A PVC FIRES LIST
Compiled by Greenpeace June 1994

This is a list of accidental fires that have involved the synthetic material polyvinyl chloride.

In all of the fires, PVC was only one of many materials that burned. But in most cases it is clear that if polyvinyl chloride had not been present, the fires either would not have started, would not have emitted life-threatening gases and chemicals, or would not have spread at such a rapid rate.

The list of fires is divided into four sections which describe the different hazards of burning PVC:

a) Dioxins
b) Hydrochloric Acid
c) Fire Spread
d) Electrical Wiring and Cable Insulation

Any given PVC fire might have elements of all four hazards, but for this list a fire was included in a particular hazard section because that hazard was dominant in increasing the tragedy level of the fire.

The sections are also in the order of data availability. For example, there are few accidental PVC fires for which dioxin data is available. Even though all PVC fires will create dioxin, these are the only ones I know of that have been tested and confirmed. I came across not one incident where dioxin tests for burned PVC came up negative.

On the other hand, it is easy to find incidences of electrical wiring/cable fires. However, detailed information is limited. But if it can be concluded that PVC was involved in a wiring/cable fire, one can only infer that the fire spread rapidly, released hydrogen chloride in the smoke, and left dioxin in the ash.

SMOKE INHALATION

The majority of fire deaths are due to "smoke inhalation". Traditionally this has meant carbon monoxide poisoning, but in modern fires, where sythetic materials release a variety of poisonous gases, the general diagnosis of "smoke inhalation" is vague and insufficient. (Journal of the American Medical Association citation)

Therefore, even though it's proven that PVC emits HCl, the PVC industry can argue there is no proof that PVC is responsible for "smoke inhalation" deaths.

It has been possible to measure the lung tissue of a victim to find if they had a lethal dose of either carbon monoxide

or hydrochloric acid before they died. However, even if the victim did not have a lethal dose of HCl he could have been incapacitated by the HCl, then died of carbon monoxide poisoning afterward.

Unfortunately, though, it appears that unless a lawsuit is filed, a death diagnosis of "smoke inhalation" is usually not investigated, and is assumed sufficient.

BACK TO THE LIST

At the beginning of each section there are citations describing the PVC fire hazard in question.

At the end of the list there are two pages describing a) the increasing proportion of smoke deaths to fire deaths in structural fires and; b) the danger of fire retardants in prolonging the pre-combustion low-temperature decomposition stage of a fire.

End

PVC FIRES: DIOXINS AND FURANS

Besides the acidic hydrogen chloride, a wide variety of chlorinated and non-chlorinated organic chemicals evolve from PVC during high temperature pyrolysis and combustion: benzene, toulene, formaldehyde, chloroform, chlorinated biphenyls, dioxins and dibenzofurans, and many others.

The emission during fires of benzene, chlorinated dioxins, and dibenzofurans - known carcinogens - appears to explain the high frenquencies of leukemia, laryngeal and colon cancer, and of the rare soft tissue cancers found in many firefighters at relatively young ages.

One of the trace constituents rarely described is PVC pyrolysis/combustion products in the dioxin/dibenzofuran family. The soot most commonly analyzed in these experiments is generated at high temperature in a helium atmosphere. Dioxin and dibenzofurans require presence of oxygen for formation. They are formed during cooling of gases and soot. Thus, sampling of the hot soot right off the materials, especially material burned in a helium atmosphere, precludes finding them.

Source: Wallace, Deborah. PhD In the Mouth of the Dragon: Toxic Fires in the Age of Plastics. Avery Publishing Group: Garden City, New York. 1990.

Test results demonstrate that in case PVC-containing materials take part in combustion processes PCDF/Ds can be found in the decomposition products in considerable concentrations. Therefore, the results confirm the classification of PVC-

containing materials as PCDF/Ds precursors.

In samples from real fires total PCDF/D contents were found mainly in the ppb concentration range, whereas samples from the laboratory combustion tests showed total contents in the ppm range.

The combustion of hard-PVC yielded the highest total PCDF/D concentrations in the generated products followed by combustion of PVC-fibre material and soft-PVC.

In nearly all investigated combustion products the FRG-limit of 5 ppb was exceeded.

Source: J. Theisen, W. Funke, E. Balfanz, and J. Konig. Chemosphere, Vol. 19, Nos. 1-6, pp 423-428, 1989.

PVC FIRES: DIOXINS AND FURANS (Examples)

ST. TERESE, MONTREAL, CANADA

1 July 1993

A fire destroyed a plastics plant Plastibec Ltd, 30 km north of Montreal. The firm is owned by Royale, Inc., which distributes prefabricated houses made almost entirely of PVC. The fire began just after midnight. Firemen gained control of the blaze shortly after 8 am, but smoke continued to billow over the leveled plant. The fire forced 250 people from their homes and burned for 18 hours, producing thick, black, corrosive smoke. St Terese's two elementary schools were closed the next day.

The fire consumed about 15,000 kg (15 tons) of polyvinyl chloride in the factory, which manufactures vertical blinds. The Plastibec plant was Quebec's biggest maker of extruded vinyl window frames, a major producer of vertical blinds, and a plastics recycler. It has about 120 employees.

The Quebec Environment Ministry released test results showing ash from the fire was contaminated with high levels of dioxins and furans, toxic by-products of the combustion of polyvinyl chloride plastic.

The tests found dioxin and furan concentrations in the ash of 18.441 parts per billion/kg, while the soil itself contained 0.55 ppb. Stephane Gingras, Greenpeace campaigner, said of these test results, "This is very serious, not only because of the concentration, but because of the amount produced. This fire produced between 40 and 85 grams of dioxins and furans - the equivalent of that produced by the pulp and paper industry in a year."

The ash from the accident was continually hosed to prevent it from dispersing and the water was collected and disposed of as

hazardous waste. A three-week cleanup operation was expected to cost the company at least CAN$ 200,000. It involved trucking the ash and contaminated soil to a toxic waste disposal site outside Quebec.

About 50 firefighters were called out. At least six were treated for smoke inhalation. Thirty firefighters required medical treatment because of the fumes.

The health authorities have sent a warning to the association of Quebec police and fire directors, laying out special measures to be taken when fighting polyvinyl chloride fires in the future.

sources: Gouvernement du Quebec; The Globe and Mail; Canada Newswire

MICROPLAST, LENGRICH, GERMANY

October, 1992

Microplast, a PVC recycling company caught fire. The German environmental protection agency (UBA) found concentrations of 13,700 nanograms of dioxin per kilo (13.7 parts per billion) in residues coming from the Microplast warehouse.

As the company was situated in a rural area, the UBA analyzed agricultural products in the region, and discovered dioxin concentrations exceeding the permitted limits of 5 nanograms per kilo (5 parts per billion).

EUROMAT, DIEST, BELGIUM

27 and 28 November 1992

A fire completely destroyed the PVC factory, Euromat, which produced PVC granules for cars, cable, shoes, and the medical industry. Experts estimate 100 tons of PVC burned. Most of the fire was extinguished after four hours, but the area had to be hosed down for one and a half days. Because the fire continued burning under the cooled plasticized melting surface layer, new outbursts would occur.

Firemen used no protective clothing except for gas masks. 211 people were evacuated from the surrounding area. No government or industry samples were taken and no investigation was done in the neighborhood for damage on vegetation or health.

Independent samples showed levels of dioxins and furans in fire residues as high as 87.750 ng/kg (.087 parts per billion) of all dioxins and furans.

HOLMSUND, SWEDEN

January 10, 1987

A fire occurred in a plastic carpet company in Holmsund, outside of Umeaa, Sweden.

A report was given on the emission of polychlorinated dioxins and polychlorinated dibenzofurans into the surrounding environment after a fire at a plastic carpet company.

The wooden warehouse, containing 200 tons of pure polyvinyl chloride (PVC) and 500 tons of plastic carpets, was completely burned out. Both polychlorinated dioxins (PCDDs) and dibenzofurans (PCDFs) were recovered as pyrolytic products of PVC. Due to the low outdoor temperature of minus 30 degrees Celsius, an inversion layer was formed and the heavy, pungent smoke containing hyrochloric acid remained close to the ground over the surrounding area, including part of a nearby village an out over the Gulf of Bothnia.

