles.
- (2017) Port Canaveral, Port Canaveral, FL – Design of a thermally applied zinc cathodic protection system.
- (2017) Port Everglades, Fort Lauderdale, FL – Verification of anode materials for cathodic protection installation
- (2017) Port Canaveral NCP 1 and 2, Port Canaveral, FL – Corrosion assessment of bent caps and deck.
- (2016) FLECT Piers QVXW, Charleston, SC – Corrosion assessment of reinforced concrete wharfs

Post Tension Structures

- (2019) Highway 2 over the Missouri River, Nebraska City, NB – Nondestructive evaluation of bonded internal post-tensioning for grouting defects and corrosion.
- (2018) Wonderwood Bridge, Jacksonville, FL – Monitoring of post tension drying process
- (2018) Sacred Heart Hospital Parking Structure, Allentown, PA – Corrosion evaluation of unboned post-tension system
- (2017) Washington Square Parking Garage, Philadelphia, PA – Evaluation and rehabilitation plan for unbonded post-tension system
- (2016) I-355/I-88 Interchange, Chicago, IL – Post-tension investigation.
- (2015) US 101 over Siletz River, Lincoln City, OR – Evaluation of post-tension system for defects and corrosion.
- (2015) OR 229 over Siletz River, Siletz, OR – Evaluation of post-tension system for defects and corrosion.
- (2015) Rogers Avenue Pedestrian Overpass, Victoria, BC – Use of nondestructive means to identify voiding in post-tension ducts.
- (2015) Sunshine Skyway Bridge, St. Petersburg, FL – Use of magnetic flux to identify breakages in transverse deck tendons.

Other Structures

- (2019) Oak Ridge National Laboratory, Oak Ridge, TN – Evaluation of reinforced concrete slabs for corrosion deterioration.
- (2019) Venetian Isles Condominium, Naples, FL – Design of cathodic protection jackets for marine piles
- (2019) FDR Promenade, New York, NY – Corrosion assessment of reinforced concrete promenade structural components.
- (2018) Buchanan Dam, Austin, TX – Evaluation of reinforced concrete corrosion and design of hybrid cathodic protection system.
- (2018) Titian America, Medley, FL – Corrosion and concrete deterioration assessment of silo ring beam columns, beam seats, and roof structure. Design of galvanic cathodic protection system to protect ring beam columns.
- (2018) 2nd Avenue Seawall, St Petersburg, FL – Design of a cathodic protection system for a steel sheet pile wall.
- (2018) Crystal Sands Condominium, Siesta Key, FL – Design of impressed current cathodic protection system.

- (2017) Caesar's Bay Shopping Pier, New York, NY – Design and installation of remote monitoring system for impressed current cathodic protection system.
- (2016) Holcim Slurry Tanks, Ada, OK – Corrosion assessment of three reinforced concrete slurry tanks.
- (2016) Oceanfront Villas, Charleston, SC – Corrosion assessment of reinforced concrete columns.
- (2016) Chalk Point Cooling Tower, MD – Design and installation of cathodic protection remote monitoring station.
- (2016) MacDill Air Force Base, Tampa, FL – Evaluation and maintenance of impressed current cathodic protection system for three water tanks.
- (2015) TECO Transmission Lines, Tampa, FL – Verification and commissioning of galvanic jacket installation to reinforced concrete piles
- (2015) Hume Lake Dam, Sequoia National Forest, CA – Impact echo and infrared thermography assessment to dam to identify dealmianations, cracking, and other deterioration.
- (2015) Franklin Field, Philadelphia, PA – Corrosion assessment and deterioration survey of reinforced concrete stands.
- (2015) Holcim, Holly Hill, SC – Evaluation of six silo walls for corrosion deterioration and reinforcing cover depth issues.
- (2015) Parcel 1B, Boston, MA – Design of an impressed current cathodic protection system to protect three transfer beams.
- (2014) St. Petersburg Municipal Pier, St. Petersburg, FL – Condition assessment of pier structure to identify feasibility of 75-year life extension.

PUBLICATIONS (Primary or co-author)

Pailes, B.M., "Reinforced Concrete Damage Identification through Fusion of Multi-Modal Non-Destructive Testing Data," Transportation Research Board 99th Annual Meeting, Washington, D.C., January 2020.

Pailes, B.M, "Electrochemical Treatments Significantly Extend the Service Life of Reinforced Concrete Structures," Concrete Repair Bulletin, Vol. 32, No. 2, March/April 2019

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Pailes, B.M., Brown, M.C, and Sharp, S.R., “Condition Assessment and Determination of Methods for Evaluating Corrosion Damage in Piles Encapsulated in Protective Jackets on the Hampton Roads Bridge-Tunnel,” Virginia Transportation Research Council, Charlottesville, VA, April 2010.

Pailes, B.M, “Determining Methods for Evaluating Corrosion Damage in Piles Encapsulated in Protective Jackets,” Master’s Thesis, University of Virginia, August 2009.

