PART II
NFPA Journal Articles on Human Behavior

Part II provides a select group of articles from the NFPA Journal *on human behavior in fires.*

SELECTION 5
Security Bars Can Have Unintended Consequences

MERI-K APPY

This selection, originally published in the NFPA Journal, *explains how the security bars on doors and windows that are used to keep intruders out can also trap people inside during a fire and how making a simple alteration to those bars and learning correct fire safety behavior can make all the difference in a fire emergency. Any internal cross references refer to the original material.*

Source: NFPA Journal, March/April 2003, p. 44.

OF THE MANY TRAGIC scenarios I've considered as a fire safety educator, the image of people trying to escape a burning home, only to be blocked by immovable security bars on their doors and windows, haunts me the most. To see and hear people dying and be unable to help must be unimaginable, especially for first responders willing to risk their own lives to save someone else's.

Recent news accounts serve as a stark reminder that metal security bars, designed to keep intruders out, can also keep occupants in during emergencies if they don't have a quick-release mechanism. Last year in Alabama, two adults and a five-year-old boy were fatally injured when burglar bars on the back door of their single-family home blocked their escape. In Georgia, bars on the window of a four-unit residence blocked escape and impeded rescue efforts in an incendiary fire that claimed the lives of two men and one woman. The victims were trapped in their rooms by the fire that was set in a first floor hall and bedroom.

"Clearly, any steps taken to keep intruders out of a home can have the unintended consequence of trapping people inside the structure in an emergency," says Sharon Gamache, executive director of the Center for High-Risk Outreach in NFPA's Public Education Division. The Center has been a leading advocate for change in this area in recent years, organizing a Home Security Fire Safety Task Force in 1993 to help reduce deaths and injuries from these fires through engineering, legislation, and public education solutions.

Quick-release mechanisms allow occupants to open the bars by pulling a lever, pushing a button, or stepping on a floor pedal. California has passed laws requiring security bars on escape windows to be releasable and labeled with safety information. Mississippi and Texas have similar laws.

"Several communities stand out as true success stories in tackling this problem," Gamache reports. "In Fort Lauderdale, Florida, for example, members of the task force and the fire and rescue department did a sidewalk survey to identify homes with security bars. Each received a notice informing residents of the danger and listing installers who could retrofit the existing bars or put in newer, safer ones. Low-income residents were offered community block grant money to help with the cost."

With few communities implementing this kind of comprehensive program, the use of security bars without quick release mechanisms remains widespread, a potential cause of unspeakable suffering for the victims, their loved ones and their valiant rescuers.

OVERCOMING DENIAL

Central to motivating people to plan and practice escape routes in advance of a fire is overcoming their tendency to deny that they'll ever be involved in a fire and convincing them of the speed and power of unwanted fire. Anything that slows you down or blocks your exit can be fatal to you or someone you love.

If you have bars on your windows, make sure they're equipped with quick-release mechanisms that everyone in your household knows how to use. Even if you don't have security bars, take the time today to find two ways out of every room of your home and practice this drill with every member of your household. A secondary means of escape can include a window or door that can be opened from the inside without tools, keys, or special effort.

I'd like to believe that every NFPA member already has an escape plan that you've practiced with every member of your household, as well as the appropriate number of working smoke alarms in the appropriate places. To take your family to the next level of fire safety, however, I encourage you to think about installing a home fire sprinkler system. Sprinklers would have rewritten the ending for most, if not all, of those whose lives were cut short by security bars.

SELECTION 6
The Human Factor

World Trade Center Evacuees Share Lessons Learned as NFPA Starts New Behavior Study

STEPHEN MURPHY

This selection, originally published in the NFPA Journal, *reviews how human behavior emerged as a key element to life safety in the September 11, 2001, attack on New York City's World Trade Center. Any internal cross references refer to the original material.*

Source: NFPA Journal, September/October 2002, pp. 54–60.

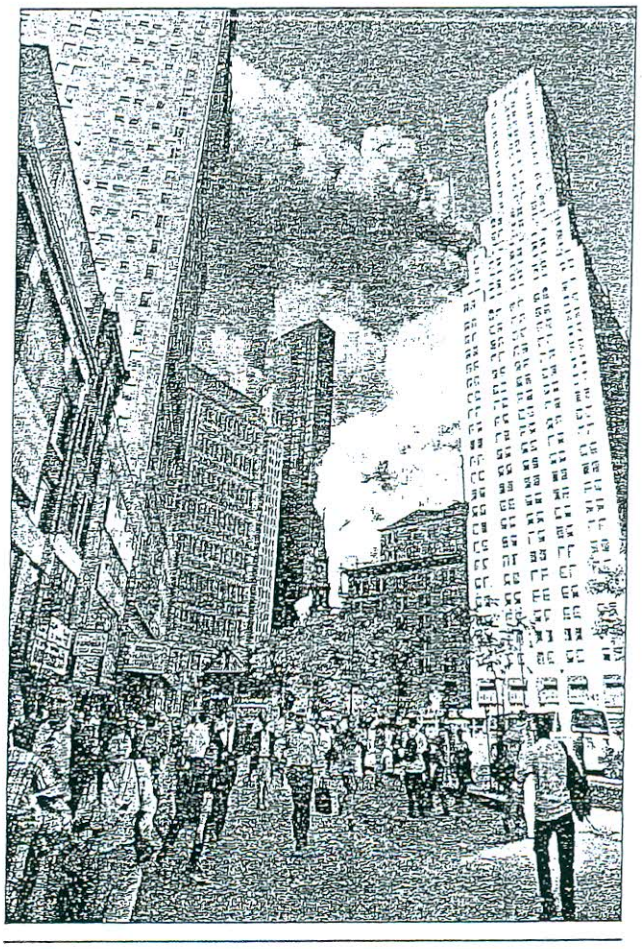
MANY VETERANS OF THE 1993 World Trade Center truck bombing weren't going to make the same decision on September 11, 2001, that they'd made eight years before.

"Every fiber in my body said, 'I'm getting out of here,' " says Magdalena Brown, who worked for Washington Group International, an engineering firm on the 91st floor of the South Tower. In 1993, she'd stayed put for hours, then had to walk down 88 flights in the dark.

On the 74th floor of the North Tower, Dharam Pal, chief mechanical engineer for plumbing and fire protection for the Port Authority of New York and New Jersey, thought the noise he heard was only the explosion of the television antenna transformer on the roof, but he didn't hesitate to leave immediately. In 1993, he and his co-workers had stayed because they didn't realize the severity of the situation.

"I might have stayed this time, too, if I hadn't gone through 1993," Pal says. "In 1993, evacuating later, I almost died in the stairway because of the smoke."

John Van Name, who'd worked in 1993 with Brown on the 88th floor of the South Tower for EBASCO, a predecessor of Washington Group International, was having lunch a block away during the bombing. Most of his colleagues stayed at their desks because the smoke from the bomb affected mostly the lowest section of the North Tower. On September 11, however, he and 150 co-workers on the 91st floor of the South Tower were among the first—Van Name believes—to evacuate offices above the 78th floor.



Pedestrians flee the area of the World Trade Center as the center's South Tower collapses.
Photograph: AP Photo/Amy Sancetta.

FIVE SURVIVORS . . . FIVE WAYS OUT

As an example of the complexity of tracking how thousands of people evacuated the Twin Towers on September 11, the five survivors interviewed for this article took quite different paths to escape, using stairs, elevators, or trains. The illustration shows the jets' impact area in the South Tower between the 78th and 84th floors, and in the North Tower between the 94th and 99th floors. See page 45 for another illustration of the World Trade Center complex.

Illustration: Christopher J. McCusker

John Van Name

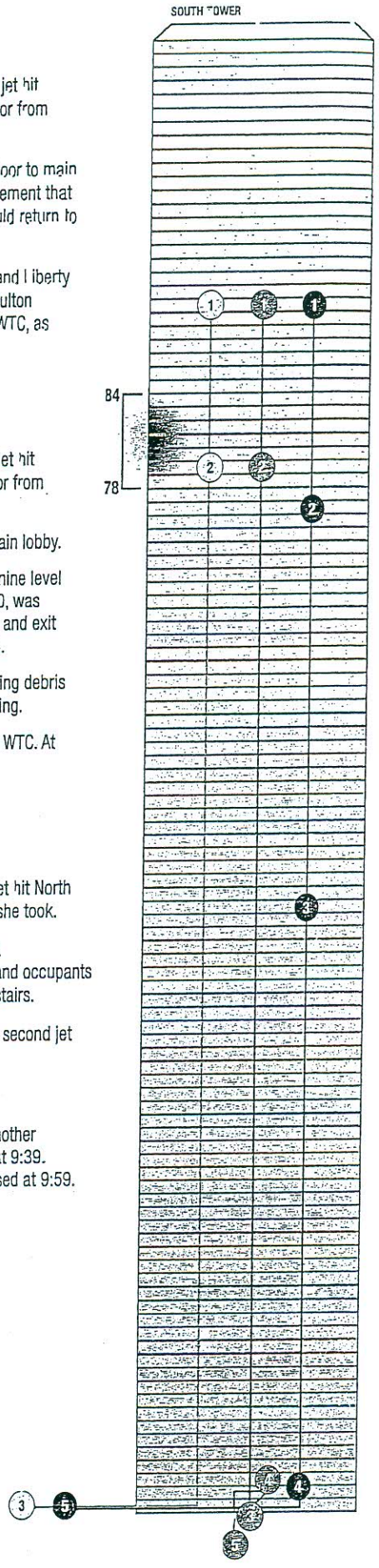
1. Left 91st floor, South Tower, minutes after jet hit North Tower at 8:46 a.m. Took local elevator from 91st floor to sky lobby at 78th floor.
2. At 8:50, took express elevator from 78th floor to main lobby. While in elevator, heard PA announcement that South Tower was safe and occupants should return to work.
3. Exited WTC through concourse at Church and Liberty Streets and reached subway entrance at Fulton Street and Broadway, two blocks north of WTC, as second jet hit South Tower at 9:03.

Pete Trombetta

1. Left 91st floor, South Tower, minutes after jet hit North Tower at 8:46 a.m. Took local elevator from 91st floor to sky lobby at 78th floor.
2. Took express elevator from 78th floor to main lobby.
3. Was directed up an escalator to the mezzanine level and to stay there. Five minutes later at 9:00, was directed to go back down to the concourse and exit the WTC by the Liberty Street exit of 4 WTC.
4. At 9:03, second jet hit South Tower and falling debris at two exits prevented his leaving the building.
5. Walked 300 to 400 feet to subway beneath WTC. At 9:10, got on train. Train left WTC at 9:20.

Magdalena Brown

1. Left 91st floor, South Tower, minutes after jet hit North Tower at 8:46 a.m. Unsure which stairwell she took.
2. Between the 80th and 70th floors, heard PA announcement that South Tower was safe and occupants could return to work. Kept going down the stairs.
3. Between the 50th and 40th floors when the second jet hit the South Tower at 9:03.
4. Reached mezzanine level around 9:20.
5. Walked down escalator to main lobby, up another escalator and exited WTC at Church Street at 9:39. Reached City Hall when South Tower collapsed at 9:59.



Dharam Pal

1. Left 74th floor, North Tower, minutes after jet hit North Tower at 8:46 a.m. Took Stairwell C.
2. Below 50th floor, stairwell became crowded.
3. At 24th floor encountered water in stairwell, and firefighters coming up slowed down the flow of evacuees.
4. Exited stairwell at mezzanine level and walked down escalator to main lobby at 9:40.
5. Stayed at bottom of escalator to help direct evacuees until 9:50.
6. Went to Marriott Hotel lobby at 3 WTC with Port Authority staff. Buried in debris in hotel lobby when at 9:59 the South Tower collapsed. Dug himself out.
7. Blinded by dust, crawled over collapsed beams and reached waterfront marina at 10:13. North Tower collapsed at 10:28, crushing hotel lobby.

