



DuPont Permeation Guide

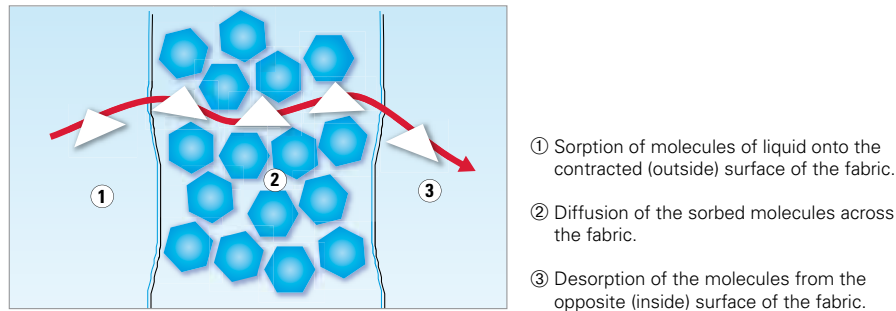


INTRODUCTION - Chemical Permeation

What is permeation?

Permeation is the process by which a potentially hazardous chemical moves through a material on a molecular level. Permeation can be represented by the following simplified diagram (Fig. 1).

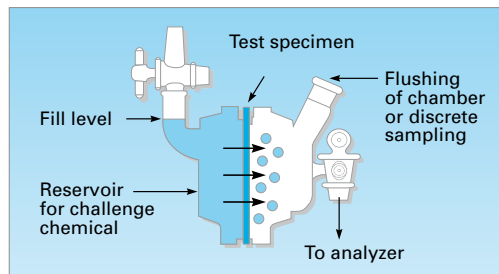
Fig. 1 - Permeation



Measuring permeation

The resistance of a protective clothing fabric to permeation by a chemical can be determined by testing a fabric against a challenge chemical according to EN ISO 6529 (method A and B), ASTM F-739 or EN 374-3. For these methods a two-chambered test cell is used. The test specimen is positioned between the two sections of the cell.

Fig. 2 - Permeation test cell



On the challenge side of the test cell the outside fabric surface is exposed continuously to the challenge chemical. The sampling side of the test cell is analytically monitored. The normal test duration is 480 minutes.

An explanation of the parameters which describe the permeation-performance of a barrier is given below.

Permeation rate

A permeation rate indicates the mass of the chemical in micrograms, which can be transferred through one square centimetre of the fabric in one minute. The unit is $\mu\text{g}/(\text{cm}^2\cdot\text{min})$.

Minimum detectable permeation rate (MDPR)

The lowest rate of permeation that is measurable is called the minimum detectable permeation rate (MDPR). The MDPR can vary depending on the sensitivity of the analytical device for the given substance. Minimum detectable permeation rates can be as low as $0.001 \mu\text{g}/(\text{cm}^2\cdot\text{min})$ in certain cases.

Breakthrough detection time (Actual breakthrough time)

The breakthrough detection time or actual breakthrough time is the time elapsed between initial contact of the chemical with the outside surface of the protective clothing fabric and its detection at the inside surface. Actual breakthrough has taken place when the minimum detectable permeation rate has been reached. A breakthrough detection time of more than 480 minutes indicates that the challenge chemical did not reach the minimum detectable permeation rate during the test time of 480 minutes.



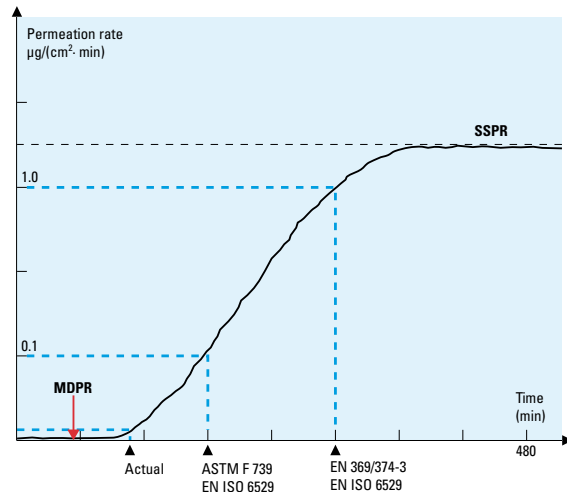
There is the possibility that a breakthrough at a lower permeation rate than the minimum detectable permeation rate has in fact taken place. To be able to interpret the actual breakthrough time the minimum detectable permeation rate should be indicated.

Normalized permeation rate

To be able to compare permeation data, the breakthrough time is reported at defined permeation rates. According to ASTM F-739 the normalized breakthrough detection time is reported at a permeation rate of 0.1 $\mu\text{g}/(\text{cm}^2\cdot\text{min})$. According to EN 374-3 the normalized breakthrough detection time is reported at a rate of 1.0 $\mu\text{g}/(\text{cm}^2\cdot\text{min})$.

The test method EN ISO 6529 provides the choice of two normalized permeation rates for reporting the results: 0.1 $\mu\text{g}/(\text{cm}^2\cdot\text{min})$ or 1.0 $\mu\text{g}/(\text{cm}^2\cdot\text{min})$.

Fig. 3 - "Typical" permeation cell results



Steady state permeation rate (SSPR)

The constant permeation rate that occurs after reaching equilibrium is called the steady state permeation rate.

Performance classes according to EN 14325*

Chemical protective clothing is classified into six classes based on a normalized permeation rate of 1.0 $\mu\text{g}/(\text{cm}^2\cdot\text{min})$.

Table 1

Normalized breakthrough time at a permeation rate of 1.0 $\mu\text{g}/(\text{cm}^2\cdot\text{min})$ in minutes	EN Class
> 10	1
> 30	2
> 60	3
> 120	4
> 240	5
> 480	6

* EN 14325: Protective clothing against chemicals - test methods and performance classification of chemical protective clothing

Permeation data table

The permeation data table for the Tychem[®] C, Tychem[®] C2, Tychem[®] F and Tychem[®] F2 fabrics is organized alphabetically. For each chemical the CAS-number and the physical state is listed. CAS-number is a unique numerical identifier created and assigned to a chemical substance by the Chemical Abstract Society. The physical state describes the state in which the chemical has been tested. Unless otherwise stated, the tests were performed with pure chemicals under laboratory conditions at room temperature and environmental pressure.

