Safety Assessment Tool Developed for Nuclear Fuel Handling Facilities

B. Dasgupta, G. Adams, R. Benke
(Center for Nuclear Waste Regulatory Analyses, San Antonio, TX)
R.K. Johnson and M. Waters
(U.S. Nuclear Regulatory Commission, Rockville, MD)

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Outline

- Background
- Objective of Presentation
- Preclosure Safety Analysis Process
- PCSA Tool Overview and Capabilities
- Example Analysis Using PCSA Tool
- Conclusion

Background

- Operational Hazards at Nuclear Fuel Handling Facilities Could Contribute Significantly to Potential Radiological Risks
- The Potential Repository at Yucca Mountain, Nevada, Will Be Designed to Handle and Emplace Up to 70,000 Metric Tons of High-Level Waste
- Waste Handling Operations May Involve Receiving, Transferring, Repackaging, On-Site Transporting, Aging, and Emplacing
- Current DOE Plan Do Not Include Bare Fuel Handling In the Air
- U.S. Regulation in 10 CFR Part 63 Requires Evaluation of Preclosure* Safety

* Preclosure is defined as the period before permanent closure

Objectives

- Present a Risk-Informed Performance-Based Approach for Assessing Public and Worker Safety During Fuel Handling
- Present a Safety Analysis Tool (PCSA Tool Software) Developed to Conduct Confirmatory Analyses to Support a Regulatory Review of the Applicant's Preclosure Safety Analysis
- Demonstrate PCS Tool Capabilities Through An Example Analysis

Preclosure Safety Analysis

- Examines Site and Facility Information
- Systematically Addresses Risk Triplet
  - What can go wrong?
  - How likely is it?
  - What are the consequences?
- Demonstrates Compliance With Regulation
- Identifies Structures, Systems, and Components Important to Safety (Relied on for Regulatory Compliance)

PCSA Tool Overview

- A Tool for Facilitating a Risk-Informed, Performance-Based Review
- Uses Existing Risk Assessment Tools and Techniques
- Provides the Capability to Conduct Analysis for Selected Areas and Systems, or the Entire Facility and Operations
- Provides the Capability to Perform Uncertainty and Sensitivity Analyses

PCSA Tool Capabilities

- Framework to Conduct Focused Analyses and Organize Data
- Hazards Analysis: Operational
  - Human-induced
- Event Sequence Analyses
  - Event sequence frequency
  - System and equipment reliability
- Consequence Analyses (Radiological Dose)
  - Public
  - Workers
    - Indoor (dry or wet fuel transfer)
    - Outdoor

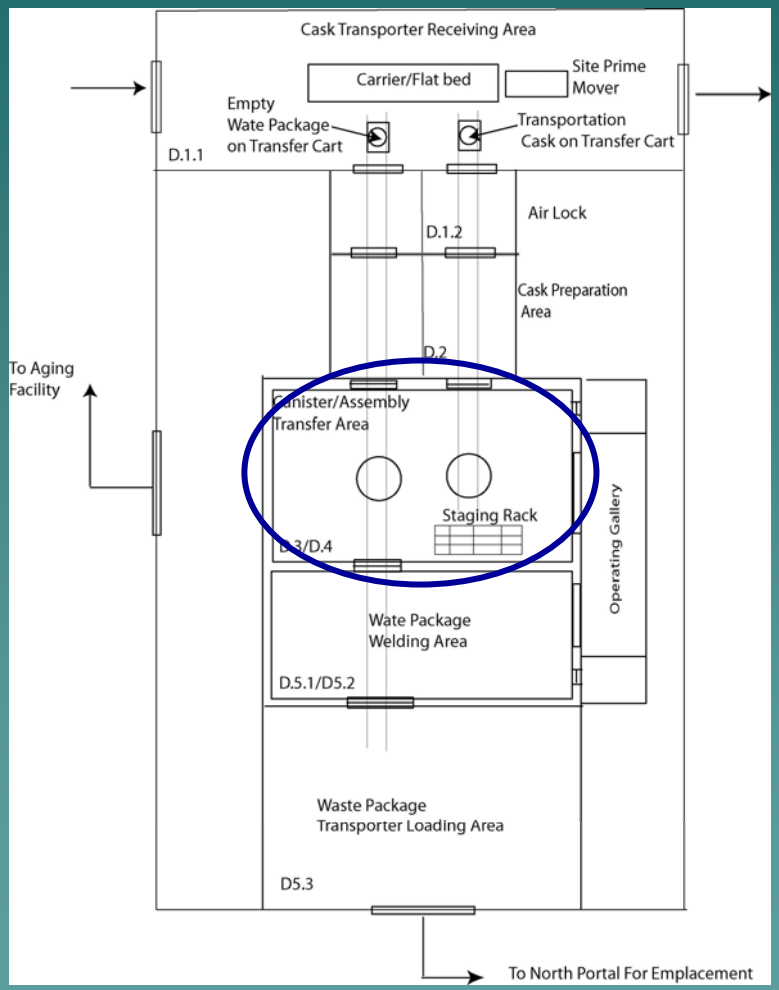
PCSA Tool Capabilities (Contd.)