Brian Bernstein

1. Left 38th floor, North Tower, minutes after jet hit North Tower at 8:46 a.m. Took Stairwell C.
2. Encountered smoke around 20th floor and firefighters coming up at about the 9th floor.
3. Had to cross over to northeast corner of core around 4th floor.
4. Exited stairwell at mezzanine level. Descent took 20 minutes.
5. Was directed to a mezzanine exit in the northwest corner. Crossed a bridge over the West Side Highway, heading toward the waterfront.

Even so, Rita Fahy, Ph.D., manager of the NFPA Fire Databases and Systems, and Guylène Proulx, Ph.D., a research officer at the National Research Council Canada (NRCC), are surprised so many people in the South Tower felt they were in danger and started evacuating before the second airliner hit.

"I would have stayed in place in the South Tower," says Proulx, who with Fahy conducted a survey of occupants' evacuation behavior during the 1993 bombing. After the bombing, the World Trade Center made a number of improvements in evacuation procedures and aids, including the installation of emergency lighting in the stairways and elevators.

Fahy and Proulx applied to the National Institute of Standards and Technology (NIST) to again fund a similar survey of occupants' behavior and their interaction with the towers' environment and the fire on September 11. The money NIST is seeking for its overall study of the collapse, of which Fahy and Proulx's study would be a part, is included in a supplemental homeland security appropriation President Bush signed in August (see "Inside the Beltway" on page 34).

After months of waiting for funding, NFPA and NRCC started the project on their own, mailing out more than 600 questionnaires last June and July. Fahy and Proulx were concerned that the longer they waited to survey survivors, the less valid the findings will be.[1]

"Time is a factor," says Proulx. "These surveys need to be done as soon as possible after the incident. As time goes by, people rationalize their responses as to why they escaped." Proulx believes that to obtain information needed to improve life safety in high-rises, it's essential to conduct a scientific survey. Although the media have published many accounts of survivors' experiences, those specific cases can't be generalized.

To obtain information needed to improve life safety in high-rises, it's essential to conduct a scientific survey. Although the media have published many accounts of survivors' experiences, those specific cases can't be generalized.

Fahy hopes the NIST funding will be available to pay for the analysis, once the responses are back.

WHAT THEY WANT TO KNOW

In the September 11 study, Fahy and Proulx want to gather statistics on the occupants' initial awareness of the attacks; their actions before evacuation; how they perceived, exchanged, and obtained information; conditions on the floors; how long they waited before starting to evacuate; their movement and the conditions in the stairwells; their evacuation training; the impact of the 1993 evacuation on their September 11 behavior; and the outcome for people with disabilities.

Unlike their 1993 survey, which was sent out five to six months after the bombing to 1,598 fire wardens for the 1,200 World Trade Center tenants, Fahy and Proulx contacted tenant companies to obtain their help in distributing this new survey to staff who were in the Twin Towers on September 11.

INITIAL AWARENESS

In the 1993 study, the wardens returned 406 useable surveys. Of these, 84 percent of the respondents in the North Tower and 73.9 percent in the South Tower said the explosion initially alerted them to the bombing.

On September 11, Pete Trombetta heard pipes clanging on the 91st floor of the South Tower and saw the lights flickering. His first thought was that it was caused by the construction that had been going on for months on the floor above him. Trombetta, a design supervisor for the Washington Group International, didn't have a window and his work area faced away from the North Tower. The first plane had hit at 8:46 a.m., and he didn't know it.

Van Name, a member of the NFPA Technical Committee on Heat Recovery Steam Generators, was in his 91st-floor office, facing the south and east sides of the North Tower, when he heard jet engines then a loud crash. Looking two or three floors up, he saw holes in the North Tower's east face and a tremendous amount of paper flying out of them, followed by a huge fireball. Then another fireball erupted on the south face.

On the same floor, but on the south side facing away from the North Tower, Brown noticed paper flying around outside and wondered if it was ticker-tape parade. She didn't feel or hear anything until a secretary ran to her side of the floor, screaming that a plane had hit the North Tower, that it was on fire, and that people were jumping.

On the 38th floor of the North Tower, Brian Bernstein was working at his desk at Lehman Brothers when he heard a thunderous boom and felt the building sway, as though someone had grabbed his shoulders and was pushing him back and forth.

"I looked out the window just a few feet away to see glass, thousands of sheets of paper, and large metal

pieces raining down," he says. "My first reaction was that the top of the building blew off in some gas explosion or that a plane or helicopter had clipped the top of the building."

EVACUATION TRAINING

The Port Authority's Pal says everyone on the 74th floor in the North Tower took the fire drills seriously after the 1993 bombing when they'd struggled to find which dark, smoke-filled stairwells were less crowded. Bernstein, who'd just started working 36 floors below Pal the previous May, believes the building policy was to evacuate the floor where a fire occurred and two floors above and below it, but he can't remember that being said during a fire drill.

"I think I can speak for most in saying that people in the workplace don't really pay too much attention to a fire drill," Bernstein says.

Working in the South Tower, Brown recalls fire drills in which people congregated where the hallways intersected in the center of the floor and were told to wait for instructions and not to use the elevators. Colleague Van Name, a senior consulting engineer, says that during the drills, which they had at least twice a year, a public announcement told them they should go three floors below or above their floor if it were on fire. But they never practiced evacuating the area by going into the stairwells.

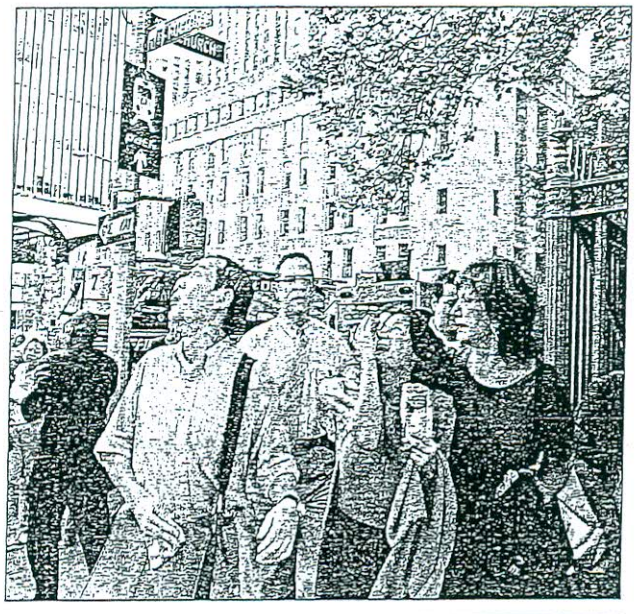
"You've done this hundreds of times since you were a school child, and you know you'll be able to get out," says Bernstein. "However, now I can't help but pay serious attention."

ACTIONS BEFORE EVACUATING

In the 1993 study, 65.9 percent of the respondents self-evacuated from the North Tower, and 45.5 percent self-evacuated from the South Tower. Of those who stayed, most did so because they were waiting for information or instructions, were told to wait, thought it was better to wait, or didn't know there was a problem.

After witnessing the fireball on September 11, Van Name started to call 911, which required getting an outside line first, but stopped when he thought someone else was probably doing it. He next tried unsuccessfully to reach a friend at LaGuardia Airport to tell him a plane had crashed into the North Tower.

"Then I decided, 'This isn't the place to be,' " Van Name says. "I've seen power plant fires, but I never saw that much fire in my life." He and another engineer started herding people out, telling them to leave everything there, call people later, and not to bother shutting down their computers.



People who had fled the World Trade Center in New York after it was struck by hijacked airplanes react to the sight of the burning towers.
Photograph: AP Photo/Gulnara Samoilova.

"Within a minute, John came down the aisle saying, 'Everybody up and out,' " Trombetta recalls. "He didn't tell us why so as not to panic us. I kidded him that I had to get my plot plans I had just printed. He said, 'No, go.' " Trombetta left the 91st floor immediately, as Brown had on her own.

In the North Tower, Pal, who's a member of the NFPA Technical Committee on Motor Vehicle and Highway Safety, looked down from the 74th floor and saw large, dark pieces of the building falling into the plaza.

"I told my staff, 'Let's get out,' " Pal says. "Some were already on their way down. Practically everyone had been there in 1993." He was off the floor within three minutes of the crash.

Thirty-six floors below, Bernstein paused a few seconds to see if the building was going to fall over. Then, he looked out the window for three to four seconds, grabbed his wallet, keys, and Palm Pilot™, which were all in front of him, and left for the stairs. His instincts got him out.

MOVEMENT IN THE STAIRWELLS

"I never really knew where the stairwells were," Bernstein says. "I just assumed they were in the core somewhere." He took Stairway C in the southeast quarter of the North Tower's core.

Several times on the way down, the flow stopped. Around the 20th floor, he encountered a lot of smoke. At about the 9th floor, he met firefighters running up. A few floors below, he noticed water rushing down the stairs.

Bernstein believes he had to cross over to the northeast quarter of the core at the 4th floor, exiting the stairway on the mezzanine at the plaza level. The descent had taken him 20 minutes.

On the 74th floor, Pal automatically took the closest stairwell, also C. Within seven or eight minutes, he smelled burning fuel. Still thinking it was a transformer fire, he felt safer in the stairwell. Below the 50th floor, the stairs got crowded, and people made room for burn victims to pass. There was still no panic, and he still didn't know what had actually happened.

At the 24th floor, Pal encountered a lot of water, and firefighters coming up the stairs slowed the downward flow. He finally exited the stairwell on the mezzanine after a 40-minute descent.

Brown is unsure which of the three South Tower stairways she took, but she was in the 70s series of floors when a public address system announcement told the occupants that the South Tower was okay and they could return to their offices. Although she didn't smell any burning jet fuel or encounter any smoke, she kept going down.

Stopping a couple of times, once as people came back up after the announcement, she was in the 40s when the second jet hit. Her body swayed with the building and her knees buckled, but people stayed calm because the stairway remained intact. Walking down at a good clip, she reached the mezzanine half an hour after she left her office.

Many people in the South Tower took elevators down, and Brown thought for a second about taking one, too. She knew that in the stairway she'd be in harm's way longer, but she also remembered that the power loss in 1993 had trapped people in the elevators for hours.

Still, Van Name and Trombetta got on the local elevators at the 91st floor. Trombetta had said to Van Name that maybe they should take the stairs instead, but Van Name said it was okay to take an elevator as they still had power.

By now, 60 to 100 people had gathered at the 78th-floor sky lobby, where passengers changed to the express elevators to the 44th-floor sky lobby or to the main lobby on the ground floor. Four or five of the 10 express elevators were running; the others were out of service for repairs or weren't scheduled to run until more businesses were open.

Trombetta, who could now smell something like burning rubber, hadn't heard the announcement that the South Tower was safe.

The 25 to 30 people in his elevator to the main lobby asked each other what had happened. One man said a 727 had hit the North Tower.

"I knew that 20- to 30-second ride enclosed in that elevator would be the longest of my life," Trombetta says.

Van Name says most of his co-workers rode rather than walked down. Concerned about using an elevator he discussed with another engineer the possibility tha: the North Tower might lean into the South Tower.

"But I felt getting out faster was better than getting out slower," he says.

At the 78th floor, Van Name met two women from his office who'd been outside smoking and who were going back up to the 91st floor to get their coats before evacuating. Two men from his office went back up with them. The two women evacuated safely by taking an elevator. The two men were among the 13 people from the Washington Group International who died that day. Several of his co-workers who returned to the South Tower's 91st floor were on the phones to their families when the second 767 jet crashed into the 78th to the 84th floors at 9:03 a.m.

At 8:50 a.m., Van Name took an express elevator to the main lobby with about 30 other people. While in the express elevator, he heard the announcement that the North Tower was in a state of emergency, the South Tower was safe, and that they should return to work. However, he felt it was better to have a 360-degree path of escape outside.

His two elevator rides took 72 seconds.

"The elevators were waiting for us," he says. "A number of businesses start at 9:00 and 9:30, so the building wasn't full."

