

## Peer Review of State-of-the-Art Reactor Consequence Analysis

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## Outline

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- *SOARCA Peer Review Charter*
- *Peer Review Scope*
- *Peer Review Methodology*
- *SOARCA Topics by Committee Members' Areas of Expertise*
- *Key Findings*
- *Conclusions*

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## SOARCA Peer Review Charter

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- *The Peer Review Committee's charter is to:*
  - *Provide independent reviews of the technical work conducted by the NRC and Sandia National Laboratories for the SOARCA project;*
  - *Assure that the SOARCA study is technically accurate;*
  - *Assess whether the conclusions are supported by the technical work presented in the SOARCA NUREG report.*
- *The final deliverable is a technical report documenting the findings of individual Committee members.*
- *The Committee began its work in July 2009 and submitted the final version of its report in January 2012.*

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## Peer Review Scope

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- *Evaluation of the accuracy, methodological approach, underlying information and assumptions, application of current standards, interpretation of results, and conclusions obtained for Peach Bottom and Surry nuclear reactors.*
- *Comment on the presentation of the SOARCA evaluations within the SOARCA NUREG documents.*
  - *Are the conclusions supported by the technical work presented?*
- *Editorial review of the SOARCA documents is not within the scope of the Peer Review Committee.*

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## Peer Review Scope

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- *Documents reviewed include:*
  - *Draft SOARCA NUREG documents*
    - *Main Report (latest, 23 Dec. 2011)*
    - *Volume 1 (latest, 12 Oct. 2011)*
    - *Volume 2 (latest, 17 Nov. 2011)*
  - *Presentation materials provided at Peer Review Committee meetings*
  - *Comment resolution documents and supporting documents that were supplied at the Committee's request.*

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## Peer Review Scope

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- *Uncertainty Quantification and Sensitivity Analysis is considered beyond the scope of the Peer Review Charter.*
  - *However a proposed Uncertainty Analysis methodology was presented to the Committee in Oct 2010, and a peer review guidance memo was requested.*
  - *The parameters and their distributions to be used in the Uncertainty Analysis were presented to the committee on Jan. 5 2012.*
  - *While the committee has had input into the parameter selection it has not and will not evaluate any further results of the SOARCA study based on the uncertainty analysis.*
- *The Peer Review Committee has conducted this review effort in an advisory capacity.*

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## Peer Review Methodology

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- Five meetings were conducted between the Peer Review Committee members and the SOARCA team.
  - 28-29 July 2009
  - 15-16 Sept. 2009
  - 2-3 March 2010
  - 26-27 Oct. 2010
  - 6-8 Dec. 2011
- Prior to each meeting, SOARCA documentation was transmitted to the Committee for review.
- Issues, questions and suggestions were presented and discussed at each meeting.
- Many comments and suggestions made by Peer Reviewers were included in the analysis.

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## Peer Review Methodology

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- Final Report of the Peer Review Committee (January 2012) includes:
  - List of written questions and comments by members and their resolution by the SOARCA team
  - Memoranda provided by Committee members submitted to the SOARCA team on specific issues.
  - Each member's individual assessment of the SOARCA effort.

8

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## SOARCA Topics by Peer Review Committee Members' Areas of Expertise

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- Committee Chair: Karen Vierow (Texas A&M University)
- Accident sequence selection
  - Ken Canavan (EPR1)
  - Bruce Mrowca (ISL)
- Accident progression
  - Ken Canavan (EPR1)
  - Bernard Clément (IRSN, France)
  - Jeff Gabor (ERIN Engineering)
  - Robert Henry (Fauske and Associates)
- Mitigation measures
  - Jeff Gabor (ERIN Engineering)
  - Robert Henry (Fauske and Associates)
  - Bruce Mrowca (ISL)

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**SOARCA Topics by Peer Review  
Committee Members' Areas of Expertise**

- *Seismic issues*
  - John Stevenson (JD Stevenson Consulting Engineering Co.)
- *Structural issues*
  - John Stevenson (JD Stevenson Consulting Engineering Co.)
- *Probabilistic Risk Assessment applications*
  - Ken Canavan (EPRI)
  - Bruce Mrowca (ISL)
- *Severe accident modeling*
  - Jeff Gabor (ERIN Engineering)
  - Robert Henry (Fauske and Associates)
  - Karen Vierow (Texas A&M University)

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**SOARCA Topics by Peer Review  
Committee Members' Areas of Expertise**