The table shows the following data for each chemical:

- Actual breakthrough time in minutes
- Normalized breakthrough time at 0.1 $\mu\text{g}/(\text{cm}^2\cdot\text{min})$ in minutes
- Normalized breakthrough time at 1.0 $\mu\text{g}/(\text{cm}^2\cdot\text{min})$ in minutes
- Performance class according to EN 14325
- Steady state permeation rate in $\mu\text{g}/(\text{cm}^2\cdot\text{min})$
- Minimum detectable permeation rate in $\mu\text{g}/(\text{cm}^2\cdot\text{min})$.

Interpreting permeation data

Tychem® F Barrier to a range of organic and highly concentrated inorganic chemicals									
	Chemical Name	Physical State	CAS-No.	Breakthrough time			EU-Class according to EN 14325	Steady State Permeation Rate µg/(cm ² ·min)	Minimum Detection Rate µg/(cm ² ·min)
				Actual	Normalized at 0.1 µg/(cm ² ·min)	Normalized at 1.0 µg/(cm ² ·min)			
				minutes	minutes	minutes			
Example 1	Sulphuric acid (98%)	L	7664-93-9	> 480	> 480	> 480	6	< 0.01	0.01
Example 2	Cresol-o	L	95-48-7	124	180	206	4	2.7	0.001
Example 3	Thionyl chloride	L	7719-09-7	imm	imm	15	1	101	0.01

Example 1: Sulphuric acid, CAS 7664-93-9, 98 % *

Tychem® F is exposed to Sulphuric acid, 98 % for a test duration of more than 480 minutes. No breakthrough has taken place at the minimum detection rate of 0.01 µg/(cm²·min), the normalized breakthrough time at 0.1 µg/(cm²·min) and 1.0 µg/(cm²·min). The breakthrough time for these permeation rates are reported with more than 480 minutes. Based on the results for the normalized breakthrough time at 1.0 µg/(cm²·min) the resistance to permeation is classified into class 6 according to EN 14325.

The permeation did not reach equilibrium at a measurable level. Therefore the steady state permeation rate is below the minimum detectable permeation rate (0.01 µg/(cm²·min)).

There is the possibility that Sulphuric acid permeates the barrier, but at a lower rate than 0.01 µg/(cm²·min). Based on the permeation data, Tychem® F fabric can be considered as offering a chemical barrier to liquid 98%* Sulphuric acid. The selected fabric should then be taken into the next step of the garment selection process as part of the workplace risk assessment.

Example 2: o-Cresol, CAS 95-48-7.

Tychem® F is exposed to o-Cresol, CAS 95-48-7 for a test duration of more than 480 minutes. Breakthrough has taken place at the minimum detection rate of 0.01 µg/(cm²·min) after 124 minutes. The normalized breakthrough time at 0.1 µg/(cm²·min) has been reached after 180 minutes and the normalized breakthrough time at 1.0 µg/(cm²·min) after 206 minutes.

Based on the results for the normalized breakthrough time at 1.0 µg/(cm²·min) the resistance to permeation is classified into class 4 according to EN 14325. The permeation reached equilibrium at a rate of 2.7 µg/(cm²·min) between 206 and 480 minutes.


Based on the permeation data, Tychem® F fabric shall be considered as offering a **limited barrier only** to o-Cresol. Tychem® F fabric may be considered in the next step of the garment selection process as part of the workplace risk assessment, but breakthrough does occur. Careful attention must be paid to the working temperature, exposure time, contaminated suit area, chemical toxicity and working practices.

Example 3: Thionyl chloride, CAS 7719-09-7.

Based on permeation data Tychem® F is a limited barrier to Thionyl chloride, CAS 7719-09-7. The minimum detection rate of 0.01 µg/(cm²·min) and the normalized breakthrough time at 0.1 µg/(cm²·min) are reached immediately. The normalized breakthrough time at 1.0 µg/(cm²·min) has been reached after 15 minutes. The steady state permeation rate of 101 mg/(cm²·min) indicates that high quantities will permeate.

Based on the permeation data, Tychem® F fabric shall be considered as an **insufficient barrier** to Thionyl chloride. For certain tasks, whereby the exposure risk is highly unlikely and the employee is trained to remove the PPE upon eventual exposure, then garments made of Tychem® F could be considered in the risk assessment, but extreme caution must be applied. If possible, identifying a fabric which offers a higher chemical permeation barrier would be a recommended safer approach.

* Warning: presence of vapours must be addressed in the garment risk assessment.



Important note: Please use the permeation data as part of the risk assessment to assist the selection of a protective fabric, garment or accessory suitable for your application. Working conditions, exposure conditions (e.g. temperature, pressure, concentration, physical state), and the toxicity data for the chemical need to be taken into account.

Breakthrough time is not the same as “safe wear time”. Breakthrough time alone is insufficient to determine how long a garment may be worn once the garment has been contaminated. Safe user wear time may be longer or shorter than the breakthrough time depending on the permeation behaviour of the substance, the toxicity of the substance and the exposure conditions. Breakthrough times are indicative of the barrier performance, but results can vary between the test methods and laboratories.

A different temperature may have significant influence on the breakthrough time. Permeation typically increases with temperature.

Permeation data are usually measured for single chemicals. The permeation characteristics of mixtures can deviate considerably from the behaviour of the individual chemicals.

The permeation data published in this document have been generated for DuPont by independent accredited testing laboratories according to the test method applicable at that time*. The data is typically the average of three samples tested.

* EN369, ASTM F739, EN 374-3 or EN ISO 6529 (method A and B).

Although the fabric itself may offer a barrier to a certain range of gaseous chemicals, chemical protective clothing category III type 3 made of Tychem® C, F, C2 or F2 is not gastight. In case you need a barrier to gases or vapours, please take a chemical protective clothing category III type 1, such as Tychem® TK into consideration.

Tychem® C/C2 and Tychem® F/F2 garments

Tychem® C Standard and Tychem® C2 model CHZ5 are certified as chemical protective clothing category III type 3B, 4, 5 and 6 and offer a barrier to pressurized liquids up to a pressure of 2 bar. They are a barrier to a range of concentrated inorganic chemicals.

Tychem® F Standard and Tychem® F2 model CHZ5 are certified as chemical protective clothing category III type 3B, 4, 5 and 6 and offer a barrier to pressurized liquids to a pressure up to 3 bar. They are a barrier to a range of organic and highly concentrated inorganic chemicals.

DuPont™ Tychem® C, C2, F and F2 garments have stitched and over-taped seams. The seam tape is a special barrier tape which offers the same permeation barrier performance as the fabric itself. Permeation data for Tychem® C fabric is applicable for the reinforced Tychem® C2 fabric and permeation data for Tychem® F fabric is applicable for the reinforced Tychem® F2 fabric.