GETTING OUTSIDE THE TOWERS

Once they reached the mezzanine or the main lobby below it, the evacuees faced more choices and greater dangers.

Brown left the stairwell on the mezzanine and walked down an escalator to the main lobby, where security guards urged people to move faster. By that time, however, she couldn't run. She went up another escalator and left the World Trade Center by the Church Street doors because all the other exits were blocked by debris.

Brown then made the final decision that saved her life. Although a lot of people were outside gawking at the fires in the towers, she kept walking because she just wanted to get away from it all. She was at City Hall 10 minutes later when the South Tower collapsed at 9:59. A co-worker who'd been in the stairway ahead of her is believed to have tried to catch a train home; his body was found in the subway under the collapsed World Trade Center.

In the South Tower lobby, Port Authority staff directed Trombetta and others through the concourse and up an escalator to the mezzanine.

"Facing the North Tower through 20- to 30-foot-high (6- to 9-meter-high) glass walls, we pasted our faces

against the glass," he says. "We were drawn to the display of carnage. The plaza looked like Armageddon and Hiroshima. We didn't realize the danger to us."

Five minutes later at 9:00, Port Authority staff returned and told the group to go back down to the concourse and out of the building by the Liberty Street exit of 4 World Trade Center. Without panicking, they started walking.

Then the second jet hit, raining debris on the exit doors, jamming them shut. Trombetta, who thought the debris was from the North Tower, unsuccessfully tried two exits, then headed toward the subway entrance 300 to 400 feet (91 to 121 meters) away. Transit personnel opened the gates so the turnstiles didn't slow people down. One of the two trains in the station was just leaving, so he got on the second at 9:10 a.m. It pulled out at 9:20.

"I owe a debt of gratitude to John (Van Name) for acting instinctively," says Trombetta.

"John 'bullied' people into elevators and saved their lives," Brown says. "One colleague had a bad hip and probably wouldn't have made it out without taking an elevator."

After stopping in the concourse several times to try unsuccessfully to call his wife on his cell phone, Van Name himself left the building through the concourse exit at Church and Liberty Streets and was entering the subway two blocks north of the World Trade Center at Fulton Street and Broadway when the second jet hit.

In the North Tower, firefighters and security personnel on the mezzanine directed Bernstein to an exit in the northwest corner. To reach a bridge over the West Side Highway, he had to cross a 20- to 30-foot (6- to 9-meter) uncovered area as debris fell. But he followed the crowd that way because they were heading where he wanted to go—the waterfront.

Also in the North Tower, Pal walked down the stopped mezzanine escalator to the lobby, where he was surprised by the amount of damage inside. There'd been no damage on the 74th floor when he left it. The time was now 9:40 a.m.

In the lobby, senior Port Authority staff asked Pal if he'd help direct people out since they were confused about which way to go, so he, several firefighters and police officers, and four or five Port Authority staff began directing people east toward the Borders bookstore, where they could take another escalator back up to street level at Church and Vesey Streets. As he did, he overheard people saying that they'd heard on the radio that planes had hit both towers and the Pentagon.

About 10 minutes later, with fewer and fewer people coming down, the Port Authority staff moved to the Marriott Hotel lobby at 3 World Trade Center to discuss what to do next. Pal and other Port Authority staff, along with 20 to 30 firefighters, had been in the lobby of the 22-story Marriott for no more than 5 minutes when they heard a loud rumble and saw the lights flicker. A rush of wind threw Pal up against a wall 15 feet (4.5 meters) away, where he ended up under a beam, buried in rubble. The South Tower had collapsed.

Cut and bruised, Pal dug himself out, but with the dust in his eyes, he couldn't see more than 2 feet (0.6 meters) away. He yelled, "Is there anyone here?" No answer. As he tried to find a way out, he saw what he thought was a light on a firefighter's helmet and went in that direction. At one point, as he crawled by himself over collapsed beams, his dust-filled eyes couldn't see how deep the pit below him was.

About six minutes later, he emerged from the ruins at a marina. Fifteen minutes later, the North Tower collapsed at 10:28. The bodies of seven firefighters and three civilians were recovered later from the hotel lobby that had been crushed by the collapse of the North Tower. All of the Port Authority staff who had been with Pal in the Marriott lobby escaped.

In addition to crediting the safety changes the Port Authority had made after the 1993 bombing, Pal sums up what had saved the survivors of the collapse of the Twin Towers: "Getting out immediately was the best decision."

1. Survivors were interviewed for this article from November 2001 to March 2002.

SELECTION 7
Human Element Key to Safety Program

NFPA *101*® Offers Essential Requirements for Emergency Planning in Health-Care Facilities

CHIP CARSON

This selection, originally published in the NFPA Journal, *looks at how staff training is a main element in fire safety in health care facilities. Any internal cross references refer to the original material.*

Source: NFPA Journal, July/August 2002, p. 30.

SPRINKLERS, FIRE ALARMS, AND compartmentation are all part of a health-care facility's fire safety program, but the human element, which includes inspecting, testing, and maintaining fire protection systems, is also critical. Unfortunately, the human element can be the weakest part of any fire safety program.

PLANNING

Because evacuating health-care occupancies is difficult, NFPA *101*®, *Life Safety Code*®, requires that every health-care facility have a staff preparedness plan that covers, at a minimum, the use of alarms, their transmission to the fire department, and staff response. The plan should also address how to isolate a fire, evacuate the immediate fire area and the smoke compartment, prepare patients for evacuation to areas of refuge or from the building, and extinguish the fire.

To ensure successful patient evacuation, Section 4.6.12 of the *Life Safety Code* requires that fire protection features, both active, such as sprinklers and fire alarms, and passive, such as fire and smoke barriers and corridor walls, be inspected, tested, and maintained daily to ensure code compliance. Inspections, tests, and maintenance should be carried out in accordance with NFPA requirements or as directed by the authority having jurisdiction.

The NFPA standards that cover inspection, testing, and maintenance include NFPA 25, *Inspection, Test, and Maintenance of Water-Based Fire Protection Systems*; Chapter 7 of *NFPA 72*®, *National Fire Alarm Code*®; Chapter 15 of NFPA 80, *Fire Doors and Fire Windows;* and Appendix B of NFPA 90A, *Installation of Air-Conditioning and Ventilating Systems*. The *Life Safety Code* also addresses these issues in the "Operating Features" section of each occupancy chapter, and requirements for new health-care facilities can be found in Section 18.7. Those for existing buildings can be found in Section 19.7.

TRAINING

To make sure the staff and the building are ready to respond to all potential emergencies, health-care facility management should make sure that every new employee is trained to complete the duties assigned to him or her under the plan, then retrained annually. It's particularly important that staff members responsible for keeping the fire protection systems code-compliant are well trained because implementing a preparedness plan requires a prompt response from facility personnel, which requires prompt notification of a fire. Quarterly drills for each shift will allow staff members to practice the fire safety plan. The drills should be conducted in a non-threatening atmosphere, without being timed, and staffers should have an opportunity to ask questions. Following the drills, training should be conducted to correct any problems. No one should be tested until they've been trained and allowed to practice the emergency procedures, including the patient relocation and evacuation procedures.

SELECTION 8
Panic Is a Misunderstood Concept

Public Safety Education Has Made the Difference in Emergency Behavior

MERI-K APPY

This selection, originally published in the NFPA Journal, *looks at how, surprisingly, lack of panic characterizes human behavior during many fires. Any internal cross references refer to the original material.*

Source: NFPA Journal, May/June 2002, p. 54.

PANIC. *WEBSTER'S DICTIONARY* DEFINES it as "a sudden overpowering fright; esp: a sudden unreasoning terror often accompanied by mass flight." The word conjures up images of mass hysteria, uncontrolled fear, and "survival of the fittest" behavior. Whenever I'm interviewed by reporters or even asked by acquaintances about my job at NFPA, inevitably the questioner will use the word "panic" to describe how they believe people react when confronted by fire. But do they?

Not according to Guylène Proulx of the National Research Council of Canada, an active NFPA member and a leading researcher in the area of fire and human behavior. Despite what we read or see, says Dr. Proulx, "panic, which supposes irrational behavior for a situation, is rarely observed in fires. Most people appear to apply rational decision-making in relation to their understanding of the situation at the time of the fire. Contrary to common belief, it appears that it's the lack of panic that characterizes most fires."

Dr. Proulx's colleague Rita F. Fahy, NFPA Fire Databases and Systems manager and another internationally respected scientist in this field, agrees with this assessment.

"It's important not to confuse 'anxiety' with 'panic,'" Dr. Fahy says. "The people evacuating the World Trade Center attack in September almost certainly experienced great distress and concern in that situation. Yet we have many reports of altruistic behavior—people helping one another despite potential risk to themselves, evacuating in an orderly fashion, weighing different options . . . actions that are inconsistent with the idea of uncontrolled, self-centered, or hysterical behavior."

Patricia Brennan at the Centre for Environmental Safety and Risk Engineering at Victoria University in Melbourne, Australia, has been researching the relationship between people and fire for use in models for performance-based codes.

"Panic is often offered as an explanation for observed behavior, especially when the outcome of the behavior is negative," says Ms. Brennan.

In other words, one may mistakenly assume panic on the part of someone who's taken an action that later proves to have been ineffective in responding to a fire, when, in fact, the action was quite rational given the circumstances.

Dr. Proulx puts it this way: "Being fearful or tense doesn't prevent a person from thinking and making decisions."

She cites three reasons decision-making during a fire is different from everyday decision-making. More is at stake; information on which to base a decision is limited at the time; and time to make a decision is limited.

"If a person already has a plan of action, well thought through and discussed and practiced with family members, decisions will be much easier to make," says Dr. Proulx. "Education and training are the keys."

NFPA agrees. It's for this reason that all our public education programs emphasize the skills needed to assess the risk of fire accurately and take effective action to prevent and survive it.

NFPA provides many opportunities for people to learn critical fire safety skills.

The more we can help people grasp basic concepts and practice well-conceived plans in advance, the better their chances of making life-saving choices in a fire. Implementing proven educational programs to help people at home or at work is an essential fire survival tool.

SELECTION 9
Safety in Numbers

The *Life Safety Code*® Takes an Integrated, All-Hazards Systems Approach to Ensuring Crowd Safety

HALLIE EPHRON TOUGER

This selection, originally published in the NFPA Journal, *details how the standards-making community uses incident investigations and behavior research to determine how crowds actually behave during an emergency and then designs systems to reinforce that behavior. Any internal cross references refer to the original material.*

Source: NFPA Journal, January/February 2002, p. 40.

MANAGING A CROWD IN a single space, no matter what the occupancy, isn't an easy task, in part because no single element ensures crowd safety. A well-designed and constructed building may be one piece of the equation, but the nature of the event, the tenor of the crowd, and the skill of the venue's management staff all contribute to a crowd's response to an emergency. Should any part of this system fail, crowd management problems can occur. And when crowd management fails, lives can be lost.

According to Crowd Management Strategies of Chicago, Illinois, 24 people died in crowd safety-related incidents at concerts in 2000. Among them were nine men who were crushed to death on June 30 at Denmark's Roskilde Festival during a performance by Pearl Jam, a Seattle-based rock band. The men were among the fans caught in crowd surges and collapses near the front of the stage. There were also 6,582 reported injuries in 2000.

SOME INDUSTRIES EXCEL

NFPA *101*®, *Life Safety Code*®, treats assembly occupancies as integrated systems. In fact, says Jake Pauls, an independent consultant on crowd control, it's the only document that "deals with a building in the total sense of design, construction, and use, including the behavior of the people who use it and how the building is managed."

Pauls is a member of NFPA's Life Safety Technical Committee on Assembly Occupancies and Membrane Structures.

"Historically, the *Life Safety Code* has managed crowds passively, first by anticipating the expected crowd behavior, then by equipping the facility with hardware and systems that mitigate adverse occupant impact," says Ron Coté, NFPA's principal life safety engineer. This means first determining how crowds actually behave during emergencies, then designing and installing systems to help direct this behavior in the way most likely to result in the safety of the largest number of people.