Two days after the fire, wipe samples were taken from three parts of the facility that had been filled with smoke. Samples were taken of the snow at six locations 10, 30, 100, 300, 1000, and 1500 meters downwind of the facility and also from five locations that were not downwind. Samples were prepared with radiolabeled PCDD and PCDF isomers and extracted. Toxic equivalent factors (TEF) of tetrachlorodibenzodioxins (TCDDs) and tetrachlorodibenzofurans (TCDFs) were estimated using the Eadon model and the Nordic model. The TEF of TCDD showed a deposition of less than 3 milligrams within 1500 meters from the fire site. The Nordic model showed TEFs higher than those estimated by the Eadon model for all TCDDs and TCDFs calculated.

The authors conclude that the pattern of PCDDs and PCDFs found in the samples obtained after the fire was similar to the pattern seen in a munical waste incinerator with an emission rate of one milligram per hour of dioxins.
source: Chemosphere

STONY BROOK, NEW YORK

September 26, 1986

Polychlorinated dibenzo-p-dioxins (PCDDs) and polychlorinated dibenzofurans (PCDFs) were detected in soot from a building fire involving PVC and a source of chlorine.

The fire occurred in the early morning hours in an internal room of an unoccupied lecture center building at the State University of New York at Stony Brook. The investigation and cleanup that followed resulted in the detection of dioxins and furans in the deposited soot.

The fire started in a concrete room which was being used as a storeroom for custodial supplies and was extinguished approximately one hour after it started. It was reported that the fire consumed 20 boxes of abrasive floor scrubbing pads, trash bags, PVC floor tiles, quaternary ammonium chloride cleaning solution, part of a desk, a chair, a wooden platform structure, and paper products. Intense heat melted several stacks of plastic chairs, a plastic waste container, a plastic covering on a stereo set, and electrical wiring in a circuit box. Due

to discomfort experienced by students who used the lecture hall in the post-fire environment, an extensive series of environmental tests were taken. Results showed dioxins and furans and resulted in the closing of the hall for cleanup.

Although sampling for dioxins and furans did not take place until several months after the date of the fire, the results for 2,3,7,8-TCDD Equivalents were 3.406 ng/gram (EPA) and 5.952 ng/gram (New York State).

STE JULIE, MONTREAL, CANADA

September 2, 1993

Hydrochloric acid was released into the air after 7 tons of PVC went up in flames at Novatech Glass Inc, 50 km southeast of Montreal. The company uses PVC parts in their manufacturing process.

No residents were evacuated, however they were told to wash their garden produce.

Sampling contracted by Novatech showed that the highest level of dioxins and furans in the ash were at 0,0051 ng/kg.

The clean up was executed with all the preventative measures normally used with heavy dioxin contamination.

The fire started just before 9am when a hose attached to an oven broke and sprayed phosphates onto a neon lamp.

Several of the 100 employees at Novatech's Murano St. plant were on the job, but noone was reported killed or seriously injured. At least one worker complained of burning eyes and throat.

No homes, schools, or other buildings were evacuated in Ste Julie. However, officers did drive down residential streets in the area and, using megaphones, urged residents to stay inside with the doors and windows shut.

It took firefighters 20 minutes to arrive on the scene. It took reinforcements another hour to arrive.

Soon after the fire started, the building was rocked by a powerful explosion that sent a fireball into the sky.

By 11 am health and safety officials feared that up to 150 homes and three schools located near the burning plant might have to be evacuated. But the call to evacuate - it would have been made by environment and health officials in consultation with the mayor and police - never came. "We don't want to create a state of psychosis," said Helene Laurin Tardif, acting mayor.

By mid-afternoon the factory was a smoldering wreck, most of its interior gutted. The flames were out, but smoke still poured from the ashes.

Chemicals, such as chlorine, phosgene, dioxins and furans, and hydrochloric acid had been released into the air.

source: The Gazette, LeDevoir, Novatech

FRANKFURT, GERMANY
Hoescht Chemical Plant

March 17, 1993

German chemical firm Hoescht AG said that explosions at its main plant in Frankfurt may have freed the cancer-causing compound dioxin. "Most likely only trace elements of dioxin, if any at all, were released when PVC panels on the building in question were burned," a Hoescht spokesman told Reuters.

Greenpeace activists were denied access to the plant's grounds when asked if they could carry out tests for dioxin created when the fire burned wall panels made of the plastic PVC.

One worker was killed and another was seriously injured in the blast, which sent a black cloud over nearby suburbs.
source: Reuters

PVC FIRES: HYDROCHLORIC ACID

PVC can kill before it ever reaches its temperature of combustion.

The normal aging process of synthetic polymers is called chemical decomposition. Increased heat can also cause decomposition.

The deadly acid gas hydrogen chloride (HCl) (in aqueous form called hydrochloric acid) comes off PVC so quickly and so easily that polymer scientists call it "unzipping."

The early stages of a fire include interrelated chemical and physical degradation.

Many of us consider flames the signal that a fire has begun. Combustion scientists think of a fire as beginning long before actual flame is present. Flame results from a process that begins with a relatively low level of heat. With plastics, the first stage of a fire is invisible; heat causes the molecules to slip and slide, and causes a great acceleration of the aging processes of oxidation, flowing and the loss of additives. Eventually, the heat builds to the softening point, then the melting point.

With PVC, by the time combustion begins, the peak of hydrogen chloride release is usually past.

As the temperature rises, the decomposition accelerates. The

temperature eventually reaches a special level called the temperature of quantitative decomposition during which large and predictable quantities of gases are emitted by the polymer.

The 480 degree Farenheit (250 degree C) oven temperature used to roast a chicken on a vertical rack will quantitatively decompose PVC and release clouds of hydrogen chloride. Yet PVC does not actually burn until it reaches about 1112 degrees F (600 degrees C).

Once the decomposition temperature is reached, lethal concentrations of hydrogen chloride appear within two to three minutes at a distance of one to two feet from a four-ounce piece of PVC. The plastic becomes a true toxic hazard during quantitative decomposition when there is no flame to warn anyone who may be nearby.

As HCl is heavier than air, heat is the only reason for the rising HCl plume from decomposing PVC.

Potentially 58 percent of the weight lost by rigid PVC during the various fire stages can be attirbuted to hydrogen chloride.

Wallace, Deborah. In the Mouth of the Dragon

PVC FIRES: HYDROGEN CHLORIDE
(Examples)

DALE CITY, PRINCE WILLIAM COUNTY, VIRGINIA, USA

April 9, 1992

Faulty electric cable wrapped around water pipes to prevent freezing apparently set off a blaze that killed a Dale City woman and her two sons.

The cable, called heating tape, which is used by thousands of homeowners to prevent water pipes from freezing, is involved in 2600 fires each year, resulting in an estimated 20 deaths, 110 injuries and $24.8 million in annual property loss, according to officials of the US Consumer Product Safety Commission.

The fire at the Elm Farm Trailor Park in the 3500 block of Davis Ford Road killed Lillie Tompkins, 37, a school bus driver, and her two sons, Benjamin, 13, and Adam, 16, and spread to three other trailors, burning out the interiors of two. It caused $120,000 in damage.

The investigation showed that the heating tape ignited a plastic water shut-off valve and the flame spread to PVC piping, which produced toxic smoke and gases.

The toxic smoke entered the trailor toward the rear, fire officials said, close to the bedroom where the teenage boys slept with the door closed, allowing the fumes to concentrate. It is

likely the youths were overcome by fumes early.

Bradley Tompkins told officials that he and his wife ran to the boys' room and were unable to open the door.

Outside, Lillie Tompkins broke a window to the boys' room and tried unsuccessfully to climb in. As her husband worked on the outside, she pulled away from neighbors holding her back and ran inside the burning trailer.

