Course Learning Outcomes for Unit I

Upon completion of this unit, students should be able to:

3. Explain the physical and chemical properties of fire.
   - 3.1 Evaluate measurement in understanding fire behavior.
   - 3.2 Examine the basic SI units of measurement and conversion into English units.

5. Define and use basic terms and concepts associated with the chemistry and dynamics of fire.
   - 5.1 Categorize the chemical elements that are related to fires.
   - 5.2 Distinguish the differences in molecules and compounds.

Reading Assignment

Chapter 1:
Fire Measurement and the SI System of Units

Chapter 2:
Chemical Elements and Compounds: Atoms and Molecules

Chapter 3:
Physical and Chemical Change

Unit Lesson

"Review of devastation wrought by fire throughout the centuries reveals that fire is a serial killer" (Corbett & Pharr, 2011, p. 2) and has changed the way we view fire today. This has caused fire service leaders to review ways to reduce "line of duty" injuries or deaths.

The National Fallen Firefighters Foundation (2013) has reviewed the many root causes of fire-related injuries and deaths. Their findings espoused that it is the "behaviors and attitudes that are the true root causes of the fatal incident" (2013, p. 1). They further suggested one of the causes is the lack of preparedness. The authors stated:

> By the very nature of their duties, firefighters must be prepared to face a virtually limitless number of response situations. Unfortunately, firefighters are sometimes killed when they attempt to conduct a level of operations for which the individual or the organization is not prepared. Lack of Preparedness was cited in 389, or approximately 1/3 of the 1252 fatality reports reviewed in 2011. (2013, p. 9)

What does this mean? The authors supposed the, "lack of preparedness is also often symptomatic of poor decision making, because no firefighter should ever attempt to do something that they are unprepared or ill-equipped to undertake" (Everyone Goes Home, 2013, p. 9). Doesn't that mean they didn't have proper personal protective clothing on or they were not trained properly? What about understanding fire behavior or combustion? Many times the need for understanding fire behavior and combustion has gone unheeded. We are taught the fire tetrahedron in the academy and often believe that is all we need to know in order to extinguish a rapidly developing fire. After all, if we remove one element of the tetrahedron the fire goes out. As leaders in the fire service we must understand the science behind rapid fire development; the chemical elements and compounds of fire; the transmission of heat, including conduction, convection, and radiation; fire extinguishment theory; fire behavior in a structure, including products of combustion; the signs, origins, and prevention of backdrafts; and the phases of fire growth as related to oxygen concentration, or the lack thereof.

Points to Ponder

A caller reported a fire at the rear of a coffee warehouse. Engines 211, 212, and 215 were dispatched for a possible structure fire behind the warehouse. Upon responding, law enforcement observed a column of smoke coming from the direction of the warehouse and notified dispatch. Engine 218 self-dispatched according to a verbal agreement between the officers in that district. The initial report from law enforcement indicated trash and debris burning outside the building near the dumpster. Upon the arrival of Engine 211 he reported fire had extended into the building from a debris fire. Engine 212 was ordered to lay a supply line into Engine 211. Engine 218 arrived and spotted in front of the warehouse on "Side A" and the Engineer from Engine 218 hand jacked a line to the hydrant in the parking lot. Engine 211's officer and one firefighter went to the front door and entered the office area to check for fire extension into the building. As they opened the door they immediately observed thick black smoke pulsing and banking down to the floor on the right of the warehouse in the back as products off-gassed. The draft pulled the door out of Engine 211 officer's hand as air from outside the store was drawn toward the fire in the rear. At the same time Engine 218's Engineer described thick black smoke pushing into the atmosphere.

(Adams, 2014)

What is this scenario telling you? Is there any importance in knowing the fire behavior in this scenario? Is there a need to understand the differences between mass and weight that involves the heat, energy and smoke involved in this scenario? Do you really need to know the importance of measurement in understanding fire behavior in a coffee warehouse? Do we really need to understand enthalpy in relation to heat or smoke as seen in this scenario? What are the chemical elements in this scenario? Why are they important to the fire? Why do we need to understand the bonding features of the organic fuel from coffee burning in a warehouse? Do we need to understand buoyant smoke and any incomplete combustion in this scenario? Are you prepared, equipped, or both to undertake the principles of fire behavior and combustion in this scenario?