Permeation data for chemical warfare agents

Permeation data for chemical warfare agents is available on request.



Contact our Techline:

www.dpp-europe.com/technicalsupport

- Need selection assistance?
- Need technical advice?
- No chemical permeation data for your chemical?

DuPont experts can provide technical assistance with your fabric and garment selection process. Using a simple web-based questionnaire, please provide relevant information on chemicals, exposure and working conditions for a customized response.

Independent permeation testing of your specific chemical with the DuPont barrier fabrics can also be facilitated.

To check the most updated permeation data, please visit our website.

TYCHEM® C/C₂ AND TYCHEM® F/F₂ FABRICS - Permeation Data

Chemical Name	Physical State	CAS No.	Tychem® C Barrier to a range of concentrated inorganic chemicals						Tychem® F Barrier to a range of organic and highly concentrated inorganic chemicals					
			Breakthrough time			EU-Class according to EN 14325	Steady State Permeation Rate	Minimum Detection Rate	Breakthrough time			EU-Class according to EN 14325	Steady State Permeation Rate	Minimum Detection Rate
			Actual	Normalized at 0.1 µg/(cm ² -min)	Normalized at 1.0 µg/(cm ² -min)				Actual	Normalized at 0.1 µg/(cm ² -min)	Normalized at 1.0 µg/(cm ² -min)			
			minutes	minutes	minutes	µg/(cm ² -min)	µg/(cm ² -min)	minutes	minutes	minutes	µg/(cm ² -min)	µg/(cm ² -min)		
Acetaldehyde	L	75-07-0	■	■	■	■	■	■	imm	imm	13	1	2	0.06
Acetic acid (glacial)	L	64-19-7	■	■	■	■	■	■	> 480	> 480	> 480	6	< 0.02	0.02
Acetone	L	67-64-1	■	■	■	■	■	■	> 480	> 480	> 480	6	< 0.01	0.01
Acetone cyanohydrin	L	75-86-5	■	■	■	■	■	■	> 480	> 480	> 480	6	< 0.05	0.05
Acetonitrile	L	75-05-8	■	■	■	■	■	■	> 480	> 480	> 480	6	< 0.1	0.1
Acetyl chloride	L	75-36-5	■	■	■	■	■	■	155	> 480	> 480	6	0.0014	0.0001
Acrolein	L	107-02-8	■	■	■	■	■	■	imm	48	> 480	6	0.41	0.001
Acryl amide (50%)	L	79-06-1	■	■	■	■	■	■	> 480	> 480	> 480	6	< 0.1	0.1
Acrylic acid	L	79-10-7	■	■	■	■	■	■	84	> 480	> 480	6	0.002	0.001
Acrylonitrile	L	107-13-1	■	■	■	■	■	■	imm	8	> 480	6	0.57	0.01
Adiponitrile	L	111-69-3	■	■	■	■	■	■	> 480	> 480	> 480	6	< 0.05	0.05
Allyl alcohol	L	107-18-6	■	■	■	■	■	■	imm	> 480	> 480	6	0.04	0.001
Allyl chloride	L	107-05-1	■	■	■	■	■	■	■	■	> 480	6	■	0.05
Ammonia (gas)	G	7664-41-7	■	■	■	■	■	■	55	79	> 480	6	0.76	0.001
Amyl acetate n-	L	628-63-7	■	■	■	■	■	■	12	136	> 480	6	0.11	0.001
Aniline	L	62-53-3	■	■	■	■	■	■	> 480	> 480	> 480	6	< 0.03	0.03
Aniline, 4-trifluoromethoxy-	L	461-82-5	■	■	■	■	■	■	> 480	> 480	> 480	6	< 0.05	0.05
Anthracene (sat'd. in toluene)	L	120-12-7	■	■	■	■	■	■	> 480	> 480	> 480	6	< 0.02	0.02
Antimony pentachloride	L	7647-18-9	■	■	■	■	■	■	15	15	15	1	> 10	0.1
Arsenic (III) chloride	L	7784-34-1	■	■	■	■	■	■	22	32	54	2	334	0.01
Benzene	L	71-43-2	■	■	■	■	■	■	> 480	> 480	> 480	6	< 0.05	0.05
Benzene sulfonyl chloride	L	98-09-9	■	■	■	■	■	■	> 480	> 480	> 480	6	< 0.02	0.02
Benzonitrile	L	100-47-0	■	■	■	■	■	■	> 480	> 480	> 480	6	< 0.001	0.001
Benzoyl chloride	L	98-88-4	■	■	■	■	■	■	> 480	> 480	> 480	6	< 0.05	0.05
Benzyl alcohol	L	100-51-6	■	■	■	■	■	■	> 480	> 480	> 480	6	< 0.04	0.04
Benzyl chloride	L	100-44-7	■	■	■	■	■	■	> 480	> 480	> 480	6	< 0.08	0.08
Benzyl cyanide	L	140-29-4	■	■	■	■	■	■	> 390	> 390	> 390	5	< 0.01	0.01
Bisphenol-A Diglycidyl Ether	L	1675-54-3	■	■	■	■	■	■	> 480	> 480	> 480	6	< 0.01	0.01
Boron trifluoride dimethyletherate	L	353-42-4	■	■	■	■	■	■	> 480	> 480	> 480	6	< 0.01	0.01
Bromine (liquid)	L	7726-95-6	■	■	■	■	■	■	imm	imm	■	-	105	0.001

KEY: ■ = Not tested • S = solid • G = gaseous • L = liquid • imm = Immediate • sat'd = saturated

