A Perspective of Nuclear Power Plant Fire Safety

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OUTLINE

- Historical Perspective
- Fire Safety Requirements
- Challenges
- Goals

Historical Perspective

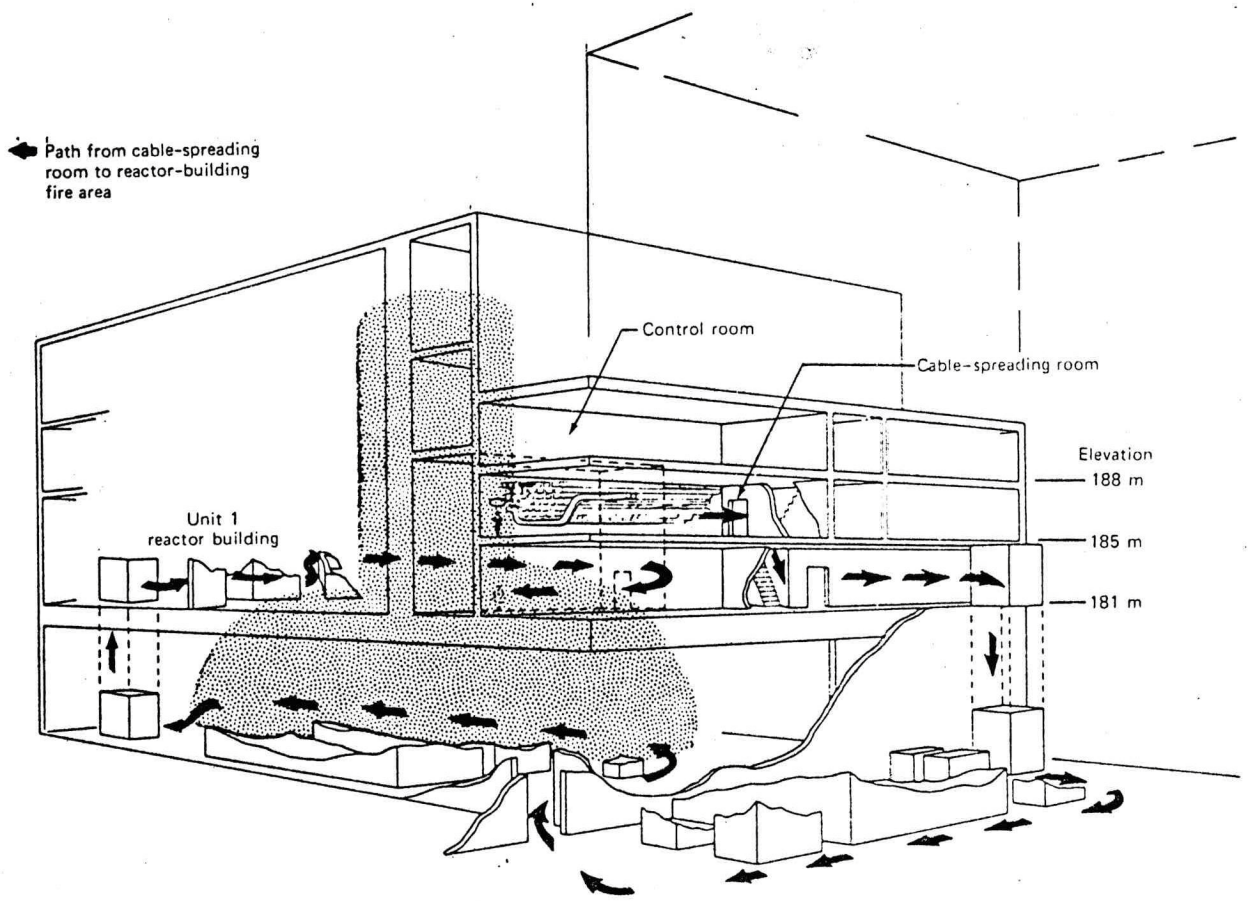
March 22, 1975

Browns Ferry (BFN) - Fire

- Damaged many cables(~ 1600 cables) which resulted in undesired operation of equipment and instrumentation
- Caused many multiple spurious actuations
- Failed many safe shutdown components
- Demonstrated inadequacies in regulatory framework

Browns Ferry

Browns Ferry Unit 1 (BFN)



