Appendix A

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Dr. Roy T. Gottesman
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Dear Dr. Gottesman,

December 4, 1989

The enclosed report, prepared at the request of the Vinyl Institute Technical Committee, contains a fairly detailed analysis of the test method for Toxic Hazard, developed under the auspices of the National Institute for Building Sciences (NIBS).

In brief, we think that the hazard concept advanced by the method, the so called IT_{50} concept, has three big flaws:

1. The significant differences it shows among products (except, perhaps, those associated with PTFE-coated wire) are due almost entirely to experimental conditions which suppress the amount of carbon monoxide formed to levels well below those one would expect under the full-scale conditions the method tries to duplicate. If more realistic test conditions could be employed, most of the differences observed among products would disappear.

2. The IT_{50} cannot predict toxic hazard, or the contribution of any single product to toxic hazard, if more than one product is burning.

3. The IT_{50} scale is compressed and thus the experimental errors of the measurements are a sizeable fraction of the apparent differences found between products.

We do not believe these flaws in the IT_{50} can be corrected without sacrificing some of the method's other desirable features - notably that which exposes all products to the same thermal conditions.

Even without the IT_{50}, however, the radiant apparatus used offers an attractive alternative to existing methods. Besides permitting uniform exposure conditions, in a well designed apparatus, it uses a radiant heat source and can be used for assembled end-use products in addition to single materials. Finally, it can be used to measure ignition time and mass loss rate as well as toxic potency. These three properties are key elements of toxic hazard, even though the form in which they are used implicitly in the present version of the test - the IT_{50} - is not a good one.

In view of the foregoing facts, we recommend the following:

1. That the Vinyl Institute support the NIBS test <u>apparatus</u> as the basis for an eventual ASTM test method for obtaining some of the component measurements needed for toxic hazard;

2. That the Vinyl Institute oppose inclusion of the IT_{50} in any submission to ASTM or in any subsequently-developed ASTM procedure;

3. That the Vinyl Institute participate actively in the proceedings leading to the final development of the test method.

Very truly yours,

F. B. Clarke

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NIBS Toxicity Test

Frederic B. Clarke and Marcelo M. Hirschler

I. Introduction and Background

The basic philosophical background behind the proposed NIBS test was that smoke toxic potency tests should not be used in isolation to regulate the fire performance of materials or products. Standard toxic potency tests measure the toxicity of the smoke from small amounts of materials, burnt under conditions which are different for each material, being based on the characteristics of the material. This means that they suffer from, at least, three major shortcomings. These are: (1) the characteristics which enhance the fire performance of a material, e.g. very low ignitability, are ignored; (2) such tests are not, generally, designed to allow for the testing of products in their final use form; and (3) the conditions under which the test is carried out may produce a spectrum of products with toxicity quite different from those formed under real full-scale conditions.

It has become widely accepted that smoke intoxication in a real fire scenario is based on at least three factors. These are: (1) the mass loss rate, or the concentration of airborne combustion products,

generated by a burning item, (2) the time to ignition (i.e. the time until such combustion products are being generated) and (3) the toxic potency of the smoke under the fire conditions of interest.

The NIBS toxicity test was intended to incorporate, implicitly or explicitly, the three factors cited above as essential for smoke toxicity and to remedy the three major objections to toxic potency tests. This document was prepared to examine how well the current version of the test succeeds in meeting these expectations.

The NIBS test was developed by a Working Group which decided to simulate post flashover conditions, because fire statistics indicate that most fire victims die in fires which are known to have left the room of origin. The NIBS test approaches the estimate of potential toxic hazard by an implicit combination of the three factors mentioned earlier. This implicit estimate has been designated as the median sample irradiation time needed to kill 50% of the exposed animals, or IT_{50}. The chosen test conditions are a radiation level of 5 W/cm^2, and a relatively high (>16%) oxygen content. Irradiation is ended when sufficient smoke has been produced to kill animals by the end of the 30 minute total exposure (and 14 days post-exposure).

Alternative proposals to the IT_{50} concept have been made which identify means for making such a combination by explicit measurements of each factor [1,2].

II. Analysis

A. Carbon Monoxide

The principal toxicant in fires is carbon monoxide, which is responsible for the overwhelming majority of fire fatalities. Therefore, a smoke toxicity test needs to be able to produce the yield of carbon monoxide, or the carbon monoxide/carbon dioxide ratio, accurately in order to be able to represent real fire scenarios.

It is possible to calculate the CO/CO_2 ratios (r) determined in many of the products tested in the NIBS apparatus, using the present protocol. They are shown in Table 1. (The basis for the calculation, including assumptions made, are explained in detail in Appendix A). Most flashover fires occur in ventilation-limited scenarios where there is excess fuel. In such full scale tests, or fires, there is a significant volume of work which reports CO yields or CO/CO_2 ratios. Some examples of CO yields are shown in Table 2.

A comparison of the results of Tables 1 and 2 shows that the majority of the NIBS tests yield CO/CO_2 ratios which are lower than 0.05, while the full scale tests yield values ranging from 0.15-0.8. This indicates that the NIBS test produces only 1/3 to 1/15 of the CO that flashover fires would produce.

This discrepancy is particularly important in light of the fact that, in such scenarios, the production of CO is affected mainly by variables such as geometry, ventilation, configuration and mixing, and only somewhat (second order) by the chemical composition of the product being burned [3]. The most important aspect of CO production which is related to the fuel is its volatilization rate.

Experience also shows that in full scale tests where flashover is achieved, as the flux passes 4 W/cm^2, the oxygen level in the room (coming out the door) is near zero. This is the rule, rather than the exception, and such conditions differ both qualitatively and quantitatively from those under which the NIBS test is being run. The oxygen is too high and the CO produced is too low to simulate flashover. This is unlikely to make much difference in materials whose smoke toxicity depends on gases such as HCl, HF or HCN, but it severely understates the relative hazard of CO producers, and thus overstates the effects of those products that generate other gases.

Table 3 presents a calculation of the range of fractional effective dose (FED) of the smoke from the NIBS tests, based on the assumption (reasonable estimate) that 30 mg/L is a lethal dose for 30 min exposure times. Table 4 contains an estimate of the lethal smoke dose, which can be calculated from the data supplied by the NIBS Working Group together with the only 12 NIBS product test results released to date (for details of the calculations see Appendix B).