"When she went back through that door she had pretty much sealed her fate," an official said. "Witnesses told us fire was around the door when she went in."

source: The Loudon Times

CAMDEN, NEW JERSEY

September 10 1992

Over 100 people were evacuated from a four-block area for about seven hours after a fire at the Custom Mill recycling plant. Ten firefighters and police officers were examined for exposure to polyvinyl chloride. A pallet with 50 50-pound bags of PVC caught fire in the Custom Mill building, apparently as a result of a breakdown in processing. The product is received in granular form and the plant pulverizes it into powder. The bags contained the powdered form. The burning PVC created hydrogen chloride gas, which burns the eyes, nose and throat. Four firefighters were treated at a local hospital and released.

source: Camden newspaper

EAST CALGARY, CANADA

July 24, 1991

Smoke from a potentially lethal landfill fire blew over the town of Forest Lawn. During the first few hours of the fire, a hazardous materials response unit tested the potentially toxic smoke every 10 or 15 minutes for dangerous chemicals.

"We could have every kind of chemical they make in there right now and even a chemist wouldn't know what kind of chemicals could be released when they burned together," said Capt. George Hemming, spokesman for the Calgary fire department.

Early samples showed the presence of polyvinyl chloride. Firefighters and hazardous waste specialists were equipped with special breathing devices to protect them from chemicals that might be released. The fire burned for at least 24 hours.

source: Calgary Herald

GARY and HAMMOND, INDIANA

February 11, 1993

At 5:00 am as many as 6,000 people were told to evacuate their neighborhood because of a fire in an auto junkyard called H&H Dump. "Auto Fluff", which is used in cars, is mostly PVC, therefore emits toxic gases when burned.

Officials also blocked off Clive Avenue, a major artery for commuters to jobs in northwestern Indiana and nearby Chicago.

To avoid runoff of hazardous chemicals, hazardous materials experts of the Indiana State Police and the US EPA sought earth moving equipment to bury the fire instead of extinguish it with water or foam.

source: UPI report, Greenpeace Investigation

BOSTON, MASSACHUSETTS

July 2, 1975

A rush-hour fire in an underground trolley car was a nightmare for passengers and firefighters. There were no firefighting facilities within the tunnel, so the Fire Department had to stretch the hose lines in from the street.
Nearly 400 passengers from the burning train and two other trains in the tunnel left the tunnel on foot safely. However, 34 fire fighters were hospitalized for possible inhalation of smoke from burning plastics, including PVC asbestos floor tiles, in the train cars.

Since the fire was near Boston's border with the town of Brookline, both jurisdictions' fire departments sent apparatus. They were met not only by hot, smokey fire, but also found some passengers still groping their way through the smoke to the station.

As a precaution, 62 members of the Boston Fire Department and 13 members of the Brookline Fire Department reported to the Boston City Hospital for examination for fear of possible inhalation of smoke from burning plastics. Twenty-one of the Boston firefighters and 13 firefighters from Brookline were held overnight.

source: Fire Journal

PLAINFIELD, NEW JERSEY

March 20-21, 1985

At about 12:15 p.m. an alarm sounded for a building fire at a large warehouse leased by a plastics company. Firefighters arrived on the scene within minutes, but the fire was already raging out of control, producing flames 40 feet high.

About an hour after the fire began, firemen battling the blaze from several locations reported skin rashes and eye irritations. Another hour later it was confirmed that the unoccupied warehouse (200m

by 70 m) illegally contained large quantities of polyvinyl chloride waste awaiting shipment to the company's Newark plant for remolding.

Initially firefighters had no idea that the unoccupied, burning warehouse was being used for illegal storage of pure, bulk polyvinyl chloride (PVC) scrap. Consequently, protective measures, like the use of masks, were only ordered once the nature of the fire became known. This resulted in additional chemical exopsure among the firefighters.

Approximately 1000 community residents were evacuated from their homes, and 28 firefighters reported to a local hospital with symptoms associated with the fire. Two-thirds of these firefighters had abnormal pulmonary function tests. Chemical analyses of debris specimens taken directly from the scene of the fire showed that hydrogen chloride was a significant combustion product of the fire.

State and local health departments were notified, as was the Red Cross and the Department of Environmental Protection. Several firefighters and community residents presented at nearby Muhlenberg hospital with a range of symptoms associated with the incident.

Tests showed that hydrogen chloride, a strong acid that can cause mucosal burns of the respiratory tract, was a significant chemical produced during the Plainfield warehouse fire.

Firefighters exposed to burning PVC were studied to assess respiratory effects at 6 weeks post-incident and again at 22 months following the fire. Exposed subjects reported significantly frequent and severe respiratory problems at both times. At 22 months, approximately 18 percent of exposed firefighters, compared with none of the control subjects, reported that since the time of the PVC exposure, a physician had told them that they had either asthma or bronchitis.

Symptoms attributed to HCL: eye irritation, skin irritation, rashes or itching, sore throat. Other symptoms: headaches, restlessness, dizziness, blurred vision, stomach pain, tingling/numbness, dry mouth, chest pains, wheezing, coughing, short of breath, increased thirst, muscle/joint pain, tiredness, daytime drowsiness.

Significant risk factors related to the fire included fighting the fire on March 20 (the first day), living within one mile of the firehouse, and being a truckman.

The fire fighters were also studied for psychological effects.

This study proposed to evaluate the long-term psychological impact of one toxic exposure event, specifically involving PVC.

Firefighters had higher levels of demoralization and specific emotional distress 22 months after the incident. This revealed there is no reduction in symptomology over time. Some

psychological distress scores actually rose over time.

It could be concluded that the Plainfield PVC incident had substantial long-term psychological effects on the firefighters who fought the chemical fire.

Some of the psychological symptomology documented in this study may have been related physiological changes associated with exposure to PVC. Elevated levels of confused thought, for example, may have been an aspect of an organic or neuropsychiatric problem directly associated with chemical exposure, rather than a long-term symptom of psychological distress linked to the occurence of a dramatic, threatening event.

It is also unlikely that the long-term psychological distress experienced by the firefighters was solely a psychophysical response associated with the physical aspects of chemical exposure.

Given the persistence of many of the somatic and other symptoms experienced by Planfield firefighters who fought the PVC fire, the study concluded, these men should be evaluated for occupational post traumatic stress disorder.

The Plainfield PVC warehouse fire has received little press coverage, particularly outside of local newspapers.

source: Behavioral Medicine, American Journal of Epidemiology, Archives of Environmental Health

Osceola, Missouri

December 2, 1974

Once ignition took place in a patient room in a modern, one-story hospital, the combustible contents of the room produced an enormous amount of heat and smoke in only a few minutes.

The fire took place during the early morning hours. Seven of the nine patients in the wing of origin died of smoke inhalation.

The burning contents in room 204 produced a rapid-developing, extremely hot, smokey fire that drove the staff out of the wing less than five minutes after smoke was first detected.

The initial fuel source was a vinyl-covered foam mattress. The floor of the one-story structure was vinyl asbestos tile on concrete slab. The corridor walls had a vinyl-type wallpaper over the lower four feet. The fire was limited to one room.

At 12:25 am, there were five staff members and one doctor on duty with 21 patients. Some staff detected a faint odor of smoke.

Then "black strings" were seen floating in the air north of the corridor. At least three members of the staff started down the corridor in the north wing at different paces. As one staff

member approached Room 204, she could see fire near the ceiling. Then, heavy, black smoke suddenly poured from Room 204. At this point, the staff members ran back down the corridor and passed through the smoke doors as they were automatically closing off the north wing.

Attempts were made to reenter the north wing, but the smoke was too thick. The smoke doors held back the major portion of the smoke, but enough leakage occurred (partly due to opening the doors) so that conditions on the protected side became unpleasant, although tenable. Because smoke was entering the rest of the hospital, total evacuation was performed.

The windows to patient rooms in the north wing were broken and nine victims were brought out, two of whom were revived.

The fire department rapidly knocked down the fire, which was confined to Room 204.

There was no significant fire spread beyond the room of origin. The fire report said that the dense, black smoke could be attributed to the PVC mattress cover and the foam core.

Although the staff had had 11 fire drills in the last year, they were not prepared for, nor did they expect, the heavy smoke conditions rapidly generated by this fire.

The rapid development of this fire is evidenced by the fact that a nurse's aid had checked the room of origin three times between midnight and approx 12:20 am. At 12:30, the corridor was untenable due to the smoke.

