

# Matthew Denman

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*Nuclear Power Probabilistic Risk Analyst*

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## Education

2007-2011 **Doctor of Philosophy in Nuclear Engineering**, *Massachusetts Institute of Technology*, Cambridge MA.

2003-2007 **Bachelor of Science in Nuclear Engineering**, *University of Florida*, Gainesville, FL.

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## Work History

2019-Present **Kairos Power**, *Principal Engineer, Reliability Engineering*, Albuquerque, NM.

- Responsible Engineer for the Kairos Power Fluoride Salt-Cooled High Temperature Reactor (KP-FHR) Mechanistic Source Term methodology development project which resulted in a topical report submitted in June, 2020.
- Contributor to the development of the KP-FHR Risk-Informed Performance-Based Licensing Basis Development Methodology Topical Report focusing on LBE and SSC classification.
- Key developer of automated analysis-as-code development tools to support rapid iterations of the safety analysis.
- Responsible Engineer for event sequence family frequency and source term analysis.

2017-2019 **Sandia National Laboratories, Nuclear Energy Systems**, *Principal Member of the Technical Staff*, Albuquerque, NM.

- Principal Investigator for the reconstitution of the Centralized Reliability Database Organization (CREDO) database to support Probabilistic Risk Assessments and Safety Analysis for Sodium Fast Reactors.
- Project Manager for joint Japanese Atomic Energy Agency and Sandia bilateral (through the Civil Nuclear Energy Working Group) research effort to benchmark effort for sodium fire codes using Sandia Lab Directed Research and Development funded sodium fire test data.
- Project Manager for the incorporation of sodium fire models into the MELCOR computer code.
- Principal Investigator for an Office of New Reactors evaluation of scoping source terms for High Temperature Gas Reactors, Liquid Fueled Molten Salt Reactors, and Sodium Fast Reactors and developing Risk-Informed Security Criteria.
- Contributing Investigator responsible for the Level 2 Spent Fuel Pool PRA development as part of the NRC Level 3 PRA project.

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- Participant in the development of the Generation 4 International Forum Sodium Fast Reactor Safety Design Guidelines Task Force.

2011-2017 **Sandia National Laboratories, Nuclear Energy Systems**, *Senior Member of the Technical Staff*, Albuquerque, NM.

- Contributing Investigator responsible for the development of uncertainty distributions for Safety Relief Valve failure, Safety Vent Valve failure, Decay Heat, and Core Collapse parameters in the Surry and Sequoyah SOARCA Uncertainty Analysis.
- Investigator responsible for characterizing of uncertainties and sensitivity studies on the Fukushima 1F1 accident analysis using MELCOR.
- Principal Investigator for a multi-institute, multi-disciplinary examination of safety and licensing gaps for the Sodium Fast Reactor.
- Principal Investigator of a Lab Directed Research and Development project to create the mathematical formulation for Dynamic Fault Trees to inform decision makers of evolving state of support system success probability mid-accident.
- Principal investigator for a two proof-of-concept Level 2 Risk Assessments to inform the development of Severe Accident Management Guidelines for both integral Pressurized Water Reactors and Sodium Fast Reactors, using a combination of:
  - Severe accident simulation (via MELCOR and SAS4a codes),
  - Discrete Dynamic Event Trees via the ADAPT code, and
  - Decision analysis using Bayesian Networks.

2007 **Sandia National Laboratories, Annular Core Research Reactor**, *Nuclear Engineering Intern*, Albuquerque, NM.

Created reactivity pulse magnitude predictive models to account for the effects of spectrum filter buckets using data derived through experimentation and MCNP simulation.

2006 **Florida Power and Light, Mechanical and Component Engineering**, *Mechanical Engineering Intern*, Port St. Lucie, FL.

Conducted preventive maintenance on auxiliary feed-water pumps, diesel air-start motors, and radioactive waste management systems. Assisted with low power physics testing and approach to critical procedures coming out of the PSL 2-16 outage.

2005 **Florida Power and Light, Nuclear Fuels Division**, *Nuclear Engineering Intern*, Juno Beach, FL.

Modeled potential particle blockage in spacer grids for pressurized water reactor fuel assemblies to address GSI-191 concerns for the Port St. Lucie 1&2, Turkey Point 3&4, and Seabrook nuclear reactors.

## Professional Society Postions

Joint Committee of Nuclear Risk Managment

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2019-Present **Sub-Committee of Standards Development**, *Chair*, Facilitating New Standards.

2017-2018 **Sub-Committee of Standards Development**, *Vice-Chair*, Facilitate Chair.