TYCHEM® C/C₂ AND TYCHEM® F/F₂ FABRICS - Permeation Data

Chemical Name	Physical State	CAS No.	Tychem® C Barrier to a range of concentrated inorganic chemicals						Tychem® F Barrier to a range of organic and highly concentrated inorganic chemicals					
			Breakthrough time			EU-Class according to EN 14325	Steady State Permeation Rate	Minimum Detection Rate	Breakthrough time			EU-Class according to EN 14325	Steady State Permeation Rate	Minimum Detection Rate
			Actual	Normalized at 0.1 µg/(cm²·min)	Normalized at 1.0 µg/(cm²·min)				Actual	Normalized at 0.1 µg/(cm²·min)	Normalized at 1.0 µg/(cm²·min)			
			minutes	minutes	minutes	µg/(cm²·min)	µg/(cm²·min)	minutes	minutes	minutes	µg/(cm²·min)	µg/(cm²·min)		
Bromofluorobenzene 4-	L	460-00-4	■	■	■	■	■	■	> 480	> 480	> 480	6	< 0.02	0.02
Butadiene 1,3- (gas)	G	106-99-0	■	■	■	■	■	■	4	> 480	> 480	6	0.005	0.001
Butanol n-	L	71-36-3	■	■	■	■	■	■	> 480	> 480	> 480	6	< 0.05	0.05
Butyl ether n-	L	142-96-1	■	■	■	■	■	■	4	192	> 480	6	0.13	0.001
Carbon disulfide	L	75-15-0	■	■	■	■	■	■	32	> 480	> 480	6	0.05	0.001
Carbon tetrachloride	L	56-23-5	■	■	■	■	■	■	4	4	> 480	6	0.57	0.001
Chlorine (gas)	G	7782-50-5	■	■	■	■	■	■	> 480	> 480	■	■	■	0.2
Chloro-1,3-butadiene 2- (50% in Butanol)	L	126-99-8	■	■	■	■	■	■	> 480	> 480	> 480	6	< 0.02	0.02
Chloroacetic acid (68%)	L	79-11-8	■	■	■	■	■	■	> 480	> 480	■	■	■	0.1
Chloroacetone	L	78-95-5	■	■	■	■	■	■	> 480	> 480	> 480	6	< 0.01	0.01
Chloroacrylonitrile 2-	L	920-37-6	■	■	■	■	■	■	> 480	> 480	> 480	6	< 0.01	0.01
Chlorobenzene	L	108-90-7	■	■	■	■	■	■	> 480	> 480	> 480	6	< 0.05	0.05
Chloroethanol 2-	L	107-07-3	■	■	■	■	■	■	> 480	> 480	■	■	■	0.001
Chloroform	L	67-66-3	■	■	■	■	■	■	4	8	8	-	10.6	0.001
Chloromethyl methyl ether	L	107-30-2	■	■	■	■	■	■	imm	8	> 480	6	0.75	0.001
Chlorosulfonic acid	L	7790-94-5	■	■	■	■	■	■	423	> 480	> 480	6	0.0003	0.0001
Chlorotoluene o-	L	95-49-8	■	■	■	■	■	■	> 480	> 480	> 480	6	< 0.02	0.02
Chlorotrinitromethane	L	76-06-2	■	■	■	■	■	■	> 480	> 480	> 480	6	< 0.05	0.05
Chromic acid 80% (H ₂ SO ₄ x CrO ₃)	L	■	> 480	> 480	> 480	6	< 0.001	0.001	■	■	■	■	■	■
Creosote	L	8001-58-9	■	■	■	■	■	■	> 480	> 480	> 480	6	< 0.02	0.02
Cresol-o	L	95-48-7	■	■	■	■	■	■	124	180	206	4	2.7	0.001
Cumene (Isopropylbenzene)	L	98-82-8	■	■	■	■	■	■	> 480	> 480	> 480	6	< 0.05	0.05
Cyclohexane	L	110-82-7	■	■	■	■	■	■	8	> 480	> 480	6	0.04	0.001
Cyclohexanone	L	108-94-1	■	■	■	■	■	■	> 480	> 480	> 480	6	< 0.05	0.05
Dichloroacetyl chloride	L	79-36-7	■	■	■	■	■	■	160	160	180	4	7.41	0.01
Dichloroethylether	L	111-44-4	■	■	■	■	■	■	> 480	> 480	> 480	6	< 0.02	0.02
Dichloromethane	L	75-09-2	■	■	■	■	■	■	imm	imm	imm	-	23.7	0.03
Dichloropropene 2,3-	L	78-88-6	■	■	■	■	■	■	4	4	54	2	2.4	0.001
Diesel fuel	L	68334-30-5	■	■	■	■	■	■	8	> 480	> 480	6	0.02	0.001
Diethyl amine	L	109-89-7	■	■	■	■	■	■	> 480	> 480	> 480	6	< 0.001	0.001

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			Breakthrough time			EU-Class according to EN 14325	Steady State Permeation Rate	Minimum Detection Rate	Breakthrough time			EU-Class according to EN 14325	Steady State Permeation Rate	Minimum Detection Rate
			Actual	Normalized at 0.1 µg/(cm ² -min)	Normalized at 1.0 µg/(cm ² -min)				Actual	Normalized at 0.1 µg/(cm ² -min)	Normalized at 1.0 µg/(cm ² -min)			
			minutes	minutes	minutes	µg/(cm ² -min)	µg/(cm ² -min)	minutes	minutes	minutes	µg/(cm ² -min)	µg/(cm ² -min)		
Diethyl sulfate	L	64-67-5	■	■	■	■	■	■	> 480	> 480	> 480	6	< 0.01	0.01
Diethylenetriamine	L	111-40-0	■	■	■	■	■	■	> 480	> 480	> 480	6	< 0.05	0.05
Dimethyl acetamide N,N-	L	127-19-5	■	■	■	■	■	■	> 480	> 480	> 480	6	< 0.05	0.05
Dimethyl amine	G	124-40-3	■	■	■	■	■	■	> 480	> 480	> 480	6	< 0.05	0.05
Dimethyl aniline N,N-	L	121-69-7	■	■	■	■	■	■	> 480	> 480	> 480	6	< 0.1	0.1
Dimethyl dichlorosilane	L	75-78-5	■	■	■	■	■	■	> 480	> 480	> 480	6	< 0.0001	0.0001
Dimethyl formamide N,N-	L	68-12-2	■	■	■	■	■	■	> 480	> 480	> 480	6	< 0.001	0.001
Dimethyl nitrosamine	L	62-75-9	■	■	■	■	■	■	> 480	> 480	> 480	6	< 0.001	0.001
Dimethyl sulfate	L	77-78-1	■	■	■	■	■	■	> 480	> 480	> 480	6	< 0.09	0.09
Dimethyl sulfide	L	75-18-3	■	■	■	■	■	■	83	271	452	5	1.21	0.02
Dimethyl sulfoxide	L	67-68-5	■	■	■	■	■	■	20	28	114	3	1.9	0.001
Dioxane 1,4-	L	123-91-1	■	■	■	■	■	■	> 480	> 480	> 480	6	< 0.05	0.05
Epichlorohydrin	L	106-89-8	■	■	■	■	■	■	204	372	> 480	6	0.51	0.001
Ethanol	L	64-17-5	■	■	■	■	■	■	> 480	> 480	> 480	6	< 0.02	0.02
Ethanolamine	L	141-43-5	■	■	■	■	■	■	> 480	> 480	> 480	6	< 0.05	0.05
Ethoxy ethylacetat	L	111-15-9	■	■	■	■	■	■	> 480	> 480	> 480	6	< 0.01	0.01
Ethyl acetate	L	141-78-6	■	■	■	■	■	■	> 480	> 480	> 480	6	< 0.001	0.001
Ethyl ether	L	60-29-7	■	■	■	■	■	■	> 480	> 480	> 480	6	< 0.01	0.01
Ethylene diamine	L	107-15-3	■	■	■	■	■	■	> 480	> 480	> 480	6	< 0.001	0.001
Ethylene dibromide	L	106-93-4	■	■	■	■	■	■	84	144	> 480	6	0.52	0.001
Ethylene dichloride	L	107-06-2	■	■	■	■	■	■	90	92	98	3	7.2	0.02
Ethylene glycol	L	107-21-1	■	■	■	■	■	■	> 480	> 480	> 480	6	< 0.001	0.001
Ethylene oxide (gas)	G	75-21-8	■	■	■	■	■	■	44	64	64	3	1.4	0.01
Fluorobenzene	L	462-06-6	■	■	■	■	■	■	> 480	> 480	> 480	6	< 0.02	0.02
Fluorosilicic acid	L	16961-83-4	■	■	■	■	■	■	> 480	> 480	> 480	6	< 0.0001	0.0001
Formaldehyde (10%)	L	50-00-0	> 480	> 480	> 480	6	< 0.1	0.1	■	■	■	■	■	■
Formaldehyde (37%)	L	50-00-0	imm	imm	> 480	6	0.31	0.1	> 480	> 480	> 480	6	< 0.001	0.001
Formic acid (96%)	L	64-18-6	■	■	■	■	■	■	172	260	> 480	6	0.24	0.001
Furfural	L	98-01-1	■	■	■	■	■	■	424	> 480	> 480	6	0.01	0.001
Gasoline, leaded	L	Mixture	■	■	■	■	■	■	imm	imm	> 480	6	0.32	0.001

