Achieving a New Level of Fire Safety for Nuclear Power Plants

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Goal

- We are building bigger & more complex buildings & industrial facilities
- We are susceptible to large scale fires, accidents, fatalities & losses
- Can we keep the risk of such accidents to a minimal level?
- Can we achieve a new level of fire safety?

Outline

- Introduction & background
- History, successes, and challenges of performance-based (P-B) fire safety
- Specific P-B initiatives for nuclear power plant fire safety
- Initiatives of International Organization of Standardization (ISO)
- The way forward to meet goal

Introduction & Background

- Performance-based (P-B) or fire safety engineering (FSE) methods initiated in mid-1990s
  - Compliance with prescriptive requirements for advanced designs difficult
  - Needed to establish *flexible* regulatory regime
- Inter-jurisdictional Regulatory Collaboration Committee (IRCC) reports

Introduction – Cont'd

- Flexibility of P-B regulation led to:
  - Widespread results in fire safety analysis
  - Non-uniform implementation of P-B codes
  - Uncertainty in levels of fire safety being achieved
- Prescriptive standards still have major role in assuring safety

Recent Initiatives

- New Zealand verification guideline (2012)
- Nordic initiative (2013)
- CEN initiatives (ongoing)
- Goals of recent initiatives
  - Specific design fires for FSE analysis
  - Quantitative performance criteria for requirements

Recent Initiatives – Cont'd

- Goals of recent initiatives
  - Specific input data and assumptions in order to decrease the spread in results
  - Requirements to address uncertainty and safety factors as part of quality assurance
- 2nd generation of P-B fire safety standards under development

P-B Initiatives for Nuclear Power Plants

- Since 80s challenges in compliance with prescriptive fire regulations in US
- Transition to P-B initiated in early 1990s
- Review of P-B initiatives world wide published in NUREG-1521 (NFPA 805)
- International effort to evaluate fire calculation methods for P-B design

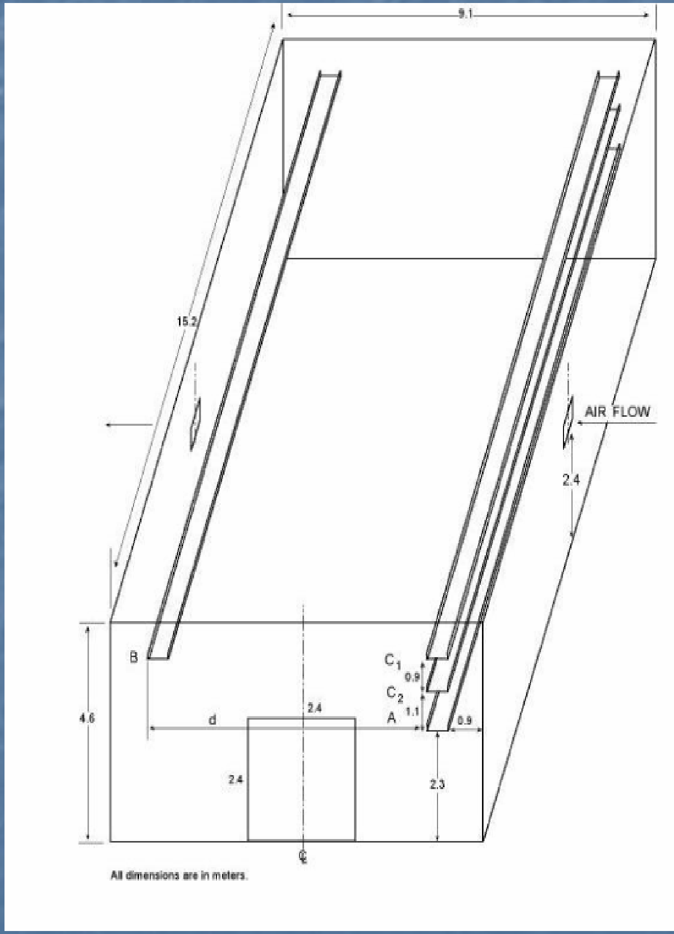
International Collaborative Fire Model Project (ICFMP)

- Conducted 1999-2008, led by US-Germany
- Evaluate fire models for nuclear plant applications through 5 benchmark exercises
  - Code to Code
  - Code to experimental data
  - Simple to challenging scenarios

