

# **LESSON ONE**

# **FIREFIGHTER I**

## **Fire Behavior**

**DOMAIN:** COGNITIVE

**LEVEL OF LEARNING:** KNOWLEDGE

### **MATERIALS**

IFSTA Essentials 5th edition or Jones and Bartlett Fundamentals of Fire Fighter Skills 2<sup>nd</sup> Edition or Delmar Firefighter's Handbook 3<sup>rd</sup> Edition; overhead projector or laptop computer and multi media projector; projection screen; candles, lighter, matches, fire extinguisher, beaker, glass, and safety glasses.

### **NFPA 1001 JPRS, 2008 edition**

- 5.3.10 Attack an interior structure fire
- 5.3.12 Perform vertical ventilation on a structure

### **Junior Member Statement:**

Junior Member training activities should be supervised by qualified instructors to assure that the cognitive and psychomotor skills are completed in a safe and non-evasive manner. While it is critical that instructors be constantly aware of the capabilities of all students both mentally and physically to complete certain tasks safely and successfully, the instructor should take every opportunity to discuss with departmental leaders and students the maturity and job awareness each participant has for the hazards associated with fire and rescue training.

### **TERMINAL OBJECTIVE**

The Firefighter I candidate shall correctly define in writing the term fire, describe the two main theories of fire, and describe the three physical states of matter.

### **ENABLING OBJECTIVES**

1. The Firefighter I candidate shall correctly define in writing the term fire.
2. The Firefighter I candidate shall correctly define in writing the theory of fire known as the fire triangle.
3. The Firefighter I candidate shall correctly explain in writing the theory of fire known as the fire tetrahedron.
4. The Firefighter I candidate shall correctly define in writing the three physical states of matter known as solids, liquids and gases.
5. The Firefighter I candidate shall correctly explain in writing the technical terms describing how a fire burns on the top of a candle.

## **OBJECTIVE PAGE**

# LESSON ONE

# FIREFIGHTER I

## Fire Behavior

### MOTIVATION

Safe and effective fire control requires a basic understanding of the chemical and physical nature of fire. Fire behavior is in essence the foundation of a firefighter's knowledge of fire science. This knowledge forms the basis for practically all types of operations at the fire scene, from initial attack to determining the origin and cause of the fire. Should the firefighter fail to see the importance of the lessons found here, all other aspects of their fire service performance will suffer.

### PRESENTATION

#### ENABLING OBJECTIVE #1

The Firefighter I candidate shall correctly define in writing the term fire.

1. Provide the class with a definition of fire.
2. Define oxidation for the class.
3. Give examples of slow and rapid oxidation like rust and explosions. Generate a discussion from the class about various kinds of oxidation typically seen by the fire service.

Reference:

Delmar Handbook 3rd edition, pages 87-89, 90

J&B Fundamentals 2<sup>nd</sup> edition, pages 129-131

IFSTA Essentials 5th edition, pages 86-87

### PRESENTATION

#### ENABLING OBJECTIVE #2

The Firefighter I candidate shall correctly define in writing the theory of fire known as the fire triangle.

1. Draw the fire triangle and discuss with the candidates its meaning.
2. Explain why we use the fire triangle to explain the process of fire.
3. Explain the oxygen side of the triangle.
  - a) Give examples of oxidizers commonly encountered in the fire service.
4. Explain the heat side of the triangle.
  - a) Give examples of heat sources known to initiate fires.
  - b) Chemical, electrical, and mechanical are sources of energy or heat.
5. Explain the fuel side of the triangle.
  - a) Give examples of fuels that we as firefighters encounter on a regular basis.
  - b) Include fuels from all three states of matter: solids, liquids, and gases.

Reference:

Delmar Handbook 3rd edition, pages 87-96  
IFSTA Essentials 5th edition, pages 87-105

## **PRESENTATION**

### **ENABLING OBJECTIVE #3**

The Firefighter I candidate shall correctly explain in writing the theory of fire known as the fire tetrahedron.

1. Draw the fire tetrahedron and discuss its meaning with the candidates.
2. Explain the relationship between fuel and a reducing agent.
3. Explain the relationship between oxygen and an oxidizing agent.
4. Explain the difference between heat and temperature.

