CPRC

CANADIAN POLICE RESEARCH CENTRE

CCRP

CENTRE CANADIEN DE RECHERCHES POLICIERES

TM-l3-94
Protective Clothing for Hazardous Spills

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Canadian Police Research Centre

TECHNICAL MEMORANDUM

Submitted by
Canadian Police Research Centre

May, 1994

NOTE: Further information about this report can be obtained by calling the CPRC information number (613) 998-6343

SUMMARY

Police members occasionally have to secure the perimeter of a site of an incident where hazardous chemicals or other materials have been spilled. Normal uniform garments provide little or no protection from such materials. The members should have readily available a garment to put over their uniform in order to provide them with a moderate level of protection from chemical contact with the uniform or the skin.

The objective of this project was to select and evaluate a sample of commercially available outer garments that provide protection from liquid or solid chemical spills. The garments were evaluated for comfort, ease of donning and removal, etc. The degree of protection offered by the protective barrier (ie. Saranex, Tyvek, Chemrel, Neoprene or Gortex) of the above products was not tested by the C.P.R.C. nor any of the review agencies.

Initial comments of reviewers were unanimous in one aspect — all the suits except the Gortex suit were very hot to wear. The two suits made with Chemrel were found to be stiff, especially in cool weather. All the suits were suitable with regard to ease of donning and removal.

RÉSUMÉ

Les membres des corps policiers doivent parfois bloquer l'accès d'une zone où des produits chimiques ou autres substances dangereuses ont été déversés accidentellement. Les uniformes ordinaires protègent peu les policiers, qui devraient pouvoir enfiler rapidement un vêtement de protection par-dessus leur uniforme. Un tel vêtement leur offrirait un degré de protection moyenne pour éviter le contact du produit avec l'uniforme ou la peau.

L'objectif du projet consistait à sélectionner et à évaluer divers vêtements de protection à porter en cas de déversement de produits chimiques liquides ou solides que l'on peut trouver dans le commerce. On a vérifié s'ils etaient confortables, faciles à mettre et à enlever etc. Le degré de protection offert par la barrière protectrice (par exemple Saranex, Tyvek, Chemrel, Neoprene ou Gortex) de ces vêtements n'a été testée ni par le Centre canadien de recherches policières ni par aucun des organismes d'évaluation. Dans leurs premiers commentaires, les évaluateurs ont été unanimes sur un point : tous les vêtements, sauf le Gortex, etaient trop chauds. Les deux Chemrel etaient trop raides, spécialement par temps froid; tous etaient faciles à enlever et à enfiler.

PROTECTIVE CLOTHING FOR HAZARDOUS SPILLS
INTERIM REPORT

Operational Requirement:

Police members occasionally have to secure the perimeter of a site of an incident where hazardous chemicals or other materials have been spilled. Normal uniform garments provide little or no protection from such materials. The members should have readily available a garment to put over their uniform in order to provide them with a moderate level of protection from chemical contact with the uniform or the skin.

Project Objective:

The objective of this project was to select and evaluate a sample of commercially available outer garments that provide protection from liquid or solid chemical spills. The garments were evaluated for comfort, ease of donning and removal, etc.

The garments were **not** selected to provide any form of protection from hazardous vapours or biological hazards. It is also important to note that the garments were **not** selected to provide long term protection from exposure to the toxic liquids and solids.

The degree of protection offered by each garment was not confirmed - technical data provided by the manufacturer was taken at face value. This report will direct the reader to a small selection of references that will discuss this issue of protection in greater detail.

Detail:

Seven protective garments that vary in protective capability and cost were purchased for evaluation. The selection was of suits was not designed to be a comprehensive survey of all protective garments on the market, but just a very brief sample of garments offering light to moderate chemical protection. The police agencies which kindly offered to evaluate the suits were: the Quebec Provincial Police, the Ontario Provincial Police, the Sarnia Police Service and the RCMP.

Products Purchased:
(1) Coverall with Hood, **Saranex 23-P film on Tyvek** from Lab Safety Supply, Janesville, Wisconsin
(2) Full Body Coverall, **Polylaminated polyethylene film on Tyvek** from Lab Safety Supply, Janesville, Wisconsin
(3) Full Body Coverall, **Chemrel** from Lab Safety Supply, Janesville, Wisconsin
(4) Full Body Coverall with Hood, **Chemrel Max** from Lab Safety Supply, Janesville, Wisconsin
(5) Jacket, Hood and Bib Pants, **Neoprene on Nylon,** from Safety Supply Canada, Gloucester, Ontario
(6) Jacket with Bib Pants, **Nomex with Gortex** inner barrier, from Lac Mac, London, Ontario

Protective Properties of Suits:
The degree of protection offered by the protective barrier (ie. Saranex, Tyvek, Chemrel, Neoprene or Gortex) of the above products was not tested by the C.P.R.C. nor any of the review agencies. Tables listing parameters such as "Breakthrough Time" and "Permeation Rate" were provided by several manufacturers. These are included with this report at **Appendix B to F - the accuracy of data contained therein was not verified and is not warranted by the C.P.R.C.** The C.P.R.C. recommended that a potential users of such protective equipment read and follow recommendations such as contained in the document entitled Chemical Protective Clothing - Selection *of* Material" that was provided by the Canadian Centre for Occupational Health and Safety. A copy of this document is found in **Appendix A** of this report. I would also recommend the following articles:

(1) "Dressed for Danger", by Mervin Fingas, OH&S Canada, Vol. 3 No. 5, pg. 5Off

(2) *"Chemical Protective Clothing",* by Mervin Fingas, OH&S Canada/ The Buyers Guide 1987/88, pg. 17f-21

(3) "Five *Factors in Selecting Chemical Protective Clothing",* Public Utilities Newsletter, National Safety Council. Nov.- Dec. 1984, pg. 3-4.

(4) *"Chemical Protective Clothing: 1. Selection and Use",* by Jimmy L. Perkins, Appl. Ind. Hyg. Vol. 2, No. 6, Nov. 1987, pg. 222-230

(5) *"Only Time Will Tell"* by Jamie Lara, OH&S Canada/l991 Buyers' Guide, pg. 62ff

(6) "Protection for the Hazmat Responder" by Stephen L. Hermann, 9-l -1 Magazine, September/October 1992, pg30-33

I would also strongly recommend the following two volume reference::

Chemical Protective Clothing,
James S. Johnson and Kevin J. Anderson, editors

It is available from the American Industrial Hygiene Association, P.O. Box 8390, 345 White Pond Drive, Akron, Ohio 44320. I have enclosed a copy of the table of contents to each of the two volumes of this reference in Appendix G of this report.

Interim Results:

Initial comments of reviewers were unanimous in one aspect -- all the suits except the Gortex suit were very hot to wear. This was somewhat expected, as these suits provide an impermeable barrier that defeats air circulation about the body as well as the natural sweating/cooling mechanism used by the body. The Gortex/Nomex suit "breathes" and therefore is more comfortable to wear. This property, however, renders the suit of little protective value against spills of highly volatile chemicals.

The two suits made with Chemrel were found to be stiff, especially in cool weather. This could create problems if flexibility of motion was critical.

All the suits were suitable with regard to ease of donning and removal. Only the Nomex/Gortex and the Neoprene/Nylon suits were designed for repeated use. Therefore, only they would require cleaning and decontamination. The others would be discarded in an environmentally safe manner.

Conclusions and Recommendations:

It is essential that any agency contemplating the use of Chemical Protective Clothing (CPC) consult a certified occupational health and safety professional before selecting specific products and implementing procedures/protocols for responding to the site of a chemical spill.

CPC does not reduce the hazard itself nor does it guarantee permanent or total protection. CPC is designed to meet criteria which can only approximate real working conditions. CPC should not be used when hazards are greater than those for which it is designed. The unexpected cannot always be predicted.

Once the need for CPC has been established, the task is to select the proper type. Two criteria need to be determined -- the degree of protection required, and the appropriateness of the equipment to the situation. The degree of protection and the design of CPC must be integrated because they affect its overall efficiency, wearability and acceptance. No mater how well a product is designed, if it is not worn (or worn improperly) the degree of protection afforded will be reduced.

Without proper maintenance, the effectiveness of “reusable” CPC cannot be assured. Maintenance should, at the very least, include inspection, care, cleaning, repair and proper storage. This concern does not arise with CPC that is designed to be disposed of after its first use.

For further information on the tested products please contact:

(1) Lab Safety Supply,
P.O. Box 1368
Janesville, Wisconsin, USA
53647-l 368
Phone: 608-754-2345
Fax: 608-754-l 806

(2) Safety Supply Canada Ltd.
90 West Beaver Creek Road
Richmond Hill, Ontario L4B 1 E7
Phone: 416-222-4111

(3) Lac Mac
425 Rectory Street
London, Ontario N5W 3W5
Phone: 519-432-2616\
Fax: 519-432-6096

APPENDIX A

Canadian Centre for Occupational Health and Safety
Centre canadien d'hygiène et de sécurité au travail

Document 92/0205I
September 28, 1992

CHEMICAL PROTECTIVE CLOTHING - SELECTION OF MATERIAL

Chemical protective clothing (CPC) should not be considered as a replacement for engineering control methods, but often there are few alternatives or emergency handling of chemicals requires their use. Since CPC is the last line of defense, care must be taken to ensure it provides the protection that is expected.

The phrase commonly found on material safety data sheets "Wear impervious clothing/gloves" is of very limited value in protecting workers and is also technically inaccurate. Any given material will not remain impervious to a specific chemical forever. Some chemicals will travel through or permeate the material in a few seconds, while other chemicals may take days or weeks.

Permeation rate is the rate at which the chemical will move through the material measured in milligrams per square meter per second. The higher the permeation rate, the faster the chemical will move through the material. Note that permeation is different from penetration; the latter occurs when the chemical leaks through seams, pinholes and other imperfections in the material.

Break&rough time is the elapsed time from the initial contact of the chemical on the exterior of the material to the time of detection of the chemical on the inside surface. This gives some indication of how long a glove can be used before the chemical will permeate through.

Degradation is a measurement of the physical deterioration of the material. The material may get harder, stiffer, more brittle, softer, weaker or may swell. The worst example of this, is the material that actually dissolves in the chemical.

Based on the preceding information it becomes apparent that you must carefully choose the appropriate material for the CPC for each job. Before the selection of the appropriate chemical protective clothing for a specific job, the following information must be gathered and analyzed:

1. Complete, accurate description of the task.

2. Identification of alI hazards that may require protection. This should include a list of the chemicals involved as well as physical hazards such as abrasion, tearing, puncture, temperature, or the need for electrostatic protection or protection from other electrical hazards.

