Safety Engineering & Risk Analysis Division

Newsletter

1st Quarter 2014

CHAIR'S CORNER

Greetings to all SERAD members. I hope you enjoy this latest edition of the SERAD Newsletter with safety and risk topics of interest to our members.

The division is doing well and growing, but we can do even more. Each year when I return from IMECE, I am always impressed by the talks I have heard and the people I have met. As a division, we can do more to sustain some of the energy from IMECE throughout the year. It is our challenge to find ways to connect with each other as many have their travel budgets trimmed. Networking is consistently identified as one of the primary ASME and SERAD membership benefits.

To address issues of improving SERAD operation and delivering value to its membership, the Executive Committee of SERAD has developed three goals for this year:

First, we want to engage early career engineers in SERAD. We have to make sure that student members who are transitioning to professional members know about SERAD and what we offer. One way we currently reach out to this group is the annual SERAD Student Safety Innovation Challenge. This is an annual competition for students to submit safety-related engineering work for a monetary prize. FM Global has proudly sponsored this competition for several years, and we greatly appreciate their support. This past year SERAD paid a portion of the travel costs for the winner (Andrew Hare of U. of South Carolina) to receive his award at the SERAD Dinner at IMECE 2013 (see picture at right). If you are a faculty member reading this, and have not heard about this competition, please contact me for details.

Second, we want to improve marketing of SERAD throughout ASME and even other professional organizations. The Executive Committee would like to work with members to produce webinars on safety engineering and risk analysis topics as one example. If you are interested in producing a webinar in your area of expertise, please contact me. We will assist you in working with ASME staff to develop a quality product.

Third, we want to improve the value of SERAD membership through increased networking opportunities. We had a successful technical track at IMECE 2013, but only a small portion of SERAD members are able to attend this conference each year. We need to think of new ways to bring people and ideas together for our division. SERAD now has a Social Media Coordinator (thank you Jennifer Cooper!) who is managing our presence on LinkedIn and ASME.org. If you have not joined the SERAD group on ASME.org, please considering doing this soon and begin contributing to the conversation there. The Executive Committee has also discussed having a division conference separate from IMECE. We are always interested in your ideas for networking opportunities.

In the end, it is the membership of SERAD that make this a great division. Please consider volunteering your time to improve this division. The Executive Committee is always looking for volunteers to review abstracts and papers for IMECE. You may even want to speak to a local student chapter regarding your experiences in safety engineering or risk analysis. We maintain a list of those who wish to volunteer their time and talents. Please send me an email if you want to be an active part of SERAD.

IMECE 2014 in Montreal will be here before we know it. This year SERAD is working with the Management and Technology and Society Divisions to offer a technical track, "Engineering Management, Safety, Ethics, Society, and Education" (Track 8). We hope you will be able to join us in Montreal to enjoy many great presentations in these areas. Also, please look for upcoming announcements regarding the SERAD Dinner at IMECE 2014.

Jim Harris, Ph.D., P.E.
JHarris@cdc.gov
2013-2014 Chair of SERAD

UPCOMING SAFETY EVENTS

IMECE 2014
(www.asmeconferences.org/Congress2014)
Submission of Full-Length Draft Paper for Review
April 14, 2014.

