Transitioning From Appendix R to NFPA 805: Combined Analysis Pathway

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September 19-22, 2004

TRANSITIONING FROM APPENDIX R TO NFPA 805: COMBINED ANALYSIS PATHWAY

Illustrative method for NFPA 805 transition (Section 4.2.4) via train free of fire damage example

Flow Diversion - MOV

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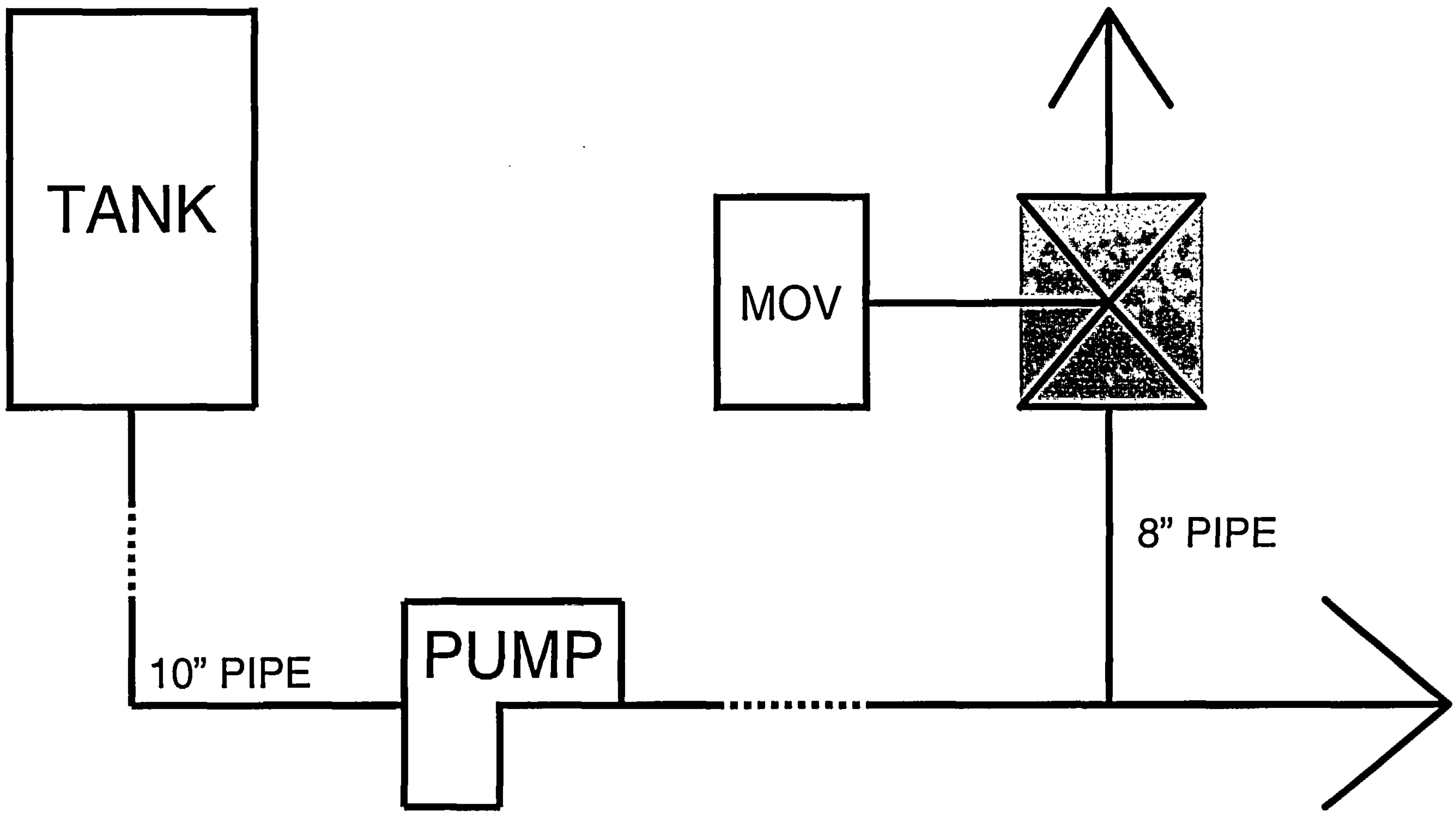
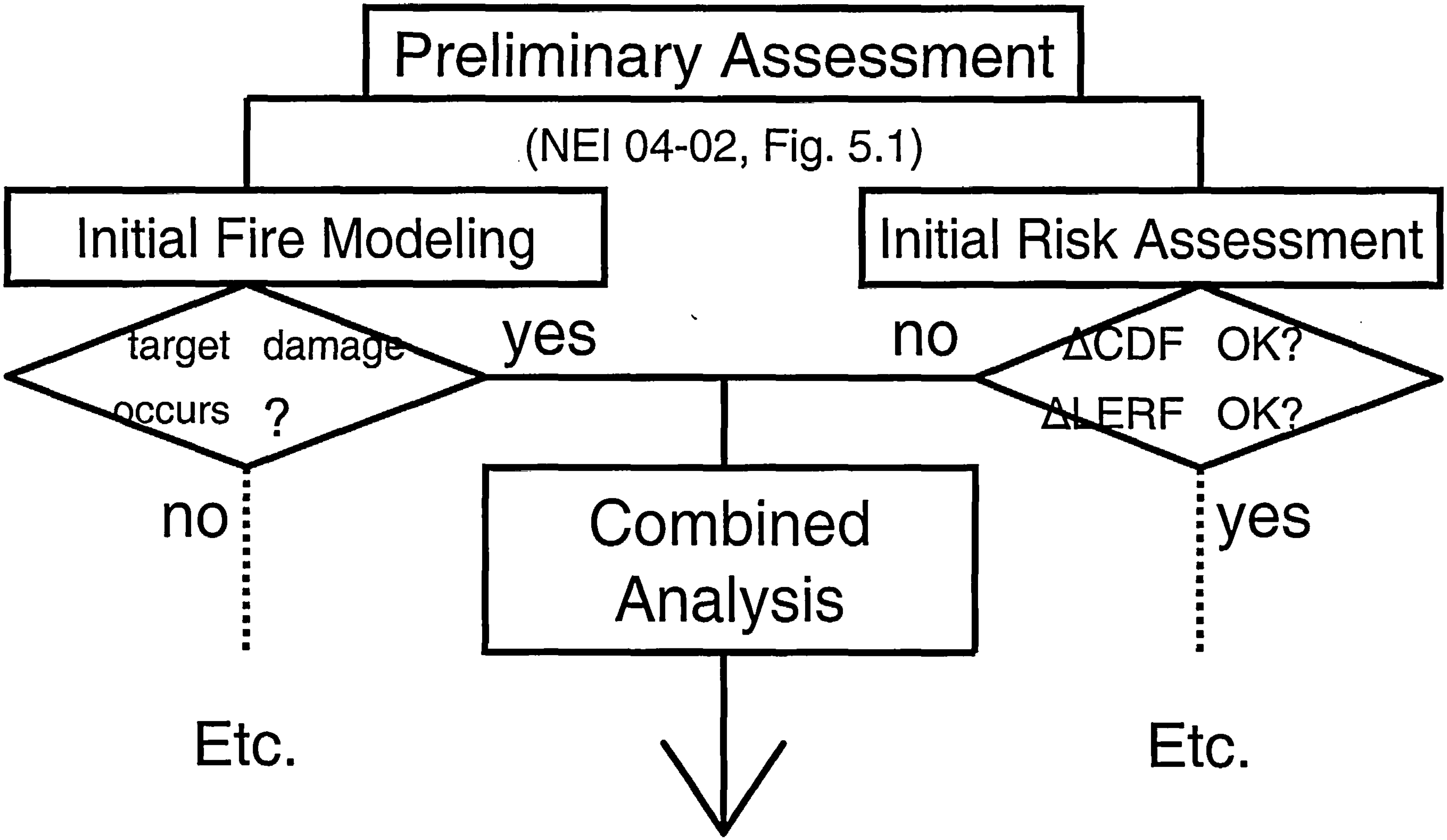