KEY: ■ = Not tested • S = solid • G = gaseous • L = liquid • imm = Immediate • sat'd = saturated

TYCHEM® C/C₂ AND TYCHEM® F/F₂ FABRICS - Permeation Data

Chemical Name	Physical State	CAS No.	Tychem® C Barrier to a range of concentrated inorganic chemicals						Tychem® F Barrier to a range of organic and highly concentrated inorganic chemicals					
			Breakthrough time			EU-Class according to EN 14325	Steady State Permeation Rate	Minimum Detection Rate	Breakthrough time			EU-Class according to EN 14325	Steady State Permeation Rate	Minimum Detection Rate
			Actual	Normalized at 0.1 µg/(cm ² -min)	Normalized at 1.0 µg/(cm ² -min)				Actual	Normalized at 0.1 µg/(cm ² -min)	Normalized at 1.0 µg/(cm ² -min)			
			minutes	minutes	minutes	µg/(cm ² -min)	µg/(cm ² -min)	minutes	minutes	minutes	µg/(cm ² -min)	µg/(cm ² -min)		
Gasoline, unleaded	L	Mixture	■	■	■	■	■	■	> 480	> 480	> 480	6	< 0.001	0.001
Hexamethylene diisocyanate	L	822-06-0	■	■	■	■	■	■	> 480	> 480	> 480	6	< 0.07	0.07
Hexamethylenediamine 1,6 (45° C)	L	124-09-4	■	■	■	■	■	■	423	> 480	> 480	6	0.003	0.0001
Hexane n-	L	110-54-3	■	■	■	■	■	■	> 480	> 480	> 480	6	< 0.05	0.05
Hexone	L	108-10-1	■	■	■	■	■	■	> 480	> 480	> 480	6	< 0.05	0.05
Hydrazine	L	302-01-2	■	■	■	■	■	■	269	283	352	5	2.3	0.001
Hydrochloric acid (32%)	L	7647-01-0	> 480	> 480	> 480	6	< 0.001	0.001	■	■	■	■	■	■
Hydrochloric acid (37%)	L	7647-01-0	60	265	> 480	6	0.46	0.001	> 480	> 480	> 480	6	< 0.1	0.1
Hydrofluoric acid (48%)	L	7664-39-3	> 480	> 480	> 480	6	< 0.05	0.05	> 480	> 480	> 480	6	< 0.1	0.1
Hydrofluoric acid (70%)	L	7664-39-3	imm	imm	15	1	15.3	0.1	imm	14	140	4	1.2	0.1
Hydrogen bromide (gas)	G	10035-10-6	■	■	■	■	■	■	> 480	> 480	> 480	6	< 0.0001	0.0001
Hydrogen chloride (gas)	G	7647-01-0	■	■	■	■	■	■	> 480	> 480	> 480	6	< 0.1	0.1
Hydrogen fluoride (gas)	G	7664-39-3	■	■	■	■	■	■	■	■	48	2	■	0.01
Hydrogen fluoride (liquid, at 18° C)	L	7664-39-3	■	■	■	■	■	■	20	28	60	2	2.2	0.01
Hydrogen peroxide (50%)	L	7722-84-1	> 480	> 480	> 480	6	< 0.01	0.01	> 480	> 480	> 480	6	< 0.01	0.01
Hydroiodic acid (55%)	L	10034-85-2	■	■	■	■	■	■	> 480	> 480	> 480	6	< 0.01	0.01
Hypophosphorus acid (50%)	L	6303-21-5	■	■	■	■	■	■	> 480	> 480	> 480	6	< 0.01	0.01
Isophthaloyldichloride (45°C)	L	99-63-8	■	■	■	■	■	■	> 480	> 480	> 480	6	< 0.0001	0.0001
Isopropanol	L	67-63-0	■	■	■	■	■	■	> 480	> 480	> 480	6	< 0.05	0.05
Isopropyl amine	L	75-31-0	■	■	■	■	■	■	> 480	> 480	> 480	6	< 0.05	0.05
Kerosene	L	8008-20-6	■	■	■	■	■	■	> 480	> 480	> 480	6	< 0.001	0.001
Limonene d-	L	5989-27-5	■	■	■	■	■	■	> 480	> 480	> 480	6	< 0.02	0.02
Lupranate® (MDI)	L	9016-87-9	■	■	■	■	■	■	> 480	> 480	> 480	6	< 0.65	0.65
Mercuric I chloride (sat'd)	L	10112-91-1	■	■	■	■	■	■	> 480	> 480	> 480	6	< 0.1	0.1
Mercuric II chloride (sat'd)	L	7487-94-7	> 480	> 480	> 480	6	< 0.01	0.01	■	■	■	■	■	■
Mercury	L	7439-97-6	■	■	■	■	■	■	> 480	> 480	> 480	6	< 0.04	0.04
Methacrylic acid	L	79-41-4	■	■	■	■	■	■	> 480	> 480	> 480	6	< 0.0001	0.0001
Methanesulfonyl chloride	L	124-63-0	■	■	■	■	■	■	> 480	> 480	> 480	6	< 0.02	0.02
Methanol	L	67-56-1	■	■	■	■	■	■	56	117	> 480	6	0.14	0.02
Methoxy ethanol 2-	L	109-86-4	■	■	■	■	■	■	168	> 480	> 480	6	0.002	0.001