2018-Present **Main Committee**, *Member*, Comment and Vote on Standards.

### Nuclear Installation Safety Division

2018-2019 **Executive Committee**, *Chair*, Budget and Plan Activities.

2017-2018 **Executive Committee**, *Vice-Chair*, Cross-Division Representation.

2014-2015 **Program Committee**, *Chair*, Organized NISD Sessions for ANS.

2013-2014 **Program Committee**, *Vice-Chair*, Division Representative to ANS.

2012-2013 **Program Committee**, *Secretary*, Record Keeping.

### ANS Trinity

2019-2020 **Executive Committee**, *Chair*, Organize and Run Dinner Meetings.

2018-2019 **Executive Committee**, *Vice-Char*, Faciliate Chair.

## Programming Experience

### My Programming Journey Most Recent Experience is Listed First

Language	Applications
Version Control	
GitHub	Code Review, Issues Tracking, Work Planning
Analysis as Code	
R LaTeX	Generating Documents and Websites; Data Cleaning Reports, Memos, and Journals
Basic Coding	
Python	Input Generation; Automation; Post-prossessing
Matlab	Input Generation; Automation; Post-prossessing; Statistics
Fortran	School Assignments

## Awards and Certificates

### Kairos Power

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- 2020 - JCNRM Certificate of Acclimation for technical contributions to the ANLWR PRA Standard
- 2019 - ANS Certificate of Governance, Chair, NISD, 2018-2019
- 2011 - MIT College of Engineering Reinhold Rudenberg Memorial Prize
- 2009 - ANS Student Conference Best Fast Reactor Presentation
- 2007 - ANS Student Conference Best in Poster Completion
- Honor Societies:
  - Alpha Nu Sigma
  - Tau Beta Pi
- Professional Development Courses:
  - 2012 - Decision-Making, Design, and Strategy Under Uncertainty
  - 2014 - Tackling the Challenges of Big Data, MIT
  - 2016 - Nuclear Plant Safety, MIT (Most Persistent Questioner Award)

## Publications

### Technical Reports

1. Denman, MR (2011). “Probabilistic Transient Analysis of Fuel Choices for Sodium Fast Reactors”. PhD thesis. Massachusetts Institute of Technology.
2. Walters, L, J Lambert, K Natesan, K Wright, A Yacout, S Hayes, D Porter, L Ott, F Garner, and MR Denman (2012). *Sodium Fast Reactor Fuels and Materials: Research Needs*. Tech. rep. SAND2011-6546. Sandia National Lab.(SNL-NM), Albuquerque, NM (United States).
3. Sofu, T, JL LaChance, R Bari, R Wigeland, MR Denman, and GF Flanagan (2012). *Sodium Fast Reactor Safety and Licensing Research Plan-Volume I*. Tech. rep. SAND2012-4260. Sandia National Laboratories (United States).
4. Ludewig, H, D Powers, JC Hewson, JL LaChance, A Wright, J Phillips, R Zeyen, B Clement, F Garner, L Walters, et al. (2012). *Sodium Fast Reactor Safety and Licensing Research Plan. Volume II*. Tech. rep. SAND2012-4259. Sandia National Laboratories.
5. Allen, T, E Blandford, G Cao, D Chapin, M Denman, T Downar, G Flanagan, B Forget, C Forsberg, E Greenspan, et al. (2013). *Fluoride-Salt-Cooled, High-Temperature Reactor (FHR) Methods and Experiments Program White Paper*. Tech. rep. UCBTH-12-002, University of California, Berkeley.
6. Denman, M, J Brown, A Goldmann, and D Louie (2013). *Regulatory Cross-Cutting Topics for Fuel Cycle Facilities*. Tech. rep. SAND2013-9367. Sandia National Lab.(SNL-NM), Albuquerque, NM (United States).
7. Denman, MR, K Groth, JN Cardoni, and TA Wheeler (2015). *Risk Management for Sodium Fast Reactors*. Tech. rep. SAND2015-0542. Sandia National Lab.(SNL-NM), Albuquerque, NM (United States).
8. Denman, MR and A Ames (2014). *Dynamical Systems Probabilistic Risk Assessment*. Tech. rep. SAND2014-4037. Sandia National Lab.(SNL-NM), Albuquerque, NM (United States).
9. Denman, MR, KM Groth, JN Cardoni, and TA Wheeler (2015). *Advanced Liquid Metal Reactor Discrete Dynamic Event Tree/Bayesian network analysis and incident management guidelines (risk management for sodium fast reactors)*. Tech. rep. SAND2015-2484. Sandia National Lab.(SNL-NM), Albuquerque, NM (United States).
10. Denman, MR and DM Brooks (2015). *Fukushima Daiichi Unit 1 Uncertainty Analysis-Exploration of Core Melt Progression Uncertain Parameters-Volume II*. Tech. rep. SAND2015-6612. Sandia National Lab.(SNL-NM), Albuquerque, NM (United States).
11. Jankovsky, ZK, MR Denman, KM Groth, and TA Wheeler (2015). Interim Status Report for Risk Management for SFRs. (SAND2015-8872).