PSAM12 (psam12.org)
June 22-27, 2014

TECHNICAL CORNER

Risk Informed Safety Margins Characterization

Dr. Curtis Smith
Idaho National Laboratory

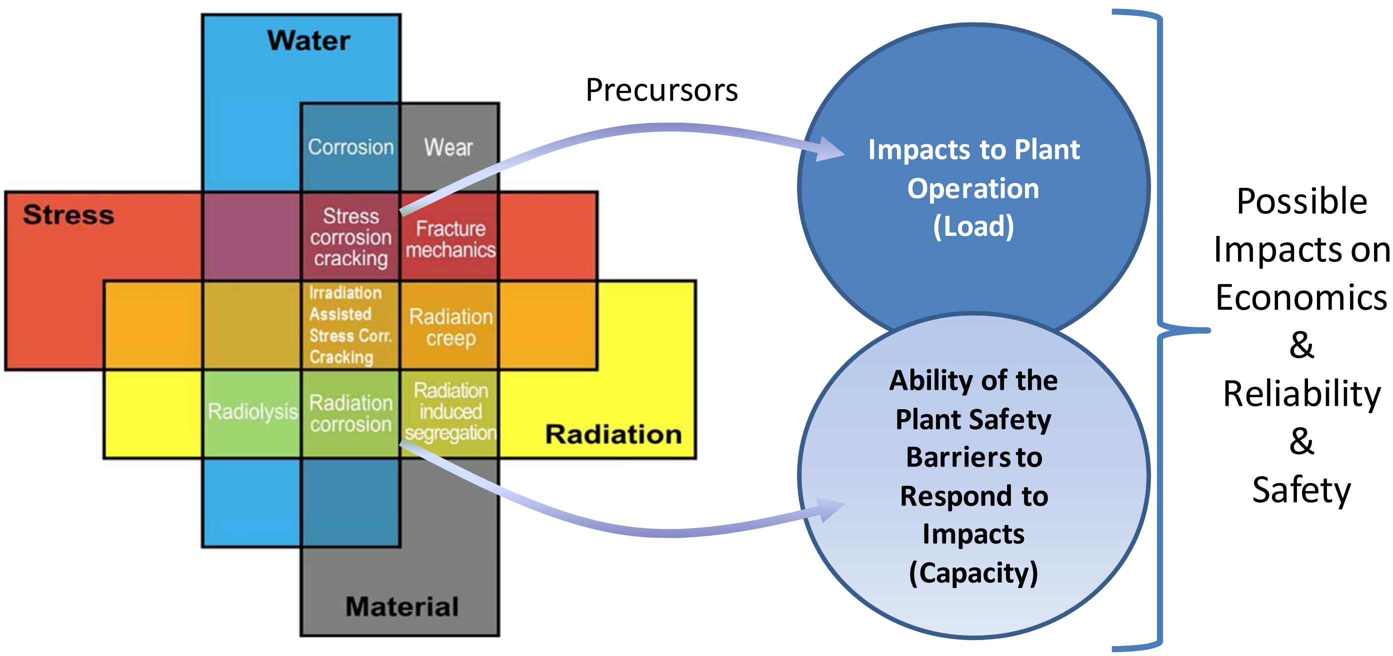
Introduction

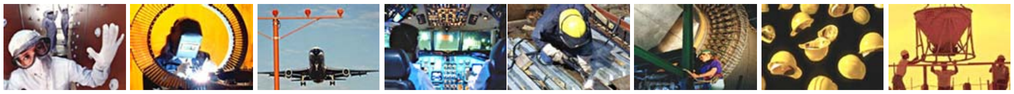
At the US Department of Energy (DOE) Laboratories, researchers are looking to improve upon traditional risk and reliability methods and tools. One of these activities is the Risk-Informed Safety Margin Characterization (RISMC) approach under way at the Idaho National Laboratory (INL). The purpose of the RISMC Pathway is to support plant decisions for risk-informed margins management, with the aim to improve economics and reliability and sustain safety of current nuclear power plants. The goals of the RISMC Pathway are twofold:

1. Develop and demonstrate a risk-assessment method coupled to safety margin quantification that can be used by nuclear power plant decision makers as part of their margin recovery strategies
2. Create an advanced RISMC toolkit that enables a more accurate representation of safety margin.

In order to carry out the research and development needed for the RISMC Pathway, the INL is performing a series of case studies that will explore methods and tools-development issues. A recently completed initial case study focused on demonstrating the RISMC approach using the Advanced Test Reactor (ATR). We describe how thermal-hydraulics and probabilistic safety calculations are integrated and used to quantify margin recovery strategies.

The ability to better characterize and quantify safety margin holds the key to improved decision making about light water reactor design, operation, and plant life extension. A systematic approach to the characterization of safety margin and the subsequent margin management represents a vital input to the licensee and regulatory analysis and decision making that will be involved. In addition, as other collaborative efforts yield new scientific understanding of aging and degradation, opportunities to better optimize plant safety and performance will become known. This interaction of degradation understanding and potential impacts to plant margins are shown below.





