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UNITED STATES NUCLEAR REGULATORY COMMISSION

Protecting People and the Environment

Phenomenological Uncertainties in SOARCA Study

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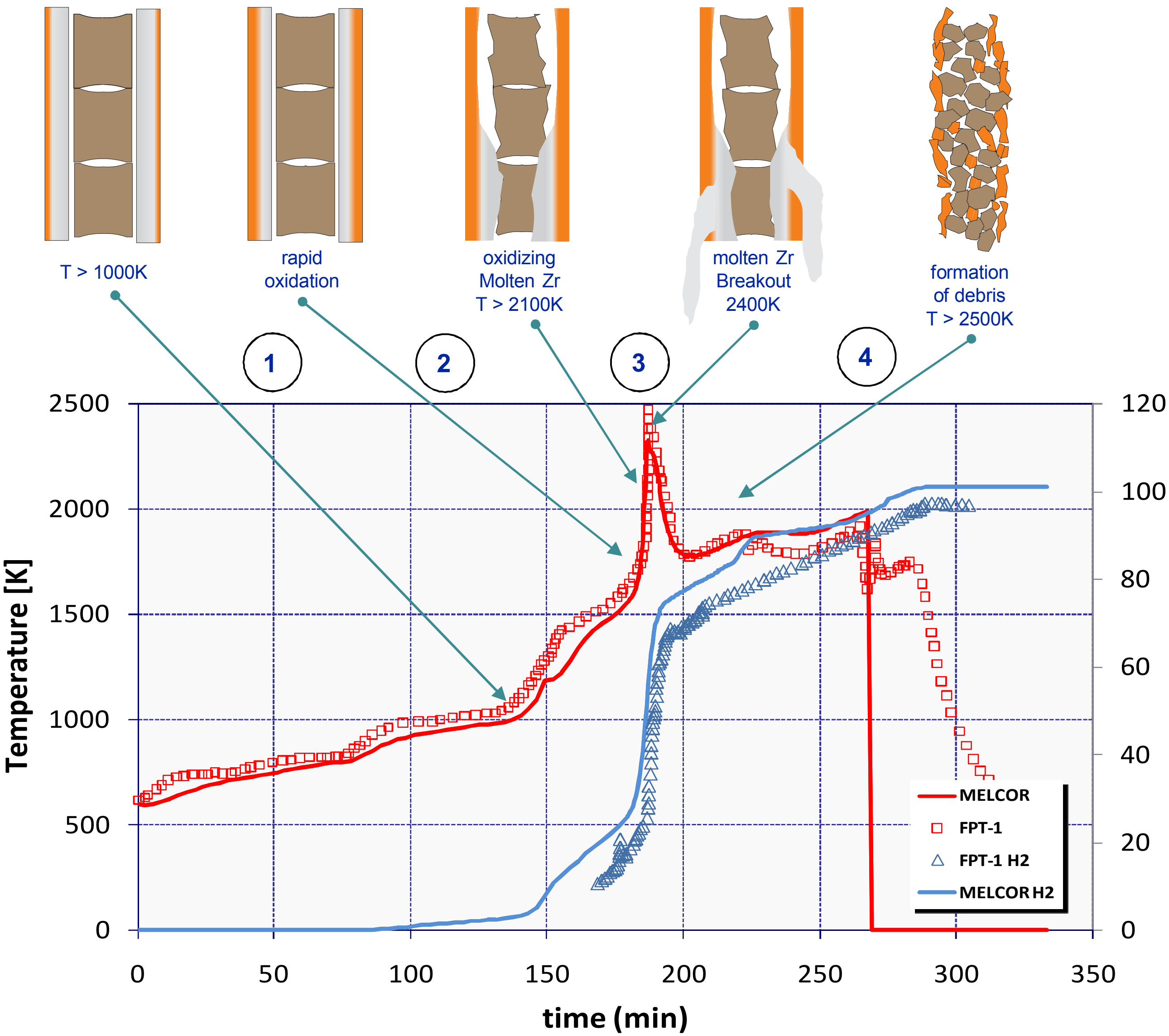
Outline

