Table _. Comparison of the carcinogenic potential of the chermal decomposition products c

Wood[a]			PVC[b]
Combustion Product	Carcinogenic Potential		Combustion Product
Carbon monoxide	No		Carbon monoxide
Carbon dioxide	No		Carbon dioxide
Acrolein	?		Hydrogen chloride
Formadehyde	Yes		Benzene
Acetaldehyde	?		Methane
Butylraldehyde	?		Ethylene
Benzene	Yes		Ethane
Dimethylbenzanthracene	Yes		Propylene
Benz(a)anthracene	Yes		Propane
Dibenzanthracene	Yes		Vinyl chloride[c]
Benzophenanthrene	Yes		1-Butene
Benzofluoroanthene	Yes		Butane
3-methylcholanthene	Yes		Isopentane
Benzopyrene	Yes		1-pentene
Idenopyrene	Yes		Pentane
Dibenzopyrene	Yes		Cyclopentene
Dibenzocarbazole	Yes		Cyclopentane
Dioxins	?		1-Hexene
Chrysene	?		Hexane
Methane	No		Methylcyclopentane
Toluene	No		Toluene

[a]Only a partial listing (Cooper 1980; Hall and Deangelis, 1980; Lee et al, 1977; Wooley a

[b]Boettner et al, 1969

[c]Probably due to residual levels of monomer.

ANTI-PVC/PLASTICS ALLEGATIONS

ALLEGATION NO. 3

Benzene, a toxic by-product of burning PVC, damages bone marrow, leading to leukemia and aplastic anemia.

RESPONSE

Fumes from PVC are not any more hazardous than those from natural products, such as wood, and may in fact be less hazardous.

Cancer which occurs from exposure to chemicals is generally believed to result from repeated exposure over many years. Since threshold or no effect doses are difficult to determine, even low levels are considered to have some finite risk. In animal studies which are used to detect potential human carcinogens, animals are exposed to high doses for nearly their lifetime, and the data is used to predict the potential cancer risk of a given exposure level (i.e. the dose that could result in one cancer case in populations of 100,000 or in 1,000,000 people).

When any organic material (natural or synthetic) undergoes thermal decomposition, a large number of chemicals are produced. Table I compares the thermal decomposition of wood and PVC and identifies those which are suspect as known carcinogens. Both wood and PVC produce simple asphyxiants (carbon monoxide and carbon dioxide, irritants such as acrolein, various aldehydes or hydrogen chloride, and trace or minor products i.e. benzene, etc.). As can be seen in Table I, many of the chemicals produced by the thermal decomposition of wood are suspect or known to cause cancer. More recent studies by Albert et al (1982) show that formaldehyde was carcinogenic in rats but that there was no evidence of a carcinogenic effect with hydrogen chloride.

Although the levels of carcinogens produced by wood (except possibly formaldehyde) are very small, there is probably some finite risk for anyone that would be exposed repeatedly for their lifetime. However, because the levels are so small and because exposures to the general public are not frequent or nil for those who never experience a fire, the actual risk is so low that it is virtually non-existent. Furthermore, even for firemen, whose exposures are more frequent, the risk posed by these trace chemicals is probably low. In any event, the data in Table I indicates that any carcinogenic hazard from PVC decomposition is not any greater than from wood, in fact, PVC is probably less hazardous.

REFERENCES

Albert, R.E., Sellakumar, A.R., Laskin, S., Kuschner, M., Nelson, N. and Snyder, C.A. (1982) Gaseous formaldehyde and hydrogen chloride induction of nasal cancer in the rat. J. Nat'l. Cancer Inst. 68(4):597-603.

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ALLEGATION NO. 3 - contd.

REFERENCES - contd.

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SUPPORTING ATTACHMENT

Table I, "Comparison of the Carcinogenic Potential of the Thermal Decomposition Products of Wood and PVC"

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Table I. Comparison of the carcinogenic potential of the thermal decomposition products o

Wood[a]		PVC[b]
Combustion Product	Carcinogenic Potential	Combustion Product
Carbon monoxide	No	Carbon monoxide
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Acrolein	?	Hydrogen chloride
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Acetaldehyde	?	Methane
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Benzene	Yes	Ethane
Dimethylbenzanthracene	Yes	Propylene
Benz(a)anthracene	Yes	Propane
Dibenzanthracene	Yes	Vinyl chloride[c]
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Benzopyrene	Yes	1-pentene
Idenopyrene	Yes	Pentane
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Dibenzocarbazole	Yes	Cyclopentane
Dioxins	?	1-Hexene
Chrysene	?	Hexane
Methane	No	Methylcyclopentane
Toluene	No	Toluene

[a]Only a partial listing (Cooper 1980; Hall and Deangelis, 1980; Lee et al, 1977; Wooley ar

[b]Boettner et al, 1969

[c]Probably due to residual levels of monomer.

ANTI-PVC/PLASTICS ALLEGATIONS

ALLEGATION NO. 4

There is a link between heart problems and exposure to PVC combustion products.

RESPONSE

There is no evidence that HCl from PVC causes heart problems; observed heart irregularities in firefighters are likely the result of carbon monoxide exposure, a common combustion product of all organic materials.

In 1976 Dyer and Esch reported clinical observations of 170 firefighters. These individuals were described as being "known to have been exposed to toxic products from thermal degradation of PVC --- from one to four times"; however, no information on how this was verified, or what other materials were involved, was provided. Symptoms were described as "pain in the anterior aspect of the chest, neck and throat pain, dyspnea (shortness of breath), severe headache, dizziness, and irregular pulse". Furthermore, about one-fifth of the fire-fighters had extra contractions of the heart (extra systoles).

The observations reported by Dyer and Esch (1976) are not unexpected when one considers that all organic materials, natural and synthetic, produce carbon monoxide (CO) when they burn. The National Institute for Occupational Safety and Health (1972) has well documented the long-known cardiovascular effects of CO and other general symptoms such as chest pain, headache, dizziness, etc. Specifically on the subject of cardiac irregularities they state that "Anderson and co-workers recently exposed normal young males and clinically normal middle-aged males to 100 ppm of CO for four hours which resulted in COHb levels at the end of that time of 5 to 9 percent. During exposure the two groups were subjected to 85% submaximal treadmill exercise testing while ECG monitoring and several cardiac function measurements were recorded. Statistical differences in the measured parameters were observed only in the older group of subjects. The investigators stated that '...low-level CO exposure may augment the production of exercise-induced myocardial ischemia in persons with preexisting subclinical heart disease, contribute to the development of myocardial dysfunction, and may lead to an increased incidence of arrhythmias in such persons.' They further stated that these findings in clinically normal persons would be more pronounced in persons with overt ischemic heart disease (e.g. angina pectoris or myocardial infarction). The investigators further said that arrhythmias observed in the older group may explain the observations of Cohen, Deare, and Goldsmith concerning the increased case fatality rates for persons with acute myocardial infarctions during periods of increased ambient levels of CO as well as explain the increased incidence of sudden death in smokers."

The implication of HCl by the authors as the cause of the cardiovascular effects is quite surprising and unconvincing in light of the vast and well-documented cardiovascular effects of CO. Furthermore, the fact that such effects have never been noted in well-documented HCl exposure situations (animal and man) indicates that such allegations are clearly unfounded.

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ALLEGATION NO. 4 - contd.

REFERENCES

Dyer, R.F. and Esch, V.H. (1976) Polyvinyl Chloride Toxicity in Fires. JAMA 235(4):393-397

Criteria for a Recommended Standard. Occupational Exposure to Carbon Monoxide, HSM-73-11000, U.S. Dept. HEW, NIOSH, pp. III-9 to III-20, 1972.

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ANTI-PVC/PLASTICS ALLEGATIONS

ALLEGATION NO. 5

One-fifth of 170 firefighters studied showed unusual heartbeats in their normal cardial rhythm because of HCl irritation of the heart muscle. This can cause a heart attack in a person with a heart problem.

RESPONSE

There is no evidence that HCl from PVC causes heart problems; observed heart irregularities in firefighters are likely the result of carbon monoxide exposure, a common combustion product of all organic materials.

In 1976 Dyer and Esch reported clinical observations of 170 firefighters. These individuals were described as being "known to have been exposed to toxic products from thermal degradation of PVC --- from one to four times"; however, no information on how this was verified, or what other materials were involved, was provided. Symptoms were described as "pain in the anterior aspect of the chest, neck and throat pain, dyspnea (shortness of breath), severe headache, dizziness, and irregular pulse". Furthermore, about one-fifth of the fire-fighters had extra contractions of the heart (extra systoles).

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The implication of HCl by the authors as the cause of the cardiovascular effects is quite surprising and unconvincing in light of the vast and well-documented cardiovascular effects of CO. Furthermore, the fact that such effects have never been noted in well-documented HCl exposure situations (animal and man) indicates that such allegations are clearly unfounded.

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ALLEGATION NO. 5 - contd.

REFERENCES

Dyer, R.F. and Esch, V.H. (1976) Polyvinyl Chloride Toxicity in Fires. JAMA 235(4):393-397

Criteria for a Recommended Standard. Occupational Exposure to Carbon Monoxide, HSM-73-11000, U.S. Dept. HEW, NIOSH, pp. III-9 to III-20, 1972.

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ANTI-PVC/PLASTICS ALLEGATIONS

ALLEGATION NO. 6

Gaseous HCl and that adsorbed on soot attack the upper and lower respiratory tract, cause severe acidosis, and leave a high number of survivors with heart damage, heart irregularity, high blood pressure, clouded cornea, collapsed nostrils, as well as recurrent skin infections and sensitization. Also caused are chronic restrictive/obstructive lung disease, loss of upper respiratory tract immune mechanisms, hoarseness, high rates of larynegeal lesions and tumors, heightened sensitivity to dust smoke asthma, and attacks of phlegm production.

RESPONSE

A. The toxicity of HCl has been well studied as shown below. Nearly a century of animal and human data fail to support these claims.

Short-term effects. The short term effects of HCl are well documente It has been known at least since the late 1800's and early 1900's (Lehman, 1886; Lehman, 1908; Lehman and Burch, 1910; and Ronzani, 190 that HCl can cause irritation or corrosion of the skin, eyes, or respiratory tract depending on the concentration. Because the protectiv response is so strong, human beings have rarely submitted to damaging concentrations (Grant, 1974). Here, low concentrations which are not harmful in short-term exposures have provided excellent warning properties (5-50 ppm) and persuasion to escape. Animal studies have indicated that HCl concentrations in the range of 1000-3000 ppm are dangerous to life in a short time (Machle, et al, 1942; Lehman, 1910; Yuill, 1974; and Henderson and Haggard, 1943).

Although few studies have been conducted on the synergistic effects of chemicals in general (other than pesticides), some information is available on HCl. Studies by Higgins et al (1972) show that varying levels of HCl and carbon monoxide exposure to rats for five minutes do not produce any synergistic effects. This is not particularly surprising since carbon monoxide is a systemic toxin while HCl is not

Long-term effects. In 1982 researchers at the New York University Medical Center reported that results of studies which evaluated the carcinogenic potential of formaldehyde (a combustion product of wood) and HCl (Albert, et al, 1982). After exposing rats six hours a day, five days per week for their lifetime, these investigations found that formaldehyde caused cancer of the nasal cavity. The authors further stated that "no carcinogenic response was observed with HCl alone".

While other non-carcinogenic effects have not been observed, only the long-term effects typical of any irritant (acrolein, formaldehyde, etc.) would be expected with HCl. Since all irritants can damage the lining of the lungs, it is generally believed that any irritant has the potential to cause chronic bronchitis. However, no serious long-term effects are expected from HCl.

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ALLEGATION NO. 6 - contd.

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ALLEGATION No. 6 - contd.

RESPONSE - contd.

B. Several investigators have noted lowered blood pH after exposure to the combustion products of PVC (Einhorn, 1977; Einhorn and Grunnet, 1980; Petajan, 1976). Although metabolic acidosis has been observed for other materials (Petajan, 1976), some individuals have attributed this effect to HCl. "Metabolic acidosis" is probably due to CO_2, a common combustion product of all materials. Further studies, such as those planned by the V.I., are needed to address these allegations.

REFERENCES

Petajan, J. H. (1976) An approach to the toxicology of combustion products of materials. Environ. Health Perspect. 17:65-73

Einhorn, I. N. (1977) Methodology for the study of toxicology in combustion: applications to PVC. J. Macromol. Sci.-Chem. A11(8):1519-1528

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C. Many natural and synthetic products produce irritating gases when they burn (Zikria, et al, 1972; Woolley and Fardell (1982). All of these gases (acrolein, formaldehyde, HCl, etc.) can produce corneal damage (Grant, 1974).

REFERENCES

Grant, W. M. (1974) Toxicology of the Eye, 2nd edition, Charles C. Thomas, publisher, Springfield, Ill.

Wooley, W. D. and Fardell, P. J. (1982) Basic aspects of combustion toxicology. Fire Safety J. 5:29-48

Zikria, B. A., Ferrer, J. N. and Flock, H. F. (1972) The chemical factors contributing to pulmonary damage in "smoke poisoning". Surgery, 71:704-709

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ANTI-PVC/PLASTICS ALLEGATIONS

ALLEGATION NO. 7

HCl is adsorbed on particulates like soot in a fire, and in this form in the lungs is even more toxic than gaseous HCl.

RESPONSE

HCl, like many other soluble gases produced by burning organic, will likely condense on soot particles. No studies have ever shown that HCl attached to soot is more or less toxic than gaseous HCl. However, the resolution of this point may be of little practical importance, since many natural and synthetic materials produce toxic gases (as toxic or more toxic than HCl) which also may combine with soot.

REFERENCES

Zikria, B. A., Ferrer, J. N. and Flock, H. F. (1972) The chemical factors contributing to pulmonary damage in "smoke poisoning". Surgery, 71: 704-709

Wooley, W. D. and Fardell, P. J. (1982) Basic aspects of combustion toxicology. Fire Safety J. 5:29-48

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ANTI-PVC/PLASTICS ALLEGATIONS

ALLEGATION NO. 8

Death in PVC exposure is due to HCl induced sensory and pulmonary irritation.

RESPONSE:

This is only the partial truth.

Like any organic material, natural or synthetic, PVC produces numerous combustion products. The most toxicologically important of these are carbon monoxide (CO), carbon dioxide (CO_2) and hydrogen chloride (HCl). (Boettner et al., 1969). CO and CO_2 are simple asphyxiants while HCl causes irritation or destruction of tissue. CO, CO_2, and/or HCl can cause death, either by asphyxiation or by pulmonary edema. These causes of death are not new or unusual and are known to result from combustion products of wood which contain CO and CO_2 and corrosive agents such as acrolein, formaldehyde, and other aldehydes (Zikria et al, 1972). Asphyxiation and pulmonary edema resulting in delayed deaths have been reported in fires long before the significant use of plastics (Mallory and Brinkley, 1943).

REFERENCES:

Boettner, E.A., Ball, G. and Weiss, B. (1969) Analysis of the volatile combustion products of vinyl plastics. J. Appl. Polymer Sci. 13:337-391.

Mallory, T.B. and Brinkley, W.J. (1943). Management of the Coconut Grove burns at the Mass. General Hospital: the problem of burn shock complicated by pulmonary damage. Ann. Surg. 117:865.

Zikria, B.A., Ferrer, J.N. and Flock, H.F. (1972). The chemical factors contributing to pulmonary damage in "smoke poisoning". Surgery, 71: 704-709.

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ANTI-PVC/PLASTICS ALLEGATIONS

ALLEGATION NO. 9

Burning PVC formulations (with phthalic anhydride) are more toxic to animals than pure PVC or wood.

RESPONSE

We are not aware of any combustion toxicity studies of PVC containing phthalic anhydride.

RESPONSE ORIGINATOR -- CONTACT FOR SUPPLEMENTAL INFORMATION

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ANTI-PVC/PLASTICS ALLEGATION

ALLEGATION NO. 10

Intoxication syndrome is caused by irritant effect of HCl and narcotic effect of organic decomposition products such as benzene and VCl, the smoke density, and HCl induced heart and cellular shock.

RESPONSE

This is only the partial truth.

Like any organic material, natural or synthetic, PVC produces numerous combustion products. The most toxicologically important of these are carbon monoxide (CO), carbon dioxide (CO_2) and hydrogen chloride (HCl). (Boettner et al., 1969). CO and CO_2 are simple asphyxiants while HCl causes irritation or destruction of tissue. CO, CO_2, and/or HCl can cause death, either by asphyxiation or by pulmonary edema. These causes of death are not new or unusual and are known to result from combustion products of wood which contain CO and CO_2 and corrosive agents such as acrolein, formaldehyde, and other aldehydes (Zikria et al, 1972). Asphyxiation and pulmonary edema resulting in delayed deaths have been reported in fires long before the significant use of plastics (Mallory and Brinkley, 1943).

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ANTI-PVC/PLASTICS ALLEGATIONS

ALLEGATION NO. 11

Inhalation of 50 ppm HCl stops a victim in his tracks, preventing escape. HCl affects on the eye prevent the victim from seeing.

RESPONSE

There is no evidence to support the claim that 50 ppm HCl prevents escape; however, the current FAA studies on primates exposed to HCl are expected to answer this question.

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ANTI-PVC/PLASTICS ALLEGATIONS

ALLEGATION NO. 12

The best indication of PVC poisoning would be a "quick knock down."

RESPONSE

Incapacitation is not unique to PVC, nor is it quick relative to many other natural and synthetic materials.

Rapid incapacitation or "quick knock down" of gases in a fire has long been recognized as important because it decreases ones chances of escaping and therefore increases the liklihood that death will result. For this reason, many scientists from government, academia, and industry have measured the time or the amount of material required to cause incapacitation when studying the combustion toxicity of materials. These studies (Table 1) have not shown PVC decomposition products to be rapidly incapacitating and to require greater amounts to cause incapacitation. In this respect, PVC was generally one of the better performing materials.

Table 1. Comparison of Time and/or Amount Required to Cause Incapacitation in Animals Exposed to PVC and Other Synthetic and Natural Products under Various Conditions

Investigator(s)	Material	Response Time to Incapacitation
Spurgeon, 1978 (fabrics)	modacrylic	1.1
	wool, FR	2.1
	cotton, FR	3.1
	rayon, FR	4.2
	wool/PVC	4.6
	PVC	7.6
Smith et al, 1978	acrylonitrile-butadiene	3.3
	Douglas Fir	5.5
	polyurethane foam	8.8
	polychloroprene	10.5
	PVC	11.7
	nylon	13.0
Crane et al, 1978 (electrical insulation)		
	Kapton	4.5 - 7.0
	Halar	4.7 - 7.9
	Teflon	6.7 -11.2
	Neoprene	7.4 - 9.4
	Polyethylene	6.8 -10.6
	PVC	7.3 -21.2
	Silicone Rubber	17.7 -19.3
Hilado and Huttlinger, 1981	wool fibers	7.0
	polyester batting	9.2
	cotton batting	9.8
	wood	14.0
	Kapok	15.1
	PVC	15.5
	polystyrene	23.8
	neoprene foam	25.8
NBS, 1982	modacrylic	3.1 - 6.4 mg/l
	Douglas Fir	13.5 - 23.5 "
	wool	19.7 - 24.5 "
	PVC	18.5 - 30 "
	red oak	23.0 - 34.8 "
	polystyrene foam	28.1 - 40 "
	flexible polyurethane	37.5 - 53.0 "
Alarie and Anderson, 1979	PTFE (Teflon)	2 - 5 g
	isocyanurate	0.3 - 5 g
	flexible urethane foam	2 - 5 g
	rigid urethane foam	2 - 8 g
	polystyrene	5.3 - 13 g
	PVC-A (42% homopolymer)	8 - 20 g
	Douglas Fir	55 - 95 g
Kishitani and Yusa, 1979	polyacrylonitrile	0.2 - 0.3 g
	wool	0.4 - 0.6 g
	plywood, fire retarded	2.2 - 3.5 g
	Japanese cedar	3.7 - 5.3 g
	PVC	34.5 - 48.6 g

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ALLEGATION NO. 12 - contd.

REFERENCES

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ANTI-PVC/PLASTICS ALLEGATIONS

ALLEGATION NO. 13

PVC combustion products cause interstitial parenchymal fibrosis.

RESPONSE

This is only part of the whole story.

Lung fibrosis, or interstitial parenchymal fibrosis, is a condition where the elasticity of the lung decreases due to the production of fibrous material called "collagen". This change in the lung occurs in people with emphysema, in workers with high exposure to certain dusts (silica, titanium dioxide, etc.) and irritants (acrolein, formaldehyde, hydrogen chloride, cigarette smoke, etc.) and in older people as part of the normal aging process. While mild fibrosis of the lung usually has no noticeable effect on the health of the individual, severe cases can greatly affect pulmonary function by making breathing more difficult. Such severe effects result from either repeated or single high exposure to certain chemicals.

Many natural and synthetic materials, including PVC, are known to release irritants during combustion. Furthermore, the effects of irritants on the lungs were noted in real fires which occurred long before the widespread use of PVC. Because of the concern about the potential release of HCl from PVC in real fires, researchers at the Harvard School of Public Health, working with the Boston Fire Department, took 242 air samples from real fires and analyzed these for various combustion gases. The primary conclusion of this study was that "carbon monoxide and acrolein were the most hazardous ingredients in these fires". HCl from PVC was not found in 64% of the samples and none exceeded the short-term lethal concentration.

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ANTI-PVC/PLASTICS ALLEGATIONS

ALLEGATION NO. 14

Exposure to PVC toxic smoke produces long-term health effects in firefighters.

RESPONSE

A. Although long-term health effects in firefighters have not been adequately verified, many natural and synthetic materials produce combustion products which pose some finite risk of long-term health effects.

Like any organic material, natural or synthetic, PVC produces numerous combustion products. The most toxicologically important of these are carbon monoxide (CO), carbon dioxide (CO_2) and hydrogen chloride (HCl). Boettner et al, 1969). CO and CO_2 are simple asphyxiants while HCl causes irritation or destruction of tissue. CO, CO_2 and/or HCl can cause death, either by asphyxiation or by pulmonary edema. These causes of death are not new or unusual and are known to result from combustion products of wood which contain CO and CO_2 and corrosive agents such as acrolein, formaldehyde, and other aldehydes (Zikria et al, 1972). Asphyxiation and pulmonary edema, resulting in delayed deaths, has been reported in fires long before the significant use of plastics (Mallory and Brinkley, 1943).

Because of the irritating/corrosive nature of all fires, damage to the lungs may occur in exposed individuals. Any irritating gas can produce lung fibrosis (production of a fibrous material called "collagen"). While mild fibrosis usually has no noticeable effect on the health of the individual, severe cases can greatly affect pulmonary function by making breathing more difficult. However, because lung fibrosis occurs naturally in people with allergies and in individuals exposed to dusts and cigarette somke, it is often difficult to determine the cause.

REFERENCES

Boettner, E.A., Ball, G. and Weiss, B. (1969) Analysis of the volatile combustion products of vinyl plastics. J. Appl. Polymer Sci. 13:337-391

Mallory, T.B. and Brinkley, W.J. (1943) Management of the Coconut Grove burns at the Mass. General Hospital; the problem of burn shock complicated by pulmonary damage. Ann. Surg. 117:865

Zikria, B.A., Ferrer, J.N. and Flock, H.F. (1972) The chemical factors contributing to pulmonary damage in "smoke poisoning". Surgery, 71: 704-709

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ALLEGATION NO. 14 - contd.

RESPONSE - contd.

B. Fumes from PVC are not any more hazardous than those from natural products, such as wood, and may in fact be less hazardous.

Cancer which occurs from exposure to chemicals is generally believed to result from repeated exposure over many years. Since threshold or no effect doses are difficul to determine, even low levels are considered to have some finite risk. In animal studies which are used to detect potential human carcinogens, animals are exposed to high doses for nearly their lifetime, and the data is used to predict the potent cancer risk of a given exposure level (i.e. the dose that could result in one cance case in populations of 100,000 or in 1,000,000 people).

When any organic material (natural or synthetic) undergoes thermal decomposition, a large number of chemicals are produced. Table I compares the thermal decomposition of wood and PVC and identifies those which are suspect as known carcinogens. Both wood and PVC produce simple asphyxiants (carbon monoxide and carbon dioxide, irrita such as acrolein, various aldehydes or hydrogen chloride, and trace or minor produc i.e. benzene, etc.). As can be seen in Table I, many of the chemicals produced by the thermal decomposition of wood are suspect or known to cause cancer. More recent studies by Albert et al (1982) show that formaldehyde was carcinogenic in rats but that there was no evidence of a carcinogenic effect with hydrogen chloride.

