FIRE
RETARDANT
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BUILDING CONTENTS -

THE REAL FIRE PROBLEM

Fall Conference at
The Bellevue Stratford Hotel
Philadelphia, Pennsylvania
October 12-14, 1981

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-- 1 - AD NUMBER: D435776
-- 5 - CORPORATE AUTHOR: FIRE RETARDANT CHEMICALS ASSOCIATION WESTPORT CT*
-- 6 - UNCLASSIFIED TITLE: BUILDING CONTENTS - THE REAL FIRE PROBLEM.
--11 - REPORT DATE: OCT 12, 1981
--12 - PAGINATION: 255P
--20 - REPORT CLASSIFICATION: UNCLASSIFIED
--21 - SUPPLEMENTARY NOTE: PROCEEDINGS: 'BUILDING CONTENTS - THE REAL
--   FIRE PROBLEMS', 12-14 OCT 81, PHILADELPHIA, PA. SPONSORED BY FIRE
--   RETARDANT CHEMICALS ASSOCIATION. (SEE PL-435121 - PL-43126).
--2? - LIMITATIONS (ALPHA):   APPROVED FOR PUBLIC RELEASE; DISTRIBUTION
        UNLIMITED. AVAILABILITY: TECHNOMIC PUBLISHING CO., 265 POST RD.
          'ST WESTPORT, CT. 06880.
            'TION CODE: . 1F

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Fire Retardant Chemicals Association
FIRE SAFETY THROUGH CHEMICAL TECHNOLOGY

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DEPARTMENT OF DEFENSE
PLASTICS TECHNICAL EVALUATION CENTER
PICATINNY ARSENAL, N.J.

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<u>"CURRENT FIRE STUDIES"</u>

James R. Bell

National Fire Protection Association

CURRENT FIRE STUDIES

James R. Bell
National Fire Protection Association

The many, complex variables that affect fire safety in high-
rise buildings were studied and documented during the early-
to mid-1970's. Basic fire-fighting tactical problems on
how to fight fires above the reach of ground-based equipment
were considered, as well as smoke spread in buildings, ex-
terior verticle fire extension, elevator use by fire fighters
and occupants, and total building evacuation. It was reported
that building design, building height, fuel load and config-
uration, interior finish, occupancy, mechanical and electrical
systems, and human behavior factors are all interrelated parts
of the complex high-rise problem.

These studies and their findings were again highlighted by
a fire on the 20th floor of the Westvaco Building in New York
City on June 23, 1980. The fire posed a major challenge to
fire fighters when smoke spread throughout several floors above
and below the fire floor, elevators malfunctioned, and other
problems typical of high-rise fires occurred. The fire was of
particular interest because New York City's high-rise safety
requirements, Local Law No. 5, had been partially implemented.

The fire that began on the 20th floor of the 42-story, midtown-
Manhattan, high-rise Westvaco office building on Monday evening,
June 23, 1980, injured 127 fire fighters and 10 civilians. Be-
cause the 20th floor had been compartmented, as required by
New York City's high-rise safety law, the fire was confined to
less than one-third of the 20th floor, with minor exterior
vertical extension to the floor above. Smoke spread through 22

stories of the building above the 20th floor, and heavy smoke
also spread through three floors below the fire floor, causing
problems for fire fighters attacking the fire. Several banks
of elevators malfunctioned, created logistical problems for
fire fighters, and contributing to the many injuries.

Most of the building's 200-to-300 occupants escaped by using
the stairways. However, smoke prevented at least 15 occupants
from leaving the building; they were forced to remain inside
for two hours during the fire. There were no fatalities. Nine-
teen of the 137 injured fire fighters and occupants were hos-
pitalized; none of the injuries were serious.

Approximately 22,000 square feet of office area surrounded the
central core on each floor. The building's original open-
concept design was still in use in 70 percent of the floors.
However, about 30 percent of the floors has been compartmen-
ted into areas of a maximum of 7,500 square feet to comply
with New York City's high-rise safety law known as Local Law
No. 5. Separation walls constructed of one-hour-rated gypsum-
board on steel studs extended from slab to slab, with 3/4-hour
metal doors protecting the openings.

The open area surrounding the core on the 20th floor had been
retrofitted with one-hour-rated separation walls to provide
four compartments of unequal size. The northeast corner com-
partment, where the fire originated, measured approximately
6,000 square feet. The separation walls were constructed of
gypsumboard on metal studs, extending from slab to slab. The
openings were protected by 3/4-inch metal doors.

The interior finish, office configurations, partitioning, furnishings, and contents varied in the individual offices on each floor. The 20th floor, the floor of fire origin, contained the Bank of America's commercial loan offices. The area of fire origin, in the northeast corner of the floor, consisted of offices with metal partition units that extended from floor to suspended ceiling.

The offices were located along the exterior walls of the building and had solid wood doors. Between the exterior offices and the central core was an open office area. Both the exterior offices and open office areas were furnished with desks, credenzas, and filing cabinets. Desks were constructed of pressed board with laminated-surface coverings.

The fire originated in an individual office on the north exterior wall of the 20th floor and extended from that office to the entire open office area, which was located between the building periphery and the core. The fire area included all of the individual offices and the open office within the limits of the compartment. This area was completely gutted by the fire.

Minor exterior, vertical extension of the fire occurred on both the north and east walls of the building. However, fire damage on the 21st floor was limited to one or two small offices along the exterior wall, where vinyl wall covering and contents received minor damage. A small area of carpeting on the 21st floor was also burned where the floor slab had been lifted by the expansion and failure of structural steel below.

Smoke damage occurred on several floors immediately above
the fire, and in the non-fire-damaged areas surrounding
the core of the fire floor. Floors below the fire floor
received water and smoke damage, but it had been limited
by salvage actions taken by the fire patrol operated by
the New York Board of Fire Underwriters.

Although structural beams and girders were protected by
a 3/4-inch layer of sprayed-on mineral fiber, beams and
girders in the fire area along the north wall of the build-
ing had been deformed by heat-caused expansion and twist-
ing. The expansion of beams caused the 4-inch floor slab
on the 21st floor to crack and heave along the length of
the beam. A preliminary estimate of damage to the build-
ing and contents was $15 million, although a final loss
figure was not available when this report was written.

The furnishings, interior finish, and contents of the com-
partmented office area of the 20th floor were sufficient
to develop sustained heat in the area of fire origin. The
fire burned for approximately one hour following discovery,
before it was extinguished by fire department hand lines.
The heat conditions were sufficient to cause spalling of
the mineral-fiber coating on the structural steel and floor
assembly components. Beams and girders in the area of the
fire origin were damaged by expansion and warping. The floor
deck over these beams heaved several inches.

The Westvaco Building fire reinforces the observations and
predictions of earlier studies that the fuel loads in high-
rise office buildings are increasing, containing sufficient
heat-release potential to create and maintain a severe fire.

The smoke developed by the 20th floor fire and its spread throughout more than 50 percent of the floors of the West-vaco Building is considered the most significant life-threatening factor in this fire.

Heavy smoke conditions extended to the other compartmented areas on the fire floor, and to floors both above and below the fire. Severe smoke conditions existed three floors above the 20th floor, and heavy smoke conditions were reported as high as the 26th floor, and as low as the 17th floor. Some smoke also penetrated from the 26th floor up to the 42nd floor.

The avenues of smoke spread were believed to be the elevator shafts and stair enclosures. Fire fighters attacking the fire and operating hose lines from stairways left the doors open, which allowed smoke to enter the stair enclosures. No means of venting was provided. The HVAC system was designed to shut down the fans when smoke detectors in the return side ducts were activated. There was no automatic exterior exhaust capability in the HVAC, and there were no operable wall panels or windows available. Venting was accomplished by breaking window lights (panels) on seven floors (17th to 23rd) in which heavy smoke conditions were present. Over 300 windows on these seven floors were broken to aid in ventilation.

The heavy smoke conditions on three floors below the fire floor forced fire fighters to utilize extra air from self-contained breathing apparatus. The extensive smoke conditions contributed to the large number of injuries sustained by fire department personnel and civilians.

The lessons to be learned from this spectacular fire are not
new. Problems relating to high-rise fire fighting and fire-
safety have been throughly documented.

New York enacted Local Law No. 5 in 1973 to improve fire-
safety in its high-rise buildings. The compartmentation phase
of the Law had been completed in about 30 percent of the West-
vaco Building, including the floor where the fire originated.
Other requirements to pressurize interior stairs or to provide
a smoke shaft that would have helped to limit smoke spread
within the building had not been completed.

The serious problems of exterior vertical fire extension and
elevator malfunctions compounded the difficult fire-fighting
logistics that fire fighters faced.

The adequacy of Local Law No. 5 cannot be judged by this fire
alone, especially since compliance with sections of the Law
might have prevented severe smoke spread throughout several
floors had not been completed. However, based on this fire,
and considering the unusual problems faced by fire fighters,
it appears that the Local Law's compartmentation requirement
(that all unsprinklered floor areas be segregated into spaces
or compartments not to exceed 7500 square feet) was well-
justified and is a valid fire protection requirement.

The need for sprinkler protection in high-rise buildings can
also be argued in light of the Westvaco Building fire. It
must be recognized that the compartmentation option, in lieu
of sprinkler protection, necessitates manual extinguishment
of a fire. Compartmentation will limit the size of a fire
by limiting the area of fire involvement, but compartmentation
in itself will not extinguish a fire.

On the morning of November 21, 1980, 84 people died and 679 were injured as a result of a fire at the MGM Grand Hotel in Las Vegas, Nevada. This was the second largest life-loss hotel fire in United States history.

The building consisted of a very large ground floor area that contained the Casino, restaurants, showrooms, a convention center, and the upper level of a jai alai fronton. The below grade level (Arcade level), which had approximate outside dimensions the same as the Casion level, contained the lower level of the jai alai fronton, a movie theatre, a large number of shops and boutiques, service areas, and underground parking. The Casino and Arcade levels communicated directly via an open staircase.

The building was of mixed construction. The construction types included fire-resistive, protected non-combustible, and unprotected non-combustible. The interior finish varied significantly and included both combustible and non-combustible materials.

The building complex was partially sprinklered. Protected areas included the Arcade level, major portions of the Casino level, and part of the 26th floor. Convention areas, showrooms, and some restaurants were protected on the Casino level. The large gambling Casino and the high-rise tower were not sprinklered.

The Clark County Fire Department has determined that the most probable source of ignition of this fire was electrical in nature. This occurred within a combustible concealed space adjacent to a pie case along the south wall of the Deli.

The first materials ignited included plywood used to en-
close the pie case. The fire most likely smoldered for
a period of time before breaking out of the concealed
space and into The Deli bus station at approximately 7:10
a.m.

Initially smoke would have moved directly from the bus sta-
tion to the return air plenum above the ceiling through an
air transfer grill. Once open flaming took place in the
bus station, the fire apparently began spreading on light-
weight fuels such as plastic and paper products and com-
bustible interior finish. The fire then spread to the
remainder of The Deli, consuming other available combus-
tibles such as wooden decorative members and foam plastic
padding of chairs and booths.

Flashover of the bus station and then The Deli along with
the lack of fire resistant barriers allowed the transfer
of thermal energy into the Casino. Large amounts of air
flowing through the adjacent Orleans Coffee House and the
Arcade provided a fresh air supply for the fire. Present
in the Casino were highly combustible furnishings and con-
tents and combustible interior finish. Large amounts of
plastic materials such as foam padding and mouldings were
included in the fuels. The presence of fuel, air supply,
and a very large undivided area allowed for extremely rapid
fire spread and heavy smoke production. The entire Casino
and porte cocher on the west end of the building were fully
involved with fire by 7:25 a.m. There were limited or non-
existent barriers to fire spread which allowed the spread
of heat, smoke, and other products of combustion to the

building's upper floors. These shafts included elevators, stairs, and shafts located at seismic joints in the high-rise tower.

Tower occupants slowly became aware of the fire by smelling or seeing smoke, hearing people yelling, or eventually due to helicopters flying around the building. Some occupants were able to exit the building without assistance. Many were rescued by fire fighters, construction workers, and passersby. Many other occupants made their way to the roof where they were removed by helicopter. A large number of guests were trapped in their rooms where they awaited rescue. Total evacuation of the building took nearly four hours.

Preliminary information as to the location of victims in the hotel accounts for approximately 78 of the total 84 fatalities. Some casualties were removed from the upper levels of the building before their locations were documented. Fourteen victims were on the Casino level and approximately 64 victims were on the upper floors of the hotel. Of the 64 victims above the Casino level, 29 were located in guest rooms, 21 in corridors and elevator lobbies, five were in elevators, and nine were in stair enclosures. Most victims were on the 20th through the 25th floors.

Three of the interior stairs were not enclosed with two-hour fire rated construction. There were direct openings from the return air plenum above the Casino to these stairs. In addition, there were non-rated access panels that allowed fire and products of combustion to spread into these stairs. The spread of smoke into the stairs directly contributed to several fatalities. At least one of the smokeproof towers

was not enclosed on the bottom with adequate fire resistant
materials which allowed direct transmission of smoke from
the Casino area into the smokeproof tower. As far as can
be determined, the air handling equipment was not equipped
with smoke detectors arranged to shut down the systems upon
sensing products of combustion. In addition some fire dampers
were disabled so that they could not close when the fusible
links melted and others did not close completly. As a re-
sult, products of combustion were distributed through the
tower by the HVAC equipment.

The fan coil units in the guest rooms most likely contributed
to the movement of products of combustion from the corridors
to the guest rooms. These fan units were not directly con-
nected to any vertical air shaft and provided a method for
spread of smoke that may also have contributed to several fa-
talities.

On December 4, 1980, a fire of incendiary origin occurred
at approximately 10:20 a.m. in the conference center at the
Stouffer's Inn of Westchester, located in the town of Harri-
son, New York, The critical location of the fire in the
exit access, the rapid fire development, and the lack of a
second means of egress from the small meeting rooms were
significant factors that contributed to the 26 fatalities
and some 40 injured occupants. This fire did not reach the
guest-room area of the hotel.

The Stouffer's Inn of Westchester consisted of a luxury
365-room hotel, recreation facilities, and conference fa-
cilities that were separated from the main guest-room build-
ing by a small raving, but connected to it by a 137-foot

enclosed ramp. The Hotel complex had been in operation since 1977.

The conference building, where the fire occurred, was a three-story structure of 2-hour fire-resistive construction. Its exterior facade consisted of either glass lights (panels) in aluminum mullions or masonry walls with a brick veneer. Structural steel had 2-hour fire-rated protection with sprayed-on mineral-fiber insulation on beams and girders, concrete encasement of spandrel girders, and colums enclosed in gypsum-board assemblies. Floor and ceiling assemblies consisted of concrete slab on steel deck. The roof and ceiling assembly of the third floor consisted of concrete slab on steel deck or 2-inch foam insulation on steel deck; both were covered by a composition roof.

The building contained the registration desk, restaurants, a coffee shop, pool, and offices. On the third floor, where the fire occurred, were meeting rooms, a ball-room that had been converted into additional meeting rooms by means of movable partitions at the time of the fire, and the banquet kitchen, with ancilliary service areas. The "Commons," a 25-foot-by-95 foot area that functioned as a lobby for the adjoining ball-room and as an accessway for other meeting areas, was located on the north side of the building. Two doorways at either end of the Commons opened onto an outside promenade deck.

Interior finish on the third floor consisted of vinyl wall coverings on gypsum wallboard. The suspended ceiling was of mineral-fiber tile. The floor covering consisted of carpeting with jute backing and a fiber underpad. The wall finish in the ballroom consisted of vinyl wall covering, painted wood molding, and

plastic laminated panels on gypsum wallboard on fire-retardant treated plywood over steel stud.

As determined by local investigators, the fire was of incendiary origin and involved flammable liquid on the carpet in the vicinity of the intersection of the Commons and the east corridor. It developed rapidly and extended into the Commons and the adjoining corridors, exposing those areas to heavy smoke and heat.

The fire quickly extended to the Commons, the adjoining corridors, three meeting rooms, and two of the three partioned meeting areas in the ballroom, causing severe damage to these areas. It also extended into the receiving and holding area through double doors that had been opened after the onset of the fire. Structural steel and masonry walls were damaged in the northeast corner of the ballroom.

Nearly 100 people were attending meetings on the third floor at the time of the fire. All of the fatalities were occupants of the third-floor conference rooms who became trapped when the corridor outside their rooms became untenable. Unable to use the corridor as a means of egress, the 11 occupants of the Harrison Room broke a fixed (non-opening) window and jumped to the ground, approximately 15 feet below. All the occupants of this room survived, but sustained numerous injuries as a result of their falls.

Eleven of the 13 occupants in the Haight Room (which had a single exit door opening to the corridor, but no window) died in the room. The bodies of the other two occupants of the Haight Room were found in the adjacent corridor. An additional

11 victims who had been in the Disbrow and Wilson Rooms were found in the Commons and in the corridor outside the Disbrow Room. Two victims also died in the Disbrow Room.

On Tuesday, February 10, 1981, a fire occurred at the 30-story Las Vegas Hilton Hotel in Clark County, Nevada. This fire resulted in eight fatalities and injuries to nearly 300 civilians and 48 fire fighters.

Of fire-resistive (reinforced concrete) construction, the hotel was built in three stages. The Central Tower was completed in 1969, the East Tower in 1975, and the North Tower in 1979. Due to varying code requirements at the time of construction, the Central Tower had no smoke detectors, the East Tower had corridor smoke detectors near an elevator lobby, and the North Tower had corridor smoke detectors.

The fire originated on the eighth floor in the East Tower elevator lobby. Local officials determined that the ignition was incendiary in nature. The fire developed rapidly due to combustible interior finish in the form of carpeting on the walls and ceiling, along with other fuels such as combustible drapes and furnishings. The elevator lobbies in the East Tower were the only areas that contained the carpeting applied to walls and ceilings.

After its ignition and initial development on the eighth floor, the fire spread vertically up the exterior of the building. There was no interior vertical fire spread, although there was some horizontal fire spread down corridors on each floor as the flame front progressed upward.

The mechanism of exterior fire spread was by radiant heat from the flame front that was transmitted through the glass of the East Tower elevator lobbies, igniting the drapes, combustible furnishings, and carpeting on the walls and ceiling. Then the flame front continued to develop up the side of the building. The spread from the eighth to thirtieth floor took approximately 25 minutes.

Three of the fatalities were found in the eighth-floor Central Tower elevator lobby, four were in guest rooms on the tenth, twenty-first, and twenty-fourth floors, and one victim jumped from the twelfth floor.

The major reason for exposure to upper floors was the exterior fire spread due to the nature and configuration of combustible interior finishes, drapes, and furnishings.

Local Law No. 5

Two high-rise fires in New York City in the early 1970s heightened concern for the safety of occupants of high-rise office structures. Fires in One New York Plaza in August 1970,[1] and at 919 Third Avenue in December 1970,[2] provided the impetus for the promulgation and passage of New York City's high-rise firesafety law, known as Local Law No. 5, in 1973. The two fires were responsible for five fatalities, 100 injuries, and $12.5 million in property damage. The Law, championed by the New York City Fire Department under Fire Commissioner John T. O'Hagan, was designed to overcome what were felt to be deficiencies in the life-safety features in many of the existing high-rise office buildings over 100 feet high that dot New York City's skyline, and to improve those features in future buildings.

Local Law No. 5, entitled *Fire Safety Requirements and Controls,* was approved on January 18, 1973. Following a lengthy court battle, the Law was upheld by the court. A system of alternatives, waivers, and revised compliance schedules was developed.

The provision for additional firesafety features in certain high-rise office buildings was amended to the Administrative Code of the City of New York in 1973. Existing buildings, those under construction, and even those for which ground had not been broken came under the local law. Features

that entailed only internal administrative changes by building management, such as fire drills, required immediate compliance with the law. Other features such as compartmentation, which could seriously affect the tenant's operations or lease arrangements, or which required more than incidental expense, were permitted compliance times as much as 15 years from the effective date of the law. Compliance with all requirements of Local Law No. 5 by every office building over 100 feet high in New York City will not be fulfilled until 1988.

Building owners must decide which available option will be used to meet the provisions of the Law: automatic sprinkler protection or compartmentation and pressurization of stairways. Following the Westvaco Building fire, it was reported that the owners of more than 300 (30 percent) of New York City's high-rise buildings who were to file plans outlining the compliance methods they planned to adopt, failed to file those plans for communication systems and detectors by the legal deadline of June 13, 1980. The management of the Westvaco Building had filed the required plan and was in compliance with scheduled building modifications.

The firesafety plan, firesafety director, and fire drill requirements had been completed in the Westvaco Building. Prefire training and firesafety knowledge of both building features and emergency behavior were cited as valuable to the building occupants. Although the fire alarm was not sounded, floor fire wardens performed their assigned roles, evacuating most of the 200 persons still in the building to safety by means of the exit stairs.

Continued

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[1] W. Robert Powers, "New York Office Building Fire," FIRE JOURNAL, Vol. 65, No. 1 (January 1971), p. 18.

[2] W. Robert Powers, "Office Building Fire, 919 Third Avenue, New York City," FIRE JOURNAL, Vol. 65, No. 2 (March 1971), p. 5.

Local Law No. 5 *continued*

Table 1.

Fire Protection Feature	With Sprinkler System Option	With Compartmentation Option
1. Fire Safety Plan	Required	Required
Fire Safety Director	Required	Required
Deputy Fire Safety Director	Required	Required
Building Evacuation Supervisor	Required	Required
Fire Brigade	Required	Required
Fire Drills	Required	Required
2. Signs in Elevator Landings	Required	Required
3. Floor Numbering Signs	Required	Required
4. Stair & Elevator Identification Signs	Required	Required
5. Stair Re-entry Signs	Required	Required
6. Compartmentation of unsprinklered floor areas	Not Applicable	Maximum 7500 sq ft segregated by 1 hr partitions; 2 hr separation into areas of refuge over 10,000 sq ft
7. Heat and smoke venting	Not Required	At least one smoke shaft by which smoke & heat shall be mechanically vented OR
8. Pressurization of stairways	Not Required	. . . All interior enclosed stairs . . . provided with a system of pressurization.
9. Door unlocking (open every 4th floor of fail-safe unlocking).	Required	Required
10. Standpipe Riser used for retrofitted sprinkler system supply.	Option Provided	Not Applicable
11. Fire Alarm Signalling System:	Required	Required
–Annunciation at: Fire Command Center Mechanical Control Center Fire Safety Director Location	Required	Required
–Interior Fire Alarm	Required	Required
–Voice Communications System	Required	Required
–Fire Command Station	Required	Required
–Information Display Panel	Required	Required
–Audible Alarm Signals	Required	Required
–Automatic Transmit to Fire Dept.	Required	Required
12. HVAC-Smoke Detection in HVAC ducts shut down air supply.	Not Required if water flow does same.	Required
13. Smoke Detectors at Elevator Landings (all cars automatically returned to designated floors).	Not Required if water flow does same.	Required

"BOARDING HOME COMBUSTIBILITY PROBLEMS"

David Holton

U.S. Senate Special Committee on Aging

BOARDING HOME COMBUSTIBILITY PROBLEMS

David Holton
U.S. Senate Special Committee on Aging

High rise building fires and boarding house fires at this
point in time constitute the two most severe multiple fatal-
ity fire problems we have in this country. More deaths have
occurred in these two types of occupancy, that is the hotel
fires and these boarding home fires, than any other types
of occupancy.

What I am going to do is to discuss how boarding home fires
have developed in this country, how it is we have boarding
homes, and then take you through several specific fire sce-
narios that will illustrate the specific fire problems we
have with this type of occupancy.

I think it may be appropriate at this point in time to say
that boarding homes represent, we think, a new class of oc-
cupancy. What is it that we mean by boarding homes? At one
end of the spectrum, the occupants they have are not totally
independent individuals who are there entirely on their own.
On the other hand, boarding homes are not health facilities,
such as nursing homes or hospitals, where the individuals are
entirely dependent and could not self-evacuate without some
kind of assistance. Indeed, boarding homes tend to care for
those people who have some sensory impairment, some congenitive
impairment, and some impairment of mobility.

These buildings range, in our experience, from 15-story high-
rises on the one hand to single story chicken coops at the
other. Most boarding homes are converted use buildings with

very few built for the purpose for which they are currently
being used. In some jurisdictions, as in New Jersey which
was mentioned today, these facilities carry the name of board-
ing home or adult care facility. In other states they are
referred to as sheltered care homes, group homes, or domi-
ciliary care homes. It varies depending upon what part of
the country you are in. Nevertheless, the characteristics
of these facilities do not vary that widely. There are some
common patterns in this classification that will be discussed.

To give you some sense of the size of the problem of this
class of occupancy, let me try to give you a point of ref-
erence. Currently in this country there are approximately
1.2 million residents of nursing homes. Some 18,000 nurs-
ing homes in this country housing approximately 1.2 million
people. The nursing home fire problem has been for many
years a major national concern. It is a problem that we
think at the moment we have some kind of a handle on, al-
though not certainly cured. By contrast, the boarding home
population is estimated at nearly twice that of the nursing
home population. Approximately 2.5 million individuals are
living in what we might loosely call boarding homes. While
there are some 18,000 nursing homes in this country, there
are some 200,000-300,000 boarding homes in this country.

Now I give you these by comparison in contrast because the
inspection costs involved currently in monitoring the nurs-
ing home program nationally are absolutely tremendous. Imag-
ine a population twice as large with twelve times as many
facilities. Because these tend to be smaller than nursing
homes, they present an enormous life insurance inspection
problem. To give you some idea of the fire problem in boarding

homes, in 1979 in six fires alone we lost 81 individuals in boarding home fires. Between 1979 and 1981, a total of 132 people were lost to boarding home fires.

What I'd like to do now is to give you some idea, a little characteristic, of the people that are in this particular class of facilities. I read to you very briefly the statement of Olga Billows. Olga is a survivor of a boarding home fire that occurred in New Jersey last year. Olga, at the time she testified before our committee, was 74 years old. She is not totally untypical of the kind of occupants in this class of facility.

Olga states "I was living in the Brindly Inn Boarding Home when the fire there killed 24 people, many were my friends. I am here today to tell you something about myself and what happened to me the night of the fire. By doing this, I hope that I can help others to live longer in boarding homes. On March 24 this year I will be 74 years old. I was born in Austria and came to this country with my father, who wanted to find factory work. After arriving at Ellis Island, we moved to New Jersey. My father found work in Passaic. During my younger years, I worked as a live-in domestic assistant doing laundry, cooking, and caring for children in families. I also worked as a beautician until I retired at age 63. Before moving to the Brindly Inn, I had an apartment in Ocean Grove. Living by myself and cooking by myself gradually became too much of a burdon and I became very nervous. I was admitted to the Jersey Shore Hospital, Psychiatric Ward, and I got better. The doctors gave me a prescription for medicine and suggested that I not live alone anymore. That is how I got to the Brindly Inn. For my nervous condition, I have to take pills every day

and a special pill at night to help me sleep. You may have
noticed that I don't see very well. I have had cataracts
on both eyes. In 1979, I had the left cataract removed,
and in 1980, I had the right cataract removed. Without my
glasses I am practically blind. With my glasses I have a
very limited side vision. I also have to use a magnifying
glass to read newsprint. Sometimes I can't see cars coming
when I go across the street. In addition, I can hear noth-
ing with my left ear. I have some hearing in my right ear
in which I use a hearing aid."

Now let me digress for a moment. Here's a woman who is 74
years old, who has decided that she can't function indepen-
dently, she is in a facility where she needs some assistance
and supervision, she has already had one hospitalization in
a Psychiatric facility. She is receiving psycho-active medi-
ciation as well as sleeping medications at night. She has
limited vision, impaired hearing, and we'll find some limited
mobility.

"I liked living in the Brindly Inn. I was there for a year
and a half. At the Brindly Inn there were some people who
had mental problems, some people there who were retired, and
there were some there who were quite old. We had fire drills
every two months. The person doing the drills would as us
'If you year the bell, how would you escape?'. They told us
to use the nearest exits to get out. My room was on the
second floor in the middle of a long corridor."

"On the night of the fire, I was in my room sitting on my bed
doing a crossword puzzle. I heard the fire alarm bell go off.
I was lucky that I still had my hearing aid in, my glasses

on, and that I hadn't taken my sleeping pill. Without my
hearing aid, I don't think I would have heard the bell.
Without my glasses, I would have been helpless. Had I
taken my sleeping pill, I probably would not have gotten
out at all. When I heard the bell, I opened my door and
walked down the corridor to the back door where there was
a metal fire escape. The bell had stopped, it did not ring
very long. I stepped out onto the fire stairs, they were
very steep."

I'll tell you that these are the old stype metal fire stairs.
Very steep is a mild characterization of what these stairs
are like. You or I would be terrified to go down these things
during the day time, let alone being 74 years old, impaired,
and doing this at night.

"They were very steep. I took the stairs as far as they went,
to the roof of the kitchen."

She exited from her floor, down the fire escape, to the roof,
top level, of the kitchen.

"There were other residents gathered on the roof. I was slow.
Some of the men pushed ahead of me and climbed down the very
steep metal ladder that went from this roof area to the street."

Once on the roof, they had a full story of hand-over-hand metal
ladder, vertical on the side of the building to make it to the
street level.

"It was on one of those ladders I had to climb down hand-over-
hand. After the men had gone, I started down the ladder myself.

It was dark and with my poor eyesight I could not see the
ground. After I got most of the way down, a policeman told
me to jump. I jumped and he caught me. I walked across
the street and sat down on the steps of a neighbor's house.
Soon a woman asked me who I was and where I lived. I told
her and she took me to a house across the street where some
of the others had made it out. Linda, one of the women who
lived at the Brindly Inn with me, came in covered with black
soot. Wilma, the weekend cook, said to Linda 'Thank God
you're still alive'. Some of my friends, Nellie, Mr. and
Mrs. Lozier, and some of the others were killed."

"I was taken to the Jersey Shore medical center where the
doctors examined my lungs and checked to see if I was OK.
I was then moved to the Miami House in Asbury Park, where
I now live.

Please listen to this very carefully.

"I like the Miami quite a bit because we have things to do
and some of the people are very friendly, sore of like family.
We help each other. Since I have been in the Miami, we have
already had another fire. It was a small one and was put out
before anyone was hurt. But I'm glad I was not in the build-
ing when that one took place. Sometimes I worry about being
there, about another bad fire, maybe when I'm sleeping."

That is the end of her testimony. I think that it is very
dramatic testimony and I think it characterizes exactly the
problem we have with this particular class of occupancy and
the fact that we'll see enormous growth in this particular
type of structure and the need for these kinds of buildings
in the next few years.

Many of the occupants of these buildings are older indivi-
duals who have come to these facilities because they need
some kind of protective supervision. A number of them have
also come from state hospital discharges, what is popularly
referred to as the movement of deinstitutionalization. In
the last eight years in this country, there has been a pro-
found emptying of the state hospitals and placing the resi-
dents in what are called community care facilities. There
have been nearly a half a million former hospital residents
discharged into these kinds of facilities over the last
eight years.

In 1980, of the elderly people in this country, those over age
65, 38 percent in 1980 were over 75 years of age. By the
year 2000 of those over 65, 44 percent will be over the age
of 75. The reason this is important is because it illustrates
that not only are we as a whole getting older as a population,
but the old are getting much older, and therefore, much more
fraile and dependent upon support of care. Once again, to
illustrate the general trends in the field of aging, in 1980
currently, there are roughly 25 million people over age 65,
constituting about 11 percent of the population. By the
year 2030, 48 million people will constitute 18 percent of
the population.

To dramatize that in another way, currently the Social Security
System is supported in the following fashion. There are ap-
proximately 3.2 people working today for every social security
retiree. By the year 2030 that ratio will drop to 2 to 1.
Which means that there will be only two people supporting
each retiree. This accounts for some of the press reports
you've seen recently about the crisis in the Social Security

System. It is in essence the post-war baby-boom moving
through the age categories and into the older age popula-
tion.

What I'd like to do is bring your attention to those fac-
tors that have contributed to bringing us where we are
today. I think it is important to understand these fac-
tors in order to understand what we can do to have a posi-
tive effect on the fire condition as it presents itself
today. It is a technical problem as much as it is a social,
economic, and political problem.

Very briefly, in about 1800 a woman by the name of Dorthea
Dix was a mental health reformer who found mentally ill
people wandering around throughout the United States in
cities and to a large extent being taken advantage of or
otherwise being neglected. She created throughout the
country a humanitarian movement, a kind of crusade, to have
these helpless individuals scooped up out of our then teem-
ing inner cities and moved to more rural settings and placed
in what she called asylums. Asylums or refuges from the
dangers from life where they were often taken advantage of.
These asylums were in fact state hospitals. It is Dorthea
Dix who is credited with the creation of the state hospital
system in this country. They were pastural sanctuaries for
people who had otherwise often been tormented and neglected.

What happened, unfortunately, was that there was an unbridled
and uncontrolled growth of mental health facilities from the
late 1800's up until approximately 1950; little or no con-
trols. Hospitals sprung up in many parts of the country,
thousands of them housing hundreds of thousands of individuals.

By 1950 or so, there had been a growing social conscious in this country that asylums were really thought of as being something different than refuges and pastural retreats. Asylums meant something akin to snakepits. That is, places where oftentimes it was difficult to distinguish the staff from their equally disturbed residents. If they hadn't been wearing uniforms in many instances, one could not tell the two apart. These facilities house senile, elderly people, schitzophrenic adults, handicapped violent individuals, children, a vast majority of what is essentially society's unwanted.

Treatments were perpetrated on these individuals against their wills which included insulin shock theraby, hydro therapy, electro shock therapy, and a variety of butcher-like psycho surgery all done in the name of mental health. It was not until the mid-1950's with the advent of psycho-thropic medications and other drugs that helped really tame-down what was a very aggressive and violent atmosphere in these state hospitals. For the first time, the politics of control which had existed in the facilities simply because of the size and brute strength changed to a control done by chemical straight jackets and the kind of assistance that can be provided by drugs. The staff of these facilities felt some profound relief that the war had ended and were very clearly ready to declare these individuals no longer in need of mental treatment because for them treatment had meant simly that - control.

Keep in mind now that there has been a growing change in social conscious with the writing of the book Snake Pit and other literature, advent of psychothropic medications

came along and helped quiet this population. Another cru-
cial element happened between 1972 and 1974 when Congress
ammended the Social Security Act and created what is known
as the SSI system (Supplemental Security Income System).
In a sense it created an income floor for all aged, dis-
abled, and handicapped individuals who had not otherwise
worked sufficient quarters under Social Security to qualify
for some minimum benefit. The Congress simply said that
these individuals who could not have worked and who did not
work are entitled to some minimum income floor. That Act
by the Congress coupled with medical changes and some changes
in our social structure contributed enormously to the growth
of a fore profit boarding home industry in this country which
we will try to describe briefly.

