Table 1	
Number of floors	36
Floor height	12.3 ft
Stair shaft dimensions	
Length	22.72 ft
Width	6.24 ft
Height	503.0 ft
Stair shaft door dimensions	
Width	3.5 ft
Height	7.0 ft
Shaft loss and door leakage characteristics	
Maximum number of doors open at one time	5
Indoor winter design temperature	72°F
Outdoor winter design temperature	6°F
Pressure differential range across stair door when 5 doors are open—0.005" gwg min to 0.4" wg max which corresponds to 25 pounds force on the stair shaft door knobs.	

This pressure-differential range complies with new Massachusetts Code requirement of 0.05" wg with all doors closed.

NOTE: Analysis was done with the lowest outdoor air temperature (winter design temperature) which is the worst case for maintaining pressure inside the shaft.

Table 2

	All Doors Closed Stairs		3 Doors Open Stairs		5 Doors Open Stairs	
	A " of WG	B " of WG	A " of WG	B " of WG	A " of WG	B " of WG
Lobby	0.12	0.22	0.23	0.12	0.03*	0.03*
5th Flr	0.12	0.2	0.14	0.14	0.08	0.01
11th Flr	0.12	0.14	0.12	0.06	0.07	0.05
14th Flr	0.02	0.14	0.02	0.08	0.05	0.06
17th Flr	0.04	0.08	0.07	0.02	0.03	0.01
19th Flr	0.06	0.09	0.05	0.02	0.03	0.02
23rd Flr	0.12	0.12	0.01	0.02	0.01	0.02
24th Flr	—	—	0.04*	0.015*	—	—
25th Flr	—	—	0.02*	0.01*	—	—
26th Flr	0.18	0.18	0.07*	0.06*	0.04	0.05
29th Flr	0.24	0.2	0.14	0.06	0.06	0.01
32nd Flr	0.22	0.24	0.1	0.16	0.02	0.04
33rd Flr	—	—	—	—	0.01*	0.01*
34th Flr	0.18	0.28	0.12	0.24	0.02*	0.01*
35th Flr	0.34	0.38	0.29	0.32	0.04*	0.02*
36th Flr	0.2	0.2	0.17	0.14	0.01*	0.01*
Total Cfm	71,500	69,670	73,200	72,100	74,200	73,000

NOTE: *Door Open
— No readings have been taken

- Indicate the zone (one zone per floor) at the operator's console and on the printer.
- Activate the master City fire alarm box.
- Shut down air-handling units by zone (2nd to 23rd floors—Zone 1, and 24th to 36th floors—Zone 2).
- Start the four stair pressurization fans.
- Indicate the run status of each stair pressurization fan at the lobby console.
- Print out the status log at a central processor located on the 35th floor engineer's office.

1. General
a. Outside air damper: Modulating type, normally open.
b. Bypass air damper: Modulating type, normally closed.
c. Discharge air damper: Modulating type, normally open.

2. System On
a. Outside air damper open.
b. Differential-pressure sensor (located at stair shaft) sensing the highest DP (Differential Pressure) shall control the bypass air damper, discharge air damper and outside air dampers to maintain its set point (0.4" w.g. maximum).

3. System Off
a. Outside air and bypass air dampers, closed. Outside air damper only, open on failure to control supply air.

PERFORMANCE TEST

The stair pressurization test was conducted on December 11, 1977, at approximately 11 AM. It was a cloudy day with 5°F outdoor temperature and 30.53" of w.g. barometric pressure. The test started with the activation of smoke detector in the return air duct on the west side of the core of the 25th floor.

- Presignal devices sounded the distinctive code identifying smoke on the 25th floor, and activate the master City fire alarm box.
- The air-handling units serving Zone 2 (24th through 36th floors) were shut down.
- The four stair pressurization fans started and the run status indicated at the lobby Command Console and also at the central processor.
- The processor printed out the status log of the events.
- Recorded the pressure-differential readings as shown in Table 2.

