CPRC

CANADIAN POLICE RESEARCH CENTRE

CCRP

CENTRE CANADIEN DE RECHERCHES POLICIERES

# TM-I3-94
# Protective Clothing for Hazardous Spills

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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.

## Proiect 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-I 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.**

**Number:** _____ **Product:** _____

CHEMRON 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. |

marketing information

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 | |
|---|---|---|---|---|
| Cheaica l | Breakthrough Tine | Permeation Rate | Breakthrough Tire | Perreation 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 al so 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.

# ANTICIPATED BREAKTHROUGH TIMES ON CHEMREL
## AT ROOM TEMPERATURE

| Chemical | jreakthrouah Time |
|---|---|
| Acetaldehyde | >4 hours |
| Acetic Acid | >24 hours |
| Acetic Anhydride | 3 hours |
| Acetic Chloride | >8 hours |
| Acetylphenylacetonitrile | >3 hours |
| Acrolein | >4 hours |
| Acrylic Acid 50% | >6 hours |
| Acrylimide | >3 hours |
| Acrylonitrile | >4 hours |
| Allylchloride | >30 min. |
| Aluminum Chloride | >8 hours |
| Aluminum Stearate No. 2 | >24 hours |
| Ammonia (solution) | >3 hours |
| Ammonium Hydroxide | >8 hours |
| Anhydrous Ammonia (gas) | >1 hour |
| Anhydrous Sodium Sulfate | >24 hours |
| Aniline | >8 hours |
| Arctic Syntex liq. Perfume | >24 hours |
| Arquad | >24 hours |
| Benzaldehyde | >45 min. |
| Benzoyl Chloride | >2 hours |
| Benzyl Chloride | >2 hours |
| Biphenyl | >8 hours |
| Black Liquor (alkali) | >8 hours |
| Butanol | >8 hours |

| Chemical | Breakthrough Tire |
|---|---|
| Jutyl Acetate | >3 hours |
| Butyl Amine | >iCC min. |
| Calcium Hydroxide | >24 hours |
| Calcium Hypochlorite (HTH) | >8 hours |
| Carbon Dioxide | 40 min. |
| Carpontetrachloride | >4 min. |
| Caustic Soda | >24 hours |
| Chlorine (20 ppn) | >24 hours |
| Chloro-2-propanone | >6 hours |
| Chloroacetic Acid 68% | >8 hours |
| Chloroacetone | >6 hours |
| Chlorobenzene | >1 hour |
| Chlorosulfonic Acid | >3 hours |
| Chromic Acid | >24 hours |
| CI Acid Blue 182 (190%) | >24 hours |
| CI Acid Grange | >24 hours |
| 01 Acid Red 52 (No. 2) | >24 hours |
| CI Pigment Green/C1 74260 (No. 1) | >24 hours |
| CI Reactive Green | >24 hours |
| Copper Cyanide | >4 hours |
| Copper Sulfate | >8 hours |
| Cresols (tech grade) | >2 hours |
| Crystal 792 Perfume (IFF) | >24 hours |
| Cyanides (for all salts) | >4 hours |
| Cyanogen Bromide | >8 hours |

| Chemical | Breakthrough Time |
|---|---|
| Cyclohexanone | >8 hours |
| O&C Green #8 | >2b hours |
| D&C Green [illegible] | >24 hours |
| D&C Yellow [illegible] | >24 hours |
| D&C Yellow [illegible] | >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 | >lO 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. |

| Chemi cal | 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) | ! 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 | ireakthrcuah Time |
|---|---|
| Silicate 43.5 | >24 hours |
| Sodium (metal) | >8 hours |
| Sodium Acetate Anhydrous | >8 hours |
| Scdiua Benzoate | >24 hours |
| Sodium Sisulfite | >8 hours |
| Soaium 8orohydride | >4 hours |
| Sodium Hydroxide 50% | >24 hours |
| Soaium Hydrosulfite | >6 hours |
| Soaium Lduryl Sulfate | >24 hours |
| Soaium Lauryl Sulfate #4 | >24 hours |
| Sodium Monofluorouhosfate | >24 hours |
| Sodium Nitrate - Coated | >24 hours |
| Sod ium Saccharin (No MSDS) | >24 hours |
| Sodium Serauicarbonate | >24 hours |
| Sodium Sulfite Bisulfide | >6 hours |
| Sodium TPP PHOS (Thermoohos NW) | >24 hours |
| Sodium Tripolypbosphate - HEXA | >24 hours |
| Sodium Xylene Sulfonate Soln | >24 hours |
| Scrbitoi 70% Solution | >24 hour |
| Styrene | >1 hour |
| Sulfolane | >1 hour |
| Sulfur Dioxide | >3 hours |
| Suifur Trioxide | >8 hours |
| Sulfuric Acid 16% | >8 hours |
| Sulfuric Acid 50% | >8 hours |