Train Free of Fire Damage

- Normally de-energized conductor for normally-closed MOV in flow diversion path located in same cable (and cable tray) with other energized conductors
  - Spurious energizing of MOV control cable due to fire-induced "hot short" with an energized conductor could open MOV → flow diversion
    - MOV and its cable are within train that needs to be free of fire damage

Change Evaluation Process



Initial Fire Modeling

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- Maximum Expected Fire Scenario (MEFS)
  - Most challenging fire that can reasonably be expected to occur → "realistic and conservative" (NFPA 805, Section 1.6.39)
  - Assume thermoplastic cables subject to MEFS with exposure temperature = 550°F
    - Thermoplastic control cables subject to fire damage at > 400°F → "target damage" can occur
      - Possible "hot shorting" of MOV control circuit with another de-energized conductor in same or adjacent cable

Initial Risk Assessment

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- Fire frequency (λ) = 0.01/yr
- Probability of non-suppression (P_{NS}) = 0.05
- Probability of cable failure (P_{CF})
  - At 550°F, thermoplastic cable fails in 7 min
  - Assume fixed halon suppression system, if effective, extinguishes fire in 1 min
    - P_{CF} (6-min "damage" margin) = 0.25

Risk Assessment
(Continued)

- Probability of spurious actuation (P_{SA})
  - Thermoplastic, intra/inter-cable = 0.6
- Conditional core damage probability (CCDP) = 0.05
- Δ Core damage frequency (CDF) = product of all of above = 4E-6/yr > 1E-6/yr
  - All of above are "mean" values