In order to change perceptions and expectations in the fire service the first initiative from the National Fallen Firefighter Foundation (2004) states, "Define and advocate the need for a cultural change within the fire service relating to safety, incorporating leadership, management, supervision, accountability and personal responsibility" (p. 4). Our personal responsibility is to understand fire behavior and combustion, and the self-sustaining process of how fires originate, spread, and progress. We need to understand the physical characteristics and chemistry of combustion.

Originally the fire triangle was used to teach the components of combustion, using oxygen, fuel and heat to explain the ignition, growth and then decay of fire. We knew that for ignition to occur we needed to have all three of the components to sustain combustion. However, we found that the triangle was not technically accurate after learning another element of combustion that is now graphically represented by the fire tetrahedron. The other element described in the tetrahedron is the self-sustained chemical reaction. In order to extinguish a fire we needed to remove any one of the components. Using the fire tetrahedron we began to describe compositional material near the fire off-gassing and the need to cool the atmosphere in order to stop the fire's progression of the superheated air-track. As more research occurred into fire behavior and combustion we understood that measurement is another key component to understand the fire phenomena (Gann & Friedman, 2015). The authors postulated:

> To help understand the phenomena, it is important to ask when the fire started, how rapidly it grew, how hot it became, and how severe the threat to the population was. The answers to all of these (and many other) questions are rooted in an ability to quantify. The meaning of relative terms, such as "fast moving" or "big," varies widely depending on people's experiences and perceptions. (p. 2)

Gann & Friedman (2015) further suggested we need to understand measurement in order to quantify fire behavior in terms of SI units. Corbett and Pharr (2011) defined SI units as a "system for quantifying measurement that uses meters, liters, grams, and calories" (p. 19). What does measurement have to do with fighting fire? In the scenario you read noted that thick black smoke was pulsing and pushing into the atmosphere and it was banking down to the floor inside of the structure as products in the warehouse were off-gassing. We all know this means flashover is about to occur, based on experience, cognitive understanding, or both. However, is it based on the mass and density of the heat and smoke? What about the volume fraction? Mass fraction? Concentration? Enthalpy units or even temperature units?

In this unit, we will discuss more about what constitutes measurement as being essential to understanding fire phenomena and performing safety calculations. Understanding fire measurement and the SI system of units will explain why it is important to be able to convert these units. You will explore the basic measurements of the fire phenomena and physical substance involved in fire. You will evaluate why fires are characterized by enthalpy rather than energy when discussing fire behavior. You will analyze the elements and their combinations and chemical bonds related to fire and understand the different ways that molecules can be represented.

References

Corbett, G., & Pharr, J. (2011). *Fire dynamics*. Upper Saddle River, NJ: Pearson Education.

Gann, R., & Friedman, R. (2015). *Principles of fire behavior and combustion* (4th ed.). Burlington, MA: Jones & Bartlett.

National Fallen Firefighters Foundation. (2004). *Firefighter life safety summit initial report*. Washington, DC: U.S. Government Printing Office.

National Fallen Firefighters Foundation. (2013). *The six root causes for firefighter line-of-duty deaths*. Retrieved from http://www.everyonegoeshome.com/

Suggested Reading

This link is for a 40 minute presentation by Steve Kerber and Dan Madrzykowski that gives a good overview of the related issues of science and firefighting. It was filmed at the IAFF Redmond Syposium last August 2013.

http://www.youtube.com/watch?v=v2JcNonr4us

This link is for a video on SI Measurement Math 10 U1LI which discusses the International System of Units.

https://www.youtube.com/watch?v=N8YWJF0MsTA

Below are some of the many PowerPoint tutorials that can be found online if you need guidance for creating effective PowerPoint presentations:

- University of Wisconsin-Eau Claire https://www.uwec.edu/Help/office/powerpoint-win2013.htm
- Florida Gulf Coast University http://www.fgcu.edu/support/office2007/ppt/index.asp
- Indezine PowerPoint Tutorials http://www.indezine.com/products/powerpoint/learn/

Learning Activities (Non-Graded)

Review What You Have Learned

The *Challenging Questions* at the end of Chapter 1, on page 11, will help you determine fire measurements and the SI System of Units.

Once you have identified these responses, figure out ways to enhance your knowledge by determining how they would apply to this picture.

(Adams, 2014)

Review What You Have Learned

The *Challenging Questions* at the end of Chapter 2, on page 26, will help you evaluate chemical elements and compounds: atoms and molecules. As you formulate an answer for each question, ask yourself how you can apply this information to your current job in the fire service.

These are non-graded activities, so you do not have to submit them. However, if you have difficulty or questions with the concepts involved, contact your instructor for additional discussion and/or explanation.