As a result of this approach, many elements of the *Life Safety Code* have been shaped by incident investigations and behavior research, which have laid to rest a number of persistent myths about how crowds behave. For example, safety experts believed for years that people would panic if they knew they were in danger. It was safer to keep people in the dark, or so said the pundits.

In fact, recent research suggests that this simply isn't the case.

"The opposite is true," says John L. Bryan, Ph.D., a former professor and researcher at the University of Maryland. Rather than panic, he says, "you get adaptive and altruistic behavior. People help one another, and they make intelligent decisions about where to go to get more information."

Research has also revealed that a fire alarm system alone may not be as effective in getting people to react correctly during an emergency as previously thought. Alarms by themselves may even be counter-productive, Dr. Bryan says.

"When a fire alarm goes off, people just sit there and look at each other," says Dr. Bryan. "The horn is just a noise. It interferes with communication. What people need is information."

Another myth is that people won't move through smoke. Again, research shows that the opposite is true. As the recent experience at the World Trade Center shows, people will, in fact, move through smoke—if they know where they're going.

"What they won't do is move through smoke if they don't know where exits are," says Dr. Bryan.

Research has also revealed that projected evacuation times are sometimes based on the faulty assumption that people begin to evacuate as soon as a fire alarm goes off and, because of the urgency of the situation, move more quickly than they would during a drill.

"In fact, it takes longer to evacuate in an actual fire than in a drill," says Dr. Bryan.

People in a group take time to assemble, gather information, and agree on what to do. Once they get going, groups tend to move at the speed of the slowest member. And people move more slowly when they can't see where they're going. In primary groups, such as families, members tend to reenter the structure if a member of the group becomes separated from the others, and reentry inhibits the flow of people out.

The myth of evacuation time may be the most pernicious of all, says Dr. Bryan, because engineers design buildings using incomplete performance-based models to determine how long it will take to evacuate the structures. Researchers worry that the standards for evacuation times for assembly occupancies may be optimistic.

"None of the models currently accounts for the complexity of human decision-making," says Dr. Bryan. "Instead, most treat the individual as a pinball—you hear the ding, and the ball starts rolling, and you assume people go. That's not how it works."

Rita Fahy, Ph.D., NFPA's manager of fire databases and systems, agrees.

"Where these models are on shaky ground is on decision-making," she says. "We don't we have the research data to predict human behavior. We don't understand what makes someone turn around and go back, or try another exit. And many performance models don't spell out their assumptions."

Obviously, research on crowd behavior will continue, refining our ability to predict what people will do during an emergency in an assembly occupancy. However, much of the research that's already been done has been incorporated into the design and installation of systems that help the occupants of an assembly facility through an emergency. Such systems include emergency evacuation and fire alarm systems that include voice announcements, not just a horn, to provide occupants with meaningful instructions on dealing with the situation.

They also include emergency hardware redesigned to give people evacuating a building a better sense of where they're going when they can't see their way out. For example, stairwells are equipped with emergency lighting that goes on automatically in the event of a power failure.

Such design improvements have also been included in recent editions of the *Life Safety Code*. For example, Section 12.2.5.6.7 defines handrail requirements for ramped aisles. Section 7.10.2 requires that directional exit signs with a chevron, indicating the direction to the nearest exit and illuminated in the event of a power loss, be placed in every location where the direction of travel to reach the nearest exit isn't apparent.

"Historically, the *Life Safety Code* has managed crowds passively, first by anticipating the expected crowd behavior, then by equipping the facility with hardware and systems that mitigate adverse occupant impact," says Ron Coté, NFPA's principal life safety engineer.

WHERE THE REQUIREMENTS ARE USED

Thirty-five states have implemented some form of the *Life Safety Code* requirements for assembly occupancies. As may be expected, however, code implementation varies according to locale and industry, and some do it better than others.

"The entertainment industry does an excellent job at managing large crowds at amusement parks, the way they queue people, process them, and communicate with their audience, and also the serious level of training they provide their staff," says Paul Wertheimer, founder of Crowd Management Strategies, and a member of the

Life Safety Technical Committee on Assembly Occupancies and Membrane Structures.

"Professional sports also do a good job today managing crowds and providing security for their audiences. They have rules and regulations to which audiences are asked to adhere. Rules are articulated when the ticket is purchased, reinforced before entry, and then enforced inside," says Wertheimer.

Stan Alexander, a member of the Life Safety Technical Committee on Assembly Occupancies and Membrane Structures and project manager with the International Speedway Corporation, which constructs automobile racetracks, agrees. He says National Association for Stock Car Auto Racing events have multiple systems designed to protect fans from a range of threats. Among these are cable barrier systems, used to protect the audience from events on the track. Fire and medical personnel are on site at all tracks. And event managers constantly monitor the weather and communicate impending changes.

Exhibit halls, too, are designed and managed for safe crowd flow.

"Many of the halls nowadays are long and narrow," says Gene Bacon, events manager for Bacon Hedland Management, which manages trade shows throughout the United States. He is also a member of the Life Safety Technical Committee on Assembly Occupancies and Membrane Structures. "There are plenty of doors enabling people to get out into the lobbies and exit ways."

Tradeshow exhibits are carefully monitored, as well.

"It used to be that customers could put a booth almost anywhere," Bacon says. "They'd rig up a sign and jury-rig an emergency exit set-up to accommodate their needs. Today, the halls themselves and local authorities are taking a much safer stance."

For example, many exhibit halls now have formalized safe egress.

"They may say the exhibitors have to stay 20 feet (6 meters) away from an exit door, where in the past you could go right up to it. They send you the rules by which they allow you to draw a floor plan, and they scrutinize floor plans much more carefully," says Bacon.

Other precautions include training personnel in multiple skills.

"Here in Chicago," Bacon says, recalling his experience as assistant general manager of McCormack Place Convention Center, "many security guards are trained as firefighters. Ushers have security training. Security people double as emergency medical personnel."

Bacon says two-way radios are essential equipment for crowd managers, enabling them to communicate with one another and ensuring special equipment and expertise are deployed when needed.

Among the safest assembly occupancies in the United States are churches. The absence of alcohol and crowds that are familiar with the buildings make the difference.

The Church of Jesus Christ of Latter-Day Saints Tabernacle in Salt Lake City, Utah, holds 6,000 worshippers, and the conference center holds 21,000. Vern Martindale, director of temple construction, says the church ensures crowd safety by design.

"These buildings can be emptied in about five minutes, and we have a life safety plan," says Martindale, who's also a member of the Life Safety Technical Committee on Assembly Occupancies and Membrane Structures.

In the aftermath of the September 11 attacks, managers of large assembly spaces, such as churches and conference facilities, are tightening their crowd management practices and delivering new training to staff.

INDUSTRIES THAT FAIL

At the other end of the spectrum is the rock music industry, which, says Wertheimer, has a dismal crowd management record.

"There tends to be a repetition of similar disasters," he notes. "Crowd crushing at the entrance. Lack of communication. Lack of proper management of large crowds. Inappropriate sites or buildings. Overcrowding. Compromised fire safety. Lack of emergency planning."

Of particular concern to Wertheimer is festival seating, standing-room-only areas with no assigned seats. The financial incentive for festival seating is formidable: event organizers can sell more tickets and save money by not having to rent chairs or hire ushers.

By its nature, however, festival seating encourages dangerous behavior, says Wertheimer.

"Every ticket-holder has the same ability as others to get up front," he says. "That gives everyone a license to be wherever they want. In large crowds, you need people to work together for the safety of all. Instead, you end up with individuals competing against one another, working against the common good," Wertheimer says. "According to our research, which goes back to 1952, festival seating is the most dangerous type of seating. Most injuries and deaths occur at events that have festival seating."

In 1994, NFPA included requirements for festival seating in NFPA *101* that called for certain safety precautions, including a reduction in crowd capacity to help lower overall crowd density and discourage crowd surfing and moshing.

Because this standard makes festival seating less, rather than more, lucrative than regular seating, it hasn't been met with enthusiasm by the concert industry.

"It was passed by 65,000 fire and life safety professionals, and it's still ignored by people in the live-music industry and their associations," Wertheimer says.

Wertheimer also faults some of the communities that have banned festival seating for failing to enforce this requirement.

"Even in communities where festival seating has been banned, events offering it continue to be held," he says.

Joe Psuik, director of the San Diego Convention Center and a representative of the International Association of Assembly Managers (IAAM), feels that, contrary to some event managers' beliefs, safety actually makes good business sense. If an attendee feels safe in a concert hall or arena, chances are good that he or she will return for another event.

"Our intent in working with NFPA is to ensure the protection and safety of those who come into these public assembly facilities," he says. "They have to feel safe, protected, and comfortable, and willing to return. We're aware that bringing a new client in is seven times more expensive than bringing in a repeat client or guest."

Up to now, the IAAM has focused on educating its members about crowd control, rather than writing standards or guidelines for managing crowds, says Larry Perkins, IAAM spokesperson. The organization doesn't currently publish any such standards, but a task force is in the process of developing written guidelines to "cover all facets of public safety." The guidelines are expected to appear next year.

"There tends to be a repetition of similar disasters. Crowd crushing at the entrance. Lack of communication. Lack of proper management of large crowds. Inappropriate sites or buildings. Overcrowding. Compromised fire safety. Lack of emergency planning," says Paul Wertheimer of Crowd Management Strategies.

SMOKE-PROTECTED ASSEMBLY SEATING

As larger and larger assembly occupancies are built in new configurations, the standards- and code-making community has had to play catch-up in terms of writing new documents to cover crowd management during emergencies. Of particular concern has been "smoke-protected assembly seating," a term used to describe large, enclosed, open-air assembly facilities with walls but no roof. These facilities are called "smoke-protected" because they're open to the sky, so smoke isn't considered a hazard.

After the construction of the Houston Astrodome in 1964, which was the first protected stadium, the number of people that smoke-protected assembly occupancies could hold jumped from 15,000 to more than 70,000.

"This is a lot of people at a high density, many unfamiliar with their surroundings," says Pauls. "Exit routes aren't separate in these facilities. Buildings tend to be as high as 12 stories, and you have to deal with stairs to get down. An incident is visible to, and impacts, everybody simultaneously."

When stadiums, like the Astrodome, were built, no evacuation standard specifically covered this hybrid type of facility, which is neither completely open nor completely closed. Existing standards for theaters required evacuation in about three minutes, but these new structures couldn't be evacuated that quickly. In the absence of specific standards, the more generous standards for open-air buildings were applied.

Open-air building standards permitted outdoor grandstands an egress capacity of 500 persons per 22-inch (558 millimeters) unit of egress width, as opposed to the 60 to 100 persons per unit required for smaller assembly buildings. Jake Pauls estimates that when the more generous standard is applied, the building takes three to four times longer to evacuate.

In 1986, the technical committee proposed that NFPA *101* be revised to increase the required evacuation time of smoke-protected assembly occupancies even more, provided they submitted an engineering assessment, Pauls recalls.

The revision didn't occur until the 1988 edition was published.

"We said we've got to beef up this evaluation which allows you to have large buildings with longer evacuation times," says Pauls.

This was the impetus for the development of what has since evolved into the life safety evaluation. The life safety evaluation was introduced in the 1988 edition of the *Life Safety Code,* along with the option for using the evaluation when implementing reduced egress widths for smoke-protected assembly seating in a range of assembly buildings. Later editions extended this option to other aspects of assembly facilities, including festival seating.

A life safety evaluation takes into account many different aspects of the specific facility being evaluated, such

as intra-event movement, ticketing and seating policies and practices, the probable duration of the attendees' occupancy, the attendees' emotional involvement in the event and with other occupants, the probable use of alcohol, facility personnel training, the rapport between facility personnel and the attendees, access to emergency medical personnel, and communications systems, among other factors. An extensive list of additional issues that should be examined is included in the code's annex.