Combined Analysis

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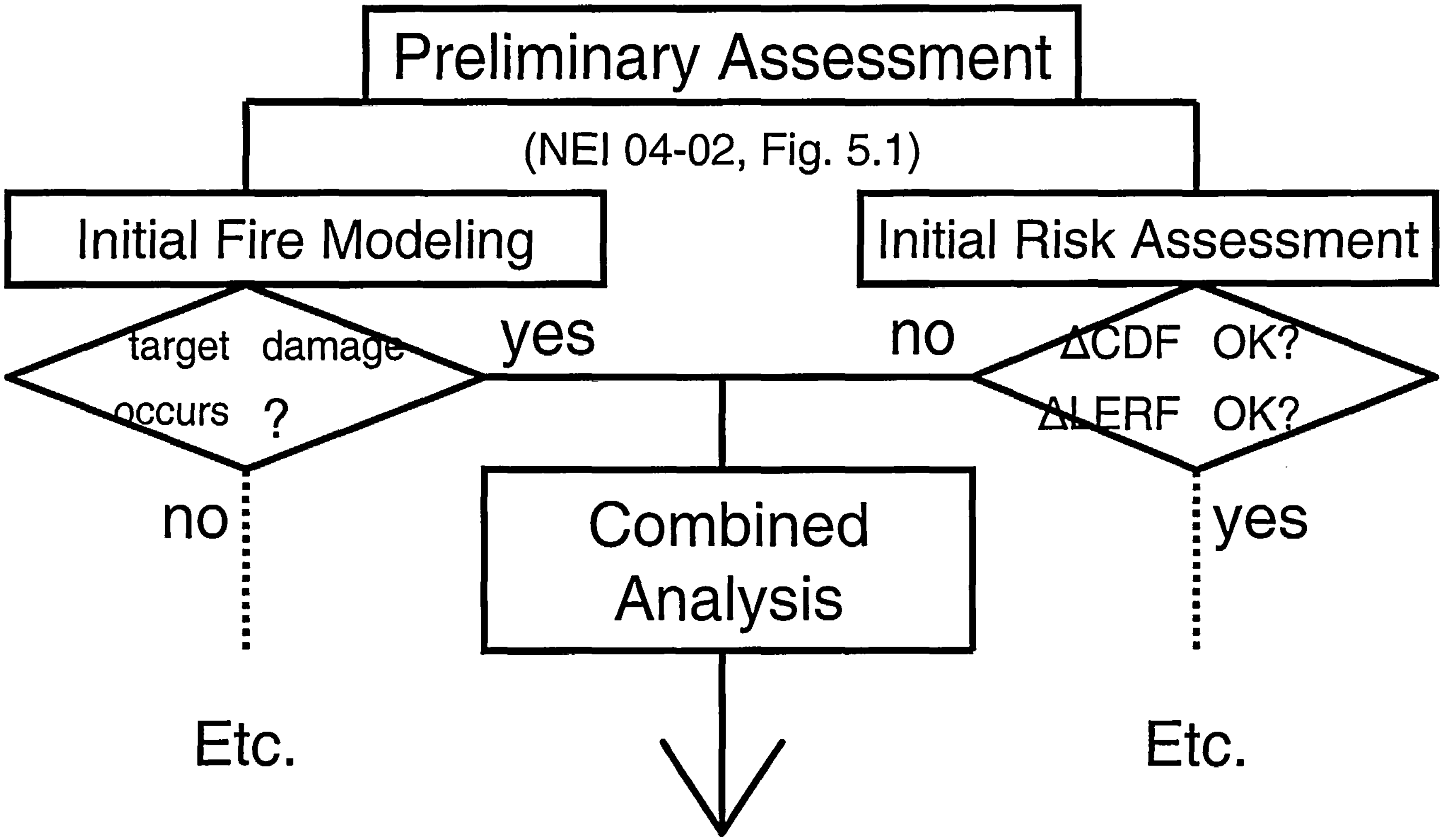
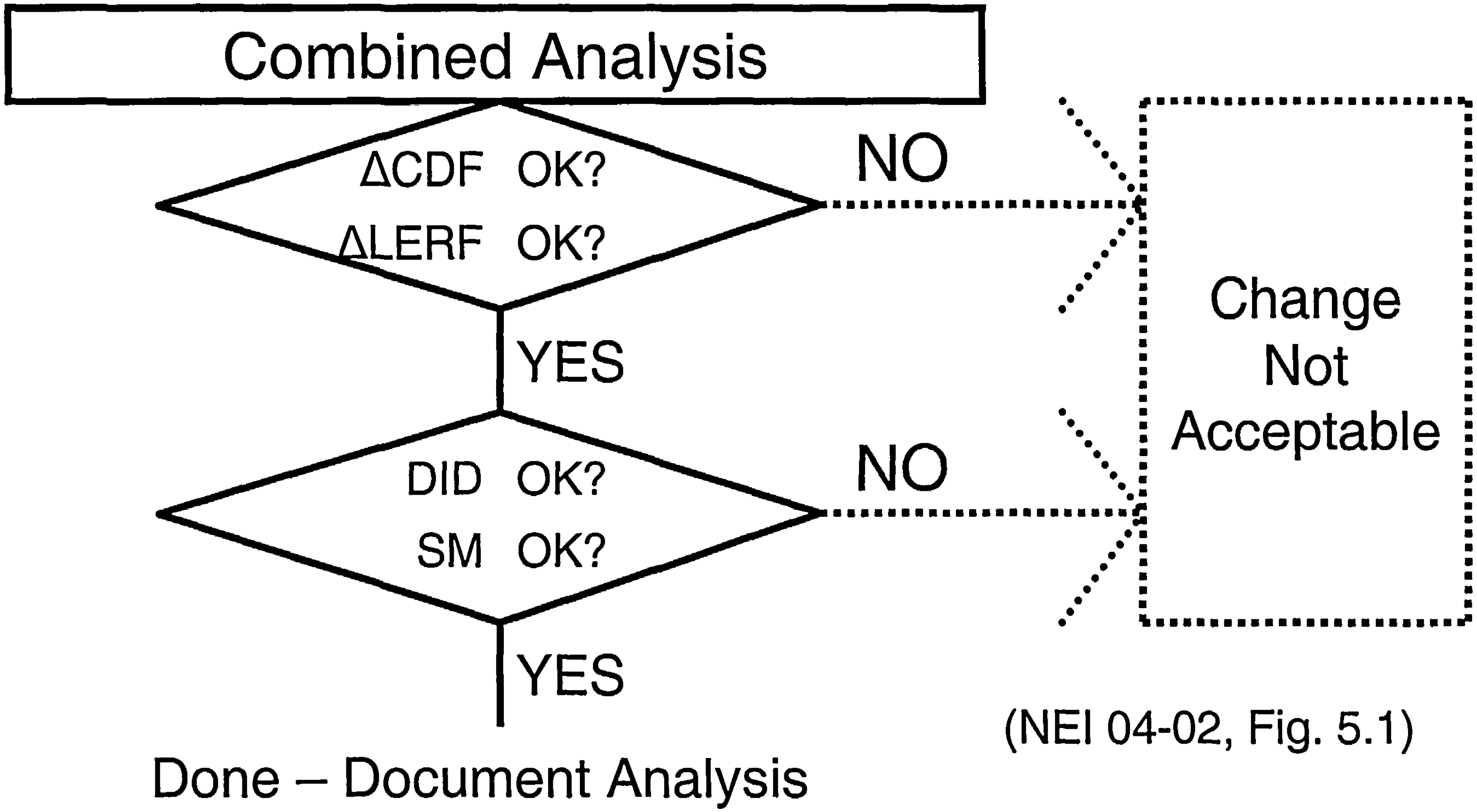
- Two pathways
  - Initial fire modeling → target damage occurs? YES (550°F > 400°F)
  - Initial risk assessment → ΔCDF (ΔLERF) ok? NO (4E-6/yr > 1E-6/yr)
- When neither pathway succeeds, perform Combined Analysis
  - More detailed modeling of fire effects may lower ΔCDF (ΔLERF)