All of the combustible contents of Room 204 were involved and consumed. The essential fire problem in this case concerns the heavy smoke exposure to other patient rooms from a fire developing in combustible contents in the room of origin.

source: Fire Journal

WASHINGTON, DC

December 10, 1975

Two electricians were killed and 21 fire fighters were injured when there was an explosion in the electric switchgear room in the basement of a new 8-story office building.

The building was approximately 95 percent completed and was being occupied on some of the floors. Apparently, sometime during the evening of December 9th, difficulty was experienced with the ground-fault interruptor on the main disconnecting means. Two electricians were assigned the first thing the next morning to correct the condition.

At 9:38am the next morning the occupants of the building reported an explosion in the basement. Upon arrival of the fire department, it was discovered that something apparently had gone

wrong in the main switchgear room and a search revealed the two electricians. A fire had started in the PVC wire insulation.

Within minutes, smoke had permeated throughout the building and in many cases firefighters had to remove breathing apparatus in order to aid civilians and provide first aid to the two injured electrians. Due to the removal of the breathing apparatus, 20 firefighters received smoke inhalation.

One of the electrician died from burns over 90 percent of his body. The other died several days later from pulmonary burns or smoke inhalation.

Thorough examination of the fire room revealed that the only material which burned was the PVC covering on the wiring. There was actually very little fire in the room and all the smoke was caused by a relatively small amount of insulation burning.

According to the NFPA, this fire presents an excellent example of the problems related to smoke given off when PVC burns. Although very little wiring was involved in this fire, smoke permeated almost entirely throughout the building and resulted in numerous injuries.

source: Fire Journal

Las Vegas, Nevada
MGM Grand Hotel

November 21, 1980

The MGM Grand Hotel occupied a city block and rose twenty six floors. The design and operation of the hotel violated codes and practices for smoke control.

Among other synthetics, the hotel had a plenum (space between the casino ceiling and the floor of the first story) that contained PVC drainage pipes (tons of plastic), and a vast electrical network, with all wires insulated in PVC plastic. Wallcovering, rigid moulded furniture, and fake leather upholstery also contained PVC.

PVC, which decomposes readily, existed in the same environment in the casino as ABS, which burns readily and emits hydrogen cyanide, and as PMMA, which burns readily and emits methylmethacrylate, which is its monomer and an irritant and nerve poison. In general, combined dosing has proven worse than single-type dosing, toxicologically.

The fire started at 7:30 am in the casino deli electrical system. The fire spread to the plenum igniting the sythetic materials. A fireball raced through the 200 yard long casino. The plastics hidden in the wall and ceiling determined the fireball speed and direction in only a few minutes.

What was unusual about this fire was the smoke: its quality, quanitity, density and the number of people it killed.

The most striking fact about about the MGM fire was that the great majority of those killed (61 out of 85) died on the 19th through the 26th floors of the hotel. These victims were as far away from the fire as they could be and still be in the building. The smoke had risen to the top floor, accumulated, and sunk downward, then up out of the building top. Control over the fan system was lost when its PVC tubing melted in the early stages of the fire, so the fans continued to push smoke around the building.

Most of the people who died on the bottom floors died of smoke inhalation before they burned. Forty seven percent of all victims showed a sublethal level of carbon monoxide in the lungs. The avenues of the fire spread to the top floor included the air handling system, the elevator shafts, the seismic joints, the fire stairs, the electrical and plumbing systems, and even the broken windows on the windward side of the building.

Over 500 were injured. Some of them had neurotoxic reactions to their exposures. Many of the injuries, which were also incurred by firefighters were respiratory problems, sleep difficulty, irritability, depression, skin sensitivity and dryness, and problems with microcirculation in the extremities.

Attributed to chlorinated hydrocarbons were: uterine dysfunctions, excessive sweating, muscle spasms and shaking, skin rashes, acne and discolorations. Some of the strongest symptom patterns were psychological. Depression, irritability, nightmares, inability to concentrate, and relational problems with friends and family were common in survivors. Irritants and hydrocarbons both have been found to influence psychological function, especially through the catecholamine system.

In some of the victims, the red blood cells had completely disintegrated. The destruction of red blood cells has been seen in victims of other plastics fires and in lab animals exposed to PVC fumes. Hydrogen chloride destroys oxygen-carrying hemoglobin, the protein that forms the major content of red blood cells.

Some of the elements in the soot found in the lungs of the victims appears to be from PVC products: antimony, zinc, and lead, iron, chlorine, nickel, calcium.

It was concluded that the synthetic polymeric products in the casino were the source of the soot found in the rooms and in the victims broncii, because wood does not contain these elements in large quantities. It was also concluded that at least some of the soot came from the PVC products, specifically.

Sixty-one people died twenty stories above the fire from soot and fumes given off by burning plastics in the ground floor casino.

Source: In the Mouth of the Dragon by Deborah Wallace

PVC FIRES: FIRE SPREAD

When the fire does ignite, the combustible gases emitted during decomposition flare rapidly, and the fire spreads quickly.

Wallace, Deborah. In the Mouth of the Dragon

PVC FIRES: FIRE SPREAD (Examples)

SARATOGA SPRINGS, NEW YORK
Wilmarth Hall, Skidmore College

5 April 1976

A fire in a three story dormitory left one person dead. Sixty people were treated and released from the hospital and 23 others were hospitalized, some in serious condition.

The walls in the dormitory were covered with a vinyl wallcovering that had been painted.

At approximately 4:00am a fire started in the first-floor trash-holding closet. The fire quickly spread to the corridor through the louvre in the door.

First-in firefighters observed that the only fire they found was in the trash-holding closet. At the same time, due to the intense heat, extensive quantities of smoke were being given off by the decomposing vinyl wallcovering and the carpeting.

Once the fire reached the hallway, the only fuel for it was the carpeting and the vinyl wall covering. The destruction of the wallcovering was considerable throughout the south end of the building.

Smoke spread between floors mostly by way of the air-handling system. Several shafts also showed evidence that they had carried smoke to the upper floors. Most of the students on the second and third floors stated that the smoke there was extremely thick, and that the only evacuation route was through the windows.

Two women who were trying to escape were incapacitated by the smoke. Firefighters searching building found them unconscious in the lobby.

The occupant of Room 117 was apparently trying to get dressed when she died of smoke inhalation.

source: Fire Journal

CAMBRIDGE, OHIO

July 31, 1979

Ten people died and another 82 were injured in a fire at a Holiday Inn. The fire was almost a carbon copy of the Holiday Inn fire that killed ten in Greece, New York on November 26, 1978.

In both cases, the primary factors that led to deaths were combustible interior finish, unprotected verticle openings, and inadequate notification of the occupants.

The interior wall covering of the guest room wings included two types of combustible vinyl. A plain vinyl was used on most the corridor walls. Around guestroom doors, a striped vinyl material was utilized. Under these solid vinyl wallcoverings were several thicknesses of material, which included vinyl, fabric and paper. The surface vinyl materials behaved quite differently during the fire incident. The striped vinyl melted, dripped, and burned, while the plain vinyl burned in place.

The nylon shag carpeting also contributed to the fire.

At the time of the fire there were approximately 200 registered guests in the 107 rooms of the hotel. Only four of the guest rooms were unoccupied.

The fire was discovered at 3:25 am by two people playing a pinball machine in the passageway that connected the guest-room wings and the lobby-restaurant area. They smelled smoke and saw it traveling at ceiling level in the guest-room corridor, which was visible from the passageway.

Fire growth and development was rapid. The fire apparently started in the corridor on the first floor. The shag carpeting and combustible wallcovering ignited and spread the fire, producing heavy smoke. The fire and products of combustion traveled horizontally down the corridor and then into the open stairway. The fire quickly spread up the wallcovering of the stairway and down the second floor corridor of the north wing.

Apparently hotel room occupants became trapped in their rooms fairly early in the fire, and thus attempted to escape through heavy plate glass (difficult to break) exterior windows. There were no survivors who used the corridors for evacuation. There was not a great deal of flame in the building, but there was a moderate amount of heat.