- Uncertainty Quantification Phase
- Focus on BWR Long Term Station Blackout
- Melt Progression Uncertainties
- Sequence Progression Uncertainties
- Atmospheric Transport Uncertainties
- Emergency Response Uncertainties
- Expectations

MELCOR UNCERTAIN PARAMETERS

- MELCOR uncertain parameters pertain to:
  - Accident sequence
  - In-vessel accident progression
  - Ex-vessel accident progression
  - Containment behavior
  - Chemical forms of iodine and cesium
  - Fission product release, transport, and deposition

Modeling Melt Progression Stages



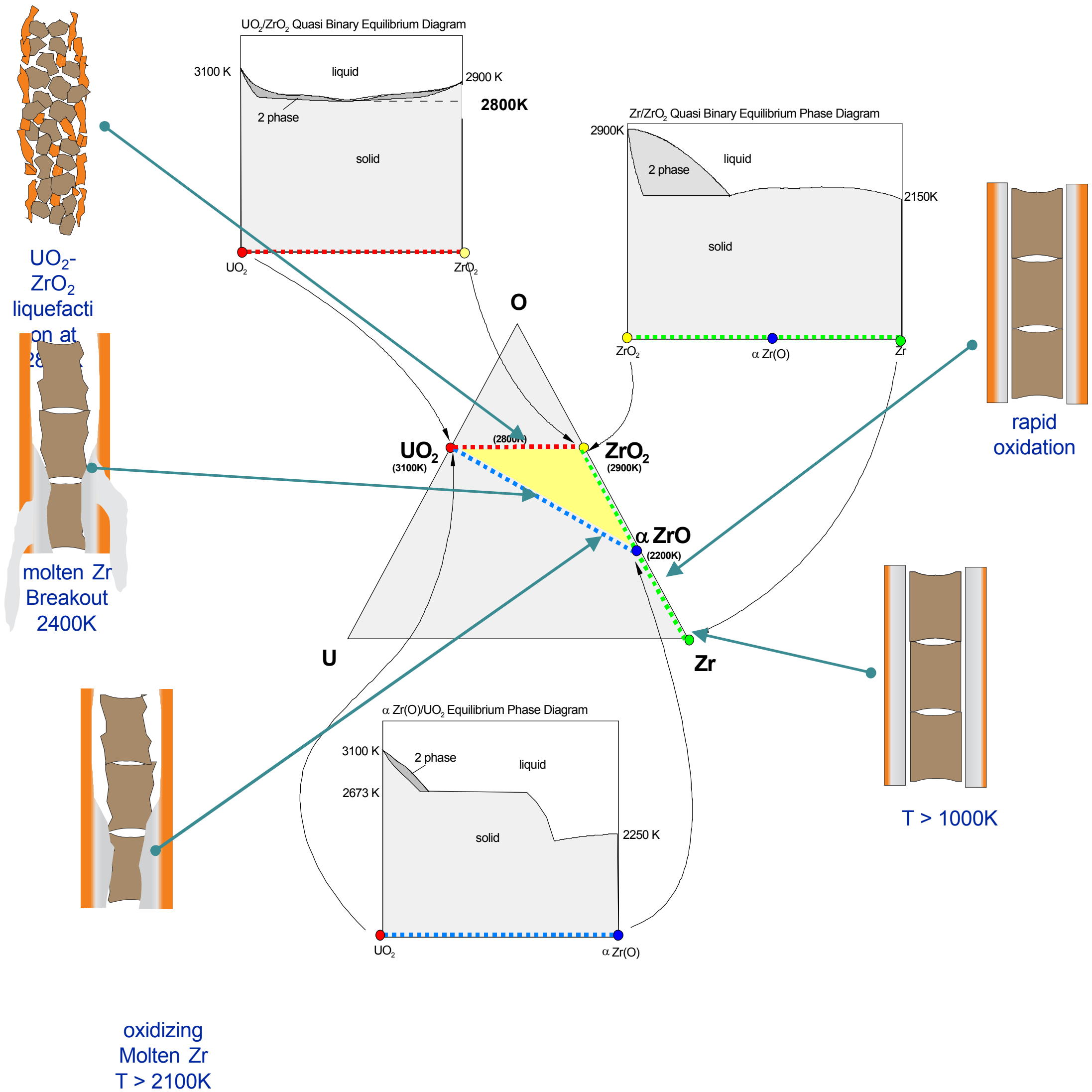
MELCOR Modeling Parameters

1. *oxidation kinetics*
2. *fuel liquefaction fraction*
3. *Zr-melt breakout temperature*
4. *Debris formation temperature*