5. Illustrate and explain an uninhibited chemical chain reaction and discuss how the reaction occurs or propagates.

Reference:

Delmar Handbook 3rd edition, pages 87-96

J&B Fundamentals 2<sup>nd</sup> edition, pages 130-131

IFSTA Essentials 5th edition, pages 87-91, 96, 103-107

## **PRESENTATION**

### **ENABLING OBJECTIVE #4**

The Firefighter I candidate shall correctly define in writing the three physical states of matter known as solids, liquids and gases.

1. List the three physical states of matter.
  - a) Solids.
  - b) Liquids.
  - c) Gases.
2. List examples of the three physical states of matter. Use water as an initial example since it can address all three physical states.
3. Generate a discussion on how things like temperature and atmospheric pressure can change something's physical state.

Reference:

Delmar Handbook 3rd edition, pages 92-94

J&B Fundamentals 2<sup>nd</sup> edition, page 129

IFSTA Essentials 5<sup>th</sup> edition, page 87

## **PRESENTATION**

### **ENABLING OBJECTIVE #5**

The Firefighter I candidate shall correctly explain in writing the technical terms describing how a fire burns on the top of a candle.

1. With the use of a candle, explain to the candidates how the fire on the top of a candle burns.
  - a) The paraffin is the reducing agent.
  - b) Inside the wax is a wick, which allows the wax when melted to rise into the heat and vaporize.
  - c) The atmosphere supplies oxygen the oxidizing agent.
  - d) When the candles wick is ignited, the flame is small and may flicker because the fuel is not vaporizing fast enough to maintain a steady flame.
  - e) As the flame increases, have the candidates turn down the lights in the room and look at the base of the flame. The flame will not or should not be touching the wick. This demonstrates that the chemical chain reaction is taken place away from the wick with the vapors of the reducing agent reacting with oxygen because of the flame's temperature.
2. Place a beaker or glass slowly over the flame, stopping at different levels.
3. Explain how the fire is using up the available oxygen and that the fuel gases are also pushing air out of the bottom of the glass (Oxygen concentration is below 14%).
4. Completely seal the glass to the table to extinguish the fire. Explain that even though the fire is out and the oxygen is deleted, the fuel is still hot enough to vaporize for a short period of time.
5. Explain that in some cases it may be possible to re-ignite the vapors after the flame is extinguished.
6. Be sure that the candidates completely understand the combustion process occurring in the demonstration.
7. Repeat the demonstration if necessary.

Reference:

Delmar Handbook 3rd edition, pages 87-96

## **APPLICATION**

Divide the class into suitable size workgroups (3 to 5 candidates). Have each group write a short technical explanation explaining their observations during the candle demonstration. Students should be asked to supply the most technical explanation that they are able to provide. Have each group select a spokesperson to present their explanation to the class. Encourage class discussion, if time permits, and be sure that the key points of the entire lesson are discussed before this exercise ends. Moderate this discussion, allowing the candidates to take the lead. This will allow the instructor to assess the students' grasp of the subject.

## **SUMMARY**

Review the definition of fire. Also, differentiate between fire and combustion.

Re-examine the theories of fire, known as the fire triangle and the fire tetrahedron, with an emphasis on the fact that the tetrahedron is most accurate.

Initiate a brief discussion, reviewing the three physical states of matter known as solids, liquids, and gases.

Summarize, in correct terminology, the process of fire as demonstrated by the flame at the top of a candle.

# **LESSON TWO**

# **FIREFIGHTER I**

## **Fire Behavior**

**DOMAIN:** COGNITIVE

**LEVEL OF LEARNING:** KNOWLEDGE

### **MATERIALS**

IFSTA Essentials 5th edition or Jones and Bartlett Fundamentals of Fire Fighter Skills 2<sup>nd</sup> Edition or Delmar Firefighter's Handbook 3<sup>rd</sup> Edition;; overhead projector or laptop computer and multimedia projector; projection screen.

