

Experiences and Lessons Learned During Verification and Validation of the MELCOR Code

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What's Coming

- Background
- Leak Path Factor Analysis
- Facility and MELCOR Model
- Planned Verification and Validation (V&V)
- Issues
- Recovery
- Summary and Recommendations



Background

■ Regulatory Background

- 10 CFR Part 830, Subpart A - Quality Assurance Requirements
 - Quality Assurance Program
 - Quality Assurance Criteria
- Defense Nuclear Facilities Safety Board
 - Technical Report 25 (TECH-25)
 - Recommendation 2002-1



Background (continued)

- Regulatory Background (continued)
 - DOE Order 414.1C – Quality Assurance Requirements
 - Attachment 5
 - Verification and Validation
 - Management of Central Registry
 - DOE Guide 414.1-4 – Safety Software Guide
 - Safety Software Types and Grading
 - MELCOR – Level A



Purpose of Leakpath Factor Analysis

- Evaluate the validity of a 10% leakpath factor (LPF) facility design criterion for a complex, multistoried laboratory facility in preliminary design phase



DOE Toolbox Code for Leakpath Factor Analysis

- MELCOR, Version 1.8.5 - Code approved by DOE for LPF analysis
- MELCOR (Methods for Estimation of Leakages and Consequences of Releases) - a fully integrated, engineering-level computer code
- Original Purpose - model progression of accidents in light water reactor nuclear power plants
- Uses for Nonreactor Nuclear Facility Applications:
 - evaluation of leak path factors
 - estimation of confinement behavior due to radiological source terms under postulated accident conditions
 - survivability of fans, filters, and other engineered systems



DOE Toolbox Code for Leakpath Factor Analysis

- Supporting documentation:
 - MELCOR Guidance Report - *MELCOR Computer Code Application Guidance for Leak Path Factor in Documented Safety Analysis*, Issued in May 2004
 - MELCOR Gap Analysis Report – *Software Quality Assurance Improvement Plan: MELCOR Gap Analysis*, Issued in May 2004



Laboratory Facility & MELCOR Model Description

- Complex, multistoried laboratory facility:
 - Basement Level, including Mezzanine
 - Laboratory Level, with 3 Laboratory Wings
 - Interstitial Level, additional work areas and space for utility systems
 - Surface Level
- Complex Ventilation Systems – 3 Zones
- Complex MELCOR Model:
 - 330 Control Volumes – Rooms, Corridors, Stairs, Elevator Shafts, Tunnels, and Ventilation System Ducting
 - 533 Connecting Flow Paths
 - 435 Heat Structures



Planned V&V Approach

- Use MELCOR, Version 1.8.5 for LPF analysis
- Use safety basis test cases in MELCOR Guidance Report
 - Spill accident, no ventilation
 - Spill accident, with ventilation
 - Fire accident, no ventilation
 - Spill accident, accompanied by post-seismic event fire, with ventilation
 - Multi-room spill accident, initiated by seismic event, different amounts of material released – 1,000 g, 100 g, 10 g, and 1 g
- Compare LPF from spill in a long corridor, as calculated by MELCOR, against the LPF results from a previously documented LPF hand calculation



Best Laid Plans Go Awry

- MELCOR, Version 1.8.5, will not run the laboratory facility model – too large to fit within existing parameter array limits
- MELCOR, Version 1.8.6, will run the laboratory facility model
- However, MELCOR, Version 1.8.6, is not sanctioned by the DOE for use in safety basis applications
- What do we do now?
 - Reduce size of laboratory facility MELCOR model to fit Version 1.8.5, or
 - Perform full V&V of Version 1.8.6 and run using existing laboratory facility model



Recovery Plan A

■ Decision

- Use existing laboratory facility model
- Perform full V&V on MELCOR, Version 1.8.6

■ Approach

- Run MELCOR Guidance Report safety basis test case problems using both Versions 1.8.5 and 1.8.6.
- Run the long corridor spill MELCOR model using both Versions 1.8.5 and 1.8.6.



Execute the Recovery Plan

- Establish Evaluation Criteria –
 - Test cases run to completion
 - Test case results from Versions 1.8.5 and 1.8.6 compare closely to each other
 - Test case results from Versions 1.8.5 and 1.8.6 compare closely to results published in the MELCOR Guidance Report and in the hand calculation report
 - For any cases not in agreement, can the reasons for the differences be explained?
- Define Output Values of Interest
 - Amount of material transported to the environment
 - Amount of material deposited inside the building
 - Total facility LPF



Another Bump in the Road

- Create MELCOR Input Files
 - Extract from MELCOR Guidance Report (PDF file)
 - Format input files exactly as presented in Guidance Report
 - Much effort required
- Run MELCOR Guidance Report test cases –
 - Using MELCOR, Version 1.8.5 – All test cases run to completion
 - Using MELCOR, Version 1.8.6 – Test cases will not run at all. A message is issued identifying an error in the way the released airborne radioactive material was defined.
 - This input parameter specification error is not trapped by Version 1.8.5 but is trapped by Version 1.8.6
- What do we do to fix this?



