Limitations Imposed on Fire PRA Methods as the Result of Incomplete and Uncertain Fire Event Data

Steven P. Nowlen, Sandia National Laboratories, Albuquerque NM, USA

and

J.S. Hyslop, U.S. Nuclear Regulatory Commission, Washington DC, USA

PSAM 10, Seattle WA, June 6-11, 2010

Fire Event Insights and Fire PRA

- **Fire probabilistic risk assessment (FPRA) has always relied on insights from actual fire events**
- **Direct applications:**
  - **Estimation of fire occurrence frequencies**
  - **Manual fire fighting effectiveness and timing**
  - **Distribution of fire events by fire source and plant location**
- **Indirectly or qualitatively applications:**
  - **General nature and intensity of plant fires**
  - **Operator performance**
  - **Fire growth and damage behaviors**

Current status and planned improvements

- **Main data source: EPRI fire event database (FEDB)**
  - **Updates based mainly on voluntary reporting to Nuclear Electric Insurance Limited (NEIL)**
- **Database has a large body of fire events but reporting is incomplete:**
  - **Not all utilities report events to NEIL**
  - **Event details lacking for many events that are reported**
- **Efforts to update and improve data are underway**
  - **An EPRI – NRC/RES collaboration**
- **The purpose here is to discuss how fire PRA could benefit from more robust event data**

Ignition frequency – risk-relevant fires

- One question that must be answered is: Of the fires reported, which are relevant to the FPRA analysis?
- Many reported fires are not of interest for various reasons:
  - Location (e.g., outside the plant boundaries)
  - Plant mode (e.g., construction)
  - Not really a fire (e.g., "smoked relay" or overheating component)
- Being able to sort out the relevant fires requires details that are often lacking
- Lacking details, we are left with uncertainty

Ignition frequency – fire event grouping

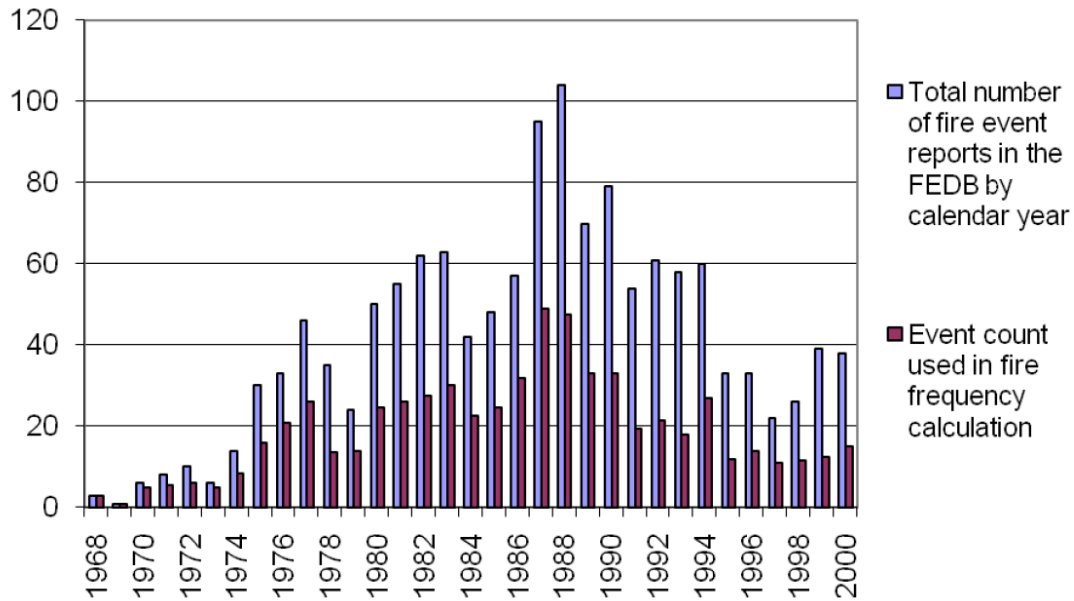
- We refine fire frequency estimates by sorting fire events by source and/or location
- We are currently limited to rather broad groupings:
  - Pumps (oil/electric), motors, transients, welding/hot-work…
  - Electrical cabinets…
- With more complete reporting of event details, we could refine further – ex: electrical cabinets:
  - Control cabinets, power distribution
  - Power distribution:
    - Load center, motor control center, switchgear, breaker…
    - Low – medium – high voltage…
- Refined estimates would again reduce uncertainty and allow for a more detailed focus on risk-important fire sources

Ignition frequency – incomplete participation

- **Reporting is largely voluntary, and not all utilities volunteer**
  - **The vast majority of fire events in the EPRI database were reported by a minority of the plants**
- **We are not confident that the majority of our plants have never had a fire that would be relevant to our assessment of fire risk**
- **Wider participation would not only add data, but would add confidence**

Ignition frequency – trends

- **Question: Are plants seeing fewer fires today than they did 10 or 20 years ago?**
- **Answer: It seems that way, but our lack of confidence in the current database reduces our confidence in the validity of that conclusion**

