Protective Glove Material Permeation by Organic Solids.

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List of Abbreviations

ASTM = American Society for Testing and Material Methods

BT = Breakthrough Time (minutes)

SST = Steady State Time (minutes)

SSPR = Steady State Permeation Rate ($\mu g/min/cm^2$)

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Significant Findings.

It has been experimentally determined that organic solids do permeate through commercially available glove membranes. A method which utilizes a stainless steel permeation cell has been tested and critiqued. The terminology which has been applied to permeation of liquids has been applied to organic solid permeation and defined experimentally. The breakthrough times vary from 2.4 minutes to 420 minutes for some glove\solid pairs. Overall, the latex membrane appear to be the poorest protector or the fastest permeated by the organic solids. Steady state permeation rates were also the highest of the five glove materials analyzed. Since many of the organic solids were carcinogenic this poses a significant health risk. The nitrile membrane yields better protection, breakthrough times were the longest of the five glove and steady state permeation rates were the lowest of the experimental values.

Other environmental factors have been studied. Temperature has been found to be indirectly proportional to breakthrough times and steady state times. An increase in temperature yields shorter breakthrough times and steady state times. Temperature can also be defined as directly proportional to permeation rates for all the glove\solid pairs tested. An artificial saline environment has been analyzed to simulate actual perspiration while the glove is in use. Initial studies have shown that the saline environment partially inhibits permeation of some of the glove\solid pairs. These factors allow a user of these organic solid materials to choose the glove material which yields the best protection allowing for the conditions of use.

Abstract.

A method has been developed for the determination of permeation characteristics of glove materials by organic solids. The system employs a stainless steel exposure cell and allows rapid and uniform contact of either solid pellets or powders with minimal membrane bowing. A gas chromatograph equipped with a flame ionization detector was used for monitoring the permeation process which provided detection limits of from 0.9–1.2 ng for the organic solids evaluated. Using an automated system for instrument control and data collection, breakthrough times, steady state times and steady state permeation rates have been determined for 5 common glove materials when exposed to 9 organic solids at room temperature and at different temperatures. Finally, two separate environments have been evaluated to simulate use.

Introduction.

A growing interest of those responsible for protecting workers from contact with potentially hazardous chemicals are the barrier properties of gloves to chemical permeation.[1] In an industrial application the need for protection against carcinogens is critical. Exposure to hazardous chemicals has been directly related to skin diseases and disorders which accounted for more than forty percent of all reported occupational illnesses every year from 1972–1982.[2] To date, most experimental work with permeation of chemicals through glove materials has focused on organic solvents as the permeant.

In general, chemical permeation testing requires that a challenge material be placed in contact with a membrane. The substance permeates through the membrane and is then collected in an appropriate medium. The method currently recommended for the evaluation of the permeation of liquids is the American Society for Testing and Materials Methods (ASTM, F 739-85).[3] F 739-85 utilizes a glass sampling apparatus which is applicable to either liquids or gases and permits either open or closed loop testing. Henry and Schlatter[4] reported data for toluene and DMF versus three membranes using this approach. Others have also applied this approach to study a wide variety of solvent/glove combinations. Forsberg and Faniadis[5] measured permeation characteristics of 8 common glove materials against 20 single or multi-component organic solvents. Menke and Chelton[6] evaluated 7 glove materials versus ethylene glycol dimethyl ether. Investigations in this laboratory[7] reported data for 8 commercially available glove materials versus 6 organic solvents using a modification of ASTM Method F 739-85.

While it is reasonable to assume that organic solids are capable of permeating through a glove material, to date there has been no reported method for the direct determination

of their permeation characteristics beyond solution studies.[5,8] Foresberg and Faniadis[5] tested two glove materials, neoprene and PVA against a mixture of methylene chloride and phenol, with breakthrough times ranging from 18 min to over 4 hr Vo-Dinh and White[8] focused on polynuclear aromatic compounds, such as H-Coal in fuel oil which permeated through latex in 1 hr These studies could not be used for direct evaluation of permeation characteristics of solids due to the effect the solvent would have on the membrane.

With a considerable amount of occupational illnesses attributed to organic solids used in industry,[1] there is a need for direct solid exposure data of protective clothing. It has been shown that solids in solution exhibit permeation through protective materials. The purpose of this study is to yield an adequate representation of direct solid contact and show that neat solids exhibit permeation characteristics when in contact with protective clothing. A method to evaluate organic solvent permeation characteristics[7] designed in this laboratory has been modified for use with solids. The cell design was modified to accept solid samples without distortion of the membrane and utilizes a continuous, open loop sampling technique. The solids and glove materials were chosen to be representative of those commonly used in the chemical industry.

According to Fick's First Law of diffusion, a factor which influences permeation of organic materials is temperature. To date there has been no method developed in the area of temperature effect on solid permeation at constant pressure. A method was developed which utilizes a modification of the method developed for the evaluation of solid permeats at room temperature.

Permeation must be further defined as either a glove or solid chemical phenomena. The driving factors behind permeation of a solid through a membrane are crucial. Such

properties as vapor pressure and solubility, have to be defined and the roll these properties have in permeation of solids needs to be understood. Finally, an alternate environment, saline was substituted in place of helium as the collection medium. This substitution was made to simulate actual glove use with perspiration from the skin. The same glove materials and organic solids were analyzed.

Methods and Materials.

Solids evaluated were p-dichlorobenzene, 4,6–dinitro-o-cresol, 2,4–dinitrotoluene, quinone, camphor, naphthalene, (Aldrich., Milwaukee, Wis.); hydroquinone, phenol, (Fisher Scientific, Pittsburgh, PA.); p-nitrotoluene, (Kodak, Rochester, NY.) which were all certified A.C.S. grade. These chemicals were chosen to represent a range of vapor pressures and polarities, and because of their common use in industry. Disks of each chemical were prepared by compressing approximately 4 grams of the material using a stainless steel press with an internal diameter of 2.5 cm. All solids were evaluated in disk form except for 2,4–dinitrotoluene and camphor which were both evaluated in powder form due to poor disk quality. Gas chromatographic standards for each of the nine solids were prepared in methylene chloride, at a concentration of 0.100–0.150 mg/mL for quantification.

