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UNITED STATES NUCLEAR REGULATORY COMMISSION
Protecting People and the Environment

Office of Nuclear Regulatory Research (RES) Meeting with Very Early Warning Fire Detection System (VEWFDS) Vendors

RES Offices

Rockville, Maryland

May 16, 2013

Office of Nuclear Regulatory Research

Fire Research Branch

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Welcome, Introductions, Purpose of Vendor Meeting

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May 16, 2013

Office of Nuclear Regulatory Research

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Purpose of Vendor Meeting

- Gain a Better Understanding of Vendors VEWFDS Systems:
  - How they work, system capabilities
  - How they are designed, installed, calibrated, tested and maintained
  - Quality Assurance (QA) of the systems
  - Nuclear Power Plant (NPP) applications

NPP Concept of Fire Protection Defense-in-Depth

- To Prevent Fires from Starting
- To Detect Rapidly, Control and Extinguish Promptly those Fires that do Occur
- To Provide Protection for Structures, Systems, and Components (SSC) important to Safety so that a Fire that is not promptly Extinguished by the Fire Suppression Activities will Not Prevent the Safe Shutdown of the Plant

Classical Fire Protection vs. Risk-Informed Performance-Based

- VEWFDS would meet Second Concept of Defense in Depth
  - Follow the NFPA Codes
- However……
  - Licensee are claiming much more credit and in fact crediting the VEWFDS as First Concept of Defense in Depth, i.e., Fire Prevention

The Reason for the NRC VEWFDS Research Program

- Does the VEWFDS Technology Currently Exist such that Today's Systems can Reliably Detect the Pre-Combustion Signature of an Impending Incipient Fire and NPP Operations Staff have Adequate Time to take Appropriate Corrective Actions to Prevent the Fire?
- <u>This is the Question we Seek to Answer</u>.

Reasonable Assurance

- How do we (NRC) assess VEWFDS will meet these claims?
- Types of Fires Detected (Prevented?)
- Reliability, Availability, Maintainability (RAM)
- Human Element
  - Human Factors (HF)
  - Human Reliability Analysis (HRA)
- Probability Risk Assessment (PRA)
  - Proper Credit of VEWFDS Instalation?

Fair and Honest Evaluation

- NRC has No Vendor Preference
- Goal is Reasonable Assurance the VEWFDS meet the Safety Goals
- Please Review QA Requirements of Generis Letter (GL) 82-21
- Do not want to repeat a Fire Barrier Failure Issue like Thermo-Lag GL 92-08 or Hemyc GL 06-03

Summary

- Thank You for taking the time to meet with us today
- Open and Honest Communication
- Productive Vendor Meeting
- Help us arrive at the correct Technical Solution
- Advance the State of the Art (if possible)
- NPP Safety

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Overview of Project

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How did we get here?

- Browns Ferry Nuclear Power Plant Fire (1975)
- NRC Deterministic Fire Protection Regulations (1981)
  - 10 CFR 50.48, Appendix A GDC 3 to Part 50, Appendix R to Part 50
- NFPA Standard 805 (2001)
  - Performance-Based Standard for Fire Protection for Light Water Reactor Electric Generating Plants
- NRC codified [10 CFR 50.48(c)] use of NFPA 805 as voluntary alternative to deterministic requirements (2004)
- NRC-RES and EPRI issue NUREG/CR-6850 (EPRI 1011989)
  - State of the art method for conducting a Fire Probabilistic Risk Assessment (PRA)

How did we get here? (cont.)

- Two Pilot Plants
  - Harris and Oconee
- NRC NFPA 805 Frequently Asked Question (FAQ) Process
  - Purpose is to provide a mechanism for resolving interpretation issues with NFPA 805 implementation
  - Defined in NRC Generic Communication
    - Regulatory Issue Summary (RIS) 2007-19, “Process for Communication Clarifications of Staff Positions Provided in Regulatory Guide 1.205 Concerning Issues Identified During the Pilot Application of NFPA 805”

How did we get here? (cont.)

