MODELING A BACKDRAFT: THE FIRE AT 62 WATTS STREET

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Modeling a Backdraft:

The Fire at 62 Watts Street

The New York City Fire Department and the National Institute of Standards and Technology join forces to discover the origin of a terrifyingly long backdraft that killed three fire fighters.

BETSY HERZOG / AP / WIDE WORLD PHOTOS

On March 28, 1994, the New York City Fire Department responded to a report of smoke and sparks issuing from a chimney of a three-story apartment building in Manhattan. The officer in charge ordered three-person hose teams to enter the first- and second-floor apartments while the truck company ventilated the stairway from the roof.

When the door to the first-floor apartment was forced open, a large flame shot out of the apartment and up the stairway, engulfing three fire fighters on the second-floor landing. The flame lasted for at least 6½ minutes, killing the three men. In the hope of understanding the factors that produced a backdraft of such duration, the fire department asked the National Institute of Standards and Technology (NIST) to model the incident.

The building

The fire occurred in a three-story, brick apartment house of ordinary construction that was approximately 20 feet (6.1 meters) wide by 46 feet (14 meters) deep. The building contained four apartments, one on each floor, with the basement apartment half belowgrade (see Figure 1). While the basement apartment had its own entrance, the others were reached by an enclosed stairway that ran up the side of the building. The building was attached to an identical building, which was not involved.

Both buildings were constructed in the late 1800s and had been altered many times over the years. Recent renovations included replacing the plaster lathe with drywall on wood studs, lowering the ceilings to 8.25 feet (2.5 meters), installing new windows and doors, installing heavy thermal insulation, and sealing and caulking the building to minimize air infiltration. The building was described as being

FIGURE 1

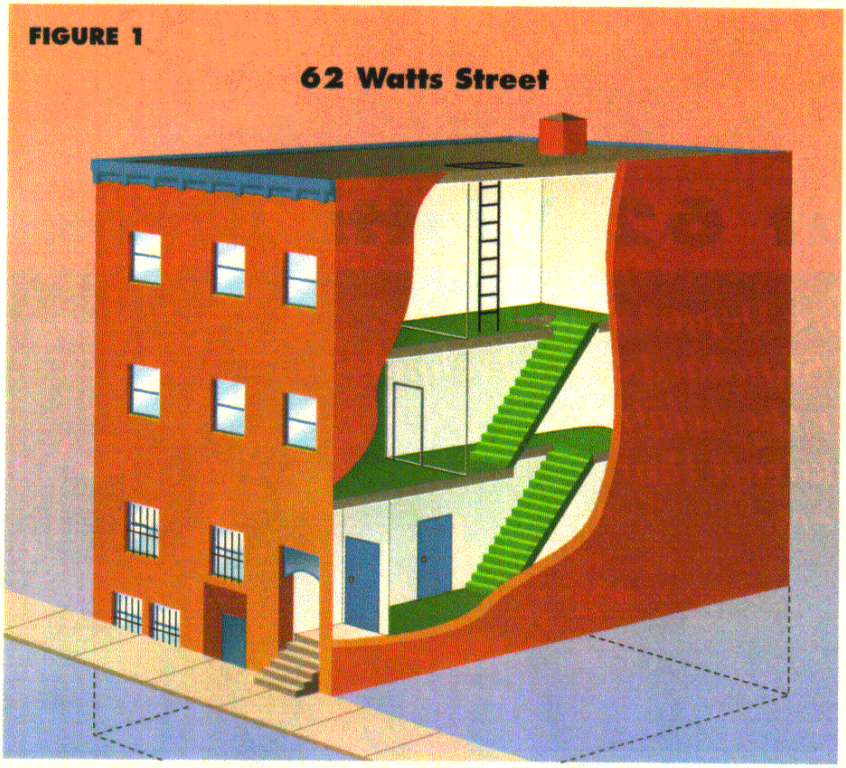
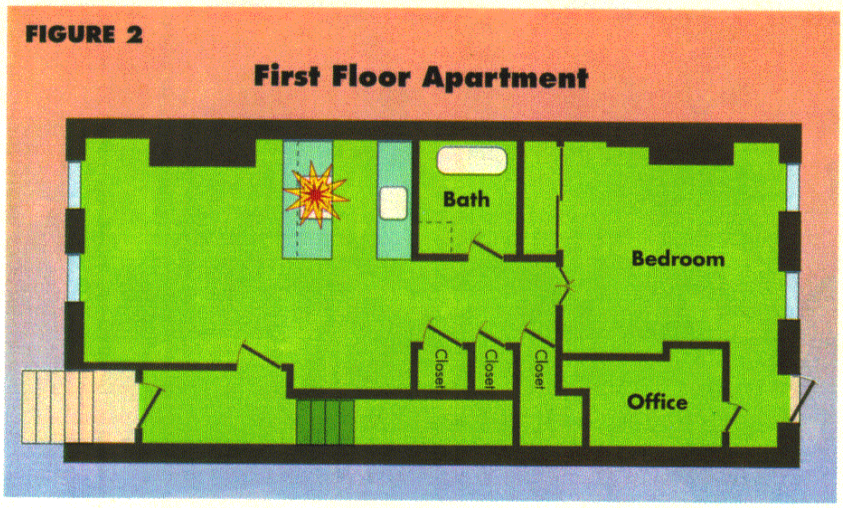