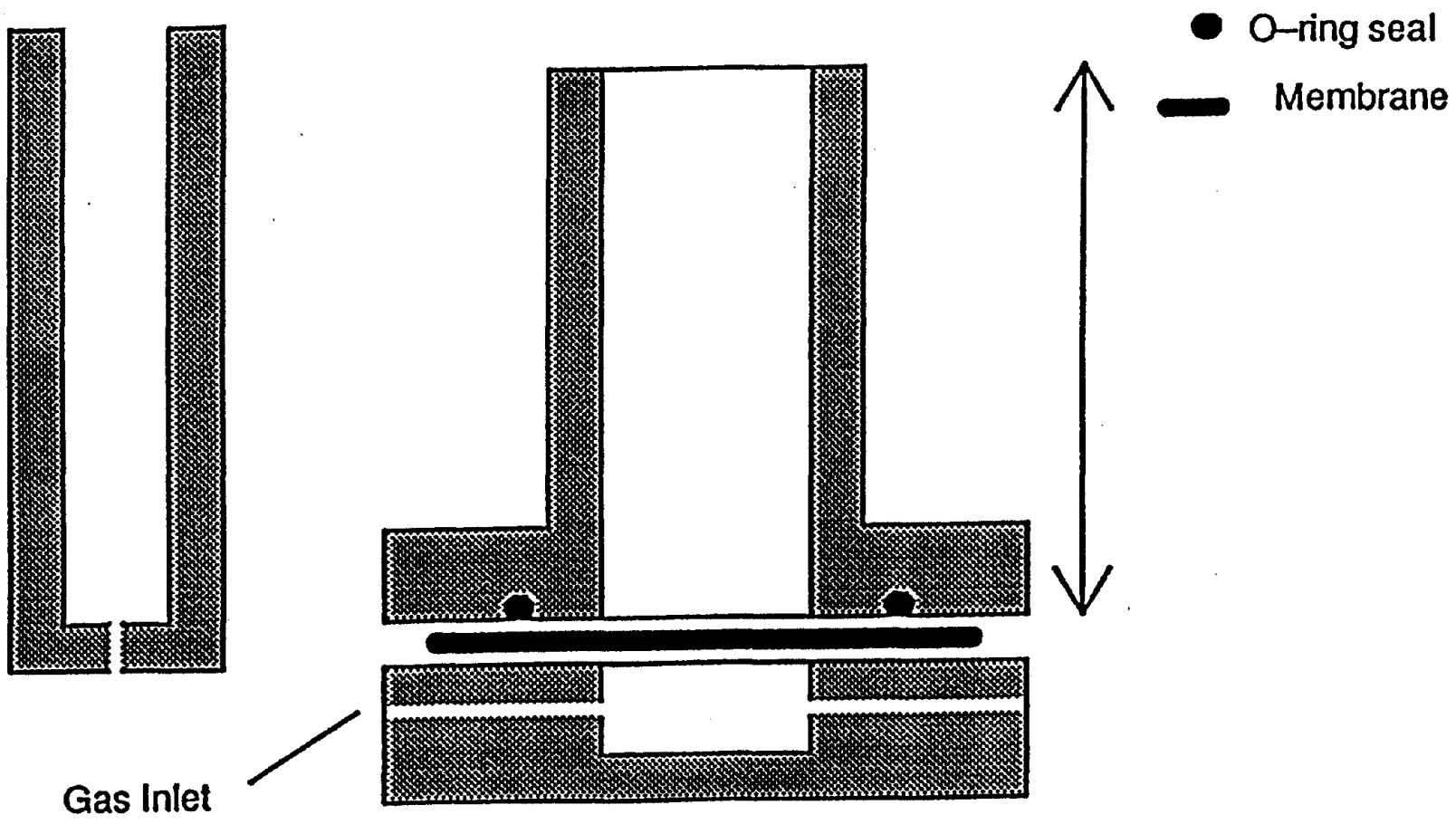
Latex, poly(vinyl chloride) PVC, urethane, nitrile, and neoprene membranes with a nominal thickness of 5.0 mil, were evaluated as glove samples. Membranes of the glove materials were prepared by The Oak Rubber Company, Ravenna, Ohio, using a dip process. A Mylar® polyester film (film–92A), (Dupont, Wilmington, Delaware) with

a thickness of 0.92 mil., was also included in the test set. The thickness of each sample was determined as the arithmetic mean of four measurements taken at different locations on each test sample using a micrometer.

A Hewlett Packard 5890A Series II Gas Chromatograph (GC) equipped with a flame ionization detector (FID) was utilized for all permeation experiments. A ten-port high-temperature valve was used for flow control of the permeant effluent. A Hewlett Packard 5895A Pascal GC Chemstation provided automated valve control, data acquisition and data editing. During data acquisition, the FID signal and the flow rate were monitored and stored. For quantification, a SPB-5 fused silica capillary column (30m, 0.53mm ID, 1.5 μm film thickness, Supelco, Bellefonte, Pa.) was used. All quantifications were performed isothermally at 100°C, using a 250 μL gas sampling loop and a helium flow rate of 7.0 mL/min.

Permeation Cell. The permeation cell, transfer line, and all fittings were constructed of 316 stainless steel to resist chemical degradation. The cell measurements are listed in Figure 1. A fluorocarbon O-ring (Parker Seals, Ky.) was used to seal the membrane and cell. The long neck allowed for easier sample addition and for a weighted plunger to be placed over the sample to promote sample contact with the membrane and minimize membrane distortion. An external gauge was used to monitor pressure fluctuations, (0.2 - 0.5 psi) which might result from membrane swelling or damage. After the system was pressurized, any reduction in pressure during the analysis was construed as a hole or distortion of the membrane. The cell's internal flow inlet was at a 90^0 angle to the outlet. The cell can also be inverted allowing for experimentation in which the solid is not in direct contact with the membrane. The experimental setup is shown in Figure 2.

Figure 1: Permeation Cell



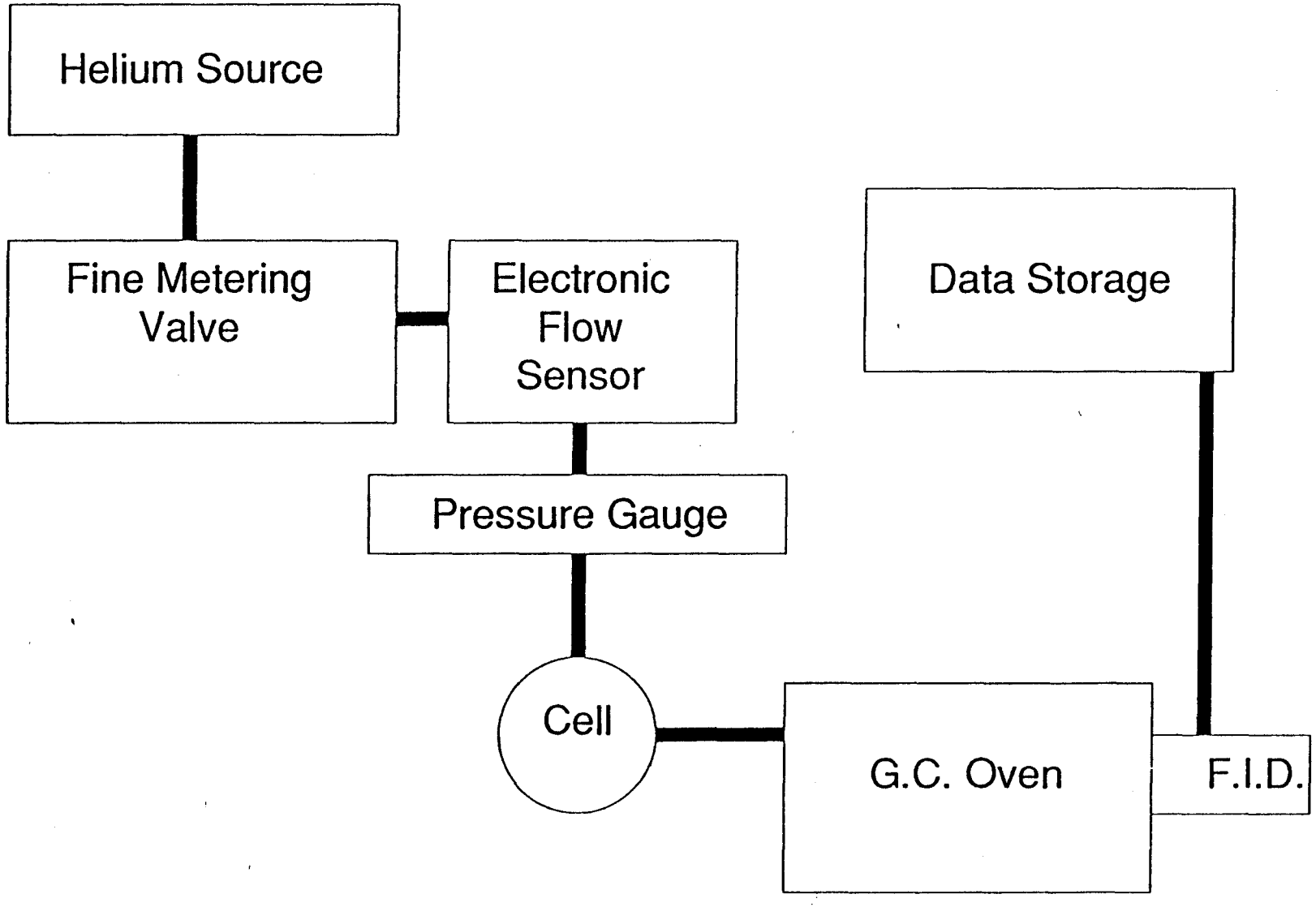


Figure 2 – Experimental Set-up.

Helium flowed through the cell (7.0 mL/min) and came into contact with the back of the membrane and then exited through a heated transfer line (200 $\pm$ 10°C) to the sampling valve (250 $\pm$ 0.1°C). Based on the valve's position, one of two flow paths could be selected (Figure 3). In position 1, after leaving the cell, the flow travels initially through a gas sampling loop (0.25mL) and then to the detector, allowing for continuous sampling. In this position, a second helium flow is maintained through the analytical column, which is vented. In position 2, cell flow is vented and the contents of the sample loop are injected onto the analytical column for quantification.