- Safety Assessment
  - Evaluation of compliance with performance objectives in 10 CFR Part 63
- Structures, Systems, and Components Important to Safety Evaluation
  - Importance of SSCs in event sequences determined by take-away analysis
- Risk Evaluation*
  - Point estimate (PSAM6)
  - Probabilistic (PSAM7)

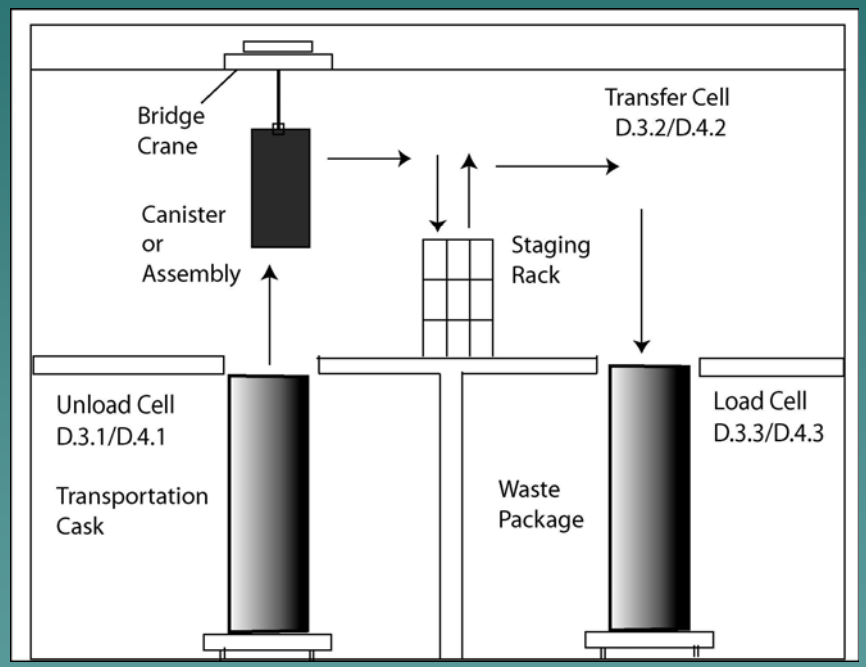
*Not required by 10 CFR Part 63

Example Analysis

Conceptual Dry Transfer Facility



Dry Transfer Cell



Hazard and Initiating Events in Dry Fuel Transfer Cell