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TYCHEM® C/C₂ AND TYCHEM® F/F₂ FABRICS - Permeation Data

Chemical Name	Physical State	CAS No.	Tychem® C Barrier to a range of concentrated inorganic chemicals						Tychem® F Barrier to a range of organic and highly concentrated inorganic chemicals					
			Breakthrough time			EU-Class according to EN 14325	Steady State Permeation Rate	Minimum Detection Rate	Breakthrough time			EU-Class according to EN 14325	Steady State Permeation Rate	Minimum Detection Rate
			Actual	Normalized at 0.1 µg/(cm ² -min)	Normalized at 1.0 µg/(cm ² -min)				Actual	Normalized at 0.1 µg/(cm ² -min)	Normalized at 1.0 µg/(cm ² -min)			
			minutes	minutes	minutes	µg/(cm ² -min)	µg/(cm ² -min)	minutes	minutes	minutes	µg/(cm ² -min)	µg/(cm ² -min)		
Methoxy ethylacetat 2-	L	110-49-6	■	■	■	■	■	■	> 480	> 480	> 480	6	< 0.05	0.05
Methyl acrylate	L	96-33-3	■	■	■	■	■	■	> 480	> 480	> 480	6	< 0.02	0.02
Methyl amine	G	74-89-5	■	■	■	■	■	■	> 480	> 480	> 480	6	< 0.05	0.05
Methyl chloride	G	74-87-3	■	■	■	■	■	■	68	> 480	> 480	6	0.02	0.002
Methyl chloroformate	L	79-22-1	■	■	■	■	■	■	99	204	> 480	6	0.17	0.05
Methyl ethyl ketone	L	78-93-3	■	■	■	■	■	■	imm	40	> 480	6	0.36	0.001
Methyl ethyl ketoxime	L	96-29-7	■	■	■	■	■	■	> 480	> 480	> 480	6	< 0.02	0.02
Methyl formamide N-	L	123-39-7	■	■	■	■	■	■	> 480	> 480	> 480	6	< 0.05	0.05
Methyl hydrazine	L	60-34-4	■	■	■	■	■	■	83	183	280	5	1.78	0.01
Methyl isocyanate	L	624-83-9	■	■	■	■	■	■	imm	4	> 480	6	0.42	0.001
Methyl mercaptan	G	74-93-1	■	■	■	■	■	■	> 480	> 480	> 480	6	< 0.05	0.05
Methyl methacrylate	L	80-62-6	■	■	■	■	■	■	4	8	180	4	1.4	0.001
Methyl pentanedinitrile 2-	L	4553-62-2	■	■	■	■	■	■	> 480	> 480	> 480	6	< 0.1	0.1
Methyl propanol 2-	L	75-65-0	■	■	■	■	■	■	10	37	> 480	6	0.26	0.02
Methyl pyrrolidone N-	L	872-50-4	■	■	■	■	■	■	> 480	> 480	> 480	6	< 0.01	0.01
Methyl tert-butyl ether	L	1634-04-4	■	■	■	■	■	■	> 480	> 480	> 480	6	< 0.02	0.02
Methyl trichlorosilane	L	75-79-6	■	■	■	■	■	■	> 480	> 480	> 480	6	< 0.0001	0.0001
Methyl vinyl ketone	L	78-94-4	■	■	■	■	■	■	■	■	> 480	6	< 0.05	0.05
Methylene biscyclohexylamine 4,4-	L	1761-71-3	■	■	■	■	■	■	> 480	> 480	> 480	6	< 0.01	0.01
Methylene bromide	L	74-95-3	■	■	■	■	■	■	imm	5	20	1	111	0.05
Naphthalene (sat'd in toluene)	L	91-20-3	■	■	■	■	■	■	> 480	> 480	> 480	6	< 0.001	0.001
Nicotine	L	54-11-5	■	■	■	■	■	■	> 480	> 480	> 480	6	< 0.1	0.1
Nitric acid (70%)	L	7697-37-2	220	> 480	> 480	6	0.00021	0.0001	> 480	> 480	> 480	6	< 0.0001	0.0001
Nitric acid (90%, fuming)	L	52583-42-3	■	■	■	■	■	■	15	15	15	1	> 50	0.1
Nitrobenzene	L	98-95-3	■	■	■	■	■	■	> 480	> 480	> 480	6	< 0.001	0.001
Nitrochlorobenzene o- (35-40°C)	L	88-73-3	■	■	■	■	■	■	> 480	> 480	> 480	6	< 0.1	0.1
Nitrogen dioxide	G	10102-44-0	■	■	■	■	■	■	< 15	< 15	■	■	> 0.2	0.01
Nitromethane	L	75-52-5	■	■	■	■	■	■	157	233	■	■	0.97	0.001
Nitropropane 2-	L	79-46-9	■	■	■	■	■	■	> 480	> 480	> 480	6	< 0.05	0.05
Oleum (30% free SO3)	L	8014-95-7	18	82	105	3	■	0.005	■	■	■	■	■	■

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TYCHEM® C/C₂ AND TYCHEM® F/F₂ FABRICS - Permeation Data