Testing Procedure. Each experiment was conducted in three stages at a relative humidity of 50 $\pm$ 10% and a temperature of 25 $\pm$ 1°C. Initially, the instrument was calibrated by making three standard injections with the valve in position 2. The valve was then switched to position 1 and the solid disk was placed in contact with the membrane. Response was monitored continuously until steady-state permeation rate was reached or 650 minutes had elapsed, which is the maximum run time for the software. At this point, the valve was switched to position 2 which passed the contents of the sampling loop to the GC column for quantification. This final step was repeated, producing three replicate assays for determination of the steady state permeation rate (SSPR).

Testing Procedure – Temperature Analysis. Temperature analysis was performed on all nine chemicals solid organics versus 5 glove materials described earlier. Each experiment allowed for breakthrough of the target solid through the selected membrane at the following temperatures: 5 °C, 15°C, 23°C, 37°C, 45°. Temperatures were maintained at $\pm$0.1°C by mounting the permeation cell inside the GC oven (Figure 4).

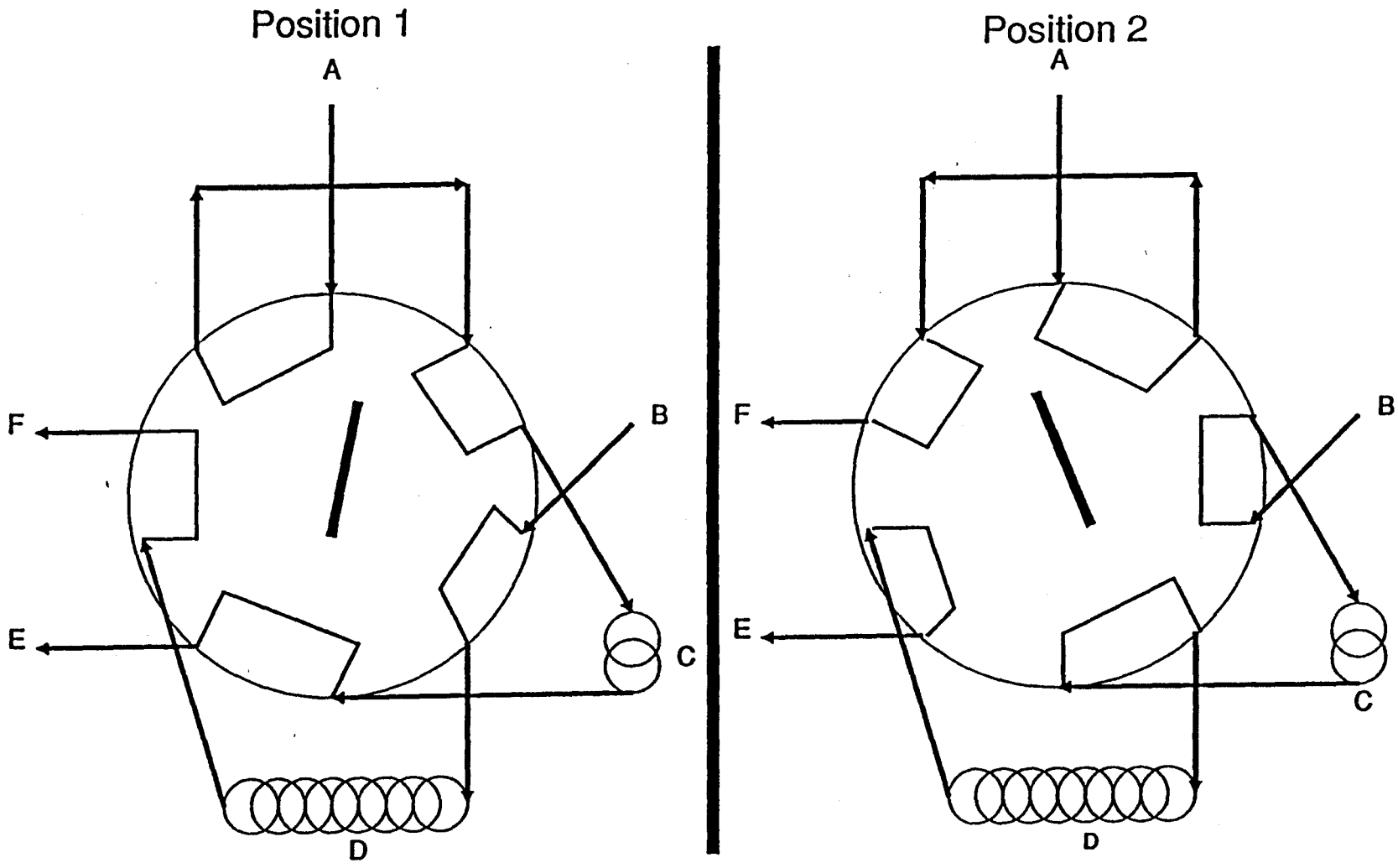


Figure 3 – GC sampling valve flow path: (A) permeation cell, (B) injection port, (C) sample loop, (D) analytical column, (E) FID, (F) vent.

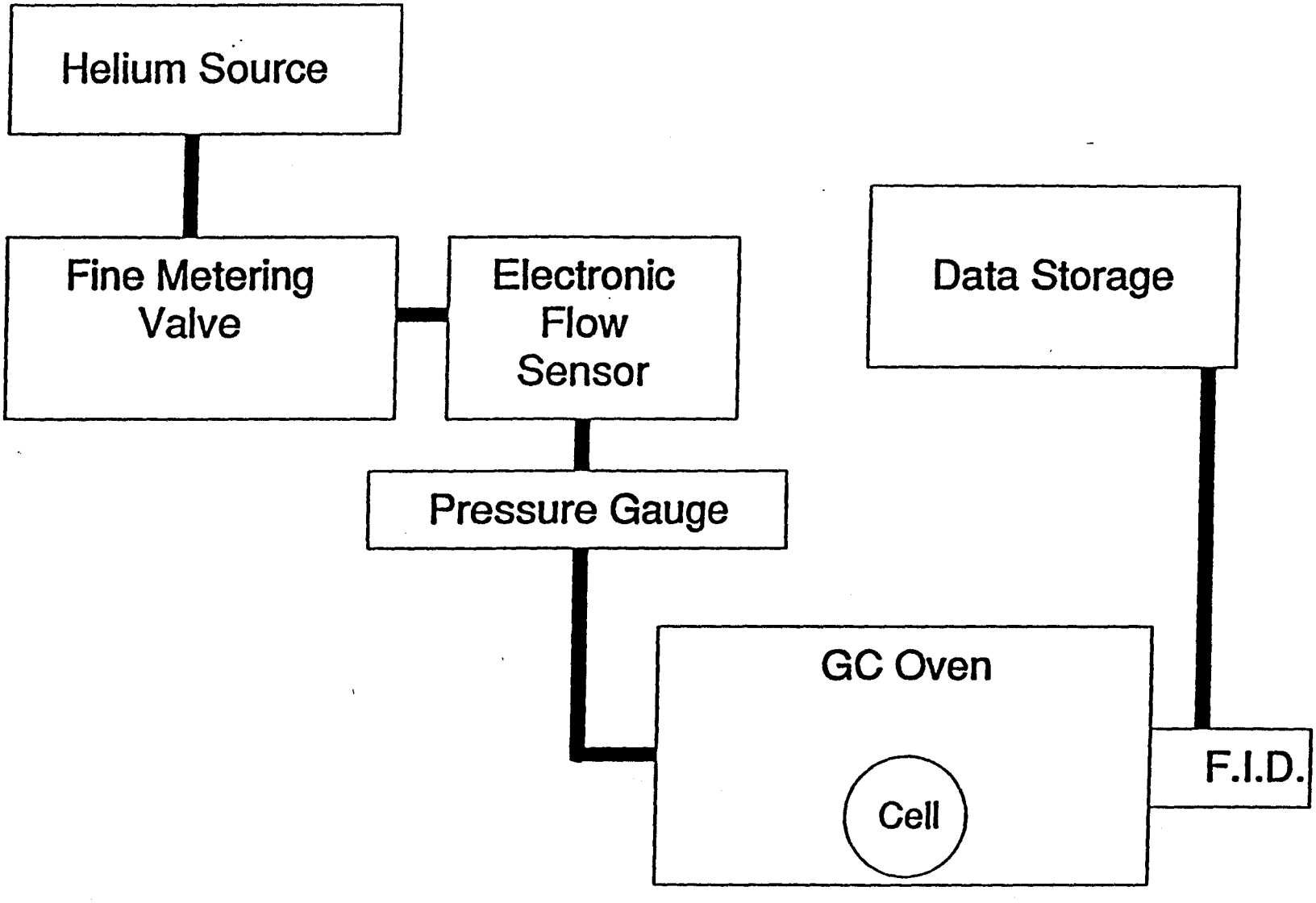


Figure 4 – Experimental Set-up (Temperature Analysis).