It is clear from Tables 3 and 4 that the NIBS smoke, especially for CO producers, is much less toxic than most smokes are known to be near flashover (and as measured by other tests). This is a consequence of the intense burning conditions, which cause relatively complete combustion of many of the products, thus decreasing the toxicity of their smoke when compared to that in real fires.

B. Methodological Problems

It is instructive to estimate the effect of potentially lower values of toxic potency on the IT_{50}. Table 5 contains a tabulation of "A", the IT_{50} value if the lethal smoke dose, the $L(Ct)_{50}$ were one third of the observed value (calculated in Table 4). Such lower values are, by no means, extreme. They range from a low of 210 mg-min/L, for painted mineral fibreboard to a high of 1500 mg-min/L for formica/particle board. For comparison, the toxic potency of Douglas fir is generally taken to be 900 mg-min/L (the reported LC_{50} value for a 30 minute exposure; this same value was used for all products in the calculations of Table 4). The value for Douglas fir calculated for Table 5 (after dividing by 3 the observed value from the NIBS test) is quite close to this: 830 mg-min/L.

Inspection of Table 5 shows that substituting a more toxic smoke for the smoke measured in the NIBS test compresses the values of the IT_{50} of all 12 samples into a range of less than 4 minutes. The experimental value of the IT_{50} has a precision of not less than ± 1 minute, so that the uncertainty of the measurement is half the range of all the values into which the measurement can reasonably be expected to fall. This is not a robust or highly-discriminatory decision-making tool.

The analytical expression for IT_{50} (see Appendix B) contains, but the IT_{50} by itself is not, a readily understandable index of hazard. It has two major shortcomings. First, its scale is more compressed where products are more hazardous, i.e. where toxic dose is low and mass loss is high. A disproportionate share of the range of the IT_{50} is applicable only to relatively inert products. This can be seen in Figure 1, where $(IT_{50} - t_i)$ is plotted against X, the ratio of the $L(Ct)_{50}$ to the mass loss rate: the lower the value of X the more hazardous the product (assuming a constant ignition time, t_i).

It should also be clear that reducing the incident radiant flux in the test method, and thereby the mass loss rate, will move a number of the better-performing products off the scale, to the right (i.e. towards low toxicity). This is not, strictly speaking, a misleading result, because it indicates that the toxicity threat from such products in many real fires is negligible.

It is unlikely, however, to satisfy those who are searching for a scale which will accommodate the toxic hazard of the full range of common products.

The second shortcoming is an outgrowth of the fact that the IT_{50}, to the extent that it has any applicability at all, aims to provide an index of hazard under intense fire conditions, where virtually everything combustible exposed will burn. A reasonable gauge of toxic hazard under such conditions would be the rate of generation of the lethal toxic dose of the total smoke from the burning compartment. This can be calculated as:

$$dF/dt = \Sigma^{N} (A_j \dot{m}''_j)/L_j = \Sigma (A_j/X_j)$$

in which the summation is made over all N combustibles, each of them with an exposed surface area A_j and a value of the X ratio X_j. Thus, while the summation of the X values of all combustibles can yield the toxic hazard of the total smoke, the IT_{50}, by contrast, cannot readily be rendered into a form proportional to X_j. It does not, therefore, lend itself either to prediction of the total room fire hazard or to any give product's relative contribution to that hazard.

III. Discussion and Conclusions

The development of the NIBS test was fueled, in large measure, by shortcomings in toxic potency tests, especially when the latter are used alone as a basis for regulation. In particular, the NIBS test sought to: (1) expose all products to the same thermal conditions; (2) work well for products in their assembled, or composite form; (3) provide at least a heuristic measure of toxic hazard, i.e. take account of the product's other fire properties besides toxic potency which bear on the threat from its smoke in a real fire. The method produced has, consequently, a unique set of features, but it also has its own set of resulting flaws. Among those flaws afflicting the method itself are the following:

1. The post-flashover conditions aspired to have not been attained. The thermal conditions of flashover can be duplicated but the ventilation conditions of flashover cannot readily be duplicated by this test in its present design.

2. The test produces conditions under which carbonaceous materials generate only a fraction of the carbon monoxide they would produce under real flashover conditions, making them look better than they should, in comparison to materials whose toxic potency is relatively unaffected by ventilation.

Among those flaws associated with the IT_{50} are the following:

1. The comparatively low toxic potency of smoke from products whose principal toxic agent is carbon monoxide is the principal reason that there is any significant differentiation of products by IT_{50}. Calculating the IT_{50} using toxic potencies characteristic of what would be observed if the products were exposed to the low oxygen levels associated with flashover causes almost all significant differences in IT_{50} to disappear.

2. The IT_{50} concept is a compressed scale of performance; the imprecision of measurement is so large in comparison to the magnitude of the quantity being measured that the IT_{50} is a poor predictor of hazard.

3. The IT_{50} formulation is necessarily based on flashover conditions, which means that everything combustible in the compartment is burning. To gauge the contribution of a given product to the overall toxic threat in such a scenario, the index used should be capable of additivity, i.e. the index of each component product should be summable to the index of the complete fire. The IT_{50} lacks this property.

The foregoing facts make clear, the authors believe, that more work is needed if the NIBS test is to approach the expectations which led to its development.

To be sure, the IT_{50} concept, which attempts to account for fire properties beyond toxic potency, depends for much of the utility it was expected to have upon an inherently unrealistic set of combustion conditions. The second anticipated advantage of the NIBS test, exposure of all materials to the same thermal conditions, has not yet been convincingly demonstrated. Indeed, the penalty the method extracts for exposing all products to the same conditions is that those conditions are necessarily contrived, and the results misleadingly favor one group of products, the CO producers, over another. Making the conditions more realistic will have another set of penalties, as yet unexplored.

There might be some merit in using the NIBS apparatus in an alternative operating manner. For example, the toxic potency could be measured by varying the amount of material exposed (rather than the irradiation time) and this accompanied by measurements of the time to ignition and the mass loss rate. Such results could then be used for an explicit calculation of a potential toxic hazard parameter replacing the IT_{50}. This approach is being investigated at the Center for Fire Research at NIST.

