THE CHEMICAL RESISTANCE

OF

POLYETHYLENE AND POLYPROPYLENE POLYOLEFINS

TTN:PT2.0
4/18/86

SUMMARY

Based on research performed by our polypropylene suppliers (Himont, Shell, Soltex), the chemical resistivity of polypropylene is outstanding. At room temperature it is essentially insoluble in common solvents. When it is removed from the solvent, its swelling is reversible. It resists acids, alkalies, moisture, and salt solutions. It is attacked by strong oxidizing agents such as concentrated nitric acid, hydrogen peroxide, and wet chlorine, especially at temperatures approaching 60°C. Except in oxidizing environments, polypropylene is immune to stress cracking, as determined by accepted testing procedures.

Based on research performed by our suppliers of high density polyethylene (Soltex and British Petroleum), due to its molecular structure, HDPE is resistant to attack by all chemicals which may be reasonably considered to be present in soil. Soltex studies find no known solvent for their high molecular weight, high density polyethylene below 60°C (140°F). The higher the molecular weight, the more HDPE is resistant to chemical attack. The Tensar Corporation employs high molecular weight fractional melt polyethylenes in the manufacture of geogrids and geonets.

Attached to this Tensar Technical Note is support documentation on the resistance to chemical attack of TENSAR® Geogrids. Specifically, *The Tensar Corporation* uses Himont, Shell, and Soltex polypropylenes for all biaxial products and Soltex XF 409 and BP HDPE for the uniaxial soil reinforcement products. Enclosed are Himont and Soltex Polypropylene and Soltex XF409 and BP High Density Polyethylene chemical resistance data. Also included in this technical note are two exerpts from research done by Dr. J. P. Giroud on the chemical resistivity of TENSAR Geogrid and Geonets and from research done by G. H. Burke of BP Chemicals on aging of HDPE in buried situations.

Requests for information on specific chemicals or their concentrations not included in the enclosed data tables can be requested from The Tensar Corporation, Director of Production Technology.

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HIMONT

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Product Data

NUMBER 511
(Supersedes PPD-32F)

PRO-FAX[1] Polypropylene
Chemical Resistance

PRO-FAX polypropylene, like most of the polyolefins, is highly resistant to solvents and chemicals.

The results of extensive laboratory and actual field installation tests of polypropylene's chemical resistance are reported in this data sheet, which is updated at intervals.

The corrosion resistance data presented here are based on unstressed specimens of Pro-fax, 3 in. long by 0.025 in. thick, in the shape of dumbbells. Results are reported after 1-month immersion. As it is difficult to create actual service conditions in the laboratory, the results of many of the environments should be taken only as an indication of behavior in service.

Pro-fax polypropylene has outstanding resistance to water and other inorganic environments. In most aqueous environments, its weight increase is less than 0.2% when it has been stored for 6 months at ambient temperatures. When the temperature is increased to 60°C (140°F), the weight increase is less than 0.5% for a similar period. According to ASTM D 570-63T, its 24-hr water absorption rate is 0.03%. It resists most strong mineral acids and bases, but, like the other polyolefins, it is subject to attack by oxidizing agents.

Pro-fax polypropylene is appreciably affected by chlorosulfonic acid and oleum at room temperature, 98% sulfuric acid, 30% hydrochloric acid, and 30% hydrogen peroxide at 100°C (212°F). It is also affected by 98% sulfuric acid at 60°C (140°F) and fuming nitric acid and liquid bromine at room temperatures. Under strain, failure could occur with strong oxidizing acids at temperatures lower than those mentioned. With few exceptions, however, inorganic chemicals produce little or no effect on Pro-fax over a period of 6 months at temperatures up to 120°C (248°F).

The permeation resistance of Pro-fax polypropylene to organic chemicals depends on the rate and extent to which absorption occurs. This, in turn, will govern the suitability of the resin to serve in a particular environment. When the plastic is removed from the environment, evaporation will take place and cause it to return almost to its original dimensions. Property changes resulting from the absorption will be reversed if evaporation is complete.

Temperature and polarity of the organic medium are the foremost factors determining the extent of absorption by polypropylene. Absorption becomes greater as temperatures are increased and polarity of the medium is decreased. Copolymers swell more than homopolymers, indicating greater absorption. Such non-polar liquids as benzene, carbon tetrachloride, and petroleum ether have a higher absorption rate by polypropylene than polar media such as ethanol and acetone. Some reduction in tensile strength and an increase in flexibility and elongation to break in tension can be expected, depending on the nature and amount of the organic medium absorbed.

Pro-fax polypropylene has excellent resistance to environmental stress-cracking. When it is tested according to ASTM D 1693-60T, the brittle fractures that occur with certain polyethylenes in contact with polar organic liquids, detergents, and silicone fluids are not observed. Failure of this type with polypropylene is rare. Those environments known to cause such cracking to polypropylene are 98% sulfuric acid, concentrated chromic/sulfuric acid mixtures, and concentrated hydrochloric acid/chlorine mixtures.

The useful life of Pro-fax polypropylene at elevated temperatures is limited by oxidative degradation. The expected life of polypropylene at any given temperature is also determined by the nature of the environment, and by the extraction of some of the antioxidant system. Any environment that tends to extract the antioxidants may lead to more rapid breakdown of the polypropylene, especially at elevated temperatures.

[1] Registered trademark of HIMONT Incorporated.

RATING SYSTEM

This chart rates the chemical resistance of Pro-fax polypropylene according to the following code:

A = **NEGLIGIBLE EFFECT** — Should be suitable for all applications where these environmental conditions exist.

B = **LIMITED ABSORPTION OR ATTACK** — Should be suitable for most applications, but the user is advised to make his own tests to determine the suitability of polypropylene in the particular environment.

C = **EXTENSIVE ABSORPTION AND/OR RAPID PERMEATION** — Should be suitable for applications where only intermittent service is involved, or where the swelling produced has no detrimental effect on the part. The user should make his own tests to determine the suitability of polypropylene in the particular environment.

D = **EXTENSIVE ATTACK** — The specimen dissolves or disintegrates. Polypropylene is not recommended.

Environment	Conc., %	Temperature, °C 20	60	100
Acetic acid (glacial)	97	A	B (80°C)	—
Acetic acid	50	A	A (80°C)	—
Acetic acid	40	A	—	—
Acetic acid	10	A	A	—
Acetone	100	A	A	—
Acetophenone	100	B	B	—
Acriflavine (2% solution in H_2O)	2	A	A (80°C)	—
Acrylic emulsions		A	A	—
Aluminum chloride		A	A	—
Aluminum fluoride		A	A	—
Aluminum sulfate		A	A	—
Alums (all types)		A	A	—
Ammonia (aqueous)	30	A	—	—
Ammonia gas (dry)		A	A	—
Ammonium carbonate	Satd.	A	A	—
Ammonium chloride	Satd.	A	A	—
Ammonium fluoride	20	A	A	—
Ammonium hydroxide	10	A	A	—
Ammonium metaphosphate	Satd.	A	A	—
Ammonium nitrate	Satd.	A	A	—
Ammonium persulfate	Satd.	A	A	—
Ammonium sulfate	Satd.	A	A	—
Ammonium sulfide	Satd.	A	A	—
Ammonium thiocyanate	Satd.	A	A	—
Amyl acetate	100	B	C	—
Amyl alcohol	100	A	B	—
Amyl chloride	100	C	C	—
Aniline	100	A	A	—
Anisole	100	B	B	—
Antimony chloride		A	A	—
Aqua regia	(a)	B	B	—
Aviation fuel (115/145 octane)	100	B	C	—
Aviation turbine fuel	100	B	C	—
Barium carbonate	Satd.	A	A	—
Barium chloride	Satd.	A	A	—
Barium hydroxide		A	A	—
Barium sulfate	Satd.	A	A	—
Barium sulfide	Satd.	A	A	—
Beer		A	A	—
Benzene	100	B	C	C
Benzoic acid		A	A	—
Benzyl alcohol		A	A (80°C)	—
Bismuth carbonate	Satd.	A	A	—
Borax		A	A	—
Boric acid		A	A	—
Brine	Satd.	A	A	—
Bromine liquid	100	D	—	—
Bromine water	(a)	C	—	—
Butyl acetate	100	—	C	C
Butyl alcohol	A	—	—	100

Environment	Conc., %	Temperature, °C 20	60	100
Calcium carbonate	Satd.	A	A	—
Calcium chlorate	Satd.	A	A	—
Calcium chloride	50	A	A	—
Calcium hydroxide		A	A	—
Calcium hypochlorite bleach	20	A	B	—
Calcium nitrate		A	A	—
Calcium phosphate	50	A	—	—
Calcium sulfate		A	A	—
Calcium sulfite		A	A	—
Carbon dioxide (dry)		A	A	—
Carbon dioxide (wet)		A	A	—
Carbon disulfide	100	B	C	—
Carbon monoxide		A	A	—
Carbon tetrachloride	100	C	C	C
Carbonic acid		A	A	—
Castor oil		A	—	—
Cetyl alcohol	100	A	—	—
Chlorine (gas)	100	D	D	—
Chlorobenzene	100	C	C	—
Chloroform	100	C	D	D
Chlorosulfonic acid	100	D	D	D
Chrome alum		A	A	—
Chromic acid	80(a)	A	—	—
Chromic acid	50(a)	A	A	—
Chromic acid	10(a)	A	A	—
Chromic/sulfuric acid		D	D	—
Cider		A	A	—
Citric acid	10	A	A	—
Copper chloride	Satd.	A	A	—
Copper cyanide	Satd.	A	A	—
Copper fluoride	Satd.	A	A	—
Copper nitrate	Satd.	A	A	—
Copper sulfate	Satd.	A	A	—
Cottonseed oil		A	A	—
Cuprous chloride	Satd.	A	A	—
Cyclohexanol	100	A	B	—
Cyclohexanone	100	B	C	—
Decalin	100	C	C	C
Detergents	2	A	A	A
Developers (photographic)		A	A	—
Dibutyl phthalate	100	A	B	D
Dichloroethylene	100	A	—	—
Diethanolamine	100	A	A	—
Diisooctyl phthalate	100	A	A	—
Emulsifiers		A	A	—
Ethanolamine	100	A	A	—
Ethyl acetate	100	B	B	—
Ethyl alcohol	96	A	A	A (80°C)
Ethyl chloride	100	C	C	—
Ethylene dichloride	100	B	—	—
Ethylene glycol		A	A	—
Ethylene oxide	100	B (10°C)	—	—
Ethyl ether	100	B	—	—

