NRR
Office of Nuclear Reactor Regulation

Transitioning From Appendix R to NFPA 805: Fire Modeling Pathway

Raymond H.V. Gallucci, Ph.D., P.E.
U.S. Nuclear Regulatory Commission
Office of Nuclear Reactor Regulation
September 19-22, 2004

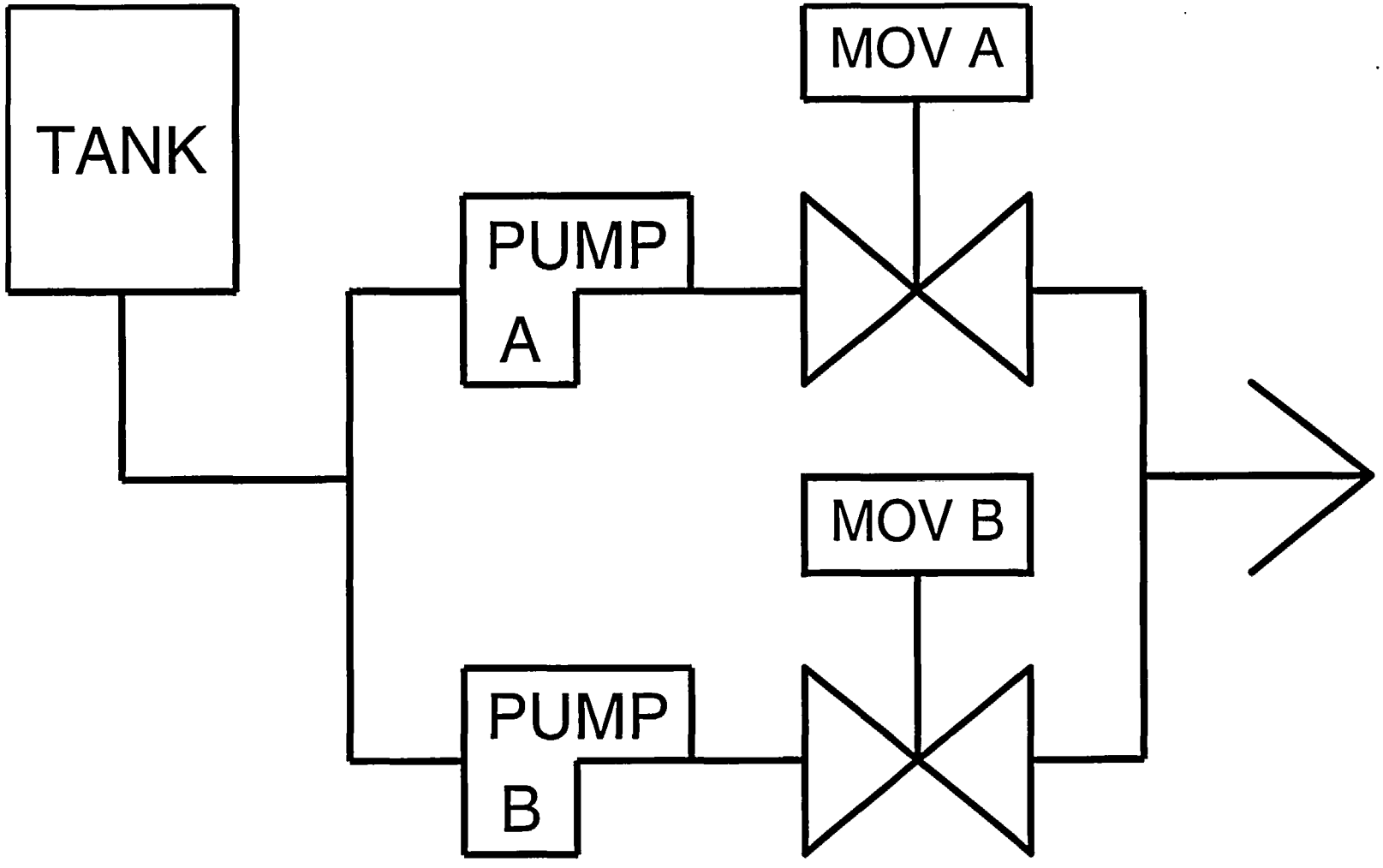
NRR
Office of Nuclear Reactor Regulation