FIGURE 2



very tight.

Built before the advent of central heating, the apartments had numerous fireplaces, most of which had been sealed. The apartment of fire origin had two fireplaces, but only the one in the living room was operable. All of the apartments had thick, plank wood floors.

The apartments had similar floor plans; the only differences resulted from the stairway. Generally, they had a living room in the front, a kitchen and bathroom in the center, and a bedroom in the rear. The first-floor apartment also had an office in the bedroom, although it didn't play a significant role in the fire (see Figure 2). The roof had a scuttle for access, and a wired glass skylight was installed over the stairway.

The fire

At 7:36 on the evening of March 28, the New York City Fire Department received a telephone report of heavy smoke and sparks coming from a chimney at 62 Watts Street in Manhattan. The initial response was three engines, two ladders, and a battalion chief.

When fire fighters arrived, they saw smoke coming from the chimney but no other signs of fire. The engine companies were assigned to ventilate the roof above the stairs by opening the scuttle and the skylight, and two three-person hose teams were sent to advance lines through the main entrance to the first- and second-floor apartments.

The first-floor hose team forced open an apartment door and noted a momentary rush of air into the apartment. This was followed by a warm—but not hot—exhaust, which was followed, in turn, by a large flame, which shot from the upper part of the door up the stairway. The first-floor team was able to duck down under the flame and run back down the stairs, but the flame filled the entire stairway, engulfing the three men on the second floor.

At the time of the fire, an amateur camcorder operator was taking a video of the scene from across the street, and the film became an important source of information when the fire department later reviewed it. It showed the flame filling the stairway and venting out the open scuttle and skylight, extending well above the building's roof. The video also showed that the flame persisted for at least 6½ minutes.

Damage to the apartment of origin was limited to the living room, the kitchen, and the hall; closed doors kept the fire from spreading to the bedroom, the bathroom, the office, and the closets. The fire didn't spread to the other apartments, and there was no structural damage. However, the wired glass in the skylight melted in long "icicles," and the wood stairs were mostly consumed.

Cause and origin

When interviewed later, the surviving hose team described a classic backdraft, although these usually last only seconds before exhausting their fuel supply. Where did the fuel come from to feed this flame for so long?

The investigation revealed that the man who lived in the first-floor apartment had left it at 6:25 p.m., after placing a plastic trash bag on top of the gas stove in the kitchen, which he was sure he'd turned off. It's reasonable to assume that the pilot light ignited the bag and that the resulting fire involved several bottles of liquor on the counter before it spread to the wood floor and other combustibles. The occupant confirmed that all the doors and windows were closed, so the only source of combustion air was the fireplace flue in the living room, from which the smoke and sparks emerged.