Environment	Conc., %	Temperature, °C		
		20	60	100
Fatty acids (C_6)	100	A	A	—
Ferric chloride	Satd.	A	A	—
Ferric nitrate	Satd.	A	A	—
Ferric sulfate	Satd.	A	A	—
Ferrous chloride	Satd.	A	A	—
Ferrous sulfate	Satd.	A	A	—
Fluosilicic acid		A	A	—
Formaldehyde	40	A	A	—
Formic acid	100	A	—	—
Formic acid	10	A	A	—
Fructose		A	A	—
Fruit juices		A	A	—
Furfural	100	C	C	—
Gas liquor		C	—	—
Gasoline	100	B	C	C
Gearbox oil	100	A	B	—
Gelatin		A	A	—
Glucose	20	A	A	—
Glycerin	100	A	A	A
Glycol		A	A	—
Hexane	100	A	B	—
Hydrobromic acid	50(a)	A	A	—
Hydrochloric acid	30(a)	A	B	D
Hydrochloric acid	20	A	A (80°C)	—
Hydrochloric acid	10	A	A (80°C)	B
Hydrochloric acid	2	A	A	A
50-50 HCl-HNO_3	(a)	B	D (80°C)	—
Hydrofluoric acid	40	A	—	—
Hydrofluoric acid	60(a)	A	A (40°C)	—
Hydrogen chloride gas (dry)	100	A	A	—
Hydrogen peroxide	30	A	—	D
Hydrogen peroxide	10	A	B	—
Hydrogen peroxide	3	A	—	—
Hydrogen sulfide		A	A	—
Hydroquinone		A	A	—
Inks		A	A	—
Iodine tincture		A	—	—
Isooctane	100	C	C	—
Isopropyl alcohol	100	A	A	—
Ketones		A	—	—
Lactic acid	20	A	A	—
Lanolin	100	A	A	—
Lead acetate	Satd.	A	A	—
Linseed oil	100	A	A	—
Lubricating oil	100	A	B	—
Magenta dye (aqueous solution)	2	A	A Some staining	—
Magnesium carbonate	Satd.	A	A	—
Magnesium chloride	Satd.	A	A	—
Magnesium hydroxide	Satd.	A	A	—
Magnesium nitrate	Satd.	A	A	—
Magnesium sulfate	Satd.	A	A	—
Magnesium sulfite	Satd.	A	A	—
Meat juices		A	A	—
Mercuric chloride	40	A	A	—
Mercuric cyanide	Satd.	A	A	—
Mercurous nitrate	Satd.	A	A	—
Mercury	100	A	A	—
Methyl alcohol	100	A	A	—
Methylene chloride	100	A	—	—
Methyl ethyl ketone	100	A	B	—
Milk and its products		A	A	A
Mineral oil	100	A	B	—
Molasses		A	A	—
Motor oil	100	A	B	—
Naphthalene	100	A	A	A
Nickel chloride	Satd.	A	A	—
Nickel nitrate	Satd.	A	A	—
Nickel sulfate	Satd.	A	A	—
Nitric acid	fuming	D	D	D
Nitric acid	70(a)	C	D	—
Nitric acid	60	A	D (80°C)	—
Nitric acid	10	A	A	A
50-50 HNO_3-HCl	(a)	A	D (80°C)	—
50-50 HNO_3-H_2SO_4	(a)	C	D (80°C)	—
Nitrobenzene	100	A	A	—
Oleic acid		A	B	—
Oleum		—	—	D
Olive oil	100	A	A	—
Oxalic acid (aqueous)	50	A	B	—
Paraffin	100	A	B	—
Paraffin wax	100	A	A	—
Petrol	100	B	C	—
Petroleum ether (boiling point 100-140°C)	100	C	C	—
Phenol	100	A	A	—
Phosphoric acid	95	A	A	—
Plating solutions, brass		A	A	—
Plating solutions, cadmium		A	A	—
Plating solutions, chromium		A	A	—
Plating solutions, copper		A	A	—
Plating solutions, gold		A	A	—
Plating solutions, indium		A	A	—
Plating solutions, lead		A	A	—
Plating solutions, nickel		A	A	—
Plating solutions, rhodium		A	A	—
Plating solutions, silver		A	A	—
Plating solutions, tin		A	A	—
Plating solutions, zinc		A	A	—
Potassium bicarbonate	Satd.	A	A	—
Potassium borate	1	A	A	—
Potassium bromate	10	A	A	—
Potassium bromide	Satd.	A	A	—
Potassium carbonate	Satd.	A	A	—
Potassium chlorate	Satd.	A	A	—
Potassium chloride	Satd.	A	A	—
Potassium chromate	40	A	A	—
Potassium cyanide	Satd.	A	A	—
Potassium dichromate	40	A	A	—
Potassium ferri-/ferrocyanide		A	A	—
Potassium fluoride		A	A	—
Potassium hydroxide	50	A	A	—
Potassium hydroxide	10	A	A	A
Potassium nitrate	Satd.	A	A	—
Potassium perborate	Satd.	A	A	—
Potassium perchlorate	10	A	A	—
Potassium permanganate	20	A	A	—
Potassium sulfate		A	A	—
Potassium sulfide		A	A	—
Potassium sulfite		A	A	—
Propyl alcohol	100	A	A	—
Pyridine	100	A	—	—
Silicone oil	100	A	A	—
Soap solution (concentrated)		A	A	—

Environment	Conc., %	Temperature, °C		
		20	60	100
Sodium acetate		A	A	—
Sodium bicarbonate	Satd.	A	A	—
Sodium bisulfate	Satd.	A	A	—
Sodium bisulfite	Satd.	A	A	—
Sodium borate		A	A	—
Sodium bromide oil solution		A	A	—
Sodium carbonate	Satd.	A	A	—
Sodium chlorate	Satd.	A	A	—
Sodium chloride	Satd.	A	A	A
Sodium chlorite	2	A	A (80°C)	—
Sodium chlorite	5	A	A (80°C)	—
Sodium chlorite	10	A	A (80°C)	—
Sodium chlorite	20	A	A (80°C)	—
Sodium cyanide	Satd.	A	A	—
Sodium dichromate	Satd.	A	A	—
Sodium ferricyanide	Satd.	A	A	—
Sodium ferrocyanide	Satd.	A	A	—
Sodium fluoride	Satd.	A	A	—
Sodium hydroxide	50	A	A	—
Sodium hydroxide	10	A	A	A
Sodium hypochlorite	20	A	B	B
Sodium nitrate		A	A	—
Sodium nitrite		A	A	—
Sodium silicate		A	A	—
Sodium sulfate	Satd.	A	A	—
Sodium sulfide	25	A	A	—
Sodium sulfite	Satd.	A	A	—
Stannic chloride	Satd.	A	A	—
Stannous chloride	Satd.	A	A	—
Starch		A	A	—
Sugars and syrups		A	A	—
Sulfamic acid		A	A (80°C)	—
Sulfates of { calcium and magnesium	Satd.	A	A	—
Sulfites of { potassium and sodium		A	A	—
Sulfur		A	A	—
Sulfuric acid	98[a]	C	—	D

[a] May produce cracking in material under stress.
[b] Registered trademark of Chesebrough-Ponds, Inc.

Environment	Conc., %	Temperature, °C		
		20	60	100
Sulfuric acid	60	A	B (80°C)	—
Sulfuric acid	50	A	B	—
Sulfuric acid	10	A	A	A
50:50 H_2SO_4/HNO_3	(a)	C	D (80°C)	—
Tallow		A	A	—
Tannic acid	10	A	A	—
Tartaric acid		A	A	—
Tetrahydrofuran	100	C	C	C
Tetralin	100	C	C	C
Toluene	100	C	C	—
Transformer oil	100	A	C	—
Trichloroacetic acid	10	A	A	—
Trichloroethylene	100	C	C	C
Triethanolamine	100	A	A (80°C)	—
Turpentine	100	C	C	C
Urea		A	A	—
Urine		A	A	—
Vaseline[b]		A	A	—
Vinegar		A	A	—
Water (distilled, soft, hard, and vapor)		A	A	A
Wet chlorine gas		—	D (70°C)	—
Whisky		A	A	A
White paraffin	100	A	B (80°C)	—
White spirit	100	B	C	—
Wines		A	A	—
Xylene	100	C	C	C
Yeast		A	A	—
Zinc chloride	Satd.	A	A	—
Zinc oxide		A	A	—
Zinc sulfate	Satd.	A	A	—