TRANSITIONING FROM APPENDIX R TO NFPA 805: FIRE MODELING PATHWAY

Illustrative method for NFPA 805 transition (Section 4.2.4.1) via transient combustibles example

Two Redundant Trains

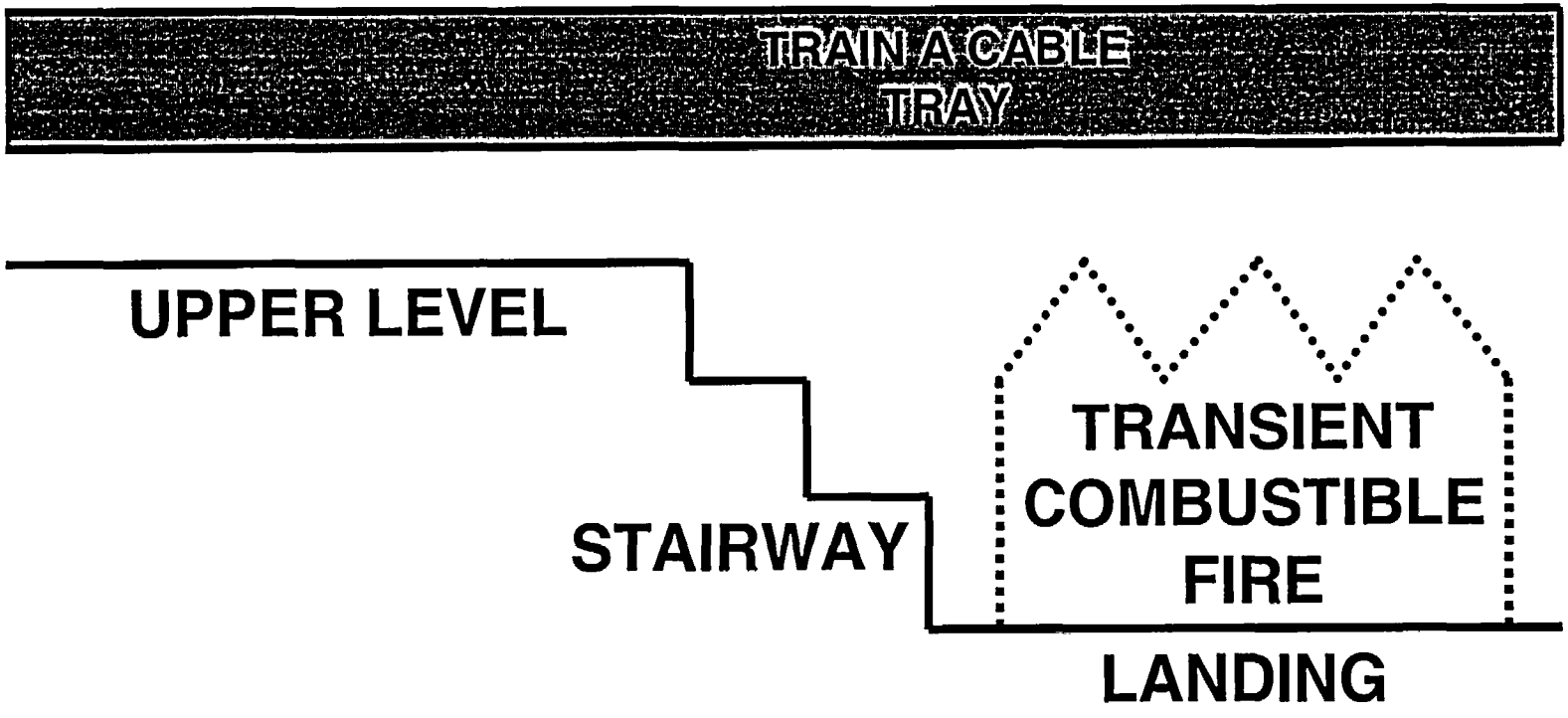
NRR
Office of Nuclear Reactor Regulation