Besides injuries related to escape methods, survivors had smoke inhalation injuries.

The county coroner listed cause of death for all ten fatalities to be smoke inhalation and carbon monoxide poisoning. One of the victims died in a hospital four days after the fire. All of the fatalities were on the second floor in the north wing corridor.

Where it was not burned the striped vinyl wall finish had pulled

away from the wall and melted throughout the north wing. The plain vinyl burned and charred in place in the area of fire origin, the stairway at the northend, and partly into the second floor.

The initial fire development created untenable conditions in the corridors before the manual alarm system was activated.

Source: Fire Journal

Kearney, Nebraska

January 16, 1981

Except for the lack of fatalities, the fire was nearly a duplication of conditions of the Holiday Inn fires in Cambridge, Ohio and Greece, New York.

At the Holiday Inn in Kearney, combustible interior finishes and unprotected vertical openings caused hazardous fire conditions. A major reason for the lack of fatalities in the Kearney incident was the early discovery of the fire.

Alterations to the hotel in 1975 added an additional layer of vinyl wallcovering applied to the original section of the hotel.

The fire was discovered at 11:45pm by an entertainer with the band performing in the restaurant lounge. During a break, the entertainer went to his room (No 105). While resting on his bed, he reportedly smelled smoke and discovered flames on the corner of the bed and on an adjacent wall. After failing to beat out the flames with his hands, he telephoned the desk to report the fire, then left the room, leaving the room door open.

At this time, one of the staff members at the front desk walked to the room of fire origin with a pressurized water-type fire extinguisher and found that the fire had progressed rapidly. The fire was beyond the capabilities of the extinguisher, and the staff member did not use it.

The fire was reportedly of electrical origin. Fire growth, development and spread were rapid. The fire and combustion products entered the corridor through the open door and traveled horizontally south along the first floor corridor, and in the opposite direction to the open stairway approximately 40 feet away.

The fire spread rapidly up the stairway to the second floor. The fire was able to spread vertically because of open stairway and the vinyl walls.

Meanwhile, the fire traveled horizontally to the nonfire-rated glass door at the other end of the guest-room wing, consuming vinyl wallcoverings in the corridor, but stopping at the glass door. If the vinyl had not been interrupted by the glass door, there would have been exposure to the restaurant and lounge areas, which were filled with patrons.

Fortunately, no casualties resulted from this fire. Smoke inhalation accounted for most of the injuries. Twenty-two people were transported to the hospital and six were admitted. Four of the injured were released the next day, and one was released two days later. These 22 included 13 guests, 2 employees, 3 police officers, and 4 firefighters.

Based on the extent and severity of the smoke damage in the corridors, the fire created heavy smoke in its early stages.

This fire again seems to indicate that combustible PVC wallcoverings can contribute heavily to fire spread and smoke generation. The double layers of vinyl wallcover in redecorated areas may have increased smoke generation.

Source: Fire Journal

New York, New York

February 13, 1975

The World Trade Center consists of two 110-story towers that rises from a large shopping and business complex.

This fire emphasizes the hazard of nonfire-stopped vertical cableways and the additional problems created by combustible cable insulation - in this case, polyvinyl chloride. Were it not for these two problems, there would have been no vertical spread of this fire.

Shortly before midnight a fire was discovered on the eleventh floor of the North Tower of the 110-story World Trade Center in Manhattan. The fire spread vertically up and down PVC insulated telephone cables. More than 125 men fought the fire, and 28 sustained injuries. The loss was estimated at over $1 million.

At 11:55 pm, a cleaning crew on the eleventh floor reported to the command center that smoke was emerging from an office suite on that floor. The command center notified the NYC Fire Dept. The first fire-fighting crews to reach the floor were met by very heavy heat and smoke. They found the fire involving the southeast corner of the floor. More than 125 fire fighters with more than 20 pieces of equipment responded. It was discovered that fire was spreading vertically both up and down along a set of PVC insulated cables. Although the fire traveled as high as the 16th floor along these cables, fire-fighting efforts essentially contained the fire to the telephone closets on each floor.

Feeding on the contents of the office areas, the fire severely damaged about 20 percent of the eleventh floor area, the floor of origin. There was extensive damage to the telephone equipment. The walls and doors to the core area prevented the fire from entering the core and were still intact after the fire. Since the walls to Suites 1107 and 1109 did not penetrate the ceiling, fire entered these two suites and did considerable damage.

The fire started in a file room. The fire spread not only within the office suite on the 11th floor, but also into the telephone closet, where it ignited plywood, plastic terminal strips, and PVC insulated wire. Once the large PVC insulated cables were ignited, there was nothing to stop the fire from spreading. The fire spread downward to the tenth floor, where it burned out the telephone closet on that floor and did some damage to the area near the closet. The fire burned upward as high as the sixteenth floor, and created minor damage to the area near the closet outside the twelfth floor.

Source: Fire Journal

ATLANTA, GEORGIA

June 30, 1989

A rapidly developing fire occurred on the sixth floor of an unoccupied office high-rise. The accidental fire killed five people, injured 20 others, and caused heavy damage on the floor of fire origin.

The fire occurred at 10:30am when an electrician, working in a 6th floor electrical room, attempted to insert a fuse into an energized circuit with a load on it. Massive arcing occurred and ignited the interior finish materials (including synthetic carpet and PVC wallcovering) in an exit access corridor. Many 6th floor occupants were not able to reach the exit stairways.

Approximately 1/2 of the sixth floor occupants were trapped.

A major factor in loss of life and property was the rapid fire spread across the vinyl wallcovering. The vinyl wallcovering of the entire 170-foot corridor had completed burning in about seven minutes.

The wallcovering was multilayered vinyl. The exterior layer was an air-entrained, imitation suede, vinyl wall covering. The carpet was 100 percent synthetic, and mostly burned where the corridor was narrow enough to increase the intensity of the heat from the walls and ceiling.

Five people died, two at the scene and three in the hospital. Six firefighters were also injured.

After the explosion in the electrical room, the wall and floor finish materials in the corridor were ignited and the fire began to spread in both directions down the corridor. In fact, the fire spread was so rapid that the fire in the corridor had burned itself out, and the only fire that remained when firefighters entered the floor, about 7 minutes after the initial alarm, was at each end of the corridor where standard office furniture was burning.

This is not the first time that multiple layers of vinyl wallcoverings have been identified as a major contributing factor in a

fire. In July 1979, a hotel in Cambridge, Ohio experienced a fire that killed 10 people and in January 1981, another fire in Kearney, Nebraska injured 22 people. In both of these fire incidents, multiple layers of vinyl wallcovering materials were identified as having contributed to the fire severity. We can recognize that this condition did exist in the Atlanta building, that the vinyl materials likely contributed to fuel load and fire spread rate.

The fire at the Peachtree 25th building is of technical significance not only because multiple-death fires in business occupancies are quite rare (this was the first in the U.S. in 17 years), but also because of the apparent unusual speed of fire development and its implications for other high-rise buildings. The fire growth rate greatly exceeded the expected fire growth from accidental fires in business occupancies.

Had the same fire occurred on the 75th floor, rescue of the occupants using aerial equipment would have been impossible.

source: National Fire Protection Association report

FORT WORTH, TEXAS
Fort Worth Ramada Inn

June 14, 1983

In the early morning hours, a pile of new carpeting ignited. Helped by synthetic interior finishings, including vinyl wall covering along the corridor and stairwell, the fire spread quickly throughout the hotel. The vinyl wallcoverings showed a burn pattern that indicated heavy decomposition and charring during the early part of the fire, when flames were confined to the piles of carpet.

Five people were killed in their rooms. By the time flames actually threatened rooms and their occupants, the occupants had either escaped through the windows or died from smoke inhalation. At the time of incapacitation leading to death, the major fuels were carpet, carpet padding and the vinyl wallcovering.

All survivors were out of the hotel within a few minutes after the fire was discovered. Even so, 36 people had to be treated for smoke inhalation, symptoms including abnormal blood gases and blood PH, breathing difficulties, headache, blood pressure instability, and heartbeat irregularity.