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10-84

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Table 4

CHEMICAL RESISTANCE OF FORTILENE POLYPROPYLENE

Legend: S = Satisfactory, O = Some Attack, U= Unsatisfactory

Reagent	70°F (21°C)	140°F (60°C)	212°F (100°C)
Acetic Acid (10%)	S	S	
Acetic Acid (50%)	S	S	O
Acetic Acid (100%)	S	S	
Acetic Anhydride	S	S	
Acetone	S	S	
Acetonitrile	S		
Acetophenone	O	O	U
Aluminum Ammonium Sulfate	S	S	
Aluminum Chloride	S	S	O
Aluminum Fluoride	S	S	
Aluminum Hydroxide	S	S	
Aluminum Nitrate	S	S	S
Aluminum Potassium Sulfate	S	S	
Alums (all types)	S	S	
Ammonia (anhydrous)	S	S	
Ammonia (30% aqueous)	S	S	
Ammonium Bifluoride	S	S	
Ammonium Carbonate	S	S	S
Ammonium Chloride	S	S	O
Ammonium Fluoride (25%)	S	S	
Ammonium Hydroxide	S	S	
Ammonium Nitrate	S	S	S
Ammonium Sulfate	S	S	S
Ammonium Sulfide	S	S	
Ammonium Thiocyanate	S	S	
Amyl Acetate	O	U	
Amyl Alcohol	S	O	U
Amyl Chloride	U	U	
Aniline	S	S	O
Anisole	O	O	U
Antimony Trichloride	S	S	
Aqua Regia	O	O	
Arsenic Acid	S	S	
Aviation Fuel	O	O	
Barium Carbonate	S	S	
Barium Chloride	S	S	O
Barium Hydroxide	S	S	
Barium Soap Grease	S	O	
Barium Sulfate	S	S	
Barium Sulfide	S	S	S
Beer	S	S	
Benzaldehyde	S	S	
Benzyl Alcohol	S	S	
Benzyl Chloride	S	S	
Bismuth Carbonate	S	S	
Borax	S	S	S
Boric Acid	S	S	
Brake Fluid	S	O	
Brine	S	S	S
Bromic Acid	U	U	
Bromine	U	U	
Bromine Water	U	U	
Butyl Acetate	U	U	
Butyl Acrylate	U	U	
Butyl Alcohol	S	S	
Calcium Bisulfate	S	S	
Calcium Carbonate	S	S	S

Reagent	70°F (21°C)	140°F (60°C)	212°F (100°C)
Calcium Chlorate	S	S	
Calcium Chloride	S	S	O
Calcium Hydroxide	S	S	S
Calcium Hypochlorite	S	S	
Calcium Nitrate	S	S	
Calcium Soap Grease	S	O	
Calcium Sulfate	S	S	
Calgonite (1%)	S	S	
Carbon Dioxide (dry)	S	S	
Carbon Dioxide (wet)	S	S	
Carbon Disulfide	O	U	
Carbon Monoxide	S	S	
Carbon Tetrachloride	U	U	
Carbonic Acid	S	S	
Castor Oil	S	S	
Cellusolve	S	S	
Cetyl Alcohol	S		
Chlorine (dry)	U	U	
Chlorine (wet)	O	U	
Chloroacetic Acid	S		
Chlorobenzene	U	U	
Chloroform	O	U	
Chlorosulfonic Acid	U	U	
Chromic Acid (10%)	S	S	
Chromic Acid (50%)	S	S	
Chromic Acid (80%)	S		
Cider	S	S	
Citric Acid	S	S	
Clorox	S	S	S
Copper Chloride	S	S	
Copper Cyanide	S	S	
Copper Fluoride	S	S	
Copper Nitrate	S	S	
Copper Sulfate	S	S	
Corn Oil	S	S	
Cottonseed Oil	S	S	
Cresol	S	S	
Cuprous Chloride	S	S	
Cyclohexane	S	O	
Cyclohexanol	S	O	
Cyclohexanone	O	U	
Decalin	U	U	
Developers (photographic)	S	S	
Dextrin	S	S	
Dibutyl Phthalate	S	S	U
Dichloroethylene	S		
Diethanolamine	S	S	
Diethyl Ether	O	O	
Diglycolic Acid	S	S	
Diisooctyl Phthalate	S	S	
Dimethyl Phthalate	S	S	
p-Dioxane	S	O	
Ethyl Acetate	S	S	
Ethyl Alcohol	S	S	S
Ethylamine	S	S	
Ethylene Chloride	U	U	
Ethylene Chlorohydrin	S	S	

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Legend: S=Satisfactory. O=Some Attack. U=Unsatisfactory

Reagent	70°F (21°C)	140°F (60°C)	212°F (100°C)
Ethylene Glycol	S	S	
Ethanolamine	S	S	
Ethyl Ether	O	O	
Ethyl Chloride	O	O	
Ethylene Dichloride	S		
Ethylene Oxide	S		
Ferric Chloride	S	S	
Ferric Nitrate	S	S	
Ferric Sulfate	S	S	
Ferrous Chloride	S	S	
Ferrous Nitrate	S	S	O
Ferrous Sulfate	S	S	
Fluorine	U	U	
Fluorosilicic	S	S	
Formaldehyde	S	S	O
Formic Acid (10%)	S	S	
Formic Acid (100%)	S		
Fructose	S	S	
Fruit Juice	S	S	
Fuel Oil	S	O	
Furfural	U	U	
Gasoline	O	[illegible]	
Gelatin	S	S	
Glucose	S	S	
Glycerol	S	S	S
Glycol	S	S	O
Glycolic Acid	S	S	
Heptane	U	U	
Hexadecyl Alcohol	S	S	
Hexane	S	S	
Hydroiodic Acid	U	U	
Hydrobromic Acid(50%)	S	S	
Hydrochloric Acid(20%)	S	S	O
Hydrochloric Acid(100%)	S	S	
Hydrofluoric Acid(35%)	S	S	
Hydrogen Peroxide(30%)	S	O	
Hydrogen Peroxide(90%)	O	O	
Hydrogen Chloride Gas(dry)	S	S	
Hydrogen Sulfide	S	S	
Hydroquinone	S	S	
Igepal	S	S	
Iodine(dry)	S	S	
Iodine(wet)	U		
Isopropyl Alcohol	S	S	
Isooctane	U		
Jet Fuel(JP 4 & 5)	O	U	
Lactic Acid	S	S	
Lanolin	S	S	
Lauric Acid	S	S	
Lead Acetate	S	S	S
Lemon Oil	O		
Linseed Oil	S	S	
Lubricating Oil	S	O	

Reagent	70°F (21°C)	140°F (60°C)	212°F (100°C)
Magnesium Sulfite	S	S	
Malic Acid	S	O	
Mercuric Chloride	S	S	
Mercuric Cyanide	S	S	
Mercuric Nitrate	S	S	
Mercury	S	S	
Merthiolate (Tincture)	S	S	
Methane	S	S	
Methanol	S	S	
Methyl Cellusolve	S		
Methyl Chloride	U		
Methylene Chloride	S	O	
Methyl Ethyl Ketone	S	S	
Methyl Isobutyl Ketone	S	S	
Methyl Sulfuric Acid	S	S	
Milk	S	S	
Mineral Oil	S	U	
Mineral Spirits	S	S	
Motor Oil	S	S	
Naphtha	S	S	
Naphthalene	S	S	S
Nickel Chloride	S	S	
Nickel Nitrate	S	S	O
Nickel Sulfate	S	S	S
Nitric Acid (10%)	S	S	S
Nitric Acid (concentrate)	O	U	
Nitric Acid (fuming)	U		
Nitric/Sulfuric Acid 50:50%	U		
Nitrobenzene	S	O	
Nitrous Acid	O		
Oleic Acid	S	S	
Oleum	U		
Olive Oil	S	S	
Oxalic Acid	S	S	
Oxygen	U	U	
Ozone	U	U	
Paradichlorobenzene	S	S	
Paraffin	S	S	
Peanut Oil	S	S	
Perchloroethylene	U	U	
Phenoil (10%)	S	S	O
Phosgene (gas)	U	U	
Phosgene (liquid)	U	U	
Phosphoric Acid (30%)	S	S	O
Phosphoric Acid (85%)	S	S	O
Phosphorus	S		
Phathalic Acid	S		
Polyvinyl Acetate	S		
Potassium Bromide	S	S	S
Potassium Carbonate	S	S	S
Potassium Chlorate	S	S	O
Potassium Chloride	S	S	O
Potassium Cyanide	S	S	
Potassium Dichromate	S	S	S
Potassium Ferrocyanide	S	S	
Potassium Hydroxide	S	S	S
Potassium Nitrate	S	S	

Table 4 (continued)

CHEMICAL RESISTANCE OF FORTILENE POLYPROPYLENE

Legend: S = Satisfactory. O = Some Attack. U= Unsatisfactory

Reagent	70°F (21°C)	140°F (60°C)	212°F (100°C)
Magnesium Carbonate	S	S	S
Magnesium Chloride	S	S	O
Magnesium Hydroxide	S	S	S
Magnesium Nitrate	S	S	
Magnesium Sulfate	S	S	
Potassium Permanganate	S	O	
Potassium Sulfate	S	S	S
Potassium Sulfide	S	S	S
Propanol	S	S	
Pyridine	S		
Silicone Oil	S	S	
Silver Cyanide	S	S	
Silver Nitrate	S	S	S
Sodium Acetate	S	S	
Sodium Benzoate	S	S	S
Sodium Bicarbonate	S	S	
Sodium Bisulfate	S	S	
Sodium Bisulfite	S	S	
Sodium Bromide	S	S	
Sodium Carbonate	S	S	S
Sodium Chlorate	S	S	O
Sodium Chloride	S	S	O
Sodium Cyanide	S	S	
Sodium Fluoride	S	S	
Sodium Hydroxide (concentrated)	S	S	S
Sodium Sulfate	S	S	
Sodium Sulfite	S	S	
Starch	S	S	
Stannic Chloride	S	S	
Stannous Chloride	S	S	

Reagent	70°F (21°C)	140°F (60°C)	212°F (100°C)
Sucrose (20%)	S	S	
Sulfuric Acid (10%)	S	S	S
Sulfuric Acid (50%)	S	S	
Sulfuric Acid (concentrated)	S	O	U
Sulfuric Acid (fuming)	U	U	
Sulfamic Acid	S	S	
Tannic Acid (10%)	S	S	
Tetrahydrofuran	S	O	O
Tetralin	O	O	O
Toluene	U	U	
Tributyl Phosphate	S	O	
Trichloroacetic Acid	S	S	
Trichloroethylene	U	U	
Tricresyl Phosphate	S	S	
Triethanolamine	O	O	
Trisodium Phosphate	S	S	
Turpentine	S	O	O
Urea	S	S	
Urine	S	S	
Water	S	S	O
Whiskey	S	S	S
Wines	S	S	
Xylene	O	U	
Xylol	S		
Yeast	S	S	
Zinc Chloride	S	S	
Zinc Oxide	S	S	
Zinc Sulfate	S	S	

