

Meeting

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OCT 18

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PVC SAFETY GROUP

COMMUNICATIONS COMMITTEE

The International Club
Washington, D. C.

Wednesday, October 18, 1978
10:00 A. M.

There will be a meeting of the PVC Safety Group's Communications Committee on Wednesday, October 18, 1978, at the International Club, 1800 K Street, Washington, D.C., in the Danube Room, beginning at 10:00 a.m. This meeting will cover a number of important issues as outlined in the attached agenda.

Your full participation is needed and we would like you to confirm your plans for attending by calling Ms. Gloria Mollison, 212/573-9400 immediately on receipt of this notice.

It is anticipated that the meeting will adjourn at approximately 3:00 p.m.

Very truly yours,

John R. Lawrence

John R. Lawrence
Technical Director

:GM

cc: D. C. Nuechterlein - Dow Chemical
T. R. Torkelson - Dow Chemical
Matt Swetonic - Hill & Knowlton

Attachment

SPI-08702

HADLEY
10-16-78

agenda

SP

PVC Safety Group Steering Committee
October 18, 1978
10:00 a.m., Dupont Plaza Hotel
Washington, DC

I. Background

- A. Status of EDF v. Train and Views of EPA Regarding EDF Litigation
- B. EPA Cancer Policy Development - Impact on Vinyl Chloride Standard and Litigation

II. National Emission Standard for Vinyl Chloride

- A. Status of Industry Compliance
 - 1. Survey - General Results
- B. Reasons for Non-Compliance
 - 1. Events Beyond a Company's Control
 - 2. Relief Valve Discharges

III. Enforcement

- A. Memorandum on Enforcement of the Standard, June 30, 1978
 - 1. Review of Issues
 - 2. Potential Amendment of the Clean Air Act
- B. EPA Memos Regarding Enforcement
 - 1. General Memo - September 18, 1978
 - 2. Relief Valve Memo
 - 3. Questions Raised with EPA Staff Regarding Enforcement

PVC Safety Group Steering Committee
October 18, 1978

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IV. Future Strategy - SPI Approach or Individual
Company Approach

A. Administrative Options

1. Meet with Washington Enforcement Staff
2. Amendments to Vinyl Chloride Standard
3. Timing

B. Legal Options

1. Immediate Action
2. Subsequent Legal Action

PVC SAFETY GROUP

COMMUNICATIONS COMMITTEE

The International Club
Washington, D.C.

Wednesday, November 29, 1978
10:00 A. M.

S U M M A R Y

- 1 - The talk "PVC and Food Packaging Safety" is in its final stages of approval and completion.
- 2 - The five position papers on PVC are now ready for final clearance. A cost estimate on the preparation of 500 copies of these reports will be prepared by Hill & Knowlton.
- 3 - The revised and approved copy for the Q&A booklet on PVC Health and Safety was reviewed. Hill & Knowlton will develop an estimate on the printing in the newly designed format.
- 4 - The draft of the article on fire hazards intended for nurse readers will be cleared for technical accuracy and efforts will be made to obtain a qualified by-line author.

ATTENDEES:

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Robert B. Downey - CHAIRMAN - B. F. Goodrich Chemical Division, 6100 Oak Tree Blvd. Cleveland, OHIO 44131

John R. Lawrence - SPI - 355 Lexington Avenue, New York, NY 10017

Matt Swetonic - Hill & Knowlton, Inc. 633 Third Avenue, New York, N.Y. 10017

- 1 - Mr. Lawrence reviewed the responses coming from member companies indicating that notwithstanding the letter of October 23, 1978 from Edward E. Reich of EPA giving further enforcement interpretations, that there was a strong desire expressed by more than half the companies for even more specific guidelines with respect to interpretation of the standard on relief valve discharges. Likewise, there is a desire for better guidelines on other enforcement questions relating to such items as operator error, back-up equipment and the like.

Plans have been made for a brief meeting of the Manufacturing Technology Committee on Tuesday, December 5 to prepare for a meeting with EPA's Engineering staff at Durham on December 6. The purpose of this meeting will be to open the way for further discussions with the engineering staff on developing more specific guidelines on enforcement of the VCM regulation. (Mr. Gary Baise and representatives of several member companies will be visiting EPA on December 6 to discuss EPA's generic cancer policy on behalf of the American Industrial Health Council (AIHC).

- 2 - It was agreed that Matt Swetonic would contact the Keller & Heckman office for clearance of the copy on the talk entitled "PVC and Food Packaging Safety", (reference July 20, 1978 cover letter and draft of talk from Matt Swetonic). A listing of slides required for this talk has been prepared by Hill & Knowlton. With a clearance from the general counsel's office, it is expected that final work on this talk can be underway by end of December and completed in January. This will be used in the SPI Speakers Bureau Program.
- 3 - The five position papers covered by Mr. Swetonic's letter of July 27 are now available. All except the Risk/Benefit paper have been reviewed and cleared for release. With clearance of these final papers, it was agreed that plans be made for publishing these in their present format in a single binder. An estimate of the cost for preparing 500 copies will be made by Mr. Swetonic.

The revised and approved copy for the PVC Health and Safety Q&A booklet together with a proposed layout were reviewed. An estimate for printing 5,000 copies will be obtained. If printing is approved, 100 copies will be distributed to each member company with the balance held in reserve at the SPI office.

- 4 - The status of actions relating to the February 1978 fire hazard article in the RN Magazine was reviewed. To date, the SPI letter to the editor has not been published.

The article entitled "Toxic Gases from Fires" appearing in the June 1978 issue of Science Magazine (copy attached) was identified as a strong factual article that to some degree represent a counter action to the RN article.

The draft article prepared by Mr. Gene McLoughlin for possible placement in a nursing publication was discussed. It was agreed that efforts should be made to finalize this article as suggested in Mr. McLoughlin's cover letter of November 15 and John Lawrence's forwarding letter of November 21. (Copy of draft article and letters attached).

- 5 - With respect to future articles such as the RN article and the Popular Mechanics article in September, it was the opinion of the group that little can be done to correct the errors and damage done by such articles after they are published. Letters to the editor serve little purpose other than to give the sender the feeling of being a responsible spokesman for the plastics industry.