250 Main St. E/250, rue Main est. Hamilton Ontario Canada L8N IH6
Telephone/Téléphone (416) 572-2981 Fax/Télécopieur (416) 572-2206

3. Flexibility and touch sensitivity needed for the task. This is particularly important for glove selection. This may significantly limit the thickness of glove material that can be used. The requirement for textured or non-slip surfaces to improve grip must also be considered.

4. Type of potential contact (i.e. occassional contact or splash protection or continous exposure to corrosive, toxic gases). This information will also help in choosing the appropriate length of glove, if gloves are the only kind of CPC being worn.

5. Contact period. How long the worker could be in contact with the chemical. This may influence the selection of type and thickness of the material.

6. Potential effects of skin exposure. Both the immediate irritation or corrosion of the skin must be considered as well as the potential health effects to the entire body from absorbing the chemical through the skin.

7. Decontamination procedures. Consider whether the CPC should be disposed of after use or how often they should be cleaned and by what method.

8. Training required. This includes the hazards of skin contact with the chemical, limitations of the gloves and when to dispose or decontaminate.

9. Based on quantitative information such as permeation rate, breakthrough time, penetration and degradation, and the other considerations mentioned above, suggested materials should be selected. Note that thickness of the material and manufacturing methods can have a significant effect on these properties. (Note: For situations where it is impossible to predict the variety of hazards, multilaminate CPC made of layers of several different materials are available.) After the correct CPC has been selected there are still several areas to consider:

Workplace evaluation

The selected CPC should be carefully tested in the actual job conditions. (In some situations it may be desirable to do laboratory tests with the workplace mixtures using American Society for Testing and Materials (ASTM) methods)

program Audit

Once there is a decision to use CPC, a CPC program should be developed and maintained.

A mechanism needs to be in place to ensure a competent person reviews the selection and use of chemical protective clothing to ensure that any changes in chemicals being used are accounted for, to uncover any problems and to make necessary improvements.

Workers should be trained in various aspects using CPC including the correct inspection, storage and maintenance of the CPC, how to put the CPC on and take it off correctly, how long to wear it under working conditions, decontamination procedures, what the limitations of the CPC are, what the consequences are if the CPC fails and what to do if it does fail.

Unfortunately, chemical protective clothing is often considered as a fast and easy method of providing skin protection. The long-term costs of implementing an on-going chemical protective clothing program may be higher than the costs for implementing proper engineering controls.

Since personal protective equipment such as CPC represents the last line of defense, considerable effort should be expended to ensure that adequate protection is actually being provided.

Some sources of information for CPC material selection

Many manufacturers of chemical protective clothing provide charts and computer software to assist in selecting the appropriate material when working with a specific chemical. In addition there are similar tools available from independent sources. Furthermore, there is no reliable way to predict what material to select for protection against a mixture containing several solvents based on permeation data on the individual solvents. The mixture should be tested. Care must be taken in interpreting generic information, since the properties, thicknesses and quality assurance of glove materials may vary between manufacturers.

Generic **Guides**

Schwop, A.D., et al. Guidelines for the selection of chemical protective clothing. Field guide. Vol. 1. American Conference of Governmental Hygienists Inc., 1987

Johnson, J.S., et al. Chemical protective clothing. Product and performance information. Vol. 2. American Industrial Hygiene Association, 1990

Foresberg, K., et al. Quick selection guide to chemical protective clothing. Van Nostrand Reinhold, 1989

CPC base. Software. Arthur D Little Inc.

Keith, L.H. Instant chemical protective clothing performance index. American Conference of Governmental Industrial Hygienists, 1989 (Software and book)

NFPA 1991 Standard on vapor-protective suits for hazardous chemical emergencies. NFPA, 1990

NFPA 1992 Standard on liquid splash-protective suits for hazardous chemical emergencies. NFPA, 1990

NFPA 1993 Standard on support function protective garments for hazardous chemical operations. NFPA, 1990

Manufacturers **Guides**

Charts in manufacturers' and distributors' catalogs

3M Select software. 3M Canada Inc. London, Ontario

Note: This information was prepared for the CCOHS Inquiries Service by technical staff. For further information please contact the Inquiries Service. Reference to trade name products does not constitute a recommendation or endorsement by CCOHS.

APPENDIX B

The accuracy of data contained in this appendix was not verified by the C.P.R.C. and is not warranted by the C.P.R.C. It is essential that any agency contemplating the use of Chemical Protective Clothing (CPC) consult a certified occupational health and safety professional before selecting specific products and implementing procedures/protocols for responding to the site of a chemical spill.

Marketing Information

Number: CHEMRON

Product: 7 November 1990

Subject: CHEMRON PROTECTIVE CLOTHING

Chemron Manufactures a line of limited use protective clothing which offers its users superior chemical resistance. Chemron has developed materials for their suits for one purpose only, and that was to provide complete chemical protection. In fact, they have developed their materials by working closely with fire departments and industrial Haz-mat response teams. The result is a line of limited use protective clothing that is uncompromising in its strength and chemical resistance.

TARGET MARKETS:

- Fire Departments
- Industrial Haz-Mat Teams
- Chemical Industry
- Pulp & **Paper** Industry
- Mining
- Transportation Industry

BUYNG INFLUENCES:

- Haz-Mat Supervisors
- Fire Chiefs
- Safety Directors
- Industrial Hygienists

FEATURES	BENEFITS
Excellent chemical resistance	Broad chemical resistance
	End user no longer needs to stock suits of various materials for specific chemical hazards
	Improves safety of worker
Sealed seams	Offers further chemical protection to the user
Suits are lightweight and versatile	**Allows worker** to move around more comfortably and safely.
Limited use design	No worries associated with decontamination.

PROTECTIYE CLOTHING SELECTIDN GUIDE

Chemron has arranged for Radian Corporation to test Cherrel and has compared the results to DuPont's publisnea data cn Saranex/Tyvek. The Chemrel results are meaningfully superior on 39 of the 41 chemicals tested and tre same an 2 chemicals. Chearel provides chemicals resistance an all 41 chemicals while Saranex/Tyvek provides chemical resistance on only 19 chemicals.

	Chemrel		Saranex/Tyvek	
Cheaical	Breakthrough Tine	Permeation Rate	Breakthrough Tire	Permeation Rate
Acetone, 99+%	>24 hours	0.0 mg/m²/sec	33 min.	3.3 mg/m²/sec
Acetonitrile, 99+%	>24 hours	0.0	Not tested by DuPont	
Acetyl Chloride, 98%	58 min.	2.0	37 min.	0.18
Benzene, 99+%	17 min.	0.002	Not tested by CuPont	
Bromine Liquid 99+%	3 min.	267	Not tested by DuPont	
Butyraldehyde, 995	234 min.	0.006	Not tested by DuPont	
Carbon Disuifide	5 min.	C.6	Not tested by DuPont	
Chlorine Gas, 100%	>24 hours	0.0	>8 hours	0.3
Chloroform, 99%	4 min.	0.3	<1 ein.	33.5+
Cyclo Hexane, 99+%	>24 hours	0.0	Not tested by DuPont	
Deithyiether, 99%	1 min.	0.05	Not tested by DuPont	
Diethylanine, 98%	110 min.	2.0	44 min.	6.3
Dioxane, 99%	>24 hours	0.0	50 min.	2.9
OMF, 99+%	>24 hours	0.0	Not tested by DuPont	
Ethyi Acetate, 99%	55 min.	0.0002	36 min.	1.1
Ethylene Oxide Gas, 98%	>24 hours	0.0	B min.	7
Formaldehyde, 37%	>8 hours	3.0	Yot tested by DuPont	
Formic Acid. 95%	>24 hours	0.0	Not tested by DuPont	
Freon 113	>2b hours	0.0	Not tested by DuPont	
Hexane. 99+%	>24 hours	0.0	No: tested by DuPont	
Hydrazine Anhydrous	>24 hours	0.0	Not tested by DuPont	
Hydrochloric Acid, 37%	>21 hcurs	0.0	>24 hcurs	0.3
Hydrofluoric Acid, 48%	>24 hours	0.0	>30 min.	0.0005
Methanol, 99+%	136 min.	0.09	Not tested by CuPont	
Methyl Ethyl Ketone, 99+%	>21 hcurs	0.0	29 min.	1.3
Methylamine, 98%	>I8 min.	0.7	Not tested by DuPont	
Methyl Isocyanate, 99+%	9 min.	0.05	2 rin.	3.5
Methylene Chloride, 99%	S min.	0.5	Not tested by DuPont	
Nitric Acid. 70%	>2b hours	0.0	>14 hcu-s	0.0
Nltrobenrene. 99+5	>24 hours	0.0	Not tested hy DuPont	

Chemical	Chemrel Breakthrough Time	Chemrel Permeation Rate	Saranex/Tyvek Breakthrough Time	Saranex/Tyvek Permeation Rate
Nitronethane. 96%	>24 hours	0.0	Nc: tested by DuPont	
PCS/Mineral Oil, 50%/50%	>8 hours	0.0	>8 hours	0.0
Phenol, 85%	>8 hcurr	0.0	Not tested by DuPont	
Propanol, 99+%	>24 hours	0.0	114 min.	None detected
Red Fuming Nitric Acid, 864	39 min.	0.5	Nc: tested by DuPont	
Sodium Hydroxide, 50%	>24 hours	0.0	>8 hours (40%)	0.0
Sulfuric Acid, 98%	>24 hours	0.0	>8 hcors	0.3
Tetrachloroethylene, 99%	26 min.	0.1	13 min.	0.19
Tetrahydrofuran, 99+%	7 min.	2.9	Not tested by DuPont	
Toluene. 99%	>142 min.	0.003	<5 min.	3.33
Toluene/MEK. 99% (50/50 mix)	32 min.	0.32	Not tested by DuPont	

INFORMATION NOTES: The chemical test data set forth herein is designed to be used as a starting point by the user in selecting the groper protective garment for handling the listed toxic chemicals. The data is bases upon breakthrough test: performed (in accordance with ASTM Standard F739-31) under laboratory conditions on the Chemrel fabric, not the complete garment, by Raaian Corporation of Austin. Texas, an AIHA accredited independent laboratory. Since end use conditions with respect to chemical exoosure, garment and seam stress, puncture potential and other conditions may be different and are outside our control. Chemron recommends that each user conduct its own tests to confirm the suitability of the Chemrel garments for a specific appllcaticn. Neither Chearon nor Radian Corporation assumes any responsibility for the suitability of an end user's selection of garments based uoon data heroin.