Table II
Chemical Resistance of Fortiflex HDPE

Legend: S = Satisfactory, O = Some Attack, U = Unsatisfactory

Reagent	21°C (70°F)	60°C (140°F)
Acetaldehyde	S	O
Acetic Acid 1-10%	S	S
Acetic Acid 10-60%	S	O
Acetic Acid 80-100%	S	O
Acetic Anhydride	S	S
Acetone	S	S
Acids, Aromatic	S	S
Acrylic Emulsions	S	S
Adipic Acid	S	S
Aluminum Chloride Dilute	S	S
Aluminum Chloride Conc.	S	S
Aluminum Fluoride Conc.	S	S
Aluminum Sulfate Conc.	S	S
Alums (all types) Conc.	S	S
Amino Acetic Acid	S	S
Ammonia 100% Dry Gas	S	S
Ammonium Acetate	S	S
Ammonium Bromide	S	S
Ammonium Carbonate	S	S
Ammonium Chloride Sat'd	S	S
Ammonium Fluoride 20%	S	S
Ammonium Hydroxide	S	S
Ammonium Metaphosphate Sat'd	S	S
Ammonium Nitrate Sat'd	S	S
Ammonium Persulfate Sat'd	S	S
Ammonium Phosphate	S	S
Ammonium Sulfate Sat'd	S	S
Ammonium Sulfide Sat'd	S	S
Ammonium Thiocyanate Sat'd	S	S
Amyl Acetate 100%	O	U
Amyl Alcohol 100%	S	S
Amyl Chloride 100%	O	U
Aniline 100%	S	U
Anise Seed Oil	O	U
Antimony Chloride	S	S
Aqua Regia	O	U
Aromatic Hydrocarbons	U	U
Arsenic	S	S
Aspirin	S	S
Barium Carbonate Sat'd	S	S
Barium Chloride Sat'd	S	S
Barium Hydroxide	S	S
Barium Sulfate Sat'd	S	S
Barium Sulfide Sat'd	S	S
Beer	S	S
Benzaldehyde	S	O
Benzene	O	U
Benzene Sulfonic Acid	S	S
Benzoic Acid		
Crystals	S	S
Saturated	S	S
Bismuth Carbonate Sat'd	S	S
Black Liquor	S	S
Bleach Lye 10%	S	S
Borax Cold Sat'd	S	S

Reagent	21°C (70°F)	60°F (140°F)
Boric Acid Dilute	S	S
Boric Acid Conc.	S	S
Brine	S	S
Bromic Acid 10%	S	S
Bromine Liquid 100%	O	U
Bromochloromethane	U	U
Butadiene	U	U
Butanediol 10%	S	S
Butanediol 60%	S	S
Butanediol 100%	S	S
Butter	S	S
Butyl Acetate 100%	O	U
Butyl Alcohol 100%	S	S
Butylene Glycol	S	S
Butyric Acid 100%	S	S
Caffeine Citrate Sat'd	S	S
Calcium Bisulfide	S	S
Calcium Bromide	S	S
Calcium Carbonate Sat'd	S	S
Calcium Chlorate Sat'd	S	S
Calcium Chloride Sat'd	S	S
Calcium Hydroxide	S	S
Calcium Hypochlorite Bleach Sol'n	S	S
Calcium Nitrate 50%	S	S
Calcium Sulfate	S	S
Camphor Crystals	S	S
Camphor Oil	U	U
Carbon Dioxide 100% Dry	S	S
Carbon Dioxide 100% Wet	S	S
Carbon Dioxide Cold Sat'd	S	S
Carbon Disulphide	O	U
Carbon Monoxide	S	S
Carbon Tetrachloride	U	U
Carbonic Acid	S	S
Carnauba Wax	S	S
Carrot Juice	S	S
Castor Oil Conc.	S	S
Catsup	S	S
Caustic Soda	S	O
Cedar Leaf Oil	U	U
Cedar Wood Oil	U	U
Chlorine Liquid	O	U
Chlorobenzene	O	U
Chloroform	U	U
Chlorosulfonic Acid 100%	U	U
Chrome Alum Sat'd	S	S
Chromic Acid 10-20%	S	O
Chromic Acid 50%	S	O
Cider	S	S
Cinnamon	S	S
Cinnamon Oil	U	U
Citric Acid Sat'd	S	S
Citronella Oil	O	U
Cloves (Ground)	S	S
Coconut Oil Alcohols	S	S
Cod Liver Oil	S	S
Coffee	S	S

Table II
Chemical Resistance of Fortiflex HDPE

Legend: S = Satisfactory, O = Some Attack, U = Unsatisfactory

Reagent	21°C (70°F)	60°C (140°F)
Copper Chloride Sat'd	S	S
Copper Cyanide Sat'd	S	S
Copper Fluoride 2%	S	S
Copper Nitrate Sat'd	S	S
Copper Sulfate Dilute	S	S
Copper Sulfate Sat'd	S	S
Corn Oil	S	S
Cottonseed Oil	S	S
Cranberry Sauce	S	S
Cresols	S	O
Cuprous Chloride Sat'd	S	S
Cuprous Oxide	S	S
Cyclohexane	U	U
Cyclohexanone	U	U
Decalin	S	U
Detergents Synthetic	S	S
Developers Photographic	S	S
Dextrin Sat'd	S	S
Dextrose Sat'd	S	S
Dibutyl Ether	O	U
Dichlorobenzene (O&P)	U	U
Diethylene Glycol	S	S
Disodium Phosphate	S	S
Dioxane	S	S
Emulsions Photographic	S	S
Ether	O	O
Ethyl Acetate 100%	O	O
Ethyl Alcohol 100%	S	S
Ethyl Alcohol 35%	S	S
Ethylbenzene	O	U
Ethylene Glycol	S	S
Ferric Chloride Sat'd	S	S
Ferric Nitrate Sat'd	S	S
Ferrous Ammonium Citrate	S	S
Ferrous Chloride Sat'd	S	S
Ferrous Sulfate	S	S
Fluoboric Acid	S	S
Fluorine	S	U
Fluosilicic Acid 32%	S	S
Fluosilicic Acid Conc.	S	S
Formaldehyde		
10-30%	S	S
30-40%	S	O
Formic Acid 20%	S	S
Formic Acid 50%	S	S
Formic Acid 100%	S	S
Fructose Sat'd	S	S
Fuel Oil	S	U
Furfural 100%	O	U
Furfuryl Alcohol	S	O
Gallic Acid Sat'd	S	S
Gasoline	S	U
Glucose	S	S
Glycerine	S	S
Glycol	S	S

Reagent	21°C (70°F)	60°F (140°F)
Glycolic Acid 30%	S	S
Grape Juice	S	S
Grapefruit Juice	S	S
Heptane	O	U
Hexachlorobenzene	S	S
Hexane	U	U
Hydrobromic Acid 50%	S	S
Hydrocyanic Acid Sat'd	S	S
Hydrochloric Acid 10%	S	S
Hydrochloric Acid 30%	S	S
Hydrochloric Acid 35%	S	S
Hydrocyanic Acid	S	S
Hydrofluoric Acid 40%	S	S
Hydrofluoric Acid 60%	S	S
Hydrofluoric Acid 75%	S	S
Hydrogen 100%	S	S
Hydrogen Bromide 10%	S	S
Hydrogen Chloride Gas Dry	S	S
Hydrogen Peroxide 30%	S	S
Hydrogen Peroxide 90%	S	O
Hydroquinone	S	S
Hydrogen Sulfide	S	S
Hypochlorous Acid Conc	S	S
Inks	S	S
Iodine Crystals	O	O
Isobutyl Alcohol	S	S
Isopropyl Alcohol	S	S
Isopropyl Ether	O	U
Kerosene	O	O
Lactic Acid 10%	S	S
Lactic Acid 90%	S	S
Lanolin	S	S
Lard	S	S
Lead Acetate Sat'd	S	S
Lead Nitrate	S	S
Lemon Juice	S	S
Lemon Oil	O	U
Lime Juice	S	S
Linseed Oil	S	S
Magnesium Carbonate Sat'd	S	S
Magnesium Chloride Sat'd	S	S
Magnesium Hydroxide Sat'd	S	S
Magnesium Nitrate Sat'd	S	S
Magnesium Sulfate Sat'd	S	S
Margarine	S	S
Mercuric Chloride	S	S
Mercuric Cyanide Sat'd	S	S
Mercurous Nitrate Sat'd	S	S
Mercury	S	S
Methyl Alcohol 100%	S	S
Methyl Ethyl Ketone 100%	U	U
Methylsulfuric Acid	S	S
Methylene Chloride 100%	U	U

Table II
Chemical Resistance of Fortiflex HDPE

Legend: S = Satisfactory, O = Some Attack, U = Unsatisfactory

Reagent	21°C (70°F)	60°C (140°F)
Milk	S	S
Mineral Oils	S	U
Molasses	S	S
Mustard (Prepared)	S	S
Naphtha	O	U
Napthalene	S	U
Natural Gas (Wet)	S	S
Nickel Chloride Sat'd	S	S
Nickel Nitrate Conc.	S	S
Nickel Sulfate	S	S
Nicotinic Acid	S	S
Nitric Acid 0-30%	S	S
Nitric Acid 30-50%	S	O
Nitric Acid 70%	S	O
Nitric Acid 95-98%	U	U
Nitrobenzene 100%	U	U
Nitroglycerine	O	U
Octane	S	S
Oleum Conc	U	U
Olive Oil	S	S
Orange Juice	S	S
Oxalic Acid Dilute	S	S
Oxalic Acid Sat'd	S	S
Ozone	O	O
Palm Oil	S	S
Paraffin Oil	S	O
Peanut Butter	S	S
Perchloroethylene	U	U
Pepper (Fresh Ground)	S	S
Peppermint Oil	O	U
Perchloric Acid 50%	S	O
Petroleum Ether	U	U
Petroleum Jelly	S	S
Phenol	S	S
Phosphoric Acid 0-30%	S	S
Phosphoric Acid 30-90%	S	S
Phosphoric Acid Over 90%	S	S
Photographic Solutions	S	S
Phthalic Anhydride	S	S
Pickling Baths		
Sulfuric Acid	S	S
Hydrochloric Acid	S	S
Sulfuric-Nitric	S	U
Pine Oil	O	U
Plating Solutions		
Brass	S	S
Cadmium	S	S
Chromium	S	S
Copper	S	S
Gold	S	S
Indium	S	S
Lead	S	S
Nickel	S	S
Rhodium	S	S
Silver	S	S