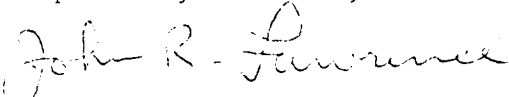
It was agreed that SPI should continue its efforts to have positive, factual articles on the relative role of plastics hazards in fires published. It was also suggested that some thought be given to the preparation of an information bulletin that might cover subjects such as "The Role of Plastics in Fire", or "What you should know about plastics fires". Such a bulletin could be widely distributed and specifically sent to publications reporting on fire hazards to aid in correcting erroneous statements. As in the case of fires themselves, the best solution is prevention of the publication of erroneous information rather than to fight the problem once it has developed.

- 6 - It was pointed out that the actions being filed against the California Air Resources Board are moving slowly. Stauffer filed its case in July and it is expected that B. F. Goodrich and SPI will file before year end. SPI will file as amicus curiae as agreed at the August 8 meeting of the PVC Safety Group's Steering Committee.

There will be no need for public relations activities on this action unless there are media inquiries which will be handled on a case by case basis.

- 7 - Mr. Lawrence reported that the ad hoc Risk Assessment Committee is working with Jerry Heckman's office to develop a position paper that would hopefully set aside the FDA proposal of 1975 to ban rigid and semi-rigid PVC for food packaging. This work will not be completed until sometime early next year.
- 8 - It was also noted that the various misstatements of information with respect to vinyl chloride during the OSHA generic carcinogen hearings were commented on in SPI's post-hearing filing in October.
- 9 - The meeting adjourned at 1:00 p.m.

Respectfully submitted,



John R. Lawrence
Technical Director

Enclosures
December 1, 1978

SPI-08707

Toxic Gases from Fires

James B. Terrill, Ruth R. Montgomery, Charles F. Reinhardt

According to ancient Greek mythology, Prometheus suffered extreme torture for giving men heavenly fire. However, without fire it is difficult to envision how humans could have advanced beyond the caves. As people crowded together in cities, the occasional, unwanted fire problem escalated drastically. Some dramatic examples include the Great Fire of London in 1666, the Chicago Fire in 1871, and the destructions of Tokyo, Dresden, and Hamburg during World War II.

Frequent fires in American cities

certed efforts of materials suppliers, fire-fighting officials, fire code groups, and the insurance industry.

In the United States today, fire exacts an annual toll of some 8000 to 9000 deaths and property losses amounting to some \$3 billion to \$4 billion (2). The survivors may also experience severe anguish. Approximately 70 percent of the 1976 fire deaths occurred in residential fires. To reduce this fire fatality rate, it will be necessary to assess the potential life hazard from dwelling fires or fires in general. The factors leading to fire tox-

Summary. The major lethal factors in uncontrolled fires are toxic gases, heat, and oxygen deficiency. The predominant toxic gas is carbon monoxide, which is readily generated from the combustion of wood and other cellulosic materials. Increasing use of a variety of synthetic polymers has stimulated interest in screening tests to evaluate the toxicity of polymeric materials when thermally decomposed. As yet, this country lacks a standardized fire toxicity test protocol.

stimulated efforts to test the fire performance of materials to minimize potential fire damage. The American Society for Testing and Materials (ASTM) accordingly devised the first scaled test procedures: door fire resistance [ASTM E-152 (1940)] and wall fire resistance [ASTM E-119 (1917)], ignition resistance [ASTM D-1692 (1959)], and flame spread [ASTM E-84 (1950); E-162 (1960)] (1). These procedures were devised through the con-

icity must be examined. This knowledge must then be applied toward developing reliable test procedures that will make it possible to evaluate the potential of a combustible material to create an extraordinary toxic gas hazard in a fire.

The total life hazard in fires results from a composite of at least four interlocking and variable sets of conditions, as shown in Fig. 1 (3). A few decades ago, the main lethal factors were frequently identified as burns, hot gases, and smoke poisoning. Disastrous fires such as the Cleveland Clinic fire in 1929 (4), the Cocoanut Grove fire in 1942 (5), the Hartford Circus fire in 1944 (6), and the S.S. *Noronic* fire in 1949 (7) raised serious questions about how people die

in fires. These and other fires resulted in more detailed fire investigations that, together with laboratory experiments with animals, made it possible to begin to identify the lethal factors in fires.

Epidemiologic Study

The first major epidemiologic study was retrospective. The Columbia Presbyterian Hospital team led by Zikria (8) conducted an extensive analysis of autopsy records of New York City fire victims during 1966 and 1967. Carbon monoxide (CO) poisoning was noted in 70 percent of all victims with a primary diagnosis of smoke poisoning or asphyxia. Among victims who died in less than 12 hours, 59 percent of the 70 percent who were tested had lethal or significant exposure to CO as determined by the blood carboxyhemoglobin (COHb) concentration (COHb is stable in postmortem tissue); CO poisoning was found almost equally in the presence or absence of surface burns (in 50 percent of the victims with burns and 39 percent of the victims without burns).

An ongoing epidemiologic study was started in September 1971 under the joint auspices of the Johns Hopkins University Applied Physics Laboratory and the Maryland State Medical Examiner's Office (9, 10). This study was limited to autopsied victims who died within 6 hours after a particular fire. Data obtained from more than 200 victims through the end of 1974 (9) indicate that 50 percent died from CO poisoning (COHb > 50 percent); 30 percent died from CO poisoning plus contributory factors such as heart disease, alcohol, or burns; 10 percent died from causes other than CO poisoning (probable laryngeal spasm, burns, or heart failure); and 10 percent died from undefined causes.

Hydrogen cyanide (HCN), hydrogen chloride (HCl), and other gases associated with the thermal decomposition of synthetic materials did not appear significant in the deaths of the Maryland fire victims. Synthetic materials likely to produce such gases were "the primary articles burning in only 5% of the fires reported" (9).

Dr. Terrill is group leader of the Inhalation Section, Department of Medicine and Environmental Health, Monsanto Company, St. Louis, Missouri 63166. Ms. Montgomery is an information specialist at the Haskell Laboratory for Toxicology and Industrial Medicine, E. I. du Pont de Nemours and Company, Wilmington, Delaware 19898. Dr. Reinhardt is director of the Haskell Laboratory. Dr. Terrill was formerly at the Haskell Laboratory.

