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Permit Application Vol 3

Part 7 of 8

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APPLICATION FOR PERMIT
OWL LANDFILL SERVICES, LLC

VOLUME III: ENGINEERING DESIGN AND CALCULATIONS
SECTION 6: GEOSYNTHETICS APPLICATION AND COMPATIBILITY DOCUMENTATION

ATTACHMENT III.6.B

GEOTEXTILES REFERENCE DOCUMENTATION

Technical Note No. 7

Chemical Resistance of Amoco Polypropylene Geotextiles

Amoco woven and nonwoven geotextiles are manufactured from polypropylene with ultra violet stabilizing additives. The excellent chemical resistance of Amoco polypropylene geotextiles is one of the qualities which has established Amoco as a leading producer of geotextiles for use in the waste containment industry. This technical note addresses the chemical resistance of polypropylene with a focus on recent testing programs which have clearly demonstrated the durability of Amoco fabrics in a variety of chemical environments.

Are polypropylene geotextiles durable in the chemical environment of landfill leachates?

Yes. Of the polymers used to manufacture geotextiles, polypropylene exhibits the greatest resistance to chemical attack. In fact, polypropylene is the polymer of choice for such commonly used products as landfill liners, synthetic grass for athletic fields, outdoor carpeting, battery cases, bleach bottles, antifreeze jugs, washing machine agitators, and thousands of other commonly used items that are routinely exposed to chemical environments. Polypropylene is stable within a pH range of 2 to 13, making one of the most stable polymers.

Polypropylene geotextiles have been found to be durable in a wide range of chemical environments (Bell, et. al., 1980; Haxo, 1978, 1983; Pucetas, et.al., 1991; Tisinger, et. al., 1989). Research has found both woven and nonwoven polypropylene geotextiles to be non-biodegradable and resistant to commonly encountered soil-bound chemicals, landfill achates, mildew, and insects.

How is the chemical resistance of polypropylene geotextiles determined?

Numerous laboratory test programs have subjected polypropylene to severe chemical environments such as solutions of organic solvents, oils, organic acids, and inorganic acids. The laboratory tests are generally performed in accordance with ASTM D 543, "Standard Test Method for Resistance of Plastics to Chemical Reagents." These test programs have found polypropylene to exhibit superb chemical resistance.

In the ASTM D 543 procedure, the specimens are immersed in a concentrated chemical solution at a specified temperature for a specified exposure period. This test method exposes the polypropylene to etremely harsh conditions which are considerably more severe than those encountered in most civil engineering applications.

The chemical compatibility of geotextiles with leachates is determined by EPA Test Method 9090 (EPA 9090), *"Compatibility Test for Wastes and Membrane Liners."* This was the laboratory method used in the Amoco geotextile test programs reported in this technical note. Geotextile samples are immersed in a constant temperature leachate bath for four months. At the end of each month samples of the fabric are removed and subjected to physical testing. Changes in properties may indicate chemically imposed degradation.

Have Amoco geotextiles been proven to be chemically resistant?

Four laboratory testing programs have been performed to evaluate the chemical compatibility of Amoco geotextiles with landfill leachates. The tests exposed both Amoco woven and nonwoven products to hazardous and municipal waste leachates.

In all testing programs there was no indication of geotextile degradation due to exposure to landfill leachates. The test results are summarized in the remainder of this technical note.

Hazardous waste leachate

A laboratory testing program was performed in 1989 to evaluate the chemical compatibility of Amoco geotextiles with a hazardous waste leachate. The program included EPA 9090 testing of 4 oz/yd² and 8 oz/yd² nonwoven specimens. The testing exposed the geotextiles to leachate in both the laboratory and in a leachate collection sump at a hazardous waste landfill. Test evaluation incorporated detailed microstructural analyses which are not typically incorporated into chemical resistance testing programs. Methods included differential scanning calorimetry, thermal gravimetric analysis, and infrared spectrophotometry. These analyses were performed to identify any changes in the microstructure of the geotextile due to immersion in the leachate.
The results of this testing program found the geotextile microstructure remained intact, stable, and unchanged (Tisinger, et. al., 1989).

Municipal waste leachate

The chemical resistance of Amoco geotextiles to municipal solid waste leachate was evaluated in three laboratory testing programs. The first program, completed in 1990, included EPA 9090 testing of 16 oz/yd² nonwoven geotextile specimens. The second test program, performed in 1992, tested specimens of 8 oz/yd² nonwoven geotextile. The third program, completed in 1993, evaluated the chemical resistance of a high strength woven geotextile. The testing programs evaluated changes in physical properties of the specimens, including specimen dimensions, thickness, grab tensile strength and elongation, puncture resistance, burst strength, and tear strength. In all cases there were no measurable changes in physical properties of the specimens after exposure to the leachate.

Are the results of these tests applicable to Amoco geotextiles which have not been similarly tested?

Yes. All Amoco geotextiles are equally resistant to chemical degradation because they are all manufactured using the same polymer and additives. This conclusion is supported by the test results, which demonstrated no difference in chemical resistance for different types of Amoco geotextiles. The information in this technical note, therefore, is considered to be applicable to all Amoco geotextiles regardless of weight, thickness, or strength.

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Technical Note No. 14

Amoco Fabrics and Fibers Company

AMOCO GEOTEXTILES

Geotextile Polymers for Waste Applications

What types of polymers are used to manufacture geotextiles?

Virtually all geotextile fibers are made from either polypropylene or polyester polymers.

Are these polymers used in a 100% pure form?

The manufacture of geosynthetics usually includes the addition of stabilizers and other additives that are blended with the base polymer. The additives constitute a minor fraction of the polymer mixture.

Additives are used primarily to counteract the effects of oxidation, to which many synthetic polymers are sensitive. Oxidation can cause a reduction in material properties such as strength and elasticity. The main sources of oxidation are heat/temperature (thermal oxidation) and ultra violet (UV) radiation from sunlight (photo-oxidation). Manufacturers of geosynthetics add a variety of proprietary additives during production to make the polymers more stable against thermal and UV degradation (see Amoco Technical Note No. 9).

Should the designer specify polypropylene or polyester for geotextiles to be used in waste applications?

The type of polymer used in the fabrication of the geotextile is not a relevant design parameter. The specifications should be developed to focus on the required physical properties of the geotextile relative to strength, hydraulic performance, and chemical compatibility and durability. These elements are addressed in detail in the Amoco Waste-Related Geotextile Guide Specifications.

Does the type of base polymer affect the chemical resistance of geotextiles used in landfills?

Geotextiles in landfills are exposed to leachates, which are generally dilute solutions of chemicals. The geotextile must be resistant to degrading in this chemical environment. Chemical resistance of geotextiles to leachates is evaluated in the laboratory using EPA Test Method 9090 (EPA 9090). The results of such testing on polypropylene and polyester have proved both polymers to be relatively inert and durable in various chemical environments of hazardous and nonhazardous waste landfills (refer to Amoco Technical Note No. 7).

Of the polymers used to manufacture geotextiles, polypropylene exhibits the greatest resistance to chemical attack. Polypropylene is inert to most chemicals except for some highly concentrated solvents. Geotextiles are not expected to be exposed to such solvents in waste applications, where the associated leachates typically contain only trace to very low concentrations of solvent constituents.

Polyester exhibits comparable chemical compatibility. However, unlike polypropylene, polyester is subject to hydrolysis in aqueous environments such as landfill leachates. Hydrolysis is a process in which water-based solvents or water alone causes the polymer chains to break. This can result in a reduction in the mechanical properties of the polymer. Despite this characteristic, the results of EPA 9090 testing on polyester do not show an impact from hydrolysis.

What effect does polymer type have on the UV resistance of geotextiles used in landfills?

There are only slight differences in the UV stability of various geotextile polymers. From a construction perspective, these differences have no impact on the selection of geotextiles for landfill applications. Regardless of the polymer type, it is important to limit exposure of the geotextile to potentially damaging UV radiation.

In landfill applications, geotextiles are usually covered by soil layers and waste soon after construction. Their exposure to UV radiation therefore generally occurs only during construction. Regardless of polymer type, exposure of the fabrics to sunlight during installation should be limited in accordance with the project specifications (see Amoco Waste-Related Geotextile Guide Specifications).

On some landfill side slopes, the geotextile might be left exposed for an extended time before being covered with soil. In these cases, the geotextile must be protected from UV radiation by alternative methods, regardless of whether the fabric is manufactured of polypropylene or polyester. Alternatives include covering the geotextile with a sacrificial geotextile layer or opaque plastic sheet. The sacrificial layer would be removed prior to placing soil cover.

Has the performance of Amoco geotextiles in landfill applications been verified?

Yes. In fact, the excellent chemical resistance of Amoco polypropylene geotextiles is one of the qualities that has established Amoco as a leading supplier of fabrics to the waste containment industry.

Laboratory testing programs have been performed specifically to evaluate the chemical compatibility of Amoco polypropylene geotextiles with landfill leachates. In all test cases there were no measurable changes in the physical properties of the Amoco geotextiles after exposure to leachates. Also, unlike polyester, polypropylene does not undergo hydrolysis. Amoco Technical Note No. 7 provides detailed information regarding the chemical compatibility test conditions, procedures, and results.

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ATTACHMENT III.6.C

GEONET REFERENCE DOCUMENTATION

PRODUCT DATA SHEET

GSE TenDrain 275 mil Geocomposite

GSE TenDrain geocomposite consists of a 275 mil thick GSE TenDrain geonet heat-laminated on one or both sides with a GSE nonwoven needle-punched geotextile. TenDrain 275 is comprised of a tri-planar structure consisting of middle ribs that provide direct channelized flow, with diagonally placed top and bottom ribs. The geotextile is available in mass per unit area range of 6 oz/yd² to 16 oz/yd². TenDrain 275 geocomposite provides high transmissivity under high and low loads.

[*]

AT THE CORE:
A 275 mil thick TenDrain geonet heat-laminated on one or both sides with a nonwoven needlepunched geotextile.

Product Specifications

Tested Property	Test Method	Frequency	Minimum Average Roll Value[1]	
Geocomposite			6 oz/yd²	8 oz/yd²
Transmissivity[2], gal/min/ft, (m²/sec) Double-Sided Composite	ASTM D 4716	1/540,000 ft²	24.2 (5x10⁻³)	24.2 (5x10⁻³)
Ply Adhesion, lb/in	ASTM D 7005	1/50,000 ft²	0.5	0.5
Geonet Core[1,3] – GSE TenDrain				
Geonet Core Thickness, mi	ASTM D 5199	1/50,000 ft²	275	275
Density, g/cm³	ASTM D 1505	1/50,000 ft²	0.94	0.94
Tensile Strength (MD), lb/in	ASTM D 7179	1/50,000 ft²	75	75
Carbon Black Content, %	ASTM D 4218	1/50,000 ft²	2.0	2.0
Creep Reduction Factor[4]	GRI-GC8	per formulation	1.2	1.2
Compressive Strength, psf	ASTM D 6364	1/540,000 ft²	60,000	60,000
Geotextile[1,3]				
Mass per Unit Area, oz/yd²	ASTM D 5261	1/90,000 ft²	6	8
Grab Tensile Strength, lb	ASTM D 4632	1/90,000 ft²	160	220
Grab Elongation	ASTM D 4632	1/90,000 ft²	50%	50%
CBR Puncture Strength, lb	ASTM D 6241	1/90,000 ft²	435	575
Trapezoidal Tear Strength, lb	ASTM D 4533	1/90,000 ft²	65	90
AOS, US sieve[1], (mm)	ASTM D 4751	1/540,000 ft²	70 (0.212)	80 (0.180)
Permittivity, sec⁻¹	ASTM D 4491	1/540,000 ft²	1.5	1.3
Water Flow Rate, gpm/ft²	ASTM D 4491	1/540,000 ft²	110	95
UV Resistance, % retained	ASTM D 4355 (after 500 hours)	per formulation	70	70
NOMINAL ROLL DIMENSIONS[5]				
Roll Width, ft			12.75	12.75
Roll Length, ft	Double-Sided Composite		200	200
Roll Area, ft²	Double-Sided Composite		2,550	2,550

NOTES:
- [1] All geotextile properties are minimum average roll values except AOS which is maximum average roll value and UV resistance is typical value. Geonet core thickness is minimum average value.
- [2] Gradient of 0.02, normal load of 7,000 psf, boundary condition: plate/sand/geocomposite/geomembrane/plate, water at 70°F for 1 hour.
- [3] Component properties prior to lamination.
- [4] 10,000 hour creep test under 10,000 psf at 70°F temperature.
- [5] Roll widths and lengths have a tolerance of ±1%.

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EVALUATION ON STRESS CRACKING RESISTANCES OF VARIOUS HDPE DRAINAGE GEONETS

M.S. Mok[1], E. Blond[2], J. Mlynarek[3] and H. Y. Jeon[4]

ABSTRACT: Specimens from each geonet were placed under various compressive loads in a vessel containing a solution of 10% surface-active agent and 90% water at a temperature of 50°C. Then the surface morphology study of the specimen was performed after 500 hours test duration. The results show that all of these geonets did not appear any kind of stress cracking in the condition of 400 kPa, which is a typical landfill's loading condition. However, in the case of bi-planar geonet there were some deposits on the surface of geonet's strand and it is expected that this phenomena is due to the results of chemical clogging. On the other hand, in the case of the tri-planar and circular type bi-planar geonets, it maintained very clean flow channels until the end of the test. For high normal pressure some environmental stress cracks were detected for the circular type bi-planar geonet. The results show that the resistance to the environmental stress cracking is related to its polymer density, crystallinity and also rigidity not its mechanical properties.

KEYWORDS: geonet, compressive loads, surface morphology, stress cracking, chemical clogging, flow channels

INTRODUCTION

Land filling, by all indications, will continue to be the predominant method of solid waste disposal. As the use of high density polyethylene (HDPE) geonets increase in landfill applications, it is required to evaluate their long-term properties in several chemical conditions. (Ward and Brown 1990; Carlson 1993)

Typically, the high crystallinity of polyethylene geonets provides an excellent chemical resistance to harsh chemical leachate, however can be problematic with regard to environmental stress cracking. (Qian and Brown 1993; Thomas 1998) Under low stresses in the circumstance of room temperature polyethylenes will fracture by slow crack growth. This mode of failure limits the lifetime of polyethylenes used in critical applications as drainage materials, lining under landfills. (Lagaron, Pastor, Kip 1999; Bobsein 1999)

Geomembranes and geonets are used as a barrier and drainage component in this system, respectively. With addition of carbon black which is an anti-oxidation material HDPE geomembranes and geonets are normally used in hazardous landfill system as a barrier and drainage respectively.

Many researchers and a lot of work about environmental stress cracking resistance for the geomembranes were done and many beneficial reports have already been published. (Peggs and Kannien 1995; Thomas and Deschepper 1993) However a few research results on the environmental stress cracking resistance for the geonet drainage material were performed. Therefore, in this study the resistance to environmental stress cracking (ESCR) was examined mainly in morphological issues for various geonets (bi-planar, tri-planar and circular type of bi-planar geonet) under condition of various normal pressures.

SPECIMEN & TEST METHODS

Total three types of geonets were test in this study. Sample A has 5.6 mm mean value of thickness and two layers which means bi-planar geonet. The cross sectional shape of strand of Sample A is more likely to a square. Sample B has average of 8.6 mm thickness and has 3 layers (tri-planar). Sample C is also bi-planar geonet however has circular type cross sectional shape and thicker than sample A. The raw material of all these samples is high density polyethylene (HDPE). Typical specifications of the samples are provided in Table 1.

Fig. 1 shows these samples. Short-term compressive deformation test was performed using the procedures set forth in Standard Test Method for Determining Short-term Compression Behavior of Geosynthetics (ASTM

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D6364) to evaluate basic mechanical properties of samples. Specimen is positioned between two rigid steel platens and compressed at a constant rate of 1.0 mm/min. To control an accurate temperature of specimen of 23°C heating platens were manufactured and its heating is 14°C/min. Also special test equipment for ESCR under compression was manufactured and this equipment is shown Fig. 2.

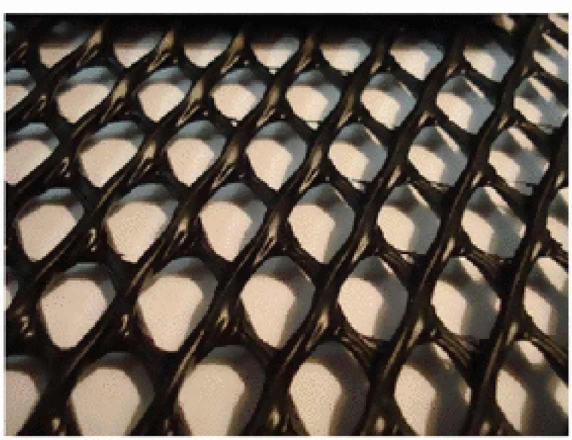
The specimens were immersed in a solution of 90% water and 10% I-gepal CO630 at a temperature of 50°C. The solution level was checked daily and de-ionized water used to keep the bath at a constant level.

And the solution was replaced every 2 weeks. 200, 400 and 700 kPa for sample A, 600, 1,000 and 1,200 kPa for sample B and 400, 600 and 800 kPa for C of load were subjected as compressive load using 6:1 arm lever loading system within considering their compressive strengths.

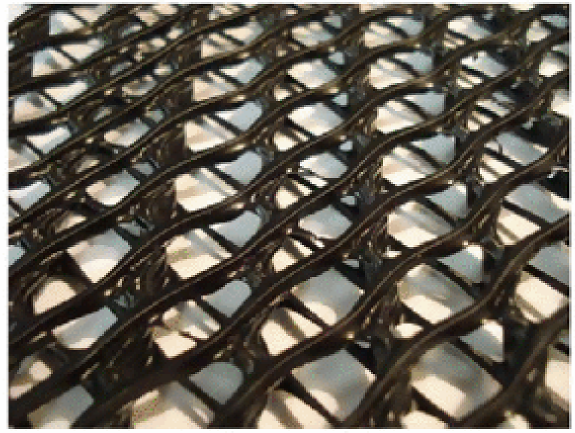
The immersion duration was 500 hours and during and after the test apparent observation and microscopic morphology was evaluated for the specimen.

Table 1 Typical specification of the samples

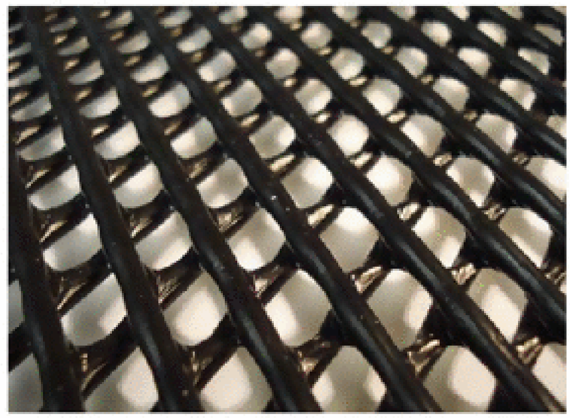
Property	Test method	Unit	Sample		
			A	B	C
Thickness	ASTM D5199	mm	5.6	8.6	8.2
Mass per unit area	ASTM D5261	g/m^2	920	1700	2300
Carbon black	ASTM D4218	%	2.3	2.2	2.3
Density	ASTM D1505	g/cm^3	0.942	0.944	0.940
Crystallinity	ASTM D2910	%	56	55	61



(a) Sample A



(b) Sample B



(c) Sample C

Fig. 2 Compressive environmental stress cracking test equipment

RESULTS & DISCUSSION

Considering the compressive strength and strain properties, the sample C has the stiffest behavior in these three Samples. Initial 5% elastic modulus is much higher than other samples. From this behavior of Sample C it is expected that sample C has rigid structure and has high crystallinity of over 60%. Table 1 confirms this phenomenon. In the other hand Sample A and C have more flexible behavior and low initial elastic modulus.

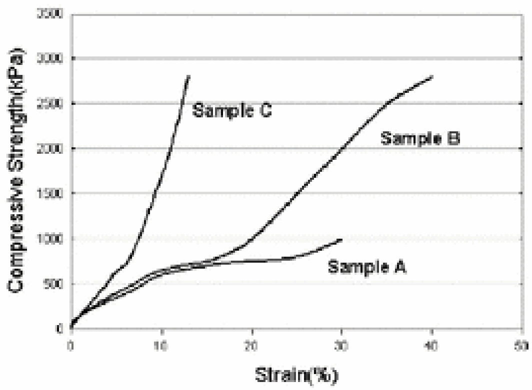


Fig. 3 Short-term compression test results

Figs. 4—9 exhibit the results of apparent observations and microscopic morphologies. Some kind of chemical clogging due to the I-gepal solution is expected for the Sample A because of its flow channel and thickness. This chemical clogging for the Sample A was confirmed by the apparent observation. Fig. 4 shows the results of apparent observations for Sample A. In this figure many deposits on the surface of the specimens were detected during and end of the test and it seems that these deposits which were induced from the chemical solution may occur clogging and therefore affect geonet's in-plane flow capacity. Also there is no chemical clogging on the surface of the specimen for Sample B and this fact was confirmed by apparent observation (Fig. 5).

Considering flowing pattern of the I-gepal solution through out the specimen, the I-gepal has zig-zag flow pattern and this courses some frictions with strands of sample A, therefore the chance of clogging is higher than the Sample B which has straight flow pattern. Also thin thickness compared to other samples can increase chance of any clogging. For the Sample C, the initial creep deformation was very low which means the initial modulus is higher than the other samples and therefore high modulus indicate more rigid than others. High rigidity has brittle failure pattern rather than ductile failure and this can induce a stress crack during the compressive creep test. Also it seems that the chemical act a stress cracking accelerator.

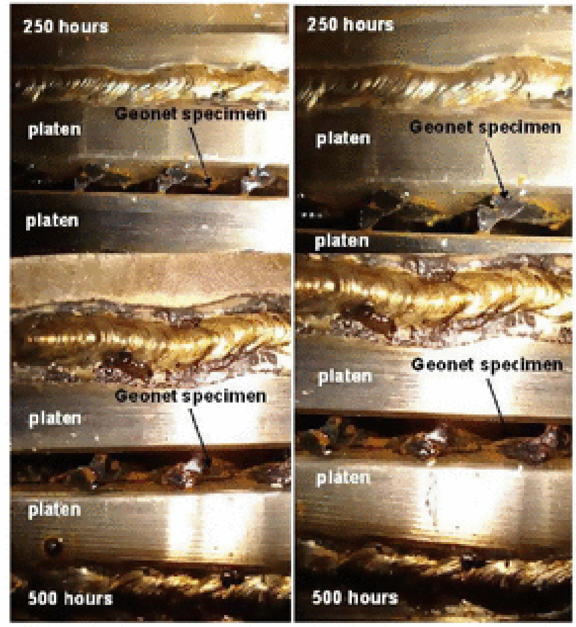


Fig. 4 Apparent observation during and end of the test for sample A (200kPa)

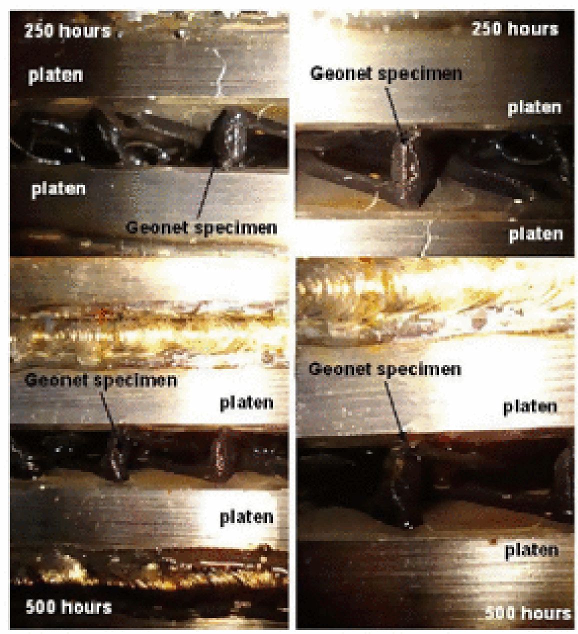


Fig. 5 Apparent observation during and end of the test for sample B (700 kPa)

Figs. 6—9 confirm this environmental stress cracking phenomenon. From these exhibitions it is clear that Sample A and Sample B which have relatively more flexible HDPE strand than Sample C didn't experience any kind of environmental stress cracking. For the Sample C which is more rigid and has high crystallinity (Table 1) likely has to chance of stress cracking. The microscopic morphologies indicate that the extent of environmental stress cracking observed in the Sample C is related to its flexibility and crystallinity. And from the morphologies it seems that the stress cracks occurred at the junction point of the strands first and then propagate to strands with increasing normal pressure.

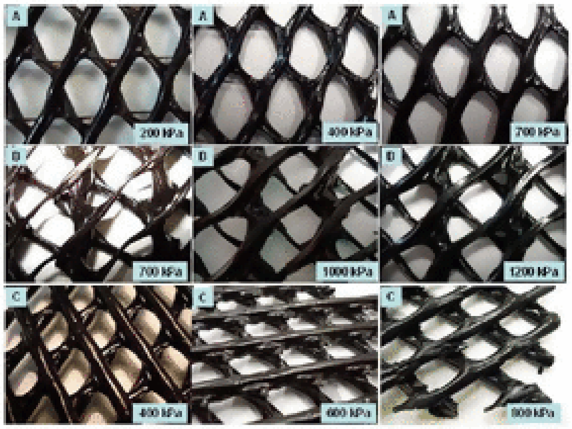


Fig. 6 Apparent observations end of the test for samples under various normal pressures

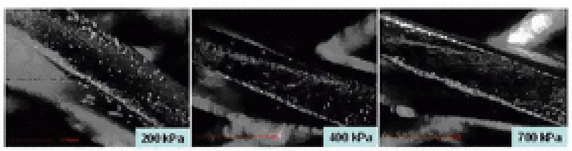


Fig. 7 Microscopic morphologies of Sample A after the test for various normal pressures

Fig. 8 Microscopic morphologies of Sample B after the test for various normal pressures

Fig. 9 Microscopic morphologies of Sample C after the test for various normal pressures

CONCLUSIONS

In this study long-term (500 hours) environmental stress cracking resistance for various geonets under various normal pressures were evaluated. The conclusions are as follows:

1. ESCR property is one of the most critical parameters for evaluating long-term chemical resistance of HDPE geonets which used in hazardous landfill systems.

2. Traditional bi-planar geonets which have square type strand and tri-planar geonet have very strong chemical and stress cracking resistance even high normal pressure.

3. Cylindrical type bi-planar geonets is more rigid material than other samples and it is very week to environmental stress cracking with increasing normal pressure

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ATTACHMENT III.6.D

GEOSYNTHETIC CLAY LINER REFERENCE DOCUMENTATION

THE EFFECTS OF LEACHATE ON THE HYDRAULIC CONDUCTIVITY OF BENTOMAT®

Compatibility testing was performed to determine the effects of solid waste landfill leachate on the permeability of Bentomat over a prescribed time period. Testing was performed in accordance with United States Environmental Protection Agency (USEPA) Method 9100, as provided in SW846.

Hydration of specimens was conducted using de-aired tap water for approximately 48 hours. Saturation was also conducted using de-aired tap water until a minimum B value of 0.95 was achieved. Following hydration and saturation, baseline hydraulic conductivity was performed using water. After the baseline hydraulic conductivity was established, the permeant was switched to leachate. Testing continued for an additional 30 days to allow a sufficient number of pore volumes to permeate the specimen to establish a hydraulic conductivity with leachate.

Results show that the hydraulic conductivity of Bentomat was unaffected when permeated with this leachate.

