

Fire Safety Engineering Workshop Session II C: Technical Methods for Fire Safety

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Quality Fire Safety Management

Presented at the Fire Safety Engineering Workshop at Sichuan Fire
Research Institute, May 26-27, 2015, Chengdu, China

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Plan for Session on Technical Methods

- General procedures for fire safety engineering
- Design fire scenarios and design fires
- Structural response and fire spread beyond the enclosure of origin
- Fire calculation methods for fire initiation, movement, and impact on structures

Plan for Session – Cont'd

- Methods for assessing the suitability of calculation methods for specific applications
- Verification & validation of fire calculation methods

Verification & Validation (V&V) of Fire Calculation Methods

- Goal of V&V
 - Establish predictive capability of calculation method for range of fire scenarios
 - Establish range of applicability of the specific calculation method

Revision of ISO Standard on Verification & Validation

- ISO 16730-1 to be published shortly
- Present “lessons learned” in International Collaborative Fire Model Project (ICFMP)
- Show how these “lessons learned” were used to revise ISO 16730-1
- Recommend the “way forward” for a V&V program at SCFRI

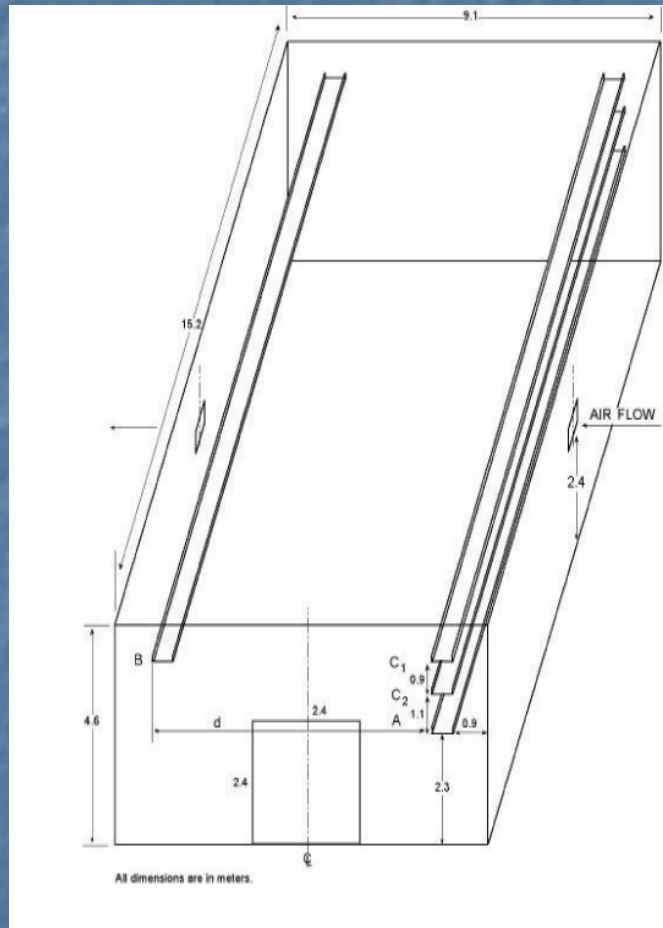
International Collaborative Fire Model Project (ICFMP)

- Conducted 1999-2008
- Evaluate fire models for nuclear plant applications through 5 benchmark exercises (BE)
 - Code to Code
 - Code to experimental data
 - Simple to challenging scenarios