APPENDIX 3: INDIVIDUAL RESPONSES

Reviewer 1 Response

Reviewer 2 Response

Reviewer 3 Response

These will be inserted in the compiled PDF.

PEER REVIEW RESPONSE

AGENCY:	US Department of the Interior, Bureau of Safety and Environmental Enforcement (BSEE)
MATERIAL REVIEWED:	2018 *Subsea Bolt Study: Technical Gaps in Current Standards and Requirements* (Subsea Bolt Study)
REVIEWED BY:	Reviewer 1
DATE:	October 20, 2022

The purpose of this peer review is to review and provide feedback on the Subsea Bolt Study. See *Peer Review Charge: Subsea Bolt Study* (23 August 2022) for more information. The Peer Reviewers shall evaluate the following Charge Questions and provide supporting documentation and rationale.

Instructions: Please answer questions requesting a numerical rating between 1 and 5. For example, if your rating is "3," input a "3" in the "Numerical Rating" column. For purposes of selecting a numerical rating, use the following categorical indicators:

1 = Unacceptable **2 = Inadequate** **3 = Mixed** **4 = Good** **5 = Excellent**

SUBSEA BOLT STUDY: TECHNICAL GAPS IN CURRENT STANDARDS AND REQUIREMENTS

A. METHODS AND ASSUMPTIONS

1. **Are applicable subsea critical drill-through equipment oil and gas and bolting standards addressed? Are there any other relevant standards that need to be addressed for this study?**

Based on the reviewer's knowledge, the standards included in this study was thorough and adequately captured applicable standards for subsea critical drill-through equipment oil and gas and bolting.

Although the study says Subsea Bolt Study, for the corrosion specific standards and literature, instead of doing a word search for "Bolt" or the keywords listed on Page 25-26, the authors should do a more material focused search. For example, bolts can be made of various materials like low carbon steels, mild steels, stainless steels and nickel alloys, thus the standards (NACE/AMPP/ DNV/ISO) would be more designed towards materials and exposure conditions like high H2S, high salinity, high temperatures, high bio fouling. Thus, the searches will yield better results if authors don't search for the keywords "bolts" or fasteners.

One item to consider, although it was slightly touched on in Section 11.2, are the standards regarding the tools used to tighten the bolts. It might be slightly out of the scope of this document, but maybe adding more discussion in Section 11.2 would be helpful to give it appropriate context with regards to this work.

2. **Are the methods appropriate? Were the methods used valid for the goals of this study project?**

Numerical Rating: 4

The methods used in this study were appropriate in determining the gaps and inconsistencies in the standards.

One method that might have helped in determining gaps in the standards would have been to survey a wide range of users of these standards. To determine the gaps the researchers used their knowledge to determine what should be in the standards and then looked to see if that was captured by the standards. As people all have different backgrounds and experiences, asking more people to determine what they think should be in these documents would have been helpful in determining all the gaps.

3. **Are limitations and uncertainties clearly identified and adequately characterized?**

Numerical Rating: 5

The researchers did a good job of discussing the limitation of this work in that there is a large network of standards, and it could have extended this project indefinitely by looking at them all. The researchers collected a wide breadth and depth of standards but set appropriate limits on the

documents so that this work didn't spiral out of control but still reviewed the important documents. This was clearly defined in the work.

4. **Are the assumptions clearly defined and appropriate?**

Numerical Rating: 5

As this was a literature review there are limited assumptions. The primary one was in how to limit the document review so that it didn't spiral out of control. The researchers had to make some assumptions on how to limit it while still capturing the necessary information. This was very appropriate for this kind of work.

5. **Are the strengths of the analytical methods used identified and relevant to the research? Are the weaknesses of the analytical methods identified, and are they relevant to the research study?**

The researchers were clear in stating the strengths and weaknesses of any of their analytical methods used in assessing the standards.

Section 7- subsection 7.1 - Graded Categories of topic coverage: The authors have created 5 categories. the two categories of "Yes, Partial," and "No, Incomplete," are defined in a way that both the categories read similar. What is the difference between "Yes, Partial," and "No, Incomplete"? Reviewer finds these two categories similar

6. **Are there gaps in the analytical methods? Are the analytical methods used relevant to determine scientific findings and recommendations (i.e., empirical data supports the analytical techniques or theoretical data)?**

There are no gaps in the analytical methods to assess the standards.

7. **Are the variables used in the research study identified and characterized?**

Numerical Rating: N/A

There really are not any variables in this document as it is really a literature review.

8. **Are the data collection methods and inputs presented in a transparent manner?**

Numerical Rating: 5

The researchers were clear in how they collected the documents, what documents they selected, how they limited the documents and how they reviewed each one.

9. **Were the database and programs utilized for the study appropriate, accurate, and sensitive enough to produce relevant data identifying bolting standards requirement gaps and applicable industry standards?**

Numerical Rating: 5

Yes, they were appropriate for this work.