BFN – Area of the Fire

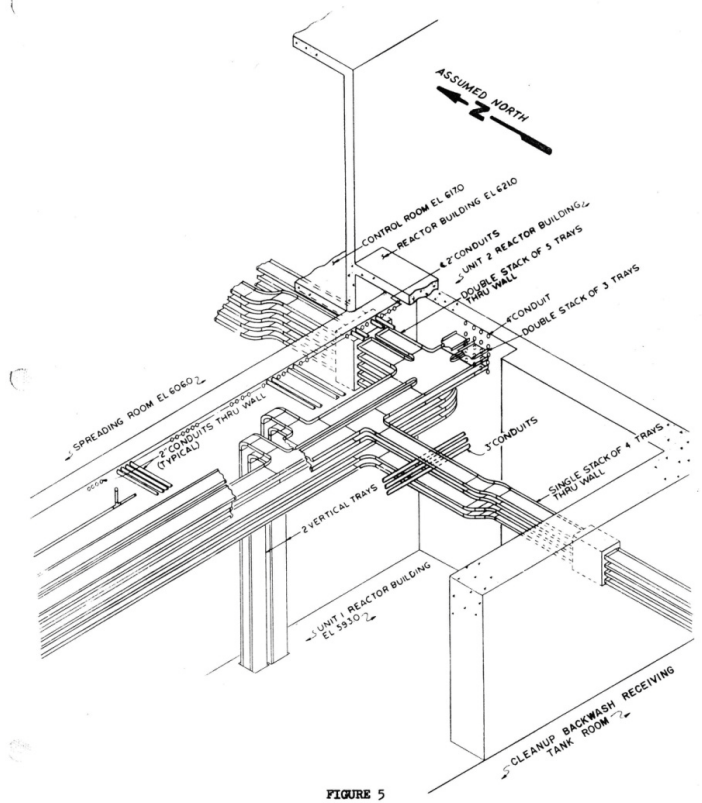
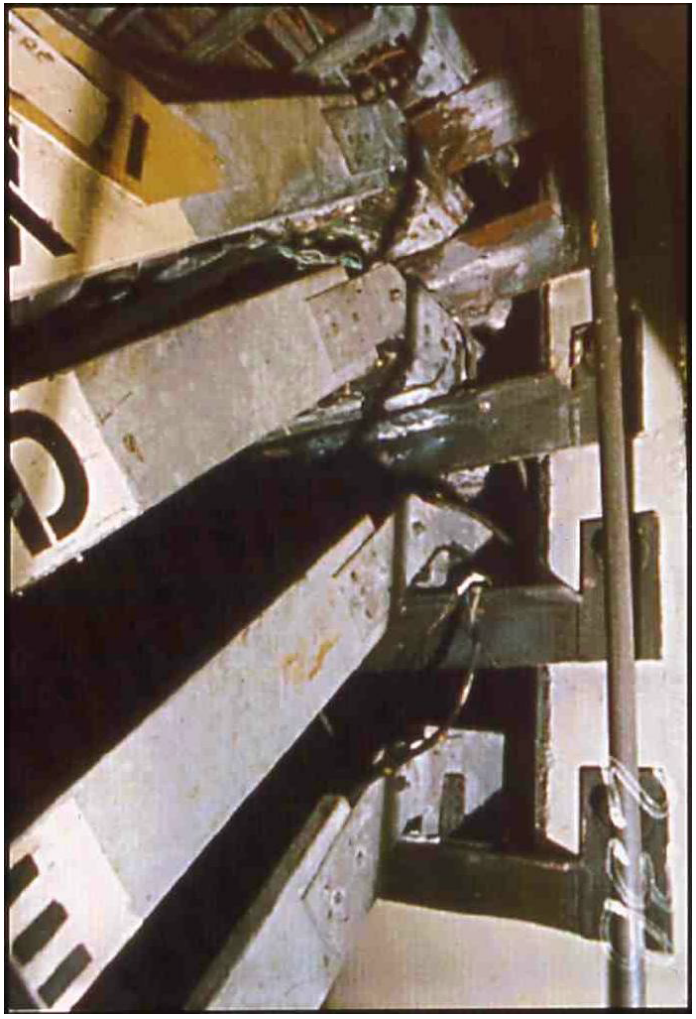