WARNING: An end user should not use a Chemrei garment (or any otner garment) if the fabric or a seam has been punctured or ruptured. Punctures or ruptures will result in immediate exoosure to the chemical and injury to tne worker. The selection of garment should include consideration of the probability of exposure of the worker to punctures or ruptures. Chemrel garments also include safety seams which will withstana normal stress and chemical [illegible] exposure: however, all garment seams are subject to tne variations in quality of the manufacturing process and the selection of garment should also include consideration of the degree of stress invoived in the work activity. If the Chemrei garment is to be useo in a gaseous environment, special closures should be oroered. Do not use any Chemrel garment for fire protection avoid open flame and intense heat.

®Saranex is the registered trademark of Dow Chemical and Tyven is the registered trademark of DuPont.

ANTICIPATED BREAKTHROUGH TIMES ON CHEMREL
AT ROOM TEMPERATURE

Chemical	jreakthrouah Time	Chemical	Breakthrough Tire
Acetaldehyde	>4 hours	Jutyl Acetate	>3 hours
Acetic Acid	>24 hours	Butyl Amine	>iCC min.
Acetic Anhydride	3 hours	Calcium Hydroxide	>24 hours
Acetic Chloride	>8 hours	Calcium Hypochlorite (HTH)	>8 hours
Acetylphenylacetonitrile	>3 hours	Carbon Dioxide	40 min.
Acrolein	>4 hours	Carpontetrachloride	>4 min.
Acrylic Acid 50%	>6 hours	Caustic Soda	>24 hours
Acrylimide	>3 hours	Chlorine (20 ppn)	>24 hours
Acrylonitrile	>4 hours	Chloro-2-propanone	>6 hours
Allylchloride	>30 min.	Chloroacetic Acid 68%	>8 hours
Aluminum Chloride	>8 hours	Chloroacetone	>6 hours
Aluminum Stearate No. 2	>24 hours	Chlorobenzene	>1 hour
Ammonia (solution)	>3 hours	Chlorosulfonic Acid	>3 hours
Ammonium Hydroxide	>8 hours	Chromic Acid	>24 hours
Anhydrous Ammonia (gas)	>1 hour	CI Acid Blue 182 (190%)	>24 hours
Anhydrous Sodium Sulfate	>24 hours	CI Acid Grange	>24 hours
Aniline	>8 hours	01 Acid Red 52 (No. 2)	>24 hours
Arctic Syntex liq. Perfume	>24 hours	CI Pigment Green/C1 74260 (No. 1)	>24 hours
Arquad	>24 hours	CI Reactive Green	>24 hours
Benzaldehyde	>45 min.	Copper Cyanide	>4 hours
Benzoyl Chloride	>2 hours	Copper Sulfate	>8 hours
Benzyl Chloride	>2 hours	Cresols (tech grade)	>2 hours
Biphenyl	>8 hours	Crystal 792 Perfume (IFF)	>24 hours
Black Liquor (alkali)	>8 hours	Cyanides (for all salts)	>4 hours
Butanol	>8 hours	Cyanogen Bromide	>8 hours

Chemical	Breakthrough Time
Cyclohexanone	>8 hours
O&C Green #8	>2b hours
D&C Green #3	>24 hours
D&C Yellow #8	>24 hours
D&C Yellow #10	>24 hours
ORSG	>3 hours
Dental Cream Flavor 105	>24 hours
Di-Borane	>1 hour
Dicalcium Phosphace	>24 hours
Di-Chlorobenzene	>1 hour
Dichloroaethane	>5 min.
Oiesel	>6 hours
Oiethyiene Trianine	>2 hours
Dimethylacetamide	>1 hour
Dimethylacetimide	>8 hours
Dimethylamine	>1 hour
Dimthylaniline	>8 hours
Dimethylsulfate	>6 hours
Dioxin	>6 hours
Diphenyioxide	>8 hours
Dishwash Fragrance	>24 hours
Dowanol TMH	>24 hours
Oowtax	>24 hours
Oyna 984 Pertume	>24 hours
Dynadet Plus Pertume N-14048	>24 hours

Chemical	Breakthrough Time
Oynadet Plus Perfume	>24 hours
EDTA 61.5% Soin	>24 hours
Epichlorohydrin	>1 hour
Ethanol	>2 hours
Etner	>1 min.
Ethoxyethanoi	>4 hours
Ethyl Alcohol	>2 hours
Ethyl Cellusoive	>8 hours
Ethyldibromide	>1 1/2 hours
Ethylenediamine	>2 hours
Ethyiene Dichloride	>30 mins.
Ethyiene Glycol	>24 hours
Etlylenedianine Tetra Acetic Acid	>6 hours
FD&C Blue #1	>24 hwrs
FD&C Yellow No. 5	>24 hours
Ferric Chloride	>8 hours
Formaldehyde 50%	>6 hours
Formalin	>2b hours
Gasoline	>6 hours
Glacialacetic Acid	>8 hours
Glycerine 99.3% C.P.	>24 hours
Green Shade No. 15936	>24 hours
Heotane	>8 hours
Hexamethylene Diisocyanate	>8 hours
Hydricdic Acid	>4 hours

Chemical	Breakthrough Time
Hydrogen (gas)	30 min.
Hydrogen Chloride	>1 hour
Hydrogen Cyanide (gas)	>1 hour
Hydrogen Flouride	>3 hours
Hydrogen Peroxide (90%)	>8 hours
Hydroxyacetfc Acid	>8 hours
Hypochlorite Soln 13%	>24 hours
Iodine	>8 hours
Iron Fillings	>24 hours
Kerosine	>4 hours
Lduryl Amine	>2 hours
Lemon Juice Concentrate	>24 hours
Lemon Perfume	>24 hours
Lemon Perfume/Colgate Compound	>24 hours
Lemstar 016 Mod. Perfume	>24 hours
Liquid Dual Enzyme	>24 hours
Liquid Dual Enzymes No. 2	>24 hours
Lmmea/SXSW Blend 5:3	>24 hours
LPKN	>24 hours
Lytron 621 Opacifier	>24 hours
Magnesium Sulfate Anhydrous	>3 hours
Rgnesium Turnings	>24 hours
Malathion 10%	>6 hours
Malathion 60%	>4 hours
Manganous Carbonate	>8 hours

Chemical	Breakthrough Time
Manganous Chloride	>8 hours
Mercuric Chloride	>8 hours
Mercury (elecental)	>8 hours
Methoxy-3-propylaaine	>2 hours
Methoxyethy1 Acrylate	>8 hours
Methyl Bromide	>80 mins.
Manganous Chloride	>8 hours
Mercuric Chloride	>8 hours
Mercury (elemental)	>8 hours
kthoxy-3-propylamine	>2 hours
kthoxyethyl Acrylate	>8 hours
Methyl Bromide	>80 nins.
kthyl Chloroacetate	>8 hours
Methyl Oiisocyanate	>10 min.
Methylene Oianiline	>8 hours
Methyl-iso butyl ketone	>24 hours
kthyl Parathion 10%	>6 hours
Methyl Parathion 57%	>2 hours
mineral Spirits	>1 hour
Hod. Cool Spearmint Flavor	>24 hours
Monochlorobenzene	>30 min.
Monochloro Cetic Acid (MCA)	>8 hours
Monochlorowthyl-ether	20 min.
Monoethanolamine	>1 hour
Monoiethylamine	>30 min.

Chemical	Breakthrough Time
Yorphoiine	>4 hours
N-Buthyl Acetate	>2 hours
N-Buthyl Alcohol (Yutanol)	>8 hours
N-Nethyltormamide	>24 hours
Napthalene	>30 mins.
Natural Soda Ash (Light Grade)	>24 hours
Neodol 25-3A Ethoxysuifate	>24 hours
Nitroethane	20 rin.
Nitrogen Tetroxide (N204)	1 hour
Nitrous Oxide 100%	>4 hours
No. 3 Liquid Dual Enzymes	>24 hours
Octagon Floating Soap Perfume	>24 hours
Oleum 653	>1 hour
Ortho-Toluioine	>3 hours
Oxydianiiine	>3 hours
PCB 50%-100%	>8 hours
PEG-400	>24 hours
Palladium on Borium Sulfate	>1 hour
Palladium Black	>8 hours
Palmolive Liauid Det. Perfume	>24 hours
Pentachlorophenol	>8 hours
Perchloric Acid	>8 hours
Peroxide	>8 hours
Petroleum Distil lants (excluding aromatics)	>3-8 hours
Petroleum Ether	1 min.

Chemical	Breakthrough Time
Phenylacetic Acid	>8 hours
Phenylacetoritrile	>8 hours
Phenyl-2-propanone	>8 hours
Phorwite BBH Pure 766	>24 hours
Phorwite BHC 766	)24 hours
Phorvite HRS	)24 hours
Phorwite RKH Pure	>24 hours
Phoschoric Acid 50%	>87 hours
Phosphor:c Acid 15%	>3 hours
Phosphorous Pentachloride	>8 hours
Phosonat;dic Acid	>8 hours
Phosphine	30 min.
Phosphorous tri Chloride	>8 hours
PKO Lmmea/Sxs Ylend (No MSDS)	>24 hours
Platinum Chips	>24 hours
Platinun Chloride	>8 hours
Poiar Brilliant Blue	>24 hours
Polyethylene Glycol 600	>24 hours
Polypeptide 37	>24 hours
Potassium Carbonate 47% Soln.	>24 hours
Potassium Hydroxide (45% sol.)	>24 hours
Propane	>8 hours
Propiophenone	30 min.
Propylene Oxide (gas)	>24 hours
Rose Perfume (All Purpose)	>24 hours

Chemical	Breakthrcuah Time	Chemical	Breakthrough Time
Silicate 43.5	>24 hours	Sulfuric Acid 90%	>8 hours
Sodium (metal)	>8 hours	Sulphalene	>24 hours
Sodium Acetate Anhydrous	>8 hours	Syloid 244	>24 hours
Scdiua Benzoate	>24 hours	Tartrarine Xtra Conc.	>24 hours
Sodium Sisulfite	>8 hours	Tetra Alkyl Lead	>2 hours
Soaium 8orohydride	>4 hours	Tetra Ethyl Lead	>6 hours
Sodium Hydroxide 50%	>24 hours	Tetra Hydro Thioohene	<30 min.
Soaium Hydrosulfite	>6 hours	Tetrasodium Pyrophosphate	>24 hours
Soaium Ldury1 Sulfate	>24 hours	Thionyl Chloride	30 min.
Soaium Lauryl Sulfate #4	>24 hours	Thionylene Chloride	>30 min.
Sodium Monofluorouhosfate	>24 hours	Thorium Nitrate	>1 hour
Sodium Nitrate - Coated	>24 hours	Tinopal 58M Conc.	>24 hours
Sod ium Saccharin (No MSDS)	>24 hours	Titanium Dioxide	>24 hours
Sodium Serauicarbonate	>24 hours	Titanium Tetrachloride	>8 hours
Sodium Sulfite Bisulfide	>6 hours	Tolune diisocyanate	>6 hours
Sodium TPP PHOS (Thermoohos NW)	>24 hours	Trich!oroacetic Acid	>2 hours
Sodium Tripolypbosphate - HEXA	>24 hours	Trichlorobenzane	>1 hour
Sodium Xylene Sulfonate Soln	>24 hours	Trichloroethane	>20 min.
Scrbitoi 70% Solution	>24 hour	Trich;oroetnylene	>20 min.
Styrene	>1 hour	Triethanoiamine 99%	>6 hours
Sulfolane	>1 hour	Triethvlanfne	>3 hours
Sulfur Dioxide	>3 hours	Uvinul US-40	>24 hours
Suifur Trioxide	>8 hours	Vinyl Acetate	>8 hours
Sulfuric Acid 16%	>8 hours	Vinyl Chloride	>8 hours
Sulfuric Acid 50%	>8 hours	Vinyl Chloro Acetic Acid (VCA)	>8 hours