Unfortunately, says Pauls, these evaluations aren't done as often as they should be, in part because the model building codes dropped the requirement for engineering assessments of smoke-protected assembly occupancies, even though they adopted proposals that dramatically increased evacuation times.

"Subsequent efforts to get the life safety evaluation included in the model building codes have been repeatedly rebuffed," says Pauls. "We have the best standards, and we've continually upgraded them. But they've been very poorly respected."

Consequently, he says, "we have buildings that are under-designed relative to rapid evacuation. This isn't bad, in itself, but without highly trained management, testing of systems, smoke control, communication, and so on, it's very troubling."

Still, Pauls is encouraged. The draft NFPA 5000, *Building Code*™, includes the assembly occupancy provisions of NFPA *101* and its life safety evaluation, making it the only building code to take an integrated systems and all-hazards approach to managing crowd safety.

SELECTION 10
Evacuation

NFPA Will Revisit Previous World Trade Center Study with an Evacuation Behavior Follow-Up

JOHN NICHOLSON

This selection, originally published in the NFPA Journal, *details NFPA's plans to revisit their previous World Trade Center behavior report with an evacuation behavior follow-up. Any internal cross references refer to the original material.*

Source: NFPA Journal, November/December 2001, pp. 40–41.

DISCOVERING HOW AND WHY people behave the way they do when confronted with an emergency has been a priority with researchers, investigators, and engineers at NFPA for years. To update their information and develop future strategies in the wake of the ultimate emergency, NFPA's Fire Analysis and Research Division plans to undertake a study on the way people behaved during the evacuation of the World Trade Center on September 11.

The study will follow up on a 1993 study, in which NFPA and National Research Council of Canada (NRCC) researchers examined human behavior following a 1993 explosion in the World Trade Center garage. The bombing killed six workers, and more than 1,000 occupants were injured as they made their way out of the towers.

Rita F. Fahy, Ph.D., NFPA's manager of Fire Databases and Systems, and Guylène Proulx, Ph.D., a researcher at NRCC, studied the behavior of building occupants in 1993 and documented the buildings' engineering details that affected it. More than 400 occupants of the two towers responded to the survey sent to the 1,600 employees and tenants who were members of the buildings' fire safety team.

"NFPA did both an investigation and a human behavior study of the World Trade Center bombing in 1993," she says. "We're looking to do a follow-up on human behavior. We haven't yet determined a methodology for this, or funding."

The original study was funded by the National Institute of Standards and Technology, the General Services Administration, NFPA, and the NRCC.

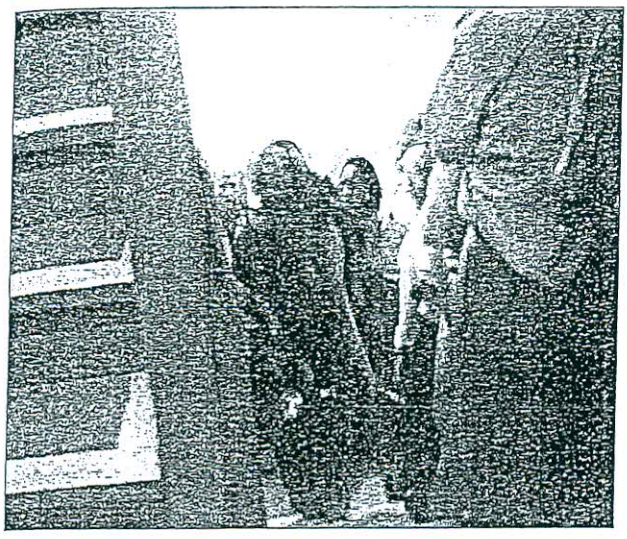
Of course, the new investigation of evacuation behavior will be hampered by the severity of the event. In 1993, the World Trade Center towers survived, and many of the people working in them were available to discuss what had happened and how they had responded. This time, far fewer occupants survived, and tracking and surveying them will be more difficult.

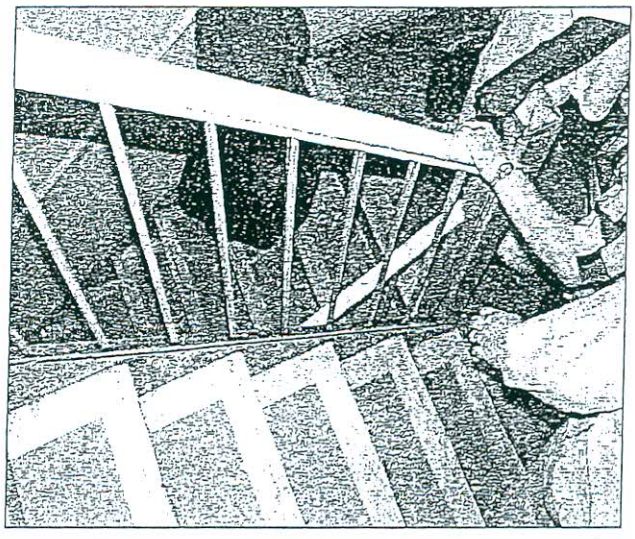
"Most of what we have to date is anecdotal. We don't have the same access we had before," says Fahy, who notes that it's possible that some of the survivors of the September 11 attack were also surveyed following the 1993 bombing.

In addition to the human behavior study, NFPA's Fire Investigations Division conducted a formal investigation of the 1993 bombing to document and analyze factors that contributed to the loss of life and property. Cooperating in the investigations were the New York City Fire Department and the Port Authority of New York and New Jersey.

LESSONS LEARNED BEHAVIOR REPORT

In the wake of this tragedy, NFPA, in its mission to reduce the loss of life, is planning to deliver a series of workshops next spring in major metropolitan areas of the United States that will prepare facility manage-





A firefighter (left) ran up the stairwell as office occupants evacuated Tower One. As water flowed down the stairs (right), people evacuated.

Photographs: © AP/Wide World Photos.

ment to develop or improve emergency evacuation planning.

The behavior of the office workers during the September 11 evacuation of the World Trade Center is of particular interest to NFPA because the Association traditionally advises a "Defend in Place" approach for high-rise emergencies.

The "Defend in Place" concept recommends evacuating only those floors immediately at risk from a fire, urging other occupants to stay where they are and relying on the building's fixed fire protection and suppression systems for protection. Among other things, defending occupants in place reduces the number of people trying to evacuate a building at one time, thus keeping the egress routes free for responding emergency personnel. It also keeps the number of people gathering outside a building to a minimum, which reduces the chance of evacuees being injured by falling debris. In a "normal" emergency, such a concept makes a great deal of sense.

"However, what we had on September 11 and back in 1993 were extremely severe conditions," Fahy says.

In this extraordinary circumstance, it appears that those who took it upon themselves to evacuate stood the better chance of survival, notes Proulx.

"There could have been as many as 50,000 people in the two towers, without counting those in the street and the rescuers," Proulx adds. "When I saw the towers collapse, I thought the toll would be around 25,000. The number of survivors is amazing."

The Port Authority made many changes to the emergency system after the 1993 bombing, and these changes eased the evacuation for many people on September 11, Fahy says.

Published reports indicate that people left the buildings in an orderly manner and there was no real panic among the building evacuees. Some of those who escaped reportedly made it from the uppermost of the towers' 110 floors to the outside in an hour. In 1993, the same trip took most of the evacuees one to three hours.

"The exit paths were there for people. The lights were there, and there were no reports of generator failure during the early moments of the evacuation," says Fahy.

This is evident in a series of photographs taken September 11 by John Labriola, an independent contractor with the Port Authority, which owns the World Trade Center. Labriola worked on the 71st floor of the north tower and escaped without injury.

Fahy notes that his dramatic images of the north tower evacuation shows people calmly walking down lighted stairways. This, she says, wasn't the case in 1993, when the stairwells were pitch black. They were so dark that evacuees walked into blank walls at crossover points in some of the stairwells.

"They had no way of knowing what was there, or where to go next. They hit the wall and then started feeling their way along the walls hoping to find a door," says Fahy.

The photographs also show office workers walking down the stairs being guided by phosphorescent paint, which was one of the changes made by the Port Authority after the 1993 bombing.

Another finding of the 1993 study showed that people were willing to move through smoke coming from below to escape. According to published reports, this was apparently borne out by the actions of those just above and below the crash floors who made it out on September 11.

"There were instances of people (in 1993) continuing into worse conditions than they were leaving," says Fahy. "Although the smoke and fire would've been coming down from the upper floors in the September 11 attack, people were willing to leave and get out as fast as they could.

"Following the 1993 bombing, people were trained in evacuation techniques, and office workers were brought into the stairwells so they'd be familiar with the exits and know where each exit went."

The lessons learned from any study of the September 11 attack will add to our store of fire protection knowledge, the way the 1993 study did. And application of these lessons will serve as a memorial to the injured and dead.

For more information on evacuation plans and answers to questions about building evacuation, go to www.nfpa.org.

SELECTION 11
What Went Wrong?

Staying Put May Be the Safest Action to Take in a High-Rise Fire, and Keeping Doors Closed Can Keep Fire from Spreading. But Recent High-Rise Apartment Building Fires Show that Most People Don't Know These Basics. And Ignorance Can Be Deadly.

ALISA WOLF

This selection, originally published in the NFPA Journal, *explains how lack of basic fire safety knowledge can lead to fatal mistakes in human behavior. Any internal cross references refer to the original material.*

Source: NFPA Journal, May/June 1999, pp. 84–88.

GET OUT—FAST. THAT'S what fire safety experts have taught us to do if the fire alarm sounds. But for those who live or work in high-rise buildings, it isn't always a good idea to head down the stairs during a fire.

On December 23, 1998, four people who might have remained safe by staying in their apartments died in a widely publicized high-rise apartment building fire in Manhattan that started in one of the two 19th-floor apartments in which actor Macaulay Culkin's mother, Patricia Bentrup lived with her children. The fire marshal's office is still investigating but tells NFPA that the fire's cause was probably an electric heater. Fire spread is blamed, in part, on the fact that on her way out, Bentrup didn't remove the props holding the apartment doors open, allowing blustery winds that entered through a heat-shattered window to push flames into the hallway and through an open fire door into the stairwell. The four victims were found in this stairwell, between the 27th and 29th floors.

Less than one week before the Culkin family fire, three firefighters died when they were caught in the hallway of another New York high-rise apartment building during a fire on December 18. Again, an open door in the apartment of fire origin allowed a fireball to rip through the long hallway, trapping the three men shortly after they neared the unit. Investigators later found that the apartment door's self-closing device had been disabled.

According to the Fire Marshal's office, the cause of the December 18th fire was smoking, says NFPA's Fire Investigator Robert Duval, who traveled to New York to investigate the two fires. He also reports that one of the factors that may have contributed to this tragedy was the fact that the building's partial sprinkler system had been turned off, keeping the potentially lifesaving system from operating. The sprinkler control valves for most of the building were concealed behind ceiling panels that had been painted over.

"What prompted NFPA's investigation," says Robert Solomon, NFPA's chief building fire protection engineer, who joined Duval in New York, "was the fact that these fire occurred so close to one another and that three firefighters died in the first, which is very unusual. In the second fire, four people died in the exit stairwell, which is also unusual. Normally, people who die in residential high-rise building fires are found in corridors or apartments near the fire's origin, not in an exit stairwell 10 floors away."

These anomalies raise several questions about fire safety in high-rise buildings. What should people who live and work in them know about relocation or evacuation during a fire, and who's responsible for fire safety training? Who's responsible for teaching basic fire safety

behaviors, such as keeping fire doors closed at all times and ensuring that other doors close when evacuating? Is it up to the landlord to provide tenants with fire-safety information, or is it up to the fire department? Should tenants be responsible for their own fire-safety education? In the December 18th fire, a partial automatic sprinkler systems was present but nonoperational. How could this have happened?