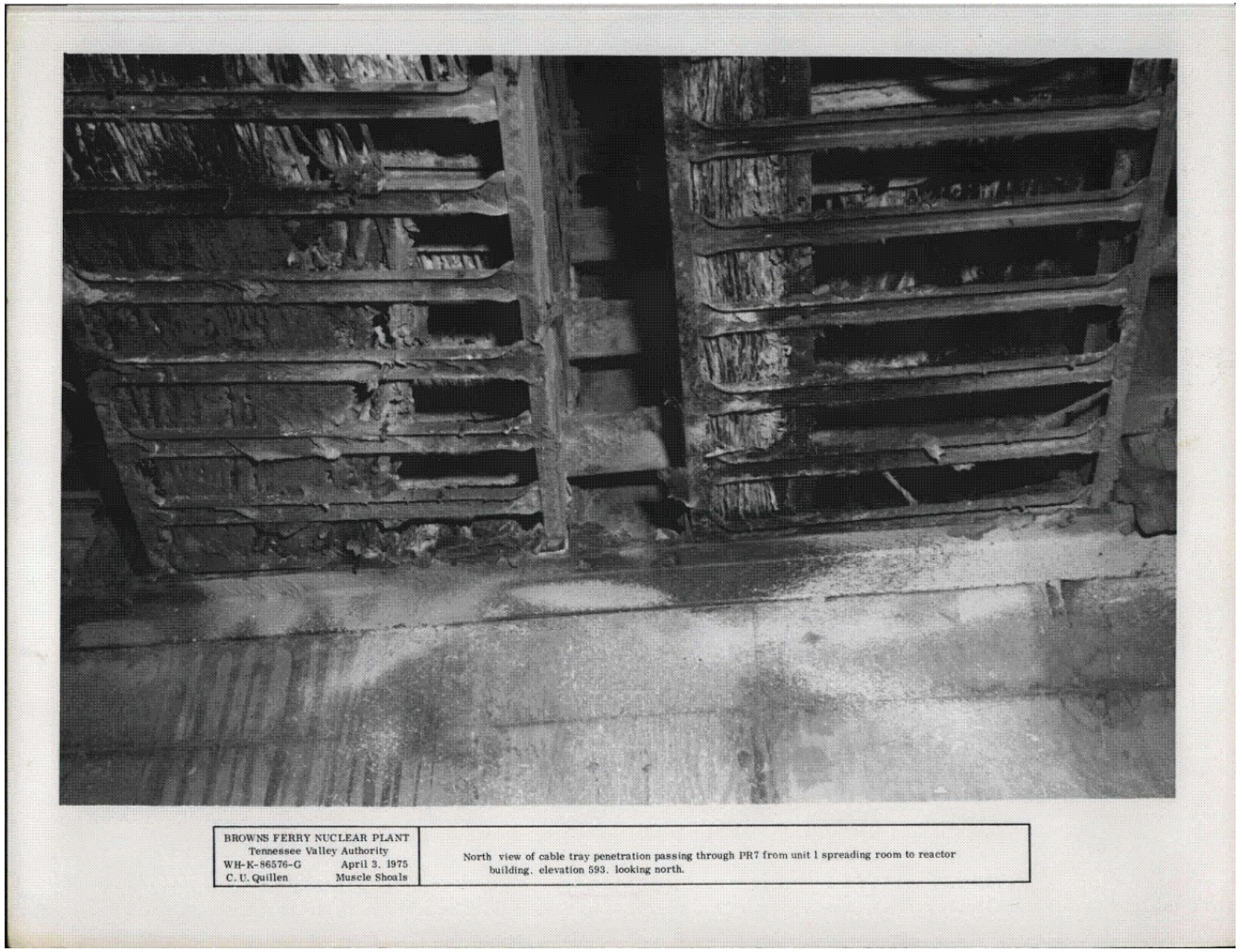
FIGURE 5

AREA OF FIRE

BFN - Penetration where Fire Started

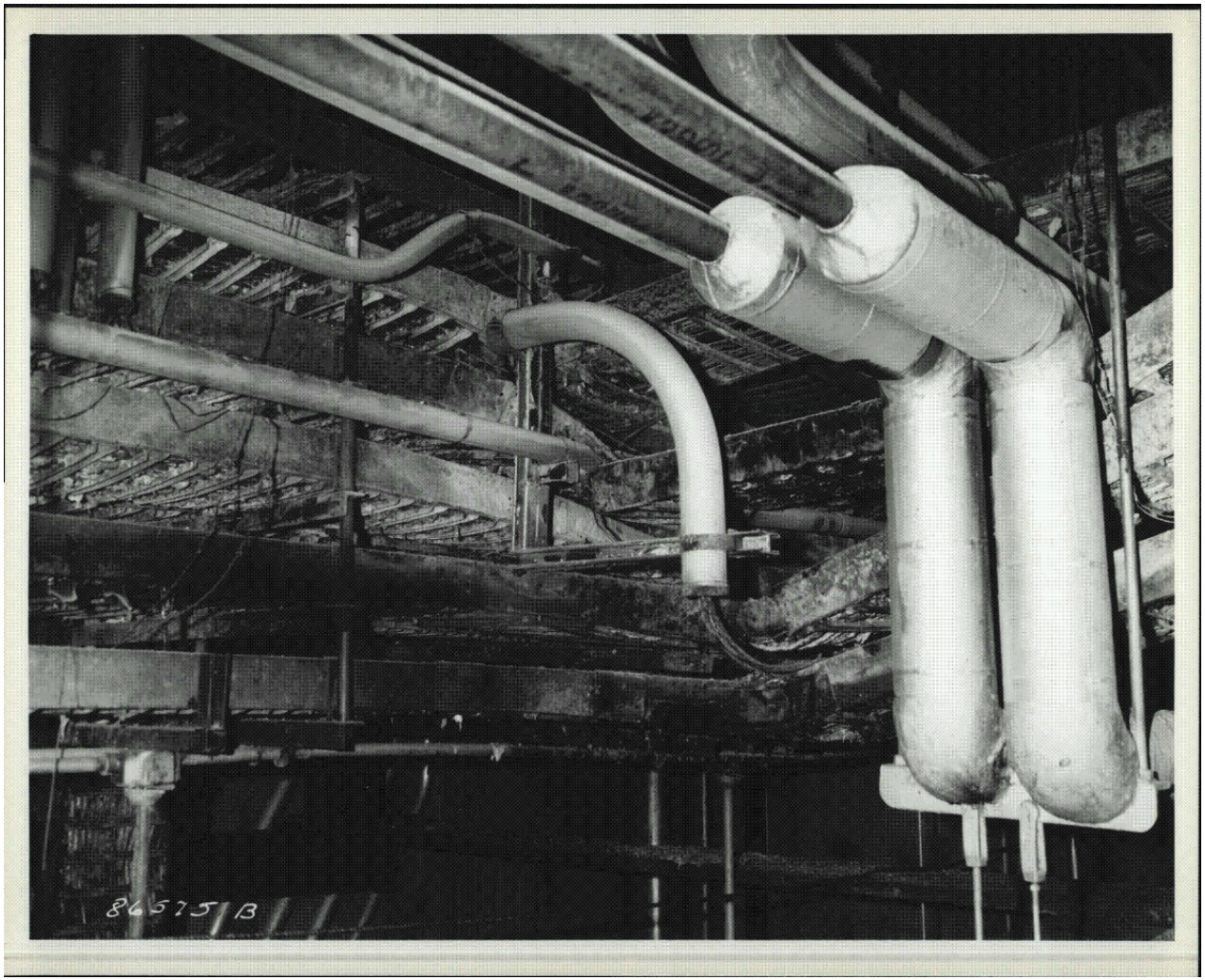


BFN – Cable Tray Fire Damage

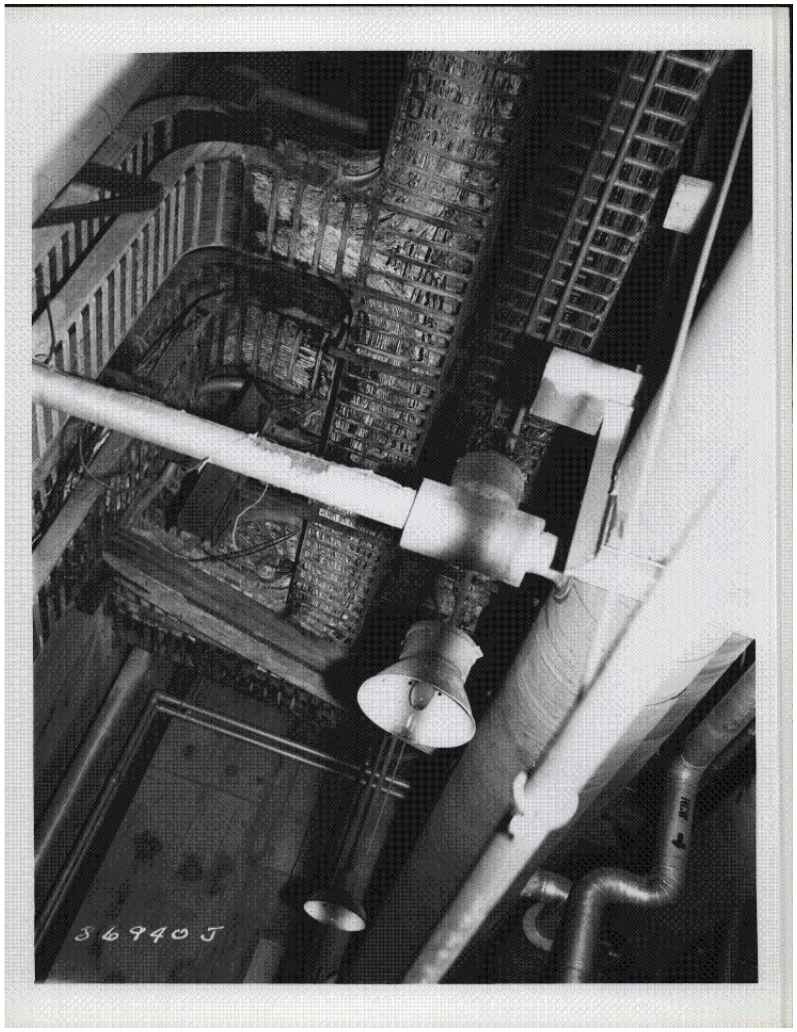


BROWNS FERRY NUCLEAR PLANT Tennessee Valley Authority WH-K-86576-G April 3, 1975 C. U. Quillen Muscle Shoals	North view of cable tray penetration passing through PR7 from unit 1 spreading room to reactor building, elevation 593, looking north.