Other investigators have raised the specter of a significant contribution by HCN (11) or HCl (12) to fire deaths. Unequivocal data on the effects of HCN in fire victims are meager and open to question because HCN can be either generated or consumed in postmortem blood (13). The determination that death is due to HCl in fire smoke is difficult, but for different reasons: HCl cannot be measured directly in the blood. In the few cases where deaths due to HCl have been reported, the conclusions appeared to have been reached on the basis of the course of pulmonary injuries sustained, low COHb concentrations, and the limited number and type of materials involved in the fire. Further studies to assess the relative importance and specific action of these and other toxicants have been recommended (3).

Perhaps the continued epidemiologic evidence pointing to CO as a cause of death in fires results from the large use of cellulosics (wood, paper, and cotton) in today's existing buildings. Will other toxicants, such as those listed in Table 1 (14), become significant problems in the fires of the future?

Basic Fire Physiology

Laboratory experiments with simulated fires involving animals (15) began during World War II. Goats were tethered in a mock bunker that was sprayed with flamethrowers; fuel fires were also statically ignited inside a mock bunker. This program was established to study the mechanisms of the deaths in victims without burns that had occurred in poorly ventilated bunkers neutralized by flamethrowers. Zapp (15) found that the basic lethal factors were heat, oxygen (O_2) deficiency, CO, and combinations thereof in the order of importance: $CO > \text{heat} > O_2$ deficiency.

Generally accepted 5-minute lethal values for the individual factors are 200°C , 0.5 to 1.0 percent CO, or 6 percent O_2 . Exposures for 15 minutes to 125°C , 0.3 percent CO, or 17 percent O_2 are usually not fatal but are associated with physiologic impairment.

Kinetic studies for human exposure to CO show a rapid uptake and also a rapid elimination (16). In healthy sedentary adults the biologic half-life is in the range of 5 hours at sea level. Vigorous treat-

ment with O_2 will accelerate clearance of CO from the blood. The half-life may then be approximately 2 hours even in patients with smoke poisoning (17). The relationship between the presence of CO and the depletion of O_2 from the blood is additive. Hemoglobin (Hb) has a greater affinity for CO than O_2 , and CO can displace O_2 from Hb: $HbO_2 + CO \rightleftharpoons HbCO + O_2$.

Work by other investigators in the 1950's and 1960's showed that a variety of toxic gases (3, 18) could be produced by the burning of various building products. The physiologic action of typical toxic gases and the sources capable of producing the respective gases are listed in Table 1. Many scientists believe that the state of the art is now sufficiently advanced to permit toxicologic evaluation of these fire gases in a variety of full-scale test situations.

Test Conditions

The fire phenomenon is commonly illustrated as the fire triangle (Fig. 2a). The combination of varying amounts of

Table 1. Sources and physiologic effects of selected thermodecomposition gases other than CO and CO_2 [see (14)]; ppm, parts per million.

Sources of thermodecomposition gases*	Highlights of physiologic effects	Estimate of short-term (10-minute) lethal concentration (ppm)
<i>Hydrogen cyanide (HCN)</i>		
From combustion of various products such as wool, silk, polyacrylonitrile, nylon, polyurethane, and paper, in varying amounts; flammable; difficult to analyze accurately	A rapidly fatal asphyxiant poison; toxicity suspected in some recent fires involving upholstery and fabrics but no definitive data	350
<i>Nitrogen dioxide (NO_2) and other oxides of nitrogen</i>		
Produced in small quantities from fabrics and in larger quantities from cellulose nitrate and celluloid (prepared from cellulose nitrate and camphor, in decreased use today)	Strong pulmonary irritant capable of causing immediate death as well as delayed injury; notorious from the 123 deaths in the 1929 Cleveland Clinic fire caused by burning "nitrocellulose" x-ray films	>200
<i>Ammonia (NH_3)</i>		
Produced in combustion of wool, silk, nylon, and melamine; concentrations generally low in ordinary building fires; inorganic combustion product	Pungent, unbearable odor; irritant to eyes and nose	>1000
<i>Hydrogen chloride (HCl)</i>		
From pyrolysis of some wire insulation materials such as polyvinyl chloride (PVC), also chlorinated acrylics and retardant-treated materials.	Respiratory irritant; potential toxicity of HCl coated on particulate greater than that for an equivalent amount of gaseous HCl	>500, if particulate is absent
<i>Other halogen acid gases</i>		
From combustion of fluorinated resins or films and some fire-retardant materials containing bromine	Respiratory irritants	HF ~ 400 COF ₂ ~ 100 HBr > 500
<i>Sulfur dioxide (SO_2)</i>		
From compounds containing sulfur; the common oxidation product of such components in fires	A strong irritant, intolerable well below lethal concentrations	>500
<i>Isocyanates</i>		
From urethane isocyanate polymers; these pyrolysis products, such as toluene-2,4-diisocyanate (TDI), have been reported in small-scale laboratory studies; their significance in actual fires is undefined	Potent respiratory irritants; believed the major irritants in smoke of isocyanate-based urethanes	~ 100 (TDI)
<i>Acrolein</i>		
From pyrolysis of polyolefins and cellulosics at lower temperatures (~ 400°C); significance, if any, in actual fires is undefined	Potent respiratory irritant	30 to 100

*All these gases can be lethal in sufficient concentration. In most common fire situations, these combustion gases would be expected to act as contributory to death rather than as primary causes of death.

will not occur when there is a substantial deficiency of any of the three ingredients. Both in small-scale tests and in full-size fires, this combination varies widely. Dramatically different combustion product profiles may result, as shown in Table 2 (19). In a screening test procedure, only a few points may be selected within the triangle model, as shown in Fig. 2b (20). We list below some pertinent variables (20).

Selection of animals. Species, sex, number, weight, age, and strain are basic variables in any toxicologic experiment.

Duration of exposure. This is one of the most critical of all test variables. Heat stands out as the unavoidable limiting factor in real fires, and the interval until such heat is generated becomes an absolute maximum for exposure. In small-scale tests an arbitrary, generalized exposure time is selected.

Chamber temperature. The animal chamber must be maintained below the temperature that will produce lethal or appreciable contributory stress from heat.