Testing Procedure – Saline Analysis. Analysis consisted of sample collection, extraction and analysis. Sample collection consisted of the use of 5% saline solution as the collection medium, in contrast to, earlier procedures which used helium as the collection medium. The saline flowed through the permeation cell from a reservoir at a flow rate of 5 mL/min. and came into contact with the back of the membrane, collecting any permeated organic material. This effluent exited the permeation cell and was collected continuously in a separatory funnel for 5 minute intervals with a total collection time 120 minutes. The extraction was lowered to pH 2.0 using sulfuric acid and consisted of the addition of 50 mL of methylene chloride to each aliquot, shaking, and decanting the methylene chloride layer. After performing the latter step three times, the 150 mL. of extract was reduced to 2 mL using a Kuderna-Danish Concentrator. Analysis consisted of quantification by gas chromatography using a the method and standards described earlier.

Results and Discussion.

System Evaluation. Due to the low volatility of the chemicals investigated, the possibility of permeant condensation on the backside of the glove material or exposed cell surfaces exists. Observed permeation rates could also be artificially low due to saturation of the helium flow directed through the cell. While the sampling valve and transfer lines were heated to at least 200°C to reduce any condensation, investigations were conducted to determine and then minimize these effects for each permeant versus the latex membrane. Initially, helium flow rates from 1 – 30 mL/min were evaluated

for each latex/permeant pair after having reached steady state permeation at a flow rate of 10 mL/min. At flow rates above 20 mL/min, distortion of the membrane was observed by a displacement of the plunger along with an increase in the response due to increased membrane area and reduced thickness. At flows below 2 mL/min, a decrease in the response was observed for phenol and p-dichlorobenzene, indicating saturation of the helium or condensation within the cell. A flow rate of 7.0 mL/min was selected for subsequent studies to prevent saturation of the helium flow and provide maximum response for the quantitation portion of the analysis.

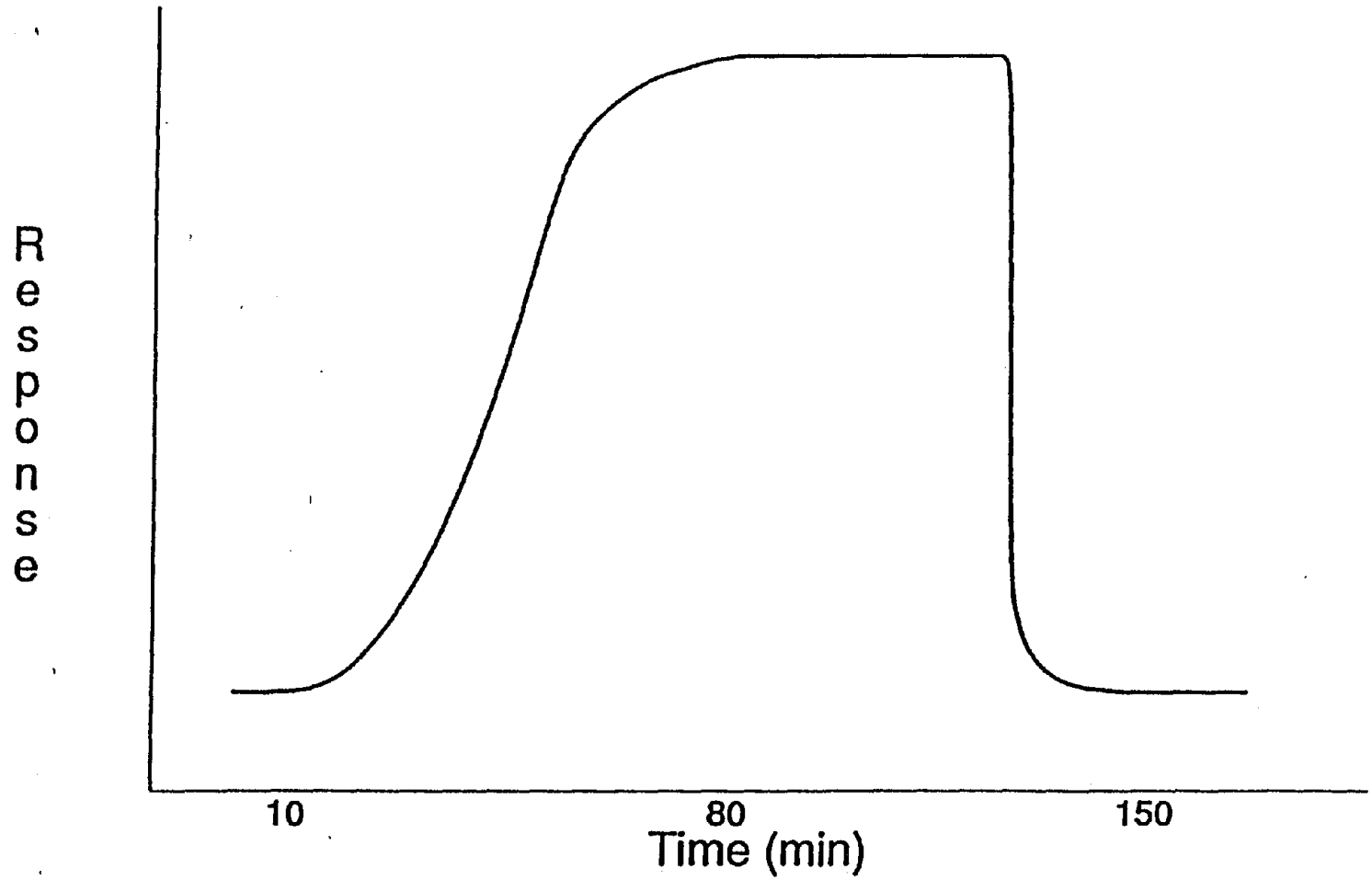
Additional testing for condensation was also conducted in which the system was allowed to reach steady state at 7.0 mL/min helium flow for each latex/permeant pair followed by removal of the disk. An immediate decrease in response, ultimately returning to baseline, was observed as shown in Figure 5 for the phenol/latex pair. If condensation were occurring, the observed response would be maintained while the permeant evaporated from the system.

The system dead volume was found by replicate injections of methane (1.0 μL) through the membrane at known system flow and found to be 6.0 mL. A peak width of 0.3 minutes indicated that there was adequate mixing and flushing of the effluent from the cell. All BT and SST values were corrected for the system dead volume by:

$$BT = t - \frac{Vo}{FR} \qquad (1)$$

where t represents the time of initial detection (min), and Vo was the system dead volume (mL) and FR was the flow rate (mL/min) . Flow rate was continuously monitored during each experiment.

Figure 5 – Phenol versus Latex .