DECEMBER 18, BROOKLYN

Human behavior played a key role in this fire, which occurred in a 10-story, public housing apartment complex in Brooklyn, built in 1983 with government funding and managed by the city's Housing Authority. Units were made of concrete and compartmentalized to help contain fire to the apartment of origin, and doors were equipped with self-closing devices.

The fire began when 67-year-old Jacqueline Pinder fell asleep in her 10th-floor apartment while smoking and ignited her couch. When she awakened, she discovered a growing char spot on the couch, but instead of calling the fire department, she spent as long as 30 minutes trying to douse the fire herself by filling her tea kettle as many as six times and pouring water on the burning cushion. By the time the fire alarm panel at the security desk indicated a smoke detector activation in the elevator lobby on the 10th floor, says Duval, the fire had filled the corridor with smoke.

Pinder stumbled out of her three-room apartment into the hallway, where she fell, overcome by smoke inhalation and burns. A neighbor who lived with a bedridden woman next door heard her in the hallway and dragged her into their apartment.

About 15 minutes into the fire, water began leaking into a downstairs apartment. The tenant called the Housing Authority's 24-hour hot line, and the operator there began calling plumbers, suspecting a leaking water pipe. Later, fire investigators discovered that this call had come in at the same time Ms. Pinder was trying to put out her couch fire. Water overflowed her kitchen sink and leaked into the apartment below.

Meanwhile, the fire continued to grow until the security guard received an alarm on the lobby panel and took the elevator to the 10th floor to investigate, says Duval. When the elevator door opened, he saw smoke and retreated into the elevator. While traveling back down to the lobby, he used his cellular phone to call 911.

A neighbor across the hall from Pinder also called 911, and the fire department received the reports of fire at 4:54 a.m. When firefighters arrived, an engine company climbed the stairs to the 10th floor with fire hoses, which they began to connect to a standpipe. Soon afterward, a team of three from a ladder company began looking for Ms. Pinder, unaware that she'd already found refuge. As they neared the apartment of fire origin, the three men found flames shooting from its door. They radioed that they were in trouble just before they were overcome by heat and smoke.

Thick smoke billows from this high-rise building in New York City where four people died.
Photograph: © David Handschuh/New York Daily News.

It took 158 firefighters to bring the three-alarm blaze under control by 5:56 a.m. The heat of the fire was so intense that the pre-tensioned concrete roof panel above the room of fire origin spalled, says Duval, exposing the steel cables within the panels.

When it was all over, three firefighters—Lieutenant Joseph Cavalieri, 42, and firefighters Christopher Bopp, 27, and James Bohan, 25—were dead, and four others were hospitalized in stable condition. Two suffered second- and third-degree burns, another was treated for smoke inhalation, and the fourth suffered a back injury. Two injured residents, including Ms. Pinder, were hospitalized in critical condition, but they've since recovered. Three other residents were injured less severely.

In a press conference from his hospital bed, one of the burned firefighters, Lieutenant Michael Donovan, told reporters that he and his team would have been

Know When to Go

BY SUSAN SIEGEL-MCKELVEY

Until the past few years, NFPA's home fire escape planning and practice messages primarily addressed one- and two-story dwellings. However, the necessary actions for safe escape from a single-family, two-story home can be different from, or even contradict, what you need to do in a high-rise apartment building fire.

With large numbers of people evacuating at the same time, cooperation and precision are extremely important. The following steps apply to residential high-rise buildings and hotels:

In general . . .

- Familiarize yourself with the building's alarm system and evacuation plan.
- Make it a habit to count the number of doors between your apartment or hotel room and the two nearest building exits. If you have to evacuate in darkness, you will be able to count doors while feeling your way to an exit.
- If you discover a fire, sound the fire alarm and call the fire department.
- If the fire is in your unit, leave the area quickly, closing all doors behind you to slow the spread of fire and smoke. Take your key so that you can return to your apartment or room if you encounter smoke or flames.
- If smoke is coming into your unit or hallway, you must decide whether to stay or to go. Sometimes the fire department can give you instructions, or you can follow the building's voice communication system. If you decide to leave, remember to be alert to signs of worsening conditions that might prompt you to re-evaluate your situation. If you know the fire is well below you, stay put and follow the directions listed below.
- If you encounter smoke or 6flames, use your alternate escape route. Some evacuation plans require residents to go to a safe area inside the building and wait for the fire department to supervise evacuation.

If you stay . . .

- Remain calm. There are things you can do to protect yourself.
- If possible, go to a room with an outside window or balcony and a telephone.
- Close all doors between you and the fire. Use tape or a wet towel to fill cracks around doors and cover vents to keep smoke out.
- If there's a phone in the room in which you've taken refuge, call the fire department and tell them exactly where you are, even if you can see fire trucks on the street below.
- If possible, open the window at the top and bottom and signal to firefighters with a light cloth or flashlight. Don't break the window, and be ready to shut it if smoke rushes in.
- Be patient. It can sometimes take hours for the fire department to evacuate a multistory building.

In all fires, one constant remains: a quick, decisive response can mean the difference between life and death. Taking early warning signs seriously and knowing how to react to them immediately is crucial to life safety, regardless of occupancy type.

caught in the fireball that killed their colleagues had they not been slowed down on the stairs by firefighters carrying a woman in a wheelchair down the stairwell from the 10th floor.

Obviously, human behavior contributed to the growth of this fire and to delayed fire department notification. But after the fire, investigators also discovered that the building's partial sprinkler system hadn't been turned on.

Fire inspectors who'd checked the system regularly were only required to check the standpipe system, since it was equipped with a fire department connection, which they'd assumed fed directly to the sprinklers. In fact, the main valve for the sprinkler system fed five interior valves hidden behind ceiling access doors that had been painted over on the first floor. Building maintenance workers apparently had no idea the valves were even there. The fire marshal's office even speculated that the system, which was installed when the building was constructed in 1983, might never have been turned on.

When the apartment building was constructed with funding from the U.S. Department of Housing and Urban Development, the federal agency required sprinklers, which accounts for the partial system, according to information the Fire Marshal's office gave NFPA investigators. NFPA 1, *Fire Prevention Code,* also requires

sprinklers in high-rise apartment buildings such as this one. However, until Mayor Guiliani signed a new bill on March 25, 1999, the New York City Housing Authority didn't require sprinklers in high-rise apartment buildings it funded. In fact, most of the high-rise apartment buildings it oversees don't have sprinkler protection.

As it happens, this building's sprinklers, supplied by common domestic plumbing pipe, were only installed in the public corridors, not inside individual apartments. As a result, says Solomon, they wouldn't have protected the occupants or contents of the apartment of fire origin, though they might have made a difference in the public areas. He adds that the sprinkler system didn't meet any recognized design practices for sprinklers required by NFPA *101*®, *Life Safety Code*®, or NFPA 13, *Installation of Sprinkler Systems*.

Perhaps the most important issue arising from this fire is not the lack or presence of the sprinklers themselves, says Solomon, but the lack of formalized inspection, testing, and maintenance for the sprinkler system.

"The *Life Safety Code* says that even nonrequired systems have to be installed and maintained as if they were required, or else removed," he says.

DECEMBER 23, MANHATTAN

The second blaze started on the 19th floor of the unsprinklered apartment building in the Culkin family's unit, which was fashioned from two separate units that had been combined. At 9:55 a.m., the housekeeper saw flames in the living room and screamed, alerting Bentrup, who was in the kitchen cooking breakfast.

Bentrup called 911 while the housekeeper soaked a blanket that had caught fire in the tub. When the housekeeper went back to the living room, however, she saw that the couch had already become involved. The two women then roused three children from the apartment of fire origin and one from the unit across the hall.

The front doors to the two adjoining apartments were habitually propped open when people were home. When they evacuated, they neglected to remove the props and close these doors, allowing heat and smoke to enter the hallway and spread through an open fire door into a stairwell. Wind also ripped through a window in the apartment of origin that had shattered from the heat, driving heat and smoke into the stairwell, and trapping four people evacuating from the upper floors. Hundreds of people were stuck in their apartments for hours, and some braved the cold on their balconies, waiting for rescue.

By the time it was over, nearly 200 firefighters and fire trucks from 48 companies had arrived on the scene. The four people trapped while evacuating from upper floors died in the stairwell, and 8 other residents and 14 firefighters suffered minor injuries. According to information the fire marshal's office gave NFPA investigators, the fire was probably caused by an electric heater.

The building was unsprinklered, says Solomon, because the New York City building code didn't require sprinklers in high-rise apartment buildings, either new or existing. To his knowledge, New York was the only U.S. city that allowed new high-rise apartment buildings to be built without sprinklers.

"After much discussion following these fires, the city passed what I'd call a long-overdue change requiring sprinklers in residential construction," he says. "The new bill also includes provisions for retrofitting sprinklers in existing apartment buildings under some conditions."

"The *Life Safety Code* clearly requires sprinklers in new high-rise apartment buildings, and, in most cases, in existing ones," Solomon says, adding that, in most large U.S. cities, "you'd be hard-pressed to find even a new six-story apartment building without sprinklers."

STAY OR GO, HOW DO YOU KNOW?

To stay or not to stay, that's the crucial question for people caught in high-rise building fires. But, says Duval, the decision isn't as easy as it is in most single-family dwellings.

"If the fire's 10 floors below you, you're better off staying put, notifying the fire department of your location, and waiting for instructions, especially in what they call a fire-resistant building of steel and concrete like the one in Manhattan," Duval says. "But if the fire's in the apartment directly below yours, you don't want to stay where you are. You might want to try the stairs or take refuge elsewhere."

If you open your door and see smoke in the hallway, however, chances are you won't know where the fire's coming from, says Duval. And without that information, where do you turn?

According to Solomon, the first thing to remember in a high-rise building fire is that it's not always necessary to leave the building.

"If you do decide to leave," he says, "be vigilant. If you see smoke, retreat or go to another floor. If that floor looks clear, stay there. You have to keep re-evaluating your situation."

The *Life Safety Code* requires that emergency instructions be available and given to each resident of a high-rise apartment building, Solomon says.

"It's the assumption that this would come from the building manager," he adds.

In reality, however, it often falls to the fire service to play a leadership role in getting that information to the proper people.

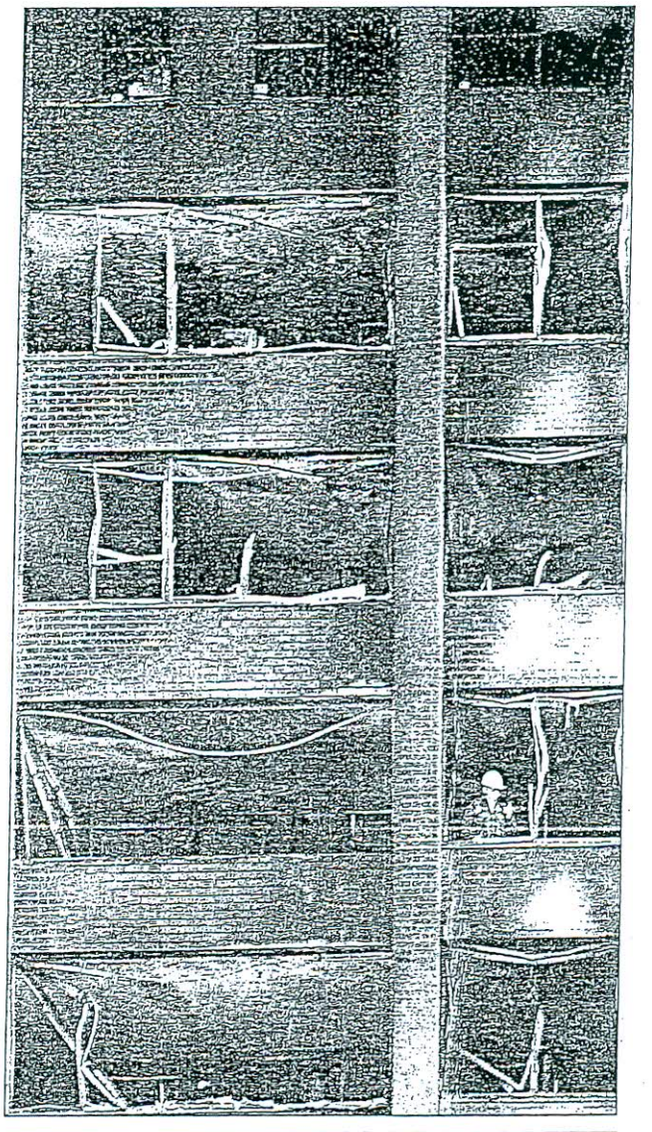
"People at the community level look to the fire service for guidance," says Meri-K Appy, NFPA's vice president of Public Education. "That's not to say that fire departments are the only ones that can make a difference. We're big believers in having fire departments team up with others in the community who have connections to audiences they're trying to reach."