| Chemical | Breakthrough Time |
|---|---|
| Sulfuric Acid 90% | >8 hours |
| Sulphalene | >24 hours |
| Syloid 244 | >24 hours |
| Tartrarine Xtra Conc. | >24 hours |
| Tetra Alkyl Lead | >2 hours |
| Tetra Ethyl Lead | >6 hours |
| Tetra Hydro Thioohene | <30 min. |
| Tetrasodium Pyrophosphate | >24 hours |
| Thionyl Chloride | 30 min. |
| Thionylene Chloride | >30 min. |
| Thorium Nitrate | >1 hour |
| Tinopal 58M Conc. | >24 hours |
| Titanium Dioxide | >24 hours |
| Titanium Tetrachloride | >8 hours |
| Tolune diisocyanate | >6 hours |
| Trich!oroacetic Acid | >2 hours |
| Trichlorobenzane | >1 hour |
| Trichloroethane | >20 min. |
| Trich;oroetnylene | >20 min. |
| Triethanoiamine 99% | >6 hours |
| Triethvlanfne | >3 hours |
| Uvinul US-40 | >24 hours |
| Vinyl Acetate | >8 hours |
| Vinyl Chloride | >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.

# 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® 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

**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.**

# 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 |
| Dust 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 lt 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 1-800-44-TYVEK.**

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

**TYVEK spunbonded olelin and BARRICADE are registered lrademarks of DuPont.**

**SARANEX 23-P is a registered lrademark of The Dow Chemical Company.**

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 | 211 Aliphalic and Alicyclic | Acelyl chloride | L | nl | nt | 37 | 1.1 | 164 | 0.89 |
| | 212 Aromalic | Benzoyl chloride | L | III | nt | nt | nt | >480 | ND |
| Aldehydes | 221 Aliphalic and Alicyclic | Bulyraldehyde | L | 1 | 22 | 47 | 6.1 | >480 | ND |
| | | Formaldehyde. 37% | L | immediale | 0.31 | >480 | ND | >480 | ND |
| Amides | 232 Aliphalic and Alicyclic | N.N-Dimelhylacelamide | L | nt | III | 64 | 2 | >480 | ND |
| | | N.N-Dimelhyllormamide | L | 45 | 1.2 | 118 | 0.91 | 226 | 2.5 |
| Amines | 241 Aliphalic and Alicyclic. Primary | Melhylaniine | G | nl | nl | nl | nl | 105 | 40 |
| | 242 Aliohalic and Alicvclic. Secondarv | Dielhylamine | L | 1 | 141 | 6 | 300 | >480 | ND |
| | 243 Aliphalic and Alicyclic. Tertiary | Iriethylamine | L | nt | nl | >480 | ND | nt | nt |
| | 245 Aromalic, Primary | Aniline | L | immediale | 2.1 | 265 | .53 | >480 | ND |
| | | d-Ioluidme | L | immediale | 1 | 255 | 0.36 | nt | nt |
| Polyamines | 252 Aliohalic and Alicvclic | Ethylenediamine | L | 139 | 3.0 | >480 | ND | nl | nl |
| | 253 Aromalic | 4.4'-Melhylene bis (o-chloroaniline). saluraled solution in melhanol | L | nt | nl | >480 | ND | >480 | ND |
| Isocyanales | 2111 Aliphalic and Alicyclic | Hexamelthylenediisocyanate | L | nl | nl | >480 | ND | >480 | ND |
| | | Ielhyl isocyanale | L | nl | nl | 2 | 210 | >480 | ND |
| | 2112 Aromalic | 4.4'-Diphenylmelhane Diisocyanale | S | nl | III | nt | nl | >480 | ND |
| | | Ioluene-2.4.diisocyanale | L | immediale | 42 | ~480 | ND | >480 | ND |
| Esters, Carboxylic | 2221 Acetales | i-Amyl acelale | L | nl | III | nt | nt | >480 | ND |
| | | Ethyl acelale | L | immediale | 1990 | 36 | 6.6 | >480 | ND |
| | | Vynil acelale | L | nt | nl | nl | nl | >480 | ND |
| | 2223 Acrylales and Melhacrylales | Methyl methacrylate | L | nl | nl | nl | nl | >480 | ND |
| Ethers | 2241 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 |
| | 2245 Glycol Ethers | Butyl cellosolve | L | nl | nt | >480 | ND | nl | nl |
| | | Ethyl cellosolve | L | nl | nl | >480 | ND | >480 | ND |
| | | Ethyl 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 | 2261 Aliphalic and Alicyclic | Carbon tetrachloride | 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.**