"Pinch Point" Schematic

NRR
Office of Nuclear Reactor Regulation

TRAIN B CABLE TRAY (90°)



Appendix R

NRR
Office of Nuclear Reactor Regulation

- III.G.2 Fire Area
  - Train B cables "protected" by non-compliant 3-hr fire barrier
    - Train A and B cables are vertically co-located only above landing ("pinch point")
    - No fire detector or suppression system in landing area
  - Landing area was not originally identified as separate from overall, larger fire area containing cables for both trains

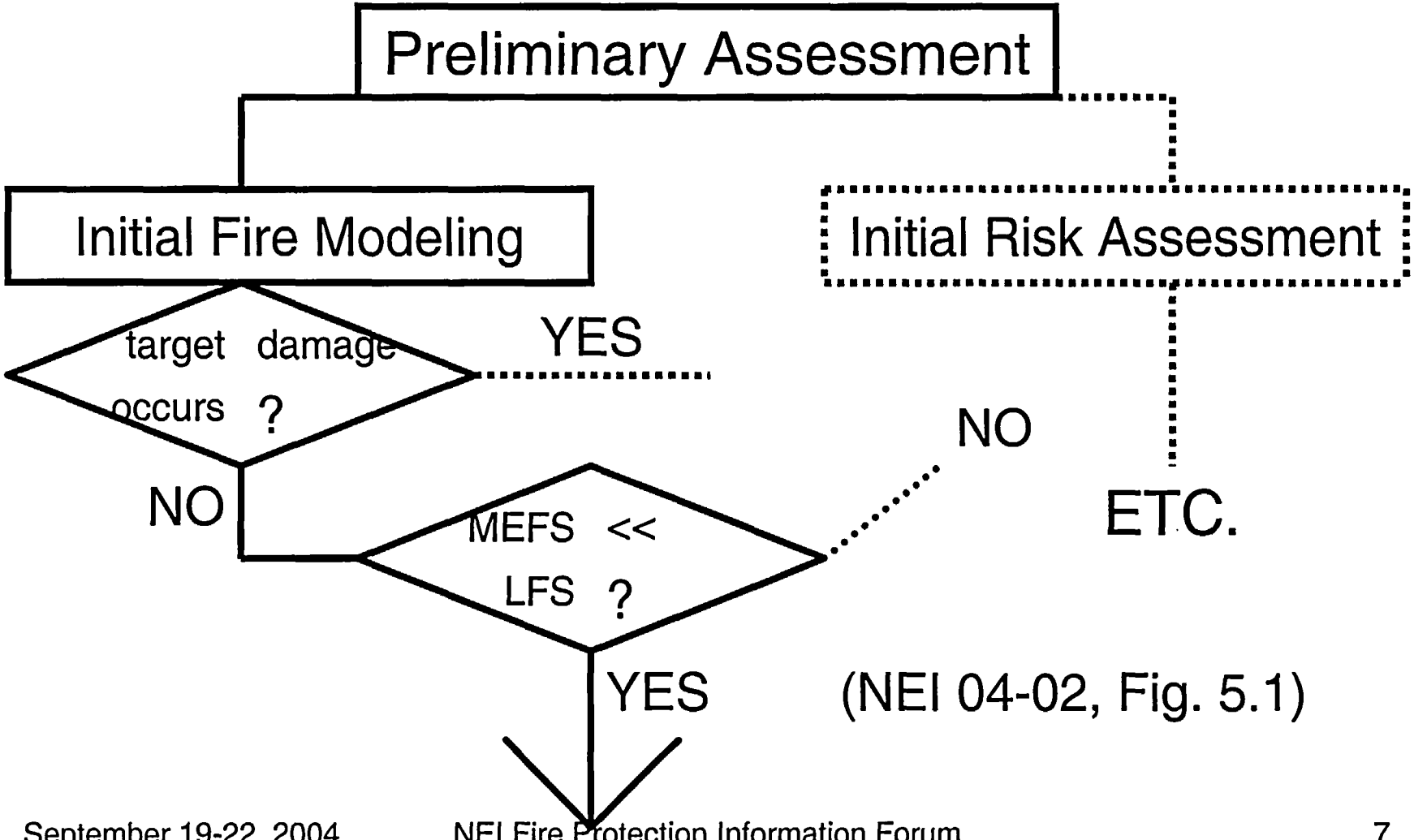