In big cities, this should include building managers, who, Appy says, "might not have a clue about the real consequences of fire."

The recent high-rise apartment building fire fatalities have alerted NFPA to the need for better fire-safety training in such buildings, says Appy, who believes the Association can do more. That's why "The Great Escape" of 1999, the second in a three-year Fire Prevention Week campaign to encourage people to practice home fire drills, will include specific messages on planning for fire in multifamily dwellings, ranging from four- to five-story structures to high rises.

The other half of the training equation is making sure people understand basic fire safety rules, such as closing doors behind you and not walking through smoke. According to Rita Fahy, NFPA's manager of Fire Databases and Systems, studies of human behavior in fire have shown that people will move through smoke, defying what fire safety experts had believed until the World Trade Center Fire of 1993.

"In the World Trade Center fire, we found that people would not only move through smoke, they'd continue through worsening conditions, even while aware they were headed into the fire," Fahy says. "We need to make sure that people in high-rise buildings understand the dangers of smoke and that they realize they have another option to evacuation. They need to know they may be safer if they stay put, and they need to know how to make a safe decision."



During a fire in this high-rise apartment building in Baltimore, one women died of cardiac arrest on the 23rd floor of a smoke-filled stairway as she tried to escape.
Photograph: © AP/Wide World Photos.

AVOIDING TRAGEDY

On February 5, 1999, less than two months after the two New York fires, there was another fatal fire, this one in an unsprinklered high-rise apartment building in Baltimore, Maryland.

According to Baltimore City Battalion Chief Hector Torres, the 30-story building had 2 commercial floors and 28 residential floors. Torres says that the fire, which the Fire Investigations Bureau found was caused by smoking, originated on the 15th floor, and flames involved floors 14 through 19.

During the evacuation, some residents above the 14th floor were directed to the roof to await air-lifted firefighters to help them down stairwells. Early in the fire's progress, however, an 86-year-old woman died of cardiac arrest on the 23rd floor as she descended a smoke-filled stairway. Over the course of the evacuation, nine other residents and one firefighter were injured, says Torres, but none seriously. The building was unsprinklered because it had been built in 1967, before sprinklers were mandatory in Baltimore.

Tragedies such as these might have been avoided in the first place if sprinklers had been retrofitted and basic fire safety procedures understood and followed. That's why NFPA targets populations at highest risk with programs such as *Learn Not To Burn®*, *Risk Watch™*, and "Remembering When," its new curriculum for seniors.

And as it did last year, NFPA will send materials for "The Great Escape" to every fire department in North America. Each package will include a new educational

video produced by the USAA Educational Foundation that firefighters can use in elementary school classrooms. The video follows three children, one of whom lives in a high-rise apartment building, as they plan and practice their home escape plans.

Updated information on the campaign will appear on the NFPA web site, www.nfpa.org, says Appy, "to educate folks so they can do a better job at the local level, where lives lost to fire are most keenly felt."

SELECTION 12
How Cognitive Factors Influence Way-Finding

Although Research Is Still in Its Initial Stages, This Article Addresses the Performance of Buildings in Supporting the Emergency Egress Behavior of Occupants.

FILIZ OZEL

This selection, originally published in the NFPA Journal, *discusses how emergency egress design limitations influence the egress performance of buildings. Any internal cross references refer to the original material.*

Source: NFPA Journal, May/June 1993, pp. 62–71.

AS FIRE PROFESSIONALS CONSIDER using performance-based codes and standards, the scope of "performance" remains loosely defined. Most performance specification proposals have focused on engineering solutions. Only limited attention has been paid to the behavioral performance ramifications of emergency egress codes.

While such an approach to code development and enforcement has helped reduce the incidence of fire and the loss of lives and property from fire, it has been insufficient in cases where human behavior has contributed significantly to fire spread or to loss of life.

RESEARCH AND THE CODES

During the past decade, many researchers have identified the behavioral limitations of many of today's fire precautions.[1,2,3,4] But fire safety professionals have been slow to respond to this data and incorporate behavioral factors into the codes.

In an article by Arthur E. Cote in the *NFPA Journal*, Dr. John Bryan, chairman of the University of Maryland's department of fire protection engineering, indicates that the lack of interpretation of fire research is one roadblock to the reflection of research in the standards process.[5] Such interpretation can originate only from a section-by-section inspection, investigation, and study of fire and life safety codes.

The performance implications of fire and life safety codes are best viewed within the following framework:

- the performance of buildings in preventing fire and smoke spread (passive precautions);
- the performance of fire protection and suppression systems in fire detection and suppression (active precautions); and
- the performance of buildings in fostering human behavioral responses that will best support life-saving activities during fire emergencies.

The first two categories of performance criteria are the most widely recognized by the fire safety community. Researchers are just beginning to investigate the performance of buildings in supporting the emergency egress behavior of occupants.[6]

The literature on environmental cognition points to several characteristics of the physical environment that affect people's spatial behavior and orientation. The emergency egress performance of buildings depends on the ways in which these characteristics influence spatial behavior and way-finding. The following environmental variables play a role in environmental cognition:

- visual access to other areas of a building or to the exterior;
- physical or functional differentiation of building parts, such as lobbies or atriums;
- signage for identification and direction purposes; and
- plan configuration.[7]

The effects of major egress design concepts on the emergency egress performance of buildings when incorporated into NFPA *101*, the *Life Safety Code*®, emerge as an important issue. The following emergency egress design concepts interact most with environmental cognitive variables:

- the separation of exits,
- the arrangement of exits,
- the capacity of exits, and
- exit signage.

This article addresses how emergency egress design restrictions affect environmental cognitive variables and the egress performance of buildings (see Figure 1). First, however, it is necessary to understand environmental cognition and how Gestalt laws of perception influence it.

PROCESSING SPATIAL INFORMATION

Theories about way-finding and how spatial information is processed have been an important part of fire safety literature. Assumptions concerning the emergency egress behavior patterns of building occupants have been incorporated into design and regulatory processes, such as provisions for occupant density, dead-end corridors, and adequate numbers of exits.[8]

In general, way-finding in buildings has been seen as a perceptual problem; for example, it is assumed that a fire provision (such as a fire door), if present, will be seen and used by occupants. However, fire safety literature appears to contradict such a perceptual approach.[9,10]

Environmental research literature provides ample evidence that most people have difficulty with spatial orientation—even when they are familiar with a building—because of the increasing complexity of the built environment. Signage and related information in buildings do not overcome users' problems with spatial orientation and way-finding.

These results have been confirmed in a range of facility types, including nursing homes,[11] shopping malls,[12] and hospitals.[13] Similar results also have been observed under fire conditions.[14,15] A few studies have tried to examine the effects of environmental stressors, such as noise[16] and fire emergencies,[17] on environmental cognition and route selection.

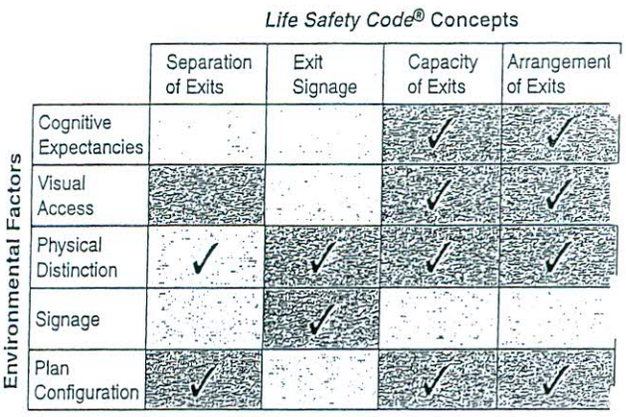


FIGURE 1 *Interaction of* Life Safety Code® *Concepts with Environmental Variables Affecting Emergency Egressing*

ENVIRONMENTAL COGNITION

People experience their environment as full and complete, rather than as partial and fragmentary. Acquiring, coding, storing, recalling, and decoding information about the relative locations and attributes of phenomena in our everyday spatial environment is called cognitive mapping.[18] The better an individual's cognitive map, the more efficient his or her spatial behavior.[19]

Cognitive mapping must be considered a factor in emergency egress behavior during fires. Fire and smoke alter people's perceptions of the environment, and modify the way they process environmental information. These changes are manifested in an increased use of cognitive processes in selecting routes and in way-finding.

Gerald Weisman hypothesizes that to the extent an environment provides perceptual access to either interim or ultimate destinations it facilitates way-finding.[20] Environments with elements of physical distinctiveness, or landmarks, also facilitate way-finding. Additional factors that influence the identification of landmarks might be personal or social significance and patterns of activity. A landmark is represented in a person's cognitive map to the extent the person has invested it with visual, inferred, or functional distinctiveness.

Of all the environmental variables, signage—the purpose of which is to provide critical choice points along exit ways—is the most widely recognized for the purposes of fire safety. The plan configuration of a given

®Reg. TM, The National Fire Protection Assoc., Inc.

setting is another environmental variable. Fire safety professionals are beginning to accept plan configuration as a factor in emergency egress. Some insurance companies now give discounts for simplicity in building layouts.[21]

COGNITIVE EXPECTANCIES

Using Gestalt laws of perceptual organization to explain way-finding behavior and cognitive expectancies, "any configuration is perceived in such a way as to make it appear as simple, clear, or comprehensible as possible." In other words, people try to superimpose on objects properties such as symmetry, regularity, and continuity.

Building plans with these qualities facilitate image-building and way-finding by supporting the creation of better cognitive maps. Discontinuous corridor layouts, such as polygons that do not enclose, complex layouts with concentric corridors, undifferentiated interiors where occupants are unable to orient themselves to the exterior, and slightly irregular layouts interfere with way-finding behavior.[22,23]

Other cognitive expectancies of occupants, such as expecting stairs at central locations or at the ends of corridors, also affect path-finding behavior. Dead-end corridors pose potential problems because the cognitive expectations of people may lead them to search for exits there.

Environmental research literature provides ample evidence that most people have difficulty with spatial orientation—even when they are familiar with a building.

SEPARATION OF EXITS

Section 5-1.2.5 of NFPA 101 states: "An exit is that portion of a means of egress that is separated from all other spaces of the building or structure by construction or equipment as required in 5-1.3.1 to provide a protected way of travel to the exit discharge. Exits include exterior exit doors, exit passageways, horizontal exits, and separated exit stairs or ramps."[24]

Although the implementation of this provision can control smoke and fire spread considerably, its impact on the formation of mental images remains unexplored. Protected egress routes limit visual access to those routes. To the degree that a setting provides perceptual access to the entire setting, it facilitates the formation of better mental images. Limiting visual access to building parts jeopardizes the formation of complete mental maps.

The separation of means of egress also can affect exit recognition. When there is a lack of visual access, people must rely more on other cues, such as signage. A study by Pauls and Jones of high-rise building evacuation found that people used an exit stairway with large glass panels—which provided visual access to the staircase—more than they used other staircases.[25] In other situations, open staircases, particularly those at physically distinctive locations such as atriums, were used more than other staircases. Open staircases may facilitate occupant way-finding best, minimizing reliance on signage.

Enclosed egress ways create double jeopardy. First, they limit the formation of complete and accurate mental maps during occupants' daily activities. Second, they fail to provide the visual access needed by occupants with incomplete cognitive maps during emergency evacuation.