Reagent	21°C (70°F)	60°F (140°F)
Tin	S	S
Zinc	S	S
Potassium Bicarbonate Sat'd	S	S
Potassium Borate 1%	S	S
Potassium Bromate 10%	S	S
Potassium Bromide Sat'd	S	S
Potassium Carbonate	S	S
Potassium Chlorate Sat'd	S	S
Potassium Chloride Sat'd	S	S
Potassium Chromate 40%	S	S
Potassium Cyanide Sat'd	S	S
Potassium Dichromate 40%	S	S
Potassium Ferri/Ferro Cyanide	S	S
Potassium Fluoride	S	S
Potassium Hydroxide 20% Conc	S	S
Potassium Nitrate Sat'd	S	S
Potassium Perborate Sat'd	S	S
Potassium Perchlorate 10%	S	S
Potassium Permanganate 20%	S	S
Potassium Sulfate Conc	S	S
Potassium Sulfide Conc	S	S
Potassium Sulfite Conc	S	S
Potassium Persulfate Sat'd	S	S
Propane Gas	S	S
Propargyl Alcohol	S	S
Propyl Alcohol	S	S
Propylene Glycol	S	S
Pyridine	S	O
Rayon Coagulating Bath	S	S
Resorcinol	S	S
Salicylic Acid	S	S
Sea Water	S	S
Shortening	S	S
Silicic Acid		
Silver Nitrate Sol'n	S	S
Soap Solution Conc.	S	S
Sodium Acetate Sat'd	S	S
Sodium Benzoate 35%	S	S
Sodium Bicarbonate Sat'd	S	S
Sodium Bisulfate Sat'd	S	S
Sodium Bisulfite Sat'd	S	S
Sodium Borate	S	S
Sodium Carbonate Conc.	S	S
Sodium Chlorate Sat'd	S	S
Sodium Chloride Sat'd	S	S
Sodium Cyanide	S	S
Sodium Dichromate Sat'd	S	S
Sodium Ferricyanide Sat'd	S	S
Sodium Ferricyanide	S	S
Sodium Fluoride Sat'd	S	S
Sodium Hydroxide Conc.	S	S

Table II
Chemical Resistance of Fortiflex HDPE

Legend: S = Satisfactory, O = Some Attack, U = Unsatisfactory

Reagent	21°C (70°F)	60°C (140°F)
Sodium Hypochlorite	S	S
Sodium Nitrate	S	S
Sodium Nitrite	S	S
Sodium Perborate	S	S
Sodium Phosphate	S	S
Sodium Sulfide 25% to Sat'd	S	S
Sodium Sulfite Sat'd	S	S
Sodium Thiosulphate	S	S
Soybean Oil	S	S
Stannous Chloride Sat'd	S	S
Stannic Chloride Sat'd	S	S
Starch Solution Sat'd	S	S
Stearic Acid 100%	S	S
Sulfuric Acid 0-50%	S	S
Sulfuric Acid 70%	S	O
Sulfuric Acid 80%	S	U
Sulfuric Acid 96%	O	U
Sulfuric Acid 98% Conc	O	U
Sulfuric Acid Fuming	U	U
Sulfurous Acid	S	S
Tartaric Acid	S	S
Tannic Acid 10%	S	S
Tea	S	S
Tetrahydrofurane	O	O

Reagent	21°C (70°F)	60°F (140°F)
Toluene	U	U
Tomato Juice	S	S
Transformer Oil	S	O
Trisodium Phosphate Sat'd	S	S
Trichloroethylene	U	U
Turpentine	O	U
Urea	S	S
Urine	S	S
Vanilla Extract	S	S
Vaseline	S	S
Vinegar Comm.	S	S
Wetting Agents	S	S
Whiskey	S	S
Wines	S	S
Xylene	U	U
Yeast	S	S
Zinc Chloride Sat'd	S	S
Zinc Oxide	S	S
Zinc Sulfate Sat'd	S	S

Rigidex
high density polyethylene

Technigram T800/1

Chemical resistance of Rigidex

Introduction

A guide to the effect that a variety of chemicals has on high density polyethylene (HDPE) is given in the following Table which is a compendium of BP Chemicals Limited information and other published literature sources.

Polyethylene materials as a class have a high resistance to chemical attack and are insoluble in all known solvents at room temperature. However, when considering the suitability of Rigidex HDPE for a particular application, certain other factors should be taken into account.

Permeation effects

HDPE has a closely packed molecular structure and as a result provides an effective barrier to many liquids, gases and vapours. Consequently, Rigidex grades are used extensively to package and transport a wide range of household and industrial products, foodstuffs, pharmaceuticals, agrochemicals and cosmetics. However, HDPE, in common with all thermoplastics is incapable of providing a complete barrier to all substances and loss by relatively low permeation rates can sometimes be accompanied by partial collapse of the container (panelling). In some instances, this can influence the stacking performance of the container in addition to detracting from the aesthetic appeal.

If panelling cannot be overcome by improving bottle rigidity, then it might sometimes be possible to camouflage the effect by using an oval cross section bottle or incorporating concave surfaces.

Photo-degradation effects

Panelling can also occur with products that are either photo-degradable or result in the absorption of oxygen from the ullage space. However, the use of opaque pigmentation and/or flushing the head space with nitrogen immediately prior to capping, will often eliminate panelling.

Absorption

This phenomenon is similar to permeation and in general the two effects tend to present problems with the same liquids. One notable exception is motor oil, which often exhibits quite high absorption levels yet negligible permeation.

When HDPE absorbs a liquid, there may be a change of dimensions and swelling. In severe cases, buckling of the container walls and panelling effects similar to those observed by permeation can occur. The swelling is usually accompanied by some loss of mechanical properties, notably tensile strength and softening of the polymer.

Environmental stress crack resistance

Products made from HDPE sometimes fail prematurely in service in the presence of certain surface active environments. Examples of these are detergents, chlorinated hydrocarbons, alcohols and some silicone products.

The brittle type of failure which occurs is always associated with a combination of the active environment and mechanical stresses in the moulded product. In any moulding there will always be regions of moulded-in stress in addition to stresses which result from externally applied loads. Also, some features of container design such as sharp corners or notches will produce areas of stress concentration which intensify the effects of applied loads. These stresses can result in brittle failure in the presence of active environments, even though the stresses involved would normally be within the mechanical limits of the polymer. In addition, these effects can be accelerated by elevated temperatures.

The activity of a liquid as a stress cracking environment and the resistance to stress cracking provided by the polymer may be assessed by a range of test methods. Generally, polyethylene materials of lower density and melt flow rate have better resistance to environmental stress cracking.

Packaging suitability

The use of small scale accelerated tests should be used only as an indication of the suitability of HDPE as a packaging material for a particular product. Information inferred from these tables for a single product may not, of course, be relevant when it is used as a component in a mixture of chemicals. Consequently, potential users of HDPE containers should always satisfy themselves that the containers are suitable for their particular product, taking into account the conditions of storage and distribution.

Guide to chemical resistance

Key

S. Satisfactory. This chemical is only absorbed to a low level and thus has little or no measurable effect on physical properties.

L. Limited resistance. A higher level of absorption occurs resulting in definite loss of physical properties. The question of the suitability of high density polyethylene would have to be considered with respect to the particular environment.

E. Environmental stress cracking may occur.

NS. Not satisfactory. Chemical attack or a high level of absorption occurs. In both cases the loss of physical properties is such that high density polyethylene is not suitable where prolonged contact is likely.

Substance	Conc.%	20°C	60°C
General chemical products			
Acetaldehyde	100	S	L
Acetic acid	10	S/E	S/E
Acetic acid	100	S/E	L/E
Acetic anhydride	100	S	L
Acetone	100	S	S
Acetophenetidin		S	S
Acetophenone	100	S	S
Acetylene	All	S	S
Acrylic emulsions	All	S/E	S/E
Acrylonitrile	100	S	S
Adipic acid		S	S
Aliphatic alcohols	100	S	S
Allyl chloride	100	S	S

Substance	Conc.%	20°C	60°C
Allyl chloride	100	L	L
Aluminium acetate	All	S	S
Aluminium carbonate	All	S	S
Aluminium chloride		S	S
Aluminium fluoride		S	S
Aluminium hydroxide		S	S
Aluminium nitrate		S	S
Aluminium oxalate		S	S
Aluminium oxychloride		S	S
Aluminium sulphate		S	S
Alums	All	S	S
Amino acetic acid	All	S	S
Ammonia (gaseous)	100	S	S
Ammonium acetate	All	S	S
Ammonium bicarbonate	All	S	S
Ammonium carbonate		S	S
Ammonium chloride		S	S
Ammonium fluoride		S	S
Ammonium hydroxide		S	S
Ammonium metaphosphate		S	S
Ammonium nitrate		S	S
Ammonium oxalate		S	S
Ammonium persulphate		S	S
Ammonium phosphate		S	S
Ammonium sulphate		S	S
Ammonium sulphide		S	S
Ammonium thiocyanate		S	S

