

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

Dr. Monideep Dey

 **Deytec, Inc.**

Quality Fire Safety Management

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

© Deytec, Inc. 2015. All rights reserved.

This document is copyrighted. It is the intellectual property of Deytec, Inc. It may not be reproduced, distributed, published, presented to or used by any other individual or organization other than within the Sichuan Fire Research Institute, for any purpose whatsoever unless written permission is obtained from Deytec, Inc.

Copyright
Deytec, Inc., 2015

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

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

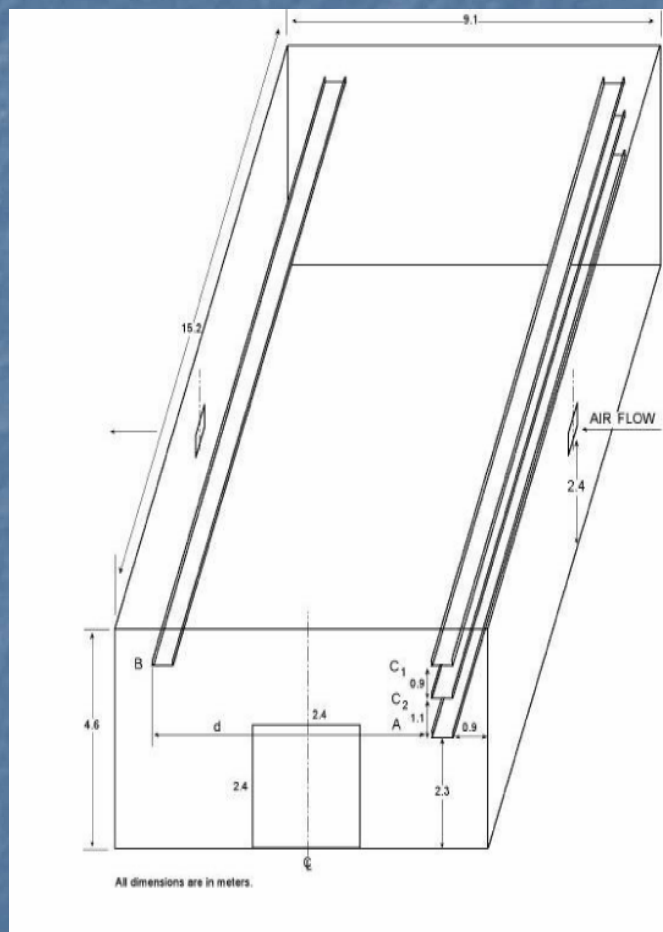
International Collaborative Fire Model Project (ICFMP)