Chemical	Breakthrough Time	Chemical	Breakthrough Tine
Xylene	>3 hours	1,1 Dioxide	>3 hours
ClO-13 Nalabs Hydrotrope	>24 hours	1.4-Oichloro-2-Butene	>3 hours
C102 (solution)	>24 hours	2-Chloroethano!	>8 hours
SO3 008 High AI Base	>24 hours	2-Propanol	>24 hours
SO3 Easy Liq. Bet. Base	>24 hours	2.2.2-Trichloroethanol	>1 hour
02	>24 hours	2,2.2-Trifluoroethanol	>8 hours

INFORMATICN NOTES: The chemical breakthrough data set forth herein is designed to be used as a starting point by the user in selecting the proper protective garment for handling the listed toxic chemicals These ddtd dre based upon an extrapolation of the actual breakthrough data collected on similar chemical families tested in accordance with ASTM Standard F739-81 under laboratory conditions on the Chemrel fabric, not the complete garment, by Radian Corporation of Austin, Texas an AIHA accredited independent laooratory. Since end use conditions with respect to chenicdi exoosure, garment and seam stress. puncture potential and other conditions may be different and dre outside our control, Chemron recommends that each user conduct its own tests to confirm the suitdbility of the Chemrel garments for a specific application. Neither Chemran nor Radian Corporation assumes any resoonsibility for the suitability of an end users selection of garments based upon data herein.
WARNING: An end user should not use d Chemrel garment (or any other garment) If the fabric or a seam has been punctured or ruptured. Punctures or ruptures will result in immediate exposure to the chemical and injury to the worker. The selection of garment should include consideration of the probability of exposure of the worker to punctures or ruptures. Chemrel garments also include satety seams which will withstand normal stress and chemical splash exposure; however, all garment seams are subject to the variations in quality of the nanutacturing process and the selection ot garment should also include consideration ot the degree of stress involved in the work activity. If the Chemrel garment is to be used in a gaseous environment, special closures should be ordered. Do not use any Chemrel garnent tor fire protection; avoid open flames and intense heat.
WARRANTIES: Chemron commercial non-consumer products are warranted to be tree from detects. Chemron's only obligation to the commercial user will be, at its option, to replace any portion Proving defective or to refund the purchase price thereof. The commercial user assumes ail other risk, it any, such as the risk of any direct or consequential loss or damage arising out of the use of, or inability to use, this product. Chemron makes this warranty to the commercial user in lieu of the warranties of merchantability, fitness for particular purpose and all other warranties, expressed or implied. No deviation is authorized. Chemron, Inc. consumer products are sold only with warranties implied by law.

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APPENDIX C

The accuracy of data contained in this appendix was not verified by the C.P.R.C. and is not warranted by the C.P.R.C. It is essential that any agency contemplating the use of Chemical Protective Clothing (CPC) consult a certified occupational health and safety professional before selecting specific products and implementing procedures/protocols for responding to the site of a chemical spill.

CHEMRON™ INC.

954 Corporate Woods Parkway
Vernon Hills, Illinois 60061
Phone: (708) 520-7300
Fax: (708) 520-9812

CHEMREL MAX TM

(LEVEL-81 MANUFACTURER'S INSTRUCTION SHEET

This manufacturer's instruction sheet contains warnings and instructions which must be reed and understood by each person who intends to wear Chemrel Max suits. Any person who reads these instructions and is still uncertain about hou to property use Chemrel Max suits should contact Chemron for more information by phoning 1-800-CHEMREL or 708-520-7300.

* There are uses and chemicals for which Chemrel Max suits are unsuitable. It is the responsibility of the user to determine if Chemrel Max suits are appropriate for the intended use and meet all health standards.

* Do not use near flames or intense heat to prevent being burned. Chemrel Max material will burn.

• This Chemrel Max suit model is designed to provide protection from chemical splash and should not be immersed in chemicels or used for chemical vapor protection.

• If using a Chemrel Max encapsulating suit, adequate breathing air must be provided inside the suit to prevent suffocation. To prevent a fire hazard, never use an oxygen cylinder with a totally encapsulating suit.

• Chemrel Max suits are &signed for limited use. Suits should not be used if punctured, torn or if signs of abrasion or wear are apparent. Suits should be removed from service as soon as possible after exposure to chemicals. Chemrel Max suits are not designed to be laundered.

• When suits are worn with noisy air systems, hearing protection may be required to prevent hearing damage.

* Use the buddy system. It is important to have SOMEONE nearby who is prepared to assist the wearer in case of an emergency.

• Suits should be stored in a cool, dry area away from direct sunl ight and should not be placed in service after three years from the date of manufacture stamped inside the suit.

• Suits rhould be worn only by persons who are in good physical condition. Persons who show signs of excessive stress such as nausea, dizziness or oxcessivo heat build up should leave the uork area immodiatoly end get out of tho suit as quickly as possiblo.

• , Static electricity discharges may be given off by suits from time to time but are moro likely in cold or dry weather. Discharges are not noraally dangerous except in situations where an electrical spark could ignito a flammable chemical When operating around flammable chemicals some measure to oliminato suit sparking should be usod.

• Suits are designed to wear ovor rogular work clothes and aro not designed to protect from all hazards in tho work place. Additional equipment such es protoctivo glasses, hard hats, protective boots, protoctivo glovos, etc. may be roquirod and should be soloctod by a safety professional.

* Sock boots, if attached, are &signed to be worn inside outer industrial grade work boots and should novor be worn as outer boots.

CHEMREL MAX
Chemical Breakthrough Test Data

Chemical	Breakthrough Time
Acetone, 99+%	>24 hours
Acetonitrile, 99+%	>24 hours
Ammonia Gas, Anhydrous 99.99%	>24 hours
Arsine Gas, 99.99%	>3 hours
Benzene, 99%	>8 hours
1,3-Butadine Gas, 99%	>24 hours
Carbon Disulfide, 99%	>8 hours
Chlorine Gas, 99.5%	>24 hours
Cyclo Hexane, 99+%	>24 hours
Diborane Gas, 50%	>3 hours
Dichloromethane (Methylene Chloride), 99.9%	>20 hours
Diethylamine, 98%	>8 hours
Dimethylformimide, 99%	>24 hours
Dimethyl Sulfate, 99%	~4 hours
Dioxane, 99%	>24 hours
Ethyl Acetate, 99.5%.	>24 hours
Ethyl Benzene, 99%	>20 hours
Ethylene Oxide (ETO) Gas, 99.7%	~24 hours
Fluorine Gas	60 min.
Formaldehyde, 37%	>8 hours
Formic Acid, 95%	>24 hours
Freon 113	>24 hours
Hexane, 95%	>24 hours
Hydrazine, Anhydrous	>24 hours
Hydrochloric Acid, 37%	>24 hours
Hydrofluoric Acid, 48%	>24 hours
Hydrogen Chloride Gas, 99%	~24 hours
Hydrogen Fluoride, Anhydrous	>6 hours
Methanol; 99.9%	>24 hours
Methyl Chloride Gas, 99.5%	~24 hours
Methylene Chloride, 99.9%	>20 hours
Methyl Ethyl Ketone, 99%	>24 hours
Methyl t-Butyl Ether, 80%	>4 hours
Monochloro Acetic Acid	>4 hours
Nitric Acid, 70%	>24 hours
Nitric Acid Fuming, 90%	>8 hours
Nitrobenzene, 99%	>24 hours
Nitrogen Tetroxide Gas	~3 hours
Nitromethane, 98%	~24 hours
Oleum	>8 hours
PCB/Mineral Oil, 50%/50%	>8 hours
Phenol, 85%	>8 hours

Chemical	Breakthrough Time
Phosphine Gas	>3 hours
Propanol, 99%	>24 hours
Silane	>3 hours
Sodium Hydroxide, 50%/50% w/w	>24 hours
Sulfuric Acid, 93.1%	>24 hours
Tetrachlorethylene, 99%	>8 hours
Tetra Ethyl Lead	>8 hours
Tetrahydrofuran, 100%	>18 hours
Toluene, 99%	>8 hours
Toluene Diisocyanate	>8 hours
1,2,4-Trichlorobenzene/PCB, 99%	>8 hours
l,l,l-Trichloroethane, 99.2%	>24 hours

INFORMATION NOTES: The chemical breakthrcugh data set forth herein is designed to be used as a starting point by the user in selecting the proper protective garment for handling the listed toxic chemicals. The data is based upon breakthrough tests performed (in accordance with ASTM Standard F739-81) under laboratory conditions on the Chemrel Hax fabric, not the complete garment, by AIHA accredited independent laboratories. Since end use conditions with respect to chemical exposure, garment and seam stress, puncture potential and other conditions may be differont and are outside our control, Chemron recommends that each user conduct its own tests to confirm the suitability of the Chemrel Hax garments for a specific' application. Chemron doss not assume any responsibility for the suitability of an end users selection of garments based upon data herein.

WARNING: An end user should not use a Chemrel Hax garment (or any other garment) if the fabric or a seam has been punctured or ruptured. Punctures or ruptures will result in immediate exposure to the chemical and injury to the uorker. The selection of garment should include consideration of the probability of exposure of the uorker to punctures or ruptures. Chemrel Hax garments also include safety seams which 'will withstand normal stress and chemical splash exposure; however, all garment seams are subject to the variations in quality of the manufacturing process and the selection of garment should also include consideration of the degree of stress involved in the work activity. Do not use any Chemrel Max garment for fire protect ion; avoid open flames and intense heat.

WARRANTIES: Chemron commercial non-con-r products are uarranted to be free from defects. Chemron's only obligntion to the commercial user will be, at its option, to replace any portion proving defective or to refund the-purchase price thereof. The commercial user assumes all other risk, if any, such as the risk of any direct or consequential loss or damage arising out of the use of, or inability to use, this product. Chemron makes this warranty to the commercial user in lieu of the warranties of merchantability, fitness for particular purpose and all other uarranties, expressed or implied. No deviation is authorized. Chemron, Inc. consumer products are sold only with warranties implied by law.

