

Case Study Example using SFPE Guidelines for Substantiating a Fire Model for a Given Application

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INTRODUCTION

- SFPE Guidelines for Substantiating a Fire Model for a Given Application
 - Intent/Methodology
 - Use
 - Stakeholders
- Performing Arts Center Atrium
 - Relatively Simple Smoke Movement/Exhaust Application
 - Specific Atrium Geometry to “Wrap” Around Theater Space

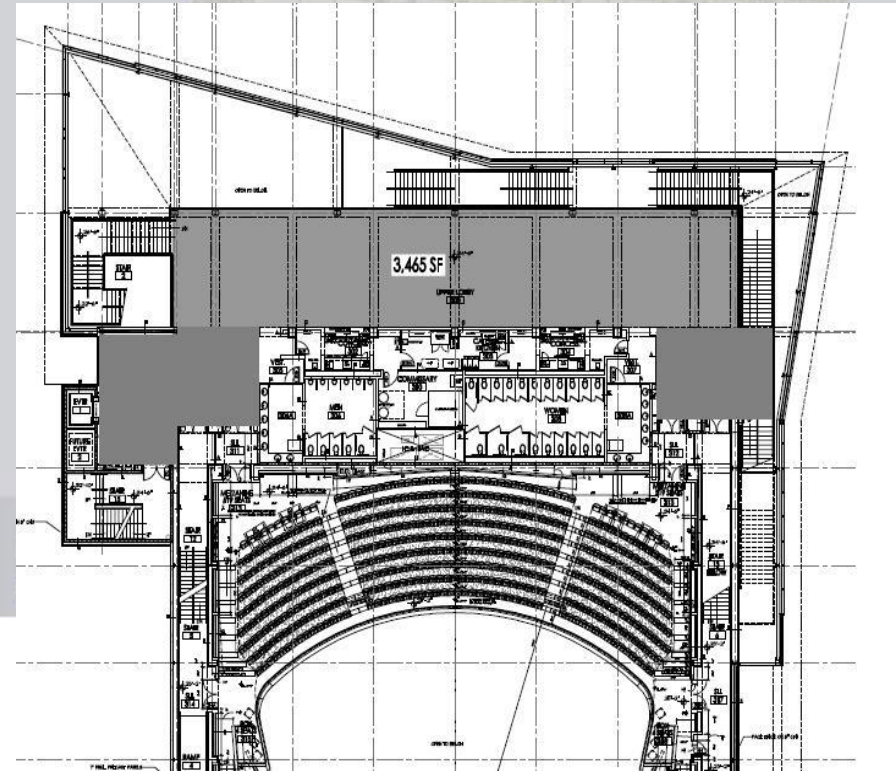
BACKGROUND

- Class A Performing Arts Center
 - 3-Story Open Circulation Space forms Atrium



BACKGROUND

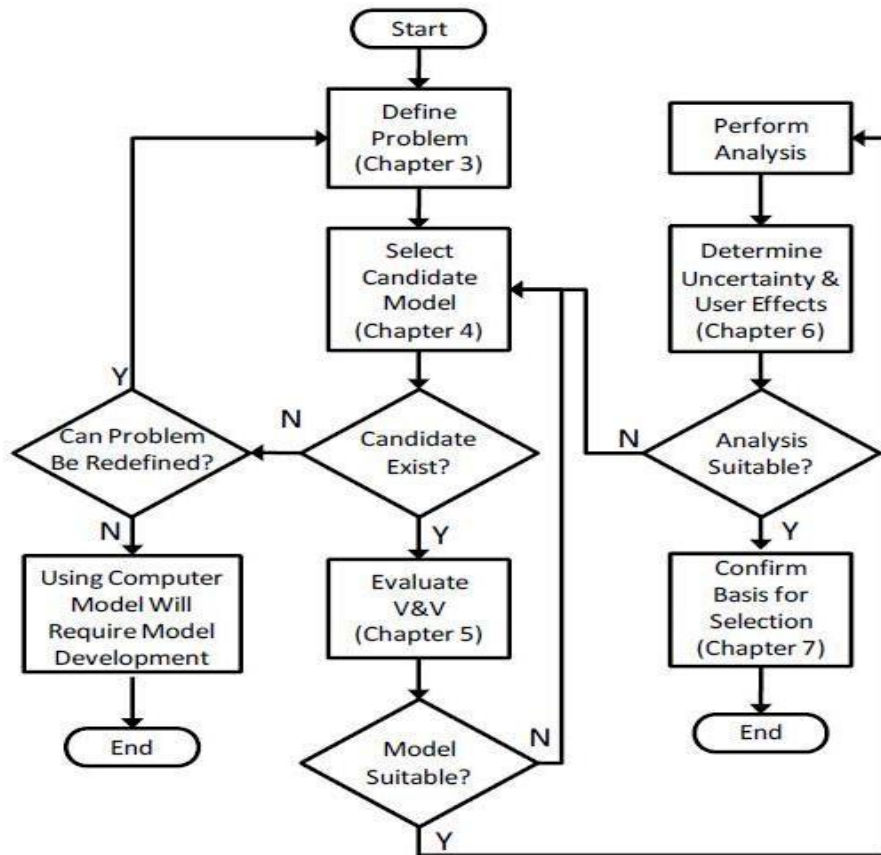
- Class A Performing Arts Center
 - Open Stairs to Access Seating on Balcony Levels



ENGINEERING GUIDE

METHODOLOGY

- SFPE Guidelines for Substantiating a Fire Model for a Given Application – published early 2011



1. Define the Problem of Interest
2. Select a Candidate Model
3. Verification and Validation
4. User Effects
5. Documentation

DEFINE THE PROBLEM OF INTEREST

- Scope of Problem

- Atrium Smoke Control

- Presumed Smoke Production, Smoke Movement, Mechanical Exhaust, and Mechanical/Passive Make-up Air
 - Review of Previous Work

- Key Physics

- Smoke Movement, Smoke Temperature, Smoke Concentration, Smoke Layer, Compartment Pressure, Compartment Ventilation, Visibility
 - Heat Release Rate, Flame Height, Heat Flux, Ceiling Jet, Sprinkler/Detector Response

DEFINE THE PROBLEM OF INTEREST

- Other Parameters

- Geometry: Relatively Well Defined
- Timeline: Transient (could be steady-state)