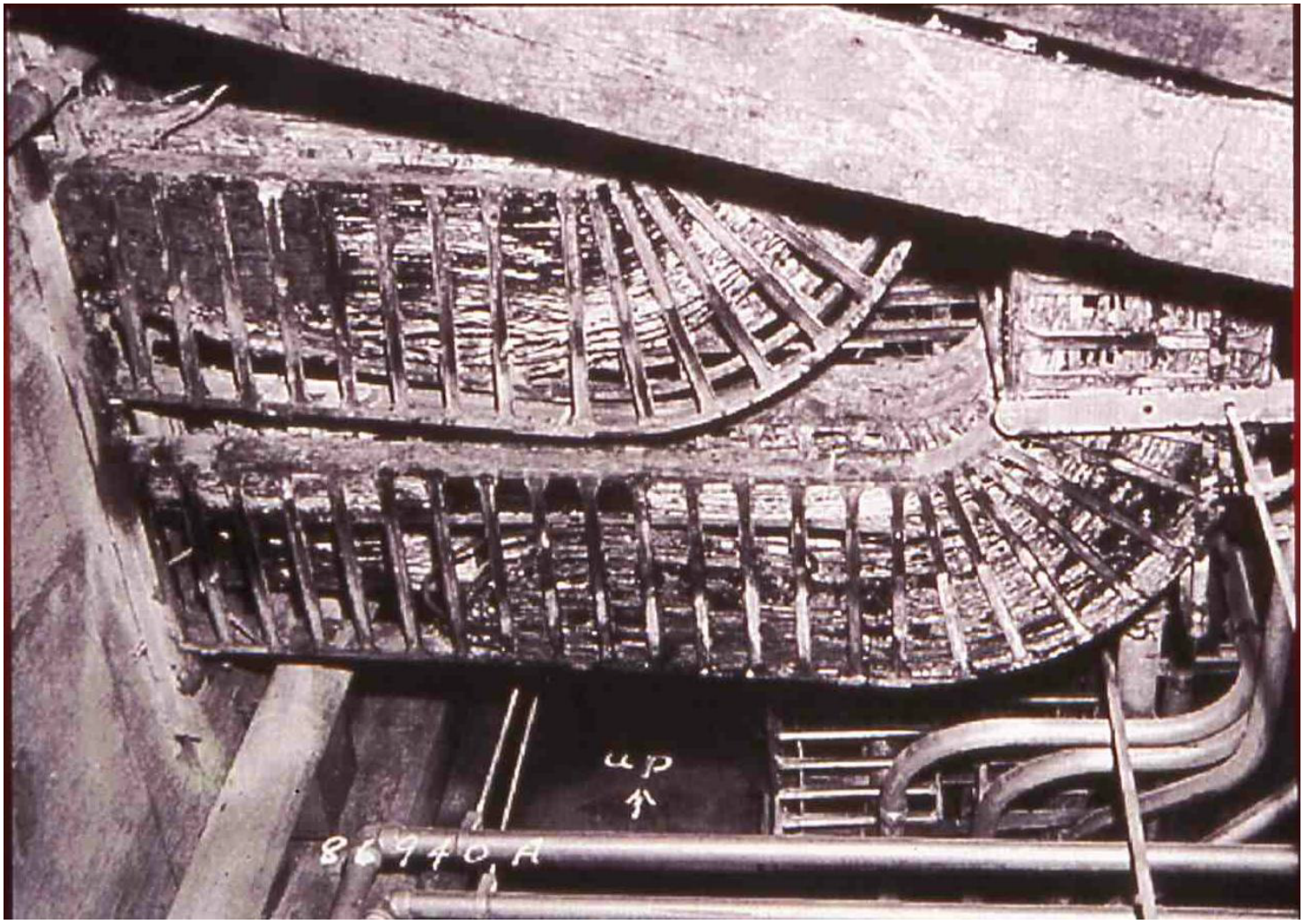
BFN – Fire Damage



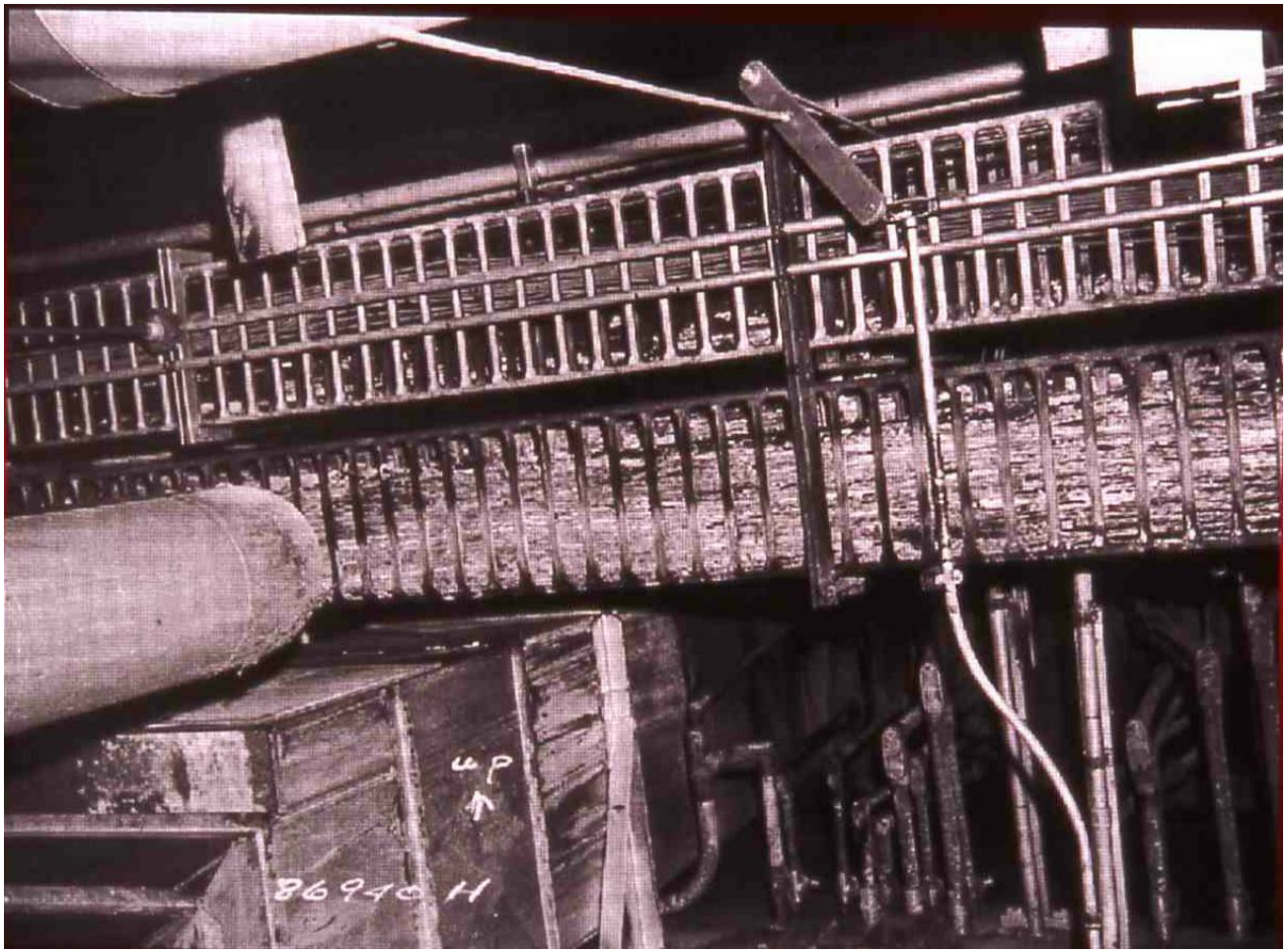
BFN – Fire Damage



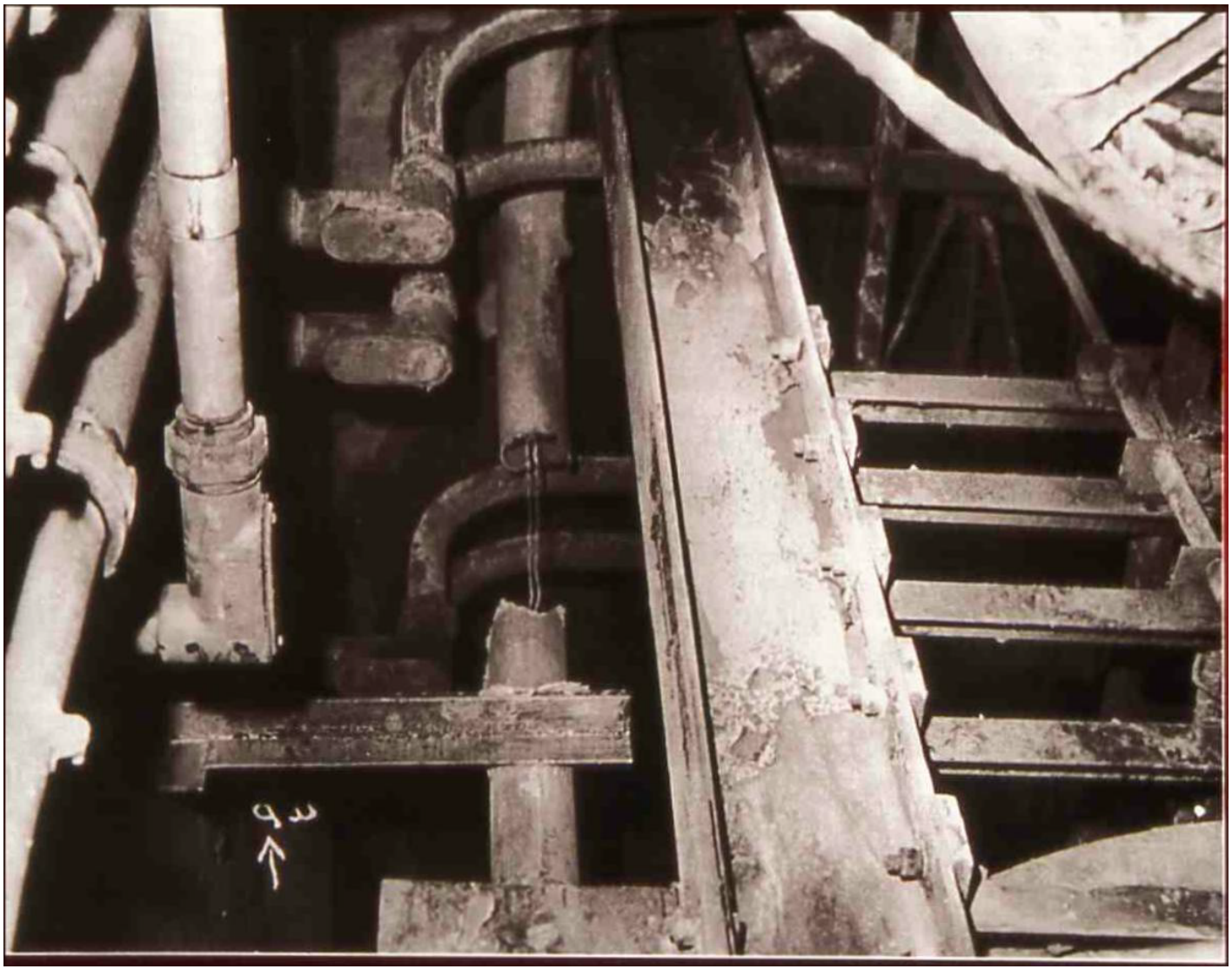
BFN - Fire Damage



BFN - Fire Damage



BFN - Melted Conduit



Historical Perspective

- Early nuclear power plant fire protection features were consistent with other large industrial facilities
- Fire loading at nuclear power plants primarily consists of cable jacketing/insulation and some lubricating oil

Historical Perspective the 1970's

- **1971**: 10 CFR 50 amended to add Appendix A, "General Design Criteria for Nuclear Power Plants"
  General Design Criterion 3 "Fire protection"
- **1975**: Browns Ferry Unit 1 fire
- **1976**: NUREG 0050, "Recommendations Related to Browns Ferry Fire"
- **1976**: Branch Technical Position (BTP) APCSB 9.5-1
- **1976**: Appendix A to BTP APCSB 9.5-1
- **Late 1970s/early 1980**: Fire hazards analyses by licensees

Historical Perspective the 1980's

- **1981**: 10 CFR 50 amended to add new section 50.48, "Fire Protection" and new Appendix R, "Fire Protection Program for Nuclear Power Facilities Operating Prior to January 1, 1979"
- **1981**: update to NUREG 0800, Standard Review Plan Section 9.5.1, Fire Protection Program (BTP CMEB 9.5.1)
- **1981/1982**: Generic Letter 81-12, "Fire Protection Rule – Appendix R
- **~1983**: Nuclear Utility Fire Protection Group and NRC Steering Committee on Fire Protection Policy
- **1986**: Generic Letter 86-10, "Implementation of Fire Protection Requirements"

Historical Perspective the 1990's

- **1991-1995**: series of Information Notices related to Thermo-Lag fire barrier systems
- **1992**: Bulletin 92-01: "Failure of Thermo-Lag 330 Fire Barrier System To Maintain Cabling in Wide Cable Trays and Small Conduits Free From Fire Damage"
- **1992**: Generic Letter 92-08, "Thermo-Lag 330-1 Fire Barriers"
- **1997**: Fire Protection Functional Inspection Program
- **1998**: Confirmatory Orders related to Thermo-Lag