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12. Grabaskas, D, M Bucknor, J Jerden, AJ Brunett, M Denman, A Clark, and RS Denning (2016). *Regulatory Technology Development Plan-Sodium Fast Reactor: Mechanistic Source Term-Trial Calculation*. Tech. rep. Argonne National Lab.(ANL), Argonne, IL (United States).
13. Allen, T, S Ball, E Blandford, T Downar, G Flanagan, C Forsberg, E Greenspan, D Holcomb, L Hu, R Matzie, et al. (2013). Fluoride-Salt-Cooled High-Temperature Reactor (FHR) Subsystems Definition, Functional Requirement Definition, and Licensing Basis Event (LBE) Identification White Paper.
14. Jankovsky, ZK and MR Denman (2017). Modification of the SAS4A Safety Analysis Code for Integration with the ADAPT Discrete Dynamic Event Tree Framework. *Sandia National Laboratories, Albuquerque, NM* (SAND2017-4764).
15. Wheeler, T, M Denman, R Williams, N Martin, and Z Jankovsky (2017). Nuclear Power Plant Cyber Security Discrete Dynamic Event Tree Analysis (LDRD 17-0958) FY17 Report. *Sandia National Laboratories, Albuquerque, NM* (SAND2017-10307).
16. Clark, AJ, MR Denman, T Takata, and H Ohshima (2017). SNL/JAEA Collaboration on Sodium Fire Benchmarking. *Albuquerque, NM* (SAND2017-12409).
17. Clark, AJ and MR Denman (2017). *Mechanistic Source Term Modeling for Sodium Fast Reactors*. Tech. rep. SAND2017-0454C. Sandia National Lab.(SNL-NM), Albuquerque, NM (United States).
18. Denman, M, Z Jankovsky, and W Stuart (2017). *Creation of the NaSCoRD Database*. Tech. rep. SAND2017-9517. Sandia National Lab.(SNL-NM), Albuquerque, NM (United States).
19. Bowman, N and MR Denman (2016). *Implementation of Fast, Emulator-based Code Calibration*. Tech. rep. SAND2016-7862. Sandia National Lab.(SNL-NM), Albuquerque, NM (United States).
20. Jankovsky, ZK, TC Haskin, and MR Denman (2018). *How to ADAPT*. Tech. rep. SAND2018-6660. Sandia National Lab.(SNL-NM), Albuquerque, NM (United States).

### Journals

1. Jankovsky, ZK, MR Denman, and T Aldemir (2018). Dynamic event tree analysis with the SAS4A/SASSYS-1 safety analysis code. *Annals of Nuclear Energy* **115**, 55–72.
2. Darling, MC, GF Luger, TB Jones, MR Denman, and KM Groth (2018). Intelligent modeling for nuclear power plant accident management. *International Journal on Artificial Intelligence Tools* **27**(02), 1850003.

### Conferences

1. Darling, MC, GF Luger, TB Jones, MR Denman, and KM Groth (2018). Intelligent modeling for nuclear power plant accident management. *International Journal on Artificial Intelligence Tools* **27**(02), 1850003.
2. Depriest, KR, KC Kajder, JN Frye, and MR Denman (2009). Control Rod Reactivity Curves for the Annular Core Research Reactor. In: *Reactor Dosimetry State of the Art 2008*. Vol. 1, pp.195–203.
3. Denman, M, N Todreas, and M Driscoll (2010). Creation and Verification of an Empirical Metallic Fuel/Clad Eutectic Predictive Relationship. *Transactions* **103**(1), 482–483.
4. Denman, M, N Todreas, and M Driscoll (2009). Risk Informed Design Choices Using the Technology Neutral Framework. *Transactions* **101**(1), 503–504.
5. Denman, M and M Zucchetti (2011). Model Uncertainty of Empirical Metallic Fuel/Clad Eutectic Predictive Relationships. In: *ANS PSA 2011 International Topical Meeting on Probabilistic Safety Assessment and Analysis*. American Nuclear Society.
6. Denman, M, N Todreas, and M Driscoll (2011). Using Importance Sampled RELAP5-3D Simulations to Evaluate Radioactive Material Release Frequencies for the Technology Neutral Framework. In: *ANS PSA 2011 International Topical Meeting on Probabilistic Safety Assessment and Analysis*. American Nuclear Society.