Oxygen. If the chamber atmosphere is overwhelmed by fire effluents, the O₂

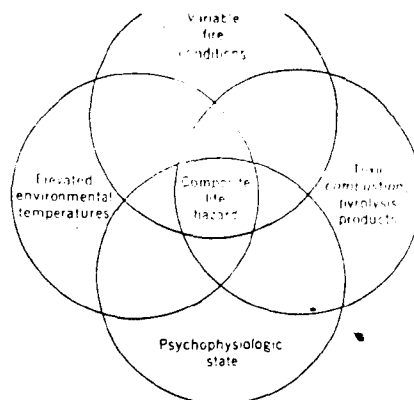


Fig. 1. Composite hazard to fire victims (3).

concentration will dip suddenly and critically in experimental tests.

Exercise. Voluntary or forced exercise is an arbitrary selection in animal tests. In real fires, exposed individuals may engage in sudden vigorous activity that can add significant stress, particularly in the case of persons with coronary disease. Activity can also increase the respiration rate, which will increase the rate at which gaseous toxicants enter the blood.

Animal observations. These may include clinical data, neurologic examina-

to monitor concentrations of COHb and cyanide (CN), and pathological examination, depending on the scope of the test. (Incapacitation is here understood as the lack of capacity to escape from a fire).

Mode of sample decomposition. This is perhaps the most complicated test variable. The combustion pyrolysis conditions specify the particular mechanisms selected to generate a fire toxicity atmosphere and will directly influence the temperature and fire gas atmosphere.

Configuration of test material. Shape, form, and density can affect heat and O₂ supply.

System configurations. These are the arrangement and use of the test apparatus other than that used for actual combustion/pyrolysis. Specifically, these include the lengths of connecting tubes in the apparatus other than that used for actual combustion/pyrolysis; the lining of the chamber and connecting tubes; and the venting, recycling, heating, dilution, or flow rate of gases given off during combustion.

Selection and sensitivity of analytic methods. These are governed by the scope of the tests as well as by the methods available. Analytic data should be

Table 2. Effects of oxygen supply, temperature, and heating rate on varying combustion products of polyvinyl chloride (homopolymer; molecular weight, 109,000; mesh size, 80) [see (19)]. Combustion products are expressed in milligrams per gram of product.

Compound	Variation with O ₂ supply			Variation with temperature					Variation with heating rate	
	Air (30 cm ³ / min)	Air (60 cm ³ / min)	Air (25 cm ³ / min) + O ₂ (21 cm ³ / min)	25° to 280°C	280° to 350°C	350° to 430°C	430° to 510°C	510° to 580°C	(3°C/ min)	(50°C/ min)
CO ₂	861	619	814		9.7	181	244	237	619	397
CO	357	429	401		20	46	151	181	429	269
Methane	6.7	4.7	3.8		0.20	1.3	1.8	0.31	4.7	8.7
Ethylene	0.76	0.53	0.28	0.04	0.33	0.39			0.53	2.3
Ethane	2.6	2.1	1.7		0.12	0.94	0.41		2.1	3.5
Propylene	0.80	0.53	0.28	0.06	0.11	0.31			0.53	1.5
Propane	1.3	1.0	0.66		0.08	0.44	0.11		1.0	1.3
Vinyl chloride	0.51	0.59	0.66	0.04	0.25	0.17	0.02		0.59	0.64
1-Butene	0.25	0.18	0.06	0.02	0.04	0.08			0.18	0.67
Butane	0.53	0.31	0.15		0.03	0.20	0.02		0.31	0.69
Isopentane	0.02	0.02	0.01			0.005	0.001		0.02	0.02
1-Pentene	0.10	0.08	0.04		0.01	0.03			0.08	0.18
Pentane	0.26	0.20	0.11		0.01	0.08	0.01		0.20	0.29
Cyclopentene	0.07	0.05	0.03		0.02	0.01			0.05	0.19
Cyclopentane	0.08	0.07	0.03		0.01	0.02			0.07	0.11
1-Hexene	0.07	0.06	0.03		0.01	0.02			0.06	0.13
Hexane	0.16	0.14	0.09		0.01	0.05	0.01		0.14	0.20
Methylcyclopentane	0.06	0.05	0.03			0.02			0.05	0.08
Benzene	35	31	32	24	6.6	0.35	0.16		31	43
Toluene	1.5	1.1	0.68	0.12	0.18	0.55	0.03	0.01	1.1	3.5
HCl	580 ± 5. "Independent of air conditions and accounts for nearly all the chlorine atoms of the polymer" (19, p. 388)			"Production of HCl . . . roughly parallels that of benzene" (19, p. 388)					"The heating rate has no significant effect on the amount of HCl produced" (19, p. 389)	

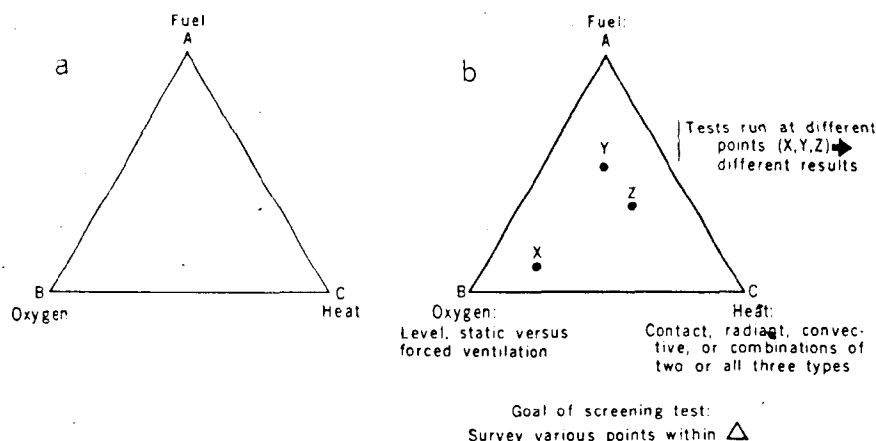


Fig. 2. Traditional fire triangle (a) and fire triangle as a test model (b) (20).

correlated with biologic data rather than used independently in an attempt to "determine" the composite toxicity of a polymer from thermal degradation.

Likely end-use conditions. Whether proposed use of the test material is minimal or extensive, industrial or consumer, in the furnishings or structurally concealed in many buildings, can, in many cases, govern the type of testing warranted. As a particular example, compare the use of textile fibers in draperies to their use in carpets.