Parameters Affect:

1. *fuel heatup rate*
2. *melt progression*
3. *hydrogen generation and peak temperatures*
4. *core degradation and slumping*

Modeling Melt Progression Stages



Zr metal melt at 2150K

UO_2 dissolution in Zr metal ~20%

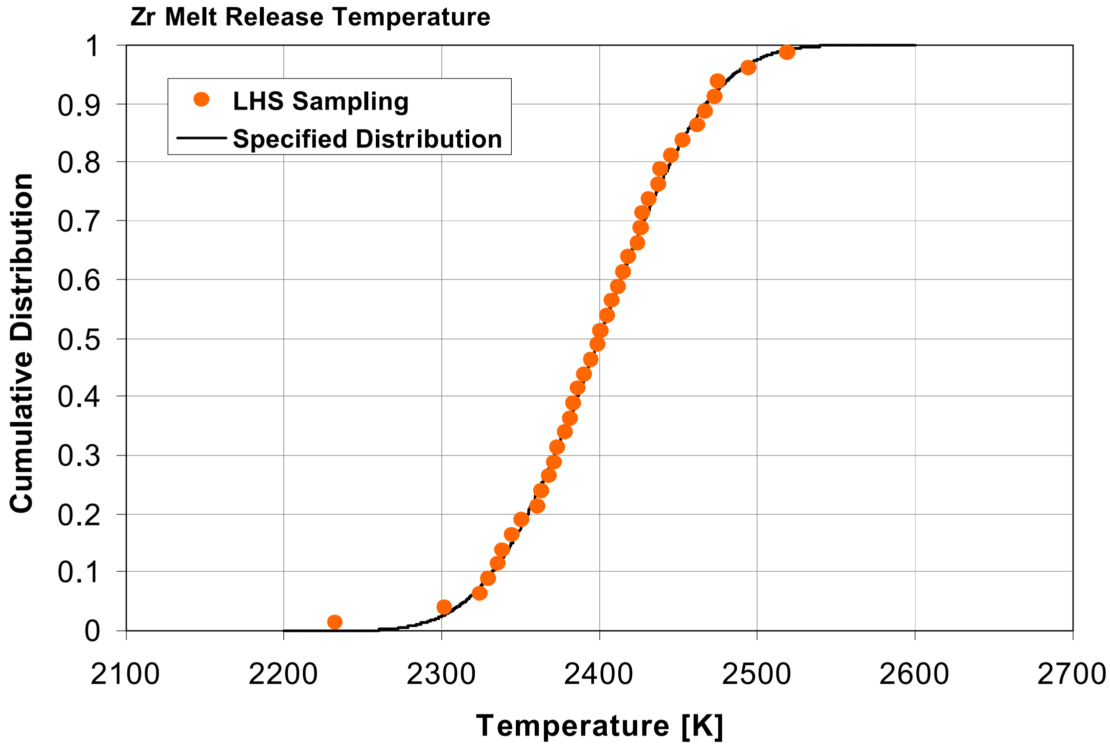
Zr melt breakout ~2400K

Loss of rod geometry ~2600K

UO_2-ZrO_2 liquefaction ~2800K

Parameters uncertain

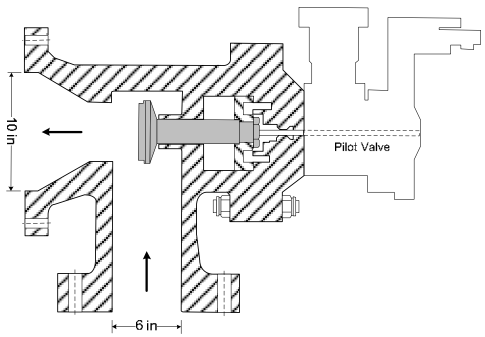
Uncertainty in Modeling Parameters