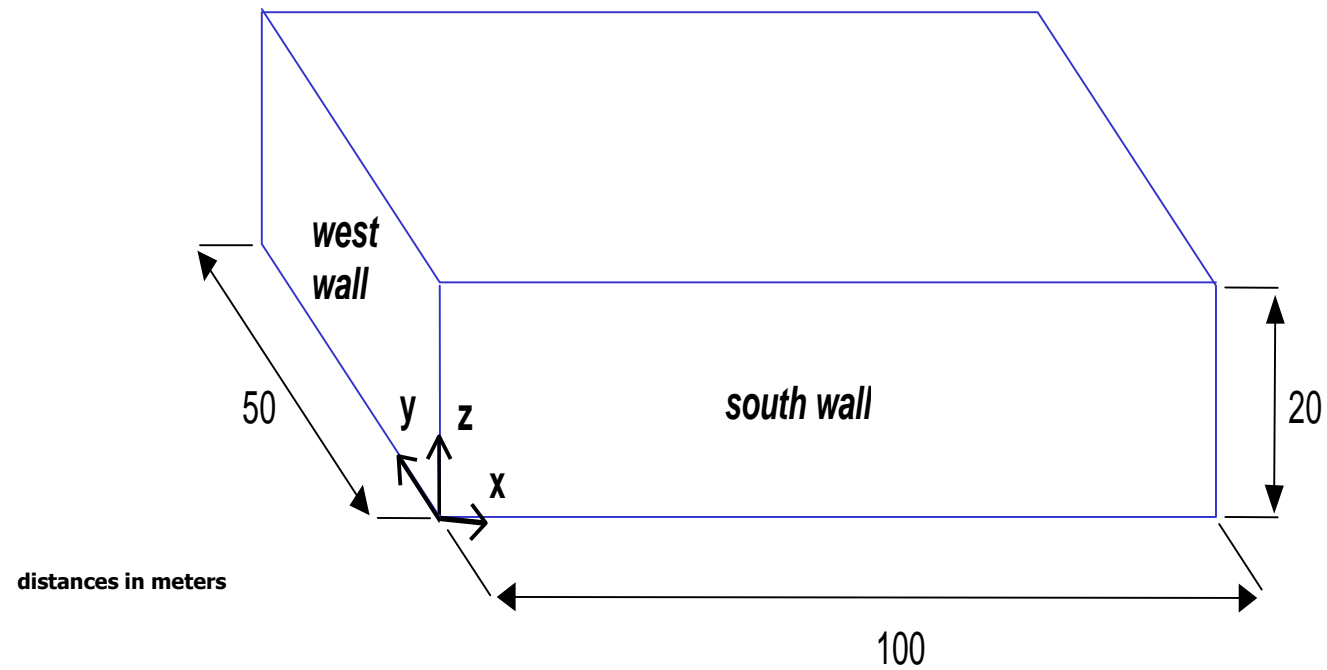
ICFMP Cont'd

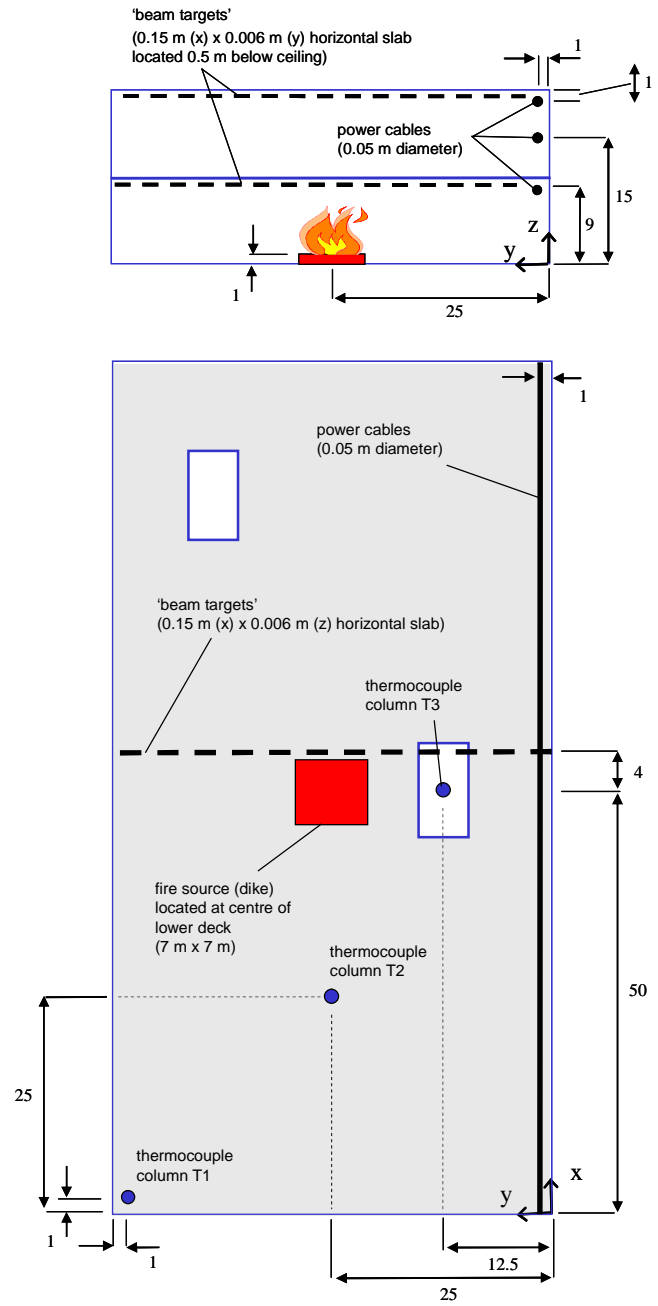
- Five countries participated, typically 7 organizations exercised fire models
 - **Germany – GRS, iBMB (COCOSYS, FDS, CFX, CFAST)**
 - **France – IRSN, EdF, CTICM (FLAMME-S, MAGIC)**
 - **UK – BRE (JASMINE, CFAST)**
 - **USA – NRC, NIST (CFAST, FDS, FDTs)**
- 10 organizations participated in peer review
- 12 international workshops over 10 years
- 5 ICFMP benchmark reports and summary report