Identify Fire Sources

NRR
Office of Nuclear Reactor Regulation

- No permanent combustibles in landing area
  - Cables for both Trains A and B are thermoset and IEEE-383 "qualified"
    - Self-ignition not a concern
    - Damage threshold = 625°F
  - Transient combustibles could be located on the landing beneath both cable trays
    - Amount based on combustible loading limits

Change Evaluation Process

NRR
Office of Nuclear Reactor Regulation



(NEI 04-02, Fig. 5.1)

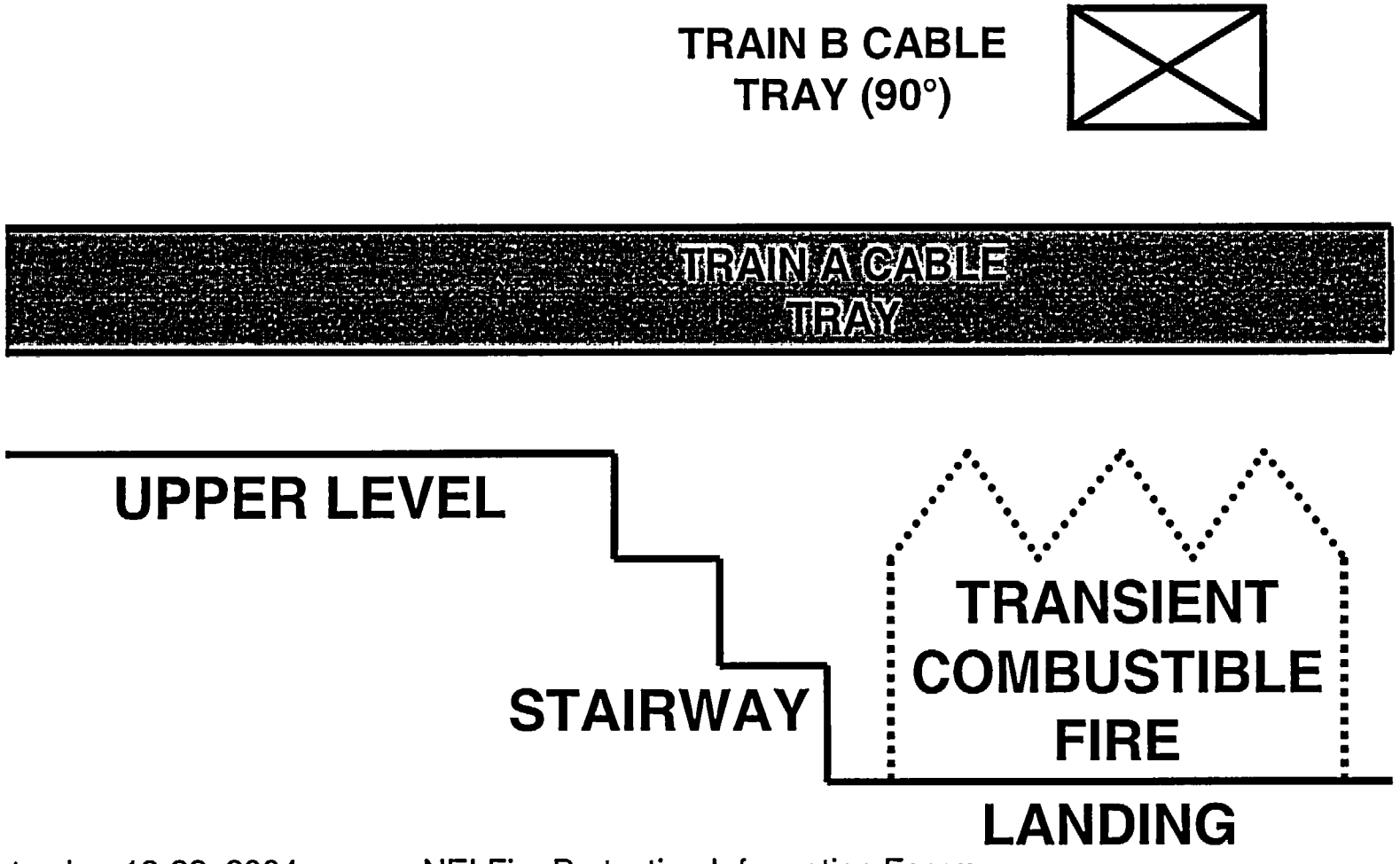
Maximum Expected Fire Scenario (MEFS)

