Fire Triangle/Tetrahedron & Combustion Cheat Sheet

by [deleted] via cheatography.com/2754/cs/8928/

The Fire Tetrahedron

The concept of fire was symbolized by the Triangle of Combustion and represented, fuel, heat, and oxygen. Further fire research determined that a fourth element, a chemical chain reaction, was a necessary component of fire. The fire triangle was changed to a fire tetrahedron to reflect this fourth element. A tetrahedron can be described as a pyramid which is a solid having four plane faces. Essentially all four elements must be present for fire to occur, fuel, heat, oxygen, and a chemical chain reaction. Removal of any one of these essential elements will result in the fire being extinguished..

Credit: http://www.firesafe.org.uk/information-about-the-fire-trianglet-etrahedron-and-combustion/

The Four Elements

The four elements are oxygen to sustain combustion, sufficient heat to raise the material to its ignition temperature, fuel or combustible material and subsequently an exothermic chemical chain reaction in the material. Each of the four sides of the fire tetrahedron symbolise the **Fuel, Heat, Oxygen and Chemical Chain Reaction**. Theoretically, fire extinguishers put out fire by taking away one or more elements of the fire tetrahedron.

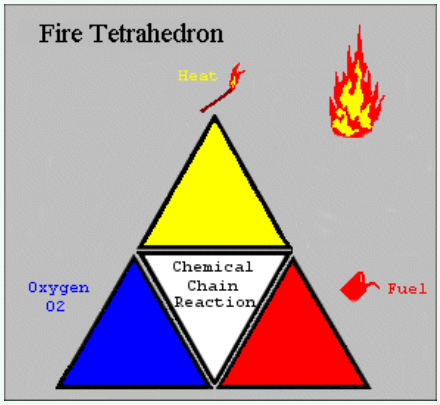
Extinguishing a Fire

The symbol although simplistic, is a good analogy, how to theoretically extinguish a fire, by creating a barrier using foam for instance and prevent oxygen getting to the fire. By applying water you can lower the temperature below the ignition temperature or in a flammable liquid fire by removing or diverting the fuel. Finally interfering with the chemical chain reaction by mopping up the free radicals in the chemical reaction using, BCF and other halon extinguishers, it also creates an inert gas barrier. However this type of extinguisher is being phased out and in the future other extinguishing agents may be found using this principle..

Classes of Fire

- Class A fires involve Organic solids like paper, wood, ...
- Class B fires involve Flammable Liquids
- Class C fires involve Flammable Gasses
- Class D fires involve Metals
- Class F fires involve Cooking oils.

The Fire Tetrahedron



The Combustion Modes

- Flaming Mode
- Non-flaming Mode, smoldering or glowing embers.

Flaming mode: it is necessary for solid and liquid fuels to be vaporized. The solid fuel vapors are thermally driven off, or distilled and the liquid fuel vapors evaporated. It is this volatile vapor from the solid or liquid fuels that we see actually burning in the flaming mode. This gas or vapor production, emitted from the fuel is referred to as pyrolysis. Once a flame has been established, heat transfer from the flame to the fuel surface continues to drive off more volatile gases and perpetuates the combustion process. For continued burning in the flaming mode requires a high burning rate, and the heat loss associated with transfer of heat from the flame area by conduction, convection, and radiation must be less than the energy output of the fire. If the heat loss is greater than the energy output of the fire the fire will extinguish.. Both modes, flaming and non-flaming surface modes, can occur singly, or in combination. Flammable liquids and gases only burn in the flaming mode. Wood, straw, and coal both modes may exist simultaneously.

Flaming combustion forms

- Premixed flames where the fuel and oxygen are mixed prior to ignition. For example the flame on a bunsen burner, gas stove, or propane torch.
- Diffusion flames, more common, where the fuel and oxygen are initially separate but burn in the region where they mix, like a burning of a pool of flammable liquid or the burning of a log.

Three Stages of a Fire

There are three generally recognized stages to a fire. The incipient stage, smoldering stage, and flame stage.

Incipient stage: where preheating, distillation and slow pyrolysis are in progress. Gas and sub-micron particles are generated and transported away from the source by diffusion, air movement, and weak convection movement, produced by the buoyancy of the products of pyrolysis.

Smoldering stage: Fully developed pyrolysis that begins with ignition and includes the initial stage of combustion. Invisible aerosol and visible smoke particles are generated and transported away from the source by moderate convection patterns and background air movement.

Flaming stage: Rapid reaction that covers the period of initial occurrence of flame to a fully developed fire. Heat transfer from the fire occurs predominantly from radiation and convection from the flame.

Explosions

Generally, an explosion is defined as a very rapid release of high-pressure gas into the environment. The energy from this very rapid release of the high-pressure gas is dissipated in the form of a shock wave.

Explosions can be classified as physical, a balloon bursting, as physical and/or chemical, a boiler explosion, or a chemical reaction of a gas/particle mixture. Our discussion will focus on chemical reaction explosions. The process of a chemical reaction explosion is similar to the combustion process whereby a fuel and oxidant have premixed prior to ignition such as petroleum vapor or fine particles of grain dust mixed with air. However, in an explosion the oxidation process proceeds at a greatly accelerated rate. The oxidation process is usually, but not always, confined within an enclosure such as a tank, grain silo, so that a rapid high-pressure rise occurs with an associated flame front. Generally, it is this high-pressure shock wave that causes the damaging effects from an explosion.. Resultant shock waves that propagate from the point of ignition at a velocity less than the speed of sound are termed deflagration. Shock wave velocities in excess of the speed of sound are termed detonations.