The correct way to compare the fire performance of products is, of course, fire hazard assessment, which may require toxicity data as input. The IT_{50} parameter cannot be employed as an explicit input into fire hazard or fire risk assessment procedures or models; its only foreseeable application is for control of materials or products based on toxicity, and for this purpose it has been found flawed. On the other hand, the explicit calculation of a toxic hazard parameter has the advantage that the individual properties measured can be used for fire hazard assessment.

Stripped of the special features intrinsic in the present operating manner, the NIBS test is simply an apparatus, employing a radiant combustion source, for the determination of toxic potency. There is a good deal of sentiment favoring such an apparatus as an alternative to most of the other existing methods, since it can accommodate assembled products and is thought to offer a more realistic method of heating the sample. It should be noted, however, that considerable data must be developed before such an apparatus can be expected to be widely adopted or to have much utility for standards making organizations.

References

1. M.M. Hirschler, J. Fire Sci. 5, 289 (1987).
2. V. Babrauskas, Int. Conf. "FIRE: control the Heat - Reduce the Hazard," Fire Research Station, October 24-25, 1988, London, UK, paper 7.
3. V. Babrauskas, R.H. Harris, R.G. Gann, B.C. Levin, B.T. Lee, R.D. Peacock, M. Paabo, W. Twilley, M.F. Yoklavich and H.M. Clark, "Fire Hazard Comparison of Fire-Retarded and Non-Fire-Retarded Products," NBS Special Publ. 749, July 1988, National Bureau of Standards, Gaithersburg, MD.

Table 1

Value of CO/CO_2 ratio, r, for NIBS test samples

#	Sample	Test ID	Minimum value	Maximum value
1	PVC conduit	1.1	1.8	1.8
2	PVC wire	2.5	0.15	0.19
4	Form/Part brd	4.2	0.027	0.028
4	Form/Part brd	4.3	0.16	0.17
5	Ptd Min Fibrbrd	5.3	0.24	0.24*
6	Nylon carpet/PU	6.1	0.034	0.36
7	Wool carpet/felt	7.1	0.023	0.026
7	Wool carpet/felt	7.3	0.063	0.068
8	Cotton Polyureth.	8.2	0.032	0.035
9	Cotton/FR PU	9.3	NA	0.137
9	Cotton/FR PU	9.4**	0.42	0.46
10	Cotton/liner/PU	10.1	0.21	0.22
11	ABS cabinet	11.3	0.038	same
11	ABS cabinet	11.2	0.059	0.061
12	FR Douglas fir	12.2	0.21	0.21*
12	FR Douglas fir	12.3	0.83	0.83*
13	D fir plywood panel	13.2	0.035	0.037
13	D fir plywood panel	13.3	0.059	0.067

* No flame

** Light cotton

Table 2

CO yields or CO/CO_2 ratios

	CO Yield g/g	CO/CO_2 ratio	Reference
Flashover-			
limited ventilation		0.10	BSI
FRCA/NBS study	0.18-0.23	0.18-0.21	Babrauskas et al, 1988
NBS basement tests		0.26-0.34	Clarke
Wood post-flashover			
fires	0.3-0.36	0.27-0.5	Beyler
Simulation of Sharon, PA,			
nursing home fire		0.1-0.4	NIST
Cable tray fires		0.1-0.5	Hirschler et al.
Post-flashover model	0.3	0.5	Mulholland
PMMA enclosure fire	1.2	0.75	Beyler
Natural gas enclosure	0.6	0.6	Zukoski

Table 3

Lethality of NIBS Smoke and Fractional Effective Dose

(FED Based on LC_{50} of 30 mg/L)

	Product	Smoke conc. mg/L	FED –	Deaths (out of 6)
1	PVC conduit	11.8	0.4-0.4	3
	PVC conduit	47.8	1.6-1.7	6
2	PVC wire	40.1	1.3-1.5	0
	PVC wire	42.9	1.4-1.6	0
	PVC wire	64.5	2.2-3.0	6
4	Form/Part brd	75.4	2.5-2.8	0
	Form/Part brd	108.4	3.6-4.2	0
	Form/Part brd	170.1	5.7-6.7	6
5	Ptd Min Fibrbrd	24.0	0.8-1.0	0
	Ptd Min Fibrbrd	29.4	1.0-1.3	0
	Ptd Min Fibrbrd	28.9	1.0-1.3	2
6	Nylon carpet/PU	31.4	1.0-1.1	0
	Nylon carpet/PU	59.9	2.0-2.1	6
7	Wool carpet/felt	131.4	4.4-4.8	6
	Wool carpet/felt	90.7	3.0-3.4	2
	Wool carpet/felt	107.3	3.6-4.1	6
8	Cotton Polyureth.	78.1	2.6-2.9	0
	Cotton Polyureth.	100.4	3.3-3.9	6
	Cotton Polyureth.	101.1	3.4-4.0	3
	Cotton Polyureth.	104.7	3.5-4.2	6
9	Cotton/FR PU	66.3	2.2-2.4	0
	Cotton/FR PU	81.0	2.7-2.9	1
	Cotton/FR PU	96.9	3.2-3.6	5
	Light Cotton/FR PU	89.4	3.0-3.3	6
10	Cotton/liner/PU	65.3	2.2-2.4	1
11	ABS cabinet	47.6	1.6-1.7	3
	ABS cabinet	71.3	2.4-2.6	6
12	FR Douglas fir	88.4	2.9-3.2	0
	FR Douglas fir	128.3	4.3-4.8	1
	FR Douglas fir	130.4	4.3-5.0	6
13	Plywood panel	89.5	3.0-3.2	0
	Plywood panel	89.3	3.0-3.2	0
	Plywood panel	91.2	3.0-3.4	6