The reason the SSI program was so important here is that in-
dividuals in state hospitals cost the state somewhere between
$25,000-$30,000 a year to maintain. By and large those are
exclusively state funds and are not reimbursed by the Federal
Government. When the SSI program came along the state saw an
opportunity to discharge individuals from this $25,000-$30,000
level of care and to place them into community residences,
the care of which was primarily paid for by the Federal Govern-
ment. The burdeon was shifted from the states to the Federal
Government. About the same time, the final peg was driven
home. It was several Supreme Court decisions which were made.
One of them, Donaldson vs. O'Connor in the 1970's was finally
decided by the supreme Court in 1975 which essentially held
that individuals could not be kept in Psychiatric facilities
against their will unless they were a danger to themselves
or a danger to others. Additionally, people could not be con-
fined to facilities without receiving proper care and attention

for the disorders that they had. If the individual was not
a danger to himself or to others and if the facility could
not provide him with care and treatment appropriate to his
condition, the facility was obligated to discharge that in-
dividual to a less confining treatment. We had a legal
Supreme Court decision coupled with actions by the Congress
coupled by advents in medicine, that is, psychothropic drugs,
and some changes in our philosophy and social structure that
contributed fuel to this enormous growth in the boarding home
industry.

Currently, to give you some brief idea, there is little or
no federal regulation of boarding homes. There is some token
language on the books. It is not very well drafted and as
a consequence it is not enforced by any of the states. States
and local jurisdictions have some codes on the books that re-
late to these facilities. Some of the codes are very good
that these jurisdictions have, some are not good whatsoever.

To give you an illustration of how sparse this situation can
be, one of the fires we'll discuss occurred in Farmington,
Missouri, and the licensor situation in Missouri was as fol-
lows. It was a state license which was offered to these kinds
of facilities. The state law said that the facility had to
comply with local building codes and local fire codes and if
it complied with those it would be granted a license by the
state as long as it met some other qualifications. In this
particular instance, the facility was located in a rural area
where there were no building codes and there were no fire codes.
As a consequence, when the questionnaire was sent out "Is
this building out of complience with local standards"? The
answer came back "No it is not out of complience". It was

licensed and it violates every imaginable code you or I know of. If was the kind of buerocratic ineptness that is characteristic of this particular problem.

The first fire we'll discuss is the fire which occurred in Connellsville, Pennsylvania, on April 1st of 1979. There were 10 fatalities in this particular fire. This building is characteristic of many boarding home usages. It is a former single family residence. What had happened is the woman's husband had died, she was a widow. Most elderly people are widowed females. She needed to make extra income and in order to do that she took in some boarders, and then a few more boarders, and then a few more boarders. They ended up becoming increasingly more in need of care. People were jammed ultimately into the upstairs, the first floor, and the basement level of this particular facility. It was a converted use from a residence. There was additional electrical load on the building placed by its new heavy occupancy, heavier than a single family. It was in part electrical failure which contributed to this fire situation.

The fire in this particular building began in an electrical fuse box in the basement. The fuse box was located between the staircase, which led out of the basement, and a room in the basement in which five residents were living. Their only single means of egress was past this fuse box. This fuse box burst into flames and the wall started in flames. The exit way immediately became unusable. Of the fatalities, all who were residents of the basement died. It was a two-story frame building. The fire took place approximately 8:30 in the evening. There were no detectors found in this

building of any type, there was no manual fire alarm system, there was no sprinkler system, and we have no indication whatsoever of any pre-fire training of the occupants of the building. Primarily the origin determined to be electrical fuse box in the basement involving then the wood wanescoat on the wall adjacent and blocking the exit door and sending smoke and particles of combustion up the staircase involving the first and second floors.

Contributing factors in this fire would be overloaded electrical service, combustible interior, lack of complete alarm system, and the location of a blocked fire exit. The only fire exit was a window located on the second floor, which was certainly a usable fire escape, it could have been used except that the window was blocked by a very heavy five-draw chest. It was not possible for any of the occupants to move that chest independently to get out. The firemen did move it while coming in, but at that point those who had been overcome by smoke had indeed already been overcome.

The next fire we'll talk about occurred in Farmington, Missouri, within just a day of the other fire. Farmington is a community not too far from St. Louis. This particular building was a U-shaped building that had gone through several stages of construction. It was basically wood frame interior with independent free standing granite exterior. When I say independent free standing is that it had some weight bearing characteristics for the roof, but other than that did not contribute to the structural strength of the building. The devistation of this building was almost total. This occurred for a variety of reasons and we'll discuss those.

The fire began or had the alarm first turned in around 4:49 in the morning. Our best analysis of what happened indicates that from approximately an area near the Wayside Inn was an electrical pole which sent service to another pole. There was power brought in from over the kitchen area and into a weatherhead. This was aluminum cable into a weatherhead. Approximately a week before the fire, a garbage truck using the alleyway had clipped this cable, hit it, and bent the weatherhead almost to a flat angle. The building staff apparently went back and straightened the weatherhead and never had the cable or anything associated with it checked any further. It is the best analysis of the people involved in the fire investigation that the point of origin is this aluminum cable at the weatherhead where the bend took place as a consequence of the injury from the garbage truck.

The fire started in the attic area and the attic area over this entire single story building was entirely open, an undivided loft. Once the fire started it is our sense that it burned at least 30 minutes, perhaps as much as an hour, smouldering, building up a head of steam in the attic area before the first sign of fire was detected by the individuals in the building. The first sign of fire was when the corridor tiles, all ceiling tiles in the main corridor of the building, imploded downward, raining fire and smoke on the occupants that were in that particular building. It was a very, very quick exposure. The contents were almost completely incinerated. We found evidence of copper water pipe which had been melted. Most of you who are engineers would know that copper melts somewhere around 2,000°. That was the temperature at the floor in certain portions of this building, an extremely hot fire.

The fire department responded to this fire when the alarm first came in with an insufficient amount of equipment and manpower. This building was located in the county outside of the city. It was the city fire department under contract with the county to respond to essentially chicken coop fires, barn fires, occasional building fires, automobile fires, was not geared in any way to respond to a health facility of this type and the type of configuration that occurs in these kinds of buildings. When the alarm came in, the fire department responded essentially with one truck and three or four men. It was a pumper truck with 500 gallons of water. It blew its 500 gallons of water in very short order. They did not use if very economically. The next move was to call for additional support. They did call for cooperative support of other agencies which brought in their equipment. A booster system was set up to the nearest fire hydrant which was approximately 9/10 of a mile away and water was boosted on down to the fire scene. You can imagine the enormous loss in time in establishing a system of that type. It is particularly tragic because immediately behind this building, I mean within 100 feet of the building, were several water reservoir pools which could have easily been drafted and supplied all of the water necessary for fire fighting in this particular structure.

Because the building had not been preflighted by the fire department, indeed many of them did not know the kinds of occupants that were in that building, the fire attack plan was willfully inadequate to address the situation that they were presented with at 5:00 in the morning. In this particular building at the time of the fire, there were 37 occupants, 25 of those 37 died. Thirteen of the dead were

veterans who had been placed there by the Veterans Adminis-
tration. We found no evidence in our investigation of either
a sprinkler, smoke detectors, or heat detectors. The ceiling
tile, as I recollect, in this particular building was of
Cellotex-type tile. There were wood studs and wood paneling
throughout. There was one person on duty, a staff person,
at the time of the fire. That person was sleeping and the
law in Missouri did not require that that person be awake
at the time of the fire. To further characterize this par-
ticular population, 12 of the occupants of this facility
had been former state mental hospital patients, obviously
many of them on a heavy use of medications. Metal casement
windows were a factor in difficulty of escape for some.

The next fire we'll discuss occurred in Washington, D.C. on
April 11, 1979. Mind you, we are only in a 10-day time span
from the first fire to this one. The Washington, D.C. fire
occurred in what is essentially a duplex building. There is
a left and right side of this building separated by a fire
wall. The point of origin in this fire is smoke materials
dropped in a sofa. The sofa was butted up against some slid-
ing doors that were heavily varnished. They were hardwood
construction doors and that helped propagate the fire. The
fire raced very, very quickly from the first floor, up the
open stairwell, to the second floor, making escape via the
main staircase totally impossible.

The left section of the building was essentially undamaged,
very minor smoke involvement in this building. The total
damage sustained was in the living room area. There were
a number of fatalities in this particular fire, 10 to be

exact. At least one of those involved jumped from the second
story to their death because there was no other means of exit.
The staircase in this particular building, like many, figures
critically into the open vertical access, significant in
these fire scenarios. The reports are that a resident took
some cups of water and tried to splash them on the fire to
put it out, but the fire was going at that point and overcame
his firefighting efforts. The centerpost and the railings
are completely gone, the wood covering is gone, plaster off
the wall. It was a very intense fire rolling up these stairs
and prohibiting any means of egress whatsoever. At the second
floor of the building the pattern of burn came right up the
stairwell, intense rolling of the fire which occurred here and
backing down the corridor of the structure. Also in the in-
terior, the fire just totally wiped off any of the interior
finish, reducing it only to the exterior brick. A window
which might have been used as a means of emergency escape
was blocked, in this instance by an air conditioner and in
another instance by a fire gate, not at all unusual. Finally
adjacent to this building was an exact duplicate of the build-
ing which burned. The building was fitted with, while very
steep certainly more acceptable than no fire escape whatsoever,
with additional means of egress off the second floor, all of
which were not available in the building which the fire took
place.

The next fire we'll discuss briefly is the Brindly Inn fa-
cility which occurred in Bradly Beach, New Jersey, recently.
This particular facility is again typical of a type of board-
ing home that we see. Along the Eastern Shore of New Jersey
we have a lot of resort beach hotels that over the years have
fallen on hard times and to offset their expenses have begun
to take in elderly people, disabled people, and mentally

impared people into this kind of a hotel classified facility or rooming or boarding house. Mind you, with codes built to standards if they did indeed exist 30 to 40 years ago. In this case the building is 55 years old.

In Far Rockaway, New York, we see a similar kind of building use where there have been resort hotels converted to this purpose. Also in the north side of Chicago in the old Gold Coast area where the Edgewater Beach Hotel and others used to be we have a similar kind of problem. There is a concentration of these kinds of facilities.

The Brindly Inn is a three and essentially half story building, three above ground and one story that is half above ground and half below grade in the basement. The fire origin was in the basement. The fire then once again went up an interior staircase mushrooming into the first floor lobby and involving the second and third stories as well. The basement level is important because that is the point of origin. It is a long building. This is Olga's building, it is the building in which Olga resided. The fire is suspected to be electrical in nature, that is the determined cause. There were some BX cable that was being used in the facility. There was a turn that was made in the BX cable and it was felt that that helped to deteriorate the cable and that there was a serious electrical overloading that occurred with ground fault short and it began to burn above the ceiling in the basement. As the fire started in that particular area, it moved out into a recreation room area.

The fire was first noticed, or suspected, by the manager who was in her room at about 11:00 when she heard an alarm

bell go off. This alarm bell was part of a centrally wired
system that was a rate of rise heat detector system in the
building. It is the first formal alarm transmitted to the
staff about the conditions in the building.

What is interesting, however, is that before the bell sounded,
we have testimony of a witness on the third floor who did
have an individual room smoke detector and said that the
smoke detector went off prior to the bells going off. And
so the smoke detector on the third floor triggered long before
the heat detectors in the basement close to the point of origin.
It is interesting in terms of the notification.

The manager smelled smoke and left her room looking forward
and moved to the back of the building to the kitchen area to
see if this was where the fire problem was. She suspected
this simply because of the electrical loading and cooking
that is done there. She did not see any evidence of fire in
this area and indeed this area was never very heavily involved
at all. There is only a small amount of smoke buildup on the
door and otherwise this area was left unaffected.

She then turned and went back to the lobby area and thought
the fire might be in the basement. She opened the basement
door and saw that the basement area was heavily charged with
smoke and by the time she tried to close the door the smoke
was already rolling up the stairs and she failed to close
the door. What was going on down there was essentially was
it was really starting to build a head down in this basement
area. By opening the door at the top of the basement stairs,
the manager allowed oxygen access to the fire, provided a

route for it to move and it began to charge quickly up the stairs.

Hopefully, from these examples of boarding home fires you can see the problem that exists. It is a real problem and one that needs effort - mainly from those that enforce the codes.

"REVIEW OF PLASTICS FIRE HAZARD"

A. Tewarson

Factory Mutual Research Corporation

FIRE RETARDANT CHEMICAL ASSOCIATION MEETING

Philadelphia, Pennsylvania

October 12, 1981

REVIEW OF PLASTICS FIRE HAZARD

by

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ABSTRACT

A general description of the hazard associated with fires was presented for treated and untreated plastics. New techniques and apparatuses developed at FM, were discussed for the reliable determination of total hazard of treated and untreated plastics in various shapes, sizes and storage arrangements. The fire hazard was defined in terms of ignition/flame spread, heat release rate, generation of smoke, toxic and corrosive products and ease of fire extinguishment/suppression.

The slides presented in the Seminar are included in the following pages.

Review of
Plastics Fire Problem

What is the Problem

- Definition of fire hazard

- Quantification of fire hazard

Fire Hazard

- Can be defined in several different ways depending on the end-use application of the products

    - Safety of people
    - Protection of buildings, structures, etc. and their contents

Fire Hazard

Can be defined in terms of

- Ignition and Surface flame spread
- Heat release rates
- Generation rates of "Smoke" and toxic and corrosive products
- Visibility through "Smoke"
- Fire extinction and suppression

Fire Hazard

Depends on

- Generic nature of the plastics and additives
- Configuration of the products and their arrangement in the end-use application
- Presence of other combustibles
- Environment
  - Extraneous heat sources
  - Ventilation

Fire Hazard

Can be reduced

- by chemical modification of the plastics —
  structural changes in the polymer and by fire
  retardant additives
- by changes in the product configurations
  and end-use arrangements
- by early fire detection and protection
  systems

Quantification of Fire Hazard

- Apparatus and procedures
  Simulating large-scale fire conditions

Large-Scale Fire Conditions

- Hot Extraneous Sources —

  Walls, ceiling, nearby burning
  materials

- Flame — radiation

- Ventilation —
  Over or under ventilated fires

- Geometrical configurations and
  arrangements of the combustibles

FACTORY MUTUAL COMBUSTIBILITY APPARATUS

A NEW APPROACH OF FIRE TESTING

- To be able to test combustibles reliably using Small-Scale tests.

- To be able to obtain data for the fire properties in quantitative fashion.

Fire Properties

- Response of combustible to heat
    - Ignition-Surface flame spread
    - Generation rate of vapors— mass loss rate

- Burning of vapors
    - Heat release rate
    - Generation rates of fire products especially "smoke" and toxic and corrosive products
    - Light obscuration by "smoke"

- Fire suppression and extinguishment
    - Water-sprays
    - Reduced oxygen concentration
    - Chemical interactions

- Generalized relationships between fire properties, fire intensity and water application (or other agents)

Factory Mutual Combustibility Apparatus

● The fire products and air are captured in Sampling ducts and measurements are made for total mass flow rate, gas temperature, and concentrations of individual fire products.

● Data are used to calculate actual, convective and radiative heat release rates.
  Three apparatuses have been developed: 1) FM small-scale apparatus (4 in. x 4 in. x 4 in. high sample); 2) FM intermediate scale apparatus (1 ft x 1 ft x 4 ft high sample); 3) FM large-scale apparatus (10 ft x 10 ft x 10 ft high commodity). The apparatuses are shown in Figure 2.

Reliability of Heat Release Rate Measurements

● Measurements have been made for a variety of combustibles
  ● Transformer fluids
  ● Plastics — Plexiglas, polystyrene, polyurethane foam in corrugated paper cartons
  ● Liquids — Heptane, methanol
  ● Wood pallets
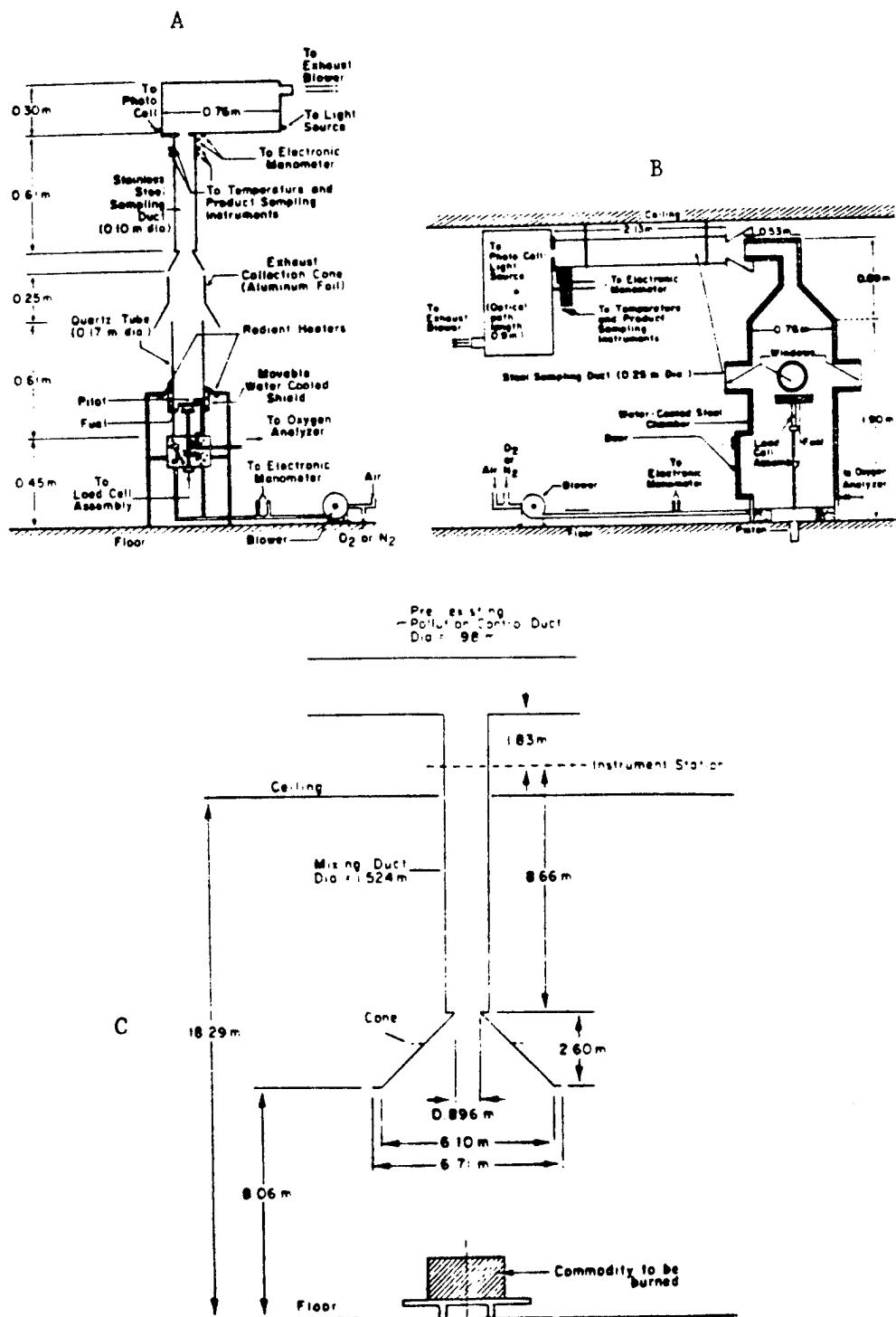
FIGURE 2   FM COMBUSTIBILITY APPARATUSES

A.   Small; B.   Intermediate;   C. Large

HEAT RELEASE RATE

- **Heat release rate**

    = heat of combustion x
    mass loss rate

- **Heat of combustion**

    $$= \frac{\text{Heat release rate}}{\text{Mass loss rate}}$$

- **Actual heat of combustion**

    $$= \frac{\text{Actual heat release rate}}{\text{Mass loss rate}}$$

- **Convective heat of combustion**

    $$= \frac{\text{Convective heat release rate}}{\text{Mass loss rate}}$$

- **Radiative heat of combustion**

    $$= \frac{\text{Radiative heat release rate}}{\text{Mass loss rate}}$$

Comparison of Data
Pool Fires

Combustible	Apparatus	Heat release rate (kW/m²)		
		Actual	Convective	Radiative
Methanol	Large-Scale	380	310	70
	Small-Scale	390	340	50
Plexiglas	Large-Scale	730	470	260
	Small-Scale	680	500	180
Heptane	Large-Scale	2700	1800	900
	Small-Scale	2400	1250	1150

PREDICTED RATING OF COMBUSTIBLES BASED ON ACTUAL
HEAT RELEASE RATE IN LARGE-SCALE FIRES

	kW/m^2
Heptane	2490
Polystyrene	1000
Transformer fluids (hydrocarbon)	930–1100
Polyethylene	960
Polypropylene	890
Plexiglas	670
Flexible polyurethane foams	420–510
Methanol	380
Rigid polyurethane foams	280–440
Delrin	230
Transformer fluids (silicone)	110–130
Polyvinyl chloride	90

Fire Retardant Additives

Problem

Currently there is a gap in the technology for
large-scale fires for the reduction of hazard
in terms of

- Heat release rate
- Generation rates of "Smoke" and toxic and
  corrosive products
- Fire extinction and suppression

Fire Retardant Additives

- Additives interacting in the Solid phase
  to increase char formation probably
  would be useful for reducing the fire
  hazard in large-scale fires.

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┌─────────────────────────────────────────────┐
│ Selected Plastics/Fire Retardant Samples and Wood │
└─────────────────────────────────────────────┘
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| FM Small-Scale Combustibility Apparatus | FM Large-Scale Combustibility Apparatus | Validity Small-Scale Predictions |

Selection of Three Best Plastic/Fire Retardant Samples (as good or better than wood)

Select A Best Plastic/ Fire Retardant Product (as good or better than wood)

Application To Other Product Development

Protection Similar To That Required For Wood

Plastic/FR Product As Good Or Better Than Wood
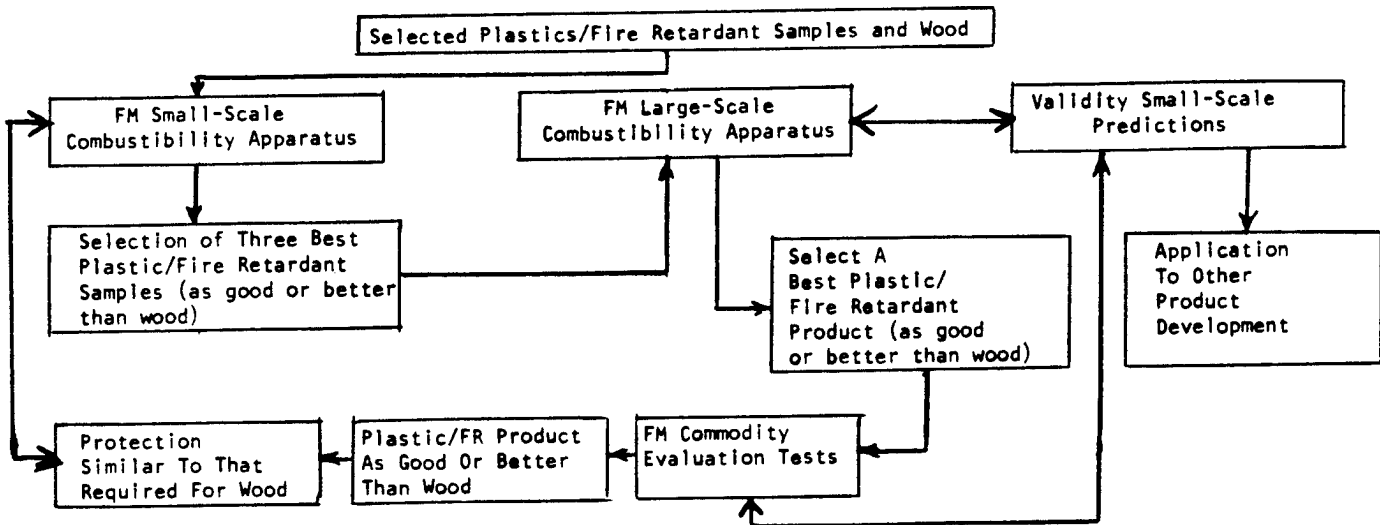
FM Commodity Evaluation Tests

FIGURE 3 AN EXAMPLE OF APPLICATION OF FM TECHNIQUES
AND CONCEPTS TO IMPROVE COMBUSTIBLES USING
FIRE RETARDANTS

"TOXICITY OF FIBERGLASS REINFORCED PLASTICS"

Kenneth L. Schaper

PPG Industries, Inc.

title also m p
6d l
o m g

TOXICITY OF FIBERGLASS REINFORCED PLASTICS

The scope of this presentation has been expanded from a consideration of the toxicity characteristics of fiberglass reinforced plastics to a more general discussion of the toxicity characteristics of synthetic polymeric materials involved in fire situations. A large number of synthetic polymers have been employed in a wide variety of applications, including their use as "materials of construction" in carpets, drapes, wall coverings, airplanes, automobiles, mass transit systems, and many others. Many of the recent well-publicized hotel fires have been referred to as "plastic" fires; the reason for this is an increasing awareness of the toxic decomposition products liberated from synthetic polymers during fire conditions.

These polymeric materials must give satisfactory performance in familiar tests such as flame spread, rate of ignition, heat release, and others. However, the materials need not pass any type of "toxicity" test and, indeed, there are no uniformly accepted tests to evaluate the potential toxicity of the thermal decomposition products of synthetic polymers.

What is desirable currently is some type of screening test using laboratory animals to assess the hazard potential of synthetic polymeric materials in fire situations. The word hazard is used in this sense to make a distinction between it and toxicity; toxicity is an inherent property of a material while hazard is the likelihood that these toxic characteristics will be manifested. Very toxic materials are often rendered essentially "non-hazardous" through the strict application of engineering controls, administrative actions, and

personal protective equipment.   Synthetic polymers, in their neat

state, present little or no hazard, but may emit highly toxic

decomposition products in a fire situation.

The problems of synthetic polymers in fire situations are widely

recognized and have recently been dramatized in the Las Vegas hotel

fires, so why hasn't a uniform screening test been developed to

evaluate the potential toxicity of these materials?   The reasons are

many, but the six listed below are the most important.

1 —   Many people feel that it is a waste of time to develop a uniform
      screening test because all fires are different.   Many groups,
      including the National Bureau of Standards, take rather strong
      exception with this view.

2 —   There is a lack of agreement on how to decompose the material.
      That is, should one pyrolyze the material or utilize flaming
      combustion? (Note that the former is easier to control than the
      latter.)

3 —   Various groups express strong sentiments as to exactly how long
      the exposures should be. It is generally agreed that toxic (and
      lethal) effects can occur within the first few minutes of a fire.

4 —   Exactly what endpoint of experimentation to be quantified is
      another unresolved issue — should one use death or some other
      physiological effect?

5 —   The conditions and stresses placed on the animals to be used in a
      model are crucial — should the exposure period be performed under
      static or dynamic conditions?

6 —   Finally, how should one express the results of this
      experimentation — what expressions of concentration and/or effect
      can be used to make the results meaningful?

There are animal models available that have answered (or attempted to

answer) all or most of the above concerns.   The one that will be

described here was developed a few years ago by Drs. Alarie and

Anderson at the University of Pittsburgh.   Drs. Alarie and Anderson

recognized that all fires, in spite of differences in origin, nature of

combustible materials, etc., exhibited a common denominator - the production of a mixture of irritating and asphyxiating agents. Utilizing this notion as a starting point, a dependable and reproducible animal model has been developed.

The model utilizes the responses of white laboratory mice (Swiss-Webster strain) exposed to the thermal decomposition products of polymeric materials and rates these materials on a _relative_ scale as to their toxicity and potential hazard. Since the common denominator of all fires is the production of a mixture of irritating and asphyxiating agents, irritation and asphyxiation (both conditions which may impede escape in a fire situation) are quantified with this model. Using the six concerns previously mentioned, the following are the characteristics of the Alarie/Anderson model:

1 - The test is uniform and has been applied to many polymeric materials.

2 - The material is thermally decomposed - starting at room temperature, the temperature of the furnace holding the material is raised 20°C/minute. When the weight sensor under the material indicates a 0.2% loss, the animal exposure is initiated.

3 - Exposures to assess irritation are generally 10 minutes long (concentration dependent) while exposures to assess lethality run until death or 30 minutes, whichever occurs first (also concentration dependent).

4 - The endpoints, or effects, quantified are two:

    a. _Respiratory Depression_ - Swiss-Webster mice have a predictable, repeatable breathing pattern. When their breathing rate is decreased by 50% (RD_{50}, a term similar in concept to the more familiar LD_{50}) as recorded through pressure transducers, the mice are at a point which is viewed as potentially harmful to humans. The RD_{50} is measured in terms of the amount of sample one must pyrolyze to decrease respiration by 50%

    b. _Lethality_ - This effect is easy to measure and the time to death also becomes very important. The unit of measure is

the LC_{50} which is expressed in terms of the amount of material that will kill 50% of the animals exposed to its pyrolysis products.

5 - The exposure situation in the Alarie/Anderson model is a dynamic one; that is, cold air is mixed in approximately equal proportions with hot air containing the decomposition products from the furnace so that thermal stress on the animals is avoided.

6 - The expression of the results is one of the most difficult areas of any experiment to define. Alarie and Anderson have done the following:

I - To assess lethality a <u>relative</u> scale has been developed. The characteristic tracing of a mouse being asphyxiated indicates that death will probably soon follow, thus making mortality an easy effect to quantify. By arbitrarily choosing Douglas fir wood as the reference point (LC_{50} of 64 grams), and applying some long-accepted evaluation criteria of Hodge and Sterner, the following relative scale has been developed.

LC_{50} (grams)	Description
0.2 - 2	Much more toxic than wood
2 - 20	More toxic than wood
20 - 200	As toxic as wood
>200	Less toxic than wood

The following is a partial listing of some materials which have been evaluated with this technique. Again, it must be emphasized that as one looks at these results, the rankings are relative, not absolute.

Abbreviation	Sample Name - Description	LC$_{50}$
PRC materials[a]		
GM 21	Flexible polyurethane foam	12.9
GM 23	Same as GM 21, with fire retardant	10.4
GM 25	High resilience, flexible polyurethane foam	8.3
GM 27	Same as GM 25, with fire retardant	14.4
GM 29	Rigid polyurethane foam	10.4
GM 31	Same as GM 29, with fire retardant	8.2
GM 35	Rigid polyurethane foam, fluorocarbon blown	7.5
GM 37	Same as GM 35, CO_2 blown	8.0
GM 41	Rigid isocyanurate foam	6.4
GM 43	Same as GM 41, contains some polyurethane	6.1
GM 47	Polystyrene expanded	5.8
GM 49	Same as GM 47, with fire retardant	10.0
GM 57	Phenol formaldehyde - phenol resin, expanded blowing agent	6.3
Non-PRC Materials		
PTFE	Polytetrafluoroethylene resin	0.64
PVC	Polyvinylchloride (92% homopolymer)	7.0
PVC-A	Polyvinylchloride (46% homopolymer)	15.2
PVC-CN	Polyvinylchloride (92% homopolymer + 5% zinc ferrocyanide)	2.3
PCP-CN	Polychloroprene (92% homopolymer + 5% zinc ferrocyanide)	2.5
ABS-3	Standard acrylonitrile/butadiene/styrene	6.3
Mod.	Modacrylic	4.9
Wool	Wool fibers - undyed	3.0
UF	Urea formaldehyde foam	2.5
Cellulose	Blowing type cellulose fiber insulation	11.9
D. Fir	Douglas Fir	63.8
Fiberglas	Fiberglas building insulation, 3.5 in. thick with paper and vapor barrier	35.7
P.E. I	Polyester resin - commercial acrylic modified unsaturated	34.8
P.E. II	Polyester resin - experimental acrylic modified saturated	57.4
H.P.E.	Polyester resin - Styrenated halogen modified	14.4
SPF Wood	Compressed spruce, pine, fir slab	48.7

[a]Obtained from the Product Research Committee (PRC) sample bank at the National Bureau of Standards.

II – Sensory irritation is an involuntary response by the body to protect you when irritants impinge on free nerve endings of the trigeminal nerve in the eyes, nose, and throat. While this response is subjective in humans, it is extremely predictable and repeatable in Swiss-Webster mice and can be quantified by assessing their respiratory depression (see previous discussion on RD_{50}). A relative scale similar to that used for assessing lethality has been developed –

RD_{50} (milligrams)	Description
0.1 – 1	Much more than wood
1 – 10	More than wood
10 – 100	Similar to wood
>100	Less than wood

Some 80 materials have been evaluated in a comparative fashion using human subjective responses and mouse respiratory depression. Thus far, a perfect correlation exists between human subjective response and measured animal response.

While by no means perfect, the Alarie/Anderson model has shown that materials can be evaluated and placed on a relative "best to worst" scale. This thermolysis testing has proved to be consistent (the methodology is now used at several other laboratories), has allowed the development of criteria for exposure times and methods, and gives results in a form so that they are understandable and comparable.

One thing that has been shown with the model is a fact which may be very important to developers of fire retardant chemicals. That is, the addition of halogenated materials to achieve the desired flammability characteristics often creates a material of greatly irritating and potentially fatal characteristics as compared to other similar materials without fire retardant characteristics (due to the liberation of materials such as HBr). The goal of future

research should be to minimize <u>all</u> undesirable effects of materials which somehow become involved in a fire situation.

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"POLYMERICS IN WIRE AND CABLE

POTENTIAL HAZARD IN BUILDING CONSTRUCTION?"

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I want to lead with some background as to who Union Carbide is and how we relate to flame retardants, particularly in the wire and cable business arena. It will come as no surprise that Union Carbide is a major manufacturer of polyolefins. A segment of our polyolefins business is concentrated in the wire and cable industry. We sell both base resins and compounds into the industry and consequently do the formulation and process development work for the compounds we market. Certain of these are flame retardant.

My objectives this morning are: to indicate how wire and cable materials fit into the building contents problem with respect to fire; to show what, if anything, in the nature of wire and cable products may be considered particularly hazardous; to discuss how flame retardants are introduced into wire and cable products; to give some indication of the tests used in the laboratory to screen materials for applications; to indicate what standards and agencies regulate the industry with respect to flame resistance, and I will close with a "wish list" from the viewpoint of a lab guy on what is required in the near future for flame resistance in wire and cable materials.

The general topic of my presentation is "Polymerics in Wire and Cable. Do They Represent a Potential Hazard in Building Construction?" If this were a T.V. documentary, the answer is quite simple. Are they combustible? Yes. Therefore, they represent a hazard. At this point, I would show some films illustrating the actuality of the hazard and then trot on recognized experts in the area; lawyers, eye witnesses, news commentators and the like, to illustrate my point. But it is not, so we will attempt to take a somewhat more scientific point of view. Recognize that as far as fire contents are concerned, I am talking about a limited area, namely wire and cable materials installed in buildings. I will try to illustrate to what extent wire and cable materials in the building contents represent a fire hazard.

