FIREFIGHTER TOOLBOX

BUILDING BETTER FIREFIGHTERS & LEADERS

5 MINUTE Clinic Series™

MODERN FIRE BEHAVIOR; PRODUCTS OF COMBUSTION

By Bryan T Smith

When a fuel burns its chemical composition changes which results in the production of new substances and a release of energy in the form of heat. In a structure fire, multiple fuels are involved and with the limited air supply found in a compartment fire the result is an extremely complex chemical reaction. This chemical reaction yields the products of incomplete combustion or non-flaming combustion and heat.

Smoke is a byproduct of incomplete combustion. It has been the constant companion of firefighters for years and we have taken it for granted. We are taught that smoke poses the greatest danger to our respiratory system and as long as we ware our SCBA we will be protected, although still true smoke and the hot gases suspended in the smoke plume have become an even greater concern when it comes to our safety.

Smoke is Fuel, is a term often used but seldom understood. One of the major considerations when determining a fuels ability to ignite and support combustion is it's surface–to-mass ratio which is the ratio of surface area (L x W x H) as compared to its mass (thickness or density) of a fuel. As the ratio increases the fuel particulates become smaller (less mass). As the surface area increases, heat transfer is easier and the material heats more rapidly speeding pyrolysis. The surface-to-mass ratio for modern fuels is very high. Their conversion from a solid to a gaseous state during a fire happens so rapidly that many of the fuel particles cant complete the conversion process and actually stay in a liquid form in the smoke plume. The smoke plume found in the modern fire environment has been compared to a cloud of diesel fuel because it is saturated with these flammable suspended liquid particles.

In the Modern Fire Environment, we need to view smoke as a separate fuel source. The primary fuel source being the animated fuels such as sofas, chairs, curtains, flooring etc… But it is the superheated fuel rich gases suspended in the smoke plume that present a secondary danger when it comes to rapid fire progression like ventilation induced flashover and smoke explosion.

Smoke can also be a source of information, when it comes to sizing-up

The Fires Location
The Direction the Fire is Moving
Stage of Fire Development
Flow path
Location to Start Fire Attack
Location to Start Ventilation

SMOKE DEFINED

In a simpler time, smoke was viewed as the particulates suspended in a thermal column. Fire gases and aerosols were listed as separate products of the combustion process. In today's world, that oversimplification is dangerous. When we see smoke leaving a building, it needs to be interpreted as an aggregate of solids, aerosols, and fire gases that are toxic, flammable, and explosive!

Solids suspended in the thermal plume include

- Carbon (soot),
- Dust and airborne fibers
- Ash and particulate

Aerosols typically include a whole host of hydrocarbons

- Oils
- Tar
- Other suspended liquid particles (Flaming Drips)

Fire gases are numerous

- Carbon Monoxide (toxic and flammable at 1,128°F)
- Carbon Dioxide (displaces oxygen)
- Hydrogen Chloride (corrosive to human tissue)
- Acrolein (toxic, inhalation of 10PPM is fatal)
- Benzene (carcinogen)
- Formaldehyde (carcinogen)
- Polycyclic Aromatic Hydrocarbons (PAH's) (carcinogens)
- Sulfur Dioxide (toxic and corrosive)