- Events: Fire Growth, Smoke/Fire Detection, Exhaust/Make-up Air Initiation
- Materials: ??? (Actual or Assumed Conservative)
- Initial and Boundary Conditions: Temperature, Fan/Vent Status, HVAC status, Wind

- Define Analysis Objectives

- Smoke Layer Analysis
- Tenability Analysis

DEFINE THE PROBLEM OF INTEREST

- Other Considerations
 - Example: Predicting the Use



SELECT A CANDIDATE MODEL

- Model Types

- Algebraic
- Zone/Lumped Parameter
- Field/CFD
- Combination

- Performing Arts Center Application

- Input/Output Considerations
 - Available Input Data (Design Uncertainties)
 - Necessary Output Data/Resolution (Drives Model Selection?)
- Smoke Layer Analysis vs. Tenability

SELECT A CANDIDATE MODEL

- Other Considerations

- Available Resources (Conservative, Bounding, Sensitivity, etc)
- Graphics/Presentation



Verification and Validation

- Purpose

- Assess the predictive capability of the model to be sure it is appropriate for its intended use
- Responsibility of model selection is that of the user
- Application of model is also responsibility of user



Verification

- Model Developer's should verify...
 - The mathematics of the model is correct
 - That physics are described by appropriate equations
 - Appropriate methods are followed (ASTM E-1355)
- User's should verify for their application...
 - Basic functionality of the model
 - Consistency of input parameters
 - That the input parameters are appropriately used
 - The range of validity for input parameter values
 - Consistency of results

Validation

- Why?

