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The Human Factor : Building designers often forget how important the reactions of the human occupants are when they specify fire and life safety systems

By Guylène Proulx, Ph.D., and Ken Richardson, P.Eng.

Building designers often view fire safety as providing a series of construction and hardware solutions, such as fire resistance ratings, exit stairs, automatic sprinklers and smoke control. Over the past decades, however, in many cases at considerable cost, it has been found that these built-in features do not necessarily establish occupant safety at the desired level. What is often missing is an adequate recognition of the importance of the behaviour and reactions of the human occupants. By applying an “occupant-based” approach, whether this means selecting the right equipment or implementing education programs, it is more likely that the fire safety solutions will support the safe evacuation of occupants in the event of a fire.

This article addresses just some occupant-based solutions that have been shown by research to have a significant impact on improving fire safety.

Alarms and audibility

It is easy to believe that occupants should be quickly and easily alerted by fire alarms and that these alarms will ensure people will undertake appropriate actions -- but that is not always the case. In today's world where bedrooms and apartments are acoustically isolated, designers must compensate and ensure that the alarm signal is able to be heard.

Researchers have discovered significant problems with fire alarm audibility. To waken occupants, the Canadian Codes specify a minimum sound pressure level of 75 dBA in bedrooms. However, the specified maximum sound pressure level is 100 dBA to prevent hearing damage, so designers must give careful consideration to the location of fire alarm sounding devices. In many cases, devices will be required in every apartment (or in every bedroom in a house) to ensure audibility and to avoid exceeding the 100 dBA limit with corridor-installed devices.

Research is now available on the attenuation of alarm signals in residential buildings to allow designers to better locate sounding devices.¹ The factors which determine the attenuation of sound include the “hardness” of the room and its furnishings_ (soft surfaces absorb more sound); size of the room, the number of rooms between the sounding device and the occupant and whether or not there is a closed door. Special devices may also be needed to alert occupants with hearing limitations.² Special vibrating devices or strobe lights (or both) may be used to alert these occupants to the fire alarm.

Need to take action

To warn occupants of the need to take action, the fire alarm signal must be distinctive so that there is no ambiguity in the occupants' minds that this warning signal is a fire alarm.

To achieve this, the National Building Code now requires a temporal pattern fire alarm signal, the international signal for evacuation._ This "temporal 3 pattern" (see Figure 1)

Figure 1 describes the sound from the alarm is intended to cause occupants to take evacuation action.³ According to research, 94% of building occupants are not familiar with the temporal 3 pattern alarm signal and don't know it means they should commence evacuation. Since it will still be many years before all buildings are equipped with the temporal 3 pattern signal, building operators must educate occupants about its meaning.

Research also has shown that occupants of large buildings tend to ignore fire alarm signals, regardless of the type of signal.⁴ The problem stems primarily from the frequent nuisance or "false" alarms.

Estimated Sources of Nuisance Alarms as Reported by U.S. Fire Departments

System Malfunctions	45.0%
Unintentional Calls	27.0%
Malicious, Mischievous Calls	15.8%
Other False Alarms (bomb scares, etc.)	12.2%

Designers can halve the number of nuisance alarms by simply ensuring that the fire alarm system equipment is reliable and malfunctions as little as possible. In addition to specifying quality equipment and its installation to current standards, the designer must provide for a long-term maintenance and testing program. There are also means by which a designer can protect fire alarm pull stations to make them less accessible to vandals or pranksters.

Effective training can help reduce the unintentional alarms as well. If occupants are given feedback explaining the reason for an alarm activation, they will become more confident in the system and therefore will begin to respond more appropriately to alarms.

Begin moving

Now that occupants know that the signal being heard is a fire alarm and not likely a nuisance alarm, it is essential for them to begin moving out of the building. During

experiments in mid-rise residential buildings, the time to start the evacuation varied from 2.5 to 5.3 minutes. Reasons given for the delay included getting dressed, gathering valuables, finding children and pets and looking in the corridor or out the window to see what is happening; i.e. investigating and finding information.

The need to reduce this delay time to start an evacuation cannot be overemphasized. One method is to have regular evacuation drills. Another is to have messages transmitted on voice communication speakers after the initial alarm signal. Research has shown that a voice message, through a voice communication system or directly from staff, is taken most seriously by occupants.

It is important, therefore, for designers to specify speaker systems that will ensure voice messages are heard throughout the building, including the corridors and exit stairs. As well, the messages must be intelligible to be effective. CAD-compatible software is now available for first designing for voice intelligibility. Testing equipment is also available for assessing voice intelligibility in a building.⁴ Recorded messages have proven to be ineffective and even dangerous in some situations. It is important, therefore, that staff who will be sending voice messages have a clear understanding of what needs to be transmitted and that regular practice drills are conducted in conjunction with the local fire department.

Occupants evacuate buildings by moving from their locations, through the common egress system -- usually corridors and stairs -- to reach a place of safety. The National Building Code requires that the egress routes be sufficiently wide to contain the occupants, be continuous to the outside and provide protection for the occupants along their path. That's not the whole story, however. Designers should also provide means to assist occupants during evacuation.

Studies have shown that communication among occupants during an emergency is essential to ensure a successful evacuation.³ Designers should avoid (especially in

corridors and stairwells) very loud fire alarm devices that will impede this communication.

Building egress systems can often be complex and non-intuitive to users. Research has shown the benefit of appropriate signage for wayfinding.⁵ Designers should not overlook this important aspect of ensuring occupant safety, especially in complex commercial buildings. Recent progress using photoluminescent way-guidance systems has shown their value as a tool in aiding timely evacuation (Figure 3).

Education and training

Fire safety in buildings cannot be fully assured unless appropriate precautions are also taken during the ongoing occupancy of the building. These actions should be consolidated in the form of a Fire Safety Plan for the building, the original of which should be prepared, prior to occupancy, by the design team and the building managers in conjunction with the fire department. Copies of this plan should also be given to each tenant at the time of occupancy and to each subsequent tenant. As well, portions of the plan should be posted prominently throughout the building. Provision should be made for translation into other languages where necessary.

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Notes

- 1 Halliwell, R.E. and Sultan, M.A., "Attenuation of Smoke Detector Alarm Signals in Residential Buildings," Proceedings of the 1st International Symposium on Fire Safety Science, Hemisphere Publishing Corporation, New York, NY, 1985.
- 2 United States Fire Administration, Emergency Procedures for Employees with Disabilities in Office Occupancies, Pub. No FA154, Emmitsburg MA. 1995.
- 3 National Fire Alarm Code Handbook, Supplement 4, National Fire Protection Association, Quincy, MA, 1999.
- 4 Bunker, M. and Edwards, R., "Huh? What Did They Say," NFPA Journal, Vol. 96, No. 1, National Fire Protection Association, Quincy, MA, 2002.
- 5 Arthur, P. and Passini, R., Wayfinding – People, Signs and Architecture, McGraw-Hill Inc., New York, NY, 1992.

Figure 1. Temporal-3 pattern for fire alarm signal

Figure 2. Evacuation drill in a highrise apartment building with the participation of the local Fire Department

Figure 3. Installation of photoluminescent wayguidance system; full lighting on the left and no lighting on the right