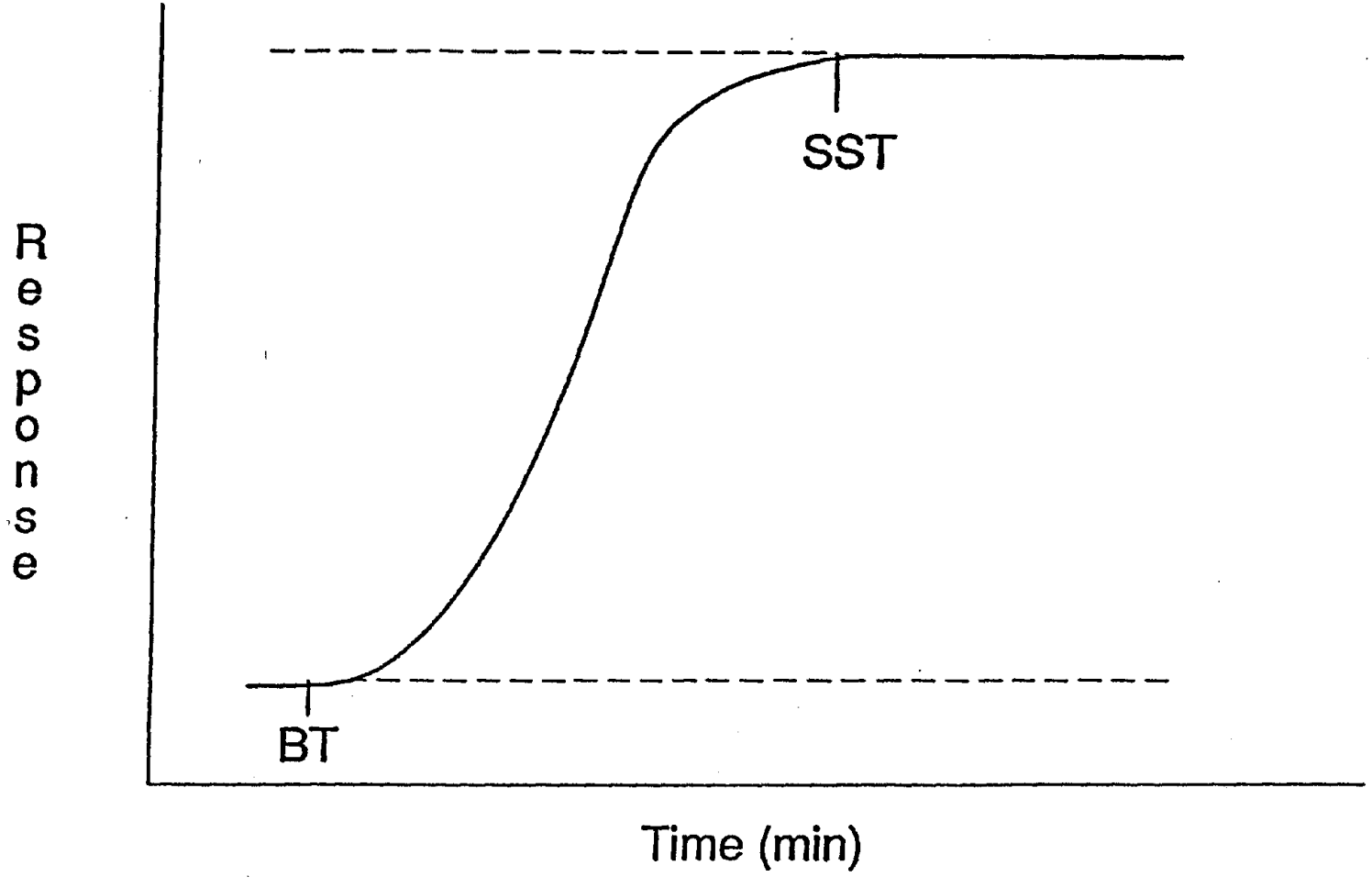
Glove/Solid Permeation Characteristics. Permeation by organic solids was found to exhibit the same general permeation curve observed for liquids.[4] Figure 6 is a representative permeation curve, indicating the three values determined: breakthrough time (BT), steady state permeation time (SST) and steady state permeation rate (SSPR).

BT is the time required for a substance to permeate through the membrane and indicates the maximum protection time afforded by a glove material. In practice, after correcting for system dead volume, BT is commonly determined as the time required for a permeant to produce a detectable response. The time for initial detection was determined as the point where detector response was at least three times the signal to noise ratio. Detection limits from 0.9 to 1.2 *n*g were observed, for the materials investigated. A system was considered to have reached steady state if the change in response was less than 1% per minute. For glove/permeant systems, SST was determined as the time required to reach 99% response. The steady state permeation rate was calculated based on the average of three effluent assays for three membrane exposures as:[9]

$$SSPR = \frac{MF}{VA} \qquad (2)$$

where SSPR is determined in μg/min/cm^2. M is the mass of permeant at steady state (μg), V is the volume of the sample loop (mL), F is the flow rate of the collecting medium (mL/min) and A is the area of exposed membrane in cm^2.

Figure 6 – Representative permeation curve (BT and SST labeled).



BT, SST, and SSPR, for each solid/membrane pair evaluated are presented in Tables I through III respectively, as well as BT and SSPR values for representative liquids. The Mylar® membrane exhibited no detectable permeation in 650 minutes by any of the target solids under continuous exposure and is not listed in the Tables. For all compounds which exhibited breakthrough but did not reach steady-state within 650 min, the permeation rate was calculated at the maximum run time.

Breakthrough was observed for the majority of the solid/membrane pairs tested, with times ranging from 2 minutes to 8 hours for the 5 glove materials with most occurring in less than 10 minutes. Breakthrough time variability ranged from 0.43% for p-nitrotoluene versus latex to 8.5% for dichlorobenzene versus nitrile, with the precision varying only 1 to 4.5% for the majority of solid/membrane pairs. Overall, nitrile and neoprene exhibited the longest BT values. An individual solid may exhibit a larger range of breakthrough times for the 5 glove materials tested: camphor 3.5 min. for latex and 475.0 min. for neoprene. This allows the user to select a particular glove material according to the time of glove use.

Steady state permeation rates of up to 8.1 $\mu g/min/cm^2$ were observed, with nitrile and neoprene exhibiting lower SSPR for the materials tested (Table III). In the case of 4,6–dinitro-o-cresol, three of the materials exhibit no response, while for latex and PVC, steady state permeation rates are slightly above the detection limit. It is important to note that the total load ($\mu g/min/cm^2$) on the system at SSPR does not exceed the calculated maximum potential permeation rate of the solid's vapor pressure at the experimental temperature and flow rate (Table III).

Table 1 Breakthrough Times for Solids

	Glove Membrane[C]				
Compound (solids)	Latex[A]	PVC[A]	Polyurethane[A]	Neoprene[A]	Nitrile[A]
benzoquinone	8.5±0.29	9.6±0.39	18.5±0.24	45.0±1.70	ND[B]
naphthalene	4.3±0.18	4.7±0.20	11.5±0.19	19.0±1.19	41.0±2.65
dichlorobenzene	5.2±0.16	5.4±0.23	3.6±0.11	6.4±0.46	9.5±0.81
p-nitrotoluene	7.0±0.03	8.1±0.09	138.0±2.94	14.2±0.86	ND
camphor	3.5±0.17	4.8±0.11	ND	475.0±8.38	420.0±8.80
phenol	10.4±0.41	10.6±0.43	28.0±1.15	21.0±0.71	185.0±7.88
hydroquinone	2.4±0.09	3.5±0.12	11.0±0.63	31.5±1.22	39.0±1.61
4,6-dinitro-o-cresol	4.5±0.21	5.2±0.20	ND	ND	ND
2,4-dinitrotoluene	6.1±0.38	6.8±0.12	7.1±0.25	35.0±1.45	142.0±2.61

BT in minutes; [A] 95% confidence limits of 3 experiments, [B]ND = No Permeation Detected, [C]Nominal membrane thickness 5 mil.