10. Are safety factors utilized, and are they supported and valid?

Numerical Rating: N/A

There are no safety factors as this is not applicable for this document, being that it is a literature review.

11. Is there enough detail provided on the methods or processes such that the manufacturer can replicate the methods or techniques to achieve similar results?

Numerical Rating: 5

If another group were to perform this literature review using the methods presented the results would be similar.

B. DATA ANALYSIS

12. Was the data analysis appropriate and are the recommendations logical, supported by the data analysis? The scope of the recommendations pertains to all submissions, not just those derived from the study results.

Numerical Rating: 4

The data analysis was appropriate, and the recommendations provided are logically based on the analysis conducted by the researchers. Except for the item discussed previously, where the researchers used their knowledge to determine what was missing and did not query others, may mean there could be more recommendations, but all the recommendations they provided were valid and supported by the analysis.

13. Are the research findings based on sound science?

Numerical Rating: 4

Yes, the researchers used sound science and techniques to develop their findings. One limitation in the findings would be the determination of what was "missing" in the standards is based on the researchers' own views. It might have been effective to ask others in the industry what they would want or expect in the standards and then use that to determine if any of those items are missing.

14. Are the uncertainties and accuracy of the data appropriately incorporated and represented in the deliverables?

Numerical Rating: 5

As this was a literature review uncertainties and accuracy of the data would relate to properly capturing the standards. The researchers addressed that they had to put a limit on the documents due to size and time, but they discussed how they put that limit in place and it was appropriate for this application.

C. CONCLUSIONS

15. Are the conclusions that were made logical and appropriate?

Numerical Rating: 4

For the most part, yes, the conclusions were logical based on the analysis of the standards conducted and appropriate for the industry.

However, in Section 13.6, there was the statement that *proprietary grade must be equivalent or better than the most appropriate ASTM grade in the standard for the application*. I think that statement is a bit vague and could be better defined. What does equivalent or better mean in this statement, a higher yield stress? It should probably say something closer to *have an equivalent or better service life under the service conditions expected of the ASTM grade it is replacing*.

Section 11.1: Reviewer is unclear of the purpose of this paragraph, is there something in the standards that are needed for new technologies? The paragraph only mentions a new technology, which is good, but how does that fit into the topic of this document.

16. Can the conclusions be efficiently and accurately interpreted, considering the complexity of the research?

Numerical Rating: 4

Yes, the conclusions are straightforward and logical based on the results of the study. Although the Executive Summary and Sections 12 and 13 state the recommendations and gaps, this report lacks a section with cohesive conclusions and recommendations for the ease of the reader.

17. Can BSEE be confident in the conclusions drawn from the research study?

The BSEE can be confident that the gaps and inconsistencies identified are there and need to be addressed. One thing to keep in mind is that there may be other missing items in these standards. As the researchers based their determination of gaps on what they thought should be included, other users of these documents may expect additional items in these standards also, therefore, there may be more gaps identified.

18. Are there any additional conclusions drawn from the subsea bolt study or bolt standards gap analysis?

There could be additional conclusions. One gap in the authors research is how to determine gaps in the standards. The authors reviewed the documents and chose topics for which they thought they should cover and determined if these topics were represented in the documents. However, there could there be things they did not know to look for. The items they thought were missing is based on their knowledge of the subsea bolt study or bolt standards. Other users in the field of subsea bolt studies or bolt standards may think that other items are missing as well. Since the topic list of what would be required in these documents came from the researchers, they may be limited in what they expect of the document.

D. OVERALL QUESTIONS

19. Did the research meet the stated goals and objectives for the subsea bolt study and bolt standards gap analysis?

Numerical Rating: 4

The research did meet its goal of performing a gap analysis. However, as stated earlier, it was limited to what the researchers thought should be in the standards. Others outside that group may expect different items in the standards as well.

20. Was the final research report written objectively and transparently? Did any part of the research study appear biased or too narrowly focused?

Numerical Rating: 4

The one item that would be biased in this research would be identifying the missing items, which would be based on the researcher's expectation for what should be in the standards. As such, there is some bias introduced from that aspect. However, the rest of the document was objective and transparent.

21. Was the decision-making made in the research process based on sound science?

Numerical Rating: 5

Yes, it was.

22. Are there any apparent weaknesses or gaps in the study that need to be addressed (e.g., methods, results, data, standards, etc.)?

I think it would have been helpful to survey relevant stakeholders who work in the subsea bolt study and bolt industry, manufacturers, suppliers, engineers, owners, installers, *etc*., and understand what they would want, expect, or need in the standards. Since the researchers used their knowledge to determine what was missing it might have limited that portion of the analysis based on only their experience.

Dissimilar metals were mentioned only once in the document. When dealing with all sorts of alloying and grades of metal in a variety of environments, dissimilar metal corrosion is a significant concern and would be good to discuss.

