Module 2b – Fire Scenarios

D-4

More on fire scenarios

- Definition: A fire scenario is a postulated sequence of events starting with the ignition of a fire and ending either in plant safe shutdown or core damage.

Fire Scenario (cont.)

- What is a Fire Scenario:

  (Fire Scenario) = (fire ignition source scenario)

  + (fire growth and damage scenario)

  + (fire suppression scenario)

  + (plant SSD response scenario)

Change any element and you have a new fire scenario!

Fire Ignition Source Scenario

- Definition: Defines the physical characteristics of the fire that will develop in a particular fire ignition source – key factors:
  - Placement of fire "origin" – how close is origin to targets
  - Heat release rate (HRR)
- SDP bins fire sources by type, and ties characteristics to each type
  - Six HRR values used to characterize all fires

Table 2.3.1 - Mapping of General Fire Scenario Characterization Type Bins to Fire Intensity Characteristics						
Fire Size Bins	Generic Fire Type Bins with Simple Predefined Fire Characteristics					
	Small Electrical Fire	Large Electrical Fire	Indoor Oil-Filled Transformers	Very Large Fire Sources	Engines and Heaters	Solid and Transient Combustibles
70 kW	50th Percentile Fire				50th Percentile Fire	50th Percentile Fire
200 kW	95th Percentile Fire	50th Percentile Fire			95th Percentile Fire	95th Percentile Fire
650 kW		95th Percentile Fire	50th Percentile Fire	50th Percentile Fire		
2 MW			95th Percentile Fire			
10 MW				95th Percentile Fire		

Fire origin

- The fire origin is a conceptual point at which we will assume the fire originates.
  - Horizontal placement determines what is overhead and therefore in the fire plume
  - Vertical placement will affect plume temperature for exposure of overhead targets
- Choice depends on the nature of the fire source
  - We'll come back to this later

Heat Release Rate (HRR)

- HRR characterizes the fire intensity or the amount of heat generated by a fire per unit time
  - Typical units are either KW or BTU/hr
- This is generally the most critical of all fire characterization input values
- Remember – SDP ties fire intensity to severity factor

Convective / Radiative Fractions

- Heat comes off in two primary forms:
  - Convective heat – The mixing of hot fire products with ambient air resulting in direct heating of the surrounding air that in turn causes buoyancy and fire plume behaviors
  - Radiative heat – the luminosity of a fire's flame zone results in direct radiant heating of opaque targets (including soot-laden air)
- Recommended split fractions are:

  0.7 convective, 0.3 radiative
  - Paired values should add to 1.0

Fire Growth and Damage Scenario

- Definition: characteristics of fire spread to secondary combustibles if such occurs, and the behaviors leading to failure of an identified thermal damage target set
  - You must define a target set – we already covered this
  - Damaging conditions may be created either due to burning of the ignition source alone, or due to fire spread
    - If fire ignition source alone is not enough, and fire cannot spread, then damage is not possible

SDP Fire Damage States (FDS)

- FDS0 – loss of only the fire ignition source
  - Not analyzed as a risk contributor
- FDS1 – localized damage near (especially directly above) the fire ignition source
  - Keys factors: plume heating, upward spread of fire, and direct radiant heating
- FDS2 – widespread damage within a single fire area
  - Key factors: horizontal fire spread, hot gas layer, and failure of degraded raceway fire barriers
- FDS3 – fire damage impacting two (or more) fire area (room-to-room)
  - Key factor: failure of an inter-compartment fire barrier element

Fire Detection and Suppression

- We credit all available means of fire detection and suppression
- Detection is important mainly because it triggers the manual response
  - Plant personnel become aware of the fire
  - Fire procedures may kick in (check plant process for when this really happens)
  - The fire brigade is activated
- Fixed automatic suppression systems require no prior detection signal, but usually are tied to alarm circuits

Fire Suppression (cont.)

- Remember, in PRA space, it's a horse race
  - Question is not so much "does suppression fail?"
  - But rather, "does suppression fail to put out the fire before damage occurs?"
- All fires are put out (or go out) eventually – we want to know if suppression is timely in the context of our specific target set

CCDP

- CCDP characterized plant/operator response to the fire
- Objective is safe shutdown (hot shutdown)
- This part can be complex – you will likely want to get your SRA involved to support this effort

Developing a fire time line

- Key events on the time line
  - Fire ignites (define this as time = 0)
  - Fire is detected ($t_{detection}$)
    - Manual/operator response begins
    - Fire brigade is activated
  - Target set fails (t_{damage})
  - Automatic suppression activates (t_{supp_auto})
  - Manual suppression is successful (t_{supp_man})
- Order of these events is TBD!