- 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

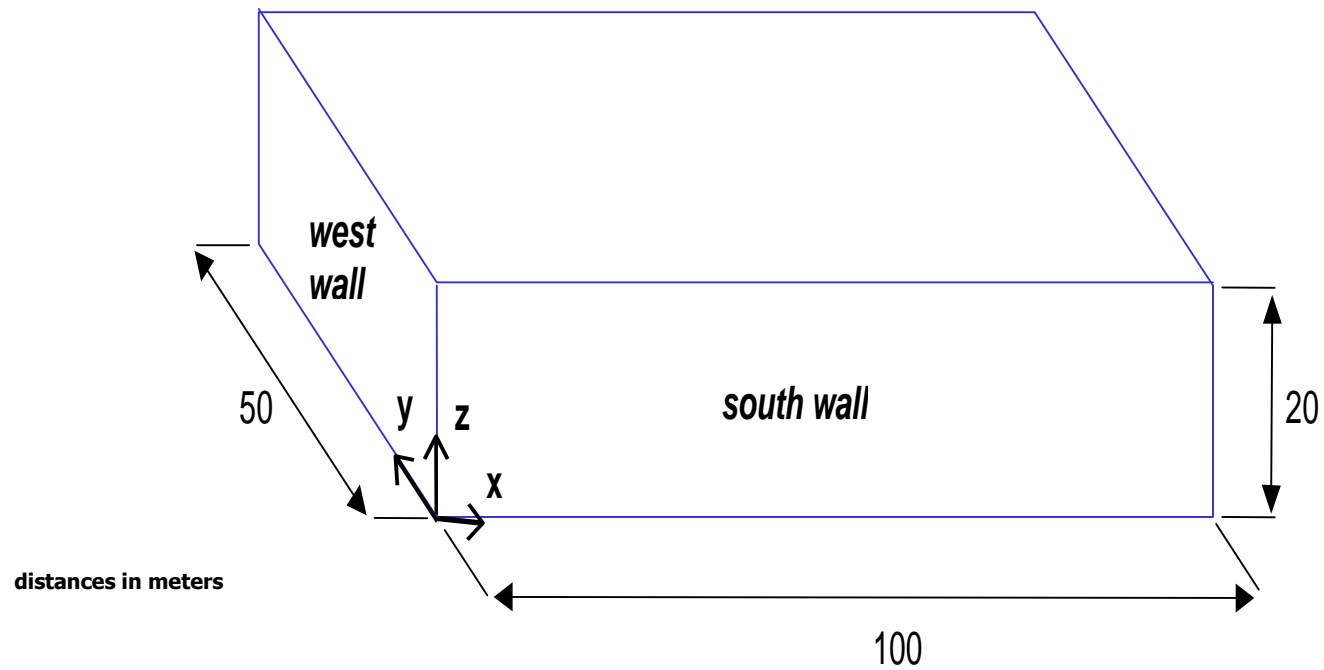
- Five countries participated, typically 7 organizations exercised fire models
 - **Germany – GRS, iBMB (COCOSYS, FDS, CFX, CFAST)**
 - **France – IRSN, EdF, CTICM (FLAMME-S, MAGIC)**
 - **UK – BRE (JASMINE, CFAST)**
 - **USA – NRC, NIST (CFAST, FDS, FDTs)**
- 10 organizations participated in peer review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

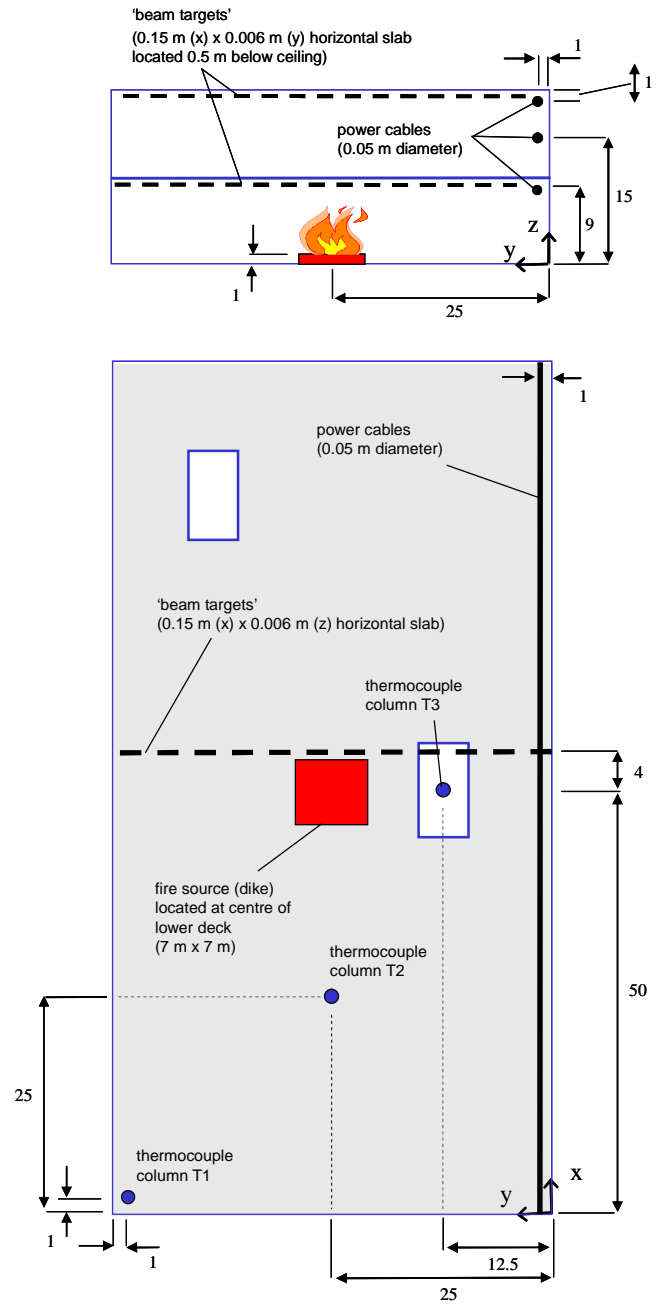
ICFMP Benchmark Exercise No. 1 – Cable Tray Fires