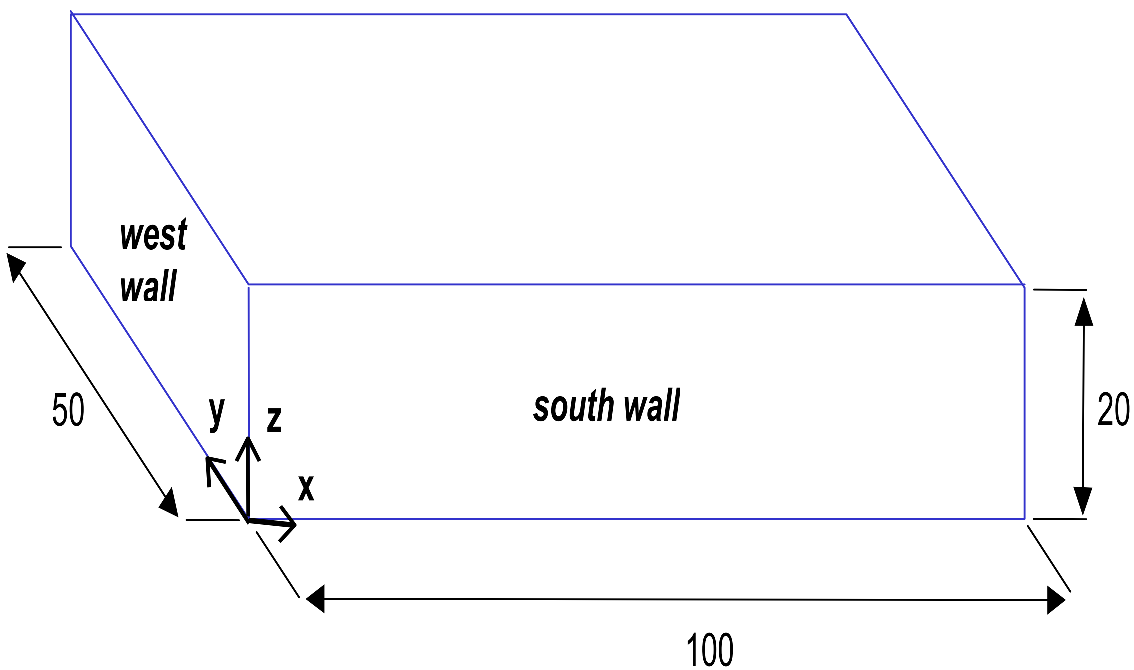
ICFMP Cont'd

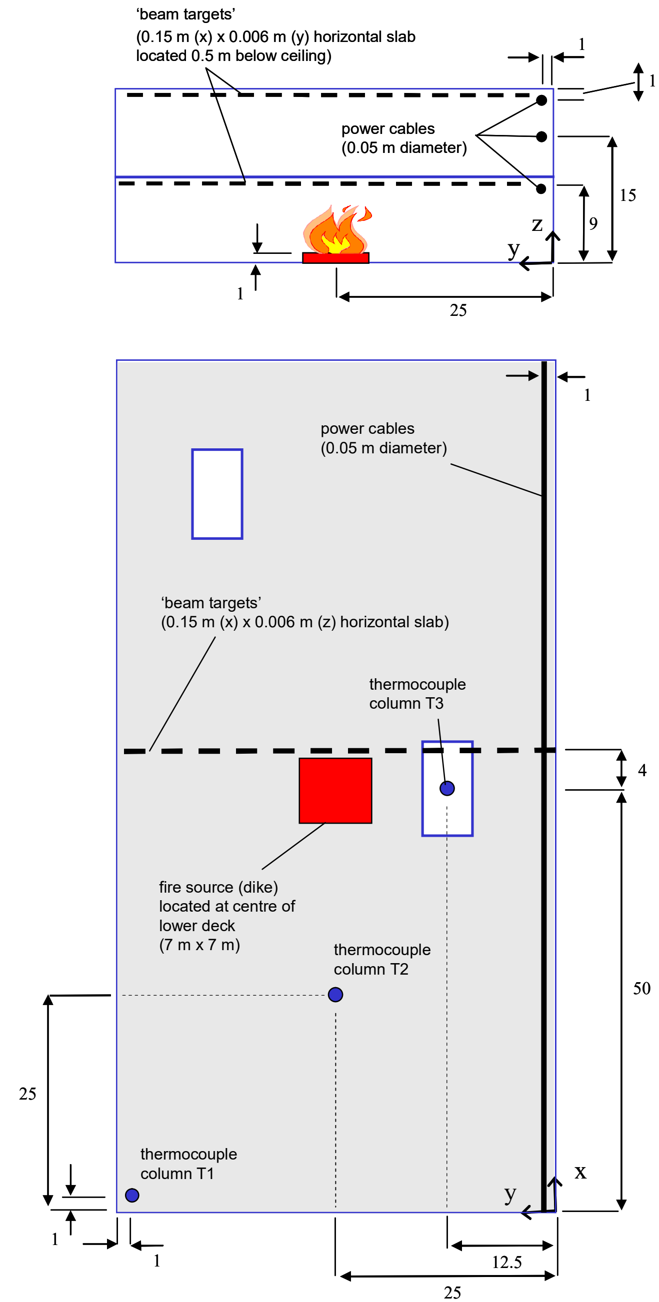
- Five countries participated, typically 7 organizations exercised fire models
    - **Germany – GRS, iBMB (COCOSYS, FDS, CFX, CFAST)**
    - **France – IRSN, EdF, CTICM (FLAMME-S, MAGIC)**
    - **UK – BRE (JASMINE, CFAST)**
    - **USA – NRC, NIST (CFAST, FDS, FDTs)**
- 10 organizations participated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