- FAQ 08-0046 initiated by Industry (4/2008)
- EPRI 1016735 published (12/2008)
  - NRC didn't endorse
- NRC issues draft position (6/2009)
- NRC closes FAQ 08-0046 (12/2009)
  - Interim Staff Position
- NRC-RES confirmatory research requested (6/2010)
- NIST contracted to complete experimental work (6/2011)

Project Focus

- Quantification of risk reduction provided by ASD VEWFDS
  - Operating Experience
    - Site Visits (Nuclear and Non-nuclear)
  - Literature Review
  - Testing
    - In-cabinet, area wide, main control room, air returns
  - Human Reliability Evaluation, Human Factors

Project Success

- Final product must provide a technically sound basis and evaluation of this technology
- Applied Research
- Manufacture independent
    - Generic - ASD VEWFDS

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Needs from Today's Meeting

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INFORMATION

PRA → Realism

Technical Basis

Advance the state of knowledge

- Areas with low state of knowledge
  1. Engineering design guidance for NPP applications
     - Electrical enclosure, area wide, air return, main control room, cable tray system
     - Minimum individual sampling port sensitivity
     - # of cabinets per zone
     - Compartment height vs. levels of detection
     - How can licensees insure they meet NFPA 76

PRA interest = System Response Time

Advance State of Knowledge (cont.)

2. Component failure mechanisms and failure sequence
   - Electronic components (relays, electrical cable and wire, circuit cards, individual electronic components, e.g., resistors, capacitors, integrated circuits, power supplies, etc.)
   - Motors, pumps, heaters, other large electrical devices
   - Components difficult to detect during incipient phase?

PRA interest = Time Available

Advance State of Knowledge (cont.)

3. Technology used to identify incipient source
   - Thermography or Portable ASD
     - Any guidance on use and effectiveness
     - Best practices
     - Training
     - Sensitivities

PRA interest = Operator Response

General Needs

- Operating Experience
  - Documentation to support claims on ability of system to detect/prevent fires;
    - hours, days, weeks in advance
  - Cases where systems fail to meet their purpose
  - Component failure mode degradation sequence data and/or studies

Vendor / Industry Testing

- Support literature review
- Test configurations of interest for NPP applications
  - Electrical enclosures
  - Area wide
  - Cable tray
  - Air Returns
  - Main Control Room

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Overview of Fire PRA applications for use of Very Early Warning Fire Detection Systems (VEWFDS)

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May 16, 2013

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NUREG/CR-6850, EPRI 1011989

- State-of-the-art methods, tools, and data for a probabilistic risk assessment (PRA) for commercial nuclear power plant (NPP) application
- Methods used are expected to form a basis for risk-informed analysis related to the plant fire protection program

PRA Methodology

- $CDF = \lambda \times p_{compnent\ damage} \times p_{core\ damage}$

Where:

- λ_i = Frequency of fire scenario
- $\mathrm{p}_{component\ damge}$ = probability of damage to “target set”
- $\mathrm{p}_{Core\ dmaage}$ = Conditional probability of core damage due to plant response

PRA Methodology

- The first term accounts for the likelihood that a fire will occur
- The second addresses the likelihood that the fire will not be suppressed prior to component damage
  - severity of the fire
  - fire growth
  - detection
  - Suppression
  - Component damageability

The third term, often referred to as the Conditional Probability of Core Damage (CCDP), addresses the ability of the plant to achieve safe shutdown given the loss of equipment damaged by the fire. Analysis of this term also requires treatment of the unavailability or random failure of equipment unaffected by the fire and the treatment of potential errors by plant operators.

NUREG-6850; Appendix P Current Guidance

- Incipient stage is assumed to have a duration of 5 minutes
- In cabinet use only
- the failure probability of the system should be considered.
- These 5 minutes should be added to the time to target damage (or, equivalently, add them to the time available for suppression).