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FINAL REPORT

LABORATORY TESTING OF BENTOMAT

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31 July 1991

2. TEST PROCEDURES

2.1 Task 1: EPA 9100 Compatibility Testing

Compatibility testing on the Bentomat was performed to measure the effect of leachate on the hydraulic conductivity of the mat product over a prescribed period of time. Testing was performed in accordance with the United States Environmental Protection Agency (USEPA) Method 9100 SW-846, Revision 1, 1987. The test conditions for Task 1 were as follows:

- Testing was conducted using flexible-wall triaxial permeameters, as shown in Photograph 2.1-1.
- Three replicate samples of the Bentomat were tested.
- Each sample was trimmed to a diameter of 2.8 in. (70 mm) and assembled in the following test configuration (from bottom to top): porous stone/filter paper/sand layer/Bentomat/sand layer/filter paper/porous stone.
- Hydration and saturation of the samples using de-aired tap water was conducted at an effective stress of 2.0 psi (14 kPa) for a time period of approximately 48 hours. Saturation was defined as a minimum Skempton's B-parameter of 0.95.
- Consolidation of the saturated test samples was performed at an effective stress of 5.0 psi (35 kPa). Pore-water displacement was monitored until primary consolidation was complete.
- To determine the baseline hydraulic conductivity, the samples were permeated using de-aired tap water. The average hydraulic gradient used for baseline permeation was approximately 50. For this testing program, initial hydration and saturation was

conducted using de-aired tap water. Hydration with leachate may or may not yield different results.

- After establishing the baseline hydraulic conductivity, the permeant was switched to the leachate. Because of the slow permeation rates and the objective to increase the volume of leachate in contact with the Bentomat, the sand layer was replaced on all samples by an Amoco 4516 geotextile after approximately three weeks of testing. Permeation of the samples with the leachate continued for an additional 30 days. The hydraulic conductivity of the sample was monitored and reported daily during this period.

- Permeation of the test specimens with the leachate was initially conducted at an average hydraulic gradient of approximately 50. In order to increase flow through the Bentomat during the prescribed time period, the average hydraulic gradient was increased to approximately 160.

- Because the final hydrated thickness of the Bentomat is unknown until the completion of testing and for comparison of the test data, the hydraulic conductivity was calculated using 0.4 in. (1.0 cm) for the Bentomat. These values were used in all calculations of hydraulic conductivity in Tasks 1 through 7.

TABLE 3.1-1

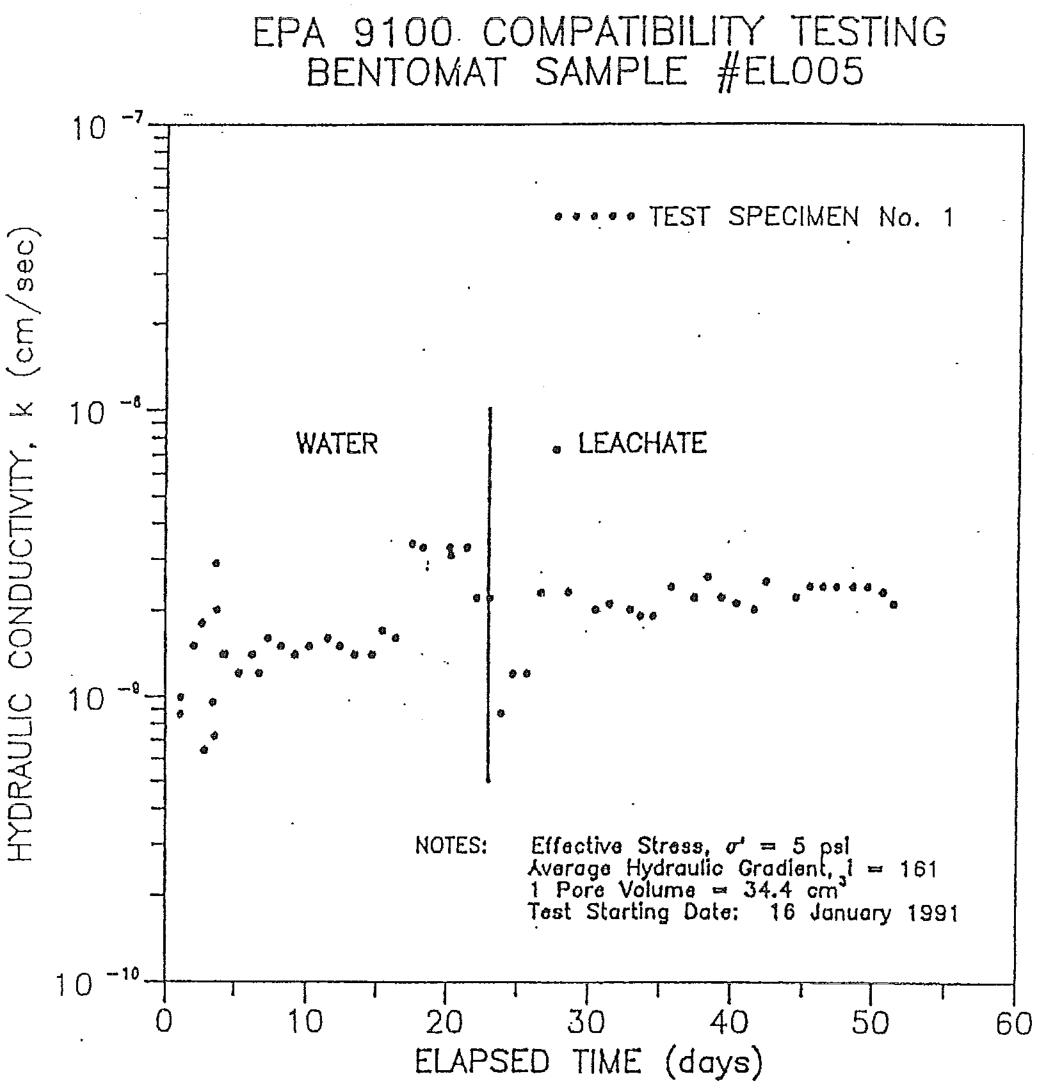
EPA 9100 COMPATIBILITY TESTING
BENTOMAT SPECIMEN CONDITIONS

American Colloid Company

Parameters	Specimen No. 1		Specimen No. 2		Specimen No. 3	
	Initial	Final	Initial	Final	Initial	Final
Thickness, in.	0.29	0.39	0.33	0.43	0.28	0.36
Diameter, in.	3.01	3.14	3.19	3.30	3.11	3.18
[1]Dry Mass, g	30.8	24.4	38.3	31.4	34.4	26.1
[2]Mass/Area, lb/ft^2	1.37	1.00	1.54	1.16	1.44	1.05
Water Content, %	18.8	170.1	15.7	169.4	10.9	167.4

Notes: [1] The dry mass includes the dry weight of the bentonite and the geotextiles bonded to the specimen.

[2] The mass/area is determined using the dry mass of the material normalized with respect to the cross-sectional area of the test specimen before drying.



GeoSyntec Consultants
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FIGURE NO.	3.1-1
PROJECT NO.	GL1614
DOCUMENT NO.	GEL91066
PAGE NO.	

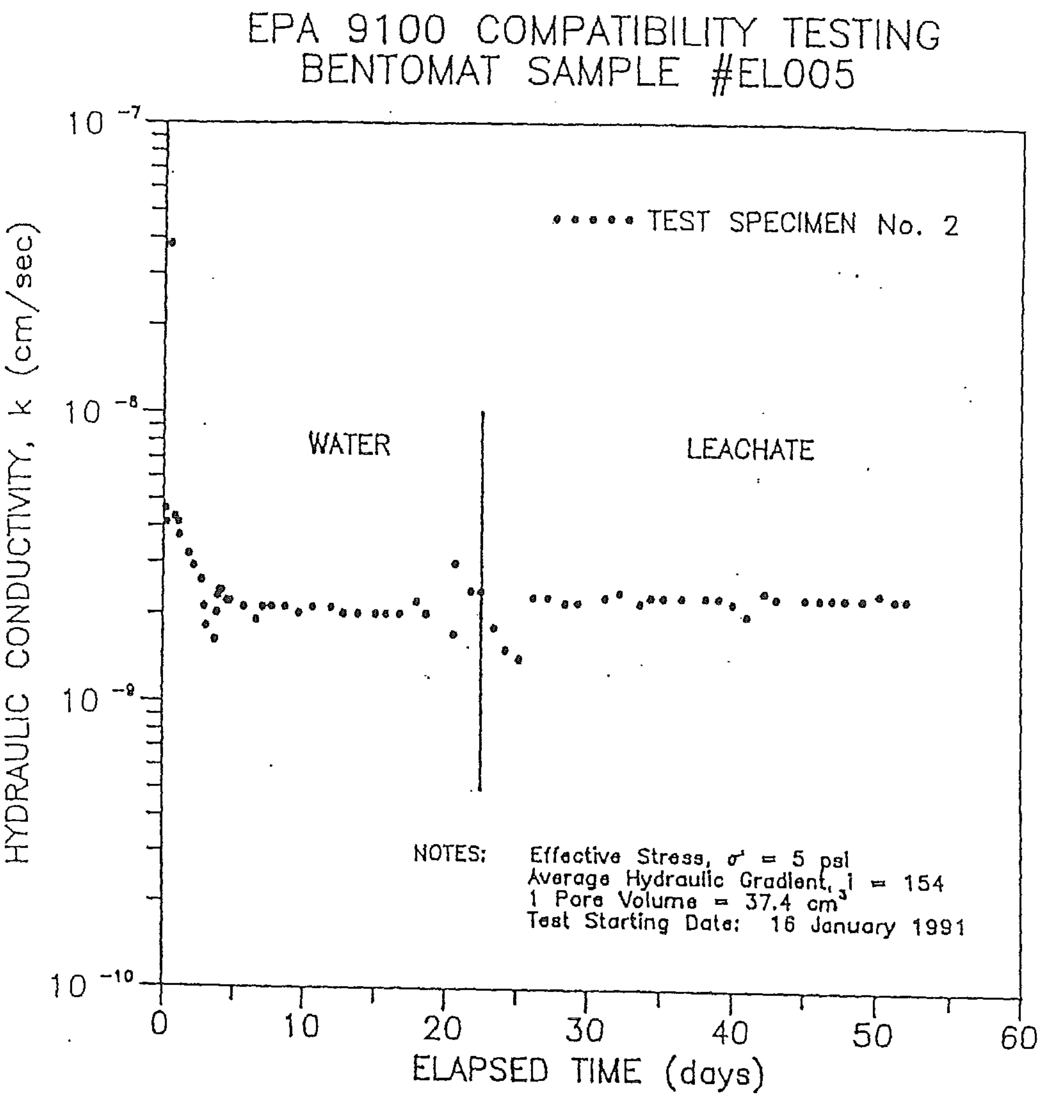

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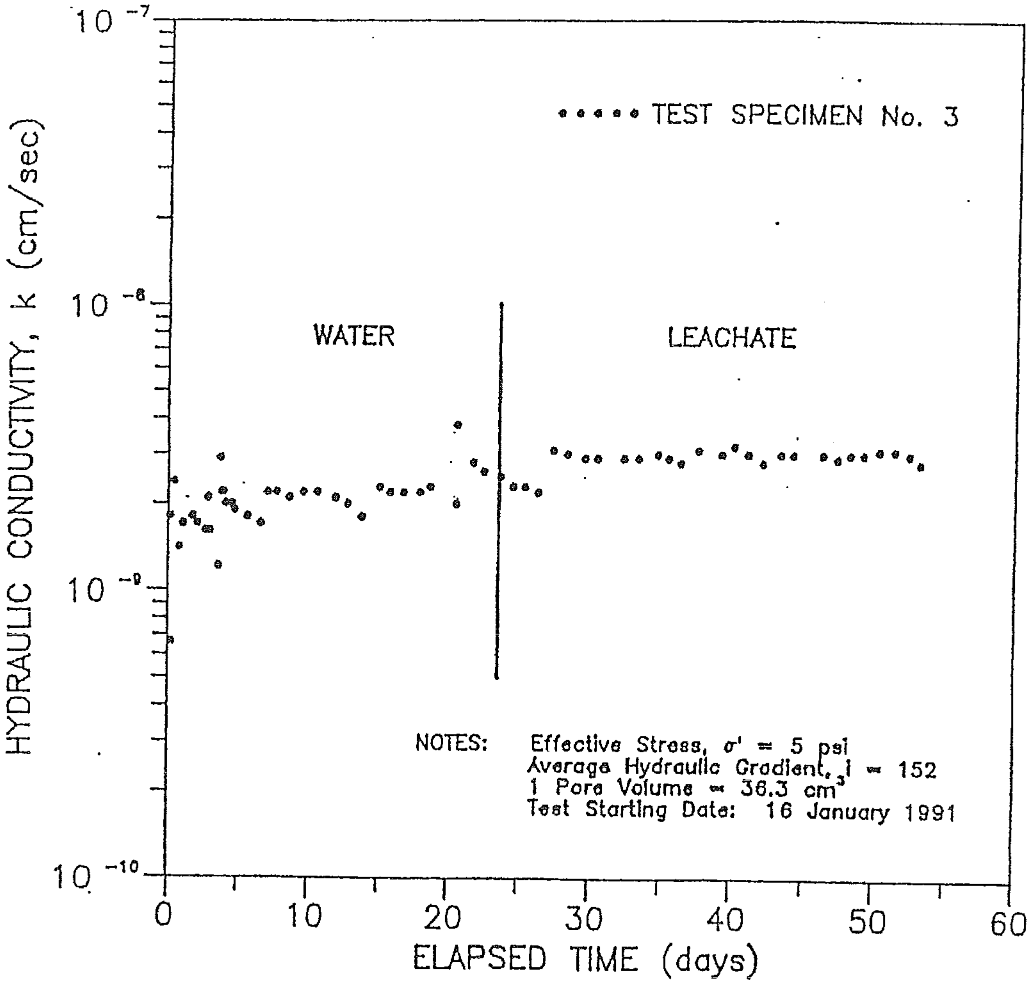
FIGURE NO.	3.1-2
PROJECT NO.	GL1614
DOCUMENT NO.	GEL91066
PAGE NO.	

EPA 9100 COMPATIBILITY TESTING
BENTOMAT SAMPLE #EL005



GeoSyntec Consultants

FIGURE NO.	3.1-3
PROJECT NO.	GL1614
DOCUMENT NO.	GEL91066

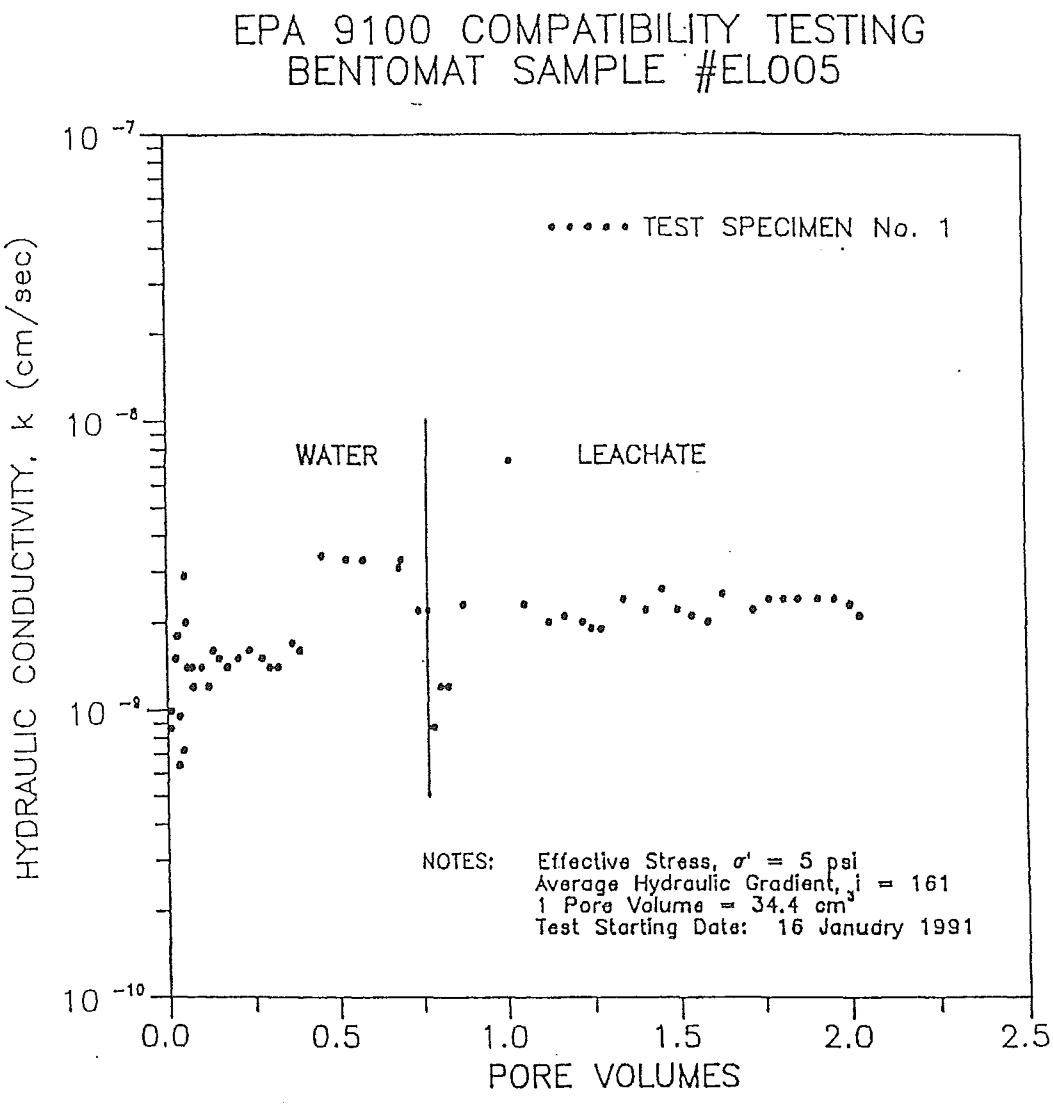


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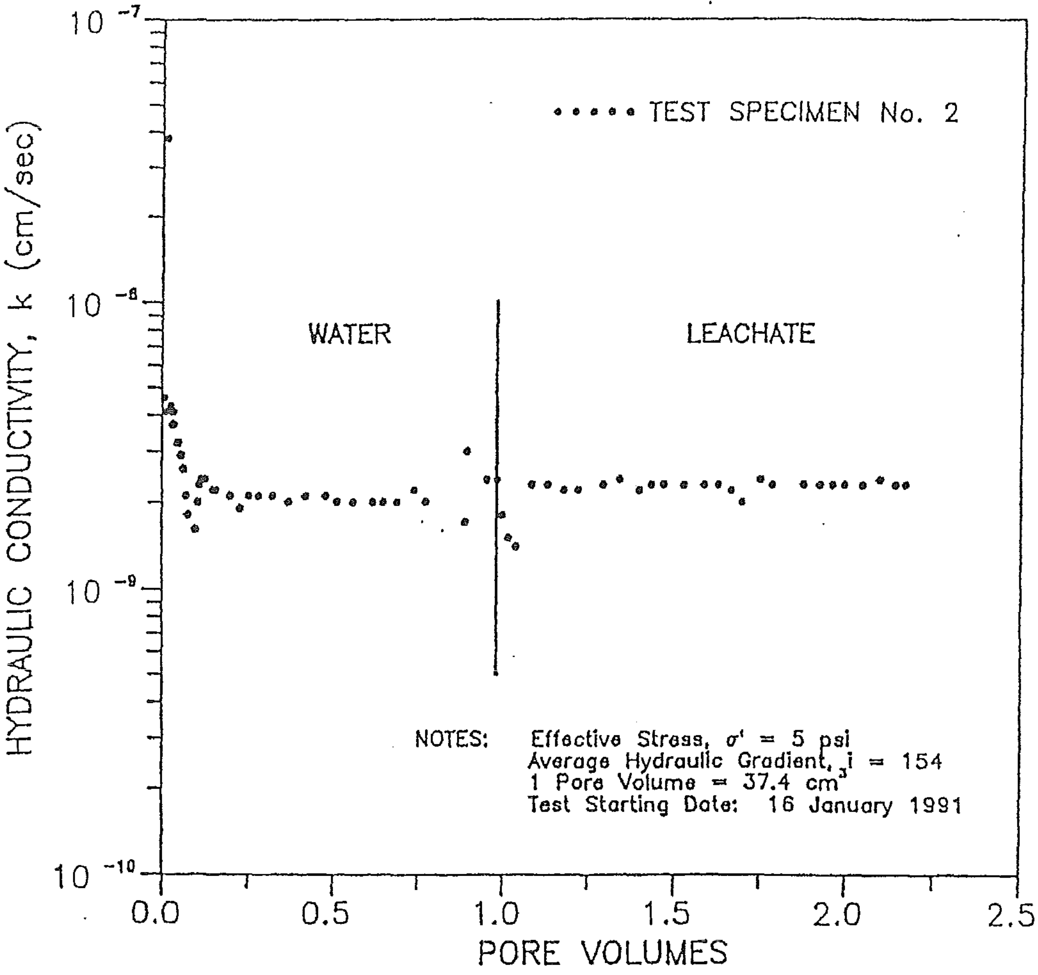
FIGURE NO.	3.1-4
PROJECT NO.	GL1614
DOCUMENT NO.	GEL91066
PAGE NO.	

EPA 9100 COMPATIBILITY TESTING
BENTOMAT SAMPLE #EL005



GEOSYNTEC CONSULTANTS
GEOMECHANICS AND ENVIRONMENTAL LABORATORY

FIGURE NO.	3.1-5
PROJECT NO.	GL1614
DOCUMENT NO.	GEL91066
PAGE NO.	

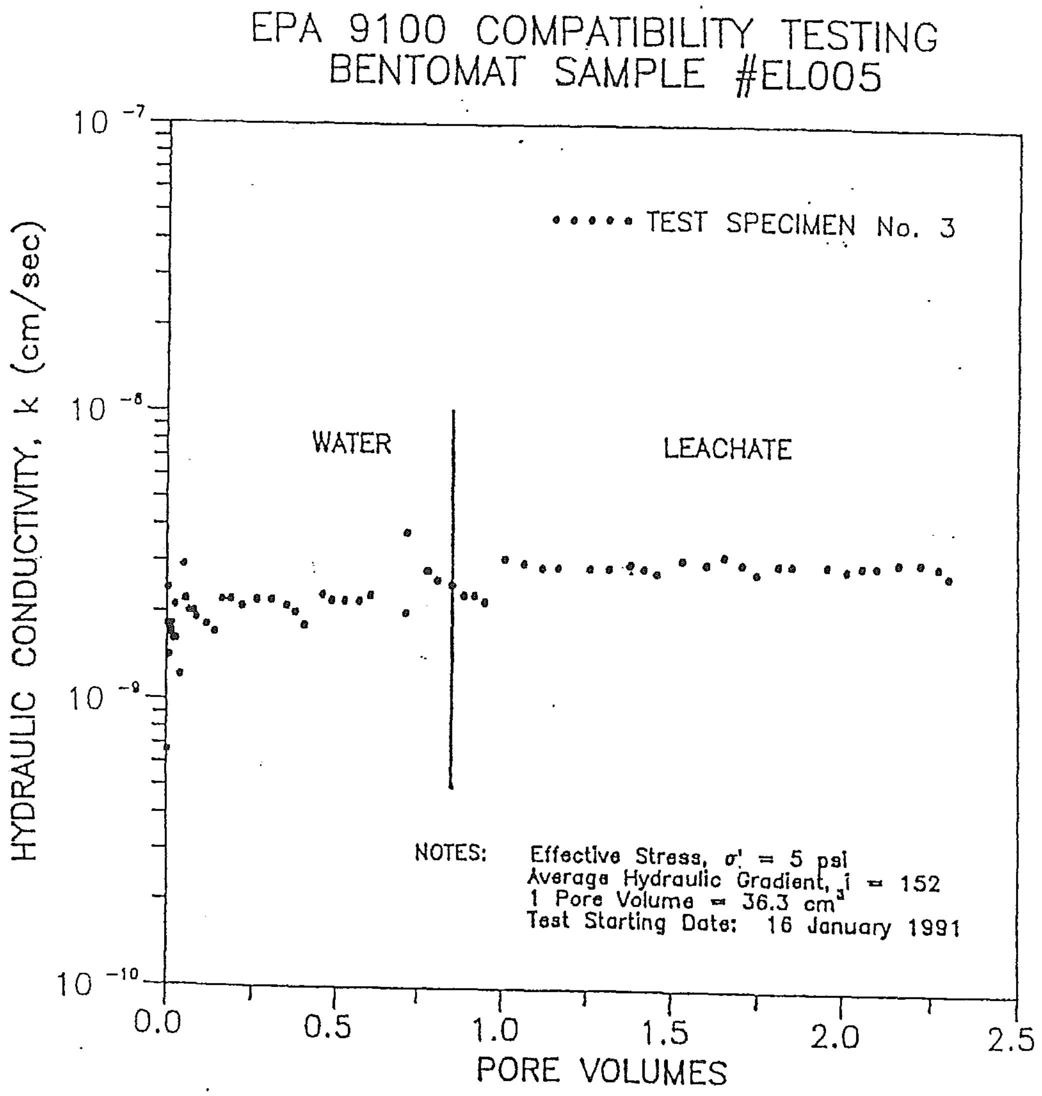


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FIGURE NO.	3.1-6
PROJECT NO.	GL1614
DOCUMENT NO.	GEL91066
PAGE NO.	

3.1 Task 1: EPA 9100 Compatibility Testing

3.1.1 Test Results

The physical conditions of the three Bentomat specimens, measured before and after the tests, are summarized in Table 3.1-1. Graphical presentations of the hydraulic conductivity as a function of elapsed time are presented in Figures 3.1-1, 2, and 3. Graphical presentations of the hydraulic conductivity as a function of the volume of liquid passed through the specimens (i.e., pore volumes) are presented in Figures 3.1-4, 5, and 6.

3.1.2 Observations

Because of the low hydraulic conductivity of the bentonite mat, and in order to maximize the volume of leachate through the mat, the sand layer in each test was replaced by an Amoco 4516 geotextile during that test. This generally occurred shortly before the permeant was switched from water to leachate. In many cases the data indicated erratic behavior for a short time after the switch, but the hydraulic conductivities eventually became consistent.

All specimens were initially permeated at a hydraulic gradient of 50. The resulting hydraulic conductivity measurements were somewhat variable. The hydraulic gradient was subsequently increased to 160 after approximately five days of testing. The test results tended to stabilize after the gradient increase. The average hydraulic gradients that were used for the remainder of each test after the initial increase gradient is indicated on each figure.

In all cases, the data presented in the tables show that each specimen swelled in thickness and in diameter, and that each specimen experienced an apparent loss of mass. The effluent water however, was not visibly cloudy in any of the tests.

In each figure, a transition from water to leachate is indicated. The variability in the test results near this transition is likely the result of disturbance due to leachate injection and removal of the sand layer. Within a short period of time, the test results stabilized.

BENCH-SCALE HYDRAULIC CONDUCTIVITY TESTS OF BENTONITIC BLANKET MATERIALS FOR LINER AND COVER SYSTEMS

by

PAULA ESTORNELL, B.S.C.E.

THESIS

Presented to the Faculty of the Graduate School of

The University of Texas at Austin

in Partial Fulfillment

of the Degree of

MASTER OF SCIENCE IN ENGINEERING

THE UNIVERSITY OF TEXAS AT AUSTIN

August, 1991

aid in maintaining a 6- to 9-in-wide overlap during installation.

2.1.2 Available Laboratory Test Data of the Hydraulic Properties of Bentomat®

2.1.2.1 Bentomat® Permeation with Water

J & L Testing Company (1990) conducted flexible-wall hydraulic conductivity tests on 6-in (150-mm) diameter samples of Bentomat® containing either untreated granular bentonite ("CS" grade) or high-contaminant-resistant bentonite ("SS" grade). Test conditions and results are summarized in Table 2.2. The duration of the tests was not reported. Figure 2.2 presents the relationship between hydraulic conductivity and maximum effective stress. Hydraulic conductivities ranged from 6 x 10^{-10} cm/s to 6 x 10^{-9} cm/s.