Clearly, the fire burned for nearly an hour under severely vitiated conditions. The open flue initially provided expansion relief and later vented smoke, as the ceiling layer dropped below the level of the opening. Such combustion produces large quantities of unburned fuel and high carbon monoxide/carbon dioxide ratios. Studies of the backdraft phenomenon show that, when a door is opened

FIGURE 3

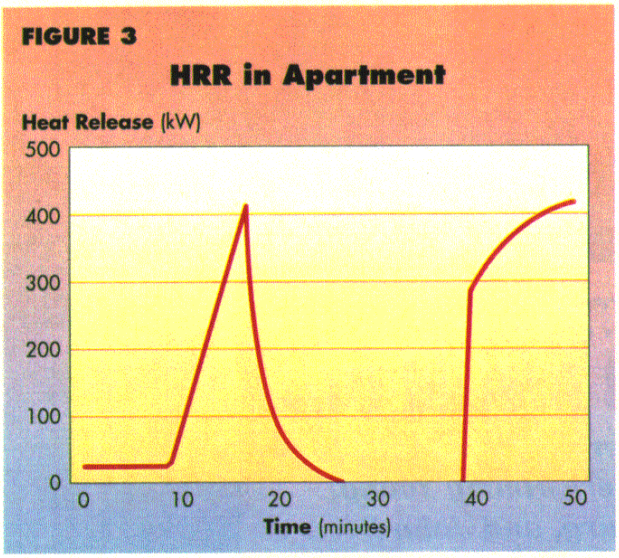
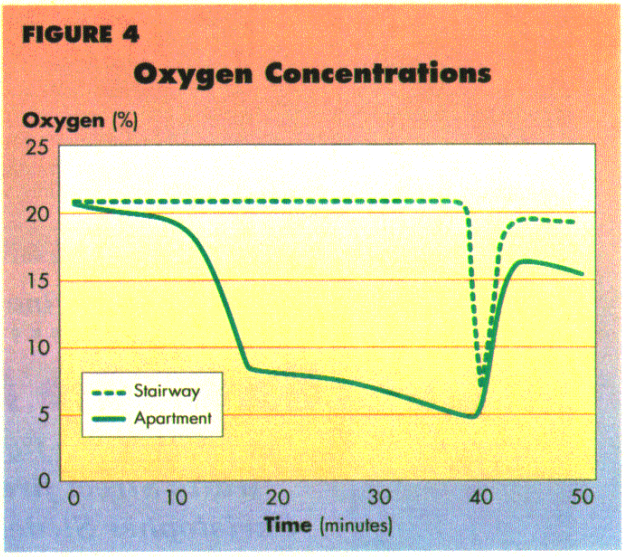


FIGURE 4



under such conditions, warm air flowing out is replaced by ambient air, which carries oxygen to the fuel.[1] When this combustible mixture ignites, a large flame extends from the door.

To determine whether enough fuel could have collected in the apartment to feed the flame for the period of time observed, NIST researchers used the CFAST model to recreate the incident.[2]

Computer analysis and results

The apartment of origin was modeled as a single room measuring 20 feet (6.1 meters) by 46 feet (14 meters) by 8.25 feet (2.5 meters). The stairway was modeled as a second room measuring 4 feet (1.2 meters) by 10 feet (3 meters) by 30 feet (9.1 meters), connected to the apartment by a closed door. This "second room" had a roof vent area of 9 square feet (0.84 square meters). The fireplace flue was modeled as a vertical duct 33 feet (10 meters) high, with a cross-section of 1.5 square feet (0.14 square meters). The fire department provided all these dimensions from measurements they took at the scene.

Using actual data on burning trash bags, researchers assumed the initial fire to be a constant heat release rate (HRR) of 25 kW.[3] This fire then became a "medium t^2" fire, with a peak heat release rate of IMV—although this was never reached because oxygen was limited (see Figure 3). It's common in engineering calculations to use exponential fire growth rates proportional to time squared—or t^2 fires. The most common of these t^2 curves—slow, medium, and fast—are defined in NFPA 72, the *National Fire Alarm Code*, for the design of fire detection systems. Such "medium t^2" fires are characteristic of most of the items commonly found in homes.[4]

It took approximately 2 hours to compile and enter the data into CFAST, and the model performed the calculations in a few seconds. The fire grew to about 500 kW over 5 minutes of simulation time, then rapidly throttled back as the oxygen concentration dropped below 10 percent (see Figure 4). Temperatures in the apartment peaked briefly at about 570°F (300°C), then rapidly dropped below 200°F (100°C) as the burning rate fell (see Figure 5). The carbon monoxide concentration rose to about 3,000 parts per million, and unburned fuel accumulated in the apartment during this stage of combustion.

