HOW FIREFIGHTER CREW SIZE RELATES TO OCCUPANT EXPOSURE TO TOXINS

The longer it takes for emergency responders to rescue trapped occupants, the greater the risk posed to both the firefighter and the occupant by increasing atmospheric toxicity in the structure. The International Standards Organization has formulated the Fractional Effective Dose (FED) as a probabilistic estimate of the effect of the toxic gases on occupants. The FED model establishes thresholds for the effects of toxins on sensitive populations (such as the very young and the elderly), the average population, and those who are extremely fit.

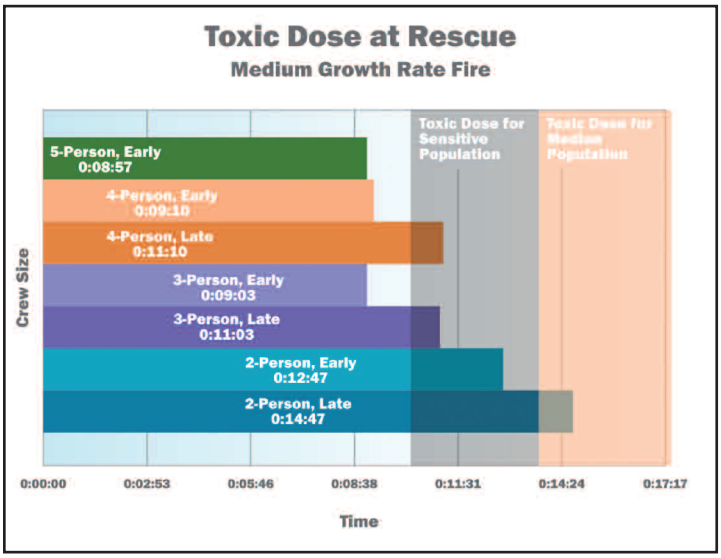
A major research project[1] has correlated fire growth rate and the associated structural atmosphere with the time it takes various firefighter crew sizes to accomplish rescue efforts should occupants be trapped in a structure and unable to facilitate their own rescue.

The increase in structural atmospheric toxicity is related to fire growth rate. For the 12' x 16' room used in the research project, the fire would be expected to move beyond the room of origin at fire growth of 2 megawatts (MW). This is about the size of an overstuffed couch fully involved in flames.

The following table shows the intervals in seconds at which 1-MW and 2-MW (fully involved) fires in this room will be reached.

Fire Growth Rate	Time in Seconds to Reach 1 MW	Time in Seconds to Reach 2 MW
Slow	600	848 (14:08 minutes)
Medium	300	424 (7:04 minutes)
Fast	150	212 (3:32 minutes)

The following chart shows the FED correlated to three different fire growth rates noted above and the time of rescue of various crew sizes with both early and late arrival. It is important to note that as useful as the FED model is, **no FED level is so low that it can be said to be safe for every exposed occupant.** Based on these data, the smaller or later the responding crew, the greater the risk to trapped occupants. These results clearly show that the safety of trapped occupants and firefighters is directly related the availability of sufficient resources.



NIST Report on Residential Structure Fire

The study is the first to quantify fire service lifesaving and firefighting operations for a low-hazard residential structure including the effects of changes in crew size, arrival time, and stagger on rescue and suppression effectiveness.[i]

The study included more than 60 controlled fire experiments, both in our large fire laboratory and at the custom low-hazard residential burn building constructed at the Montgomery County Training Academy.

Overall, the results of the study show that that the number of fire service crew members in each company responding to a fire in a 2,000 square-foot, two-story structure had a substantial effect on the crew's ability to protect lives and property. The results also provide quantitative data to fire chiefs and public officials responsible for determining safe staffing levels, appropriate station locations, and necessary funding for community and firefighter safety.

Methods

A team of fire service experts designed a research methodology that led to over 60 experiments measuring time-to-task completion with crew sizes of two, three, four, and five firefighters, with different arrival times and different intervals between arrival of each apparatus. A burn building with sophisticated instrumentation was specially constructed for the project. Twenty-two key tasks were measured, beginning with the first engine stopped at the fire hydrant and ending with a fan operating at the front door for mechanical ventilation. Using firefighters acquainted with the tasks as timers and corroborating their data with video records, the researchers accurately timed each task as it was performed by the different crew sizes. Personnel from the Montgomery County (Maryland) and Fairfax County (Virginia) Fire and Rescue Departments performed the various tasks specified by the research methodology. The data from the time to task experiments were combined with results of fire modeling conducted at the National Institute of Standards and Technology to correlate task timing to fire growth rates.

NIST National Institute of Standards and Technology U.S. Department of Commerce

[1] Funded by a grant from the Department of Homeland Security/Federal Emergency Management Agency Grant Program Directorate for Assistance to Firefighters Grant Program, the project was conducted by a research partnership of the Commission on Fire Accreditation International, the International Association of Fire Chiefs, the International Association of Firefighters, the National Institute of Standards of Technology, and Worcester Polytechnic Institute. The complete report is available for download at http://www.nist.gov/cgi-bin/view_pub.cgi?pub_id=904607&division=866