Example: Zr Melt Breakout Temperature

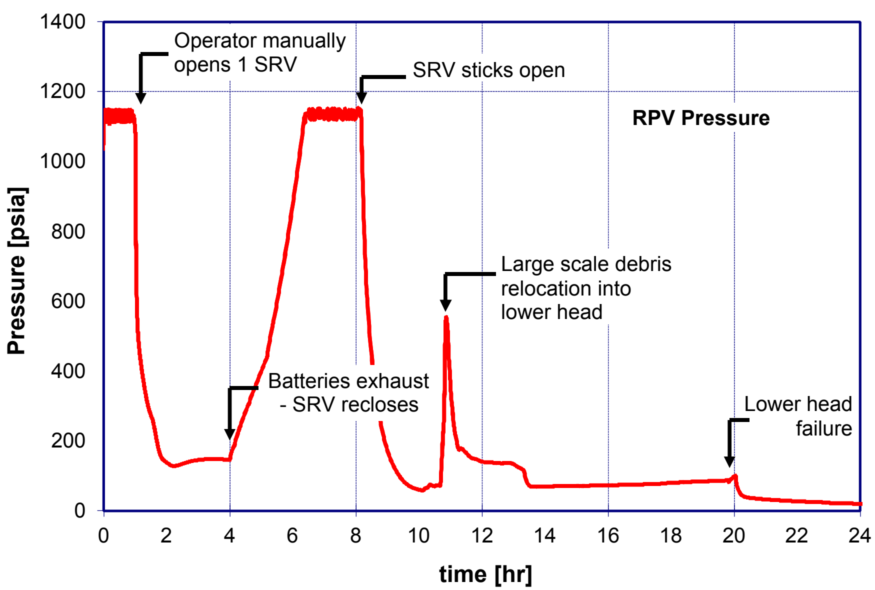
- Lower bound – 2100K melting temperature
- Upper bound – 2800K ZrO_2 melting temperature, but evidence suggests 2600K
- Most probable – 2400K
- Distribution expresses degree of belief
- Monte Carlo Sampling

BWR SRV Seizure Modeling



Modes of Valve Seizure

- Excessive cycling
- Differential thermal expansion
- Material deformation



In severe accident conditions, high temperature gases well exceed design conditions

