
# FNP Fire Modeling LAR Submittal Overview

March 19, 2012

**Fire Modeling Overview**

# Fire Modeling Topics

The purpose of this presentation is to describe the fire modeling applications at FNC that are used to support the NFPA 805 licensing basis. Fire modeling is performed in one of three general areas:

- Generic Fire Modeling Treatments
  - Original report (2008)
  - Supplements 1, 2, and 3
- Main Control Room Abandonment Calculation
- MG Set Motor ZOI Calculation

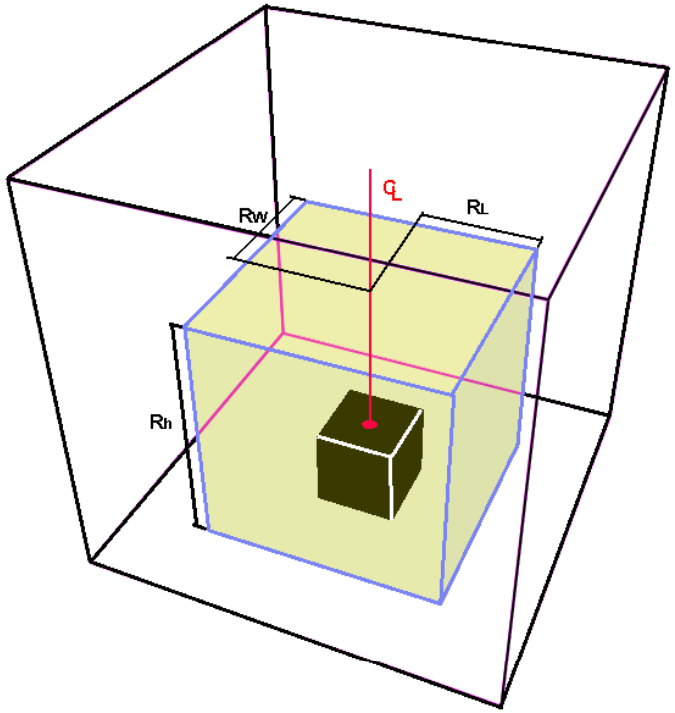
# Generic Fire Modeling Treatments

- Purpose
  - Quantify/tabulate the ZOI dimensions around plant ignition sources
    - NUREG/CR-6850 ignition sources (bins)
    - Combustible liquid spill fires
  - Quantify/tabulate the time to reach threshold HGL temperatures
- ZOI Concept
  - ZOI is defined by one or more lateral dimensions and a vertical dimension
  - The ZOI is associated with a steady state damage threshold heat flux
    - 5.7 kW/m² (thermoplastic/non-IEEE-383 qualified cables
    - 11.4 kW/m² (thermoset/IEEE-383 qualified cables