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7. Denman, M, N Todreas, and M Driscoll (2010). Applying the Technology Neutral Framework to Evaluate Core Outlet Temperature Changes in a Sodium Fast Reactor. In: *ICAPP'10*. American Nuclear Society, pp.10307.
8. Denman, M (2010). Uncertainty Quantification by Bayesian Updating of Importance Sampled Evidence. In: *Verification and Validation for Nuclear Systems Analysis Workshop II*. American Nuclear Society.
9. Denman, M and A Ames (2012). Methodology for Incorporating Dynamic Behavior into Fault Trees Using System Dynamics. *Transactions* **107**(1), 722–725.
10. Denman, M, N Todreas, and M Driscoll (2012). Review of fuel/cladding eutectic formation in metallic SFR fuel pins. In: *Proceedings of the 2012 International Congress on Advances in Nuclear Power Plants-ICAPP'12*.
11. Osborn, D, KW Ross, NE Bixler, JN Cardoni, and MR Denman (2013). MELCOR/MACCS2 Analysis for BWR Mark I Filtered Containment Venting. In: vol. 109. 1. American Nuclear Society.
12. Jankovsky, Z, M Denman, and T Aldemir (2017). A Dynamic Assessment of Auxiliary Building Contamination and Failure due to a Cyber-Induced Interfacing System Loss of Coolant Accident. In: *International Conference on Topical Issues in Nuclear Installation Safety: Safety Demonstration of Advanced Water Cooled Nuclear Power Plants, Vienna, Austria*.
13. Groth, KM, MR Denman, MC Darling, TB Jones, and GF Luger (2020). Building and using dynamic risk-informed diagnosis procedures for complex system accidents. *Proceedings of the Institution of Mechanical Engineers, Part O: Journal of risk and reliability* **234**(1), 193–207.
14. Hughes, J, M Liu, B Wallace, A Ali, M Denman, N Zweibaum, P Peterson, and E Blandford (2016). On the Question of Decay Heat Removal System Redundancy for Fluoride Salt-Cooled High-Temperature Reactors (FHR). In: *Proc. Int. Congress Advances in Nuclear Power Plants (ICAPP 2016)*, pp.17–20.
15. Denman, M and J Cardoni (2014). Comparison of MELCOR and SAS4a for Dynamic Event Simulations. *Transactions* **110**(1), 352–354.
16. Sonehara, M, M Aoyagi, A Uchibori, T Takata, H Ohshima, AJ Clark, and MR Denman (2019). Multi-Dimensional Numerical Benchmark Analysis of SNL T3 Sodium Spray Combustion Experiment with Aqua-SF Code. In: *The Proceedings of the International Conference on Nuclear Engineering (ICONE) 2019.27*. The Japan Society of Mechanical Engineers, pp.2089.
17. Jankovsky, ZK and MR Denman (2018). Recent Analysis and Capability Enhancements to the ADAPT Dynamic Event Tree Driver. In:
18. Jankovsky, ZK, ZW Stuart, and MR Denman (2019). Sodium Pump Performance in the NaSCoRD Database. In: *Proceedings International Topical Meeting on Probabilistic Safety Assessment and Analysis (PSA 2019)*, pp.811–817.
19. Jankovsky, ZK, MR Denman, and T Aldemir (2016). Extension of the ADAPT Framework for Multiple Simulators. In: vol. 115. American Nuclear Society.
20. Jankovsky, ZK, MR Denman, and T Aldemir (2016). Conditional Tree Reduction in the ADAPT Framework. In: vol. 115. American Nuclear Society.
21. Denman, MR, KM Groth, and TA Wheeler (2013). Proof of Principle Framework for risk informed Severe Accident Management Guidelines. In: vol. 109. American Nuclear Society.
22. Jankovsky, ZK, MR Denman, and T Aldemir (2016). Dynamic Importance Measures in the ADAPT Framework. In: vol. 115. American Nuclear Society.
23. Martin, N, MR Denman, and TA Wheeler (2016). Pruning of Discrete Dynamic Event Trees Using Density Peaks and Dynamic Time Warping. In: vol. 115. American Nuclear Society.
24. Cardoni, JN, MR Denman, and TA Wheeler (2016). Severe Accident Modeling for Cyber Scenarios. In: vol. 115. American Nuclear Society.