23. Should other techniques or analytic platforms (methods) have been considered?

A survey of other users of the standards to understand what they would want or expect in the standards could have given the researchers a more complete gap analysis.

24. Are there any additional studies or sources of information/data that the research authors should have consulted?

A survey of other users of the standards to understand what they would want or expect in the standards could have given the researchers a more complete gap analysis.

25. To what extent is the subject matter novel or complex compared to others research studies?

Numerical Rating: 5

While this was primarily a literature review, it was novel in that it looked at a compiled list of important standards and really dug deep to determine where the gaps or inconsistencies were. That is something I think other industries should do more of. There are a lot of professional societies creating various standards, but I don't know many who really take the time and look at all of them together and make sure that they are consistent and determine what things they are missing. This should be done more in every industry.

26. What is your overall assessment of the research and study? Provide advice on the reasonableness of judgments made from the scientific evidence.

Numerical Rating: 5

This document provided a great analysis of a lot of standards to determine what is missing from the subsea bolt study and bolt industry. Other industries could learn from this, and I think this should be a regularly occurring activity for standards like this. These standards are put together by a range of different people in different groups and it is inevitable that inconsistencies and gaps occur. To take the time and determine what those are so that they can correct them, is extremely valuable, and as a result I think this research study is extremely valuable.

E. ADDITIONAL COMMENTS

List of Acronyms: National Association for Corrosion Engineers International (NACE) is now Association for Materials Protection and Performance (AMPP) should include AMPP in *List of Acronyms and Abbreviations Notations* and reference AMPP anywhere in the document NACE is mentioned.

Page 21, 7th bullet item: Should say AMPP (formerly known as the National Association of Corrosion Engineers).

Section 2.1: "The pH varies significantly, too, *ranging from slightly acidic* at the surface to slightly basic over most of the depth range." Based on review of Figure 1 the pH remains slightly basic for the entire depth. Slightly acidic would be lower than 7, the line never goes below 7 in that figure.

Table 4: Some of the definitions mentioned in Table 4 are either nonspecific or inaccurate some of the examples are

- Hardness: Resistance of metal to plastic deformation. In metallurgical terms, hardness relates to the resistance to local plastic deformation.
- Stress Relief: Tests involving the application of stresses to bolt or bolt materials as a means to measure mechanical properties. Generally, stress relief is any process which relieves stresses that have been absorbed by metal from any manufacturing or heat treatment process.

Reviewer recommends authors to correct and revise the definitions for their accurateness.

Section 7.2.2, Cathodic Protection: Authors says "… since this type of protection is not something that can be readily done at the bolt level." Generally, the need and the criteria of cathodic protection are dependent on the nature of the material used and the environment it is exposed to. It is not defined by the size of the component.

Authors should thoroughly review the article for any grammatical and typographical errors. Below are some instances where reviewers found errors.

Section 5.1: There is an odd gap in text in line 5 after Table 5.

Section 8.1, paragraph 2, line 3: The text says "*proprietaryprocesses.*" A space is needed between words.

Page 3 – Varying Subsea Environment: Typographic error "Temperature gradually *degrees* with depth, and salinity gradually increases, but neither linearly."

Page 15-16: There is an incomplete sentence: "One important role and responsibility is establishing the person or organization responsible for keeping records to establish traceability throughout the life cycle, especially if the bolt is used for a critical."

Page 22, Table 4, last row: Typographical error: "Yield Strength- Maximum strength the bolt can withstand *unstill* deformation begins"

PEER REVIEW RESPONSE

AGENCY:	US Department of the Interior, Bureau of Safety and Environmental Enforcement (BSEE)
MATERIAL REVIEWED:	2018 *Subsea Bolt Study: Technical Gaps in Current Standards and Requirements* (Subsea Bolt Study)
REVIEWED BY:	Reviewer 2
DATE:	November 6, 2022

The purpose of this peer review is to review and provide feedback on the Subsea Bolt Study. See *Peer Review Charge: Subsea Bolt Study* (23 August 2022) for more information. The Peer Reviewers shall evaluate the following Charge Questions and provide supporting rationales for their answers.

Instructions: Please answer questions requesting a numerical rating between 1 and 5. For example, if your rating is "3," input a "3" in the "Numerical Rating" column. For purposes of selecting a numerical rating, use the following categorical indicators:

1 = Unacceptable 2 = Inadequate 3 = Mixed 4 = Good 5 = Excellent

SUBSEA BOLT STUDY: TECHNICAL GAPS IN CURRENT STANDARDS AND REQUIREMENTS

A. METHODS AND ASSUMPTIONS

1. Are applicable subsea critical drill-through equipment oil and gas and bolting standards addressed? Are there any other relevant standards that need to be addressed for this study?