Substance	Conc.%	20°C	60°C
Amyl alcohol	10	L	L
Amyl chloride	All	L	L
Aniline	100	L	L
Antimony	100	S	S
Antimony trichloride	100	S	S
Aqua regia	100	NS	NS
Arsenic	100	S	S
Arsenic acid		S	S
Aryl sulphonic acid	100	S	S
Benzaldehyde	100	S	L
Benzaldehyde (AQ)	Sat.	S	—
Benzene	100	L	NS
Benzene sulphonic acid	100	S/E	S/E
Benzoic acid	Sat.	S	S
Benzophenone	100	S	S
Benzoyl cloride	100	L	L
Bismuth carbonate		S	S
Boric acid		S	S
Boron trifluoride	100	S	
Bromic acid	10	S	S
Bromine (liquid)	100	NS	NS
Bromine (vapour)	High	NS	NS
Bromine water	Sat.	NS	NS
Bromochloromethane	100	NS	NS
Butadiene	100	NS	NS
Butanediol	100	S/E	
Butane (gaseous)	100	S	S
Butane (liquid)	100	L	—
Butanol	100	S	S
Butoxyl (methoxy butyl acetate)	100	S	L
Butyl acetate	100	L	NS
Butyl alcohol	100	S/E	S/E
Butylene glycol	100	S	S
Butyric acid	100	S	L
Carbon dioxide (dry)	100	S	S
Carbon dioxide (wet)	100	S	S
Carbon disulphide	100	L	—
Carbon monoxide	100	S	S
Carbon tetrachloride	100	NS	NS
Caustic potash (soln.)	50	S	S
Caustic potash (soln.)	10	S	S
Caustic soda	50	S	S
Caustic soda	10	S	S
Chloral hydrate	100	S	S
Chlorine gas (moist)		L	NS
Chlorine liquid		NS	NS
Chlorine water		L	NS
Chloroacetic acid	100	S	S
Chlorobenzene	100	L	NS
Chloroethanol	100	S	S
Chloroform	100	NS	NS
Chloromethane	100	L	—
Chlorosulphonic acid	100	NS	NS
Chrome alum		S	S
Chromic acid	Sat.	S/L	NS
Chromium salts	Sat.	S	S
Citric acid		S/E	S/E
Copper salts (aqueous)	Sat.	S	S
Cresols	100	S	S
Cresylic acid	100	L	—
Cresylic acid	50	S	S
Cyclohexane	100	L	L
Cyclohexanol	100	S/E	S/E
Cyclohexanone	100	S	L
Decahydronaphthalene	100	L	NS
Dibutyl ether	100	L	NS
Dibutyl phthalate	100	L	L
Dibutyl sebacate	100	S	—
Dichloroacetic acid	100	S	L
Dichloroacetic acid	50	S	S
Dichloroacetic acid/methyl ester		S	S
o-dichlorobenzene		L	NS
p-dichlorobenzene		L	NS
Dichloroethane	100	L	L
Dichloroethylene	100	NS	NS
Diethyl ether	100	L	L
Diethylene glycol	100	S/E	S/E
Diglycolic acid	100	S/E	S/E
Dihexyl phthalate	100	S	S
Diisobutyl ketone	100	S	NS
Dimethyl carbinol	100	S	—
Dimethyl formamide	100	S	L
Dimethyl sulphoxide	100	S	S
Dinonyl adipate	100	S	—
Dinonyl phthalate	100	S	L
Dioctyl adipate	100	S	—
Dioctyl phthalate	100	S	L
1,4-Dioxane	100	S	S
Diphenyl ether	100	L	L
Disodium phosphate	100	S	S
Epichlorhydrin	100	S	S
Epoxy resins	100	S	S
Ethanediol	100	S	S
Ether	100	S/E	L
Ethyl acetate	100	S	L
Ethyl acrylate	100	L	L
Ethyl alcohol	100	S/E	S/E
Ethylbenzene	100	L	NS

Substance	Conc.%	20°C	60°C
Ethyl butyrate	100	L	NS
Ethyl chloride	100	L	NS
Ethylene chloride	100	L	NS
Ethylenediaminetetra-acetic acid	100	S	S
Ethylene dichloride	100	L	NS
Ethylene glycol	100	S/E	S/E
2-Ethylhexanol	100	S	—
Fatty acids (> 6)		S/E	S/E
Ferric chloride		S	S
Ferric nitrate		S	S
Ferric sulphate		S	S
Ferrous ammonium citrate chloride	Sat.	S	S
Ferrous sulphate		S	S
Fluoboric acid	100	S	S
Fluoric acid	40	S	S
Fluorine	100	NS	NS
Fluorosilicic acid		S	S
Formaldehyde (aqueous)	40	S/E	S/E
Formalin		S	S
Formic acid		S/E	S/E
Furfural	100	L	NS
Furfuryl alcohol	100	S	L
Gallic acid		S/E	S/E
Glycolic acid	30	S/E	S/E
Glycolic acid butyl ester	100	S	S
Heptane	100	S	NS
Hexachlorobenzene	100	S	S
Hexamine	100	S/E	S/E
Hexane	100	NS	NS
Hydrazine	100	S/E	S
Hydrazine hydrate	100	S/E	S
Hydrobromic acid	50	S	S
Hydrochloric acid	Conc.	S	S
Hydrocyanic acid	100	S	S
Hydrocyanic acid	Sat.	S	S
Hydrocyanic acid	10	S	S
Hydrofluoric acid	40	S	S
Hydrofluoric acid	70	S	S
Hydrogen	100	S	S
Hydrogen bromide	10	S	S
Hydrogen peroxide	30	S	S
Hydrogen peroxide	90	S	NS
Hydrogen phosphite	100	S	S
Hydrogen sulphide	Low	S	S
Hydroquinone		S	S
Hypochlorites	100	S	S
Hypochlorous acid	All	S	S

Substance	Conc.%	20°C	60°C
Iron salts (aqueous)	Sat.	S	S
Isobutyl alcohol	100	S	—
Isooctane	100	S	L
Isopropanol	100	S	S
Isopropyl ether	100	L	NS
Lactic acid	100	S/E	S/E
Lead acetate	Sat.	S	S
Lead tetraethyl		S	
Magnesium carbonate		S	S
Magnesium chloride		S	S
Magnesium hydroxide		S	S
Magnesium nitrate		S	S
Magnesium sulphate		S	S
Maleic acid	50	S	S
Manganese sulphate		S	S
Mercuric chloride		S	S
Mercuric cyanide		S	S
Mercurous nitrate		S	S
Mercury	100	S	S
Methoxybutanol	100	S	L
Methyl acrylate		NS	NS
Methyl alcohol		S/E	S/E
Methyl bromide		L	NS
Methyl cyclohexane		L	NS
Methylene chloride		NS	NS
Methyl ethyl ketone	100	S	L
Methyl glycol		S	S
4-Methyl-2-pentanol		S	L
Methyl sulphuric acid		S/E	S/E
Monochloroacetic acid		S	S
Monochlorobenzene		S	S
Naphthalene	100	S	
Natural gas		S	S
Nickel salts (aqueous)	Sat.	S	S
Nicotine	Dil.	S/E	S/E
Nicotinic acid		S/E	S/E
Nitric acid	50	L	NS
Nitric acid	98	NS	NS
Nitrobenzene	100	NS	NS
Nitroglycerine	100	NS	NS
Nitropropane		L	L
o-nitrotoluene	100	S	L
Nitrous gases	100	S	S
Nonyl alcohol	100	S	—
Oleic acid	100	S/E	L/E
Oleum		NS	NS
Oxalic acid		S/E	S/E

Substance	Conc.%	20°C	60°C
Oxygen	100	S	S
Ozone		NS	NS
Palmitic acid		S/E	S/E
Pentane		NS	—
Perchloric acid	20	S	S
Perchloric acid	50	S	S
Perchloric acid	70	S	NS
Petroleum ether	100	S	L
Phenol (aqueous phase)		S	S
Phenol (solid phase)	100	S	S
Phenyl sulphonate		S	S
Phosgene		S	—
Phosphoric acid	25	S	S
Phosphoric acid	50	S	S
Phosphoric acid	Conc.	S/L	NS
Phosphoric anhydride		S	S
Phosphorous		S	S
Phosphorous oxychloride		S	L
Phosphorous pentoxide		S	S
Phosphorous trichloride		S	L
Phthalic acid	50	S	S
Phthalic anhydride		S	S
Picric acid		S	S
Polyglycol ethers		S	S
Potassium antimonate		S	S
Potassium bicarbonate		S	S
Potassium bichromate		S	S
Potassium bisulphate		S	S
Potassium borate		S	S
Potassium bromate		S	S
Potassium bromide		S	S
Potassium carbonate		S	S
Potassium chlorate		S	S
Potassium chloride		S	S
Potassium chromate		S	S
Potassium cuprocyanide		S	S
Potassium cyanide		S	S
Potassium dichromate		S	S
Potassium ferri/ ferrocyanide		S	S
Potassium fluoride		S	S
Potassium hydroxide		S	S
Potassium hypochlorite		S	S
Potassium iodide	Sat.	S	S
Potassium nitrate		S	S
Potassium orthophosphate		S	S

Substance	Conc.%	20°C	60°C
Potassium perborate		S	S
Potassium permanganate		S	S
Potassium persulphate		S	S
Potassium sulphate		S	S
Potassium sulphide		S	S
Potassium sulphite		S	S
Propane (gaseous)	100	S	S
Propane (liquid)	100	S	—
Propargyl alcohol		S/E	S/E
Propionic acid	50	S	S
Propionic acid	100	S	L
Propyl alcohol	100	S/E	S/E
Propylene dichloride	100	NS	NS
Propylene glycol		S/E	S/E
Pseudocumene		L	L
Pyridine	100	S	NS
Quinine		S	
Resorcinol	100	S	S
Salicylic acid		S	S
Selenic acid	100	S	S
Silicic acid		S	S
Silicone fluids		S/E	S/E
Silver nitrate		S	S
Silver salts (aqueous)	Sat.	S	S
Sodium acetate		S	S
Sodium benzoate		S	S
Sodium bicarbonate		S	S
Sodium bisulphate		S	S
Sodium borate		S	S
Sodium bromide		S	S
Sodium carbonate		S	S
Sodium chlorate		S	S
Sodium chloride		S	S
Sodium chlorite		S	S
Sodium cyanide		S	S
Sodium dichromate		S	S
Sodium dodecyl-benzenesulphonate		S	S
Sodium ferricyanide		S	S
Sodium ferrocyanide		S	S
Sodium fluoride		S	S
Sodium hydroxide		S	S
Sodium hypochlorite		S	S
Sodium hyposulphate		S	—
Sodium nitrate		S	S
Sodium nitrite		S	S