ICFMP Benchmark Exercise No. 1 – Cable Tray Fires



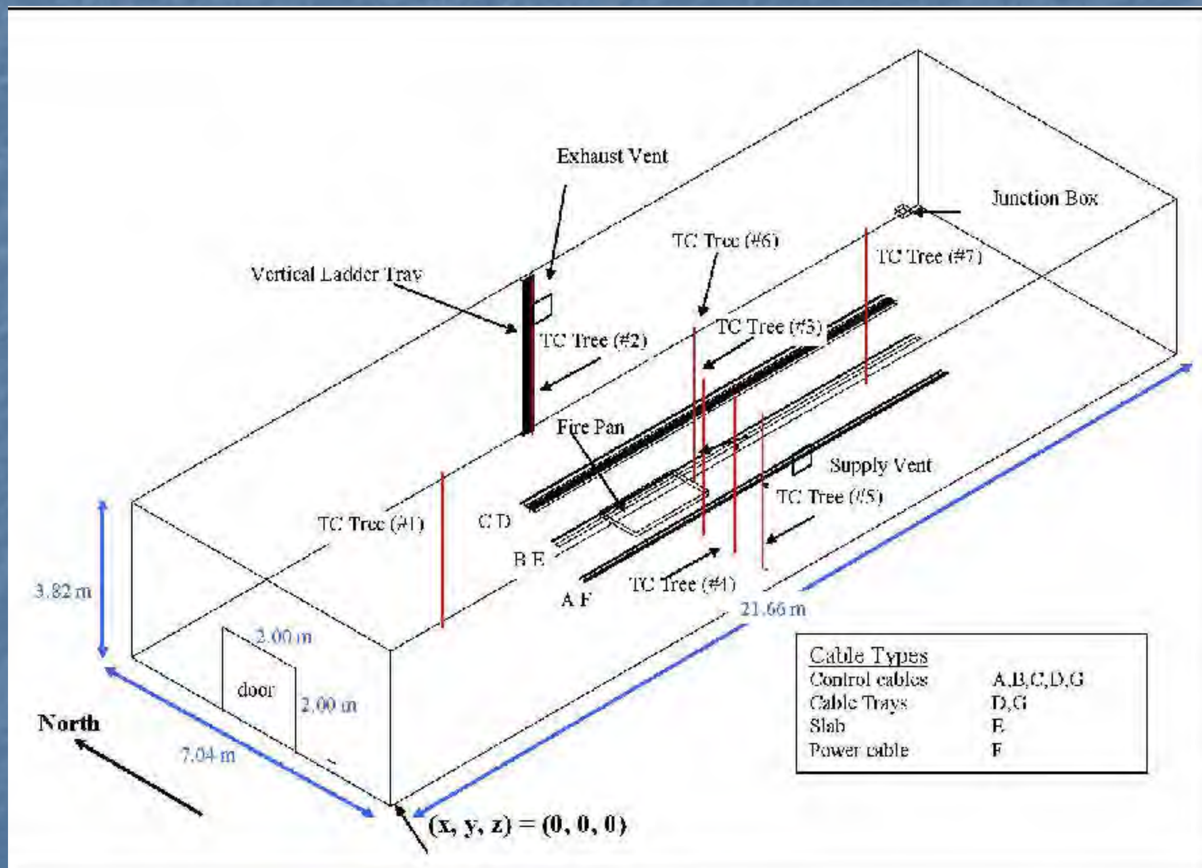
ICFMP Benchmark Exercise No. 2 – Pool Fires in Large Halls