2.1.2.2 Bentomat® Permeation with Chemical Leachates

GeoSyntec Consultants (1991a) performed compatibility tests on Bentomat® in flexible-wall permeameters in order to measure the effect of landfill leachate on the alternative barrier material. Three 2.8-in (70-mm) diameter replicate samples were permeated first with de-aired water (under an effective stress of 2.0 psi (14 kPa) and a hydraulic gradient of about 50) and then with leachate (under an effective stress of

Table 2.2 Summary of Results of Hydraulic Conductivity Tests on Bentomat® (J&L Testing Company, 1990)

	Stress (psi)				Hydraulic Conductivity
Grade of Bentonite	Cell	Headwater	Tailwater	Maximum Effective	(cm/s)
High-Contaminant-Resistant ("SS")	50	42.2	41.8	8.2	2.1×10^{-9}
	50	44.6	39.4	10.6	7.5×10^{-10}
	50	47.2	36.8	13.2	5.8×10^{-10}
Untreated Granular Bentonite ("CS")	50	42.2	41.8	8.2	5.6×10^{-9}
	50	44.6	39.4	10.6	1.1×10^{-9}
	50	47.2	36.8	13.2	9.8×10^{-10}

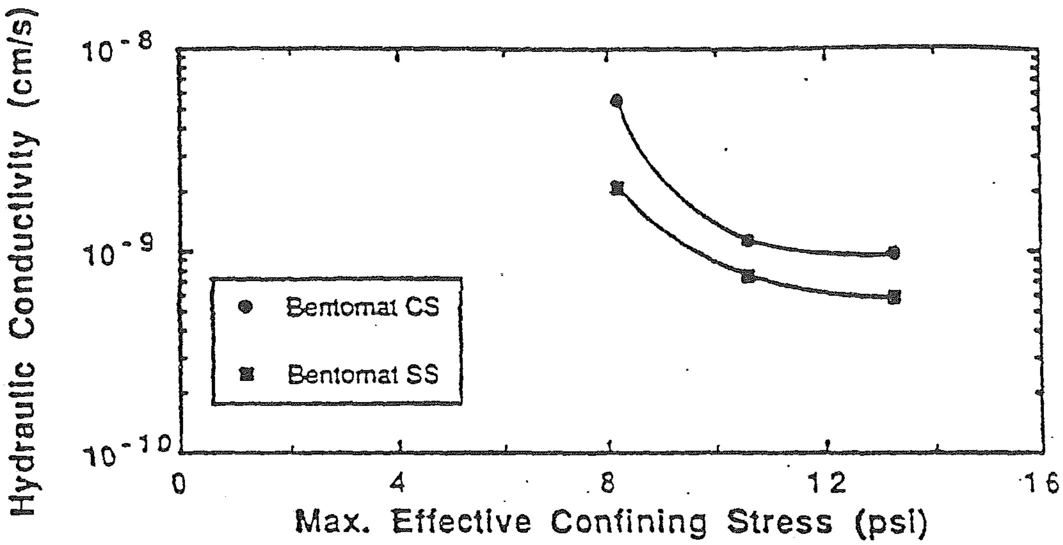

Fig. 2.2 Results of Flexible-Wall Hydraulic Conductivity Tests on Bentomat® (J&L Testing Company, 1990)

5.0 psi (35 kPa) and an average hydraulic gradient of approximately 160). The steady-state hydraulic conductivity, after two months of testing and 2.3 pore volumes of flow, was approximately 2 x 10^{-9} cm/s using the de-aired water and approximately 2.5 x 10^{-9} cm/s using the landfill leachate. The results seem to indicate that Bentomat® samples that have been hydrated first with de-aired water will have very little increase in hydraulic conductivity after the introduction of landfill leachate.

2.1.2.3 Effects of Desiccation on Bentomat®

GeoSyntec Consultants (1991a) conducted a flexible-wall hydraulic conductivity test on a 2.8-in (70-mm) sample of Bentomat® that had undergone 4 desiccation cycles. Each cycle involved first permeating the sample with de-aired water (using an effective stress of 5.0 psi (34 kPa) and an average hydraulic gradient of approximately 25) then desiccating the sample for two weeks in a 40°C (104°F) oven. This procedure was repeated 4 times. The steady-state hydraulic conductivity, measured after each cycle, ranged sporadically between 1 x 10^{-9} cm/s and 3 x 10^{-9} cm/s. The results show little effect of desiccation on the hydraulic conductivity of Bentomat®.

2.2.2 Available Laboratory Test Data on the Hydraulic Properties of Claymax®

2.2.2.1 Claymax® Permeation with Water

Literature published by the James Clem Corporation lists 2×10^{-10} cm/s as the hydraulic conductivity of Claymax® permeated with de-aired water. A summary of published measurements of the hydraulic conductivity of Claymax® to water is given in Table 2.4. Results are plotted in Fig. 2.5 in terms of hydraulic conductivity versus effective confining stress. The results show that the hydraulic conductivity to water varies from just under about 1×10^{-8} cm/s at low effective stress to just above 1×10^{-10} cm/s at high effective stress.

2.2.2.2 Claymax® Permeation with Various Liquid and Chemical Leachates

The information available concerning hydraulic conductivity of Claymax® permeated with liquids other than water is summarized in Table 2.5. All of the test specimens that were hydrated with water and then permeated with chemicals maintained a hydraulic conductivity $\leq 1 \times 10^{-8}$ cm/s, even for compounds such as diesel fuel and heptane that would normally be very aggressive to soil liner materials. Brown, Thomas, and Green (1984), for example, found that the

Table 2.4 Results of Hydraulic Conductivity Tests on Claymax® Permeated with Water

Source of Information	Permeameter	Backpressure Saturation?	Permeant Water	Diameter of Sample (in.)	Effective Stress (psi)	Hydraulic Conductivity (cm/s)
Clem Corp. Literature	- -	- -	Deaired Water	- -	- -	2×10^{-10}
Chen-Northern (1988)	Flex. Wall	Yes	- -	2.5	3.5	2×10^{-9}
GeoServices (1988a)	Flex. Wall	Yes	Deaired Tap Water	2.8	29	4×10^{-10}
GeoServices (1989c)	Flex. Wall	Yes	Deaired Tap Water	2.8	30	8×10^{-10}
GeoServices (1989c)	Flex. Wall	Yes	Deaired Tap Water	2.8	30	8×10^{-10}
GeoServices (1989c)	Flex. Wall	Yes	Deaired Tap Water	2.8	30	3×10^{-10}
GeoServices (1989c)	Flex. Wall	Yes	Deaired Tap Water	2.8	30	7×10^{-10}
Shan (1990)	Flex. Wall	No	Distilled Water	4.0	2	2×10^{-9}
Shan (1990)	Flex. Wall	No	Tap Water	4.0	2	2×10^{-9}
Shan (1990)	Flex. Wall	No	Distilled Water	4.0	5	1×10^{-9}
Shan (1990)	Flex. Wall	No	Tap Water	4.0	5	8×10^{-10}
Shan (1990)	Flex. Wall	No	Distilled Water	4.0	10	6×10^{-10}
Shan (1990)	Flex. Wall	No	Distilled Water	4.0	20	3×10^{-10}
Shan (Unpub.)	Flex. Wall	Yes	Tap Water	12	2	2×10^{-9}
GeoServices (1990b)	Flex. Wall	Yes	Deaired Water	- -	30	3×10^{-10}
GeoSyntec (1990a)	Flex. Wall	Yes	Deaired Water	- -	1.0	2×10^{-9}
GeoSyntec (1990a)	Flex. Wall	Yes	Deaired Water	- -	1.5	4×10^{-9}

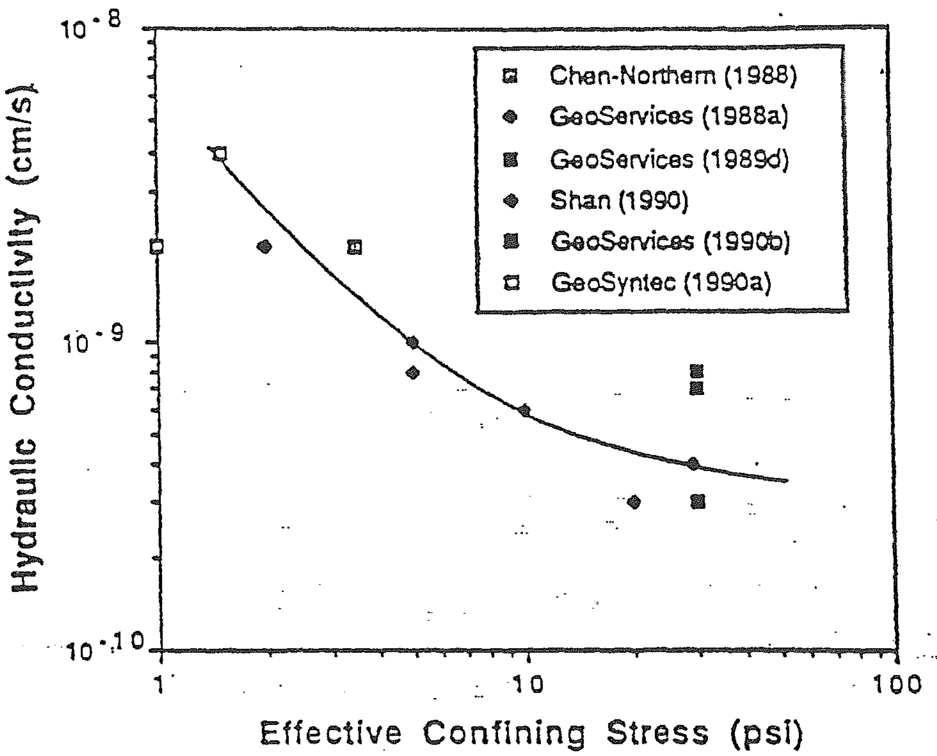

Fig. 2.5 Results of Hydraulic Conductivity Tests on Claymax® Permeated with Water

Table 2.5 Hydraulic Conductivity of Claymax® Permeated with Various Liquids

Source of Information	Permeant Liquid	Hydration Liquid	Pore Volumes of Flow	Effective Stress (psi)	Hydraulic Conductivity (cm/s)
STS Consultants (1988b)	Sewage Leachate	Sewage Leachate	- -	- -	8×10^{-10}
STS Consultants (1988c)	Paper Pulp Sludge	Paper Pulp Sludge	- -	- -	2×10^{-10}
GeoServices (1988b)	Simulated Seawater	Simulated Seawater	- -	30	2×10^{-10}
STS Consultants (1989a)	Landfill Leachate	Landfill Leachate	- -	- -	4×10^{-10}
STS Consultants (1989b)	Ash-Fill Leachate	Ash-Fill Leachate	- -	- -	1×10^{-10}
GeoServices (1989c)	Diesel Fuel	Water	1.5	30	9×10^{-10}
GeoServices (1989c)	Jet Fuel	Water	2.5	30	9×10^{-10}
GeoServices (1989c)	Unleaded Gasoline	Water	1.6	30	3×10^{-10}
Shan (1990)	50% (Vol) Methanol	Water	2.2	5	9×10^{-10}
Shan (1990)	Heptane	Water	0.2	5	1×10^{-10}
Shan (1990)	Sulfiric Acid	Water	3.1	5	6×10^{-11}
Shan (1990)	0.01 N $CaSO_4$	Water	2.2	5	1×10^{-9}
Shan (1990)	0.5 N $CaCl_2$	Water	2.4	5	8×10^{-9}
Shan (Unpublished)	50% (Vol) Methanol	50% Methanol	4	5	5×10^{-6}
Shan (Unpublished)	Methanol	Methanol	5.4	5	3×10^{-5}
Shan (Unpublished)	Heptane	Heptane	4.3	5	5×10^{-5}
GeoServices (1990a)	Methyl Tertiary Butyl Ether	Deaired Water	1.6	30	7×10^{-10}
Klohn Leonoff (1990)	Solution from Goldmine	Solution from Goldmine	1.8	17.4	2×10^{-10}
GeoSyntec (1991b)	Landfill Leachate	Deaired Water	1.7	5	3×10^{-9}

hydraulic conductivity of a compacted, micaceous soil was 1 to 4 orders of magnitude higher to kerosene, diesel fuel, and gasoline than it was to water. The inconsistency of results reported in Table 2.5 to the research conducted by Brown and his co-workers may be related to either a small cumulative pore volumes of flow in the tests on Claymax® or application of a high compressive stress to the test specimens. The cumulative pore volumes of flow of permeant liquid was not reported in many of the test referenced in Table 2.5; in many cases, there was probably an insufficient quantity of flow to determine the full effects of the permeant liquids. In some tests, a large effective confining stress was used. Broderick and Daniel (1990) found that one compacted clay was vulnerable to significant alterations in hydraulic conductivity when compressive stresses were ≤ 5 - 10 psi (34 - 69 kPa) but did not undergo an increase in hydraulic conductivity when the specimens were permeated with compressive stresses larger than 5 to 10 psi (34 to 69 kPa). Brown and his co-workers applied no compressive stress to their test specimens.

Tests on specimens of Claymax® that were hydrated with the same liquid as the eventual permeant liquid (rather than water) showed mixed results. For leachates, a paper pulp sludge, and simulated seawater, the hydraulic conductivity was found to be < 1×10^{-9} cm/s. However, the significance of these results is questionable because the duration of the tests was short, the cumulative pore volumes of flow was not reported, and the applied compressive stress was not reported. In as-yet unpublished tests by Shan, markedly different results were obtained when Claymax® was not prehydrated with water. Shan found that when dry Claymax® was permeated directly with a 50% mixture of water and methanol, with pure methanol, or with heptane, the bentonite did not hydrate even after several pore volumes of flow, and the hydraulic conductivity did not drop below 1 x 10^{-6} cm/s. Shan used a compressive stress of 5 psi (34 kPa). Thus, with concentrated organic liquids, the conditions of hydration appear to play an important role in determining the ability of the bentonitic blanket to resist the deleterious action of organic chemicals. The bentonite appears to be more chemically resistant if hydrated with fresh water before exposure to concentrated organic chemicals.

2.2.2.3 Effects of Desiccation on Claymax®

The effects of desiccation were investigated by GeoServices (1989d). Three hydrated samples of Claymax® were placed in a temperature- and humidity-controlled chamber. The chambers operated on a timed cycle to simulate day and night conditions. The temperature and humidity during thick HDPE geomebrane, was the material tested during this study.

2.3.2 Available Laboratory Test Data of the Hydraulic Properties of Paraseal and Gundseal

2.3.2.1 Paraseal Permeation with Water

Pittsburgh Testing Laboratory (1985) conducted a hydraulic conductivity test on a 2.5-in (64-mm) diameter sample of Paraseal. A 15-ft (4.6-m) head of water was applied to the sample, which was soaked for 5 days prior to permeation. A single, falling-head test was performed, which yielded a hydraulic conductivity reported to be 4 x 10^{-10} cm/s. Further details of the test procedures are not available. However, because the direction of flow was apparently through the HDPE membrane, the test may have provided a measure of sidewall leakage rather than flow through the material.

2.3.2.2 Gundseal Permeation with Chemical Leachates

The hydraulic conductivity of Gundseal permeated with landfill leachate was measured by GeoSyntec Consultants (1991c). A grid of 0.12-in (3-mm) diameter holes on 0.3 in (0.75 cm) centers were drilled into the Gundseal test samples in order to effectively test the bentonite portion of the Gundseal product. Three 2.8-in (70-mm) diameter samples were placed in flexible-wall permeameters and subjected to an effective stress of 5.0 psi (35 kPa). The test specimens were permeated, first with de-aired water then with leachate. The average hydraulic gradient applied during permeation with de-aired water was 50. The hydraulic gradient was increased to 230 during permeation with the leachate in order to increase flow through the Gundseal. The average hydraulic conductivity of the punctured Gundseal specimens was 1 x 10^{-9} cm/s for both the de-aired water and the leachate after approximately 1.2 pore volumes of flow. The hydraulic conductivity of the prehydrated bentonite appeared unaffected by the introduction of the leachate.

2.3.2.3 <u>Effects of Desiccation on Gundseal</u>

GeoSyntec Consultants (1991c) measured the hydraulic conductivity of a sample of Gundseal that had undergone 4 desiccation cycles. The 2.8-in (70-mm) diameter sample was punctured with small holes in the same grid pattern as the samples described previously. The test sample was permeated with de-aired water in a flexible-wall permeameter under an effective stress of 5.0 psi (34 kPa) and an average hydraulic gradient of 215 in order to determine hydraulic conductivity. The sample was removed from the permeameter, subjected to a 0.4 psi (3 kPa) confining stress, and placed in an oven for two

2.5 Summary of Hydraulic Properties of Bentomat®, Claymax®, and Paraseal/Gundseal

Table 2.10 is an abridged summary of the hydraulic conductivity data of Bentomat®, Claymax®, and Paraseal/Gundseal. The table includes results from tests conducted by GeoSyntec (1991a,b,c), GeoSyntec (1990b), and Shan (1990). Results from hydraulic conductivity tests conducted by other laboratories have not been included in Table 2.10 in order to present the information in a simplified and consise form.

Table 2.10 Summary of Hydraulic Conductivity Tests on Bentomat®, Claymax®, and Paraseal/Gundseal

Sample	Bentomat® Reference	Bentomat® Effective Stress (psi)	Bentomat® Hydraulic Conductivity (cm/s)	Claymax® Reference	Claymax® Effective Stress (psi)	Claymax® Hydraulic Conductivity (cm/s)	Paraseal/Gundseal Reference	Paraseal/Gundseal Effective Stress (psi)	Paraseal/Gundseal Hydraulic Conductivity (cm/s)
Sample Permeated with Desired Water	GeoSyntec (1991a)	2.0	2.0×10^{-9}	GeoSyntec (1991b)	2.0	1.8×10^{-9}	GeoSyntec (1991c)	5.0	1×10^{-9}
Sample Permeated with Landfill Leachate	GeoSyntec (1991a)	5.0	2.5×10^{-9}	GeoSyntec (1991b)	5.0	2.8×10^{-9}	GeoSyntec (1991c)	5.0	1×10^{-9}
Deslocated Sample	GeoSyntec (1991a)	5.0	1.0×10^{-9} to 3.0×10^{-9}	Shan (1990)	2.0	2.0×10^{-9}	GeoSyntec (1991c)	5.0	5.0×10^{-10} to 2.0×10^{-9}
Freeze-Thaw Sample	GeoSyntec (1991a)	5.0	1.0×10^{-9} to 6.0×10^{-9}	Shan (1990)	2.0	2.2×10^{-9}	GeoSyntec (1991c)	- -	1.0×10^{-9}
Damaged Sample									
1-in diameter hole	GeoSyntec (1991a)	- -	1.3×10^{-4}	Shan (1990)(1)	2.0	5.0×10^{-9}	GeoSyntec (1991c)	- -	1.0×10^{-3}
2-in diameter hole		- -	1.7×10^{-4}		- -	- -		- -	1.0×10^{-3}
3-in long slit		- -	3.0×10^{-5}		- -	- -		- -	1.0×10^{-3}
Composite Sample	GeoSyntec (1991a)	- -	3.0×10^{-9}	Shan (1990)	2.0	4.0×10^{-9}	GeoSyntec (1991c)	- -	2.0×10^{-9}
Overlapped Seam Sample	GeoSyntec (1991a)	- -	5.0×10^{-7} to 2.0×10^{-5}	GeoSyntec (1990b)	1.0	2.0×10^{-9}	GeoSyntec (1991c)	- -	5.0×10^{-8}

(1) The damaged Claymax® sample tested by Shan (1990) was punctured with 3 - 1 inch diameter holes.

Report

. roject

HYDRAULIC CONDUCTIVITY AND
COMPATIBILITY TESTING OF CLAYMAX
BALTIMORE COUNTY LANDFILL PROJECT
TOWNSON, MARYLAND

Client

CLEM ENVIRONMENTAL CORPORATION
444 NORTH MICHIGAN AVENUE, SUITE 1610
CHICAGO, IL 60611

Project # 25868-XH

Date MAY 11, 1989

STS Consultants Ltd.
Consulting Engineers
111 Pfingsten Road

HYDRAULIC CONDUCTIVITY AND COMPATIBILITY TESTING OF CLAYMAX
BALTIMORE COUNTY LANDFILL PROJECT
TOWNSON, MARYLAND

SCOPE OF SERVICES

STS was to perform two hydraulic conductivity tests on sections of Claymax liner material in conjunction with a six inch sand layer utilizing leachates as the hydration medium and the permeants. The Claymax specimens were supplied to STS by Clem Environmental and the leachate specimens were obtained from L.A. Solamen. Inc. All testing materials were delivered to our Northbrook Testing Facility.

Test Equipment

The equipment used in the compatibility study was a triaxial compression permeameter. This equipment incorporates the use of a flexible membrane, preventing sidewall seepage. back pressure to facilitate specimen saturation small diameter burettes making measurement of small volumes of collected permeant possible and the system is closed preventing the permeant from being exposed to the surrounding air.

Specimen Construction

Each of the specimens, utilized throughout the testing program, consisted of an approximately six inch cylindrical column of silica sand on top of which a circular section of Claymax was placed. The orientation of the Claymax to the sand provided for permeant flow initiated through the sand followed by the Claymax section. The directional flow of the permeant. is similar to those conditions found in the field applications.

Once the specimens were assembled, a flexible rubber membrane was used to encase the specimens while sealed in the triaxial permeameter chamber.

Test Procedures

After its initial construction and placement in a triaxial compression permeameter each of the specimens is backpressure saturated. To aide in specimen saturation, carbon dioxide gas was allowed to flow freely through the test specimen, inundating the voids in the sand and dry Claymax. The use of this carbon dioxide gas has been accepted as a procedure to aide in specimen saturation. The carbon dioxide gas will go into solution more readily than normal atmospheric air. Once it was determined that the carbon dioxide gas had completely inundated the voids of the test specimen, the permeants were allowed to free flow through the test specimen first saturating the silica sand and then the Claymax section. For this study, the leachates were utilized both as a set hydrating medium and as the actual permeant for the hydraulic conductivity determination.

Two leachates were used during the study. The first was labeled Parkton Landfill and the second labeled as Eastern Sanitary Landfill. It is the understanding of STS Consultants that the two leachates were a municipal landfill leachate and contained such things as heavy metals, phenals, cyanide, copper, phosphorus and other substances.

Once the leachate had fully hydrated the test specimen, the specimen was allowed to stand for a 24 hour hydration period. Following the hydration period, the backpressure saturation techniques were implemented to complete the saturation procedures. This was accomplished by simultaneously increasing the cell and back pressures in increments while maintaining a pressure differential of 0.125 kilograms per square centimeter (KSC). Pressures were incrimentally increased until obtaining testing pressures of 4.125 KSC cell pressure and 4.00 KSC back pressure.

Specimen saturation was considered complete when a Skempton's Pore Pressure B-parameter of 0.95 or greater was obtained. The "B" parameter is simply a ratio of an increase in pore water pressure to a simultaneous increase in confining pressure. When full specimen saturation was determined, permeant flow was initiated through the bottom of the test specimen, allowed to flow through the top of the test specimen and collect in a calibrated burette. The test was performed utilizing two separate gradients. The initial gradient consisted of an application of a hydraulic head of one foot. The second gradient was applied as a hydraulic head equivalent to 35 feet.

During the entire test, permeant volume versus time measurements were recorded and the hydraulic conductivity of the test specimen at the two gradients was determined. The test was allowed to continue until it had been determined that a minimum of three pore volumes of pore fluid had passed through the test specimen. Once this had occurred and steady state flow had been established, the test was terminated.

Laboratory Test Results

As a result of the testing as outlined above, the Claymax section utilizing the Parkton Landfill Leachate, as the permeant, obtained hydraulic conductivity values of 2×10^{-10} centimeters per second (cm/sec) for a hydraulic head of one foot and 4×10^{-10} cm/sec for a hydraulic head of 35 feet. The Claymax section exposed to the Eastern Sanitary Landfill leachate obtain hydraulic conductivity values of 3 x 10 -10 cm/sec utilizing a hydraulic head of 1 foot and 4×10^{-10} cm/sec utilizing a hydraulic head of 35 feet. A summary of specific specimen characteristics and final hydraulic conductivity values is attached to this report.

STS Consultants Ltd.

STS PROJECT NO. 25868-XH

PROJECT Baltimore County Landfill Project

DATE 4-24-89

SUMMARY OF HYDRAULIC CONDUCTIVITY TESTS

Permeant	Parkton Landfill	Eastern Sanitary Landfill
Sample No.	1	2
Classification	Claymax with 6" Silica Sand	Claymax with 6" Silica Sand
[illegible]y Unit [illegible]ght (pcf)	51.6	62.5
Water Content (%)	Dry	Dry
Diameter (cm)	7.028	7.026
Length (cm)	0.568	0.616
Saturation B Value	0.97	0.99
Hydraulic Conductivity k (cm/sec)	1 ft. 2×10^{-10} 35 ft. 4×10^{-10}	1 ft. 3×10^{-10} 35 ft. 4×10^{-10}

Rev: 12/87

BALTIMORE COUNTY
WASTEWATER MONITORING AND ANALYSIS DIVISION
INDUSTRIAL DISCHARGE CONTROL PROGRAM

Dennis F. Rasmussen
County Executive

SAMPLING/ANALYSIS FORM

Sample No.: 9 01110

Industry Name: EASTERN SANITARY LANDFILL Facility No.:

Address: Days Cove Road

Telephone: Requested by: P. Phillips

Sampling Site Location: Leachate pit

Special Instructions: STD 5, metals, Total alkalinity & Chlorides

FIELD

Date and Time of Sampling: Start 1/18/89 10:20 a.m. Finish

Sampled by: P. Phillips, T.E. Ryan

Type of Sample: Grab

Sampler Settings: N/A

Sample Characteristics: 1 quart; dark gray; 1 quart; dark brown

Preservatives Added: Cooled with ice

Comments and Observations:

Delivered to Lab by: PP, TER Date: 1/18/89 Time: 11:50 a.m.

LABORATORY

Sample received by: WP Date: 1/18/89 Time: 11:50 a.m.

Characteristics of Note:

(Origin of Seed: Polyseed)

ANALYTICAL RESULTS

Code	BDL	Parameter	Conc. (mg/L)	Code	BDL	Parameter	Conc. (mg/L)
		pH	6.3	3011	0.05	Ni (Nickel)	BDL
		BOD	122 mg/L	3015	0.01	Zn (Zinc)	0.05 mg/L
		COD	148 mg/L	3130		Phenols	
		TSS	125 mg/L	3013	0.01	Silver	BDL
5012		FOG - A&V					
5013		FOG - Petr		*		GRAB pH	
2026		P(Phosphorus)	2.52 mg/L				
3006	0.01	Cd(Cadmium)	BDL			Total Fe	3.88 mg/L
3007	0.05	Cr(Chromium)	BDL			Total alkalinity	350 mg/L
3008	0.02	Cu(Copper)	0.04 mg/L			Chloride	80 mg/L
4		Cn(Cyanide)					
3009	0.10	Pb (Lead)	0.36 mg/L				

Dennis F. Rasmussen
County Executive

Rev: 12/87

BALTIMORE COUNTY
WASTEWATER MONITORING AND ANALYSIS DIVISION
INDUSTRIAL DISCHARGE CONTROL PROGRAM
SAMPLING/ANALYSIS FORM

Sample No.: 9 02104

Industry Name: PARKTON Facility No.:

Address:

Telephone: Requested by: R. Much

Sampling Site Location: Cell 03

Special Instructions: pH, BOD, COD, TSS, Alkalinity, Chloride, Metals

FIELD

Date and Time of Sampling: Start 2/9/89 Finish

Sampled by: R. Much, B. Kramer

Type of Sample: Grab

Sampler Settings:

Sample Characteristics:

Preservatives Added:

Comments and Observations:

Delivered to Lab by: BK, RM Date: 2/9/89 Time: 2:20 P.M.