EXIT MARKING

Exit marking refers primarily to the placement and design of exit signage. Redefining it as an environmental cognitive factor can bring a broader definition to the concept.

Typically, exit signage is used to produce physical distinctiveness at a location, such as an exit door, that otherwise might not be recognized during a fire. Design methods—standardized exit elements, color coding, and greater visual access to exits and stairs—may facilitate exit recognition. As new design concepts are incorporated into exit marking, we should be aware that any physical feature that enhances the physical distinctiveness of a setting and increases visual access will facilitate better use of such settings.

A study by Sixsmith et al. investigated the effect of painted murals on fire exit doors on exit recognition in a shopping mall.[26] Their findings indicated that the murals hindered exit recognition and that occupants tend to associate panic hardware and wired-glass panels with fire exits. Exit recognition is a factor of associations with multiple environmental cues. Exit signage is only one of those cues. Panic hardware and wired-glass panels are cues that are just as strong as exit signage.

The types of associations with environmental cues are critical. People tend to focus on the negative aspects of an event when pressed for time during decisionmaking.[27] Since emergency exiting is a decision process that occurs under time pressure, we must consider how people use environmental cues.

Subjects in at least one study said that negative associations with warning signs on exit doors—indicating

that an alarm would sound if the door were opened—caused them to avoid those exits during fire emergencies.[28] Even occupants in rooms adjacent to the exits cited these negative associations.

EXIT CAPACITIES

Unless otherwise indicated, NFPA *101* assumes equal use of alternative exits. But route selection must be the determining factor in calculating the capacity of exits, particularly in buildings where more than two protected exits meet egress capacity requirements. Occupants are more likely to use exits that are at physically distinctive locations, provide more visual access, and are located at specific locations with respect to the overall geometry of the building.

The cognitive expectancies of occupants also are important in determining the capacity of exits. This factor influenced the use of staircases in the MGM Grand Hotel fire in Las Vegas. During that fire, occupants used staircases located at the ends of the corridors more than they used staircases in the middle of corridors.[29]

A monitored evacuation study by Sime and Kimura compared route selection and exit use in two lecture halls. All of the occupants in one study and 70 percent of the occupants in a follow-up study used a fire door in one of the lecture rooms more frequently than other doors. In explaining this, the researchers indicated that "... it [was] in full view and regularly used after lectures to relieve pressure from incoming students."[30]

The study also showed that most of the occupants did not leave through the door they used to enter the lecture hall. Clearly, direct visual access to this door and its use on a regular basis contributed to the formation of a biased cognitive map in which the exit was represented more than the main entrance.

The cognitive properties of buildings, as well as patterns of daily use, must form the basis of calculations of the capacity of exits. A rule-based approach to code development and enforcement can fall short in predicting emergency exit use patterns. For this reason, it is important to develop emergency egress performance specifications for calculating exit capacities.

ARRANGEMENT OF EXITS

Section 5-5.1.1 of NFPA *101* states: "Exits shall be so located and exit access shall be so arranged that exits are readily accessible at all times." In this section of the *Code*, accessible refers only to physical accessibility. We must also consider cognitive accessibility.

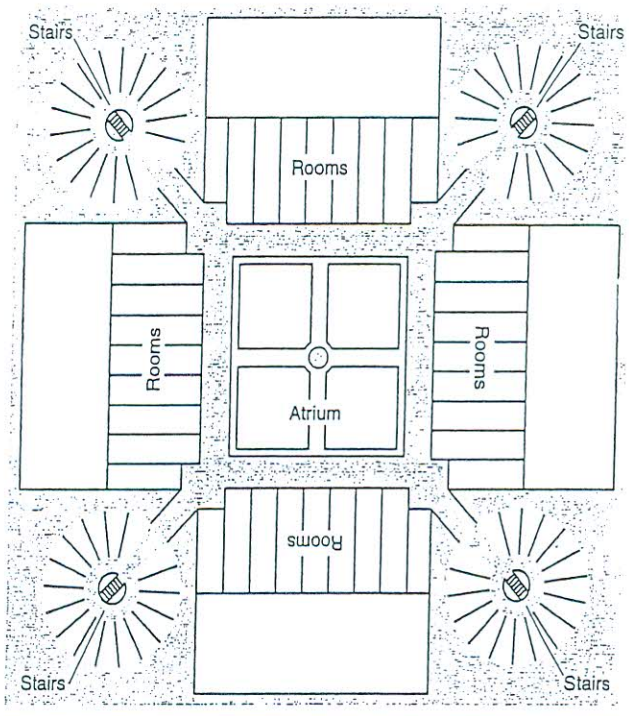


FIGURE 2 *Hyatt Regency Hotel Rosemont, Illinois*

During a fire in the Hyatt Regency Hotel in Rosemont, Illinois, more than 1,000 occupants rushed to the building's central atrium, where elevators were located, because the area was physically distinctive (see Figure 2). Fire fighters had to ride the elevators to prevent occupants from using them because there were no protected staircases at that location.[31]

People try to superimpose on objects properties such as symmetry, regularity, and continuity.

Clearly, the physical and functional distinctiveness of the atrium with elevators made that area of the building more cognitively accessible. The staircases in the hotel's corner towers were physically accessible to hotel occupants, but were not cognitively accessible.

Section 5-5.1.2 of the *Code* states: "Where exits are not immediately accessible from an open floor area, safe and continuous passageways, aisles, or corridors shall be maintained leading directly to every exit and shall be so arranged as to provide access for each occupant to at least two exits by separate ways of travel."

Two separate ways of travel to exits should be cognitively accessible as well. Occupants should have as complete and accurate a representation of both egress ways as possible. This can be achieved only if a building's cognitive properties support good mental maps and if both egress ways are experienced by users on a regular basis.

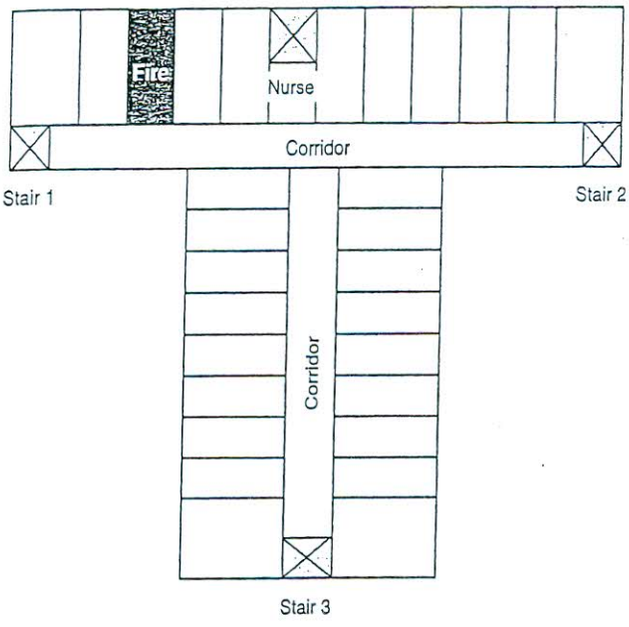


FIGURE 3 *Nursing Home Fire*

A report by Bickman et al. on a fire in a nursing home revealed that both patients and fire fighters used the building's central staircase even though two separate means of egress were available from any point in the building corridors.[32] The staircase that was used was centrally located (meeting cognitive expectancies) and was associated with the nurses' desk (it was functionally distinctive) (see Figure 3).

NFPA *101*, section 5-5.1.3, specifies that "Where more than one exit is required from a building or portion thereof, such exits shall be remote from each other and so arranged and constructed as to minimize any possibility that more than one may be blocked by any one fire or other emergency condition."

Physical and cognitive accessibility are important in the design of remote exits. Remoteness of exits from each other may not guarantee their use. In the Hyatt Regency Hotel, the four corner-tower exits were remotely located and physically accessible, but they did not facilitate use during the fire.

Plan configuration also plays an important role in cognitive accessibility to remote exits. Typically, people expect staircases at central locations and at the ends of corridors.[33] Data from the MGM Grand Hotel fire support this.[34] For these reasons, concentric corridor configurations or undifferentiated interiors can create difficulties with spatial orientation and way-finding for occupants.

The floor plan of the Renaissance Center in Detroit is an example of a concentric circulation pattern that creates difficulties in orientation. Although the building has a physically distinctive center atrium, an inner circulation path jeopardizes occupants' orientation. The lack of visual access to the atrium or to the exterior, as well as a lack of physically distinctive features around the corridor, contribute to difficulties in orientation.

Although no formal way-finding study has been conducted in the Renaissance Center, an informal study using University of Michigan students as subjects cited the following way-finding experiences: difficulty in reaching escalators that could be seen across the atrium; difficulty in locating destinations; and returning inadvertantly to starting points because of disorientation.

INCORPORATING COGNITIVE FACTORS IN CODES

Environmental cognitive factors and properties of the physical environment that contribute to the formation of more accurate and complete cognitive maps must be incorporated in the emergency egress performance specifications. Because it is neither practical nor possible to list all building configurations, materials, and surface finishes that promote better way-finding and orientation, it may be necessary to specify the performance of buildings for way-finding.

We must develop specifications that reflect the combined effect of building features on emergency egress and way-finding processes. Cognitive accessibility can be a key measure of such performance. Just as we can specify a 4- or 3-hour fire resistance-rated wall, we can specify the amount of time that building occupants will need to locate an exit for safe egress.

We should replace the term "exit time" with "exit access time." Factors that affect exit access time should be specified as part of the performance criteria. While exit time implies immediate access to and use of exits, exit access time makes a distinction between having physical and cognitive access to an exit and its actual use.

We must also rate exit elements cognitively. Such specifications require the grouping of building configurations, such as linear, concentric, U-shaped, atrium or courtyard, and composite buildings; rating the degree of visual access to other sections of a building and/or to its exterior; and rating the physical distinctiveness of building parts. These are only some examples of assessing the performance of a building under emergency egress conditions. An extensive guide covering these principles should be provided in the *Life Safety Code Handbook*.

Finally, full-scale tests are needed to address the combined egress performance of exit elements, similar to tests of other building components to obtain fire ratings for those assemblies. Moreover, such tools as emergency egress simulation can assist code enforcement officials in assessing the emergency egress performance of buildings.

Glossary

Cognition: The process of knowing what things are like by restructuring and synthesizing one's perceptions.

Cognitive expectancies: The process of expecting objects to have simpler, symmetrical, more regular and continuous configurations due to the misconceptions created by the Gestalt laws of perception.

Cognitive mapping: Acquiring, coding, storing, recalling, and decoding information about the relative locations and attributes of phenomena in our everyday environment.

Cognitive properties: Those properties of an object that contribute to the formation of a mental image of the object. Some examples of these properties are physical distinctiveness, overall configuration, etc.

Environmental cognition: The process of knowing what a physical environment is like by restructuring and synthesizing one's perceptions of the environment.

Environmental cues: Features of an environment that contribute to environmental cognition. For example, features that create physical distinctiveness, such as color, size, form, and height, can become cues for way-finding and orientation.

Gestalt: A synthesis of separate elements of emotion, experience, perception, etc. that constitute more than the mechanical sum of parts.

Gestalt laws: Laws that govern the synthesis of what we perceive. According to the laws of Gestalt, people tend to perceive things in a simplified, regularized, and continuous manner, that is, they expect things to possess such properties. Thus, objects whose actual properties slightly vary from these may be mistakenly perceived to have such attributes. See cognitive expectancies.

Spatial behavior: Any behavior that requires a person to relate to his or her physical environment. Behaviors can be physical actions, such as movement, or nonactions, such as orientation—that is, knowing one's directions and location in space.

Spatial orientation: Knowing where one is located in a physical setting and knowing one's major directions relative to those settings that are not immediately perceivable.

Way-finding: The process of negotiating one's way in a physical environment. Being able to make intelligible decisions in getting to places that are not within a person's immediate vicinity.

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