As background, the first slide divides building constructions into residential and nonresidential segments showing the fire impact in these categories. First, as far as residential is concerned, the primary result is in fatalities. About 90 percent of all fire fatalities occur in residential buildings. In the United States, this represents the loss of about 10,000 lives per year. In nonresidential building fires, the major loss is to property. About 60 percent of the fire property loss occurs in nonresidential fires. Overall then, the approximate cost of building fires in the United States is somewhere between 10 to 12 thousand lives and upwards of five billion dollars per year in property loss. From a wire and cable contents point of view, the statistics on the residential fires, for example, show about eight percent are electrical in origin. From the hazard's point of view, the first conclusion you can draw is that wire and cable contents are not a primary source of fire hazard in buildings.

On slide two, I show the major polymerics and their estimated use volume in the fabrication of Wire and Cable constructions. These are marketing figures and subject to marketing error. The saliant point is that there are two polymers used in substantial volume, polyvinyl chloride and polyolefins, primarily polyethylene. A subsection of polyolefins is the thermosets. Combined PVC and PE represent the lion's share of the polymerics used in Wire and Cable construction. Your attention is drawn to the feature shown on the bottom of the slide, namely that the materials used to fabricate wire and cables in building contents represent only about 12 percent of the polymerics used in building construction. Hence, the second point to be made is that from a fuel point of view, wire and cable materials do not represent a primary fire hazard in buildings. The question arises then, what specific features of

wire and cable materials represent potential fire hazards? How are they distinguished, for example, from a waste basket or a set of drapes in a building? I believe the features are summarized on the next slide.

Grouped cables installed in buildings present the greatest potential for fire. Cables are installed in buildings in trays, conduits, raceways and the like. With grouped cables, you have concentrated the fuel content and increased statistically the chance of an electrical failure. Secondly, cables are unsightly and their installation is therefore behind the ceiling; behind the wall. They are not accessible. They escape a primary method of detection, namely vision. A fire situation can develop, smolder, and burn for a period of time without detection. Smoke may signal the incident but may not be readily traced to the source. Beyond this, cables by their functional nature permit area to area access. They function to distribute power and carry various signals throughout a building. The result is room to room and floor to floor connection. A potential for rapid spread of fire and the products of combustion definitely exists. Finally, we should note the consequences of a fire induced disruption of electrical service, namely the potential loss of the fire safety devices. This event could hamper the alarm, evacuation and fire fighting apparatuses including smoke exhaust systems in a building.

I would like to turn our attention now to a discussion of the process of combustion of polymerics. The next slide sketches in a general way what occurs when a polymer burns.

In simple terms, polymers are big molecules made out of small molecules. If they are exposed to an external heat source you begin to fragment the molecule into its component parts, breaking along the weak links in the chain. This process generates fuel. The fuel will vaporize, mix with

the oxygen of the air and give an ignitable mixture. With ignition you get flaming combustion; flaming combustion generates more heat. An oxidative reaction ensues with a free radical chain mechanism to continue the burning. This is an exothermic reaction generating a substantial quantity of heat depending upon the polymer. A portion of the heat generated is fluxed back into the condensed phase. If the quantity of heat fluxed back is sufficient to continue the fragmentation reaction and generate fuel, you will no longer require the external heat source. You have closed the loop and you have a fire situation. The schematic shown illustrates this process. The next slide illustrates, via chemical reactions, a mechanistic pathway for the oxidative decomposition of a polymer. A key point to remember is that the oxidative burning reaction is a free radical chain process. The chain mechanism is through generation of high reactivity species such as the hydroxyl and hydrogen radicals as shown. Certain of the flame retardant additives, I will be discussing shortly, owe their effectiveness to an ability to alter the reaction rate and pathway of these chain carrying species.

The approaches to fire control used in Wire and Cable are along the lines as shown on the next slide. First, in the construction of a building suitable devices including sprinklers, smoke and fire detectors, fire stops and the like may be included. This approach, however, is not the subject of this presentation. Also in cable construction and installation, techniques towards fire prevention have been developed such as metal sheathed cables and metal conduits, flame painting of cables and the application of flame resistant tapes in the cable construction. Again, this is not the topic under discussion. Perhaps Jerry Rose will touch on certain of these

features in the following presentation. What I intend to discuss is the materials approach to fire control. In the main, this approach proceeds along the three lines as illustrated. It includes the introduction of additives, the use of inherently flame resistant polymers and combinations of these. The approach probably most dear to the hearts of the people assembled here and to the speaker himself, is the first--flame retardant additives to polymers. Polyethylene is a superior insulator, and an ideal compound for wire and cable applications. The problem with it is that it burns. Therefore, for applications requiring even modest degrees of flame resistance, some steps must be taken. Anything that we add to polyethylene detracts from its electrical properties. Hence, we are always looking for a balance between the required performance and the cost for the fabricated article. In polyethylene, the additive approach is taken in two ways. What can be accomplished in the condensed phase and what can be accomplished in the vapor phase. First, the condensed phase approach is illustrated by the chemical heat sink effect as shown on the next slide. Recall the combustion slide. What we are attempting to do here is to consume the heat flux to an end other than polymer degradation. In the example this is done by promoting a preferential endothermic dehydration reaction of a filler. As shown, aluminum trihydrate in the temperature range of 250-500 degrees centigrade utilizes the heat in this manner. An advantage of this approach is the straight substitution of an interactive mineral filler for the diluent or extender fillers generally used in Wire and Cable compounds. The by-product of the reaction has the added benefit of being nonflammable, nontoxic and noncorrosive. Additionally, smoke generation is not promoted. What then is the disadvantage? It shows up in the effect on electrical properties mainly

wet environment electricals. In order to get the maximum effect in poly-
ethylene, you need a loading of about 40 weight per cent aluminum trihydrate.
At that level you have seriously affected the electrical properties of the
material in application as an insulant. As far as a jacketing material, where
the electricals are not that important, high loading of aluminum trihydrate
remains a useful approach towards flame resistance.

The second approach, namely control of combustion in the vapor phase,
is illustrated on the next slide. Shown here are both halogen acid
acting as a flame inhibitor in the vapor phase and the well known antimony-
halogen synergism. In both cases we are trying to scavage the hot radicals--
hydroxyl and hydrogen atoms and trade them for less reactive radicals,
for example, halogen radicals. The latter are poor chain carriers and do not
promote oxidative burning.

In the antimony oxide-halogen systems, I have shown the first step
in the accepted mechanism as being generation of halogen acid, followed by
reaction of halogen acid in the condensed phase with antimony trioxide to form
the antimony halides and oxy-halides. These generate inhibitors, shown to
exist spectroscopically, which become involved with the gas phase radical pro-
cess through interaction as shown with the hydrogen atoms and hydroxyl radicals.
The overall effect is similar to that detailed for the halogen acid inhibition.
Antimony oxide-halogen synergism is quite effective in Wire and Cable materials.

The next slide presents the advantages of the antimony oxide-halogen
additive approach and the areas of concern. As mentioned, the combination is
highly effective in Wire and Cable compounds. Antimony trioxide in the com-
pound has a minimal effect on electrical properties. In the ground state, it

functions as a diluent filler. It has good compounding characteristics pre-
senting little problem in mixing. Where there may be a dusting problem, coated
grades and suitable masterbatches are available. In the compound itself, it
has a minimal effect on the extrusion processing. There are, however, draw-
backs or areas of concern with the use of this system. Antimony salts present
the potential of heavy metal toxicity. OSHA is reviewing this situation
presently. Many of you are perhaps better informed on this matter than I.
A second area of concern was shown on the previous slide. The oxide reacts to
form strong Lewis acids. These materials in the presence of polyolefins
promote charring. They are very reactive at the temperatures experienced.
Airborne char is a component of smoke. So, in general, when you add antimony
compounds you increase the smoke produced during combustion. Another area is in
corrosivity. The mechanism depends on the generation of acids and hence you
have corrosion to building contents following the fire. Lastly, in a functional
area of concern, is that of afterglow. Ash produced from antimony-halogen
flame retarded systems tends to glow following extinction of the flame.
Reignition through the glowing ash is a problem. Oftentimes, borate salts
and the like are added to control this phenomenon. A final concern is from a
cost view. Antimony oxide has a relatively high pound volume cost to the
user and historically the availability has fostered vagrant pricing. This
situation has stabilized in recent years and may be behind us.

The second general approach to flame resistant Wire and Cable pro-
ducts is the application of less flammable polymers. This is widely practiced
particularly through use of PVC. Polymers finding application are shown on
the next slide. Previously a good deal of installed cable in a building was
PVC insulated/PVC jacketed or PVC jacketed/polyethylene insulated. These

cables were installed above ceilings in steel conduit. Recently, flourocarbons have been developed for this application with the main selling points being savings on installation costs and ease of rerouting cable at a future date. The flourocarbons are notable for their low smoke and low flame spread. They are being used as plenum cables under a UL listing.

The second inherently flame retardant polymer class is the chlorocarbons. Representative materials are shown on the slide. The first, PVC, is very flame resistant with an oxygen index of about 45. It requires plasticizers for end use and in application has a lower oxygen index. It is used for insulation, jacketing, and is notable for low cost. The second polymer in this class, chlorinated polyethylene, probably represents a balance between polyethylene and PVC. Chlorinated polyethylene used in Wire and Cable has a halogen content of about 36 percent vs. 56 for PVC. It has a lower oxygen index than PVC but requires little or no plasticizer. Neoprene and hypalon which are chlorinated and chlorosulfonated polyethylenes, respectively, are notable for their flexibility. They are somewhat flame resistant and find use primarily as jacketing materials. Any of the above polymers can be used with the additives previously discussed including antimony oxide and aluminum trihydrate. In addition, phosphorous containing plasticizers and secondary plasticizers such as chloroparaffins find application in certain flame resistant formulations.

The next slide presents representative Wire and Cable formulations used where a degree of flame resistance is desired. Consider first a polyolefin insulating or jacketing compound. It will generally contain about 50 to 60 percent by weight polyethylene copolymer. The insulating compounds will contain a filler; generally not a flame retardant filler. The filler

level for the jacketing material can be higher, as shown, because the electrical properties are not as important in the jacket. In the case of thermosetting resins the flame retardant additives cannot contain functionality labile to free radicals, as for example, aliphatic halogen. Such materials interfer with the established crosslinking processes. The flame retardant additives most often used in crosslinked polyolefin systems would be in the nature of the dechloranes, BT-93, DE-83 and Pyrochek 77B. These additives are combined with antimony trioxide at various levels depending on the level of flame resistance sought. Shown also are antioxidants and other adjuvants including the smoke suppressants currently being developed and commercialized by many companies represented in our audience.

The difference between insulating and jacketing compounds is often found in the particular resin. Because the jacketing materials are not required to meet the dielectric properties of insulating material, they may contain higher levels of copolymer. Higher comonomer levels in polyethylene imparts flexibility, a desirable property in jackets.

On the next slide, I present a PVC resin based building wire formulation. This is a building wire formulation used in the wiring in your home. Generally, the construction consists of three wires: two hot wires and a neutral with a paper wrap filler. The wires are jacketed with PVC. These are 60°C rated and thermoplastic. The construction contains PVC in the insulation and the jacket at approximately the level shown. They contain a filler or filler mixture. Clay and calcium carbonate are fillers of choice. Included also are plasticizers and stabilizers. Starting with these formulations you can build or add flame retardancy by putting in flame retardant plasticizers and secondary plasticizers, and combining these with an additive,

such as antimony. Smoke suppressants and other adjuvants of choice may be added depending on the application.

The next slide indicates how materials are screened in the laboratory for application in Wire and Cable. The first screening tool we use is the oxygen index test to measure relative flammability. Within a family of polymers, for example polyethylene, the test is a good indicator of flammability. You have to be cautious when crossing lines and comparing an oxygen index for a polyethylene with an oxygen index for a PVC. There are too many other features not taken into account by this simple testing procedure. It is only a small scale lab test. It tells you nothing about an actual fire situation.

The second test procedure used is closer to end-use application and requires access to wire extrusion equipment. The procedure involves a flame test on a wire coated with the material under investigation. There are two UL tests. These give data on the time of burning, the rate, and the drip characteristics of the material. Either of the wire tests shown is used for laboratory screening of fabricated material. The tests differ in the configuration of the sample. Vertical is far more severe and revealing than the horizontal mode.

For smoke in our laboratory we use the Arapahoe Smoke Chamber. This is a rapid and reproducible test. It measures the smoke gravimetrically and gives some indication of the ash formed on burning. We have found a fair correlation between the Arapahoe smoke test and the NBS smoke chamber results.

For acid gas analysis in our lab we use elemental analysis. We absorb the gas evolved from a burn carried out in a quartz tube and measure acid (halogen ion) using a specific ion electrode. Alternatively and more

accurately I believe, is our measurement on the halogen retained in the ash. Given the percent halogen in the compound and measuring the halogen in the ash, by difference, an accurate measurement of the acid evolved is obtained. Error introduced by absorption of the reactive halogen acid in the test chamber is obviated by the ash measurement technique.

Toxic gas has been measured by Drager tubes, again evolved from the quartz combustion chamber.

Larger scale tests are summarized on the next slide. The largest scale tests on Wire and Cable materials that we carry out is that set forth in the IEEE 383 Testing Standard. This procedure tests cables mounted in an eight foot vertical tray. The fire source is a 70,000 BTU flame burner impinged on the cables for 20 minutes. The test is intended to measure the flammability and flame propagation of cables installed in a tray. Recall the importance of this because it is widely reported that cables facilitate fire spread from one area to another.

The second larger scale test is one designed for plenum cables. It (ASTM E85) involves the Steiner Tunnel Test. Multiple cables are mounted in a 25 foot horizontal tray and a measurement is made of the flame spread. The total fuel contribution of the materials, and the smoke produced by the burning cables are quantified by this procedure.

In our lab we have used the NBS smoke test carried out on various size slab samples. This procedure yields smoke, heat release and rate of toxic gas production.

The next slide lists groups and agencies responsible for standards in the Wire and Cable area.

Before I go into my wish list, I would like to briefly summarize to this point. Wire and cable materials do present a hazard in building construction. The potential is not primarily one of ignition or of fuel contribution but rather one of flame and smoke spread throughout a building. This adversity may be turned to advantage with proper design and installation. With proper detection devices installed in key locations, the tendency of cables in trays and conduits to spread smoke and flame could be used for early detection of a fire incident.

The wish list. First on my wish list are standards covering smoke and corrosive combustion gasses. I believe that if these were in existance we would have commercial products in the marketplace meeting such standards. I think it is a case of "necessity being the motherhood of invention." There is a tendency in any industry to strive to write the perfect standard on the first attempt. I feel this stalls progress. Standards once issued can be modified either up or down to reflect what is technically possible taking into account a balance of risk-cost-performance.

From a lab guy's point of view, I think we need flame retardants tailored for the specific high volume polymers, for example, polyethylene. We all realize that a given flame retardant additive may be effective in one polymer and not in another. One reason for the differences found is no doubt that the effectiveness relates to the decomposition temperature of the particular polymer and the additive package. More detailed studies to correlate FR effectiveness with polymer decomposition behavior I believe would allow for tailoring additives to specific commodity polymers.

I think that more development effort towards multi-purpose additives is required. There is a tendency to develop just a flame retardant material and not to consider perhaps the effect of structural changes of the additive

to afford benefits to performance in areas other than flame retardance. An illustrative example would be a flame retardant, smoke suppressant flexibilizer. Development and introduction of multiple function materials would command premiums in the marketplace.

You can control fire in the condensed phase and in the vapor phase. I believe a good deal of R&D has gone into developing intumescent coatings for cellulosics and the like. We are lacking similar materials for polymers such as polyolefins. Development of this type technology coupled with, for example, antimony-halogen synergism would go a long way towards optimizing flame retardance in the difficult to flame retard polymers such as polyolefins.

Finally, I think that we in the Wire and Cable industry who are involved with thermosetting resins have to develop new finishing techniques (new thermoset processes and materials) that are compatible with the existant flame retardant technology. At Union Carbide, we are involved in developing this technology.

Thank you.

POLYMERICS IN WIRE AND CABLE

POTENTIAL HAZARD IN

BUILDING CONSTRUCTION?

BUILDING CONSTRUCTION AND FIRE IMPACT

TYPE CONSTRUCTION	FIRE IMPACT
RESIDENTIAL*	FATALITIES (~10,000/YR; 90% TOTAL)
ONE AND TWO FAMILY	
APARTMENTS	
MOBILE HOMES	
NONRESIDENTIAL	PROPERTY LOSS (>60% TOTAL)
COMMERCIAL AND CUSTODIAL	
INDUSTRIAL	

APPROXIMATE COST - 10-12,000 LIVES/YEAR
>5B$/YEAR

* ~8% ELECTRICAL IN ORIGIN.

POLYMERS USED IN (MM LBS) BUILDING WIRE AND CABLES

	1978
PVC	400
NYLON	5
LDPE/HDPE	300
XLPE	40
EPR	10
NEOPRENE/HYPALON	2
TOTAL	757

% TOTAL POLYMERICS $\cong$ 12

SPECIFIC FEATURES OF INSTALLED WIRE AND CABLE

- W&C GENERALLY NOT AN IGNITION SOURCE.

- GROUPED CABLES (TRAY, CONDUITS) HAZARD POTENTIAL.

- SINGLES LOW HAZARD.

- NOT READILY ACCESSIBLE.

- AREA TO AREA ACCESS (FLAME, SMOKE SPREAD).

- CONNECT SAFETY AND CONTROL DEVICES.

COMBUSTION OF POLYMERS

EXTERNAL HEAT SOURCE + ∿∿∿ ⟶ ∿∿∿(FUEL)

AIR (O_2)

$\dfrac{\text{HEAT}}{\text{FLUX}}$

OXIDATIVE BURNING ⟵ FLAMING COMBUSTION ⟵ IGNITION

A SCHEMATIC FOR PROCESS

$$R \longrightarrow 2R'\cdot$$

$$R'\cdot + O_2 \longrightarrow R''CHO + HO\cdot$$

$$RCHO + HO\cdot \longrightarrow R''CO\cdot + H_2O$$

$$RCO \longrightarrow CO + H\cdot$$

$$CO + HO\cdot \longrightarrow CO_2 + H\cdot$$

OVERALL PROCESS:

$$RH + O_2 \longrightarrow CO_2 + H_2O$$
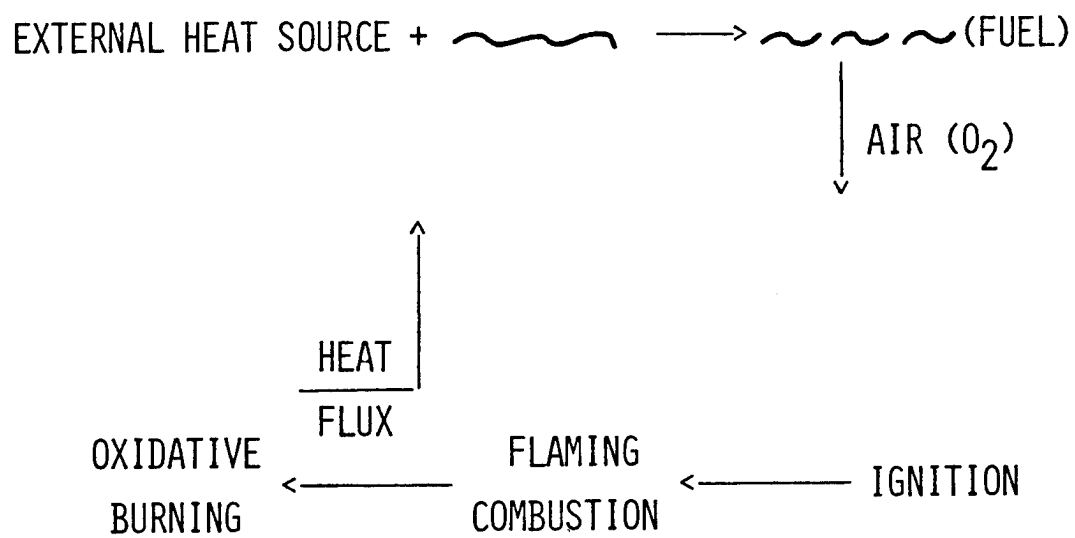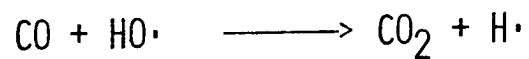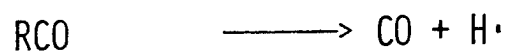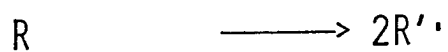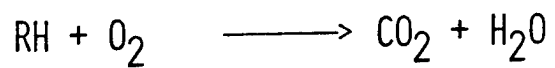
APPROACH TO FIRE CONTROL IN WIRE AND CABLES

- OVERALL SYSTEMS DESIGN (SPRINKLERS, SMOKE DETECTORS, FIRE STOPS, ETC.).

- CABLE CONSTRUCTION - METAL SHEATHED AND FLAME PAINTED.

- MATERIALS APPROACH:

    - FLAME RETARDANT ADDITIVES TO POLYMERS.

    - APPLICATION OF LESS FLAMMABLE POLYMERS.

    - COMBINATIONS.

I. ADDITIVE APPROACH TO

FLAME RETARDANCE IN

WIRE AND CABLE MATERIALS.

CHEMICAL "HEAT SINK" FILLERS

PRINCIPLE

HEAT DISSIPATION VIA ENDOTHERMIC REACTION.

EXAMPLE

$$AL(OH)_{3(S)} \xrightarrow{250-500^{o}C} AL_2O_{3(S)} + 3H_2O_{(G)}$$
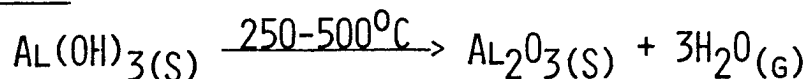
ALSO: $Mg(OH)_2$ AND CERTAIN COMPLEX SALTS.

ADVANTAGES:

MULTIPLICITY OF USE - EXTENDER, FIRE RETARDANT, COST.

NONFLAMMABLE, DILUENT BY-PRODUCT.

NONSMOKE MECHANISM.

DISADVANTAGES:

HIGH LOADINGS (>40 WEIGHT %) FOR SELF-EXTINGUISHING.

POOR ELECTRICALS (WET LOCATIONS).

MAJOR USE AREA:

JACKET COMPOUNDS.

A GAS PHASE INHIBITION SCHEME

HALOGEN (GAS PHASE)
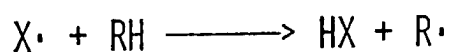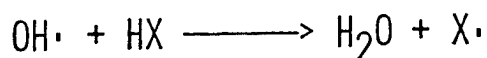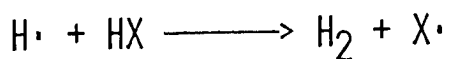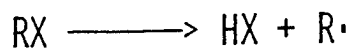
$$RX \longrightarrow HX + R\cdot$$

$$H\cdot + HX \longrightarrow H_2 + X\cdot$$

$$OH\cdot + HX \longrightarrow H_2O + X\cdot$$

$$X\cdot + RH \longrightarrow HX + R\cdot$$

ANTIMONY/HALOGEN SYNERGISM

$$HALOGEN\ ADDITIVE \longrightarrow HX$$

$$Sb_2O_3 + HX \longrightarrow SbX_3 + H_2O$$

$$Sb_2O_3 + HX \longrightarrow SbOCl + H_2O$$

INHIBITOR GENERATION

$$SbX_3 + H\cdot \longrightarrow Sb + HX$$

$$Sb + OH\cdot \longrightarrow SbOH^*$$

$$SbOH + H\cdot \longrightarrow SbO + H_2$$

INHIBITION REACTIONS

$$SbO + H\cdot \longrightarrow SbOH^*$$

$$SbOH + H\cdot \longrightarrow SbO + H_2$$

$$Sb + HO\cdot \longrightarrow SbOH^*$$

$$HX + H\cdot \longrightarrow H_2 + X\cdot$$
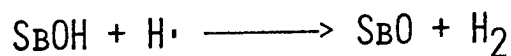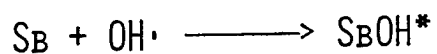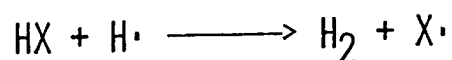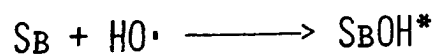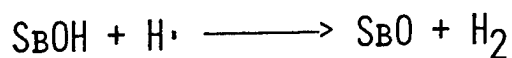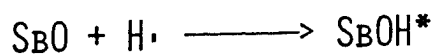
ANTIMONY/HALOGEN SYNERGISM IN WIRE AND CABLE

ADVANTAGES (ANTIMONY OXIDE)

- HIGHLY EFFECTIVE IN ALL WIRE AND CABLE COMPOUNDS.

- MINIMUM EFFECT ON ELECTRICAL PROPERTIES.

- GOOD COMPOUNDING CHARACTERISTICS.

- MINIMUM EFFECT ON EXTRUSION PROCESSING.

AREAS OF CONCERN

- HEAVY METAL TOXICITY POTENTIAL.

- LEWIS ACID PRODUCED (SbX_3) SMOKE INCREASED.

- ACID CORROSIVITY ON COMBUSTION.

- AFTERGLOW REIGNITION POTENTIAL IN CHAR.

- HIGH POUND-VOLUME COST.

II. INHERENTLY FLAME RESISTANT POLYMERS USED IN

WIRE AND CABLE BUILDING CONSTRUCTION.

POLYMER TYPES

POLYMER CLASS	GENERAL APPLICATION	FEATURES
FLUOROCARBON (FEP, ECTFE)	PLENUM CABLE	LOW SMOKE, LOW FLAME SPREAD
CHLOROCARBON*		
PVC	INSULATION AND JACKET	LOW COST; PLASTICIZERS NEEDED
CLPE	JACKET	SOME FR, FLEXIBILITY
NEOPRENE	JACKET	SOME FR, FLEXIBILITY
CLSO PE (HYPALON)	JACKET	SOME FR, FLEXIBILITY

* MAY BE USED IN COMBINATION WITH ADDITIVES: Sb_2O_3, ATH, P-BASED PLASTICIZERS.

FR - WIRE AND CABLE FORMULATIONS

POLYOLEFIN RESIN BASE (WEIGHT %)

	INSULATION (INDUSTRIAL)	JACKET
POLYETHYLENE COPOLYMER	50 - 60	50 - 60
FILLER (FR)	10 - 25	10 - 50
FR-ADDITIVE	15 - 20	0 - 20
ANTIMONY OXIDE	0 - 10	0 - 10
OTHERS (A/O, COUPLING, SMOKE SUPPRESSANT)	0.5 - 10	0.5 - 10

DIFFERENCE: I & J RESIN COPOLYMER CONTENT

PVC RESIN BASED BUILDING WIRE FORMULATIONS

(60°C RATED)

	INSULATION (WEIGHT %)	JACKET (WEIGHT %)
PVC	55-65	50-55
FILLERS (CLAY, $CaCO_3$)	10-15	15-20
PLASTICIZERS	20-30	20-35
STABILIZERS	3-7	3-7

FLAME RESISTANCE CONTROLLED: FR PLASTICIZERS

SYNERGISTIC ADDITIVES

(S_B, ETC.)

SMALL SCALE FIRE CHARACTERIZATION TESTING

FLAME SCREENING	MEASURES
OXYGEN INDEX TEST (ASTM D-2863-74)	RELATIVE FLAMMABILITY
VERTICAL WIRE FLAME TEST (VW-1)	BURNING EXTENT, TIME DRIP
HORIZONTAL WIRE FLAME TEST (UL SUBJECT 44)	

SMOKE	
ARAPAHOE SMOKE CHAMBER	SMOKE - GRAVIMETRICALLY ASH

CORROSIVITY (ACID GAS)	
ELEMENTAL ANALYSIS - SPECIFIC ION ASH	HX EVOLVED HX EVOLVED BY DIFFERENCE

TOXIC GAS	
DRAEGER TUBES	CO IN COMBUSTION GAS

LARGER SCALE FIRE CHARACTERIZATION TESTING

TEST/STANDARD	TESTS	FOR RESULTS
IEEE-383-74, (-422-77)	MULTIPLE CABLES MOUNTED 8' VERTICAL TRAY	FLAMMABILITY AND PROPAGATION OF CONSTRUCTION
MODIFIED ASTM E-84 TUNNEL TEST (UL-723, 910 (P))	MULTIPLE CABLES MOUNTED 25' HOR-ZONTAL TRAY	FLAME SPREAD, FUEL CONTRIBUTION AND SMOKE
NBS SMOKE TEST	SLAB SAMPLES (VARIABLE SIZES)	SMOKE, HEAT RE-LEASE RATE AND TOXIC GAS

GROUPS WITH RESPONSIBILITY FOR WIRE AND CABLE REGULATIONS

DEVELOPER	RECOMMENDATION AND INPUT TO STANDARD
UNDERWRITERS' LAB (UL)	CONSUMER PRODUCT SAFETY COMM.
AMERICAN SOCIETY FOR TESTING MATERIALS (ASTM)	INSTITUTE OF ELECTRICAL AND ELECTRONIC ENGINEERS (IEEE)
IEEE	NATIONAL ELECTRIC CODE (NEC) NATIONAL FIRE PROTECTION ASSOC. (NFDA)
INSULATED POWER CABLE ENGINEERS ASSOCIATION (IPCEA)	MODEL BUILDING CODES
FEDERAL GOV'T. (MILITARY, BUREAU OF MINES)	IPCEA, NATIONAL ELECTRICAL MANUFACTURERS ASSOCIATION

"FR USERS" NEEDS VIEW IN WIRE AND CABLE MATERIALS

ACCELERATED STANDARDS DEVELOPMENT COVERING SMOKE AND
CORROSIVE COMBUSTION GASES--REFLECTING A REALISTIC
RISK-COST-PERFORMANCE BALANCE.

ADDITIONAL FR ADDITIVES TAILORED FOR SPECIFIC HIGH
VOLUME POLYMERS AND END USES.

FURTHER DEVELOPMENTS OF MULTI-PURPOSE ADDITIVES OR SYSTEMS.

DEVELOPMENT OF INTUMESCENT AND/OR CHAR FORMING MATERIALS
SUITABLE FOR WIRE AND CABLE APPLICATION.

NEW WIRE AND CABLE FINISHING TECHNOLOGY AMENABLE TO
TODAY'S FR PRODUCTS.

"DESIGN & CONSTRUCTION OF

WIRE AND CABLE FOR FIRE RETARDANT APPLICATIONS"

Jerry C. Rose

United Technologies Corporation

Abstract

A review of the state of the art of flame retardant materials used in the wire and cable industry is presented. This includes both polymers and flame retardant chemicals used as additives in polymeric systems. Particular emphasis is placed on developmental testing. Flame tests being used in wire and cable are also reviewed, especially large scale burn tests. Related smoke and toxicity standards are also mentioned.

INTRODUCTION

A review of the impact that flame resistance and/or flame retardant additives have had on the wire and cable industry is a challenging task. It is especially so when one considers that all polymeric insulated wire in above ground applications can be made to burn. With few exception, there is a flame test involved to demonstrate a degree of flame resistance necessary for the intended application or end use. These uses vary from residential wiring within a structure to automotive, commercial buildings, mining, industrial, and the generation and transmission of electrical energy by the utility companies. This, of course, is a broad range. The common factor to all is not flame resistance.

Above all else, it is the safe and efficient transmission of electricity. Flame resistance is important, but is secondary to the electrical characteristics and performance of the products involved.

This paper will attempt to cover polymers used in the industry, flame retardant additives, material testing and requirements, flame tests, smoke, and toxicity.

POLYMERS

PVC - The largest volume polymer used in wire and

cable. It is generally limited in its use as an
insulation to low voltage (less than 1000 volts)
applications, but is utilized as an outer pro-
ductive jacket in higher voltage products. Its
inherently high flame resistance due to chlorine
content is reduced substantially by plasticizers
needed to obtain flexibility.

Polyethylene - High volume polymer used as a ther-
moplastic or cross-linked XLPE. It lacks inherent
flame resistance, but can be formulated to meet
flame test requirements.

EPDM - Generally used for insulations. Since it is
a hydrocarbon, it also needs additives to import
flame resistance.

Polychloroprene - Chlorinated elastomer used pri-
marily for jackets and low volt insulation. Very
good flame resistance.

Chlorosulfonated polyethylene - good heat and insul-
ating qualities with associated flame resistance.

Chlorinated polyethylene - Newest member of chlor-
inated polymers. Good heat and flame resistance.

Fluoropolymers - Excellent heat and flame resistance;
used for specialty applications.

FLAME RETARDANT ADDITIVES

There are generally two types of polymers systems that need to be considered.

Chlorinated polymers with high chlorine content generally have adequate flame resistance in typical formulations and don't require the addition of additional halogen. The addition of small quantities of antimony oxide usually suffices.

As the amount of chlorine in the polymer decreases, it sometimes became necessary to add more halogen from flame retardants along with antimony oxide.

Hydrocarbon base polymers containing no halogen require flame retardants. These are usually chlorine or bromine containing materials. They also must be used with antimony oxide in varying ratios for the greatest efficiency. It is possible to add a high degree of flame resistance and still maintain excellent electrical properties.

The hydrocarbon polymers also are very amendable to high loadings of alumina trihydrate. This results in polymer systems that have good flame resistance along with excellent heat ageing attribute, but limits their use to dry environments. The systems have very poor long term wet electrical properties at 75°C and 90°C.

Other additives have been proposed. These include other metal oxides and metal hydrates[1], borates, and others. It was recognized though by Trexler[2] that the most efficient systems is antimony oxide/halogen. This can easily be debated and has yet to be proved. However, it is the most widely accepted and used method to date.

MATERIAL DEVELOPMENT

Due to the critical nature or use of some of the materials, it is frequently necessary to devote months or even years to the development of wire and cable compounds. All material must conform to the designed life of the end product. In the extreme case, a nuclear generating station, this is 40 years. All of the polymer suppliers, wire and cable makers, and others, including FRCA members, have on-going research in this area. As an example of the type of effort needed, the results of U. Vaidya[3] are cited in Table I. This demonstrates all of the different tests that are necessary, especially heat ageing and electrical tests on small wire.

This represents only a small portion of a test program for Class IE Nuclear use. An Arrhenius graph of time vs. temperature needs to be obtained. This involves heat ageing for extended periods of time at several temperatures in order to predict a service life of 40 years at 90°C. After fabrication of the cable in

Whatever design and construction deemed necessary, the materials are then aged according to the predicted life, irradiated to a Design Basis Event or Loss of Coolant Accident (LOCA), Figure I. At the end of the test format, the cable shall withstand a dielectric test. The entire program is intended to simulate a normal 40 year life in a containment environment, and then be able to withstand a DBE at the end. All of this development and testing is for qualification purposes only. There is no guarantee that a Class IE order for cable will ever result due to economic and market factors.