LABORATORY

Sample received by: WP Date: 2/9/89 Time: 2:20 P.M.

Characteristics of Note:

(Origin of Seed: Polyseed)

ANALYTICAL RESULTS

Code	BDL	Parameter	Conc. (mg/L)	Code	BDL	Parameter	Conc. (mg/L)
		pH	6.1	3011	0.05	Ni (Nickel)	1.44 mg/L
		BOD	38,888 mg/L	3015	0.01	Zn (Zinc)	5.45 mg/
		COD	60,831 mg/L	3130		Phenols	
		TSS	691 mg/L	3013	0.01	Silver	0.03 mg/L
3012		FOG - A&V					
3013		FOG - Petr		*		GRAB pH	
3026		P(Phosphorus)	interference				
3006	0.01	Cd(Cadmium)	0.10 mg/L			Total Fe	736.00 mg/L
3007	0.05	Cr(Chromium)	0.22 mg/L			Total alkalinity	15,000 mg/L
3008	0.02	Cu(Copper)	0.17 mg/L			Chloride	1,500 mg/L
3002		Cn(Cyanide)					
3009	0.10	Pb (Lead)	0.60 mg/L				

APPLICATION FOR PERMIT
OWL LANDFILL SERVICES, LLC

VOLUME III: ENGINEERING DESIGN AND CALCULATIONS
SECTION 6: GEOSYNTHETICS APPLICATION AND COMPATIBILITY DOCUMENTATION

ATTACHMENT III.6.E

HDPE PIPE REFERENCE DOCUMENTATION

Chemical Resistance of Plastics and Elastomers Used in Pipeline Construction

1. Introduction

It is now inconceivable to construct pipelines without the use of plastics. Pipes made from plastics are used not only for drinking water, water for general use and waste water, but also for the conveyance of aggressive liquids and gases. Expensive pipe materials such as lined metal, ceramic or glass, have been largely superseded by plastic pipes. It is, however, important that the most suitable plastic material is selected for each application. This "Chemical Resistance List" serves as a useful guide in this respect. The list is periodically revised to include the latest findings. It contains all plastics and elastomers in the George Fischer product range which can come into direct contact with the media.

The information is based on experiments, immersion and, when available, on data from tests which include temperature and pressure as stress factors. The results achieved in immersion experiments cannot be applied without reservation to pipes under stress, i.e. internal pressure, as the factor "stress corrosion cracking" is not taken into consideration. In certain cases it can be of advantage to test the suitability under the planned working conditions. The tests referred to have been carried out partly by George Fischer and partly by the International Standardization Organization (ISO) or national standards organizations.

Pure chemicals were used for the tests. If a mixture of chemicals is to be conveyed in practice this may affect the chemical resistance of the plastic. It is possible in special cases to carry out appropriate tests with the specific mixture. Suitable test equipment is available at George Fischer for this purpose, which we regard as part of our service to the customer. It goes without saying that we are willing to give individual advice at any time. In this connection it is worth mentioning that George Fischer already possesses information concerning the behavior towards plastics of a number of chemicals or mixtures of chemicals which are not yet included in this list. The "Chemical Resistance List" gives valuable assistance in the planning of plastic pipelines. Please refer to the following instructions, which are important for the application and evaluation of this list.

2. Instructions for the Use of the Chemical Resistance List

2.1 General

As stated in the introduction, the "Chemical Resistance List" is only intended as a guide. Changes in the composition of the medium or special working conditions could lead to deviations. If there is any doubt, it is advisable to test the behavior of the material under the specific working conditions, by means of a pilot installation. No guarantees can be given in respect of the information contained in this booklet. The data shown is based upon information available at the time of printing, but it may, however, be revised from time to time in the light of subsequent research and experience.

2.2 Classification

The customary classifications: **resistant, conditionally resistant** and **not recommended** are depicted by the signs: +, O, and –, which allow simple presentation and application. These classifications are defined as:

Resistant: +
Within the acceptable limits of pressure and temperature the material is unaffected or only insignificantly affected.

Conditionally Resistant: O
The medium can attack the material or cause swelling. Restrictions must be made in regard to pressure and/or temperature, taking the expected service life into account. The service life of the installation can be noticeably shortened. Further consultation with George Fischer is recommended.

Not recommended: –
The material cannot be used with the medium at all, or only under special conditions.

(Courtesy George Fischer Engineering Handbook)

2.3 Pipe Joints

2.3.1 Solvent Cement Joints (PVC)

Solvent cement joints made with standard PVC cement and primer systems are generally as resistant as the PVC material itself. The following chemicals are, however, an exception:

- Sulphuric acid H_2SO_4 in concentrations above 70 percent
- Hydrochloric acid HCl in concentrations above 25 percent
- Nitric acid HNO_3 in concentrations above 20 percent

Hydrofluoric acid in any concentration
In conjunction with the above media the solvent cement joining is classified as "conditionally resistant". Previously recommended solvent cement (Dytex, by Henkel, Germany) used for pipe and fittings to carry concentrated acids, can no longer be brought into the United States because of its methylene chloride solvent system being classified as a carcinogen. There is no known domestically available substitute. Special consideration should be given to the possible attack of the cemented joints by these concentrated acids.

2.3.2 Fusion Joints

In the case of PE, PP, and PVDF (SYGEF®) heat fusion joints have practically the same chemical resistance as the respective material. In conjunction with media which could cause stress cracking, the fused joints can be subjected to an increased risk due to residual stress from the joining process.

2.4 Sealing Materials

Depending upon the working conditions and the stress involved, the life span of the sealing materials can differ from that of the pipeline material. Seals in PTFE, which are not included in this list, are resistant to all the chemicals indicated. The greater permeability of PTFE should, however, be considered. Under certain working conditions, for example when conveying highly aggressive media such as hydrochloric acid, this material characteristic must be taken into account.

2.5 General Summary and Limits of Application

The following table includes all the materials contained in the George Fischer product range, and their abbreviations. The summary gives preliminary information regarding the general behavior of the materials and the temperature limits.

2.6 Standards

This list has been compiled with reference to the following ISO standards:
ISO/TR 7473
Unplasticized polyvinyl chloride pipes and fittings – Chemical resistance with respect to fluids.
ISO/TR 7474
High density polyethylene pipes and fittings – Chemical resistance with respect to fluids to be conveyed.
ISO/TR 7471
Polypropylene (PP) pipes and fittings – Chemical resistance with respect to fluids.
ISO TR 10358
Plastic pipes and fittings – Combined chemical resistance classification table.
DVS 2205 Part I
Calculations for thermoplastic containers and appliances.
DIN 8080 Supplement 1 «Pipes of chlorinated polyvinyl chloride (PVC-C), PVC-C 250 – Chemical Resistance».

(Courtesy George Fischer Engineering Handbook)

Material	Abbreviation	Remarks	Maximum Permissible Temperature (Water) °C	
			Constant	Short Term
Polyvinyl Chloride	PVC	Resistant to most solutions of acids, alkalis and salts and to organic compounds miscible with water. Not resistant to aromatic and chlorinated hydrocarbons	60°	60°
Chlorinated Polyvinyl Chloride	CPVC	Can be used similarly to PVC but at higher temperatures. Consult factory for specific applications.	90°	110°
High-density Polyethylene	PE 50	Resistant to hydrous solutions of acids, alkalis and salts as well as to a large number of organic solvents. Unsuitable for concentrated oxidizing acids.	60°	80°
Polypropylene, heat stabilized	PP	Chemical resistance similar to that of PE but suitable for higher temperatures	90°	110°
Polyvinylidene Fluoride	PVDF (SYGEF®)	Resistant to acids, solutions of salts, aliphatic, aromatic and chlorinated hydrocarbons, alcohols and halogens. Conditionally suitable for ketones, esters, organic bases and alkaline solutions	140°	150°
Polybutylene-1	PB	Similar to PE 50, but can be used up to 90°C	90°	100°
Polyoxymethylene	POM	Resistant to most solvents and hydrous alkalis. Unsuitable for acids	60°	80°
Polytetrafluoroethylene (e.g. Teflon®)	PTFE	Resistant to all chemicals in this list	250°	300°
Nitrile Rubber	NBR	Good resistance to oil and petrol. Unsuitable for oxidizing media	90°	120°
Butyl Rubber Ethylene Propylene Rubber	IIR EPDM	Good resistance to ozone and weather. Especially suitable for aggressive chemicals. Unsuitable for oils and fats	90°	120°
Chloroprene Rubber (e.g. Neoprene®)	CR	Chemical resistance very similar to that of PVC-U and between that of Nitrile and Butyl Rubber	80°	110°
Fluorine Rubber (e.g. Viton®)	FPM	Has best chemical resistance to solvents of all elastomers	150°	200°
Chlorine Sulphonyl Polyethylene (e.g. Hypalon®)	CSM	Chemical resistance similar to that of EPDM	100°	140°

®Registered trade name

The abbreviations listed below are found throughout the listings and have the following definition:

Q/E (Quellung/Erweichung) = swelling/softening
D/P (Diffusion/Permeation) = diffusion/permeation
SpRB (Spannungsrissbildung) = environmental stress cracking

(Courtesy George Fischer Engineering Handbook)

Aggressive Media					Chemical Resistance											
Medium	Formula	Boiling point °C	Concentration	Temperature °C	PVC	CPVC	ABS	PE	PP-H	PVDF (SYGEF)		EPDM	FPM	NBR	CR	CSM
Acetaldehyde	CH_3-CHO (C_2H_4O)	21	technically pure	20	-	-	-	+	O	-		+	O	-	-	O
				40				O	-			O	-			-
				60								-				
				80												
				100												
				120												
				140												
Acetaldehyde			40%, aqueous solution	20	O	-	-	+	+	-		+	+	-	+	+
				40	-			+	+			+	+		+	+
				60				O	+			+	O		O	+
				80					O			+	-		-	+
				100					-							
				120												
				140												
Acetic acid (SpRB)	CH_3COOH	118	technically pure, glacial	20	O	-	-	+	+	+		O	-	-	O	O
				40	-			+	+	O						
				60				O	O	-						
				80					-							
				100												
				120												
				140												
Acetic acid (SpRB)	CH_3COOH		10%, aqueous	20	+	+	+	+	+	+		+	O	+	+	O
				40	+	+	+	+	+	+		+	-	O	+	-
				60	O	+	O	+	+	+		O			O	
				80		+			+	+						
				100					+	+						
				120						+						
				140												
Acetic acid (SpRB)			50%, aqueous	20	+	+	-	+	+	+		+	O	-	O	O
				40	+			+	+	+						
				60	O			+	+	+						
				80						O						
				100						O						
				120												
				140												
Acetic acid (SpRB)	CH_3COOH		60%	20	+	-	-	+	+	+		+				
				40												
				60												
				80												
				100												
				120												
				140												
Acetic acid (SpRB)		118	98%	20	-	-	-	+	+	+		O	-			
				40												
				60												
				80												
				100												
				120												
				140												
Acetic acid anhydride (SpRB)	$(CH_3\text{-}CO)_2O$	139	technically pure	20	-	-	-	+	+	-		O	-	-	-	+
				40				O	O							
				60												
				80												
				100												
				120												
				140												

(Courtesy George Fischer Engineering Handbook)

Aggressive Media					Chemical Resistance											
Medium	Formula	Boiling point °C	Concentration	Temperature °C	PVC	CPVC	ABS	PE	PP-H	PVDF (SYGEF)		EPDM	FPM	NBR	CR	CSM
Acetic acid isobutyl ester	$(CH_2)_2$-CH-$(CH_2)_2$-CO_2H		technically pure	20						-						
				40												
				60												
				80												
				100												
				120												
				140												
Acetone	CH_3-CO-CH_3	56	technically pure	20	-	-	-	+	+	-		+	-	-	-	O
				40				+	+			+				O
				60				+	+			+				O
				80												
				100												
				120												
				140												
Acetone			up to 10%, aqueous	20	-	-	O	+	+	O		+	O	-	+	O
				40				+	+	O		+	O		O	O
				60				+	+	O		+	-		-	O
				80												
				100												
				120												
				140												
Acetonitrile	CH_3CN	81.6	100%	20	-	-	-			-						
				40												
				60												
				80												
				100												
				120												
				140												
Acetophenone	CH_3-CO-C_6H_5		100 %	20	-	-	-			-		+	-	-	-	
				40												
				60												
				80												
				100												
				120												
				140												
Acrylic acid methyl ester	CH_2=CHCOOCH_3	80.3	technically pure	20	-	-	-			+		O				
				40												
				60												
				80												
				100												
				120												
				140												
Acrylic ester	CH_2=CH-COO CH_2CH_3	100	technically pure	20	-	-	-		-	-		O	-	-	O	+
				40												
				60												
				80												
				100												
				120												
				140												
Acrylonitrile	CH_2=CH-CN	77	technically pure	20	-	-	-	+	+	-		+	O	-	+	O
				40				+	O			+	O		+	O
				60				+				O	-		+	-
				80												
				100												
				120												
				140												

(Courtesy George Fischer Engineering Handbook)

Aggressive Media					Chemical Resistance											
Medium	Formula	Boiling point °C	Concentration	Temperature °C	PVC	CPVC	ABS	PE	PP-H	PVDF (SYGEF)		EPDM	FPM	NBR	CR	CSM
Adipic acid	$HOOC-(CH_2)_4-COOH$	Fp 153	saturated, aqueous	20	+	+	-	+	+	+		+	+	+	+	+
				40	+	+		+	+			+	+	+	+	+
				60	-	+		+	+			+	+	+	+	+
				80		+			+							
				100												
				120												
				140												
Aluni	see Potassium/ aluminium sulphate															
Alcoholic spirits (Gin, Whisky,etc.)			approx. 40% ethyl alcohol	20	+	O	-	+	+	+		+	+	+	+	+
				40												
				60												
				80												
				100												
				120												
				140												
Allyl alcohol	$H_2C=CH-CH_2-OH$	97	96%	20	O	O	-	+	+			O	O	+	O	+
				40	-			+	+			O	-	+	-	+
				60				+	+			O		+		+
				80								-		+		-
				100												
				120												
				140												
Aluminium chloride	$AlCl_3$		10%, aqueous	20	+	+	+	+	+	+		+	+	+	+	+
				40	+	+	+	+	+	+		+	+	+	+	+
				60	+	+	+	+	+	+		+	+	O	+	+
				80		+				+		+	+			+
				100						+		+	+			
				120						+						
				140												
Aluminium chloride	$AlCl_3$	115	saturated	20	+	+	+	+	+	+		+	+	+	+	+
				40	+	+	+	+	+	+		+	+	+	+	+
				60	+	+	+	+	+	+		+	+	+	+	+
				80		+			+	+			+	O	+	+
				100					O	+			+	-		+
				120						+						
				140												
Aluminium fluoride	AlF_3		saturated	20		+				+						
				40		+				+						
				60		+				+						
				80						+						
				100												
				120												
				140												
Aluminium hydroxide	$Al(OH)_3$		Suspension	20		+						+				
				40		+						+				
				60		+						+				
				80		+										
				100												
				120												
				140												
Aluminium nitrate	$Al(NO_3)_3$		saturated	20		+				+		+				
				40		+				+		+				
				60		+				+		+				
				80		+										
				100												
				120												
				140												

(Courtesy George Fischer Engineering Handbook)

Aggressive Media					Chemical Resistance											
Medium	Formula	Boiling point °C	Concentration	Temperature °C	PVC	CPVC	ABS	PE	PP-H	PVDF (SYGEF)		EPDM	FPM	NBR	CR	CSM
Aluminium sulphate	$Al_2(SO_4)_3$		10%, aqueous	20	+	+	+	+	+	+		+	+	+	+	+
				40	+	+	+	+	+	+		+	+	+	+	+
				60	O	+	+	+	+	+		+	+	+	+	+
				80		+			+	+			+			O
				100					+	+						
				120						+						
				140												
Aluminium sulphate			cold saturated, aqueous	20	+	+	+	+	+	+		+	+	+	+	+
				40	+	+	+	+	+	+		+	+	+	+	+
				60	+	+	+	+	+	+		+	+	+	+	O
				80		+			+	+			+			O
				100						+						
				120						+						
				140												
Ammonia (SpRB)	NH_3	-33	gaseous, technically pure	20	+	-	-	+	+	+		+	+	+	+	+
				40	+			+	+	+			O			
				60	+			+	+	O						
				80						O						
				100						O						
				120												
				140												
Ammonium acetate	CH_3COONH_4		aqueous, all	20	+	+	O	+	+	+		+	+	+	+	+
				40	+	+		+	+	+		+	+	O	+	+
				60	O	+		+	+	+		+	+		O	
				80		+			+	+		O				
				100					+	+						
				120												
				140												
Ammonium aluminium sulfate				20						+						
				40						+						
				60						+						
				80						+						
				100						+						
				120												
				140												
Ammonium bromide				20						+						
				40						+						
				60						+						
				80												
				100												
				120												
				140												
Ammonium carbonate	$(NH_4)_2CO_3$		50%, aqueous	20	+	+	+	+	+	+		+	+	+	+	+
				40	+	+	+	+	+	+		+	+	+	+	+
				60	O	+	+	+	+	+		+	+	+	+	+
				80		+			+	+		+	+			+
				100					+	+						
				120						+						
				140												
Ammonium chloride	NH_4Cl	115	aqueous, cold saturated	20	+	+	+	+	+	+		+	+	+	+	+
				40	+	+	+	+	+	+		+	+	+	+	+
				60	O	+	+	+	+	+		+	+	+	+	+
				80		+			+	+		+	+		+	+
				100					+	+		+	+			+
				120						+			+			
				140												

(Courtesy George Fischer Engineering Handbook)

Aggressive Media					Chemical Resistance											
Medium	Formula	Boiling point °C	Concentration	Temperature °C	PVC	CPVC	ABS	PE	PP-H	PVDF (SYGEF)		EPDM	FPM	NBR	CR	CSM
Ammonium citrate				20	+					+						
				40	+					+						
				60	+					+						
				80						+						
				100						+						
				120												
				140												
Ammonium dicromate	$(NH_4)_2\ Cr_2\ O_7$		saturated	20		+										
				40		+										
				60		+										
				80		+										
				100												
				120												
				140												
Ammonium dihydrogenphosphate				20	+			+	+							
				40	+			+	+							
				60	+			+	+							
				80					+							
				100												
				120												
				140												
Ammonium fluoride	NH_4F			20	+	+		+	+	+						
				40	+			+	+	+						
				60	+			+	+	+						
				80					+	+						
				100						+						
				120												
				140												
Ammonium formiate				20						+						
				40						+						
				60						+						
				80						+						
				100						+						
				120												
				140												
Ammonium hexafluorosuilicate				20						+						
				40						+						
				60						+						
				80						+						
				100						+						
				120												
				140												
Ammonium hydrogen fluoride	NH_4HF_2		50%, aqueous	20	+	+	-	+	+	+		+	+			
				40	+	+		+	+	+						
				60	O	+		+	+	+						
				80												
				100												
				120												
				140												
Ammonium hydrogencarbonate				20	+			+	+							
				40	+			+	+							
				60	+			+	+							
				80					+							
				100												
				120												
				140												

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Aggressive Media					Chemical Resistance											
Medium	Formula	Boiling point °C	Concentration	Temperature °C	PVC	CPVC	ABS	PE	PP-H	PVDF (SYGEF)		EPDM	FPM	NBR	CR	CSM
Ammonium hydrogenphosphate				20	+			+	+							
				40	+			+	+							
				60	+			+	+							
				80					+							
				100												
				120												
				140												
Ammonium hydrogensulfite				20						+						
				40						+						
				60						+						
				80						+						
				100						+						
				120												
				140												
Ammonium hydroxide	NH_4OH		aqueous, cold saturated	20	+	-	+		+	-		+	-	+	+	+
				40	+		+		+			+		O	+	+
				60	O		O		+			O		O	+	O
				80											O	-
				100												
				120												
				140												
Ammonium nitrate	NH_4NO_3	112	aqueous, saturated	20	+	+	+	+	+	+		+	+	+	+	+
				40	+	+	+	+	+	+		+	+	+	+	+
				60	+	+	+	O	+	+		+	+	O		O
				80		+			O	+			+			
				100						+						
				120						+						
				140												
Ammonium oxalate	$H_4NOOC\text{-}COONH_4$			20						+		+				
				40						+						
				60						+						
				80						+						
				100						+						
				120												
				140												
Ammonium persulphate	$(NH_4)_2S_2O_8$			20		+				+						
				40		+				+						
				60		+				+						
				80		+				+						
				100						+						
				120												
				140												
Ammonium phosphate	$(NH_4)_3PO_4$		saturated	20	+	+	+	+	+	+		+	+	+	+	+
				40	+	+	+	+	+	+		+	+	+	+	+
				60	+	+	+	+	+	+			+	O	+	O
				80					+	+			+			
				100						+			+			
				120												
				140												
Ammonium sulphate	$(NH_4)_2SO_4$		aqueous, saturated	20	+	+	+	+	+	+		+	+	+	+	+
				40	+	+	+	+	+	+		+	+	+	+	+
				60	+	+	+	+	+	+		+	+	O	+	O
				80		+			+	+		+	+			
				100					+	+			+			
				120						+						
				140												

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Aggressive Media					Chemical Resistance											
Medium	Formula	Boiling point °C	Concentration	Temperature °C	PVC	CPVC	ABS	PE	PP-H	PVDF (SYGEF)		EPDM	FPM	NBR	CR	CSM
Ammonium sulphide	$(NH_4)_2S$		aqueous, all	20	+	O	+	+	+	+		+	+	+	+	+
				40	+	O	+	+	+	+		+	O	+	+	+
				60	O	O	+	+	+	+		+	-	+	+	+
				80		-			+							
				100												
				120												
				140												
Ammonium tetrafluoroborate				20						+						
				40						+						
				60						+						
				80						+						
				100						+						
				120												
				140												
Ammonium thiocyanate	NH_4SCN		saturated	20		+				+						
				40		+				+						
				60		+				+						
				80		+										
				100												
				120												
				140												
Amyl acetate	$CH_3(CH_2)_4$-$COOCH_3$	141	technically pure	20	-	-	-	+	O	+		O	-	-	-	-
				40				+	O	O						
				60				+	-	O						
				80												
				100												
				120												
				140												
Amyl alcohol (SpRB)	$CH_3(CH_2)_3$-CH_2-OH	137	technically pure	20	+	+	-	+	+	+		+	O	+	+	O
				40	+	+		+	+	+		+		+	+	
				60	O	+		+	+	+		+		+	+	
				80					+	+						
				100						+						
				120						O						
				140												
Aniline	$C_6H_5NH_2$	182	technically pure	20	-	-	-	O	O	+		-	O	-	-	-
				40						O			O			
				60						-			O			
				80												
				100												
				120												
				140												
Aniline hydrochloride	C_6H_7N+HCl	245	aqueous, saturated	20	+	+	-	+	+	+		+	O	O	-	+
				40	O	+		+	+			+	-	-		+
				60				O	O			+				+
				80												O
				100												
				120												
				140												
Antimony thiocyanate				20						+						
				40						+						
				60						+						
				80						+						
				100						+						
				120												
				140												

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Aggressive Media					Chemical Resistance											
Medium	Formula	Boiling point °C	Concentration	Temperature °C	PVC	CPVC	ABS	PE	PP-H	PVDF (SYGEF)		EPDM	FPM	NBR	CR	CSM
Antimony trichloride (SpRB)	$SbCl_3$		90%, aqueous	20	+	+	-	+	+	+		+	+	-	+	+
				40	+			+	+	+						
				60				+	+	+						
				80												
				100												
				120												
				140												
Aqua regia (SpRB)	HNO_3+HCl			20	+	+	-	-	-	O		-	O	-	-	O
				40	O											
				60												
				80												
				100												
				120												
				140												
Arsenic acid	H_3AsO_4		80%, aqueous	20	+	+	+	+	+	+		+	+	+	+	+
				40	+	+	+	+	+	+		+	+	+	+	+
				60	O	+	+	+	+	+		+	+	+	+	+
				80		+			+	+		+	+	O	+	+
				100						+			+			
				120						+						
				140												
Barium carbonate	$BaCO_3$			20	+	+	+	+	+	+		+	+	+	+	+
				40	+	+		+	+	+		+	+	+		
				60	+	+		+	+	+		+				
				80		+			+							
				100												
				120												
				140												
Barium chloride	$BaCl_2$		saturated	20	+	+	+	+	+	+		+	+	+	+	+
				40	+	+		+	+	+		+	+	+		
				60	+	+		+	+	+		+	+			
				80		+			+	+			+			
				100						+						
				120												
				140												
Barium hydroxide	$Ba(OH)_2$	102	aqueous, saturated	20	+	+	+	+	+	-		+	+	+	+	+
				40	+	+	+	+	+			+		+	+	O
				60	O	+	+	+	+			+		+	+	
				80		+			+			+				
				100												
				120												
				140												
Barium salts			aqueous, all	20	+	+	+	+	+	+		+	+	+	+	+
				40	+	+	+	+	+	+		+	+	+	+	+
				60	+	+	+	+	+	+		+	+	+	+	+
				80		+			+	+		+	+			
				100						+						
				120												
				140												
Barium sulfate	$BaSO_4$			20	+			+	+	+		+				
				40	+			+	+	+		+				
				60	+			+	+	+		+				
				80					+	+						
				100						+						
				120												
				140												

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Aggressive Media					Chemical Resistance											
Medium	Formula	Boiling point °C	Concentration	Temperature °C	PVC	CPVC	ABS	PE	PP-H	PVDF (SYGEF)		EPDM	FPM	NBR	CR	CSM
Barium sulfide	BaS		suspension	20	+	+		+	+	+		+				
				40	+	+		+	+	+		+				
				60	+	+		+	+	+		+				
				80		+			+	+						
				100						+						
				120												
				140												
Battery acid	see Sulphuric acid 40%															
Beef tallow emulsion, sulphonated (SpRB)			usual commercial	20	+	o	+	+	+	+		-	+	+	+	+
				40						+						
				60						+						
				80												
				100												
				120												
				140												
Beer			usual commercial	20	+	+	+	+	+	+			+	+	+	+
				40	+	+	+	+	+	+						
				60	+	+	+	+	+	+						
				80		+				+						
				100												
				120												
				140												
Benzaldehyde	C_6H_5-CHO	180	saturated, aqueous	20	-	-	-	+	+	+		+	+	O	-	-
				40				+		O		+	+			
				60				+		-		+	+			
				80												
				100												
				120												
				140												
Benzene	C_6H_6	80	technically pure	20	-	-	-	O	O	+		-	+	O	-	-
				40				O	-	O						
				60						-						
				80												
				100												
				120												
				140												
Benzenesulfonic acid	$C_6H_5SO_3H$		technically pure	20						+			+			
				40						+			+			
				60						+						
				80						+						
				100						+						
				120												
				140												
Benzoic acid	C_6H_5-COOH	Fp.*, 122	aqueous, all	20	+	+	+	+	+	+		+	+	-	-	-
				40	+	+	+	+	+	+		+	+			
				60	O	+		+	+	+			+			
				80		O			+	+			+			
				100					+	+			O			
				120						+						
				140												
Benzoyl chloride	$C_6H_5CHCl_2$		technically pure	20						+						
				40						+						
				60						+						
				80						O						
				100						-						
				120												
				140												