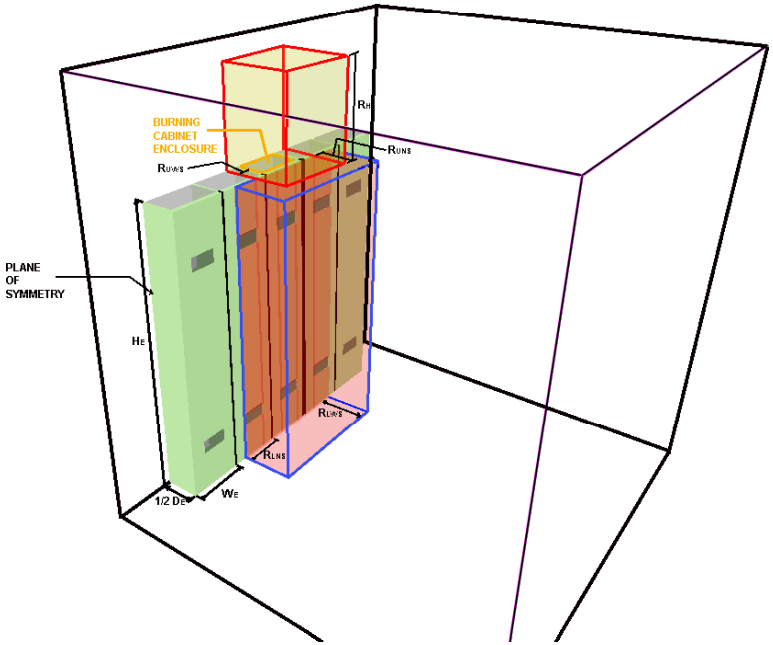
# Generic Fire Modeling Treatments

- ZOI Calculation
  - Uses empirical plume models and steady state damage thresholds
    - Includes same models used in NUREG-1805; selects most adverse among all models used
  - Variable fire diameter/area (via heat release rate per area)
- Ignition Sources
  - Five NUREG/CR-6850 electrical panels cases (fifteen HRR bins each)
  - Transient (fifteen HRR bins)
  - Unconfined/confined liquid fire
  - Cable tray stacks (applicable to thermoplastic cables only)

# Generic Fire Modeling Treatments




Transient ZOI Dimensions




Panel ZOI Dimensions



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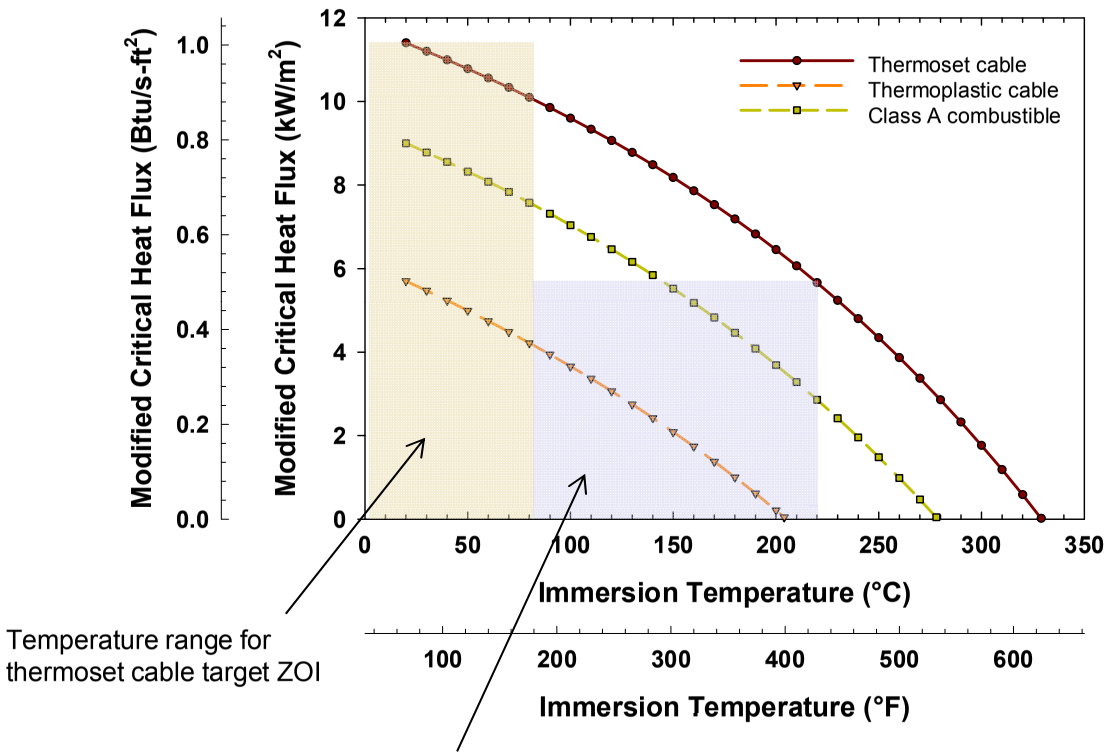
# Generic Fire Modeling Treatments

- ZOI Implementation
  - 98$^{th}$ percentile ZOI dimensions assembled in walkdown form
  - Largest horizontal ZOI dimension used when there are multiple dimensions (panels)
  - Vertical ZOI dimension used if no secondary combustibles in ZOI
  - Ceiling height used do define vertical ZOI dimension if secondary combustibles are in ZOI
  - Vertical ZOI dimension is relative to:
    - The fire base (transient and combustible liquid fires)
    - The floor (panel fires)
    - The lowest tray in stack (cable tray fires)