### **NFPA 1001 JPRs, 2008 edition**

5.3.11 Perform horizontal ventilation on a structure

5.3.12 Perform vertical ventilation on a structure

### **Junior Member Statement:**

Junior Member training activities should be supervised by qualified instructors to assure that the cognitive and psychomotor skills are completed in a safe and non-evasive manner. While it is critical that instructors be constantly aware of the capabilities of all students both mentally and physically to complete certain tasks safely and successfully, the instructor should take every opportunity to discuss with departmental leaders and students the maturity and job awareness each participant has for the hazards associated with fire and rescue training.

### **TERMINAL OBJECTIVE**

The firefighter I candidate shall correctly explain in writing how to recognize and identify incipient fire, rollover, hot smoldering fire, flashover, steady state burning, back draft, three products of combustion commonly found in structure fires, and explain the relationship of the concentration of oxygen to combustibility and life safety.

**ENABLING OBJECTIVES**

1. The Firefighter I candidate shall correctly state in writing the definition of incipient fire, and describe the hazards associated with it.
2. The Firefighter I candidate shall correctly state in writing the definition of steady state burning and describe the hazards associated with it.
3. The Firefighter I candidate shall correctly state in writing the definition of rollover, and describe the hazards associated with it.
4. The Firefighter I candidate shall correctly state in writing the definition of flashover and describe the hazards associated with it.
5. The Firefighter I candidate shall correctly state in writing the definition of hot smoldering fire, and describe the hazards associated with it.
6. The Firefighter I candidate shall correctly state in writing the definition of back draft, and describe the hazards associated with it.
7. The Firefighter I candidate shall correctly identify in writing three different products of combustion.
8. The Firefighter I candidate shall correctly define in writing the relationship of oxygen to combustibility and life safety.

# LESSON TWO

## FIREFIGHTER I

### Fire Behavior

#### MOTIVATION

A fire can start at any time of the day or night. If a fire starts when people can call for help, firefighters may be able to put the fire out while it is still in the first stage. If a fire starts when no one is present to call for help, it may burn for minutes or hours and progress rapidly. The firefighter may be confronted by one or all of these stages of fire. A working knowledge of these stages, their conditions, signs, and indicators is crucial to the proper choice of ventilation, attack methods, and overall safety of personnel.

**NOTE:** Traditionally, the fire service has used the terms: incipient, steady state, and hot smoldering to describe the phases or stages of fire. Fire science researchers have recently categorized fire into five phases: ignition, growth, flashover, fully developed, and decay. The Instructor is advised to provide a correlation between the traditional terminology and the latest terminology concerning the phases of fire.

#### PRESENTATION

##### ENABLING OBJECTIVE #1

The Firefighter I candidate shall correctly state in writing the definition of incipient fire, and describe the hazards associated with it.

1. Define incipient fire or ignition phase of fire and discuss piloted and non-piloted ignition.
2. Describe the oxygen levels found within this type of fire, and explain that such oxidizing agents are not combustible.
3. Explain and list the products being produced by the fire.

4. Describe the heat levels in this fire as it goes from ignition phase into the early growth phase.
5. Point out the hazards found in these phases of the fire.

Reference:

Delmar Handbook 3rd edition, pages 100

J&B Fundamentals 2<sup>nd</sup> edition, pages 135-136

IFSTA Essentials 5th edition, pages 114-115

## **PRESENTATION**

### **ENABLING OBJECTIVE #2**

The Firefighter I candidate shall correctly state in writing the definition steady state burning, and describe the hazards associated with it.

1. Define steady state or free burning and point out that this a combination of the late growth, flashover, and fully developed phases of the new terminology.
2. Describe how oxygen is drawn into the fire and what effects it has on the fire through the growth, flashover, and fully developed phases.
  - a) This is the steady state phase.
3. Explain how heat and gases are carried upward, and how this will aid the fire in spreading.
4. Discuss oxygen levels and temperatures that will be present in a compartmentalized fire and how this affects the safety of firefighters.
5. Illustrate the way flames will spread through a structure.
6. Point out the hazards associated with a fire in its steady state burning phase.

Reference:

Delmar Handbook 3rd edition, pages 102

J&B Fundamentals 2<sup>nd</sup> edition, pages 136

IFSTA Essentials 5th edition, pages 116-121

## **PRESENTATION**

### **ENABLING OBJECTIVE #3**

The Firefighter I candidate shall correctly state in writing the definition of rollover, and describe the hazards associated with it.