ICFMP Benchmark Exercise No. 1 – Cable Tray Fires

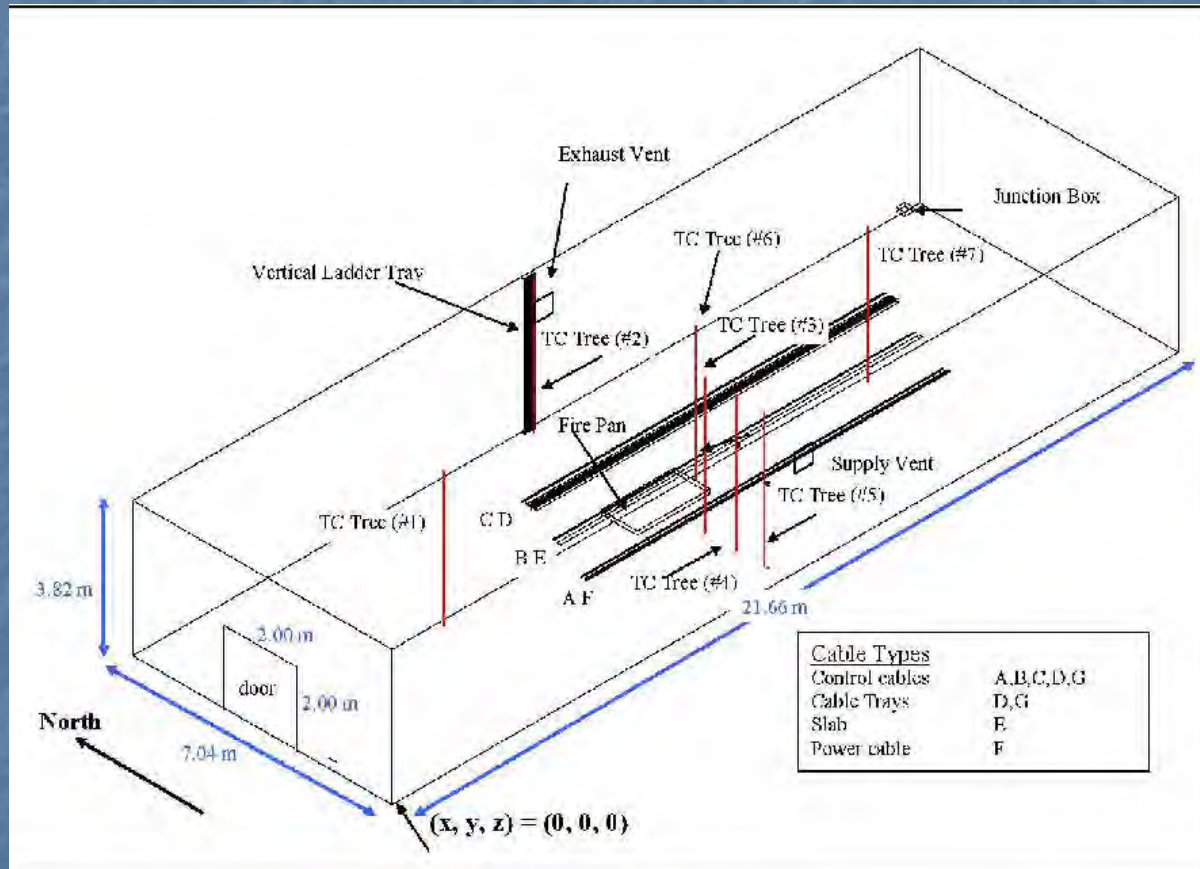


ICFMP Benchmark Exercise No. 2 – Pool Fires in Large Halls





ICFMP Benchmark Exercise No. 3 – Full Scale Compartment Fire Tests