Substance	Conc.%	20°C	60°C
Soya bean oil	100	S	S
Tallow	100	S	—
Transformer oil	100	S	L
Turpentine oil	100	L	NS
White spirit		S/L	L
Foods etc.			
Beer		S	S
Brandy		S	—
Butter		S	—
Buttermilk		S	—
Cider		S/E	S/E
Cinnamon		S	—
Cloves		S	—
Coca Cola		S	S
Cocoa		S	—
Coffee		S	—
Cream		S	—
Curds		S	—
Dextrose		S	S
Fructose		S	S
Fruit juices		S	S
Gelatine		S	S
Gin	40	S	L
Glucose		S	S
Glycerine	100	S/E	S/E
Glycerine (aqueous)	High	S	S/E
Glycerine (aqueous)	Low	S	S
Grapefruit juice		S	S
Honey		S	S
Horse radish		S	—
Jam	100	S	S
Jelly	100	S	S
Lard		S	
Lemon juice		S	S
Lime juice		S	S
Margarine	100	S	S
Mayonnaise	100	S	—
Milk		S	S
Molasses		S	S
Mustard		S	S
Orange juice		S	S
Paprika	100	S	S

Substance	Conc.%	20°C	60°C
Pectin	Sat	S	S
Pepper		S	S
Pineapple juice		S	S
Rum		S	S
Saccharose	100	S	S
Soda water		S	—
Starch		S	S
Sugar beet syrup	100	S	S
Tea (leaves)		S	S
Tomato juice	100	S	S
Tomato ketchup	100	S	S
Vanilla	100	S	S
Vinegar	All	S	S
Whisky	40	S/E	
Wine (mulled claret)	100	S	S
Wine spirit	100	S	S
Yeast	100	S	S
Car, garden, household products			
Antifreeze		S	S
Bleach		L	L
Borax		S	S
Brake fluid	100	S/E	S/E
Brine		S	S
Creosote	100	S	S
Cresol (aqueous)		S	S
Detergents		S/E	S/E
Dextron		S	S
Emulsions (photographic)	100	S/E	S/E
Floor wax	100	S	L
Furniture polish	100	S/E	L
Hair shampoo		S	S
Hydraulic fluid	100	S	L
Ink	100	S	S
Methylated spirit		S/E	S/E
Nail polish and remover	100	S	L
Petroleum jelly	100	S	S
Shoe polish	100	S	L
Talc		S	S
Tar	100	S	L

Substance	Conc.%	20°C	60°C
Sodium orthophosphate		S	S
Sodium perborate		S	S
Sodium peroxide	10	S	—
Sodium peroxide	Sat.	L	—
Sodium phosphate		S	S
Sodium silicate		S	S
Sodium sulphate		S	S
Sodium sulphide		S	S
Sodium sulphite		S	S
Sodium tetraborate		S	S
Sodium thiosulphate		S	S
Stannic chloride		S	S
Stannous chloride		S	S
Stearic acid	100	S/E	S/E
Succinic acid	Sat.	S	S
Sulphur		S	S
Sulphur dioxide (dry)		S	S
Sulphur dioxide (wet)		S	S
Sulphur trioxide		NS	NS
Sulphuric acid	10	S	S
Sulphuric acid	50	S	S
Sulphuric acid	95	S	L
Sulphurous acid	30	S	S
Sulphuryl chloride		NS	
Tannic acid		S/E	S/E
Tartaric acid	100	S	S
Tartaric acid (aqueous)	Sat.	S	S
Tetrabromomethane	100	NS	NS
Tetrachloroethane	100	NS	NS
Tetrahydrofuran	100	L	NS
Tetralin	100	S	L
Thioglycolic acid	100	S	S
Thionyl chloride		NS	
Thiophene	100	L	L
Toluene	100	L	NS
Trichloroacetic acid	50	S	S
Trichloroacetic acid	100	L	NS
Trichloroethylene	100	L	NS
Tri ß chloroethylene phosphate	100	S	S
Tricresyl phosphate	100	L	L
Triethanolamine		L	L
Urea		S/E	S/E

Substance	Conc.%	20°C	60°C
Xylene	100	L	NS
Zinc ammonium carbonate		S	S
Zinc carbonate		S	S
Zinc chloride		S	S
Zinc oxide		S	S
Zinc sulphate		S	S
Oils and Waxes			
Aniseed oil	100	L	NS
Beeswax	100	S	S
Carnauba wax		S	S
Castor oil	100	S/E	S/E
Cedar leaf oil		NS	NS
Cedar wood oil		NS	NS
Cinnamon oil		NS	NS
Citronella oil		NS	NS
Clove oil		S	S
Coconut oil		S	NS
Coconut oil alcohols		S/E	S/E
Cod liver oil	100	S	—
Corn seed oil		S	L
Cotton seed oil		S/E	S/E
Diesel oil		S	S
Fuel oil	100	S	L
Kerosene		L	L
Lanolin	100	S	—
Lemon peel oil		S	L
Linseed oil	100	S	S
Menthol	100	S	S
Mineral oil		L	L
Motor oil	100	S	L
Olive oil	100	S	S
Orange peel oil	100	S	—
Palm oil	100	S	—
Paraffin oil	100	S	L
Paraffin wax	100	S	S
Peanut oil	100	S	S
Peppermint oil		L	NS
Petrol		S/L	S/L
Pine needle oil	100	S	S
Pine oil	100	L	NS
Salad oils	100	S	L
Silicone oil	100	S/E	L/E

EVALUATION OF RESISTANCE OF TENSAR POLYPROPYLENE BIAXIAL GEOGRIDS TO CHEMICAL ATTACK AND SOIL BURIAL FROM AVAILABLE INFORMATION.

Technical Note
Prepared for The Tensar Corporation
by J. P. Giroud, GeoServices, Inc.

Tensar biaxial geogrids, SS1, SS2 and AR1, are made of polypropylene. This polymer is known for having a high chemical resistance. In addition, the molecular orientation, imparted to the polymer by the manufacutirng process of Tensar geogrids, decreases polypropylene permeability, which is considered likely to increase chemical resistance. A summary of data regarding chemical resistance of polypropylene is presented below, with conclusions on the use of geogrids in civil engineering.

Polypropylene is not affected by detergents, organic salts in aqueous solutions, and by almost all inorganic acids and alkalis, even at high concentration and high temperture (60°C or more). Due to the resistance of polypropylene to alkalis, polypropylene Tensar geogrids are not affected by cement and concrete.

Polypropylene is attacked by strong oxidizing agents, such as fuming sulphuric acid, concentrated nitric acids and halogens. Such chemicals are not normally encountered in civil engineering but they can be present in a waste disposal cell. To decide if a Tensar polypropylene geogrid can be put in contact with such chemicals, the attached table can be used as a first guide and tests should be conducted.

Polypropylene has some sensitivity to certain solvents, oils, and hydrocarbons, such as asphalt. Polypropylene geogrids could be slowly affected if they were exposed during a long period of time to diesel fuel. Also, polypropylene geogrids could be slowly affected if they were placed below a thin layer of asphalt exposed to the sun in a very hot climate (where the surface of asphalt can reach 140°F during several hours every summer day). Polypropylene is inert to sulphur included in some asphalt pavements.

Polypropylene is not a nutrient medium for micro-organisms, and is therefore not attacked by them. Consequently, polypropylene Tensar geogrids can be used safely in the ground, even in highly organic soils. In fact, polypropylene geotextiles have been extensively used in the past two decades, and experience has shown that they can be expected to have a service life of several dozens of years when placed in most naturally occurring soil environments. Since geogrid rib thickness is at least 20 times the diameter of typical geotextile fibers, the durability of polypropylene geogrids is expected to be greater than the durability of polypropylene geotextiles.

J. P. Giroud
1984 August

EVALUATION OF CHEMICAL RESISTANCE OF TENSAR DRAINAGE NETS FROM AVAILABLE INFORMATION

Technical Note
Prepared for The Tensar Corporation
by J.P. Giroud, GeoServices, Inc.

Tensar drainage nets are made from polyethylene. This polymer is known for having a high resistance to chemical attack and being insoluble in all known solvents at room temperature.

The chemical resistance of polyethylene materials increases in general with increasing density. As shown in the attached Table, the resistance of polyethylene to aromatic solvents is affected by density. However, the effect is known to be small and, as shown in the Table, the resistance of polyethylene to acids and alkalis is not noticeably affected by density.

The influence of density on the chemical behavior of polyethylene is linked to the structure of the polymer. A high density polyethylene macromolecule is a linear chain of CH2 elements, while low density polyethylene macromolecules are usually a complex arrangement of branches of CH, CH2, and CH3. Because of its many branches, a low density polyethylene is more prone to react with chemials than a high density polyethylene, while a high density polyethylene is more likely to crack in certain environments (stress cracking) because it is made of parallel chains.

Tensar drainage nets (with a specific gravity of 0.925 to 0.930) and high density polyethylene geomembranes (0.935 to 0.945) are in the middle of the range of existing polyethylenes (0.91 to 0.97). It may therefore be concluded that there should be no significant difference in chemical behavior between the polyethylene used for Tensar drainage nets and the polyethylene used for high density polyethylene geomembranes.

High density polyethylene geomembranes have been subjected to extensive chemical compatibility testing in the past five years in view of their utilization in waste management facilities. Test results have shown that high density polyethylene geomembranes have a better compatibility with most chemicals than other available geomembranes. As a result, they are now used routinely to line hazardous waste disposal facilities.

The thickness of materials exposed to chemcials is also believed to have some influence on their durability. The thickness of Tensar net strands is typically two or three times the thickness of a 60mil-thick geomembrane. However, geomembranes are exposed on only one side and one may conclude that Tensar nets and 60mil-thick geomembranes are equivalent regarding thickness.

Some of the Tensar drainage nets are made of a foamed polyethylene. The foam structure results from the inclusion of bubbles that do not communicate. Therefore, foaming should not increase exposure to chemicals. Also, according to the manufacturer of the net, the foaming agent used in the manufacturing process has no effect on the chemical resistance of the polymer.