1. Define the term rollover or as it is sometimes called, flame over.
2. Describe the development of the compartmentalized fire as it leads to rollover / flame over.
3. Discuss the recognition of conditions leading up to rollover so that firefighters can reverse the effects or evacuate the area before the rollover occurs.
4. Discuss in detail the hazards associated with rollover.

Reference:

Delmar Handbook 3rd edition, pages 107

J&B Fundamentals 2<sup>nd</sup> edition, pages 138-140

IFSTA Essentials 5<sup>th</sup> edition, page 118

### **PRESENTATION**

#### **ENABLING OBJECTIVE #4**

The Firefighter I candidate shall correctly state in writing the definition of flashover, and describe the hazards associated with it.

1. Define flashover.
2. Point out that flashover and rollover are extremely different occurrences and the two are often mistaken.
3. Describe the conditions of the fire as they lead up to flashover.
4. Points out the hazards associated with flashover, and discuss the importance of controlling the fire and cooling the upper level room atmosphere prior to flashover.

Reference:

Delmar Handbook 3rd edition, pages 107

J&B Fundamentals 2<sup>nd</sup> edition, pages 137-138, 405-406  
IFSTA Essentials 5th edition, pages 118-120

**NOTE: The ability to recognize the conditions associated with rollover and flashover will save the firefighter's life. Many firefighters have survived rollover, but few have survived a flashover.**

## **PRESENTATION**

### **ENABLING OBJECTIVE #5**

The Firefighter I candidate shall correctly state in writing the definition of hot smoldering fire and describe the hazards associated with it.

1. Define hot smoldering fire, or as it is now called the decay phase, and point out the fact that this is normally a fuel-controlled fire.
2. Illustrate the fact that the visible flames may cease to exist; however, this should be recognized as an indicator of a dangerous, potentially explosive atmosphere.
3. Discuss the oxygen levels typically present during the decay phase of the fire as well as the products of combustion and illustrate the effects of their potential interaction.
4. Describe the temperature levels within the compartment during the decay phase and emphasize the fact that even though the temperature is dropping, it is still moderately high.
5. Review the potential hazards that exist for the firefighter when making entry into a compartment fire that has reached the hot smoldering or decay phase.

Reference:

Delmar Handbook 3rd edition, pages 102  
J&B Fundamentals 2<sup>nd</sup> edition, page138  
IFSTA Essentials 5th edition, pages 121-125

## **PRESENTATION**

### **ENABLING OBJECTIVE #6**

The Firefighter I candidate shall correctly state in writing the definition of back draft and describe the hazard associated with it.

1. Define the term back draft.
2. Describe the fire conditions that lead up to a back draft.
3. List characteristics or conditions that act as indicators for the possibility of a back draft.
4. Explain in detail what the introduction of oxygen into this ventilation-controlled atmosphere will do.
5. Discuss the critical importance of proper ventilation techniques in relation to potential back draft situations, and the hazards of improper ventilation.
6. Go over hazards of a back draft and emphasize the explosion potential.

Reference:

Delmar Handbook 3rd edition, pages 107-108

J&B Fundamentals 2<sup>nd</sup> edition, pages 140-141, 405

IFSTA Essentials 5th edition, pages 122-125

## **PRESENTATION**

### **ENABLING OBJECTIVE #7**

The Firefighter I candidate shall correctly identify in writing three different products of combustion.

1. Explain what is meant by “products of combustion.”
2. Discuss Carbon as the most common element found in a fire.
3. List and discuss some of the products of combustion that are formed from carbon.
4. Point out the fact that Hydrogen is the second most common element found in a fire.
5. List and discuss some of the products of combustion that are formed from Hydrogen.

6. Discuss the production of water vapor in a fire.
7. Describe the fuels that may produce Hydrogen Cyanide and Sulfur Dioxide.
8. Point out that heat and flame are also considered products of combustion.
9. Ask the candidates if they name any other products of combustion that may be produced.

Reference:

Delmar Handbook 3rd edition, pages 103-104

J&B Fundamentals 2<sup>nd</sup> edition, pages 131-132

IFSTA Essentials 5th edition, pages 107-110

## **PRESENTATION**

### **ENABLING OBJECTIVE #8**

The Firefighter I candidate shall correctly define in writing the relationship of oxygen to combustibility and life safety.