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

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## PERMEATION DATA TABLE (Cont'd)



| Class Group | Sub-Class | Chemical | Physical Phase | TYVEK® QC | | TYVEK®/SARANEX® 23-P | | BARRICADE™ | |
|---|---|---|---|---|---|---|---|---|---|
| | | | | Breakthrough Time (min) | Permeation Rate (µg/cm²/min) | Breakthrough Time (min) | Permeation Rate (µg/cm²/min) | Breakthrough Time (min) | Permeation Rate (µg/cm²/min) |
| Halogen Compounds, *continued* | 261 Aliphatic 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 delected 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.**

**TYVEK spunbonded oletin and BARRICADE are registered trademarks of DuPont.**

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

## PERMEATION DATA TABLE (Cont'd)



| Class croup | Sub-Class | Chemical | Physical Phase | TYVEK* QC | | TYVEK*/SARANEX* 23-P | | BARRICADE* | |
|---|---|---|---|---|---|---|---|---|---|
| | | | | Breakthrough Time (min) | Permeation Rate (µg/cm²/min) | Breakthrough Time (min) | Permeation Rate (µg/cm²/min) | Breakthrough Time (min) | 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 | Ill | 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 | Ill | >480 | ND | >480 | ND |
| | | Sodium fluoride, 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 | immediate | high | >480 | ND | >480 | ND |
| | | Hydrogen fluoride | G | 7 | 6 | 20 | 3 | 83 | 15.7 |
| | | Nitrogen dioxide | G | nl | nl | >480 | ND | nt | nl |
| | | Nitrogen tetroxide | G | nt | nt | nt | nt | 24 | 66 |
| | | Sulfur 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 trichloride | L | nt | nt | 20 | 28.3 | >480 | ND |
| Inorganic Acids | **170** Inorganic Acids | Hydrochloric acid, 37% | L | 63 | 1.2 | >480 | ND | >480 | ND |
| | | Hydrofluoric acid, 50% | L | 180 | 0.08 | >480 | ND | >480 | ND |
| | | Hydrofluoric acid, 92% (90°C) | L | nt | nt | nl | nt | 67 | 2.8 |
| | | Nitric 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** Aliphatic 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** Unsubstituted | Nitrobenzene | L | immediate | 2.4 | 135 | 0.28 | >480 | ND |
| | | Nitromethane | 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% Irichloroknrenel 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 |

("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.

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## 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

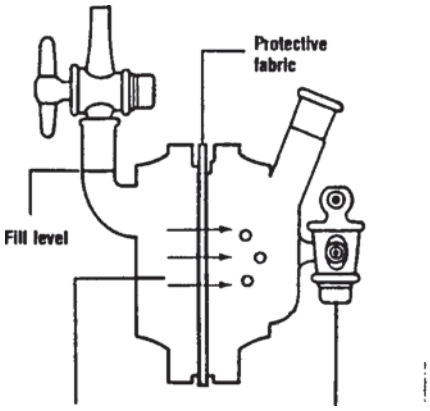


Figure 1

## 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

| Chemical Name | Class | Phase | TYVEK* QC | | TYVEK*/SARANEX* 23-P | | BARRICADE" | |
|---|---|---|---|---|---|---|---|---|
| | | | Breakthrough lime (min.) | Permeation Rate (µg/cm²/min) | Breakthrough Time (min.) | Permeation Rate (µg/cm²/min) | Breaklhrough Time (mtn.) | Permeation Rate (µg/cm²/min) |
| Acetone | Kelones | L | immediate | 8 | 29 | 12 | >480 | ND |
| Acetonitrile | 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 | immediale | 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 |
| Sulfuric acid (cont.) | Inorganic Acids | L | >480 | ND | >480 | ND | >480 | ND |
| Tetrachlorethylene | 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**

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# 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-!TEX 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 | F A I L |
| 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.

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# APPENDIX G

# *Chemical Protective Clothing*

**Volume 1**

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International Standard Book Number 0-932627-43-9 (Volume 1)
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# Chemical Profecfive Clothing

**Volume 2**

## Product and Performance Information

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