NRR
Office of Nuclear Reactor Regulation

- NFPA 805, Section 1.6.39
  - MEFS represents "the most challenging [fire] that could reasonably be anticipated for the occupancy type and conditions in the space"
- Define "target set"
  - Lower of two cable trays above landing
    - If lower ignites, upper can be ignited by lower

"Pinch Point" Schematic

NRR
Office of Nuclear Reactor Regulation



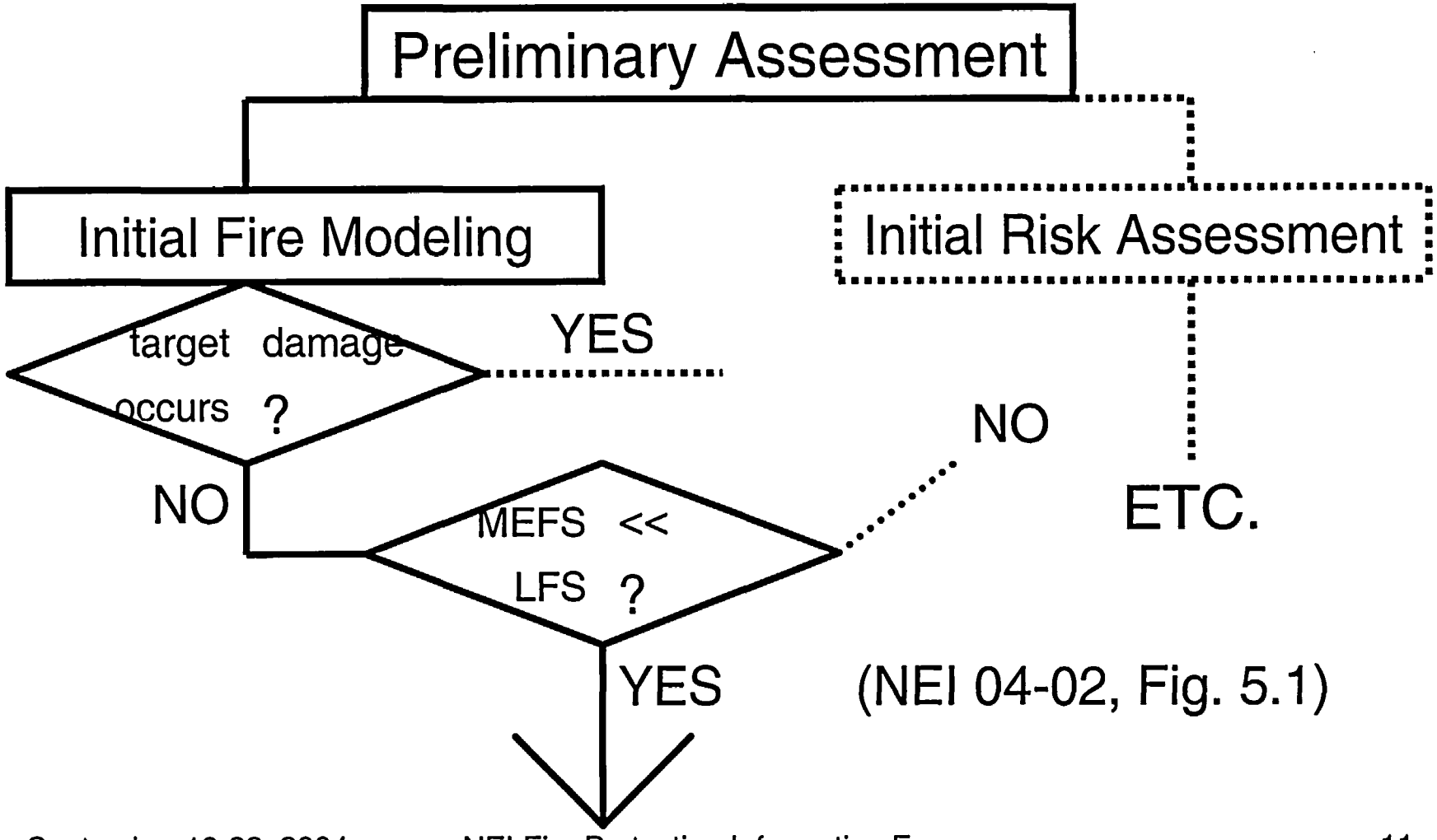
MEFS (continued)