Table 4
Results of Calculations Using Data from the NIBS Test

#	Product	Test ID	NIBS Test Data t_i (min)	IT_{50}* (min)	$\dot{m}$ (g/min)	L (mg-min/L)
1	PVC conduit	1.1	0.6	1.5	8.0	1400
2	PVC wire	2.5	1.3	15.0	1.0	1500
4	Form/Part brd	4.3	1.4	7.5	5.2**	4500
5	Ptd Min Fibrbrd	5.3	0**	>15.0	0.4**	630
6	Nylon carpet/PU	6.1	1.2	2.5	6.7	1700
7	Wool carpet/felt	7.1	0.5	6.0	3.3	2900
8	Cotton Polyureth.	8.2	0.5	9.0	2.2	2600
9	Cotton/FR PU	9.3	0.5	4.5	3.9	2700
10	Cotton/liner/PU	10.1	0.6	4.5	3.2	1900
11	ABS cabinet	11.2	2.0	3.5	7.1**	2100
12	FR Douglas fir	12.3	0**	7.0	3.5**	3400
13	D fir plywood panel	13.3	0.5	6.0	3.0	2500

* Estimated from animal lethality
** no ignition observed; $\dot{m}$ is somewhat overstated.

Table 5
Effect of Lower Toxic Potency on the IT_{50}

#	Product	Test ID	Z* (min)	IT_{50}** (min)	L/3 (mg-min/L)	A (min)
1	PVC conduit	1.1	0.9	1.5	470	1.0
2	PVC wire	2.5	13.7	15.0	500	4.8
4	Form/Part brd	4.3	6.1	7.5	1500	3.4
5	Ptd Min Fibrbrd	5.3	>15.0	>15.0	210	3.7
6	Nylon carpet/PU	6.1	1.3	2.5	570	1.8
7	Wool carpet/felt	7.1	5.5	6.0	970	2.6
8	Cotton Polyureth.	8.2	8.5	9.0	870	3.3
9	Cotton/FR PU	9.3	4.0	4.5	900	2.1
10	Cotton/liner/PU	10.1	3.9	4.5	630	1.9
11	ABS cabinet	11.2	1.5	3.5	700	2.7
12	FR Douglas fir	12.3	7.0	7.0	1130	2.3
13	D fir plywood panel	13.3	5.5	6.0	830	2.4

* $Z \equiv IT_{50}$ - Time to Ignition; see Table 4.
** Estimated from animal lethality.

Appendix A

Estimate of CO/CO_2 ratios in the NIBS test

Assumptions

1. CO production in the NIBS test looks like one of the curves in Figure 1. It begins at t_i and stops at t_c. The time of cessation of CO production, t_c, lies between flameout time, t^{fo} and IT, time when irradiation is stopped.

2. The system is leak-free: CO and CO_2, once produced, do not escape.

As a consequence of assumption 1, the minimum value of ß, the final CO level, is $[CO]_1$, and the maximum value is $[CO]_2$, with the value somewhat in between:

$$[CO]_1 \leq ß \leq [CO]2$$

The area under the CO production curve is measured and reported as the CO 30 minute Ct product. The integration (of [CO] dt) is carried out between time = t_i and 30 min, along curve 1 or curve 2. Assuming no leaks, each curve is a trapezoid, with an area of:

$$\text{Area} = 0.5\ (b_1 + b_2) * h,$$

where h is the final CO concentration. Thus:

$$[CO]_1 = 2 * Ct/[(30 - t_i) + (30 - t_{fo})]$$

and

$$[CO]_2 = 2 * Ct/[(30 - t_i) + (30 - t_{IT})]$$

Since the chamber does not leak, the measured maximum concentration of CO_2 is also its final concentration and:

$$[CO]_1/([CO_2] \text{ max}) \leq \beta/([CO_2] \text{ max}) \leq [CO]_2/([CO_2] \text{ max}).$$

The calculated range of τ, using this approach, is reported in Table 1 for each of the 12 NIBS products with sufficient reported results.

Appendix B

Mathematical aspects of the NIBS test

1. Analytical expression of IT_{50}

The IT_{50} is the sum of the time required for the sample to burn appreciable mass loss (t_i) and the time required to produce a lethal level of smoke (Z).

$$IT_{50} = t_i + Z.$$

The lethal smoke concentration is produced during the irradiation period and exposure is continued for the balance of the 30 min exposure. Hence, the lethal concentration-time product, over a 30 min period starting at t_i, can be expressed as:

$$L(Ct)_{50} \equiv L = \text{Integral(between 0 and Z)}[c(t)dt] + [c(Z)(30-Z)]$$

Assuming that the mass loss rate is constant with time, between t_i and IT, with V the volume:

$$c = (\dot{m}*t)/V$$

$$L = (1/V)[\tfrac{1}{2}*\dot{m}*Z^2 + \dot{m}*(30Z - Z^2)]$$

The resulting quadratic equation can be solved, for the unknown Z, yielding:

$$Z = 30 - \sqrt{(900 - [(2LV)/\dot{m}])}$$

(since the other root is greater then 30 min, and is, thus, impossible) and

$$IT_{50} = t_i + 30 - \sqrt{(900 - [(2LV)/\dot{m}])}$$

2. Estimates of toxic potency

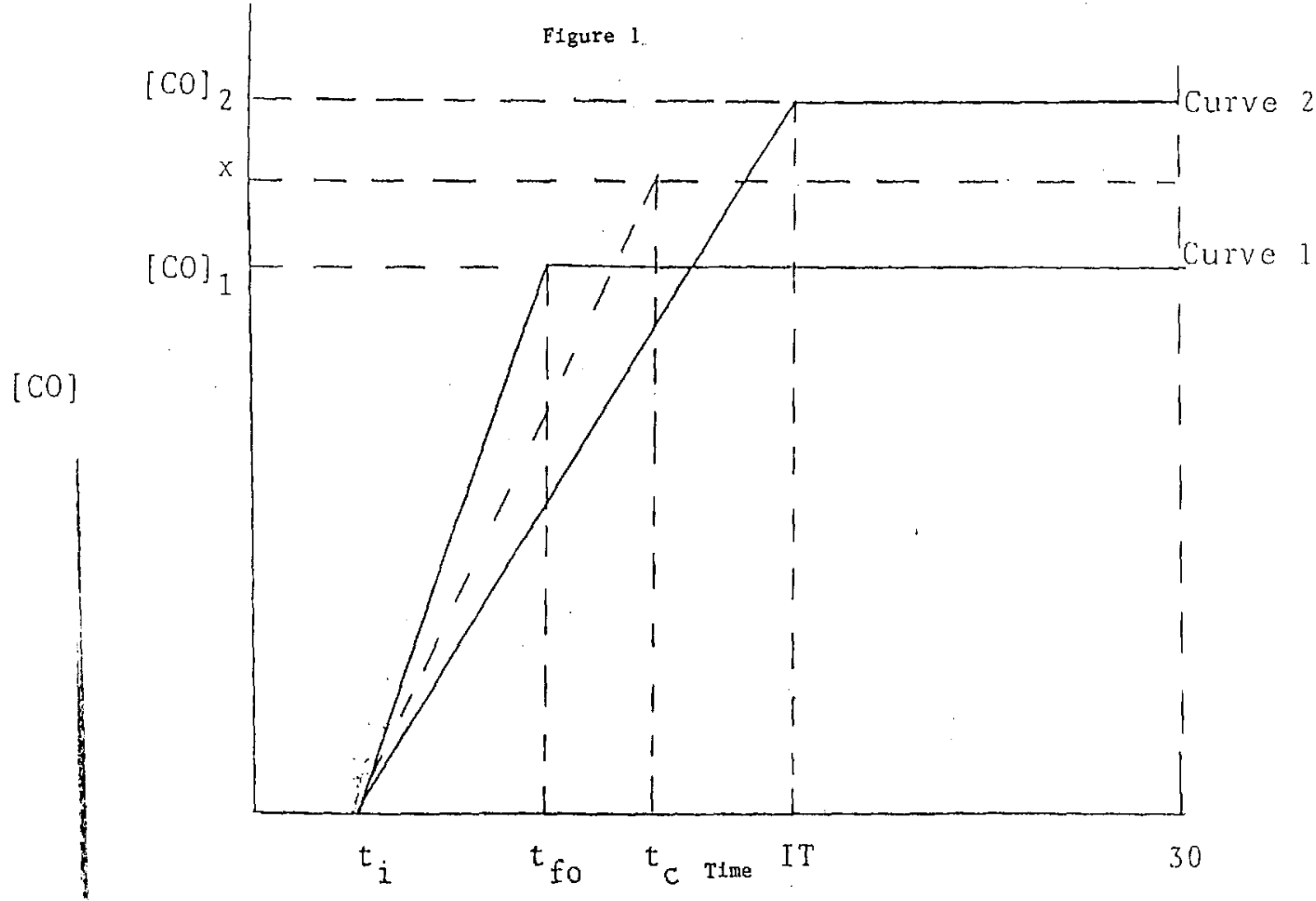
The values of IT_{50} (rough) and t_i and data to calculate $\dot{m}$, are all available for the 12 products for which full NIBS results have been reported. The foregoing expression can, thus, be evaluated for L.

$$Z = IT_{50} - t_i$$

$$L = (1/2V)*[\dot{m}*Z*(60-Z)].$$

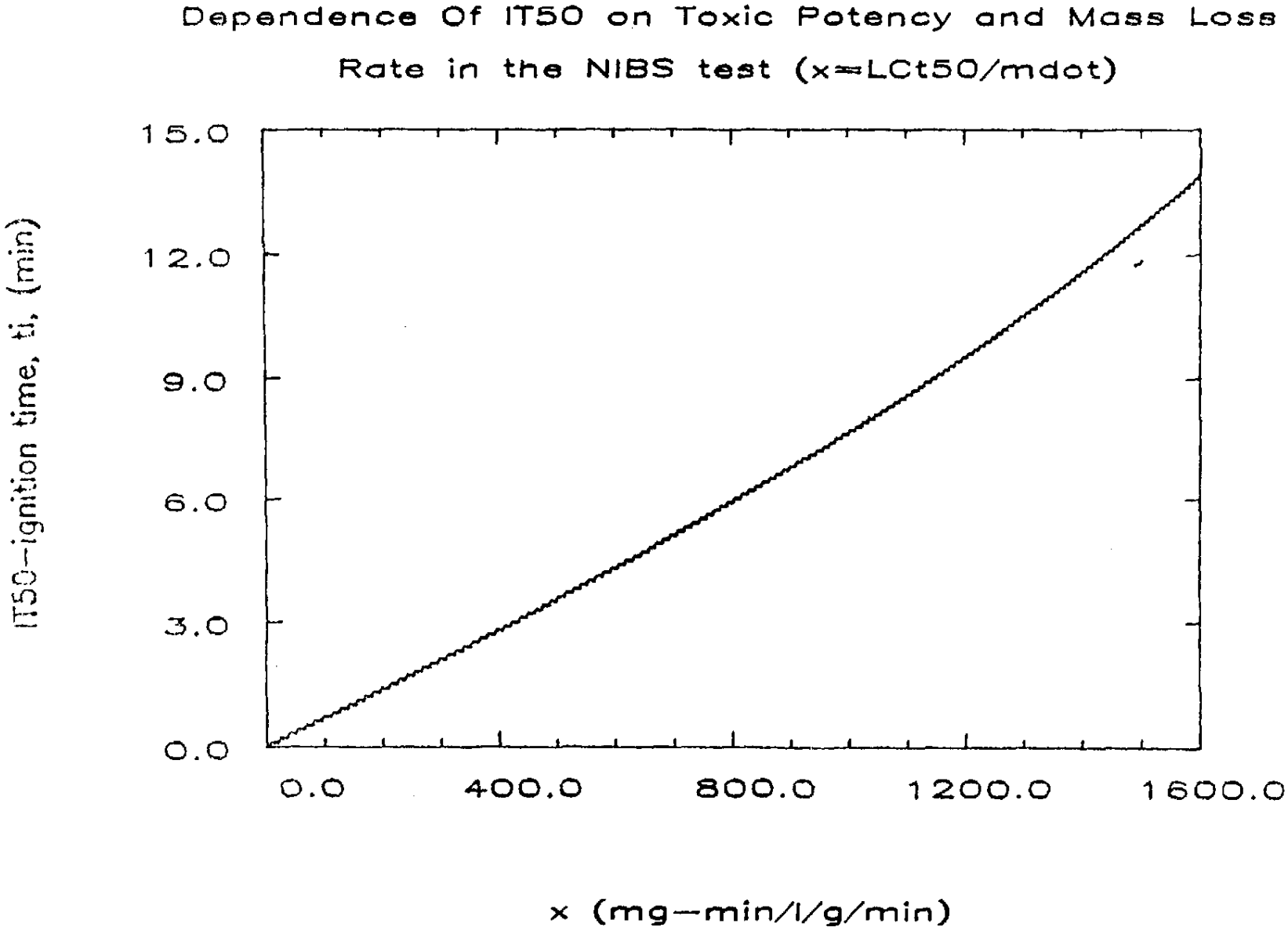
It was assumed for this that: $\dot{m}$ = (increase in m)/Z, and that no appreciable mass loss occurred before t_i or after irradiation was stopped (when the communication from exposure to combustion chamber is closed). The calculated values of L are listed in Table 4.