Although the levels of carcinogens produced by wood (except possibly formaldehyde) are very small, there is probably some finite risk for anyone that would be expose repeatedly for their lifetime. However, because the levels are so small and because exposures to the general public are not frequent or nil for those who never experien a fire, the actual risk is so low that it is virtually non-existent. Furthermore, even for firemen, whose exposures are more frequent, the risk posed by these trace chemicals is probably low. In any event, the data in Table I indicates that any carcinogenic hazard from PVC decomposition is not any greater than from wood, in fac PVC is probably less hazardous.

REFERENCES

Albert, R.E., Sellakumar, A.R., Laskin, S., Kuschner, M., Nelson, N. and Snyder, C. (1982) Gaseous formaldehyde and hydrogen chloride induction of nasal cancer in the rat. J. Nat'l. Cancer Inst. 68(4):597-603.

Wooley, W.D. and Fardell, P.J. (1982) Basic aspects of combustion toxicology. Fire Safety J. 5:29-48.

Lee, H.L., Prado, G.P., Howard, J.B., and Hites, R.A. (1977) Source identification of urban airborne polycyclic aromatic hydrocarbon by gas chromatographic mass spectrometry and high resolution mass spectrometry. Biomed. Mass. Spectrom. 4:182-186

ALLEGATION NO. 14 - contd.

RESPONSE - B - contd.

REFERENCES - contd.

Cooper, J.A. (1980) Environmental impact of residential wood combustion emission and its implications. J. Air Pollut. Contr. Assn. 30(8):855-861.

Hall, R.E. and Angelis, D.G. (1980) EPA's research program for controlling residential wood combustion emissions. J. Air Pollut. Control Assn. 30(8):863-867.

SUPPORTING ATTACHMENT

Table I, "Comparison of the Carcinogenic Potential of the Thermal Decomposition Products of Wood and PVC"

RESPONSE ORIGINATOR -- CONTACT FOR SUPPLEMENTAL INFORMATION

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Table 1. Comparison of the carcinogenic potential of the thermal decomposition products

Wood[a]		PVC[b]
Combustion Product	Carcinogenic Potential	Combustion Product
Carbon monoxide	No	Carbon monoxide
Carbon dioxide	No	Carbon dioxide
Acrolein	?	Hydrogen chloride
Formadehyde	Yes	Benzene
Acetaldehyde	?	Methane
Butylraldehyde	?	Ethylene
Benzene	Yes	Ethane
Dimethylbenzanthracene	Yes	Propylene
Benz(a)anthracene	Yes	Propane
Dibenzanthracene	Yes	Vinyl chloride[c]
Benzophenanthrene	Yes	1-Butene
Benzofluoroanthene	Yes	Butane
3-methylcholanthene	Yes	Isopentane
Benzopyrene	Yes	1-pentene
Idenopyrene	Yes	Pentane
Dibenzopyrene	Yes	Cyclopentene
Dibenzocarbazole	Yes	Cyclopentane
Dioxins	?	1-Hexene
Chrysene	?	Hexane
Methane	No	Methylcyclopentane
Toluene	No	Toluene

[a]Only a partial listing (Cooper 1980; Hall and Deangelis, 1980; Lee et al, 1977; Wooley

[b]Boettner et al, 1969

[c]Probably due to residual levels of monomer.

ANTI-PVC/PLASTICS ALLEGATIONS

ALLEGATION NO. 15

The synergistic effects of HCN and HCl cannot be overlooked.

RESPONSE

Hydrogen chloride (HCl) in combination with carbon monoxide (CO) is not synergistic.

Synergism is defined as a greater than additive effect between to or more chemical While information on the potential synergistic effects of chemicals is often unknown, studies have been conducted to determine whether HCl and CO are synergistic

Studies by Higgins et al (1972) compared the acute toxicity of hydrogen fluoride (HF), nitrogen dioxide (NO_2), hydrogen cyanide (HCN), and HCl, both individually and in combination with CO. No synergistic effects nor any enhancement of toxicity were observed with HCl plus CO or with any of these chemicals in combination with CO. Although the LC_{50} values "with CO" are slightly lower on a minimal basis for some compounds, they are well within the range of normal inter-laboratory variability established by Weil and Wright (1967) for such acute tests and therefore are not different. These results are not particularly surprising since CO and HCl have different mechanisms of action - the former affects the central nervous system while HCl does not.

REFERENCES

Higgins, E.A., Fiorca, V., Thomas, A.A. and Davis, H.V. (1972) Acute toxicity of brief exposures to HF, HCl, NO_2, and HCN with and without CO. Fire Technol., 8:120-130.

Weil, C.S. and Wright C.J. (1967) Intra and inter-laboratory comparative evaluations of single oral test. Toxicol. Appl. Pharmacol. 11:378-388.

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ANTI-PVC/PLASTICS ALLEGATIONS

ALLEGATION NO. 16

PVC is the leading cause of cancer in firefighters who have been exposed to burning plastics.

RESPONSE

Fumes from PVC are not any more hazardous than those from natural products, such as wood, and may in fact be less hazardous.

Cancer which occurs from exposure to chemicals is generally believed to result from repeated exposure over many years. Since threshold or no effect doses are difficult to determine, even low levels are considered to have some finite risk. In animal studies which are used to detect potential human carcinogens, animals are exposed to high doses for nearly their lifetime, and the data is used to predict the potential cancer risk of a given exposure level (i.e. the dose that could result in one cancer case in populations of 100,000 or in 1,000,000 people).

When any organic material (natural or synthetic) undergoes thermal decomposition, a large number of chemicals are produced. Table I compares the thermal decomposition of wood and PVC and identifies those which are suspect as known carcinogens. Both wood and PVC produce simple asphyxiants (carbon monoxide and carbon dioxide, irritants such as acrolein, various aldehydes or hydrogen chloride, and trace or minor products i.e. benzene, etc.). As can be seen in Table I, many of the chemicals produced by the thermal decomposition of wood are suspect or known to cause cancer. More recent studies by Albert et al (1982) show that formaldehyde was carcinogenic in rats but that there was no evidence of a carcinogenic effect with hydrogen chloride.

Although the levels of carcinogens produced by wood (except possibly formaldehyde) are very small, there is probably some finite risk for anyone that would be exposed repeatedly for their lifetime. However, because the levels are so small and because exposures to the general public are not frequent or nil for those who never experience a fire, the actual risk is so low that it is virtually non-existent. Furthermore, even for firemen, whose exposures are more frequent, the risk posed by these trace chemicals is probably low. In any event, the data in Table I indicates that any carcinogenic hazard from PVC decomposition is not any greater than from wood, in fact, PVC is probably less hazardous.

REFERENCES

Albert, R.E., Sellakumar, A.R., Laskin, S., Kuschner, M., Nelson, N. and Snyder, C.A. (1982) Gaseous formaldehyde and hydrogen chloride induction of nasal cancer in the rat. J. Nat'l. Cancer Inst. 68(4):597-603.

Wooley, W.D. and Fardell, P.J. (1982) Basic aspects of combustion toxicology. Fire Safety J. 5:29-48.

Lee, H.L., Prado, G.P., Howard, J.B., and Hites, R.A. (1977) Source identification of urban airborne polycyclic aromatic hydrocarbon by gas chromatographic mass spectrometry and high resolution mass spectrometry. Biomed. Mass. Spectrom. 4:182-186

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ALLEGATION NO. 16 - contd.

REFERENCES - contd.

Cooper, J.A. (1980) Environmental impact of residential wood combustion emission and its implications. J. Air Pollut. Contr. Assn. 30(8):855-861.

Hall, R.E. and Angelis, D.G. (1980) EPA's research program for controlling residential wood combustion emissions. J. Air Pollut. Control Assn. 30(8):863-867.

SUPPORTING ATTACHMENT

Table I, "Comparison of the Carcinogenic Potential of the Thermal Decomposition Products of Wood and PVC"

RESPONSE ORIGINATOR — CONTACT FOR SUPPLEMENTAL INFORMATION

Dr. Robert K. Hinderer
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Table ... Comparison of the carcinogenic potential of the ...ermal decomposition products of

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Benzene	Yes	Ethane
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Benz(a)anthracene	Yes	Propane
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Chrysene	?	Hexane
Methane	No	Methylcyclopentane
Toluene	No	Toluene

[a]Only a partial listing (Cooper 1980; Hall and Deangelis, 1980; Lee et al, 1977; Wooley anc

[b]Boettner et al, 1969

[c]Probably due to residual levels of monomer.

ANTI-PVC/PLASTICS ALLEGATIONS

ALLEGATION NO. 17

HCl is slow acting, and damage will increase with time after exposure if not neutralized.

RESPONSE

The effects of inhaling irritants such as acrolein, formaldehyde and HCl occur relatively quickly.

When one exposes the skin to an acid solution, the extent of the damage depends on the strength of the acid, the amount of liquid. If the volume of acid solution is large relative to the amount of tissue exposed, the degree of damage can usually be reduced by quickly removing the excess acid solution.

Inhalation exposures, on the other hand, are quite different. Although some acids such as acrolein, formaldehyde and HCl will combine with moisture in the air to form, in essence, an acid solution, the volume is relatively small compared to the lung surface area. Therefore, an increase in damage will be the result of continued inhalation.

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ANTI-PVC/PLASTICS ALLEGATIONS

ALLEGATION NO. 18

In fire victims with low carboxyhemoglobin levels, it must be concluded that HCN and/or HCl contributed to most or all deaths.

RESPONSE

Low carboxyhemoglobin values alone are not evidence that HCN and/or HCl were involved in fire deaths.

When any organic material, natural or synthetic, burns it releases carbon monoxide (CO) which will combine with hemoglobin in the blood. Carboxyhemoglobin (COHb) levels of 50-60% are usually fatal. Therefore, some people believe that since 50% COHb will kill you, any fatalities with COHb levels less than 50% must be the result of other toxicants such as HCN or HCl.

While such deductions may seem logical, Myers and Cowley (1979) report that some people may have severe CO poisoning and still have low COHb levels. The most important factor is how much CO has diffused into the tissues. Low COHb levels alone can be very misleading. Reports by the Consumer Product Safety Commission of space heater victims confirm this and show that deaths occur even when COHb levels are very low. Both of these reports emphasize the important role played by alcohol and existing myocardial damage in some CO poisoning. Furthermore, low O_2 levels occurring in a fire may also potentiate the toxicity of CO.

REFERENCES

Myers, RAM and Cowley, R.A. (1979) Carbon monoxide poisoning and its treatment. J. Comb. Toxicol. 6:87-90

U.S. Consumer Report Safety Commission, U.S. Government Memorandum, Unvented Gas Space Heater Related Deaths. From E.A. Tyrrell and D.A. Kale to S. Morrow, Feb. 1, 1979.

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ANTI-PVC/PLASTICS ALLEGATIONS

ALLEGATION NO. 19

PVC emits HCl at temperatures as low as 200°F.

RESPONSE

Not aware of any scientifically credible study supporting the allegation.

Woolley calculated that in air, 20% of the theoretical amount of HCl could be released in 1.9 hours if PVC is held constant at 394°F. 1/

Wood emits toxic formic and acetic acids when held at 392°F. 2/ Western red cedar self-ignites at 378°F. 2/

PVC is processed between 350-450°F. HCl evolution would be expected only if held constant for about 2 hours at 350°F or 10 or more minutes at 450°F. 1/

A human exposed to heat sufficient to cause formic and acetic acid from wood and HCl from PVC is in serious trouble: mouth breathing difficult -- temperature limit for escape, 300°F; irreversible injury to dry skin in 30 seconds, 360°F; respiratory threshold, 390°F. 3/

REFERENCES

1/ Woolley, W. D., "Toxic Products from Plastic Materials in Fires," Plastics and Polymers, pp. 280-286, December, 1973.

2/ Fire Protection Handbook, Fifteenth Edition, NFPA, pg. 4-11, 1981.

3/ Volume 3, "Smoke and Toxicity," Report of the Committee on the Fire Safety Aspects of Polymeric Materials, National Academy of Sciences, Washington, D.C., NMAB 318-3, 1978.

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ANTI-PVC/PLASTICS ALLEGATIONS

ALLEGATION NO. 20

PVC produces poisons, carcinogens and irritants before it ignites.

RESPONSE

The very same statement can be said for most, if not all, materials. It is certainly true for wood. Decomposition of wood progresses in stages approximately as follows: 1/

- 392°F	Water vapor, carbon dioxide (asphyxiant), formic acid (irritant) and acetic acid (caustic, irritant)
- 392-536°F	Carbon monoxide (asphyxiant)
- Above 536°F	Flammable vapors, particulates. Ignition occurs.

Ignition temperatures of woods vary -- most being in the 400-500°F range. All would emit irritants and perhaps poisons and carcinogens before ignition.

Burning of any solid material requires pre-ignition emission of gases. Materials do not burn directly -- ignitable gases emitted from a material as a result of external heat, not the material itself, are what burns.

"Wood evolves carbon monoxide above 220°C (428°F), almost 100°C (212°F) below the temperature it spontaneously ignites. It will also evolve formaldehyde and acrolein." 2/

REFERENCES

1/ Fire Protection Handbook, Fifteenth Edition, NFPA, pg. 4-11, 198

2/ Edgerly, P. G., "A Study of Fume Evolution at Polymer Processing Temperatures," Plastics and Rubber Processing and Applications, pp. 81-86, Vol. 1, No. 1, 1981.

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ANTI-PVC/PLASTICS ALLEGATIONS

ALLEGATION NO. 21

Heating PVC to only 350°F can release phosgene, CO and benzene.

RESPONSE

No scientifically credible study exists supporting the allegations "heating PVC to only 350°F can release phosgene (or) benzene."

National Bureau of Standards (NBS) put to rest rumors about phosgene. Virtually no phosgene from PVC was found by NBS under conditions of pyrolysis, combustion or electrical overload. Under very special decomposition conditions -- a 10,000-volt electrical arc -- NBS reportedly found that a very small amount of phosgene may occur. 1/

Raising an issue about phosgene is an attempt to create fear about something that doesn't really exist.

Benzene is a common decomposition product of hydrocarbon materials, including wood. 2/ The primary exposure to benzene for the majority of the population will be from gasoline vapors -- especially at "self-serve" pumps.

Scientific studies show that HCl precedes benzene formation. 3/ HCl has a strong, pungent odor at very low levels (i.e., 5-10 ppm) which provides an effective warning of its presence. Although possibly present, benzene would not be toxicologically significant because of the greater presence of HCl.

Scientific studies show that measurable amounts of benzene begin to occur at about 525°F 3/, not 350°F. Most species of wood will have already ignited by the time any benzene is formed.

(For HCl, see response to Statement 19).

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ALLEGATION NO. 21 - contd.

REFERENCES

1/ Brown, J. E., and Birky, M. M., "Phosgene in the Thermal Decomposition Products of Poly(vinyl chloride): Generation, Detection and Measurement," Journal of Analytical Toxicology, Vol. 4, July/August, 1980, pp. 166-174.

2/ Woolley, W. D., and Fardell, P. J., "Basic Aspects of Combustion Toxicology," Fire Safety Journal, Vol. 5 (1982), pp. 29-48.

3/ Chang, E. P., and Salovey, Journal of Poly. Science., 12, 2927 (1974 Reference reported by Koebel, R. F., "A Letter to Andersen: Specific Descriptive Chemistry. The Issue of Benzene in PVC Extrusion Volatiles," March 3, 1978.

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ALLEGATION NO. 22

Rapid release of HCl does not require combustion.

RESPONSE

Significant heat is required to cause rapid release of HCl.

Scientific studies show that rapid release of HCl from PVC does not occur until temperatures of approximately 482°F are achieved. 1/, 2/. This coincides with the ignition temperature of many materials:

Material	Ignition Range, °F 3/
Western red cedar	378
White pine	406-507
Douglas fir	500
Cotton	446-511
Wool	401
Newsprint	445

Wood, wool, cotton and paper are aflame -- "feeding the fire"; contributing to the total fire hazard at about the same point at which HCl evolution from PVC just begins to become significant.

REFERENCES

1/ Boettner, E. A.; Ball, G. and Weiss, B., "Analysis of the Volatil Combustion Products of Vinyl Plastics," Journal of Applied Polyme Science, Vol. 13, pp. 377-391, 1969.

2/ Woolley, W. D., "Toxic Products from Plastic Materials in Fires," Plastics and Polymers, pp. 280-286, December 1973.

3/ Hilado, C. J., Flammability Handbook for Plastics, Third Edition, Table 2.5, p. 37, 1982.

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ANTI-PVC/PLASTICS ALLEGATIONS

ALLEGATION NO. 23

HCl precedes the appearance of smoke.

RESPONSE

Possibly true, but questionable significance under real world conditions. Hydrogen chloride is a colorless gas which, in combination with moisture in the air, is transformed to visible white fumes or smoke. Even if it remained colorless, HCl has a pungent odor detectable at 1-5 parts per million in the atmosphere. This could provide an early indication of a decomposition situation -- even earlier than the presence of visible signs, i.e., smoke or flame.

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ALLEGATION NO. 24

Non-flaming decomposition products of many synthetic material are toxic, flammable and explosive.

RESPONSE

W. D. Woolley of England's Fire Research Station states this accusation must be shared equally by natural and synthetic materials. Non-flaming thermal decomposition (smoldering) is "self propagating" combustion, usually at a low temperature, which can continue for long periods of time. It can be initiated in both natural materials (cotton, kapok) and natural-synthetic combinations (cotton-polyurethane foam).[1] ...smoke released during smoldering is flammable and when confined may lead, under very critical conditions, to an explosion.[2]

REFERENCES

(1) "Smoke & Toxic Gas Production from Burning Polymers", Woolley, W. D., Journal of Macromolecular SCL-Chemistry, A-17(1), pp. 1-33 (1982).

(2) Woolley, W. D. and Ames, S. A., The Explosion Risk of Stored Foam Rubber (CP 36/75), Building Research Establishment, Borehamwood, 1975.

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ANTI-PVC/PLASTICS ALLEGATIONS

ALLEGATION NO. 25

PVC burns twice as hot and twice as fast as wood, and can give off up to 500 times as much toxic gases as conventional material.

RESPONSE

This charge is not true. The facts are that wood burns four times as fast as PVC and its heat of combustion is greater than PVC's: 1/

Flame Spread (ASTM E-84)	
Red Oak	100
PVC	15-35

Flame Spread (ASTM E-162)	
Red Oak	100
PVC	10

Total Heat Release (Btu/Ft^2)*	
Pine	8000
PVC	1500

Heat of Combustion (Btu/Lb)	
PVC	7730
Wood (avg.)	8680

*OSU Release Rate Test, 2.5-2.6 $watt/cm^2$ exposure

PVC does not produce "500 times" as much toxic gases as conventional material. Apparently, the allegation is meant to lead people to believe that PVC is 500 times more toxic than conventional material. National Bureau of Standards toxicity protocol shows combustion products of Douglas fir, wool and PVC are about equivalent in toxicity.

The relative hazard of materials in a fire cannot be predicted by merely comparing type and level of combustion gases. The fact that the by-products are different does not necessarily mean that one material is more or less of a hazard in a fire. Compared to conventional materials, PVC typically shows a higher ignition temperature, slower flame spread, less heat produced and less willingness to burn, all adding up to one important fact -- PVC is not a fire hazard.

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ANTI-PVC/PLASTICS ALLEGATIONS

ALLEGATION NO. 26

At temperatures not much higher than needed to bake apple pie, PVC decomposes and produces huge amounts of HCl.

RESPONSE

The temperature required to bake an apple pipe, 425°F for 45-50 minutes (McCall's Cookbook, Random House, 1963.), exceeds the limit for human survivability. "In fire tests conducted by the National Research Council of Canada, 300°F was taken as the maximum survivable breathing air temperature. A temperature this high can be endured only for a short period and not at all in the presence of moisture." 1/

Temperatures lower than those required to bake an apple pie will have profound adverse effects on humans: e.g., rapid unbearable pain to dry skin -- 320°F; irreversible injury to dry skin in 30 seconds -- 360°F; respiratory system threshold -- 390°F. 2/

Hydrogen chloride will be released from PVC if held at 425°F for a sufficient period of time. Woolley calculated that in air, 20% of the theoretical amount of HCl could be released in 24 minutes. To release 60% of the theoretical amount of HCl (at 425°F) would require two hours. 3/

At temperatures no different than that necessary to bake an apple pie, wood emits toxic formic and acetic acids (at 392°F). 4/ Western red cedar self ignites at 378°F. 4/

REFERENCES

1/ Fire Protection Handbook, Fifteenth Edition, NFPA, p. 3-21, 1981.

2/ Volume 3, "Smoke and Toxicity," Report of the Committee on the Fire Safety Aspects of Polymeric Materials, National Academy of Sciences, Washington, D. C., NMAB 318-3, 1978.

3/ Woolley, W. D., "Toxic Products from Plastic Materials in Fires," Plastics and Polymers, pp. 280-286, December 1973.

4/ Fire Protection Handbook, Ibid., p. 4-11.

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ANTI-PVC/PLASTICS ALLEGATIONS

ALLEGATION NO. 27

PVC melts and burns, giving off toxic fumes and accelerates the fire.

RESPONSE

Recent media criticism of PVC's fire performance has resulted in additional rigorous testing. The intent - prove or disprove such allegations.

Rigid PVC normally appearing as pipe or house siding will burn if and only if a continual ignition source remains in contact with it. Remove that source and the fire stops.

However, many market areas require a material with greater flexibility. Rigid vinyl becomes flexible by adding plasticizers. Because plasticizers are flammable, the flexible recipes must include fire retardants to counteract that effect.

Recent testing of PVC insulated electrical cables concluded that hydrogen chloride evolved in the initial thermal degradation phase (400^{o}F) did not diffuse - penetrating the entire area - but in fact, remained close to the degrading wire and actually suppressed the flame. The greater amounts of PVC used - as in wire bundles - the greater the flame suppressing effect.

"No other polymer tested demonstrated this unique property."(1)

REFERENCES

(1) "Flammability of Polymers for Electric Cables and Their Evaluation", Akita, Kazuo; Mikado, Tuneo (Fac. Eng. Univ. Tokyo, Tokyo, Japan 113). Kenkyu Hoko - Asahi Garasu Kogyo Gijutsu Shoreikai 1981, 38, 197-205 (Japan).

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ANTI-PVC/PLASTICS ALLEGATIONS

ALLEGATION NO. 28

PVC produces very rapid smoke, compared to wood.

RESPONSE

In quantitative comparisons of the smokiness of materials, the most frequently cited data comes from the NBS Smoke Density Chamber. In this test a small (3" x 3" x use thickness) sample of material in the vertical orientation is exposed to a mild heat source (2.5 watts of radiant heat energy applied per square centimeter of sample surface). The smoke released is measured by the degree to which it blocks a beam of light. Another test is the Steiner tunnel or ASTM E84 test. In this test a two foot wide by 25 foot by use thickness sample is mounted on the ceiling of the burn tunnel. The first five feet of the sample are exposed to a 5000 BTU gas flame. The experiment is carried out in a stream of air and the flames may or may not spread along the length of the sample. Smoke is measured by the extent of blocking of a beam of light by the smoke in the stream of air. The results of these tests (as well as others) in general show PVC to release more smoke and release it sooner than wood.

However, the results of these tests are not necessarily indicative of the expected performance of these materials under real fire conditions. There are two reasons for this. First these small scale tests are run under only one set of fire exposure conditions whereas in a real fire a range of conditions is encountered. In general the smoke yield of a material depends on the exposure conditions. Some of the fire exposure condition parameters include intensity of the fire source and extent of oxygen depletion. A second consideration involves the response of the material to the fire exposure. In small scale laboratory tests such as the NBS smoke density chamber the complete surface of the sample is exposed to heat in an attempt to force it to degrade. In a real fire situation this may or may not be realistic depending on the flame spreading tendency of the material in question. Another problem of this type is the tendency of some materials in the NBS smoke test to melt and drip and evade conversion to smoke. Such materials appear on the basis of the NBS test to be much less smokey than they really are.

In a real fire situation which might involve PVC there are two situations to be considered, a growing fire and a fully involved fire. In a growing fire the tendency of PVC to resist the spread of flame can result in less smoke being produced than might

ALLEGATION NO. 28 - contd.