End-use conditions are included as a factor because a screening test should simulate a real fire and should, if aimed at comparing various materials, evaluate them all under similar constraints. Specific uses may require consideration of additional factors, such as (i) the amounts of test material, compared to the amounts of other materials that may also be present; (ii) the rate of combustion of the test material in a fire; (iii) the nature of the actual combustion, non-flaming or flaming; (iv) the rate of ventilation; and (v) the ease of egress.

Coordination of research results has not yet generated a combustion gas toxicity test that would be useful in screening programs for identifying materials with an extraordinarily toxic potential. More than a dozen different laboratory test methods were described in the National Academy of Sciences' recent review (18) of small-scale combustion/pyrolysis methodologies. Moreover, some procedures appear to have been adopted solely on the basis of the reproducibility of results (precision) or the equipment currently available in the investigator's laboratory, not the parameters of the actual fire.

The importance of test design is strongly underscored by the study of Cornish *et al.* at the University of Michigan (21), in which the ranking order,

based on the toxicity of gases given off in a test with ten common materials, literally depended on the test procedure. Subsequently, Hilado at the University of San Francisco and Crane at the Federal Aviation Administration in Oklahoma City—both using a tube furnace for sample decomposition—reported a distinct variation in their comparative ranking "best-to-worst" for seven materials (22). Each used slightly different conditions, such as different airflows and different amounts of sample, but the pyrolysis temperature and heating mode were the same.

The dependence of the off-gas profile on the pyrolysis temperature is further illustrated by specific studies of polyvinyl

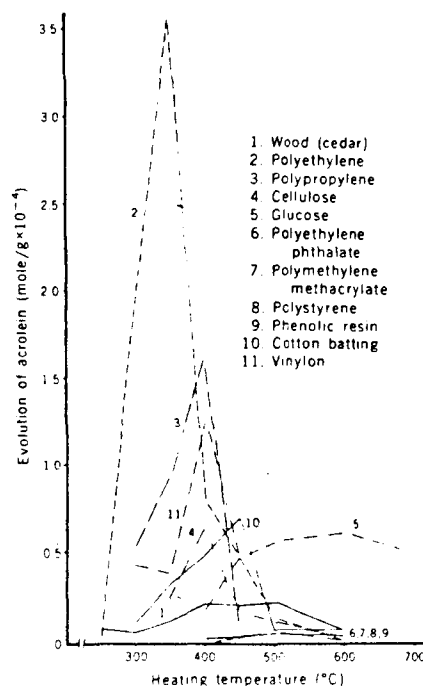


Fig. 3. Evolution of acrolein from various materials, based on a sample weight of 500 milligrams (23).

chloride (PVC), polyurethane, and polyolefins. With PVC, HCl is released between 200° to 400°C as well as at higher temperatures (Table 2). The yield per gram of polymer is independent of heating rate and ventilation. However, these two parameters, as well as temperature, strongly affect the production of CO from PVC (19). In the case of the polyolefins, Fig. 3 (23) shows that production of acrolein, which is highly toxic, occurs only over a fairly narrow temperature range.

Polyurethane products contain both carbon and nitrogen. Woolley and Fardell (24) report that peak yields of HCN are typically observed at 800°C. Toxicologically important isocyanates were found in low-temperature (300°C) pyrolysis but are destroyed at 800°C (24). Combustion/pyrolysis data obtained with other nitrogenous polymers at > 650°C (25, 26) also show the strong dependence of HCN production on temperature.

Temperatures in full-scale fires vary widely, and therefore some full-scale fire tests, such as with these three products, appear needed in order to assess the significance of quantitative small-scale combustion gas toxicity data. Nevertheless, several standard combustion/pyrolysis toxicity test methods have now been formulated or are being currently explored. Germany specifies a pyrolysis method based on an annular, revolving combustion furnace for all construction materials (27). Samples are rated on the basis of the lowest temperature (typically 300° to 600°C) causing death in exposed rats. The French test (28) that became effective on 10 January 1977 applies only to synthetic polymers that are used in the furnishing or construction of public buildings and contain nitrogen or chlorine atoms. Materials are scored on their chlorine or nitrogen content and relative flammability; no animal exposure is required. In this country the National Bureau of Standards is currently engaged in a cooperative effort with some 20 organizations from government, academia, and industry to develop a screening test based primarily on the combustion system of Potts and Lederer (29).

Further variations in test methodology and experimental sophistication are evident in methods used to determine incapacitation—the lack of capacity to escape from a fire—as a test end point. Considerable attention has recently been given to neuromuscular dysfunction, which in fire situations is primarily due to various forms of tissue anoxia. One or more physiologic mechanisms may be in-

volved, but the net result is the same—loss of the individual's own capacity to escape from a fire before being burned or otherwise killed. Nonfatal but elevated blood concentrations of CO and HCN have been correlated with neuromuscular dysfunction determined by failure in tests with mechanically rotated activity wheels (30), with rotating rods (31), and in conditioned avoidance as leg-flexion response (32). Data obtained with rats exposed to the pyrolysis/combustion off-gases of 75 materials used in aircraft shows that the time to loss of function was roughly two-thirds of the time to death (30).

Another approach for determining incapacitation of the fire victim is to study overwhelming irritation of the eyes and nose. Although the physiologic effect of irritants as riot control agents is well understood, the contribution of these irritants to incapacitation in humans exposed to smoke remains undefined. Mice exposed to upper-respiratory irritants exhibit a characteristic pause in respiratory expiration and an overall decrease in the respiratory rate. Alarie and his co-workers (33) have used this technique to predict the potential irritation to humans of smoke from various polymers. However, subsequent work by Potts and Lederer (34) indicates that the concentration of red oak smoke predicted on the basis of tests with mice as "intolerable" to human volunteers was only irritating; they were clearly *not* incapacitated. Thus, further understanding of this mouse-to-human extrapolation appears necessary before this technique can be used in a quantitative manner to evaluate a variety of materials.

Conclusion

Overall, the most concise statement on screening tests comes from the National Academy of Sciences' subcommittee (18, p. 28): "acceptable screening tests to evaluate the relative toxicities of polymeric materials are not available. All present methods have one or more shortcomings. Many of the methods described in this report were designed for research; they were not intended for use as screening methods." This committee went on to give detailed recommendations on testing for methodologies. In their recommendations for research, particular emphasis was placed on developing a simple reproducible technique for assessing incapacitation.