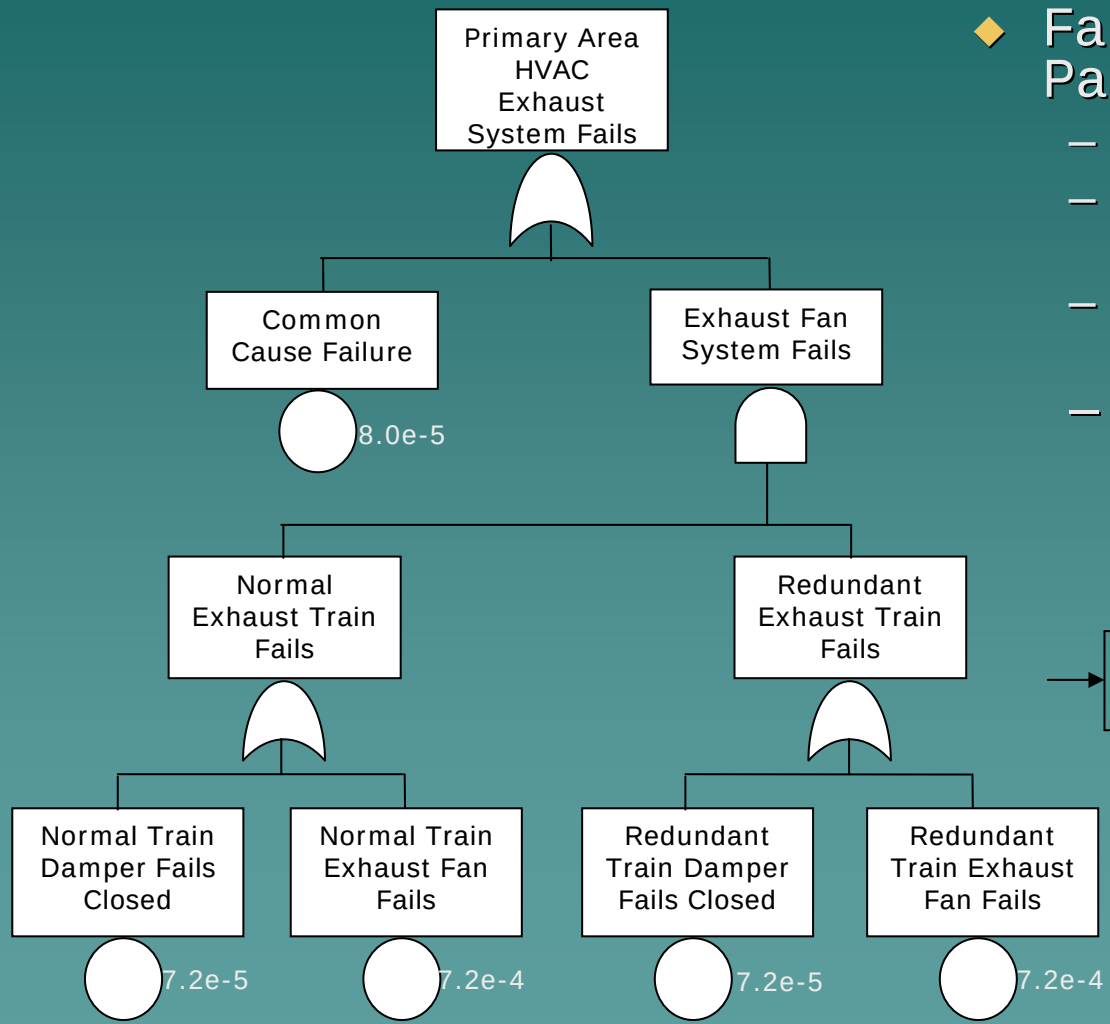
Hazard	Initiating Event	Initiating Event Frequency (Per Year)	Event Sequence Assembly Breach → HVAC Failure → HEPA Failure	Fuel Assembly Type and Number
Assembly Drop	Bridge Crane Failure	0.672	Drop into transportation cask	2 PWR
		0.084	Drop onto floor	1 PWR
		0.134	Drop into empty waste package	1 PWR
		0.538	Drop onto another assembly in waste package	2 PWR
Loss of Ventilation	HVAC Failure	0.024	Dose to indoor worker	1 PWR

Example Event Scenario (Assembly Drop Into Transportation Cask in Transfer Cell)