- Determine that the predictions are appropriate for the intended use

- How?

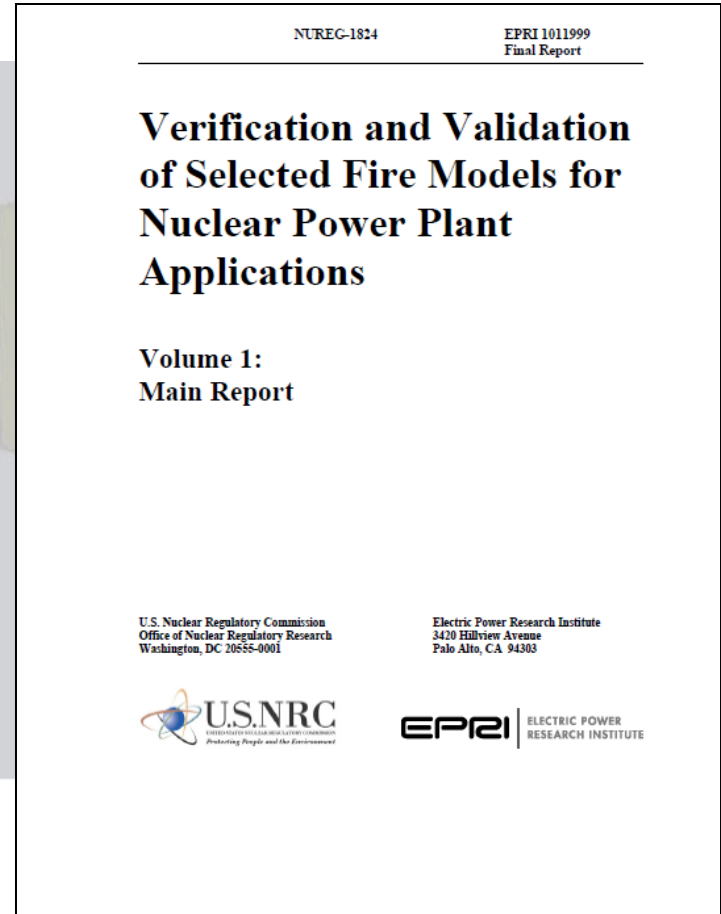
- Comparison between predictions and experimental test data
 - Calculated relative differences to experimental uncertainty

- Sources of Experimental Data

- Existing validation studies
 - Commission fire testing for specific applications