From our present knowledge on chemical compatibility, and considerations on density and thickness, it may be concluded that Tensar drainage nets can be used in waste disposal facilities where the use of currently available high density polyethylene geomembranes has been approved.

J.P. Giroud
1984.08.01

'AGEING' OF HIGH DENSITY POLYETHYLENE IN BURIED SITUATIONS

Publications such as BSI CP312 and manufacturers' data sheets which refer to ageing tests relate to the effects of ultraviolet or near visible radiation attack on the polymer which can result in oxidative degradation and embrittlement. Although buried PE does not suffer from this problem changes in free volume, crystallinity, and the possible effect of chemical and microbiological attack need to be considered with respect to any potential long term effect on properties.

Work initiated by RAPRA (Reference 1) some 16 years ago has involved a storage and examination of HDPE. Samples of polymer were stored, in Aluminium boxes with free air circulation, in temperate, hot wet and hot dry climates in the absence of radiation. No significant changes occurred in the basic properties of the HDPE after this period. This leads to the conclusion that any crystallinity changes, had an insignificant effect.

HDPE has been used in buried pipe applications for agricultural drainage, potable water, effluent and gas distribution for up to 30 years. A major reason is its corrosion resistance to acid soils and its generally excellent chemical resistance - HDPE is generally inert to chemicals other than strongly oxidising acids because of its chemical structure (2) HDPE has also been used to sheathed metal pipes in buried soil conditions in order to eliminate corrosion. Rigidex is an approved grade in the U.K.

HDPE sheathed Transatlantic telephone cables have also been used in a salt water environment for nearly 20 years without problems of chemical attack.

Certain types of chemicals such as detergents cause stress cracking of unoriented HDPE test pieces but creep rupture tests carried out in water and 2% detergent solutions at 23°C on samples of Tensar to compare the environments, have shown no deleterious effects. These data compare well with tests normally carried out on pressure pipe grades which are required to possess a high resistance to stress cracking in order to fulfill their 50 year design life requirement.

HDPE also has excellent resistance to microbiological attack and will not rot away when buried (3).

Field service evidence to date on the use of HDPE in civil engineering applications is based on non-annealed products. Orientation is known to reduce the permeability of HDPE and this enhancement coupled with the evidence of improved stress crack resistance lends support to the deduction that oriented grid structures will have no less a permanence in buried soil conditions than that of the established uses of non-oriented products. For example, HDPE gas pipe is supplied on a prognosis of a 50 year minimum life - the critical element is the risk of internal wall softening due to occluded gas condensate - the risk of attack resulting from the buried soil environment is considered to be not critical.

G. H. BURKE

30th October, 1981

R E F E R E N C E S

1. RAPRA Members Journal, July/August 1975, P53 and March/April 1976, P19 by R. C. Moakes.

2. Vinyl and Allied Polymers, Volume 1, Iliffe Books P148 (1968).

3. British Plastics, October 1967, P105, B. Dolezal, Micro-organisms and Plastics.

30th October, 1981

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-	chlorosulphonic acid resistant to 5% concentration
-	other acids resistant to 95%
Inorganic Bases -	resistant to 100% concentration
Inorganic Salts -	resistant to 100% concentration
* Ketones -	resistant to 100% concentration
Natural Fats and Oils -	resistant to 100% concentration
Organic Acids -	resistant to 100% concentration

* These materials are significantly absorbed by the liner causing some "softening" but no degradation. Concentrations in liquid next to the liner should be prudently limited to 1500 ppm for long term containment. Concentrations in soils may, however, be higher.

Note 1: This information is for containment at 23 $\pm$ 5°C. Higher temperatures would increase reactivity, especially of the inorganic acids.

Note 2: This data does not apply to the mixture of certain chemicals, e.g., a strong acid and base would react releasing much heat and possible rupture of the liner at "hot spots".

Actual report data can be obtained from Gundle by requesting the chemical resistance reports index. Other specific data is available from independent laboratory testing and from polyethylene manufacturers. Please call if you have questions.

CHEMICAL COMPATIBILITY TEST DATA
(Reports Available)

Report Number	Type of Chemical
105	Stripped Gas Liquor (70° C)
109	Sulphuric Acid (97.3%) (25° C)
111	Metal Hydroxide Waste Water Sludge
156*	E-2 Sludge
185	No. 6 Fuel Oil
197*	Sludge E-1; Sludge T-1; Flyash E-2; Neutralized T-1
208	Contaminated Water Samples
210	Kerosene
216	Hydrochloric Acid; Methanol; Diethylbenzene
227	Aromatic Waste Containing Inorganics
234	Creosote Emulsion
251	Potato Plant Wastewater
298	Escaid 100 (Kerosene)
334	Kerosene (Jet Fuel)
425*	Wastewater - Synthetic & Rutile Ore; Petroleum Coke; Sand & Grid; Hydroxides; oxides; iron; chromium; calcium carbonate; manganese, arsenic; nickel; salts; calcium sulfate
451	Shop dust leachate' pickle liquor sludge leachate
533	Leachate solution
553	Fuel Oil (Automotive Fuels)
563	Leachate Solution (PVC); 3300 Polylefin
567	Metals Leachate (black mud slurry waste)
629	Creosote
644	Petroleum Waste Sludge
656	Black Liquor (Hypalon)
667	Aromatic Leachate
671*	Trichloroethylene
690	Synthetic Leachate (Gundnet; Gundfab: Gundflex 300)
730*	Boiler Blow-down Waste; Brine Concentrate
731	Aromatic Hydrocarbons
763	Leachate generated from air pollution sludge; flue dust
796	Herbicides & Metals Leachate
914	Exposure to Metal Leachate after One Year
962	Nitric Acid (10% & 50%)
1118	Chemical Waste (Organic & Acidic/Basic)
1119	Cholorinated Hydrocarbon Leachate
1195	Dichlorobenzene
1196	Dichlorobenzene Plus Water
1197	Dichloroethylene
1198	Dichloroethylene Plus Water
1315	Ethylene Dichloride Solution (2-3%)
1316	Resin Waste Containing Methyl Methacrylate (40 Days)
1327	Typical Landfill Leachate
1370	Landfill Leachate
1371	Synthetic Hazardous Waste Mixture
1374	Municipal Landfill Leachate (PVC)
1375	Municipal Landfill Leachate (Driline)
1376	Nacl Solution

*** Chemical Analysis Included**

1448	Pond Water
1449	Methyl Methacrylate (120 Days)
1450	Oil Retention Pond Waste
1519	Synthetic Leachate/Neutralization Sludge
1520	Spent Carbon
1521	Mill Waste
1522	Flame Retardant
1523	Municipal/Residual Waste
1524	Chemical Waste Solution from NUS Corp.
1525	Municipal Landfill Leachate
1584	Brominated Hydrocarbon Solution (ALRS)
1617	Treated Sludge (Dust)
1705	Phosphate Leachate
1775	Wastewater Leachate
1785	Cyanide
1824	Heavy Metals Leachate
1825	Landfill Leachate
1870	Waste Water
1952	Creosote Emulsion
1953	Flume Wastewater
1954	Solvent/Pesticide Waste (Casmalia)
1989	Ground Wastewater (Aromatic Hydrocarbon Waste)
2043	Paint Reducer & Paint Thinner
2044	Creosote Emulsion (LDPE & HDPE)
2098	Chlorinated Pesticide
2114	Metals Leachate
2148	Waste Sludge
2214	Dichlorobenzene
2277	Toluene
2357	Nitric Acid
2817*	Metal Salts, Hydrocarbons & Halogenated Compounds
2901*	Landfill Leachate
3183*	Toluene, Ethylbenzene
3600*	Dichloroethane & Miscellaneous Organic Solvents
3601*	Incinerator Ash Sludge
4214*	Chlorinated Hydrocarbon Waste, Ketones, Alcohols
4215*	Phenolic Landfill Leachate
5081*	Heavy Metal Leachate
5771*	Aromatic & Phenolic
5812*	Phenolics, Aromatics, Sulfates, Nitrates
5815*	Chromate Copper Arsenate (Wood Preservative)
5882*	Anthraquinones (Aromatic Solvent)
5969*	Aromatics, Phenolics
OL 001*	Chemical Compatibility Testing of HDPE Chevron Resin
OL 002*	Chemical Compatibility Testing of HDPE Union Carbide Resin
OL 003*	Chemical Compatibility Testing of HDPE Solvay Resin
OL 004*	Chemical Compatibility Testing of HDPE Geomembrane
OL 005*	Chemical Resistance of Jet Fuel--TRI Test Results (80mil)
OL 006*	Chemical Resistance of Jet Fuel--TRI Test Results (60mil)
OL 007*	Chemical Compatibility Testing of HDPE Quantum Resin

*** Chemical Analysis Included**

Another Way to Go

Another approach to evaluating some amount of a chemical is to find a standard for that chemical, then calculate how much air or water would be needed to dilute that amount of a chemical down to acceptable levels. For example, a few years ago, a large computer company best-known for its typewriters, who shall remain nameless, was caught dumping trichloroethylene onto the ground in South Brunswick, NJ. The company said, "There's really no problem because we only dumped ten gallons during the whole year." Ten gallons really doesn't sound like very much, does it? Let's see.

From Sittig's book (see Appendix A), we learn that the federal guideline for trichloroethylene in water is 2.7 parts per billion (micrograms per liter); this is an amount the government thinks will cause one cancer in a million people who drink water contaminated at that level for a lifetime. Ten gallons is 37.8 liters (see Appendix E). The problem looks like this:

$$\frac{2.7}{10^9} = \frac{37.8}{?}$$

Solving for ?, we can see that it's $37.8 \times 10^9/2.7 = 14$ billion liters. A human drinks two liters of water each day (average). Thus 14 billion liters of water is a drinking water supply for 19 million people for one year ($14 \times 10^9/2/365 = 19.2 \times 10^6$). Thus 10 gallons of trichloroethylene is enough to contaminate the entire year's drinking water supply for a city bigger than New York or Los Angeles.