Argonne National Laboratory (ANL) did a comprehensive review of the bolting standards and other relevant standards applicable to oil and gas exploration and production. ANL analyzed an extremely broad range of applicable standards including those from American Petroleum Institute (API), American Society for Testing and Materials (ASTM), Det Norske Veritas and Germanischer Lloyd (DNV-GL), and Norwegian Standards Organization (NORSOK) which presented a more global view. The decision to include non-oil and gas organizations such as the National Aeronautics and Space Administration (NASA) and Nuclear Regulatory Commission (NRC) was particularly commendable as the approach that these organizations take to safety is directly related to the bolt failure issues. The challenge of accessing and analyzing so-called "proprietary" standards was addressed by recommending that the proprietary fastener grade be equivalent to or better than the most appropriate ASTM grade in the standard for the application. This approach avoids the near impossible task of removing proprietary grades while also not allowing them to meet all minimum requirements.

2. Are the methods appropriate? Were the methods used valid for the goals of this study project?

Numerical Rating: 5

The combination of collection of standards from a variety of sources and a more comprehensive word search of both the standards and broader engineering sources was the most reasonable means of finding important information. Limiting review to only those references related to potential failures was critical in allowing sufficient depth of analysis given the finite resources of time and funding available. ANL's use of multiple word queries of available databases ensured a high likelihood of capturing standards of relevance and importance that may not have been in the direct path of most studies.

Below are detailed comments regarding the methods used:

- The strategy of looking at relationships among the standards, identifying common or unique references to find useful patterns and gaps was appropriate to the task. Establishing the ASTM Core Group of standards provided a foundation or a touchstone.
- The strategy of linking the requirements in standards to the product life cycle success paths was also very useful as it provides a different, but important, perspective to the use of standards than simply as means of specification disconnected from function.
- Topic isolation was needed to identify all consequential gaps between standards and particulars across industries. It allowed identification of the major gaps with respect to

fatigue design basis and corrosion management (*i.e.*, coatings, cathodic protection, avoidance of hydrogen embrittlement susceptibility, *etc.*).

- Creation of a searchable database using widely available COTS software tools was an excellent approach to make the current study extendable in the future. Avoidance of copyright infringement by use of predefined topic categories was wise.
- The principles with respect to standards collection and organization/means of relating topical coverage of standards were appropriate and critical to allow identification of gaps such as fatigue and corrosion.

3. Are limitations and uncertainties clearly identified and adequately characterized?

Numerical Rating: 5

The report clearly identified and described the limitations and uncertainties. These included:

- Inconsistent terminology among standards, time limitations, budget, foreign language, proprietary/export control, only US non-oil and gas industries were included in the study.
- The report utilized a finite, but reasonable number of topics of interest.
- It was noted that some domestic standards are applied internationally, making classification of such standards as international vs. domestic challenging and somewhat arbitrary.
- The partial overlap of topics/scope between standards from different organizations and issues of rough equivalence inevitably led to some uncertainty.

None of these uncertainties critically impacted the conclusions.

4. Are the assumptions clearly defined and appropriate?

Numerical Rating: 4

The report clearly stated that the analysis was based on a snapshot of the standards available as of January 2017, with the understanding that there are other versions of some of the reviewed standards that may be more current than those used in the ANL gap analyses (Section 3.1). That said, the report notes that the differences between the assessed standards and the other versions are sufficiently small that the conclusions of this study would not be affected.

5. Are the strengths of the analytical methods used identified and relevant to the research? Are the weaknesses of the analytical methods identified, and are they relevant to the research study?

The evolution of the analysis approach was described in detail, including the reasons for adaptations. No weaknesses of the analytical method were identified explicitly in the report. An implicit weakness could be inherent to the database and search algorithms used, but those are outside my technical expertise.

6. **Are there gaps in the analytical methods? Are the analytical methods used relevant to determine scientific findings and recommendations (*i.e.*, empirical data supports the analytical techniques or theoretical data)?**

There were no clear gaps in the analytical methods. The methods used were well suited to the technical task at hand. In particular, the use of topic isolation and connection to the life cycle success process were both very well selected.

7. **Are the variables used in the research study identified and characterized?**

Numerical Rating: 4

The report describes all the aspects of standard variability in terms of what they address, how they address it, and what they either do not address explicitly or implicitly.

8. **Are the data collection methods and inputs presented in a transparent manner?**

Numerical Rating: 4

The report clearly describes the data collection methods and the Appendices assist in clarifying the applications of those methods via inputs. Appendix A provides a matrix of the data collection from the different standards by connecting each ASTM standard to those addressing similar issues.

9. **Were the database and programs utilized for the study appropriate, accurate, and sensitive enough to produce relevant data identifying bolting standards requirement gaps and applicable industry standards?**

Numerical Rating: 5

The sheer volume of standards and the issues described above made identifying and connecting all the applicable industry standards a daunting task. The use of Microsoft Access and Excel formats were appropriate as both are widely used and have been vetted for a wide variety of similar studies.

