Perspectives on Fire PRA Realism

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All models are wrong....

...the scientist must be alert to what is importantly wrong. It is inappropriate to be concerned about mice when there are tigers abroad.

Just as the ability to devise simple but evocative models is the signature of the great scientist so overelaboration and overparameterization is often the mark of mediocrity.

George E. P. Box
University of Wisconsin
1919-2013

George E. P. Box, "Science and Statistics," Journal of the American Statistical Association, Vol. 71, No. 356. (Dec., 1976), pp. 791-799.

Why realism?

- What is it and how do we know when we achieve it?
- How much realism is really needed?
- How does the quest for realism influence research programs?

Some comments during the May 11, 2017 Commission briefing on risk-Informed regulation :

- *"We need to make sure that the PRA is very realistic…"*
- *"…we continue to focus efforts on enhancing the realism of these models."*
- *"Work on improving the level of realism in fire PRA continues"*

What is PRA "realism"?

- No consistent operational definition
- Can find some context for realism in the PRA standard and associated guidance documents:
  - Degree to which expected response of the plant is addressed
  - Relates to impact on conclusions and risk insights (moderate, small, negligible). Realism increases with increasing PRA standard capability category (I, II, III)
  - Reflect as-designed, as-built, as-operated plant

Realism insights -

- PRA evaluations in support of regulatory decisions should be as realistic as practicable and appropriate supporting data should be publicly available(PRA Policy Statement)
- It is often necessary to find a compromise between realism and practicality (NUREG-1855)
  - Improving realism requires an increased level of effort
  - Increasing realism does not always reduce risk estimates
- Obtaining PRA realism is an iterative process

Review  **Refine**

Regulatory Decision-making

- A PRA may be acceptable for regulatory decision-making, but may not be as realistic as possible in all areas
- The level of realism does not need to be uniform across all areas of the PRA
- A risk-informed process integrates PRA information with other information to support decision-making

... the level of realism needed in the PRA is commensurate with the intended application (NUREG-1855)

Realism and Operating Experience

- Comparisons to Operating experience (OpE) can provide useful quantitative and qualitative insights for PRA modeling
- But comparisons must be done with appropriate care…
  - Account for uncertainties
  - Consider statistical significance

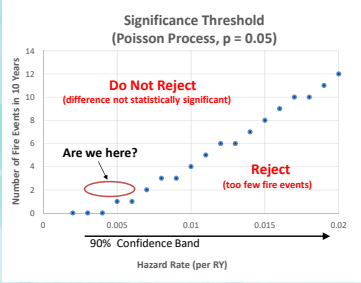
Issue:
- Industry fire PRAs indicate that there should have been ~15 significant fire events over the last 10 years (i.e., CCDP > 1E-04)
- ASP program has only identified two events (Robinson and Fort Calhoun)

Realism and Operating Experience

- "Back of the envelope" comparison to OpE
  - Estimate of 15 significant fire events over 10 years equates to a mean hazard rate of ~0.015/RY
  - Based on EPRI 3002002936/NUREG-2169, error factors for fire ignition frequencies generally range from ~4 to over 20
  - 90% confidence band for hazard rate of 0.015/RY (with an EF = 4) is approximately 0.003 to 0.040/RY
  - There is a chance of observing fewer actual events than the expected value of 15 significant fire events over 10 years

Realism and Operating Experience

A different picture may develop if parameter uncertainty and statistical significance is considered….



Realism and Operating Experience

- Other considerations
  - Need to continue to ensure PRA is based on data that is complete, relevant to PRA use, and representative of as-built, as-operated plants
  - Actual operational events are generally more complicated than PRA modeling would suggest
    - Fire events may result in additional failures not included in PRAs. For example, the Robinson fire event(2010) included unexpected closure of flow control valve for RCP seal cooling, failure of VCT/RWST switchover, and a rapid RCS cooldown
    - Need to consider both qualitative and quantitative insights from OpE
  - Numerical comparisons of OpE to PRA results need to consider parameter uncertainties and appropriate statistical significance
  - Operating experience provides an opportunity to further refine/improve PRAs

Active Research Areas Fire Research Plan 2018-2023

- Radiation Heat Transfer ZOI
- Motor and Transformer HRR
- Cabinet to Cabinet Fire Propagation
- HEAF
- MCR Abandonment
- Transient HRR
- Fire Progression Event Tree
- Plant Personnel Fire Suppression
- MCB Fire Modeling
- Fire Dynamics Wall and Corner Effects

Concluding Thoughts

- The state-of-practice for fire PRA is capable of supporting regulatory decision-making
  - Many well trained and experienced practitioners
  - Stable framework
  - Research needs driven by identified gaps
  - Successful application to several regulatory areas
- Level of realism can be impacted by resource allocation or modeling/data limitations
  - Research and development activities are needed to continue to address identified needs
- Understanding key uncertainty drivers and their impacts is more important than debating the level of PRA realism

U.S.NRC United States Nuclear Regulatory Commission Protecting People and the Environment

RIC 2018

All models are wrong….

… but some are useful.

Fortunately to be useful, a model does not have to be perfect.

G. E. P. Box, "Robustness in the Strategy of Scientific Model Building," University of Wisconsin-Madison Mathematics Research Center Technical Summary Report #1954, May 1979.

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Acronyms

ASP – Accident Sequence Precursor
CCDP – Conditional Core Damage Probability
EF – Error Factor
HEAF – High Energy Arcing Fault
HRR – Heat Release Rate
MCB – Main Control Board
MCR – Main Control Room
OpE – Operating Experience
PRA - Probabilistic Risk Assessment
RCP – Reactor Coolant Pump
RWST – Refueling Water Storage Tank
RY – Reactor Year
VCT – Volume Control Tank
ZOI – Zone of Influence