RESPONSE - contd.

be expected. Another material such as wood might be completely consumed under the same conditions such that it would actually produce more smoke than the PVC fire. In a fully involved fire situation any PVC present would be expected to be completely consumed. However the conditions here of heat exposure and oxygen depletion are much different than those existing in the NBS chamber such that wood might produce more smoke than expected. These issues need to be further investigated.

RESPONSE ORIGINATOR -- CONTACT FOR SUPPLEMENTAL INFORMATION

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ANTI-PVC/PLASTICS ALLEGATIONS

ALLEGATION NO. 29

PVC generates 38 times more smoke than wood.

RESPONSE

In quantitative comparisons of the smokiness of materials, the most frequently cited data comes from the NBS Smoke Density Chamber. In this test a small (3" x 3" x use thickness) sample of material in the vertical orientation is exposed to a mild heat source (2.5 watts of radiant heat energy applied per square centimeter of sample surface). The smoke released is measured by the degree to which it blocks a beam of light. Another test is the Steiner tunnel or ASTM E84 test. In this test a two foot wide by 25 foot by use thickness sample is mounted on the ceiling of the burn tunnel. The first five feet of the sample are exposed to a 5000 BTU gas flame. The experiment is carried out in a stream of air and the flames may or may not spread along the length of the sample. Smoke is measured by the extent of blocking of a beam of light by the smoke in the stream of air. The results of these tests (as well as others) in general show PVC to release more smoke and release it sooner than wood.

However, the results of these tests are not necessarily indicative of the expected performance of these materials under real fire conditions. There are two reasons for this. First these small scale tests are run under only one set of fire exposure conditions whereas in a real fire a range of conditions is encountered. In general the smoke yield of a material depends on the exposure conditions. Some of the fire exposure condition parameters include intensity of the fire source and extent of oxygen depletion. A second consideration involves the response of the material to the fire exposure. In small scale laboratory tests such as the NBS smoke density chamber the complete surface of the sample is exposed to heat in an attempt to force it to degrade. In a real fire situation this may or may not be realistic depending on the flame spreading tendency of the material in question. Another problem of this type is the tendency of some materials in the NBS smoke test to melt and drip and evade conversion to smoke. Such materials appear on the basis of the NBS test to be much less smokey than they really are.

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ALLEGATION NO. 29 - contd.

RESPONSE - contd.

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ANTI-PVC/PLASTICS ALLEGATIONS

ALLEGATION NO. 30

PVC produces up to 500 times as much smoke per sq. ft. of surface as red oak.

RESPONSE

In quantitative comparisons of the smokiness of materials, the most frequently cited data comes from the NBS Smoke Density Chamber. In this test a small (3" x 3" x use thickness) sample of material in the vertical orientation is exposed to a mild heat source (2.5 watts of radiant heat energy applied per square centimeter of sample surface). The smoke released is measured by the degree to which it blocks a beam of light. Another test is th Steiner tunnel or ASTM E84 test. In this test a two foot wide by 25 foot by use thickness sample is mounted on the ceiling of the burn tunnel. The first five feet of the sample are exposed to a 5000 BTU gas flame. The experiment is carried out in a stream of air and the flames may or may not spread along the length of the sample. Smoke is measured by the extent of blocking of a beam of light by the smoke in the stream of air. The results of these tests (as well as others) in general show PVC to release more smok and release it sooner than wood.

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ALLEGATION NO. 30 - contd.

RESPONSE - contd.

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RESPONSE ORIGINATOR -- CONTACT FOR SUPPLEMENTAL INFORMATION

Dr. Greg F. Smith
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ALLEGATION NO. 31

Burning or smoldering plastics give off toxic gases such as HCl, HCN and H_2S, among others.

RESPONSE

The statement is a clear effort to mislead the public by purposely withholding the pertinent fact that all burning or smoldering materials give off toxic gas. For instance, wood begins to emit toxic carbon monoxide at about $428^{\circ}F$ and will also evolve formaldehyd (cancer-causing chemical) and acrolein (a severe toxic respiratory irritant). 1/ In addition, Emmons reports that when wood is burned, as many as 175 different fire gases may be produced. 2/ Woolley, as shown below, identified numerous toxicants, including benzene, in the products of combustion of large-scale wood fires: 3/

TABLE 7

Yields of fingerprint compounds at three stages of fire (low ventilation) (ppm)

Wood			
Chemical interpretation	Growth	Steady state	Decay
Methane	11.9	95.9	7.9
Acetylene	0.8	35.8	5.7
Ethylene	1.9	22.2	9.0
Ethane	0.2	0.3	
Allene			
Propene	5.7	103.9	10.0
Cyclopropane	0.1		
Propyne	0.6	22.3	1.1
Methanol	3.7	329.3	34.1
Acetaldehyde	7.2	65.4	1.6
Butene Butadiene	1.3	90.7	1.0
Ethanol		0.2	*
Acrolein	2.7	3.7	*
Acetone	2.7	269.1	52.1
Cyclopentadiene	2.5	248.3	48.1
Crotonaldehyde		6.3	*
Hexene/Cyclohexane	*	2.4	6.0
Benzene	1.8	603.3	152.9
Cyclohexadiene	*	*	
Heptene	0.1	*	
Heptyne	0.1	*	
Heptadiene	0.2	*	
Toluene	0.6	182.0	20.4
Octene	0.5	3.6	2.3
Xylene	0.8	28.6	5.1
Styrene	0.5	72.1	3.0
Nonene	0.3		
Benzaldehyde	3.0	94.9	60.4
Methyl styrene	0.3	23.4	*
Decene	0.3		
Indene	0.7	85.1	8.2
Ethyl styrene	1.6	12.2	*
Methyl indene	*	19.6	
Naphthalene	2.2	164.0	

*Present but concentration too low to measure.

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ALLEGATION NO. 31 - contd.

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2/ Emmons, H. W., "Fire and Fire Protection," Scientific American, Vol. 231, No. 1, pp. 21-27, July, 1974.

3/ Woolley, W. D., and Fardell, P. J., "Basic Aspects of Combustion Toxicology," Fire Safety Journal, Vol. 5 (1982), pp. 29-48.

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ANTI-PVC/PLASTICS ALLEGATIONS

ALLEGATION NO. 32

PVC gives off chlorine, phosgene, VCl, benzene and other unknown toxicants.

RESPONSE

When PVC burns in a fire the chlorine is released almost quantitatively as hydrogen chloride. Much less than one percent of the available chlorine is converted to any chlorine containing product other than HCl. Thus only negligible quantities of chlorine containing products such as chlorine, phosgene, vinyl chloride or other unknown chlorine containing products are expected. Nevertheless it is not impossible for a negligible amount of such products to be formed.

Considering these potential products individually:

Chlorine (Cl_2) - When suitable analytical methods are applied, chlorine has not been observed as a combustion product of PVC. Considering the highly reactive nature of this chemical, this is not surprising.

Vinyl Chloride - Vinyl chloride has been observed in the combustion products of PVC. However the amount is insignificant. About one part per million of the original sample may be released as vinyl chloride.

Phosgene ($COCl_2$) - It has been determined that under typical fire conditions which could conceivably involve PVC such as flaming combustion or electrical overload of wire, no significant amount of phosgene is released. Under laboratory conditions simulating unusual fire conditions involving electrical arcs traces of phosgene have been found. For each one pound of PVC degraded, about one onethousandth of a pound of phosgene was produced.

Benzene (C_6H_6) - Under non flaming thermal degradation conditions benzene can be released. About one percent of the weight of flexible PVC may be released as benzene. Under flaming conditions benzene will still be released but at a reduced yield.

Unknown Toxicants - The balance of the combustion products of PVC consist mainly of low molecular weight hydrocarbons and oxygenated hydrocarbons such as methane, acetaldehyde, acetic acid ethanol and others.

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ANTI-PVC/PLASTICS ALLEGATIONS

ALLEGATION NO. 33

In the Colonial warehouse, 400,000 pounds of PVC burned; several pounds of phosgene were produced, 4 pounds at 10 ppm, 14 pounds at 35 ppm.

RESPONSE

Under flaming conditions, PVC may release traces of phosgene. There is data which suggests that for each one gram of PVC burned, 0.1 milligrams of phosgene is produced. If these figures are correct, 400,000 pounds of PVC would produce 40 pounds of phosgene (not 4 as stated in the problem).

If 400,000 pounds of anything is on fire, then there are two major problems. The first is that you have a very large fire. The second is that tens or hundreds of thousands of pounds of carbon monoxide is being released. If PVC is burning approximately 200,000 pounds of HCl is being released. Under these conditions, 40 pounds of phosgene isn't the greatest problem.

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ANTI-PVC/PLASTICS ALLEGATIONS

ALLEGATION NO. 34

Other than HCl, the main components of the gaseous products from burning PVC are chloromethane, benzene, toluene, xylene, indene, naphthalene chlorobenzene, divinylbenzene, methyl ethyl cylopentane, and dioxan, according to the polymer and conditions of thermal degradation.

RESPONSE

The person responsible for the quote has unfortunately mixed two situations that must be separated for a proper understanding of the literature data. The first situation is the generation of hydrocarbon fuel by thermal degradation of the polymer. The generation of fuel is modeled in the lab by inert gas pyrolysis of the polymer. The second situation is the combustion in air of the hydrocarbon fuel generated.

When we pyrolyze a polymer in an inert atmosphere we find a spectrum of hydrocarbons formed by fragmenting the carbon containing polymer backbone. Usually more of the lower molecular weight fragments are found because they are easier to detect than the higher molecular weight fragments. Pyrolysis of polymers yields useful scientific information in that it tells us how the polymer chains break down (whether they cross-link or fragment), how different additives put into plastics for processing stability or long term use might affect this polymer degradation process, and serves as a means of identifying polymer compositions when small amounts of samples are available. It does not, however, tell us very much about the nature of the products of combustion when that polymer is burnt in air.

The reason for this is that virtually all hydrocarbon fuels, when burnt in air, make the same products of combustion, regardless of the specific chemical formula of the hydrocarbon. One way to visualize this is to note that the flame is so hot that it fragments the gaseous hydrocarbons even further to very simple fuels such as methane, acetylene, etc., regardless of the chemical structure of the starting hydrocarbon. These in turn burn in air to form just carbon monoxide and carbon dioxide.

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ALLEGATION NO. 34 - contd.

RESPONSE - contd.

To summarize then, all plastics undergo thermal pyrolysis when exposed to sufficient heat to produce a variety of hydrocarbons and in the case of polymers like PVC also non-hydrocarbon gases such as HCl. If the situation we are describing is actual burning in air then these fuels must first pass through the flame where the hydrocarbon gases are all converted to carbon monoxide, carbon dioxide, and soot. Non-hydrocarbon gases, such as HCl, will not undergo oxidation under these conditions and will pass directly through the flame. So although polymers can produce many hydrocarbon fragments of known or unknown toxicity they are not actually encountered in real fires where the major toxicant found is carbon monoxide.

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Fenimore, C.P. and Martin, F.J., Combustion and Flame, Volume 10, page 135, 1966; and Volume 12, page 125, 1968.

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ANTI-PVC/PLASTICS ALLEGATIONS

ALLEGATION NO. 35

PVC emits 5 times as much CO as wood.

RESPONSE

A. In small-scale tests, PVC produces less CO than wood does. However, the performance of materials in small-scale tests probably isn't well related to the performance in real fires. In a small-scale test, the major mode of carbon monoxide production is by the slow oxidation of a char phase. This is exactly the type of burning exhibited by charcoals in a barbeque grill. It is a very slow process. In real fires, the major production of carbon monoxide probably occurs at or just after flashover. This can occur as soon as one minute after a fire starts. In this case, carbon monoxide production increases tremendously because the onset of flashover consumes practically all the available oxygen in the area. This results in incomplete combustion resulting in carbon monoxide -- an incompletely oxidized combustion product. Thus, the hazard due to carbon monoxide is greatest in the case of materials which burn fastest or otherwise lead most easily to flashover. Materials which easily lead to flashover include wood, materials which resist flashover inclue PVC.

B. It is not true that more CO is emitted from PVC.

Carbon Monoxide Evolution (ppm)

	482°F	518°F	554°F	590°F	626°F
PVC	40	100	100	110	110
Wood (fir)	120	500	3800	5000	1300

(SEE REFERENCE 1)

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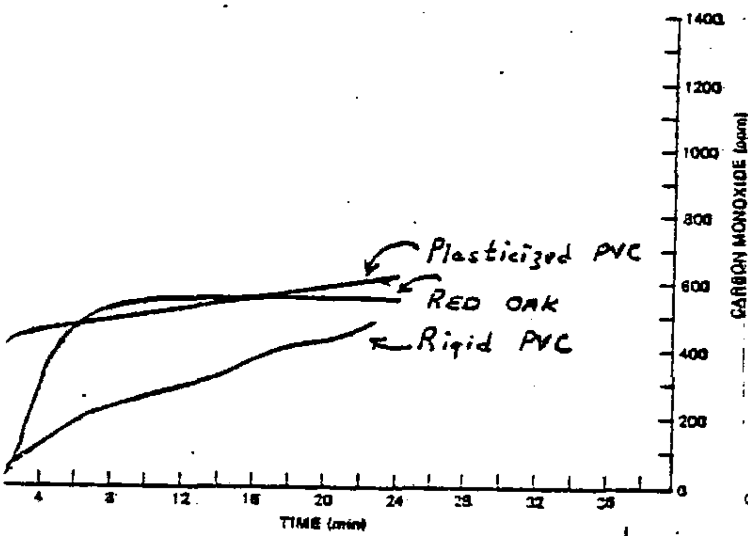
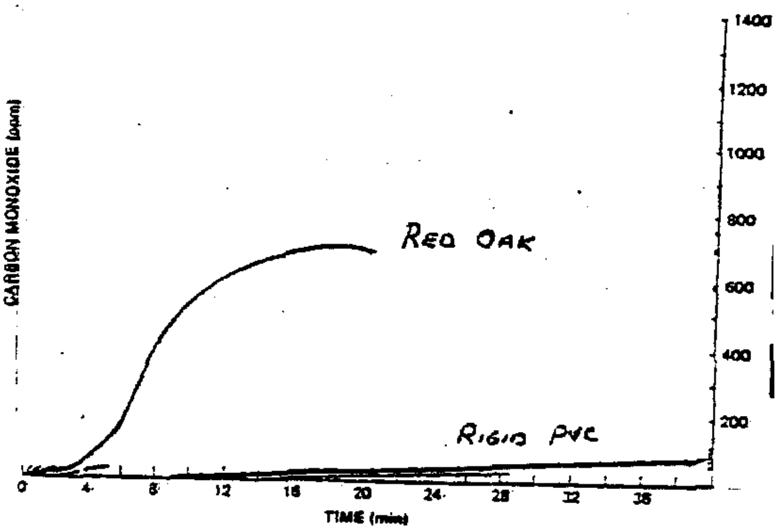
ALLEGATION NO. 35 - contd.

RESPONSE - contd.

B. - contd.



carbon monoxide from various materials, average triplicate tests flaming exposure (2.00 w/cm²).



carbon monoxide from various materials, average of triplicate tests smoldering ex[posure] (2.00 w/cm²)

National Bureau of Standards
(NBS) Smoke Chamber

(SEE REFERENCE 2)

REFERENCES

1. Edgerley, P. G., "A Study of Fume Evolution at Polymer Processing Temperatures," Plastic and Rubber Processing and Applications, pp. 81-86, Vol. 1, No. 1, 1981.

2. Volume 3, "Smoke and Toxicity," Report of the Committee on the Fire Safety Aspects of Polymeric Materials, National Academy of Sciences, Washington, D. C., NMAB 318-3, 1978.

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ANTI-PVC/PLASTICS ALLEGATIONS

ALLEGATION NO. 36

When PVC decomposition occurs, a large amount of HCl is released first, then CO.

RESPONSE

When PVC is heated very slowly, we can clearly differentiate the different stages it goes through in its decomposition process. At these low rates (10 degrees/minute) the HCl does start coming off first and much of the HCl will come off before other gases will be detected. However, plastics exposed to real fire or even small fire environments will not see such low heating rates and the relevance of the laboratory observation is questionable. If PVC is exposed to real fire environments it will decompose and produce HCl and its hydrocarbons fragments will produce CO. But the yield of these gases from PVC will be in direct response to the amount of PVC exposed to a large enough fire to cause its involvement. And the relative increase in overall hazard represented by the PVC will be very dependent on the other fire already going since the PVC cannot burn by itself and its response will be directly related to the size of the fire causing its decomposition.

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ANTI-PVC/PLASTICS ALLEGATIONS

ALLEGATION NO. 37

The LC_{50} of PVC is 8 times more toxic than wood; however, when results with mice are extrapolated to humans, PVC is 70-80 times more toxic than wood.

RESPONSE

When one considers the breadth of the data, the combustion toxicity of PVC is generally comparable with many natural and synthetic materials. Furthermore, more recent attempts to extrapolate animal studies to man are theoretical and have never been validated.

Combustion toxicities comparing PVC with other materials have been reviewed by Hinderer and O'Mara (1982). World-wide studies by academia, government, and industry have shown that the combustion toxicity and hazard potential of PVC is not unique or extreme, but is similar to that of many other materials, including wood. In fact, the combustion products of many common materials can cause incapacitation or death in test animals faster, or by burning less material, than PVC.

While rodents (mice and rats) have been used to study the combustion toxicity of materials, questions have remained as to how these responses relate to man. For some chemicals such as CO, the sensitivity/biological response appears to be close to that of man. However, for other chemicals such as the irritant gases (acrolein, HCl), there is little information relating rodent and human responses.

Another concern which has been raised is that mice and rats are obligate nasal breathers whereas man breathes through both his mouth and nose. Alarie (unpublished report) has theorized that since mice do not breathe through their mouth, surgical procedures (cannulation) should be used to by-pass the nasal cavity. This has been done by surgically inserting a tube in the trachea, allowing direct administration of combustion gases. By using this procedure Alarie has calculated that PVC is 70-80 times more toxic than wood.

Alarie has quite correctly recognized that mice do not breathe like humans. Namely, mice (and rats) are obligate nasal breathers. He is also accurate when he says that HCl is highly water soluble. However, his comparative analysis of the impact of nasal vs. buccal breathing of PVC decomposition products is questionable.

As you know, corrosive gases such as HCl (PVC) and acrolein, formaldehyde, etc. (wood) reach the respiratory passages via soot as a gas and, depending on the humidity, as aqueous HCl. The transport of these forms does provide some potential for biological variability.

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ALLEGATION NO. 37 - contd.

RESPONSE - contd.

In the case of soot, the degree of lower respiratory tract deposition does depend on particle size and on whether nasal or buccal breathing occurs. If we exposed two groups of humans to the same particle size distribution of soot, one by nasal exposure and the other by mouth breathing, we might expect to see greater deposition in the nasal cavity than in the mouth. Also, we might expect greater amounts in the trachea and large bronchi. However, we would not expect a difference in the amount that reaches the lower respiratory tract since this is almost totally dependent on the amount of "respirable" (10 micron or less) material. We are not talking about 60 vs. 0% decomposition for the nose and mouth respectively; it is probably something like 60 vs. 20-40% depending on particle size. Aqueous HCl (mist) would also follow similar laws of particle decomposition.

Alarie however, does not consider soot or mist, but gaseous HCl exposure only. He says that HCl gas deposition is high in the nasal mucosa. This is supported by the studies of Morris and Smith (1980) using HF. Alarie states that a correction factor is needed for mouth breathing but he does not provide any data for the buccal route of exposure to support this contention. Furthermore, he proposes to correct for this difference by tracheal cannulation. Such a manipulation is not appropriate for mouth breathing because it by-passes a significant portion of the alternate upper respiratory tract, namely the oral cavity, pharynx, and upper trachea (above the point of cannulation). By by-passing a major porition of the upper respiratory tract, Alarie has eliminated a significant part of the body's normal protective mechanism.

In the case of soluble gases such as HCl, surface area and moisture play an important role in deposition. More surface area and moisture will cause greater deposition. Although the surface area of the nasal cavity is greater than the oral cavity, this value may be somewhat misleading since the sinus cavities to some degree can be considered dead space (i.e. a limited amount of air movement).

Essentially what we are saying here is that when one considers "effective surface area", the differences are not as great. On the other hand, the moisture content while high in both, is probably somewhat higher in the mouth. Taken together these two differences may serve to cancel each other out, or at least make any differences in deposition of HCl less significant.

Studies with primates are now being conducted to indicate that the rodent and human response to irritants is quite different. Until further comparative information on the effect of irritants in rodents and man is available, procedures such as the one proposed by Alarie are questionable.

REFERENCE

Hinderer, R.K. and O'Mara, M.M. (1982) Polyvinyl chloride combustion toxicity: a comparative review. Geon Vinyls, Technical Service Report, The BFGoodrich Company.

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ALLEGATION NO. 38

PVC fumes are explosive.

RESPONSE

The answer to this allegation depends upon the context in which it is made. If the context is a real fire environment with materials burning, then the response to Response 34 separating the concepts of fuel generation from fuel combustion also apply here. Regardless of how wide the flammability limit, concentration range of the fuel is it never builds in concentration because of the flame burning.

If the context is fuel generation due to an external source of heat, such as pyrolysis due to electrical arcing, etc., then one must use the rule of mixtures for calculating the lower flammability limit of a mixture of gases comprising the measured products of pyrolysis in the right concentration. This rule sums up the relative contributions of each gas to the limit for the mixture in such a way that the mixture will be sensitive to the lowest flammable limit member but also sensitive to the concentration of each. In the case of PVC pyrolysis, HCl is a large part of the gas mixture and has, practically speaking, no lower flammability limit so it makes it very difficult, if not impossible, to cause explosions with gas mixtures made solely from decomposition products of PVC.

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ANTI-PVC/PLASTICS ALLEGATIONS

ALLEGATION NO. 39

Plastic pipes can burn through and allow smoke and toxic gases to penetrate fire partitions.

RESPONSE

Everyone involved in promotion of plastic pipe for applications involving penetration of fire partitions must do th part to make sure that the effectiveness of the fire barrier wil not be reduced. In general, simply boring a hole through such a partition and inserting the plastic pipe will result in a loss o efficiency of the fire barrier. There are several factors to consider. All plastic pipe will at least tend to melt with the result that fire gases will transport through the opening. Thus engineering solution to the potential situation is required. Ma effective designs have been created and are available. Secondly not all plastic pipe material performs in the same way. ABS typ pipe, for example, is flammable in comparison to PVC pipe. Thus ABS pipe itself may tend to spread fire past the partition. Tes have shown that protection of plastic pipe penetration of a fire partition is more difficult in the case of ABS because of these considerations. By comparison a much simpler engineering design required to effectively protect a fire partition penetrated by P' pipe.

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ANTI-PVC/PLASTICS ALLEGATIONS

ALLEGATION NO. 40

Burning synthetics yield toxic gases which disable and disorient people more quickly than traditional materials.

RESPONSE

Numerous studies have shown that PVC does not cause incapacitation more rapidly than traditional materials (Hilado and Cummings, 1978; Hilado and Huttlinger, 1981; and NBS, 1982). Furthermore, other investigators have reported that PVC compares favorably with many natural and synthetic materials (Hinderer and O'Mara, 1982).

REFERENCES

Hinderer, R.K. and O'Mara, M.M. (1982) Polyvinyl chloride combustion toxicity: a comparative review. Geon Vinyls Technical Service Report, The BFGoodrich Company.

Further Development of a Test Method for the Assessment of the Acute Inhalation Toxicity of Combustion Products. NBSIR 82-2532, U.S. Department of Commerce, National Bureau of Standards, National Engineering Laboratory, Center for Fire Research, Washington, D.C. June 1982(a).

Hilado, C.J. and Cumming, H.J. (1978). Relative toxicity of pyrolysis gases from materials: effects of chemical composition and test conditions. Fire and Materials, 2(2):68-79.

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ANTI-PVC/PLASTICS ALLEGATIONS

ALLEGATION NO. 41

Smoke from burning PVC incapacitates victims.

RESPONSE

Numerous studies have shown that PVC does not cause incapacitation more rapidly than traditional materials (Hilado and Cummings, 1978; Hilado and Huttlinger, 1981; and NBS, 1982). Furthermore, other investigators have reported that PVC compares favorably with many natural and synthetic materials (Hinderer and O'Mara, 1982).