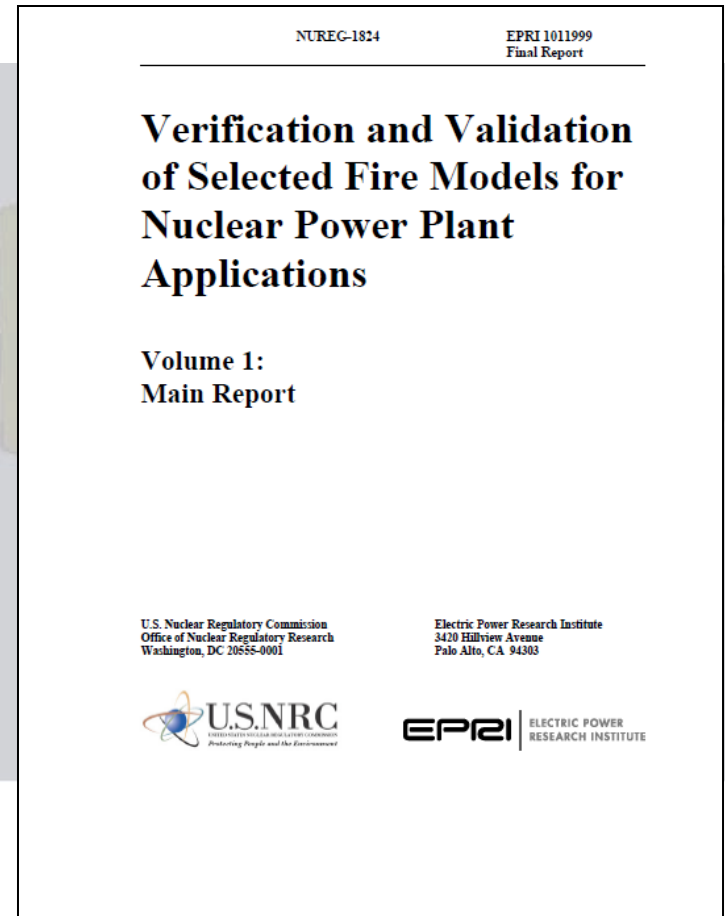
Validation

- NRC/EPRI Report
 - NUREG-1824
 - EPRI 1011999 Final Report
- Calculations
 - FDT^S
 - FIVE-Rev1
- Two-Zone Fire Models
 - CFAST
 - MAGIC
- Field Fire Model
 - FDS



Validation

- Fire Modeling Parameters
 - HGL temperature & height
 - Ceiling jet temperature
 - Plume temperature
 - Flame height
 - Radiant heat flux to target
 - Total heat flux to targets & walls
 - Wall surface temperature
 - Target surface temperature
 - Smoke concentration
 - Oxygen concentration
 - Room pressure



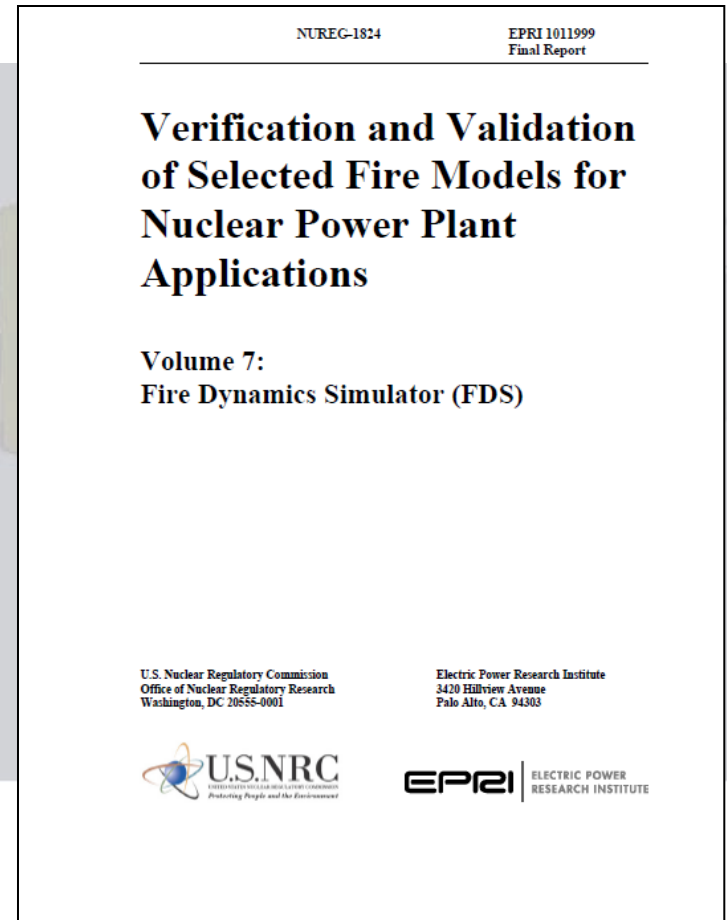
Validation

- FDS Modeling Parameters

- V&V study compared model results to fire experiment measurements

- Ranking Criteria

- Are physics of the model appropriately described by the calculation?
 - Do the model results differ significantly from the measured data?