Advanced Test Reactor

Constructed in 1967, ATR is a pressurized water test reactor that operates at low pressure and low temperature. It is located at the Advanced Test Reactor Complex on the INL site. The reactor is pressurized and is cooled with water. The reactor vessel is a 12-ft diameter cylinder, 36-ft high, and is made of stainless steel. The reactor core is 4 ft in diameter and height and includes 40 fuel elements capable of producing a maximum power of 250 MW. The reactor inlet temperature is 125°F and the outlet temperature is 160ºF. The reactor pressure is 390 pounds per square inch.

As part of the RISMC demonstration, we successfully coupled the risk assessment simulation to the thermal-hydraulics analysis (using RELAP5) in order to integrate probabilistic elements with mechanistic calculations. With the knowledge of plant response, we needed to determine whether or not a particular outcome is “success” (meaning no fuel damage) or “failure” (meaning fuel damage). For our analysis, we assumed that any event that saw a peak cladding temperature of 725°F (658 K) was a fuel damage outcome.

RISMC Case Study

The purpose of the RISMC ATR case study is to demonstrate the RISMC approach using realistic plant information, including both real probabilistic risk assessment (PRA) and thermal-hydraulics models. As part of this case study, we evaluated emergency diesel generator issues. Historically, ATR has had a continually running emergency diesel generator as a backup power supply, which is different than all commercial nuclear power plants in the United States (commercial plants have their emergency diesel generators in standby). Margin recovery strategies under consideration include the following:

- Keep the emergency power system as is (emergency diesel generator running, one in standby, and commercial power as backup)
- Redundant commercial power as primary backup, single new emergency diesel generator as backup
- Redundant commercial power as primary backup, two existing emergency diesel generators as backup.

For the different strategies, we simulate the plant behavior both probabilistically and mechanistically. To perform this simulation, we used the existing PRA and thermal-hydraulics information (e.g., SAPHIRE probabilities, RELAP5 input). We then defined the simulation for different scenarios and different strategies and ran a large number of iterations to determine overall safety margins.

What differentiates the RISMC approach from traditional PRA is the concept of a safety margin. In PRA, a safety *metric* (such as core damage frequency) is estimated using static fault and event-tree models. However, we do not know how close (or beyond) we are to physical safety limits (say peak clad temperature) for most accident sequences described in the PRA. In the RISMC approach, what we want to understand is not just the frequency of an event like core damage, but how close we are (or not) to this event and how might we improve our safety margin through margin recovery strategies.

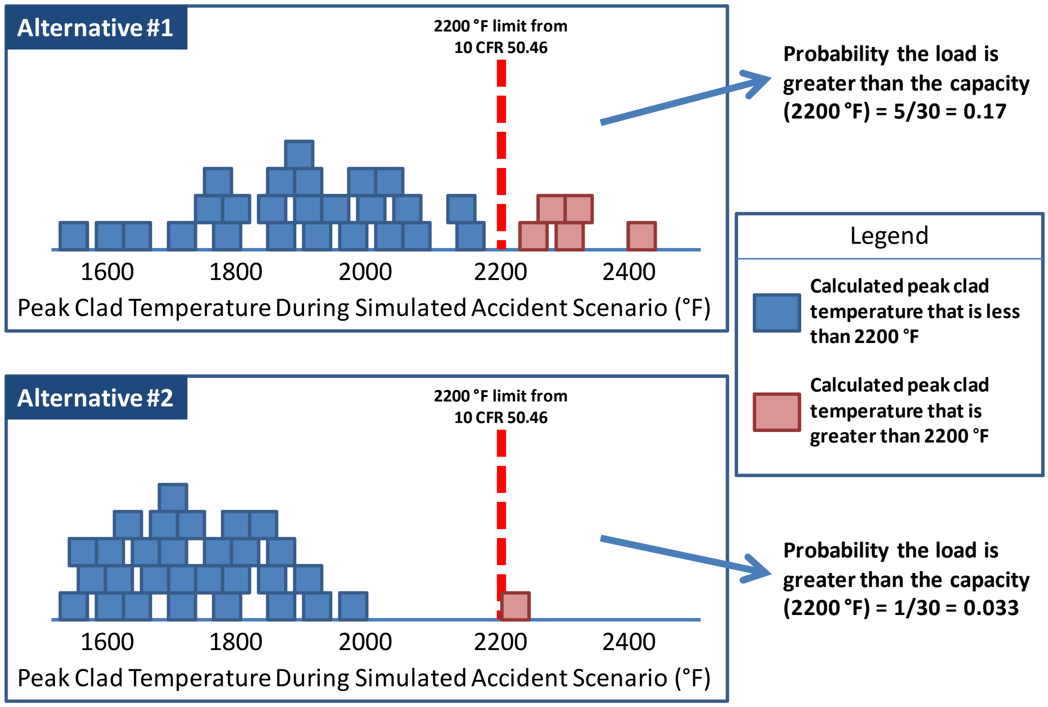
As an example of the type of results that are generated via the RISMC method and tools, we show a simple hypothetical example (see the figure on the next page). For this example, we suppose that a nuclear power plant has two alternatives to consider: (1) retain an existing, but aging, component as-is, or (2) replace the aging component with a new one. We run 30 simulations and calculate the outcome of a safety metric (e.g., peak clad temperature) and compare that against a capacity limit (assumed to be 2200°F in this example). The results of these simulations are then used to determine the probabilistic margin:

Alternative #1: Pr(Load exceeds Capacity) = 0.17

Alternative #2: Pr(Load exceeds Capacity) = 0.033

(note lower values are better).

In this example, the “load” is the boxes shown in the figure (representing the peak clad temperature for each scenario) and the “capacity” is the10 CFR 50.46 limit of 2200°F. If the safety margin were the only decision factor, then Alternative #2 would be preferred (its safety characteristics are better) because we only realized one case where we exceeded our 2200°F safety limit. It should be noted that while the focus of the ATR case study was on a safety margin determination, other considerations (e.g., cost and schedule) are generally a part of decision making for complex issues.



RISMC example when evaluating alternatives for risk-informed margins management.

For the ATR case study, a probabilistic simulation model was created based on the ATR PRA. As part of the research and development, we developed an approach to automatically create a dynamic simulation model using an existing static-based PRA as a starting point. From this, we used an event simulation tool, where the model consists of simulation objects that transition through various states to describe a plant response scenario to an off-normal condition. For example, using the ATR PRA model and evaluating the loss-of-electrical-power initiating event over a 10-year period, we simulated loss-of-electrical-power events in the queue. During processing for the loss-of-electrical-power occurrence, other questions are resolved such as the plant response to the loss-of-electrical-power. For example, one step in the simulation checks the electric diesel generators for operation; therefore, the "diesel system event" is placed in the queue. This type of processing continues until an end state in the evaluation is reached – this indicates that the probabilistic scenario is complete. However, we will not know if fuel damage occurs for this scenario; therefore, we create a thermal-hydraulics calculation event that will perform the mechanistic analysis.

Following evaluation of the ATR probabilistic behavior, the plant physics is determined mechanistically. The plant systems-level code is used to develop distributions for the key plant process variables (i.e., loads) and the capacity to withstand those loads for the probabilistic scenarios. To couple a scenario to the thermal-hydraulics calculation, we have to customize the thermal-hydraulics code model (or input deck if using a legacy code) specific to the scenario. For example, when a component fails in the simulation, a RELAP5 input also is generated that mimics the failure.

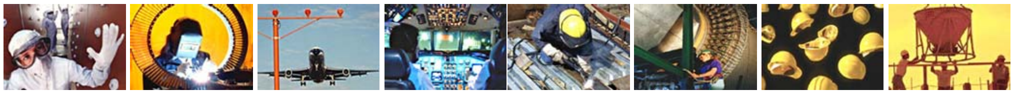
Safety Margin Results

Once the load and capacity information is known (from the probabilistic and mechanistic analysis), it is possible to then determine the probabilistic safety margin. For ATR, the safety margin was given by the number of simulations where the peak clad temperature exceeds 725°F – in other words any simulation case that results in fuel damage is defined as having "depleted" the safety margin.

After evaluating the proposed Margin recovery strategies, the results will indicate which of the associated safety margins are most preferential.

Several successful outcomes have resulted from performing the case study. The RISMC approach does the following:

- Provides the safety case to decision makers in order to select operational alternatives as part of margin management.
- Develops a significantly improved plant physics approach, wherein we can couple, in an automated fashion, to mechanistic codes such as RELAP.
- Improves the U.S. risk-analysis capabilities by creating a unique suite of simulation methods that builds upon traditional PRA approaches.