REFERENCES

Hinderer, R.K. and O'Mara, M.M. (1982) Polyvinyl chloride combustion toxicity: a comparative review. Geon Vinyls Technical Service Report, The BFGoodrich Company.

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Hilado, C.J. and Cumming, H.J. (1978). Relative toxicity of pyrolysis gases from materials: effects of chemical composition and test conditions. Fire and Materials, 2(2):68-79.

Hilado, C.J. and Huttlinger, P.A. Toxic hazards of common materials. Fire Tech. August 1981, pp. 117-182.

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ALLEGATION NO. 42

PVC (HCl) causes "Intoxication Syndrome" which incapacitates and results in fire deaths.

RESPONSE

Numerous studies have shown that PVC does not cause incapacitation more rapidly than traditional materials (Hilado and Cummings, 1978; Hilado and Huttlinger, 1981; and NBS, 1982). Furthermore, other investigators have reported that PVC compares favorably with many natural and synthetic materials (Hinderer and O'Mara, 1982).

REFERENCES

Hinderer, R.K. and O'Mara, M.M. (1982) Polyvinyl chloride combustion toxicity: a comparative review. Geon Vinyls Technical Service Report, The BFGoodrich Company.

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Hilado, C.J. and Huttlinger, P.A. Toxic hazards of common materials. Fire Tech. August 1981, pp. 117-182.

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ANTI-PVC/PLASTICS ALLEGATIONS

ALLEGATION NO. 43

The potential for escape from PVC decomposition products is low, compared to fires of natural products.

RESPONSE

Numerous studies have shown that PVC does not cause incapacitation more rapidly than traditional materials (Hilado and Cummings, 1978; Hilado and Huttlinger, 1981; and NBS, 1982). Furthermore, other investigators have reported that PVC compares favorably with many natural and synthetic materials (Hinderer and O'Mara, 1982).

REFERENCES

Hinderer, R.K. and O'Mara, M.M. (1982) Polyvinyl chloride combustion toxicity: a comparative review. Geon Vinyls Technical Service Report, The BFGoodrich Company.

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Hilado, C.J. and Cumming, H.J. (1978). Relative toxicity of pyrolysis gases from materials: effects of chemical composition and test conditions. Fire and Materials, 2(2):68-79.

Hilado, C.J. and Huttlinger, P.A. Toxic hazards of common materials. Fire Tech. August 1981, pp. 117-182.

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ANTI-PVC/PLASTICS ALLEGATIONS

ALLEGATION NO. 44

In actual PVC fires, there was little smoke; they were small and easily extinguished, but firefighters were often incapacitated by HCl fumes.

RESPONSE

Many fires have been described as "PVC fires". However, since PVC will not continue to burn unless some other material provides a continuous source of heat, there is no such thing as a "PVC fire". Therefore, the combustion products of a fire where PVC is present will always be more than just those from PVC.

A second important point is that documentation of what materials were involved in real fires is not always done. PVC is often considered just another plastic and many other plastics are often mistakenly identified as being PVC.

Finally, when any organic material (natural or synthetic) burns, carbon monoxide (CO) is released. CO is widely recognized as the major cause of incapacitation and death (Birkey et al, 1979 and Myers and Cowley, 1979). Therefore, reports of the incapacitation of firefighters is neither an uncommon nor unexpected result of the overexposure to combustion products of any combustible material.

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Birky, M.M., Halpin, B.M., Caplan, Y.H., Fisher, R.S., McAllister, J.N., and Dixon, A.M. (1979) Fire Fatality, Fire and Materials 3:211-217.

Meyers, RAM and Cowley, R.A. (1979) Carbon monoxide poisoning and its treatment. J. Comb. Toxicol. 6:87-90.

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ANTI-PVC/PLASTICS ALLEGATIONS

ALLEGATION NO. 45

50-100 ppm of PVC combustion products can prevent escape vs. 1500 - 4000 ppm of CO.

RESPONSE

There is no evidence to support the claim that 50 ppm HCl prevents escape; however, the current FAA studies on primates exposed to HCl are expected to answer this question.

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ANTI-PVC/PLASTICS ALLEGATIONS

ALLEGATION NO. 46

Testing at the U of Pitts shows that 5 ounces of burning PVC in an average size bedroom will kill the occupants in ten minutes. (.335 pounds/5 feet of PVC conduit/8' x 10' x 12'/10-15 minutes - Alarie).

RESPONSE

Such statements that a given amount of PVC will kill you are very misleading. Since these predictions are based on theoretical calculations derived from small-scale laboratory studies, there is reason to question their relationship to real world fires. With PVC, chamber size and configuration can be very important due to the propensity for HCl to decay or plate on the walls. Furthermore, since PVC requires another fuel source to continue to burn, the above statement fails to acknowledge the contribution of other materials and other fire conditions such as low O_2 and temperature. Finally, by only mentioning toxicity, this statement fails to address the real question, fire hazard. Other factors such as quantity, configuration, proximity to other combustibles, compartment volume, ventilation, ignition resistance, flame spread resistance, BTU contribution, presence and type of ignition source, fire protection systems and building occupancy must be taken into consideration when determining the acceptability of a material.

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ANTI-PVC/PLASTICS ALLEGATIONS

ALLEGATION NO. 47

100 pounds of PVC in 10,000 ft^3 produces 57,385 ppm of HCl when burned, 57 times the concentration required to cause edema after brief exposure.

RESPONSE

Such statements that a given amount of PVC will kill you are very misleading. Since these predictions are based on theoretical calculations derived from small-scale laboratory studies, there is reason to question their relationship to real world fires. With PVC, chamber size and configuration can be very important due to the propensity for HCl to decay or plate on the walls. Furthermore, since PVC requires another fuel source to continue to burn, the above statement fails to acknowledge the contribution of other materials and other fire conditions such as low O_2 and temperature. Finally, by only mentioning toxicity, this statement fails to address the real question, fire hazard. Other factors such as quantity, configuration, proximity to other combustibles, compartment volume, ventilation, ignition resistance, flame spread resistance, BTU contribution, presence and type of ignition source, fire protection systems and building occupancy must be taken into consideration when determining the acceptability of a material.

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ANTI-PVC/PLASTICS ALLEGATIONS

ALLEGATION NO. 48

Smoke from the average synthetic polymer is 5-6 times more toxic than wood smoke, and kills almost twice as fast.

RESPONSE

A generalization that synthetic polymers are 5-6 times more toxic and kill twice as fast cannot be made. As with PVC, the combustion toxicity depends on the conditions of the tests (Hinderer and O'Mara, 1982). However, results from the recently developed NBS combustion toxicity test method indicate that most are "as toxic as wood" (i.e., within one order of magnitude) (NBS 1982a and NBS, 1982b).

REFERENCES

Hinderer, R. K. and O'Mara, M. M. (1982) Polyvinyl chloride combustion toxicity: a comparative review. Geon Vinyls Technical Service Report, The BFGoodrich Company.

Further Development of a Test Method for the Assessment of the Acute Inhalation Toxicity of Combustion Products. NBSIR 82-2532, U.S. Department of Commerce, National Bureau of Standards, National Engineering Laboratory, Center for Fire Research, Washington, D.C., June 1982(a).

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ANTI-PVC/PLASTICS ALLEGATIONS

ALLEGATION NO. 49

PVC fumes kill much faster than wood smoke.

RESPONSE

When one considers the breadth of the data, the combustion toxicity of PVC is generally comparable with many natural and synthetic materials. Furthermore, more recent attempts to extrapolate animal studies to man are theoretical and have never been validated.

Combustion toxicities comparing PVC with other materials have been reviewed by Hinderer and O'Mara (1982). World-wide studies by academia, government, and industry have shown that the combustion toxicity and hazard potential of PVC is not unique or extreme, but is similar to that of many other materials, including wood. In fact, the combustion products of many common materials can cause incapacitation or death in test animals faster, or by burning less material, than PVC.

While rodents (mice and rats) have been used to study the combustion toxicity of materials, questions have remained as to how these responses relate to man. For some chemicals such as CO, the sensitivity/biological response appears to be close to that of man. However, for other chemicals such as the irritant gases (acrolein, HCl), there is little information relating rodent and human responses.

Another concern which has been raised is that mice and rats are obligate nasal breathers whereas man breathes through both his mouth and nose. Alarie (unpublished report) has theorized that since mice do not breathe through their mouth, surgical procedures (cannulation) should be used to by-pass the nasal cavity. This has been done by surgically inserting a tube in the trachea, allowing direct administration of combustion gases. By using this procedure Alarie has calculated that PVC is 70-80 times more toxic than wood.

Alarie has quite correctly recognized that mice do not breathe like humans. Namely, mice (and rats) are obligate nasal breathers. He is also accurate when he says that HCl is highly water soluble. However, his comparative analysis of the impact of nasal vs. buccal breathing of PVC decomposition products is questionable.

As you know, corrosive gases such as HCl (PVC) and acrolein, formaldehyde, etc. (wood) reach the respiratory passages via soot as a gas and, depending on the humidity, as aqueous HCl. The transport of these forms does provide some potential for biological variability.

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ALLEGATION NO. 49 - contd.

RESPONSE - contd.

In the case of soot, the degree of lower respiratory tract deposition does depend on particle size and on whether nasal or buccal breathing occurs. If we exposed two groups of humans to the same particle size distribution of soot, one by nasal exposure and the other by mouth breathing, we might expect to see greater deposition in the nasal cavity than in the mouth. Also, we might expect greater amounts in the trachea and large bronchi. However, we would not expect any difference in the amount that reaches the lower respiratory tract since this is almost totally dependent on the amount of "respirable" (10 micron or less) material. We are not talking about 60 vs. 0% decomposition for the nose and mouth respectively; it is probably something like 60 vs. 20-40% depending on particle size. Aqueous HCl (mist) would also follow similar laws of particle decomposition.

Alarie however, does not consider soot or mist, but gaseous HCl exposure only. He says that HCl gas deposition is high in the nasal mucosa. This is supported by the studies of Morris and Smith (1980) using HF. Alarie states that a correction factor is needed for mouth breathing but he does not provide any data for the buccal route of exposure to support this contention. Furthermore, he proposes to correct for this difference by tracheal cannulation. Such a manipulation is not appropriate for mouth breathing because it by-passes a significant portion of the alternate upper respiratory tract, namely the oral cavity, pharynx, and upper trachea (above the point of cannulation). By by-passing a major porition of the upper respiratory tract, Alarie has eliminated a significant part of the body's normal protective mechanism.

In the case of soluble gases such as HCl, surface area and moisture play an important role in deposition. More surface area and moisture will cause greater deposition. Although the surface area of the nasal cavity is greater than the oral cavity, this value may be somewhat misleading since the sinus cavities to some degree can be considered dead space (i.e. a limited amount of air movement).

Essentially what we are saying here is that when one considers "effective surface area", the differences are not as great. On the other hand, the moisture content, while high in both, is probably somewhat higher in the mouth. Taken together these two differences may serve to cancel each other out, or at least make any differences in deposition of HCl less significant.

Studies with primates are now being conducted to indicate that the rodent and human response to irritants is quite different. Until further comparative information on the effect of irritants in rodents and man is available, procedures such as the one proposed by Alarie are questionable.

REFERENCE

Hinderer, R.K. and O'Mara, M.M. (1982) Polyvinyl chloride combustion toxicity: a comparative review. Geon Vinyls, Technical Service Report, The BFGoodrich Company.

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ANTI-PVC/PLASTICS ALLEGATIONS

ALLEGATION NO. 50

PVC is a significant hazard, compared to other furnishing materials in a building.

RESPONSE

The term hazard has a special meaning in the area of fire testing. Historically much effort has been applied to the development of tests to measure smoke, flame spread, ignitability toxicity and other material fire properties. Hazard analysis involves making a determination of when a potential fire would become untenable considering all of the material fire performance characteristics and their interactions. Hazard analysis methods are still in the process of development, however an outline of th basic approach is as follows. Using heat, smoke and toxic gas release rate data, the growth of the potential fire is calculated. From this the amount of heat, smoke and toxic gases are calculate as a function of time. Human tolerance of heat, smoke and toxic gas is then considered to define the point in time where the fire situation would become intolerable. Although work in this area is just beginning, existing results indicate that heat is the major problem and that this heat is a result of the flashover stage of the fire. The amount of heat required is not great enough to caus burns, rather a type of incapacitation or collapse is induced. Once this happens, toxic gases can result in death.

Considering this, PVC would be a lesser hazard than many other materials because it resists flashover. PVC helps prevent the growth of a fire consequently reducing the chance that flashover will occur.

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ANTI-PVC/PLASTICS ALLEGATIONS

ALLEGATION No. 51

Smoke inhalation now causes more firefighters casualties.

RESPONSE

No adequate studies have been conducted to determine whether there are more occurrences of smoke inhalation in firefighters than previously. However, it is very unlikely that there has been any real increase, since firemen today are more aware of the hazards of combustion products and of the need to wear respirators. To some degree, this greater awareness today may lead to the false perception that conditions are worse.

RESPONSE ORIGINATOR -- CONTACT FOR SUPPLEMENTAL INFORMATION

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ANTI-PVC/PLASTICS ALLEGATION

ALLEGATION No. 52

Smoke is now more irritating to the respiratory tract.

RESPONSE

This is only the partial truth.

Like any organic material, natural or synthetic, PVC produces numerous combustion products. The most toxicologically important of these are carbon monoxide (CO), carbon dioxide (CO_2) and hydrogen chloride (HCl). (Boettner et al., 1969). CO and CO_2 are simple asphyxiants while HCl causes irritation or destruction of tissue. CO, CO_2, and/or HCl can cause death, either by asphyxiation or by pulmonary edema. These causes of death are not new or unusual and are known to result from combustion products of wood which contain CO and CO_2 and corrosive agents such as acrolein, formaldehyde, and other aldehydes (Zikria et al, 1972). Asphyxiation and pulmonary edema resulting in delayed deaths have been reported in fires long before the significant use of plastics (Mallory and Brinkley, 1943).

REFERENCES:

Boettner, E.A., Ball, G. and Weiss, B. (1969) Analysis of the volatile combustion products of vinyl plastics. J. Appl. Polymer Sci. 13:337-391.

Mallory, T.B. and Brinkley, W.J. (1943). Management of the Coconut Grove burns at the Mass. General Hospital: the problem of burn shock complicated by pulmonary damage. Ann. Surg. 117:865.

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ALLEGATION NO. 53

PVC smoke from electrical cables can kill in ten minutes.

RESPONSE

When one considers the breadth of the data, the combustion toxicity of PVC is generally comparable with many natural and synthetic materials. Furthermore, more recent attempts to extrapolate animal studies to man are theoretical and have never been validated.

Combustion toxicities comparing PVC with other materials have been reviewed by Hinderer and O'Mara (1982). World-wide studies by academia, government, and industry have shown that the combustion toxicity and hazard potential of PVC is not unique or extreme, but is similar to that of many other materials, including wood. In fact, the combustion products of many common materials can cause incapacitation or death in test animals faster, or by burning less material than PVC.

While rodents (mice and rats) have been used to study the combustion toxicity of materials, questions have remained as to how these responses relate to man. For some chemicals such as CO, the sensitivity/biological response appears to be close to that of man. However, for other chemicals such as the irritant gases (acrolein, HCl), there is little information relating rodent and human responses.

Another concern which has been raised is that mice and rats are obligate nasal breathers whereas man breathes through both his mouth and nose. Alarie (unpublished report) has theorized that since mice do not breathe through their mouth, surgical procedures (cannulation) should be used to by-pass the nasal cavity. This has been done by surgically inserting a tube in the trachea, allowing direct administration of combustion gases. By using this procedure Alarie has calculated that PVC is 70-80 times more toxic than wood.

Alarie has quite correctly recognized that mice do not breathe like humans. Namely, mice (and rats) are obligate nasal breathers. He is also accurate when he says that HCl is highly water soluble. However, his comparative analysis of the impact of nasal vs. buccal breathing of PVC decomposition products is questionable.

As you know, corrosive gases such as HCl (PVC) and acrolein, formaldehyde, etc. (wood) reach the respiratory passages via soot as a gas and, depending on the humidity, as aqueous HCl. The transport of these forms does provide some potential for biological variability.

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ALLEGATION NO. 53 - contd.

RESPONSE - contd.

In the case of soot, the degree of lower respiratory tract deposition does depend on particle size and on whether nasal or buccal breathing occurs. If we exposed two groups of humans to the same particle size distribution of soot, one by nasal exposure and the other by mouth breathing, we might expect to see greater deposition in the nasal cavity than in the mouth. Also, we might expect greater amounts in the trachea and large bronchi. However, we would not expect ly difference in the amount that reaches the lower respiratory tract since this is almost totally dependent on the amount of "respirable" (10 micron or less) material. We are not talking about 60 vs. 0% decomposition for the nose and mouth respectively; it is probably something like 60 vs. 20-40% depending on particle size. Aqueous HCl (mist) would also follow similar laws of particle decomposition.

Alarie however, does not consider soot or mist, but gaseous HCl exposure only. He says that HCl gas deposition is high in the nasal mucosa. This is supported by the studies of Morris and Smith (1980) using HF. Alarie states that a correction factor is needed for mouth breathing but he does not provide any data for the buccal route of exposure to support this contention. Furthermore, he proposes to correct for this difference by tracheal cannulation. Such a manipulation is not appropriate for mouth breathing because it by-passes a significant portion of the alternate upper respiratory tract, namely the oral cavity, pharynx, and upper trachea (above the point of cannulation). By by-passing a major porition of the upper respiratory tract, Alarie has eliminated a significant part of the body's normal protective mechanism.

In the case of soluble gases such as HCl, surface area and moisture play an important role in deposition. More surface area and moisture will cause greate deposition. Although the surface area of the nasal cavity is greater than the oral cavity, this value may be somewhat misleading since the sinus cavities to some degree can be considered dead space (i.e. a limited amount of air movement).

Essentially what we are saying here is that when one considers "effective surface area", the differences are not as great. On the other hand, the moisture content, while high in both, is probably somewhat higher in the mouth. Taken together these two differences may serve to cancel each other out, or at least make any differences in deposition of HCl less significant.

Studies with primates are now being conducted to indicate that the rodent and human response to irritants is quite different. Until further comparative information on the effect of irritants in rodents and man is available, procedures such as the one proposed by Alarie are questionable.

REFERENCE

Hinderer, R.K. and O'Mara, M.M. (1982) Polyvinyl chloride combustion toxicity: a comparative review. Geon Vinyls, Technical Service Report, The BFGoodrich Company.

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ANTI-PVC/PLASTICS ALLEGATIONS

ALLEGATION NO. 54

Smoldering and burning plastics are becoming a major contributor to fire deaths.

RESPONSE

There is no evidence that plastics are the major cause of fire deaths.

Carbon monoxide (CO), a common combustion product of all organic materials, is widely recognized as the major cause of incapacitation and death in fires (Birky et al, 1979 and Myers and Cowley, 1979). This understanding has been based not only on studies of fire victims, but also on the analyses of combustion products in fire environments. In 1979 researchers at Harvard, working with the Boston Fire Department, took 242 air samples from real fires and analyzed these for various combustion gases (Burgess et al, 1979). The primary conclusion of the report was that "carbon monoxide and acrolein were the most hazardous ingredients in these fires". HCl from PVC was not found to be a significant air contaminant. Although HCl was detected in about one-third of the samples, none of the values exceeded the short-term lethal concentration. More recent studies conducted by Southwest Research Institute with the San Antonio Fire Department also provided testimony to the importance of CO (Grand et al, 1981). No evidence was found that would support the contention that the cause of fire deaths is any different today than prior to the large-scale use of plastics.

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Birky, M.M., Halpin, B.M., Caplan, Y.H., Fisher, R.S., McAllister, J.N., and Dixon, A.M. (1979) Fire Fatality, Fire and Materials 3:211-217.

Burgess, W.A., Treitman, R.D. and Gold, A. (1979) Air contaminants in structural firefighting. Harvard School of Public Health.

Grand, A.F., Kaplan, H.L., Lee, G.H. Investigation of Combustion Atmospheres in Real Building Fires. Southwest Research Institute, submitted to: The Society of the Plastics Industry, Inc. and the U.S. Fire Administration, May 1981.

Myers, RAM and Cowley, R.A. (1979) Carbon monoxide poisoning and its treatment. J. Comb. Toxicol. 6:87-90.

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ANTI-PVC/PLASTICS ALLEGATIONS

ALLEGATION NO. 55

Toxic gases from burning plastics collect in the lungs and cause edema, filling the lung with fluids, causing death by dry-land drowning.

RESPONSE

This is only part of the story. Like any organic material, natural or synthetic, PVC produces numerous combustion products. The most toxicologically important of these are carbon monoxide (CO), carbon dioxide (CO_2), and hydrogen chloride (HCl). (Boettner et al, 1969). CO and CO_2 are simple asphyxiants while HCl causes irritation or destruction of tissue. CO, CO_2, and/or HCl can cause death, either by asphyxiation or by pulmonary edema. These causes of death are not new or unusual and are known to result from combustion products of wood wich contain CO and CO_2 and corrosive agents such as acrolein, formaldehyde and other aldehydes (Zikria et al, 1972). Asphyxiation and pulmonary edema, resulting in delayed deaths, has been reported in fires long before the significant use of plastics (Mallory and Brinkley, 1943).

Because of the concern about the potential release of HCl from PVC in real fires, researchers at the Harvard School of Public Health, working with the Boston Fire Department, took 242 air samples from real fires and analyzed these for various combustion gases. The primary conclusion of this study was that "carbon monoxide and acrolein were the most hazardous ingredients in these fires". HCl from PVC was not found in 64% of the samples and none exceeded the short-term lethal concentration.

REFERENCES

Boettner, E.A., Ball, G. and Weiss, B. (1969) Analysis of the volatile combustion products of vinyl plastics. J. Appl. Polymer Sci. 13:337-391.

Mallory, T.B. and Brinkley, W.J. (1943) Management of the Coconut Grove burns at the Mass. General Hospital; the problem of burn shock complicated by pulmonary damage. Ann. Surg. 117:865

Zikria, B.A., Ferrer, J.N. and Flock, H.F. (1972) The chemical factors contributing to pulmonary damage in "smoke poisoning". Surgery, 71:704-709.

Burgess, W.A., Treitman, R.D. and Gold, A. (1979) Air contaminants in structural firefighting. Harvard School of Public Health.

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ANTI-PVC/PLASTICS ALLEGATIONS

ALLEGATION NO. 56

The presence of antimony and heavy metals in the lungs of victims implicates PVC combustion products as the cause of death.

RESPONSE

Although organo-metallic compounds are used in the compounding of PVC, heavy metals are commonly found in many building materials. Therefore, the presence of heavy metals are neither evidence that PVC caused the fatality, nor that PVC was even present.

Note: Examples of other sources of heavy metals may be useful.

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ANTI-PVC/PLASTICS ALLEGATIONS

ALLEGATION NO. 57

People die in fires with very low carboxyhemoglobin, indicating an unknown toxicant is killing them.

RESPONSE

Low carboxyhemoglobin values alone are not evidence that HCN and/or HCl were involved in fire deaths.

When any organic material, natural or synthetic, burns it releases carbon monoxide (CO) which will combine with hemoglobin in the blood. Carboxyhemoglobin (COHb) levels of 50-60% are usually fatal. Therefore, some people believe that since 50% COHb will kill you, any fatalities with COHb levels less than 50% must be the result of other toxicants such as HCN or HCl.

While such deductions may seem logical, Myers and Cowley (1979) report that some people may have severe CO poisoning and still have low COHb levels. The most important factor is how much CO has diffused into the tissues. Low COHb levels alone can be very misleading. Reports by the Consumer Product Safety Commission of space heater victims confirm this and show that deaths occur even when COHb levels are very low. Both of these reports emphasize the important role played by alcohol and existing myocardial damage in some CO poisoning. Furthermore, low O_2 levels occurring in a fire may also potentiate the toxicity of CO.

REFERENCES

Myers, RAM and Cowley, R.A. (1979) Carbon monoxide poisoning and its treatment. J. Comb. Toxicol. 6:87-90

U.S. Consumer Report Safety Commission, U.S. Government Memorandum, Unvented Gas Space Heater Related Deaths. From E.A. Tyrrell and D.A. Kale to S. Morrow, Feb. 1, 1979.

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ANTI-PVC/PLASTICS ALLEGATIONS

ALLEGATION NO. 58

PVC is 70-100 times more toxic than wood.