Validation

- FDS Rankings

- **Green**: Model satisfies both criteria
- **Yellow**: Physics are properly satisfied but predictions may not match the experimental data
- **Red**: Neither criteria satisfied

- Project parameters

- **HGL temperature**
- **Smoke concentration**
- **Specie concentration**

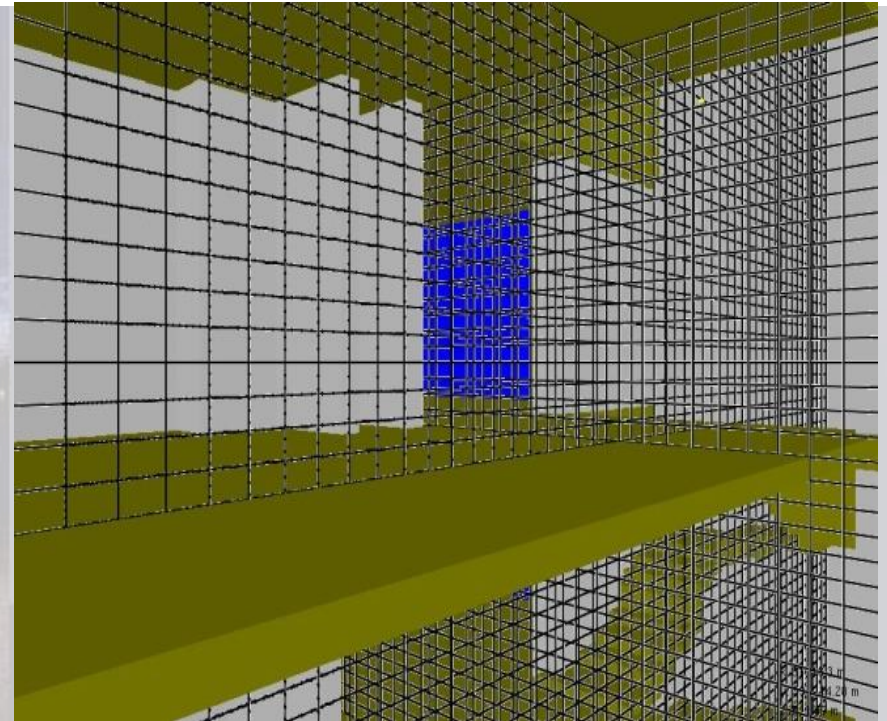
User Effects

- Additional Sources of Uncertainty
 - User-defined parameters
 - Spatial domain
 - Input assumptions
- User Responsibility
 - Sensitivity of parameters
 - Impact on model output



User Effects – Spatial Domain

- Physical Space
 - Depends on model type
 - Resource limitations
- Grid Resolution
 - Understand effect on analysis
 - Results may vary
- Grid Selection
 - General guidelines
 - Grid resolution study



