Collaborative Bachelor's Degree Program of Fire Protection and Safety Engineering Technology between Southwest Jiaotong University and Oklahoma State University, U.S.A.

FPST 1213 Fire and Safety Hazard Recognition

Fire Behavior – Part 1

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Objectives

- Introduction to Fire Behavior Terminology and Science

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What is Fire?

- Fire
  - Flaming combustion
- Combustion
  - Combustion is an exothermic chemical reaction that is a self-sustaining process of rapid oxidation of a fuel that produces **heat**, **light**, and **smoke**.
- Physical vs. chemical change
  - **Physical** - material remains the same (ice melting)
  - **Chemical** - reaction between two different substances to form a compound, involve a reaction.
  - Physical and Chemical both involve an exchange of energy
- Fire is an exothermic oxidation reaction
  - **Endothermic** - absorbs energy
  - **Exothermic** - produces energy
  - An example of exothermic reaction is oxidation
    - Oxidation is a chemical reaction involving the combination of oxygen with other materials.
      - rust: slow
      - combustion: fast

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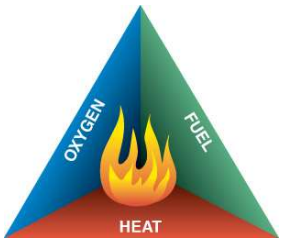
Fire Triangle

- Three elements required for combustion:
  - Fuel
  - Oxygen
  - Heat



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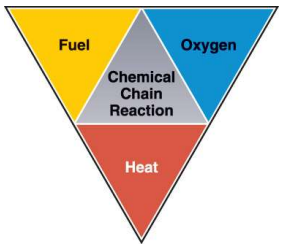
Fire Tetrahedron



- Three elements required for combustion:
  - Fuel
  - Oxygen
  - Heat
- Self-Sustained Chemical Chain Reaction

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Chemical Chain Reaction

- Which burns faster?
- Why?

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Chemical Chain Reaction

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Chemical Chain Reaction

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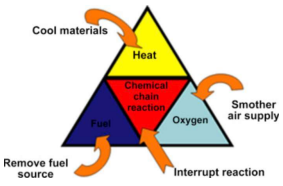
Understanding the Science



- Understanding the science of fire helps determine the requirements for fuel separation, interior finishes, sprinkler coverage, etc.

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Fire

- Depends on a number of factors:
  - Available fuel
  - Sustaining enough heat/temperature
  - Amount of oxygen available

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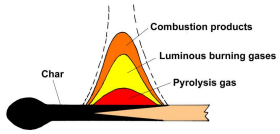
Solid Fuels



- Solid Fuels
  - Pyrolysis
    - Decomposing a solid by hearting
  - Surface to Mass Ratio
    - P. 93
  - Ignition Temperature
    - Piloted vs. Auto
      - P. 79

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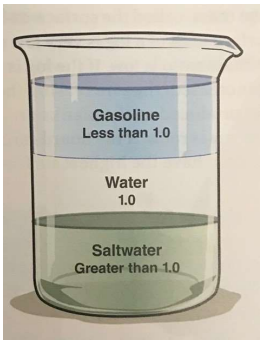
Liquid Fuels

- Liquid Fuels
  - Specific Gravity
    - Weight of a substance compared to the weight of an equal volume of water at a given temperature
    - Water = 1



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Liquid Fuels

- Liquid Fuels
  - Vaporization
    - Transformation of a liquid to a vapor or gaseous state. Must overcoming atmospheric pressure of 14.7 psi
    - Liquids must be vaporized in order to burn.
    - Adding heat allows a liquid to overcome atmospheric pressure and vaporize more rapidly.
  - Vapor Pressure
    - P. 90
  - Vapor Density
    - Air = 1

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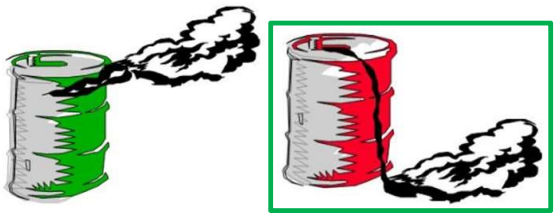
Which one has the higher vapor density?