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Aggressive Media					Chemical Resistance											
Medium	Formula	Boiling point °C	Concentration	Temperature °C	PVC	CPVC	ABS	PE	PP-H	PVDF (SYGEF)		EPDM	FPM	NBR	CR	CSM
Benzyl alcohol (SpRB)	C_6H_5-CH_2-OH	206	technically pure	20	O	-	-	+	+	+		-	+	-	+	O
				40				+	+	+					+	
				60				O	O	O					+	
				80						-						
				100												
				120												
				140												
Beryllium chloride				20						+						
				40						+						
				60						+						
				80												
				100												
				120												
				140												
Beryllium sulfate				20						+			+			
				40						+			+			
				60						+			+			
				80						+						
				100						+						
				120												
				140												
Borax	$Na_2B_4O_7$		aqueous, all	20	+	+	+	+	+	+		+	+	+	+	+
				40	+	+	+	+	+	+		+	+	+	+	+
				60	O	+		+	+	+		+	+	+	+	O
				80		+			+	+		+	+			
				100					+	+						
				120												
				140												
Boric acid	H_3BO_3		all, aqueous	20	+	+	+	+	+	+		+	+	+	+	+
				40	+	+	+	+	+	+		+	+	+	+	+
				60	O	+	+	+	+	+		+	+	+	+	+
				80		+			+	+		+	+			
				100					+	+			+			
				120						+						
				140												
Brine, containing chlorine				20	+	+	-	+	O	+		O	+	O	O	O
				40	+	+				+						
				60	+	+				O						
				80												
				100												
				120												
				140												
Brombenzene	C_6H_5Br			20	-	-				+			+			
				40												
				60												
				80												
				100												
				120												
				140												
Bromine, liquid	Br_2	59	technically pure	20	-	-	-	-	-	+		-	+	-	-	-
				40						+						
				60						+						
				80						+						
				100						O						
				120												
				140												

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Aggressive Media					Chemical Resistance											
Medium	Formula	Boiling point °C	Concentration	Temperature °C	PVC	CPVC	ABS	PE	PP-H	PVDF (SYGEF)		EPDM	FPM	NBR	CR	CSM
Bromine, vapours	Br_2		high	20	-	-	-	-	-	+		-	+	-	-	-
				40						+						
				60						+						
				80						+						
				100						O						
				120												
				140												
Bromine water	$Br.H_2O$		saturated, aqueous	20	+	o	-	-	-	+		-	+	-	-	-
				40						+						
				60						+						
				80						+						
				100												
				120												
				140												
Butadiene (Q/E)	$H_2C{=}CH{-}CH{=}CH_2$	-4	technically pure	20	+	+	-	+	+	+		-	O	-	+	+
				40					+	+					+	O
				60					+	+					O	-
				80						+						
				100						+						
				120												
				140												
Butane	C_4H_{10}	0	technically pure	20	+	+	+	+	+	+		-	+	+	+	+
				40												
				60												
				80												
				100												
				120												
				140												
Butanediol (SpRB)	$HO{-}(CH_2)_4{-}OH$	230	aqueous, 10%	20	+	+	-	+	+			+	+	+	O	+
				40	O	+		+	+			+	+	+	-	+
				60				+	+			+	+	+		+
				80												
				100												
				120												
				140												
Butanol (SpRB)	C_4H_9OH	117	technically pure	20	+	+	-	+	+	+		+	+	+	+	+
				40	+	+		+	+	+		+	O	+	+	+
				60	O	+		+	O	+		+	-	+	O	+
				80		O			-	+						
				100						O						
				120												
				140												
Butyl acetate	$CH_3COOCH_2CH_2CH_2CH_3$	126	technically pure	20	-	-	-	+	O	+		+	O	-	O	O
				40						O		-	-		-	-
				60						-						
				80												
				100												
				120												
				140												
Butyl phenol, p-tertiary	$(CH_3)_3C{-}C_6H_4{-}OH$	237	technically pure	20	O	O	-	O	+	+		-	O	-	-	-
				40	-	-				+						
				60						+						
				80						+						
				100												
				120												
				140												

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Aggressive Media					Chemical Resistance											
Medium	Formula	Boiling point °C	Concentration	Temperature °C	PVC	CPVC	ABS	PE	PP-H	PVDF (SYGEF)		EPDM	FPM	NBR	CR	CSM
Butylene glycol (SpRB)	HO-CH_2-CH=CH-CH_2-OH	235	technically pure	20	+	+	+	+	+	+		+	+	-	+	O
				40	+	+	+	+	+	+		+	+		+	-
				60	O	+	+	+	+	+		+	O		+	
				80						+						
				100												
				120												
				140												
Butylene liquid	C_4H_8	51	technically pure	20	+			-	-	+		O	+	+	+	O
				40												
				60												
				80												
				100												
				120												
				140												
Butyric acid (SpRB)	CH_3-CH_2-CH_2-COOH	163	technically pure	20	+	+	-	+	+	+		O	O	-	O	O
				40				+		+						
				60				O		+						
				80						+						
				100						O						
				120												
				140												
Cadmium bromide	$CdBr_2$			20	+	+		+	+			+	+			
				40	+	+		+	+			+	+			
				60	+	+		+	+			+	+			
				80		+							+			
				100												
				120												
				140												
Cadmium chloride	$CdCl_2$			20	+	+		+	+			+	+			
				40	+	+		+	+			+	+			
				60	+	+		+	+			+	+			
				80					+							
				100												
				120												
				140												
Cadmium cyanide	Cd(CN)2			20	+			+	+							
				40	+			+	+							
				60	+			+	+							
				80					+							
				100												
				120												
				140												
Cadmium sulfate	$CdSO_4$			20	+	+		+	+			+	+			
				40	+	+		+	+			+	+			
				60	+	+		+	+			+	+			
				80		+			+				+			
				100												
				120												
				140												
Calcium acetate	$(CH_3COO)_2Ca$		saturated	20	+	+	+	+	+	+		+	+			
				40	+	+		+	+	+		+				
				60		+		+	+	+		+				
				80		+										
				100												
				120												
				140												

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Aggressive Media					Chemical Resistance											
Medium	Formula	Boiling point °C	Concentration	Temperature °C	PVC	CPVC	ABS	PE	PP-H	PVDF (SYGEF)		EPDM	FPM	NBR	CR	CSM
Calcium bisulphite	$Ca(HSO_3)_2$		cold saturated, aqueous	20	+	+	+			+		+	+	-	O	+
				40		+	+			+			+			
				60		+				+			+			
				80		+				+			+			
				100						+			+			
				120						+						
				140												
Calcium carbonate	$CaCO_3$			20	+	+		+	+	+		+	+			
				40	+	+		+	+	+		+	+			
				60	+	+		+	+	+		+	+			
				80		+			+	+		+	+			
				100						+						
				120												
				140												
Calcium chlorate	$Ca(ClO_3)_2$			20	+	+		+	+	+						
				40	+	+		+	+	+						
				60	+	+		+	+	+						
				80		+										
				100												
				120												
				140												
Calcium chloride	$CaCl_2$	125	saturated, aqueous, all	20	+	+	+	+	+	+		+	+	+	+	+
				40	+	+	+	+	+	+		+	+	+	+	+
				60	O	+		+	+	+		+	+	+	+	+
				80		+			+	+		+	+	O	O	+
				100					+	+		O	+			+
				120						+						
				140												
Calcium fluoride	CaF_2			20	+			+	+				+			
				40	+			+	+				+			
				60	+			+	+				+			
				80					+							
				100												
				120												
				140												
Calcium hydrogencarbonate				20						+		+	+			
				40						+		+	+			
				60						+		+	+			
				80						+		+	+			
				100						+			+			
				120												
				140												
Calcium hydrogensulfide	$Ca(SH)_2$			20		+				+		+				
				40		+				+		+				
				60		+				+		+				
				80		+				+						
				100						+						
				120												
				140												
Calcium hydrosulfite	$Ca(HSO_3)_2$		saturated	20						+						
				40						+						
				60						+						
				80						+						
				100						+						
				120												
				140												

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Aggressive Media					Chemical Resistance										
Medium	Formula	Boiling point °C	Concentration	Temperature °C	PVC	CPVC	ABS	PE	PP-H	PVDF (SYGEF)	EPDM	FPM	NBR	CR	CSM
Calcium hydroxide	$Ca(OH)_2$	100	saturated, aqueous	20	+	+	+	+	+	O	+	+	+	+	+
				40	+	+	+	+	+	-	+	+	+	+	+
				60	+	+	+	+	+		+	+	O	+	+
				80		+			+		+	+			+
				100								+			+
				120											
				140											
Calcium nitrate	$Ca(NO_3)_2$	115	50%, aqueous	20	+	+	+	+	+	+	+	+	+	+	+
				40	+	+	+	+	+	+	+	+	+	+	+
				60		+		+	+	+	+	+			+
				80		+				+		+			
				100						+					
				120											
				140											
Calcium phosphate	$Ca(H_2PO_4)_2$ $CaHPO_4$ $Ca_3(PO_4)_2$			20						+					
				40						+					
				60						+					
				80						+					
				100						+					
				120											
				140											
Calcium sulfide	Ca_5			20	+				+		+				
				40	+				+						
				60	+				+						
				80					+						
				100											
				120											
				140											
Calcium sulphate	$CaSO_4$		suspensions	20	+	+				+	+				
				40	+	+				+	+				
				60	+	+				+	+				
				80		+				+					
				100						+					
				120											
				140											
Calcium sulphite	$Ca(HSO_3)_2$		aqueous, cold saturated	20	+			+	+		+				
				40	+			+	+						
				60	+			+	+						
				80					+						
				100											
				120											
				140											
Calcium tungstate				20						+					
				40						+					
				60						+					
				80											
				100											
				120											
				140											
Calciumbromide	$CaBr_2$			20	+	+		+	+		+	+			
				40	+	+		+	+		+	+			
				60	+	+		+	+		+	+			
				80		+			+						
				100											
				120											
				140											

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Aggressive Media					Chemical Resistance												
Medium	Formula	Boiling point °C	Concentration	Temperature °C	PVC	CPVC	ABS	PE	PP-H	PVDF (SYGEF)		EPDM	FPM	NBR	CR	CSM
Calciumlactate	$(CH_3COO)_2Ca$		saturated	20				+	+	+		+				
				40				+	+	+		+				
				60				+	+	+		+				
				80					+	+						
				100						+						
				120												
				140												
Caprolactam	$C_6H_{11}NO$			20		-										
				40												
				60												
				80												
				100												
				120												
				140												
Caprolactone	$C_6H_{10}O_2$			20		-										
				40												
				60												
				80												
				100												
				120												
				140												
Carbon dioxide -carbonic acid	CO_2		technically pure, anhydrous	20	+	+	+	+	+	+		+	+	+	+	+
				40	+	+	+	+	+	+		+	+	+	+	+
				60	+	+	+	+	+	+			+	+	+	+
				80		+			+	+			+			+
				100						+						
				120												
				140												
Carbon disulphide	CS_2	46	technically pure	20	-	-	-	O	O	+			+	-	-	-
				40												
				60												
				80												
				100												
				120												
				140												
Carbon tetrachloride	CCl_4	77	technically pure	20	-	-	-	-	-	+		-	+	-	-	-
				40												
				60												
				80												
				100												
				120												
				140												
Carbonic acid				20	+	+		+	+	+		+	+			
				40	+	+		+	+	+		+	+			
				60	+	+		+	+	+		+	+			
				80		+			+	+		+	+			
				100						+			+			
				120												
				140												
Caro's acid	see Peroxomonosulfuric acid															
Casein				20						+						
				40						+						
				60						+						
				80												
				100												
				120												
				140												

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Aggressive Media					Chemical Resistance											
Medium	Formula	Boiling point °C	Concentration	Temperature °C	PVC	CPVC	ABS	PE	PP-H	PVDF (SYGEF)		EPDM	FPM	NBR	CR	CSM
Cäsium chloride	ClCs			20						+						
				40						+						
				60						+						
				80												
				100												
				120												
				140												
Cäsiumhydroxide	CsOH			20						+						
				40						+						
				60						+						
				80												
				100												
				120												
				140												
Caustic potash solution (potassium hydroxide)	KOH	131	50%, aqueous	20	+	+	+	+	+	-		+	-	O	-	+
				40	+	+	+	+	+			+		-		O
				60	O	+	+	+	+			+				O
				80		+			+			O				-
				100					+							
				120												
				140												
Caustic soda solution	NaOH		50%, aqueous	20	+	+	+	+	+	O		+	-	O	-	+
				40	+	+		+	+			+		-		O
				60		+		+	+			+				-
				80					+							
				100												
				120												
				140												
Cerium (III) -chloride	$CeCl_3$			20						+						
				40						+						
				60						+						
				80												
				100												
				120												
				140												
Chloral hydrate	CCl_3-$CH(OH)_2$	98	technically pure	20	-		-	+	O	-		O	O	-	O	+
				40				+								
				60				+	-							
				80												
				100												
				120												
				140												
Chloric acid (SpRB)	$HClO_3$		10%, aqueous	20	+	+	-	+	-	+		+	-	-	-	+
				40	+	+		+		+		+				+
				60	O	+						+				+
				80												
				100												
				120												
				140												
Chloric acid (SpRB)	$HClO_3$		20%, aqueous	20	+	+	-	O	-	+		+	-	-	-	+
				40	+	+						+				+
				60	O	+										
				80												
				100												
				120												
				140												

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Aggressive Media					Chemical Resistance											
Medium	Formula	Boiling point °C	Concentration	Temperature °C	PVC	CPVC	ABS	PE	PP-H	PVDF (SYGEF)		EPDM	FPM	NBR	CR	CSM
Chlorosulphonic acid	$ClSO_3H$	158	technically pure	20	O	-	-	-	-	O		-	-	-	-	-
				40						-						
				60												
				80												
				100												
				120												
				140												
Chrome alum (chromium potassium sulphate)	$KCr(SO_4)2$		cold saturated, aqueous	20	+	+	+	+	+	+		+	+	+	+	+
				40	+	+	+	+	+	+		+	+	+	+	+
				60	+	+		+	+			+	+	+	+	+
				80								+	+			
				100									+			
				120												
				140												
Chromic acid (SpRB)	CrO_3+H_2O		up to 50%, aqueous	20	O	+	-	O	O	+		O	+	-	-	O
				40	O	O		-	-	+		O	+			O
				60	-	O				+		O	+			O
				80		-				+						
				100						O						
				120						O						
				140												
Chromic acid (SpRB)			all, aqueous	20	O	O	-	O	O	+			+	-	-	O
				40						+			+			O
				60						+			O			O
				80						O						
				100						O						
				120												
				140												
Chromic acid + sulphuric acid + water (SpRB)	CrO_3 H_2SO_4 H_2O		50 g 15 g 35 g	20	+	+	-	-	-	+		O	+	-	-	O
				40	+	+				+		O	+			O
				60	O	+				+			+			
				80		O				O						
				100												
				120												
				140												
Chromium (II) -chloride				20	+					+						
				40	+					+						
				60	+					+						
				80						+						
				100						+						
				120												
				140												
Chromium (III) -fluoride	CrF_3			20						+						
				40						+						
				60						+						
				80												
				100												
				120												
				140												
Chromium (IIII) -chloride	$CrCl_3$			20	+					+						
				40	+					+						
				60	+					+						
				80						+						
				100						+						
				120												
				140												

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Aggressive Media					Chemical Resistance											
Medium	Formula	Boiling point °C	Concentration	Temperature °C	PVC	CPVC	ABS	PE	PP-H	PVDF (SYGEF)		EPDM	FPM	NBR	CR	CSM
Chlorine	Cl_2		moist, 97%, gaseous	20	-	-	-	-	-	-		-	+	-	-	O
				40												
				60												
				80												
				100												
				120												
				140												
Chlorine	Cl_2		anhydrous, technically pure	20	-	-	-	O	-	+		O	+	-	-	O
				40				O		+						
				60				-		+						
				80						+						
				100						O						
				120												
				140												
Chlorine	Cl_2		liquid, technically pure	20	-	-	-	-	-	+		-	O	-	-	-
				40												
				60												
				80												
				100												
				120												
				140												
Chlorine water (SpRB)	Cl_2 H_2O		saturated	20	+	+	O	O	O	O		O	O	-	O	-
				40	+	+		O								
				60	O	O										
				80		-										
				100												
				120												
				140												
Chloroacetic acid, mono (SpRB)	$ClCH_2COOH$		50%, aqueous	20	+	-	-	+	+	+		O	-	-	-	O
				40	+			+	+	O						
				60				+	+	-						
				80												
				100												
				120												
				140												
Chloroacetic acid, mono (SpRB)	$ClCH_2COOH$	188	technically pure	20	+	-	-	+	+	-		O	-	-	-	O
				40	+			+	+							
				60	O			+	+							
				80												
				100												
				120												
				140												
Chlorobenzene	C_6H_5Cl	132	technically pure	20	-	-	-	O	+	+		-	-	-	-	O
				40						+						
				60						O						
				80						-						
				100												
				120												
				140												
Chloroethanol	$ClCH_2$-CH_2OH	129	technically pure	20	-		-	+	+	+		O	-	+	-	O
				40				+	+	O						
				60				+	+	O						
				80						-						
				100												
				120												
				140												

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Aggressive Media					Chemical Resistance											
Medium	Formula	Boiling point °C	Concentration	Temperature °C	PVC	CPVC	ABS	PE	PP-H	PVDF (SYGEF)		EPDM	FPM	NBR	CR	CSM
Chromium (III) -nitrate	$Cr(NO_3)_3$			20	+					+						
				40	+					+						
				60	+					+						
				80						+						
				100						+						
				120												
				140												
Chromium (III) -sulfate	$Cr_2(SO_4)_3$			20	+					+						
				40	+					+						
				60	+					+						
				80						+						
				100						+						
				120												
				140												
Cider				20	+	+	+	+	+	+		+	+	+	+	+
				40			+			+						
				60						+						
				80												
				100												
				120												
				140												
Citric acid		Fp. *153	10%, aqueous	20	+	+	+	+	+	+		+	+	+	+	+
				40	+	+	+	+	+	+		+	+	+	+	+
				60	O	+	+	+	+	+		+	+	O	+	+
				80					+	+						
				100					+	+						
				120												
				140												
Citric acid				20	+			+	+							
				40	+			+	+							
				60				+	+							
				80					+							
				100												
				120												
				140												
Citric acid up to 10 %				20						+						
				40						+						
				60						+						
				80												
				100												
				120												
				140												
Coal gas, benzene free				20	+	+	+	+	+	+			+	+	O	+
				40												
				60												
				80												
				100												
				120												
				140												
Coconut fat alcohol (SpRB)			technically pure	20	+	-	-	+	+	+			+	+	+	+
				40	+			O	+	+			+	+	O	O
				60	O				O	+			+	+		
				80												
				100												
				120												
				140												

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Aggressive Media					Chemical Resistance											
Medium	Formula	Boiling point °C	Concentration	Temperature °C	PVC	CPVC	ABS	PE	PP-H	PVDF (SYGEF)		EPDM	FPM	NBR	CR	CSM
Compressedair, containing oil (SpRB)				20	-	-	-	+	O	+		-	+	+	+	+
				40				+		+						
				60						+						
				80												
				100												
				120												
				140												
Copper salts	CuCl, $CuCl_2$, CuF_2, $Cu(NO_3)_2$, $CuSO_4$, $Cu(CN)_2$		all, aqueous	20	+	+	+	+	+	+		+	+	+	+	+
				40	+	+	+	+	+	+		+	+	+	+	+
				60	O	+	+	+	+	+			+	O	+	O
				80		+			+	+			+			
				100						+						
				120												
				140												
Corn oil (SpRB)			technically pure	20	O	O	O	+	+	+			+	+	O	+
				40		O		+	+	+			+	+	-	+
				60				O	O	+			+	+		O
				80						+						
				100												
				120												
				140												
Cresol	HO-C_6H_4-CH_3		cold saturated, aqueous	20	O	-	-	+	+	+			+	O	-	O
				40				+	+	+			+	O		
				60						+						
				80						O						
				100												
				120												
				140												
Crotonic aldehyde	CH_3-CH=CH-CHO	102	technically pure	20	-	-	-	+	+	+		+	+	+	+	+
				40						O						
				60						-						
				80												
				100												
				120												
				140												
Cyclohexane (Q/E)	C_6H_{12}	81	technically pure	20	-	-	-	+	+	+		-	+	+	-	-
				40				+		+						
				60				+		+						
				80						+						
				100												
				120												
				140												
Cyclohexanol (SpRB)	$C_6H_{12}O$	161	technically pure	20	+	+	-	+	+	+		-	+	O	+	+
				40	+	+		+	+	+						
				60	+	+		+	O	O						
				80		O				O						
				100						-						
				120												
				140												
Cyclohexanone	$C_6H_{10}O$	155	technically pure	20	-	-	-	+	+	+		O	-	-	-	-
				40				O	O	O						
				60				O	O	-						
				80												
				100												
				120												
				140												

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Aggressive Media					Chemical Resistance											
Medium	Formula	Boiling point °C	Concentration	Temperature °C	PVC	CPVC	ABS	PE	PP-H	PVDF (SYGEF)		EPDM	FPM	NBR	CR	CSM
Densodrine W				20	+	+	O			+			+	+	+	
				40	+	+										
				60	+	+										
				80												
				100	-											
				120												
				140												
Detergents (SpRB)	see washing powder		for usual washing lathers													
Dextrine	$(C_6H_{10}O_5)_n$		usual commercial	20	+	+	+	+	+	+		+	+	+	+	+
				40	+	+	+	+		+		+	+	+	+	+
				60	+	+	+	+		+		+	+	+	+	+
				80		+				+						
				100						+						
				120						+						
				140												
Dextrose	siehe Glucose			20	+	+	+	+	+	+		+	+			
				40	+	+		+	+	+		+	+			
				60	+	+		+	+	+		+	+			
				80		+			+	+		+	+			
				100						+			+			
				120												
				140												
Dibuttyl ether	$C_4H_9OC_4H_9$	142	technically pure	20	-	-	-	O	O			-	+	+	-	O
				40									+	O		O
				60				-	-				O	-		O
				80												
				100												
				120												
				140												
Dibutyl phthalate	$C_6H_4(COOC_4H_9)_2$	340	technically pure	20	-	-	-	+	+	+		O	O	-	-	-
				40				O	O	+						
				60				O	O	O						
				80												
				100												
				120												
				140												
Dibutyl sebacate	$C_8H_{16}(COOC_4H_9)_2$	344	technically pure	20	-	-	-	+	+	+		+	+	-	-	-
				40												
				60												
				80												
				100												
				120												
				140												
Dichlorbenzol	$C_6H_4Cl_2$	180	technically pure	20	-	-	-									
				40												
				60												
				80												
				100												
				120												
				140												
Dichloroacetic acid	$Cl_2CHCOOH$	194	technically pure	20	+	-	-	+	+	+		+	O	-	O	+
				40	+			+	+	+		+	-		-	O
				60	O			O	O	O		+				-
				80						-						
				100												
				120												
				140												

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Aggressive Media					Chemical Resistance											
Medium	Formula	Boiling point °C	Concentration	Temperature °C	PVC	CPVC	ABS	PE	PP-H	PVDF (SYGEF)		EPDM	FPM	NBR	CR	CSM
Dichloroacetic acid (SpRB)	$Cl_2CHCOOH$		50%, aqueous	20	+	-	-	+	+	+		+	O	-	+	+
				40	+			+	+	+		+	O		O	+
				60	O			+	+	+		+	-		-	O
				80						O						
				100						-						
				120												
				140												
Dichloroacetic acid methyl ester	$Cl_2CHCOOCH_3$	143	technically pure	20	-	-	-	+	+	O		+	-	-	-	+
				40				+	+			+				+
				60				+	+			O				O
				80												
				100												
				120												
				140												
Dichloroethan	Ethylene chloride															
Dichloroethylene	ClCH=CHCl	60	technically pure	20	-	-	-	-	O	+		-	O	-	-	-
				40						+						
				60												
				80												
				100												
				120												
				140												
Dichloromethane				20	-	-	-									
				40												
				60												
				80												
				100												
				120												
				140												
Diesel oil (SpRB, Q/E)				20	+	+	O	+	O	+		-	+	+	O	O
				40	+	+				+			+	+		-
				60				O		+						
				80						+						
				100						+						
				120						+						
				140												
Diethyl ether				20	-	-	-									
				40												
				60												
				80												
				100												
				120												
				140												
Diethylamine	$(C_2H_5)_2NH$	56	technically pure	20	O	-	-	+	+	+		O	-	-	-	-
				40						O						
				60						-						
				80												
				100												
				120												
				140												
Diethylene glycol butyl ether				20	-	-	-									
				40												
				60												
				80												
				100												
				120												
				140												

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Aggressive Media					Chemical Resistance											
Medium	Formula	Boiling point °C	Concentration	Temperature °C	PVC	CPVC	ABS	PE	PP-H	PVDF (SYGEF)		EPDM	FPM	NBR	CR	CSM
Diglycolic acid (SpRB)	$HOOC-CH_2-O-CH_2-COOH$	Fp*., 148	30%, aqueous	20	+	+	+	+	+	+		+	O	+	+	O
				40	+	+		+	+							
				60	O	+		+	+							
				80												
				100												
				120												
				140												
Di-isobutyl ketone	$[(CH_3)2CHCH_2]_2CO$	124	technically pure	20	-	-	-	+	+	+		O	-	-	-	-
				40						+						
				60				-	-	O						
				80												
				100												
				120												
				140												
Dimethyl formamide	$(CH_3)_2CHNO$	153	technically pure	20	-	-	-	+	+	-		O	-	O	+	+
				40				+	+							
				60				O	+							
				80												
				100												
				120												
				140												
Dimethylamine	$(CH_3)_2NH$	7	technically pure	20	O	-	-	+	+	O		O	-	-	-	-
				40						-						
				60				O								
				80												
				100												
				120												
				140												
Dimethylphthalate (DMP)	$C_6H_4(CH_3)_2$			20	-	-	-									
				40												
				60												
				80												
				100												
				120												
				140												
Dinonylphthalate (DNP)			technically pure	20	-	-	-	O	+			O	+	-	-	-
				40												
				60												
				80												
				100												
				120												
				140												
Dioctylephthalate (SpRB) (DOP)			technically pure	20	-	-	-	O	+			O	+	-	-	-
				40												
				60					-							
				80												
				100												
				120												
				140												
Dioxane	$C_4H_8O_2$	101	technically pure	20	-	-	-	+	O	-			-	O	-	-
				40				+	O							
				60				+	O							
				80					-							
				100												
				120												
				140												
Drinking water	see water															

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Aggressive Media					Chemical Resistance											
Medium	Formula	Boiling point °C	Concentration	Temperature °C	PVC	CPVC	ABS	PE	PP-H	PVDF (SYGEF)		EPDM	FPM	NBR	CR	CSM
Ethanolamine	see Annino ethanol															
Ethyl acetate	CH_3COOCH_2-CH_3	77	technically pure	20	-	-	-	+	+	O		+	-	-	-	-
				40				O	O							
				60				O	O							
				80												
				100												
				120												
				140												
Ethyl alcohol + acetic acid (fermentation mixture)			technically pure	20	+	O	-	+	+	+		O	O	O	+	+
				40	+			+		+		O	O	O	+	+
				60	O			+		+			O		+	+
				80						O						
				100												
				120												
				140												
Ethyl alcohol (Ethnoc) (SpRB)	CH_3-CH_2-OH	78	technically pure, 96%	20	+	O	-	+	+	+		+	O	O	+	+
				40	+			+	+	O		+	O			
				60	O			+	+	-		+	O			
				80					+							
				100												
				120												
				140												
Ethyl benzene	C_6H_5-CH_2CH_3	136	technically pure	20	-	-	-	O	O	O		-	+	-	-	-
				40												
				60					-							
				80												
				100												
				120												
				140												
Ethyl chloride	CH_3-CH_2Cl	12	technically pure	20	-	-	-	O	O	O		-	O	-	-	-
				40												
				60												
				80												
				100												
				120												
				140												
Ethyl ether	CH_3CH_2-O-CH_2CH_3	35	technically pure	20	-	-	-	+	O	+		-	-	-	-	-
				40												
				60												
				80												
				100												
				120												
				140												
Ethylenchloride (1,2-Dichloroethane)				20	-	-	-									
				40												
				60												
				80												
				100												
				120												
				140												
Ethylene chloride	$ClCH_2$-CH_2Cl	83	technically pure	20	-	-	-	O	O	+		-	+	O	O	-
				40						+			+	-	-	
				60						+			O			
				80						O						
				100						-						
				120												
				140												