The front door was opened 2,250 seconds into the simulation; this is the time the first-floor team is estimated to have entered the apartment. Warm air with a temperature of 200°F (100°C) immediately flowed from the upper part of the doorway, followed by an inrush of ambient air through the lower part of the

FIGURE 5

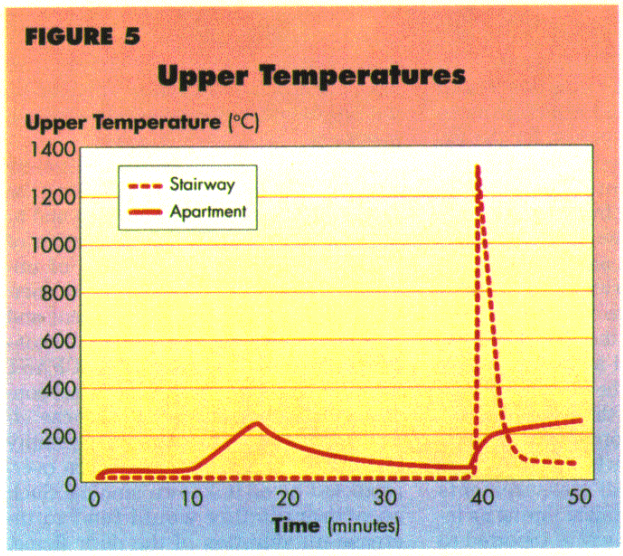
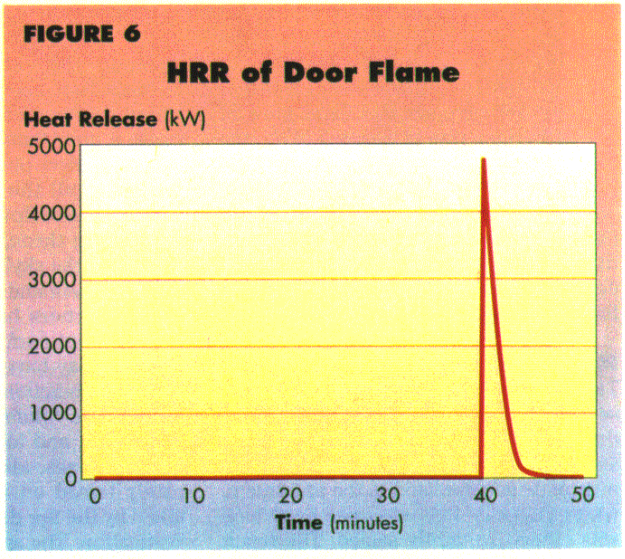


FIGURE 6



Vina Drennan

Heroes Are All Around Us...

The three fire fighters who died in the Watts Street fire were Jimmy Young, Christopher Siedenburg, and John Drennan. On April 26, 1995, John Drennan's wife, Vina, addressed the seventh annual National Fire and Emergency Services dinner, held in Washington, D.C. The following are excerpts of her remarks.

March 28, 1994—it started out like any other day. We went to the supermarket that morning, and he helped carry the groceries into the house. We talked about our kids and tuition payments and Easter dinner. He wanted to make love, and I said, "Not now," and I kissed him good-bye, and I went off to have lunch with a friend. On his way to work, he stopped off at the Wiz, and he bought a new tape deck for his car to replace the one that had been stolen.

Meanwhile, a couple was spending the day getting ready to move into their apartment near the Holland Tunnel in Greenwich Village. The stairs had been polyeurethaned, and before they went out to dinner, they placed a bag of garbage atop the stove—sadly, too near the pilot light. At 7:35 p.m., Ladder 5 and Engine 24 responded to the alarm at 62 Watts Street—and to the tragedy that's become painful history for so many of us.