Recovery Plan B

- Run original Guidance Report test cases using MELCOR, Version 1.8.5
- Revise Guidance Report test cases and run using MELCOR, Version 1.8.5
- Run revised Guidance Report test cases using MELCOR, Version 1.8.6
- Compare results
- Comparison – Successful



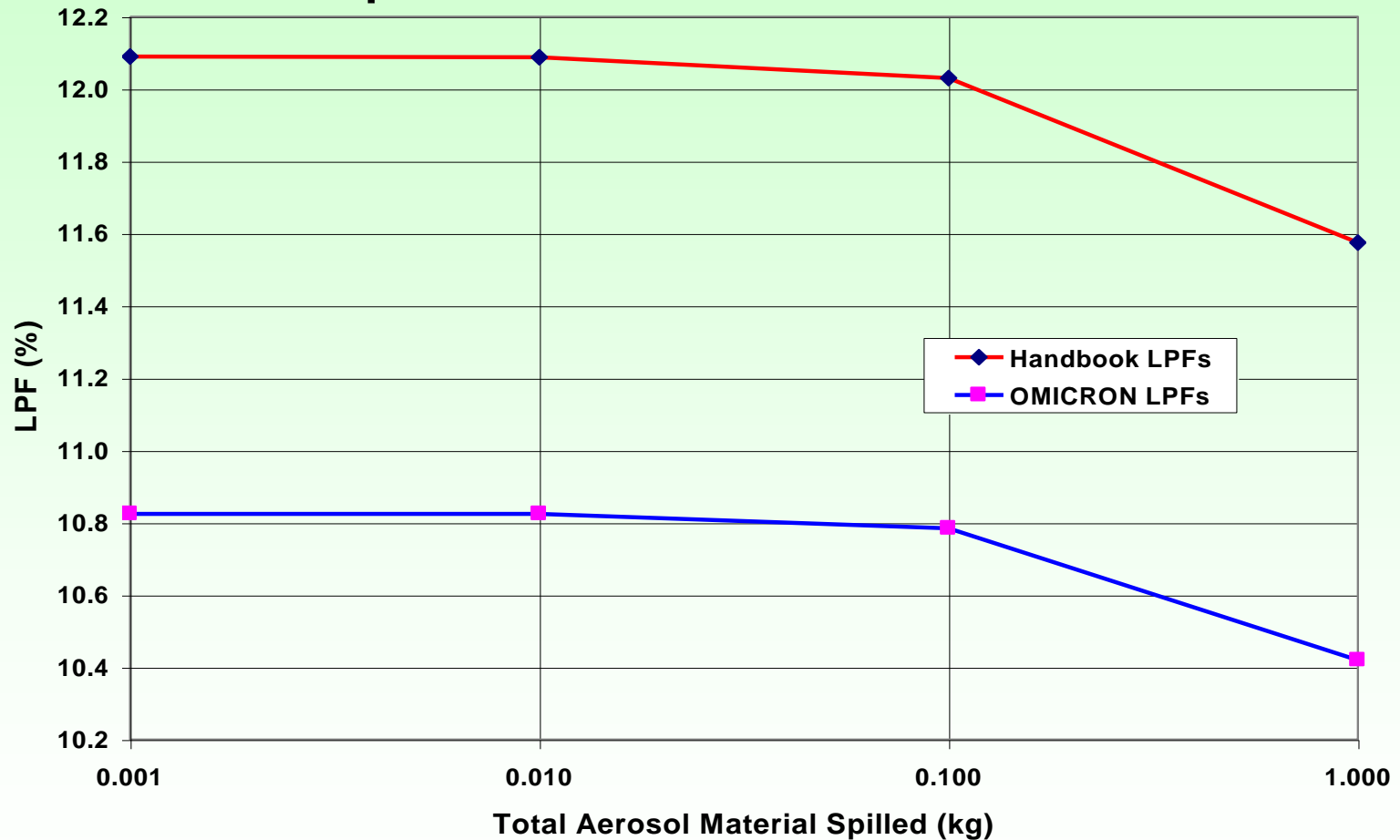
Another V&V Problem

- Guidance Report Test Case 5
 - Seismic Spill
 - Releases in 3 rooms
 - Range of releases material – 1000 g, 100 g, 10 g, 1 g
- Intent – Observe the sensitivity of LPF to amount of material released
- Problem
 - OMICRON MELCOR V&V runs using code Versions 1.8.5 and 1.8.6 calculate identical LPF results
 - OMICRON V&V LPF results do no match those published in MELCOR Guidance Report



Test Case 5 LPF Plot Results

Comparison of Test Case 5 LPF Results





Test Case 5 Problem Resolution

- Initiated systematic review of Test Case 5 input files
- Found no errors in Test Case 5 input files
- Notified DOE QA personnel of problem
- Since OMICRON Test Case 5 V&V LPF results generated using MELCOR, Versions 1.8.5 and 1.8.6
 - Identified the anomaly in the V&V document
 - Postulated that Test Case 5 LPF results presented in the Guidance Report might not be correct for the Test Case 5 input files listed
- Completed the V&V document and sent it forward for review
- LANL reviewer examined the Test Case 5 problem but could not find a “smoking gun”



Summary and Recommendations

- V&V of MELCOR is:
 - Necessary, prior to use for safety basis LPF analysis
 - Complicated, under the best circumstances
 - Time consuming, especially the first time it is done
- Actions that would help:
 - Provide Guidance Report Test Case input files online for DOE Toolbox Codes
 - Certify current versions of Toolbox Codes for use
 - Provide support function for Toolbox Code V&V efforts