'beam targets'
(0.15 m (x) x 0.006 m (y) horizontal slab
located 0.5 m below ceiling)
power cables
(0.05 m diameter)
1
1
15
9
z
y
1
25
1
power cables
(0.05 m diameter)
'beam targets'
(0.15 m (x) x 0.006 m (z) horizontal slab)
thermocouple
column T3
4
fire source (dike)
located at centre of
lower deck
(7 m x 7 m)
thermocouple
column T2
50
25
thermocouple
column T1
x
y
1
1
12.5
25

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



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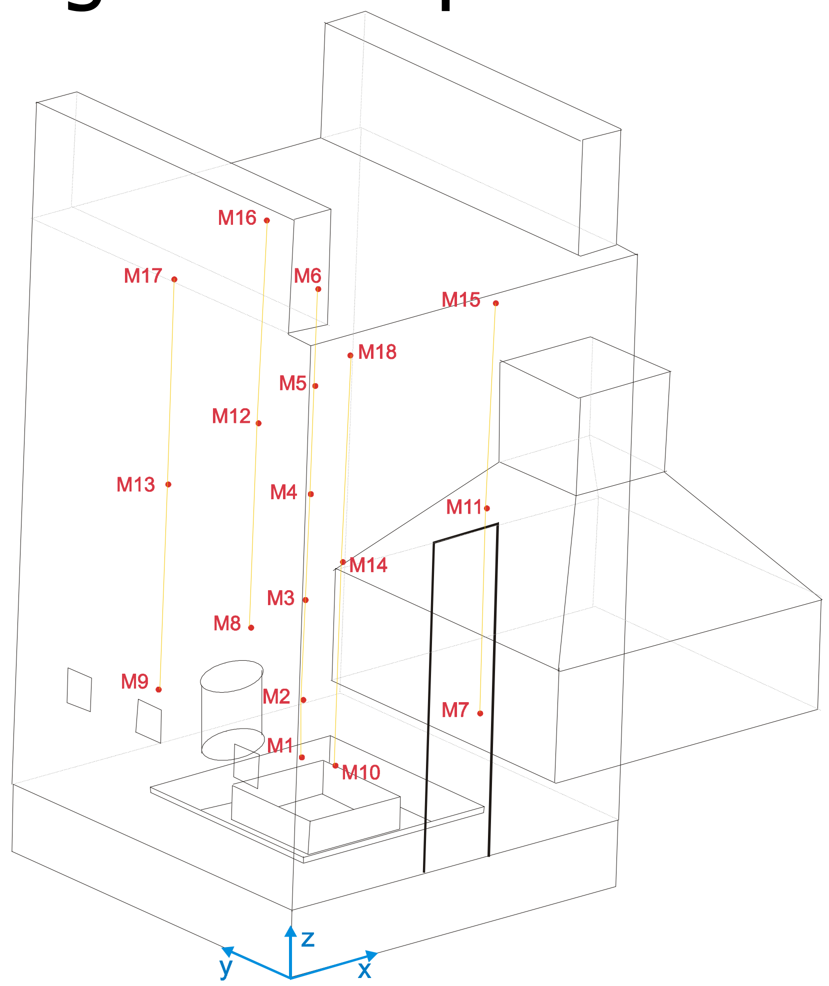
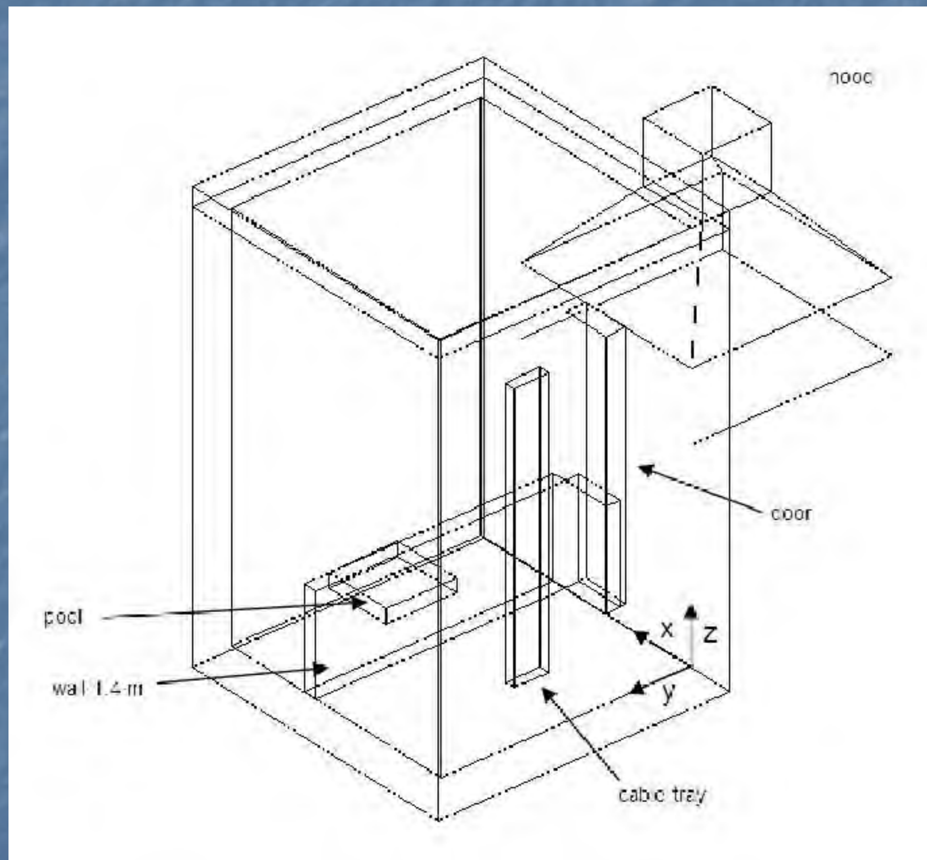
ICFMP Benchmark Exercise – No. 4
Large Fire Experiments



