FIRES:
More Toxic Than Before

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SAFE 806 – Advanced Topics in EH&S
Final Presentation
Objectives

• Define Fire & Smoke
• Review Fire Statistics, Injuries, and Deaths
• Toxic Gases Generated by Fire
• Causes of Increases in Toxicity
• Conclusion
Fire & Smoke

• **Fire**: A rapid oxidation process, which is a chemical reaction resulting in the evolution of light and heat in varying intensities (NFPA 921).

• **Smoke**: The airborne solid and liquid particulates and gases evolved when a material undergoes pyrolysis or combustion, together with the quantity of air that is entrained or otherwise mixed into the mass (NFPA 921).
There are approximately 1,500,000 fires in the United States per year, resulting in:

- Over 4,000 civilians perish in structure fires.
- More than 15,000 injuries occur due to structure fires.
- Over 100 firefighters die in the line of duty.
- More than 70,000 firefighters are injured in the line of duty.

*Up to 80% of fire related injuries and deaths are attributed to smoke inhalation.*
Carbon Monoxide & Hydrogen Cyanide

Two of the most deadly gases present in a structure fire:

<table>
<thead>
<tr>
<th></th>
<th>CO</th>
<th>HCN</th>
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<tbody>
<tr>
<td>TWA</td>
<td>35 ppm</td>
<td>4.7 ppm</td>
</tr>
<tr>
<td>IDLH</td>
<td>1200 ppm</td>
<td>50 ppm</td>
</tr>
<tr>
<td>LEL</td>
<td>12.5 %</td>
<td>5.6 %</td>
</tr>
<tr>
<td>UEL</td>
<td>74 %</td>
<td>40 %</td>
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HCN is 24 times more toxic than CO.
Carbon Monoxide

• Produced by the incomplete combustion of carbon materials and is both colorless and odorless.

• Is an asphyxiant that is 200 to 250 times more effective in binding to red blood cells than oxygen.

• Exposure to 1-70 ppm is benign.

• Exposure to 70 – 150 ppm results in headache and weakness.

• Exposure to 150 – 200 ppm results in disorientation and unconsciousness.

• Exposure to 800 -1200 ppm results in immediate death.
Hydrogen Cyanide

- Produced by the incomplete combustion of nitrogen and carbon containing materials in high temperature, low oxygen fires.
- Is a histo-toxin, cellular asphyxiant (prevents cells from taking up or utilizing oxygen from the bloodstream).
- Signs and symptoms of exposure mimic CO exposure – red discoloration in skin, headache, weakness, dizziness.

<table>
<thead>
<tr>
<th>Concentrations</th>
<th>Effect</th>
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<tbody>
<tr>
<td>Concentrations</td>
<td>mg/m3</td>
</tr>
<tr>
<td>300</td>
<td>270</td>
</tr>
<tr>
<td>200</td>
<td>180</td>
</tr>
<tr>
<td>150</td>
<td>135</td>
</tr>
<tr>
<td>120-150</td>
<td>108-135</td>
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<tr>
<td>20-40</td>
<td>18-36</td>
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The building materials and contents of structures have drastically changed over the years:

- Buildings are more energy efficient and “tighter,” leading to less oxygen entrainment and incomplete combustion.
- Glue Bonded Wood, Expandable Foams, Plastics, and Insulation are more prevalently used in construction.
- Synthetic Polymers are found in Carpets, Mattresses, Cushions, and Electronics.

The combustion of synthetic materials, including nylon, polyurethane, synthetic rubber, melamine, resins for molding, and various laminates, produce HCN when they burn.

The changes in construction materials and contents are making fires burn 2 to 3 times hotter, creating faster flashovers, and producing larger amounts of turbulent smoke during combustion. Because synthetics burn hotter than natural materials and produce quicker flashovers, they also speed up the release of HCN.
Necessary Actions:

Liberated gases and vapors remain in the overhaul environment; airborne concentrations do not drop off as a function of time.

1. Monitoring CO concentrations alone does not predict other lethal gases (HCN).
   - Monitor for HCN using instruments with electrochemical sensors or colorimetric detector tubes.

2. Firefighters need to use the SCBA, do not just wear it. Investigators need to wear respiratory protection.
   - Don before you enter the structure
   - Wear it during overhaul
Conclusion

- Fires in structures today are not the same as they were 20 years ago. With the addition of synthetic materials in construction and contents, fires are burning faster, hotter, and generating more toxic gases and vapors than ever.

- The leading cause of line of duty injuries and deaths for firefighters and investigators is attributed to smoke inhalation.

- HCN and CO are synergistic – have a greater combined toxicity than either toxicant alone – and exposure to large concentrations manifest to cardiac arrhythmia and other respiratory distress.

- Monitor the scene for HCN as well as CO – wear appropriate respiratory protection during overhaul and the investigation.