T_{op} ~ 600K

T_{SA} > 800 to 1100K

cycles for hours

Seizure in stuck open eventually occurs

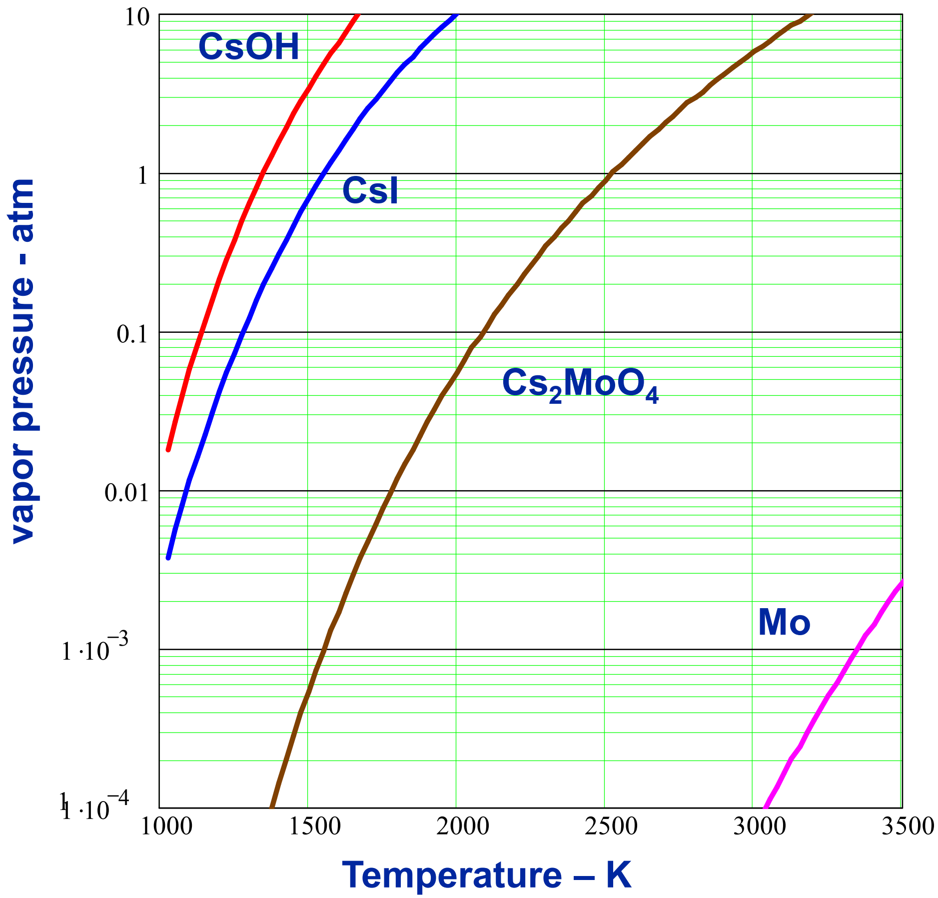
excessive cycling

thermal deformation

partial or full open

Valve behavior potentially important to accident progression

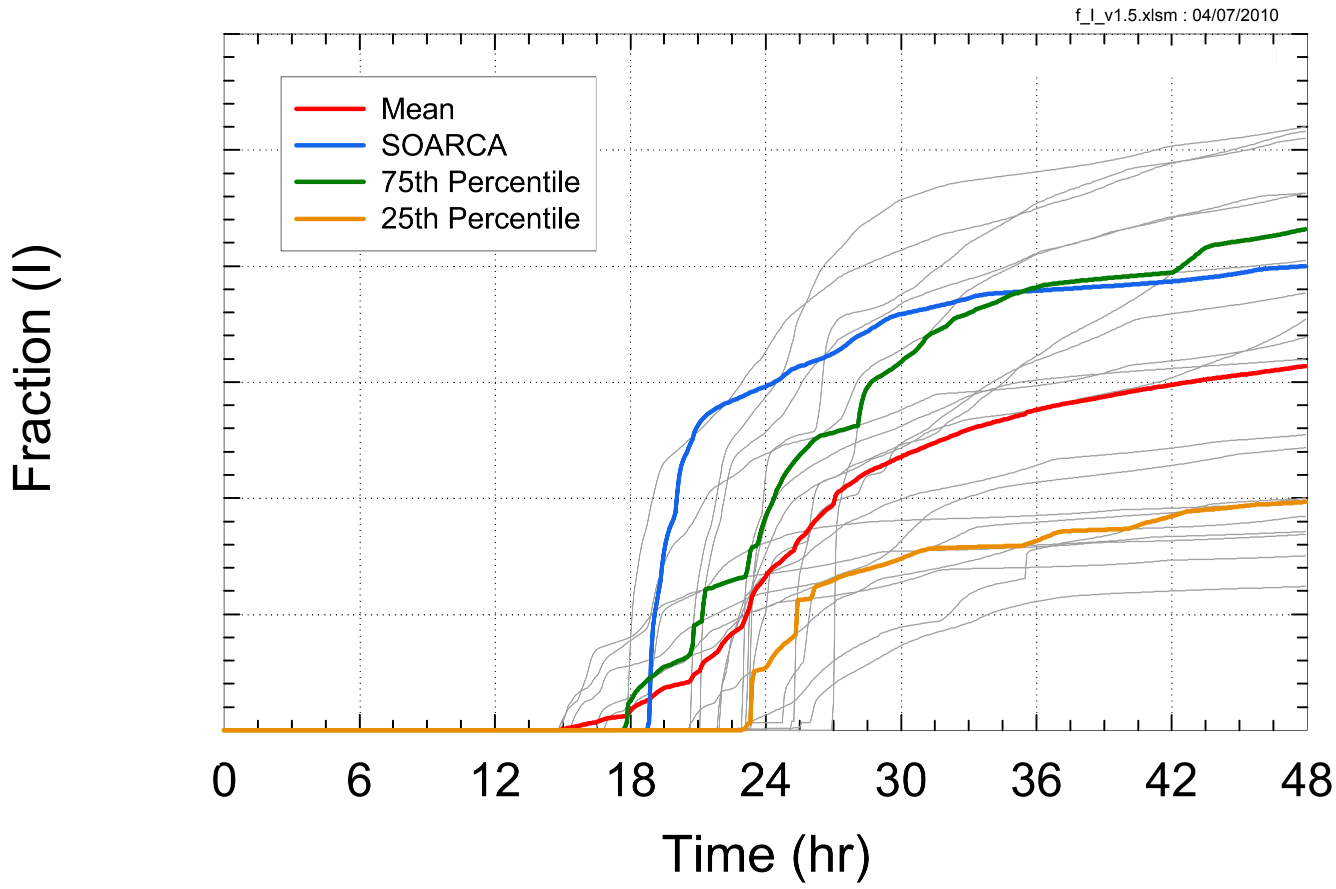
Speciation of Cesium and Iodine



- Based on Phebus Program Findings
  - Iodine treated as CsI
  - Cs treated as CsI and Cs_2MoO_4
- Cs_2MoO_4 considerably less volatile than CsOH or CsI
  - Affects retention in RCS and long term revaporization
- Uncertainty Study will explore alternative balance of speciation
  - I_2, CsOH, CsI and Cs_2MoO_4

Example Case Probabilistic Analysis: MELCOR Results

MELCOR Fraction of Iodine Core Inventory Released to the Environment



MACCS Consequence Uncertainties

- Distributions for non-site-specific parameters based on expert elicitations (NUREG/CR's 6244, 6526, 6545, and 6555)
- Site-specific parameters will be developed as part of the study
- Significant parameters for uncertainty analysis include
  - Vertical and crosswind dispersion
  - Dry deposition velocity
  - Wet deposition scavenging rate
  - Breathing rate
  - Inhalation protection factor

Example Evacuation Delay

- Delay to Evacuation is the length of the sheltering period from the time the public enters the shelter until the point at which they begin to evacuate.
- Delay to shelter is typically 1.5 hours for LTSBO: therefore delay to evac of 0.0 hrs means that evacuees leave at 1.5 hours.

parameter	baseline	distribution
evacuation delay – cohort 1 Public	1.0	LB = 0.0 hr UB = 4.0 hr