After resetting the system back to normal, the test was repeated with the activation of a smoke detector on the 7th floor. As designed, the air-handling units serving Zone 1 (2nd through 23rd) were shut down, presignal device sounded the distinctive code identifying the floor, and activated the master city fire alarm box; stair pressurization fans were started with a run status at the lobby Command Console and the central processor printed out the status log of events. Satisfactory results were obtained with the Zone 1 smoke detection.

Overall, the results of the stair pressurization system were in line with the design.

The design and construction cost for complete smoke detection and stair pressurization system was determined to be under 40 cents a sq. ft. of the building area. □□

#6113

Air for Smoke Control

This article reviews a major electrical control room fire which occurred at the Allegheny General Hospital in Pittsburgh, PA. The loss exceeded $400,000. One-hundred and fifty-five patients were evacuated and smoke damage was heavy throughout the top half of the building. All electrical systems went out when the fire swept the control room. Stack effect played a major role in the fire which overcame 22 nurses. Information in this article was presented at a Seminar on Fire and Smoke Control during ASHRAE's 1978 Semiannual Meeting in Atlanta, GA.

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Control of Fire & Smoke

EASTER Sunday morning, April 7, 1977 at approximately 6:45 A.M. a fire at Allegheny General Hospital in Pittsburgh, PA highlighted the single greatest problem slowing the adoption of air systems for smoke and fire control: While fire services have been given rudimentary training in "ventilating" techniques, they have never been trained in why such techniques work and how to adapt them to the everyday fireground. Field fire officers, for the most part, have been given no training in HVAC systems or components and how they can be used to make "ventilation" or smoke control more effective in helping them in fire attack as well as in reducing life risk and degree of property losses.

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The fire underlines the need to understand "stack effect" and how smoke and fire gases move from a fire, lest protection of people in a building may become difficult and fire-fighting may be exasperating. The problem is further compounded when firefighters may not recognize how little material it takes to create major smoke and fire gas concentrations remote from the initial fire area, even in the early stages of a fire.

In this case smoke from an alleged arson fire in a basement D.C. switchgear room traveled horizontally through exposed open and empty electrical conduit to a corridor area near an elevator lobby. Due to stack effect, the smoke then moved vertically up through an elevator shaft to the top stories of the 22-story building. As the smoke built-up on patient floors, an estimated 165 patients were moved down stairways by the hospital staff. Patients from 16 through 10 were moved to lower floors below the neutral plane which were not contaminated by smoke and where air systems were operating. It is reported that 22 nurses suffered from smoke inhalation and exhaustion. No firemen helped in the evacuation.

Fig. 1, shows how the smoke moved via "stack effect" up the elevator shaft and stairwells as doors were opened for the evacuation. None of the nurses or patients appears to have suffered any long term effects. It should be noted that the coatings on the wiring that was burning was old and basically did not involve modern polymers.

THE STRUCTURE

The hospital was built in 1932. Additions and renovations have been made since then. Constructed of fire resistive materials, it has a capacity of 676 beds. Each floor below the 8th has a different floor configuration. From 8 up to 16 the floor layouts are almost identical. Patient rooms end on 16. Offices and mechanical rooms use the space uo to 22.

The hospital originally operated on its own DC electrical supply. The present switch gear room was originally the DC power supply room with all power for the hospital originating from there. When the hospital switched over to commercial AC power, only certain equipment (3 low-lift elevators, 1 high-rise elevator, some pumps, and ventilation fans) were left on DC. At that time the function of the room changed considerably and was used for routing control wires for the emergency 110V circuits, for housing some emergency switchover equipment, and as a DC wire terminus point.

The building is heated by radiators from a central power house. From the 9th floor up, there is no air conditioning. Ventilation is through windows. A corridor and bathroom exhaust system has it fans in the upper mechanical rooms. These fans have direct current (DC) motors. Below the 8th floor, all floors are air conditioned with power being supplied by the 440V service coming up the mechanical tower. An exception is the 5th floor which has a separate power source for the air conditioning.