10. **Are safety factors utilized, and are they supported and valid?**

Numerical Rating: 5

Specific, quantitative safety factors are not widely discussed, but are described where possible. In many cases the safety factors will vary depending upon the details of the design and application, so an in-depth analysis of safety factors would be outside the scope of the study. Validation of safety factors in the standards would be well outside the scope of this study.

11. Is there enough detail provided on the methods or processes such that the manufacturer can replicate the methods or techniques to achieve similar results?

Numerical Rating: 4

Due to the complexity of the task, full replication of the results would require a tremendous amount of information to be included in the report. If it can be assumed that the database and related software and files will be available, then Appendix B provides an excellent example of how the Life Cycle Success Path approach was used.

B. DATA ANALYSIS

12. Was the data analysis appropriate and are the recommendations logical and supported by the data analysis? The scope of the recommendations pertains to all submissions, not just those derived from the study results.

Numerical Rating: 5

The analysis of links among standards in terms of cross-referencing, life cycle success paths, as well as the topic isolation and sorting analyses resulted in important conclusions that could have been easily missed. This approach pointed out the need for establishing roles and responsibilities for recordkeeping to maintain traceability. It also showed that connecting the standards to responsibility in organizations was challenging and would likely lead to inconsistency and lost records greatly impeding traceability. The voluntary nature of API 20E and API 20F directly lead to some of these gaps. For example, there are parallel paths in different standards on coatings that could lead to the missing of important issues.

The recommendations are all strongly supported by the data analyses. The major gap in the standards with regards to fatigue is well documented in the analysis with a description of the source of the gap. The recommendation with regards to the gap in standards concerning corrosion issues was telling. Since some of the corrosion issues are actually systems problems and not specific to individual components (*e.g.*, coatings and cathodic protection), it is easy for these to fall between the cracks. Although complete prevention of failures is the ultimate goal, the report makes excellent recommendations with regards to the need for improved traceability to be included in standards. The need to explicitly clarify roles and responsibilities is strongly supported.

13. Are the research findings based on sound science?

Numerical Rating: 5

The findings are based on sound science. ANL applied a strong understanding of design, mechanics, materials, and environmental effects on durability/safety in service to the data and in arriving at their conclusions. The report is devoid of unsupported opinions with respect to the conclusions and recommendations.

14. Are the uncertainties and accuracy of the data appropriately incorporated and represented in the deliverables?

Numerical Rating: 4

To the extent possible given resource constraints, the ANL report addresses uncertainties and data accuracy. ANL did as well as possible considering they did not have access to the original data regarding standards development, nor the resources to do an in-depth analysis.

C. CONCLUSIONS

15. Are the conclusions that were made logical and appropriate?

Numerical Rating: 5

I think the conclusions are both logical and appropriate. The major gaps and recommendations section follows directly from the analyses and connects a disparate range of data to point out the gaps with respect to fatigue, corrosion, and traceability. It also points out the fact that some of these challenges are ongoing and are inherent because of continuous publication cycle of standards. That cycle is the path to improvement, but coordination of the various paths for the different standards is an epic challenge. The gaps that are specific to the multiple organizations involved (BSEE, API, ASTM, and others) are clearly laid out and connected where appropriate.

16. Can the conclusions be efficiently and accurately interpreted, considering the complexity of the research?

Numerical Rating: 5

Despite the complexity of the problem, the conclusions are very well organized as mentioned above. This organization allows efficient and accurate interpretation for the range of stakeholders and allows them to focus on recommendations directly applicable to them, whereas BSEE can focus on the recommendations on which it can act.

17. Can BSEE be confident in the conclusions drawn from the research study?

The BSEE should be very confident in the conclusions drawn from the research study. The study strategy was well designed, comprehensive, and well executed. The data analysis was well organized, and the conclusions are strongly supported by relevant science and engineering.

The importance of consideration of fatigue loading is high, as is the likelihood of a great variability in how it is addressed for a given application as the standards are either vague or non-existent. Taking advantage of what was found in foreign standards, such as those in NORSOK, is an important recommendation. The recommendation that there be a more systems-focused corrosion management approach codified in the standards is clearly described and its need is substantiated based on the root cause analyses performed on failed bolts. The need for such an approach is clear. In addition, the critical need for improved traceability and definition of terms, especially roles and responsibilities regarding records retention, cannot be overemphasized.

18. Are there any additional conclusions drawn from the subsea bolt study or bolt standards gap analysis?

No.

D. OVERALL QUESTIONS

19. Did the research meet the stated goals and objectives for the subsea bolt study and bolt standards gap analysis?

Numerical Rating: 5

The report met the stated goals and objectives of the subsea bolt study. It collected and reviewed all applicable and publicly available specifications and standards for alloy material used in subsea bolting. It described the application of those standards to offshore oil and gas operations. It then analyzed those results with respect to overlap, contradictions, and gaps between and among the collected standards. Finally, it provided clear, well-supported and actionable recommendations for improvement in the standards in order to close the documented gaps to increase safety of operation.