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APPENDIX D

The accuracy of data contained in this appendix was not verified by the C.P.R.C. and is not warranted by the C.P.R.C. It is essential that any agency contemplating the use of Chemical Protective Clothing (CPC) consult a certified occupational health and safety professional before selecting specific products and implementing procedures/protocols for responding to the site of a chemical spill.

CHEMICAL COMPATIBILITY CHART

	S/1422A		TYVEK PE		TYVEKSARANEX	
	BREAK TLME	BATE	BREAK TIME	HATE	BREAK TIME	BATE
Acetic Acid			300		>4000	
Acetone 98%					33	19.8
Acetyl Chloride 98%					37	1.1
Acrylonitrile			5	0.0006	23	0.0013
Ammonium Hydroxide 28.8%			(1	10.13		
Bromine			1	high		
1-Butanol			>480	30		
Chlorine, 20 PPM			> 480	nd	>480	nd
Chloroacetic Acid, 20°C			> 480			
Chloroacetic Acid, 65'C			5		60	
2-Chloroethanol			> 480	< la.0		
Chloroform			<l	348	<1	201
Chlorosulfonic Acid			63		350	
Cresols, Technical Grade			40-60	0.4	>20	< .14
1,4-Dichloro-2-Butene			75			
Diethylamine					44	38
Dimethylacetamide 99%					64	2
Dioxane					50	17.4
Epichlorohydrin 99%					57	52.2
Ethyl Acetate 99%					36	6.6
Ethyl Cellosolve					>480	nd
Ethylenediamine 99%			15	10.20	>480	nd
Formaldehyde, 37%			> 480	nd		
Formic Acid, 95%			4	.33		
Hexamethylene Diisocyanate 98% -					>480	nd
Hydrochloric Acid, 37%			35		>2800	nd
Hydrofluoric Acid, 50%			> 30	< 0.1	> 30	< 0.1
Hydrofluoric Acid, Anhydrous -			< 13	.006	>30	(0.15
Hydrogen Cyanide, 100%			< 60	.111		

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	S/1422A		TYVEK PE		TYVEKSARANEX	
	BREAK TIME	BATE	BREAK TIME	RATE	BREAK TIME	KATE
Methomyl, **Lannate**[R] L			< '15	0.0032	< 15	0.005
Methyl Bromide					> 480	nd
Methyl Chloroacetate					>480	518
Methyl Ethyl Ketone 99%					29	780
Methyl Parathion, 10%	<5	45	30-45	0.2	> 240	< 0.002
Methyl parathion, 57%			15	0.09	120-180	.0l
Mineral Spirits			<5	7	> 10	< 0.2
Nitric Acid, 70%			50		> 2800	nd
Nitric Acid, 90%					107	
Oleum, 65%			1		37	
Ortho-Toluidine			<5	1	>120	< .03
Oxydianiline	< 90		270			
Phosphoric Acid			> a40		> a40	
Polychlorinated Biphenyl			< 60	0.0002	60-l 20	0.0002
Propionaldehyde			5	76.20		
Propionic Acid			2.7	1.62		
Sodium Dichromate Solution	80	.0091	> 480	nd	> 480	nd
Sodium Cyanide, 10% 60°C			360	.009		
Sodium Cyanide, 45% 70°C			< 240	.006		
Sodium Hydroxide 40%	<10	.636	> 480	nd	> 480	nd
Sulfuric Acid, 16%	30	.918	> 480	nd	>480	**nd**
Sulfuric Acid, 50%	6	4.5	> 480	nd	> 480	nd
Sulfuric Acid, 90%	<5	38.3	> 480	nd	>480	nd
Sulfuric Acid, 96% - 65'C			>120	nd	330	
Sulfuric Acid, 98%		50	> 480	nd	7480	nd-
Styrene					43	69.60
Tetraalkyl Lead			< 30	8.36	60	0.079
Tetrachloroethylene 99%					13	1.14
Titanium Tetrachloride					> 1000	nd
Toluene			<5	165	< 5	20
Trichloroacetic Acid			5		120	
'richlorobenzene			< 15	5	15.60	0.1
2,2,2Trichloroethanol 98%					10	13.20
2,2,2Trifluoroethanol 99%			> 480	nd		

APPENDIX E

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Du Pont's Family of Fabrics for Limited-Use Protective Apparel

TYVEK® for Dry Particulate Barrier

TYVEK@ spunbonded olelin is a unique Du Ponl material that offers high strength and provides excellent barrier to many dry particulates, including asbestos, lead dust, and radioactive dusts.

Allhough uncoated TYVEK provides some liquid splash proleclion, it is not suggesled for use againsl liquid chemicals or gases because chemical permealion from continual exposure usually occurs quickly.

Dry Particulate Penetration-Uncoated **TYVEK®**

Particulate Hazards	Average % Penetration		
	TYVEK® 1422A	TYVEK® 1443R	TYVEK® 1445A
Dusl particles (0.2-6μ)	<0.6	nt	nt
Asbestos (< 1μ)	0.9	0.3	nt
Co 60 Colloid	ND	ND	ND
Radioactive dust particles (0-80μ)	ND	ND	ND

ND = None delecled. nt = not tested: < = less than

TYVEK® QC for liquid Splash Protection

Du Ponl TYVEK® QC is made from TYVEK that has been "quality coaled" by Du Ponl with 1.25 mils polyethylene. TYVEK QC offers excellent splash protection againsl many bases, acids, and other liquid chemicals.

TYVEK QC is available in yellow, while, and gray.

TYVEK QC is the on/y polyethylene-coated TYVEK for which Du Pont provides permeation data and technical support.

Don't settle for a subslilute. Specify TYVEK QC.

TYVEK®/SARANEX® 23-P for a Broad Range of liquid Splash Protection

TYVEK®/SARANEX® 23-P is a laminate of Du Ponl's TYVEK and Dow Chemical's Saranex 23-P film. This fabric is lighlweight and offers economical protection against a broad range of chemicals.

TYVEK/SPARANEX 23-P is available in while and gray.

TYVEK/SPARANEX 23-P is the only Saranex-laminated fabric for which Du Pont provides permeation data and technical support.

Don'1 settle for a subslilute. Specify TYVEK/ SARANEX 23-P

BARRICADE@ Chemical Barrier Fabric for the Broadest Range of Chemical Protection

BARRICADE@ chemical barrier fabric is Du Ponl's slate-of-lhe-art mullilayer laminate tl 'rovides excellenl chemical resistance.. Du Pont BARRICADE is strong and durable and it offers the low cost, convenience, and safety of a limiled-use labric.

BARRICADE is available in yellow.

BARRICADE meets all labric requirements of NFPA 1993.

Du Pont manufacturers proleclive apparel fabrics, not garmenls. Garmenls made from Du Ponl's proleclive apparel fabrics may be purchased from your local safely equipmenl distributor For more informalion about Du Ponl's family of fabrics for limiled-use proleclive apparel, call l-800-44-TYVEK.

TYVEK. TYVEK OC. TYVEWSARANEX 23-P and BARRICADE should not be used around heal, llame, sparks or in potentially flammable or explosive atmospheres.

DUPONT

H-42404 5/92 Printed in U.S A

PERMEATION DATA TABLE

Class Group	Sub-Class	Chemical	Physical Phase	TYVEK' QC Breakthrough Time (min)	TYVEK' QC Parmealion Rate (tq/cm~/mln)	l'YVEK*/SARANEX" 23-P Breakthrough Time (min)	l'YVEK*/SARANEX" 23-P Permeation Rate (pg/cmVmin)	BARRICADE" Breakthrough Time (min)	BARRICADE" Permeation Rate (pg/cmz/min)
Acids, Carboxylic	102 Aliphalic and Alicyclic. Unsubstituled	Acelic acid, glacial	L	7	3	>480	ND	145	3.9
		Acrylic acid	L	7	5.4	>480	ND	79	6
		Formic acid	L	4	0.33	>480	ND	>480	ND
	103 Aliphalic and Alicyclic, Subsliluled	Chloroacelic acid. sat.	L	>480	ND	nl	nl	nl	n
Acid Halides, Carboxylic	11 Aliphalic and Alicyclic	Acelyl chloride	L	nl	nt	37	1.1	164	0.89
	12 Aromalic	Benzoyl chloride	L	III	nt	nt	nt	>480	ND
Aldehydes	21 Aliphalic and Alicyclic	Bulyraldehyde	L	1	22	47	6.1	>480	ND
		Formaldehyde. 37%	L	immediale	0.31	>480	ND	>480	ND
Amides	32 Aliphalic and Alicyclic	N.N-Dimelhvlacelamide	L	nt	III	64	2	>480	ND
		N.N-Dimelhyllormamide	L	45	1.2	118	0.91	226	2.5
Amines	41 Aliphalic and Alicyclic. Primary	Mlelhylaniine	G	nl	nl	nl	nl	105	40
	42 Aliohalic and Alicvclic. Secondarv	Dielhylamine	L	1	141	6	300	>480	ND
	43 Aliphalic and Alicyclic. Tertiary	Iriethylamine	L	nt	nt	>480	ND	nt	nt
	145 Aromalic, Primary	Aniline	L	immediate	2.1	265	.53	>480	ND
		d-loluidme	L	immediale	1	255	0.36	nt	nt
Polyamines	152 Aliohalic and Alicvclic	Elhvlenediamine	L	139	3.0	>480	ND	nl	nl
	153 Aromalic	4.4'-Melhylene bis (o-chloroaniline). saluraled solution in melhanol	L	nt	nl	>480	ND	>480	ND
Isocyanales	211 Aliphalic and Alicyclic	Hexamelthylenediisocyanate	L	nl	nl	>480	ND	>480	ND
		tielhyl isocyanale	L	nl	nl	2	210	>480	ND
	212 Aromalic	4.4'-Diphenylmelhane diisocyanale	S	nl	III	nt	nl	>480	ND
		Toluene-2.4.diisocyanale	L	immediale	42	~480	ND	>480	ND
Esters, Carboxylic	222 Acetales	i-Amy1 acelale	L	nl	III	nt	nt	>480	ND
		Elhvl acelale	L	immediale	1990	36	6.6	>480	ND
		Vynil acelale	L	nt	nl	nl	nl	>480	ND
	223 Acrvlales and Melhacrvlales	Methyl methacrylate	L	nl	nl	nl	nl	>480	ND
Ethers	141 Aliphalic and Alicyclic	Butyl eher	L	nt	nl	nl	nl	>480	ND
		Diethyl ether	L	nt	nt	1	1.8	>480	ND
		Telrahydroluran	L	immediale	162	immediale	high	>480	ND
	245 Glycol Ethers	Butyl cellosolve	L	nl	nt	>480	ND	nl	nl
		Ethyl cellosolve	L	nl	nl	>480	ND	>480	ND
		Elhvl cellosolve acelale	L	nl	nl	39	1.8	>480	ND
		Ethylene diglycol monoethyl ether	L	nt	nt	>480	ND	nt	nt
		Methyl cellosolve	L	nt	nt	80	110	nt	nt
		Methyl cellosolve acetale	L	nt	nt	260	1.1	nt	nt
Halogen Compounds	261 Aliphalic and Alicyclic	Carbon letrachloride	L	nt	nt	nt	nt	>480	ND
		Chloroform	L	immediate	350	immediale	200	>480	ND
		1,4-Dichloro-2-butene	L	75	250	nt	nt	nt	nt
		2,3-Dichloropropene	L	nt	nt	nt	nt	>480	ND
		Ethylene dibromide	L	nt	nt	nt	nt	>480	ND
		Ethylene dichloride	L	nl	nl	nt	nl	>480	ND