Because of the age and design of the structure, the hospital management has planned a new hospital to be built in stages so that the same site can be used and the old building torn down. Unfortunately, local civic groups have considerably delayed the new construction. The hospital engineer responsible for fire safety recognized the smoke and fire safety problems in the existing structure and instituted a rigorous fire safety campaign including fire prevention education, use of fire fighting equipment, patient evacuation, and other basic operations. This is reviewed in the May 1978 NFPA Fire Jorunal. This outstanding emphasis on training may well have been the major reason no lives were lost or patients further injured during the evacuation.

THE FIRE

The actual fire itself started in stored disposable linens in the switchgear room some time before 6:00 A.M. The centralized control system started to print out abnormal conditions at approximately 6:09 A.M., most likely because the control lines went through the fire room and the heat (fire) affected the continuity of the system. Unfortunately, since no one was in the printer room, the readings went unnoticed. (This occurrence emphasizes the need for audible alarms, or a secondary printout in a 24-hour supervised area.)

At 6:45 A.M. several events occurred almost at once. A call on the emergency telephone line from the third floor reported smoke in an elevator; the smoke detector circuit alarmed at the receptionist's fire panel and a waterflow alarm (control wires went through the fire room) tripped the city master box alerting the Pittsburgh Fire Department at 6:47 A.M. The switchboard operator also called the fire department.

When firemen arrived on the scene, smoke was evident in the hospital and crews went to the third floor where the receptionist had reported smoke. It was determined that the fire was not on the third floor, and finding the fire was going to be difficult *because* of the smoke. A second alarm was struck. Total equipment on the scene at this point was six engines, one elevating platform, two trucks, one rescue squad, one salvage squad, one battalion chief and one deputy chief for a total of approximately 48 men.

Smoke was also observed to be coming from the ground floor area (one floor below the first floor, above ground in front, underground in rear). Smoke continued to build. An unusual amount of smoke was issuing from an electric ceiling junction/pull box cover in the first floor corridor near the elevator shaft. The cover was removed and large quantities of smoke poured from empty conduits on the east side of the box.

At 7:38, the fire department decided to check out the old boiler house area. At this time, the fire in the switchgear room was discovered and water applied about seven minutes later.

Approximately 15 minutes after the fire was reported, the hospital emergency plan was put into effect and each floor was notified to prepare for evacuation. Smoke started to build-up heavily on upper floors and opening windows only appeared to intensify the smoke movement. (This is a natural occurrence as the upper floors are above the neutral plane. Air flow at those points would be out of the windows.)

Between 7:20 and 7:30 evacuation of patients on upper floors began. Many patients were ambulatory and walked down stairwells. Other patients were carried down. Patients were removed from 16 down through 10. (Fortunately, since it was Sunday, no workers were on the office floors above.) Smoke from lower floors invaded stairwells on each floor as doors were held open for evacuation. There was also dense smoke from the third floor down. Little or no smoke was reported on the floors below the neutral plane from 4 through 9. It should be noted those air systems stayed on. The interesting thing is that the smoke was dense from 3 down. Dense smoke on the basement level kept firemen from finding the fire for a considerable time. At the time the fire was finally surpressed it was just starting to cause the ceiling to fail and the wall to buckle in the adjoining storage room.

The fire was apparently of incendiary origin and burned for a considerable amount of time before discovery. As best as can be determined the fire was discovered at the same time as the power failed. The outdoor temperature was near freezing; this would help account for the rapid stack action in carrying smoke upward.