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Aggressive Media					Chemical Resistance											
Medium	Formula	Boiling point °C	Concentration	Temperature °C	PVC	CPVC	ABS	PE	PP-H	PVDF (SYGEF)		EPDM	FPM	NBR	CR	CSM
Ethylene diamine	$H_2N\text{-}CH_2\text{-}CH_2\text{-}NH_2$	117	technically pure	20	O	-	-	+	+	O		+	O	+	+	O
				40				+	+	O			O	O	O	O
				60				+	+	-			-	-	-	-
				80												
				100												
				120												
				140												
Ethylene glycol (SpRB)	$HO\text{-}CH_2\text{-}CH_2\text{-}OH$	198	technically pure	20	+	O	-	+	+	+		+	+	+	+	+
				40	+			+	+	+		+	+	+	+	+
				60	+			+	+	+		+	+	O	O	+
				80					+	+		+	O			O
				100					+	+						
				120						+						
				140												
Ethylene glycol	CH_2OHCH_2OH	198	technically pure	20	+		-	+	+	+		+	+	+	+	+
				40	+			+	+	+		+	+	+	+	+
				60	+			+	+	+		+	+	O	O	+
				80					+	+			O			O
				100						+						
				120												
				140												
Ethylene oxide	$CH_2\text{-}CH_2$	10	technically pure, moist	20	-	-	-	-	O	+		O	-	-	-	-
				40												
				60												
				80												
				100												
				120												
				140												
Ethylenediaminetetra-acetic acid (EDTA)				20				+	+	+		+				
				40												
				60												
				80												
				100												
				120												
				140												
Fatty acids $>C_6$ (SpRB)	R-COOH		technically pure	20	+	+	-	+	+	+		+	+	O	O	-
				40	+	+		+	+	+						
				60	+	+		O	+	+						
				80						+						
				100												
				120												
				140												
Fatty alcohol sulphonates (SpRB)			aqueous	20	+	+		+	+	+		+	+	+	+	+
				40	+	+		+	+	+		+	+	+	+	+
				60	O	O		+	O	+		+	+	+	+	+
				80						+						
				100						+						
				120												
				140												
Fertilizers			aqueous	20	+	+	O	+	+	+		+	+	+	+	+
				40	+	+		+	+	+		+	+	+	+	+
				60	O	+		+	+	+		+	+	+	+	+
				80		+				+			+			+
				100									+			
				120												
				140												

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Aggressive Media					Chemical Resistance											
Medium	Formula	Boiling point °C	Concentration	Temperature °C	PVC	CPVC	ABS	PE	PP-H	PVDF (SYGEF)		EPDM	FPM	NBR	CR	CSM
Fluorine	F_2		technically pure	20	-	-	-	-	-	-		-	-	-	-	-
				40												
				60												
				80												
				100												
				120												
				140												
Fluorosilicic acid (Q/E)	H_2SiF_6		32%, aqueous	20	+	+	+	+	+	+		+	O	O	O	+
				40	+	+	+	+		+				-	-	O
				60	+	+	+	+		+						-
				80						+						
				100						+						
				120												
				140												
Formaldehyde (SpRB)	HCHO		40%, aqueous	20	+	+	+	+	+	+		+	+	+	+	+
				40	+	+	+	+	+	+		+	+	+	+	+
				60			+	+		+		+	+	O	O	O
				80						+						
				100												
				120												
				140												
Formamide	$HCONH_2$	210	technically pure	20	-	-	-	+	+			+	O	+	+	
				40				+	+							
				60				+	+							
				80												
				100												
				120												
				140												
Formic acid (SpRB)	HCOOH		up to 50%, aqueous	20	+	-	O	+	+	+		+	+	-	+	+
				40	+			+	+	+		+	+		+	+
				60	O			+	O	+		O	O		O	+
				80						+			-			O
				100						+						
				120												
				140												
Formic acid (SpRB)	HCOOH	101	technically pure	20	+	-	-	+	+	+		+	+	-	+	+
				40	O			+	O	+		+			O	+
				60	-			+	-	+		+			-	+
				80						+		O				O
				100						+						
				120												
				140												
Formic acid (SpRB)			25%	20	+	+		+	+	+		+				
				40	+	+		+	+	+		+				
				60	+	+		+	+	+		+				
				80					+	+						
				100												
				120												
				140												
Freon 113	see trifluoro, trichlorethane	48														
Frigen 12 (D/P)	see Freon 12	-30	technically pure													

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Aggressive Media					Chemical Resistance											
Medium	Formula	Boiling point °C	Concentration	Temperature °C	PVC	CPVC	ABS	PE	PP-H	PVDF (SYGEF)		EPDM	FPM	NBR	CR	CSM
Fruit juices (SpRB)				20	+	+	+	+	+	+		+	+	+	+	+
				40	+	+	+	+	+	+		+	+	+	+	+
				60	+	+	+	+	+	+		+	+	+	+	+
				80		+			+	+		+	+	+	+	+
				100						+		+	+	+		+
				120						+			+			
				140												
Fruit pulp				20	+	+	+	+	+			+	+	+	+	+
				40			+	+	+							
				60				+	+							
				80												
				100												
				120												
				140												
Fuel oil				20	+	+		O	O	+		-	+	+	+	-
				40	O	+		-	-	+			+	+	+	
				60						+			+	+	O	
				80						+						
				100						+						
				120												
				140												
Furfuryl alcohol (SpRB)	$C_5H_6O_2$	171	technically pure	20	-	-	-	+	+	+		O	-	-	O	O
				40				+		+						
				60				+	O	O						
				80						-						
				100												
				120												
				140												
Gasoline (SpRB)	C_5H_{12} to $C_{12}H_{26}$	80-130	free of lead and aromatic compounds	20	+	+	-	+	O	+		-	+	+	-	O
				40	+	+		+		+			+	+		-
				60	+	+		O	-	+			+	+		
				80						+						
				100						+						
				120						+						
				140												
Gelatin			all, aqueous	20	+	+	+	+	+	+		+	+	+	+	+
				40	+	+	+	+	+	+		+	+	+	+	+
				60		+	+	+	+	+						
				80						+						
				100												
				120												
				140												
Glucose	$C_6H_{12}O_6$	Fp*., 148	all, aqueous	20	+	+	+	+	+	+		+	+	+	+	+
				40	+	+	+	+	+	+		+	+	+	+	+
				60	O	+	+	+	+	+		+	+	+	+	+
				80		+			+	+		+	+	+	+	+
				100						+			+			
				120												
				140												
Glycerol	HO-CH_2-CH(OH)-CH_2OH	290	technically pure	20	+	+	+	+	+	+		+	+	+	+	+
				40	+	+	+	+	+	+		O	+	+	+	+
				60	+	+		+	+	+		O	O	+	+	+
				80		+			+	+			-	O	+	+
				100					+	+					O	O
				120						+						
				140												

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Aggressive Media					Chemical Resistance											
Medium	Formula	Boiling point °C	Concentration	Temperature °C	PVC	CPVC	ABS	PE	PP-H	PVDF (SYGEF)		EPDM	FPM	NBR	CR	CSM
Glycocoll (SpRB)	NH_2-CH_2-COOH	Fp.*	10%, aqueous	20	+	+	+	+	+	+			+	+	+	+
		233		40	+	+	+	+	+	+			+	O	+	O
				60		+				+						
				80						+						
				100												
				120												
				140												
Glycol	see Ethylene glycol															
Glycolic acid	HO-CH_2-COOH	Fp.*,	37%, aqueous	20	+	-	+	+	+	+			+	+	+	+
		80		40			+	+		+						
				60				+		+						
				80						+						
				100						+						
				120												
				140												
Heptane (SpRB)	C_7H_{16}	98	technically pure	20	+	O	-	+	+	+		-	+	+	+	+
				40						+			+	+	+	O
				60				O	O	+			+	+	+	-
				80						+						
				100						+						
				120												
				140												
Hexane (SpRB)	C_6H_{14}	69	technically pure	20	+	O	-	+	+	+		-	+	+	+	+
				40						+			+	+	+	O
				60				O	O	+			+	+	+	-
				80						+						
				100						+						
				120												
				140												
Hydrazine hydrate (SpRB)	H_2N-NH_2 . H_2O	113	aqueous	20	+	-	-	+	+	-		+	O	-	-	+
				40				+	+							
				60				+	+							
				80												
				100												
				120												
				140												
Hydrobromic acid (SpRB)	HBr	124	aqueous, 50%	20	+	+	+	+	+	+		+	+	O	+	+
				40	+	+	+	+	+	+		+	+	-	+	+
				60	+	+		+	+	+		O	+		O	+
				80		O				+		-	O		-	O
				100						+			-			-
				120												
				140												
Hydrochloric acid (Q/E, D/P)	HCl		up to 38%	20	+	+	-	+	O	+		+	+	-	O	+
				40	+	+		+		+			+			
				60	+	+				+						
				80						+						
				100						+						
				120												
				140												
Hydrochloric acid (Q/E, D/P)	HCl		5%, aqueous	20	+		+	+	+	+		+	+	O	O	+
				40	+		+	+	+	+		+	+	-	-	O
				60	O			+	+	+		+	+			-
				80					O	+			+			
				100						+						
				120						+						
				140												

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Aggressive Media					Chemical Resistance											
Medium	Formula	Boiling point °C	Concentration	Temperature °C	PVC	CPVC	ABS	PE	PP-H	PVDF (SYGEF)		EPDM	FPM	NBR	CR	CSM
Hydrochloric acid (Q/E, D/P)	HCl		10%, aqueous	20	+	+	+	+	+	+		+	+	O	O	+
				40	+	+	+	+	+	+		+	+	-	-	O
				60	O	+		+	O	+		+	+			-
				80		+			O	+			+			
				100						+						
				120						+						
				140												
Hydrochloric acid (Q/E, D/P)	HCl		up to 30%, aqueous	20	+	+	O	+	+	+		+	+	-	-	+
				40	+	+	-	+	O	+		+	+			O
				60	O	+		+	O	+		O	O			-
				80		+			-	+						
				100						+						
				120												
				140												
Hydrochloric acid (Q/E, D/P)	HCl		36%, aqueous	20	+	+	-	+	+	+		O	+	-	-	O
				40	+	+		+	O	+		O	O			-
				60	O	O		+	-	+		-	-			
				80		O				+						
				100						+						
				120												
				140												
Hydrocyanic acid	HCN	26	technically pure	20	+	+	-	+	+	+		+	+	O	O	+
				40	+	+		+	+	+		O	O	-	-	O
				60	O	+		+	+	+						
				80						+						
				100												
				120												
				140												
Hydrofluoric acid	HF			20	+	-	-	+	+	+		-	+	-	-	+
				40	O			+	+	+			+			+
				60	O			O	+	+			O			O
				80						+						
				100						+						
				120												
				140												
Hydrogen	H_2	-253	technically pure	20	+	+	+	+	+	+		+	+	+	+	+
				40	+	+	+	+	+	+		+	+	+	+	+
				60	+	+	+	+	+	+		+	+	+	+	+
				80		+				+		+	+	+	+	+
				100					-	+		+	+	+		
				120												
				140												
Hydrogen chloride (Q/E)	HCl	-85	technically pure, gaseous	20	+	+	-	+	+	+		+	+	O	O	O
				40	+	+		+	+	+		+	+	-	-	O
				60	O	+		+	+	+		+	+			-
				80		O				+						
				100						+						
				120												
				140												
Hydrogen perocide			70%	20	+	+	-	+	+	O		O	+			
				40						O						
				60												
				80												
				100												
				120												
				140												

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Aggressive Media					Chemical Resistance											
Medium	Formula	Boiling point °C	Concentration	Temperature °C	PVC	CPVC	ABS	PE	PP-H	PVDF (SYGEF)		EPDM	FPM	NBR	CR	CSM
Hydrogen peroxide (SpRB)	H_2O_2		50%, aqueous	20	+	+	-	+	+	O		O	+			
				40												
				60												
				80												
				100												
				120												
				140												
Hydrogen peroxide (SpRB)	H_2O_2		10%, aqueous	20	+	+	-	+	+	O		O	+	O	-	+
				40	+			+	+	O		O	O	-		+
				60	O			+	+	-		-	-			O
				80												-
				100												
				120												
				140												
Hydrogen peroxide (SpRB)	H_2O_2	139	90%, aqueous	20	+		-	+	-	O			O	-	-	O
				40												
				60				-								
				80												
				100												
				120												
				140												
Hydrogen peroxide (SpRB)	H_2O_2	105	30%, aqueous	20	+	+	-	+	+	O		O	+	-	-	+
				40												O
				60												-
				80												
				100												
				120												
				140												
Hydrogen sulphide	H_2S		technically pure	20	+	+	+	+	+	+		+	+	+	O	+
				40	+	+	+	+	+	+		-	+	O	-	O
				60	+	+		O	+	+			O	-		O
				80						+			-			-
				100						+						
				120						+						
				140												
Hydrogen sulphide	H_2S		saturated, aqueous	20	+	+	+	+	+	+		+	+	-	+	+
				40	+	+	+	+	+	+		-	+	-	-	+
				60	O	+		+	+	+			+			O
				80						+			O			-
				100						+						
				120						+						
				140												
Hydroquinone	$C_6H_4(OH)_2$		saturated	20	+	+		+	+			+				
				40	+	+		+	+							
				60				+	+							
				80					+							
				100												
				120												
				140												
Hydrosulphite	see Sodium dithione															
Hydroxylamine sulfate				20	+			+				+				
				40	+			+								
				60	+			+								
				80												
				100												
				120												
				140												

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Aggressive Media				Chemical Resistance												
Medium	Formula	Boiling point °C	Concentration	Temperature °C	PVC	CPVC	ABS	PE	PP-H	PVDF (SYGEF)		EPDM	FPM	NBR	CR	CSM
Hydroxylamine sulphate	$(NH_3OH)_2SO_4$		all, aqueous	20	+	+	-	+	+			+	+	+	O	+
				40	+	+		+	+				+	O		+
				60				+	+							
				80												
				100												
				120												
				140												
Iodine-potassium iodide solution (lugol's solution)				20	+	-	-			+			+			
				40												
				60												
				80												
				100												
				120												
				140												
Iodium	I_2	185	100%	20	-	-	-			+			+			
				40												
				60												
				80												
				100												
				120												
				140												
Iron (II) -chloride			saturated	20	+	+	+	+	+	+		+	+			
				40	+	+		+	+	+		+	+			
				60	+	+		+	+	+		+	+			
				80		+			+	+			+			
				100						+			+			
				120												
				140												
Iron (II) -chloride	$FeCl_2$		saturated	20	+	+	+	+	+	+		+	+			
				40	+	+		+	+	+		+	+			
				60	+	+		+	+	+		+	+			
				80		+			+	+		+	+			
				100						+			+			
				120												
				140												
Iron (II) -nitrate	$Fe(NO_3)_2$		saturated	20	+	+	+	+	+	+		+	+			
				40	+	+		+	+	+		+	+			
				60	+	+		+	+	+		+	+			
				80		+			+	+			+			
				100						+			+			
				120												
				140												
Iron (III) -chloride	$FeCl_3$		saturated	20	+	+	+	+	+	+		+	+			
				40	+	+		+	+	+		+	+			
				60	+	+		+	+	+		+	+			
				80		+			+	+		+	+			
				100						+			+			
				120												
				140												
Iron (III) -chloride			saturated	20	+	+	+	+	+	+		+	+			
				40	+	+		+	+	+		+	+			
				60	+	+		+	+	+		+	+			
				80		+			+	+		+	+			
				100						+			+			
				120												
				140												

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Aggressive Media					Chemical Resistance											
Medium	Formula	Boiling point °C	Concentration	Temperature °C	PVC	CPVC	ABS	PE	PP-H	PVDF (SYGEF)		EPDM	FPM	NBR	CR	CSM
Iron (III) -chloridsulfate			saturated	20	+	+	+	+	+	+		+	+			
				40	+	+		+	+	+		+	+			
				60	+	+		+	+	+		+	+			
				80		+			+	+		+	+			
				100						+			+			
				120												
				140												
Iron (III) -nitrate			saturated	20	+	+	+	+	+	+		+	+			
				40	+	+		+	+	+		+	+			
				60	+	+		+	+	+		+	+			
				80		+			+	+		+	+			
				100						+			+			
				120												
				140												
Iron (III) -nitrate	$Fe(NO_3)_3$		saturated	20	+	+	+	+	+	+		+	+			
				40	+	+		+	+	+		+	+			
				60	+	+		+	+	+		+	+			
				80		+			+	+		+	+			
				100						+			+			
				120												
				140												
Iron (III) -sulfate	$Fe_2(SO_4)_3$		saturated	20	+	+	+	+	+	+		+	+			
				40	+	+		+	+	+		+	+			
				60	+	+		+	+	+		+	+			
				80		+			+	+		+	+			
				100						+			+			
				120												
				140												
Iron (III) -sulfate			saturated	20	+	+	+	+	+	+		+	+			
				40	+	+		+	+	+		+	+			
				60	+	+		+	+	+		+	+			
				80		+			+	+		+	+			
				100						+			+			
				120												
				140												
Iron (III) -nitrate	$FE(NO_3)3$		saturated	20	+					+		+	+			
				40	+					+		+	+			
				60	+					+		+	+			
				80						+		+	+			
				100						+			+			
				120												
				140												
Iron (II) -sulfate	$FeSO_4$		saturated	20	+	+	+	+	+	+		+	+			
				40	+	+		+	+	+		+	+			
				60	+	+		+	+	+		+	+			
				80		+			+	+		+	+			
				100						+			+			
				120												
				140												
Iron (III) -sulfate			saturated	20						+						
				40						+						
				60						+						
				80						+						
				100						+						
				120												
				140												

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Aggressive Media					Chemical Resistance											
Medium	Formula	Boiling point °C	Concentration	Temperature °C	PVC	CPVC	ABS	PE	PP-H	PVDF (SYGEF)		EPDM	FPM	NBR	CR	CSM
Iron salts			all, aqueous	20	+	+	+	+	+	+		+	+	+	+	+
				40	+	+	+	+	+	+		+	+	+	+	+
				60	O	+		+	+	+		+	+	+	+	+
				80		+			+	+		+	+			+
				100						+			+			
				120						+						
				140												
Isooctane (SpRB)	$(CH_3)_3$-C-CH_2-CH-$(CH_3)_2$	99	technically pure	20	+		-	+	+	+			+	+	+	O
				40						+						
				60				O	O	+						
				80						+						
				100						+						
				120												
				140												
Isophorone (SpRB)	$C_9H_{14}O$		technically pure	20						-						
				40												
				60												
				80												
				100												
				120												
				140												
Isopropyl alcohol (SpRB)	$(CH_3)_2$-CH-OH	82	technically pure	20				+	+	+		+				
				40						+						
				60						+						
				80						O						
				100												
				120												
				140												
Isopropyl ether	$(CH_3)_2$-CH-O-CH-$(CH_3)_2$	68	technically pure	20	-	-	-	O	O	+		O	-	-	-	-
				40						+						
				60				-	-	+						
				80												
				100												
				120												
				140												
Isopropylbenzene				20	-	-	-									
				40												
				60												
				80												
				100												
				120												
				140												
Jam, Marmalade				20	+	+	+	+	+	+		+	+	+	+	+
				40	O	+	+	+	+	+		+	+	+	+	+
				60	O	+		+	+	+		+	+	+	+	+
				80					+	+		+	+			
				100					+	+						
				120						+						
				140												
Lactic acid (SpRB)	$CH_3CHOHCOOH$		10%, aqueous	20	+	+	+	+	+	+		O	+	-	-	O
				40	O	+	O	+	+	+		O	O			O
				60	-	+	-	+	+	O		O	O			O
				80		+			+	O		-	O			
				100					+	-						
				120												
				140												

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Aggressive Media					Chemical Resistance											
Medium	Formula	Boiling point °C	Concentration	Temperature °C	PVC	CPVC	ABS	PE	PP-H	PVDF (SYGEF)		EPDM	FPM	NBR	CR	CSM
Lanolin (SpRB)			technically pure	20	+	o	+	+	+	+			+	+	+	O
				40	O		+	+	+	+			+	+	O	-
				60			+	+	+	+			+	+	-	
				80						+						
				100						+						
				120						+						
				140												
Lead acetate	$Pb(CH_3COO)_2$		aqueous, saturated	20	+	+	+	+	+	+		+	+	+	+	+
				40	+	+	+	+	+	+		+	+	+	+	+
				60	+	+	+	+	+	+		+	+	+	+	+
				80		+				+						
				100						+						
				120												
				140												
Lead salts	$PbCl_2$, $Pb(NO_3)_2$, $PbSO_4$		saturated	20		+										
				40		+										
				60		+										
				80		+										
				100												
				120												
				140												
Leadcarbonate				20	+	+		+	+	+		+				
				40						+						
				60						+						
				80												
				100												
				120												
				140												
Leadnitrate	$Pb(NO_3)2$			20		+										
				40		+										
				60		+										
				80		+										
				100												
				120												
				140												
Leadnitrate				20	+					+						
				40	+					+						
				60	+					+						
				80						+						
				100						+						
				120												
				140												
Leadtetrafluoroborate				20						+						
				40						+						
				60						+						
				80						+						
				100						+						
				120												
				140												
Linoleic acid				20						+						
				40						+						
				60						+						
				80						+						
				100						+						
				120												
				140												

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Aggressive Media					Chemical Resistance											
Medium	Formula	Boiling point °C	Concentration	Temperature °C	PVC	CPVC	ABS	PE	PP-H	PVDF (SYGEF)		EPDM	FPM	NBR	CR	CSM
Linseed oil (SpRB)			technically pure	20	+	+	+	+	+	+			+	+	O	+
				40	+	+	-	+	+	+			+	+	-	O
				60	O			+	+	+			+	+		-
				80					+	+						
				100					+	+						
				120						+						
				140												
Liqueurs				20	+			+	+	+		+	+	+	+	+
				40	+			+		+						
				60						+						
				80						+						
				100												
				120												
				140												
Liquid fertilizers				20				+	+			+				
				40				+	+			+				
				60				+	+			+				
				80					+							
				100												
				120												
				140												
Lithiumbromide	LiBr			20	+	+		+	+	+		+	+			
				40						+						
				60						+						
				80						+						
				100						+						
				120												
				140												
Lithiumsulfate				20	+	+		+	+	+		+	+			
				40						+						
				60						+						
				80												
				100												
				120												
				140												
Lubricating oils				20	+	O	-	+	O	+		-	+	+	+	+
				40	+			+		+			+	+	O	O
				60	+			O		+			+	O	-	-
				80						+			O			
				100						+			-			
				120						+						
				140												
Magnesium salts	$MgCl_2$, $MgCO_3$, $Mg(No3)_2$, $Mg(OH)_2$, $MgSO_4$		all, aqueous,saturated	20	+	+	+	+	+	+			+	+	+	+
				40	+	+	+	+	+	+			+	+	+	+
				60	O	+		+	+	+		+	+	+	+	+
				80		+			+	+		+	+			+
				100					+	+			+			
				120						+						
				140												
Magnesiumhydrogen-carbonate				20	+			+	+			+				
				40	+			+	+			+				
				60	+			+	+			+				
				80												
				100												
				120												
				140												

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Aggressive Media					Chemical Resistance											
Medium	Formula	Boiling point °C	Concentration	Temperature °C	PVC	CPVC	ABS	PE	PP-H	PVDF (SYGEF)		EPDM	FPM	NBR	CR	CSM
Maleic acid (SpRB)	$(CH\text{-}COOH)_2$	Fp. *131	cold saturated, aqueous	20	+	+	+	+	+	+			+	-	-	-
				40	+	+		+	+	+			+			
				60	O			+	+	+			+			
				80						+			-			
				100						+						
				120						+						
				140												
Media water or similar media				20	+	+	+	+	+	+						
				40	+	+	+	+	+	+						
				60	+	+	+	+	+	+						
				80		+			+	+						
				100					+	+						
				120						+						
				140						+						
Mercury	Hg	357	pure	20	+	+	+	+	+	+		+	+	+	+	+
				40	+			+	+	+		+	+	+	+	+
				60	+			+	+	+		+	+	+	+	+
				80						+			+			
				100						+						
				120						+						
				140												
Mercury (II) -chloride	$HgCl_2$			20	+	+	+	+	+	+		+	+	+	+	+
				40	+	+		+	+	+		+	+	+	+	+
				60	+	+		+	+	+		+	+	+	+	+
				80		+			+	+						
				100						+						
				120												
				140												
Mercury (II) -cyanide	$Hg(CN)2$			20	+	+	+	+	+	+		+	+	+	+	+
				40	+	+		+	+	+		+	+	+	+	+
				60	+	+		+	+	+		+	+	+	+	+
				80		+				+						
				100						+						
				120												
				140												
Mercury (II) -cyanide	$Hg(NO_3)_2$			20	+	+		+	+	+		+	+	+	+	+
				40	+	+		+	+	+		+	+	+	+	+
				60	+	+		+	+	+		+	+	+	+	+
				80		+			+	+			+			
				100						+						
				120												
				140												
Mercury (II) -sulfate				20	+	+	+	+	+	+		+	+	+	+	+
				40	+	+		+	+	+		+	+	+	+	+
				60	+	+		+	+	+		+	+	+	+	+
				80		+			+	+			+			
				100						+						
				120												
				140												
Mercury salts	$HgNO_3$, $Hg Cl_2$, $Hg(CN)_2$		cold saturated, aqueous	20	+	+	+	+	+	+		+	+	O	O	O
				40	+	+		+	+	+		+	+	O	O	O
				60	O	+		+	+	+			+	-	-	-
				80						+						
				100						+						
				120						+						
				140												
Methane	see natural gas	-161	technically pure													

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Aggressive Media					Chemical Resistance											
Medium	Formula	Boiling point °C	Concentration	Temperature °C	PVC	CPVC	ABS	PE	PP-H	PVDF (SYGEF)		EPDM	FPM	NBR	CR	CSM
Methanol (SpRB)	CH_3OH	65	all	20	+	-	-	+	+	+		+	O	+	+	+
				40	+			+	+	O		+	O	+	+	+
				60	O			+	+	-		+	O	+	O	+
				80												
				100												
				120												
				140												
Methyl acetate	CH_3COOCH_3	56	technically pure	20	-	-	-	+	+	+			-	-	-	-
				40					+	O						
				60					O							
				80												
				100												
				120												
				140												
Methyl amine	CH_3NH_2	-6	32%, aqueous	20	O	-	-	+	+	O			+	-	+	+
				40												
				60												
				80												
				100												
				120												
				140												
Methyl bromide	CH_3Br	4	technically pure	20	-	-	-	O	-	+			O	-	-	O
				40						+						
				60						+						
				80												
				100												
				120												
				140												
Methyl chloride	CH_3Cl	-24	technically pure	20	-	-	-	O	-	+			-	-	-	-
				40						+						
				60						+						
				80												
				100												
				120												
				140												
Methyl ethyl ketone	$CH_3COC_2H_5$	80	technically pure	20	-	-	-	+	+	-			-	-	-	-
				40				O	O							
				60				-	O							
				80												
				100												
				120												
				140												
Methylene chloride	CH_2Cl_2	40	technically pure	20	-	-	-	O	O	+			O	-	-	-
				40						O						
				60						O						
				80												
				100												
				120												
				140												
Methylisobutylketone	$C_6H_{12}O$			20	-	-	-									
				40												
				60												
				80												
				100												
				120												
				140												