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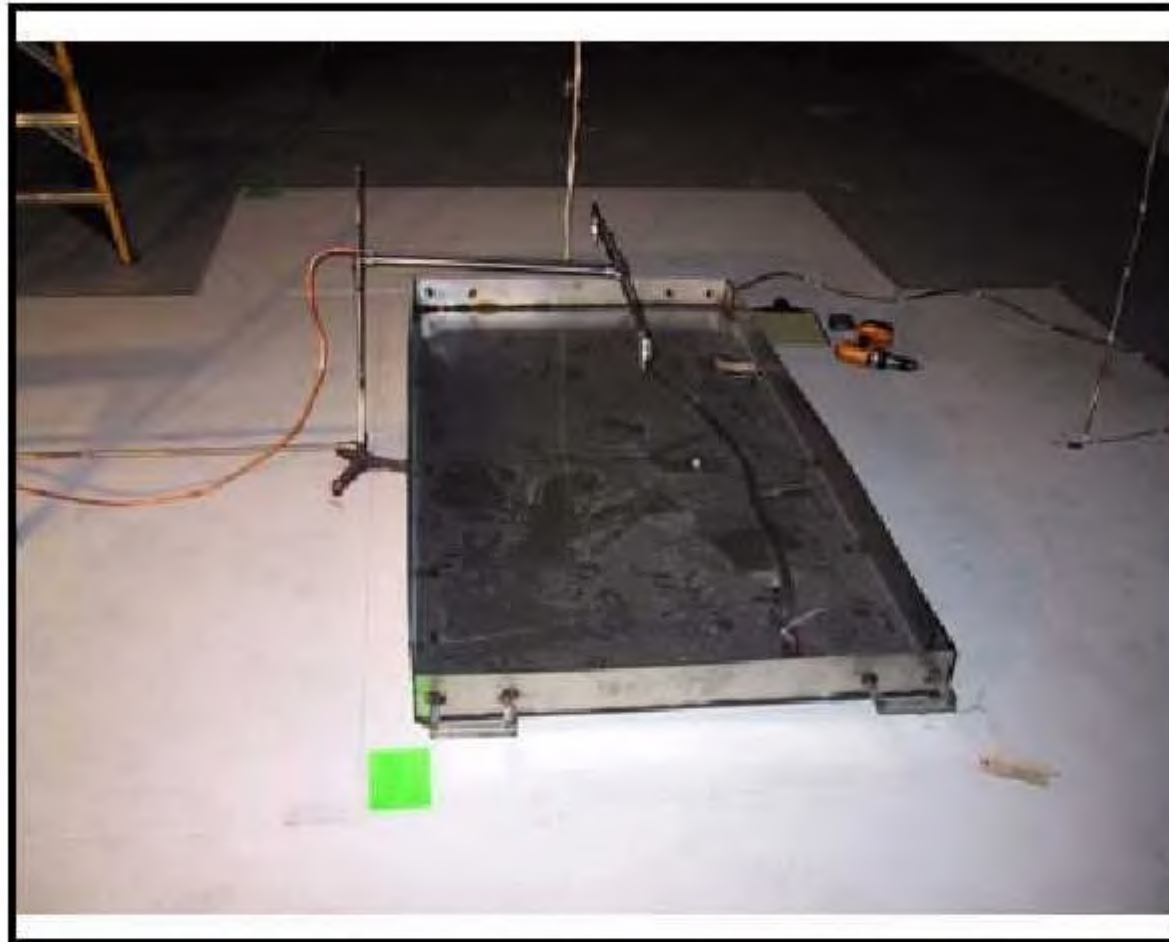


Figure 2.12 Fuel Pan with Spray Nozzle



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Figure 3.3 Hot Gas Layer in Test 3