# Generic Fire Modeling Treatments

- Key ZOI Limitations (Original Document)
  - No secondary combustibles (see Supplement 2)
  - No hot gas layer effects
  - Open fire configuration
- Hot Gas Layer Effects on ZOI Dimensions
  - A modified critical heat flux is used to establish reasonable maximum temperature and to extend ZOI applicability
    - 80°C alters critical heat flux by about 1 kW/m² and is considered the maximum value beyond which non-conservative results could be generated
    - Not a required limitation for plume and heat flux models in NUREG-1805 (same methods), but model bias is low due to HGL effects
  - Used to extend ZOI for some target classes

# Generic Fire Modeling Treatments



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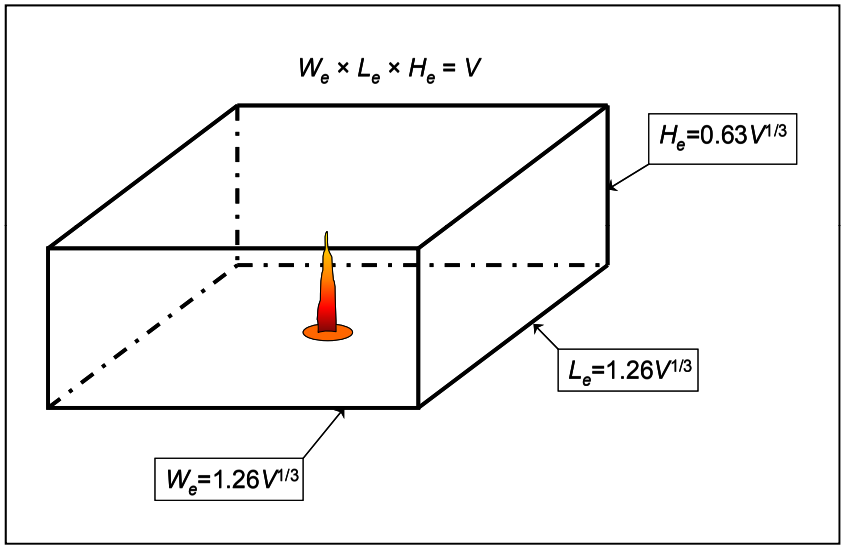
# Generic Fire Modeling Treatments

- Wall and Corner Configurations
  - Within 2 ft of a wall or corner boundary
  - 'Image' Method used
    - Change entrainment characteristics of model plume to account for corner or wall:
      - Model HRR – 2 or 4 X Bin HRR (wall or corner)
      - Model fire diameter is $2^{1/2}$ or 2 X Bin fire diameter (wall or corner) to maintain constant Q/A
    - Change enclosure characteristics to accommodate 'virtual' portions of model fire plume:
      - Wall and ceiling area doubled/quadrupled
      - Natural and forced ventilation flow paths/volumes doubled/quadrupled

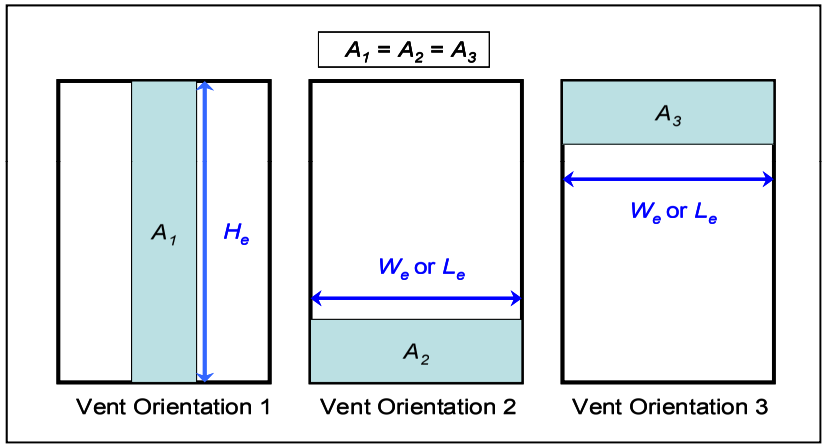
# Generic Fire Modeling Treatments

- Hot Gas Layer Tables
  - List time the HGL reaches threshold value in generic enclosure
  - Tabulated by:
    - Fire size
    - Enclosure volume
    - Leakage fraction
  - For a given fire size and enclosure volume, the minimum time among all leakage fractions is selected
  - Generic enclosure derived from sensitivity runs:
    - Minimizes surface area
    - Adiabatic floor
    - Three potential vent combinations for each scenario