NRR
Office of Nuclear Reactor Regulation

- Perform CFAST fire model for transient combustible fire at the landing
  - Assume transients based on combustible loading limits (Fire Protection Program)
    - Representative transient fire → peak heat release rate = 332 kW with fire duration = 10 min
    - CFAST smoke layer environment with corner thermal plume at target elevation
    - Maximum exposure temperature = 270°F << threshold of 625°F → *NO TARGET DAMAGE!*

Change Evaluation Process

NRR
Office of Nuclear Reactor Regulation



(NEI 04-02, Fig. 5.1)

Limiting Fire Scenario (LFS)

NRR
Office of Nuclear Reactor Regulation

- NFPA 805, Section 1.6.37
  - LFS is scenario where "one or more of the inputs to the fire modeling calculation (e.g., heat release rate ...) are varied to the point that the performance criterion is not met"
  - Intent is to determine if reasonable margin exists between MEFS conditions and failure threshold, i.e., is MEFS << LFS?

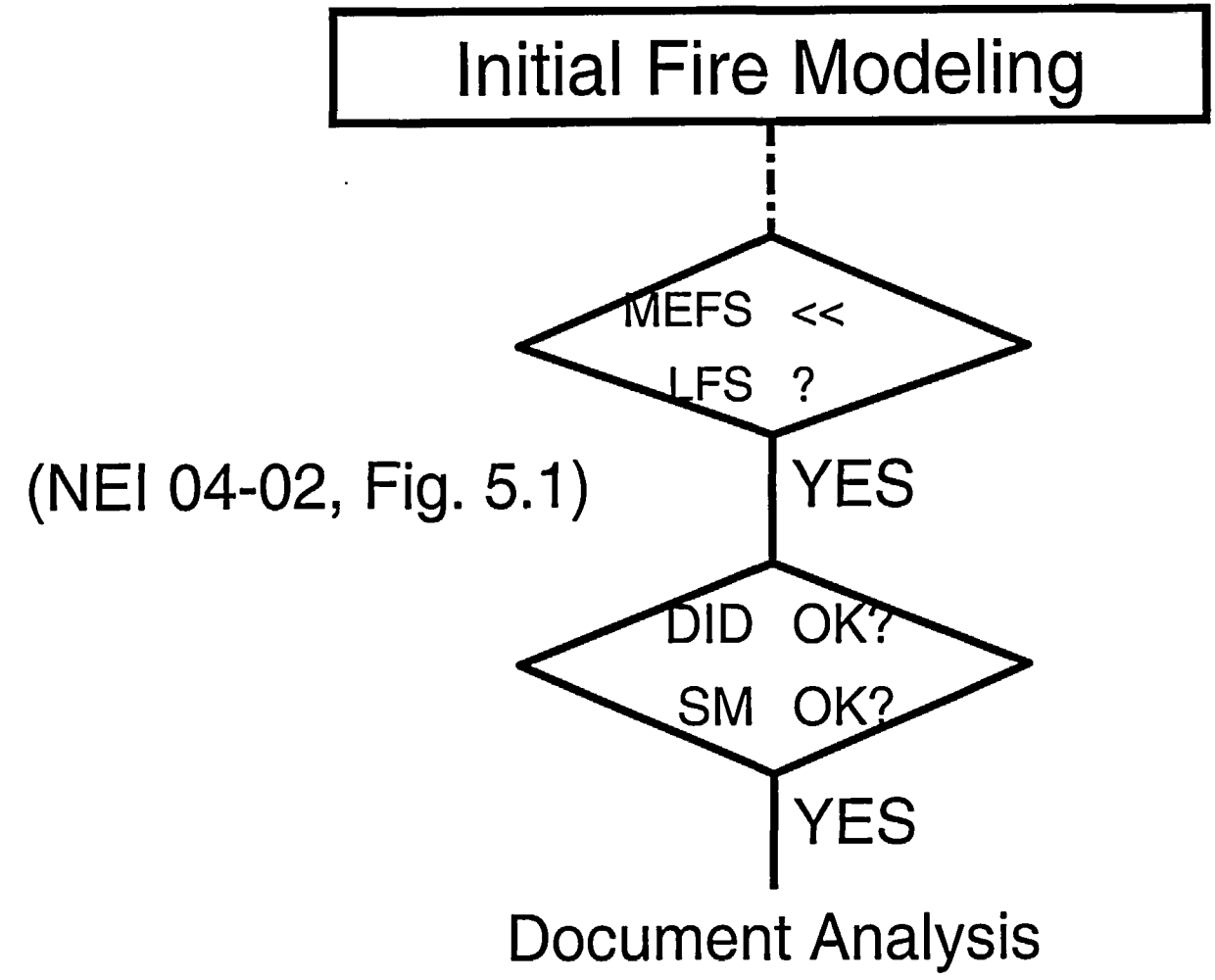
LFS (continued)

NRR
Office of Nuclear Reactor Regulation

- LFS is one where threshold ignition temperature of 625°F is reached
  - Heat release rate would have to be at least four times greater than 332 kW from MEFS
    - For representative transient fire, combustible mass would have to be nearly 10 times larger
      - May be physically (if not procedurally) impossible to locate this large a mass of transient combustibles on the landing
    - LFS requirements (heat release rate, combustible loading) are >> MEFS requirements