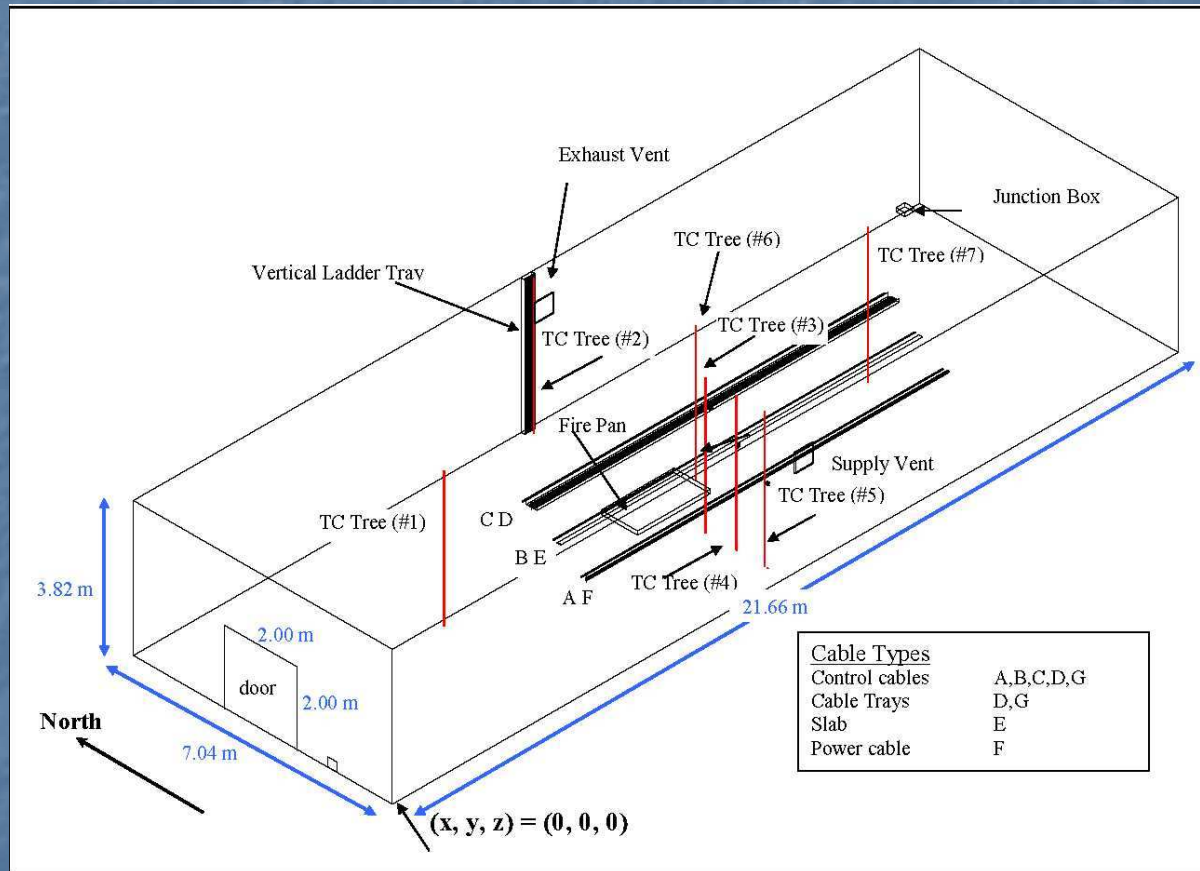
Presented at the Fire Safety
Engineering Workshop at
Sichuan Fire Research Institute
May 26-27, 2015, Chengdu, China