evacuation delay – cohort 2 10-20 Shadow	1.0	LB = 0.0 hr UB = 4.0 hr
evacuation delay – cohort 3 Schools/0-10 shadow	0.75	LB = 0.0 hr UB = 4.0 hr
evacuation delay – cohort 4 Special Facilities	4.25	LB = 0.0 hr UB = 6.0 hr
evacuation delay –cohort 5 Tail	4.25	LB = 4.0 hr UB = 8.0 hr
Note: Evacuation delays are sampled independently for each cohort and for each radial ring within each cohort. Distributions to be determined.		

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Evacuation Speed

- 3 speeds are established in WinMACCS for each cohort: early, mid and late.
- Early is typically 15 minutes for the public and shadow (2 largest groups).
- Late speed begins after evacuees have exited the EPZ.
- Therefore we only varied the mid speed which covers the majority of the travel time within the EPZ.

parameter	baseline	distribution
evacuation speed – cohort 1 Public	3 mph	LB = 1.0 UB = 10.0
evacuation speed – cohort 2 10-20 Shadow	3 mph	LB = 1.0 UB = 10.0
evacuation speed – cohort 3 Schools/0-10 shadow	20 mph	LB = 10.0 UB = 30.0
evacuation speed– cohort 4 Special Facilities	20 mph	LB = 1.0 UB = 30.0
evacuation speed – cohort 5 Tail	20 mph	LB = 10.0 UB = 30.0
Note: Evacuation speeds are perfectly rank correlated between cohorts. Cohorts 1 and 2 are triangular with mode at 3. Remaining cohorts are uniform distribution.		

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Summary

- Uncertain parameters being identified
  - Strong engineering judgement component
- Preliminary mechanics of study underway
- Figures of Merit under discussion
- Study to commence Spring 2011