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**Publisher's version / Version de l'éditeur:**

*ASHRAE Journal, 45, July 7, pp. 33-35, 2003-07-01*

# Playing with fire : understanding human behavior in burning buildings

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**NRCC-46619**

**A version of this document is published in / Une version de ce document se trouve dans:**
**ASHRAE Journal, v. 45, no. 7, July 2003, pp. 33-35**

# Playing with FIRE


## Why People Linger In Burning Buildings

**By Guylène Proulx, Ph.D.**

Smoke does not turn people back. Although most building occupants know that smoke kills, they often move *through* the smoke instead of away when evacuating a burning building. Studies show occupants behave differently during a fire event than traditionally anticipated by HVAC designers and fire protection engineers.

During a 30-story residential building fire, 95% of occupants located above the fire floor (fifth floor) attempted to evacuate the building through smoky corridors and stairs.[1] Smoke migrated on each floor above the fire, inside most suites and in the two stairwells. Several occupants persisted in attempting to progress in smoke over several floors before seeking refuge on a floor or returning to their apartment. Six unrelated, healthy adults died in the two stairwells due to smoke inhalation.

Studies in small residential buildings conducted in the United Kingdom and United States (reported in the *SFPE Handbook of Fire Protection Engineering*) have shown people are prepared to move into smoke in an attempt to escape.[2] Data on occupants who turned back in smoke are fairly consistent. People said they turned back when they couldn't see more than 10 ft (3 m).

### Response Time

Another unexpected occupant response to a fire is the amount of time that it takes to begin evacuation. One difficulty in assessing the amount of time

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available for escaping a burning building is the timing of specific events. Traditionally, the stopwatch starts at the moment of fire detection, which ideally leads to automatic notification of occupants and then immediate evacuation. Unfortunately, reality is somewhat different.

When automatic detection systems trigger a general alarm, the occupant's response is anything but automatic. Upon hearing the alarm bell, seconds, or more likely minutes, are spent in non-evacuation activity. This phase is called pre-movement time, although considerable movement may occur during this phase.

This pre-movement time is a delay during which occupants are trying to figure out what is happening. For example, they make phone calls or seek to investigate the reason for the fire alarm. Once convinced that they should evacuate, they may not start readily. Occupants return to their apartment, hotel room or office to retrieve personal belongings. Or, they try to warn and gather family and friends before starting evacuation. These activities can take a few seconds to several minutes.

Response time also depends on the fire cues received. The sound of a fire alarm is not a strong cue to occupants that an actual fire is occurring. The smell of smoke or the sight of flames are cues that become increasingly stronger and more convincing to the occupant that evacuation is necessary.

Response time also depends on the characteristics of occupants. People with disabilities, the very young or very old and those under the influence of alcohol or other drugs may need more time to respond.

Finally, response time depends on the type of building that is on fire. In a home, a strange smell or sound of a smoke detector alarm is sufficient to trigger actions by the residents. However, visitors to a shopping center may continue shopping after hearing an alarm. The author was visiting a shopping center a few years ago when the fire alarm activated. A smell of burning plastic and a thin haze invaded the food court because a welder had ignited insulation material in the ceiling of a toy store. Occupants began the evacuation more than 10 minutes after the alarm sounded. And that was only after the building security guards instructed them to leave.

### Improving Evacuations

To speed occupant's response time to begin evacuation, education is necessary (prior to the event) to help occupants better judge a fire situation and to understand the importance of rapidly moving to an area of safety. Fire drills help occupants experience alternative routes that may become vital if the fire or a crowd block the familiar way out of the building. A voice communication system informs occupants of the nature and location of the problem, and provides instructions. Wardens and uniformed staff also can prompt occupants' movement and provide instructions.

Despite all of this planning to support a rapid and safe evacuation, those systems may fail during actual fires and occupants may take a long time to start evacuating. Occupants are likely to move around the building to find out what is happening, which allows smoke to travel in different areas.

Smoke can migrate due to occupants opening windows and doors, through the building ventilation system and through existing or new cracks and holes. Buildings usually have systems to prevent smoke distribution through the ventilation system.

Pressurization systems prevent smoke movement from one area to another. Typically, pressurization systems in stairwells are designed to prevent the smoke from penetrating in the stairwell when a few doors from the floors to the stairwells are opened. However, these systems may not be effective when several doors on different floors are opened simultaneously. This is typically the case when a full evacuation occurs in a high-rise structure instead of a phased evacuation.

**"...if occupants decide to evacuate simultaneously during a fire, smoke is likely to penetrate in the stairwells, endangering all occupants above the fire floor."**

It is essential to find methods to keep the air clean in areas of egress since smoke does not deter people from moving in a potentially fatal environment.

Since the events of September 11, 2001 in the World Trade Center towers, high-rise occupants appear less likely to accept the phased-evacuation approach. In a 60-story office building, if occupants decide to evacuate simultaneously during a fire, smoke is likely to penetrate in the stairwells, endangering all occupants above the fire floor. Areas of refuge and evacuation by elevators may become necessary to ensure rapid and safe evacuation of all occupants.

It is essential for engineers to properly design systems to allow occupants in and let smoke out. Further, this design should be based on realistic expectations regarding occupants' likely response during a fire.

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