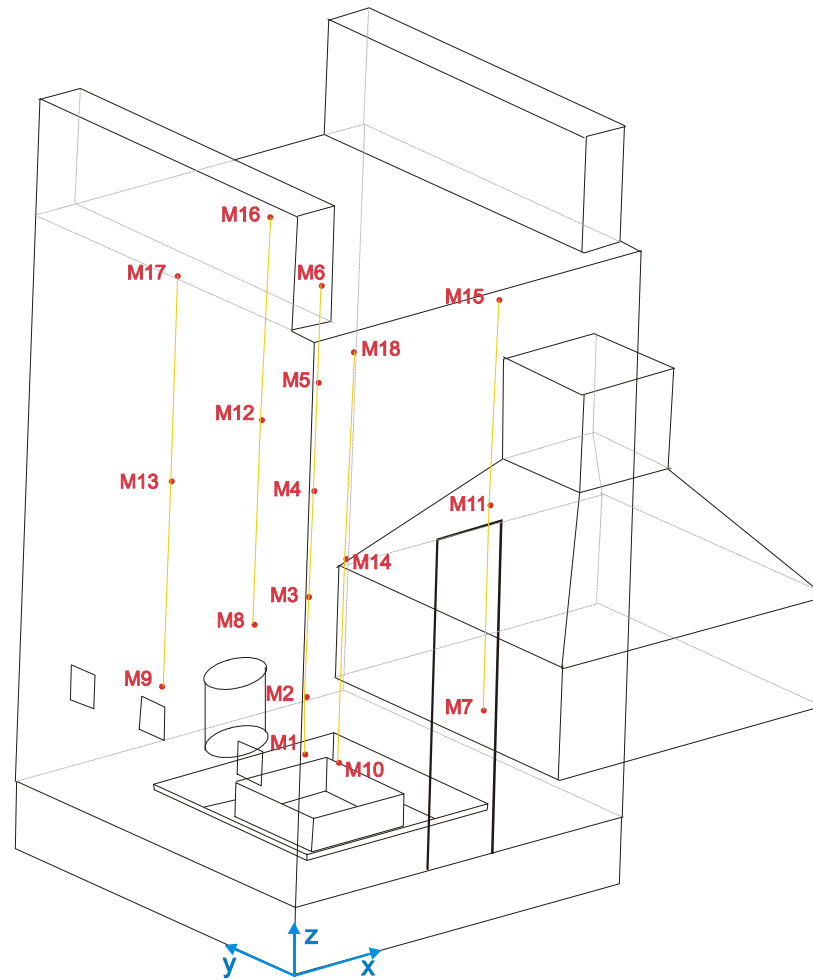


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ICFMP Benchmark Exercise – No. 4