FLAME TESTS

There are several flame tests used. The one commonly used for screening or evaluation of compounds is the LOI. It is rapid, reproducible, and predictive of material flamability on wire. It is seldom used in specifications, and is not recognized as an end product test.

The horizontal burn test of small wire is used in automotive wire, and sometimes in Underwriters Laboratories standards.

The test involves a bunson burner ignition of a horizontally placed wire. Flame spread and self-extinguishing are the criteria for passing.

Another U.L. test is the familiar VW-1 flame test in

which a burner flame is placed for 5 separate 15 second applications to a vertical wire. The flaming insulation shall not destroy a paper strip placed at a specified distance above the point of flame impingement. Many of the wire types in U.L. 44, 62, and 83 must pass this test. It is, of course, more severe than the horizontal test and frequently, attention must be paid to flame retardation by methods previously mentioned.

The most severe test of all is the IEEE-383 tray test. It is always specified on multi-conductor control cables and power cables. The test is conducted by placing a specified number of cables in a vertical position. The length of each cable is 8 feet. A propane burner is ignited at the bottom of the tray. A specified propane/air ratio generates 70,000 BTU/hr. at 1400-1600°F and burns for 20 minutes. At the conclusion of the time period, the burner is turned off. The cables in the tray must self-extinguish and also must not be destroyed at the top of the tray. This test has been adopted by U.L. for Tray Cable listing, and by Insulated Cable Engineers Association.

This test produces the most anomalies. It is now evident after several years of testing, that the design and construction of a cable is as important as the materials used. Metal conductor size, insulation thickness, metal shields, and overall jackets all play an important role for large size FR cable.

SMOKE REQUIREMENTS

It has only been recent that reduced smoke levels are being studied. Significant advances are being made, but the variability of results due to sample size, type, and test method do not indicate any standards in the near future. There are no regulations pending.

TOXICITY

The requirement for toxicity levels is much further away than even smoke levels. ICEA has only addressed flame, not the resultant effects. It is usually recognized that any large ignition in a building releases significant quantities of smoke and toxic gases. Whatever can be done to prevent or stall flame ignition or spread allows personnel a better chance to evacuate. An excellent study[4] of combustion products indicates that the decomposition of chlorinated materials results in large amounts of HCl gas. This of course is corrosive to electrical contacts and other metal surfaces. The release of HCl even from a small fire can be enough to severely damage electrical components. The effect of HCl on humnas is edema, one of the large causes of loss of life and health due to fires. It is interesting to note in the study that no HBr was detected from the decomposition of decabromodiphenyl oxide.

SUMMARY

A review of wire and cable materials and tests has been presented. The rapid growth of flame retardants in the industry reflect that specially formulated materials are now needed to meet more stringent requirements. Hopefully, you will recognize some problem areas and address yourselves to them now. Remember, the typical time for development of a cable product is 5 years. The end result of an improved product is that we, as consumers, are better protected in our homes, work place, or wherever we may be.

REFERENCES

1) M. Moseman and J.D. Ingham, Rubber Chem. & Tech., 51, (5), 970, 1978.

2) H.E. Trexler, Rubber Chem & Tech., 46 (4), 1114, 1973.

3) U. Vaidya, 114th Meeting of the Rubber Division of the Am. Chem. Soc., Boston, Oct. 1978.

4) Coal Mine Combustion Products Identification and Analysis, U.S. Dept. of the Interior Bureau of Mines. Final Report on Contract No. HO133004, Sept. 1978.

Table I

Compound	NDX-4474-C
NORDEL 2722 Pellets	90
Dynh #1	20
Zinc Oxide	5
ERD-90	5
TLD-90	-
Paraffin	5
Antioxidant ZMB	2
Aminox	1
Translink Clay 37	60
Burgess KE Clay	-
Vinyl Silane A-172	1
SRF Black	2
Dechlorane Plus 25	33
Antimony Oxide	12
Di-Cup R	3
Vul-Cup R	-

Properties on #12 AWG Wire with 45 Mil Insulation

Stress/Strain Original

100% Modulus, psi	810
Tensile Strength, psi	1650
Elongation at Break, %	290

100% Modulus at 130°C, psi — 265

30 Days at 302°F

Tensile Strength, psi	1260
Elongation at Break, %	200

10 Days at 325°F

Tensile Strength, psi	1280
Elongation at Break, %	200

5 Days at 350°F

Tensile Strength, psi	1000
Elongation at Break, %	110

90 Days at 275°F

Tensile Strength, psi	1590
Elongation at Break, %	290

Moisture Absorption

7 days at 70°C, mgms/in^2	1.8

18 Hrs. ASTM #2 Oil at 121°C

% Tensile Retained	62
% Elongation Retained	61

FR-1 Flame Test   OK

Rate of Oxidation (Arrhenius Plot)

  Temperature to retain 60% of   124°C
  original tensiles after
  10,000 hours.

  Hours needed to retain 60% of   60,000
  original tensiles at 110°C

Immersion in 90°C Water with 600V (A.C.)
Applied Continuously During Immersion

Volts/Mil		40	80
SIC	1 day	2.74	2.74
	7 days	2.76	2.76
	14 days	2.80	2.80
	6 months	2.99	2.99

% Increase in SIC
After 6 Months   9.1

PF, %	1 day	0.45	0.47
	7 days	0.33	0.36
	14 days	0.34	0.38
	6 months	0.44	0.46

  Volts/Mil   40   80

% Increase in PF, % - 6 Months   0.0

Stability Factor, After 6 Months   0.02

IR Constant K   >50,000

Figure 1

LOCA SIMULATION
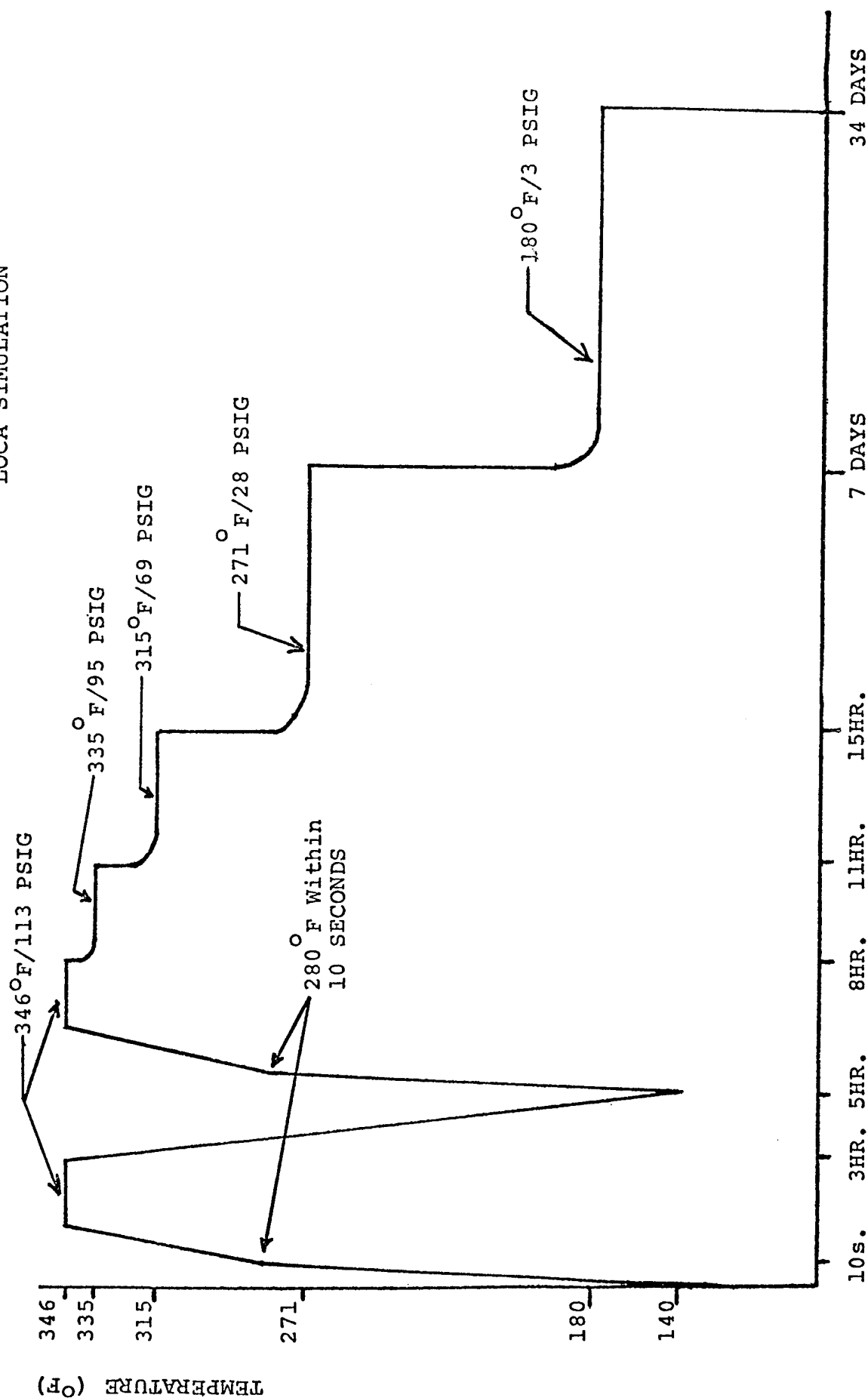
FIGURE 1

TEMPERATURE/PRESSURE PROFILE

346°F/113 PSIG

335°F/95 PSIG

315°F/69 PSIG

271°F/28 PSIG

180°F/3 PSIG

280°F Within
10 SECONDS

TEMPERATURE (°F)

346
335
315
271
180
140

10s. 3HR. 5HR. 8HR. 11HR. 15HR. 7 DAYS 34 DAYS

Biography

Jerry Rose is the Chief Polymer Chemist for Essex Group, UTC at Lafayette, IN. He has been associated with the wire and cable industry for 13 years. He first joined Essex in 1968 as a Research Fellow at Carnegie-Mellon University, Mellon Institute in Pittsburgh, transferring in 1973 to Lafayette. Jerry has a B.S. in Chemistry from Ohio State University, and a M.S. in Chemistry from Marshall University. Prior to Mellon Institute, he had worked 5 years at Chemical Samples Co., Columbus, Ohio as an organic chemist.

"URETHANE ROOFING AND THE BUILDING CODES"

James D. Orefice

Arco Chemical Co.

ABSTRACT

Urethane Roofing and the Building Codes

The effects of the national building codes on the manufactuie and use of foam plastic roofing materials, primarily urethane foam-based materials, will be addressed. Specific foam plastic building code language which is found is ICBO, SBCCI, and Boca will be examined as it relates to its effect on the use of foam plastic roofing materials.

The historical growth of regulatory activities in foam plastic building products and/or effects on present and future use of these materials will be examined.

URETHANE ROOFING AND THE BUILDING CODES

THE BUILDING CODE TRADITION IN THE UNITED STATES HAS DEVELOPED AS A SYSTEM OF LOCALLY ENACTED AND LOCALLY ENFORCED LAWS UNDER THE PREMISE THAT THE RESIDENTS OF EACH COMMUNITY CAN SET THE RULES FOR THE DEVELOPMENT OF THEIR OWN COMMUNITY.

THERE ARE, HOWEVER, APPROXIMATELY 10,000 MUNICIPAL GOVERNING UNITS IN THE UNITED STATES AND IF EACH ONE WENT TOTALLY ITS OWN WAY IT WOULD PRESENT CONTRACTORS AND BUILDING MATERIAL SUPPLIERS WITH A COMPLETELY DIFFERENT SET OF RULES FOR EACH COMMUNITY. IN ORDER TO RAISE THE STANDARDS OF BUILDING CODES, AND ACHIEVE SOME UNIFORMITY, COMMUNITIES JOINED TOGETHER IN SEVERAL GEOGRAPHICAL AREAS TO ESTABLISH MODEL CODE PROVISIONS WHICH THE INDIVIDUAL COMMUNITIES COULD ADOPT AS SUGGESTED, OR IN A REVISED VERSION. (SLIDE 1). WHAT EVENTUALLY EMERGED FROM THESE EFFORTS WAS THREE MAJOR ORGANIZATIONS KNOWN AS MODEL CODE GROUPS. THEY ARE THE INTERNATIONAL CONFERENCE OF BUILDING OFFICIALS (ICBO), THE SOUTHERN BUILDING CODE CONGRESS INTERNATIONAL (SBCCI), AND BUILDING OFFICIALS AND CODE ADMINISTRATORS INTERNATIONAL (BOCA). THESE GROUPS ARE CONSENSUS ORGANIZATIONS, MEANING THAT PROPOSALS FOR CHANGES,BOTH IN THEIR RULES AND IN THEIR BOOKS OF STANDARDS, ARE ADOPTED ONLY AFTER FULL AND OPEN DELIBERATION WHICH IS OPEN TO THE PUBLIC AND A VOTE OF THE MEMBERSHIP REPRESENTATIVES.

(SLIDE 2) THERE IS, IN ADDITION, A FOURTH MODEL CODE CALLED THE NATIONAL BUILDING CODE. THE NATIONAL BUILDING CODE UNTIL QUITE RECENTLY WAS WRITTEN BY THE STAFF OF THE AMERICAN INSURANCE ASSOCIATION AND WAS NOT

CONSENSUS CODE. THIS PAST YEAR, THE NATIONAL CONFERENCE OF STATES FOR BUILDING CODES AND STANDARDS (NCS-BCS) TOOK OVER THE RESPONSIBILITY FOR THE NATIONAL BUILDING CODE. NCS-BCS IS IN THE PROCESS OF REQUESTING INPUT FROM GOVERNMENT, INDUSTRY, AND OTHER CODE MAKING BODIES ON WAYS THAT THEY CAN REWRITE THE CODE USING A CONSENSUS TYPE ORGANIZATION. HOWEVER, THIS MOVE IS BEING RESISTED IN MANY QUARTERS MAINLY DUE TO THE FACT THAT THE INTRODUCTION OF A FOURTH MODEL BUILDING CODE DOES NOT APPEAR TO SERVE ANY USEFUL PURPOSE.

(SLIDE 3) IN THE LAST TWENTY YEARS, EFFORTS HAVE BEEN MADE TO REDUCE THE NUMBER OF BUILDING CODES THROUGH STANDARDIZATION. IN THE 1970's, ICBO, BOCA, AND SPCC GOT TOGETHER AND FORMED THE COUNCIL OF AMERICAN BUILDING OFFICIALS (CABO). THIS WAS DONE AS A JOINT EFFORT TO ACHIEVE SOME DEGREE OF UNIFORMITY AMONG THE MODEL CODE GROUPS WHILE STILL ALLOWING FOR DIFFERENT REGIONAL AND GEOGRAPHICAL NEEDS. CABO AND ITS OPERATING ARM, BCMC, EXPLORE MEANS OF AGREEMENT ON CODE LANGUAGE THROUGH THE SAME TYPE OF CONSENSUS MEANS AS THE PARENT ORGANIZATIONS.

IT APPEARS TO ME THAT THE ADDITION OF ANOTHER MODEL BUILDING CODE CAN ONLY MUDDY THE WATER BY ADDING MORE EXPENSE FOR BOTH INDUSTRY PARTICI-PANTS AS WELL AS BUILDING OFFICIALS, CERTAINLY MORE CONFUSION, AND INEVITABLE DELAYS INHERENT TO ANY NEW ORGANIZATION.

(SLIDE 4) SOME STATES HAVE ENACTED STATE-WIDE BUILDING CODES, USUALLY THESE CODES SET MINIMUM PROVISIONS AND ALLOW MUNICIPALITIES TO REVISE THEM WITHIN CERTAIN LIMITATIONS. USUALLY, BUT NOT NECESSARILY, THE

STATE BUILDING CODE WILL REFERENCE ONE OF THE THREE MODEL BUILDING CODES. NEW JERSEY, CALIFORNIA, NORTH CAROLINA, AND WISCONSIN ARE EXAMPLES OF STATES WITH MODEL BUILDING CODES WHICH REFERENCE A MAJOR MODEL CODE. A CODE PROVISION PROMULGATED BY A MODEL BUILDING CODE DOES NOT BECOME LAW UNLESS, AND UNTIL, IT IS APPROVED BY A GOVERNING BODY WHICH HAS JURISDICTION OVER THAT CODE. THIS CAN BE ON A STATE OR ON A MUNICIPAL LEVEL.

(SLIDE 5) SPECIFIC PROVISIONS ON PLASTIC FOAMS BEGAN ENTERING THE MODEL CODES IN 1975. THE MAJOR FACTOR IN THE DRAFTING OF THESE MODEL CODE PROVISIONS WAS THE PLASTICS AND CONSTRUCTION COUNCIL OF THE SOCIETY OF THE PLASTICS INDUSTRY. THE PICC SUBMITTED MODEL BUILDING CODE LANGUAGE ON PLASTICS IN AN EFFORT TO CLEAR THE AIR ON THE SAFE USES OF FOAM PLASTICS IN CONSTRUCTION, AS WELL AS TO MAKE RECOMMENDA-TIONS ON THE PROPER USE OF FOAM. (SLIDE 6) THE LATEST VERSIONS OF THESE MODEL CODES ARE ICBO'S 1980 UNIFORM BUILDING CODE WITH THE 1981 SUPPLEMENT, SOUTHERN BUILDING CODE CONGRESS'S 1979 STANDARD BUILDING CODE AND BOCA'S BASIC BUILDING CODE - 1981. EACH MODEL CODE CONTAINS SOMEWHAT THE SAME REQUIREMENTS CONCERNING FOAM PLASTICS INSULATIONS BUT THERE ARE DIFFERENCES WITHIN THE MODEL CODES IN VARIOUS AREAS CON-CERNING FOAM PLASTICS. HENCE, IT IS IMPORTANT THAT THESE DIFFERENCES BE POINTED OUT AND THAT WE BE AWARE OF THE REASONS BEHIND THEM.

(SLIDE 7) TODAY WE ARE GOING TO ADDRESS OURSELVES TO THE ROOFING PRO-VISIONS OF THE MODEL CODES. WE WILL BASICALLY COVER THE ORIGINAL PRO-POSED ROOFING LANGUAGE AS IT APPEARED IN 1975 COMPARED WITH THE ROOFING

LANGUAGE AS IT APPEARS IN 1980 AND TAKE A LOOK AT WHAT IS PROPOSED
IN 1981.

(SLIDE 8)   ALL THREE OF THE MODEL BUILDING CODES, WHICH YOU'LL NOTICE
COVER VARYING GEOGRAPHICAL AREAS IN THE UNITED STATES (SLIDE 9), HAVE
THE SAME MINIMUM REQUIREMENTS FROM A COMBUSTIBILITY POINT OF VIEW.
THAT IS, THAT FOAM PLASTICS WOULD HAVE NO GREATER THAN 75 FLAME SPREAD
AND NO GREATER THAN 450 SMOKE AS TESTED ON THE ASTM E 84 TUNNEL TEST.
NOT DIRECTLY RELATED TO ROOFING, BUT INCLUDED IN ALL OF THE BUILDING
CODES, IS THE REQUIREMENT FOR LESS THAN 25 FLAME SPREAD AND LESS THAN
450 SMOKE FOAM PLASTIC FOR METAL PANELS.   THIS REQUIREMENT CAME AS A
RESULT OF AN EXTENSIVE AMOUNT OF TEST WORK DONE USING THE FACTORY MUTUAL
FULL SCALE CORNER TEST WHICH SHOWED THAT WHEN LESS THAN 25 FLAME SPREAD
FOAMS WERE INCORPORATED IN METAL PANELS THESE PANELS COULD BE USED ON
NON-SPRINKLER CONSTRUCTION.   TWO THINGS NEED TO BE SAID AT THIS POINT.
ONE, THE FLAME SPREAD REQUIREMTNS WHICH ARE USED THROUGHOUT THE FOAM
PLASTICS SECTION OF THE BUILDING CODE, WERE PUT IN AT THE EXPRESS RE-
QUEST OF THE BUILDING CODES THEMSELVES.   THE E 84 TUNNEL TEST HAS BE-
COME A COMBUSTIBILITY TEST STANDARD FOR BUILDING CONSTRUCTION AND WAS
USED EXTENSIVELY THROUGHOUT THE MODEL CODES TO DEFINE THE RELATIVE
FLAMABILITY OF DIFFERENT BUILDING MATERIALS (SLIDE 10).   BUILDING
CODE OFFICIALS DID NOT LOOK UPON THE FTC CLAIMS CONCERNING THE E 84
TUNNEL TEST WITH ANY DEGREE OF ENTHUSIASM AND, AS A MATTER OF FACT,
BELIEVED THAT THE FTC WAS REMOVING FROM THEM A RELIABLE TOOL WHICH
HAD BECOME A STANDARD IN THEIR INDUSTRY.

(SLIDE 11) THE SECOND POINT WE NEED TO KEEP IN MIND AS WE GO THROUGH THIS PRESENTATION IS THAT THE NUMERICAL FLAME SPREAD RATINGS ARE NOT INTENDED TO REFLECT HAZARDS PRESENTED BY THIS OR ANY OTHER MATERIALS UNDER ACTUAL FIRE CONDITIONS. IT WOULD BE USEFUL TO KEEP THIS CAVIET IN MIND BECAUSE THE STATEMENT LOOMS LARGE IN THE EVOLUTIONARY TENDENCIES WITHIN THE BUILDING CODE.

(SLIDE 12) THE ROOFING PARAGRAPH OF THE 1976 ICBO AND SOUTHERN BUILDING CODE INTRODUCES NEW COMBUSTIBILITY TESTING. THE ROOFING SECTION IS BROKEN UP INTO TWO PARTS. THE FIRST PARAGRAPH COVERS COMMERCIAL AND INDUSTRIAL CONSTRUCTION. IT SAYS "FOAM PLASTICS MAY BE USED AS A ROOF COVERING IF THE FOAM PLASTIC IS A PART OF THE CLASS A, B OR C ROOFING ASSEMBLY. THAT PLASTIC FOAM WHICH IS NEAREST THE INTERIOR OF THE BUILDING SHALL BE PROTECTED BY AN APPROVED BARRIER WHICH NEED NOT HAVE A 15 MINUTE RATING." THE ORIGINAL SUBMISSION OF PARAGRAPH 1 REQUIRED A 15 MINUTE THERMAL BARRIER, BUT SINCE SO MUCH WOOD DECKING IS USED IN LIGHT COMMERCIAL ROOF DECKS IT WAS FELT ADVISABLE TO ALLOW THOSE KIND OF ROOF DECKS WHICH HAD TRADITIONALLY BEEN USED WITHOUT FURTHER TESTING. THIS WAS, BY THE WAY, AT THE REQUEST AND WITH THE APPROVAL OF, THE BUILDING OFFICIALS.

(SLIDE 13) THE SECOND PARAGRAPH IS PRIMARILY DESIGNED FOR RESIDENTIAL CONSTRUCTION, BUT INCLUDES SOME LIGHT COMMERCIAL. IT SAYS "ORDINARY ROOF COVERINGS OTHER THAN CLASS A, B OR C MAY BE APPLIED OVER FOAM PLASTICS WHEN THE FOAM IS SEPARATED FROM THE INTERIOR OF THE BUILDING BY PLYWOOD SHEATHING NOT LESS THAN 1/2" IN THICKNESS WITH EXTERIOR GLUE,

WITH EDGES SUPPORTED BY BLOCKING, TONGUE AND GROOVE JOINTS, OR OTHER APPROVED TYPE OF EDGE SUPPORT, OR AN EQUIVALENT MATERIAL." ALL THIS BASICALLY SAYS IS THAT YOU CAN USE STANDARD ASPHALT SHINGLES IN RESIDENTIAL CONSTRUCTION WITH A FOAM PLASTIC BASE PROVIDED CERTAIN CONSTRUCTION PERIMETERS ARE MET IN THE BUILDING OF THE ROOF DECK ITSELF.

(SLIDE 14) YOU WILL NOTE THAT IN THE INDUSTRIAL AND COMMERCIAL TYPES OF ROOF THERE IS A REQUIREMENT FOR A CLASS A, B OR C ROOFING ASSEMBLY. THIS RATING IS THE RESULT OF TESTING BY ASTM E 108 OR US 790 WHICH IS AN EXTERIOR FIRE SOURCE TEST. THE A, B OR C RATING IS THE RESULT OF VARIOUS BRAND SIZES WHICH ARE PLACED ON THE ROOF DECK AND ALLOWED TO BURN, THEN MEASURING THE DISTANCE THE FLAME TRAVELS AWAY FROM THE BRAND. PLEASE NOTE THAT THERE IS NO SPECIFIC REQUIREMENT IN THIS LANGUAGE DIFFERENTIATING BETWEEN VARIOUS TYPES OF ROOF DECKING, SUCH AS STEEL, CONCRETE OR WOOD. NOTE ALSO THAT THE CODE LANGUAGE DOES NOT TAKE INTO ACCOUNT ANY INTERIOR FIRE SOURCE. THE TESTS THAT WE HAVE MENTIONED, ASTM E 108 AND US 790 ARE EXTERIOR FIRE SOURCES THAT MEASURE DAMAGEABILITY TO THE ROOF FROM OUTSIDE FIRE EXPOSURE. THE THIRD DESIGNATION IN THE SLIDE, UBC 32-7, IS ICBO'S DESIGNATION OF UL 790 TEST PROCEDURE FOUND IN THEIR BOOK OF STANDARDS. THE PRESUMPTION IN THIS LANGUAGE WAS THAT THE APPROVED BARRIER WOULD PROVIDE SUFFICIENT PROTECTION FROM AN INSIDE FIRE SOURCE AND OTHER THAN THAT THE DECKS THEMSELVES WOULD PROVIDE PROTECTION FROM AN INSIDE FIRE SOURCE. IN RESIDENTIAL CONSTRUCTION IT WAS FELT THAT SINCE SO MUCH EXPOSED WOOD WAS ALLOWED ALREADY THERE WAS NO NEED TO OVERKILL ON THE USE OF MATERIALS ABOVE THE EXPOSED WOOD.

(SLIDE 15) THE FINAL NOTE WE NEED TO MAKE CONCERNING THIS ORIGINAL LANGUAGE WAS THAT THE BASE REQUIREMENTS OF THE GENERAL SECTION HAD TO BE MET IN ORDER TO SATISFY THESE CODE REQUIREMENTS. THAT IS TO SAY, FOAM PLASTICS USED FOR ROOF INSULATION HAD TO HAVE A MAXIMUM 75 FLAME SPREAD AND A MAXIMUM 450 SMOKE WHEN TESTED BY ASTM E 84.

(SLIDE 16) IT SHOULD BE KEPT IN MIND THAT FOAM PLASTIC MATERIALS WHICH DID NOT MEET THESE REQUIREMENTS COULD BE APPROVED UNDER THE SPECIFIC APPROVAL SECTION OF ALL THREE OF THE CODES. THE SPECIFIC APPROVAL SECTION OF ALLOWS FOR MATERIALS TO BE TESTED BASED ON ALTERNATIVE TESTING APPROACHES WHICH MAY OR MAY NOT BE IN THE CODE TEXT. THE LAST SENTENCE OF THE SPECIFIC APPROVAL SECTION ALLOWS APPROVAL TO BE BASED ON END USE, QUANTITY, LOCATION AND SIMILAR CONSIDERATIONS WHERE TESTS WOULD NOT BE APPLICABLE OR PRACTICAL. THE INTENT WAS TO ALLOW THE BUILDING CODE OFFICIAL OR RESEARCH COMMITTEE BROAD LATITUDE IN APPROVING PRODUCTS BASED ON A RAPIDLY CHANGING STATE OF THE ART. (SLIDE 17) SOME MANUFACTURERS, SUCH AS COMPOSITE BOARD MANUFACTURERS, VERY EARLY ON WENT FOR SPECIFIC APPROVAL OF THEIR PRODUCTS BASED ON THIS PARTICULAR SECTION OF THE CODE.

(SLIDE 18) IN 1977 THE PICC SUBMITTED TO THE MODEL CODE GROUPS AN ADDITION TO THE ROOFING SECTION CONCERNING SMOKE. THAT STATEMENT WAS "... FOR SUCH PLASTIC FOAMS, THE SMOKE DENSITY IS NOT LIMITED.". THE REASON FOR THIS PROPOSAL WAS SIMPLE. REQUIRING A SPECIFIC SMOKE RATING ON A FOAM PLASTIC MATERIAL UNDERNEATH FOUR OR FIVE PLYS OF HOT MOP BUILT-UP ROOFING DID NOT MAKE MUCH SENSE. IT MADE NO SENSE EITHER FROM

THE TECHNICAL PERSPECTIVE OR FROM THE COMMON SENSE PERSPECTIVE. THIS CHANGE, WHICH HAS BEEN ADOPTED BY ALL THREE OF THE MODEL CODES, WAS ONE OF THE LEAST CONTROVERSIAL CODE CHANGES SUBMITTED BY THE PICC.

(SLIDE 19) THE NEXT MAJOR REVISION OF THE ROOFING SECTION WAS INITIATED IN LATE 1977 AND WAS ADOPTED BY ICBO AT THEIR ANNUAL MEETING IN ANCHORAGE IN SEPTEMBER OF 1979. THIS CHANGE INVOLVED THE ADDITION OF TWO STANDARD TEST PROCEDURES FOR EVALUATING THE FIRE RESISTENCE OF FOAM PLASTIC MATERIALS WHEN USED AS ROOF INSULATION. THE TWO TESTS WERE UL SUBJECT 1256 AND THE FACTORY MUTUAL CONSTRUCTION MATERIALS CALORIMETER. THESE TWO TESTS HAVE BEEN DEVELOPED IN THE LATE 1950'S IN RESPONSE TO THE NEED FOR EVALUATION OF MATERIALS WHICH ARE EXPOSED TO AN INTERIOR FIRE SOURCE IN A METAL ROOF DECK ASSEMBLY. THIS PROBLEM WAS DISCOVERED AFTER AN INTERIOR FIRE WHICH SHOULD NOT HAVE BEEN A MAJOR PROBLEM RESULTED IN THE LOSS OF AN ENTIRE GENERAL MOTORS PLANT IN LAVONIA, MICHIGAN IN THE MID-50'S. IN RETROSPECT, THE PROBLEM WAS OBVIOUS. BUILT-UP ROOFING HAD BEEN HOT MOPPED DIRECTLY DOWN ON A COMBUSTIBLE FIBERBOARD MATERIAL WHICH WAS LOOSELY CALLED INSULATION AND AS THE FIRE BURNER THROUGH THE FIBER-BOARD MATERIAL, IT MELTED THE ASPHALT AND THE DECK WAS HEATED. THE MELTED ASPHALT RAN AND LEAKED THROUGH THE JOINTS IN THE DECKING, DROPPING DROPLETS OF BURNING ASPHALT INTO THE PLANT FROM ONE END TO THE OTHER, THEREBY SPREADING THE FIRE. THE INVESTIGATION OF THIS FIRE RESULTED IN THE DEVELOPMENT OF WHAT BECAME KNOW AS THE WHITE HOUSE TEST. THIS WAS A 100 FOOT LONG BUILDING WHICH COULD BE USED FOR FULL SCALE FIRE TESTING ROOF ASSEMBLIES. THE PROBLEM WAS THAT THE TEST WAS PROHIBITIVELY EXPENSIV AND SMALLER SCALE TESTS CORRELATED TO THE WHITE HOUSE TEST WERE NEEDED.

THIS IS WHERE THE CALORIMETER AND UL 1256 COME INTO FOCUS. FACTORY MUTUAL'S ANSWER TO A CORRELATABLE SMALL SCALE TEST IS THE CALORIMETER. UL'S ANSWER IS SUBJECT 1256. BOTH OF THESE TESTS WERE DEVELOPED FAIRLY EARLY ON AND BOTH WERE AND ARE FULLY RECOGNIZED TESTS FOR THE EVALUATION OF ROOF DECK ASSEMBLIES AS REGARDS AN INTERIOR FIRE SOURCE. THE PICC FELT THAT THESE WERE THE TWO STANDARD TESTS THAT SHOULD BE USED FOR EVALUATION OF ROOFING MATERIALS AND AS A RESULT SUBMITTED A CODE CHANGE.

(SLIDE 20) THE CONTROVERSIAL SECTION IN THIS PARTICULAR CODE CHANGE IS THE LAST PARAGRAPH. HERE, THE STATEMENT IS MADE THAT THE THERMAL BARRIER IS WAIVED IN FIELD ASSEMBLY ROOF COVERINGS INCORPORATING A FOAM PLASTIC HAVING A FLAME SPREAD OF 75 OR LESS AND ALSO MEETING THE REQUIREMENTS OF UBC STANDARD 17-4 WHICH IS THE UL 1256 AND OR FACTORY MUTUAL CALORIMETER. THE REASONING BEHIND THIS LANGUAGE WAS THAT SPRAY FOAM MATERIALS COULD EASILY BE MISUSED AND THEREFORE A MINIMUM FLAME SPREAD REQUIREMENT WAS NECESSARY TO PREVENT THIS MISUSE. IT NEEDS TO BE KEPT IN MIND THAT THE CODE SUBMITTAL AS ORIGINALLY INTENDED ALLOWED FOAM PLASTICS WHICH, AS PART OF AN ASSEMBLY, PASSED EITHER UL 1256 OR THE FACTORY MUTUAL CALORIMETER TO BE USED IRRESPECTIVE OF THEIR FLAME SPREAD RATING. AS MOST OF YOU ARE AWARE, THE FEDERAL TRADE COMMISSION ACTIVITY IN THE MID-70'S WAS AIMED SQUARELY AT MISREPRESENTATIONS OF COMBUSTIBILITY TEST DATA. WE BELIEVE THAT THE ADDITION OF THESE TWO ROOFING TESTS AND DELETION OF FLAME SPREAD RATINGS WAS IN THE SPIRIT OF THE FTC CONSENT DECREE. ON THE OTHER HAND, SOME MEMBERS AND SOME BUILDING OFFICIALS WANTED THE FLAME SPREAD RATING LEFT IN FOR SPRAY FOAM, HENCE YOU SEE IT IN THE LANGUAGE.

(SLIDE 21) ANOTHER PARAGRAPH IN THIS CODE CHANGE SAYS THAT " FOAM PLASTIC WHICH IS A COMPONENT TO FACTORY MADE INSULATION BOARD, OR A FACTORY MADE ASSEMBLY, WHICH ALSO APPLIES WITH UBC STANDARD 17-4, NEED NOT MEET THE REQUIREMENTS OF 1717 A ABOVE.". THAT 1717 A MEANS BOTH FLAME SPREAD AND THERMAL BARRIER REQUIREMENTS ARE WAIVED FOR A FACTORY MADE INSULATION BOARD.