RESPONSE

When one considers the breadth of the data, the combustion toxicity of PVC is generally comparable with many natural and synthetic materials. Furthermore, more recent attempts to extrapolate animal studies to man are theoretical and have never been validated.

Combustion toxicities comparing PVC with other materials have been reviewed by Hinderer and O'Mara (1982). World-wide studies by academia, government, and industry have shown that the combustion toxicity and hazard potential of PVC is not unique or extreme, but is similar to that of many other materials, including wood. In fact, the combustion products of many common materials can cause incapacitation or death in test animals faster, or by burning less material than PVC.

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As you know, corrosive gases such as HCl (PVC) and acrolein, formaldehyde, etc. (wood) reach the respiratory passages via soot as a gas and, depending on the humidity, as aqueous HCl. The transport of these forms does provide some potential for biological variability.

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ALLEGATION NO. 58 - contd.

RESPONSE - contd.

In the case of soot, the degree of lower respiratory tract deposition does depend on particle size and on whether nasal or buccal breathing occurs. If we exposed two groups of humans to the same particle size distribution of soot, one by nasal exposure and the other by mouth breathing, we might expect to see greater deposition in the nasal cavity than in the mouth. Also, we might expect greater amounts in the trachea and large bronchi. However, we would not expect difference in the amount that reaches the lower respiratory tract since this is almost totally dependent on the amount of "respirable" (10 micron or less) material. We are not talking about 60 vs. 0% decomposition for the nose and mouth respectively; it is probably something like 60 vs. 20-40% depending on particle size. Aqueous HCl (mist) would also follow similar laws of particle decomposition.

Alarie however, does not consider soot or mist, but gaseous HCl exposure only. He says that HCl gas deposition is high in the nasal mucosa. This is supported by the studies of Morris and Smith (1980) using HF. Alarie states that a correction factor is needed for mouth breathing but he does not provide any data for the buccal route of exposure to support this contention. Furthermore, he proposes to correct for this difference by tracheal cannulation. Such a manipulation is not appropriate for mouth breathing because it by-passes a significant portion of the alternate upper respiratory tract, namely the oral cavity, pharynx, and upper trachea (above the point of cannulation). By by-passing a major porition of the upper respiratory tract, Alarie has eliminated a significant part of the body's normal protective mechanism.

In the case of soluble gases such as HCl, surface area and moisture play an important role in deposition. More surface area and moisture will cause greater deposition. Although the surface area of the nasal cavity is greater than the oral cavity, this value may be somewhat misleading since the sinus cavities to some degree can be considered dead space (i.e. a limited amount of air movement).

Essentially what we are saying here is that when one considers "effective surface area", the differences are not as great. On the other hand, the moisture content while high in both, is probably somewhat higher in the mouth. Taken together these two differences may serve to cancel each other out, or at least make any differences in deposition of HCl less significant.

Studies with primates are now being conducted to indicate that the rodent and human response to irritants is quite different. Until further comparative information on the effect of irritants in rodents and man is available, procedures such as the one proposed by Alarie are questionable.

REFERENCE

Hinderer, R.K. and O'Mara, M.M. (1982) Polyvinyl chloride combustion toxicity: a comparative review. Geon Vinyls, Technical Service Report, The BFGoodrich Company.

RESPONSE ORIGINATOR -- CONTACT FOR SUPPLEMENTAL INFORMATION

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ANTI-PVC/PLASTICS ALLEGATIONS

ALLEGATION NO. 59

CO accounts for no more than 50% of the fire deaths.

RESPONSE

Low carboxyhemoglobin values alone are not evidence that HCN and/or HCl were involved in fire deaths.

When any organic material, natural or synthetic, burns it releases carbon monoxide (CO) which will combine with hemoglobin in the blood. Carboxyhemoglobin (COHb) levels of 50-60% are usually fatal. Therefore, some people believe that since 50% COHb will kill you, any fatalities with COHb levels less than 50% must be the result of other toxicants such as HCN or HCl.

While such deductions may seem logical, Myers and Cowley (1979) report that some people may have severe CO poisoning and still have low COHb levels. The most important factor is how much CO has diffused into the tissues. Low COHb levels alone can be very misleading. Reports by the Consumer Product Safety Commission of space heater victims confirm this and show that deaths occur even when COHb levels are very low. Both of these reports emphasize the important role played by alcohol and existing myocardial damage in some CO poisoning. Furthermore, low O_2 levels occurring in a fire may also potentiate the toxicity of CO.

REFERENCES

Myers, RAM and Cowley, R.A. (1979) Carbon monoxide poisoning and its treatment. J. Comb. Toxicol. 6:87-90

U.S. Consumer Report Safety Commission, U.S. Government Memorandum, Unvented Gas Space Heater Related Deaths. From E.A. Tyrrell and D.A. Kale to S. Morrow, Feb. 1, 1979.

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ANTI-PVC/PLASTICS ALLEGATIONS

ALLEGATION NO. 60

In the last 30 years, use of plastics in buildings has increased, and more and more firefighters have died in cancer, presumably from inhaling fumes when they burn.

RESPONSE

Fumes from PVC are not any more hazardous than those from natural products, such as wood, and may in fact be less hazardous.

Cancer which occurs from exposure to chemicals is generally believed to result from repeated exposure over many years. Since threshold or no effect doses are difficult to determine, even low levels are considered to have some finite risk. In animal studies which are used to detect potential human carcinogens, animals are exposed to high doses for nearly their lifetime, and the data is used to predict the potenti cancer risk of a given exposure level (i.e. the dose that could result in one cancer case in populations of 100,000 or in 1,000,000 people).

When any organic material (natural or synthetic) undergoes thermal decomposition, a large number of chemicals are produced. Table I compares the thermal decomposition of wood and PVC and identifies those which are suspect as known carcinogens. Both wood and PVC produce simple asphyxiants (carbon monoxide and carbon dioxide, irritan such as acrolein, various aldehydes or hydrogen chloride, and trace or minor product i.e. benzene, etc.). As can be seen in Table I, many of the chemicals produced by the thermal decomposition of wood are suspect or known to cause cancer. More recent studies by Albert et al (1982) show that formaldehyde was carcinogenic in rats but that there was no evidence of a carcinogenic effect with hydrogen chloride.

Although the levels of carcinogens produced by wood (except possibly formaldehyde) are very small, there is probably some finite risk for anyone that would be exposed repeatedly for their lifetime. However, because the levels are so small and because exposures to the general public are not frequent or nil for those who never experien a fire, the actual risk is so low that it is virtually non-existent. Furthermore, even for firemen, whose exposures are more frequent, the risk posed by these trace chemicals is probably low. In any event, the data in Table I indicates that any carcinogenic hazard from PVC decomposition is not any greater than from wood, in fac PVC is probably less hazardous.

REFERENCES

Albert, R.E., Sellakumar, A.R., Laskin, S., Kuschner, M., Nelson, N. and Snyder, C.A. (1982) Gaseous formaldehyde and hydrogen chloride induction of nasal cancer in the rat. J. Nat'l. Cancer Inst. 68(4):597-603.

Wooley, W.D. and Fardell, P.J. (1982) Basic aspects of combustion toxicology. Fire Safety J. 5:29-48.

Lee, H.L., Prado, G.P., Howard, J.B., and Hites, R.A. (1977) Source identification of urban airborne polycyclic aromatic hydrocarbon by gas chromatographic mass spectrometry and high resolution mass spectrometry. Biomed. Mass. Spectrom. 4:182-186

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ALLEGATION NO. 60 - contd.

REFERENCES - contd.

Cooper, J.A. (1980) Environmental impact of residential wood combustion emission and its implications. J. Air Pollut. Contr. Assn. 30(8):855-861.

Hall, R.E. and Angelis, D.G. (1980) EPA's research program for controlling residential wood combustion emissions. J. Air Pollut. Control Assn. 30(8):863-86

SUPPORTING ATTACHMENT

Table I, "Comparison of the Carcinogenic Potential of the Thermal Decomposition Products of Wood and PVC"

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Dr. Robert K. Hinderer
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Table I. Comparison of the carcinogenic potential of the thermal decomposition products of

Wood[a]		PVC[b]
Combustion Product	Carcinogenic Potential	Combustion Product
Carbon monoxide	No	Carbon monoxide
Carbon dioxide	No	Carbon dioxide
Acrolein	?	Hydrogen chloride
Formadehyde	Yes	Benzene
Acetaldehyde	?	Methane
Butylraldehyde	?	Ethylene
Benzene	Yes	Ethane
Dimethylbenzanthracene	Yes	Propylene
Benz(a)anthracene	Yes	Propane
Dibenzanthracene	Yes	Vinyl chloride[c]
Benzophenanthrene	Yes	1-Butene
Benzofluoroanthene	Yes	Butane
3-methylcholanthene	Yes	Isopentane
Benzopyrene	Yes	1-pentene
Idenopyrene	Yes	Pentane
Dibenzopyrene	Yes	Cyclopentene
Dibenzocarbazole	Yes	Cyclopentane
Dioxins	?	1-Hexene
Chrysene	?	Hexane
Methane	No	Methylcyclopentane
Toluene	No	Toluene

[a]Only a partial listing (Cooper 1980; Hall and Deangelis, 1980; Lee et al, 1977; Wooley an

[b]Boettner et al, 1969

[c]Probably due to residual levels of monomer.

ALLEGATION NO. 61

PVC was a contributing factor at the MGM Grand fire.

RESPONSE

The responsibility for responding to this allegation did not rest with the Vinyl Institute, the Society of Plastics Industry, or with any organization remotely connected to the plastics industry because the response was already a matter of record. In November, 1982, the National Fire Protection Agency issued its final report on the MGM Grand Hotel fire. "The cause of the fire was a short circuit in the hotel's metal conduit."[2] The primary cause of death for 79 of 85 victims was smoke inhalation alone or combined with carbon monoxide. Accounting for the remaining six:

- 3 deaths were attributed to smoke inhalation plus burns.
- 1 died of extensive bodily burns.
- a fractured skull killed one.
- heart failure was responsible for the last.[1]

Fortune magazine (February, 1983) reiterated that the "final report on the MGM Hotel fire never mentioned synthetic materials - plastic pipe or whatever - as the primary cause of any death."[2]

Those responses are specific enough to satify the most scrutinizing, critical intelligence.

REFERENCES

(1) National Fire Protection Association, Final Report, MGM Grand Hotel Fire, November, 1982.

(2) Fortune, "The Dubious War on Plastic Pipe", Flax, Steven, February 7, 1983.

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Staff Technical Services
Avon Lake Technical Center

ANTI-PVC/PLASTICS ALLEGATIONS

ALLEGATION NO. 62

PVC pipe helped spread the fire at MGM.

RESPONSE

That's pretty harsh criticism against something that wasn't there. The Clark County Fire Department's official report of the MGM Grand Hotel fire clearly states that the permanent plumbing in the MGM Grand Hotel was metal - not PVC.[1,2] Thus, PVC can't contribute to or surpress any fire - it can't help and it can't hurt - when it isn't there.

REFERENCES

(1) Clark County Fire Department, Final Report on the MGM Grand Hotel Fire.

(2) Plastics Technology, "Regulatory Update", May, 1982, p. 180.

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ANTI-PVC/PLASTICS ALLEGATIONS

ALLEGATION NO. 63

PVC cooked in the false ceiling at Beverly Hills without visible flame, forming a dense smoke.

RESPONSE

Separating "smoke" from a capacity crowd of cigarette, cigar, and pipe puffing patrons from "smoke" from a smoldering ceiling fire could be extremely difficult - unless that smoke was HCl (from PVC) as is claimed.

If PVC is maintained at a temperature of about 400°F (roughly twice the boiling point of water), it gradually decomposes. The first product to evolve, hydrogen chloride, is also the most abundant. Exposure to HCl is irritating - causing coughing and tearing[1] - but most important - it evokes an unmistakable urge to remove oneself from the area. Therefore, we contend that had the Beverly Hills patrons been exposed to even low concentrations of HCl, they would have reacted instinctively, left the area, and would have lived to tell it.

REFERENCES

(1) Noxious Gases - 2nd Ed. N.Y. Reinhold - 1943, pg. 126-127 - Henderson, Y. and Haggard, H. W.

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ALLEGATION NO. 64

Beverly Hills victims showed upper respiratory tract damage from HCl bound to soot. Carboxyhemoglobin levels in all but one victim were below the lethal level; one was 10%.

RESPONSE

As a result of similiar accusations, PVC's fire performance has received thorough investigations by impartial academic and government agencies.

"According to Jack Snell, director of the Center for Fire Research at the National Bureau of Standards, PVC conduit would probably be among the least of the worries in most fires. 'Plastics would not create a significant additional hazard to life."[1]

Also, Dr. Edward Radford of the University of Pittsburgh's Graduate School of Public Health says, "there is no evidence that PVC plays a major role in whether an individual dies in a fire."[1]

REFERENCES

(1) *Fortune*, "The Dubious War on Plastic Pipe", Flax, Steven, February 7, 1983.

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ALLEGATION NO. 65

Long term effects of PVC fumes on those involved at Beverly Hills shown by study to include those on respiratory tract, circulatory, epidermal epithelial, neurol, ears, eyes, and excretory systems.

RESPONSE

This statement - and others - located within the body of a study conducted by Deborah Wallace, Ph.D. (Physiological ecology), precipitated a thorough investigation by the National Institute for Occupational Safety and Health. "NIOSH" has the awesome responsibility of protecting the nations populus against unusual or exceptional safety hazards. NIOSH's harsh criticism of this study - compounded by those of F. P Cleveland, M.D., were sufficient to make a true scientist turn in his lab coat. Both criticisms follow: The National Institute for Occupational Safety and Health said that Dr. Wallace's study suffered "major methodological deficiencies...was not epidemilogically sound and the conclusions could not be supported by the data."

> ..."these articles are totally inadequate case reports. The failure of the author to follow basic principles of epidemilogy in obtaining and reporting these data makes it impossible to draw conclusions about possible etiological agents.
>
> ...the author fails to consider or possibly to understand that the combustion gases in real world fires are complex mixtures. Thus, the surveys do not have the capability to differentiate potential effects of PVC from those of a multitude of other materials consumed in a fire - or even to determine whether the effects were the result of the fire."[1]

REFERENCES

(1) "A Critique of Two Papers on Dangers of Polyvinyl Chloride Wire Insulation Decomposition", Cleveland, F. P., M.D., *Journal of Combustion Toxicology*, Vol. 9 (August, 1982), p. 115.

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Avon Lake Technical Center

ANTI-PVC/PLASTICS ALLEGATIONS

ALLEGATION NO. 66

HCl and HCN contributed to most, if not all of the West Chase Hilton deaths.

RESPONSE

Merritt Birky (Ph.D., Toxicology) who investigated that fire for the National Bureau of Standards, disputes this claim. According to him, "Plastic conduit plays little role in an ordinary hotel fire. It is unlikely that plastic conduit played any role in, for example, the fire at the Westchase Hilton in Houston."(1)

REFERENCES

(1) *Fortune*, "The Dubious War on Plastic Pipe", Flax, Steven, February 7, 1983.

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ANTI-PVC/PLASTICS ALLEGATIONS

ALLEGATION NO. 67

Plastic piping is a hazard to the populace at large, and the cause of concern to plumbers and pipefitters in particular.

RESPONSE

Numerous allegations have been made that plumbers who install plastic pipe and consumers who drink the water which flows through it are at risk of disease, particularly cancer, from the solvents which are used in the pipe. These allegations come largely as anecdotal reports from plumbers and limited surveys of plumbers which are inadequate to support the allegations.

Several studies by NIOSH have shown that plumbers engaged in installing plastic pipe have small exposures to solvents when compared with the accepted threshold limit values. While there is much analytical data to show that appreciable amounts of solvents may leach from a new plastic pipe installation, ordinary flushing quickly reduces the concentration of these materials to insignificant levels.

The safety of plastic plumbing, in contrast to the allegations, is well summarized in the "Final Report on Potential Health Hazards Associated with the use of Plastic Pipe in Potable Water Systems" published by the California Department of Industrial Relations. This report states that:

1. "Adverse worker health effects from the major solvents found in cements and primers are unlikely based on their relatively low toxicity and field measurements of exposures under a range of working conditions", and

2. "Based on the present study, when properly installed and flushed, plastic pipe systems do not appear to pose a health hazard under normal usage conditions."

RESPONSE ORIGINATOR — CONTACT FOR SUPPLEMENTAL INFORMATION

Dr. Robert K. Hinderer
Corporate Environmental Health Department

ALLEGATION NO. 68

Plumbers who work with plastic pipe have weird symptoms and serious diseases, including a high incidence of cancer and weaknesses of the central nervous system.

RESPONSE

Numerous allegations have been made that plumbers who install plastic pipe and consumers who drink the water which flows through it are at risk of disease, particularly cancer, from the solvents which are used in the pipe. These allegations come largely as anecdotal reports from plumbers and limited surveys of plumbers which are inadequate to support the allegations.

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Corporate Environmental Health Department

ANTI-PVC/PLASTICS ALLEGATIONS

ALLEGATION NO. 69

The solvent used to glue plastic pipe, as well as the plastic pipes themselves leach hazardous chemicals into the water supply, as shown by the Montgomery report.

RESPONSE

Numerous allegations have been made that plumbers who install plastic pipe and consumers who drink the water which flows through it are at risk of disease, particularly cancer, from the solvents which are used in the pipe. These allegations come largely as anecdotal reports from plumbers and limited surveys of plumbers which are inadequate to support the allegations.

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ANTI-PVC/PLASTICS ALLEGATIONS

ALLEGATION NO. 70

Solvents used in installing plastic pipe represent a hazard to installers, and may cause lymph-gland cancer.

RESPONSE

Numerous allegations have been made that plumbers who install plastic pipe and consumers who drink the water which flows through it are at risk of disease, particularly cancer, from the solvents which are used in the pipe. These allegations come largely as anecdotal reports from plumbers and limited surveys of plumbers which are inadequate to support the allegations.

Several studies by NIOSH have shown that plumbers engaged in installing plastic pipe have small exposures to solvents when compared with the accepted threshold limit values. While there is much analytical data to show that appreciable amounts of solvents may leach from a new plastic pipe installation, ordinary flushing quickly reduces the concentration of these materials to insignificant levels.

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ANTI-PVC/PLASTICS ALLEGATIONS

ALLEGATION NO. 71

Cancer causing agents migrate from plastic pipe into drinking water.

RESPONSE

Numerous allegations have been made that plumbers who install plastic pipe and consumers who drink the water which flows through it are at risk of disease, particularly cancer, from the solvents which are used in the pipe. These allegations come largely as anecdotal reports from plumbers and limited surveys of plumbers which are inadequate to support the allegations.

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2. "Based on the present study, when properly installed and flushed, plastic pipe systems do not appear to pose a health hazard under normal usage conditions."

RESPONSE ORIGINATOR — CONTACT FOR SUPPLEMENTAL INFORMATION

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ANTI-PVC/PLASTICS ALLEGATIONS

ALLEGATION NO. 72

Tests have shown carcinogens in drinking water taken from plastic pipes.

RESPONSE

Numerous allegations have been made that plumbers who install plastic pipe and consumers who drink the water which flows through it are at risk of disease, particularly cancer, from the solvents which are used in the pipe. These allegations come largely as anecdotal reports from plumbers and limited surveys of plumbers which are inadequate to support the allegations.

Several studies by NIOSH have shown that plumbers engaged in installing plastic pipe have small exposures to solvents when compared with the accepted threshold limit values. While there is much analytical data to show that appreciable amounts of solvents may leach from a new plastic pipe installation, ordinary flushing quickly reduces the concentration of these materials to insignificant levels.

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Corporate Environmental Health Department

ANTI-PVC/PLASTICS ALLEGATIONS

ALLEGATION NO. 73

Flammable plastic pipe acts as a fuse during a fire.

RESPONSE

PVC pipe will not act as a fuse in a fire. However ABS pipe might tend to perform in this way. The oxygen index of ABS is about 18-19 which means it will burn in air while the oxygen index of PVC is about 40-50 which means it will not.

RESPONSE ORIGINATOR -- CONTACT FOR SUPPLEMENTAL INFORMATION

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Flammability Group
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ANTI-PVC/PLASTICS ALLEGATIONS

ALLEGATION No. 74

Plastic pipe systems have failed to satisfy minimum safety requirements in every government fire test involving plastic pipe in standard fire walls. NBS 1970-1975 wall test program cited.

RESPONSE

This statement can be interpreted several ways inasmuch as it states "Plastic pipe systems had failed to satisfy minimum requirements in every government fire test ---". If the intent was to say that all plastic pipe systems had failed, then the generality is most assuredly false. As we read from a 1975 NBS report entitled "Fire Endurance of Gypsum Boardwall and Chases Containing Plastic and Metallic DWV Plumbing Systems", we find that this report contains a number of references which make this statement untrue. For example, Table I on page 5 of the report shows that in 23 of the tests, time to failure was greater than 60 minutes which was the required time for particular wall construction being tested. On this basis, we can hardly see how the intent of how this author intended to say all plastic pipe systems failed.

If we interpret the statement to mean that some of the systems failed, then we would have to concur. And this would be expected since the investigation and experiment here was to determine what techniques of installation resulted in satisfactory performance. Obviously, if one tests only systems that are successful, one would not learn what techniques are unsuccessful. In conclusion we would have to point out that the summary section of this report (page 20) includes such statements as "The PVC DWV systems with 4" stacks and 1-1/2" laterals in a 20" X 20" chase met the criteria for 60 minutes fire endurance". In addition we find in Section 5.2 the statement, "The one hour fire rated walls containing ABS and PVC with back-to-back laterals with the stack met the 60 minute criteria when all of the following conditions were satisfied:

1. The annular openings around the laterals were sealed.
2. The wall cavity depth was 5-1/2 in or more.
3. The stack was limited to 2- or 3-in diameter. A 4-in diameter PVC stack in a 9-1/2-in deep wall cavity also met the criteria when the annual opening around the lateral was sealed."

Therefore, we believe the totality of the report indicates this statement is grossly incorrect.

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ALLEGATION NO. 74 - contd.

