This special edition is devoted to understanding fire behavior.

Members should always consult department operational procedures and training materials when using any of the Weekly Fire Drill materials.

Instructors should use these worksheets as guides for company level training sessions using your department SOG's and your equipment.

**Special Edition Subjects**
- Fire Triangle
- Methods of Heat Transfer
- Phases of Fire
- Thermal Layer
- Flashover-Point of No Return
- Fire Behavior & Building Construction
- Fuel Load & Ignition Temperature
- Backdraft
- Fire Behavior Terms
- Fire Behavior Quiz
The four basic methods of extinguishing fires require the understanding of how they affect the fire triangle and tetrahedron. The four basic methods of extinguishing fires are:

1. Cool the burning material (reduce temperature)
2. Exclude oxygen
3. Remove fuel from fire
4. Break (inhibit) chemical chain reaction

Identify as many examples of how these extinguishment methods can be accomplished as you can.

<table>
<thead>
<tr>
<th>Cooling</th>
<th>Excluding Oxygen</th>
<th>Removal of Fuel</th>
<th>Inhibit Chain Reaction</th>
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</table>
There are 4 methods of heat transfer.

1. Direct flame contact
2. Radiant heat
3. Conduction
4. Convection

Describe your actions to identify and stop the transfer of heat from one object to another.

<table>
<thead>
<tr>
<th>Method of Heat Transfer</th>
<th>Where you would see this during a fire.</th>
<th>Identification methods.</th>
<th>Actions taken to stop, reduce or prevent heat transfer</th>
</tr>
</thead>
<tbody>
<tr>
<td>Direct Flame Contact</td>
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<tr>
<td>Radiant Heat</td>
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<td>Conduction</td>
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<tr>
<td>Convection</td>
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</table>
Pictured above are the 4 stages of fire. Describe your extinguishment, control, containment and general operations for each of these phases of fire.

- What stage might produce a flashover?
- What stage might produce a backdraft?
- Review Text references to determine approximate temperatures in each phase.

1. What extinguishing methods are used in each phase?
2. What safety precautions are used during attack in each of these phases of fire?
3. Which phase produces the most amount of heat?
4. Review appropriate tactics & strategies for attack in each phase.
While operating on the interior of a fire, it is important to note the thermal layers that are present. These thermal layers are the separation between different temperatures and products of combustion.

- What happens when the thermal layer is disturbed?
- What could cause the thermal layer to be disturbed?
- How could you avoid or reduce disturbing the thermal layer during interior operations?

**Thermal Layering**

- Superheated gases collect near ceiling.
- Temperatures are lowest near floor.
- Fire streams create steam which expands and rises.
- Prevention:
  - Coordinate fire attack with ventilation.
  - Use straight streams to minimize steam formation.
POINT OF NO RETURN

- According to the Time Temperature Curve, a Firefighter is exposed to 1000° to 1500° F during a Flashover.
- A person will experience extreme pain from temperatures of 280° to 320° F on unprotected skin.
- The average speed a Firefighter can crawl in full protective clothing is about 2 ½ feet / second.
- At these temperatures a Firefighter could expect to last about **2 - SECONDS** in a Flashover before being overcome by the heat and pain.
- Therefore a Firefighter should not go more than **5 - FEET** into a room that may Flashover.
- Use tools to extend your reach into a room when searching and keep within 5 – Feet of the door or window you entered.

Fire behaves differently in each type of building construction. Some hold heat and limit the amount of fire spread while other structural types have common spaces that allow for fire travel and extension. Other types of construction add fuel to the fire load.

Review and discuss the types of building construction and what happens when fuel burns inside them.

<table>
<thead>
<tr>
<th>Building Type</th>
<th>Fire Spread Route</th>
<th>Smoke Travel Route</th>
<th>Avenue(s) of Extension</th>
<th>Fire Behavior Considerations</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fire Resistive (I)</td>
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<tr>
<td>Non-Combustible (II)</td>
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<tr>
<td>Ordinary (III)</td>
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<tr>
<td>Heavy Timber (IV)</td>
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<tr>
<td>Wood Frame (V)</td>
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⇒ **Surface to mass ratio**

1. Ratio of surface area of the fuel to the mass of the fuel
2. As ratio increases, fuel particles become smaller and more finely divided and ignitability increases tremendously
3. As surface area increases, heat transfer is easier and the material heats easier thus accelerates pyrolysis

⇒ **Positioning**

1. Vertical is best for fire spread

⇒ **Moisture content**

1. More moisture means slower ignition

⇒ **Arrangement (air)**

1. Material packed tight vs. piles of skids at lumberyard

⇒ This means that the more finely divided the fuel, the easier it is ignited.

⇒ Larger dimensions need higher temperatures to ignite.
List as many of the BACKDRAFT indicators that you know of.

- If any of these indicators are present, what are your actions?

- What types of building construction are prone to backdraft?

- Where in a structure could a backdraft occur?
<table>
<thead>
<tr>
<th>Fire Behavior Term</th>
<th>Where Illustrated in this Photo</th>
<th>Danger to Firefighters</th>
<th>Prevention/ Prediction</th>
</tr>
</thead>
<tbody>
<tr>
<td>Flashover</td>
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<tr>
<td>Direct Flame Contact</td>
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<td>Convection</td>
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<tr>
<td>Backdraft</td>
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<tr>
<td>Radiant Heat</td>
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<td>Rollover</td>
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<td>Ignition Temperature</td>
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<td>Products of Combustion</td>
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<tr>
<td>Law of Heat Flow</td>
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<tr>
<td>Fuel Load</td>
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<tr>
<td>Fire/ Combustion</td>
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</tbody>
</table>
1. Convection is:
   A. transfer of heat through space by infrared rays.
   B. transfer of heat through a solid medium.
   C. not considered a method of heat transfer.
   D. transfer of heat through liquids or gases by circulating currents.

2. The phase of fire characterized by temperature decline and diminishing fire is called:
   A. ignition.
   B. growth.
   C. fully developed.
   D. decay.

3. Which stage of fire releases the maximum amount of heat for the available fuel and produces large volumes of fire gases?
   A. ignition.
   B. fully developed.
   C. growth.
   D. rapid oxidation.

4. The principle which most closely describes how water extinguishes fire is:
   A. removal of fuel.
   B. reduction of temperature.
   C. exclusion of oxygen.
   D. inhibition of chain reaction.

5. ________________________ is the transition between the growth and fully developed stages of fire.
   A. Flashover
   B. Backdraft
   C. Flash point
   D. Ignition temperature

6. Fire can be extinguished by:
   A. reducing heat, removing oxygen, removing fuel, or stopping the chemical chain reaction.
   B. radiation, conduction, or convection.
   C. reducing heat, increasing oxygen, or removing fuel.
   D. ordinary combustibles, flammable liquids, electrical equipment, and combustible metals.

7. A condition that could be a factor leading to a backdraft situation is:
   A. natural ventilation.
   B. lack of fire stops.
   C. confinement of products of combustion.
   D. rapid extinguishment of products of combustion.

8. The fire tetrahedron includes all the elements of the fire triangle plus:
   A. radiation energy.
   B. chemical reaction.
   C. carbon dioxide.
   D. carbon monoxide.

References for this Edition:
⇒ Fundamentals of Firefighter Skills
⇒ IFSTA Essentials
⇒ Delmar Firefighters Handbook
⇒ Building Construction for Fire Safety; Brannigan, 3rd
⇒ (Photo & Illustration Credits available upon request)