20. Was the final research report written objectively and transparently? Did any part of the research study appear biased or too narrowly focused?

Numerical Rating: 5

The final report showed no bias towards any standards organization, industry, or other entity. It was objective and its methods transparent. The focus was appropriate in its breadth, although it would have been easy to make it too narrow, for example, by considering a small set of alloys used, or too broad, for example, by extending consideration to applications that are not relevant or connected to offshore oil and gas operations in terms of materials or safety criticality.

21. Was the decision-making made in the research process based on sound science?

Numerical Rating: 5

Yes.

22. Are there any apparent weaknesses or gaps in the study that need to be addressed (e.g., methods, results, data, standards, etc.)?

None.

23. Should other techniques or analytic platforms (methods) have been considered?

The techniques and analytic platforms selected were sufficient to do the analysis. I know of no other techniques that would have provided any better or more efficient results.

24. Are there any additional studies or sources of information/data that the research authors should have consulted?

None of which I know.

25. To what extent is the subject matter novel or complex compared to others research studies?

Numerical Rating: 5

This research study is unique in my experience in terms of breadth and depth of analysis of such a broad range of standards and sources. The complexity of the topic is very high considering the vagueness of some of the standards, the inconsistent nomenclature used, and the wide range of technical areas that needed to be brought to bear.

26. What is your overall assessment of the research and study? Provide advice on the reasonableness of judgments made from the scientific evidence.

Numerical Rating: 5

The report does an excellent job of comprehensively organizing and linking the range of standards that can be applicable to the bolt failure issue. In addition, the analysis provides strong support for all the recommendations and conclusions provided. Finally, the report provides a clear path forward for BSEE and the industry to follow to improve safety by addressing gaps in the standards.

E. Additional Comments

None.

PEER REVIEW RESPONSE

AGENCY:	US Department of the Interior, Bureau of Safety and Environmental Enforcement (BSEE)
MATERIAL REVIEWED:	2018 *Subsea Bolt Study: Technical Gaps in Current Standards and Requirements* (Subsea Bolt Study)
REVIEWED BY:	Reviewer 3
DATE:	December 19, 2022

The purpose of this peer review is to review and provide feedback on the Subsea Bolts Study. See *Peer Review Charge: Subsea Bolt Study* (23 August 2022) for more information. The Peer Reviewers shall evaluate the following Charge Questions and provide supporting documentation and rationale.

Instructions: Please answer questions requesting a numerical rating between 1 and 5. For example, if your rating is "3," input a "3" in the "Numerical Rating" column. For purposes of selecting a numerical rating, use the following categorical indicators:

1 = Unacceptable **2 = Inadequate** **3 = Mixed** **4 = Good** **5 = Excellent**

SUBSEA BOLT STUDY: TECHNICAL GAPS IN CURRENT STANDARDS AND REQUIREMENTS

A. METHODS AND ASSUMPTIONS

1. Are applicable subsea critical drill-through equipment oil and gas and bolting standards addressed? Are there any other relevant standards that need to be addressed for this study?

The report is a comprehensive gap analysis of standards, specifications, and recommended practices for fasteners used in subsea oil and gas drill-through equipment (*i.e.,* risers, wellheads and blowout preventers). It is my opinion that it includes the relevant publicly available documents that I have used or reviewed in my experience in the petroleum industry.

2. Are the methods appropriate? Were the methods used valid for the goals of this study project?

Numerical Rating: 5

I believe that the methods used resulted in a comprehensive understanding of where gaps exist. While there are some typographical errors in the narratives, the tables and charts appear to be complete and relatively easy to follow, as well as consistent with the narrative. In particular, I reviewed the table of references in Section 14.0 and found it to be comprehensive, based on my experience.

3. Are limitations and uncertainties clearly identified and adequately characterized?

Numerical Rating: 4

The limitations appear to be clearly identified, to the extent that the authors clearly described their objectives and acquired a comprehensive set of documents to review. In my opinion, the authors surveyed and included documents which I have used in my experience in both applications and in my work with the National Academy committee on the subject of bolts and fasteners for subsea equipment. I believe that the authors adequately characterized the source of the documents, their content, and have properly mapped the gaps between documents and industries from which the have been acquired.

4. Are the assumptions clearly defined and appropriate?

Numerical Rating: 5

Yes, in my opinion the authors clearly defined the objectives and scope of their work. This was not a treatise on the mechanics of bolts and fasteners. Rather, the authors set out to identify the pertinent documents, review them, and then identify the gaps in coverage and content. There may be other documents in other industries that I may not be fully familiar with, but the authors did, in my opinion, reach over several industries with relevant scopes of coverage, including the aviation and nuclear industries.

5. Are the strengths of the analytical methods used identified and relevant to the research? Are the weaknesses of the analytical methods identified, and are they relevant to the research study?