Chemical Name	Physical State	CAS No.	Tychem® C Barrier to a range of concentrated inorganic chemicals						Tychem® F Barrier to a range of organic and highly concentrated inorganic chemicals					
			Breakthrough time			EU-Class according to EN 14325	Steady State Permeation Rate	Minimum Detection Rate	Breakthrough time			EU-Class according to EN 14325	Steady State Permeation Rate	Minimum Detection Rate
			Actual	Normalized at 0.1 µg/(cm ² -min)	Normalized at 1.0 µg/(cm ² -min)				Actual	Normalized at 0.1 µg/(cm ² -min)	Normalized at 1.0 µg/(cm ² -min)			
			minutes	minutes	minutes	µg/(cm ² -min)	µg/(cm ² -min)	minutes	minutes	minutes	µg/(cm ² -min)	µg/(cm ² -min)		
Oleum (40% free SO ₃)	L	8014-95-7	■	■	■	■	■	■	130	455	> 480	6	0.32	0.0001
PCB in transformer oil	L	na	■	■	■	■	■	■	324	> 480	> 480	6	0.032	0.01
Pentanol 1-	L	71-41-0	■	■	■	■	■	■	> 480	> 480	> 480	6	< 0.1	0.1
Pentene nitrile 2-	L	13284-42-9	■	■	■	■	■	■	> 480	> 480	> 480	6	< 0.02	0.02
Perchloric acid (70%)	L	7601-90-3	> 480	> 480	> 480	6	< 0.0001	0.0001	■	■	■	■	■	■
Phenol (85%)	L	108-95-2	■	■	■	■	■	■	182	238	276	5	4	0.001
Phosgene	G	75-44-5	■	■	■	■	■	■	> 480	> 480	> 480	6	< 0.02	0.02
Phosphine	G	7803-51-2	■	■	■	■	■	■	imm	imm	■	■	> 0.11	0.003
Phosphoric acid (85%)	L	7664-38-2	> 480	> 480	> 480	6	< 0.01	0.01	> 480	> 480	> 480	6	■	0.1
Phosphorus oxychloride	L	10025-87-3	■	■	■	■	■	■	■	> 480	> 480	6	< 0.01	0.01
Phosphorus trichloride	L	7719-12-2	■	■	■	■	■	■	200	> 480	> 480	6	0.0055	0.001
Picoline 2-	L	109-06-8	■	■	■	■	■	■	> 480	> 480	> 480	6	< 0.05	0.05
Picoline 3-	L	108-99-6	■	■	■	■	■	■	> 480	> 480	> 480	6	< 0.05	0.05
Potassium chromate (sat'd)	L	7789-00-6	> 480	> 480	> 480	6	< 0.01	0.01	> 480	> 480	> 480	6	< 0.1	0.1
Propylamine n-	L	107-10-8	■	■	■	■	■	■	7	16	> 480	6	0.52	0.05
Propylene oxide 1,2-	L	75-56-9	■	■	■	■	■	■	4	12	■	6	0.96	0.001
Pyridine, 2-fluoro-6-(trifluoromethyl)	L	94239-04-0	■	■	■	■	■	■	> 480	> 480	> 480	6	< 0.02	0.02
Pyridine	L	110-86-1	■	■	■	■	■	■	> 480	> 480	> 480	6	< 0.05	0.05
Pyrrolidine	L	123-75-1	■	■	■	■	■	■	40	45	145	4	4.7	0.05
Silane	G	7803-62-5	■	■	■	■	■	■	> 480	> 480	> 480	6	< 0.1	0.1
Silicon tetrachloride	L	10026-04-7	■	■	■	■	■	■	> 480	> 480	> 480	6	< 0.0001	0.0001
Sodium acetate (sat'd)	L	127-09-3	■	■	■	■	■	■	■	■	■	■	■	■
Sodium cyanide (45%)	L	143-33-9	■	■	■	■	■	■	> 480	> 480	> 480	6	< 0.1	0.1
Sodium hydroxide (42%)	L	1310-73-2	> 480	> 480	> 480	6	< 0.01	0.01	■	■	■	■	■	■
Sodium hydroxide (50%)	L	1310-73-2	> 480	> 480	> 480	6	< 0.005	0.005	> 480	> 480	> 480	6	< 0.1	0.1
Sodium hydroxide (solid)	S	1310-73-2	■	■	■	■	■	■	■	■	■	■	■	■
Sodium hypochlorite (13% active Chlorine)	L	7681-52-9	> 480	> 480	> 480	6	< 0.01	0.01	■	■	■	■	■	■
Sodium hypochlorite (30%)	L	7681-52-9	■	■	■	■	■	■	> 480	> 480	> 480	6	< 0.1	0.1
Styrene	L	100-42-5	■	■	■	■	■	■	140	> 480	> 480	6	0.055	0.001
Sulphur dioxide	G	7446-09-5	■	■	■	■	■	■	24	24	24	1	2.6	0.34

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TYCHEM® C/C₂ AND TYCHEM® F/F₂ FABRICS - Permeation Data