AS WE SEE IT, THERE ARE SOME MAJOR PROBLEMS WITH THIS ADOPTION AS IT IS; 1. (SLIDE 22) WE DO NOT BELIEVE THAT IT IS THE INTENT OF BUILDING CODE LANGUAGE PER SE TO POLICE THE MISUSE OF BUILDING MATERIALS. A MATERIAL WHICH MEETS THE REQUIREMENTS OF THE BUILDING CODE WHEN USED CORRECTLY SHOULD BE ALLOWED TO BE USED. IT IS THE BUILDING OFFICIALS FUNCTION TO PREVENT MISUSE. IF WE TOOK THE POSITION WITH EVERY BUILDING MATERIAL THAT THE CODE SHOULD BE WRITTEN TO PREVENT MISUSE, WE WOULD ONLY BE ABLE TO BUILD OUT OF CONCRETE UNDER 10 FEET OF WATER. 2. (SLIDE 23 WITH THIS LANGUAGE THERE IS AN IMPLICATION THAT THE 75 FLAME SPREAD RATING IS SAFE, OR SAFER, THAN A NON-75 FLAME SPREAD RATED MATERIAL. THAT STATEMENT IS PATENTLY FALSE, ESPECIALLY WHEN ONE CONSIDERS THE APPLICATION. (SLIDE 24) WE SHOULD KEEP THE FTC'S CAVEAT FULLY IN MIND IF WE CONSIDER THIS PROBLEM. IF THE CONTRACTOR WERE TO SPRAY 75 FLAME SPREAD FOAM WITH AN UNLIMITED SMOKE RATING AND LEAVE IT EXPOSED ON THE INSIDE OF A BUILDING, THE FACT THAT IT IS 75 FLAME SPREAD WILL NOT HELP TO PREVENT THAT ROOM FROM FLASHING OVER. 3. (SLIDE 25) IF THIS ARGUMENT IS VALID FOR FLAME SPREAD, IT IS ALSO VALID FOR SMOKE SINCE EVERYONE KNOWS THAT SMOKE IS THE MAJOR FACTOR IN MOST FIRE FATALITIES.
4. (SLIDE 26) LATELY AN EXTENSION HAS BEEN MADE THAT EVEN COMPOSITE BOARD SHOULD HAVE A 75 FLAME SPREAD BECAUSE IT IS POSSIBLE TO MISUSE

THEM IN THE FIELD. IT IS SAID THAT CONTRACTORS FLIP THE BOARDS OVER PUTTING THE ASPHALT SATURATED FELTS DOWN ON THE DECK WITH THE NON-COMBUSTIBLE UP IN AN EFFORT TO PREVENT BLISTER FORMATION. THE ARGUMENTS GIVEN ABOVE FOR SPRAY FOAM HOLD AS WELL FOR BOARD MATERIALS AND I THINK THE THIRD POINT IS THAT THERE IS SOME IMPLICATION THAT A 75 FLAME SPREAD MATERIAL IS "BETTER" FOR THIS APPLICATION IS TERRIBLY MISLEADING. THERE IS NO DATA TO SHOW THAT A 75 FLAME SPREAD FOAM WHEN PLACED DIRECTLY ON A ROOF DECK ACTS ANY DIFFERENTLY IN THE CALORIMETER OR IN UL 1256 THAN A 250 OR 750 FLAME SPREAD FOAM. THE PICC IS REQUIRED TO SUBMIT CODE CHANGES ONLY WHEN THERE IS SUFFICIENT TECHNICAL BACK UP TO SUPPORT THEM. IN MY OPINION, THE ISSUE OF 75 FLAME SPREAD IN ROOFING MATERIALS HAS NO TECHNICAL DATA TO SUPPORT IT, WHEREAS, THERE IS A TREMENDOUS AMOUNT OF DATA AVAILABLE ON UL 1256 AND FACTORY MUTUAL CALORIMETER FOAM TESTING. (SLIDE 27) THIS LEADS US TO OUR LAST SUB-MITTAL-THAT TO BOCA WHICH WAS ADOPTED BY THEM IN NEWPORT, VIRGINIA IN THE SUMMER OF 1979. THIS IS, WE BELIEVE, THE BEST LANGUAGE FOR ROOFING AND IT COVERS RESIDENTIAL, COMMERCIAL AND INDUSTRIAL AND DOES NOT INVOLVE ITSELF WITH EXTRANEOUS TEST REQUIREMENTS WHICH HAVE NO BEARING ON THE END USE APPLICATION. THIS LANGUAGE SIMPLE "FOAM PLASTIC ROOF INSULATION WHICH COMPLIES WITH FACTORY MUTUAL STANDARD 4450 OR UNDERWRITERS LABORATORY 1256 NEED NOT MEET THE GENERAL REQUIREMENTS UNDER 876.5.1.".

(SLIDE 28) THE PICC CONTINUES TO LOOK AT DATA, STUDY THE ISSUES, AND PROPOSE CODE CHANGES. WE BELIEVE THAT THE BUILDING CODES TODAY HAVE AN EXCELLENT TECHNICAL GRASP OF THE CONCEPT OF THE SAFE USE OF FOAM PLASTICS AND WE BELIEVE CONTINUED LIASON BETWEEN THE INDUSTRY, TESTING

LABORATORIES AND BUILDING CODE OFFICIALS WHICH HAS GENERATED THE PRESENT EXCELLENT CODE LANGUAGE WILL ONLY HELP TO IMPROVE AND BRING A BETTER UNDERSTANDING OF THESE MATERIALS IN THE YEARS TO COME.

THANK YOU VERY MUCH FOR YOUR ATTENTION.

"EPS IN HIGH RISE CONSTRUCTION:

A SAFE APPLICATION

Hugh T. Warren

Arco Chemical Co.

MY NAME IS HUGH WARREN AND I AM REALLY A YOUNG PERSON.
THE REASON I LOOK SO OLD, TIRED, BATTERED AND DEPRAVED
IS BECAUSE I HAVE SOLD EXPANDED POLYSTYRENE FOAM INSULATION
INTO THE BUILDING AND CONSTRUCTION MARKETPLACE FOR THE
PAST TWENTY-ONE YEARS. DURING THOSE YEARS I HAVE HAD TO
DEAL WITH OVER TWENTY AGENCIES OF THE FEDERAL GOVERNMENT,
MOST OF THE STATE GOVERNMENTS, ALL OF THE MODEL CODE
INSTITUTIONS, MOST LEADING CASUALTY INSURANCE COMPANIES,
FM, UL, MORE THAN A HALF DOZEN COMMITTEES OF THE SOCIETY
OF THE PLASTICS INDUSTRY AND MY BOSS WANTS TO KNOW WHY I
HAVEN'T SOLD MORE EPS. I HAVE FINALLY TOLD HIM, "I'M UP
TO MY KNEES IN ALLIGATORS AND YOU EXPECT ME TO DRAIN THE
SWAMP."

IN FACT, ALLIGATORS ARE NOT ALL THAT BAD - THEY
NEITHER BURN NOR GIVE OFF TOXIC GASSES. THE FACT THAT
THEY ARE LOCATED ONLY IN THE SOUTH GIVES TESTIMONY TO
THE IDEA THEY ALSO KNOW LITTLE ABOUT INSULATION. ENOUGH
OF THE 'GATORS.

EPS HAS GAINED INCREASING PREFERENCE AS A MATERIAL
IN NEARLY ALL APPLICATIONS FOR RIGID INSULATION: RESIDENTIAL,
COMMERCIAL, AGRICULTURAL, COLD STORAGE, AND SO ON. IT
IS USED FOR PERIMETER, CAVITY WALL, ROOF AND SOME EXCITING
INNOVATIONS: IT CAN EVEN BE PLACED WITHIN POURED CONCRETE
WALLS. IT IS ALSO USED ON THE INTERIOR SURFACES OF EXTERIOR
WALLS AND, TO A LESSOR DEGREE, AS A CEILING TILE. THESE
ARE THE TWO AREAS OF APPLICATION I ADDRESS TODAY.

SINCE EPS IS A CELLULAR FOAM PLASTIC, IT IS COVERED BY ALL
THREE MODEL BUILDING CODES AND, IN GENERAL, MUST HAVE A
FLAME SPREAD OF LESS THAN 75 AND SMOKE DEVELOPMENT OF
LESS THAN 450 WHEN TESTED IN THE THICKNESS OF INTENDED
USE BY ASTM E-84 METHOD. FURTHER, THE PRODUCT MUST BE
COVERED BY AN APPROPRIATE THERMAL BARRIER. THE CODES
ALSO PROVIDE FOR DIVERSIFIED TESTS WHICH MAY ALLOW
EXCEPTION FROM THE GENERAL PROVISIONS. SUCH IS THE CASE
FOR EPS CEILING TILE WHICH WOULD LOSE MUCH OF ITS APPEAL
IF IT HAD TO BE COVERED WITH A THERMAL BARRIER.

I WANT TO SHOW SOME SLIDES THAT WILL ILLUSTRATE
SOME OF THESE AREAS. THE TEST WORK INVOLVED HERE WAS
DONE AT UL LAB IN NORTHBROOK, ILLINOIS, AND BY THE EPS
BLOCK MOLDERS COMMITTEE OF SPI.

THIS TEST METHOD IS THE ICBO CLOSED ROOM TEST.
THE ROOM IS 8' WIDE, 12' DEEP AND 8' HIGH WITH A FULL-
SIZED OPEN DOOR SO AIR CAN MAKE IT TO THE FAR REACHES
OF THE ROOM WITHOUT RESTRICTION.

THE WOOD CRIB IS 30 POUNDS WHICH WILL YIELD
TEMPERATURES ABOVE 1,000°F FOR 15 MINUTES.

I'LL SHOW YOU THE CELING TILE SLIDES FIRST: 22 - 41

NEXT, WE'LL LOOK AT 2" THICKNESS OF EPS WITHOUT
BENEFIT OF A THERMAL BARRIER: 43 - 61

NEXT, 2" OF EPS WITH 1/2" GYPSUM BOARD MECHANICALLY
FASTENED: 4 - 21

NOW, A SPECIAL TREAT, PREFINISHED WOOD PANELING -
NO FOAM OF ANY KIND: 63 - ---

FAIR? NOT HARDLY. BUT WHO EVER SAID LIFE WAS FAIR?

WE HAVE WORKED HARD TO IMPROVE OUR PRODUCTS AND
MILLIONS OF DOLLARS HAVE BEEN SPENT AND ARE BEING SPENT
TO CONTINUE THIS IMPROVEMENT. MORE, MUCH MORE, MUST BE
DONE AND I CRY TO YOUR INDUSTRY TO HELP. IF ANY OF YOU
HERE TODAY HAPPENS TO HAVE A LITTLE BOTTLE OF MAGIC
FLUID THAT WE CAN MIX WITH OUR EPS SO THAT IT WON'T BURN
OR SMOKE, I'D LIKE TO MEET WITH YOU PRIVATELY AND TALK
ABOUT HOW WE CAN SPEND ALL THE MONEY WE'LL MAKE. HOPE-
FULLY, THIS SECRET ELIXIR WOULD CONTAIN SOME ALCOHOL
IN CASE IT DOESN'T WORK WE COULD FIND SOME USE FOR IT.
AT ANY RATE, THANK YOU FOR HEARING ME.

EDITORIAL NOTE: Speaker did not supply The Fire Retardant
Chemicals Association with copies of his slides.

"NONMETALLIC CONDUIT IN FIRE RATED CONSTRUCTION"

H.F. van der Voort

Carlon Company

NONMETALLIC CONDUIT IN FIRE RATED CONSTRUCTION

H. F. van der Voort

October 1981

Nonmetallic conduit has been in use for many years. The nonmetallic conduit used in above-ground construction is officially referred to as "rigid nonmetallic conduit" by the National Electrical Code (NEC). The code permits rigid nonmetallic conduit for use above ground when the conduit is "flame retardant, resistant to impact and crushing, resistant to distortion from heat under conditions likely to be encountered in service, and resistant to low temperature and sunlight effects."

These criteria are met only by PVC Schedule 40 conduit as specified in Underwriters Laboratories, Inc. Standard for Safety 651. This conduit has been in use since 1955 and received U.L. recognition in 1962, when it first appeared in the National Electrical Code. While most of you are aware of the type of polyvinyl chloride (PVC) compound used in manufacturing a Schedule 40 conduit, let me give you the ingredients of a typical blend:

	Parts per 100 Resin
PVC Resin (pipe grade)	100
Carstab 692 (tin stabilizer)	.6 - .7
Calcium stearate	.8
Wax	1.1
TiO_2	1.0
Carbon black	.05
Calcium carbonate	4.0
AC 626 (polyethylene)	.15
CPE (chlorinated polyethylene)	4.0

PVC conduit has gained wide acceptance and over the years the National Electrical Code has been amended to enlarge the areas where it can be used.

Today, the code generally permits it to be used concealed in walls, floors and ceilings and for exposed work where not subject to physical damage. There are restrictions on the use of the conduit in specific building areas. Rigid nonmetallic conduit is not permitted in "ducts or plenums used for environmental air", or as the code refers to it, "other space used for environmental air". Furthermore, it cannot be used unless encased in concrete in "Places of Assembly" (Article 519) and in "Theaters and Similar Locations" (Article 520). The limitations placed on the use of rigid nonmetallic conduit by the National Electrical Code are based on the concern about its fire characteristics. In earlier versions of the National Electrical Code, PVC conduit had to be encased in concrete in most above-ground applications. This was based on a fear that PVC conduit when installed in fire rated walls, floors or ceilings would impair the fire rating of the structure. In the 1971 Code, this restriction was eliminated based on the general fire characteristics of PVC. These characteristics were demonstrated by laboratory or small scale data which were challenged by competitive product manufacturers. In 1973, the Thermoplastic Conduit Section of the National Electrical

Manufacturers Association sponsored an Underwriters' Laboratory report entitled "Fact Finding Report on PVC and Rigid Metallic Conduit and Metallic Outlet Boxes in a Nonbearing Partition Assembly". The object of the fact finding investigation was to compare the differences, if any, between the effects of PVC conduit and electrical metallic tubing (EMT) on the fire resistive performance of the tested assemblies by means of fire endurance tests conducted in accordance with the Standard, Fire Tests of Building Construction and Materials, UL263 (ASTM E119, NFPA No. 251). This data could in turn be compared with that for a similar assembly without electrical equipment which had been previously tested and is shown in U.L.'s Fire Resistance Index as Design No. U411.

The Underwriters' test was conducted on a two-hour fire rated gypsum wallboard wall supported by metal studs. Part of the wall contained PVC conduit and steel outlet boxes and part contained EMT and boxes. Both conduit systems were typical NEC installations with the prescribed wiring. Neither system impaired the two-hour rating. As an aside, let me point out that similar wall and floor-ceiling tests were run at Ohio State University on thermoplastic drain, waste and vent piping at about the same time. Since then, these ASTM E119 tests have also been run on electrical systems using nonmetallic-sheathed cable and thermoplastic boxes. This data when reviewed "in toto" generates the conclusion that PVC wiring systems can be used without diminishing fire resistant ratings. Furthermore, it has set a precedent for using the ASTM E119 testing procedure for measuring the acceptability of conduits in building structures.

Building codes or at least the model codes were initially silent on the use of thermoplastic conduit. They do reference the NEC and have done so for a long time. However, many building officials have been concerned that there was a gap or conflict between the requirements of the building code and the uses of nonmetallic conduit as spelled out in the National Electrical Code. Consequently therefore, there has been a move to specifically address the matter in building codes.

For many years building codes have placed limitations on the use of plastics although such limitations and requirements dealt with surface materials and trims.

One model building code, the Uniform Building Code (UBC), places limitations on interior wall and ceiling finish based on ratings determined by ASTM E84 "The Tunnel Test". These limitations call for flame spread classifications ranging from 25 to 200, dependent on area of use, and smoke density no greater than 450. While it has some other requirements for light transmitting plastics, there has been a tendency for some building officials to believe that nonmetallic conduit should pass flame spread and smoke density limitations similar to those for surface materials. The problem has always been how to run an ASTM E84 test on profiles. How should they be installed in the furnace? How much material should be utilized?

Some early testing was done with conduit split in two length-wise and held against the tunnel ceiling. Some tests like this produced results similar to those for surface materials. But again, what diameter conduit do you use?

The test has not been practical or realistic for such products. The UBC now specifies that copper or ferrous pipes or conduits may penetrate walls or partitions and limits the size of openings. However, other materials and larger openings may be qualified by tests conducted in accordance with UBC 43-1, the ASTM E119 test. The same applied to floor-ceilings or roof-ceilings. This approach to building construction seems reasonable. If the total assembly passes the E119 test, it's safe. While this could theoretically produce fire tests without number, typical assemblies can be selected for test and qualified. This general procedure of testing products in the form in which they are used is also being adopted by other model codes.

While the ASTM E119 doesn't address products of combustion, all codes have fire stopping requirements and the NEC specifically says:

"300-21. Spread of Fire or Products of Combustion.
Electrical installations in hollow spaces,
vertical shafts, and ventilation or air-handling
ducts shall be so made that the possible spread
of fire or products of combustion will not be
substantially increased. Openings around
electrical penetrations through fire resistance
rated walls, partitions, floors, or ceilings
shall be firestopped using approved materials."

There has been a plethora of testing in this area and
many penetration sealants approved for use. In addition,
many tests of wall penetrations by plastic piping have been
conducted. Some of us are now exploring the possibility of
fire classifications for various types of nonmetallic conduit
wall penetration systems. There is no doubt in my mind that
the spread of both fire and products of combustion is and
can be controlled.

Various sealing materials and systems now available
and used both within and without a conduit in a wall penetration
are effective. Nevertheless, any economic development that
further retards either flame spread or smoke development in
a thermoplastic conduit will enhance product growth.

However, an area of construction from which PVC conduit is excluded is the plenum - environmental air handling space area. Buildings which use the space above suspended ceilings for return air do not use PVC conduit. It is impractical to use nonmetallic conduit in walls and convert to EMT in the ceiling area. The means of maintaining continuity of ground and installation problems preclude it.

Any interpretation of the NEC limits electrical systems in air handling spaces to those enclosed in metal raceways (rigid steel conduit, IMC, or EMT). The effort to get thermoplastic conduit into these areas has not been persuasive. The reason for this is: (1) that there has been no real test criteria or test method for determining what should be used in these air handling spaces; (2) there has been a general concern about smoke developed in these areas by PVC. For many years low voltage communication cables were permitted in air handling spaces without being enclosed in conduit. Because of their low voltage, fires would not be initiated in such systems and the cables were small in diameter. In this day of rapid communication however, communication cable proliferated in the plenum and a requirement for placing them in non-combustible raceways was made mandatory. The code did leave an opening, however. It indicated that in communication circuits:

"Single and multiconductor cables listed
as having adequate fire-resistant and low-
smoke producing characteristics shall be
permitted for ducts, hollow spaces used
as ducts, and plenums other than those
described in Section 300-22(a)."

This has raised the question as to what are "adequate
fire-resistant" and "low-smoke producing characteristics".
To answer that question, Bell Laboratories and Underwriters'
Laboratories began work on test procedures and criteria.
They developed a test method for determining the flame spread
and smoke generating characteristics of communications cable.
The test facility is an E84 tunnel furnace with a cable rack
or tray running the length of the tunnel. The tray is 12 inches
wide, 23 feet 10 inches long and mounted about 7 inches above
the furnace floor (now a Proposed Standard - UL910).

Bell Laboratories ran a great many tests on different
cables and cable configurations measuring flame spread in time
and distance and smoke development at 10, 15, and 20 minute
increments. They also compared results with a "real" fire
simulation under actual installation conditions in a plenum.
This proved the modified tunnel test was considerably more
severe than a real plenum fire.

Bell tested some wiring in metal conduits for a reference point of what is now permitted by code. Although the test procedure seemed overly severe, we at Carlon recognized it as the first realistic approach to testing products for use in environmental air spaces. If it is accepted for use to qualify cables, why not use the same testing to qualify all materials in these spaces? While the criteria for passing the test has not yet been established and may not be for a while, it seemed appropriate to explore the matter. And so Carlon did some test work using U.L.'s tunnel furnace at Northbrook, Ill. Our criteria for comparative purposes were the results obtained from standards currently permitted in plenums. We have run a number of these tests now with PVC and CPVC conduit. Based on our criteria, it was concluded that smoke developed by uninhibited PVC would probably place the product outside the acceptable criteria parameters. The tests do suggest, however, that a suitable smoke limited compound can in fact be developed.

The data seems to suggest that flame spread should be limited to less than 10 feet and that smoke developed should be in the 500 or less area. Because the test is severe, in my opinion there may be room for alternative procedures but the modified tunnel test method is in place and has served a useful purpose. So its continued use promises the earliest results, and appears to be a good starting point for compound development. It is quite clear that small scale test results

using the NBS or Arapahoe smoke chamber will not buy code acceptance. The tunnel test is large scale and if it is not acceptable, a similarly large test method will have to replace it.

You will notice that I have not addressed one issue and that is the question of toxic products of combustion. Usually those who refer to these products are concerned with Hydrogen chloride, phosgene, benzene, and similar combustion products from PVC. There are as yet no acceptable test procedures for measuring the amount of these products produced in a fire situation or deciding how much is dangerous. In a dynamic fire situation, such data appears extraneous. It is important to remember that in a non-fire situation, nonmetallic conduit has some inherent advantages over metal raceways, not the least of which is its dielectric properties.

For that reason, continued product improvement and expanded useage is a worthy goal.

"FLAMMABILITY AND SMOKE EVALUATION IN

VINYL CARPET BACKING"

Gregory J. Divis

M-R Plastics and Coatings, Inc.

"FLAMMABILITY AND SMOKE EVALUATION IN VINYL CARPET BACKING"

Governmental Agencies on Federal, State and Local Levels, as well as Insurance Firms and Certifying Authorities continue to concern themselves with the fire safety of consumer products. In particular, Building Codes and Fire Prevention Codes limit the use of flammable materials in the construction of walls, ceilings and floors of buildings as the behavior of these materials in a fire situation will determine the extent of harm to property and life.

With the advent of improved production techniques, the carpet industry was able to produce carpeting that could compete with the more traditional floor coverings, such as wood, vinyl asbestos tile and linoleum. Although carpeting experienced a rapid increase in useage, a growing concern about the role of carpet materials in a fire situation also became evident and it was feared that some carpet materials would perform radically different than the more commonly used floor coverings. As a result of this concern, a first attempt was made in 1965 to regulate the floor covering by a flammability test. Since then, much research and development work has been undertaken to better understand the phenomenon of fire spread[1]. This concern for the fire safety of building and construction materials, has lead to the proliferation of test methods for evaluating the performance of these materials in a real fire situation. Not only has debate arisen between which test is a better measure of flame retardance but also the validity of extrapolating such test data to a real fire situation has seriously been questioned [2,3,4].

Hilado[2] has divided these flammability tests into two general types: Research Tests and Acceptance Tests.

Research tests can provide reproductive data based on procedures that are technically sound and have scientific value. The acceptance tests are those tests that have become standards in the industry. These standards must be met in order to sell the product in the market place. Hopefully, it is the best of the research tests that become acceptance tests. There are three general categories of testing that have evolved in determining the flammability characteristics of carpeting:

      1.) Ease of Ignition

      2.) Flame Spread

      3.) Smoke Evolution

The first category "Ease of Ignition" addresses the problem of how easily a fire may be started and spread in the initial stage of growth. Since April 16, 1971, all carpets have been required to meet DOC FF 1-70. This standard is commonly referred to as the "Pill Test". It involves the exposure of eight conditioned samples to a standard igniting source (methenamine tablet) in a draft free enclosure. The methenamine tablet is ignited and the carpet is allowed to burn until either the last sign of flame disappears, or the flaming and smoldering reaches within one inch of the flattening frame. If the flaming or smoldering reaches within one inch of the ring, that sample fails to meet the standard. This test will identify those systems that are easily ignited by a small flaming source. In a series of experiments performed by the National Bureau of Standards [5] it was reconfirmed that: "Carpet Systems, used in rooms, will not normally spread fire provided they meet the requirements of DOC FF 1-70".

However, once a fire has progressed from a small flaming source, such as a waste basket fire, to the stage where everything in the room is burning and an intense heat has developed, it is very possible for the fire to spread via carpeted passageways. This brings us to the second testing category, "Flame Spread", which focuses on the ease and extent of flame propagation, once the fire is well underway. For years, one of the standard tests to evaluate surface burning characteristics of building materials was ASTM E-84, the Steiner Tunnel Test. Although this test was originally designed to evaluate flammability characteristics of wall and ceiling materials, it was extended to include floor coverings.

When this method is used, the sample (25' x 18") is mounted on the ceiling of the tunnel and it is ignited at one end and allowed to burn until the burning sample extinquishes itself. The sample is rated on the basis of two standards, asbestos is assigned a zero value and red oak is assigned a flamespread value of 100. The value of this test method in predicting performance in a real fire situation has been challenged because the sample is mounted on the ceiling of the tunnel.

A new test was developed in order to reflect more accurately the conditions of a real fire situation. This test is called the Flooring Radiant Panel Test[6]. The Flooring Radiant Panel Test utilizes a test chamber that has a horizontally mounted sample which receives radiant energy from a panel mounted above one end of the sample and inclined at an angle of 30°. The radiant panel generates a radiant flux profile along the length of the sample ranging from a maximum of 1.1 watts/cm^2 to about 0.1 watts/cm^2 at the end opposite the radiant panel. Ignition is obtained with a gas burner below the radiant panel and the test is completed when the burning stops. The point of extinquishment is converted to watts/cm^2 and reported as <u>critical</u> <u>radiant</u> <u>flux</u>. The radiant flux simulates the thermal radiation levels likely to impinge on the floor of a corridor whose upper surfaces are heated by flames and hot gases from a fully developed fire in an adjacent room. The Flooring Radiant Panel Test is different from most tests in that it measures an actual property of the carpet system and is not based on an arbitrary scale such as the 0-100 scale of the Tunnel Test. The recommended criteria for passing this test varies with the location of the carpeting. The minimum radiant flux for carpeting within corridors and exitways of hospitals and nursing homes is 0.45 watts/cm^2 and for corridors and exitways of other occupancies, except one and two family dwellings, is 0.22 watts/cm^2. Generally, however, carpet manufacturers prefer a rating of greater than 0.50 watts/cm^2 so as not to be restricted. It has been determined that such values should provide a level of safety for the carpeted corridor which is equal to or in excess of that required in the NFPA 101 Life Safety Code[11].

The third category of testing the flammability characteristics of carpeting is "Smoke Evolution". More and more attention is being given to the matter of smoke and its impact on the loss of life in a fire. Although a number of

tests have been developed to quantitatively measure the variation in smoke generation from material to material, the acceptance test that is most widely cited in material specifications, building codes or fire prevention codes is the National Bureau of Standards Smoke Chamber Test.

It is possible to measure the smoke generated under both flaming and non-flaming modes. The sample (3" x 3" with maximum thickness of 1") is irradiated by a radiant panel at a rate of 2.5 watts/cm^2 in the smoldering mode and additional gas-fired pilot flames impinge on the sample during the flaming mode. A photometric system with a given vertical light path measures the continuous decrease in light transmission as smoke accumulates. It is possible to calculate the maximum specific optical density for each of the tested samples. The higher the number, the greater is the smoke generation. A comparison of the NBS Chamber with other methods as well as evaluating how the small scale test correlates with the large scale, real-life testing has been made[4,9]. The safety standard for flammability of floor coverings set by the Department of Health, Education and Welfare requires a specific optical density (Dm) of 450 or less in the flaming mode as determined by the standard "Smoke Generated by Solid Materials" published by the National Fire Protection Association as Standard No. 258-1976.

As a formulator of various Polyvinylchloride (PVC) dispersions for carpet backing applications, M-R Plastics and Coatings has to be concerned about these three testing categories and their respective requirements. As stated very recently in PLASTICS COMPOUNDING[10]..."Because of the question of test validity and the fact that flame retardancy as measured does not indicate performance in acutual fire situations, the concept of flame retardancy is difficult to sell. A passing score is sold intead". As a consequence, we often find ourselves in the position where our efforts are directed towards obtaining just "the passing score".

Our concern, however, is not limited to only the vinyl portion of the carpeting but also the different types of composites that are manufactured. For the purpose of comparing various types of composites available in the makrket place, four systems will be considered.

I. UNBACKED BROADLOOM CARPETING

→ Tufted Yarn
→ Primary Backing
→ Adhesive
→ Secondary Backing

In unbacked broadloom carpeting the yarn is tufted into a primary backing, often made of jute. The back of the jute is coated with an adhesive and a secondary backing is laminated to it. The adhesive serves as a "Tuft Lock" for the looped end of the yarn. The adhesive may be a rubber latex or a vinyl dispersion. This type of carpeting may be directly glued down but generally an underlayment or carpet pad is used.

II. BACKED BROADLOOM CARPETING

→ Tufted Yarn
→ Primary Backing
→ Foamed Backing
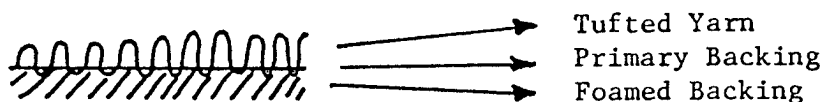
The backed broadloom carpeting utilizes a foamed high density latex or foamed PVC backing that is applied directly on the back of the primary backing. The foamed backing serves two functions: first, it provides the "Tuft Lock" for the yarn and second, it eliminates the need for carpet underlayment.

III. FUSION BONDED CARPETING

→ Face Yarn
→ Vinyl Adhesive
→ Primary Backing
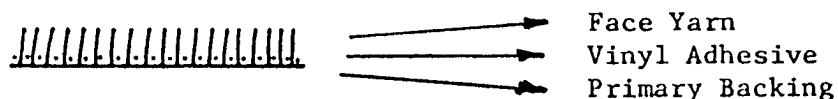
Fusion bonded carpeting is one of the most recent advances in the technology of carpet manufacturing. This process was initially developed in Europe and has since moved into the United States. In fusion bonding the face fibers are placed directly into the vinyl adhesive.

Much better use is made of the fiber as only about 1/16th" of the fiber is implanted in the adhesive whereas in tufting much more is lost in the loop under the primary backing. Recently, the carpet industry has offered to the market place 18" x 18" carpet tiles and the response has been very positive.

IV. CARPET TILE

A. Unbacked Broadloom

→ Tufted Yarn
→ Primary Backing
→ Adhesive Vinyl
→ Backing

B. Fusion - Bonded

→ Face Yarn
→ Vinyl Adhesive
→ Primary Backing
→ Backing

Either the unbacked broadloom or fusion bonded carpeting may have a vinyl tile backing applied.

Each of these four composites brings to the vinyl formulator differing processing requirements. However, it becomes necessary not only to custom formulate for each of the composite types but also each customer presents slightly different manufacturing requirements -- in other words -- there is no universal vinyl backing formulation that is suitable for everyone's needs. Although the vinyl portion of each of these composite types will vary, we can still control the flame and smoke characteristics by the ingredients chosen to be used. There are other variables within each of these composite types that are not controllable; yet, they play an important role in determining how the composite performs in the flammability tests we have discussed. Three variables that exist in each of these composite types are listed below:

VARIABLES IN CARPET SURFACE

A. Composition
   1. Polypropylene
   2. Polyester
   3. Nylon
   4. Wool

B. Construction
   1. Denier
   2. Ply

C. Density of the Pile

The flammability characteristics will vary with the various types of face yarn that are available. The yarn that is used in these composites may be single, double or triple ply and the thickness of each ply can be controlled by how

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tight the fibers are twisted. The amount of face yarn per square yard can also range from a low density of 14-16 oz./yd^2 to a high density of 48 oz./yd^2. Cost and aesthetics of the finished product determine what the exact composite will be. All of these variables come into consideration when the vinyl formulator is asked to provide a material that will be used to manufacture a composite which must meet a given set of specifications.

What does it take to obtain a passing score? How have vinyl backed carpeting faired?

In the "Methenamine Pill" Test, composition and construction of the face yarn contribute significantly to whether the carpet passes or fails. This test is generally not a source of difficulty to the vinyl formulator.

Variation of face yarn and vinyl formulation can affect the values obtained in the Radiant Panel Flooring Test. Two typical carpet tile formulations are given below:

MATERIAL	FORMULA A	FORMULA B
Resin	100	100
Plasticizer	50	50
Stabilizer	2	2
Filler	75	75
Additives	0	5

Using Formula A, the variation of critical radiant flux with the composition of face yarn is shown in Table I.

TABLE I
FLOORING RADIANT PANEL TEST

Formula	Polypropylene (watts/cm^2)	Nylon (watts/cm^2)
A	0.13	0.38
B	>0.50	>0.50

The carpet tile composites were identical except for the composition of the face yarn. Variation of face yarn had a pronounced effect on the test results. The polypropylene system failed to meet the minimum criteria of 0.22 watts/cm^2. The nylon system is suitable for corridors and exitways of facilities other than hospitals or nursing homes. The role of the Vinyl Formulation is indicated by the test data obtained with Formula B. Besides the incorporation of specific flame retardant additives, changes were also made in the plastizer and filler composition. It was possible by making changes in the vinyl formulation to increase the critical radiant flux of both types of face yarns above the required

level, 0.5 watts/cm^2. Therefore, with Formula B, both composites are not restricted in placement of corridors or exitways.

Without question the test category that has presented the greatest challenge has been the level of smoke generation as determined by the NBS Smoke Chamber. Yet, some systems have passed very easily. For example, an unbacked broadloom carpet that has a thin coating of 10-15 mils of a vinyl adhesive may be used in a direct glue down installation as the smoke generated from such a small amount of adhesive is well below a specific optical density of 450. In this example, the amount of vinyl adhesive was the major factor.

Smoke data was also obtained on the typical formulations A & B and is given in Table II.

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TABLE II
NSB SMOKE CHAMBER DATA

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Formula	Polypropylene (Dm)	Nylon (Dm)
A	900	900
B	< 450	< 450

The data indicates very clearly that the vinyl formulation is crucial to this composite meeting the specific optical density requirements. It should be noted again that composites made with Formulas A & B were identical except for the changes in the vinyl formulation. This data represents a very nic success story for this composite, yet, the path from Formula A to Formula B required extensive research and testing.

To facilitate the development work in a program such as this, it was necessary to evaluate the vinyl alone as it was not always possible to interrupt the carpet manufacturer's production to obtain experimental composites for testing. Normally, one would expect that if improvement was obtained in the specific optical density for the vinyl alone, a parallel improvement could be expected in the specific optical density for the composite. The data shown in Table III indicates this to generally be the case: however, the magnitude of improvement on the vinyl alone does not necessarily produce a comparable improvement in the composite.