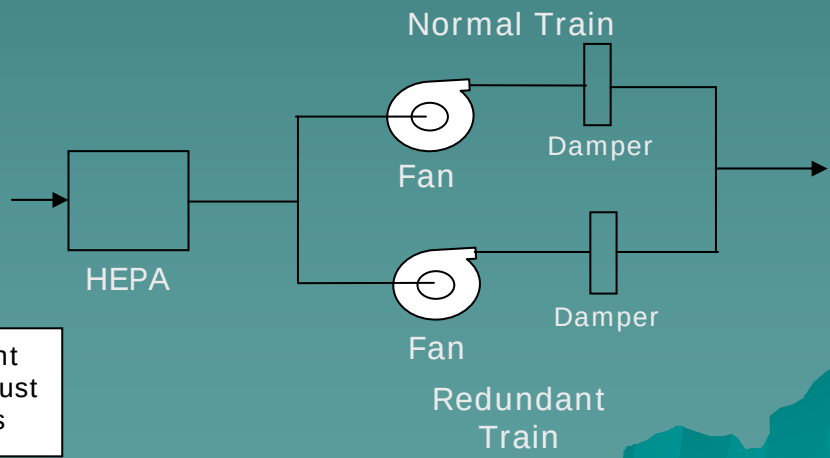
Failure of Bridge Crane	Assembly Breach	HVAC Failure	HEPA Failure	Frequency (1/yr)	Category	Consequence	
						Public	Worker
0.672/yr	No			0	1	No release	No Dose
	0						
			No	6.7×10^{-1}	1	1.11×10^{-4} rem (Mitigated)	Outdoor Worker
			Yes	8.0×10^{-6}	2	4.66×10^{-4} rem (Unmitigated)	Outdoor Worker
			p = 1.2e-5				
	Yes						
	p =1.0						
		Yes		5.4×10^{-5}	2		Indoor Worker
		p =8.0×10^{-5}					

(Note: 1 rem = 0.01 Sv)

HVAC System Reliability



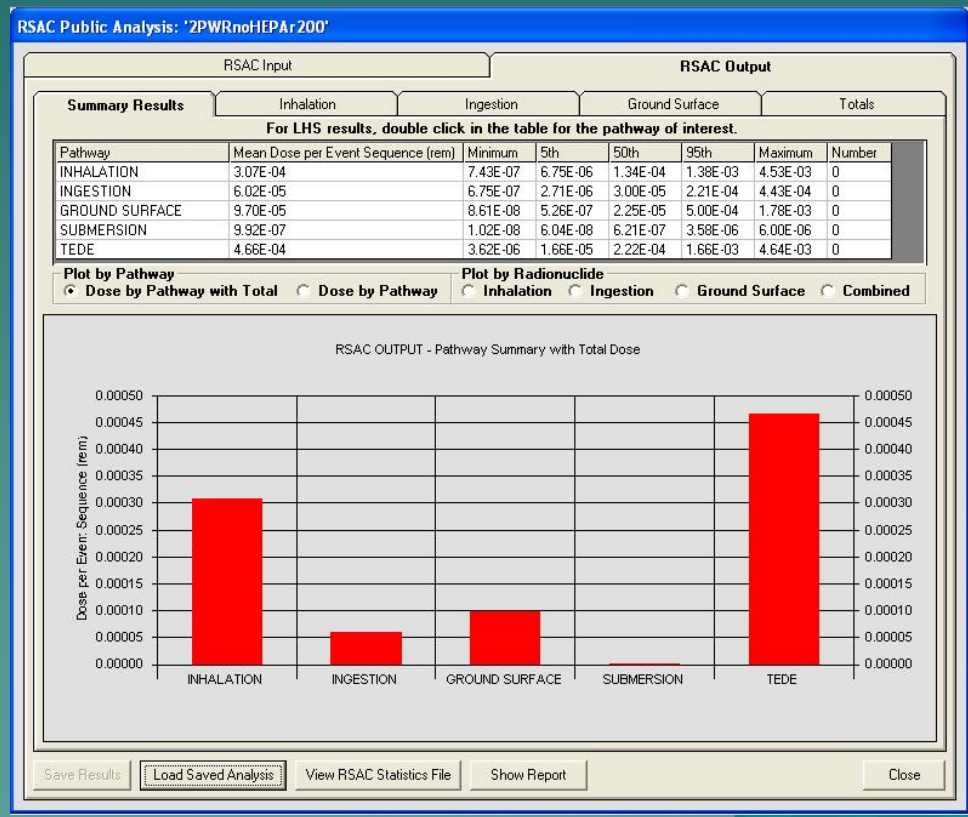
- Fault Tree Analysis of the Partial HVAC System
  - Modeled exhaust system
  - Used Saphire Software invoked from the tool
  - Used failure rate database from literature
  - Point estimate analysis