Are gas cylinders really safe in terms of material specifications after their periodic inspection and testing?

Mr. Akula Ramakrishna, University of Petroleum and Energy Studies, Dehradun, India

Dr. P Sojan Lal, ADCO, Oil & Gas

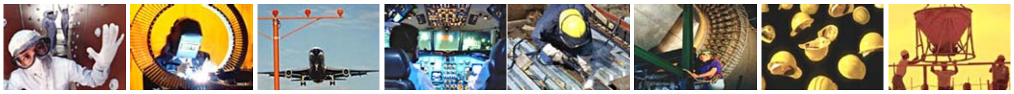
Dr. Nihal A Siddiqui, University of Petroleum and Energy Studies, Dehradun, India

Liquefied Petroleum Gas (LPG) is most common and convenient fuel for domestic applications such as indoor cooking, outdoor barbeque. LPG Cylinders plays a prominent role in carrying hazardous LPG conveniently from one place to another. Majority of these cylinders are made of low carbon steel. Although several standards, best practices and guidelines are in place to monitor LPG cylinder life cycle, LPG cylinders are greatly abused in market with wrong handling practices. In this article an attempt has been made to briefly highlight requirements of material safety compliance in LPG cylinder life cycle, which is missing in current standards particularly related to United Arab Emirates (UAE).

Emirates Authority for Standardization and Metrology (ESMA) is a standards administration body in UAE, adopted Standardisation Organisation for GCC (Gulf Cooperation Council)'s standard, UAE.S/GSO ISO 22991:2008 (Gas cylinders - Transportable refillable welded steel cylinders for liquefied petroleum gas (LPG) - Design and construction) for LPG cylinders specifications in UAE. Further GCC standards, GSO ISO 10691:2008 (Gas cylinders - Refillable welded steel cylinders for Liquefied petroleum gas (LPG) - Procedures for checking before, during and after filling) is referred for pre and post cylinder bottling operations. The standard GSO 2024:2010 (Gas Cylinders – Transportable refillable welded steel Cylinders for liquefied petroleum gas (LPG) - ownership and responsibilities) provides guidelines for safe handling of LPG Cylinder as responsible owners. Finally, all LPG Cylinders needs to be complied GCC standard GSO ISO 10464:2008 (Gas cylinders - Refillable welded steel cylinders for liquefied petroleum gas (LPG) - Periodic inspection and testing) during their periodic inspection to extend their existing life span to next five years.

In a LPG Cylinder life cycle, cylinder material plays a prominent role in containing hazardous LPG. The material specifications are checked before (Raw material) and immediately after manufacturing a cylinder (Finished product) in a production unit. However, there is no provision to check these material specifications during LPG Cylinder life cycle. That is after releasing a LPG Cylinder into market for use. This is mainly due to the nature of tests involved (destructive tests) in obtaining material specifications. Interestingly, raw material and finished product specifications are different due to the manufacturing process, which included welding and heat-treatment / Stress relieving process. Due to these processes, the material specifications are verified at raw material and finished product stages to ensure cylinders are meeting stated specifications as per standard. However, it is expected that the material doesn't subjected to elevated temperatures in use and hence the periodic testing (as per GSO ISO 10464:2008) is limited to internal pressure test only. Although, cylinders does subject to elevated temperatures; as a result of routine inspection (as per the GSO ISO 10691:2008) few cylinders in bottling plant are segregated for replacing damaged base rings (Also known as foot rings) or valve protection rings (also known as shoulders). These damaged rings are replaced in cylinder repairer premises by cutting old components and replaces with fresh components by welding. Once new components are welded, these repaired cylinders are heat treated to relieve internal stresses. This heat treatment process obviously changes cylinder material properties. Current standard (GSO ISO 10464:2008) doesn't stipulate the requirement of material compliance during periodic inspection and testing of cylinders. As there is no check at this stage, cylinders can be either over heat-treated or under heat-treated. Overheat treatment of cylinders can result in reduction of cylinder material's yield strength and under heat treatment or absence of heat treatment can result in fragmented burst, in case a cylinder is subjected to adverse internal pressure. Both these scenarios are serious threats to cylinder consumer.