The tables and charts presented in the report are easy to follow and comprehensive. I thought Appendix B, Life Cycle Success Path Examples, was particularly illustrative. It may be worthwhile in the future to expand this type of analysis to the American Petroleum Institute (API) standards, specifications, and recommended practices as well. In particular, it may be worthwhile to include or expand analysis of API Spec 20E and API Spec 20F.

6. Are there gaps in the analytical methods? Are the analytical methods used relevant to determine scientific findings and recommendations (i.e., empirical data supports the analytical techniques or theoretical data)?

I believe the methods used have provided a comprehensive analysis and satisfied the scope and objectives of the work. If there are additional analytical techniques that could be brought to bear on this work, then I am not aware of them. Having written that opinion, it could be that feeding the electronic documents into a database and using automated intelligence or machine learning might yield benefits.

7. Are the variables used in the research study identified and characterized?

Numerical Rating: 5

Yes. The scope and objective of the work was identified, and the methods used to characterize and analyze the data was appropriate.

8. Are the data collection methods and inputs presented in a transparent manner?

Numerical Rating: 5

Yes, definitely.

9. Were the database and programs utilized for the study appropriate, accurate, and sensitive enough to produce relevant data identifying bolting standards requirement gaps and applicable industry standards?

Numerical Rating: 4

Yes, I believe so. However, see my comments above in Item 6.

10. Are safety factors utilized, and are they supported and valid?

Numerical Rating: N/A

I do not believe safety factors were part of the scope of work.

11. Is there enough detail provided on the methods or processes such that the manufacturer can replicate the methods or techniques to achieve similar results?

Numerical Rating: 5

Most definitely.

B. Data Analysis

12. Was the data analysis appropriate and are the recommendations logical, and supported by the data analysis? The scope of the recommendations pertains to all submissions, not just those derived from the study results.

Numerical Rating: 4

I believe the analysis was comprehensive, but see Item 6, Section A, for possible other data analysis techniques.

13. Are the research findings based on sound science?

Numerical Rating: 5

In my opinion, yes.

14. Are the uncertainties and accuracy of the data appropriately incorporated and represented in the deliverables?

Numerical Rating: 5

Yes, I believe so. The data based on specifications and standards is large and complex. I believe this analysis took an immense amount of time and effort. In my opinion and based on my experience in the industry, I believe that the results of the efforts yielded worthwhile and useful results.

C. Conclusions

15. Are the conclusions that were made logical and appropriate?

Numerical Rating: 4

Yes, in my opinion.

16. Can the conclusions be efficiently and accurately interpreted, considering the complexity of the research?

Numerical Rating: 5

I believe the conclusions are clear to one who works in the industry. The report should be presented to the industry to discuss taking the next steps to address or fill in the gaps.

17. Can BSEE be confident in the conclusions drawn from the research study?

In my opinion, yes.

18. Are there any additional conclusions drawn from the subsea bolt study or bolt standards gap analysis?

I believe that the authors identified the significant and relevant gaps, based on the stated scope and objectives. The next step, as stated above, is to acquire industry feedback, particularly that of the API.

D. Overall Questions

19. Did the research meet the stated goals and objectives for the subsea bolt study and bolt standards gap analysis?

Numerical Rating: 4

Yes. As one involved in the industry, I believe the work achieved the stated objectives. Of course, more can be done (see Item 6, Section A), but I believe the next step is to get this to the API/industry to address the gaps.

20. Was the final research report written objectively and transparently? Did any part of the research study appear biased or too narrowly focused?

Numerical Rating: 4

The report is objective and transparent. There was no impression to me that the study was biased.

21. Was the decision-making made in the research process based on sound science?

Numerical Rating: 5

I believe so.

22. Are there any apparent weaknesses or gaps in the study that need to be addressed (e.g., methods, results, data, standards, etc.)?

See Item 6, Section A, however, the methods used, and the conclusions reached satisfactorily achieved the stated objective.

23. Should other techniques or analytic platforms (methods) have been considered?

See Item 6, Section A.

24. Are there any additional studies or sources of information/data that the research authors should have consulted?

I do not believe so.

25. To what extent is the subject matter novel or complex compared to others research studies?

Numerical Rating: 4

I do not believe a study as comprehensive as this has been done. However, The National Academy study (High-Performance Bolting Technology for Offshore Oil and Natural Gas Operations, 2018), made a similar effort, though not as comprehensive.

26. What is your overall assessment of the research and study? Provide advice on the reasonableness of judgments made from the scientific evidence.

Numerical Rating: 5

I believe the conclusions reached are appropriate, based on the analysis performed by the authors. I am keen to see the industry's reception of the work.

E. ADDITIONAL COMMENTS

Thank you for the opportunity to review this report. Having had the privilege of working on the National Academy Committee on Connector Reliability for Offshore Oil and Natural Gas Operations, I am pleased to see this gap analysis performed. It will be helpful to the industry.