- *Radiological release*
  - Bernard Clément (IRSN)
  - Jeff Gabor (ERIN Engineering)
  - Robert Henry (Fauske and Associates)
  - David Leaver (WorleyParsons Polestar)
- *Off-site emergency planning and response*
  - Roger Kowieski (Natural and Technological Hazards Management Consulting, Inc.)
  - David Leaver (WorleyParsons Polestar)
- *Off-site radiological consequences*
  - David Leaver (WorleyParsons Polestar)
  - Kevin O’Kula (Washington Safety Management Solutions)
  - Jacquelyn Yanch (Massachusetts Institute of Technology)

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**Key Findings**

- *Reviewers in general find that the SOARCA study has largely met its objectives:*
  - *Performs a more realistic evaluation of severe accident progression, radiological releases, and offsite consequences;*
  - *Addresses two operating plants (Surry and Peach Bottom) in an integrated, consistent manner for important (high risk) sequences (e.g., SBO, ISLOCA);*
  - *Accounts for plant-specific design and operational improvements, credit existing and newly developed mitigative measures, and site specific emergency plans.*

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## Key Findings

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- *In general, the methodology was sound and the process was performed in a transparent way with emphasis on open communication about the process (with Peer Reviewers, with the public).*
- *The study appears to be objective and uninfluenced by interested parties.*
- *The presentation of the study methodology and results is appropriate.*

13

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## Key Findings

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- *The study itself represents a significant advancement on the state-of-the-art for accident analysis.*
- *Study generated a MELCOR "Best Practices" document that will be useful for accident and risk analysis in the future.*
  - *Comparisons of MELCOR code predictions against experimental and plant data concerning thermal hydraulic and fission product behavioral characteristics of the reactor core, the RCS, and the containment.*

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## Key Findings

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### *Limitations Cited by Various Reviewers:*

- *Selection of accident scenarios.*
  - *A full PRA was not conducted to determine the accident scenarios.*
  - *According to other reviewers, risk- significant scenarios have not been overlooked.*
  - *Assumption that hydrogen burn would occur before hydrogen detonation needs to be evaluated more fully.*
- *Results are plant-specific and can be influenced in many ways by plant-specific features.*
  - *However the approach offers insight into many aspects of nuclear accidents.*
  - *Differences in soil liquefaction and consolidation during or immediately following a large earthquake should be evaluated on a site-by-site basis.*
    - *Potential for radionuclide release due to rupture of penetrations (eg. pipes) between containment and other buildings.*

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## Key Findings

### Limitations Cited by Various Reviewers:

- *Lack of human reliability assessment in quantifying likelihood of operator actions.*
  - *This impacts confidence in success of mitigating actions*
  - *Assuming successful mitigation is not unreasonable, according to other reviewers*
- *Not every aspect of the study is "best estimate". In some cases significant conservatisms have been retained.*
  - *Operator-based mitigating actions*
  - *Economics and success of decontamination and clean-up procedures*
  - *Impact of very low dose-rate on estimates of latent cancer fatality risk.*
  - *Straight line Gaussian plume segment model*

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## Key Findings

### Limitations Cited by Various Reviewers:

- *No impact on the population other than latent cancer fatality risk, is evaluated.*
  - *The consequence of a severe reactor accident is prolonged evacuation of homes and communities by the public.*
  - *Evacuated population receives no additional dose until people return home*
  - *The social and economic impact resulting from prolonged (perhaps permanent) relocation is not examined in the SOARCA study.*

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## Key Findings

### Recommendations by Various Peer Reviewers:

- *A Level 3 Probabilistic Risk Assessment on one of the SOARCA plants.*
- *Extension of the analysis to other plants.*
- *Perform a human reliability assessment.*
- *Quantify the social and economic impact of prolonged evacuation of the public.*
- *Quantify the economic impact of property decontamination and clean-up.*

18

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## Conclusions

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- *A peer review of the SOARCA project by independent experts has been conducted.*
- *A final report has been completed. No consensus amongst committee members has been attempted.*
- *Review results were generally favorable to the SOARCA methodology and communication of results.*
- *General opinion that the project and its associated documentation make a significant contribution to the understanding of U.S. commercial reactor risk.*

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## Acronyms

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- *ACRS – Advisory Committee on Reactor Safeguards*
- *EPRI – Electric Power Research Institute*
- *IRSN - Institut de Radioprotection et de Sûreté Nucléaire (France)*
- *ISL – Information Systems Laboratories*
- *ISLOCA - Interfacing Systems Loss-of-Coolant Accident*
- *SBO – Station Blackout*
- *SOARCA – State of the Art Reactor Consequence Analyses*

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