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





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



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

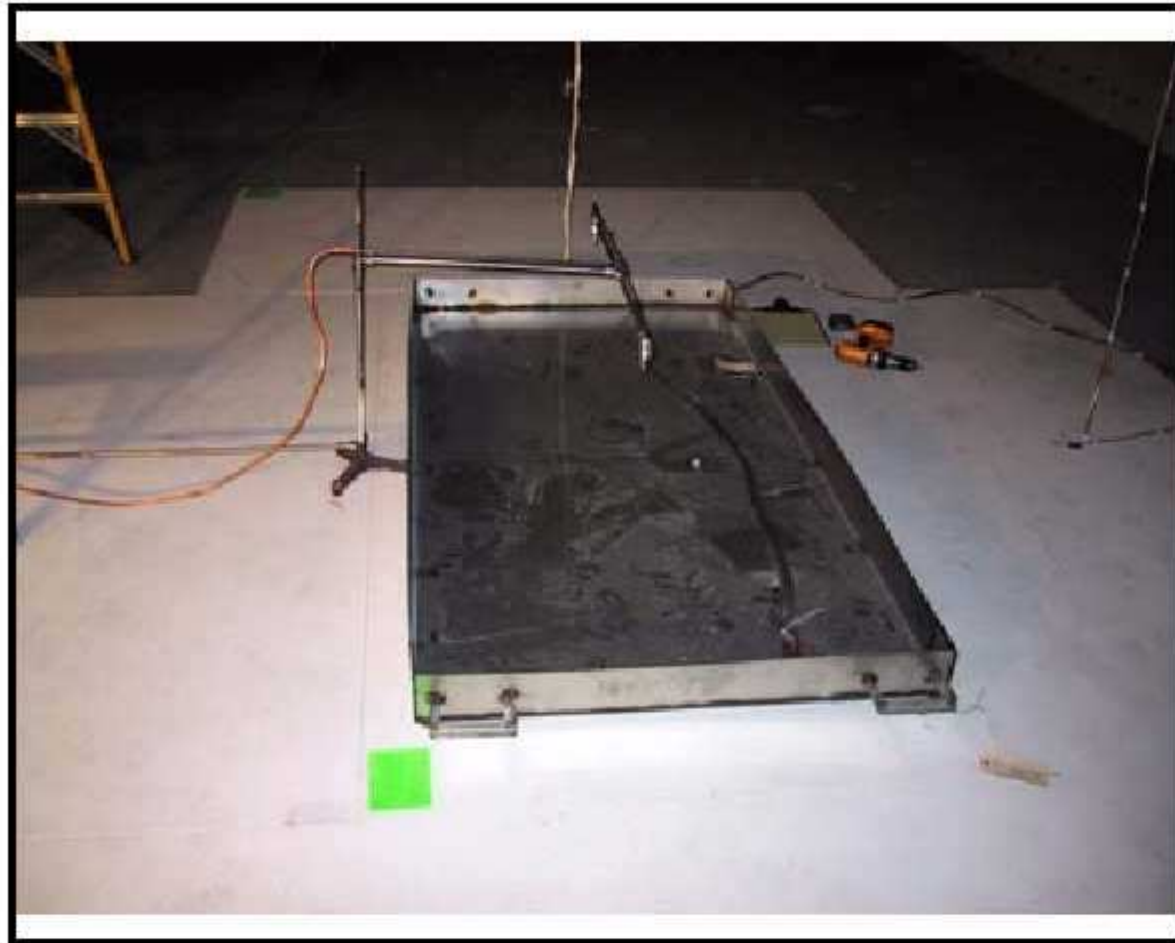
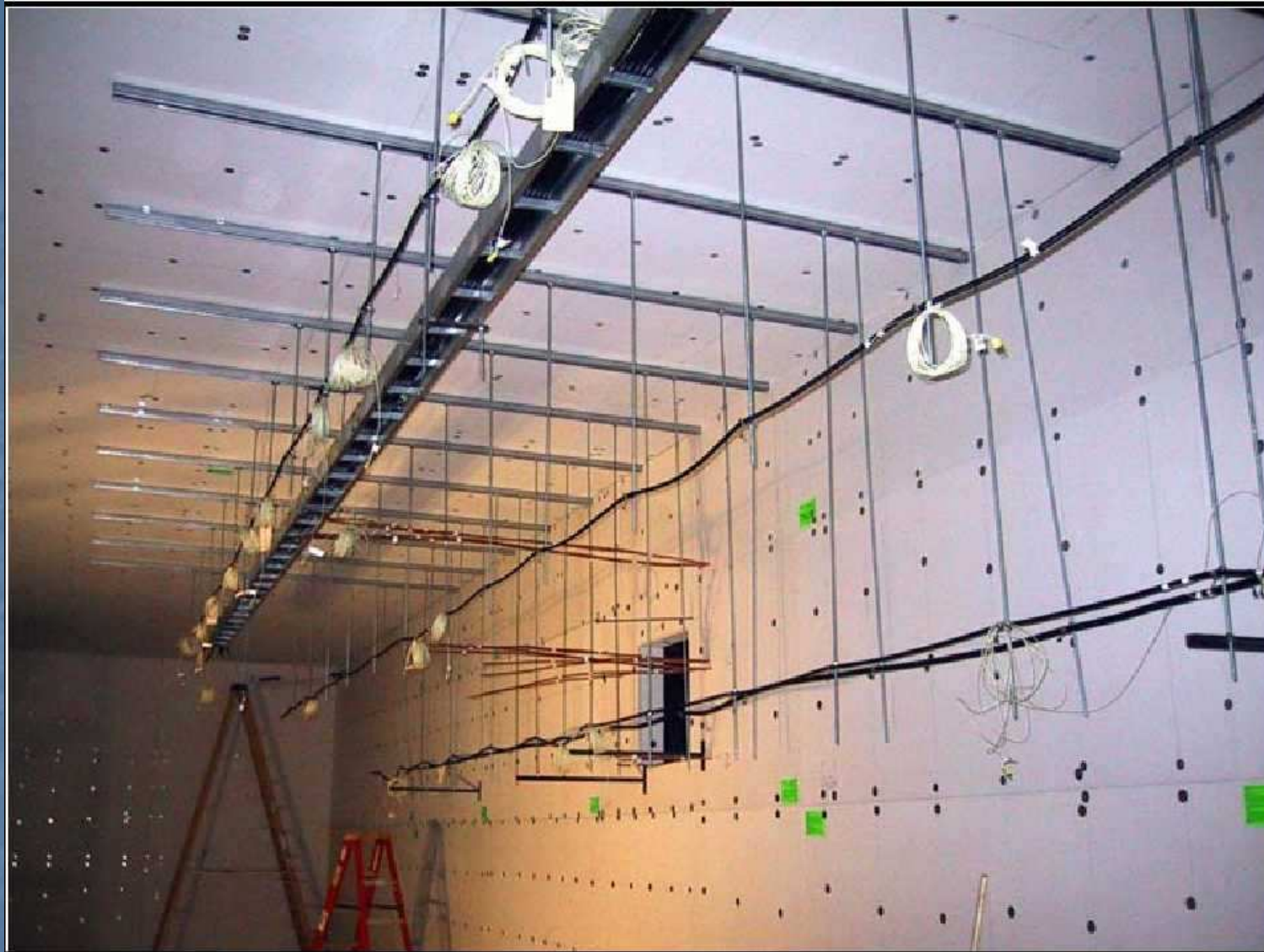