25. Denman, MR, PL Turner, R Williams, JN Cardoni, and TA Wheeler (2016). Development of the SharkFin Distribution for Fuel Lifetime Estimates in Severe Accident Codes. In: vol. 115. American Nuclear Society.
26. Clark, AJ and MR Denman (2016). Sodium Spray Fire Simulations using CONTAIN-LMR. In: vol. 115. American Nuclear Society.
27. Denman, MR, JL LaChance, T Sofu, GF Flanagan, R Wigeland, and R Bari (2012). Sodium Fast Reactor Research Plan. In: vol. 107. American Nuclear Society.
28. Denman, MR (2013). Safety Relief Valve Cyclic Failure Analysis for use in Discrete Dynamic Event Trees. In: Columbia, SC: American Nuclear Society.
29. Liao, H, JN Cardoni, MR Denman, and TA Wheeler (2013). Leveraging Existing Tools for Simulating Operator Performance in Discrete Dynamic Event Trees. In: Columbia, SC: American Nuclear Society.
30. Denman, MR, KM Groth, TA Wheeler, and JN Cardoni (2013). Discrete Dynamic Event Tree Analysis of Small Modular Reactor Severe Accident Management. In: Columbia, SC: American Nuclear Society.
31. Groth, KM, MR Denman, JN Cardoni, and TA Wheeler (2014). "Smart Procedures": Using dynamic PRA to develop dynamic context-specific severe accident management guidelines (SAMGs). In: Columbia, SC.
32. Jones, TB, MC Darling, KM Groth, MR Denman, and GF Luger (2016). A Dynamic Bayesian Network for Diagnosing Nuclear Power Plant Accidents. In:
33. Groth, KM, MR Denman, TB Jones, M Darling, and GF Luger (2015). Proof-of-concept accident diagnostic support for sodium fast reactors. In:
34. Denman, MR, PL Turner, R Williams, JN Cardoni, and TA Wheeler (2016). Preliminary Cyber-Informed Dynamic Branch Conditions for Analysis with the Dynamic Simplified Cyber MELCOR Model. In: vol. 107. American Nuclear Society.
35. Louie, D, LL Humphries, and MR Denman (2017). Containment Sodium Chemistry Models in MELCOR. In:
36. Takata, T, H Ohshima, MR Denman, and AJ Clark (2017). Numerical Investigation of Sodium Spray Combustion Test with SPHINCS code. In:
37. Denman, MR, ZK Jankovsky, and AJ Clark (2017). Development of the US Sodium Component Reliability Database. In: Pittsburgh, PA.
38. Denman, MR, ZW Stuart, and ZK Jankovsky (2018). Sodium Valve Performance in the NaSCoRD Database. In: Los Angeles, CA.

## Panels

1. Denman, MR, M Corradini, DA Powers, LC Walters, RC Schmidt, and JI Sackett (2011). Regulatory Gaps for the Sodium Reactor a DOE Perspective-Panel. *Transactions* **105**.
2. Denman, MR (2019). [Grand Challenge] Sodium Reactor Database to Support Knowledge Management-Panel. *Transactions* **120**(1), 563–563.
3. Denman, MR, J Hagaman, K Fleming, R Budnitz, and D Grabaskas (2019). Meeting the Challenges in Non-LWR PRA Standard Development-Panel. *Transactions* **120**(1), 563–563.
4. Denman, M, M Gonzalez, Z Jankovsky, AG Yigitoglu, K Groth, and M Diaconeasa (2019). Current Applications of Dynamic PRA-Panel. *Transactions* **121**(1).
5. Denman, M, M Gonzalez, Z Jankovsky, C Smith, K Groth, and M Diaconeasa (2019). NRC Seminar - Current Applications of Dynamic PRA-Panel.
6. O’Kula, K, M Denman, D Powers, and C Martin (2014). Round Table on Organizing Special Sessions for ANS Meetings-WORKSHOP. *Transactions* **110**(1).

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7. Denman, M, B Wagner, R Linthicum, F von Hippel, R Henry, and S Durbin (2017). NRC Spent Fuel Pool Level 3 PRA Insights-Panel. *Transactions* **117**(1).
8. Denman, M, J Kinsey, M Holbrook, A Afzali, G Apostolakis, and NV Smith (2018). [Grand Challenge] Expedite Licensing and Deployment of Advanced Reactor Designs-Panel. *Transactions* **119**(1).
9. Denman, M, T Sofu, C Tomchik, A Oaks, D Wootan, and Z Jankovsky (2019). [Grand Challenge] Sodium Reactor Database to Support Knowledge Management-Panel. *Transactions* **120**(1).

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