Uncertainties in Level 2 PRA

29 February 2012

M.T. Leonard

dycoda LLC

General Comments on Uncertainty

- Basis for characterizing uncertainty in Level 2 PRA is changing
  - Decreasing reliance on reference plant analysis
    - Uncertainties explored through extensive, structured, plant-specific deterministic sensitivity analysis
  - Role of expert judgment shifting from interpretation/scaling of lean “data base” to design, integration and application of extensive deterministic analysis
  - NUREG-1150 has limited value as a contemporary reference
- Full-scope: Rigorous deterministic analysis expected for sequences ‘At-power’ and LPSD

Acknowledgements

- Insights and examples of uncertainties in Severe Accident Progression (SA) developed from ongoing work at Sandia National Laboratories as part of the SOARCA Uncertainty Assessment (UA).
  - Key contributors:

    NRC -- Tina Ghosh

    SNL -- Patrick Mattie, Doug Osborn, Kyle Ross, Don Kalinich, Randy Gauntt

"CP" Uncertainties

General Issue	Source(s) of Uncertainty	Effects / Importance
Containment Behavior -- General		
Enhanced leakage due to seismic initiators	• Penetration response • Soil liquefaction	• Start time for release • Constrain mitigation
Hydrogen detonations	• Practical tools for assessment of loads and containment response	Lack of practical tools leads to 'bounding' approach. Importance increases for LPSD scenarios for structures with SFPs
Secondary Containment (Reactor Bldg) Behavior		
H_2 flammability	Ignition criteria (esp. with no obvious ignition source)	Structural integrity of building and FP retention affected by combustion

BWR/4 Mark I "CP" Uncertainties

General Issue	Source(s) of Uncertainty	Effects / Importance
Containment Behavior – Mark I		
Head flange leakage criteria and area	• Thermal response of drywell head • Head bolt strain and leak area • Effects pressure rise <u>rate</u> (quasi-static, but faster than flange response time)	• Possibly an elastic failure mechanism • Affects release pathway to environment • Over-pressure failure vs flange leakage • Important only for MSL creep rupture cases

SA -- Severe Accident Progression

- Major modeling uncertainties examined in SOARCA UA
  - Limitations: BWR only, LTSBO only
  - "Importance" not yet quantified (underway)
- Major modeling uncertainties depend strongly on particulars of reactor/containment design and accident sequence (PDS)
  - Can cite examples, but a comprehensive listing is not realistic