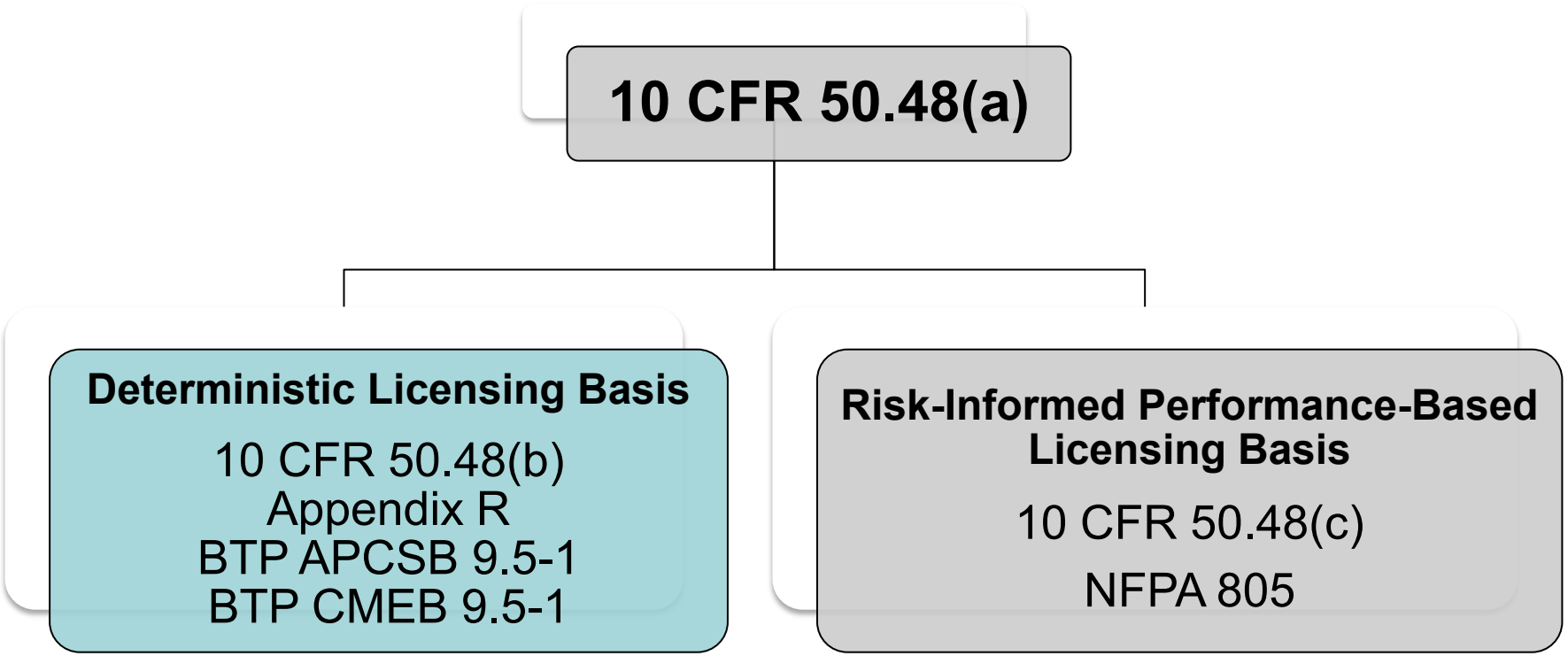
Historical Perspective the 2000's

- **2000**: new Reactor Oversight Process
- **2004**: 10 CFR 50 amended to add 50.48(c) "National Fire Protection Association Standard NFPA 805"
- **2005**: Oconee and Shearon Harris plants submit letters of intent to transition to NFPA 805
- **2006**: NRC withdraws proposed rule on post-fire operator manual actions
- **2006**: Generic Letter 2006-03, "Potentially Nonconforming Hemyc and MT Fire Barrier Configurations"
- **2008**: Oconee and Shearon Harris plants submit license amendments to transition to NFPA 805

Historical Perspective the 2010's

- **2010**: NRC issues Oconee and Shearon Harris plant license amendments to transition to NFPA 805
- **2012**: NRC completes approximately a dozen licensing actions for licensees to use post-fire operator manual actions
- **2011-2014**: NRC expects that approximately half of the operating fleet of reactors will have submitted license amendments to transition to NFPA 805

Fire Safety Requirements



10 CFR 50.48(b) and Appendix R

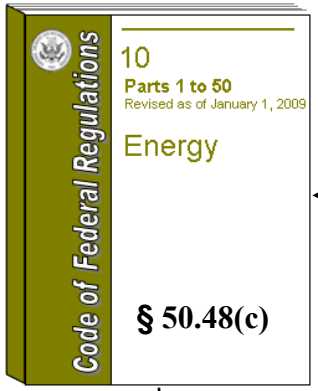
- Prescriptive requirements
- One set of equipment needed for safe shutdown protected by:
  - A 3 hour fire barrier; or
  - A 1 hour fire barrier with installed automatic detection and suppression systems; or
  - A separation of 20 feet with no intervening combustibles or fire hazards, with installed automatic detection and suppression systems; or
  - Alternate shutdown capability

10 CFR 50.48(c): NFPA 805

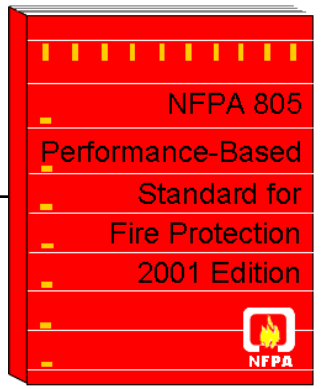
- An alternative risk-informed, performance-based fire protection program for existing nuclear power plants, that can replace the current deterministic fire protection program

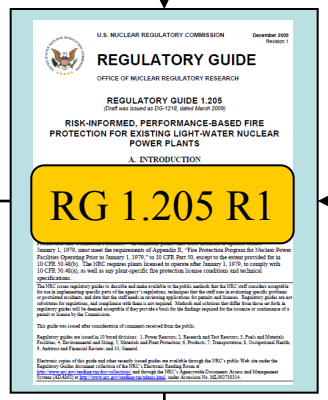
- The NFPA 805 fire protection program must meet specified performance criteria for nuclear safety and radiological release based on qualitative and quantitative analyses

Risk-Informed, Performance-Based Fire Protection Regulation and Guidance Documents



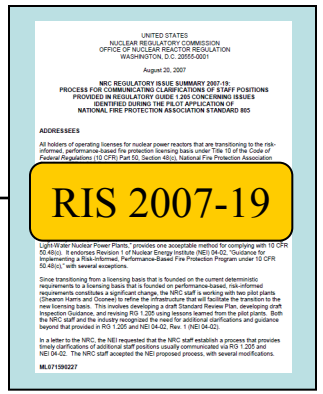
Incorporated by Reference (Part of Rule)



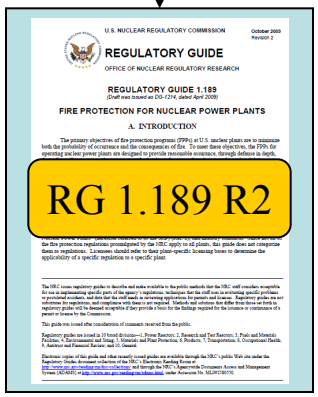


Referenced

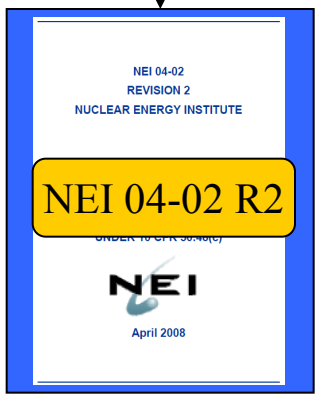
FAQ Process (Interim Staff Guidance)