SUPPORTING ATTACHMENT

National Bureau of Standards, Institute for Applied Technology, Center for Fire Research, W. J. Parker, M. Paabo, J. T. Scott, D. Gross and I. A. Benjamin, Fire Endurance of Gypsum Board Walls and Chases Containing Plastic and Metallic Drain, Waste and Vent Plumbing Systems, Washington, DC, Sept., 1975

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Mr. Robert C. Wilging
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Table 1. Construction Details and Summary of Test Results

Test No.	Construction Details	Stack Materials	Lateral Materials	Wall Penetration	Time to Failure (Minutes): Flame-through	Time to Failure (Minutes): Surface Temp. Rise (181 °C)	Time to Failure (Minutes): Heavy Smoke
1-1	20" X 20" Chases of 2" X	4" PVC	1-1/2" PVC	Sealed	> 60[a]	> 60[a]	> 60[a]
1-2	4" Wood Studs Covered with	4" PVC	1-1/2" PVC/Steel Sleeve	Sealed	> 60[a]	> 60[a]	> 60[a]
1-3	5/8" Type X Gypsum Board	4" PVC	1-1/2" Galvanized Iron[b]	Sealed	> 60[a]	> 60[a]	> 60[a]
1-4	Both Inside and Outside	None	None	None	> 60[a]	> 60[a]	> 60[a]
2-1	Same as for Test No. 1	4" PVC	1-1/2" PVC	Sealed	> 60[a]	> 60[a]	> 60[a]
2-2	Except 5/8" Gypsum Board	4" PVC	1-1/2" PVC/Steel Sleeve	Sealed	> 60[a]	> 60[a]	> 60[a]
2-3	Not on Inside of Chases	4" Cast Iron, Hubless	1-1/2" PVC	Sealed	> 60[a]	> 60[a]	> 60[a]
2-4		4" Cast Iron, Hubless	1-1/2" Galvanized Iron	Sealed	> 60[a]	> 60[a]	> 60[a]
3-1	2" X 4" Wood Stud Wall	2" PVC	1-1/2" PVC	Sealed	> 60[a]	> 51	> 60[a]
3-2	16" on Centers with 5/8"	2" Copper	1-1/2" Copper	Sealed	> 60[a]	> 60[a]	> 60[a]
3-3	Gypsum Board on each Face[c]	2" ABS	1-1/2" ABS	Sealed	42	48	45
3-4	(3-1/2" Cavity)	2" Galvanized Iron	1-1/2" Galvanized Iron	Sealed	> 60[a]	> 60[a]	> 60[a]
4-1	2" X 6" Wood Stud Wall	2" PVC	1-1/2" PVC	Sealed	> 60	> 60	> 60
4-2	16" on Centers with 5/8"	2" Copper	1-1/2" Copper	Sealed	> 60	> 60	> 60
4-3	Gypsum Board on each Face	2" ABS	1-1/2" ABS	Sealed	> 60	> 60	> 60
4-4	(5-1/2" Cavity)	2" Galvanized Iron	1-1/2" Galvanized Iron	Sealed	> 60	> 60	> 60
5-1	Wood Stud Wall Formed with	4" PVC[d]	1-1/2" PVC	Sealed	55	55	42
5-2	Double Row of 2" X 4" Studs	4" Copper	1-1/2" Copper	Sealed	> 60	> 60	> 60
5-3	On 10" Plate. See fig. 15	4" ABS[d]	1-1/2" ABS	Sealed	27	—	23
5-4	(9-1/2" Cavity)	4" Cast Iron, Hubless	1-1/2" Galvanized Iron	Sealed	> 60	> 60	> 60
6-1	2" X 4" Steel Stud Wall	2" ABS	1-1/2" ABS	Sealed	28	—	—
6-2	16" on Centers See fig. 16	2" ABS	1-1/2" ABS	Not Sealed[f]	19	—	—
6-3	Gypsum Board on each Face	2" ABS[e]	1-1/2" ABS	Sealed	25	—	25
6-4	(3-1/2" Cavity)	2" PVC	1-1/2" PVC	Sealed	56	51	40
7-1	2" X 6" Wood Stud Wall	3" ABS	1-1/2" ABS	Sealed	> 60	> 60	> 60
7-2	16" on Centers, See fig. 17	2" ABS	1-1/2" ABS	Not Sealed[f]	29(27)[j]	—	—
7-3	Gypsum Board on each Face	3" PVC	1-1/2" PVC	Sealed	> 60	60	> 60
7-4	(5-1/2" Cavity)	2" PVC	1-1/2" PVC	Not Sealed[f]	30(28)[j]	—	—
8-1	Construction of Wall is	4" ABS	1-1/2" ABS	Sealed	44	—	17
8-2	Similar to that of Test 5	4" PVC	1-1/2" PVC	Sealed	> 60	> 60	> 60
8-3	(9-1/2" Cavity)	4" ABS	2" ABS	Sealed	> 60	> 60	> 60
8-4		4" PVC	2" PVC	Sealed	> 60	> 60	> 60
9-1	Construction of Wall is	2" Copper	1-1/2" Copper	Not Sealed[g]	> 60	> 60	> 60
9-2	Similar to that of Tests	2" PVC	1-1/2" PVC[h]	Not Sealed[g]	> 60	> 60	34
9-3	4 and 7	2" ABS	1-1/2" ABS[h]	Not Sealed[g]	> 60	> 60	34
9-4	(5-1/2" Cavity)	2" ABS	1-1/2" ABS[i]	Not Sealed[g]	21	—	5
10-1	Construction is Similar	2" ABS	1-1/2" ABS	Sealed	23	—	—
10-2	To that of Test 6, with	2" PVC	1-1/2" PVC	Sealed	55	60	—
10-3	Glass Fiber Insulation	2" ABS	1-1/2" ABS	Not Sealed[g]	22	—	9
10-4	(3-1/2" Cavity)	2" PVC	1-1/2" PVC	Not Sealed[g]	16	—	—

[a] Estimated. Gas off at 45 min (Test 1), 50 min (Test 2), and 56 min (Test 3).

[b] With a drop in elevation before joining a double upright wye on the stack.

[c] Holes in gypsum board for hub of a 2" X 1-1/2" reducing sanitary tee.

[d] Hub of 4" double sanitary tee penetrates gypsum wall board.

[e] Stack bottom closed. [f] 1/2 " oversized hole. [g] 1" oversized hole. [h] Lateral offset from stack but located in same stud space.

[i] Lateral offset from stack but located in adjacent stud space. [j] Corrected (and uncorrected) time to failure due to slight departure from standard exposure.

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To the extent a comparison could be made, the CO levels were about an order of magnitude higher than HCl levels in the cavities containing PVC piping. Since the level of CO present in the other cavities due to the burning of the wood studs was of the same order of magnitude, the burning of the PVC only added to the potential toxic gas hazard already in existence. The additional hazard should be considered in terms of the protected location of the pipe, and the confinement of the pyrolysis products during burning.

4.3. DWV in Steel-Stud Walls

Two full-scale fire tests were performed to examine the effect of plastic DWV systems on the fire endurance of a wall constructed with 2 x 4 steel studs. Two of the variables studied were the effects of sealed versus unsealed penetrations for the laterals coming through the wall and the effect of adding insulation batting to the stud spaces which was done in the Test 10.

Test 6 had three ABS and one PVC DWV installations. In ABS cavity No. 1, the fire penetrated the steel-stud wall at 28 minutes, which is earlier than a comparable wood-stud wall (42 minutes: Test 3). Flame-through occurred at 19 minutes in ABS cavity No. 2 which had the unsealed penetrations around the laterals. Although the ABS stack in cavity No. 3 was capped at the bottom to minimize the airflow, no significant difference in the failure time between cavity No. 1 and cavity No. 3 was observed. An unexposed-surface temperature-rise failure was recorded at 51 minutes on the PVC installation. Additionally, flame-through at the lower PVC lateral occurred at 56 minutes.

In Test 10 glass fiber batt insulation was installed in the stud spaces. One ABS and one PVC DWV installation were left unsealed, while two comparable installations were sealed. There was only a 3minute differential between the failure times for the unsealed (22 min) and sealed (25 min) penetrations for the two ABS installations. The results of Test 10 correlated with Test 6 wherein the failure due to flame-through occurred at the same time (25 min) for the ABS DWV installation with the bottom of the stack sealed off. Comparing the PVC DWV installations, there was a significant time differential in the failure time as a result of the unsealed penetration (16 vs 55 min). With the sealed penetration, the test results correlated well with Test 6 with only a one-minute difference in the failure times (55 vs 56 min). No improvement in the wall performance was measurable as a result of adding the insulation, as failure times of the wall due to flame-through correlated with the previous test on a wall without insulation.

The indicated gas concentrations reported for Test 6 (also other tests) may not be representative of actual gas concentrations in the wall cavities because of measurement difficulties as mentioned earlier. The HCl and HCN values obtained with colorimetric indicator tubes are to be considered semi-quantitative only, since the high temperatures within the wall cavities exceeded the prescribed operating temperature limits for the indicator tubes.

Based on the tests described, involving DWV plumbing systems in fire-rated chases and wall assemblies, a suggested test procedure and set of acceptance criteria with respect to fire spread are given in appendix B.

5. SUMMARY

The following observations were drawn from the series of 10 full-scale fire tests involving 39 piping assemblies within wall cavities and pipe chases. These observations are based on the performance of the iron, copper, ABS and PVC drain, waste and vent pipe in both walls and chases using the plumbing configuration and construction details described in this report. The observations are predicated on three failure criteria which were established for the purpose of this research: flames coming through the wall; excessive temperature rise at selected locations on the unexposed wall surface; or heavy smoke coming through the wall prior to a one-hour exposure time for the test. It should be emphasized that these were research tests rather than rating tests.

5.1. The PVC DWV systems with 4-inch stacks and 1-1/2-inch laterals in 20-inch by 20-inch chases met the criteria for 60 minutes fire endurance (see Tests 1-1 and 2-1). The annular openings around the laterals were sealed for these tests. Although not tested, it appears likely that a similar ABS installation would also meet the criteria.

5.2. The one-hour fire-rated walls containing ABS and PVC pipe with back-to-back laterals in line with the stack met the 60-minute criteria when all of the following conditions were satisfied:

3. Smoke and gaseous combustion products from the burning room could enter the chase or wall cavity through the hole left by the burning of the plastic pipe and penetrate into adjacent living areas. The rate of movement through such a hole would depend largely on the difference between the pressures in the room and in the cavity.

In addition to their fire spread potential, the common plastic plumbing materials, polyvinyl chloride (PVC) and acrylonitrile-butadiene-styrene (ABS) when they burn, generate a considerable amount of smoke (particulates) and toxic gases. Besides carbon monoxide, PVC releases hydrogen chloride and ABS generates small amounts of hydrogen cyanide.

It must be realized that in a burning room, those furnishings made of organic material may release great quantities of toxic gases and smoke. The quantities could be many times greater than that which would result from the complete burning of installed plastic plumbing pipe. Even when plastics are not involved in the fire, carbon monoxide from the incomplete combustion of other materials in the burning room could spread and reach excessively high levels in adjacent rooms. Building codes and plumbing codes can place limits on kinds of materials used in construction and installation, but not on materials that subsequently become the furnishings and content of the dwelling. The basic question addressed here is to what extent does a plumbing system compromise the integrity of a partition or a pipe chase with respect to the role of either as a fire (and smoke) barrier.

To evaluate the extent of these potential problems, ten full-scale fire tests involving 39 plastic and metal plumbing configurations have been performed in this program. The results of these tests are being used to provide technical background data necessary to prescribe guidelines for the use of plastic plumbing systems and to suggest criteria for acceptance of such systems in building and plumbing codes. From the standpoint of fire safety, the suitability of the plastic plumbing will depend on: the type of application, including the details of the wall, chase, or shaft construction; the pressure in the shaft in the case of high-rise buildings; the particular plastic material; the pipe size, the type of fittings; and the manner in which the pipe penetrates the wall.

The full-scale fire tests described in this report apply to kitchen sink or lavatory drain systems made of either plastic or metal. The kitchen is the more likely room in the house to have a fire involving drain, waste, and vent pipe. Such a fire could be very intense in the vicinity of the trap due to the common use of wooden base cabinets and the practice of storing household chemicals and other combustibles under the sink. The test duration was arbitrarily taken as 1 hour in accordance with the fire endurance requirement in many building codes for an interdwelling wall in a garden-type apartment.

Full-scale fire tests were performed on ABS DWV piping in two-hour pipe chases in cooperation with the ABS Institute in 1970 [1].[3] The experimental procedures used in the present tests are similar to those employed in the earlier ones.

1.2. Performance Criteria

There are no established performance criteria for evaluating the acceptability of DWV pipe in a wall assembly, other than the general statement that the piping should not decrease the fire resistance of that assembly. The first phase of this project has been directed towards the evaluation of 1-hour fire resistive wall constructions containing DWV. These walls are commonly used between dwelling units in multi-family buildings which may contain DWV systems.

The fire resistance of a wall assembly, under test conditions, should be sufficient to prevent the spread of the fire from one dwelling unit to another for the designated time -- in this case, 60 minutes. The limitations on the spread of fire would restrict the passage of flame through the wall assembly and would prevent the development of an unacceptable temperature rise on the unexposed surface of the wall and the loss of structural integrity. These limitations would prevent open flame from coming through and igniting objects in an adjacent room and would prevent self-ignition or smoldering

[3] Numbers in brackets correspond with the literature references listed at the end of this paper.

of combustible objects in contact with a high temperature wall surface. The critical range for self-ignition would be about 163 to 204 °C (325 to 400 °F). The ASTM E 119 test standard [2] also mentions preventing the passage of hot gases without specific reference to smoke. However, there has been increasing evidence in recent years of the need to consider the regulation of smoke coming through the walls as part of the criteria for containing the fire. The passage of excessive smoke into an adjacent dwelling unit would endanger the occupants of the adjacent unit. In view of the above, the standard ASTM E 119 time-temperature curve was used in this test program, and performance criteria were adopted as follows:

1. There should be no passage of flame through the wall as a result of the DWV installation.

2. The temperature rise on the unexposed surface of the wall should not be affected by the DWV installation and should not exceed 181 °C (325 °F) at any measured point. This corresponds to the highest temperature allowed at any point on the surface according to the ASTM test standard. The temperatures recorded on the laterals are not regarded as wall surface temperatures.

3. Large quantities of smoke should not pass through the unexposed face. This last criterion is not defined in quantitative terms but was based on observations during the test which indicated when heavy smoke was seen to be issuing from the construction.

The above three criteria were used to judge the extent to which the wall assembly tested had met the requirements for the one-hour fire endurance. No hose stream tests (optional in ASTM E 119) were conducted.

2. TEST PROCEDURE

2.1. Construction

2.1.1. Test 1

A one-hour fire-rated wall 10 feet high by 16 feet long, constructed of nominal[4] 2 x 4 fir studs with one layer of 5/8-inch type X gypsum board on each side was built into a test frame for the NBS wall furnace. Four plumbing chases with interior cross sections of 20 x 20 inches and heights of 12 feet were attached to one side of the wall. This wall served as a common wall for each of the chases as seen in figure 1.

The other three side walls of each chase were also constructed with 2 x 4 fir studs with 5/8-inch type X gypsum board on each side. The chases were closed at the top and bottom. The side of the common wall opposite the chases formed the closure to the NBS wall furnace and was subjected to the standard ASTM E 119 fire exposure applicable to construction assemblies [2]. This arrangement permitted the simultaneous testing of four plumbing chases.

Chase 1, sketched in figure 2, had a 4-inch PVC stack and three 1-1/2-inch PVC laterals.[5] One lateral near the bottom of the chase penetrated the wall into the furnace. The furnace pressure at the point of penetration was +0.02 inches of water relative to the pressure in the chase. This represents a pressure which would likely be found about 20 inches above the floor in a room involved in fire, with no building stack effect.

Two laterals passed through the opposite wall of the chase, one at the same elevation as the lateral entering the furnace and one 8 feet above it. The lateral into the furnace represented a kitchen sink or lavatory drain in the room of fire origin. The other two laterals represented locations where the fire could pass from the chase into other dwelling unit rooms on the same floor or on the floor above. The openings around all of the laterals were sealed with plaster spackling and covered with escutcheon plates. An expansion joint in the 4-inch stack was located at the simulated second

[4]All lumber sizes refer to nominal dimensions in inches.
[5]Throughout the report the word "lateral" is synonymous with "fixture drain" or "trap arm" passing through the chase wall.

Fire Endurance of Gypsum Board Walls and Chases Containing Plastic and Metallic Drain, Waste and Vent Plumbing Systems

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FIRE ENDURANCE OF GYPSUM BOARD WALLS AND CHASES CONTAINING PLASTIC AND METALLIC DRAIN, WASTE AND VENT PLUMBING SYSTEMS

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The use of plastic pipe in plumbing systems of multiple-occupancy buildings has raised considerations regarding fire safety. To provide needed data, ten full-scale fire endurance tests were performed involving a total of 39 plumbing chase and wall assemblies containing plastic and metal drain, waste, and vent (DWV) systems typical of installations serving one or two story buildings.

Two tests were conducted using plumbing chase configurations simulating kitchen sink drain systems. The PVC DWV piping in these installations did not contribute to spread of fire from one side of the construction to the other.

Six fire endurance tests were conducted in which the performance of ABS, PVC, copper, and iron was compared directly in kitchen sink drain systems as installed in wood-stud and gypsum-board walls. The stacks ranged from 2 inch to 4 inch in diameter and the laterals from 1-1/2 inch to 4 inches. In these tests it was noted that the plumbing configuration and wall construction details, particularly the sealing of plumbing penetrations, seriously affected the fire endurance of the barrier. Satisfactory performance was achieved when certain conditions were met.

In the two tests involving nominal 2 by 4 steel-stud-and-gypsum-board walls it was determined that the one-hour fire resistance rating of the wall was reduced considerably when ABS or PVC DWV was installed within it using the construction details described in this report. These details included back to back 1-1/2-in diameter laterals feeding directly into 2-in diameter stacks.

Key words: ABS; DWV; fire endurance; fire spread; fire test; gases; plastic pipe plumbing; PVC; smoke.

1. INTRODUCTION

1.1. General

The use of plastic plumbing systems is growing in the residential housing market. Availability, ease of handling and installation, and economics are playing a part in the transition from the conventional materials of copper, steel and cast iron to plastics. These same factors are also playing an important role in the introduction of plastics into the multiple-occupancy building.

The use of plastic pipe in the DWV[1] plumbing systems of multiple-occupancy buildings raises two important questions in regard to its involvement in fire. Will the plastic pipe serve to spread fire to other dwelling units when it might otherwise be contained? Will there be a serious life hazard introduced due to the smoke and toxic gases generated by the burning of the pipe? To help answer these questions, the National Bureau of Standards, with the support of the Department of Housing and Urban Development, established a research and test program.

When plastic DWV piping is incorporated in fire-rated construction, the following possibilities must be considered.

1. The fire could spread from the room of origin along the burning pipe inside the wall or chase cavity, and thus into an adjacent residential unit.

2. The additional heat generated in the shaft, chase,[2] or wall cavity due solely to the burning of the pipe could cause a premature failure of the wall.

[1]DWV refers broadly to drain, waste and vent piping.
[2]The term "chase" in plumbing usage connotes a shaft constructed specifically to enclose the plumbing piping in a fire resistant construction.

1. The annular openings around the laterals were sealed.

2. The wall cavity depth was 5-1/2 in or more.

3. The stack was limited to 2- or 3-in diameter. (See Tests 4-1, 4-3, 7-1 and 7-3.) A 4-in diameter PVC stack in a 9-1/2-in deep wall cavity also met the criteria when the annual opening around the lateral was sealed. (See Tests 8-2 and 8-4.)

5.3. The fire endurance of the wall containing PVC or ABS pipe with back-to-back laterals in line with the stack was reduced when any of the following conditions existed:

1. The plumbing fittings (e.g., tees, wyes) penetrated the gypsum board. (See Tests 8-1 vs 5-3 and 8-2 vs 5-1.) (See also Tests 3-1 and 3-3).

2. The annular hole around the PVC or ABS lateral was not sealed. (See Tests 4-3 vs 7-2 and 4-1 vs 7-4.)

3. The PVC or ABS pipe was used in a 3-1/2-in deep wall cavity with either wood or steel studs. (See Tests 3-1, 3-3, 6-1, 6-2, 6-3, 6-4, and 10-1, 10-2, 10-3, 10-4.)

5.4. Offsetting the lateral from the stack in the same stud space for a 2 x 6 wood-stud wall increased the time to flame passage. However, when the annular openings around the lateral was not sealed, a considerable quantity of smoke was released into the room at 34 minutes and the ABS and PVC systems failed this criterion (see Tests 9-2 and 9-3). When the lateral was offset from the stack in an adjacent stud space, the heavy smoke criterion was reached at 5 minutes and failure by flame-through occurred at 21 minutes (see Test 9-4). The effect of offsetting the laterals in 2 x 4 wood-or steel-stud walls was not examined in these tests.

5.5. The performance of the PVC system was superior to the ABS type, both in time to flame-through and in time to heavy smoke development in almost all the tests where a direct comparison was possible, (see Tests 3-1 vs 3-3, 5-1 vs 5-3, 6-1 vs 6-4, 8-1 vs 8-1 vs 8-2, 10-1 vs 10-2). These tests covered a variety of wall-cavity depths and stack sizes. However, in each of the above cases, the comparison is based on the condition where the annular hole around the lateral was completely sealed off with plaster spackling. When the annular hole was not sealed, the performance was difficult to compare since the times to failure were short in both cases.

5.6. All copper, galvanized iron and cast iron systems installed in wall cavities, a total of seven constructions, met the criteria for 60 minutes in every case. In six tests, the openings around the lateral were sealed, (see Tests 3-2, 3-4, 4-2, 4-4, 5-2, 5-4); and in one test the opening around the lateral was not sealed (Test 9-1). The wall cavities in these tests were of three depths, 3-1/2 in, 5-1/2 in, and 9-1/2 in. While the wall-surface temperature-rise did not exceed 181 °C (325 °F) the temperature of the copper lateral reached 500 °C (932 °F) just outside of the wall.

5.7. Based on the results from this series of tests, plastic DWV Systems with lateral sizes of 2 inches or less would not be expected to reduce the 1-hour fire endurance rating of wood-stud-and-gypsum board walls and chases in one- and two-story buildings provided that:

1. the annular hole in the wall around the lateral is sealed (an adequate inspection system may be required), and

2. the stud space depth is sufficient to obviate the need for the hubs of any tees or wyes in the vertical stack to penetrate the wall.

5.8. There was a quantitative difference in the fire performance of ABS and PVC DWV systems. However, neither system degraded the one-hour fire rating of wood-stud-and-gypsum board walls where the above conditions were followed.

5.9. This investigation covered only the fire performance of plastic (and metallic) pipe in one-hour fire-rated chases and walls. It did not address the fire performance of DWV in "high-rise" buildings nor DWV penetrating floor-ceiling assemblies. Further studies may be needed to determine whether pressure differences due to the stack effect in high-rise buildings will contribute to rapid fire and smoke spread. Also, there is a need for developing a procedure for quantitative measurements of smoke and gas accumulation in adjacent dwelling areas.

ANTI-PVC/PLASTICS ALLEGATIONS

ALLEGATION NO. 75

California Analytical Laboratories performed tests which showed carcinogens in water stored in plastic pipe.

RESPONSE

Numerous allegations have been made that plumbers who install plastic pipe and consumers who drink the water which flows through it are at risk of disease, particularly cancer, from the solvents which are used in the pipe. These allegations come largely as anecdotal reports from plumbers and limited surveys of plumbers which are inadequate to support the allegations.

Several studies by NIOSH have shown that plumbers engaged in installing plastic pipe have small exposures to solvents when compared with the accepted threshold limit values. While there is much analytical data to show that appreciable amounts of solvents may leach from a new plastic pipe installation, ordinary flushing quickly reduces the concentration of these materials to insignificant levels.

The safety of plastic plumbing, in contrast to the allegations, is well summarized in the "Final Report on Potential Health Hazards Associated with the use of Plastic Pipe in Potable Water Systems" published by the California Department of Industrial Relations. This report states that:

1. "Adverse worker health effects from the major solvents found in cements and primers are unlikely based on their relatively low toxicity and field measurements of exposures under a range of working conditions", and

2. "Based on the present study, when properly installed and flushed, plastic pipe systems do not appear to pose a health hazard under normal usage conditions."

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ANTI-PVC/PLASTICS ALLEGATIONS

ALLEGATION NO. 76

NRC (Canada) January 1971 pipe tests confirmed the failure of plastic pipe assemblies to maintain the integrity of fire restrictive construction.

RESPONSE

Mr. J. H. McGuire of the National Research Council of Canada, ran a series of tests, and his comprehensive technical report published in Fire Technology, Feb. 1973, covers 41 fire barrier penetration tests under positive pressure conditions. This statement deals with that work with the brief phrase "...confirmed the failure of plastic pipe assemblies to maintain the integrity of fire resistive construction." Anyone who even reads the brief conclusions finds these statements:

> "By careful consideration of the pattern of pressure differentials likely to prevail within a building, it is possible to devise largely plastic DWV systems for buildings that will not give rise to undue hazard of fire propagation across fire partitions. Such DWV pipe systems might well involve combinations of metal and plastic pipe."
>
> "Another aspect to be noted concerning the test work reported is "that not all metal DWV systems would react favorably if subjected to the test conditions described".
>
> "With certain modern jointing concepts, penetrations of a metal pipe would be quite likely in the event of a fire."

Based on the above quotations plus newer technology currently available, it is obvious that PVC piping can be installed in multi-story buildings without impairing the fire ratings of the various walls and slabs. Conversely, it is also evident that simply using metal piping does not guarantee maintenance of these fire ratings.

SUPPORTING ATTACHMENT

National Research Council of Canada, Fire Research Section, Division of Building Research, J. H. McGuire, SFPE, "Penetration of Fire Partitions by Plastic DWV Pipe," Fire Technology, Feb. 1973

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See back for notes
on TC w/ John Houlihan!
Chm Tech Com 12-13-83

Earthquakes, lifelines and ASCE

What happens to transportation and public utility systems during an earthquake? The disastrous effects of an earthquake can be compounded by the failure of such facilities. Design criteria should be established for the vital "lifelines" as they have been for buildings. ASCE has taken the first step in that direction. Here is a report by the interim committee on lifeline engineering.

ASCE HAS UNDERTAKEN the role of elevating the state-of-the-art of lifeline engineering by establishing an interim Committee on Lifeline Earthquake Engineering (CLEE). "Lifelines" are here defined as utilities and transportation systems. The present technology is dangerously underdeveloped and no major organization has been committed to the problem area. The Society's goals and structure correspond uniquely with the dimensions of the problem.