1. Discuss each phase of fire as presented in the previous seven enabling objectives to explain the relationship of oxygen to combustibility and life safety.
2. Point out that while oxygen is not considered a flammable gas, it supports and enables combustion through the process of oxidation.
3. Illustrate the fact that the higher the percentage of oxygen, the higher the degree of risk for a fire to ignite.
4. Discuss the situations where firefighters may encounter more than a 21% oxygen atmosphere.
5. Discuss the fact that atmospheres with less than 21% oxygen also present a serious life threat as well as reduce the probability of fires.
6. Remind the candidates that reduced oxygen levels also slow the combustion process causing a fire to recede into the third stage or decay phase.

7. Remind candidates of the hazards associated with third stage or decay phase fires and back draft.
8. Discuss with the candidates how smoldering or decay phase fires generally produce higher concentrations of carbon monoxide.

Reference:

Delmar Handbook 3rd edition, pages 95

J&B Fundamentals 2<sup>nd</sup> edition, pages 130-131, 135-141

IFSTA Essentials 5th edition, pages 103-105, 112-125

## **SUMMARY**

Review each of the three stages of burning or, as it is now called, the five phases of fire.

Re-examine the definition of rollover or flame over and the fire conditions that lead up to rollover.

Remind the candidates of the hazards of flashover and the importance of recognizing its indicators.

Re-emphasize the deadly potential of a back draft and how to prevent it from occurring.

Summarize the products of combustion and their associated hazards.

Review the correlation of oxygen levels and combustibility of fuels along with the associated hazards.

# **LESSON THREE**

# **FIREFIGHTER I**

## **Fire Behavior**

**DOMAIN:** COGNITIVE

**LEVEL OF LEARNING:** KNOWLEDGE

### **MATERIALS**

IFSTA Essentials 5th edition or Jones and Bartlett Fundamentals of Fire Fighter Skills 2<sup>nd</sup> Edition or Delmar Firefighter's Handbook 3<sup>rd</sup> Edition; overhead projector or laptop computer and multimedia projector; projection screen.

### **NFPA 1001 JPRs, 2008 edition**

5.3.12 Perform vertical ventilation on a structure

5.3.13 Overhaul a fire scene

### **Junior Member Statement:**

Junior Member training activities should be supervised by qualified instructors to assure that the cognitive and psychomotor skills are completed in a safe and non-evasive manner. While it is critical that instructors be constantly aware of the capabilities of all students both mentally and physically to complete certain tasks safely and successfully, the instructor should take every opportunity to discuss with departmental leaders and students the maturity and job awareness each participant has for the hazards associated with fire and rescue training.

### **TERMINAL OBJECTIVE**

The Firefighter I candidate shall correctly define in writing the three methods of heat transfer, and describe the process of thermal layering and how to avoid disturbing the normal layering of heat in a compartmentalized fire.

## **ENABLING OBJECTIVES**

1. The Firefighter I candidate shall correctly describe in writing the law of heat flow.
2. The Firefighter I candidate shall correctly define in writing the term conduction.
3. The Firefighter I candidate shall correctly define in writing the term convection.
4. The Firefighter I candidate shall correctly define in writing the term radiation.
5. The Firefighter I candidate shall correctly describe in writing the term thermal layering.
6. The Firefighter I candidate shall correctly describe in writing the practices used to prevent disturbing the normal thermal layering in a structural fire.

## **OBJECTIVE PAGE**

# **LESSON THREE**

# **FIREFIGHTER I**

## **Fire Behavior**

### **MOTIVATION**

When fighting fire, the firefighter may be faced with a fire that moves or ignites other fires that seem to be totally unrelated to the initial fire. The other fires are caused by the transfer of heat from the first fire to other areas. A typical residential fire may initially appear to be very easy to control. Then without warning, fire can show itself in another area of the structure, far from where the fire started. With this in mind, the firefighter must remain proactive to prevent this movement of the fire. If we as firefighters fail to anticipate the transfer of heat when dealing with fire, the fire will win in combat.

### **PRESENTATION**

#### **ENABLING OBJECTIVE #1**

The Firefighter I candidate shall correctly describe in writing the Law of Latent Heat Flow.