Public Dose Consequence

- Interface Provided for RSAC Code Calculations
  - Nuclear source terms
  - Airborne release fractions
  - Building retention of radionuclides (MELCOR code)
  - Filtration of airborne radionuclides
  - Atmospheric dispersion and deposition
  - Dose pathway analysis
- Probabilistic (Latin Hypercube Sampling) or Point-Estimate Calculations
- Archive Input/Output Data Sets

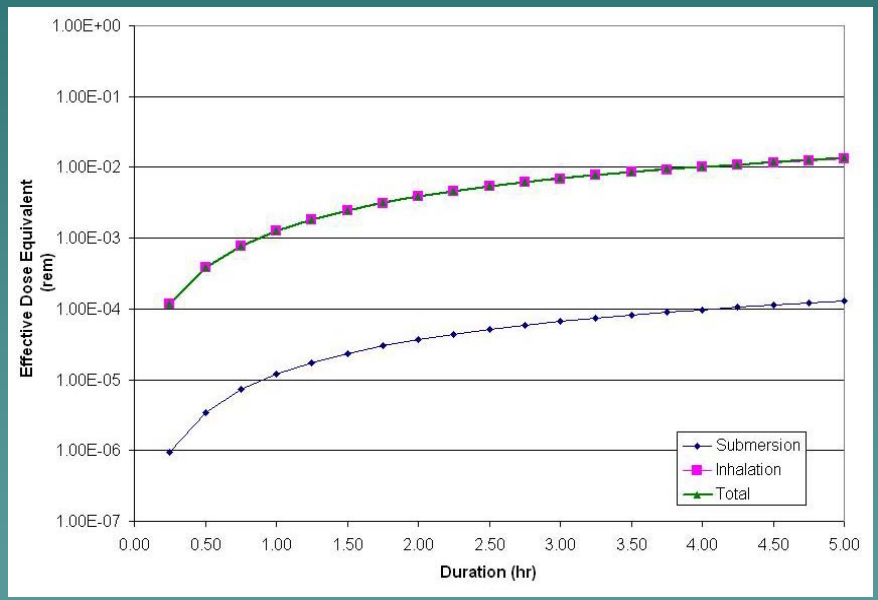
(Note: 1 rem = 0.01 Sv)



Public dose consequence for event sequence

Indoor Worker Consequence

Effective Dose Equivalent to an Indoor Worker in a Room Adjacent to the Dry Transfer Cell