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



Recommendations from ICFMP for Enhancing V&V Standards

- Establish measurement methods & values for input parameters for fire calculations
- Establish option for "blind" & 3rd party validation in international standards
- Goal is to increase quality assurance
- Details presented at 9th Int'l Conf. on P-B Codes & Fire Safety Design Methods, June 2012, Hong Kong

Initiatives at ISO TC 92 Fire Safety Committee

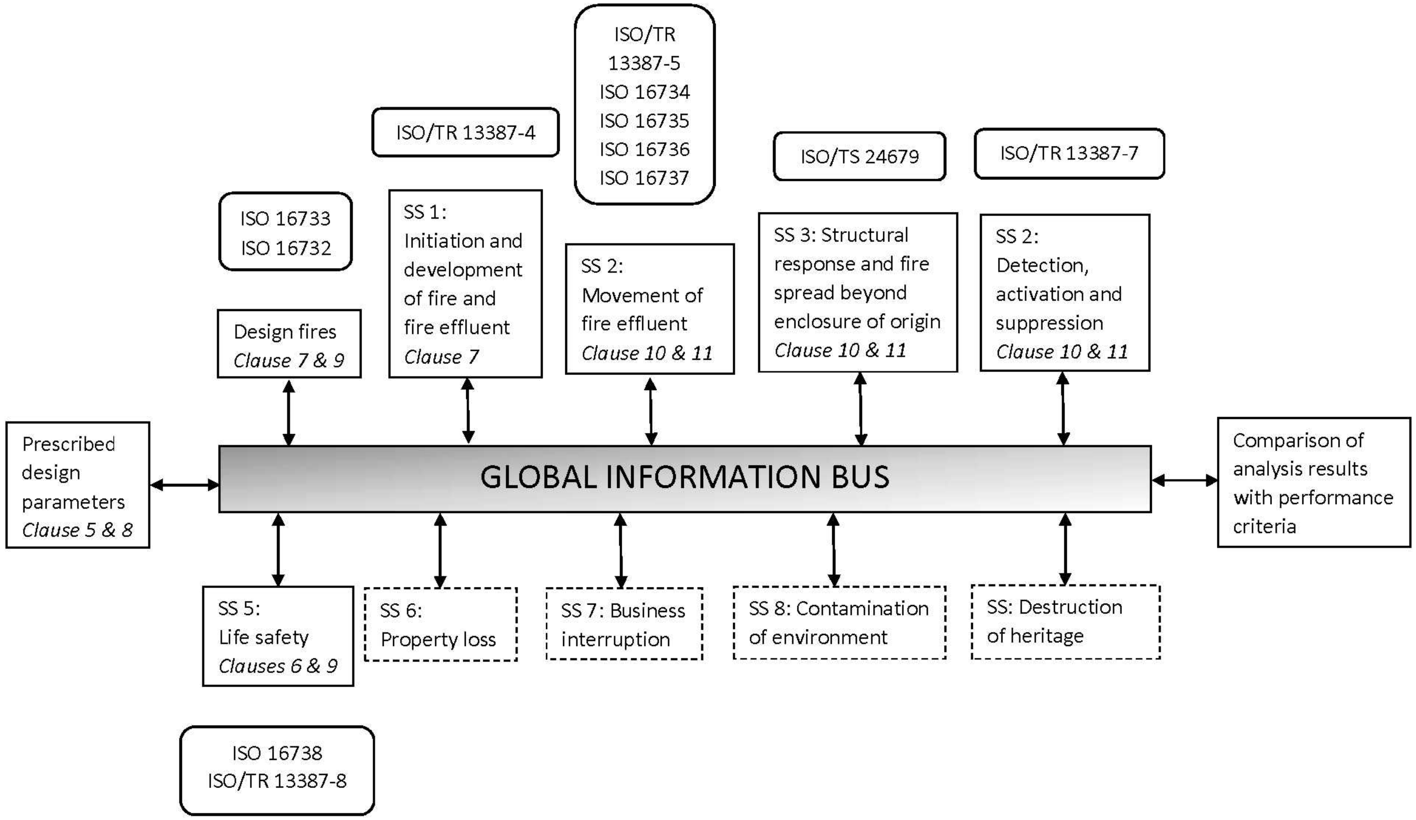
- Presented work of ICFMP & Deytec, Inc. to ISO TC 92 in 2009-2011
- Presently serving as United States Delegate to ISO TC 92 SC4
- Initiatives for fire safety engineering standards ongoing