Large Fire Experiments

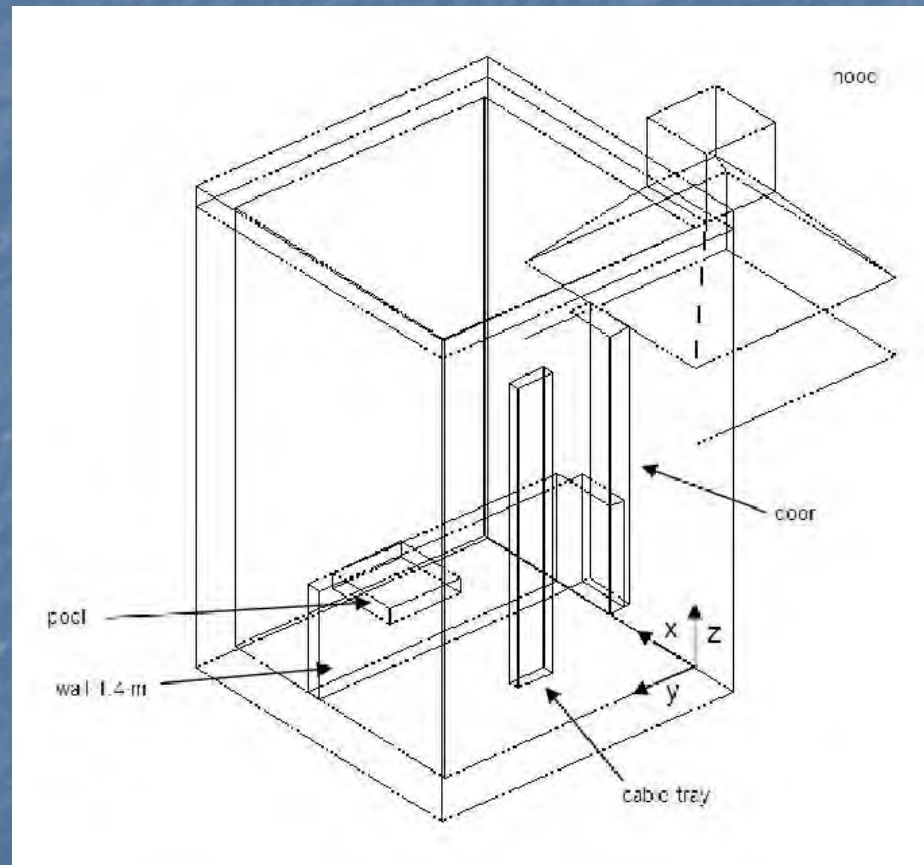




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ICFMP Benchmark Exercise No. 5 – Pool Fires in a Trench



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V&V Process to Determine Fire Model Predictive Errors

- ICFMP established to conduct “blind” benchmark exercises
- Need credibility of V&V process by determining true predictive errors
- Necessary for development of uncertainties in performance-based designs

“Blind” vs “Open” Predictions

- In a priori (aka *blind*) modeler has no access to experimental data
- In a posteriori (aka *open*) modeler has access to the experimental data and measurements of predicted parameters
- Comparison of *blind vs open* calculations
 - Dalmarnock fire test project
 - Possible to match measured parameters by adjusting model input data

