B90 Yes, Everybody Knows a Fire Needs Oxygen, But Why Should We Care?

John J. Lentini, BA, Scientific Fire Analysis, LLC, Islamorada, FL 33036*

Learning Overview: After attending this presentation, attendees will: (1) have a greater appreciation for the role of oxygen in the development of fire patterns, (2) understand some of the history of fire investigation with respect to all three legs of the fire triangle, and (3) understand the history of changes in fire investigation techniques.

Impact on the Forensic Science Community: This presentation will impact the forensic science community by showing results of tests measuring oxygen consumption and providing a greater appreciation for the role of oxygen in the behavior of compartment fires.

"The fire triangle," fuel, heat, and oxygen is something that fire investigators have known forever. It is grammar school science. However, what is new about the fire triangle is a recent appreciation for the importance of oxygen.

In just about every fire, the source of oxygen is the earth's atmosphere, which contains 20.95% oxygen. The depletion of oxygen by the fire itself is something that has only recently begun to be appreciated. Experiments conducted by the Bureau of Alcohol, Tobacco, and Firearms (ATF) at their National Training Facility and at outside meetings of fire investigators beginning around 2005 revealed that because of oxygen depletion, as well as enhancement around sources of oxygen, fully involved fires can produce fire patterns that tend to mislead investigators into determining the wrong area of origin, something that almost inevitably leads to determining the wrong cause of the fire.

A new focus on considering oxygen when determining the origin of the fire was put forward by Cox in 2013 in a paper entitled "Origin Matrix Analysis."[1] The conclusion is that once a fire becomes fully involved, patterns produced subsequently offer little or no insight into where the fire started. Utiskul et al performed an elegant experiment showing the movement of flames from the source of the fuel to the source of the oxygen once the compartment becomes saturated with the products of combustion.[2]

More recently, Underwriters Laboratories (UL) Firefighter Safety Research Institute has conducted experiments showing the utter dependence of a fire's temperature on the oxygen concentration. Once a fire reaches the point of flashover, the oxygen concentration drops dramatically, as does the temperature.

Throughout much of the 1980s and 1990s, the fire protection engineering profession tried to educate the fire investigation profession on the importance of radiation in compartment fires. For the most part, that attempt succeeded, and now there are fewer incorrect determinations of fire cause based on "low burning." After a certain point, burning on the floor means only that the room has become fully involved.

The current task is to acquaint fire investigators with a procedure for considering the effects of ventilation on the production of fire patterns. NFPA 921, *Guide for Fire and Explosion Investigations*, contained, for its first eight editions, a series of five drawings showing the progression of fire growth in a compartment starting with free burning and ending with full room involvement. In the ninth (2017) edition, the diagram showing full room involvement was changed to demonstrate that the only place flames are likely to be found is where there is a source of oxygen, and the patterns produced in those places may have nothing to do with where the fire started.[3]

This presentation will show some of the results from the UL tests, and leave attendees with a greater appreciation for the role of oxygen in the behavior of compartment fires.

Reference(s):

1. Cox (2013), Origin matrix analysis: a systematic methodology for the assessment and interpretation of compartment fire damage, *Fire and Arson Investigator*, 64 (1), 37-47. Crofton, MD, International Association of Arson Investigators.
2. Utiskul, Y., Quintiere, J. G., Rangwala, A. S., Ringwelski, B. A., Wakatsuki, K., Naruse, T. (2005) Compartment fire phenomena under limited ventilation. *Fire Safety Journal*, 40(4):367–390. Elsevier.
3. NFPA (2014), NFPA 921, *Guide for Fire and Explosion Investigations*, Quincy MA, National Fire Protection Association. 45-47.

Oxygen, Ventilation, Temperature