Figure 2.12 Fuel Pan with Spray Nozzle



Copyright
Deytec, Inc., 2015

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



Figure 3.3 Hot Gas Layer in Test 3

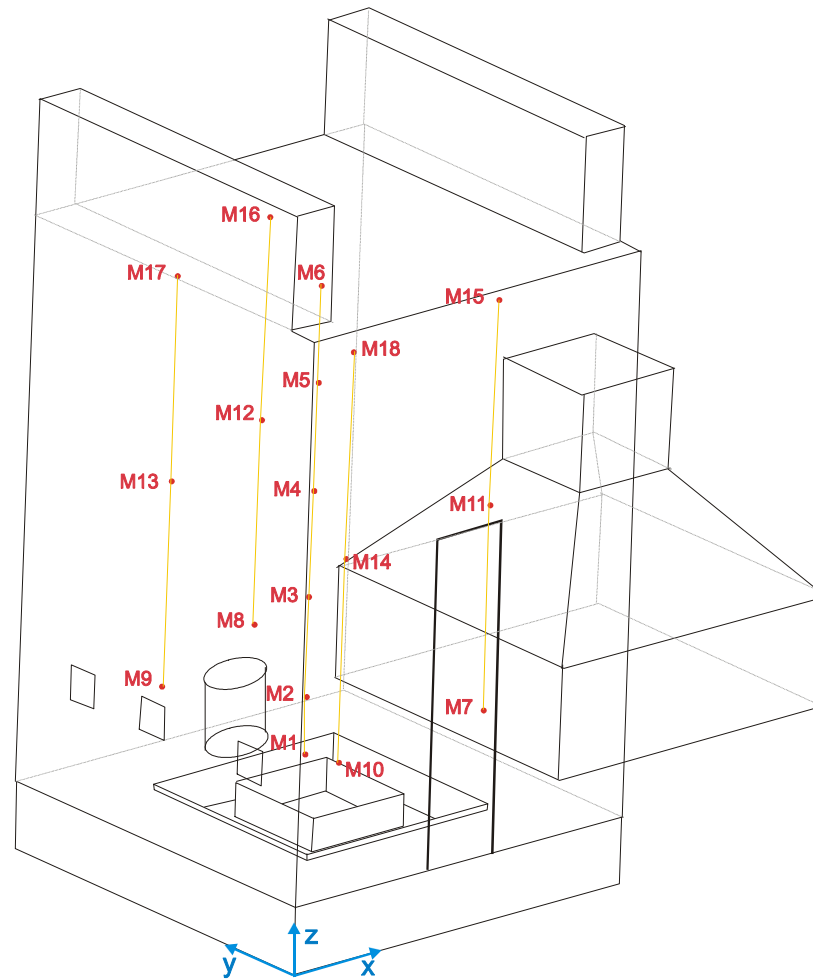


Copyright
Deytec, Inc., 2015

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

ICFMP Benchmark Exercise – No. 4

Large Fire Experiments

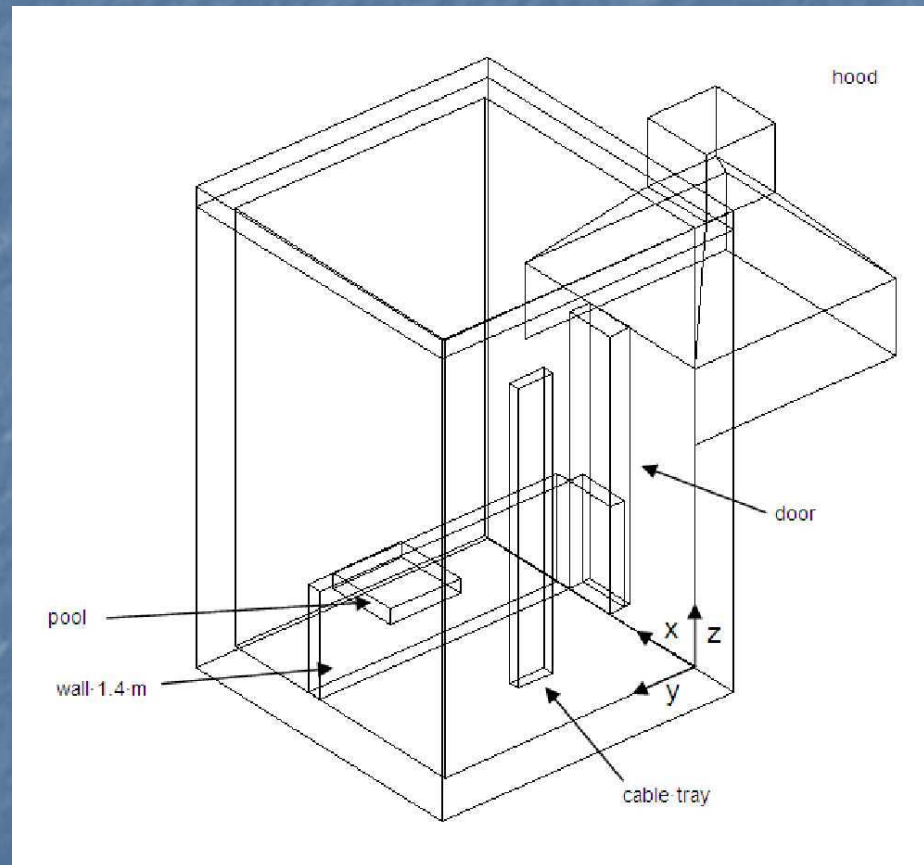




Copyright
Deytec, Inc., 2015

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