Figure 1



SPI-11036

FIGURE 2



SPI-1037

THE CORROSIVITY OF FIRE GASES

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Unit of Fire Safety Engineering
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Appendix B

SPI-11038

MATERIALS

1. Douglas Fir
2. Fire Retarded ABS
3. Nylon
4. Noryl
5. Rigid PVC (CIM) Compound
6. Standard PVC Wire and Cable Compound
7. Low Flammability PVC Wire and Cable Compound
8. Fire Retarded Polypropylene

SPI-11039

CHAMBER MEASURES 13.5 M^3 IN VOLUME.

EXPOSURE LASTED 1 H.

TARGETS WERE COPPER MIRRORS, 500 A THICK, 1 IN X 0.25 IN.

POST-EXPOSURE WAS CARRIED OUT AT ROOM TEMPERATURE & 75% RH.

RESISTANCE MEASUREMENTS WERE MADE AFTER 1H, 24H, 48H AND 72H.

EXPOSURE CONDITIONS

F FREE BURNING

O ENCLOSED SAMPLE, WITH OPEN AIR ACCESS

R ENCLOSED SAMPLE, WITH RESTRICTED AIR ACCESS

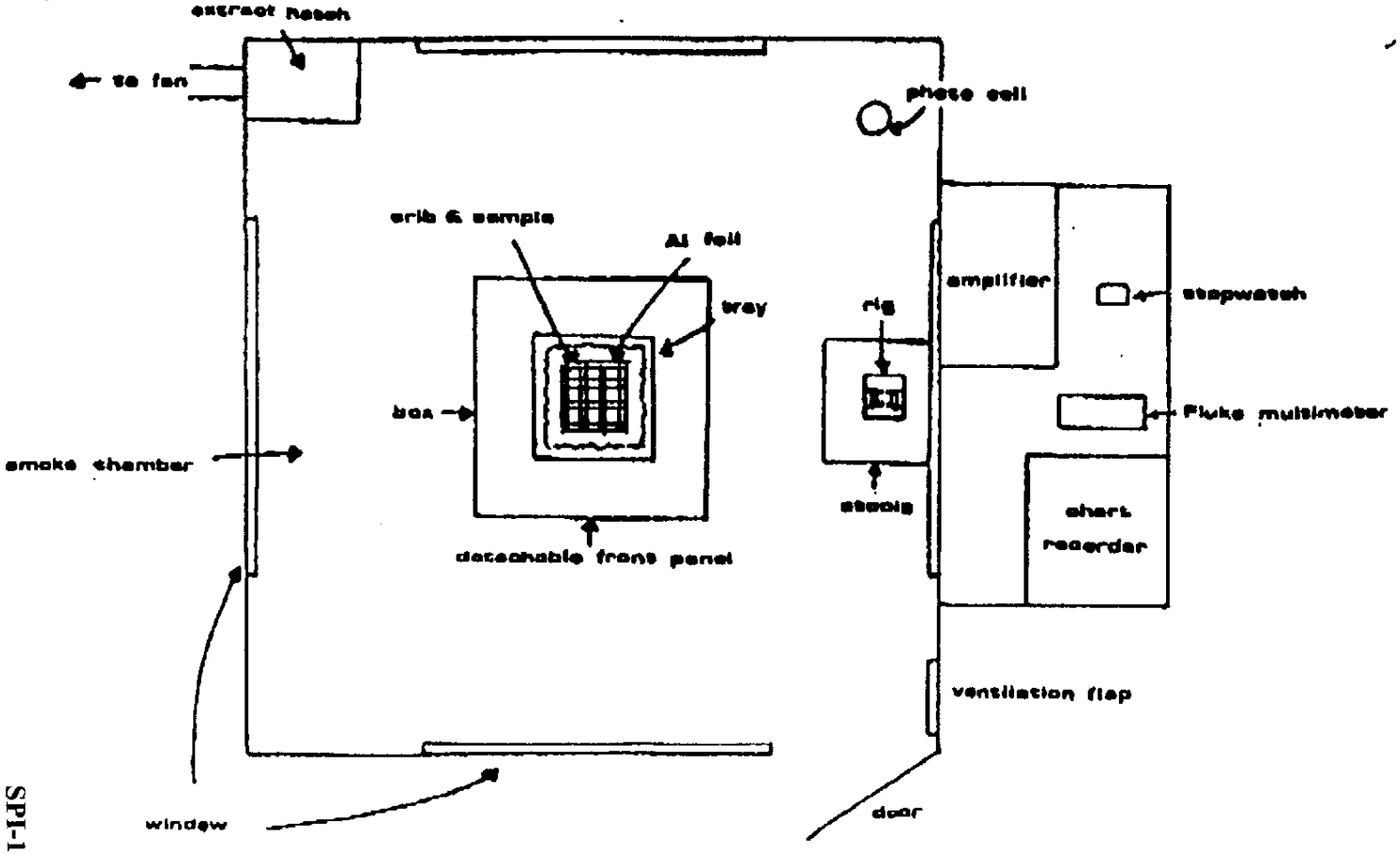

Fig 1

SPI-11042

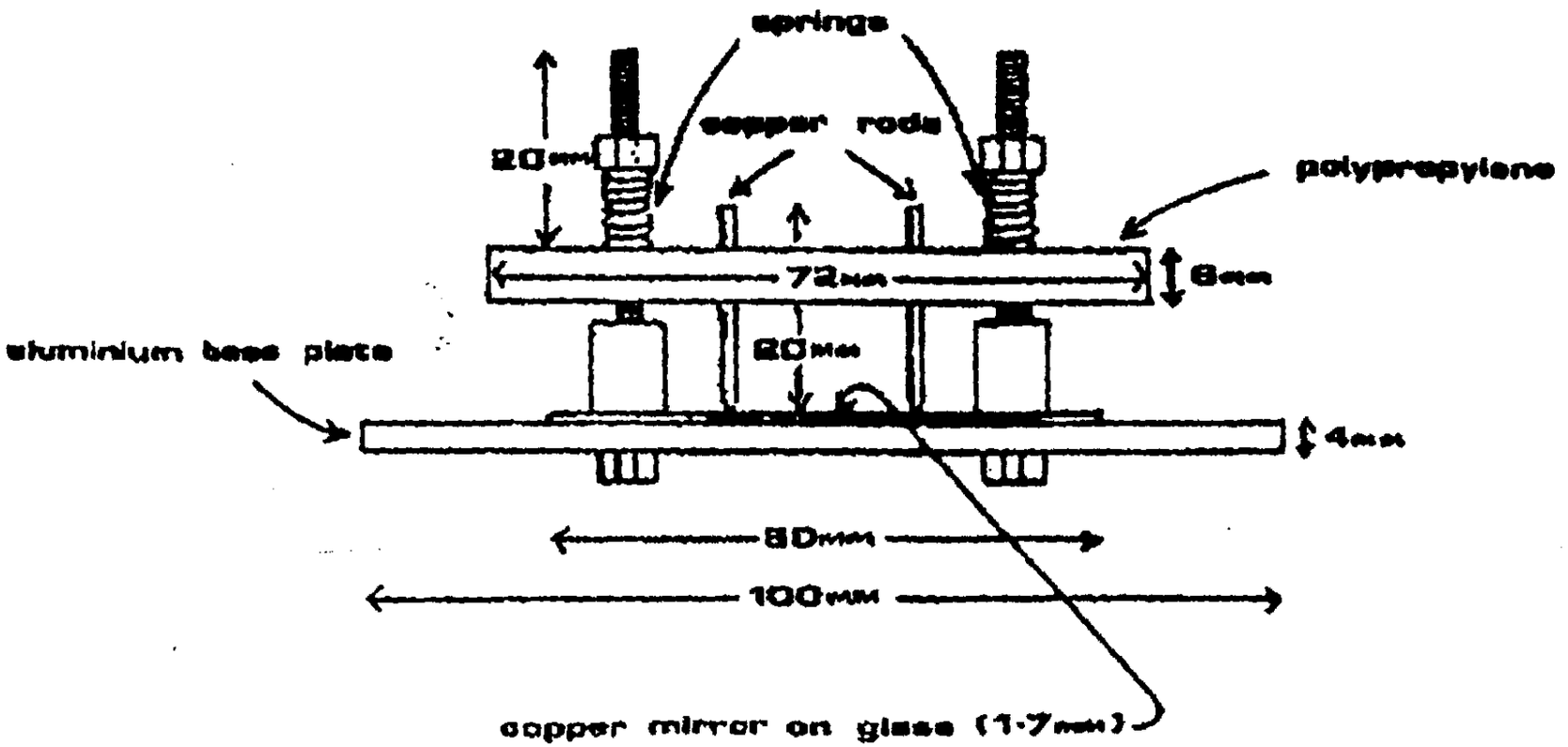

FIG. 2

SPI-11043

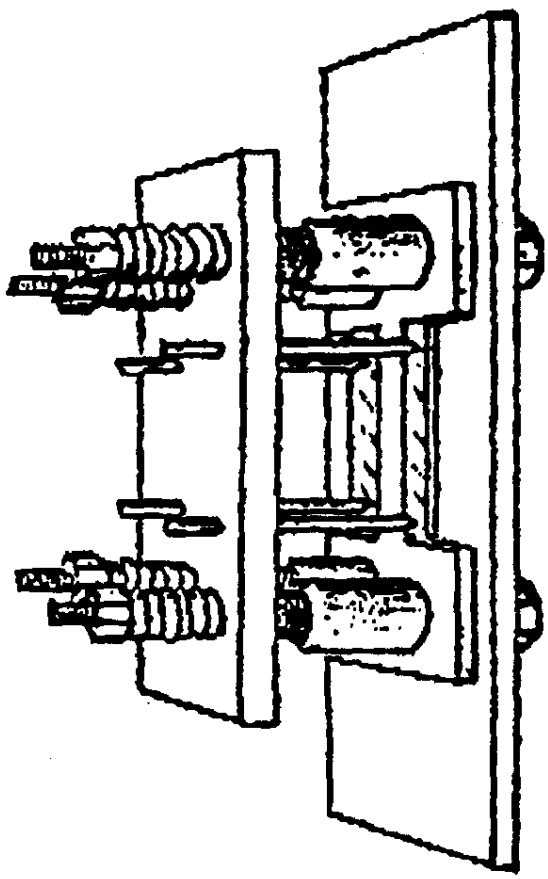

Fig 3.

THE PVC SAMPLES PRODUCED MORE CORROSIVITY THAN THE OTHER SAMPLES, BUT THE DIFFERENCES WERE NOT VERY LARGE: ALL WERE IN THE SAME BALL-PARK.

AT HIGHER AMBIENT TEMPERATURES, THE NYLON SMOKE CORRODED MUCH MORE HEAVILY THAN THE PVC SAMPLES: ALL MIRRORS WERE TOTALLY CORRODED LONG BEFORE THE END OF THE EXPOSURE.

EXPERIMENTS WERE DONE IN WHICH NYLON WAS TESTED WITH THE CHAMBER AT ELEVATED TEMPERATURE (UP TO 100° C).

THE INCREASE IN TEMPERATURE CAUSED A DRAMATIC EFFECT IN THE CORROSIVITY OF NYLON SMOKE.