TABLE III

Formula	Vinyl	(Dm)	Composite	(Dm)
1.	404	----	755	----
2.	287	-117	726	-29
3.	229	-174	636	-119

Significant improvements in lowering the smoke levels of the vinyl portion (Formulas 2 & 3) did not necessarily result in significant improvements in the smoke levels of the entire composite. Data obtained in this study also indicates that the sum of the individual specific optical densities is much less than the specific optical density of the composite. Table IV compares the calculated sum with the experimentally determined value of the composite.

TABLE IV

Formula	Vinyl	Backing/Yarn	Sum	Composite
1.	404	45	449	755
4.	224	45	269	576
5.	168	45	213	518

Samples were prepared in such a way that the amount of vinyl on the composite was equal to the amount of vinyl tested without face yarn and backing. If the smoke contributions were additive, all of the formulas would meet the requirement, $D_m < 450$. However, the composites test at much higher values and none of the formulas provided a composite that met the specification. Because of this synergistic effect, it is not possible to predict the performance of a composite from the individual components. Rather, it becomes necessary to test the composite and measure the results directly.

Only three testing categories have been considered. The area of toxic fumes and gases seems to be commanding a lot of attention these days and may be the next barrier that the vinyl formulator has to overcome.

Regulatory agencies are becoming more demanding in the quality of products to be offered to the consumer. Whatever the demands, M-R Plastics & Coatings is confident that the challenges presented, can be met. Occasionally, the challenge is extreme and all our resources are called upon to complete the job. We are also aware of the vital role that the Fire Retardant Manufacturers have in this scenario. You are a most valued resource and we look forward to continuing a working relationship that allows us to be part of a market that provides the consumer with a product of highest quality and safety.

I would also like to thank Mr. Lou Raether of Marketing Technical Services
and Mr. Donald Hopper of M-R Plastics of Georgia for their helpful discussions
and assistance in obtaining data for this paper.

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"NEW OPPORTUNITIES FOR PRODUCT FIRE PERFORMANCE"

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NEW OPPORTUNITIES FOR PRODUCT FIRE PERFORMANCE
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Presented at the Fire Retardant Chemicals Association's meeting on Building

Contents - The Real Fire Problem on October 13, 1981, in Philadelphia, Pa.

In preparing for this meeting, I gave serious consideration to what I

might offer of value to your understanding of product fire performance.

It is my thought that a view of current activities may be of value, and

for this reason, I have picked several subjects which I intend to discuss

briefly with you. These subjects are the NFPA Decision Tree, cost/benefit

analysis, fire risk assessment, and bioassay protocols.

There are probably some of you who are familiar with the NFPA Decision Tree;

others, though, I am sure are not. It is for this latter group that the

following presentation is intended.

First, the NFPA is the National Fire Protection Association. It is a

voluntary organization consisting of approximately 32,000 members. These

members are building officials, fire service personnel, government officials,

researchers, industry representatives, insurance representatives, and

others who are interested in fire protection. The NFPA, through an organiza-

tion of committees, prepares technical fire protection standards that are

adopted by many authorities-having-jurisdiction. Some of these standards

are very familiar to you. For example, NFPA Standard No. 70, which is the

National Electrical Code. NFPA Standard No. 13, which is the Automatic

Sprinklers Standard. NFPA Standard No. 101, which is the Life Safety Code.

It was in 1972 that the NFPA Committee on Systems Concepts for Fire Protection in Structures was organized, and in time, became the author of the NFPA Decision Tree. This Committee was in response to a challenge posed to the Association when several high-rise building fires occurred in the United States (in New York City, Atlanta, and New Orleans) in modern buildings -- fires that should not have happened. At least, it was thought that they should not have happened, certainly with the severe consequences, for these buildings had been built in accordance with modern building codes. The NFPA Adhoc Committee that preceded the Systems Concepts Committee recognized the problem as one of a "fragmented approach to fire protection in structures." This Committee also recognized "the need to develop a total fire safety system, to develop a concept of viewing the fire problem as a set of interrelated, interdependent parts working together for the overall objective of the whole."

In essence, it was found that a typical building code was a book of redundancies. On every occasion when a fire catastrophe occurred, the typical reaction had been to prepare a change to the building code, really an addition, to correct that particular problem that had led to the fire catastrophe. This change was inserted into the building code without any consideration to any other elements that were then in the building code. One can well imagine that, after several fire catastrophies, the building code was a very large and fragmented document.

This fragmentation has given people two different, but related, areas of concern. The first is the obvious one of whether or not these additions

have added in any way to the total fire protection of the structure in question. Have they, as we suspect, been redundancies in many cases, or have they truly been additive, and conceivably even synergistic? One can hardly tell when there is very little evidence that any studies have been made after the fact of the value of any addition to the building code, based on use of the code with that addition.

The other area of concern is also of importance, and that is the area of cost effectiveness. Are we, with this book of redundancies, pricing building construction out of the market?

I would be remiss, though, in not pointing out that some degree of re-dundancy is necessary, and worthwhile. Especially when we talk about fire protection as it impacts on safety to life. But, there is a real concern with the unknown value in terms of fire protection of these redundancies in a building code, and the known, prohibitive cost in providing them.

One of the first decisions made by the NFPA Systems Concepts Committee was to use a systems approach. The Committee elected to use a logic tree analysis which is now identified as the NFPA Decision Tree. This logic tree analysis is expressed in a positive fashion, in the form of those events that need to succeed in order to meet the goal.

I would now like to take a few minutes to explain the tree, and following that to suggest the various ways in which the tree can be used and has been used to date, including the analysis of design alternatives. A copy of the tree is being provided with this presentation to help in this understanding.

The very top of the tree identifies the final goal, "fire safety objectives," but more importantly, sets forth on the lower line the two means -- "prevent fire ignition" and "manage fire impact" -- to obtain this goal. Please note that each box on the tree is an event that acts as both a goal for the lower events and a means or method for the higher event. Furthermore, events are connected by either an "or gate" or an "and gate." The former indicates independence. In other words, if we are successful in either event, we will be successful in the higher event. The "and gate" indicates dependence. In other words, if we are to be successful in the higher event, we must be successful in all the lower events. The part of the tree that appears on the left side can be identified as a fire prevention code. The right side of the tree can then be considered a building code.

With this description of the tree, I hope you have foreseen some of the uses to which the tree can be placed. To date, the qualitative use is obviously the more common use. In this regard, the Decision Tree can serve as a curriculum guide for the study of fire protection; the tree can serve as a plan for research in fire protection; the tree can serve as a design regimen for the architect who is honestly concerned with fire protection; the tree can also serve as a building fire safety survey form for the conscientious building owner; and for the building materials manufacturer, the tree can provide the rational means for acceptance of its product by the authority-having-jurisdiction.

There is also the hoped for quantitative use of the tree, which at this time is only of a future value. The Committee is currently working in this area.

The second subject which I would like to discuss with you briefly is cost/benefit analysis. One cannot help but have been exposed to recent discussions on this subject, particularly as prompted by the Reagan Administration in terms of deregulation. The Standards Council of NFPA has charged the Systems Concepts Committee to develop a rationale for the application of cost/benefit analysis by all of the other Committees of NFPA in the development of their Standards. After much discussion, the Systems Concepts Committee has agreed on the following major points.

First, that there is a need for an impact statement relative to both cost and benefits, but not for a cost/benefit analysis. The Committee, frankly, fears the latter in that it is not clear that an appropriate analysis can be made of the benefit side of the equation. However, the Committee does find that there is a need for those people who will vote on a new Standard or a major change to an existing Standard to receive information of the impact on both cost and on benefits.

Second, that these statements are to be prepared by the Standards Committee for only a new Standard or for a change to an existing Standard that causes a major impact on cost or benefits, as determined by the Standards Committee. In this regard, the Committee felt that a proponent of a change, when not the Standards Committee, shall also be required to prepare these statements, but in an elementary form.

Third, the alternatives should be identified. As a matter of fact, the Committee felt that there was a need to look at more than one solution to the problem.

Fourth, that the reference for an impact statement can be either in qualitative or quantitative terms. Obviously, in the latter, this can be in dollars. Note, though, that the Committee is willing to accept impact statements that are framed in qualitative terms.

Fifth, that the persons or group to whom each cost and benefit is assigned shall be identified. This was specially noted from past work where the cost was of one person or group, while the benefit was of an entirely different person or group, which, therefore, led to an illogical comparison.

Six, that documentation in the form of these impact statements shall be published with the new Standard or the change to an existing Standard in the appropriate technical committee reports, which are reviewed by the entire membership prior to voting, but that are not subsequently published as part of the approved Standard.

The timeliness of this presentation on cost/benefit analysis is reinforced by a recent article in the October, 1981, issue of Business Week. Its specific subject is the action taken by the State of California to create a new agency, known as the Office of Administrative Law. Reportedly, this new agency can review a State Regulation on four main grounds: need, legal authority, clarity, and consistency with other rules and laws. In contrast, this article reports that at the federal level, the Office of Management and Budget is screening major regulations on three grounds: need, whether benefits outweigh costs and whether a proposed regulation is the least costly alternative.

The third subject which I would like to discuss with you is fire risk assessment. This is a subject which is now incorporated in the organization of ASTM Committee E-5 on Fire Standards. This organization has its genesis in the action by the Federal Trade Commission some years ago relative to cellular plastics. The Committee is attempting to define risk, and consequently develop a protocol for fire risk assessment standards of products.

Risk is now defined by ASTM Committee E-5 as the combination, probably the product, of the expected frequency of the event, the expected degree of exposure, and the potential for harm. In the case of fire risk, the event is the fire itself; the exposure is of the people, property, or the operation exposed to the fire; and the potential for harm is the result of the applicable products of the fire -- e.g., heat, flame, smoke, toxic gases on the exposed.

These three elements of risk, i.e., the expected frequency of the event, the expected degree of exposure, and the potential for harm -- were all, on reflection after the fact, included in the Three Mile Island, Pennsylvania, Nuclear Power Plant accident in 1979, as evidenced by the subjective response of the people, including me, who live near the plant. It is my perception that these people were spoken to before the accident and, interestingly, after it, both in print and by word of mouth, principally of the expected frequency of the event -- not so much as if it were the sole element of risk, but rather with an emphasis that precluded recognition of the other elements. However, the TMI accident itself suggested to many the expected degree of exposure ("we live next door, down wind") and of the potential for harm ("a devastated area for 40 years"). And, these words were loud enough that, although quieted by the low expected frequency of

the event, there is now an innate understanding by these people of the level of risk higher than previously understood.

ASTM Committee E-5 has further identified risk as the qualitative measure for which we are seeking a quantitative dimension. In other words, risk is the scalar quantity that extends from zero risk to total risk. At some qualtity of risk, which can vary for a variety of reasons, it is expected that the authority having jurisdiction, or society's representative, will define the quantity of risk above this level as hazardous, and will define the quantity of risk below this level as safe. This, then, becomes our definition of "hazard," and, consequently, of "safe." Note, and this is of extreme importance, that safe is not solely a zero quantity of risk. Safe can be a very measurable amount of risk.

It has been accepted that Committee E-5 should focus its attention on developing values for the potential for harm, specifically, methods to obtain these values. To this end, it has been conceived that the potential for harm can be obtained from large-scale fire tests. Alternatively, it has also been conceived that the potential for harm might be derived by the integration of the results from one or more fire performance test methods, plus other parameters, in an appropriate order that generates the potential for harm of the object of interest. Currently, there is activity in ASTM Committee E-5, specifically, in the Subcommittee for Interior Furnishings, on developing an understanding of the contribution of type of occupancy to the fire risk assessment of upholstered furniture.

Previous speakers have spoken of the various bioassay protocols which
have been developed for assessing the toxicity of the products of combustion.
A major activity in this area has been the work of the NBS Adhoc Committee.
This Committee has developed a bioassay protocol which is expected to be
available in draft form for review in the very near future. The elements
of this protocol are severalfold. Basically, a sample of the material is
burned under a given condition, the products of combustion are then the
exposure for a group of animals, the response therewith serving to identify,
on a relative basis the toxicity for that particular material.

In the case of the sample, to date it has been defined in terms of weight,
for which I do have a question. Very frankly, most products are sold and
installed on an area basis, rather than on a weight basis. Therefore,
there is some logic that the proposed protocol should evaluate products
on an equivalent area basis.

In the case of the combustion process, the proposed protocol relies on
identifying the autoignition temperature for the material in question,
and then testing both 25°C below this temperature and 25°C above this
temperature. These two test conditions are expected to produce both a
smoldering and a flaming response of the material. Unfortunately, I
believe that this is in disregard of actual fire conditions, where all
of the products, in a given room fire situation, will see the same fire.

In the case of exposure, the proposed protocol relies on six animals,
specifically, rats. The test is conducted under a static condition,
but the size of the test equipment has been designed so as to preclude
both oxygen depletion, and excessive temperature rise.

The results of the application of this protocol have been evaluated on the basis of both incapacitation of the animals, and death of the animals. Very frankly, as the result of an interlaboratory evaluation, the Committee did conclude that death of the animals can alone serve to rank order the toxicity of the various materials. Incapacitation of the animals is not needed.

In the case of the criteria of acceptance, and as directed by the toxicologists, the Committee has acted to define unusual toxicity as two orders of magnitude worse than wood. Presumably, this degree of difference is needed to assure the user of these results of a real difference between the toxicities of two different materials.

Toxicity of the products of combustion is the wave of the future, now on the rise in building code circles. It is not without problems, for which everyone must apply their attention.

The future is very exciting in regard to product fire performance as documented by these reports. Please feel that you are individually invited to join in these activities.

"THE WALLCOVERING INDUSTRY

CHANGES FORTHCOMING IN FIRE HAZARD CLASSIFICATION"

Wayne Judy

Columbus Coated Fabrics

THE WALLCOVERING INDUSTRY

CHANGES FORTHCOMING IN FIRE HAZARD CLASSIFICATION

BY

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ABSTRACT

During recent years, a number of major fires in public buildings have focused attention on the flammability of interior furnishings resulting in attempts to reduce the flame response characteristics in wallcoverings. One investigation is also underway to determine the toxicity of fumes generated during the burning of interior furnishings, including wallcoverings.

Currently, wallcoverings installed in public buildings require at least a "Class A" rating based on the results of the ASTM E-84 Tunnel Test. A "Class A" rating for wallcoverings is defined as a maximum flame spread of 25 and a maximum smoke development of 50.

Building codes in certain geographical areas already specify fire hazard classifications which are more stringent than the commonly accepted Class 'A' rating. However, the most profound effect on future fire hazard classifications within the wallcovering industry may result from the fume toxicity investigation currently being conducted.

RECENT PUBLICITY

Within the past few years, a number of major fires resulting in the loss of human life have focused considerable public attention on the hazards of interior furnishings in an actual fire situation.

The Beverly Hills Night Club fire in Newport, Kentucky during the early 1970's resulted in the loss of numerous lives. Litigation continued for several years in this case during which the courts attempted to determine what caused the fire, why so many

lives were lost, and who was responsible. A number of statements were made during the course of the litigation relating to the fire hazards associated with various materials, and to whether or not sufficient precautions had been taken by the property owners.

During 1978, a hotel fire in Cambridge, Ohio again resulted in the loss of several lives. In this instance, a statement made by a local government official, to the press, specifically noted the wallcovering as having caused the dense smoke associated with the fire. Though it has since been proven that this fire resulted from arson, the publicity of that statement had already established a public image.

More recently, all the national news media covered the fire at the MGM Grand Hotel in Las Vegas. Though no reference was made to specific materials, at least one television news cast did include a statement about the "plush" furnishings contributing to the spread of the fire and smoke.

Events such as these, and a heightened public awareness of all types of potential hazards, have caused all of us to take a second look at the real hazards associated with building fires.

CURRENT SPECIFICATIONS

Federal Specification CCC-W-408A, the currently accepted standard for vinyl wallcoverings, prescribes ASTM E-84 (24 ft Tunnel) as the test method for determining fire hazard classifications.

A "Class A" rating, required of all wallcoverings installed in federal buildings or federally funded buildings, is defined as a flame spread of 25 or less and a smoke generation of 50 or less.

Most local building codes throughout the United States include the requirement for a "Class A" fire hazard rating for installations in public buildings. However, some local authorities have reduced the acceptable flame spread to 15 or less. For hospitals funded through the Department of Health and Human Services, a maximum flame spread of 25 is required but the smoke rating is established on the basis of the NBS smoke chamber. A 450 rating in the NBS smoke chamber is required.

Three major testing services are used by the wallcovering industry to establish fire hazard classifications on their products: Underwriters Laboratories, Inc.; Southwest Research Institute; and United States Testing. Most of the major suppliers to the commercial market establish ratings through Underwriters Laboratories and participate in a follow-up service which involves periodic inspections of products, raw materials, and manufacturing procedures. The ratings obtained from the other two testing labs apply only to the material tested. No follow-up service is offered for subsequent production.

CURRENT PRODUCTS

Three grades of vinyl wallcoverings are outlined in the federal specification predicated an end use. The minimum vinyl weight for the three grades is 5 ounces per square yard while the heaviest grade requires a vinyl weight of at least 12 ounces per square yard. All three are subject to the same flame spread and smoke limitations.

Commercially available products generally range up to 15 ounces per square yard of vinyl though some have as much as 22 to 25 ounces per square yard. Fire hazard classifications published by Underwriters Laboratories for the wallcovering industry show nearly all products to have a maximum flame spread of 25 and a maximum smoke figure of 35. Though deviations do exist, the flame and smoke ratings are roughly proportional to the weight of the product.

Commonly used flame and smoke inhibitors include antimony oxide, phosphate plasticizers, and the various antimony synergists, i.e., Zinc Borate, Barium Metaborate, and Molybdenum compounds.

FUTURE CONSIDERATIONS

The most expedient approach to reduction of fire hazards associated with vinyl wallcovering would be the reduction of the product mass. Escalating product costs have already started a movement in this direction for applications such as hotel rooms and office spaces. However, the heavier products are required in high

FUTURE CONSIDERATIONS (CONTINUED)

traffic areas such as hotel and hospital corridors where the
walls are frequently bumped with luggage and service carts.

The future may hold a totally different approach to fire hazard
classifications. The applicability of the Tunnel Test to an
actual fire situation has come under considerable scrutiny in
recent years.

Alternative approaches have included large scale room fire tests,
corner fire tests, and evolved gas analysis. The larger scale
tests are complicated and expensive. The evolved gas analysis
now appears to be giving way to actual toxicity studies.

Southwest Research Institute (SwRI) in San Antonio has established
a smoke toxicity laboratory within its Department of Fire Techno-
logy and has participated in an interlaboratory evaluation sponsored
by the National Bureau of Standards.

NBS is currently spearheading an effort to establish a standardized
test procedure to be termed a "Toxicity Protocol". To date, the
toxicologists have not agreed upon a standard test. However, the
basics of the procedure involve exposing laboratory animals to
the smoke and gases evolved from a test material in both a
flaming and smoldering situation.

FUTURE CONSIDERATIONS (CONTINUED)

During the test, the animals are studied for effects on physical
coordination and blood analyses are performed to determine the
presence of known toxins, change in pH, and gas concentrations.

Most of the smoke toxicity tests thus far have been performed on
rodents. However, SwRI hopes to obtain funding for similar tests
on primates.

CONCLUSIONS

Established procedures for determining potential fire hazards,
not only in the wallcovering industry, but for all interior
furnishings, are being questioned. Data on flame spread and
smoke quantity do not necessarily provide an accurate account
of potential fire hazards.

Increasing the ignition temperature or char formation of a material,
or even rendering it self-extinguishing, does not necessarily make
it a "safe" product in a fire situation where other materials
may be fueling the flame. The fire toxicity studies, at this
point, appear to be more relevant than previous tests and may
ultimately produce the specifications of the future.

"VAPOR TREATMENT OF COTTON UPHOLSTERY FABRICS

WITH TRIMETHYLBORATE"

William F. Baitinger

Cotton Incorporated

VAPOR TREATMENT OF COTTON UPHOLSTERY FABRICS WITH TRIMETHYLBORATE

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ABSTRACT

Chemical treatment of fabrics in the textile finishing plant presents some unique challenges and opportunities. In cooperation with a major commission finisher of upholstery fabric, Cotton Incorporated has developed pilot scale capability to confer smolder resistance to heavyweight cotton upholstery fabrics using trimethylborate/methanol azeotrope as a chemical source for boric acid.

The paper reviews the laboratory work preceding the mill phase of this effort and presents a schematic representation of the requirements of the process for both chemical delivery and fabric preparation. The chemical and kinetic details that were considered in design are illustrated. Types of fabrics amendable to treatment, the economics of the treatment and smolder performance are examined in detail. In summary, the relationship of boric acid treated cotton fabrics is compared with other developmental means of producing upholstered furniture with improved smolder resistance.
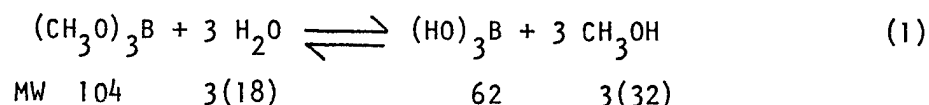
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INTRODUCTION

In a paper presented at the Natural Fibers Textile Conference in 1978 {1}, researchers at Southern Regional Research Center[2] described a laboratory method of treating upholstery fabrics to confer cigarette ignition resistance. The method employed trimethylborate vapor application to water-containing fabrics and resulted in deposition of boric acid in the fabric. The work represented a technical demonstration of the method upon which larger scale engineering design studies and commercial implementation could be based.

Research carried out by Cotton Incorporated[3] in the 1970's {3,4} led to the development of commercial scale equipment for the treatment of fabrics in a continuous fashion with vaporous chemicals requiring containment. In the ensuing decade, variations of this equipment have been utilized to treat fabrics to confer durable press and fire retardance characteristics.

The analysis of fabric processing details and the results of initial plant trials conducted with TSG Incorporated[4] form the body of the subsequent discussion in this paper covering new technology implementations. From an engineering viewpoint, it provides a model for process implementation exercises applicable to textile processing.

DISCUSSION

The chemistry involved in the trimethylborate (TMB) vapor process is illustrated in equation (1).

$$(CH_3O)_3B + 3\ H_2O \rightleftharpoons (HO)_3B + 3\ CH_3OH \tag{1}$$

$$MW\ \ 104 \quad\quad 3(18) \quad\quad\quad\quad 62 \quad\quad 3(32)$$

The hydrolysis of TMB to boric acid is quantitative in a very fast chemical reaction. The kinetics in aqueous solution are too fast to measure {2}. On a weight basis, 1.7 lbs. of TMB reacts with 0.9 lbs. of water to form 1.0 lbs. of boric acid. The simple chemistry suggests that for fabric treatment, the moisture content of the fabric can be used as the controlling factor for boric acid deposition level and that the progress of the reaction can be followed conveniently by monitoring water loss from the fabric.

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[2] One of the facilities of the Southern Regional, Agricultural Research Service; U.S. Department of Agriculture.

[3] Cotton Incorporated is the research and marketing company funded by voluntary contributions of the U.S. Upland Cotton Producers.

[4] 2 Bala Cynwyd Plaza, Bala Cynwyd, PA 19004.

A better understanding of the potential utility of using a vapor approach to treating fabrics requires some understanding of textile wet processing methods and their limitations. Water soluble materials are applied conventionally by dipping fabric in a solution of the material, followed by drying and curing (if necessary). Boric acid is soluble to the extent of $\sim 5\%$ in room temperature water, therefore, with expected wet pick-up by fabric of 70% only 3.5% of boric acid can be deposited. The fabric then would have to be dried, an energy intensive requirement. Further limitations of a wet process result from upholstery fabrics limited dimensional stability when wet. Thus the vapor, moist process shows significant advantage.

Preliminary fabric treatment of selected styles and weights of 100% cotton upholstery fabrics was conducted with the laboratory unit at Southern Regional Research Center. In anticipation of the product to be used commercially, the 70% TMB-methanol azeotrope was employed for these experiments. Supplemental moisture above the normal regain values for the fabric was required to deposit adequate boric acid in the fabric to confer smolder resistance. Moisture measurements were made using a Mahlo moisture meter, Type DMB-6, with a roller electrode. (All values reported subsequently employ this unit.) Actual dwell time requirements for adequate boric acid deposition were 90 seconds or higher, suggesting a limiting factor either in TMB concentration or in penetration of the reagent into the fabric. The final factor examined in the laboratory was dwell time following moisturization of the fabric and prior to exposure to TMB. Most experiments were run with a one hour minimum dwell or greater. In one instance in which water as applied immediately prior to exposure, evidence of heavy surface deposits was obvious.

Based upon the chemistry and small scale laboratory treatments, a process flow diagram (Figure 1) was developed to describe the commercial scale system. On contract to Cotton Incorporated[5], Vapor Systems Incorporated designed, constructed, and installed equipment at Synthetics Finishing[6] to vaporize TMB-70 (the 70% methanol azeotrope of trimethylborate, the common commercial form of this product), to conduct the vapor to the fabric and to expose the fabric in open width form to the vapors, and to remove effluent vaporous by-products of the reaction. Technical details of this installation are proprietory to Cotton Incorporated and Synthetics Finishing. Fabric moisturization was accomplished by spraying a monitored, predetermined amount of water onto the fabric and allowing various dwell times for equilibration of the water throughout the fabric. Actual values employed are presented in the tabulated data.

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[5] Contract No. 78-435 between Cotton Incorporated and Vapor Systems Inc., Bethesda, MD 20016, Negotiated 11/15/78.

[6] 539 U.S. Highway 321, Hickory, NC; a Division of TSG Incorporated.

Particular attention was required to an effective means of adding moisture to the fabric to achieve the desired control of the process and to avoid problems of surface treatment. Wetting, followed by drying was ruled out for reasons already explained. Steaming was tried, but found to be an equilibrium process itself that fell short of adding the requisite additional moisture. For the experiments described, spraying, followed by adequate time for equilibration, 2-24 hours, has been employed.

The initial plant trials used the same scheme as employed in the laboratory studies to investigate the boric acid deposition relationship to moisture content and TMB-70 flow rate. To convert TMB-70 flows from ft^3/min. to lbs. divided by 6, i.e., 1 lb. = 6 ft^3. Allowance must be made for the 70% concentration. The fabric employed for the initial trial was a 100% cotton, dobby weave (weight = 1.7 lbs. per linear yard at 54 inches width). From unit speed, fabric weight and moisture content, calculations of TMB/H_2O ratio can be made logically. Boric acid determinations were made based on a simplified, approximate method developed from the more precise method of Van Liempt {5}.

The results are presented in Table 1. In all cases, a substantial excess of TMB/H_2O was employed so that the absolute effect of fabric moisture condition could be evaluated. For ambient moisture levels (Sample 1), low boric acid deposition results, paralleling laboratory observations. Added water and multiple passes (extended dwell) enhance boric acid deposition. Flow ratios over the range studied seem to have little effect and the significance of dwell time in the reactor could not be determined with certainty. The treating unit holds about 3.3 yards of fabric, thus, actual exposure times for this series varied from about 40 seconds to 10 seconds. Samples with boric acid contents over 5% test as Class I when examined by the UFAC Fabric Classification test.[7]

In the next series of experiments, a Haitian cotton fabric (weight = 1.8 lbs. per linear yard at 54 inches width) was sprayed with sufficient water to provide a measured moisture content of 15%. Samples were allowed to equilibrate for 2 hours and for 24 hours and then exposed in the treating unit with the conditions listed in Table 2. At 10 yds/min. similar boric acid levels are obtained for either equilibration period or regardless of flow rate. At 20 yds/min., fabric speed (i.e., reduced dwell time) some diminuation of boric acid deposition is seen.

Two problems were recognized in the process development at this juncture. From results of the initial trials showing lower boric acid deposition at higher processing speed and from excessive buildup of boric acid in the scrubber, loss of trimethylborate in the exhaust was suspected. Exhaust flows were set high initially in the interest of safety. Two process unit modifications were made: exhaust flows were reduced and

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[7]Information on test details can be obtained from Upholstered Furniture Action Council, Box 2436, High Point, NC 27261.

teflon seals were provided at the exit and entry slots of the reactor. The second problem was the apparent loss of boric acid when fabrics were backcoated following boric acid treatment. A statistical series of experiments verified that fabrics that were already backcoated could be successfully treated with TMB-70 by a one-sided application (Table 3). Excellent levels of deposition resulted in all cases; in fact, the one sided treatment to backcoated fabric may actually prove advantageous by providing resistance to TMB vapor flow through the fabric.

Based on the results obtained in this last series, one yard cuts of both the Haitian and dobby fabrics (backcoated) were moisturized to approximately 15% total and were exposed to TMB-70 flows at the unit speeds indicated in Table 4. Under all conditions greater than 5% boric acid was deposited from the one-sided application. Variations seen are more likely the result of unevenness in moisturization rather than variation resulting from dwell or TMB-70 flow. At 25 yds/min. fabric is in the exposure unit 8 seconds. Under these conditions (speed and TMB-70 flow) for this fabric only a 20-30% excess of TMB-70 has been employed to achieve adequate boric acid deposition.

For a final experiment in the developmental study reported, a 35 yd. length of Haitian cotton was exposed to the conditions indicated for Sample 7 in Table 4. Portions of the fabric from the beginning, middle, and end were examined across the width of the fabric for boric acid content. The results are illustrated in Figure 2. The results suggest relatively even treatment considering that Haitian cottons are essentially greige state fabrics and as such may wet quite unevenly.

Although test results are indicated for the data, the primary intent of the work reported was not to meet the test requirements, but rather to develop systematically a commercial scale process for treating upholstery fabrics to confer smolder resistance. The capacity to accomplish this objective is demonstrated by the results. Similarly, a wide variety of fabrics have not been covered in the initial experiments, so that multiple variables would not have to be considered. The fabrics examined represent examples with a high propensity to smoldering when ignited with a burning cigarette. Optimization of treatment levels for various fabrics will be required in subsequent phases of the work.

SUMMARY

Fabric treatment trials utilizing an engineered vapor treating unit for exposing fabric to trimethylborate vapor continuously have been used to develop a commercial process for conferring smolder resistance to cotton upholstery fabrics. To obtain adequate boric acid deposition, supplemental

moisture must be added to the fabric and allowed to equilibrate. Treatment speeds up to 25 yds/min. have been accomplished, verifying the very fast and quantitative reactivity of trimethylborate with moist fabric.

ACKNOWLEDGEMENTS

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CAPTIONS FOR FIGURES AND TABLES

Figure 1.   Process Flow Diagram

Table 1.   Initial Application to Dobby Fabric

Table 2.   Boric Acid Deposition in Haitian Cotton Fabrics

Table 3.   Effect of TMB-70 Vapor Spray Configuration

Table 4.   Fabric Speed/TMB-70 Flow Relationship

Figure 2.   Boric Acid Distribution in Fabric

FIGURE 1.

PROCESS FLOW DIAGRAM
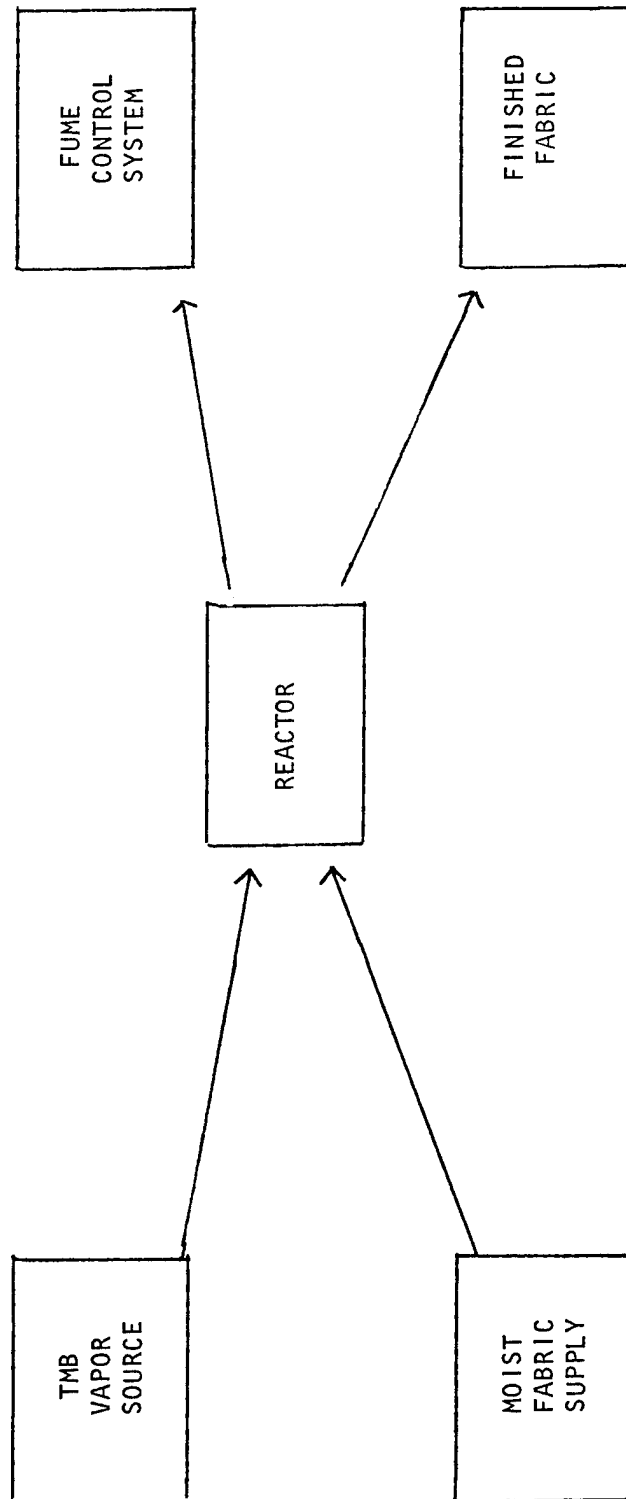
TABLE 1

INITIAL APPLICATION TO DOBBY FABRIC

Sample No.	Unit Speed (yds/min)	TMB-70 Flow (ft^3/min)	% H$_2$O In	% H$_2$O Out	% H$_3$BO$_3$	TMB/H$_2$O Ratio
1	5	18	5	< 4	1.0	5.0
2	5[1]	18	10(7)	6.5(5)	(5.9)[2]	5.0
3	5	20	13	9	3.6	2.9
4	5	40	14	9	8.6[2]	5.7
5	10	40	14	9	4.5	2.9
6	20	100	14	9	5.8	3.5
7	20	150	14	9	5.3[2]	5.2

[1] 2 passes through unit; ( ) data for second pass.

[2] UFAC Class I; all others UFAC Class II.

TABLE 2.