Table 2 Steady State Times for Solids

Compound	Latex[A]	PVC[A]	Polyurethane[A]	Neoprene[A]	Nitrile[A]
benzoquinone	35±3.45	59±6.43	170±9.72	300±12.76	T[B]
naphthalene	151±9.32	160±9.02	104±7.64	205±8.89	T
dichlorobenzene	50±3.70	152±8.20	147±9.07	165±9.59	131±7.84
p-nitrotoluene	120±10.35	146±10.07	T	T	T
camphor	44±3.28	75±7.82	T	T	T
phenol	80±4.56	103±5.49	122±7.05	135±8.35	T
hydroquinone	260±10.18	300±12.84	292±22.45	250±9.10	T
4,6-dinitro-o-cresol	110±4.55	133±10.49	T	T	T
2,4-dinitrotoluene	210±8,48	239±17.26	241±16.82	360±10.55	600±28.11

SST in minutes; [A] 95% confidence limits of 3 experiments, [B]T = Steady State was not reached in 650 minutes

Table 3 Steady State Permeation Rates for Solids

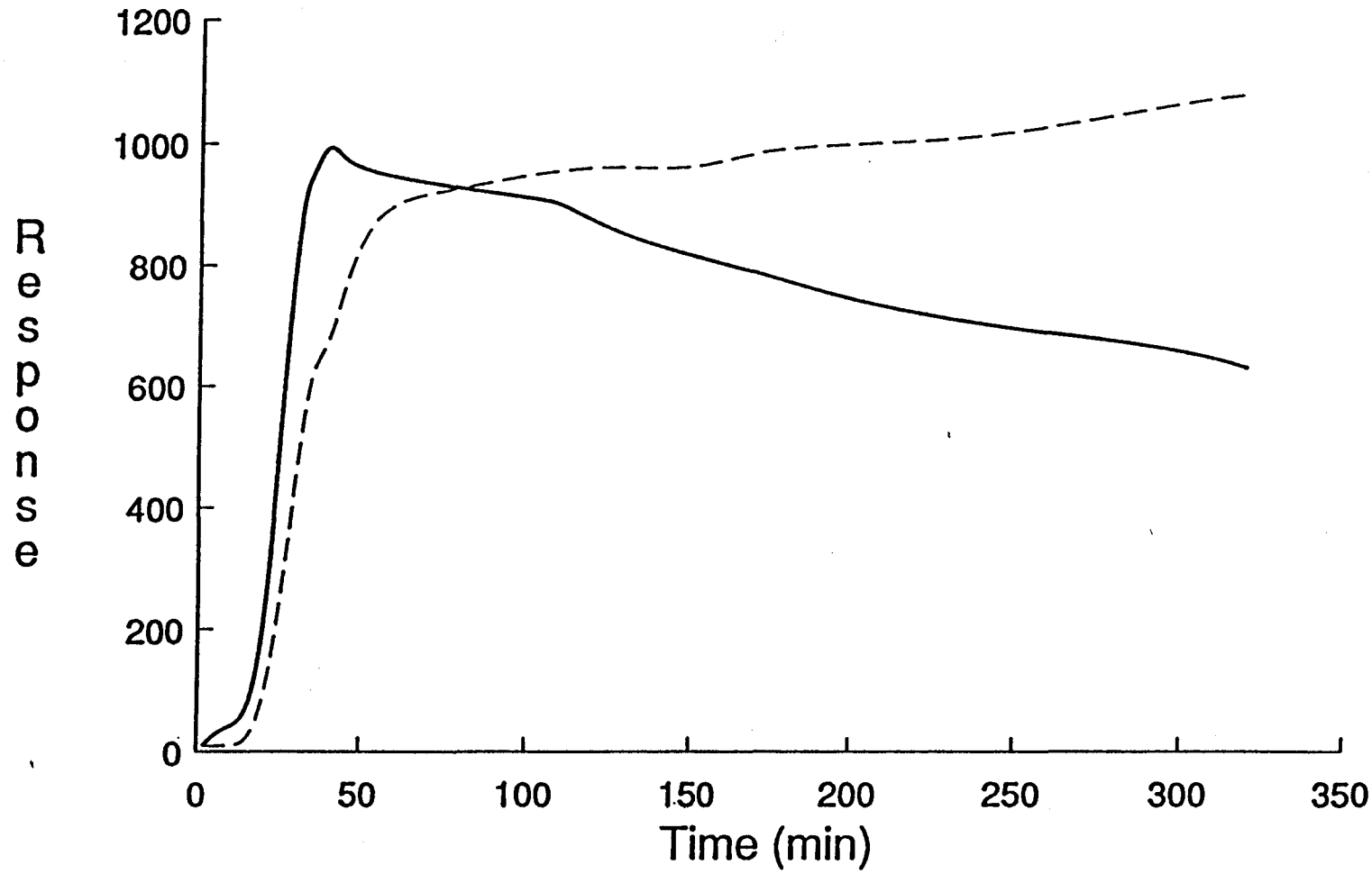
Compound (solid)	V[B]	Latex[A]	PVC[A]	Polyurethane[A]	Neoprene[A]	Nitrile[A]
benzoquinone	7.006	$1.595\pm8.083\times10^{-2}$	$4.458\pm3.290\times10^{-2}$	$1.727\pm1.375\times10^{-1}$	$3.207\times10^{-1}\pm1.879\times10^{-2}$	ND[C]
naphthalene	5.397	$1.127\pm7.404\times10^{-2}$	$8.467\times10^{-1}\pm7.059\times10^{-2}$	$1.144\pm8.523\times10^{-2}$	$1.787\times10^{-1}\pm1.128\times10^{-2}$	$3.267\times10^{-1}\pm1.629\times10^{-2}$
dichlorobenzene	47.58	$8.074\pm3.093\times10^{-1}$	$1.141\pm4.757\times10^{-2}$	$4.997\pm2.137\times10^{-1}$	$3.164\times10^{-1}\pm2.179\times10^{-2}$	$3.256\times10^{-1}\pm1.307\times10^{-2}$
p-nitrotoluene	10.27	$2.037\pm8.560\times10^{-3}$	$1.476\times10^{-1}\pm1.023\times10^{-2}$	$1.647\pm8.018\times10^{-2}$	$5.033\times10^{-1}\pm3.257\times10^{-2}$	ND
camphor	20.08	$1.111\times10^{-1}\pm4.067\times10^{-3}$	$4.032\times10^{-1}\pm1.030\times10^{-2}$	ND	$3.672\times10^{-1}\pm1.794\times10^{-2}$	$2.329\times10^{-1}\pm1.011\times10^{-2}$
phenol	37.38	$1.505\pm8.769\times10^{-2}$	S[D]	$2.332\pm1.192\times10^{-1}$	$2.012\times10^{-1}\pm1.420\times10^{-2}$	$1.137\pm4.196\times10^{-2}$
hydroquinone	0.08152	$1.517\times10^{-2}\pm8.221\times10^{-4}$	$9.583\times10^{-3}\pm4.726\times10^{-4}$	$1.306\times10^{-2}\pm6.455\times10^{-4}$	$9.054\times10^{-3}\pm7.701\times10^{-4}$	$8.217\times10^{-3}\pm3.661\times10^{-4}$
4,6-dinitro-o-cresol	0.006511	$1.383\times10^{-3}\pm7.726\times10^{-4}$	$6.390\times10^{-3}\pm3.649\times10^{-4}$	ND	ND	ND
2,4-dinitrotoluene	108.5	$7.034\pm2.813\times10^{-1}$	$5.793\times10^{-1}\pm1.681\times10^{-2}$	$8.130\pm6.2902\times10^{-1}$	$3.467\times10^{-1}\pm1.990\times10^{-2}$	$2.512\times10^{-1}\pm1.488\times10^{-2}$

SSPR in $\mu g/min//cm^2$; [A] 95% confidence limits of 3 experiments, [B]V = maximum potential permeation rate in $\mu g/10$ mL at 23°C , From reference 10

[C]ND = No Permeation Detected, [D]S = Membrane Solubilized.

Figure 7 – Permeation curves: (—) hydroquinone versus latex,

(- - -) camphor versus neoprene.



The precision of the SSPR varies from 2 to 8.8 percent. The poorer precision can be attributed to the neoprene membranes, ranging from 6.0 to 8.8%, in which many of the membrane/solid pairs did not reach SST and had to be calculated at the default time of 650 minutes.