NUREG 6850 Supplement 1 FAQ(08-0046) Current Guidance

- NRC staff interim position
- Based on the staff's best engineering judgment with limited in-cabinet experimental data

NUREG-6850; Appendix P Current Guidance

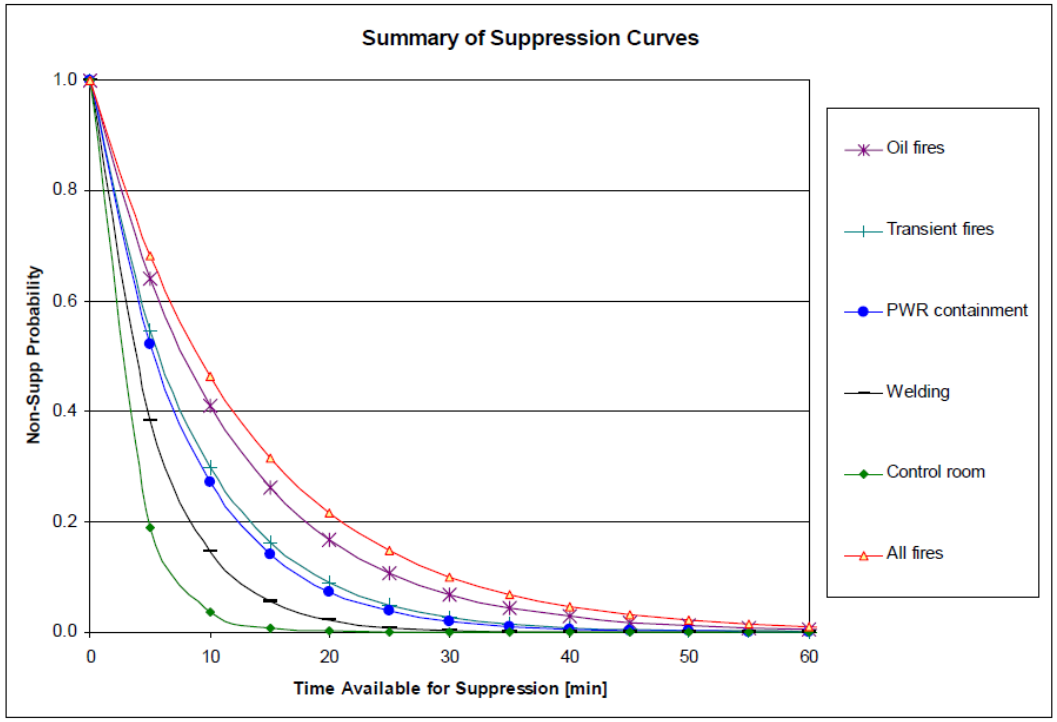
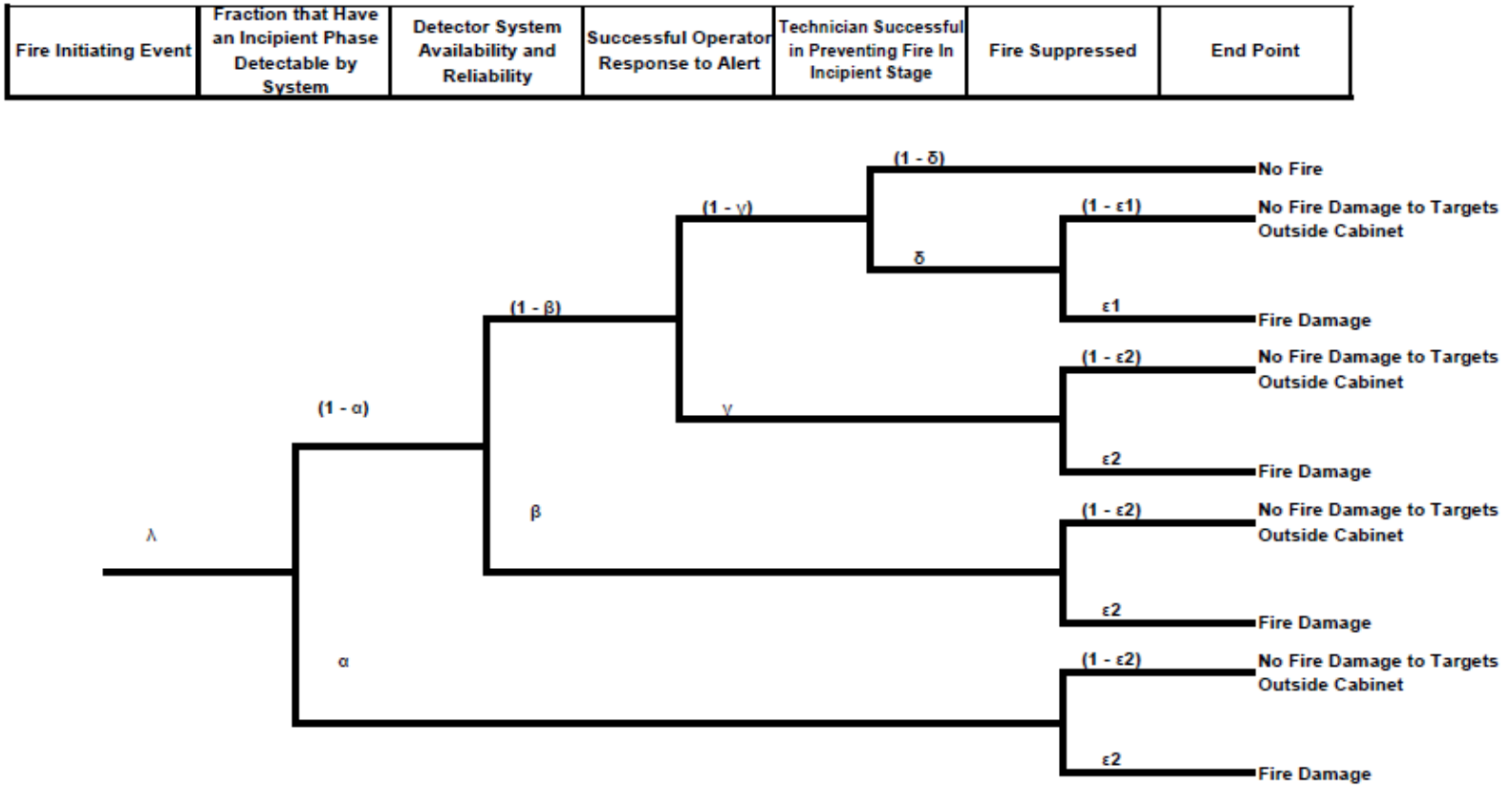