Future Trends

We appear to be at a crossroads in the development and acceptance of a meaningful small-scale screening test that would identify combustible materials having great potential to yield large amounts of toxic agents. Three pathways can be followed. One way would be to abandon consideration of such a test because the variability of actual fires prohibits the selection of fixed testing conditions. A second way would be to adopt an available test, simply to have a test, immediately. The third way would be to continue additional research and to refine existing methodology toward a useful preliminary screening test. The third is the only viable choice. Real protection of the public is essential, but no generally acceptable test protocol exists at the present time.

A clear blueprint for development of such a first-tier screening test is contained in the report from the National Academy of Sciences (18). These guidelines are an integral part of a national commitment to reduce this country's fire death toll. In conjunction with the safe use of the many new exotic types of materials in our built environment, "men of good intent" must work together to construct a first-tier toxicity screening test. Such a test (used in conjunction with other fire performance tests) would denote materials that generate significant quantities of highly toxic gases when pyrolyzed or burned. Some material suppliers may forego the expense of testing, unless some minimal testing regulations come into effect. Furthermore, we need to obtain significant scientific advancement within a finite time period, preferably the next decade. It is therefore imperative to have nationally funded, well-managed test projects with clear objectives, technically qualified personnel, and realistic goals.

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SPI-08712

HILL AND KNOWLTON, INC.

633 THIRD AVENUE
NEW YORK, N. Y. 10017
212-697-5666

Memo to: Ed Collins, SPI

Date: November 15, 1978

From: J. Eugene McLoughlin

Copies: D.G. Hearle

Subject: Nursing Article

Here is a draft of an article which attempts to straighten out, for nurses, the known facts about treating fire victims for inhalation injury. I have done this solely on readily accessible research material in our files and without discussion with medical and fire authorities. It definitely needs careful review by both.

In addition, this article needs two more sections:

1. On page 8 there is reference to a list of things nurses can do to save their own lives and the lives of others if caught in a structural fire. This can and should be obtained from the National Fire Protection Association in Boston, and the article should give proper credit.
2. On the last page, I have exhausted my own references on symptoms and treatment except for the RN layout and I don't think we wish to use that as a reference. This section should be expanded by the physician or a nurse who is familiar with the procedures.

Is there anything further you want me to do on this project?

J.E.M.

mr
Enclosure

SPI-08713

Hill and Knowlton, Inc.

Article on Inhalation Injury

November 15, 1978

"Warning: The Surgeon General Has Determined That
Furniture Smoking Is Hazardous To Your Health."

Furniture smoking?

Yes, furniture smoking. Or, if you wish, put in your own
substitute for cigarettes. Draperies. Carpets. Newspapers.
Clothing. Lumber. Lampshades. Plastics. In fact, anything
that will burn.

Except for the fact that the Surgeon General was dealing
with what he then perceived to be a specific situation which
needed urgent and special attention, he might well have been
counseled to extend the cigarette smoking warning label to
every organic product in our environment. Because they all
can burn. Anything that burns can represent a threat to life
safety.

The direct threat to life is not so much from the flames
themselves but, rather, what the flames produce. In 1973, the
National Commission on Fire Prevention and Control produced a
report titled "America Burning" ¹ which contained this description
of "How to Die in a Fire:"

"Most people, when they think of fire as a killer, think of flames. Those who have set fire safety standards for materials have emphasized flame resistance. Yet, in a list of the five ways in which fire can kill, when arranged in declining importance, flames rank last.

"Asphyxiation. Fire consumes oxygen from the surrounding atmosphere, thus reducing its concentration. If the oxygen concentration falls below 17 percent, thinking may be an effort and coordination difficult. Below 16 percent, attempts to escape the fire may be ineffective or irrational, wasting vital seconds. With further drops, a person loses his muscular coordination for skilled movements, and muscular effort leads rapidly to fatigue. His breathing ceases when the oxygen content falls below 6 percent. At normal temperatures, he would be dead in 6 to 8 minutes.

"Attack by superheated air or gases. With temperatures above 300°F., loss of consciousness or death can occur within several minutes. In addition, hot smoke with a high moisture content is a special danger since it destroys tissues deep in the lungs by burning.

"Smoke. Inhalation of smoke -- or, more correctly, of the products of incomplete combustion -- kills people who suffer no skin burns at all. In addition to carrying toxic products, such as carbon monoxide and hydrogen cyanide, thick smoke may be laden with organic irritants, such as acetic acid and formaldehyde. In the early stages of a fire, the irritants, which attack the mucous membranes of the respiratory tract, are often the more important danger. Smoke often blocks the visibility of exits.

"Toxic products. Many toxic components of smoke are responsible for the damage done -- including oxides of nitrogen, aldehydes, hydrogen cyanide, sulfur dioxide, and ammonia, to name only a few. There is ample evidence that the hazard of two or more toxic gases is greater than the sum of the hazards of each. Moreover, low oxygen and high temperatures increase the toxic effects. In addition to toxic gases that attack the lungs, there are irritants that attack the eyes with blinding effect, preventing escape. Some fire gases dull the senses of the victim or his awareness of injury.

"Flames. Since the aforementioned factors can debilitate, confuse, blind, or kill without warning, the person who goes to sleep confident that advancing flames will provide sufficient warning for escape may be taking a fatal gamble.

"Until such time as all five of these hazards have been well-studied and controlled by materials standards, too little will have been done to control the built environment and thus reduce the gamble Americans take in their daily lives."

Five years after that report was published, the nation is making perceptible progress toward a fire safe environment.

To achieve this aim we, as a nation, have taken a number of steps. Possibly the most promising has been in the direction of automatic detection and warning. Very simply, this means installation of devices in our homes and other places of occupancy which will discover a fire in its early stages and signal human occupants to vacate the premises. There

may be no other more effective single step that can be taken to protect life in a structural fire.

A second step we have taken has been in the direction of fire testing of materials on a large scale that simulates, to a more accurate degree than laboratory tests, the behavior of materials and construction assemblies in actual fire situations.