ND = none detected nt = not tested > grealer lhan < less lhan S = solid L = liquid G = gas sat. = saluraled solution in waler

TWEK. TYVEK QC. TYVEK/SARANEX 23-P. and BARRICADE should not be used **around heal, flame. sparks or in potentially flammable or explosive atmospheres.**

PERMEATION DATA TABLE (Cont'd)

Class Group	Sub-Class	Chemical	Physical Phase	TYVEK* QC Breakthrough Time (min)	TYVEK* QC Permeation Rate (μg/cm²/min)	TYVEK*/SARANEX* 23-P Breakthrough Time (min)	TYVEK*/SARANEX* 23-P Permeation Rate (μg/cm²/min)	BARRICADE* Breakthrough Time (min)	BARRICADE* Permeation Rate (μg/cm²/min)
Halogen Compounds, *continued*	261 Aliphalic and Alicyclic, *continued*	FREON* 113	G	nt	nt	nt	nt	>480	ND
		Methyl bromide	G	nt	nt	47	0.01	nt	nt
		Methyl chloride	G	immediate	.3	>480	ND	>480	ND
		Methylene chloride	L	immediate	600	2	320	413	0.02
		1,1,2,2-Tetrachloroethane	L	nt	nt	75	2	>480	ND
		1,1,1-Trichloroethane	L	nt	nt	nt	nt	>480	ND
	263 Aromatic	Chlorobenzene	L	nt	nt	nt	nt	>480	ND
		o-Chlorotoluene	L	nt	nt	26	30	>480	ND
		PCB 1254	L	55	>3.6	>480	ND	nt	nt
		50% PCB 1254/ 50% Trichlorobenzene	L	nt	nt	>480	ND	>480	ND
			See sub-class 590 for data on other PCB mixtures						
		1,2,4-Trichlorobenzene	L	immediate	8	115	0.9	>480	ND
	267 Vinyl Halides	Tetrachloroethylene	L	1	410	13	3.6	>480	ND
		Trichloroethylene	L	nt	nt	nt	nt	>480	ND
Helerocyclic Compounds	275 Oxygen, Epoxy Compounds	Epichlorohydrin	L	nt	nt	57	52	>480	ND
		Ethylene oxide	G	0.3	18	6	8.4	>480	ND
		1,2-Propylene oxide	L	nt	nt	nt	nt	>480	ND
	277 Oxygen, Furan Derivalives	2-Furaldehyde	L	nt	nt	245	0.21	>480	ND
Hydrazines	260 Hydrazines	1,1-Dimethylhydrazine	L	nt	nt	12	6	>480	ND
		Hydrazine	L	nt	nt	>480	ND	>480	ND
Hydrocarbons	291 Aliphalic and Alicyclic, Saturated	Cyclohexane	L	nt	nt	nt	nt	>480	ND
		Diesel fuel	L	nt	nt	nt	nt	195	0.09
		n-Hexane	L	immediate	410	2	0.03	311	0.01
		Jet A Fuel	L	nt	nt	465	3	nt	nt
		JP-4	L	nt	nt	12	140	>480	ND
		Mineral spirits	L	immediate	7	>480	ND	>480	ND
	282 Aromatic	Benzene	L	nt	nt	nt	nt	>480	ND
		Ethylbenzene	L	nt	nt	nt	nt	>480	ND
		Gasoline, leaded	L	nt	nt	nt	nt	>480	ND
		Styrene	L	nt	nt	43	70	>480	ND
		Toluene	L	immediate	500	immediate	25	>480	ND
		Xylene (mixed isomers)	L	nt	nt	nt	nt	>480	ND
	284 Alkenes (Olelins)	1,3-Butadiene	G	immediate	high	>480	ND	>480	ND
Peroxides	366 Peroxides	Hydrogen peroxide, 30%	L	>480	ND	nt	nt	nt	nt
Hydroxylic Compounds	311 Aliphalic and Alicyclic, Primary	Allyl alcohol	L	nt	nt	nt	nt	>480	ND
		n-Butanol	L	3	1.6	nt	nt	>480	ND
		Methanol	L	1	2.2	>480	ND	142	2.5
	314 Aliphalic and Alicyclic. Polyols	Ethylene glycol	L	>480	ND	>480	ND	nt	nt
	315 Aliphalic and Alicyclic. Substituted	2-Chloroethanol	L	3	3.1	nt	nt	>480	ND
		2,2,2-Trichloroethanol	L	nt	nt	19	13	>480	ND
		2,2,2-Trifluoroethanol	L	6	high	nt	nt	>480	ND
	316 Aromatic, Phenols	Cresol (mixed isomers)	L	37	0.4	>480	ND	nt	nt
		Phenol, 85%	L	immediate	0.4	>480	ND	>480	ND
Elements	330 Elemenls	Bromine	L	immediate	high	nt	nt	9	520

ND = none delecled nt = nol tested **> greater lhan** < less than S = solid L = liquid G = gas

TYVEK TYVEK QC TYVEK/SARANEX 23-P. and BARRICADE should not be used around heal. flame sparks or in potentially flammable or explosive atmospheres.

PERMEATION DATA TABLE (Cont'd)

Class croup	Sub-Class	Chemical	Physical Phase	TYVEK* QC Breakthrough Time (min)	TYVEK* QC Permeation Rate (μg/cm²/min)	TYVEK*/SARANEX* 23-P Breakthrough Time (min)	TYVEK*/SARANEX* 23-P Permeation Rate (μg/cm²/min)	BARRICADE* Breakthrough Time (min)	BARRICADE* Permeation Rate (μg/cm²/mi
Elements *continued*	130 Elements. *continued*	Chlorin	G	1	18	>480	ND	>480	ND
		Chlorine (20 ppm)	G	>480	ND	>480	ND	nt	nt
		Iodine	S	440	30	>480	ND	nt	nl
		Mercury	L	nl	lll	210	<0.001	>480	ND
Inorganic Salls (Solutions)	140 Inorganic Salls (Solutions)	Mercuric chloride, sat.	L	nl	nt	>480	ND	~480	ND
		Potassium acelate, sal	L	nt	nl	>480	ND	>480	ND
		Potassium chrornale. sat.	L	nt	lll	>480	ND	>480	ND
		Sodium lluoride, sal.	L	nt	nt	>480	ND	nt	nt
		Sodium hypochlorile, 5.25%	L	>480	ND	>480	ND	nt	nt
Inorganic Gases and Vapors	150 Inorganic Gases and Vapors	Ammonia anhydrous	G	11	0.12	19	0.24	68	1.7
		Hydrogen chloride	G	immediale	high	>480	ND	>480	ND
		Hydrogen lluoride	G	7	6	20	3	83	15.7
		Nilrogen dioxide	G	nt	nl	>480	ND	nt	nl
		Nilrogen tetroxide	G	nt	nt	nt	nt	24	66
		Sullur dioxide	G	immediate	high	>480	ND	>480	ND
Inorganic Acid Halides	160 Inorganic Acid Halides	Antimony pentachloride	L	nt	nt	>480	ND	nt	nl
		Phosphorus lrichloride	L	nt	nt	20	28.3	>480	ND
Inorganic Acids	170 Inorganic Acids	Hydrochloric acid, 37%	L	63	1.2	>480	ND	>480	ND
		Hydrolluoric acid, 50%	L	180	0.08	>480	ND	>480	ND
		Hydrolluoric acid, 92% (90°C)	L	nt	nt	nl	nl	67	2.8
		Nilric acid, 70%	L	335	0.72	>480	ND	>480	ND
		Oleum, 40% free SO_3	L	398	0.2	>480	ND	>480	ND
		Phosphoric acid. 85%	L	nt	nl	>480	ND	>480	ND
		Sulfuric acid, 16% lo 95%	L	>480	ND	>480	ND	>480	ND
Inorganic Bases	180 Inorganic Bases	Ammonium hydroxide, 28%	L	immediale	62	>480	ND	100	1.1
		Sodium hydroxide, 40% lo 50%	L	>480	ND	>480	ND	>480	ND
Kelones	191 Aliphalic and Alicyclic	Acetone	L	immediale	7.8	29	12	>480	ND
		Chloroacelone	L	nl	nl	360	0.08	nl	nt
		Methyl ethyl kelone	L	nt	nt	29	7.8	>480	ND
Inorganic Cyanides	120 Inorganic Cyanides	tiydrocyanic acid	L	60	110	nl	nl	108	0.5
		Sodium cyanide, 10% (60°C)	L	360	9	nt	nt	nt	nl
		Sodium cyanide, 95%	L	nt	nt	>480	ND	>480	ND
Nitriles	131 Aliphalic and Alicyclic	Acetonitrile	L	1	13	97	0.54	>480	ND
		Acrylonitrile	L	5	<.01	23	<0.1	>480	ND
	132 Aromatic	Benzonitrile	L	nt	nt	nt	nt	>480	ND
Nitro Compounds	141 Unsubsliluted	Nilrobenzene	L	immediate	2.4	135	0.28	>480	ND
		Nilromelhane	L	nt	nt	nt	nt	>480	ND
Sulfur Cornpounds	502 Sulfides, Disulfides	Carbon disulfide	L	immediate	high	immediate	high	>480	ND
Miscella-neous (Not Classified)	590 Miscellaneous (Not Classified)	Gasohol[1]	L	immediate	7.8	>480	ND	170	0.24
		4% PCB 1254/ 6% lrichloroknrenel 90% mineral spirils	L	nl	nt	60	0.04	nt	nt
		50% PCB 1254/ 50% mineral oil	L	nt	nt	>480	ND	nt	nl
		1% PCB 1254/ 99% mineral spirils	L	nt	nl	>480	ND	nt	nt

(1) 7% gasoline, 60% ethanol. 33% methanol ND = none detected nt = not lesled > greater than < less lhan S = solid L = liquid G = gas sat = saluraled solution in wat

TYVEK. TYVEK QC. TYVEK/SARANEX 23-P. and BARRICADE should not be used around heal. flame, sparks or in potentially flammable or explosive atmospheres.