The vinyl wallcovering along the stairwell, exposed to growing heat and chemicals of pyrolysis and combustion, began to emit hydrgen chloride and plasticizer, a highly combustible organic compound. A cloud of thermal products began to move laterally along the ground floor and second floor corridors. This cloud contained carbon monoxide, hydrogen cyanide, and nitrogen oxides from the carpet; and hydrogen chloride, plasticizer, and possibly styrene and various hydrocarbons from the padding and wallcovering.

Source: In the Mouth of the Dragon by Deborah Wallace

HARRISON, NEW YORK
Westchester Stouffers Inn

December 4, 1980

The Stouffers Inn fire was a corridor fire of the worst kind: burning floor covering, rapidly decomposing wallcovering, a relatively low and heat reflective ceiling, and a long, narrow corridor that channeled all form of fire product in one direction.

The conference center fire originated where three corridors met, raced down the corridors, spread smoke widely and killed 26 people. The fire ignited at about 10:15 am and was discovered at about 10:20 am.

The three major factors that determined this fire's outcome were the two initial decomposing materials (the carpet and vinyl wallcovering), the design of the building and location of the primary fire, and the fire safety systems and procedures followed once the fire was dicovered.

Because the fire was in the corridor itself, survivors raced smoke and wall covering flames down the North corridor. Delay in reaching the decision to run that way or to jump out of a window meant death.

People seemed to drop when they came into contact with the smoke because the smoke contained corrosive acid gas.

The symptoms of the 24 injured survivors were typical of inhalation of acid gases. The respiratory tract is injured by the acid and the body tries to compensate for the intake of acid by what is called respiratory compensation. The respiratory symptoms show that the whole respiratory tract could be injured in this type of smoke, from the deep lungs to the upper tract where the vocal cords sit.

One survivor showed a typical delayed reaction to PVC smoke inhalation: sensitivity to dust and smoke, loss of lung elasticity (over-inflated lung), wheezing, and airways sensitization, nasal congestion, and sleep disruption.

The rooms held a dense fuel load in the form of synthetic furniture, finishings and decorations. The walls of the corridors and meeting rooms were covered with plasticized PVC wallcovering. The carpeting and this wallcovering formed the two major fuels during the early stages of the fire. It emitted not only hydrogen cyanide, but also nitrogen dioxide, a potent pulmonary acid that turns to nitric acid in tissue.
Fuels that rapidly release combustible gases at low temperatures particularly feed fires with a high-speed front.

The floor finishing consisted of nylon/wool carpeting with jute padding, which ignites at a lower temperature than the PVC

wallcovering, but PVC decomposes at and below the carpet ignition temperature. Thus along the upper wall right below the ceiling where the radiant heat accumulated, the plasticized PVC rapidly unraveled chemically and released its acid gas and combustible plasticizer.

In most of the rooms, the wallcoverings decomposed just under the ceiling. This decomposition accounted for much of the heat damage from the fire in the rooms that had no direct fire damage. The rapid spread and density of the smoke and the rapid spread of the fire depended on corridors that were lined with combustible, toxic finishings. Because of the rapidity of the fire spread, firefighters required 45 minutes to control the blaze.

PVC furniture and decorations included a PVC Christmas tree, PVC-covered and Naugahyde vinyl chairs, and PVC flooring.

The raised roof area above the Grand Ballroom accumulated products of combustion and separated from the building when these products exploded. At this point in the fire, large quantities of fuels had been decomposed and could have generated large quantities of hydrocarbons. Nearly everything present besides the piano was plastic. All of these materials decompose to release large quantities of hydrocarbons.

Ninety five people were present. 26 died and 24 were injured. Of the 24 injured, most suffered from smoke inhalation.

Both the NFPA and the counsel's experts found that the PVC wallcovering would emit large quantities of decomposition products when subjected to unusual heat. Bubbles would appear under the surface of the plastic, eventually burst the surface and release gases. Those gases would flare up an intense flame. This flame obviously contributed to the rapid, under-the-ceiling spread of the fire along the corridors. In addition, counsel's experts found that the gases included high levels of the acid gas hydrogen chloride, and pthalates, which are quite combustible.

The chairs and other combustibles in the rooms that burned may have influenced the length of time the victims lived. The PVC covering on the chairs and the carbon monoxide generated by the polyester fabric and the acrylic certainly contributed to rapid death.

Lab tests also showed that the wallcovering was plasticized PVC and that it emitted large quantities of hydrogen chloride and phthalate. The NBS combustion toxicologists analyzed soot samples and found elements that were consistent with a mixed origin of carpet and wallcovering.

The lines of evidence that identify the carpeting and the wallcovering as the origins of the early killing smoke are:
*eyewitness accounts
*autopsy findings
*injury patterns
*lab tests on materials
*soot anaysis

Source: In the Mouth of the Dragon by Deborah Wallace

PVC FIRES: ELECTRICAL WIRING AND CABLE INSULATION

When PVC is exposed to even low levels of heat decomposition can occur, which releases the combustible gas, hydrogen chloride. If heat reaches high enough levels the concentrated gas ignites and spreads fire rapidly across wiring and cables, which are usually stored together, and which can be spread throughout a building uninterrupted.

PVC FIRES: ELECTRICAL WIRING AND CABLE INSULATION (Examples)

SUFFOLK, NY, USA

December 28, 1991

A fatal subway fire trapped 900 straphangers in a smokey tunnel where two people sustained fatal injuries and 148 more suffered smoke inhalation. Two died, one of a heart attack, and the other, who had a history of asthma, of smoke inhalation. In addition, 188 riders suffered injuries, mostly from smoke inhalation. Passengers were trapped in the train for 36 minutes. Four people who had been trapped on the train described the incident as a nightmare that seemed to have no end, telling of passengers vomiting, having heart attacks, gasping for air and trying to break windows to escape the reddish-brown smoke created by burning PVC.

There was a five-minute gap between the time train operators tried to contact the TA command center and when the command center received word of the blaze. Although no samples were taken at the time of the fire, the city ordered McDogell Owens, specialists in researching fires and explosions, to analyze materials from the fire.

Attorneys for 40 people sued the TA for trapping them in the Clark Street tunnel, seeking a total of $15 million in damages on the basis of their fear of exposure to toxic, cancer-causing polyvinyl chloride burned in the exposed piece of cable. One claimed that TA was negligent "in failing to have a proper evacuation plan and a delay in the rescue attempt."

The cable that is believed to have caused a short circuit and started the fire was encased in PVC. The smoke that poured through the IRT tunnel after the short circuit explosion came

from the burning PVC that insulated the cable, the cable itself and the wooden cover over the subway line's third rail.

A similar fire involving halogenated wire occurred in the Port Authority Subway System in 1982. The City Council President Carol Bellamy's response was to seek the removal of PVC from the subway stations, citing its potential to emit deadly fumes during a fire. At the time, an environmental physiologist, Deborah Wallace, warned that the combination of PVC, the increasing number of track fires and problems with subway doors "renders the public unsuspecting sitting ducks."

According to Metropolitan Transportation Authority figures, there were more than 3000 fires in the system in 1981.

Since then environmental groups, riders advocates, and unions have petitioned the TA to replace the PVC with newer and more chemically stable compounds.

The Transit Authority declined to follow Ms. Bellamy's suggestion, saying it did not consider the presence of PVC to pose a hazard. But the authority also said in 1982 that it did not plan to use the material in future wiring projects.

TA spokesman Bob Previdi said TA has been replacing the PVC with new materials as part of its normal replacement schedule since 1988.

Transit Authority blamed the blaze on the Brooklyn Heights neighborhood where it occurred, saying that debris left by homeless people was the cause. They also claimed the opposition by neighborhood groups to the location of a new electric power substation in the Brooklyn Heights neighborhood kept the Clark Street station from being modernized sooner, which would have prevented the fire.

Wallace said victims probably were exposed to 500 ppm of PVCs in the fumes they breathed. The federal government says more than 5 ppm over a fifteen minute period is dangerous.

No air samples were taken, instead the length of the PVC cable burned was measured to determine exposure.