Some organic solids and glove pairs show a consistent deviation from the representative permeation curve. These trends were most evident for camphor/neoprene and hydroquinone/latex (Figure 7). With camphor/neoprene, an initial rapid increase is observed followed by a slower, near linear rise in response. Other workers have reported this phenomenon for liquid/membrane permeation and attributed it to membrane swelling during exposure.[6] For hydroquinone/latex, there is a steady decrease in response after reaching a maximum at 39.5 minutes. This phenomenon has been documented in samples which exhibit some physical deformation or degradation by chemical reaction of the membrane.[11] Similarly, these phenomena are also observed in permeation of solids and can be attributed to deformation or degradation of the test membrane. When either of these profiles was observed, the steady state permeation rate for this solid/membrane pair was calculated at the default time of 650 minutes.

Effect of Direct Contact versus Vapor Phase. Both vapor phase transfer and direct dissolution of a permeant can represent significant modes for initiating the permeation process. Studies were conducted to determine differences between these two modes for both phenol and p-dichlorobenzene. The cell was inverted allowing the disk to be placed at known distances from the membrane, and the BT and SSPR were determined (Table IV).

Table 4 BT for Direct Contact and Vapor Phase Transfer

Material	Distance(cm)	phenol		p-dichlorobenzene	
		BT[D]	SSPR[A]	BT[D]	SSPR[A]
Latex	0	10.4	1.505	5.2	8.074
	1	19.5	1.685	8.0	8.871
PVC	0	10.6	S[C]	5.4	1.141
	1	15.0	0.3713	5.8	1.149
Nitrile	0	185	1.136	9.5	0.3271
	1	320	1.169	ND[B]	
Urethane	0	28.1	2.332	3.6	4.997
	1	54.9	4.976	10.5	5.899
	2	64.4		11.7	
	3	71.4		12.0	
Neoprene	0	21.0	0.2012	6.4	0.3161
	1	60.4		9.7	0.4991
	2	69.0		18.5	
	3	79.2		22.2	

BT in minutes; [A]μg/min/cm^2, [B]ND = Not Detected, [C]S = Membrane Solubilized, [D]Minutes

Overall, significant increases in BT were observed well beyond the time required to achieve the equilibrium vapor pressure at the exposed membrane face. In the case of phenol versus neoprene and p-dichlorobenzene versus polyurethane, the experiment was completed at different distances to determine if the effect was due to variations in concentration or in the time required to saturate the vapor phase. It was observed that breakthrough times increase when there is no contact. This indicates that the initial dissolution of the permeant greatly reduces the BT.

Effect of Temperature on Permeation Characteristics The analysis temperatures were chosen because they represent a range of temperature use in an industrial application. Data shows that breakthrough time decrease with the increase in temperature (Figure 8). Arrhenius plots for Latex versus 7 of the solids (Figure 9) show various activation energies for permeation through the membrane. In contrast, an Arrhenius Plot of p-dichlorobenzene exhibits the same activation energy or slope for all five glove materials (Figure 10). This phenomena was present for all five glove materials and seems to signify the idea of permeation is a solid related phenomena and not a glove related phenomena.

Effect of Saline on Permeation Characteristics Preliminary results show these environments do effect the permeation characteristics such as breakthrough time, steady state time and steady state permeation rate. A goal is to predict the behavior of glove materials versus a particular solid and whether a membrane is aided or hindered by the environment. Table V is a comparison of permeation characteristics of two organic solids in their particular environment. There is a increase in the breakthrough times of the saline environment.

Figure 8 – Breakthrough Time vs. Temperature (p-nitrotoluene)