Once, when I was a young wife, I said to John that I was afraid for him. It was years ago, and he said to me, "Burn to death, we don't burn to death. We fall, buildings collapse, we die from smoke inhalation."

Jimmy Young died right away that night. Christopher Siedenburg died the next day. And John Drennan suffered.

He was burned over 65 percent of his body, and the burns were all very deep. No one so badly burned has ever survived so long. For 40 days, he struggled to live.

The fire burned the three of them for 4 or 5 minutes at 2,200°F—it melted the glass in the apartment until it hung like icicles. Sometimes, when I'm running, I realize how long 5 minutes can be, and my heart just cries. . . .

Their deaths were not gentle. They were gobbled up by those flames, cremated alive, and that sacrifice shouldn't be forgotten. There are ways too horrible to die.

At one point this year, someone said to me, "Boy, I'd bet you'd like to get your hands on the people that were responsible for the fire." I was surprised. I had never thought about it. I said, "Oh no, they were just careless. They didn't mean it, just careless."

But we tolerate carelessness in America. We tolerate carelessness even when we lose close to 5,000 people to fire a year in our country. We tolerate carelessness even when 2 million people suffer severe burns that require extensive hospitalization. We tolerate carelessness even when it costs our country $8 billion a year. . . .

In America, if you get drunk and fall asleep with a cigarette burning, if you overload your electrical outlet, indeed, if you put your garbage bag next to the pilot light, we don't consider the subsequent fire to be your fault. If you did it in Japan, the crime would be called grave negligence, and if it led to someone's death, you could face life in prison. In Germany, you would be financially liable for any property damage your carelessness caused. In Switzerland, insurance only pays to replace property, so there's no arson because the profit has been eliminated.

Not too long ago, our country tolerated drunk driving. My own mother would mutter, "God protects the drunks," when my father stopped off for a beer and forgot to come home. But we realized that that wasn't so, and society stopped tolerating drunk drivers. I took a child abuse course, and I asked why all this abuse was only coming to light now. The professor replied, "Abuse has always been, but it's only since 1970 that

doorway. This was followed, in turn, by the emergence of a large door flame—exactly as the fire fighters had reported. Within a few seconds, this flame grew to a peak burning rate of nearly 5 MW, raising the temperature in the stairway to more than 2,200°F (1,200°C)—hot enough to melt the glass in the skylight (see Figure 6). Most important, the quantity of unburned fuel that had accumulated in the apartment caused the door flame to persist for more than 7 minutes.

Discussion

The CFAST calculations confirm the researchers' theory of the development of this fire. They also support the hypothesis that unburned fuel and carbon monoxide accumulated in the apartment, whose fireplace flue was open but which was otherwise tightly sealed. The result was a backdraft when the front door was opened. The calculations show that enough fuel could accumulate under these underventilated conditions to cause a door flame to persist for the extended period observed. The model reproduced all the reported conditions, such as smoke flowing from the chimney, air flowing through the doorway, glass melting in the skylight, and fire damaging the apartment and stairway.

Researchers had to make some assumptions to perform these calculations, and this may have had an impact on the model's predictions. The results are sensitive to the volume of the apartment and to the size and locations of the ventilation openings, all of which were accurately based on actual measurements taken by the fire department during its investigation. The apartment is reported to have been very tightly sealed, so the assumption of no additional leakage was justified, and the ventilation provided by the fireplace flue was based on actual dimensions.

The combustion was predominately controlled by the ventilation, making the results insensitive to fuel loading and to the specific burning characteristics of the fuel. The generation rate of unburned fuel should be affected by energy feedback from the environment and any flames present during ventilation-controlled combustion. The CFAST model doesn't contain such a self-consistent combustion model, so these effects weren't included, and the quantity of unburned fuel might have been overpredicted by an unknown amount. Such an overprediction would tend to increase the duration of the door flame,

society has refused to tolerate it." Today, we strap babies and young children into car seats. Children and adult bike riders routinely use safety helmets. We know how important seatbelts are. So behaviors do change, and we must rethink our concept that fire is accidental.