Initiatives at ISO TC 92 Fire Safety Committee

- Initiatives
  - Integration of ISO Fire Safety Engineering Standards for Performance-Based Applications
  - Revision of ISO Standard for Verification and Validation of Fire Safety Calculation Methods
  - ISO Standard for Nuclear Power Plant Fire Safety

Integration of ISO Fire Safety Standards for FSE

- ISO/TR 13387 FSE series (8) published in 1999
- 12 new ISO standards published since
- Project goals:
  - Integrate new standards
  - Identify data flow and provide data needed
  - Global Fire Safety Engineering Analysis and Information System
- O



Global Fire Safety Engineering Analysis and Information System

Integration – Cont'd

- ISO/TR supplement to General Principles standard – ISO 23932 (to be revised also)
- ISO initiative following global trend
- Benefits:
  - Standards more usable for engineers
  - Less engineering resources needed
  - Compliance more readily determined
  - Reduced uncertainty & spread in results

ISO Standard for V&V of Fire Calculation Methods

- Goal is to enhance verification & validation process for fire calculation methods – revise ISO 16730
- Use lessons learned from ICFMP
- Include options for enhanced quality assurance: open, blind, 3rd party validation

ISO V&V Standard – Cont'd

- Address experimental data needs for V&V
- Benefits
  - Reduce uncertainty
  - Develop data for establishing safety factors
  - Increase quality assurance for P-B design
  - Increased confidence in P-B fire safety design

ISO Standard for Nuclear Power Plant Fire Safety

- Safety Objectives
  - Prevention of radiological release
  - Plant personnel safety
  - Power production interruption
- Use NFPA 805 as starting point
  - Improve by using material and referencing ISO FSE standards (global information bus)

ISO Standard for NPP Fire Safety – Cont'd

- Outline
  - Objectives and functional requirements for fire safety of nuclear power plants
  - Performance criteria for requirements
  - Design process for fire safety of nuclear power plants
  - Guidance on use of engineering methods & quality assurance

The Way Forward

- Can we keep the risk of serious accidents to a minimal level?
- Can we achieve a new level of fire safety?
- Prescriptive regulation still has major role to cover gaps in knowledge
- Standardization of PB methods necessary to achieve a new level of fire safety

The Way Forward – Cont'd

- Encourage participation in international standards development, e.g. ISO
- Recommend use of 2^{nd} generation fire safety standards for advanced buildings & facilities in Middle East
- Vigilance needed to minimize fatalities & property losses

Questions

- Questions and discussion welcome
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- Thank you.