The authors jointly worked on domestic LPG Cylinder material safety as per Indian standards and published nine research papers in five International journals, as a part of first authors' doctoral research. This work is pending for final review and award of PhD degree. In the research, author suggested a novel method to ensure material safety compliance at all stages of LPG Cylinder life cycle using a set of empirical formulas derived from mathematical models. The outcome of the research is advantages of all stakeholders of LPG cylinder business globally viz. Manufacturers, marketing companies, bottling plants,



certification bodies, inspection authorities, accident and incident investigators, finally the end-users and for environment. The research outcome can be incorporated in several National and International standards related to steel cylinders periodic inspection and testing specifications.

References:

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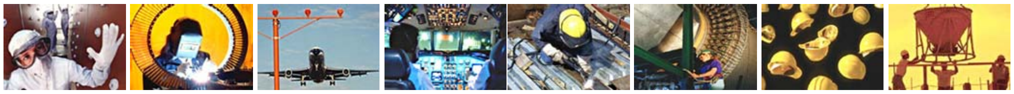
About the Authors

Ramakrishna Akula is research Scholar from University of petroleum and Energy Studies, Dehradun, India. He is having more than 14 years of LPG industry experience. He completed his bachelor degree in mechanical technology from NIT Warangal. He won several national level awards from prestigious institutes like IIT Bombay on student design projects and presented several technical papers at various student conferences and published so far 9 research papers in academic journals. He started his professional career with Hindustan Petroleum Corporation limited as a management trainee and demonstrated unique R&D skills for projects related LPG equipment. He was deputed as a mechanical lab in charge in LPG Equipment Research Centre (LERC), Bangalore in 2003. He led several R&D projects in LERC and successfully completed those projects during 2003-2007. He investigated several equipment failure and accident investigations related to LPG equipment during his tenure. He can be reached at akula.ramakrishna@gmail.com

Dr. P. Sojan Lal, ASME Member and formerly ASME District (J, Middle East and Africa) Operating Board Member, is working with ADCO, Oil & Gas fields since 1999 in Abu Dhabi, UAE. He received BE in Mechanical Engineering from Bangalore University, Karnataka, in 1985, M.Tech in Computer Science from National Institute of Technology (NIT), Warangal, India in 1993 and Ph.D from Cochin University of Science and Technology, Kerala, India in 2002. He is an approved research guide with University of petroleum and energy studies, Dehradun and Mahatma Gandhi University, India. Dr Sojan, who has 27 years of diverse experience, has published 56 technical papers and one textbook, obtained MBA from Strathclyde Business School, Scotland, UK. His research interests includes: safety engineering, image processing, web usage mining, software protection, Semantic web and Ontology. He is a Fellow of The Institution of Engineers (FIE-India) since 2004 and member of ISTE, CSI and Engineering Council (UK). Dr Sojan is a lead organizer and an inspirational speaker for budding engineers of various universities/ MBA program. Listed since 2009 Edition of Who's Who in the World®, published by Marquis Who's Who, as the biographical reference representing the world's most accomplished individuals. He can be reached at: padikkakudy@gmail.com

Dr Nihal Anwar Siddiqui is a dynamic and distinguished HSE academician having 17+ years of combined experience in academic, research and industrial domains. He is currently



working as a Professor and head, Department of health safety fire and environment, in university of petroleum and energy studies, Dehradun. Dr. Siddiqui is an eminent member in several renowned professional bodies such as IOSH, Energy institute, London and National safety council etc. He was trained in several HSE and Fire safety specializations and became certified professional on topics like managing safety, construction safety, OHSAS lead auditor etc. He attended several national and international conferences as a speaker. Dr. Siddiqui is an author for more than 40 + research publications, published in prominent national and international journals. So far, He guided 50+ M.Tech dissertations and supervised 3 PhD's. He undertook several sponsored R& projects in HSE field from both government and private sectors. His patent on odor pollution monitoring kit is pending. He was exclusively selected for international academic service and working as an assistant professor for Ethiopian medical college. His first book on natural resources and environment management was published from Kannan publications. Dr. Siddiqui is available at nsiddiqui57@gmail.com.

SERAD VOLUNTEER OPPORTUNITIES

Throughout the year, there is always a need for volunteers to assist with SERAD activities. Some specific needs are listed below. You can also volunteer for other activities or general assistance by contacting any of the SERAD Executive Committee members listed in the Contacts section of this newsletter.