Change Evaluation Process



Evaluation Process
(Continued)



(NEI 04-02, Fig. 5.1)

Combined Analysis
(Continued)

- ΔCDF (4E-6/yr) assumed zonal $\lambda = 0.01$/yr
  - More detailed modeling of fire scenario indicates "severity factor" (likelihood that MEFS actually damages target cable) = 0.1
    - Also, fire cannot damage all components in zone, leaving available some previously assumed to be lost → CCDP reduced by factor of 2
  - ΔCDF = (0.1/2) x 4E-6/yr = 2E-7/yr < 1E-6/yr
    - (Similar approach for ΔLERF, omitted in example)

Evaluation Process
(Continued)

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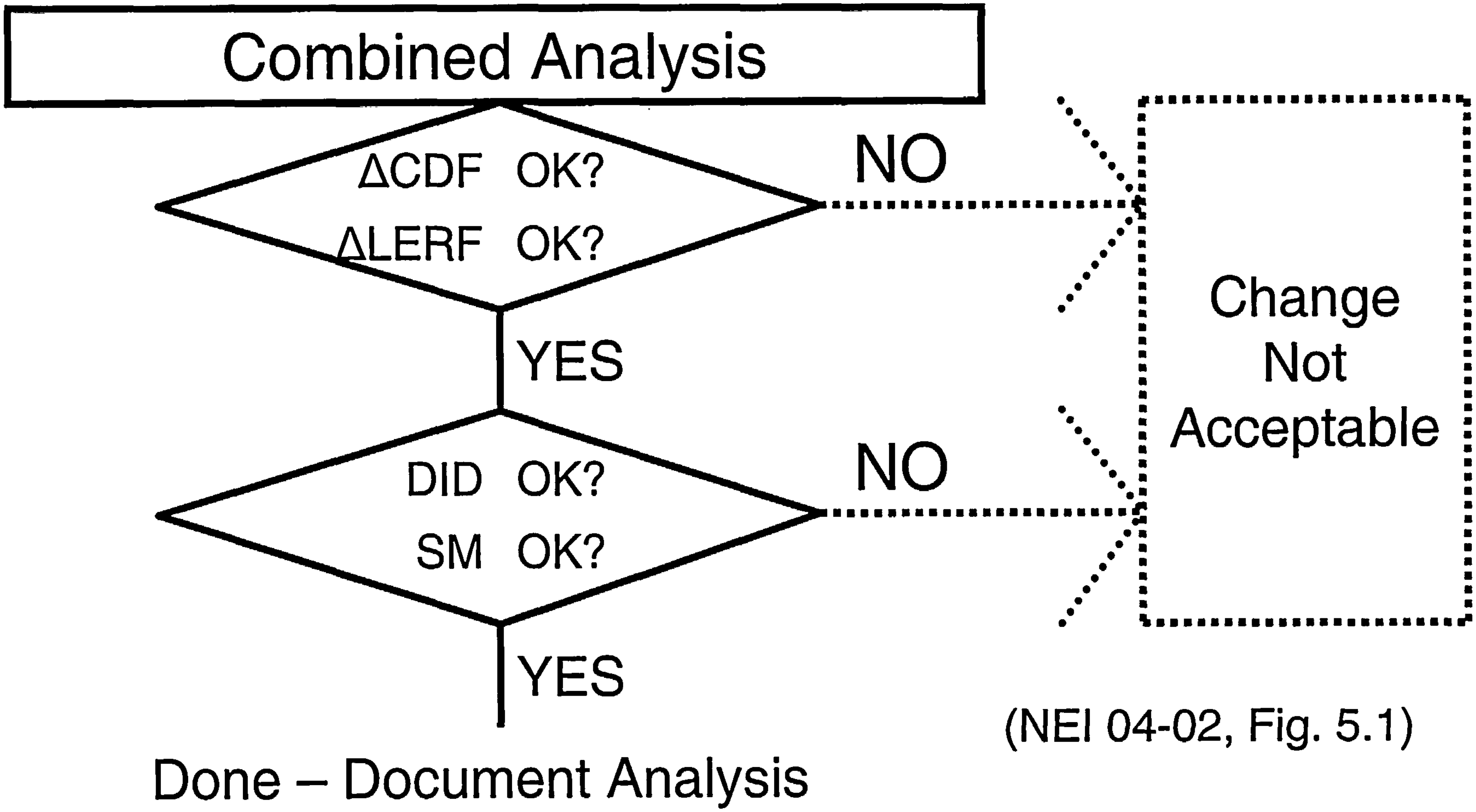

(NEI 04-02, Fig. 5.1)

Adequate DID and SM

- Although typically qualitative, a quantitative estimate on the upper bound ΔCDF can suggest whether additional DID or SM is needed
  - Assume λ, P_{NS}, P_{CF} and CCDP are lognormal variables with large EFs of 10 each
    - Total compound EF on ΔCDF = $\exp\{(4[\ln 10]^2)^{0.5}\} \approx 100$, implying an upper bound ≈ 4E-7/yr < 1E-6/yr
  - DID and SM criteria, in addition to ΔCDF and ΔLERF (omitted in example) are satisfied

Summary

- Example for train free of fire damage chosen to illustrate transition to NFPA 805 via Change Evaluation Process pathway for combined analysis
  - Initial fire modeling indicates that target damage occurs, AND
  - Initial risk assessment indicates ΔCDF or ΔLERF > RG 1.174 acceptance threshold