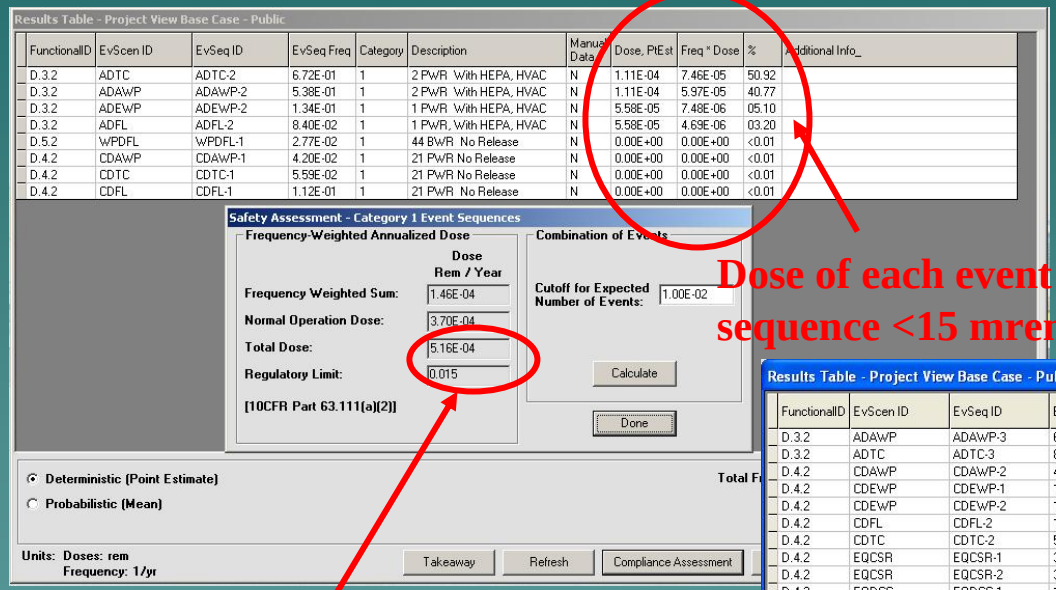


- Dry Fuel Transfer: Leakage of Airborne Radioactive Material From Transfer Cell Into Adjacent Room
- Wet Fuel Transfer: Release of Radioactive Gases Into Operating Spaces Above Pool

(Note: 1 rem = 0.01 Sv)

Example Compliance Analysis

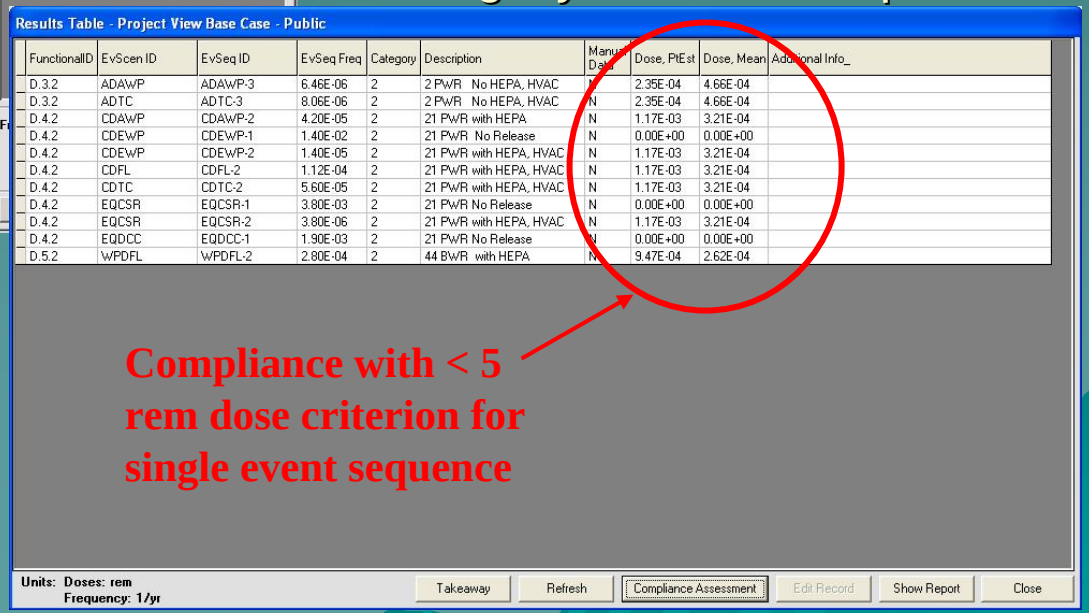
Category 1 Event Sequences



Dose of each event sequence <15 mrem

Sum of frequency weighted dose <15 mrem/yr

Category 2 Event Sequences



Compliance with < 5 rem dose criterion for single event sequence

(Note: 1 rem = 0.01 Sv)

Conclusions

- U.S. Nuclear Regulatory Commission Regulations in 10 CPR 63 Require Demonstration of Safety to Public and Workers During Field Handling Operations at Yucca Mountain
- The PCSA Tool Was Developed for Evaluating Preclosure Safety at Yucca Mountain
- The PCSA Tool Is Based on a Risk-Informed, Performance-Based Approach
- The Structure of the Tool Is General Enough for Applications in Other Nuclear Facilities, e.g.,
  - Fuel fabrication
  - Transportation
  - Interim storage

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- This paper is an independent product of the CNWRA and does not necessarily reflect the view or regulatory positions of the NRC.

- The NRC staff views expressed herein are preliminary and do not constitute a final judgment or determination of the matters addressed or of the acceptability of a license application for a geologic repository at Yucca Mountain.