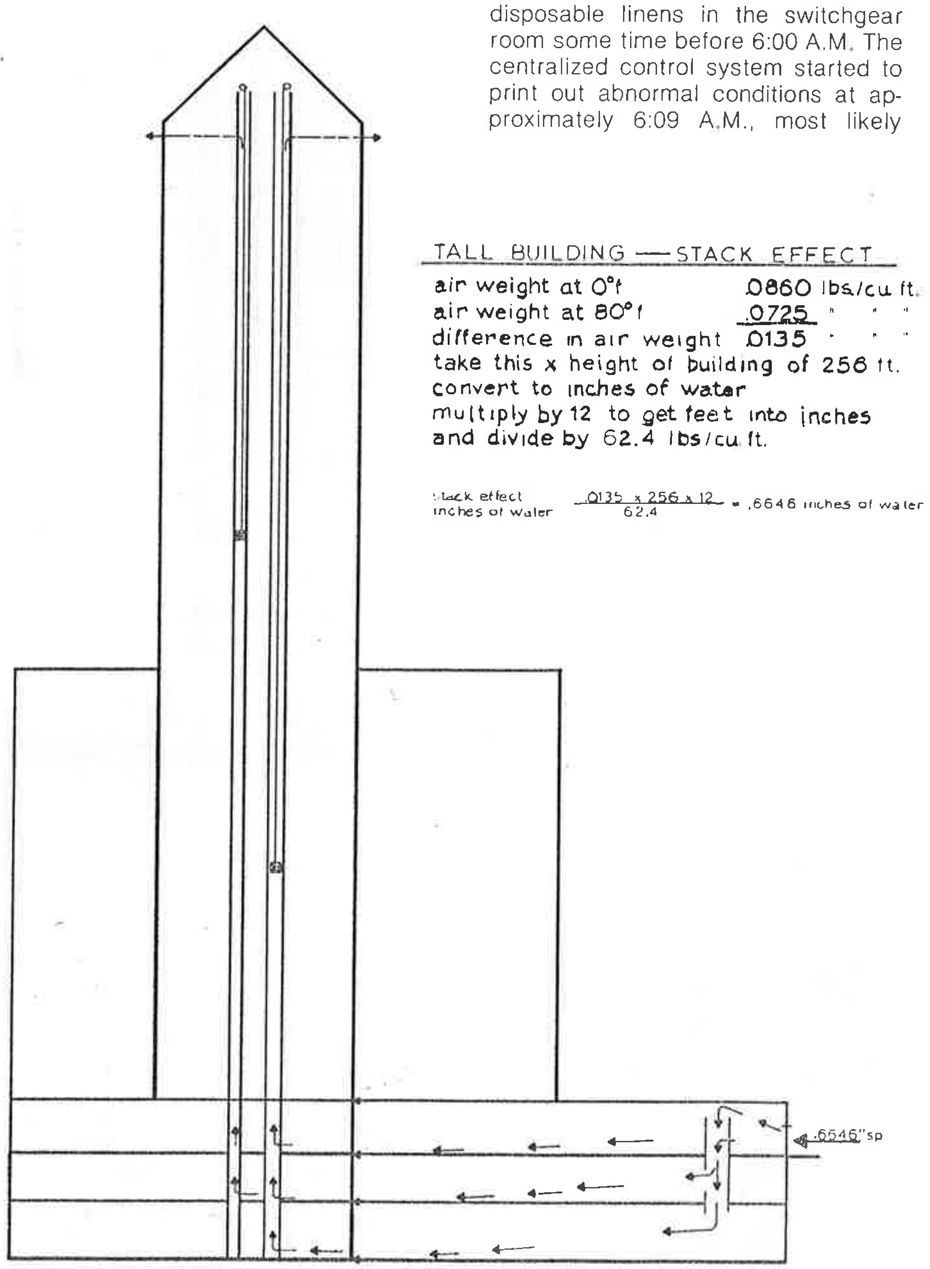
The smoke spread from the switchgear room to the base of the tower through empty electrical conduit and some partially filled conduit from which the cover plates had been removed or were removed by the fire department in the corridor near the central elevator shaft. This allowed substantial smoke into the elevator lobby for movement upstairs.

Virtually everything in the switchgear room including the DC switchgear and some of the fire alarm wiring was lost. There was loss of all the 110V branch circuits from the third floor to basement. This meant no lights at all in this area. This occurred because the transfer switch for these circuits from normal power to emergency power was located in the switchgear room. Approximately 60% of the emergency power lines for upper floors went through the room and would have been lost if needed since these lines were destroyed as well. Two of 13 operating rooms lost power.

The fact that the fire department lacked knowledge of smoke movement may have caused them to underestimate the severity of the smoke movement upwards. Had the hospital staff not been extremely well trained this could have resulted in perhaps much more serious life and injury consequences. The opening of the vents at the top of the tower by the hospital staff probably reduced the smoke hazard on upper floors as well. Had this occurred during warm weather with slight "stack action" the result could have been disastrous to patients.