1. Define the Law of Latent Heat Flow. The colder of two bodies will always absorb heat until both objects are the same temperature.
2. Ask as an overhead question, "What are the three methods of heat transfer?"
  - a) Conduction.
  - b) Convection.
  - c) Radiation.
3. Discuss the fact that under the International System of Units, heat transfer is measured in Kilowatts.
4. Emphasize that transmission of heat is measured by the amount of heat generated over a given period of time.

Reference:

Delmar Handbook 3rd edition, pages 96-100

J&B Fundamentals 2<sup>nd</sup> edition, pages 132-133

IFSTA Essentials 5th edition, pages 93-96

## **PRESENTATION**

### **ENABLING OBJECTIVE #2**

The Firefighter I candidate shall correctly define in writing the term conduction.

1. Define conduction and ask candidates for examples of conduction and list them.
2. Explain why the firefighter needs to be aware of conducted heat and how this will affect the firefighter's attack as well as the search for hidden fires.
3. Point out that conducted heat is often responsible for fires that seem to be unrelated to the initial fire.

Reference:

Delmar Handbook 3rd edition, pages 97

J&B Fundamentals 2<sup>nd</sup> edition, page 132

IFSTA Essentials 5th edition, pages 94-95

## **PRESENTATION**

### **ENABLING OBJECTIVE #3**

The Firefighter I candidate shall correctly define in writing the term convection.

1. Define the term convection.
2. Ask candidates for examples of convection and list them on the board.
3. Explain why the firefighter needs to be aware of convection heat and how this will affect their attack procedures and their search for hidden fires.
4. Point out that convection heat is mainly responsible for the spread of fires within structures, especially to upper levels.

Reference:

Delmar Handbook 3rd edition, pages 97-98

J&B Fundamentals 2<sup>nd</sup> edition, page 132

IFSTA Essentials 5<sup>th</sup> edition, page 95

## **PRESENTATION**

### **ENABLING OBJECTIVE #4**

The Firefighter I candidate shall correctly define in writing the term radiation.

1. Define the terms radiation and radiant heat.
2. Ask candidates for examples of radiation or radiant heat and list them.
3. Explain why the firefighter needs to be aware of radiation or radiant heat and discuss how this heat will affect the firefighter's tactics.
4. Point out to the candidates that radiant heat is the primary heat source for external exposure fires.

Reference:

Delmar Handbook 3rd edition, pages 99-100

J&B Fundamentals 2<sup>nd</sup> edition, pages 132-133, 136

IFSTA Essentials 5th edition, pages 95-96

## **PRESENTATION**

### **ENABLING OBJECTIVE #5**

The Firefighter I candidate shall correctly describe in writing thermal layering.

1. Describe how heat is layered in a structure fire by drawing an example on the board.
2. Describe the fire attack practices that are designed to prevent the disruption of thermal layering in a structure fire.
3. Discuss the terms thermal balance and heat stratification.

4. Emphasize the hazards associated with the disruption of thermal balance when making an attack on a fire inside of a structure.

Reference:

Delmar Handbook 3rd edition, pages 101

J&B Fundamentals 2<sup>nd</sup> edition, page 140

IFSTA Essentials 5th edition, pages 117-118

## **PRESENTATION**

### **ENABLING OBJECTIVE #6**

The Firefighter I candidate shall, in writing, describe practices to prevent disturbing the normal thermal layering in a structural fire.

1. Emphasize the hazards associated with the disruption of thermal balance when making an attack on a fire inside of a structure.
2. Describe the fire attack practices that are designed to prevent the disruption of thermal layering in a structure fire.
3. Point out the fact that with the creation of thermal imbalance, forced ventilation will be required.

Reference:

Delmar Handbook 3rd edition, pages 101, 690-691

J&B Fundamentals 2<sup>nd</sup> edition, pages 140-141

IFSTA Essentials 5th edition, pages 117-118

## **SUMMARY**

Review the law of heat flow and how it determines the direction of heat transmission.

Summarize the three methods of heat transfer: conduction, convection, and radiation.

Review the condition of thermal layering, and briefly reiterate the attack methods that prevent or reduce its disruption.