SERAD Awards Dinner Committee: Organization of the annual SERAD Awards dinner, typically held at ASME IMECE in November. Duties would include finding a guest speaker, arranging for a banquet room, selection of dinner menu, sending invitations. Contact any of the SERAD Executive Committee members listed in the Contacts section of this newsletter.

SERAD Technical Paper Reviewers: Peer review technical papers for SERAD sessions at future conferences. There are needs for reviewers for abstracts / papers submitted for the Fall IMECE. If you are interested, please contact the SERAD Chair or Vice Chair listed in the Contacts section of this newsletter.

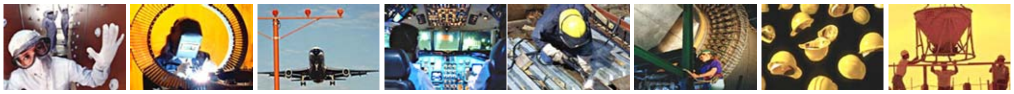
SERAD Website Maintenance: Assistance with all aspects of maintaining the SERAD website, updating content for the website. Contact any of the SERAD Executive Committee members listed in the Contacts section of this newsletter.

REMINDER

Remember that one of the benefits of being a SERAD member is the opportunity to purchase a subscription to the Elsevier journal, ***Reliability Engineering and System Safety***. Normally not available to individuals, as a SERAD member, you can purchase a year-long *(12 issue)* subscription to this valuable journal for $206. See the Important Website Links section below for a hyperlink to the order form on the SERAD website.

IMPORTANT WEBSITE LINKS

Elsevier Journal, "Reliability Engineering and System Safety" SERAD Member Order Form:
http://files.asme.org/Divisions/SERAD/22426.pdf



CONTACTS

<u>SERAD Executive Committee</u>

Chair
James R. Harris, Ph.D., P.E.
Research Safety Engineer
Division of Safety Research
National Institute for Occupational Safety and Health (NIOSH)
1095 Willowdale Rd. MS-G800
Morgantown, WV 26505
T: 304-285-6120
F: 304-285-6047
E: jrh6@cdc.gov

1st Vice Chair
W.R. (Bill) Byrd, P.E.
President
RCP Inc.
801 Louisiana St., #200
Houston, TX 77002
T: 888-727-9937
F: 713-655-8083
E: wrb@rcp.com

2nd Vice Chair
John Weichel
Research Scientist
The Ohio State University
7349 Worthington-Galena Rd
Columbus, OH 43085
T: 614-888-4160
F: 614-888-3326
E: wiechel.4@osu.edu

3rd Vice Chair, Treasurer
Chimba Mkandawire, Ph.D., P.E., CAISS
3rd Vice Chair, Treasurer
Principal Engineer
Exponent, Inc.
3350 Peachtree Road NE
Suite 1620
Atlanta, GA 30326
T: 678-412-4812
F: 678-412-4899
E: cmkandawire@exponent.com

4th Vice Chair, Secretary
Juan C. Ramirez
Senior Engineer
Exponent, Inc.
4580 Weaver Parkway
Suite 100
Warrenville, IL 60555
T: 630-658-7520
F: 847-922-7840
E: jramirez@exponent.com

<u>SERAD - Other Contacts</u>

ASME
Jacinta McComie-Cates
Administrator, K & C
Three Park Avenue
New York, NY 10016
T: 212-591-7052
E: mccomiej@asme.org

ASME
Marian Heller
Global, Technical & Affinity Communities
Three Park Avenue
New York, NY 10016
T: 212-591-7079
E: hellerm@asme.org

SERAD Newsletter Editor
Ward O. Baun III, C.R.E., P.E.
Fellow-Reliability Engineering
UTC Power
195 Governors Highway
South Windsor, CT 06074
T: 860-727-7234
E: ward.Baun@clearedgepower.com

SERAD Newsletter Co-Editor
Curtis Lee Smith, Ph.D.
Distinguished Staff Engineer
Idaho National Laboratory
PO Box 1625, Mail Stop 3850
Idaho Falls, ID 83415-3850
T: 208-526-9804
E: Curtis.Smith@inl.gov

SERAD Social Media Editor
Jennifer Seals Cooper
RCP Inc.
C: 936.499.1737
E: jcooper@rcp.com