Lifelines represent approximately half of the economic value vulnerable to earthquakes. Their failure cannot be tolerated. Yet, as emphasized in recent earthquakes, they do fail with dire consequences to public health and welfare. Well documented examples include failures of dams, aqueducts, freeway bridges, harbor quay walls, airport towers, gas transmission lines, power distribution systems, and communication facilities.

This area affects every one of ASCE's technical divisions. Establishment of a new Technical Council has been recommended to the Technical Activities Committee and as a result the interim committee has been authorized to develop a charter for such a council.

Lifelines

Every city has lifelines that provide for the supply and the flow of people, goods, information, energy and water by means of the transportation, communication, energy and water systems. In an earthquake the city lifelines are severely tested and may fail to function. Such failure or impairment compounds the consequences of a quake.

Unfortunately, "lifeline earthquake engineering" is a relatively immature professional field. "Building earthquake engineering," in contrast, has developed tremendously since the Long Beach quake of 1933 and is a mature professional field.

The typical city's lifelines may be classified as:

- Energy—electricity; gas; liquid fuel; and steam.
- Water—potable; flood; sewage and solid waste; and fire water.
- Transportation—highway; railway; airport; harbor; and transit.
- Communication—telephone and telegraph; radio and television; mail and press.

In general, each of these is a network within which there are sources, major transmission lines, storage, and a distribution or collection system. They are public utilities. Each has a terminus outside the city and an extensive matrix of contact or distribution points inside. For example, the natural gas supply of Los Angeles is piped in from Texas and the San Joaquin Valley and ends up at countless industrial furnaces and kitchen stoves.

Experience with lifeline failures in earthquake points to three kinds of associated disasters such as fires, famines and epidemics. The latter two, of course, also have economic implications. Even though lifeline failures in historic earthquakes have not killed as many people as have building collapses, seismic sea waves and avalanches, some such failures have had a high potential life hazard.

Each type of lifeline has its own characteristic design and operational features and its own special vulnerabilities to earthquakes. It is essential that these vulnerabilities be understood in detail so they may be minimized. Rather than precipitating a calamity, the lifeline must serve to alleviate the effects of the quake. Telephones must work if disaster relief is to be accomplished effectively; water supplies must not be endangered. If a lifeline component or system fails, it should be rapidly repairable or replaceable by emergency

Measuring earthquakes

The San Fernando earthquake had a magnitude of 6.6 on the Richter scale, which is computed from a seismograph record and is an index of the amount of vibrational energy in the earthquake. Magnitude 7 signifies 32 times as much vibrational energy as magnitude 6 and the largest magnitude ever measured was about 8.7.

The Modified Mercalli Scale measures intensity on a scale of 1 to 12. *Local values of intensity are* established by observing kinds of damage caused to different kinds of structures. Intensities of 8 and above are considered major. Based on an analysis of historical intensities in California, for example, the U.S. Department of Commerce has determined that the state should expect an intensity of 8 or greater at some location every 2½ years on the average. Intensity of 7 or greater would be experienced somewhere every 9 months.

For the sake of comparison, the Managua, Nicaragua, quake measured 6.5 on the Richter scale and caused 9,000 deaths. The San Fernando quake measured 6.6 and caused 64 deaths. Luckily, the latter occurred when most people were asleep in characteristically earthquake-resistant wood frame houses and the quake did not extend to downtown. Besides differences in structural practices in Managua, the earthquake's effects were magnified by lifeline failure. For example, there was no water at Managua with which to quench quake-caused fires. It could happen here. —*V. F.*

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TABLE 2-1

Summary of Permanent Ground Movement and Related Pipeline Damage for Selected Earthquakes

Earthquake	Magnitude/ Intensity	Faults	Landslides	Liquefaction/ Seismic Compaction	Reported Pipeline/Conduit Damage	Remarks	References
San Francisco, California 1906	Magnitude 8.3 Intensity XI	Up to 6.4m of right lateral strike slip on San Andreas fault; max throw 0.9m. Similar displacements on subparallel faults. Width of fault disturbance generally from 1 to 15m, up to 125m. Length of fault 435km. Fault appeared as (1) trench, (2) low ridge, and (3) series of en echelon cracks.	Extensive slope failure, including (1) rotational slumps, (2) earth flows, (3) rock avalanches. Many additional slides occurred the following year when rainfall infiltrated ground cracks.	Three major zones of liquefaction-induced lateral spreading in San Francisco causing substantial damage to buried utilities.	Extensive damage to gas and water lines in liquefaction areas of San Francisco.	Much pipeline damage attributed to lateral spreading and ground cracks; fault damage generally low because of population density. Many previously faulted areas now are highly populated.	15, 29, 49, 122
Kanto, Japan 1923	Magnitude 7.9 - 8.1	Uplift and subsidence of sea floor along block faults; several uncertain in a wide zone on bottom of Sagami Bay.			Failure rate for small diameter pipelines (.22/km) higher than for large diameter (.16/km).		54
Managua, Nicaragua 1972	Not reported	Two main strike slip faults; lateral displacement not measured; max throw (0.2m); max length exceed 2.5km and width of zone of faulting 150m.	Landslides primarily along steep natural slopes.	No liquefaction or seismic compaction reported.	Principal cast iron water mains pulled apart at fault line. Welded steel pipe (0.3m diam.) ruptured by landslide. Most house connections to water distribution network were broken.	Extensive destruction attributed to surface faulting. Water main ruptures contributed significantly to fire damage.	28, 106
Imperial Valley, California 1940	Magnitude 7.1 Intensity X	Max 5.8m of right lateral strike-slip displacement caused for 60km. Fault developed dip slip component south of U.S.-Mexican border. Max throw about 1.2m.	Area characterized by low topography—no landslides reported.	Numerous sand boils and vents produced in Colorado River delta area.	Many irrigation pipes ruptured. Extensive damage to the All-American irrigation canal. Elevated storage tank collapsed.	Area was largely agricultural with relatively low population density.	87, 112
Fukui, Japan 1948	Intensity VI	No definite surface expression of causative fault. Movement on Ono Valley fault postulated, but evidently unconfirmed. Two zones of minor faulting appeared in Fukui with horizontal displacement of 6 inches.	Landslides occurred in unconsolidated sand terrace region north of Fukui plain.	Fissures were the most prevalent geologic evidence of the earthquake; many were marked by sand boils. Highway and railroad embankments slumped. Compaction of fill in buried water courses, some of which are remnants of moats of ancient castles.	Pumphouse foundations were cracked and heaved upward, rupturing pipes. Pumps which were not anchored slid, fracturing scroll casings. Reservoirs and connecting pipes were fractured. Underground piping broke at hydrants, tee and wye connections and sewer outlets. Failure of concrete pipe was general. Elevated railroad water tank collapsed.		54, 88
Kern County, California 1952	Magnitude 7.2 Intensity VII-XI	Reverse oblique surface faulting; length of fault 60km, width of fault zone 1/2 to 15m; max throw 1.2m and left lateral slip 0.6m. Fault displacement appeared as pressure ridges, en echelon fractures, and tension cracks.	Extensive landslides in the form of rock falls. Avalanches, shallow soil flows, and movements up to several feet along old scarps, massive slides.	Mud volcanoes and extensive cracking in water saturated terraces along creek beds.	Elevated storage tank collapsed. Wells damaged due to lateral displacement. Pipeline ruptures with compression and extension at fault crossings. Oil pipeline ruptured along narrow extension of surface fault.	No surficial faulting in deep alluvium of San Joaquin Valley, although substantial movement along fault trace on either side.	21, 27, 87, 103

TABLE 2-1

Summary of Permanent Ground Movement and Related Pipeline Damage for Selected Earthquakes (continued)

Earthquake	Magnitude/ Intensity	Faults	Landslides	Liquefaction/ Seismic Compaction	Reported Pipeline/Conduit Damage	Remarks	References
San Francisco, California 1957	Magnitude 5.3 Intensity VI	No observed surface displacements on faults.	Shallow landslides along seacliffs; 100m-wide slide in artificial fill induced by liquefaction.	Landslide caused by liquefaction; seismic compaction indicated by differential settlement at San Francisco Airport and settlement near water tanks.	Pipeline breaks at San Francisco Airport from differential settlement. Pipeline separations caused by fill settling around water tanks.	Many pipeline breaks at rigid or semi-rigid connections with structures.	19, 24, 101, 108
Hebgen Lake, Montana 1959	Magnitude 7.1 Intensity X	Several steeply inclined normal faults; max throw 1.5 to 6m. Surface ruptures include scarps, stairsteps, and ... warping.	Widespread landslides, rock falls, and slumping of sediments.	Liquefaction phenomena include sand spouts and sandboils.	Maximum damage confined to areas adjacent to the major faults where water supply lines were ruptured. Steel bridges and a culvert collapsed.	Area 60km long and 23km wide subsided as much as 6.6m. Widespread formation of grabens next to faults.	39, 41, 78, 114, 119
Prince William Sound, Alaska 1964	Magnitude 8.5 Intensity XI - XII	Two faults on Montague Island in Prince William Sound; max throw 3m, length 30km.	Extensive slope failures: (1) rock avalanches in glaciated areas; (2) near horizontal spreading of saturated soils; (3) subaqueous sliding on lake shores and seacoasts; (4) large translatory sliding in sensitive clay.	Extensive liquefaction of saturated, granular soils, causing ground cracking and sliding.	Pumphouses, well casings, water treatment damaged. Several surface tanks collapsed; damage to roofs, shells and columns observed. More than 100 breaks in water distribution systems at Anchorage.	Most pipeline damage due to landslides and ground cracking.	32, 33, 61, 66
Niigata, Japan 1964	Magnitude 7.7				Failure rate of .46/km reported overall; rate was much higher in zones of liquefaction.	Damage to underground pipelines was concentrated in areas of extensive liquefaction.	54, 68
Puget Sound, Washington 1965	Magnitude 6.5 Intensity VII - VIII	No surface faulting reported; focal depth 59km.	Landslide cut one railroad branch line in the Olympia area.	Zone of incipient liquefaction and settlement at industrial sites of hydraulic fill or sand alluvium.	Majority of pipe leaks occurred in 3/4", 2" galvanized steel service laterals; 48" main carrying water to Everett broke. No fire problems occurred.	Corrosion at exposed, threaded portions of laterals was a dominant factor in damage.	48, 111
Borrego Mountain, California 1968	Magnitude 6.4 Intensity VII - IX	Three main strike slip surface faults; max right lateral displacement 38cm; max throw 23cm in isolated locations.	Widely distributed slides in dry surficial deposits; widespread slumping of soil mostly within 3 to 5km of main surface faults.	Sand boils as evidence of liquefaction; widespread seismic compaction.	Pipe ruptures at fault crossings; cracked concrete canal lining from slumping along canal embankments.	Earthquake caused 1-2.5cm displacement on the Imperial, Superstition Hills and San Andreas faults at distances of 70, 45 and 50km, respectively, from epicenter.	1, 2, 23
Santa Rosa, California 1969	Magnitude 5.6 - 5.7 Intensity VII - VIII	Surface fractures attributable directly to fault movement were not found.		Heavy shaking of nearby ground caused cracks in fill ground and roadbed.	Majority of leaks in steel and galvanized steel mains were related to corrosion; breaks in cast iron pipe were due to other causes.		48, 74, 102, 110

ANTI-PVC/PLASTICS ALLEGATIONS

ALLEGATION NO. 77

Plastic piping systems are unsafe in earthquake zones.

RESPONSE

This very brief and all inclusive statement "Plastic piping systems are unsafe in earthquake zones" really is so general and unspecific that it is ridiculous. Earthquakes, we know, are fairly infrequent and generally localized occurrences. Because of this the exact areas and points that will suffer damage cannot be predicted except that identified fault zones may be points of maximum stressing and displacement. In 1973 the American Society of Civil Engineers established a committee on Lifeline Earthquake Engineering to elevate the state-of-the-art in this area. To-date we have been unable to find any reports that show plastic piping to be more vulnerable to earthquake damage than other piping materials when subjected to indentical exposure. When earthquakes occur they can produce a wide range of disturbances all the way from vibration with no visible displacement to substantial shearing or tearing. Based on the properties of the various materials used in piping systems, it is safe to say that in many cases plastic pipe can withstand far more distortion than many other piping materials. One California manufacturer of plastic piping reports that they investigated some after-earthquake damage and found a hospital in which the cast iron DWV system sustained numerous fractures, the copper water system sustained numerous joint leaks, but their plastic piping which was used in a drainage system within the building suffered no failures.

A very recently published report entitled "Advisory Notes on Lifeline Earthquake Engineering" by the ASCE Technical Council on Lifeline Earthquake Engineering includes a fairly extensive table with the title "Summary of Permanent Ground Movement and Related Pipeline Damage for Selective Earthquakes". This table lists 19 different quakes and describes very briefly pipeline/conduit damage. Throughout these descriptions reference is made to damage to water and sewer pipes of various materials but no mention is made of any plastic piping. For example, there are indications that rigid clay sewers suffered gross cracking, and that 38 km had to be replaced; that cast iron and asbestos cement pipe suffered signficant cracking; that rigid joints in all kinds of pipe were more vulnerable to fracture than gasketed joints; and that older corroded pipe was very much weakened and had more failure breaks.

Throughout the references it appears that corrosion, rigidity and lack of ductility are the primary factors in the failure of pipelines exposed to earthquakes. Since plastic pipe does not suffer corrosion and offers some degree of ductility and flexibility, we find that the statement is just grossly incorrect. As a matter of fact, the information available suggests that plastic piping is a preferred material for use under such conditions.

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ALLEGATION NO. 77 - contd.

SUPPORTING ATTACHMENTS

American Society of Civil Engineers, "Earthquakes, Lifelines and ASCE," Civil Engineering, page 65, Dec. 1973

American Society of Civil Engineers,Technical Council on Lifeline Earthquake Engineering, "Advisory Notes on Lifeline Earthquake Engineering, Table 2-1, pages 124-127 (recently published)

RESPONSE ORIGINATOR -- CONTACT FOR SUPPLEMENTAL INFORMATION

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Fire Technology
Feb 1973

Penetration of Fire Partitions by Plastic DWV Pipe

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The hazard of fire propagation across a wall or floor has been found to be very real in the case of many pipe-floor penetrations and in the case of pipe-wall penetrations under adverse air pressure differentials and where the system on the unexposed side of the wall is vented.

FIRE-RESISTIVE partitions must remain substantially imperforate, particularly when adverse air pressure differentials prevail, if they are to perform their function of containing fire. In establishing services in a building, however, penetration of partitions is almost inevitable. This paper reports the results of tests aimed at investigating the circumstances under which various plastic DWV (drain, waste, and vent) pipes can penetrate fire partitions without creating undue hazard of transmitting fire from one side of the partition to the other. The tests were particularly oriented toward high-rise building applications because they can involve the greatest adverse pressure differentials and hence the greatest risk of fire propagation across a partition. Such fire propagation also constitutes a greater potential threat to life safety when it occurs in a high-rise rather than a low-rise building.

In addition to the possible hazard of fire propagation across a partition, the use of certain plastic pipes could enhance the potential smoke, toxic gas, and corrosion problems in a building. These questions, however, are outside the scope of this paper.

CONDITIONS TO BE REPRESENTED

As the issue under consideration concerned fire resistance, it was assumed at the outset that the heating conditions should be based on the *Standard Methods of Fire Tests of Building Construction and Materials*, NFPA No. 251 (also ASTM E 119 and UL No. 263) fire-resistance furnace time-temperature curve. No NFPA fire-resistance test standard, however, performance for one hour. Adequate insulation would eliminate the hazard associated with the glowing sleeve, but it might also accelerate the destruction of the pipe higher up.

CONCLUSIONS

The penetration of floors and walls by plastic DWV pipe of the sizes and types examined presents risk of fire propagation under various conditions. The hazard exists for almost all penetrations of floors; and in the case of walls, it arises when adverse pressure differentials prevail and when the pipe on the unexposed side of the wall leads to a vented system. By careful consideration of the pattern of pressure differentials likely to prevail within a building, it is possible to devise largely plastic DWV pipe systems for buildings that will not give rise to undue hazard of fire propagation across fire partitions. Such DWV pipe systems might well involve combinations of metal and plastic pipe.

It should be borne in mind that the scope of this paper has been confined to propagation of fire across partitions. Other factors could enter into fire protection considerations, among them being the smoke generating and corrosive potentialities of certain plastics.

Another aspect to be noted concerning the test work reported is that not all metal DWV systems would react favorably if subjected to the test conditions described. If penetration of the pipe occurred in the fire region, a positive pressure differential and a vented system could give rise to a high metal temperature beyond the penetrated partition as occurred with the PVC pipes penetrating the floors (Tests 30, 36, and 38). With certain modern jointing concepts, penetration of a metal pipe would be quite likely in the event of fire.

REFERENCES

[1] Tamura, G. T., "Computer Analysis of Smoke Movement in Tall Buildings," *ASHRAE Transactions*, Vol. 75, Part II, 1969, pp. 81–93.

[2] Fire Tests with Plastic Tubes Carried out at the Research Station in Studsvik, Spring 1963, Report 18:1966.

[3] van Sante, F. J., "Results of Fire Tests on Plastic Pipes and Sheets for Covering Walls and Ceilings," Foundation Ratiobouw, Holland, 1968.

TABLE 2-1
Summary of Permanent Ground Movement and Related Pipeline Damage for Selected Earthquakes
(continued)

Earthquake	Magnitude/ Intensity	Faults	Landslides	Liquefaction/ Seismic Compaction	Reported Pipeline/Conduit Damage	Remarks	References
San Fernando, California 1971	Magnitude 6.4 Intensity XI	Reverse oblique fault dipping 70° north. Most movement distributed across zone 50 to 100m wide. Max combined displacement 1.9m; max throw 1.39m; length of faulting 1.5km. Movement on many small faults continued for days after the main shock.	Many landslides, including slumps and rockslides in nearby foothills of San Gabriel Mtns. and extensive slumping around upper and lower Van Norman Reservoirs. Sliding was predominantly in bedrock, alluvial soils, and fills. Deep slumping generally absent.	Estimated $30 million damage to various utilities. Liquefaction-induced lateral spreading near Juvenile Hall. Sand boils observed at several locations.	Contamination by broken sewer; extensive to wells and well piping. Outlet towers cracked. Extensive damage to water treatment plant. Damage to roof, shell and piping of water storage tanks. Cracked storm drain culvert. Extensive pipeline damage, especially in areas of active faulting. 30km of sewer pipe required replacement. Damage concentrated at pipe joints; flexible joints (rubber gasket) behaved significantly better than rigid joints (cement caulked) in water distribution system.	Earthquake caused extensive pipeline damage by faulting, landsliding, and liquefaction. 25 to 50% of pipeline damage occurred within the fault zones, which represented only 0.5% of the area affected by strong ground shaking.	18, 44, 48, 51, 56, 58, 72, 73, 80, 82, 90, 92, 98, 99, 100, 108, 118, 119, 124
Managua, Nicaragua 1972	Magnitude 5.6	Four main, strike slip surface faults; max left lateral displacement 38.1cm; max throw 10.2cm; max length mapped 5.9km; max width of zone of faulting 2.5km.	Landslides primarily along steep natural slopes and steep granular embankments.	No obvious movement related to liquefaction. No reported seismic compaction.	Pumping station equipment damaged; inlet blocked, chlorine cylinders toppled. Damage to tank shells. Extensive damage to water distribution system with many pipelines ruptured at fault crossings. Substantial damage to asbestos-cement pipe and cast iron pipelines with lead joints.	Extensive destruction attributed to surface faulting. Lack of liquefaction effects, in part, due to low water table and short duration of shaking.	20, 22, 28
Lima, Peru 1974	Magnitude 7.5 Intensity V - VIII		Rock slides in mountainous regions.	Densification of soils in marshy areas; horizontal slippage of soils toward the ocean along the waterfront; splits in roadway fill.	Little damage to underground utilities is attributed to competent ground throughout Lima. Water treatment plant suffered light cracking in dikes. Broken walls and pipes. Two of four old concrete surface storage tanks and a new covered reservoir cracked. Three elevated tanks suffered cracks.	The good performance of buried pipelines in competent soil was confirmed.	71

TABLE 2-1
Summary of Permanent Ground Movement and Related Pipeline Damage for Selected Earthquakes
(concluded)

Earthquake	Magnitude/ Intensity	Faults	Landslides	Liquefaction/ Seismic Compaction	Reported Pipeline/Conduit Damage	Remarks	References
Tangshan, China 1976	Magnitude 7.8 Intensity XI	Observed surface movement primarily horizontal in a right lateral sense with maximum observed movement of 1.5m. A surface rupture zone extended 10km.		Extensive liquefaction occurred; area consists of loose silty sand to a depth of 12m.	Thousands of wells damaged; 33% of masonry water tanks, 10% of concrete tanks damaged. Extensive damage occurred to pipes and sewers situated in "soft soil, loose sand, silt-like soil with high water table..." The number of breaks/km is greater for smaller pipes.	Reported damage rates between 1.9-5.2 breaks/km.	50, 89, 105, 107
Miyagi-Ken-oki, Japan 1978	Magnitude 7.4 Intensity VIII			Many sewerage pumping stations inoperative. Broken joints in sewage treatment plants. Considerable damage to minor distribution mains occurred. More than 200 breaks occurred in mains with diameter greater than 50mm. Steel pipe with turnbuckle experienced greatest damage per unit length; ductile cast iron performed best.	Damage was slight in the central city located on stable terrace; damage concentrated in areas of cut and fill and on the alluvial plain of sand, silt, gravels, and peat overlying bedrock at least 40m depth.		53, 58
Imperial Valley, California 1979	Magnitude 6.6	Shallow focal depth, right lateral slip on northwest trending Imperial Fault. 30km of surface rupture; possible additional 7km of discontinuous faulting. Maximum horizontal offset of 55cm; vertical displacement of 19cm.		Sand boils indicated liquefaction at depth. All American Canal suffered breaches due to liquefaction.	Damage to waste water clarifier. Leaks in canals. Collapse of elevated storage tank and damage to others. No breaks in water pipeline joints reported; about 30 leaks in cast iron pipe at joints weakened by corrosion.		30

ALLEGATION NO. 78

Plastic piping systems are penetrated by ground conaminants and pose a threat of pollution where used to carry potable water.

RESPONSE

PVC pipe is an excellent choice for transporting potable water. Unlike metal pipes, it is resistant to corrosive chemicals and is a good choice in unstable ground conditions.

Under extreme environmental conditions, e.g. where massive solvent spills have occurred, it has been shown that all commonly used piping systems are permeable to certain chemicals. Recent tests conducted by the Battelle Memorial Institute[1] have shown that wherever jointed pipe with elastomeric gaskets is used, permeation is independent of the material used to produce the pipe. Because gasketed joints are permeable, neither plastic, ductile iron, nor asbestos cement piping systems can prevent permeation from major spills or from chemical dump sites.

Therefore, in an area known to be contaminated by solvents, all conventional piping systems are suspect in that they are permeable to those solvents.

REFERENCE

1. Evaluation of the Permeation of Organic Solvents through Gasketed Jointed and Unjointed Poly (Vinyl Chloride), Asbestos Cement, and Ductile Iron Pipes by Battelle Memorial Institute, 10/28/83.

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ANTI-PVC/PLASTICS ALLEGATIONS

ALLEGATION NO. 79

Choose noncombustibles over combustibles, where there is a choice.

RESPONSE

A noncombustible environment would consist only of concrete, metal and glass and would deprive us of many of the products which make life more comfortable, healthier, cleaner, less work and less expensive.

Unilaterally choosing noncombustibles over combustibles ignores many of the benefits these products provide. Plastic plumbing pipe, for instance, does not corrode or leak the way metal pipe can and is easier to install. Plastic electrical conduit does not arc or conduct electricity the way metal conduit can, thus reducing the risk of fires caused by short-circuits.

Even the most adamant critic of combustible products does not advocate the elimination of wood construction materials or all-natural decorative fabrics. One must conclude, therefore, that the criticism of combustible materials actually is an attempt to eliminate from the marketplace those materials which pose an economic threat to certain noncombustible products.

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ANTI-PVC/PLASTICS ALLEGATIONS

ALLEGATION NO. 80

Choose materials that give off CO and CO_2 rather than HCN or HCl, where there is a choice.