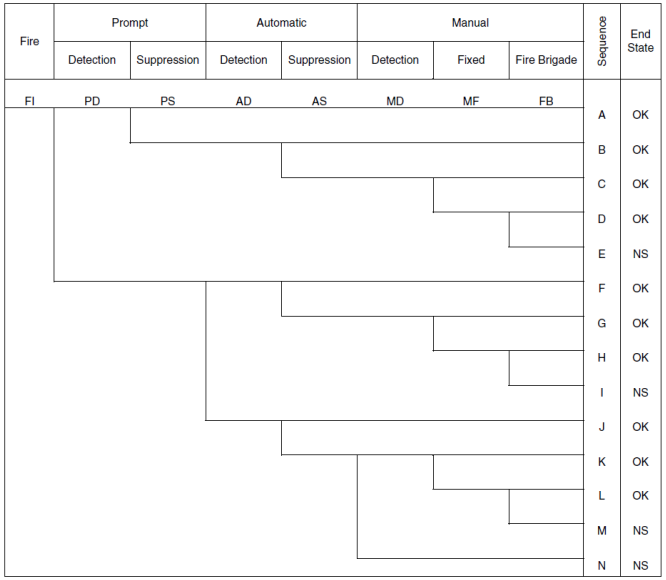


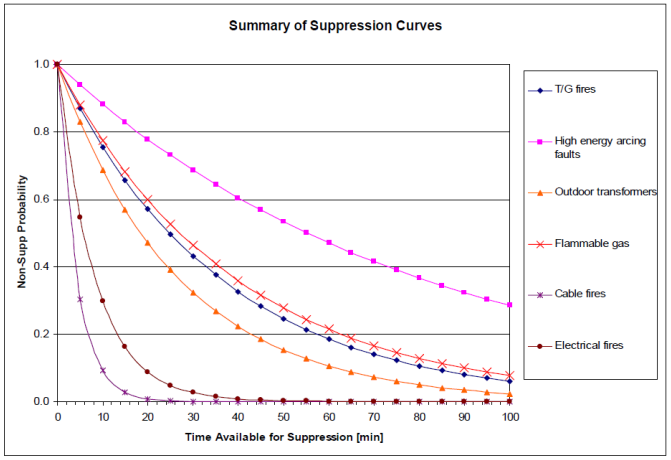
Analysis tools – incipient detection

- **Relatively new technology now finding its way into U.S. NPPs**
- **Current FEDB reflects experience without these systems (pre-2000)**
- **These systems *should* reduce fire frequency *where installed***
  - **An interim analysis approach treats accordingly**
- **Fire PRA challenges going forward:**
  - **How do we ensure that credit goes to installed locations (rather than being spread over all plants and all locations)?**
  - **What is the appropriate way to reflect system credit (extend the fire time line, reduce fire frequency, or…)?**
- **Once again, data will be the key!**
  - **How are these systems performing - how reliable are they?**
  - **How many alert signals, what was response, what was found?**
  - **In effect – how many fires are these systems preventing?**

Manual fire fighting

- **Most fires extinguished by plant personnel**
- **Manual fire fighting credit key to FPRA**
- **Current models relatively simplistic**
- **Refinement would benefit fire PRA, but we need more information on actual performance:**
  - **Fire detection: who/what/when?**
  - **First response: who/when, what did they find?**
  - **Was an initial attack made, how, and did it succeed?**
  - **When did the fire brigade arrive and what did they do?**





Fire growth and damage behaviors

- **Actual fires could tell us much about fire growth and damage, but reports rarely provide much detail**
  - **Most reports focus on plant operational response, not the fire itself**
  - **If a fire causes loss of a safety system, that will typically be reported**
  - **General extent of fire damage is not typically discussed**
- **One key challenge is FPRA practice – we decouple fire growth and damage analysis from fire suppression analysis**
  - **Real fires don't work that way – fire don't grow unchecked, intervention begins as quickly as possible**
- **Very difficult to reconstruct fire growth and damage timeline**
  - **When did fire ignite (e.g., relative to time of detection)**
  - **What were fire conditions at time of first observation**
  - **What would have happened if there had been no intervention**

Other topics…

- **Cable failure modes and effects**
  - **Can we tell how cables responded to fire exposure (e.g., spurious actuations, impact on instruments, etc.)?**
- **Smoke effects**
  - **Do we have evidence that smoke has caused the failure of equipment or systems?**
  - **What effect has smoke had on plant personnel and their response to a fire?**
- **Fire HRA**
  - **How do operators interpret fire impact on plant systems?**
  - **How do they respond?**
  - **What decisions do they make in responding to a fire and how did they make those decisions?**

Summary

- **Fires are not uncommon events, and each fire that occurs provides and opportunity for us to learn**
- **Lessons from fire events could help fire PRA**
  - **Refined methods of analysis**
  - **Reduced uncertainty**
  - **More realism (less conservatism)**
- **The key to learning from event will be better data**
  - **Broader participation in voluntary reporting**
  - **More complete reports (fill in all the fields!)**
  - **More attention paid to reporting fire behaviors (growth and damage)**
  - **Better timing information (building the timeline…)**
- **NRC and EPRI are trying to improve the FEDB – they need the support of the utilities to succeed**