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Aggressive Media					Chemical Resistance											
Medium	Formula	Boiling point °C	Concentration	Temperature °C	PVC	CPVC	ABS	PE	PP-H	PVDF (SYGEF)		EPDM	FPM	NBR	CR	CSM
Methylmethacrylate	$C_5H_8O_2$			20	-	-	-									
				40												
				60												
				80												
				100												
				120												
				140												
Methylphenylketone (Acetophenon)	C_8H_8O			20	-	-	-									
				40												
				60												
				80												
				100												
				120												
				140												
Milk (SpRB)				20	+	+	+	+	+	+			+	+	+	+
				40	+	+	+	+	+	+						
				60	+	+	+	+	+	+						
				80		+			+	+						
				100					+	+						
				120						+						
				140												
Mineral oils, free of aromatics				20	+	+	-	+	+	+			+	+	O	O
				40	+			+	+	+			+	+	-	-
				60	+			O	O	+			+	+		
				80						+						
				100						+						
				120						+						
				140												
Mineral water				20	+	+	+	+	+	+		+	+	+	+	+
				40	+	+	+	+	+	+		+	+	+	+	+
				60	+	+	+	+	+	+		+	+	+	+	+
				80		+			+	+		+	+	+		+
				100					+	+		+	+			+
				120						+			+			
				140												
Mixed acids	15% HNO_3		3 parts	20	O	O	-	O	-	+			+	-	-	+
- nitric	15% HF		1 part	40						+			O			O
- hydrofluoric	18% H_2SO_4		2 parts	60						+						
- sulphuric				80												
				100												
				120												
				140												
Mixed acids	H_2SO_4		48%	20	+	+	-	-	-	+			-	-	-	-
- sulphuric	HNO_3		49%	40	O											
- nitric	H_2O		43%	60	-											
- water				80												
				100												
				120												
				140												
Mixed acids	H_2SO_4		50%	20	O	O	-	-	-	+			-	-	-	-
- sulphuric	HNO_3		50%	40	-											
- nitric	H_2O		40%	60												
- water				80												
				100												
				120												
				140												

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Aggressive Media					Chemical Resistance											
Medium	Formula	Boiling point °C	Concentration	Temperature °C	PVC	CPVC	ABS	PE	PP-H	PVDF (SYGEF)		EPDM	FPM	NBR	CR	CSM
Mixed acids	H_2SO_4		10%	20	O	O	-	-	-	O			-	-	-	-
- sulphuric	HNO_3		87%	40												
- nitric	H_2O		43%	60												
- water				80												
				100												
				120												
				140												
Mixed acids	H_2SO_4		50%	20	+	+	-	-	-	+			+	-	-	O
- sulphuric	HNO_3		33%	40	O											
- nitric	H_2O		17%	60												
- water				80												
				100												
				120												
				140												
Mixed acids	H_2SO_4		10%	20	+	+	-	O	-	+			+	-	O	+
- sulphuric	HNO_3		20%	40	+					+			+			O
- nitric	H_2O		70%	60						+			+			
- water				80						+						
				100												
				120												
				140												
Mixed acids	H_2SO_4		50%	20	+		-	-	-	+			+	-	O	O
- sulphuric	HNO_3		31%	40												
- nitric	H_2O		19%	60												
- water				80												
				100												
				120												
				140												
Mixed acids	H_2SO_4		30%	20	+	+	-	+	+	+			+	-	+	+
- sulphuric	H_3PO_4		60%	40	+	+		O	O	+			+		O	O
- phosphoric	H_2O		10%	60		+				+			+			
- phosphoric				80						+						
				100												
				120												
				140												
Molasses				20	+	+	+	+	+	+		+	+	+	+	+
				40	+	+	+	+	+	+		+	+	+	+	+
				60	O	+	+	+	+	+		+	+	+	+	+
				80		+				+		+	+	+	O	+
				100												
				120												
				140												
Molasses wort				20	+	+	+	+	+	+		+	+	+	+	+
				40	+	+	+	+	+	+		+	+	+	+	+
				60	+	+	+	+	+	+		+	+	+	+	+
				80		+				+						
				100												
				120												
				140												
Monochloroacetic acid ethyl ester	$ClCH_2COOC_2H_5$	144	technically pure	20	-	-	-	+	+	O			O	-	-	-
				40				+	+	-						
				60				+	+							
				80												
				100												
				120												
				140												

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Aggressive Media					Chemical Resistance											
Medium	Formula	Boiling point °C	Concentration	Temperature °C	PVC	CPVC	ABS	PE	PP-H	PVDF (SYGEF)		EPDM	FPM	NBR	CR	CSM
Morpholin	C_4H_9NO	129	technically pure	20	-	-	-	+	+	+			+	-	O	O
				40				+	+	+						
				60				+	+	O						
				80												
				100												
				120												
				140												
Mowilith D			usual commercial	20	+	+		+	+	+			+	+	+	+
				40												
				60												
				80												
				100												
				120												
				140												
Naphthalene		218	technically pure	20	-	-	-	+	+	+		-	+	+	-	O
				40						+			+	+		-
				60				O		O			+	+		
				80												
				100												
				120												
				140												
Natriumhydrogensulfite	$NaHSO_3$			20	+	+		+	+	+		+	+			
				40	+	+		+	+	+		+				
				60	+	+		+	+	+		+				
				80		+			+	+						
				100						+						
				120												
				140												
Natriumsulfate				20	+	+	+	+	+	+		+	+			
				40	+	+		+	+	+		+	+			
				60	+	+		+	+	+		+	+			
				80		+			+	+		+	+			
				100						+			+			
				120												
				140												
Natriumtetraborate (Borax)				20	+	+	+	+	+	+		+	+			
				40	+	+		+	+	+		+				
				60	+	+		+	+	+		+				
				80		+			+							
				100												
				120												
				140												
Nickel salts	$(CH_3COO)_2Ni$, $NiCl_2$, $Ni(NO_3)_2$, $Ni\ SO_4$		cold saturated, aqueous	20	+	+	+	+	+	+		+	+	+	+	+
				40	+	+	+	+	+	+		+	+	+	+	+
				60	O	+	+	+	+	+			+	+	+	+
				80						+			+			
				100						+			+			
				120						+						
				140												
Nitrating acid	H_2SO_4		65% 20%	20						+						
	HNO_3		15%	40												
	H_2O			60												
				80												
				100												
				120												
				140												

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Aggressive Media					Chemical Resistance											
Medium	Formula	Boiling point °C	Concentration	Temperature °C	PVC	CPVC	ABS	PE	PP-H	PVDF (SYGEF)		EPDM	FPM	NBR	CR	CSM
Nitric acid (SpRB)	HNO_3			20	+	+	-	+	O	+		+	+			
				40	+	+				+			+			
				60	+	+				+			+			
				80						+						
				100						+						
				120												
				140												
Nitric acid (SpRB)	HNO_3			20	+	+	-	+	+	+		+	+			
				40	+	+		+	O	+			+			
				60	+	+		+		+						
				80		+				+						
				100						+						
				120												
				140												
Nitric acid up to 55% (SpRB)				20	+	+	-	+	-	+			+			
				40	+	+				+						
				60						+						
				80												
				100												
				120												
				140												
Nitric acid (see note 2.3.1 on jointing) (SpRB)	see Salpetre		6,3%, aqueous													
Nitric acid (see note 2.3.1 on jointing) (SpRB)	see Salpetre		up to 40%, aqueous													
Nitric acid (see note 2.3.1 on jointing) (SpRB)	see Salpetre		65%, aqueous													
Nitric acid (see note 2.3.1 on jointing) (SpRB)	see Salpetre		100%													
Nitric acid (see note 2.3.1 on jointing) (SpRB)	see Salpetre		85%													
Nitric oxide	see Nitrous gases															
Nitrilotriacetic acid	$N(CH_2\text{-}COOH)_3$			20				+	+			+				
				40												
				60												
				80												
				100												
				120												
				140												
Nitrobenzene	$C_6H_5\text{-}NO_2$	209	technically pure	20	-	-	-	+	+	+		-	O	-	-	-
				40				O	+	O						
				60				O		-						
				80												
				100												
				120												
				140												

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Aggressive Media					Chemical Resistance											
Medium	Formula	Boiling point °C	Concentration	Temperature °C	PVC	CPVC	ABS	PE	PP-H	PVDF (SYGEF)		EPDM	FPM	NBR	CR	CSM
Nitrotoluene (o-, m-, p-)		222-238	technically pure	20	-	-	-	+	+	+		-	O	O	-	-
				40				O	O	+			-	-		
				60						+						
				80						+						
				100						O						
				120												
				140												
Nitrous acid	HNO_2			20	+	+	-	+	-	+		+	+			
				40	+	+				+						
				60						+						
				80												
				100												
				120												
				140												
Nitrous gases	see Nitric oxide		diluted, moist, anhydrous													
N-Methylpyrrolidon				20	-	-	-									
				40												
				60												
				80												
				100												
				120												
				140												
N,N-Dimethylaniline	$C_6H_5N(CH_3)_2$		technically pure	20	-	-	-	+	+			+				
				40												
				60												
				80												
				100												
				120												
				140												
n-Pentylacetate				20	-	-	-									
				40												
				60												
				80												
				100												
				120												
				140												
Oleic acid (SpRB)	$C_{17}H_{33}COOH$		technically pure	20	+	O	-	+	+	+		-	+	O	-	-
				40	+			+	+	+			O	-		
				60	+			O	O	+			-			
				80						+						
				100						+						
				120						+						
				140												
Oleum (SpRB)	$H_2SO_4+SO_3$		10% SO_3	20	-	-	-	-	-	-		-	-	-	-	-
				40												
				60												
				80												
				100												
				120												
				140												
Oleum vapours (SpRB)			traces	20	+	-	-	-	-	-		-	+	-	-	O
				40												
				60												
				80												
				100												
				120												
				140												

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Aggressive Media					Chemical Resistance											
Medium	Formula	Boiling point °C	Concentration	Temperature °C	PVC	CPVC	ABS	PE	PP-H	PVDF (SYGEF)		EPDM	FPM	NBR	CR	CSM
Olive oil (SpRB)				20	+	-	-	+	+	+		-	+	+	+	+
				40	+			+	+	+			+	+	+	+
				60	+			O	+	+			+	+	+	O
				80					+	+			+			-
				100												
				120												
				140												
Oxalic acid (SpRB)	$(COOH)_2$		cold saturated, aqueous	20	+	+	+	+	+	+		+	+	O	O	O
				40	+	+	+	+	+	+			+	-	-	O
				60	+	+		+	+	+			O			-
				80		O				+			-			
				100						+						
				120												
				140												
Oxygen	O_2		technically pure	20	+	+	+	+	+	+		+	+	+	+	+
				40	+		+	+	+	+		+	+		+	+
				60	+		+	O	O	+		+	+		+	+
				80						+			+		+	+
				100						O			+			+
				120						O			+			
				140												
Ozone (SpRB)	O_3		up to 2%, in air	20	+	+	-	O	O	O		O	+	-	O	+
				40				-	-							
				60												
				80												
				100												
				120												
				140												
Ozone (SpRB)	O_3		cold saturated, aqueous	20	+	+	-	O	O	O		-	+	-	O	+
				40	+			-	-				O		-	+
				60									-			O
				80												
				100												
				120												
				140												
Palm oil, palm nut oil (SpRB)				20	+	O	+	+	+	+		-	+	+	+	O
				40	-			+	+	+			+	+	O	-
				60				O	O	+			+	O	-	
				80						+						
				100						+						
				120												
				140												
Palmitic acid (SpRB)	$C_{15}H_{31}COOH$	390	technically pure	20	+	-	+	O	O	+		O	+	O	+	O
				40						+			O	-	-	-
				60					-	+			-			
				80						+						
				100						+						
				120						+						
				140												
Paraffin emulsions			usual commercial, aqueous	20	+	+	O	+	+	+		-	+	+	+	+
				40	+	+		+	+	+			+	+	O	-
				60				O	O	+			+	O	-	
				80						+			+			
				100						+						
				120												
				140												

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Aggressive Media					Chemical Resistance											
Medium	Formula	Boiling point °C	Concentration	Temperature °C	PVC	CPVC	ABS	PE	PP-H	PVDF (SYGEF)		EPDM	FPM	NBR	CR	CSM
Paraffin oil				20	+	+	O	+	+	+		-	+	+	+	O
				40	+			+	+	+			+	O	O	-
				60	O			+	O	+			+	O	-	
				80						+			O			
				100						+						
				120						+						
				140												
p-Dibromo benzene	$C_6H_5Br_2$		technically pure	20	-	-	-	O	O	+		-	+	-	-	-
				40						+						
				60						+						
				80						+						
				100						+						
				120												
				140												
Perchlorethylene (tetrachlorethylene)	$Cl_2C{=}CCl_2$	121	technically pure	20	-	-		O	O	+			+	O	-	-
				40						+			+	-		
				60						+			+			
				80						O						
				100						-						
				120												
				140												
Perchlorid acid (SpRB)	$HClO_4$		10%, aqueous	20	+	+	O	+	+	+		+	+	-	-	+
				40	+	+		+	+	+		O	+			+
				60	O	+		+	+	+			+			O
				80						+			O			-
				100						+						
				120												
				140												
Perchlorid acid (SpRB)			70%, aqueous	20	O	O	-	+	O	+		-	+	-	-	+
				40				O	-	+			+			+
				60				-		+			+			O
				80						+			O			
				100						+						
				120												
				140												
Petroleum			technically pure	20	+	-	-	+	+	+		-	+	+	O	-
				40				+	O	+			+	+	-	
				60				O	O	+			O	+		
				80						+						
				100						+						
				120						+						
				140												
Petroleum ether (SpRB)		40-70	technically pure	20	+	-	-	+	+	+		-	+	+	-	-
				40	+			O	O	+			+	O		
				60	+			O	O	+			O	-		
				80						+						
				100						+						
				120												
				140												
Phenol (SpRB)	$C_6H_5\text{-}OH$	182	up to 10%, aqueous	20	+	+	-	+	+	+			+	-	-	-
				40	O	+		+	+	+			+			
				60				O	+	+		+	+			
				80						+		O	O			
				100						+						
				120												
				140												

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Aggressive Media					Chemical Resistance											
Medium	Formula	Boiling point °C	Concentration	Temperature °C	PVC	CPVC	ABS	PE	PP-H	PVDF (SYGEF)		EPDM	FPM	NBR	CR	CSM
Phenol (SpRB)			up to 5%	20	+	+	-	+	+	+		+	+	-	-	
				40		+		+	+	+		O	+			
				60				+	+	+			+			
				80						+			O			
				100						O						
				120												
				140												
Phenol (SpRB)	C_6H_5-OH		up to 90%, aqueous	20	O	-	-	+	+	+		-	+	-	-	-
				40				+	+	+			O		O	
				60				O	+	O			-			
				80												
				100												
				120												
				140												
Phenylhydrazine	C_6H_5-NH-NH_2	243	technically pure	20	-	-	-	O	O	O		-	+	-	-	-
				40						-			+			
				60									O			
				80												
				100												
				120												
				140												
Phenylhydrazine hydrochloride	C_6H_5-NH-NH_2.HCl		aqueous	20	O	O	-		+	+			+	O	O	+
				40					O	+			+	-	-	+
				60					O	+		O	O			O
				80									-			-
				100												
				120												
				140												
Phosgene (SpRB)	$COCl_2$	8	liquid, technically pure	20	-	-	-	-	-	-		-	+	O	+	+
				40												
				60												
				80												
				100												
				120												
				140												
Phosgene (SpRB)			gaseous, technically pure	20	+	-	-	O	O	+		+	+	+	+	+
				40	O					+			+	+	O	O
				60	O								O	+	-	
				80												
				100												
				120												
				140												
Phosphate disodique	see d'isodiumphosphate		saturated													
Phosphoric acid	H_3PO_4		up to 30%, aqueous	20	+	+	+	+	+	+		+	+	O	+	+
				40	+	+	+	+	+	+		+	+	O	+	+
				60	O	+	O	+	+	+		O	+	-	+	+
				80		+			+	+			+		O	O
				100						+			+			
				120						+						
				140												
Phosphoric acid			50%, aqueous	20	+	+	+	+	+	+		+	+	O	+	+
				40	+	+	+	+	+	+		O	+	-	+	+
				60	+	+	O	+	+	+			+		O	+
				80		+			+	+			+			+
				100						+			O			O
				120						+						
				140												

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Aggressive Media					Chemical Resistance											
Medium	Formula	Boiling point °C	Concentration	Temperature °C	PVC	CPVC	ABS	PE	PP-H	PVDF (SYGEF)		EPDM	FPM	NBR	CR	CSM
Phosphoric acid			85%, aqueous	20	+	+	+	+	+	+		+	+	-	+	+
				40	+	+	+	+	+	+		+	+		+	O
				60	+	+	O	O	+	+		O	+		O	-
				80		+			+	+			+			
				100						+			O			
				120						+						
				140												
Phosphoric acid	H_3PO_4			20	+	+	-	+	+	+		O	+	-	-	-
				40	+	+		+	+	+			+			
				60		+				+			O			
				80						+						
				100												
				120												
				140												
Phosphoric acid	H_3PO_4			20	+	+	-	+	+	+			+			
				40	+	+		+	+	+			+			
				60	+	+			+	+			+			
				80		+			+	+			+			
				100						+			O			
				120												
				140												
Phosphoric acid tributyl ester	(HaC_4O)3P=O			20	-	-	-	+	+	-		+	-			
				40												
				60												
				80												
				100												
				120												
				140												
Phosphorous chlorides: - Phosphorous trichloride - Phosphorous pentachloride - Phosphorous oxichloride (SpRB)	PCl_3 PCl5 $POCl_3$	175 162 105	technically pure	20	-	-	-	+	O	-			+	-	-	+
				40												
				60				O	O							
				80												
				100												
				120												
				140												
Photographic developer (SpRB)			usual commercial	20	+	+	+	+	+	+		+	+	O	+	+
				40	+	+	+	+	+	+		+	+	O	+	+
				60	O	+	O	O		+						
				80		O										
				100												
				120												
				140												
Photographic emulsions (SpRB)				20	+	+	+	+	+	+		+	+	O	+	+
				40	+	+	+	+	+	+		+	+		+	+
				60		O				+						
				80												
				100												
				120												
				140												
Photographic fixer (SpRB)			usual commercial	20	+	+	+	+	+	+		+	+	+	+	+
				40	+	+	+	+	+	+		+	+	+	+	+
				60	O	+	O			+						
				80												
				100												
				120												
				140												

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Aggressive Media					Chemical Resistance											
Medium	Formula	Boiling point °C	Concentration	Temperature °C	PVC	CPVC	ABS	PE	PP-H	PVDF (SYGEF)		EPDM	FPM	NBR	CR	CSM
Phthalic acid (SpRB)	$C_6H_5(COOH)_2$	Fp.*, 208	saturated, aqueous	20	+	-	-	+	+	+		+	-	-	+	+
				40	O			+	+	+		O			+	+
				60	-			+	+	+					O	
				80						+						
				100						+						
				120												
				140												
Phthalic acid dioctayl ester	$C_{24}H_{38}O_4$			20	-	-	-	+	+	-		+	-	-		
				40												
				60												
				80												
				100												
				120												
				140												
Picric acid (SpRB)	$C_6H_3N_3O_7$	FP. 122	1%, aqueous	20	+	-	-	+	+	+		+	+	O	O	+
				40						+		+	+	-	-	O
				60						+		+	+			-
				80						+		+	+			
				100						+		+	+			
				120												
				140												
Potash	see potassium carbonate		cold saturated, aqueous													
Potash lye	KOH		50%	20	+	+		+	+	-		+				
				40	+	+		+	+			+				
				60	+	+		+	+			+				
				80												
				100												
				120												
				140												
Potassium (SpRB)	$KMnO_4$		cold saturated, aqueous	20	+	+		+	+	+		+	+	O	O	+
				40	+	+		+	+	+			+	-	-	+
				60	O			O		+			+			+
				80						+			+			
				100						+						
				120												
				140												
Potassium acetate (SpRB)	CH_3COOK		saturated	20	+	+	+	+	+	+		+	-			
				40	+	+		+	+	+		+				
				60	+	+		+	+	+		+				
				80		+			+	+		+				
				100						+						
				120												
				140												
Potassium bichromate (SpRB)	$K_2Cr_2O_7$	107	saturated, aqueous	20	+	+	+	+	+	+		+	+	+	O	+
				40	+	+	+	+	+	+			+	O	-	+
				60	O	+	+	+	+	+			+			+
				80					+	+						
				100					+	+						
				120						+						
				140												
Potassium borate	K_3BO_3		10%, aqueous	20	+	+	+	+	+	+		+	+	+	+	+
				40	+	+	+	+	+	+			+	+	+	+
				60	O	+	+	+	+	+			+	+	+	+
				80		+										
				100												
				120												
				140												

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Aggressive Media					Chemical Resistance											
Medium	Formula	Boiling point °C	Concentration	Temperature °C	PVC	CPVC	ABS	PE	PP-H	PVDF (SYGEF)		EPDM	FPM	NBR	CR	CSM
Potassium bromate	$KBrO_3$		cold saturated,	20	+	+	+	+	+	+		+	+	+	+	+
			aqueous	40	+	+	+	+	+	+		+	+	+	+	+
				60	O	+	+	O	+	+		+	+	+	+	+
				80		+			+	+			+	+	O	+
				100					+	+				+	O	+
				120						+						
				140												
Potassium bromide	KBr		all, aqueous	20	+	+	+	+	+	+		+	+	+	+	+
				40	+	+	+	+	+	+		+	+	+	+	+
				60	O	+	+	+	+	+		+	+	+	+	+
				80		+				+			+	O	+	+
				100						+			+	O	O	+
				120						+						
				140												
Potassium carbonate (potash)				20	+	+	+	+	+	O		+				
				40	+	+		+	+			+				
				60	+	+		+	+			+				
				80		+			+							
				100												
				120												
				140												
Potassium chlorate (SpRB)	K ClO_3		cold saturated,	20	+	+	+	+	+	O		+	+	+	+	+
			aqueous	40	+	+	+	+	+	-		+	+	O	O	+
				60	+	+	+	+	+				+			+
				80		+							+			O
				100									+			
				120												
				140												
Potassium chloride	KCl		all, aqueous	20	+	+	+	+	+	+		+	+	+	+	+
				40	+	+	+	+	+	+		+	+	+	+	+
				60	+	+	+	+	+	+		+	+	+	+	+
				80		+			+	+			+			+
				100					+	+			+			
				120						+						
				140												
Potassium chromate (SpRB)	K_2CrO_4		cold saturated,	20	+	+	+	+	+	+		+	+	+	+	+
			aqueous	40	+	+	+		+	+			+	O	+	+
				60	+	+	+		+	+			+	-	O	O
				80						+						
				100						+						
				120												
				140												
Potassium cyanide	KCN		cold saturated,	20	+	+	+	+	+	+			+	+	+	+
			aqueous	40	+	+	+	+	+	+			O	+	+	+
				60	+	+	+	+	+	O		+	-	+	O	+
				80		+			+			+		+	-	+
				100												
				120												
				140												
Potassium dichromate	$K_2Cr_2O_7$		saturated	20		+		+	+	+		+	+			
				40		+		+	+	+						
				60		+		+	+	+						
				80		+				+						
				100						+						
				120												
				140												

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Aggressive Media					Chemical Resistance											
Medium	Formula	Boiling point °C	Concentration	Temperature °C	PVC	CPVC	ABS	PE	PP-H	PVDF (SYGEF)		EPDM	FPM	NBR	CR	CSM
Potassium fluoride	KF		saturated	20	+	+		+	+	+			+			
				40	+	+		+	+	+						
				60	+	+		+	+	+						
				80		+			+	+						
				100						+						
				120												
				140												
Potassium Hexacyanoferrate -(II)	$K_4[Fe(CN)_6]\cdot 3H_2O$			20	+	+		+	+	+		+	+			
				40	+	+		+	+	+						
				60	+	+		+	+	+						
				80		+			+	+						
				100						+						
				120												
				140												
Potassium hydrogen carbonate	$KHCO_3$		saturated	20	+	+		+	+	+		+	+			
				40	+	+		+	+	+		+				
				60	+	+		+	+	+		+				
				80		+			+							
				100												
				120												
				140												
Potassium hydrogen sulphate	$KHSO_4$		saturated	20	+	+		+	+			+				
				40	+	+		+	+			+				
				60	+	+		+	+			+				
				80		+			+			+				
				100												
				120												
				140												
Potassium iodide	KJ		cold saturated, aqueous	20	+	+	+	+	+	+		+	+	+	+	+
				40	+	+	+	+	+	+			+	O	O	+
				60	+	+	+	+	+	+			+	-	-	+
				80		+				+			+			
				100						+						
				120												
				140												
Potassium nitrate	KNO_3		50%, aqueous	20	+	+	+	+	+	+		+	+	+	+	+
				40	+	+	+	+	+	+			+	+	+	+
				60	+	+	+	+	+	+			+	+	+	+
				80		+				+						
				100						+						
				120												
				140												
Potassium perchlorate (SpRB)	$KClO_4$		cold saturated, aqueous	20	+	+		+		+		+	+	+	+	+
				40	+	+				+			+	O	O	+
				60	O	+				+			+			+
				80		+				+			+			O
				100												
				120												
				140												
Potassium persulphate (SpRB)	$K_2S_2O_8$		all, aqueous	20	+	+	+	+	+	+		+	+	-	+	+
				40	+	+	+	+	+	+		+	+		+	+
				60	O	+	+	+	+	+			+		+	+
				80						+			+		O	O
				100									+			
				120												
				140												

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Aggregate Media					Chemical Resistance											
Medium	Formula	Boiling point °C	Concentration	Temperature °C	PVC	CPVC	ABS	PE	PP-H	PVDF (SYGEF)		EPDM	FPM	NBR	CR	CSM
Potassium sulphate	K_2SO_4		all, aqueous	20	+	+	+	+	+	+		+	+	+	+	+
				40	+	+	+	+	+	+		+	+	+	+	+
				60	O	+	+	+	+	+			+	+	+	+
				80		+				+			+			
				100						+			+			
				120												
				140												
Potassium sulphide	K_2S		saturated	20	+	+		+	+	O		+				
				40	+	+		+	+	O		+				
				60	+	+		+	+	O		+				
				80		+			+			+				
				100												
				120												
				140												
Potassium sulphite	K_2SO_3		saturated	20	+	+		+	+			+				
				40	+	+		+	+							
				60	+	+		+	+							
				80		+										
				100												
				120												
				140												
Potassium-aluminiumsulfate (alum)			50%	20	+	+		+	+	+		+				
				40	+	+		+	+	+		+				
				60	+	+		+	+	+		+				
				80		+			+	+		+				
				100						+						
				120												
				140												
Pottasium hexacyanoferrate -(III)	$K_3[Fe(CN)_6]$.			20	+	+		+	+	+		+	+			
				40	+	+		+	+	+						
				60	+	+		+	+	+						
				80		+			+	+						
				100						+						
				120												
				140												
Pottasium tartrat				20	+			+	+	+		+				
				40	+			+	+	+		+				
				60				+	+	+		+				
				80					+	+						
				100						+						
				120												
				140												
Pottasiumhydrogensulfite				20	+					+		+				
				40	+					+		+				
				60						+						
				80						+						
				100						+						
				120												
				140												
Pottasiumhypochlorite	$KOCl$			20	+	O		+	+	O		+	O			
				40												
				60												
				80												
				100												
				120												
				140												