How Permeation Tests are Conducted

Permealion is the process by which a chemical moves lhrough protective clothing material on a molecular level. Permeation tests are conducted lollowing the ASTM F739-85 lest method: "Test Method for Resistance of Protective Clolhing Malerials to Permeation by Liquids and Gases:' The outside surface of a test fabric is exposed lo a challenge chemical using a special test cell (see Figure 1).

Breaklhrough lo the inside labric surface is monitored by sampling the collection side of the cell and analytically determining when the chemical has permeated the labric. Breaklhrough lime is the average elapsed lime between initial contact of the chemical with the oulside surface of the fabric and detection of the chemical on the inside surface of the fabric. Permealion rate is the average constant rate of permeation that occurs alter breakthrough when the chemical contact is continuous and all forces affecting permeation have reached equilibrium.

ASTM F739-85 Test Cell

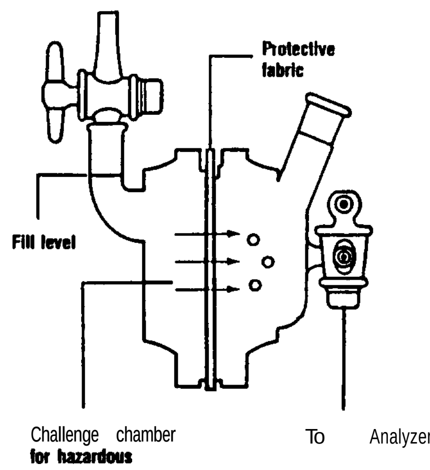

Figure 1

Barrier Performance of Two-Ply **TYVEK®/SARANEX®** 23-P

Permeation tests of two layers of TYVEK®/ SARANEX® 23-P against ASTM F1001 chemicals indicate that breaklhrough limes for lhis labric are greatly increased if two layers of fabric are worn, In the tests the two layers of fabric were placed in the ASTM permeation lest cell with the SARANEX 23-P side of each layer toward the challenge chemical. This simulates double-suiting with garments of TWEWSARANEX 23-P Call 1-800-44-TYVEK lo request permeation data for 2-ply TYVEK/SARANEX 23-P

ASTM F1001-89 List of Chemicals

			TYVEK® QC		TYVEK®/SARANEX® 23-P		BARRICADE"	
Chemical Name	**Class**	**Phase**	Breakthrough lime (min.)	Permeation Rate **(μg/cm²/min)**	Breakthrough Time (min.)	Permeation Rate **(μg/cm²/min)**	Breaklhrough Time (mtn.)	Permeation Rate **(μg/cm²/min)**
Acelone	Kelones	L	immediate	8	29	12	>480	ND
Acelonitrile	Nitriles	L	1	13	97	0.54	>480	ND
Ammonia (anhydrous)	Inorganic Gases and Vapors	G	11	0.12	19	0.24	68	1.7
1,3-Butadiene	Hydrocarbons	G	immediale	hiuh	>480	ND	>480	ND
Carbon disullidc	Sullur Compounds	L	imniediale	high	irnniediale	tigh	>480	ND
Chlorine	Elements	G	1	18	>480	ND	>480	ND
Dielhylarnine	Amines	L	1	141	6	300	>480	ND
Dimethylformamide	Amides	L	45	1.2	118	0.91	226	2.5
Ethyl acetate	Esters, Carboxylic	L	immediale	high	36	6.6	>480	ND
Ethylene oxide	Helerocyclic Compounds	G	0.3	18	6	8.4	>480	ND
Hexane	Hvdrocarbons	L	immediale	410	2	0.03	311	0.01
Hydrogen chloride	Inbrganic Gases and Vapors	G	immediate	hiyh	>480	ND	>480	ND
ethanol	ttydroxylic Compounds	L	1	2.2	~480	ND	142	2.5
Methyl chloride	ttalogen Compounds	G	immediate	03	>480	ND	>480	ND
Mcthylene chloride	Halogen Compounds	L	immediate	600	2	320	413	0.02
Nilrobenzenc	Nitro Compounds	L	immediate	2	135	0.28	>480	ND
Sodium hydroxide (50%)	Inorganic Bases	L	>480	ND	>480	ND	>480	ND
Sullu:ic acid (cont.)	Inorganic Acids	L	>480	ND	>480	ND	>480	ND
Tetrachlorethvlene	Halogen Cornpounds	L	1	410	13	3.6	>480	ND
Tetrahydroluran	Ethers	L	imniediale	162	immediate	high	>480	ND
Toluene	Hydrocarbons	L	immediale	500	immediale	25	>480	ND

ND = none detected > greater than < less than S = solid L = liquid G = gas

TYVEK, TYVEK QC TYVEK/SARANEX 23-P. **and** BARRICADE should not be used around **heal. flame. sparks or in potentially flammable or explosive atmospheres.**

TYVEK spunbonded oletin and BARRICADE are registered trademarks of Du Pont.

SARANEX 23-P is a registered trademark of The Dow Chemical Company

APPENDIX F

The accuracy of data contained in this appendix was not verified by the C.P.R.C. and is not warranted by the C.P.R.C. It is essential that any agency contemplating the use of Chemical Protective Clothing (CPC) consult a certified occupational health and safety professional before selecting specific products and implementing procedures/protocols for responding to the site of a chemical spill.

4.4 oz/yd² Polyester Oxford/2.0 oz/yd² Polyester Tricot
(Industrial Grade)

GORE-TEX® FABRIC
Technical Data and Application Guide

DECEMBER, **1991**

Selecting chemical protective clothing

Until now, choosing the right chemical protective clothing has been very difficult due to a lack of standards and insufficient data. **Material performance** has often been determined by **permeation** data alone. And clothing ensembles are even selected by their EPA design level classifications. Each of these methods has its shortcomings, is often misleading, and may result in inconsistent usage of chemical protective clothing.

New standards and performance definitions

Choosing the correct protective clothing requires a clear understanding of what the garment is expected to do and why it is being worn. This simple but practical approach was used by the National Fire Protection Association to establish the first performance-oriented protective clothing standards, as follows:

NFPA 1991 Vapor Protective Suits for Hazardous Chemical Emergencies
NFPA 1992 Liquid Splash Protective Suits for Hazardous Chemical Emergencies
NFPA 1993 Support Function Protective Garments for Hazardous Chemical Operations

These new standards address, for the first time, full ensemble performance. They associate vapor-tight integrity and **permeation** data with vapor protection, while they associate liquid-tight integrity and **penetration** data with liquid splash protection. (In **contrast to permeation, the process by which a chemical moves through material on a molecular level, penetration is the bulk flow of a liquid chemical through the material, seams, or suit closures.)**

Each standard sets minimum levels of performance for protection provided by the overall garment, garment materials, seams, closures, and other components. These **criteria have been written with the hazardous chemical emergency response team in mind, but they can apply to a number of other protective clothing applications as well.**

Because the NFPA Standards define performance levels, instead of design levels, they may be more appropriate than the EPA levels of protection for describing and selecting types of suits or suit ensembles. The terminology from these standards can be directly applied to the selection of protective suits:

Perfommnce Required	NFPA standard	EPA Standard
Vapor protection	NFPA 1999	Level A (gas tight)
Liquid splash protection	NFPA 1992/ NFPA 1993	Levels B & C

When you need vapor protection

When you need vapor protection, it is appropriate to choose a certified vapor-tight suit for which its capability to protect against a specific chemical is based on **permeation** data. Vapor protective suits compliant with NFPA 1991 are suitable for this purpose.

When you need liquid splash protection

When you need liquid splash protection and do not need vapor protection, it is appropriate to choose a certified liquid splash protective suit (i.e.; NFPA 1992 or NFPA 1993 compliant ensemble) for which its capability to protect against a specific chemical is based on **penetration** data. Since this clothing is designed to protect the wearer from liquid contact, but allows exposure to vapors, **permeation** data is inappropriate for judging material performance for this level of protection.

In addition, the overall ensemble must also demonstrate liquid-tight integrity. NFPA 1992 and 1993 provide test methods and criteria for making this assessment. Organizations such as the Safety Equipment Institute (SEC)will certify complete protective clothing ensembles that meet the NFPA standards.

Other test methods are often used to describe the liquid resistance of materials. However, the choice of liquid splash protective clothing should be based on the results of **penetration** testing that has been performed in accordance with the procedures in ASTM Standard Test Method F903, Procedure C, or NFPA Standards 1992 and 1993. This criterion is a truer evaluation of liquid barrier performance ***(continued on page 4)***

4.4 oz/yd² Polyester Oxford/2.0 oz/yd² Polyester Tricot (Industrial Grade)
GORE-TEX Fabric Application Guide

How to use the Chemical Penetration Guide

This guide shows penetration testing results for GORE-TEX fabric. It can be used to determine applications for garments made from GORE-TEX fabric. **This clothing should be used only for those situations where you do not need vapor protection or where vapor exposure is determined to be acceptable by a safety and health professional.**

Penetration resistance

Penetration of protective clothing is the bulk flow of a liquid through porous materials, seams, closures, and pinholes or other imperfections in a protective clothing material. Penetration may occur from chemical deterioration of the material which leads to liquid passing through the material.

Measurement of penetration resistance

The penetration test[1] measures the'resistance of protective clothing materials to penetration by liquids using a one-hour, one-sided liquid exposure to the normal outside material surface. The test is conducted at atmospheric pressure except for the sixth minute of the test, which is conducted at 2 psig to stimulate the pressure from a burst pipe. Liquid penetration is detected visually at the end of the test. Penetration results are recorded as either "pass" or "fail".

Color Coding

The chemical penetration data is color coded, as described below, to assist in determining the proper application for garments made from GORE-TEX fabric.

- Green GORE-TEX fabric passes the penetration test for chemicals printed in green. These chemicals represent potential liquid splash hazards as defined by NFPA 1993 guidelines".
- Yellow GORE-TEX fabric passes the penetration test for chemicals printed in yellow, but these chemicals represent both potential vapor and liquid splash hazards". **Significant amounts of chemical vapor permeate this material. Use GORE-TEX fabric for these chemicals only in controlled situations if vapor exposure is acceptable. Consult a trained professional in industrial safety or hygiene when making this determination. Failure to comply with this warning may result in serious injury or death.**
- **Red** GORE-TEX fabric fails the penetration test for chemicals printed in red. Do not use.