Most people, ranging from those who have fought real fires to those who studied the chemistry of fire degradation in the laboratory, are quite ready to concede that the more we learn about fire, the more we need to learn about it. No two real world fires are identical. But we are beginning to be able to predict, within some broad parameters, how a certain material or a type of assembly will behave in certain real fire situations.

A third step -- directly stemming from step two -- has been the development of materials and assemblies and structural configurations which are designed to reduce hazards from unwanted fires.

A fourth has been in the development and dissemination of materials which are designed to inform and educate you and me in the fire hazards that may confront us and how to cope with them.

Finally, as a nation, we have taken significant steps in development of our techniques in treating fire injuries -- not just burns but inhalation damage.

This treatise mainly concerns steps four and five. Briefly, we will tell you, as a nurse, how to help save your own life and the lives of others caught in a structural fire. Next we will tell you what symptoms, other than external burns, you should be aware of in fire victims. Finally, we will provide a suggested range of treatment.

The one thing to remember in all of this discussion is that every victim of a fire, whether he or she has visible burns or not, has inhaled an alien atmosphere. As "America Burning" pointed out, it could be a reduced concentration of oxygen, super-heated air or gases, smoke, or toxic products of combustion. Or it could be a combination of any or all of them. That makes for a complicated diagnosis.

WHERE WILL THE FIRE OCCUR?

The National Fire Prevention and Control Administration has instituted an ambitious undertaking to determine, statistically, who are fire victims, how they become fire victims, where they are most likely to be exposed to a fire accident, and why. It is not an easy undertaking because so many fires go unreported, and others are inadequately reported. But a picture is beginning to emerge.

Most people, if asked where fire takes its greatest human toll, will cite mass human tragedies -- 602 dead in the Iriquois theater fire in Chicago in 1903, 492 killed in Boston's Cocoanut Grove fire in 1942, 145 victims in the Triangle Shirtwaist Factory fire in New York in 1911. Or they will mention some of the major transportation crashes and fires.

But the NFPCA has determined that if you are caught in a fire, you probably will not be in a factory or a nightclub or a theater or an office building or an airplane. You will be in your own home.

"Roughly two-thirds of fire deaths occur in ones and twos in the victims' own homes," says the NFPCA.² "Less than 4 percent of fire deaths occur in multiples of five or more at a time. The residential danger has been underappreciated, perhaps because of the publicity surrounding major fires. In fact, only a small fraction of deaths (for example, 7 percent in California and Ohio) are in commercial or institutional places such as nightclubs, schools, jails, offices, or nursing homes."

Based on limited data from Ohio and California, the NFPCA says the most frequently reported cause of residential fires leading to deaths and injuries is smoking, mostly cigarettes, and cooking. Together they account for about half of the deaths and a third of the injuries in residential fires.

One rather common characteristic of serious accidental residential fires is that ignition occurs when nobody is there to detect it. The human body is an extraordinarily good fire detection and alarm system. It can feel heat, hear combustion, see and smell smoke, and sound the alert.

Automatic fire detection and alarm systems represent man's efforts to duplicate that system. However imperfect in comparison, they have saved many lives and injuries by sensing fires and sounding the alert in early stages of combustion. Aside from prevention of ignition in the first place, early detection is the most important factor in life safety.

There are two critical concepts the layman -- well known by the professional firefighter -- should keep in mind about fire: (1) a seemingly innocuous fire can, under proper conditions grow to astounding proportions at a rapid rate, and (2) fire gases and smoke can incapacitate and kill at some distance from the fire source.

These two principles lead inevitably to the most crucial action the non-professional firefighter can take in case of fire: isolate yourself and others from the source of the hazard.

Ideally, this means leaving the structure quickly. If you have others in your care, your concern will be to get them out with you.

Beginning with our residences, where most of the fire problem lies, every household should be concerned with pre-planning in case of accidental fire. Such pre-planning should include means of alarm, alternate means of escape, and a central place of assemblage for all members of the household who reach safety. There have been too many tragic instances of individuals going back into burning buildings in futile efforts to save a family member who already escaped.

Because of the unusual problems associated with fires in health care facilities -- such as nursing homes and hospitals -- pre-planning plays an even more important role.

As the National Fire Protection Association points out, movement of certain patients, even for short distances, can be accomplished only with great difficulty, and evacuation may be impossible without seriously jeopardizing a patient's survival.³

"In these respects, the hospital resembles a ship at sea or a high rise building," NFPA says. "It is far better to keep the fire from the patient than to remove the patient from the fire. Thus, hospital design and operation must incorporate methods by which fires may be detected early, contained, and fought rapidly and successfully. Early alarm, containment, horizontal evacuation, and rapid extinguishment are essential; they require careful consideration in hospital design as well as operation."

If we all lived and worked in ideal fire-safe environments, we would not have to worry. But we don't. Our surroundings are packed with organic materials which burn, and our fire detection, alarm and suppression systems have not yet reached the point of where we are totally protected.

As a nurse, you probably do not have a great deal to say about fire safety in design, either for residences or for health care facilities. That is a fact of life, not a criticism of the system. Comes the revolution, maybe things will be different.

However, you do have control over "operation," meaning the handling of yourself and others -- whether they be patients or members of your own family -- in fire situations.

On page____, you will find a list of things to do which may help save your own life and the lives of others in your care if caught in a structural fire. These are guidelines only, and not meant to replace your own good judgement. Every real fire situation is different, and each will require a slightly different priority for action. But if you firmly fix in your mind the

possible courses of action, you will be more likely to take the life saving measures most appropriate to those particular conditions.

AFTER THE FIRE

Every nurse, at some time in her career, has had to handle a burn patient. In extreme cases, there may be no more difficult or frustrating type of injury with which a nurse has to deal. Because of the highly visible nature of burns, medicine has made great progress in treatment of exterior burns. Not so with internal damage which may be caused by products of combustion other than flames.

In spite of its significance, inhalation problems associated with fire received little attention in the medical literature up to a dozen years ago. In 1967, three midwestern physicians reported case histories which demonstrated "the variable course of this entity and the need for individualized care of the victims."⁴

"Of particular importance," they wrote, "is recognition of the 6- to 48-hour latent period which may ensue before complications of acute bronchial obstruction, pneumonia, pulmonary edema, and eventual cardiopulmonary failure develop. Management may require tracheostomy, prolonged intermittent positive-pressure breathing with appropriate concentrations of oxygen and high humidity, and, when indicated, administration of systemic antibiotics and steroids. Frequent arterial blood gas measurements are essential for proper evaluation in these

cases, both to delineate the status of the patients and to guide and determine the effectiveness of therapy. If victims of smoke inhalation can be managed through the acute phases of their illness, they often make a complete recovery."