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Liquid Fuels

- Liquid Fuels
  - Flash Point
  - Fire Point
    - P. 90

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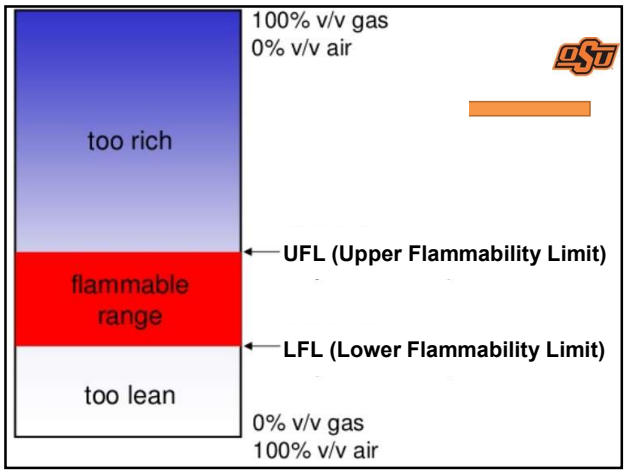

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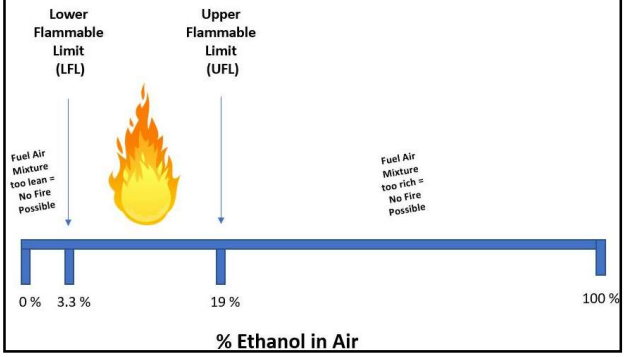
Example: Ethanol



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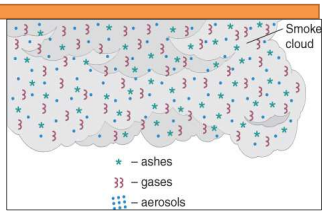
Smoke

- Products of combustion
  - Ashes
  - Gases
  - Aerosols
- Major Killer
  - Carbon monoxide
  - Hydrogen cyanide
  - Phosgene
    - Cl and CO reaction



50 ppm = OSHA PEL
100 ppm = headaches
1200 ppm = IDLH
1600 ppm = fatal in 2 hrs

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Heat Transfer

- Combustion gives off heat that can ignite other nearby fuels
- Heat energy always flows from hotter to colder via three methods of heat transfer:
  - Conduction
  - Convection
  - Radiation

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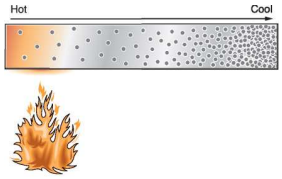
Conduction

- Heat transferred from one molecule to another (direct contact)



Wood vs. Metal

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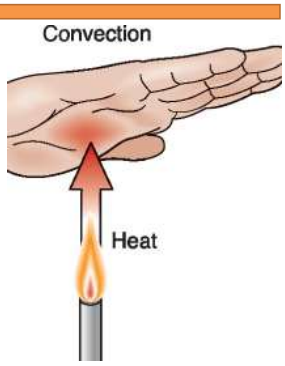
Convection

- Movement of heat through a fluid medium such as air or a liquid as a result of circulation
- Creates convection currents
- Can be in any direction but is more so upward



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Radiation

- Transfer of heat in the form of an invisible energy wave
- Heat radiated to a nearby structure can ignite it
- Radiated heat passing through a window can ignite an object
- Effected by distance from heat source

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Fuel Classification

A		Ordinary Combustibles	Wood, Paper, Cloth, Etc.
B		Flammable Liquids	Grease, Oil, Paint, Solvents
C		Live Electrical Equipment	Electrical Panel, Motor, Wiring, Etc.
D		Combustible Metal	Magnesium, Aluminum, Etc.
K		Commercial Cooking Equipment	Cooking Oils, Animal Fats, Vegetable Oils

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Fuel Class?

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Fuel Class?

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Fuel Class?

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Fuel Class?

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Fuel Class?

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Fuel Class?

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Fuel Class?

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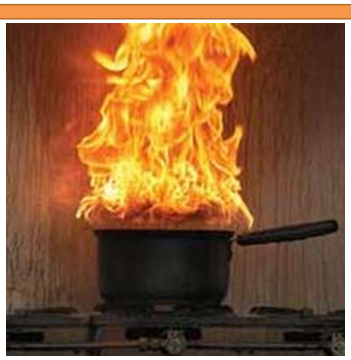
Fuel Class?



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Fuel Class?

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Fuel Class?

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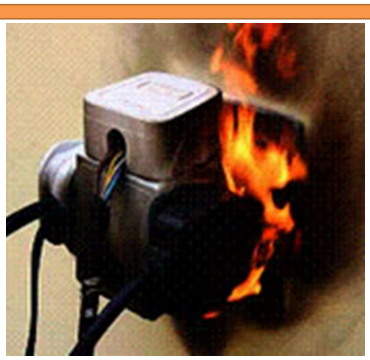
Fuel Class?



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Fuel Class?

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Fuel Class?

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