BORIC ACID DEPOSITION IN HAITIAN COTTON FABRICS

Sample No.[1]	Unit Speed (yds/min)	TMB-70 Flow (ft³/min)	% H_3BO_3 Treated	% H_3BO_3 Treated & Backcoated
(2 hr. equil.)				
1	10	36	5.3	4.0
2	10	48	5.6	4.1
3	10	60	7.2[2]	6.3
4	20	48	3.3	2.7
(24 hr. equil.)				
5	10	36	4.0	2.0
6	10	48	5.1	3.7
7	10	60	5.4	2.9
8	20	48	3.3	2.0

[1] Initial moisture content = 15%.

[2] UFAC Class I; all others UFAC Class II.

TABLE 3

EFFECT OF TMB-70 VAPOR SPRAY CONFIGURATION

Sample No.[1]	Fabric	Unit Speed (yds/min)	TMB-70 Flow (ft³/min)	Spray Config. (sides)	Backcoating (+/-)	% H_3BO_3
1	D	5	10	2	-	7.4
2	D	5	10	2	+	8.6
3	D	10	10	2	-	8.4[4]
4	D	10	10	2	+	7.3
5	D	5	10	1	-	8.8
6	D	5	10	1	+	9.3
7	D	10	10	1	-	6.5
8	D	10	10	1	+	7.6
9	D	5	5	1	-	7.1
10	D	5	5	1	+	7.2
11	H	5	10	2	-	10.2
12	H	5	10	1	-	9.7
13	H	5	10	1	+	8.2
14	H	5	5	1	-	8.4

[1] Initial moisture content = 12-15%.

[2] D = Dobby fabric;

H = Haitian Cotton.

[3] Average of two values.

[4] UFAC Class II, All others Class I.

TABLE 4

FABRIC SPEED/TMB-70 FLOW RELATIONSHIP

Sample No.[1]	Fabric[2]	Unit Speed (yds/min)	TMB-70 Flow (ft^3/min)	% H$_3$BO$_3$
1	H	10	10	6.8
2	D	10	10	6.1[3]
3	H	15	15	6.5
4	D	15	15	7.6
5	H	20	20	5.6
6	D	20	20	6.0
7	H	25	25	5.3
8	D	25	25	6.3

[1] Initial moisture content = 12-15%.

[2] H = Haitian; D = Dobby

[3] UFAC Class II; all others UFAC Class I

FIGURE 2

BORIC ACID DISTRIBUTION IN FABRIC

SPECIMEN

Sample [1,2]	A	B	C	D	E	F
1	5.8 I	5.9 I	6.1 I	5.3 I	6.3 I	5.1 II
2	5.1 II	5.3 I	5.6 I	5.3 I	5.4 I	4.6 I
3	5.2 I	5.2 I	5.3 I	5.2 II	5.1 I	5.1 II

[1] Initial moisture content = 15-18%.

[2] Fabric = backcoated Haitian.

BIOGRAPHICAL SKETCH

Dr. William F. Baitinger

Dr. Baitinger has been with Cotton Incorporated since October, 1974.
During this period he has risen from Manager, Fire Retardance Research
to Director of Product Safety Research. His current responsibilities
include direction of corporate programs in upholstery and safety
apparel flammability; he also monitors chemical safety activities and
develops corporate posture in these matters. Prior to joining Cotton
Incorporated, he held research and management positions in textile and
chemical intermediates research with American Cyanamid Company. He
holds numerous patents in his fields of research and has published
regularly in recent years on subjects of textile wet processing and
safety.

He is a member of the American Chemical Society, AATCC and ASTM and
is an active participant in association activities.

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"LIQUID PAINT AS A FIRE RETARDANT"

Emil Martin

Tom Ward

PPG Industries, Inc.

LIQUID PAINT AS A FIRE RETARDANT

Introduction

Interest in fire retardant coatings has increased steadily. This interest wakes and wanes with the occurrence of disasterous fires. A real and permanent need exists for these coatings, and major coating manufacturers are expanding their research efforts to develop more sophisticated fire retardant coatings. Currently marketed fire retardant coatings can be divided into two categories, those that intumesce and those that do not. The most efficient of the two is the intumescent type. When subjected to heat, intumescent coatings foam or swell to produce a cellular carbonaceous barrier that insulates the substrate from the flame. This prevents the substrate from reaching ignition temperature. The insulating layer is formed by the interaction of four basic components: a compound that acts as a carbon source, an intumescent catalyst, a blowing agent, and a polymeric binder. These intumescent compostions puff to a thickness as much as 200 times greater than the original thickness of the coating. The primary function of these coatings is to delay the fire sufficiently so that occupants can be evacuated, and fire fighting equipment can be summoned to prevent property damage.

Non intumescent coatings are usually applied so as to achieve a one to two mil dry film thickness and are designed to function in the same capacity as other non fire retardant coatings. Non intumescent coatings have a high degree of utility in marine applications where repeated painting is required to maintain substrate protection. As a result, multi layers of paint film are developed and in the event of a fire, these coatings do not sustain combustion. The most commonly used non intumescent coatings are based on the following polymer compositions:

1. chlorinated alkyds
2. polyurethanes
3. epoxies
4. polyvinyl chloride
5. vinylidene chloride

"Liquid Paint as a Fire Retardant" was selected as the topic for this presention based on the following:

1. The coating's fire retardant characteristics are established by application during the liquid phase by controlling the spreading rate and degree of film build. The higher the film build and the lower the spreading rate, the greater the degree of protection achieved; conversely the higher the spreading rate the poorer the degree of performance.

2. This condition is independant of the actual chemical reaction of fire retardancy which takes place when the coating is converted from a liquid to a solid state. In order for the film to be highly functional, both conditions must be present, i.e. low spreading rate and a functional chemical rection.

3. Interest in field applied coatings to reduce a current hazard.

Nature of Combustion

Combustion is an exothermic reaction consisting of fuel, heat and oxygen. To bring about a fire condition, energy must be given off in the form of heat to a critical temperature. Once the critical temperature is reached, combustion becomes self propogating. The process can only be stopped when one of the ingredients is exhausted or sufficient heat is dissipated to reduce the temperature below the critical value. The primary mechanism for controlling a fire via the coating is to control the oxygen. This is accomplished when the intumescent reaction is initiated at approximately 350°C and the degree of foam volume generated is sufficient to shut off the oxygen supply and to insulate the substrate so as to keep it below the critical combution temperature.

Coating

The two basic classifications of intumescent fire retardant coatings are aqueous and oleoresinous. However, because of the convenience associated with aqueous systems, water based coatings have steadily increased in popularity for use in both residential and commercial facilities. In addition to convenience, water based coatings are designed

to meet existing rules and regulations governing hydrocarbon emissions and do not pose a fire hazard during application. Traditionally, a coating's primary function is to cover, beautify, and protect, with the term protection being primarily limited to that of the substrate i.e. metal protection to prevent rusting, etc., however the term when affixed to a fire retardant coating denotes an added functional requirement of protecting not only property but saving lives. These coatings are designed to protect military equipment, space ship launch pads, schools, hospitals, institutions, nursing homes, ships, airplanes, entrances to mines, or any interior structure with either combustible or non combustible walls. Therefore, the coating must be highly functional in terms of both esthetics, fire retardancy, and general performance properties.

Having established the primary function of these coatings and end use, let's now examine the chemistry.

Chemistry

The necessary ingredients in an aqueous intumescent fire retardant coating are:

1. Catalyst - a source of phosphorous.

2. Source of carbon - containing hydroxyl groups.

3. Blowing agent - forms an incombustible gas when heated and creates foaming. The phosphorous compound breakds down when heated, and the phosphoric acid which is formed reacts with the hydoryxl forming an ester. This in turn decomposes and greatly expands in volume when the blowing agent releases its gas. It requires a proper balance of these materials both in amounts and also in the right combinations. Laboratory testing has established that these components should be within these ranges:

Catalyst	45-55%
Source of Carbon	25-30%
Blowing Agent	20-25%

The intumescent catalyst is usually monoammonium phosphate or ammonium polyphosphate.

When either phosphate is heated, it decomposes to form phosphoric acid which reacts with the carbon compound to accelerate its conversion to char. The carbon compounds generally used for this purpose are mono-, di-, or tripentaerythritol. Among the blowing agents used are melamine (which upon heating releases ammonia) or chlorinated paraffin which releases hydrogen chloride. The resin binder most often used is an emulsion vinyl chloride copolmer that softens or melts at the desired temperature. These materials are used in combination with other pigments (such as titanium dioxide) and surfactants and compounded so as to achieve a finished product.

Structures

Monoammonium phosphate

$$NH_4 H_2 PO_4$$

Ammonium Polyphosphate

$$H_{(n-m)+2} (NH_4)_m P_n O_{3n+1}$$
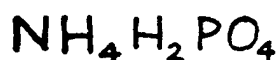
n has an average value greater than 10

m/n is about 0.7 and 1.1

maximum value of m is n + 2.

Pentaerythritol
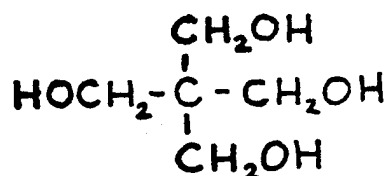
$$HOCH_2 - \overset{\displaystyle CH_2OH}{\underset{\displaystyle CH_2OH}{C}} - CH_2OH$$

Dipentaerythritol

$$HOCH_2 - \overset{\displaystyle CH_2OH}{\underset{\displaystyle CH_2OH}{C}} - CH_2 - O - CH_2 - \overset{\displaystyle CH_2OH}{\underset{\displaystyle CH_2OH}{C}} - CH_2OH$$

Tripentaerytritol

$$HOCH_2 - \overset{\displaystyle CH_2OH}{\underset{\displaystyle CH_2OH}{C}} - CH_2 - O - CH_2 - \overset{\displaystyle CH_2OH}{\underset{\displaystyle CH_2OH}{C}} - CH_2 - O - CH_2 - \overset{\displaystyle CH_2OH}{\underset{\displaystyle CH_2OH}{C}} - CH_2OH$$

Melamine

$$H_2N-C \overset{N}{\underset{N}{\underset{\displaystyle C}{\parallel}}} \overset{\displaystyle C-NH_2}{\underset{\displaystyle NH_2}{}}$$

Chlorinated Paraffin

70% Cl $C_{28} H_{33} Cl_{25}$

40% Cl $C_{24} H_{43} Cl_7$
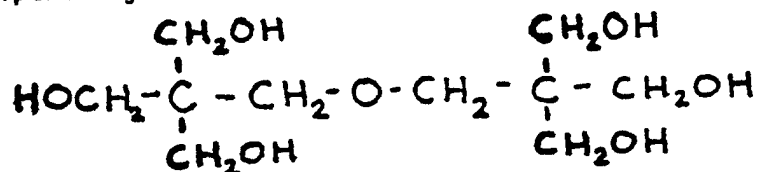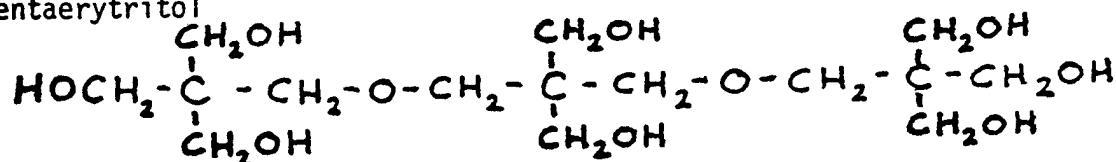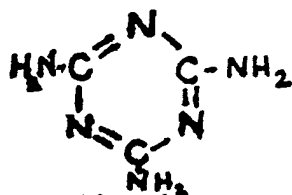
Application

With conventional architectural coatings, the applicator strives to maximize coverage with a minimal amount of material. This approach does not work with fire retardant coatings. The approach which must be taken in applying fire retardant materials is to obtain the recommended amount of coating per unit area so as to achieve the degree of protection established by the manufacturer and sanctioned by Underwriters' Laboratories. Application can be effected by brush, roller, or spray, and in all cases uniformity dictates the degree of protection that will be achieved.

The following table shows a comparison between a conventional water base interior flat and a Class A fire retardant interior latex flat. The chart clearly demonstrates how crucial the proper spreading rate is on the degree of fire retardancy.

SURFACE BURNING CHARACTERISTICS OF
ARCHITECTURAL AND SPECIAL PURPOSE COATINGS

Fire Retardant Coating

	SURFACE			
	Douglas Fir	Douglas Fir	Douglas Fir	Cellulose Tile
Flame Spread	10	15	10	20
Fuel contributed	10	10	10	10
Smoke developed	0	5	5	55
Number of preliminary coats	None	None	1	None
Rate per coat (sq. ft. per gal.)	-	-	450	-
Number of fire-retardant coats	1	2	2	1
Rate per coat (sq. ft. per gal.)	150	350	300	100
Number of overcoats	None	None	None	None
Rate per coat (sq. ft. per gal.)	-	-	-	-

Conventional Coating

	Douglas Fir	Cement Asbestos Board
Flame Spread	55	0
Fuel contributed	65	0
Smoke developed	60	0
Spreading rate in sq. ft./gal.	400.0	400

Performance Properties

As previously indicated, a fire retardant coating not only has to function in th. conventional manner but must also maintain a high degree of fire retardancy. The following chart demonstrates the difference of performance properties of a commercially available interior latex flat and a commercially available interior fire retardant flat latex.

	A. CONVENTIONAL INTERIOR LATEX FLAT WALL COATING	B. INTERIOR LATEX FLAT FIRE RETARDANT COATING
Wt./Gal.	11.41	10.87
#4 @ 60RPM Viscosity	2400-2850 CPS	2450-6000 CPS
Ph.	8.5-9.5	7.5-8.0
Weight Solids	49.2%	62.74%
Volume Solids	29.9%	51.4 %
PVC	65.26%	66.42%
% Pigment	40.50	30.51
% Vehicle	59.50	69.49
Gloss	1-5	0-15
Reflectance*	.860%	.880%
Contrast Ratio	98.6%	98.0%
Enamel Hold Out	Fair	Fair
Scrub Resistance	450 Cycles	460 cycles
Stain Removal	4.7	5.8
General Appearance	7.0	6.0
Flow and Leveling	3.0	1.0

*Shaded
+ 10 = Best   0 = Poorest

Advantages

Aqueous fire retardant coatings have the following advantages:

1. They can be used on combustible materials already in place.
2. They are inexpensive.
3. Equipment can be cleaned up with soap and water.
4. They have good serviceability.
5. They are easy to apply.
6. They are esthetically pleasing due to a wide array of colors and uniformity the dry film.

Disadvantages

Aqueous fire retardant coatings have the following disadvantages:

1. Limited to interior applications due to the high degree of permeance.
2. Must have controlled application.
3. Requires more than one coat so as to achieve maximum efficiency.
4. Generally available only in flat quality due to the high pigment loadings required to achieve fire retardancy.
5. Limited shelf life (viscosity instability).

It is obvious that the advantages far outweigh the disadvantages with aqueous fire retardant coatings, when it is recognized the degree of serviceability and protection these coatings offer.

Substrates

In dealing with fire retardant coatings there are basically two types of substrates that must be considered - load bearing and non load bearing. These can be further divided into combustible and non combustible substrates. The previously described coatings have dealt with non load bearing combustible and non combustible surfaces. Now let's examine what this means. Wood doors, trim, and paneling would be considered combustible non load bearing. Dry wall sheeting and plaster would be considered to be non combustible non load bearing, and it is obvious why the previously described intumescent fire retardant coating would be highly functional in protecting these substrates. It is obvious that in load bearing structures and substrates, an entirely different fire retardant coating must be used, and this brings us to the following compsitions which are classifed as mastics.

Mastics for Metal

In order to achieve thermal protection of structural steel, a number of conditions must be recognized. Temperatures during a fire will exceed 2000^oF. Steel will rapidly lose both compressive and tensile strength above 600^oF and collapse at approximately 1000^oF. Delaying structural failure allows for evacuation, safety override equipment to function, and additional time for arrival of fire fighting equipment and personnel. If the fire is quickly extinguished, structural damage is minimized resulting in lowered repair cost and shortened down time.

Coatings in Use Today

All mastic coatings integrate the following three factors for thermal protection:

Insulation: Results from shear mass as is the case with concrete compared to the carbonaceous foam structures formed when mastics intumesce.

Heat Reflection: Ability to reflect infrared radiation.

Endothermic Processes: Heat absorbing phase changes such as sublimation and vaporization, which also function by keeping hot gases away from the substrate.

The market for structural steel coatings can be segmented into two broad areas. The commercial which includes office buildings, hospitals, schools, etc., where the steel is often concealed behind walls, ceilings, and floors. The second area is industrial where the steel is exposed, often to corrosive environments that exist in petroleum refineries, chemical plants, coastal and offshore locations.

The products for the market are often referred to as soft coat materials which are cementatious binders, usually highly filled with such additives as vermiculite, pearlite, mineral wool, or glass fibers. These materials should be used for interior use.

These materials are adequate, but some properties could be improved such as increased hardness to resist damage, and application in temperatures as low as $35^{\circ}F$.

The Industrial Market can be subdivided into three areas:

1. high density cementatious (concrete)

2. low density cementatious (plaster, magnesium oxychloride)

3. Mastics

The high density cementatious materials, which cover concrete or gunite produce four hours of protection when four inches are applied. Materials and labor based on a square foot basis are relatively costly. These materials are difficult to apply to existing structures, and due to the additional weight, the structural design has to be sufficent to accomodate the weight.

The low density cementatious or plaster types include aggregate plasters or gypsum, but these systems are not suitable for all exterior environments for lack of durability. The magnesium oxychloride material has a very good fire rating when related to film thickness. Some disadvantages are accelerated corrosion of the steel if not properly primed. Also the material is fragile and easily subjected to damage and must be top coated to enhance durability.

Mastics are light weight coatings that intumesce and protect mainly by insulation and endothermic processes. Their typical advantages are light weight, good adhesion, and durability. They can be applied to steel structures having complex shapes. The disadvantages are external reinforcements are needed for longer rating times, and no four hour systems are available.

Miscellaneous Type Coatings

There is an increasing demand for clear intumescent fire retardant coatings for coating of paneling and other surfaces where the esthetics are maintained by the visual appearance of the substrate. These coatings are based on either chlorinated rubber, epoxy, or polyurethanes, with pigments as previously described being incorporated to achieve intumescence. Because of the pigmentation employed, these coatings do not have the same degree of film clarity of conventional varnishes (polyurethane, alkyds, etc.). However, they are highly functional materials and in some instances are found to display Class A fire retardant ratings.

As mentioned earlier, most architectural coatings are applied in the field and must cure under ambient conditions. However, there is an increasing demand for manufactured wood paneling and simulated wood materials with flame retardancy better than unpainted wood. Since these materials are usually coated in factories, elevated cure temperatures can be used. Flame retardant coatings of this type usually also have improved stain and solvent resistance over that of field applied materials.

Testing

Extensive testing and evaluation on a Monsanto Tunnel of fire retardant coatings were undertaken in order to determine which formulations yield lower flame spread and may become a Class A material.

The construction and operation of the Monsanto Tunnel was described in great detail by Vandersall. Vandersall as well as Levy, Hilado, and Burgess reported good agreement between the 25 foot tunnel flame spread rating and those obtained in the small tunnels. However, our experience with the Monsanto Tunnel did not lead to the same conclusions. Most of the problems encountered in the operation of the Monsanto Tunnel and the UL Tunnel are due to the difficulties in controlling and measurements of the flame front. Therefore, one must establish the accuracy limits and the reproducibility of the tunnel before any attempt is made to correlate the results of the two tunnels, or a prediction is made as to the behavior of a certain material in the 25 foot tunnel based on the Monsanto Tunnel.

The use of a small two-foot tunnel is convenient for the laboratory evaluation of flame spread ratings. The inclined flame tunnel used by Monsanto is a modification of the tunnel designed by the U.S. Gypsum Company. A 24 3/4"x 3 3/4" panel (or two 11 3/4" x 3 3/4" panels) is mounted in the tunnel with the coated side face down. A gas flame is directed onto the panel surface at the lower end. Observation of the flame spread across the surface of the panel is made from a side window (vycor). The coating is subjected to the flame for five minutes. The flame is allowed to burn for an additional one minute, during which time no recordings are made, and then extinguished. The flame spread rating is calculated from the maximum flame front advance of the panel surface as compared to that with preconditioned one-inch red oak and asbestos mill board, which arbitrarily are assigned values of 100 and 0, respectively.

The product finalization is conducted at Underwriters' Laboratories using a 25 foot tunnel provided the product is to carry a UL label.

Challenge of the Eighties

As previously indicated, there is an increased activity and interest in developing new technologies for developing fire retardant coatings. However, this activity is hampered by the lack of laws and regulations dictating the use of these products. This condition limits the degree of research activity most companies are willing to invest. In addition to the foregoing, the other major drawback is the fact that the state of technol which exisits today makes mass merchandising prohibitive due to the vicosity instability (limited shelf life).

Therefore the challenge is to develop new technologies which will elimiate instability so as to have products which can be mass merchandised with the net result being greater marketing input so as to educate the general populace of the beneficial performance of these coatings, and secondly to become more active with agencies who can impact on laws and standards governing the use of fire retardant materials.

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"BUILDING CONTENTS, THE REAL FIRE PROBLEM

IN THE ROOM"

Raymond C. Ellis

American Hotel & Motel Association

Remarks by Raymond C. Ellis, Jr., Director of Operational Services
and Research, American Hotel & Motel Association, New York City

Presented to the Fire Retardant Chemical Association, Philadelphia,
Wednesday, October 14, 1981

Over the years improvements in construction technology have resulted in
making our buildings "better incinerators." While the basic structural
members of ceiling, walls and floors have withstood fires, the con-
tents have been incinerated. With a special sensitivity to fire
problems, the lodging industry is looking for those techniques and
developments that will enable the hotel or motel to provide an in-
creased degree of fire retardant capability in the guest room and
throughout the public and meeting areas of our establishments.

One has a certain disadvantage in taking part in the wrap-up session.
In the past two days, you have considered the nature and extent of
the problem of building contents and have explored what might better be
done in fire protection strategy for those installations behind
the wall and ceiling, on the wall and floor; and now, within the room.
So, let us dispense with some of the obvious concerns in the room,
by reference, as you have already heard papers and participated in
the discussion of floor covering, wall covering, paints, ceiling tiles
and other basic design factors that are an integral part of our lodging
establishment rooms; whether in the guest, restaurant, lounge, meeting
or general public areas.

These elements are of great concern to our industry as they have been significant contributors to rapidity of flame-spread and the movement of toxic fumes, soot and smoke throughout portions or the entirety of a hotel or motel. Obviously, making the floor, wall, ceiling and behind the wall and ceiling installations more fire retardant would be a major contribution to the fire safety of the lodging industry.

Designers, executives responsible for purchasing and the executive committees and boards to which they report, fire protection consultants and staff at the corporate level are very much aware of the need to upgrade the fire retardant contents of all of our rooms. Needless to say, first costs, front-end money or whatever other designation you may prefer on the cost of presenting a finished room to the public for lodging, refreshment, conferences, recreation, or entertainment, is a primary consideration. So, it is hoped that advanced fire retardant chemical technology and a viable market will permit establishments, large and small.

Obviously one could create a sterile environment within which one could uncomfortably sit or repose upon concrete and steel elements that would replace the more comfortable but flammable furnishings in many contemporary rooms. That is a solution that is not considered, even in jest.

Let's first consider one element in the guest room... the smoking material; especially the cigarette. There have been recent efforts, perhaps by some of you in attendance this morning to develop a self-extinguishing cigarette.

There have been recent efforts, perhaps by some of you in attendance this morning to develop a self-extinguishing cigarette. I hope that you will "join battle" to assess the feasibility of a cigarette that would extinguish itself should it roll from a receptacle into a waste-basket or onto the bed covering. Smoking materials consistently appear as the most frequent source of hostile fires in the United States.

The Upholstered Furniture Action Council, has worked with the U.S. Consumer Product Safety Commission for several years in the development of fire safety for upholstered furniture. In response to the possibility of Federal legislation that would mandate such fire safety, the UFAC established a Voluntary Action Program that consists of a fabric-rating system, construction criteria, a labeling plan, and a compliance procedure. Many of you have significantly contributed to the fire-retardant capability of one or more of the several elements in upholstered furniture. We need a continuing emphasis on implementation of this program...again, with the cost consideration under review.

Two mattress manufacturers are currently testing a fire retardant ticking. Others may be conducting similar experiments. Mattresses with fire retardant ticking will be more expensive than those in conventional contract lines. We look to you for an advance in technology that will reduce the cost of fire retardant mattresses so as to put this within the reach of the smaller as well as the larger lodging establishment or chain.

The sheets, blankets and coverlets need special attention too as these frequently provide the fuel for the fire following careless use or disposal of smoking materials.

It goes without saying that the chemical treatment must not have deleterious side effects for the people sleeping on, or who otherwise come in contact with the treated fabrics. Furniture also warrants your attention. Many of you have seen the remaining few springs or metal parts from what had been a chair or sofa in an incinerated room. Our guests enjoy the comfort of over-stuffed upholstered pieces. Tragically, the cigarette dropped between the cushions may start a disastrous and fatal fire. Fabric, wood, foam, feathers...all need fire retardant capability within the limits of economic feasibility.

The plastic contents of a room are considerable. Lampshades, radio and TV casings, wastebaskets, trays, drinking containers...the listing goes on and on. Curiously enough, as you well know, some of the chemicals that will reduce the flammability of plastic items sharply increase the amounts of smoke and toxic fumes. We need your assistance in developing plastics that will minimize flame-spread, smoke and toxic fumes. A larger order; but one that advanced technology must address. An architectural firm has scheduled the building of a 3,600 room King Nevada Hotel in Las Vegas, with completion set for late 1983. It will be the world's largest hotel. While it will have the most modern fire protection systems, the statement from Gerald A. Mulhall, financial chairman of McLaughlin Architects and Engineers, reflects the lodging industry's concern with building and room contents. He noted that the building interior will be done largely in "natural materials," wood, plaster and metal.

According to current plans, ornamentation will be of gypsum plaster, carpeting of wool and probably of a wool-cotton blend.

"We plan to stay away as far as possible from synthetics," Mulhall says.

Here, then, is a challenge for the future. You also should consider developing the fire retardant treatments for these natural decorative materials. This, despite the fact that synthetic materials are more widely used in hotels and motels today.

Remember, over 70% of the American Hotel & Motel Association membership consists of properties with 150 rooms or less. This is a pretty good cross-section of the Nation's lodging establishments. Thus cost as well as performance must be uppermost in your research development and marketing strategies. If the most effective fire-retardant item is beyond the financial capacity of the smaller property owner, it will not hold the answers so critically needed as our industry seeks to enhance the safety of millions of guests that we serve each year.

ADVISORY SAFETY PROVISIONS
OFFICE FURNITURE AND FURNISHINGS

In all offices, conference rooms, waiting rooms, assembly areas and similar spaces, it is recommended that all furniture and furnishings should be of fire resistive quality in accordance with the following requirements.

Furniture

a. All furniture such as desks, tables, wardrobes, cabinets, bookcases, etc., should be constructed entirely of noncombustible materials or fire retardant treated wood except that a combustible veneer not exceeding one-eight inch may be used on the top surface of such articles.

b. All free standing chairs, sofas, coat, racks, etc., should be constructed with frames of non-combustible materials or fire retardant treated wood.

c. Wastepaper baskets should be constructed of noncombustible materials with solid sides and bottom.

d. All upholstery materials including covering, lining, webbing, cushioning and padding, should be self-extinguishing as defined by Federal Specification ccc-T-191 b Method 5903.

e. All self-supporting plastic materials should be self-extinguishing as defined by the "Standard Method of Test for Flammability of Self-Supporting Plastics," ASTM Designation: D 635-68.

f. Where the item contains other than noncombustible materials, the manufacture should submit a copy of a certification of the service life of the flame retardancy of the treated material or a certification that the self-extingiushing properties of the material are inherent there in by virtue of the chemical properties of the material. Materials which are not inherently self-extinguishing should be used only when the certified flame retardant service life exceeds that of the planned service life of the finished item.

Draperies and Curtains

a. If the material contains 100% fibers that are inherently noncombustible by virtue of the chemical properties of the untreated fiber, the manufacturer should submit a copy of written certification so stating.

b. If the material contains fibers which are not inherently noncombustible in the untreated state the manufacturer should submit a copy of a written certification attesting that the treated materials have been rendered safe against fire as required by the test in section 4 (b).

Rugs and Carpets

a. All rugs and carpets should be of wool or other materials meeting the test requirements recommended in this Advisory Bulletin Appendix.

b. The manufacturers of the assembly components (carpet and underlayments) should submit a certification of the service life of the flame retardance of the treated material or a certification that the self-extinguishing properties of the material are inherent there in by virtue of the chemical properties of the material. Materials which are not inherently self-extinguishing should be used only when the certified flame retardant service life exceeds that of the planned service life of the carpet and underlayments, when cleaning, traffic, and other environmental conditions which may affect the treatment, are taken into consideration.

FIRE DEPARTMENT
ADVISORY SAFETY PROVISIONS
OFFICE FURNITURE AND FURNISHINGS

The purpose of this advisory is to provide an understanding of the fundamental considerations of fuel content of buildings as it relates to design for fire safety and to encourage architects, designers, owners, building managers, tenants, and others to keep office furniture and furnishings within certain fuel content standards.

If it were feasible to eliminate all combustible contents from a building by using only non-combustible furniture, furnishings, and building materials, the hazard of fire would be further reduced from the present level. The Building Code reduces the combustible contents of the construction. However, limiting contents drastically would be impractical and defeat the purpose of having buildings where people can conduct business, provide services, and participate in all forms of commerce effectively.

The amount of combustible material in the building, including both contents and combustible parts of the structure, determines the fire load, a definite figure which should be considered in design (fire safety) just as it is common practice to consider weight loads in building design (structural). For more detailed fire load information, see Appendix II.

In addition to trying to control combustible contents, it is suggested that low flame spread and self-extinguishing furnishings be used.

For example, it is suggested that the following items meeting the recommended requirements in the attached Appendix be used:

1. Furniture constructed of a high proportion of noncombustible materials or of fire retardant treated wood.

2. Self-extinguishing upholstery and plastic materials.

3. Glass fiber drapery lining and curtain materials or other flameproofed materials.

4. Carpeting and carpeting underlayments with relative low flame spread and smoke developed ratings.

Since this is an advisory until such time as adequate national standards under the U.S. Flammable Fabrics Act are established, the test methods and standards in the attached Appendix I provided only as a frame of reference and for information purposes. As new developments occur, we intend to issue amended advisory bulletins reflecting such developments.

"SMOLDER RESISTANT BACKCOATING TECHNOLOGY FOR

UPHOLSTERED FURNITURE FABRIC"

Barry Saxe

Stauffer Chemical Company

SMOLDER RESISTANT BACKCOATING TECHNOLOGY
FOR UPHOLSTERED FURNITURE FABRIC

by Barry Saxe

Upholstered furniture fires account for more deaths and property damage than any other consumer product. Last year in the United States there were 25,000 residential fires in which the initial item ignited was upholstered furniture, primarily due to smoldering cigarettes. These fires resulted in 1,200 deaths and with property damage estimated at $119 million.

Both the furniture industry and the Consumer Products Safety Commission (CPSC) expected that a voluntary flammability program developed by the Upholstered Furniture Action Council (UFAC) in 1978 would alleviate the problem of fires in upholstered furniture. This program incorporates a fabric classification system along with an engineered safety concept based on certain construction criteria for a finished furniture product.

However, the results of extensive testing by CPSC of furniture built in compliance with the UFAC program indicated a high rate of failure and brought into question the effectiveness of the UFAC program. This has prompted discussions between CPSC and UFAC to effect improvements in current furniture flammability practices.

At the same time, California has modified its flammability regulation on polyurethane cushioning to include a smolder requirement. Further evaluation work is underway in California which may lead to a flammability or smolder resistant standard for fabrics as well as to the possibility of a small scale composite testing requirement.

Based on both CPSC concerns and the activities in California, it is evident that a more effective flammability standard for upholstered furniture will be forthcoming, be it voluntary or mandatory or under federal or state

regulations. Stauffer has developed a technology that offers a safe and practical solution to the smolder ignition problem of upholstered furniture.

Stauffer's approach is to incorporate a flame retardant into the polymeric backcoating of upholstery fabric rendering it smolder resistant. This technique is advantageous since the fabric serves as the first barrier of defense against ignition and the smolder is halted at its source. I'd like to discuss briefly Stauffer's development work and experimentation in an attempt to define the contribution that this technology offers as a solution to the upholstered furniture flammability problem.

It is generally agreed that fabrics that contain high proportions of cellulosic fiber are more prone to smoldering ignition. Therefore, Stauffer's experimentation focused on fabric blends ranging from 100% cotton to 100% rayon. About one-half of the yardage of these types of fabrics are presently backcoated with a polymeric material such as styrene-butadiene or acrylic latices to improve dimensional stability, durability, resistance to seam slippage, and unravelling.

Early tests indicated that Stauffer's Fyrol 6 flame retardant added to these backcoating compounds proved to be an efficient smolder resistant agent that had the least effect on fabric aesthetics, notably hand. This was confirmed in coating trials using production equipment.

Fabrics from these coating trials were subsequently used in chair constructions using UFAC recommended construction criteria and subjected to full scale burn tests with smoldering cigarettes. These fabrics demonstrated excellent smolder resistance compared to both uncoated fabrics, as well as pre-UFAC construction methods.

Once the feasibility of smolder resistant backcoating technology was established by this first series of tests, additional coating trials were conducted to improve the aesthetic properties, mainly the hand, of the coated fabric without sacrificing smolder resistance. This was accomplished by modifying both the backcoating formulation and application technique to reduce penetration of the coating into the fabric and minimize add-on level. One useful technique is that of frothing, which simply involves the introduction of a known volume of air into the coating mix to reduce the density and increase the surface area so as to minimize the penetration of the coating into the matrix of the fabric.

These improved fabrics were also evaluated in full scale chair constructions, this time in parallel with chairs built with polyester fiberfill wrap over the cushions. This is a construction method recommended by the UFAC program. Here is a sequence of slides which shows the progress of one of these tests. The results of these tests indicated that smolder resistant backcoating technology represents a practical and economic alternative to the use of expensive fiberfill (Table 3).

This technology can be used by itself or in conjunction with fiberfill depending on the aesthetic properties desired. This backcoating technology can also upgrade the smolder resistance of the upholstery fabric to almost any degree required based on the adequacy of the smolder resistant properties of the composite construction. On the other hand, if the polyester fiberfill material by itself does not provide sufficient smolder resistance, the addition of a low level smolder resistant backcoating to the upholstery fabric may be just the boost that's needed to help that particular composite construction pass a smolder resistance test.