Note: GORE-TEX fabric is readily permeable by most chemical challenges when tested for permeation resistance in accordance with ASTM F739.

Footnotes

1. Penetration test procedures as specified in National Fire Protection Association (NFPA) 1993 — Standard on **Support Function Protective Garments for Hazardous Chemical Operations. These** procedures are identical to those in ASTM F903, Procedure C.

2. NFPA 1993 — Standard **on Support Function Protective Garments for Hazardous Chemical Operations —** does not permit certification for chemicals, or specific chemical mixtures, which have known or suspected carcinogenicity in specified references, or "akin" toxicity notations in the "Threshold Limit Values and Biological Expoeure Indices for 1988-1989".

3. Certification for these chemicals is permitted by NFPA 1991- Standard **on Vapor protective Suits for Hazardous Chemical** Emergencies. It is the user's responsibility to determine the level of toxicity and the **proper** personal protective equipment needed. If you **need to protect skin from exposure to a safety or health** threat based **on permeation of vapors, or vapors produced by liquids, do not use GORE-TEX fabric.**

4. Do **not use GORE-TEX fabric for protection against chemicals or chemical mixtures not listed below. Do not use GORE-!I'EX fabric without penetration test data directly supplied by W. L. Gore & Associates, Inc.** For chemicals not included in this list, contact W. L. Gore & Associates, Inc. (410-392-3700). **Failure to comply with this warning may result in serious injury or de&h.**

6. This data was produced independently by TRI/Environmental, Inc., in accordance with NFPA 1993. Requets User Report Number 91382 for complete details of this test. All tests were performed under laboratory conditions and not under conditions of actual usage. TRI/Environmental Inc. makes no warranties or other **guarantees** concerning protection by this material and assumes no liability for use of this material with the chemicals tested. The user should determine the applicability of test conditions when assessing the suitability of the material for actual anticipated exposure.

CHEMICAL PENETRATION DATA

CHEMICAL[4]	SYNONYM	PENETRATION RESULT[5]
Acetic Acid, Glacial	Ethanoic Acid	Pass
Acetone*+	2-Propanone	Pass
Acetonitrile*	Methyl Cyanide	Pass
Acrylonitrile	P-Propenenitrile	Pass
Aluminum Ammonium Sulfate (12.2%)	Alum	Pass
Ammonium Hydroxide (30%)	Aqua Ammonia	Pass
Ammonium Phosphate (Monobasic, Satd. Soln.)	Ammonium Acid Phosphate	Pass
Calcium Hydroxide (Satd. Soln.)	Caustic Lime	Pass
Calcium Hypochlorite (Satd. Soln.)	Calcium Oxychloride	Pass
Chloroacetic Acid Satd. Soln.)	Monochloroacetic Acid, MCA	Pass
Chlorosulfonic Acid	Sulfuric Chlorohydrin	Pass
Chromic Acid (100%)	Chromium Trioxide	Pass
Citric Acid (50%)	B-Hydroxytricarballylic Acid	Pass
Cyclohexylamine	Hexahydroaniline	Pass
Diesel Fuel		Pass
Diethylamine *+		Pass
Ethyl Acetate *+	Acetic Ether	Pass
Ethylene Glycol	Ethylene Alcohol	Pass
Fire Resistant Hydraulic Fluid		Pass
Formaldehyde (37%)	Oxymethylene	Pass
Gasoline		Pass
Hexane *+		Pass
Hydrochloric Acid (37%)	Muriatic Acid	Pass
Hydriodic Acid (47%)		Pass
Hydrofluoric Acid (10%)	Hydrogen Fluoride (HF)	Pass
Hydrofluoric Acid (49%)	Hydrogen Fluoride (HF)	FAIL
Hydrogen Peroxide (30%)	Hydrogen Dioxide	Pass
Isooctane	2,2,4-Trimethylpentane	Pass
Isopropanol	Isopropyl Alcohol	Pass
JP4 Jet Fuel		Pass
Mercuric Sulfide	Vermillion	Pass
Mercury	Quicksilver	Pass
Methyl Ethyl Ketone	2-Butanone, MEK	Pass
Methyl Methacrylate	Methyl-Alpha-Methacrylate	FAIL
Motor Oil, SAE 30 wt.		Pass
Nitric Acid (50%)	Aquafortis	FAIL
Nitric Acid (70%)	Aquafortis	FAIL
Oleum (18-24% SO^2)	Fuming Sulfuric Acid	FAIL
1% PCB/99% Mineral Oil		Pass
4% PCB/6% Trichlorobenzene/SO% Mineral Oil		Pass
50% PCB/50% Mineral Oil		Pass
Phenol (90%)	Carbolic Acid	Pass
Phosphoric Acid (80%)	Orthophosphoric Acid	Pass
Picric Acid	Trinitrophenol	Pass
Potassium Hydroxide (53%)	Caustic Potash	Pass
Silicon (IV) Chloride	Silicon Tetrachloride	Pass
Sodium Chlorate (Satd. Soln.)	Chlorate of Soda	Pass
Sodium Chlorite (Satd. Soln.)		Pass
Sodium Hydroxide (50%) *+	Caustic Soda	Pass
Sodium Hypochlorite (5.5%)	Bleach	Pass
Sodium Methylate	Sodium Methoxide	Pass
Sulfuric Acid (93%)	Hydrogen Sulfate	Pass
Sulfuric Acid (96%) *+	Hydrogen Sulfate	Pass
Sulfur Monochloride	Sulfur Chloride	FAIL
Tetrachloroethylene *	Perchloroethylene	Pass
Tetrahydrofuran *+	THF	Pass
Toluene *+	Methylbenzene	Pass
Trichloroethylene	TCE	Pass
Urea (54%)	Carbamide	Pass
Xylene, Mixed Isomers	Dimethylbenzene	Pass

*** Liquid chemical listed in ASTM F1001, *Standard for Test Chemicals to Evaluate Protective Clothing Materials***

+Chemical listed in NFPA 1992/1993 battery

When you need both vapor and liquid splash protection

In these situations, it is appropriate to choose a certified vapor-tight suit compliant with NFPA 1991 since, by definition, vapor protective suits also provide liquid splash protection. **Never use a liquid splash protective suit in these situations, even if the material offers acceptable resistance to chemical permeation, because these suits lack overall vapor-tight integrity.**

When to use a liquid splash protective suit

Heat stress is a serious hazard to wearers of chemical protective clothing. In some cases, this threat may be even more dangerous than the chemical hazard itself.

To release heat, your body sweats; and when the sweat evaporates, your body is cooled. The problem is that chemical protective clothing limits sweat evaporation. In vapor protective suits, sweat evaporation is prevented altogether. And liquid splash suits based on continuous film materials perform similarly.

GORE-TEX fabric is the first product that offers liquid splash protection and also allows sweat vapor to escape. It satisfies the material requirements of NFPA 1993, and garments made from this remarkable fabric have been certified to be compliant with NFPA 1993.

Therefore, you may use a GORE-TEX fabric liquid splash protective suit when you need protection against the chemicals that are listed in the NFPA 1993 battery, as well as other chemicals meeting the NFPA 1993 guidelines — i.e., those that pose no threat in a vaporous state. (Color coded green on the Chemical Penetration Data Table)

It is also appropriate to use a GORE-TEX fabric liquid splash protective suit when you need protection against chemicals that are outside NFPA 1993 guidelines and it has been determined that a certain level of vapor exposure is acceptable. Not all exposures to hazardous chemicals are in an emergency situation, for which the NFPA Standards were developed. Under certain controlled circumstances, it may be acceptable to use a garment made from GORE-TEX fabric for challenges outside those guidelines where it has passed the penetration test. (Color coded yellow on the Chemical Penetration Data Table)

Each end-use situation must be evaluated for its particular risks. A chemical-by-chemical determination alone is not always sufficient to capture the various situations where chemical protective clothing is used. **(Always consult a trained professional in safety or industrial hygiene when making this determination.)**

Safety Considerations

Consult a trained professional in industrial safety/hygiene when determining fitness for use.

Chemical protective clothing made from GORE-TEX fabric does not provide protection from all chemicals or in all conditions. The technical information set forth in this Technical Data and Application Guide documents laboratory performance under laboratory conditions. Testing and other results presented herein are for fabric only. Performance of any particular garment will depend on a number of factors including, but not limited to, seams, closures, accessories, duration of use, maintenance of garment and proper handling.

Warning: Do not use GORE-TEX fabric for conditions of deluge or continuous exposure.

GORE-TEX fabric is a barrier to many inorganic and organic liquid challenges. It is not a barrier against all liquid chemicals. It has been tested for the chemicals documented in the Chemical Penetration Data Table. If your only safety requirement is to keep one or more of these liquids off your skin, chemical protective clothing made from GORE-TEX fabric, in conjunction with good safety training and good safety practices, may be used. Test results on other liquid chemical challenges can be provided on request.

Warning: Do not use GORE-TEX fabric for any untested, unknown, or "failed" liquid chemical challenges.

GORE-TEX fabric is permeable to all vapors. If a vapor, or a liquid producing a vapor, represents a safety or health hazard, do not use garments made from GORE-TEX fabric. Consult a trained professional in safety or industrial hygiene when making this determination.

Warning: Do not use GORE-TEX fabric for vapor protection.

If the chemical challenge also represents a flammable hazard, chemical protective clothing made with Nomex GORE-TEX fabric should be used instead of the polyester GORE-TEX fabric described in this Technical Data and Application Guide.

GORE
Creative Technologies Worldwide

W. L. Gore & Associates, Inc.
Industrial Fabrics
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Phone: 410-392-3700 • FAX: 410-392-4452

APPENDIX G

Chemical Protective Clothing

Volume 1

Edited by
James S. Johnson, Ph.D.
and
Kevin J. Anderson

AMERICAN INDUSTRIAL HYGIENE ASSOCIATION

American Industrial Hygiene Association, Akron, Ohio

ACKNOWLEDGMENT

The editors and chapter authors would like to acknowledge the initial funds from the American Industrial Hygiene Association as well as ongoing financial support from the Hazards Control Department of the Lawrence Livermore National Laboratory for the preparation of volumes 1 and 2 of *chemical Protective Clothing.* Each author's organization also provided resources that permitted the completion of the work.

International Standard Book Number 0-932627-43-9 (Volume 1)
International Standard **Book Number 0-932627-44-7 (Volume 2)**

American Industrial Hygiene Association
P.O. Box 8390,345 White Pond Drive
Akron, Ohio 44320

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Chemical Profecfive Clothing

Volume 2

Product and Performance Information

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James S. Johnson, Ph.D.
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AMERICAN INDUSTRIAL HYGIENE ASSOCIATION

American Industrial Hygiene Association, Akron, Ohio

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