Chemical Name	Physical State	CAS No.	Tychem® C Barrier to a range of concentrated inorganic chemicals						Tychem® F Barrier to a range of organic and highly concentrated inorganic chemicals					
			Breakthrough time			EU-Class according to EN 14325	Steady State Permeation Rate	Minimum Detection Rate	Breakthrough time			EU-Class according to EN 14325	Steady State Permeation Rate	Minimum Detection Rate
			Actual	Normalized at 0.1 µg/(cm ² -min)	Normalized at 1.0 µg/(cm ² -min)				Actual	Normalized at 0.1 µg/(cm ² -min)	Normalized at 1.0 µg/(cm ² -min)			
			minutes	minutes	minutes	µg/(cm ² -min)	µg/(cm ² -min)	minutes	minutes	minutes	µg/(cm ² -min)	µg/(cm ² -min)		
Sulphuric acid (50%)	L	7664-93-9	> 480	> 480	> 480	6	< 0.01	0.01	■	■	■	■	■	■
Sulphuric acid (98%)	L	7664-93-9	> 480	> 480	> 480	6	< 0.005	0.005	■	■	> 480	6	■	0.01
Sulphuryl chloride	L	7791-25-5	■	■	■	■	■	■	> 480	> 480	> 480	6	< 0.01	0.01
Tetrachloro-bisphenol-A 2,2',6,6'-	S	79-95-8	■	■	■	■	■	■	> 480	> 480	> 480	6	< 0.1	0.1
Tetrachloroethylene 1,1,2,2-	L	127-18-4	■	■	■	■	■	■	13	> 480	> 480	6	0.022	0.001
Tetrahydrofuran	L	109-99-9	■	■	■	■	■	■	40	444	> 480	6	0.14	0.001
Thioglycolic acid	L	68-11-1	■	■	■	■	■	■	> 480	> 480	> 480	6	< 0.0001	0.0001
Thionyl chloride	L	7719-09-7	■	■	■	■	■	■	imm	imm	15	1	101	0.01
Tin chloride, mono-n-butyl	L	1118-46-3	■	■	■	■	■	■	> 480	> 480	> 480	6	< 0.0001	0.0001
Tin chloride, tri-n-butyl	L	1461-22-9	■	■	■	■	■	■	■	■	> 480	6	■	0.2
Titanium tetrachloride	L	7550-45-0	■	■	■	■	■	■	> 480	> 480	> 480	6	< 0.0001	0.0001
Toluene	L	108-88-3	■	■	■	■	■	■	> 480	> 480	> 480	6	< 0.05	0.05
Toluene-2,4-diisocyanate (80%)	L	584-84-9	■	■	■	■	■	■	> 480	> 480	> 480	6	< 0.001	0.001
Toluidine o-	L	95-53-4	■	■	■	■	■	■	> 480	> 480	> 480	6	< 0.001	0.001
Trichloroacetic acid	L	76-03-9	■	■	■	■	■	■	> 480	> 480	> 480	6	< 0.1	0.1
Trichloroacetone 1,1,3-	L	921-03-9	■	■	■	■	■	■	■	■	> 480	6	■	0.05
Trichlorobenzene 1,2,4-	L	120-82-1	■	■	■	■	■	■	> 480	> 480	> 480	6	< 0.001	0.001
Trichloroethane 1,1,2-	L	79-00-5	■	■	■	■	■	■	120	164	202	4	9.1	0.01
Trichloroethanol 2,2,2-	L	115-20-8	■	■	■	■	■	■	> 480	> 480	> 480	6	< 0.02	0.02
Trichloroethylene	L	79-01-6	■	■	■	■	■	■	> 480	> 480	> 480	6	< 0.01	0.01
Trichlorophenylsilane	L	98-13-5	■	■	■	■	■	■	> 480	> 480	> 480	6	< 0.0001	0.0001
Trifluoroacetic acid	L	76-05-1	■	■	■	■	■	■	> 480	> 480	> 480	6	< 0.01	0.01
Trifluoromethanesulfonic acid	L	1493-13-6	■	■	■	■	■	■	> 480	> 480	> 480	6	< 0.01	0.01
Trimethyl quinone (at 30°C)	L	935-92-2	■	■	■	■	■	■	■	■	> 480	6	■	0.05
Vinyl acetate	L	108-05-4	■	■	■	■	■	■	4	8	■	■	0.81	0.001
Vinyl chloride	G	75-01-4	■	■	■	■	■	■	imm	> 480	> 480	6	0.02	0.001
Vinylidene chloride	L	75-35-4	■	■	■	■	■	■	> 480	> 480	> 480	6	< 0.02	0.02
Xylene (mixed isomers)	L	1330-20-7	■	■	■	■	■	■	8	40	> 480	6	0.16	0.001

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Permeation data for Tyvek®

Please find below a selection of permeation data for Tyvek® White 1422A / 1431N.

Tyvek®, extremely tough, tear and abrasion resistant, offers strong barrier against particles and resists low-pressurized water-based liquid chemical splashes.

Tyvek® Classic Xpert is the chosen category III protection against solid particles larger than 1 µm (Type 5), and mist, i.e. low-level liquid aerosols from water-based chemical spray (Type 6).

Tyvek® Classic Plus is a chemical protective clothing category III type 4B, 5 and 6, providing high barrier against many inorganic chemicals in low concentrations and particles larger than 1 micron. With its overtaped seams, this suit is ideal for toxic dry particulate environments or to prevent liquid penetration through seams.

Permeation vs. penetration and repellency

Permeation is not the same as penetration.

Liquid chemical penetration is a physical process whereby a liquid penetrates a fabric by passing through pores or holes in the fabric.

The European standard EN ISO 6530 (referred to as the "gutter test") measures liquid penetration through a fabric and liquid repellency by a fabric. Penetration & repellency tests, such as the gutter test, are typically "short duration tests" of 1 minute.

Fabrics may show high repellency and penetration indices to certain chemicals, but when exposed for several minutes will allow the chemical to permeate.

TYVEK® FABRIC - Permeation Data

Chemical Name	Physical State	CAS No.	Tyvek®					
			Breakthrough time			Classification according to EN 14325	Steady State Permeation Rate µg/(cm ² -min)	Minimum Detection Rate µg/(cm ² -min)
			Actual minutes	Normalized at 0.1 µg/(cm ² -min) minutes	Normalized at 1.0 µg/(cm ² -min) minutes			
Glycerol	L	56-81-5	450	> 480	> 480	6	0.03	0.01
Hydrochloric acid (16%)	L	7647-01-0	30	60	65	3	11.1	0.005
Hydrochloric acid (30%)	L	7647-01-0	imm	imm	imm	■	10.1	0.01
Hydrogen peroxide (10%)	L	7722-84-1	> 480	> 480	> 480	6	<0.01	0.01
Hydrogen peroxide (30%)	L	7722-84-1	imm	15	■	■	> 0.11	0.04
Mercuric II chloride (sat'd)	L	7487-94-7	> 480	> 480	> 480	6	<0.01	0.01
Nitric acid (10%)	L	7697-37-2	> 480	> 480	> 480	6	<0.005	0.005
Nitric acid (30%)	L	7697-37-2	45	60	60	2	4.6	0.001
Phosphoric acid (50%)	L	7664-38-2	> 480	> 480	> 480	6	<0.005	0.005
Potassium chromate (sat'd)	L	7789-00-6	> 480	> 480	> 480	6	<0.005	0.005
Potassium hydroxide (40%)	L	1310-58-3	60	60	> 480	6	0.7	0.001
Sodium acetate (sat'd)	L	127-09-3	> 480	> 480	> 480	6	<0.005	0.005
Sodium hydroxide (40%)	L	1310-73-2	> 480	> 480	> 480	6	<0.005	0.005
Sodium hydroxide (50%)	L	1310-73-2	10	220	> 480	6	0.85	0.01
Sodium hydroxide (solid)	S	1310-73-2	> 480	> 480	> 480	6	<0.01	0.01
Sodium hypochlorite (13% active Chlorine)	L	7681-52-9	> 480	> 480	> 480	6	<0.005	0.005
Sodium hypochlorite (sat'd)	L	7681-52-9	> 480	> 480	> 480	6	<0.01	0.01
Sulphuric acid (18%)	L	7664-93-9	480	480	> 480	6	0.2	0.005
Sulphuric acid (30%)	L	7664-93-9	135	160	168	4	9.7	0.005
Sulphuric acid (50%)	L	7664-93-9	10	50	75	3	38	0.01

KEY: ■ = Not tested • S = solid • G = gaseous • L = liquid • imm = Immediate • sat'd = saturated

**For more information on our support services,
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Disclaimer

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