D5 The Impact of Ventilation on Fire Damage Patterns From Room Fires in Full-Scale Structures

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After attending this presentation, attendees will better understand the cause-and-effect relationship between ventilation and fire damage inside of full-scale residential structures. This research addresses a topic that, in the past, has challenged arson investigation findings.

This presentation will impact the forensic science community by providing data and analysis from ventilation-limited structure fires and the flow path(s) within the fire structure. This type of analysis is essential for accurately determining the area of origin based on the fire damage patterns. The results from a series of full-scale fire experiments document the repeatability and development of fire patterns based on the availability of oxygen within the structures and how this aids in determining the area of origin.

During the past decade, research conducted for the purpose of examining fire-fighting tactics has brought to light the impact that changes in home construction materials, contents, size, and geometry have had on fire incidents. Today, fires are predominantly fueled by synthetic contents. The combination of energy-efficient construction and high-heat release-rate fuel loads commonly lead to ventilation-limited fire conditions. Therefore, how and where the fire receives oxygen for combustion impacts the fire dynamics and subsequent fire-damage patterns.

The experiments were planned with the assistance of a technical panel that included members of the Bureau of Alcohol, Tobacco, Firearms and Explosives (ATF), International Association of Arson Investigators (IAAI), National Association of State Fire Marshals (NASFM), National Institute of Standards and Technology (NIST), NIST Organization of Scientific Area Committees (OSAC), and National Fire Protection Association (NFPA) 921. The test scenarios ranged from fires in the structures with no exterior ventilation to room fires with flow paths that connected the fires with remote intake and exhaust vents throughout the structures. Room-of-origin scenarios included the living room, bedroom, and kitchen.

An overview of the results from a series of 20 full-scale residential-style structure experiments examining the impact that changes in ventilation had on the fire damage inside will be presented. The test structures included a one-story ranch and a two-story colonial. The floor area of the ranch was approximately 110m^2 (1,200ft^2). The colonial had a two-story family room and open foyer with an approximate floor area of 300m^2 (3,200ft^2). Each of the comparable experiments used similar furnishings and interior finishes, providing a level of repeatability between the experiments. Each structure had more than 200 channels of instrumentation. Sensors to monitor temperature, pressure, gas velocity, and oxygen concentration were located at strategic points throughout the structures. Video and infrared imaging cameras were also used to document the experiments.

This research demonstrated how combining a basic knowledge of fire dynamics with an understanding of the flow paths of oxygen and heat through a given structure can serve as a tool for analyzing the movement of the fire through the structure as well as identifying the area of origin.

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