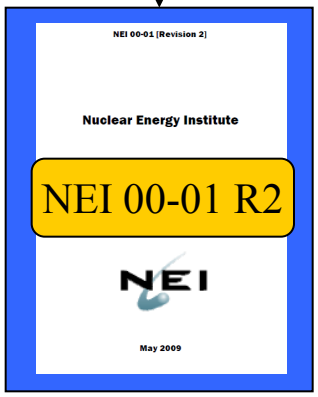


Endorsed



(EEEE Guidance Only)





(Ch 3 Circuit Analysis Only)

10 CFR 50.48(c): NFPA 805

- Risk-informed, performance-based approach
  - Fire Modeling
  - Fire Risk Evaluation
- Fundamentally based on deterministic fire protection requirements
  - Includes requirement for extensive documentation of licensing basis, including supporting engineering analyses
- Maintains defense-in-depth and has adequate safety margins

Fire Safety Defense-in-Depth

- Nuclear power plant fire protection requirements include layers of protection to provide defense-in-depth
  - Preventing fires from starting
  - Rapidly detecting, controlling, and promptly extinguishing those fires that do occur
  - Providing protection for structures, systems, and components important to safety so that a fire that is not promptly extinguished by fire suppression activities will not prevent the safe shutdown of the plant

Appendix R vs. NFPA 805

Appendix R	NFPA 805
Prescriptive requirements	Performance-based, risk-informed
Exemptions	Self-approval allowed for changes
Resources focused on prescriptive requirements	Resources focused on risk areas
Maintains defense-in-depth	Maintains defense-in-depth

Challenges - What Lies Ahead

- Ensure that emerging fire safety issues are resolved in a clear and predictable way
- Knowledge management
  - Remember lessons learned
  - Understand and maintain the basics
- Unknowns

Goals

- Safety, Safety, Safety
- Operating Reactors Fully Embrace and Implement Risk-Informed, Performance-Based Fire Safety
- NRC Regulatory Framework and Positions are Clear and Based on Sound Science and Engineering
- NRC Licensing Decisions are Predictable and Efficient

Reference List

Documents available on NRC web site or in the Agencywide Documents Access and Management System (ADAMS) by entering the below listed document specific ML########## at

http://www.nrc.gov/reading-rm/adams.html

GENERAL FIRE PROTECTION REFERENCES

Fire Protection (NRC Public Web Site)
http://www.nrc.gov/about-nrc/fire-protection.html

10 CFR 50.48, “Fire Protection”
http://www.nrc.gov/reading-rm/doc-collections/cfr/part050/part050-0048.html

10 CFR 50, Appendix A, “General Design Criteria for Nuclear Power plants”
http://www.nrc.gov/reading-rm/doc-collections/cfr/part050/part050-appa.html

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DETERMINISTIC FIRE PROTECTION REFERENCES

10 CFR 50, Appendix R, “Fire Protection Program for Nuclear Facilities Operating Prior to January 1, 1979”

http://www.nrc.gov/reading-rm/doc-collections/cfr/part050/part050-appr.html

Regulatory Guide 1.189, Revision 2 “Fire protection for Nuclear Power Plants”

http://pbadupws.nrc.gov/docs/ML0925/ML092580550.pdf

GL 86-10, “Implementation of Fire Protection Requirements”, dated April 24, 1986

http://www.nrc.gov/reading-rm/doc-collections/gen-comm/gen-letters/1986/gl86010.html

NUREG-1852, “Demonstrating the Feasibilty and Reliability of Operator Manual Actions in Response to Fire”

http://pbadupws.nrc.gov/docs/ML0730/ML073020676.pdf

NUREG/BR-0361 “The Browns Ferry Nuclear Plant Fire of 1975 and the History of NRC Fire Regulations”

http://www.nrc.gov/reading-rm/doc-collections/nuregs/brochures/br0361/

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RISK-INFORMED FIRE PROTECTION REFERENCES

NFPA 805, “Performance-Based Standard for Fire Protection for Existing Light Water Reactor Electric Generating Plants,” 2001 Edition

Regulatory Guide 1.205, “Risk-Informed, Performance-Based Fire Protection for Existing Light-Water Nuclear Power Plants”
http://pbadupws.nrc.gov/docs/ML0927/ML092730314.pdf

Standard Review Plan, Section 9.5.1.2, “Risk-Informed, Performance-Based Fire Protection
http://pbadupws.nrc.gov/docs/ML0925/ML092590527.pdf

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NUREG/CR-6850/EPRI 1011989, "EPRI/NRC-RES Fire PRA Methodology for Nuclear Power Facilities," Volume 1: "Summary and Overview," Volume 2: "Detailed Methodology," September 2005. ADAMS Accession Nos. ML052580075 and ML052580118.

http://www.nrc.gov/reading-rm/doc-collections/nuregs/contract/cr6850/v1/cr6850v1.pdf

http://www.nrc.gov/reading-rm/doc-collections/nuregs/contract/cr6850/v2/cr6850v2.pdf

NUREG/CR-6850, Supplement 1/EPRI 1019259, "Fire Probabilistic Risk Assessment Methods Enhancement," September 2010. (ML103090242)

NUREG-1824, EPRI 1011999, "Verification and Validation of Selected Fire Models for Nuclear Power Plant Applications," Volumes 1–7, May 2007. ADAMS Accession Nos. ML071650546, ML071730305, ML071730493, ML071730499, ML071730527, ML071730504, and ML071730543.

http://www.nrc.gov/reading-rm/doc-collections/nuregs/staff/sr1824/sr1824v1.pdf

http://www.nrc.gov/reading-rm/doc-collections/nuregs/staff/sr1824/sr1824v2.pdf

http://www.nrc.gov/reading-rm/doc-collections/nuregs/staff/sr1824/sr1824v3.pdf

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http://www.nrc.gov/reading-rm/doc-collections/nuregs/staff/sr1824/sr1824v7.pdf