Sources: New York Times; Newsday

NEW YORK TELEPHONE EXCHANGE BLAZE, NY, USA

February 27, 1975

At 12:18am a fire broke out in cables leading to a major New York Telephone switching station in lower Manhattan. Seven hundred firefighters worked for 16 hours. 300 were sent to the hospital and the neighborhood was enveloped in a thick, acrid smoke plume that sent hundreds to seek medical help.

Months before the fire, a combustion chemist/engineer circulated a report around AT&T alerting executives to the potential fire

problems at the switching exchanges. His predictions were based on the building design and the enormous concentrated amount of plasticized PVC cable sheathing and wire insulation.

The official Fire Department report lists 239 FDNY employees injured during the fire. One man died of a heart attack two weeks later. His autopsy revealed older, heavy deposits of greasy soot that had eaten its way completely through the lung on the pleural side. At the time of the death he still had lung edema, and he had dead patches on the lung.

Others became sick later. Delayed symptoms from inhalation of smoke from PVC or Teflon sometimes resemble flu, and firefighters may not have connected their "flu" with this fire.

A later survey of the injured firefighters showed other symptoms including acid-burned respiratory tracts, eyes and skin; inability to get enough oxygen because of lung damage; loss of control over limbs; impairment of the whole perception process; nausea and feelings of weakness and exhaustion; and confusion and disorientation.

Two of the men surveyed later died of rare cancers - one from a brain tumor and one from liver cancer. A third was the only firefighter who sued, because his lungs were so damaged that at the time of his court date, they were functioning at only 50 percent of what was normal for his size and age.

Sixty four percent of the firefighters reported permanent effects. The most common complaints included impaired disease resistance, coughing, hoarseness, sensitivity to smoke, asthma and repetitive bronchitis.

PVC in the stage of decomposition and combustion can deliver an acute dose of toxicants which result in permanent serious injury and even delayed fatalities.

If a local building code allows large quantities of PVC in a building, the fire department and other city agencies must budget and plan for major disaster, including the hospitalization of hundreds of people at a time.

Source: In the Mouth of the Dragon by Deborah Wallace

SOUTHGATE, KENTUCKY

May 18, 1977

The Beverley Hills Supper Club was a large multi-function entertainment center in the northern Kentucky near Cincinnati. The night of the fire over 2000 patrons were in the Cabaret Room. There was approximately 6000 feet of PVC insulated wiring in the plenum of the Cabaret Room alone. The fire was initially fueled by the PVC wiring.

Events around the fire were explained by the Kentucky State Police and witnesses.

Although the fire was discovered in the Zebra Room about 8:40-8:45 p.m., it had been building in the wall undiscovered for about one-two hours. By this time, the process of thermal decomposition, which is the initial stage of a PVC fire, had already spread through the wiring to the Cabaret Room.

The reservationist of the Supper Club noticed white-to-gray wispy smoke whirling down from the ceiling of the Zebra Room. When she entered the room, it wound around her head, and she stumbled out of the room immediately. Her eyes were so irritated and watery that she could not see, and her nasopharyngeal area burned and filled with fluid. Her fingernail polish reacted with the smoke and her fingernails were eaten through. She developed second-degree burns wherever the wispy grey-white smoke touched her.

Several more patrons noticed wispy, grey-white smoke near the ceiling of the Cabaret Room before the fire was announced. After the announcement, several more noticed the smoke becoming rapidly darker grey and denser. One patron interviewed by council staff became involved with the grey-white phase of the smoke in the Cabaret Room and experienced the same distress of the eyes, nose, pharynx, and skin as the reservationist in the Zebra Room.

Between the time the fire was discovered and the time it was announced in the Carbaret Room, the hall between the Cabaret Room and the Zebra Room was used by employees and patrons for exiting. No flame was openly spreading via the wall surfaces in that hall. The white and grey-white smoke resulted from processes hidden in the ceilings. The one surviving lighting technician who saw the Cabaret plenum from his box described the grey-white smoke in the plenum turning dense and black. No flames were visible until very late in this change, nor was wood or another structural building material burning visibly.

With the announcement, the patrons began to exit rapidly and in an orderly fashion, but a dense black cloud of smoke descended within three minutes on those remaining in the room. Those who came in contact with it fell to the floor. Those near one of the exits were again assaulted by the smoke because the air conditioner blew recirculated air from the Cabaret Room directly into the little exit hall. As soon as the black smoke descended, the patrons still in the Cabaret Room began to scream, which brought the patrons and employees who had already exited around to the outside of the Cabaret Room where they began dragging people out of the exitways and out of a hole punched in one of the walls.

After the Fire Department had been on the scene several minutes, the fire fighters were directed to the rear of the Club outside the Cabaret Room and joined rescue operations. By this time, the smoke had dissipated and rescuers could actually enter the room to drag bodies out. The great majority were dead already, although very little material in the room was visably burning, and rescuers could actually drag bodies out for a long time after the killing smoke had descended. Often the same pile of bodies contained both dead victims and an unconscious survivor. After

this interval, flames did reach the Cabaret Room which later experienced vast explosions of combustible gases. A total of 161 people died that night without any direct involvement with the flame and long before carbon monoxide had reached a concentration which affected the rescuers most of whom wore no respiratory masks.

Some of the nonrespiratory symptoms are noteworthy. Three of the four autopsies revealed kidney damage, one of which was identified as nephrocalcinosis, a common result of acidosis.

Four survivors died within two weeks and nine months primarily from severe respiratory impairments: bronchopneumonia, tracheobronchitis, and, in one case, bronchitis obliterans, pulmonary emphysema, pulmonary vasulitis, and pulmonary edema. The four delayed deaths brought the total to 165.

Those survivors that suffered immediate health effects continue to be affected on a long-term basis.

Symptoms included: severe damage to the upper and lower respiratory tracts and secondary subsequent infections; long term diminution of respiratory disease resistance; recurrent bronchitis; attacks of coughing because of excessive phlegm production, wheezing and asthmatic attacks; hoarseness; sinus condition; shortness of breath; chest congestion with or without pain; sensitivity to smoke and dust; headaches; sleep problems; and inability to work; poor microcirculation in one or more extremities; irregular heartbeat; skin problems; visual perception impairment. Psychological effects included frequent nightmares; memory lapses; and heavy guilt characteristics of survivor syndrome.

Symptoms are debilitating for six of the survivors. The manifest symptoms indicate that edema had occurred and that diffuse fibrosis and large areas of necrotic and scarred tissue all along the respiratory tract are present.

The women survivors of reproductive age (under 40) showed severe uterine dysfunctions, some resulting in hysterectamies or other hospitalization. Two (100%) of pregnancies miscarried. There were two apparent impotencies. All reported no pre-fire problems of this nature.

The fire did not differentiate between the young, middle-aged, and elderly. Every age group from the 20's through the 60's was represented among the fatalities and permanently injured victims. In contrast to most survivors of carbon monoxide inhalation episodes, many survivors of PVC fires suffer permanent painful, life-threatening, life-changing, and sometimes socially embarrassing injuries. Some will never be able to work, to participate in athletics or simple activities such as hiking, or even sleep through an entire night.

PVC cable was burned in the courtroom for survivors to smell. All agreed that that was the exact odor of the smoke which descended on the Cabaret Room.

source: Journal of Combustion Toxicology

HINSDALE, ILLINOIS

May 8, 1988

The Hinsdale Central Office is one of the largest telephone central offices in the Illinois Bell system. The two-story facility handles an estimated 3.5 million calls each day.

Tests showed that all of the sample insulation and jacket materials used at HCO were based on rubber, polyethylene, and polyvinyl chloride.

On the afternoon of May 8th a fire occurred at HCO. The fire had been burning for 1/2 hour by the time the firefighters arrived. Smoke had spread through much of the first floor even before fire fighters arrived on the scene. When they opened the door to the central corridor, the firefighters found thick black smoke within 6 inches of the floor.

The thick smoke made forward progress into the building a difficult task for the fire fighters. An overhead fire about six feet in diameter had bluish-green flames (indicates burning chlorine from the PVC) with lazy movement.

As heavy black smoke continued to be generated by this fire, the chief officers became more and more concerned about toxic materials that might be contained in the smoke and requested that hazardous materials experts and the EPA be brought to the scene.