Figure P-2
Summary of Suppression Curves

NUREG 6850 Supplement 1 FAQ(08-0046) Current Guidance

- ASD VEWFDS must meet requirements of NFPA 76
  - Two sensitivity criteria based on NFPA 76
    - Alert thresholds of at least 0.2 percent per foot obscuration (effective sensitivity at each port)
    - Alarm thresholds of at least 1 percent per foot of obscuration(effective sensitivity at each port)
- Licensees are free to propose the use of other technologies that meet these sensitivity requirements, but additional information/justification will be required

NUREG-6850 Supplement 1



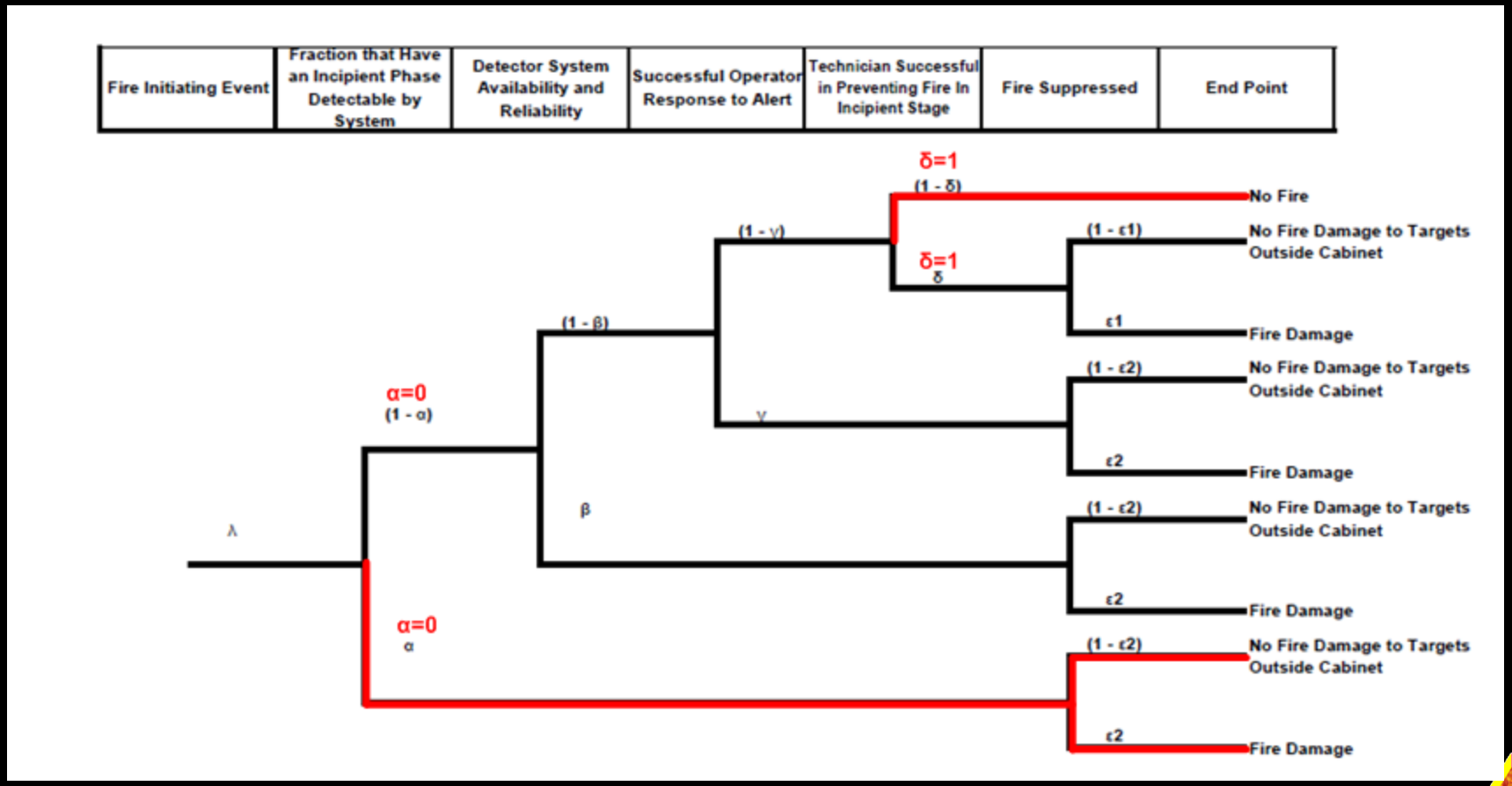
VEWFDS Contributing Factors

- Detection System Availability and Reliability (β)
  - EPRI 1016735 process or set equal to 1E-02
- Successful Operator Responses to Alert (γ)
  - human reliability analysis (HRA) based
  - 1E-02 if addressable to multiple cabinets
  - 5E-03 if addressable to an individual cabinet
    - assumes at least one hour of warning prior to the actual outbreak of an open flaming fire

VEWFDS Contributing Factors

- Technician Successful in Preventing Fire in Incipient Stage (δ)
  - Set to 1 or unless an adequate detailed human reliability analysis is provided
- Fire Suppressed (ε1, ε2)
  - ε1, the probability of "enhanced" non-suppression, 1E-03
  - ε2, the probability of "normal" non-suppression, should be taken from the Detection Suppression Event Tree in NUREG/CR-6850, Appendix P

NUREG-6850 Supplement 1



Questions ?