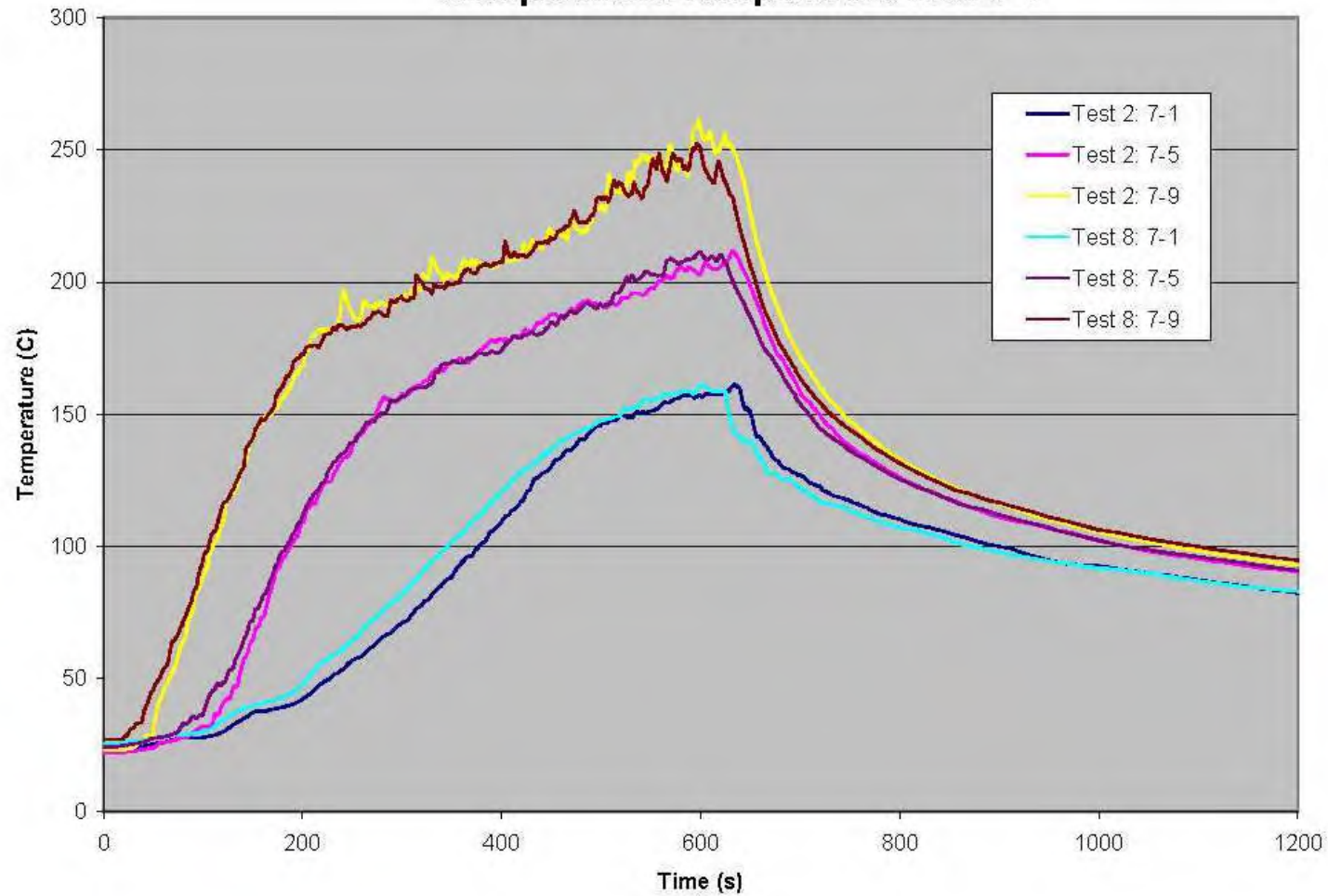
Bias in V&V Process

- Natural bias exists in *open* predictions
- Most fire model validations conducted a posteriori (*open*)
- Extent of bias presently unknown & currently being researched
- Need true predictive errors to establish uncertainties in PB designs
- “Real World” fires – PB designs

Challenges of *Blind* V&V Overcome in ICFMP

- Replication of experiments
- Conduct of tests according to test plan
- Uncertainty in model input data
- Sensitivity & uncertainty analysis
- Need to establish “optimal” prediction

BE # 3 Replicate Tests 2 & 8 Compartment Temperature Tree 7-1



Parameter Issues

- Heat Release Rate (HRR)
- Radiative Fraction
- Thermal Parameters of Compartment Boundary

Heat Release Rate (HRR)

- Knowledge of combustion process/need to input parameter to models
- Predominantly determines magnitude of fire effects
- Major source of uncertainty

Recommendations for Fire Model V&V Standard

- Establish measurement methods for parameters needed as input to fire models
- Develop values for parameters input to fire models
- Establish procedure for conducting & ensuring that *blind* calculations are used to establish predictive model errors
- Examine and include “third party validation” as an option for establishing true model errors

ISO 16730-1 Procedures & Requirements for V&V of Calculation Methods

- Documentation
 - Technical documentation
 - User's manual
- Methodology
 - Verification
 - Validation
 - Sensitivity analysis
 - Quality assurance

ISO 16730-1 Procedures & Requirements for V&V of Calculation Methods

- Requirements for validation data
- Annex A: Guidance on audits in ISO 9000 family of standards
 - 2nd party audit
 - 3rd party audit and certification
- Annex E: Quality assurance methodology

ISO 16730-1 Procedures & Requirements for V&V of Calculation Methods

- Validation is process of determining degree calculation method is accurate representation of real world
- Verification is process of determining calculation method implementation represents developer's conceptual description of calculation method

ISO 16730-1 Procedures & requirements for V&V of calculation methods

- Validation
 - Open validation procedure
 - Blind validation procedures
- Open procedure
 - Party conducting the validation has access to initial & boundary conditions of experiments & measurements of output parameters before calculation methods are exercised

ISO 16730-1 Procedures & requirements for V&V of calculation methods

- Blind procedure
 - Party conducting validation only has access to initial & boundary conditions of experiments, but has no access to measurements of output parameters before calculations methods are exercised

ISO 16730-1 Procedures & requirements for V&V of calculation methods

- Reporting requirements
 - Description of the experiments & measurements, including uncertainty
 - Input data used for calculation methods
 - Comparison of outputs of calculation method with experimental data using established metrics in quantitative terms

ISO 16730-1 Procedures & requirements for V&V of calculation methods

- Tabulation of discrepancies using established metrics in quantitative terms
- Boundary & initial conditions of experiments & therefore resulting fire scenario(s) for which validation is applicable

ISO 16730-1 Procedures & requirements for V&V of calculation methods

- Caution:
 - Significant errors in safety decisions & fire protection measures implemented will result from use of calculation method outside range of stated scenarios determined through a [blind] validation process

Recommended Approach to SCFRI

- Conduct experiments to cover wide range of fire scenarios for typical applications
- Assess predictive capability of methods through V&V studies
- Determine appropriate calculation methods based on above knowledge for different application

Questions

- Comments and discussion
- Thank you

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