# Generic Fire Modeling Treatments




Generic Space




Vent Orientations



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# Generic Fire Modeling Treatments

- Verification
  - Independent review of all calculations performed using Excel®
- Validation
  - Most applications include at least one fire scenario that falls within the NUREG-1824 non-dimensional parameter space
  - Additional basis is provided in LAR Attachment J for plume and heat flux applications that fall outside the NUREG-1824 non-dimensional parameter space
  - CFAST simulations include a geometry that by definition conforms with NUREG-1824 validation range. At least one scenario has an equivalence ration that falls within the NUREG-1824 validation range.

# Generic Fire Modeling Treatments

- Supplement 1: Closed Panel HRR Estimates
  - Uses ventilation and leakage area fractions with mass and energy balance to determine maximum internal HRR
  - Results compared with available test data (verification) and shown to be conservative when no external burning is observed or the door does not fail
- Supplement 2: Expanded HGL Tables
  - Original Generic Fire modeling treatment approach expanded to include:
    - Time-dependent fires
    - Secondary combustibles (two side-by-side, 18 inch wide cable trays Ignited at five minutes at a point above a panel; lateral flame spread per NUREG/CR-6850 recommended rates)

# Generic Fire Modeling Treatments

- Supplement 3: Transient Ignition Source Characteristics (Technical Report)
  - Characterizes ZOI sensitivity to assumed fire diameter or area
  - Determines fire area/diameter range for transients based on NUREG/CR-6850 test data
  - Identifies special case of 98$^{th}$ percentile transient
  - Identifies 98$^{th}$ percentile transient fire duration based on energy content
  - Provides revised ZOI dimensions based on 98$^{th}$ fire area and fire duration
  - Uses same methods as original Generic Fire Modeling Treatments report to generate revised ZOIs



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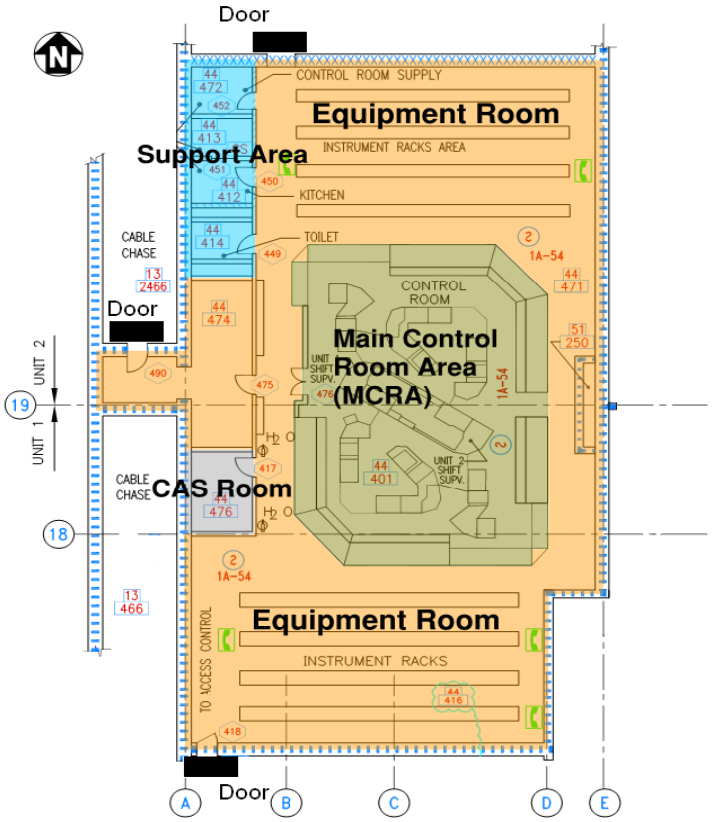
# Main Control Room Abandonment Calculation

- Purpose
  - Tabulate the abandonment time for ignition sources present in the MCR
  - Provide a sensitivity study of the abandonment times to parameter uncertainty
- Method
  - CFAST, Version 6.1.1 used
  - NUREG/CR-6850 Optical Density (OD) and temperature criteria used to define abandonment