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



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



Copyright
Deytec, Inc., 2015

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

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

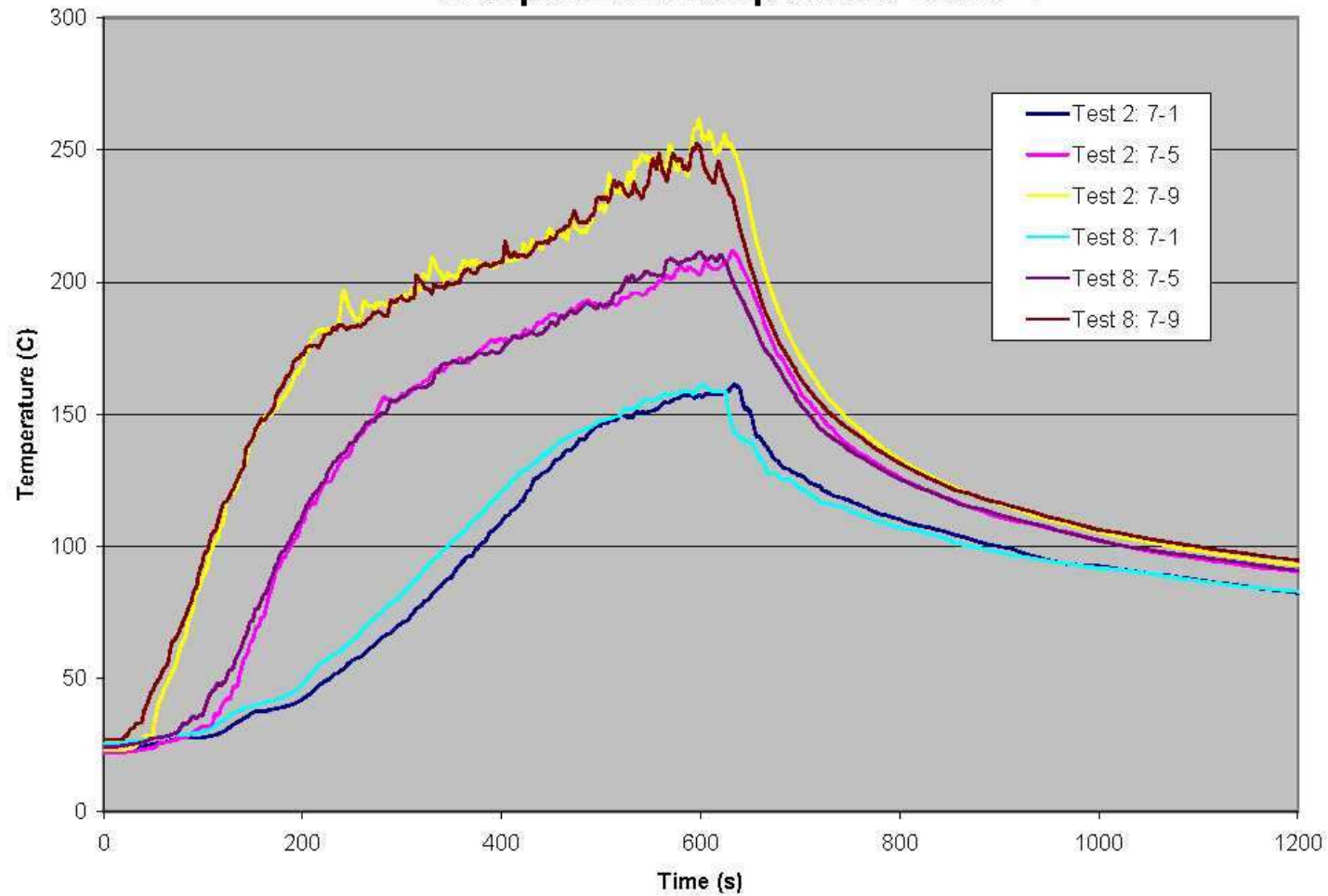
Bias in V&V Process

- 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
- Contact Information:
 - deytec@frontiernet.net
 - www.deytecinc.com or www.linkedin.com/pub/dr-monideep-dey/1b/94/a13