The engineer for the hospital had anticipated the problems of "stack effect" and was in the process of planning how to pressurize stairwells and the elevator shaft to reduce potential smoke movement. It is little short of prophetic that the arsonist chose to strike at the Achilles heel as pre-planned by the engineer. Fate takes strange twists.

This fire did not represent a "planned smoke control system." It was a classic case of cold weather stack effect. The results were completely predictable. Teaching fire departments how to anticipate these "predictable fires" in buildings without smoke control systems is a part of the this new TC 5.6 program for the fire services. Equally important, however, is teaching the fire services how to use and pre-plan the use of designed "smoke control systems" so that the engineered system is used under the real fire situation as planned to reduce both life risk and property losses. □□



HVAC Systems and Smoke Control ASHRAE TC 5.6 Leads the Way

At present, ASHRAE's major thrust has been towards high-rise buildings. A new project undertaken by TC 5.6 will assess the problems in lower buildings as well, and the problems involved in everyday fires in homes and apartments.

One of the most perplexing situations to firemen is "stack effect." Most field fire officers and firemen know very little about how air systems in buildings function even in normal situations, let alone what happens due to "stack effect" when a fire actually occurs and the building air system is turned off and "stack effect" takes over.

One would think also that insurance underwriters would be quick to adopt a technique which promises to keep most fires to incidents and reduce property losses from smoke and fire dramatically. Yet so far, few have really been involved. It must be said now that some companies are becoming involved.

ASHRAE has sponsored many seminars across North America for architects, engineers and building officials on smoke and fire control using air. More are scheduled. However, TC 5.6 has now taken a new direction and started to present command courses for the fire service. The first was sponsored by the City of Beachwood, OH Fire Department in February 1978 through their Fire Prevention Bureau, and under the direction of Fire Chief George Vild and Lieutenant Bud Billings. It was called "Air—And How Do *WE* Use It To Fight Fires" and was attended by thirty departments. The seminar was held at the new Marriott Hotel in Beachwood. The Marriott has two sleeping room wings, both of which are pressurized. The system includes stairwell, elevator shaft and corridor pressurization. These systems were demonstrated to those who attended. Basically however, the program concentrated on how air systems and HVAC systems work, how they can be easily used for fire control, and how they, as firefighters, can use air systems, either with automatic or manual controls, to their advantage during fire suppression.

Since that start in February, a similar program has been presented to the entire Cleveland Fire Department command Cleveland, OH and programs are being planned for the New York City Fire Command, the Chicago, Illinois area and others.

Hopefully the program will become a basic part of the National Fire Prevention and Control Administration's future basic fire fighting courses. Among the subjects covered which directly relate to existing low-rise as well as high-rise structures, including homes and apartments, were the following:

Basic air movement problems:

- Preplanning use of existing building systems to control smoke/fire—location of critical controls for the fire service and owner cooperation.
- Pre-size-up of the extent of the problems that can develop—assessing exposure hazards.
- Wind direction, temperature, and humidity effects on preplanned fires.
- Maintaining window and door integrity.
- Exhaust system use to help locate fire, remove combustible fire gases.
- People—to evacuate or not.

Emphasis then was placed on fire attack procedures, with a discussion of "stack effect" and negative wind pressure problems, in the following areas of structures:

- Basements
- Below the neutral plane
- Above the neutral plane

These discussions included:

- Handling of flame plumes.
- Controlling radiant heat exposures.
- Use of air fans and fog lines to control smoke and fire remotely.
- An understanding of the limitations and abilities of natural ventilation.
- Possible problems with sprinkler systems when HVAC systems are operational.
- Use of existing HVAC equipment.

As a working knowledge of these procedures becomes second nature to firemen, dramatic changes in the extent of losses in property and people may well occur. This offers, in my opinion, is one of the greatest steps forward in fire attack since the widespread adoption of fog lines. R.E.T. □□