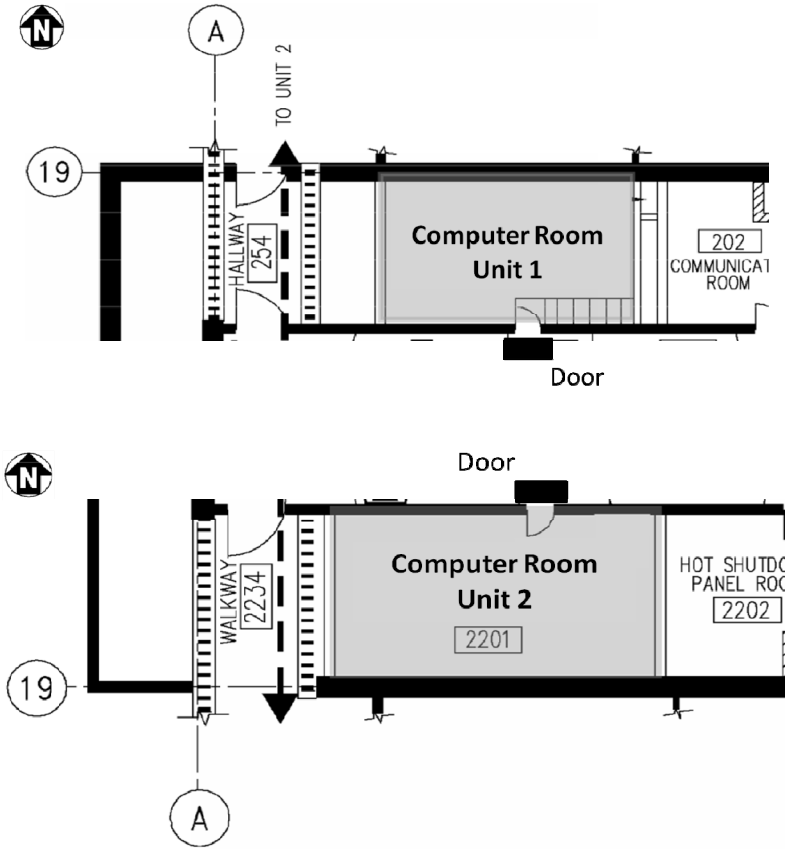
# Main Control Room Abandonment Calculation

- NUREG/CR-6850 Fire Scenarios (15 HRR Bins Each)
  - Panel (closed, single/multiple bundle, non-IEEE-383 qualified)
  - Panel fire that propagates to adjacent panels (open, non-IEEE-383 qualified cables)
  - Transient
- Multiple Geometric/Boundary Configurations
  - Normal HVAC/no HVAC/purge mode
  - Boundary door open/closed/open at 15 minutes
  - Operating area/equipment area
- 1080 Base Simulations (4 fires X 15 bins X 9 Geometries X 2 Locations)

# Main Control Room Abandonment Calculation




MCR Plan




Computer Rooms (same HVAC Zone)



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# Main Control Room Abandonment Calculation

- Sensitivity Analysis (Appendix B)
  - Nine parameters assessed for each ignition source (Bin 14 fires)
  - Low sensitivity observed in most computed abandonment times (typically ± 1 – 2 minutes or less)
    - Some parameters conservatively biased
    - Some parameter are not conservatively biased
  - Sensitivity is not expected to affect the order of magnitude of risk
- Appendix D Provides Discussion of Verification and Validation/Benchmark Installation
  - Includes comparison against NUREG 4527, Vol. 2 test cases (validation)
  - Includes comparison against NUREG 1824 simulations (verification and validation)



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# MG Set Motor ZOI Calculation

- NUREG 1805 Computation
  - Thermal plume temperature (vertical ZOI dimension)
  - Thermal radiation model (horizontal ZOI dimension)
  - Enclosure hot gas layer sensitivity analysis (Appendix B)
- Analysis Follows NUREG-1934 Process
- Verification Provided by NUREG-1824
- Applications Outside of NUREG-1824 Validation Range
  - Results are used with conservative bias
  - LAR Attachment J provides additional basis for application



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# FNC Fire Modeling Overview

Questions?



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