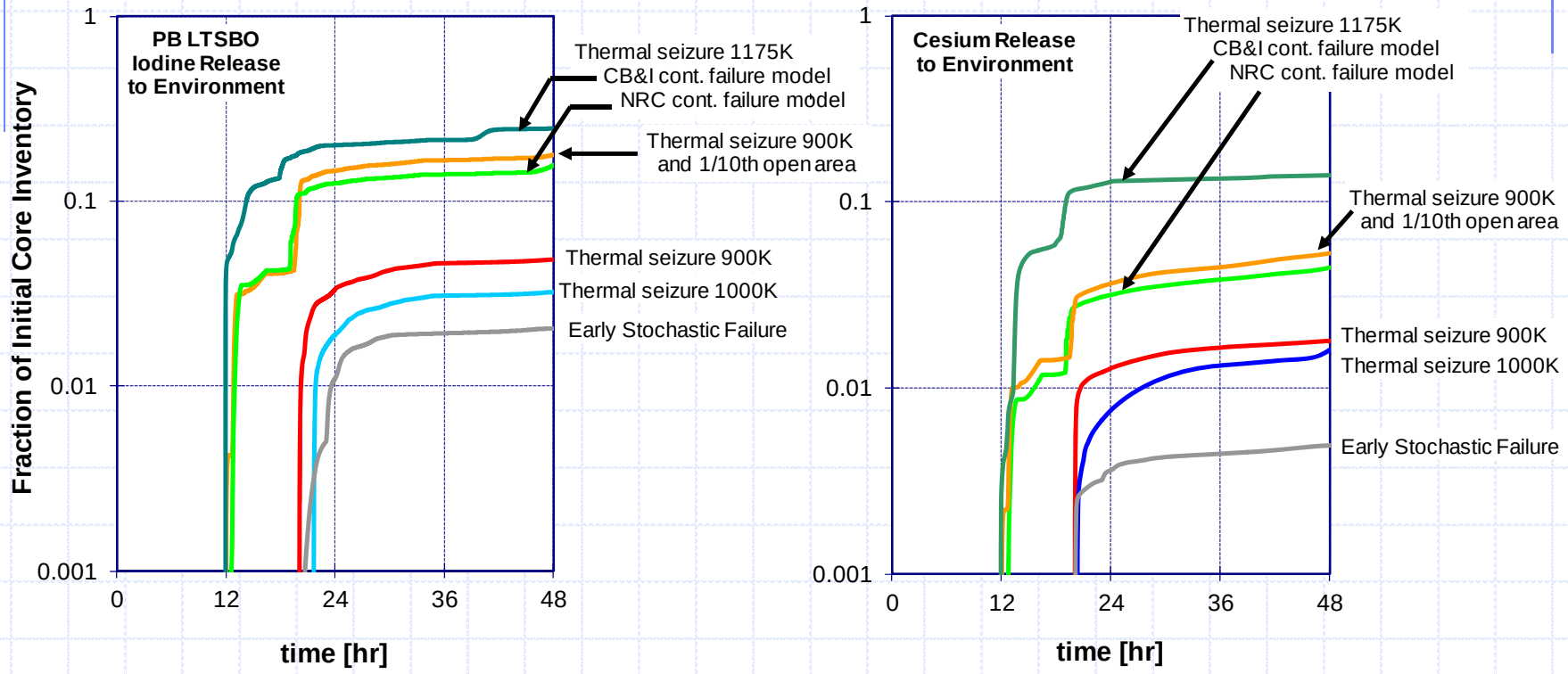
"SA" Uncertainties

General Issue	Source(s) of Uncertainty	Effects / Importance
In-vessel Accident Progression – General		
Duration of fuel integrity during oxidation, prior to bulk relocation	• Factors influencing clad oxidation • Factors influencing downward relocation of unoxidized, molten Zr • Fuel collapse criteria [implementation specific to particular code used]	• Variations in peak fuel temperature and duration cascade to: - debris behavior - FP release/transport - lower head failure characteristics
Early RPV leakage via open instrument tubes [not in SOARCA UA]	• Effectiveness of containment isolation • Precise leak pathway (tube creep?)	• Advance time of FP release to environment • Inhibit mitigation actions

BWR "SA" Uncertainties

General Issue	Source(s) of Uncertainty	Effects / Importance
In-vessel Accident Progression – BWR High Pressure Sequences (SBO)		
SRV Failure to Reclose (after onset of CD)	• Stochastic failure probability – NUREG/CR-6928 • Thermal seizure criteria • Open fraction upon failure	RPV depressurization prior to VB
Main Steam Line (MSL) Creep Rupture	• Advection of energy to MSL • Failure area	• Potential for early containment over-pressure failure (prior to VB) • Suppression pool bypass

Effects of Uncertainties in SRV Behavior



"ST" Uncertainties

General Issue	Source(s) of Uncertainty	Effects / Importance
Fission Product Release/Transport		
Cesium chemical form	Partitioning among CsI, CsOH, Cs_2MoO_4	Affects volatility and potential for permanent retention (chemisorption)
Iodine chemical form	Partitioning between aerosol (CsI) and vapor forms (I_2, CH_3I).	Affects overall iodine release when CsI release fractions are small

"PT" Uncertainties – treatment in the context of ANS 58.24

- Important correlations among uncertainties in deterministic parameters/models
- Method for consistent classification of uncertainty is not defined
  - Requirement is to describe "nature" of uncertainty
- What demands does the nature of uncertainty have on its numerical implementation?
  - Can frequency be numerically combined with epistemic uncertainty?