In summary, the addition of Fyrol 6 flame retardant to a fabric backcoating is a new, but non-proprietary, technology. Stauffer has worked with formulations that can be modified in many ways. This technology represents one economical approach to making upholstered furniture safer from smoldering cigarettes.

<u>"UPHOLSTERED FURNITURE FLAMMABILITY"</u>

L.J. Sharman

Consumer Product Safety Commission

UPHOLSTERED FURNITURE FLAMMABILITY

ABSTRACT OF PAPER

L. J. SHARMAN
CONSUMER PRODUCT SAFETY COMMISSION

Upholstered furniture fires are responsible for approximately 1,500 deaths annually, of which 1,200 are from cigarette ignitions and 140 from small open flames. During 1980, the Upholstered Furniture Action Council's (UFAC) Voluntary Action Program was evaluated to determine its effectiveness in reducing the ignition of upholstered furniture by cigarettes. The results of this evaluation are discussed. Commission staff have recommended that UFAC be encouraged to conduct and improve their Voluntary Action Program for another year. The Commission is now considering this recommendation and other alternatives. The Commission also has under consideration petitions requesting the issuance of flammability standards addressing the open-flame ignition hazard.

UPHOLSTERED FURNITURE FLAMMABILITY

The Consumer Product Safety Commission (CPSC) stands at a thresh-hold today. There is no question that too many people die from uphol-stered furniture fires. Should CPSC establish a mandatory regulation forcing manufacturers to construct cigarette-resistant furniture? Or should the Commission encourage the industry to continue to try to solve the problem voluntarily? I cannot now predict the Commission's future direction nor can I discuss Commission policy. Those are matters which can only be decided by majority vote of the Commissioners, and which are beyond the authority of any individual member of the Commission staff. I can, however, describe how we got to this point.

Upholstered furniture fires cause more deaths than any other single product under this Commission's jurisdiction. These fires are respon-sible for approximately 1,500 deaths, of which 1,200 are from cigarette ignitions and 140 from small open flames. Property loss is estimated at $189 million; $119 million related to cigarette ignitions, $30 million to open flame ignitions. Deaths in residential fires involving uphol-stered furniture represent about 27 percent of all fire deaths. Clearly, upholstered furniture fires account for a significant portion of the total U.S. fire deaths, and cigarette ignitions account for most of these deaths. Not surprisingly, cigarette ignition receives our primary attention.

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FIRE RETARDANT CHEMICALS ASSOCIATION
OCTOBER 11-14, 1981
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*/ The opinions expressed by Dr. Sharman do not necessarily represent
the views of the Commission. Since this material was written by
Dr. Sharman in his official capacity, it is in the public domain, and,
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Lets look at this problem of smoldering ignition. Work on upholstered furniture started in 1972. Comments from fire chiefs and fire marshals indicating that upholstered furniture was a major ignition source in residential fires established the need for action. A study carried out by the Southwest Research Institute showed that upholstered furniture could easily be ignited by cigarettes and a lethal atmosphere could be generated in a relatively short period of time.

The National Bureau of Standards (NBS) developed, by 1974, a smoldering ignition test method which involved a) classification of fabrics into categories by their resistance to cigarette ignition and b) testing of furniture mock-ups, constructed from the materials to be used in the furniture, for their resistance to cigarette ignition. Late in 1976, CPSC staff submitted a draft proposed standard based upon the NBS test method to the Commission for their consideration. The Commission agreed that action was needed on the problem of upholstered furniture flammability. The draft proposed standard, however, seemed too complex, so the Commission directed that the standard be simplified without significantly affecting the safety provided. Staff provided such a simplified revised draft standard.

December 1978 saw a public meeting on upholstered furniture flammability when CPSC received considerable new information. The Upholstered Furniture Action Council (UFAC) took this occasion to introduce their plans for a voluntary industry program for the production of improved cigarette-resistant furniture. Their program requires upholstered furniture to be constructed, in a specified manner, from materials which meet the UFAC component test requirements. Furniture meeting the requirements are eligible to display a gold UFAC hang tag.

The Commission, in November, 1979, voted to defer any mandatory regulatory action on upholstered furniture flammability in order to determine the effectiveness of the Voluntary Action Program in reducing the ignition of upholstered furniture by cigarettes. Both CPSC staff and UFAC expected that a major portion of the UFAC labeled furniture would resist ignition by cigarettes. The key evaluation activity was the actual cigarette testing of UFAC labeled furniture purchased on the open retail market.

The Commission purchased and tested a total of 78 UFAC labeled furniture items representing products manufactured by 70 firms. Since we expected that a major portion of the furniture would resist ignition, fiber content of the fabrics was skewed in the direction of those fabrics expected to be more prone to ignite, predominantly cellulosics.

We tested the crevice areas, welt areas, cushion surface, arms and backs as appropriate. Of the 78 furniture items tested, 61 (78%) ignited. Crevices (side and back), and welts ignited most frequently. By combining the test results with other market data, such as the quantity of fibers used in upholstery fabrics, we estimated that 51% of the UFAC furniture on the market could be expected to ignite from cigarettes.

Neither UFAC nor CPSC staff anticipated the high number of ignitions observed. However, the full scale furniture tests provided new insight into areas requiring further work, such as the crevices and welts. They also indicated modifications in furniture constructions which could be expected to further improve the cigarette ignition

resistance. These include the use of barrier materials on all six sides of cushions, and not just the top and bottom as is now frequently the case; and the use of smolder resistant inner fabrics in place of the untreated cotton fabrics now commonly used.

Now the Commission must address, in light of these results, further actions on the problem of cigarette ignition of upholstered furniture. In their report to the Commission, the majority of the Commission staff recommended:

UFAC be encouraged to conduct and improve their Voluntary Action Program for another year. CPSC staff would actively assist in the program during the year, and at the end of the year would carry out a second furniture test program on UFAC labeled upholstered furniture, to determine the improvements achieved in resistance to ignition by cigarettes.

To provide a basis for an objective evaluation of improvements achieved by UFAC, the staff proposed a series of goals as part of their recommendation. The fundamental goal proposed by the staff was that, by the end of the year, no more than 20% of the UFAC furniture should ignite.

The Commission is now considering the above recommendation and other alternatives.

As I mentioned at the outset, a lesser, but still significant number of upholstered furniture fires result from small open-flame ignition sources. The Commission has received three petitions requesting that it issue a flammability standard to address this aspect of

upholstered furniture flammability: one from Olin Corporation, a second from the Los Angeles Fire Department, and a third from the State of California. The Commission has not yet acted to grant or deny these petitions, and is considering whether it is practical to approach both open-flame and smoldering ignition hazards in a single standard, either voluntary or mandatory.

In conclusion, the Commission recognizes the serious problem caused by the smoldering ignition of upholstered furniture. The Commission selected this project as one of high priority. The status of our work may be summarized as follows. Upholstered furniture fires are a major cause of deaths and property loss in the United States. The furniture industry is taking positive action to reduce this toll; however, we need further giant steps forward before this problem is defeated. As I indicated at the beginning of this paper, the Commission is at a threshold. Whatever the Commission decides, mandatory or voluntary, I believe that the final solutions to this problem will be based upon technical changes to furniture construction. Upholstered furniture must be built in such a way that it resists ignition from cigarettes. These changes, these innovations, can only come from people such as you, the industry. I am confident that you can do it.

"CALIFORNIA UPHOLSTERED FURNITURE COMBUSTIBILITY STANDARD

1981 UPDATE

Gordon H. Damant

California Bureau of Home Furnishings

CALIFORNIA UPHOLSTERED FURNITURE COMBUSTIBILITY STANDARD

1981 Update

History

Legislation passed in California in 1972 required all upholstered furniture offered for sale in California to be "flame retardant", and also specified that all such furniture should meet the requirements, regulations and standards developed by the California Bureau of Home Furnishings.

It is important to notice that the legislative mandate required:

(a) All California furniture to be flame retardant,

(b) The Bureau to develop fire performance standards for all such furniture, and

(c) The effective date of such regulations to be April 1, 1975.

The legislative mandate did not require the Bureau to:

(a) Establish a finding of need for a furniture flammability standard,

(b) Perform any hazard/risk/benefit assessment,

(c) Produce an economic impact statement or analysis,

(d) Address any environmental impact of the regulation, or

(e) Validate the standard by a subsequent assessment of effectivenesss.

In essence the California Legislature said to the Bureau, "We have determined that there is a need for an upholstered furniture flammability standard in California, the Bureau will produce a standard by April 1, 1975."

Under California law the essential definition of upholstered furniture is: "Any product containing a concealed filling material which can be used

to support any part of the body or limbs of a person while in a sitting or reclining position."

The legislative mandate was therefore very broad, covering almost every conceivable furniture article under the flammability umbrella, and contained no provision that would allow the exemption of any product from the Bureau's flammability requirements.

Subsequent California legislation introduced at the request of the furniture industry and enacted in 1975 modified the 1972 legislation in two ways:

(a) The effective date of the flammability standard was delayed six months, until October 1, 1975; and

(b) The Chief of the Bureau of Home Furnishings was authorized to exempt from the flammability requirements any furniture product which in his judgment did not constitute a serious fire hazard.

As a result of this clear-up legislation, the Bureau has exempted from the flammability requirements the following furniture products by product class:

(a) Any furniture manufactured and sold solely for outdoor use,

(b) Cushions manufactured and sold solely for decorative purposes, and

(c) Any furniture containing one-half inch or less of a stuffing material in which the horizontal and vertical surfaces do not meet.

In addition on an individual product-by-product basis, the Bureau has exempted furniture designed purely for recreational purposes, such as weight-lifting benches, gymnasium equipment, etc.

Technical Bulletins 116 and 117

The essential features of California's upholstered furniture flammability standard are contained in two documents known as Technical Bulletin 116, "Requirements, Test Procedure and Apparatus for Testing the Flame Retardance of Upholstered Furniture" and Technical Bulletin 117, "Requirements, Test Procedure and Apparatus for Testing the Flame Retardance of Resilient Filling Materials Used in Upholstered Furniture". As originally proposed in 1972 these Technical Bulletins required that by October 1, 1975, all furniture component materials used in furniture offered for sale in California must meet the following flaming and smoldering requirements:

TABLE 1

California Furniture Test Requirements

	FLAMING	SMOLDERING
Cellular Foams (Polyurethane Foams, Latex Foam Rubber, Neoprene, etc.)	T.B. 117, Section A, Part I	T.B. 117, Section D
Shredded Foams	T.B. 117, Section A, Part II	T.B. 117, Section D
Polystyrene Beads	T.B. 117, Section A, Part III	T.B. 117, Section D
Non-Manmade Fiber Battings, (Cotton, Wool, Kapok, etc.)	T.B. 117, Section B, Part I	T.B. 117, Section D
Feathers and Down	T.B. 117, Section B, Part II	T.B. 117, Section D
Man-Made Fiber Battings (Polyester, Nylon, Acetate, Acrylic, etc.)	T.B. 117, Section C	T.B. 117, Section D
Upholstery Fabrics	T.B. 117, Section E	

In addition to the requirements in Table 1, Technical Bulletin 117, Section F, required that all upholstery fabrics be flame retardant by October 1, 1977; and Technical Bulletin 116, with a test for the finished furniture piece, required that all furniture offered for sale in California after October 1, 1977, be totally cigarette resistant. It was under this format and test scheme that California's furniture flammability standard became fully effective on October 1, 1975.

Litigation

During the progress of the legislation through the California State Legislature, it received very little opposition from the furniture industry. Thus the furniture legislation sailed through the Legislature almost without a dissenting voice. However, the publication by the Bureau in 1974 of proposed flammability standards for upholstered furniture coincided with the formation of the Upholstered Furniture Action Council (UFAC). This industry consortium of trade associations was formed primarily to address furniture flammability legislation and standards both at the State level in California and at the Federal level before the Consumer Product Safety Commission (CPSC). In California UFAC became very active in representing the interests of the furniture industry before the State Legislature and in negotiations with the Bureau of Home Furnishings. In addition UFAC took action through the courts to have the California law overturned, basically on the premise of pre-emption of State standards by Federal standards under the provisions of both the Flammable Fabrics Act and the Consumer Product Safety Act. As a result of UFAC vs. State of California, the Bureau was enjoined in March, 1976, from any further enforcement of the Furniture Flammability Standard until the courts had an opportunity to judge the merits of the pleadings. Therefore the California Standard was

was enforced for a six-month period, from October 1, 1975 - March, 1976, prior to the injunction.

Following a number of court hearings, the injunction against the Bureau was finally dissolved in November, 1976, and the Bureau began enforcement of the furniture flammability standard on a continuous basis on March 1, 1977.

Development

Along with the re-enforcement of the regulation in March, 1977, the Bureau also made several technical modifications to the flammability standard at this time. Section F of Technical Bulletin 117, requiring that all upholstery fabrics be flame retardant was deleted from the standard, on the basis that technology did not exist to allow industry to uniformly comply with this requirement. In addition Technical Bulletin 116 requiring all finished furniture articles offered for sale in California to be totally cigarette resistant by October 1, 1977, was modified to initially be a voluntary standard with the provision and intent that at some future time it would become a mandatory requirement. The modification to the enforcement of Technical Bulletin 116 was again necessitated by considerations of the available technology, or lack of, which would enable furniture manufacturers to make all California furniture cigarette resistant. In particular, smoldering problems caused by the extensive use of fabrics consisting predominently of cellulosic fibers such as cotton, rayon and linen, did not appear to be solvable in a reasonable and economic manner at that time.

By January 1, 1978, a flammability labeling requirement was added to the Bureau's standard. Under the provisions of this requirement all

furniture in compliance with the mandatory requirements of Technical

Bulletin 117 and the voluntary requirements of Technical Bulletin 116

are labeled as follows:

<u>NOTICE</u>

THIS ARTICLE MEETS ALL FLAMMABILITY REQUIREMENTS OF
CALIFORNIA BUREAU OF HOME FURNISHINGS' FLAMMABILITY
REQUIREMENTS. CARE SHOULD BE EXERCISED NEAR OPEN FLAME
OR WITH BURNING CIGARETTES.

Furniture articles in compliance with Technical Bulletin 117, but not

the requirements of Technical Bulletin 116, are labeled:

<u>NOTICE</u>

ONLY THE RESILIENT FILLING MATERIALS CONTAINED IN THIS
ARTICLE MEET CALIFORNIA BUREAU OF HOME FURNISHINGS'
FLAMMABILITY REQUIREMENTS. CARE SHOULD BE EXERCISED
NEAR OPEN FLAME OR WITH BURNING CIGARETTES.

And products which have been exempted by the Bureau from the provisions

of both Technical Bulletins 116 and 117 must be labeled:

<u>NOTICE</u>

THIS ARTICLE DOES NOT MEET THE CALIFORNIA BUREAU OF HOME
FURNISHINGS' FLAMMABILITY REQUIREMENTS - TECHNICAL
BULLETIN 117. CARE SHOULD BE EXERCISED NEAR OPEN FLAME
OR WITH BURNING CIGARETTES.

Thus all furniture offered for sale in California must show one of the

above three types of flammability labeling.

The Bureau's approach to flammability regulation of upholstered

furniture has always recognized that such regulations are not, and must

not be, set in concrete. The Bureau does not consider its furniture

standard to be the ideal solution to a very complex problem , nor does

the Bureau claim that furniture manufactured to the Bureau's specifications

will not burn under any reasonable circumstances. On the contrary, the

Bureau recognizes the imperfections in the regulation and is also cognizant
of areas of the standard where improvements must be made, as technology
becomes available, if the regulation is to achieve the ultimate goal of
offering the California consumer the safest furniture in the United States,
at a reasonable increase in cost.

Because of this recognition, the Bureau has attempted to maintain
a degree of flexibility in the furniture standard which allows it to
modify the standard, to take advantage of the latest technological develop-
ments in materials and supplies. This approach has also enabled the Bureau
to suggest to industry the direction it should be moving to improve the
flammability characteristics of its products. The Bureau believes that this
dynamic approach to regulation is in the best interest of both the consumer
and the industry, provided that such an approach is reasonable, is conducted
in a cooperative spirit with the effected industries, and attempts to keep
pace with technology rather than outstrip it.

The first major modification in the Bureau's furniture flammability
standard occured in January, 1980, when the Bureau published revisions of
the Flammability Information Package including some substantial revisions in
Technical Bulletins 116 and 117. The major change proposed by this revision
addressed for the first time a realistic test procedure for evaluating
the smoldering resistance of cellular foam. This procedure, known as
Technical Bulletin 117, Section D, Part II, ideally complemented the
Bureau's open flame test procedure for foams in Section A, Part I. As a
result of this new procedure, all cellular foam used in any furniture
offered for sale in California, irrespective of the point of manufacture,
must be both flame retardant (FR) and smolder resistant (SR). Other modi-
fications in the January, 1980, document consisted of a general "tidying-up"

of a number of technical points of Technical Bulletins 116 and 117, and additional clarification of some test requirements.

A Status Report

On October 1, 1981, the California standard for upholstered furniture flammability had been in existance for six years with an effective enforcement time of five years.

Eventhough the standard is admittedly less than perfect and still falls short of the ideal solution to a difficult problem, an evaluation and status report is certainly in order.

The most promising and encouraging evaluation comes from statistics provided by the California State Fire Marshall. These statistics, which focus on total fires, deaths and injuries in California from fires in which upholstered furniture articles are the first point of ignition, show a significant decline of such casualties in California over the life of the furniture standard.

TABLE 2
RESIDENTIAL FIRES WHERE UPHOLSTERED FURNITURE FIRST ITEM TO IGNITE
California

	1974	1975	1976	1977	1978	1979
TOTAL FIRES	3,317	3,146	2,840	2,814	2,488	2,348
SMOKING MATERIAL FIRES						
Total	2,001	1,837	1,737	1,608	1,382	1,212
Cigarette	1,583	1,441	1,361	1,292	1,068	964
OPEN FLAME FIRES						
Total	575	515	427	441	466	438
Matches	319	332	267	258	248	257
TOTAL CASUALTIES	2,351	2,735	2,485	2,422	2,142	1,958
Injuries	243	215	207	168	134	179
Deaths	54	59	56	53	51	48

A recent analysis of this data, using the years 1977-79, by the Consumer Product Safety Commission staff produced the following conclusion:

"California's fire incident data shows a significant decrease in upholstered furniture fires started by cigarettes but no comparable decline in open flame ignitions. The fact that California's reduction in cigarette ignitions was sharper than that reported by other states may be related to California's flammability standards but may also be due to other factors."

Bea Harwood
March 27, 1981

If lives are being saved and injuries prevented in California as a result of the furniture standard, then we are encouraged that even an imperfect standard has produced positive results, and are gratified to realize that California consumers are perhaps better protected from the insideous dangers of upholstery fires than elsewhere in the United States.

With regard to rather more practical statistics, a survey by the Bureau of more than 900 furniture manufacturers doing business in California indicates the following:

TABLE 3

COMPLIANCE WITH FURNITURE STANDARD BY TYPE OF FLAMMABILITY LABEL USED

LABEL TYPE	PERCENTAGE OF MANUFACTURERS
Technical Bulletin 116	16.2
Technical Bulletin 117	78.2
Technical Bulletins 116 and 117	3.4
Exemption Label	1.7
Other Combination Labels	0.5
TOTAL	100.0

An analysis of the Bureau's laboratory records of component furniture materials tested during the first eight (8) months of 1981 indicate the following:

TABLE 4

TESTS OF F.R. BLENDED COTTON BATTING

SAMPLES TESTED		234
Technical Bulletin 117, Section B	- PASS	86.3%
	- FAIL	13.7%
Technical Bulletin 117, Section D	- PASS	91.5%
	- FAIL	8.5%

TABLE 5

TESTS OF POLYESTER FIBER BATTING

SAMPLES TESTED		462
Technical Bulletin 117, Section C	- PASS	99.1%
	- FAIL	0.9%
Technical Bulletin 117, Section D	- PASS	100.0%
	- FAIL	0%

TABLE 6

TESTS OF POLYURETHANE FOAMS

SAMPLES TESTED		1,204
Technical Bulletin 117, Section A	- PASS	87.0%
	- FAIL	13.0%
Technical Bulletin 117, Section D, Part II	- PASS	87.1%
	- FAIL	12.9%

The smoldering pass/fail requirement for polyurethane foams when
tested in accordance with Technical Bulletin 117, Section D, Part II
is that at least 80 percent of the polyurethane foam remain, non-combusted
or non-smoldered, at the termination of the test. An analysis of the
data generated in testing 1,204 polyurethane foams indicated the following:

TABLE 7

POLYURETHANE FOAMS
Technical Bulletin 117, Section D, Part II - 1,204 Samples Tested

PERCENT NON-SMOLDERED RESIDUE (Average 3 Test Specimens)	PERCENT SAMPLES TESTED
> 95	59.7
90 - 95	14.8
85 - 90	9.1
80 - 85	4.2
< 80	12.2

The Future

(a) Furniture Survey

The population of furniture manufacturers whose product is
offered for sale in California includes manufacturers from all
over the world. Since California's furniture flammability
standard applies to all furniture offered for sale in California
irrespective of the point of manufacture, all manufacturers
doing business within the State must be in compliance with the
flammability requirements. From the enforcement viewpoint it is
obviously easier for the Bureau to enforce at the manufacturing

level in California since the Bureau's inspectors have direct access to all manufacturing facilities within the State and can, therefore, make on-the-spot inspections and physically obtain representative component samples for Bureau analysis. However, enforcement testing of furniture manufactured by manufacturers not resident within California is rather more difficult, since these manufacturers may reside in any other state or in fact in many foreign countries. Under such circumstances the Bureau's furniture enforcement program must be directed to furniture obtainable in California at the retail level. This in itself presents the problem of taking for analysis articles costing many hundreds of dollars, for which the Bureau is not required to provide any reimbursement to the retailer. In fact, California State law permits the Bureau to take, at no cost to the Bureau, such materials and articles as may be necessary for laboratory evaluation.

In an effort to equitably enforce the flammability standard, for both out-of-state and in-state furniture manufacturers, the California Legislature authorized the Bureau to spend a total of $80,000 - $100,000 in fiscal years 1981-82 and 1982-83 for the purchase of furniture at the retail level in California.

Under this pilot purchase program, Bureau inspectors will buy a cross-section of furniture from a cross-section of furniture retailers. The primary emphasis of the initial portion of the program will be upon furniture manufactured outside of California but offered for sale within the State.

The purpose of this program is to:

(1) Ensure that all furniture is in compilance with State law as regards the furniture contents as shown on the official law label,

(2) Ensure that the official law label format is in compliance with State law,

(3) Ensure that all furniture is in compliance with California's flammability standard,

(4) Verify that each piece for furniture is appropriately labeled as regards flammability and is in fact truthfully labeled, and

(5) Determine that any product claims are truthful, not misleading, and substantiable.

In addition we expect to look carefully at any furniture showing the UFAC hangtag or claiming compliance with the UFAC program, to ensure that all such furniture is in fact in compliance with both the California and UFAC requirements.

(b) <u>Modifications to the Standard</u>

The Bureau is constantly looking at its upholstered furniture flammability program seeking ways in which it may be improved and made more effective. Our philosophy of doing what we can, when we can, has enabled the Bureau to work with industry to develop test procedures that are compatible with the generally available technology, and which are carefully researched and thoughtfully implemented.

The Bureau feels that the most serious problem confronting the furniture industry, in terms of flammability, continues to be the extensive use of upholstery fabrics which predominantly consist of cellulosic fibers. Numerous persons and groups have carefully and thoroughly pinpointed the primary hazard of upholstered furniture flammability. The consistent conclusion has been that the accidental smoldering ignition of upholstery by smoking materials, specifically cigarettes, is by far the principal hazard. In general, fabrics made of cellulosic fibers smolder, and fabrics made of thermoplastic fibers do not smolder. Therefore, the heavy use of cellulosic fibers in fabrics will tend to compound the hazard, unless:

(1) Cellulosic fabrics can be modified in some way to make them inhibit smoldering, or

(2) Cellulosic fibers can be blended with a certain percentage of thermoplastic fibers to product fabrics of significantly reduced hazard, or

(3) Furniture systems can be developed which can be shown to be smolder resistant irrespective of the type of fabric used.

The Bureau's existing furniture standard does not address the smoldering hazard of fabrics. However, the Bureau has indicated to the industry that it does intend to address the smoldering hazard presented by upholstery fabrics, by the inclusion of an upholstery fabric smoldering test procedure in the next revision of the Bureau's standard. In this regard the Bureau has been

working with the American Textile Manufacturers Institute (ATMI),
the trade association representing many fabric manufacturers,
to develop a standard which will improve the smoldering properties
of the population of fabrics used in California. At the same time
it is the Bureau's position that such a standard must be reason-
able in its effect on the industry, in the esthetic choices offered
consumers, and is the economic effect on the retail price of
furniture pieces.

Long-Term Projects

In addition to the future projects mentioned, the Bureau has several
long-term programs which are connected in some way with upholstered
furniture flammability.

Briefly, two of these programs involve the areas of combustion toxicity,
and the development of a full-scale fire test for furniture for use in
higher risk occupancies.

(a) Toxicity

The Bureau's toxicity program is specifically dedicated to
investigating the presence of material in home furnishings
articles which may produce super-toxic, or extraordinary toxic
environments under smoldering and/or flaming combustion conditions.
Test procedures used will include both bio-assay and analytical
testing protocols.

(b) High Risk Furniture Test

The Bureau has received numerous requests from fire depart-
ments and institutional administrators to develop a test protocol
for the evaluation of furniture systems for use in places of high

risk and/or public occupancy. It is the Bureau plan to develop

such a standard for furniture to complement Technical

Bulletin 121, the full-scale fire test for mattresses used in

high risk situations. Such a standard would have force of law

only if adopted by regulation by a government agency or if

specified as the standard for a specific high risk occupancy.

Summary

~~This paper has summarized:~~

(2) ~~(a)~~ [The history of the California Flammability Standard for
Upholstered Furniture *is summarized*,

~~(b)~~ Litigation involving the standard, ~~and~~ *is discussed, and*

~~(c)~~ *a* status report of the results of the first five years of
the standard *is presented*.

In addition, plans for the future of the California requirements ~~has been~~ *is*
discussed both from the long- and short-term perspectives. It is the Bureau's
position that California is a safer place to live as a result of the
upholstered furniture standard, and that California consumers are among the
best protected in the Nation from the insideous effects of fires involving
upholstered furniture.]   *author,*

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"UFAC UPDATE"

Joseph J. Ziolkowski

Upholstered Furniture Action Council

UFAC - THE UPHOLSTERED FURNITURE ACTION COUNCIL IS A FEDERATION OF FURNITURE
ASSOCIATIONS ATTEMPTING TO ACHIEVE A COMMON GOAL WHICH IS THE SUBSTANTIAL
REDUCTION OF THE IGNITION HAZARD OF UPHOLSTERED FURNITURE WHEN EXPOSED TO
SMOLDERING CIGARETTES THROUGH VOLUNTARY ACTION. WE EXPECT TO ACHIEVE THIS
GOAL OVER A PERIOD OF TIME AS SOLUTIONS AND TECHNOLOGY BECOME AVALIABLE.

BY·USING PROPER MATERIALS AND METHODS AS RECOMMENDED IN THE VOLUNTARY
PROGRAM, THE INDUSTRY HAS ALREADY ACHIEVED A SUBSTANTIAL DEGREE OF PROTECTION.
BECAUSE OF THE COMPLEXITY OF OUR ASSEMBLED PRODUCT, ACTION IS BEING TAKEN
STEP BY STEP, COMPONENT BY COMPONENT.

OUR VOLUNTARY PROGRAM HAS NOW BEEN ACTIVELY IN PLACE FOR ALMOST THREE YEARS.
DURING THIS TIME WE HAVE BROUGHT ABOUT MAJOR CHANGES IN THE UPHOLSTERY
PROCESS. TO A DEGREE, WE HAVE BEEN ABLE TO MAINTAIN CONSUMER CHOICE OF
FABRICS, STYLING AND GEOMETRY, AND HAVE IMPOSED NO·UNDUE FINANCIAL BURDEN
ON OUR CUSTOMERS OR OUR INDUSTRY.

A SERIOUS PROBLEM WE HAVE FACED IS THAT OUR INDUSTRY, MADE UP MOSTLY OF
SMALLER COMPANIES, FUNCTIONS WITH LITTLE TECHNOLOGY. THEREFORE, OUR METHODS
MUST BE KEPT SIMPLE ENOUGH FOR COMPLETE UNDERSTANDING BY OUR PEOPLE WHO MUST
USE THEM. MOST OF THE TECHNICAL AND SCIENTIFIC INPUT COMES FROM OUR SUPPLIERS.
THEIR SUPPORT HAS BEEN ESSENTIAL FOR OUR PROGRAM TO SUCCEED AND THEY ARE
TO BE COMMENDED FOR THE ASSISTANCE THEY HAVE RENDERED OUR INDUSTRY BUT WE
STILL NEED MORE HELP IF WE ARE TO REACH OUR GOAL.

IN ORDER TO EXPEDITE DEVELOPMENT AND EVALUATION OF NEW PRODUCTS WE HAVE
INSTITUTED A PROTOCOL FOR LABORATORY EVALUATION OF NEW PRODUCTS AND PROCESSES.

WE HAVE ALSO INITIATED THE FORMATION OF A NEW GROUP CALLED THE LABORATORY

ALLIANCE. THIS GROUP CONSISTS OF UPHOLSTERED FURNITURE COMPANIES WHO HAVE

LABORATORIES AND ARE CAPABLE OF PERFORMING TESTS OF ALL KINDS. THEIR

PRIMARY FUNCTION IS TO IMPROVE THE FLAMMABILITY PERFORMANCE OF OUR PRODUCTS

BY EVALUATING PRODUCTS AND DOING APPLIED RESEARCH WHERE NECESSARY.

THE PROTOCOL FOR NEW PRODUCT INNOVATION AND EVALUATION IS AS FOLLOWS:

(SEE ATTACHMENT)

"INITIAL CONTACT BY THE MANUFACTURER OF A NEW PRODUCT SHOULD BE REFERRED

TO THE TECHNICAL COMMITTEE. THE COMMITTEE WILL DISCUSS ITS MERITS AND

EITHER DESIGNATE ONE OF THE LAB ALLIANCE PARTICIPANTS OR GUILFORD LABS

TO DO A PRESCREENING. IF IT FAILS THE PRESCREENING, A DETERMINATION WILL

BE MADE AT THAT TIME TO TERMINATE FURTHER WORK OR THE SUPPLIER WILL BE

ASKED TO DO FURTHER WORK AND RESUBMIT NEW SAMPLES. IF THE PRESCREENING

IS SUCCESSFUL, SEVERAL OTHER MEMBERS OF THE LAB ALLIANCE WILL ALSO BE ASKED

TO EVALUATE THE PRODUCT."

AT THIS TIME, FURTHER CONSIDERATION WILL ALSO BE GIVEN TO EFFECTS ON OTHER

PROPERTIES IF THE PRODUCT CONTINUES TO PASS, THE TECHNICAL COMMITTEE WILL

BRING THE PRODUCT TO THE ATTENTION OF THE BOARD OF DIRECTORS FOR THEIR ACTION.

A LISTING OF THE PARAMETERS OF PERFORMANCE WOULD INCLUDE NOT ONLY THE

FLAMMABILITY CHARACTERISTICS BUT ALSO THE FOLLOWING:

IS IT PRACTICAL IN PRODUCTION?

IS IT COST EFFECTIVE?

ARE ITS AESTHETICS ACCEPTABLE?

DOES IT ADVERSELY AFFECT OTHER MATERIALS?

IS IT AVAILABLE IN COMMERCIAL QUANTITIES?

ARE THERE TOXILOGICAL OR HEALTH CONCERNS?

IS ITS LONGEVITY PROVEN?

IS THERE ANY MAJOR CHANGE IN THE PHYSICAL CHARACTERISTICS?

FURTHER WORK UNDERWAY BY THE TECHNICAL COMMITTEE IS A REVISION OF THE UFAC TEST PROCEDURES. THE CHANGES BEING MADE ARE PRIMARILY EDITORIAL IN NATURE BUT THERE ARE ALSO MINOR TECHNICAL CHANGES. CURRENTLY THE DRAFT REVISED METHODS ARE UNDERGOING INTER LABORATORY STUDIES TO ASSURE THE TEST METHODOLOGY IS PRACTICAL AND REPRODUCIBLE PRIOR TO FINAL ISSUANCE TO THE INDUSTRY.

FROM THE INCEPTION OF THE VOLUNTARY ACTION PROGRAM WE OF UFAC COMMITTED OURSELVES AND OUR INDUSTRY TO MAINTAIN A VIABLE ORGANIZATION. ALL OF OUR ACTIVITY SINCE THEN LEADS US TO CONCLUDE THAT WE ARE MAKING MEANINGFUL PRO-GRESS, EVEN THOUGH WE OCCASIONALLY TRAVEL A ROCKY ROAD. IN TERMS OF INDUSTRY ACCEPTANCE WE ARE FAR AHEAD OF OUR COMMITTED SCHEDULE. WE HAVE MAINTAINED OUR FLEXIBILITY AND ARE UPGRADING OUR CONSTRUCTION TO USE EVERY AVAILABLE TECHNOLOGY TO MEET THE NEEDS OF PROGRESS.

OUR GOAL HAS REMAINED THE SAME, SUBSTANTIAL REDUCTION AND EVENTUAL ELIMINATION OF THE CIGARETTE IGNITION HAZARD OF UPHOLSTERED FURNITURE WHERE REASONABLE AND PRACTICABLE. WE ARE ACHIEVING OUR GOAL.

PROTOCOL FOR LABORATORY EVALUATION OF NEW PRODUCTS AND PROCESSES

Any new product offered to UFAC
is to be referred to the Technical Director

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                    │  TECHNICAL   │
                    │  DIRECTOR    │
                    └──────────────┘
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                        ╲ One    ╱
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              ▼                              ▼
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      │ INDEPENDENT  │              │  LABORATORY  │
      │ LABORATORY   │              │  ALLIANCE    │
      └──────────────┘              │  COCHAIRMEN  │
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   ┌────TEST────┐                          │
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 │ FAIL │  │ PASS │──Lab Alliance──▶    ╲ One   ╱
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  Terminate               │     ONE      │◀─────────┘
                          │  LABORATORY  │          │
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                              ┌─TEST─┐      ┌──────────────┐
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                    ┌──────┐      ┌──────┐  │ LABORATORIES │
                    │ FAIL │      │ PASS │─▶└──────────────┘
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                                              ┌───TEST───┐
                    Terminate            ┌────┘         └────┐
                                    ┌──────┐            ┌──────┐
                                    │ FAIL │            │ PASS │
                                    └──────┘            └──────┘
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Terminate   Refer to UFAC
Tech Committee &
Board of Director:

A WRITTEN REPORT SHALL BE FORWARDED
FOR EACH PRODUCT EVALUATED