      - Essentially satisfies safety margin criteria

Evaluation Process
(Continued)

NRR
Office of Nuclear Reactor Regulation



(NEI 04-02, Fig. 5.1)

Adequate DID and SM

NRR
Office of Nuclear Reactor Regulation

- NFPA 805 also requires that adequate defense-in-depth (DID) and sufficient safety margin (SM) be maintained
  - Typically, DID is evaluated qualitatively based on objectives for Fire Protection Program in 10 CFR Part 50, Appendix R, Section II.A
    - Prevent fires from starting
    - Rapidly detect, control, and extinguish fires that do occur
    - Provide protection for structures, systems, and components (SSCs) important to safety so that a fire that is not promptly extinguished will not prevent plant safe shutdown (SSD)

DID and SM
(Continued)

NRR
Office of Nuclear Reactor Regulation

- Non-compliant 3-hr fire barrier for Train B cables
  - No challenge to fire ignition or rapid detection, control, and extinguishment
  - Challenges protection for SSCs important to SSD when exposed to non-extinguished fire
    - Challenge shown to be negligible via Fire Modeling (MEFS << LFS)
- Both DID and SM criteria are satisfied

Summary

NRR
Office of Nuclear Reactor Regulation

- Example for transient combustibles chosen to illustrate transition to NFPA 805 via Change Evaluation Process pathway for initial fire modeling
  - MEFS does not damage target set, AND
  - Reasonable margin exists between MEFS conditions and failure threshold, i.e., MEFS << LFS
    - Qualitative DID and SM criteria