. . . Some nations focus on individual responsibility for the behaviors that start fires—and that makes a difference. In Great Britain, the fire safety slogan is "Don't let a fire be your fault." A greater portion of Britain's budget is spent on the media to get the message out in an emotionally appealing way. They use market research extensively to target groups that are at higher risk, such as the elderly, the unemployed, and the immigrant population. They are very creative—a leading character in a soap opera suffers from burns, and a television cooking show does a program on kitchen fire safety. Over and over, the message is stressed: Fire is not an act of God. . . .

It's not God's will that twice as many New York City residents die as a result of fire as residents of London. It is not God's will that 50 to 60 people die annually in fires in Austria, but three times that number—about 175—die in fires in a U.S. state of comparable size. Let's place more of our budgets into educating the public. Let's not neglect the high-risk groups. In many states, we emphasize school-age children, but let's expand our focus to include the elderly, the alcoholic, the unemployed, the poor, and the immigrant population.

My next proposal is not what you want to hear. Not one of you became a fire fighter to be a fire safety teacher. You want to extinguish flames and rescue people. John Drennan would come home exhausted, smelling of smoke, and talk of a "good job." You didn't become a fire fighter to talk about fire safety, but let's elevate this important task to the prominent place it deserves. In some countries, it's a mandatory part of the job. . . .

. . . You honor the fire fighters who died at the Watts Street fire. Their death certificates read, "Cause of death: multiple burns." Yet we in this room know that the real cause of their deaths was nothing more than carelessness. Lack of basic common sense puts us all in danger, but it can be stopped . . . I believe the message will be heard: Learn fire prevention strategies and take seriously the fire safety lessons that every city has in place already. If you don't, you're responsible for your actions, and you'll be ashamed.

Vina Drennan's husband John was one of the three fire fighters killed in the Watts Street backdraft.

John Drennan loved being a fire fighter. For 25 years, he went to work happy and grateful to help others. John Drennan was one of those lucky people who spent his days doing what he loved best. . . .

Heroes are all around us. Maybe there's one sitting next to you right now. What's special about John is that he did what we all can do. He said "yes" whenever he could. He believed in people, and he made everybody feel special. He made people believe in themselves, and he overlooked the bureaucracy to help a person. He had fun. He never spoke badly about anybody. He smiled and tried his best to be kind and fair.

His legacy lives on here. I see it in your faces. You people share his commitment to serve others. You know about courage and determination, and you know about sacrifice. You know all about being involved in something that's more important than yourself. John Drennan's life . . . wasn't about winning or losing, it was about giving.

In his memory, let's move to create a climate where we, as a society, demand responsibile behavior with fire. In his memory, let's get the message across that carelessness can kill. John Drennan's life had great meaning. If, in his memory, we can reduce the number of victims who endure the agony of being burned, if we can reduce the number of burn fatalities, then we can find even greater meaning in his suffering and death. Let this be John Drennan's last gift.

but not its peak value. Since the duration of the model flame matched that observed during the actual fire, the effect is either small, or compensating errors were made in the estimate of the extent of fire involvement. The fire was in steady state for quite a while before the door is assumed to have been opened, so the predicted results are insensitive to that time. The backdraft occurred spontaneously in the model when the door was opened.

Lessons learned

During follow-up discussions, the New York City Fire Department concluded that, although the fire service has long recognized the dangers of backdraft, the unusually long duration of the flame under these conditions represents a hazard against which fire fighters' protective equipment is ineffective. As buildings become better insulated and sealed for energy efficiency, such hazards may become increasingly common. Thus, new operational procedures must be developed to reduce the likelihood of exposure to flames of this duration.

The fire department also noted that, as a result of the publicity surrounding this incident, a few similar incidents were reported. These incidents occurred before this particular fire, but they'd gone unreported because no one had been injured. The fact that the Watts Street fire wasn't an isolated incident reinforces the need for improved operational procedures. The success of this exercise also points out the benefits of using modern computer fire modeling to reconstruct fires so that we may better understand how to mitigate their effect.

Richard W. Bukowski is senior research engineer at the Building and Fire Research Laboratory at the National Institute of Standards and Technology in Gaithersburg, Maryland.

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