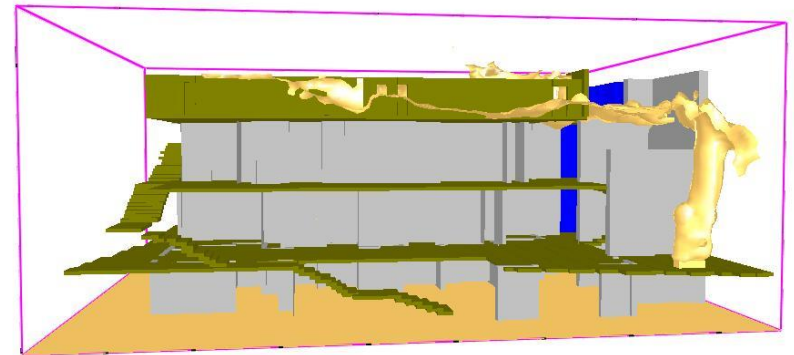
User Effects – Fire Definition

- Heat Release Rate

- Appropriate Size
- Growth

- Impacts

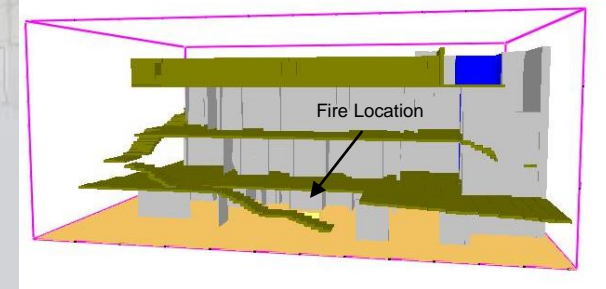
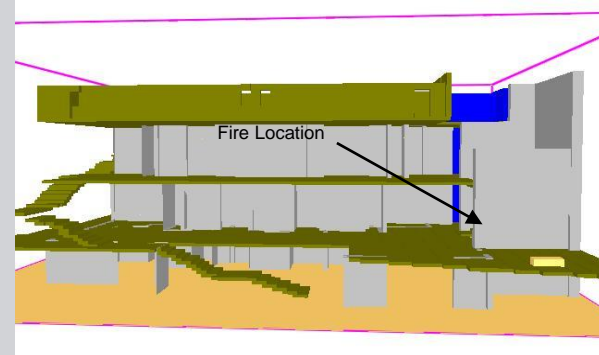
- Intentional (suppression)
- Unintentional (ventilation)



Frame: 852
Time: 1022.4

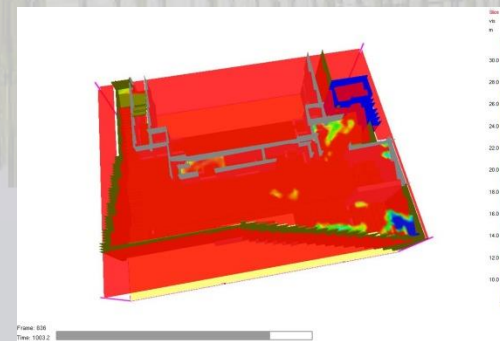
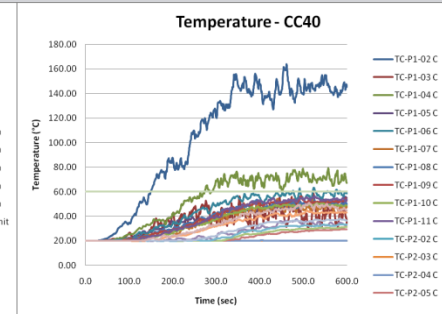
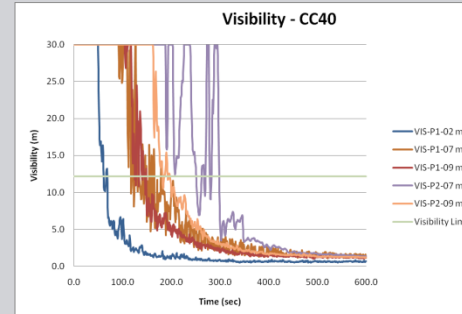
User Effects – Fire Location

- Smoke Production
 - Axisymmetric
 - Balcony spill plume
- Spatial Concerns
 - Boundaries
 - Grid resolution impact
- Surface properties
 - Thermal impacts
 - Secondary item ignition
 - Flame spread



User Effects – Measurements

- Location
 - Point vs. average value
 - Visualization vs. reported value
- Time-Dependence
 - Frequency
 - Threshold vs. averaged
- Safety Factors



Documentation

- Don't Ignore this Last Step
- Engineering Guide Structured with a Purpose
 - Logical progression of steps
 - Self-documenting
- Qualification
 - Model's use as appropriate for the application
 - Thoroughness of assessment
- Disqualification
 - Model's use as inappropriate for the application

Documentation

- Requirements

- AHJ
- Project Stakeholder
- Internal procedures
- Other authorities

- Undefined Format

- Checklist
- Project Report
- Appendix
- Internal record



Questions?



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