Perhaps coincidentally, the first major epidemiologic study to identify the lethal factor in fires was done by a team at Columbia Presbyterian Hospital in New York which conducted an extensive analysis of autopsy records of New York City fire victims during 1966 and 1967.⁵ Carbon monoxide (CO) poisoning was noted in 70 percent of all victims with a primary diagnosis of smoke poisoning or asphyxia, and almost equally in the presence or absence of surface burns.

An ongoing epidemiologic study begun in 1971 by the Applied Physics Laboratory of Johns Hopkins University and the Maryland State Medical Examiner's office obtained data from more than 200 autopsies of victims who had died within 6 hours of fire exposure through 1974.^{6,7} The study indicated that half the victims died from CO poisoning and 30 percent from CO poisoning plus contributory factors such as heart disease, alcohol or burns.

Other gases, such as hydrogen cyanide (HCN) and hydrogen chloride (HCL) associated with the thermal decomposition of some plastics and some natural materials, did not appear significant in these deaths.

It has been suggested by some investigators that with increasing uses of plastics -- and, consequently, increasing involvement of synthetic materials in fires -- HCN, HCL and, perhaps, other gases pose a significant new threat to life safety.

Terrill, et al,³ report that such suggestions are open to question at present:

"Unequivocal data on the effects of HCN in fire victims are meager and open to question because HCN can be either generated or consumed in postmortem blood. The determination that death is due to HCl in fire smoke is difficult, but for different reasons; HCl cannot be measured directly in the blood. In the few cases where deaths due to HCl have been reported, the conclusions appeared to have been reached on the basis of the course of pulmonary injuries sustained, low COHb concentrations, and the limited number and type of materials involved in the fire."

At the present time the evidence indicates that most fire victims brought to a health care facility for treatment will have been exposed to products of combustion of a variety of materials, both natural and synthetic, and that the primary inhalation problem will be some degree of carbon monoxide poisoning. This may be complicated by the patient having been exposed to an atmosphere of superheated air or gases, an oxygen deficiency, smoke, and other toxic gases.

Your focus on treating the problem might change if you knew that the victim -- a fireman, for example -- had been severely exposed to products of combustion of a concentration of a single type of material. For example, a storeroom full of burning wool clothing would emit large amounts of HCN or a vault jammed with PVC cables would emit large amounts of HCl. Even then, however, CO should be the prime suspect.

The current state of science requires us to conclude that the only uniform features in the toxicology of burning plastics are those of the toxicology of fire -- heat, carbon monoxide, deficiency of oxygen, other combustion gases, and smoke.⁹

It may be somewhat comforting to note that prompt and proper therapy can be very effective in handling inhalation cases. A report by five physicians on the treatment of firemen involved in a high-rise fire in Los Angeles in 1974 states:

"We recently studied 21 Los Angeles firemen, 19 of whom developed transient acute hypoxemia following exposure to a fire in a high-rise office building in which large amounts of PVC were combusted. These same firemen were re-evaluated one month following the fire to ascertain any possible effects on pulmonary function as a result of this episode of inhalation of smoke. In light of previous studies suggesting impairment in pulmonary function as a consequence of fighting fires, we were surprised to find that our group of Los Angeles firemen had relatively few respiratory symptoms, as well as remarkably normal pulmonary function, compared with published predicted values."

TREATMENT OF INHALATION VICTIMS

That experience will not always hold true for all cases, of course, particularly where there has been substantial and prolonged exposure to an alien fire atmosphere and where proper treatment has been delayed or ignored.

An important consideration to keep in mind is that symptoms of carboxyhemoglobinemia (carbon monoxide poisoning) and hypoxia (deficient oxygenation of the blood) may not show up for hours after exposure.

Nurses should be aware of the need to administer oxygen routinely as soon as possible -- preferably humidified -- and to observe the patient closely for cerebral complications of CO¹⁰ and respiratory insufficiency which may ensue after a deceptively tranquil interval.¹¹

(copy on specific symptoms and treatment to be added)

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The Society of the
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November 21, 1978

Mr. Robert B. Downey
B. F. Goodrich Chemical Company
6100 Oak Tree Blvd.
Cleveland, OHIO 44131

Dear Bob:

I am attaching a copy of a draft article prepared by Gene McLoughlin discussing the health effects of victims exposed to fires. This in fact is the draft article prepared in an attempt to respond to the article appearing in an RN magazine earlier this year.

I believe that Gene has gone a long way toward developing the basis for an article that could be very useful. I believe that this article and general plan on how we could finalize it should be discussed at the PVC Communications Committee meeting on November 29.

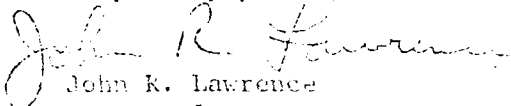
I believe that in addition to the specific suggestions made by Gene in his cover letter, that the article should be carefully critiqued by medical and industry specialists. For this reason, I am sending copies to Messrs. Johnson and Tanzilli.

I further believe that it will be very important for us to obtain a qualified medical person who would be willing to stand as the author of the article in whatever modified form may be mutually agreed upon. One suggestion for an author might be Dr. Anne W. Phillips who you may recall is head of the National Smoke, Fire and Burn Institute, Inc., in Boston, Massachusetts. There may be other medical authors we should consider before approaching anyone.

It will also be important to develop a strategy for convincing a publication like the Journal of Nursing that this is an appropriate article for their readers. My familiarity with this Journal is such that I can say is not as technical as most other articles and, therefore, might not be acceptable unless we can sell them on the importance of this information for all nurses.

I will be looking forward to our discussion of this matter at our November 29 meeting.

Very truly yours,


John R. Lawrence
Technical Director

Encl.

SPI-08728

cc: Messrs. M. N. Johnson - B. F. Goodrich •
J. Tanzilli - B. F. Goodrich
E. Collins - SPI
G. McLoughlin - Hill & Knowlton
D. Hearle - Hill & Knowlton

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