With the smoke continuing to vent from the building and an increasing wind, the Hinsdale fire chief decided to evacuate the immediate area downwind of the fire. The evacuation of a five-by-five block area began at 6:00 pm.

Early in the fire it was not known what materials were present in the smoke. As a result, 34 fire fighters were decontaminated and held for observation.

Eleven fire fighters were transported to the hospital.

It is believed that the fire was created by the heat generated by electrical faults which decomposed the PVC cable insulation. Combustible off-gases were produced, and sparks ignited those gases. Fueled by the insulation, the fire quickly spread into the cable trays.

Although the flame damage was limited to a specific area, smoke spread throughout the building. A heavy smoke residue covered all interior surfaces and equipment on the first floor. Although the particulate matter carried by the smoke damaged some equipment, the most severe damage away from the area of fire origin was the result of the corrosive gases carried in the smoke.

Hydrochloric acid was formed when chlorine, released during the pyrolysis and burning of the PVC insulation materials, combined with the natural moisture in the air as well as the water spray.

All equipment was removed from the building and brought to a warehouse for evaluation, and none was reused at Hinsdale. All of the wiring and cables on the first and second floors were also replaced. Initial estimates indicated that the damage to the building and the equipment replacement cost will be between 40 and 60 million dollars.

Heavy smoke and difficulty in shutting down the electrical power source kept fire fighters battling for 6.5 hours before the fire was declared out.

source: National Fire Protection Association report

WEST DES MOINES, IOWA

Merle May Mall
November 5, 1978

A fire in the Younkers Brothers department store produced a thick, black curtain of smoke that killed quickly. The toxic smoke was traced to the PVC wire insulation in the electrical system of the building.

Twenty two people were present that Sunday morning; ten died, and at least four were injured. Two of the survivors died shortly afterwards, one of cancers and lung disease.

The first sign of fire was a low energy explosion that occurred in the ceiling of the second floor, knocking down ceiling tiles. Immediately, a black curtain of smoke descended from the second floor ceiling in the southwest corner of the store, incapacitating all who came in contact with it almost instantaneously. Those who couldn't flee the smoke died. The medical examiner and the forensic pathologist both concurred that the deaths occurred before the flames touched the bodies.

The plaintiffs' council found that the soot found in the lungs of the victims was from PVC.

Later, it was discovered that the fire had actually started late the night before. An unspecified electrical malfunction occurred in the southeast quadrant of the second floor plenum. The wiring involved in the malfunction overheated and decomposed. The other wiring in the area also overheated and decomposed directly from the heat radiated from the malfunction and indirectly from the hot gases generated. The overheating spread and continued for at least many hours and produced both corrosive and combustible gases.

This occurred before workers arrived Sunday morning. One of the first to arrive went to the boiler/utility area of the store and turned on the air circulation fans. This caused the oxygen level in the effected quadrant to rise until the oxygen/fuel ratio

reached the explosive level. Then the flaming stage of the fire began. The explosion knocked ceiling tiles and freed the soot and decomposition gases that had accumulated during those hours of overheating. The pressure wave and the expanding gases moved the smoke and fumes through the store.

As the smoke and fumes moved through the store, they became diluted, and the acid reacted with the surrounding surfaces so that the smoke became less harmful. Those people present at the point where the smoke was first released were exposed to lethal concentrations of decomposition/combustion products almost immediately. Those farther away either became incapacitated and died later or were injuried. Those farthest from the first release of the smoke were either injured or got away without permanent injury, depending on susceptibility and length of time exposed to the smoke.

The heat from the fire traveled through the air ducts in the store and set secondary fires. At first the smoke was white and hazy, then it became black and thick. The smoke was so dense that arriving firefighters had to turn on the headlights of their rigs while they were still approaching the parking lot from the highway. In trying to get into the store, their handheld flashlamps proved useless against the pervasive darkness of the smoke.

Of the survivors, two young people, a man and a woman, suffered frequent respiratory infections of prolonged duration. The woman also felt tired all the time, had upper respiratory membrane swelling and reddening that included sinus troubles, and was troubled by lower back pain. The young man was suddenly afflicted with high blood pressure and two types of heart problems, tachycardia and a systolic ejection murmur.

An older man came down with chronic coughing, phlegm production and winter bronchitis. This man was taken to the hospital hours after the fire because of adult respiratory distress.

The long decomposition period also explains the fire that was seen by the firefighters and attributed to natural gas. Natural gas does not burn with a green flame, such as the firefighters saw. Chlorine, however, imparts a green color to the flame. A mix of chlorinated and non-chlorinated hydrocarbons, which arise from pyrolizing PVC, would behave like a natural gas fire and impart a green flame.

A jury ruled that PVC caused the fire and the damage. All the plantiffs then each settled out of court. Noone went to trial to assess damages.

Source: Wallace, Deborah. In the Mouth of the Dragon

SMOKE INHALATION DEATHS INCREASING IN PROPORTION TO BURN DEATHS IN STRUCTURAL FIRES:

Approximately 467,000 residential structural fires occurred in the United States in 1990. These fires are estimated to have caused 4,115 deaths, 20,560 injuries, and $4,253 billion in property loss. When compared to similar data available since 1980, fire incidence decreased 38 percent and fire deaths declined 25 percent, but fire injuries were reduced only 2 percent.

Data shows that between 1979 and 1985 the 17 percent decrease noted in total fire deaths was accompanied by a 34 % drop in fire burn deaths and a 6 % decrease in smoke inhalation deaths. Their analysis indicates that smoke inhalation deaths accounted for about two-thirds of fire deaths compared to almost one third for burns. As a possible explanation for the relative increase of smoke inhalation deaths over burn deaths, the authors suggest that the furniture and building materials used today may produce smoke which is generated faster and is more toxic than that produced by materials used in the past.

Source: Toxicological Aspects of Firesmoke: Polymer Pyrolysis and Combustion. Rita A. Orzel, PhD. Occupational Medicine:State of the Art Reviews-Vol 8, No. 3, July-September 1993. Philadelphia, Hanley & Belfus, Inc. p. 415

According to the Consumer Product Safety Commission, an increasing proportion of all deaths from structural fires in the United States over recent years has been attributable to smoke inhalation. Between 1970 and 1985, for example, total deaths from structural conflagrations decreased from approximately 5,000 to 4,000 per year, while the number of deaths attributed primarily to smoke inhalation stayed relatively constant at about 3,000 annually. Studies elsewhere have estimated that about 30 % of all major burn victims suffer smoke inhalation injury, with corresponding estimates for fire fatality cases ranging up to 80 %. That smoke inhalation has come to be listed as the primary cause of death for nearly 75 % of structural fire deaths in the United States may reflect changes in coding practices, greater progress in treating cutaneous burns than inhalation injury, increased toxicity of fire smoke, or some combination of these factors. Changes in firesmoke toxicity, in turn, could result from changes in building materials, or consumer products.

Source: Clinical Smoke Inhalation Injury: Systemic Effects. Dennis J. Shusterman, MD, MPH. Occupational Medicine: State of the Art Reviews- Vol 8, No 3, July-September 1993. Philadelphia, Hanley & Beltus, Inc.

PVC FIRES: FIRE RETARDANTS

Materials can be modified using fire retardants; while these compunds can improve resistence to a fire they tend to make smoke production considerably worse.

Source: Firesafe Composites Design for Living. Bacon, M. Material Edge. No. 14, Nov/Dec 1989, p. 25/36. 1989

Most plastics have a number of chemicals added to them, such as fire retardants, stabilizers, lubricants, plasticizers, and colorants. These additives can only modify the problem somewhat. Fire retardants cannot alter the decomposition temperature-they can only delay the outbreak of flames. Generally, the gases emitted during the decomposition stage of a fire are more toxic than those emitted during actual burning. Thus, in many fires, the decomposition stage is the real killer. It is a killer because of its insidious and invisible nature, its high toxicity, and the long period of time between attainment of quantitative decomposition temperature and ignition temperature. In this respect, fire-retarded plastics are worse than non-fire-retarded plastics.

Source: Wallace, Deborah. In the Mouth of the Dragon. p 8

END.