RESPONSE

The use of combustion product types as a basis for selecting materials can be very misleading and can result in the selection of a more toxic/hazardous material. While toxicity depends on the chemical, toxicological hazard is dependent on the amount of chemical present and the probability that toxic levels will be generated and reach a potential victim. Furthermore, other factors such as quantity, configuration, proximity to other combustibles, compartment volume, ventilation, ignition resistance, flame spread resistance, BTU contribution, presence and type of ignition source, fire protection systems and building occupancy must be taken into consideration when determining the acceptability of a material.

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ANTI-PVC/PLASTICS ALLEGATIONS

ALLEGATION NO. 81

Building fires, and smoke in them, develop faster than in the past.

RESPONSE

No evidence exists to support such a claim. In fact, because of the flame retardant characteristics of many building and furnishing products used today, fires actually may develop more slowly than in the past. Moreover, in tests comparing the fire performance of various construction materials, newer materials frequently perform better than traditional ones. When rigid PVC and wood are compared, for instance, PVC releases heat at a slower rate, requires more oxygen to burn, encourages flame spread at a slower rate, releases less heat and produces less smoke than wood.

REFERENCE

Vinyl Institute technical position paper: "Combustion Properties of Polyvinyl Chloride," 1983.

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ANTI-PVC/PLASTICS ALLEGATIONS

ALLEGATION NO. 82

The use of plastic pipes and other synthetic materials in high-rise buildings has made some structures plastic bombs.

RESPONSE

This charge is not true. Examination of the nation's fire record shows that the "bombs" occurred before the widespread use of plastics: 1/

- Iroquois Theater, Chicago, 1903........... 602 dead
- Steamer "General Slocum," New York, 1904...1,030 dead
- Lakeview Grammar School, Ohio, 1908......... 175 dead
- Ohio State Penitentiary, Columbus, 1930......320 dead
- Rhythm Club, Mississippi, 1940................207 dead
- Cocoanut Grove, Boston, 1942.................492 dead
- LaSalle Hotel, Chicago, 1946.................. 61 dead
- Winecoff Hotel, Atlanta, 1946................119 dead

In today's fires, NFPA finds severe violation of code requirements in large loss-of-life fires.

> "An outstanding example is the MGM Grand Hotel fire in Las Vegas, Nevada on November 21, 1980. In that fire, in which 85 persons lost their lives, the following are some of the factors that contributed to the loss of life: lack of automatic fire extinguishment; unprotected vertical openings; substandard enclosure of interior stairs, smokeproof towers and exit passageways; improperly designed heating, ventilating and air conditioning systems; and smoke spread through elevator hoistways." 2/

The installation of vinyl drain, waste and vent (DWV) and plumbing systems in one- and two-family dwellings and many other types of buildings has been widespread for many years, dating back in some areas of the United States to the early 1950s. And, there has generally been little or no problem from a fire safety standpoint.

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ALLEGATION NO. 82 - contd.

RESPONSE - contd.

Many cities permit the use of PVC plumbing and DWV systems in high-rise construction. Cities include Houston, Washington, D. C., Miami, Baltimore, Detroit, Atlantic City, New Haven, Wilmington, Columbus, Dayton, Dallas, Fort Worth, Arlington and Irving. The prophencies of performance failure or increased hazards in fire situations simply have not materialized.

PVC pipe has undergone a great deal of fire testing, indicating that it can be installed in fire-rated construction without impairing the rating of the wall or floor. Research demonstrates that at least four different techniques -- sleeving, sealing, intumescent materials and mechanical devices -- allow PVC pipe to be installed without compromising fire integrity of a wall or floor. It does go without question that proper installation techniques are mandatory for all penetrations of fire barriers -- that includes penetrations by metal pipe as well as PVC.

REFERENCES

1/ "Selected Fires Causing Large Loss of Life," Fire Facts, National Fire Protection Association, pp. 8-10, 1982.

2/ "Report of the Committee on the Toxicity of the Products of Combustion...," Fire Journal, Vol. 77, No. 2 (March, 1983), pp. 21-27.

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ANTI-PVC/PLASTICS ALLEGATIONS

ALLEGATION NO. 83

Tests with ionization detectors showed they are particularly insensitive to smoke from PVC.

RESPONSE

Under certain conditions an ionization smoke detector is insensitive to the decomposition products of PVC. If PVC coated wires are exposed to the mildest electrical overload which can cause degradation of the insulation, a mist of HCl can be released. Ionization detectors are insensitive to this smoke because it lacks the carbon particles to which the detector responds. Before we can decide the significance of these facts we must ask two questions 1) what type occupancy is being protected, and 2) how relevant is this type of "fire" to the occupancy being considered. Much of the research which lead to the discovery of the insensitivity of ionization detectors to PVC smoke was aimed at development of systems approach to the protection of computer equipment. In this case an extremely early warning of any problem situation is required. Thus the lack of sensitivity of the ionization detector to PVC smoke may be a significant problem. However there are other detection systems available which can detect such a problem situation under these conditions.

Another potential problem situation involves the typical residence. Here the probability of such a mild electrical overload situation must be determined before the significance of the risk can be established. However the probability of this situation may be slight. It is more likely that the overload will be sufficient to also release carbon particles or that other building materials which will release carbon particles will also be involved in the fire. It should also be recognized that early fire detection by itself doesn't guarantee successful escape from the fire. The fire must be growing slowly enough to permit escape. A wire coating which resists ignition into flames and spreads fire slowly is a critical advantage.

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ANTI-PVC/PLASTICS ALLEGATIONS

ALLEGATION NO. 84

The gases formed when synthetics burn are more lethal and potent than gases we have been dealing with for years.

RESPONSE:

This is only the partial truth.

Like any organic material, natural or synthetic, PVC produces numerous combustion products. The most toxicologically important of these are carbon monoxide (CO), carbon dioxide (CO_2) and hydrogen chloride (HCl). (Boettner et al., 1969). CO and CO_2 are simple asphyxiants while HCl causes irritation or destruction of tissue. CO, CO_2, and/or HCl can cause death, either by asphyxiation or by pulmonary edema. These causes of death are not new or unusual and are known to result from combustion products of wood which contain CO and CO_2 and corrosive agents such as acrolein, formaldehyde, and other aldehydes (Zikria et al, 1972). Asphyxiation and pulmonary edema resulting in delayed deaths have been reported in fires long before the significant use of plastics (Mallory and Brinkley, 1943).

REFERENCES:

Boettner, E.A., Ball, G. and Weiss, B. (1969) Analysis of the volatile combustion products of vinyl plastics. J. Appl. Polymer Sci. 13:337-391

Mallory, T.B. and Brinkley, W.J. (1943). Management of the Coconut Grove burns at the Mass. General Hospital: the problem of burn shock complicated by pulmonary damage. Ann. Surg. 117:865.

Zikria, B.A., Ferrer, J.N. and Flock, H.F. (1972). The chemical factors contributing to pulmonary damage in "smoke poisoning". Surgery, 71: 704-709.

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ANTI-PVC/PLASTICS ALLEGATIONS

ALLEGATION NO. 85

Smoke is more obscuring than in the past.

RESPONSE

Vision is obscured by smoke. The relationship between human visibility and the optical properties of smoke has been studied and is reasonably well understood. Vision is affected by the concentration of smoke nad how far you are trying to see. Vision is also affected by the type of smoke in that white smokes reflect and absorb a lot of light and are harder to see through than black smokes which just absorb light. The reason for bringing in the technical aspects of vision is that a comparison of smokes without knowledge of the how long a distance vision was attempted over (the pathlength) or the mass concentration of smoke is useless. Furthermore, once smoke concentrations get above a certain concentration the human eye is not capable of telling the difference and hence dense smokes all appear to the eye as the same but to proper instruments may be vastly different.

In summary, the comment cannot be confirmed or denied because it is not based on actual data obtained on the correct type of equipment which would be critical to assessing its validity.

REFERENCES

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Jin, T., Report of Fire Research Institute of Japan, Number 33, page 31, 1971.

Blackwell, H.R., J. Optical Society of America, Volume 36, page 624, 1946.

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ANTI-PVC/PLASTICS ALLEGATIONS

ALLEGATION NO. 86

Some fire experts blame the growing deadliness of smoke on increased use of plastics in buildings and furnishings.

RESPONSE

No evidence exists to support such a claim. Carbon monoxide, the proven killer in fires and a combustion product of all organic materials -- natural as well as synthetic, is just as much a problem in fires today as it was before plastics came to be. Fire experts who cite the toxic combustion products of synthetics as the culprits ignore the fact that burning natural materials produce toxic gases as lethal -- or more lethal -- than synthetics. These include hydrogen cyanide (produced by burning wool) and benzene and acrolein (produced by burning wood). Moreover, while the use of synthetics -- particularly plastics -- has grown dramatically over the past forty years, the number of fire deaths actually has decreased.

REFERENCE

Vinyl Institute technical position papers: "Fires of the Eighties — Are They Different?" and "Combustion Gases of Various Building Materials," 1983.

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ANTI-PVC/PLASTICS ALLEGATIONS

ALLEGATION NO. 87

A trash fire in a subway situation could ignite PVC conduit and create a life-threatening situation.

RESPONSE

PVC conduit is made from rigid PVC. Rigid PVC cannot support combustion without an external source of heat being applied at all times. In the section of conduit exposed to the trash fire damage to the conduit could occur, however, because the trash fire is limited in extent (I assume) the amount of external heat being seen by the PVC falls off rapidly as we move away from the trash fire. Because of this fall off of external heat, the PVC will become less and less subject to damage. And because PVC cannot propagate flames by itself without external heat, the damage will be limited to the area around the trash fire.

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ANTI-PVC/PLASTICS ALLEGATIONS

ALLEGATION NO. 88

Profit considerations prevent the development of lower smoke and toxicity products, which industry knows how to make.

RESPONSE

Industry has responded to the alleged need for lower smoke products and has spent many millions of dollars on the development of such products. Products are available from a number of manufacturers including B.F.Goodrich (the Temprite LC materials). These high performance materials may be desirable in some applications but it is not clear based on fire fatality or or measures of the fire problem in the United States that plastics such as PVC are part of the problem. In fact, it would appear to knowledgeable workers in the field that PVC is part of the answer. In terms of profit it is noteworthy that high performance materials command a higher price and normally have higher returns so manufacturers would actually prefer to sell the higher performance materials.

RESPONSE ORIGINATOR -- CONTACT FOR SUPPLEMENTAL INFORMATION

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ALLEGATION NO. 89

Existing tests can separate on the basis of toxicity.

RESPONSE

A number of small-scale laboratory tests have been developed to compare the combustion toxicity of materials. However, none of these have received wide acceptance because of our inability to relate these tests to "real world" fires and "real world" toxic hazard. Furthermore, the results of many tests are so variable that for many materials their combustion toxicity cannot be determined. The many shortcomings of these tests has led groups like the National Fire Protection Association to conclude that no tests are presently available which can assess the combustion toxicity of materials for regulatory/code setting purposes.

RESPONSE ORIGINATOR -- CONTACT FOR SUPPLEMENTAL INFORMATION

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ANTI-PVC/PLASTICS ALLEGATIONS

ALLEGATION NO. 90

When PVC materials are burned in municipal incinerators, they give off dioxine.

RESPONSE

There is not one piece of scientific documentation to support the allegation that poly(vinyl chloride) (PVC) materials directly produce polychlorodibenzo-p-dioxins (PCDDs) or polychlorodibenzofurans (PCDFs) during their combustion in municipal or other waste incinerators. The known chemical synthetic routes to PCDD or PCDF formation involve either chlorophenols, chlorophenates, chlorobenzenes or polychlorobiphenyls (PCBs). For example, the formation of PCDDs and PCDFs in the Binghamton, New York State Office Building fire in 1981 resulted from the combustion of a transformer dielectric mixture of PCBs (65%) and chlorobenzenes (35%). The primary allegation against PVC results on very well documented pyrolysis evidence published by BFG and others that PVC affords hydrogen chloride, benzene and trace levels of chlorobenzenes. Other studies have shown chlorobenzene levels to increase at temperatures above 750°C and to increase with increased chlorination of PVC (CPVC). At best, the only role of PVC in the emission of chlorinated organics from waste incinerators is that of a precursor or source of chlorine. Phenols, resulting from the combustion of biological materials are readily chlorinated at high temperatures to chlorophenols which in turn are converted to PCDDs. Under incineration conditions, chlorobenzenes can be converted to chlorophenols (ultimately PCDDs) and to PCBs (ultimately PCDFs). There is no experimental evidence showing the direct formation of PCDD or PCDF from PVC.

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RESPONSE ORIGINATOR -- CONTACT FOR SUPPLEMENTAL INFORMATION

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ANTI-PVC/PLASTICS ALLEGATIONS

ALLEGATION NO. 91

PCB's are formed in the manufacture of VCl and become incorporated in VCM products.

RESPONSE

Polychlorinated biphenyls, PCBs, are not normally produced in the manufacture of vinyl chloride monomer, VCM. If they occur during process upsets, they appear at a very low level, 0 - 10 ppm, in an intermmediate process stream, and are easily removed during normal separation and purification. By virtue of the great difference in boiling points between VCM (-13.4°C) and PCBs (320°C - 450°C, depending upon the extent of chlorination), and even considering only the last purification step in the manufacturing process, it is clear that any PCBs which might be present in the feed to the multi-tray vinyl fractionating column cannot go up the column, and therefore, cannot possibly be present in the VCM product. An ASPEN (1) computer process simulation of the vinyl column, and the resulting separation efficiency, clearly demonstrates this to be the case. Even using assumptions involving unrealistically high levels of PCBs in the feed to the vinyl column, the product VCM going overhead is free from any PCBs. Since the product VCM does not contain any PCBs, neither can any polyvinyl chloride product which is made from such monomer.

Commercial production of vinyl chloride monomer is based on ethylene and chlorine as the primary feedstocks. Component processes include the direct chlorination of ethylene to produce 1,2 -dichloroethane (EDC), the oxychlorination of ethylene with hydrogen chloride (HCl) and oxygen (O_2) to produce EDC, and the pyrolysis of EDC to VCM and HCl. The combination of such component processes constitutes the so-called "balanced process" for production of VCM from ethylene and chlorine, in which neither a deficiency nor a surplus of HCl occurs. In a typical balanced plant producing VCM from EDC, all the HCl produced in the EDC pyrolysis process is normally used as feed for the oxychlorination process. EDC production is about evenly divided between direct chlorination and oxychlorination. The three principal operating steps used in the balanced process for ethylene based VCM production are shown by the block diagram in Figure 1, and a schematic of the overall process for a conventional plant is shown in Figure 2.

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ALLEGATION NO. 91 - contd.

RESPONSE - contd.

Since all vinyl chloride produced must go through the vinyl column, the last purification step in the VCM manufacturing process, a grossly exaggerated scenario was evaluated in which it was assumed that the feed to the vinyl column contained an unrealistically high concentration of biphenyl, 10% by weight (100,000 ppm). Biphenyl (or diphenyl) was used in this assessment because, compared with PCBs which are chlorinated biphenyls, its physical properties are better known, and because it has even a lower boiling point (255^{o}C). The lower boiling point means that biphenyl is more difficult to remove in the separation and purification process than PCBs would be. In other words if biphenyl is removed, PCBs must also be removed. An evaluation to test for the removal of biphenyl was conducted using the ASPEN computer process simulation of the vinyl column, with no biphenyl in the column feed stream. This model duplicates actual operating data from the vinyl column in the VCM plant.

The result of the simulation of this grossly exaggerated scenario, with 10% by weight biphenyl in the feed to the vinyl column, shows that the concentration of biphenyl in the product VCM would be 5×10^{-36} weight percent, or about $1X10^{30}$ parts per billion. Therefore, the probability of there being PCBs in vinyl chloride is essentially zero for all practical purposes, and the probability of there being PCBs in polyvinyl chloride products is also essentially zero.

(1)The ASPEN (Advanced System for Process Engineering) computer program was developed at M.I.T. between 1976 and 1981 and required over 60 man years of development and $6 million of funding by the U.S. Department of Energy and industry. Therefore, ASPEN is the state-of-the-art computer process simulator and is widely used in the synfuels and petrochemical industries.

SUPPORTING ATTACHMENTS

Fig. 1, "Principal Steps in Balanced VCM Process"

Fig. 2, "Schematic of the Overall Process for a Conventional Plant"

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ALLEGATION NO. 91 - contd.

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RESPONSE ORIGINATOR -- CONTACT FOR SUPPLEMENTAL INFORMATION

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FIGURE 1

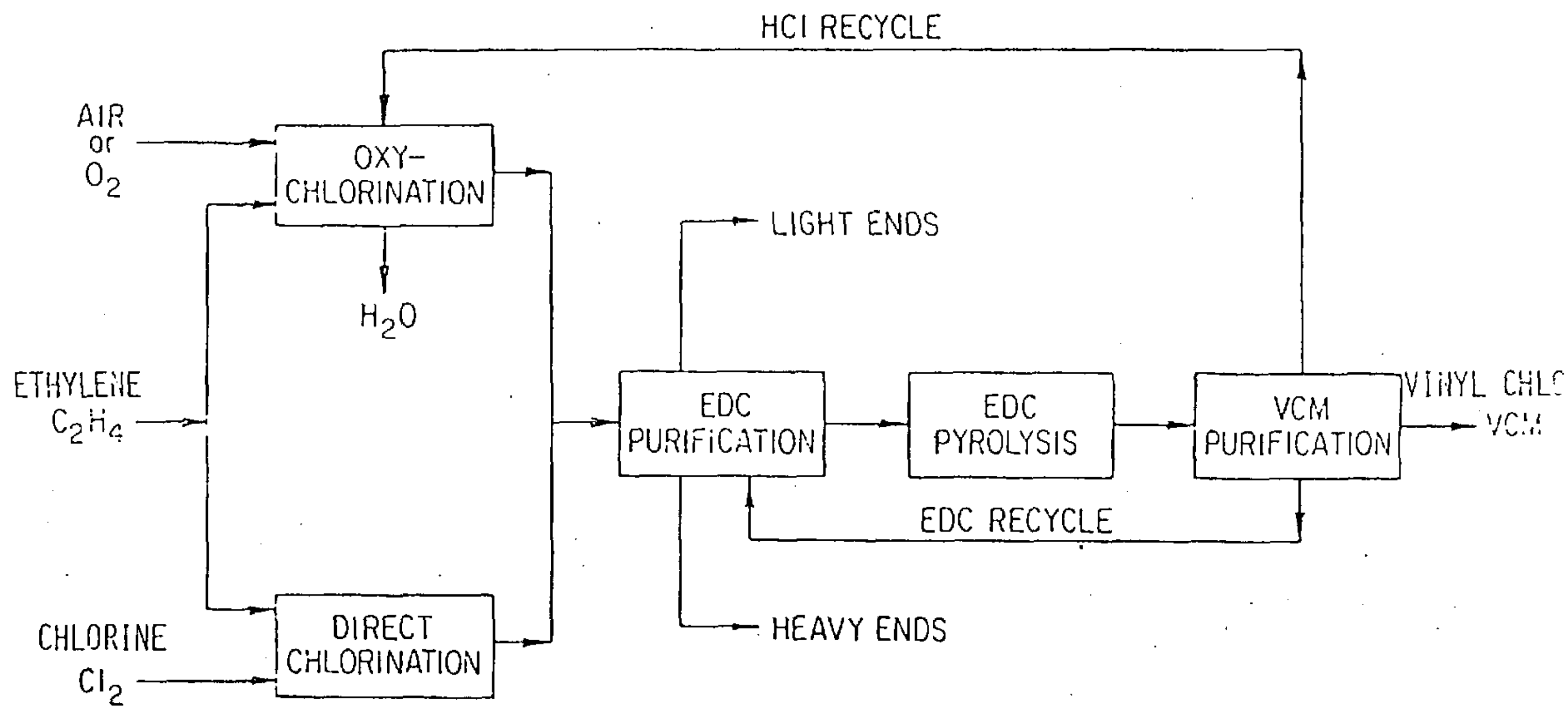

Figure I. PRINCIPAL STEPS in BALANCED VCM PROCESS

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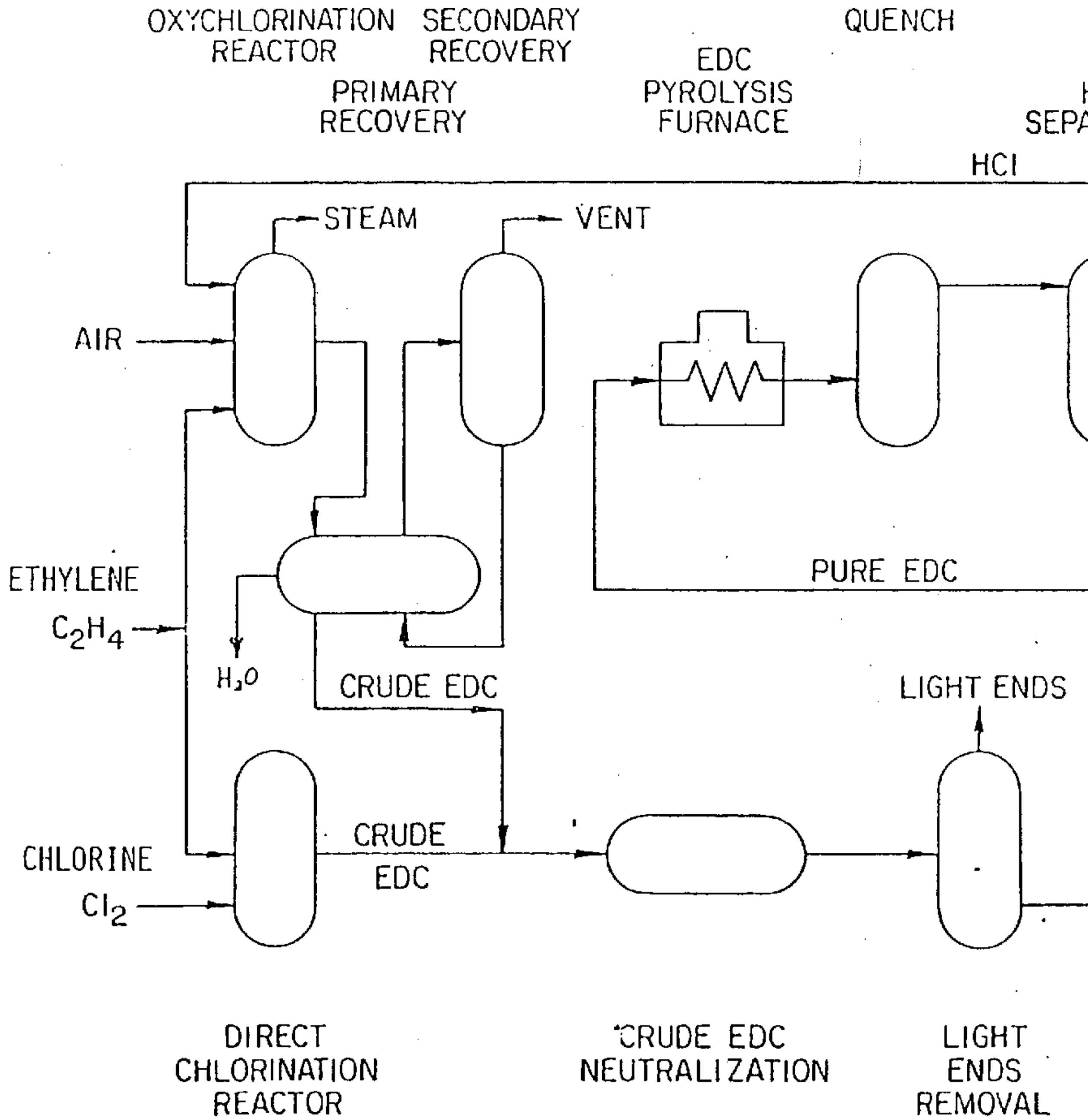
FIGURE 2



OXYCHLORINATION REACTOR
SECONDARY RECOVERY
PRIMARY RECOVERY
EDC PYROLYSIS FURNACE
QUENCH
SEPA
HCl
STEAM
VENT
AIR
ETHYLENE
C_2H_4
H_2O
CRUDE EDC
PURE EDC
LIGHT ENDS
CHLORINE
Cl_2
CRUDE
EDC
DIRECT CHLORINATION REACTOR
CRUDE EDC NEUTRALIZATION
LIGHT ENDS REMOVAL