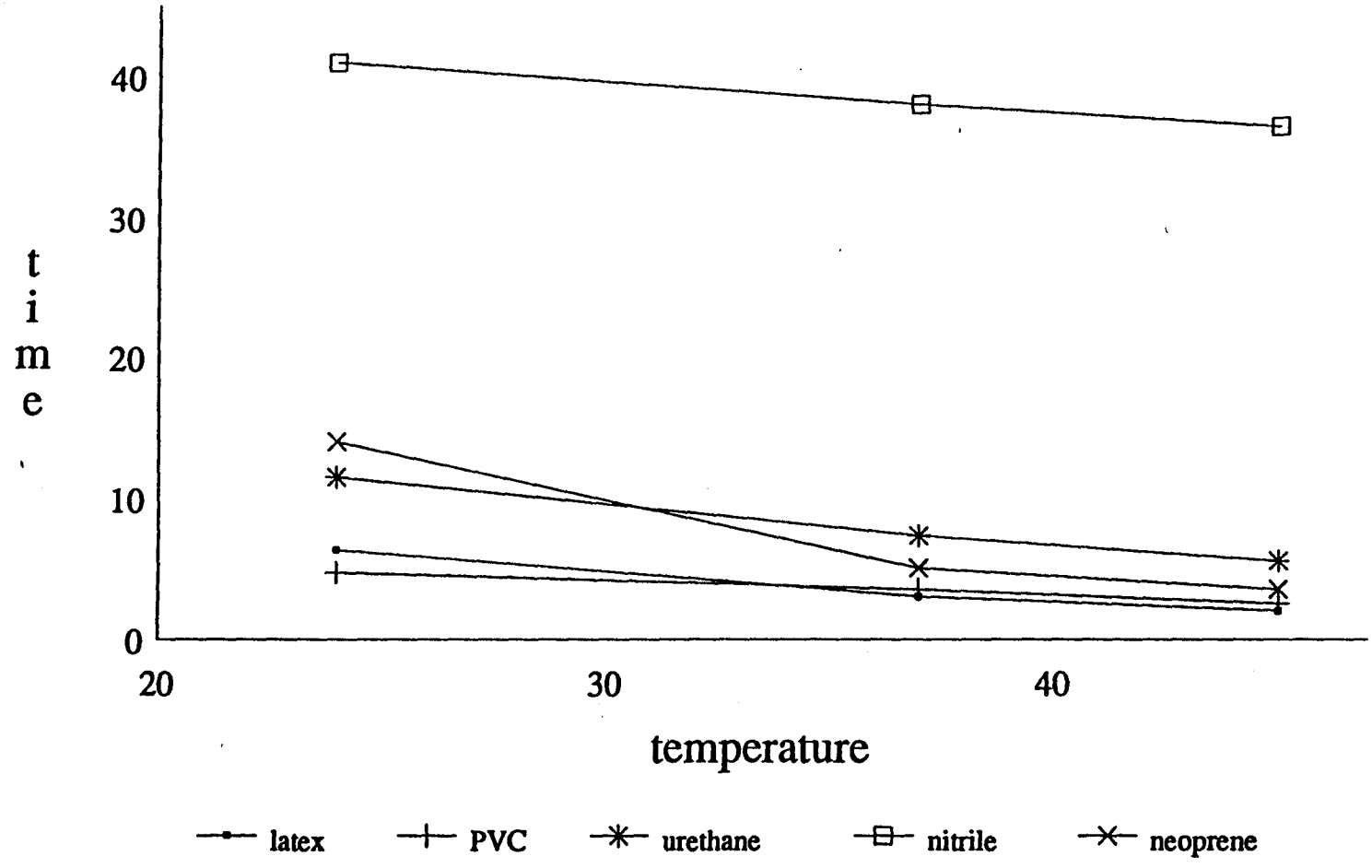
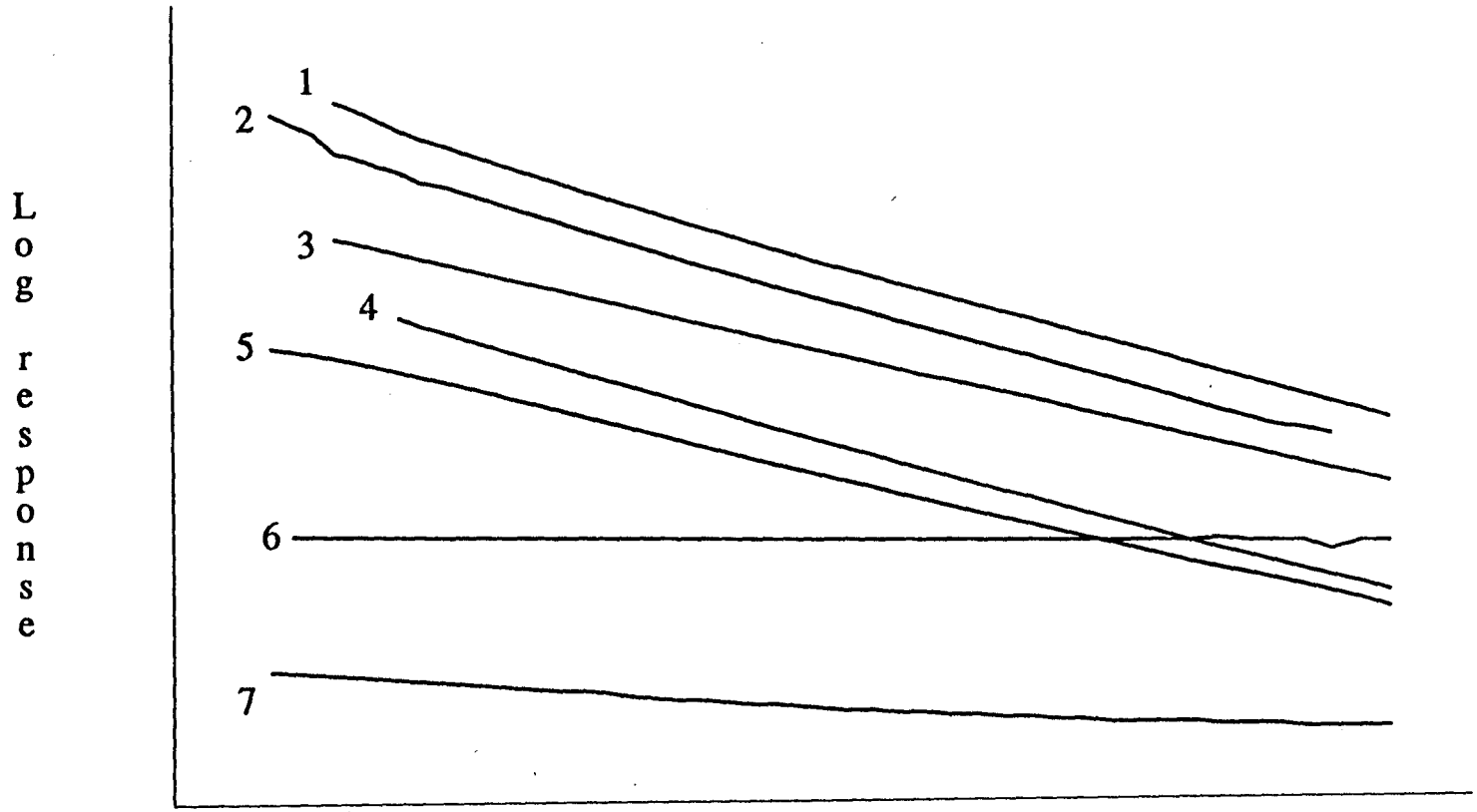
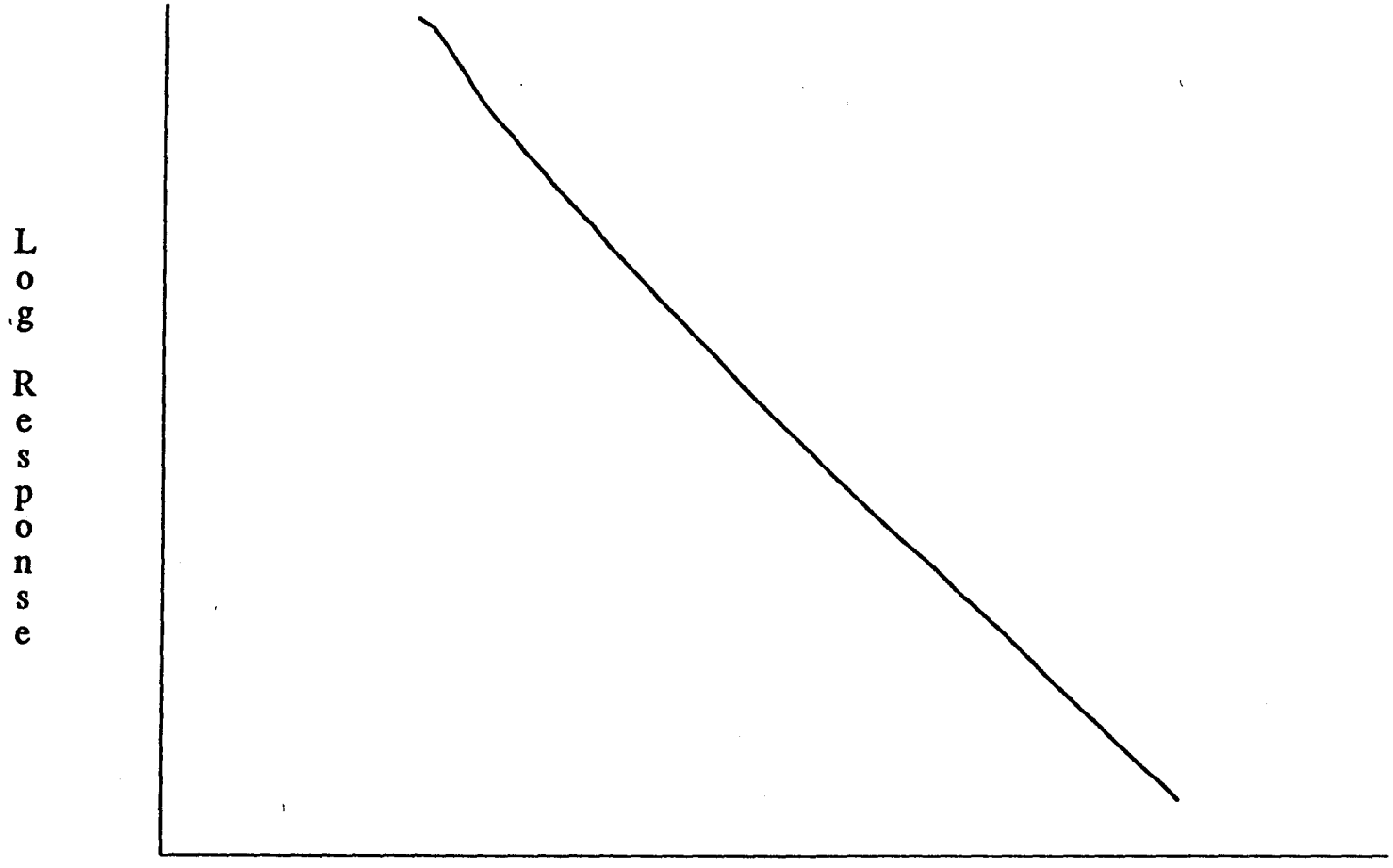


Figure 9 – Latex vs. 7 Organic Solids



(1)dichlorobenzene (2)benzoquinone (3)camphor (4)dinitrocresol (5)dinitrotoluene (6)p-nitrotoluene (7)naphthalene

Figure 10 – Dichlorobenzene vs. 5 Glove Materials



Latex, PVC, Nitrile, Neoprene, Urethane

Table 5 Comparison of Helium versus Saline Environments

		BT (min)	SSPR(g/min/cm^2)
1,4-dichlorobenzene			
	saline	7.4	0.8801
	helium	5.2	8.074
phenol			
	saline	18.2	19.21
	helium	10.4	1.505

Conclusion.

Using a modification of a previously described method for the characterization of permeation by organic solvents, it has been demonstrated that organic solids permeate through common glove materials. SSPR values are low for solids, most likely due to lower vapor pressures. A significant variation in BT and SSPR between direct contact and vapor phase permeation demonstrates that permeation is not totally a vapor pressure phenomenon. Temperature, as well as, alternate environments may also effect the BT and SSPR's of many organic solids in actual use. The work reported shows that while some glove materials can offer adequate protection for specific chemical species, individual permeant evaluations may be required.

Acknowledgment.

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List of Publications.

1. **Fricker, C.M. anf J.K. Hardy.:** *Protective Glove Material Permeation by Organic Solids.* In Press.

Equipment List.

Description	Manufac./Model	Serial # /Condition	Date purchased	Cost/%of grant
Gas Chromatograph	Hewlett Packard /5890A Series II	2921A23576/Good	7/27/89	$11,408.00 /100%

Final Invention Statement.

No inventions were conceived under grant RE: 5 R01 OH0261–02