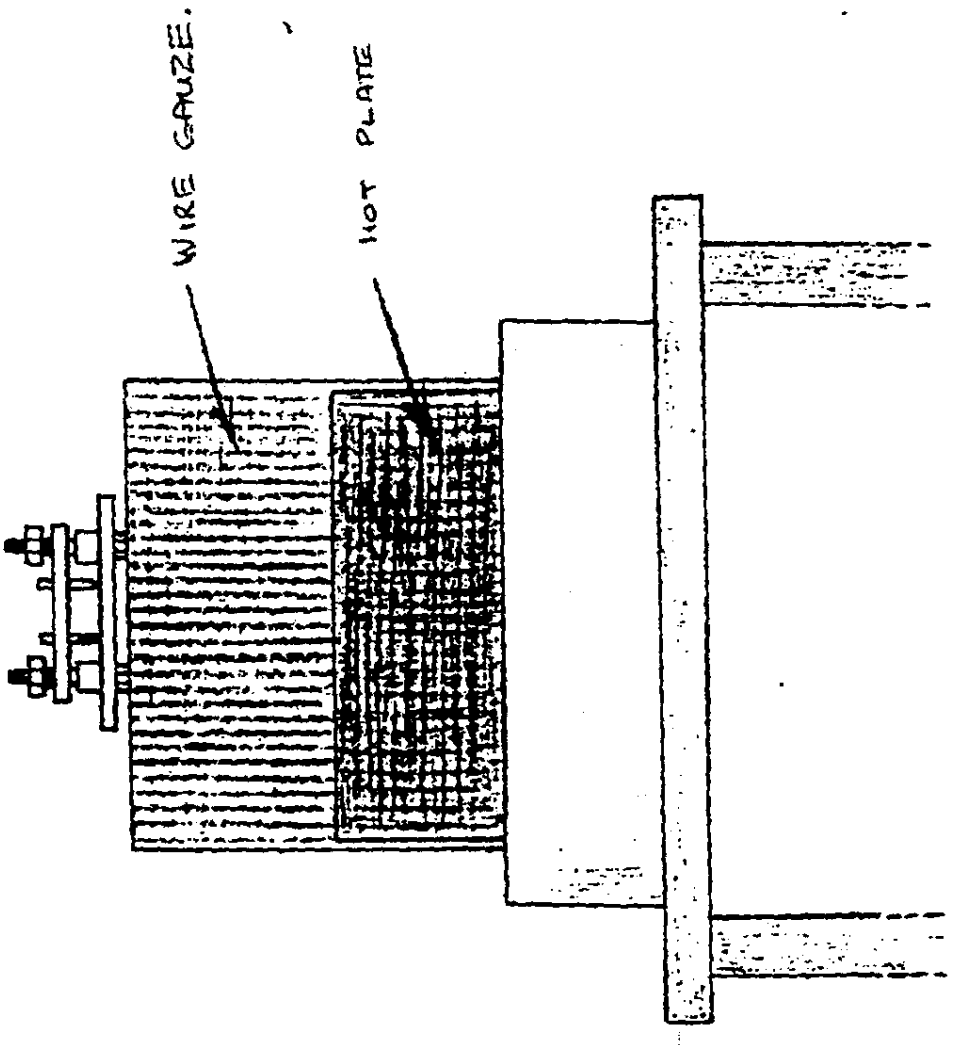

FIG. 3.

RANKING ORDERS OF MATERIALS CHANGE DEPENDING ON SEVERAL THINGS:

OXYGEN LEVELS DURING EXPOSURE

TEMPERATURE OF ENVIRONMENT DURING EXPOSURE

TIME OF MEASUREMENT, COMPARED TO EXPOSURE

HUMIDITY DURING EXPOSURE

BFG\MMH

SPI-11048

Appendix C

To: R.T Gottesman/C.N. Bush
From: Marcelo M. Hirschler

December 5, 1989

NIST Center for Fire Research 1989 Fire Research Conference

This conference is the forum for NIST (ex NBS) researchers and their grantees to explain the research they have done over the last year. The research usually runs the gamut of very fundamental theoretical work to quite applied programs. This year's meeting had an additional feature: it contained three panel discussions on relevant wide-interest issues.

The programs of interest to the Vinyl Institute were probably mostly in the area of smoke toxicity. It was stated very clearly that small-scale toxicity tests are mostly useful as screening tests to identify any (very rare) products which give off smoke of unusual toxicity, either in terms of it being higher than the norm or in terms of it being different from the norm. This can only, of course, be done by using animals. As far as using toxicity results for fire hazard assessment, the consensus at NIST is that small scale tests can tell you something about the generation of toxicants other than CO, but in order to get the CO contribution it is essential to carry out full scale tests. Moreover, there is virtually no effect (or at most only a minimal one) of fuel (combustible) structure on CO generation in full scale fires where there is no excess of air present. Therefore, toxicity contributions of any particular smoke in a specific scenario should be calculated from a combination of two parts: (a) a small scale test that measures all gases other than CO, (b) a model that predicts CO formation in the scenario in question, independent of the product being considered. NIST is working on developing that model. The tests being carried out by NIST on full scale rooms will help guide the NIST work in that direction, but the overall model is not expected to be ready for ca. 5 years.

The only exception to this toxicity concept is Yves Alarie (UPITT), who has combined his mice and exposure chamber with the output from the cone calorimeter, to get a time to toxic effect from burning the top layer of materials. This is unlikely to result in either good science or practical testing technology. NIST sees it as a "last chance" for the concept of flow through technology to demonstrate relevance.

The other important results presented are the measurement, at SwRI, of the toxicity of HBr and of combinations of HCl and HCN and of HCl, HCN and CO, in rats. HBr appears to be roughly as toxic as HCl (maybe 10% more, which is statistically indistinguishable), while the lethal effects of the combinations are all additive (or even perhaps slightly less) within a 20% error.

One issue of importance raised in the discussions is the fact that the fire hazard model HAZARD I may be too easy to use, so that the user (who can then claim to be an expert witness in litigation) might not understand the implications of the results he is generating. This is a novel idea, which merits a lot of thought.

Marcelo M. Hirschler