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Aggressive Media					Chemical Resistance											
Medium	Formula	Boiling point °C	Concentration	Temperature °C	PVC	CPVC	ABS	PE	PP-H	PVDF (SYGEF)		EPDM	FPM	NBR	CR	CSM
Pottasiumperoxodisulfate	$K_2S_2O_8$		saturated	20	+	+										
				40	+	+										
				60	+	+										
				80		+										
				100												
				120												
				140												
Pottasiumphosphate	KH_2PO_4 und $K_2H\ PO_4$		all, aqueous	20	+	+	O	+	+	+		+	+	+	+	+
				40	+	+		+	+	+		+	+	O	O	+
				60	O	+		+	+	+			+	-	-	+
				80		+			+	+			+			O
				100									+			
				120												
				140												
Pottasiumphosphate				20	+				+							
				40	+				+							
				60	+				+							
				80					+							
				100												
				120												
				140												
Propane	C_3H_8	-42	technically pure, liquid	20	+	-	-	+	+	+		-	+	+	-	-
				40						+						
				60						+						
				80												
				100												
				120												
				140												
Propane			technically pure, gaseous	20	+	+	-	+	+	+		-	+	+	+	O
				40						+						
				60						+						
				80												
				100												
				120												
				140												
Propanol, n- and iso- (SpRB)	C_3H_7OH	97 bzw. 82	technically pure	20	+	-	-	+	+	+		+	+	+	+	+
				40	O			+	+	+		+	+	O	+	O
				60	O			+	+	+			+	-	+	O
				80						O						
				100												
				120												
				140												
Propargyl alcohol (SpRB)	CHčC-CH_2-OH	114	7%, aqueous	20	+	-	-	+	+	+		+	+	+	+	+
				40	+			+	+	O		+	+	+	+	+
				60	+			+	+	O			+	+	O	O
				80												
				100												
				120												
				140												
Propionic acid (SpRB)	CH_3CH_2COOH	141	50%, aqueous	20	+	O	-	+	+	+		+	+	-	O	O
				40	+			+	+	+		+	+		-	-
				60	O			+	+	+			O			
				80												
				100												
				120												
				140												

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Aggressive Media					Chemical Resistance											
Medium	Formula	Boiling point °C	Concentration	Temperature °C	PVC	CPVC	ABS	PE	PP-H	PVDF (SYGEF)		EPDM	FPM	NBR	CR	CSM
Propionic acid (SpRB)		141	technically pure	20	+	O	-	+	+	+		+	+	-	-	-
				40	O			O	O	+		O	+			
				60				O	O	+			+			
				80									O			
				100												
				120												
				140												
Propylene glycol (SpRB)	$C_3H_8O_2$	188	technically pure	20	+	-	O	+	+	+		+	+	+	+	+
				40	+			+	+	+		+	+	O	+	+
				60	+			+	+	+			O	-		+
				80												
				100												
				120												
				140												
Propylene oxide	C_3H_6O	35	technically pure	20	O		-	+	+	+		O	-	-	-	-
				40						O						
				60												
				80												
				100												
				120												
				140												
Pyridine	C_5H_5N	115	technically pure	20	-	-	-	+	O	+		O	-	-	-	-
				40				O	O	-						
				60				O	O							
				80												
				100												
				120												
				140												
Pyrogallol	$C_6H_3(OH)_3$		100%	20						+			+			
				40						+						
				60												
				80												
				100												
				120												
				140												
Ramsit fabric waterproofing agents			usual commercial	20	+			+	+	+		+	+	+	+	+
				40	+					+						
				60	+					+						
				80												
				100												
				120												
				140												
Salicylic acid	$C_6H_4(OH)COOH$		saturated	20	+	+	O	+	+	+		+	+	+	+	+
				40	+			+	+	+		+				
				60				+	+	+		+				
				80						+						
				100												
				120												
				140												
Sea water	see Brine															
Silicic acid	$Si(OH)_4$			20	+	+	+	+	+			+				
				40	+	+		+	+			+				
				60	+	+		+	+			+				
				80					+							
				100												
				120												
				140												

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Aggressive Media					Chemical Resistance											
Medium	Formula	Boiling point °C	Concentration	Temperature °C	PVC	CPVC	ABS	PE	PP-H	PVDF (SYGEF)		EPDM	FPM	NBR	CR	CSM
Silicone oil				20	+	+	+	+	+	+		+	+	+	+	+
				40	O	+		+	+	+		+	+	+	+	+
				60	-			+	+	+		+	+	+	O	
				80					+	+						
				100						+						
				120												
				140												
Silver	AgCn		saturated	20	+	+	+	+	+	+		+	+	+	+	+
				40	+	+		+	+	+		+	+			
				60	+	+		+	+	+		+	+			
				80												
				100												
				120												
				140												
Silver salts	$AgNO_3$, AgCN, AgCl		cold saturated, aqueous	20	+	+	+	+	+	+		+	+	+	+	+
				40	+	+	+	+	+	+		+	+	+	+	+
				60	O	+	+	+	+	+		+	+	+	+	+
				80		+			+	+						
				100						+						
				120												
				140												
Silvercyanide				20	+	+	+	+	+	+		+	+	+	+	+
				40	+	+		+	+	+		+	+			
				60	+	+		+	+	+		+	+			
				80												
				100												
				120												
				140												
Soap solution (SpRB)			all, aqueous	20	+	+	+	+	+	+		+	+	+	+	+
				40	+	+	+	+	+	+		+	+	+	+	+
				60	O	+		+	+	+		+	+	+	+	+
				80						+						
				100						+						
				120												
				140												
Soda	see Sodium carbonate															
Sodium acetate	CH_3COONa		all, aqueous	20	+	+	+	+	+	+		+	-	+	+	O
				40	+	+		+	+	+		+		+	+	
				60	+	+		+	+	+		+				
				80		+			+	+						
				100					+	O						
				120												
				140												
Sodium aluminium sulfate				20	+			+	+							
				40	+			+	+							
				60	+			+	+							
				80					+							
				100												
				120												
				140												
Sodium arsenite	Na_3AsO_3		saturated	20	+	+		+	+			+				
				40	+	+		+	+			+				
				60	+	+		+	+			+				
				80		+			+							
				100												
				120												
				140												

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Aggressive Media					Chemical Resistance										
Medium	Formula	Boiling point °C	Concentration	Temperature °C	PVC	CPVC	ABS	PE	PP-H	PVDF (SYGEF)	EPDM	FPM	NBR	CR	CSM
Sodium benzoate	C_6H_5-COONa		cold saturated, aqueous	20	+	+	-	+	+	+	+	+	+	+	+
				40	+	+		+	+	+	O	+	+	+	+
				60	O	+		+	+	+		+			O
				80		+				+		O			
				100						O					
				120											
				140											
Sodium bicarbonate	$NaHCO_3$		cold saturated, aqueous	20	+	+	+	+	+	+	+	+	+	+	+
				40	+	+	+	+	+	+	+	+	+	+	+
				60	+	+	+	+	+	+	+	+	+	+	+
				80					+	+	+	+			
				100						+					
				120											
				140											
Sodium bisulphate	$NaHSO_4$		10%, aqueous	20	+	+	+	+	+	+	+	+	+	+	+
				40	+	+	+	+	+	+	O	+	O	+	+
				60	O	+	+	+	+	+		+	-	O	
				80						+		+			
				100						+		+			
				120						+					
				140											
Sodium bisulphite	$NaHSO_3$		all, aqueous	20	+	+		+	+	+	+	O	O	+	+
				40	O	+		+	+	+	O	-	-	+	+
				60	-	+		+	+	+	-			O	+
				80						+				-	O
				100						+					
				120											
				140											
Sodium borate	Na_3BO_3		saturated	20	+	+		+	+		+	+			
				40	+	+		+	+		+	+			
				60	+	+		+	+		+	+			
				80		+			+						
				100											
				120											
				140											
Sodium bromate	$NaBrO_3$		all, aqueous	20	+	+		+	+	+	+	+	+	+	+
				40	O	+		O	O	+		+	O	+	+
				60						+		+	-	O	+
				80						+					
				100						+					
				120											
				140											
Sodium bromide	NaBr		all, aqueous	20	+	+	+	+	+	+	+	+	+	+	+
				40	+	+	+	+	+	+		+	O	+	+
				60	O	+	+	+	+	+		+		O	O
				80		+			+	+		+			
				100						+					
				120						+					
				140											
Sodium carbonate	see soda		cold saturated, aqueous												
Sodium chlorate (SpRB)	$NaClO_3$		all, aqueous	20	+	+	+	+	+	O	+	+	+	+	+
				40	+	+	+	+	+		+	+	O	+	+
				60	O	+	+	+	+		+	+	-	O	+
				80		+					O	+		-	O
				100							-				
				120											
				140											

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Aggressive Media					Chemical Resistance											
Medium	Formula	Boiling point °C	Concentration	Temperature °C	PVC	CPVC	ABS	PE	PP-H	PVDF (SYGEF)		EPDM	FPM	NBR	CR	CSM
Sodium chlorite (SpRB)	$NaClO_2$		diluted, aqueous	20	O	+		+	+	+		+	+	-	O	+
				40		+		O	O	O		+	+		-	+
				60		+				O		+	+			+
				80		+										
				100												
				120												
				140												
Sodium chromate (SpRB)	Na_2CrO_4		diluted, aqueous	20	+	+	+	+	+	+		+	+	+	+	+
				40	+	+	+		+	+		+	+	O	+	+
				60	O		+			+		+	+	-	O	O
				80						+						
				100						+						
				120												
				140												
Sodium disulphite	$Na_2S_2O_5$		all, aqueous	20	+	+		+	+	+		+	+	O	+	+
				40	+	+				+		+	+	-	+	+
				60	O	+				+		+	+		+	O
				80						+						
				100						+						
				120												
				140												
Sodium dithionite	see hyposulphite		up to 10%, aqueous													
Sodium fluoride	NaF		cold saturated, aqueous	20	+	+	+	+	+	+		+	+	+	+	+
				40	+	+	+			+		+	+	+	+	+
				60	+	+	+			+		+	+	O	+	+
				80						+						
				100						+						
				120												
				140												
Sodium hydroxide (see Caustic soda)																
Sodium hypochlorite (SpRB)	NaOCl		12,5% active chlorine, aqueous	20	+			O	O	O		+	+	-	-	+
				40	+			-	-							
				60	O											
Sodium iodide	NaI		all, aqueous	20	+	+	+	+	+	+		+	+	+	+	+
				40	+	+	+			+			+	+	+	+
				60	O	+	+			+			+	O	+	O
				80		+				+						
				100						+						
				120												
				140												
Sodium nitrate	$NaNO_3$		cold saturated, aqueous	20	+	+	+	+	+	+		+	+	+	+	+
				40	+	+	+	+	+	+		+	+	+	+	+
				60	O	+		+	+	+		+	+	+	+	+
				80					+	+						
				100						+						
				120						+						
				140												
Sodium nitrite	$NaNO_2$		cold saturated, aqueous	20	+	+	+	+	+	+		+	+	+	+	+
				40	+	+	+	+	+	+			+	O	+	+
				60	+	+		+	+	+			+	-	+	+
				80		+			+	+						
				100						+						
				120						+						
				140												

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Aggressive Media					Chemical Resistance											
Medium	Formula	Boiling point °C	Concentration	Temperature °C	PVC	CPVC	ABS	PE	PP-H	PVDF (SYGEF)		EPDM	FPM	NBR	CR	CSM
Sodium oxalate	$Na_2C_2O_4$		cold saturated, aqueous	20	+	+	+	+	+	+			+	+	+	+
				40	+	+				+						
				60	O	+				O						
				80												
				100												
				120												
				140												
Sodium perborate	$NaBO_3\ 4H_2O$		saturated	20	+	+		+	+	+		+	+			
				40	+	+				+						
				60	+	+				+						
				80		+										
				100												
				120												
				140												
Sodium perchlorate	$NaClO_4$		saturated	20	+	+		+	+			+	+			
				40	+	+										
				60	+	+										
				80		+										
				100												
				120												
				140												
Sodium persulphate (SpRB)	$Na_2S_2O_8$		cold saturated, aqueous	20	+			+	+	+		+	+	-	+	+
				40	+			+	+	+		+	+		+	+
				60	O			+	+	+			+		+	+
				80									+		O	O
				100									+			
				120												
				140												
Sodium phosphate	Na_3PO_4		cold saturated, aqueous	20	+	+	+	+	+	+		+	+	+	+	+
				40	+	+		+	+	+		+	+	+	+	+
				60	O	+		+	+	+		+	+	+	+	+
				80		+			+	O						
				100					+	-						
				120												
				140												
Sodium silicate	Na_2SiO_3		all, aqueous	20	+	+	+	+	+	+		+	+	+	+	+
				40	+	+	+	+	+	+		+	+	+	+	+
				60	O	+		+	+	O		+	+	+	+	+
				80					+	-						
				100												
				120												
				140												
Sodium Sulfide	Natriumsulfid															
Sodium sulphate	Na_2SO_4, $NaHSO_4$		cold saturated, aqueous	20	+	+	+	+	+	+		O	+	+	+	+
				40	+	+	+	+	+	+		O	+	+	+	+
				60	O	+	+	+	+	+		O	+	+	+	+
				80					+	+			+			
				100						+						
				120						+						
				140												
Sodium sulphide	Na_2S		cold saturated, aqueous	20	+	+	+	+	+	O		+	+	+	-	+
				40	+	+	+	+	+	O		+		+		+
				60	O	+	+	+	+	O		+		+		+
				80		+			+							
				100												
				120												
				140												

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Aggressive Media					Chemical Resistance										
Medium	Formula	Boiling point °C	Concentration	Temperature °C	PVC	CPVC	ABS	PE	PP-H	PVDF (SYGEF)	EPDM	FPM	NBR	CR	CSM
Sodium sulphite	Na_2SO_3		cold saturated, aqueous	20	+	+	+	+	+	+	+	+	+	+	+
				40	+	+		+	+	+	+	+	O	+	+
				60	O	+		+	+	+	+	+	-	O	+
				80		+			+	+					
				100						+					
				120											
				140											
Sodium thiosulphate	$Na_2S_2O_3$		cold saturated, aqueous	20	+	+	+	+	+	+	+	+	+	+	+
				40									O	+	+
				60									-	O	O
				80											
				100											
				120											
				140											
Sodiumchloride	NaCl		each, aqueous	20	+	+	+	+	+	+	+	+			
				40	+	+	+	+	+	+	+	+			
				60	+	+		+	+	+	+	+			
				80		+			+	+	+	+			
				100						+		+			
				120											
				140											
Sodiumcyanide	NaCN			20	+	+		+	+	+	+	+			
				40	+	+		+	+	+	+	+			
				60	+	+		+	+	+	+	+			
				80		+			+						
				100											
				120											
				140											
Sodiumdichromate	Na_2Cs2O_7			20	O	+		+	+		+	+			
				40		+		+			+	+			
				60		+						+			
				80		+									
				100											
				120											
				140											
Sodiumhydrogen-carbonate	$NaHCO_3$			20	+	+	+	+	+	+	+	+			
				40	+	+		+	+	+	+				
				60	+	+		+	+	+	+				
				80		+			+						
				100											
				120											
				140											
Sodiumhydrogensulfate	$NaHSO_4$			20	+	+	+	+	+	+	+	+			
				40	+	+		+	+	+	+	+			
				60	+	+		+	+	+	+	+			
				80		+			+	+					
				100						+					
				120											
				140											
Spindle oil				20	O	O	-	O	+	+	-	+	+	O	-
				40					O	+		O	+	-	O
				60				O	-	+		-	O		-
				80						+			-		
				100											
				120											
				140											

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Aggressive Media					Chemical Resistance											
Medium	Formula	Boiling point °C	Concentration	Temperature °C	PVC	CPVC	ABS	PE	PP-H	PVDF (SYGEF)		EPDM	FPM	NBR	CR	CSM
Spinning bath acids containing carbon disulphide (SpRB)			100 mg CS_2/l	20	+			+	+	+			+	-	-	O
				40	+					+						
				60												
				80												
				100												
				120												
				140												
Spinning bath acids containing carbon disulphide (SpRB)			200 mg CS_2/l	20	O			+	+	+		-	+	-	-	-
				40						+						
				60												
				80												
				100												
				120												
				140												
Spinning bath acids containing carbon disulphide (SpRB)			700 mg CS_2/l	20	-			+	+	+		-	+	-	-	-
				40						+						
				60												
				80												
				100												
				120												
				140												
Stannous chloride	see Tin II chloride		cold saturated, aqueous													
Stannous chloride - Tin IV chloride	$SnCl_4$		cold saturated, aqueous	20				+	+							
				40				+	+							
				60				+	+							
				80					+							
				100												
				120												
				140												
Starch solution	$(C_6H_{10}O_5)n$		all, aqueous	20	+	+	+	+	+	+		+	+	+	+	+
				40	+	+	+	+	+	+		+	+	+	+	+
				60	+	+		+	+	+		+	+	+	+	+
				80		+				+						
				100						+						
				120												
				140												
Starch syrup			usual commercial	20	+	+	+	+	+	+		+	+	+	+	+
				40	+	+	+	+	+	+		+	+	+	+	+
				60	+	+		+	+	+		+	+	+	+	+
				80		+			+	+		+	+	+	+	+
				100						+		+	+	+	+	+
				120												
				140												
Stearic acid (SpRB)	$C_{17}H_{35}COOH$	Fp. 69	technically pure	20	+	O	+	+	+	+		+	+	+	+	O
				40	+		+			+		+	+	+	+	O
				60	+			O	O	+		O	O	O	O	-
				80						+						
				100						+						
				120						+						
				140												
Styrol				20	-	-	-			+			+			
				40												
				60												
				80												
				100												
				120												
				140												

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Aggressive Media					Chemical Resistance											
Medium	Formula	Boiling point °C	Concentration	Temperature °C	PVC	CPVC	ABS	PE	PP-H	PVDF (SYGEF)		EPDM	FPM	NBR	CR	CSM
Succinic acid	HOOC-CH_2-CH_2-COOH	Fp*., 185	aqueous, all	20	+	+	+	+	+	+		+	+	+	+	+
				40	+	+		+	+	+		+	+	+	+	+
				60	+	+		+	+	+		+	+	+	+	+
				80									+			
				100												
				120												
				140												
Sugar syrup			usual commercial	20	+	+	+	+	+	+		+	+	+	+	+
				40	+	+	O	+	+	+		+	+	+	+	+
				60	O	+		+	+	+		+	+	+	+	+
				80					+	+		+	+			+
				100					+	+						
				120						+						
				140												
Sulfur	S	Fp.*, 119	technically pure	20	O	O	-	+	+	+		+	+	-	+	+
				40	-			+	+	+			+			+
				60				+	+	+			+			+
				80					+	+			+			+
				100						+						
				120						+						
				140												
Sulfur dioxide	SO_2	-10	technically pure, anhydrous	20	+	+	-	+	+	O		+	+	-	-	O
				40	+	+		+	+	O		O	O			-
				60	+	+		+	+	-		-				
				80												
				100												
				120												
				140												
Sulfur dioxide	SO_2		technically pure, moist	20	-	-	-	-	-	-		-	O	-	-	O
				40												
				60												
				80												
				100												
				120												
				140												
Sulfur dioxide	SO_2		all, moist	20	+	+	-	+	+	+		+	+	-	-	O
				40	+	+		+	+	O		O	O			-
				60	O			+	+	-		-	-			
				80												
				100												
				120												
				140												
Sulfur trioxide	SO_3			20	-	-	-	-	-	-		-	-	-	-	-
				40												
				60												
				80												
				100												
				120												
				140												
Sulfuric acid saturated by Chlorine	H_2SO_4+Cl_2		60%	20						+						
				40						+						
				60						+						
				80						+						
				100						+						
				120												
				140												

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Aggressive Media					Chemical Resistance											
Medium	Formula	Boiling point °C	Concentration	Temperature °C	PVC	CPVC	ABS	PE	PP-H	PVDF (SYGEF)		EPDM	FPM	NBR	CR	CSM
Sulfuric acid (see note 2.3.1 on jointing)	H_2SO_4	120	up to 40%, aqueous	20	+	+	+	+	+	+		+	+	O	+	+
				40	+	+	O	+	+	+		+	+	-	O	+
				60	O	+		+	+	+		+	+			O
				80		+				+		O	O			O
				100						+		-	-			-
				120						+						
				140												
Sulfuric acid (see note 2.3.1 on jointing) (SpRB)	H_2SO_4	140	up to 60%, aqueous	20	+	+	-	+	+	+		+	+	-	-	+
				40	+	+		+	O	+		+	+			O
				60	+	+		+	-	+		O	+			O
				80		+				+		-	O			-
				100						+						
				120						+						
				140												
Sulfuric acid (see note 2.3.1 on jointing) (SpRB)	H_2SO_4	195	up to 80%, aqueous	20	+	+	-	+	+	+		O	+	-	-	+
				40	+	+		+	+	+		O	+			O
				60	+	+		O	O	+		-	O			-
				80		+				+			-			
				100						+						
				120						O						
				140												
Sulfuric acid (see note 2.3.1 on jointing) (SpRB)	H_2SO_4	250	90%, aqueous	20	+	+	-	O	O	+		-	+	-	-	-
				40	+	+				+			+			
				60		+				+						
				80						+						
				100						O						
				120						O						
				140												
Sulfuric acid (see note 2.3.1 on jointing) (SpRB)	H_2SO_4		96%, aqueous	20	+	+	-	-	-	+		-	+	-	-	-
				40	+	+				+			+			
				60	O	+				-						
				80												
				100												
				120												
				140												
Sulfuric acid (see note 2.3.1 on jointing) (SpRB)	H_2SO_4		97%	20	+	+	-	-	-	O		-	+	-	-	-
				40		+										
				60												
				80												
				100												
				120												
				140												
Sulfuric acid (see note 2.3.1 on jointing) (SpRB)	H_2SO_4	340	98%	20	+	+	-	-	-	-		-	O	-	-	-
				40	O	+										
				60		O										
				80												
				100												
				120												
				140												
Sulfurous acid	H_2SO_3		saturated, aqueous	20	+	+	O	+	+	+		+	+	-	-	O
				40	+	+	+	+	+	+		-	+			O
				60	O			+	+	+			O			-
				80						+			-			
				100						+						
				120												
				140												

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Aggressive Media					Chemical Resistance										
Medium	Formula	Boiling point °C	Concentration	Temperature °C	PVC	CPVC	ABS	PE	PP-H	PVDF (SYGEF)	EPDM	FPM	NBR	CR	CSM
Sulfuryl chloride	SO_2Cl_2	69	technically pure	20	-	-	-	-	-	O		+	-	O	+
				40											
				60											
				80											
				100											
				120											
				140											
Surfactants (SpRB)			up to 5%, aqueous	20	O	-	-	+	+	+	+	+	+	+	+
				40	O				O	O					
				60	O				O	O					
				80						O					
				100											
				120											
				140											
Surfactants (ESC)				20	O	O	O	O	O	O	O	O	O	O	
				40											
				60											
				80											
				100											
				120											
				140											
Tallow (SpRB)			technically pure	20	+	-	-	+	+	+	+	+	+	+	+
				40	+			+	+	+	+	+	+	+	+
				60	+			+	+	+	+	+	+	+	+
				80						+					
				100						+					
				120											
				140											
Tannic acid (SpRB)			all, aqueous	20	+	+	+	+	+			+	+	+	+
				40		+	+	+	+						
				60		+		+	+						
				80											
				100											
				120											
				140											
Tanning extracts form plants (SpRB)			usual commercial	20	+	+	+	+	+	+	+	+	+	+	+
				40		+	+								
				60											
				80											
				100											
				120											
				140											
Tartaric acid				20						+					
				40						+					
				60											
				80											
				100											
				120											
				140											
Tartaric acid	$HO_2C\text{-}CH(OH)\text{-}CH(OH)\text{-}CO_2H$		all, aqueous	20	+	+	+	+	+	+	+	+	+	+	+
				40	+		+	+	+	+	+	+	+	+	+
				60	O			+	+	+	+	+	O	+	+
				80						+					
				100						+					
				120						+					
				140											

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Aggressive Media					Chemical Resistance											
Medium	Formula	Boiling point °C	Concentration	Temperature °C	PVC	CPVC	ABS	PE	PP-H	PVDF (SYGEF)		EPDM	FPM	NBR	CR	CSM
Tartaric acid up to 10%				20						+						
				40						+						
				60						+						
				80												
				100												
				120												
				140												
Tetrachlorethylene				20	-	-	-	-	-	+		-	+			
				40												
				60												
				80												
				100												
				120												
				140												
Tetrachloroethane	$Cl_2CH\text{-}CHCl_2$	146	technically pure	20	-	-	-	O	O	+		-	O	-	-	-
				40						+						
				60						O						
				80												
				100												
				120												
				140												
Tetrachloroethylene	see Perchloroethylene	121														
Tetraetylene lead (SpRB)	$(C_2H_5)_4Pb$		technically pure	20	+	+	-	+	+	+		O	+	+	O	+
				40						+						
				60						+						
				80						+						
				100						+						
				120						+						
				140												
Tetrahydrofurane	C_4H_8O	66	technically pure	20	-	-	-	O	O	-		O	-	-	-	-
				40												
				60												
				80												
				100												
				120												
				140												
Tetrahydronaphthalene	Teralin	207	technically pure													
Thionyl chloride	$SOCl_2$	79	technically pure	20	-	-	-	-	-	-		O	+	-	-	-
				40												
				60												
				80												
				100												
				120												
				140												
Tin (IV) -chloride				20	+	+				+		+	+			
				40	+	+				+		+	+			
				60	+	+				+		+	+			
				80		+				+			+			
				100						+						
				120												
				140												

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Aggressive Media					Chemical Resistance											
Medium	Formula	Boiling point °C	Concentration	Temperature °C	PVC	CPVC	ABS	PE	PP-H	PVDF (SYGEF)		EPDM	FPM	NBR	CR	CSM
Tin-(II)-chloride	$SnCl_2$			20				+	+							
				40				+	+							
				60				+	+							
				80					+							
				100												
				120												
				140												
Toluene	C_6H_5-CH_3	111	technically pure	20	-	-	-	O	O	+		-	+	-	-	-
				40												
				60												
				80												
				100												
				120												
				140												
Triacetin (Glycerintriacetat)	$C_9H_{14}O_6$			20	-	-	-	+	+	+		+				
				40						+						
				60												
				80												
				100												
				120												
				140												
Tributylphosphate	$(C_4H_9)_3PO_4$	289	technically pure	20	-	-	-	+	+	+		+	-	-	-	-
				40				+	+							
				60				+	+							
				80												
				100												
				120												
				140												
Trichloroacetic acid	Cl_3C-COOH	196	technically pure	20	O	-	-	+	+	O		O	-	-	-	-
				40				O	+							
				60				-	O							
				80												
				100												
				120												
				140												
Trichloroacetic acid	Cl_3-C-COOH		50%, aqueous	20	+	-	-	+	+	+		O	-	-	-	-
				40	O			+	+	+						
				60				+	O	O						
				80						-						
				100												
				120												
				140												
Trichloroethane	Methylchloroform	74	technically pure													
Trichloroethylene	Cl_2C=CHCl	87	technically pure	20	-	-	-	-	O	+		-	+	-	-	-
				40						+						
				60						+						
				80						O						
				100												
				120												
				140												
Trichloromethane	Chloroform	61														

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Aggressive Media					Chemical Resistance											
Medium	Formula	Boiling point °C	Concentration	Temperature °C	PVC	CPVC	ABS	PE	PP-H	PVDF (SYGEF)		EPDM	FPM	NBR	CR	CSM
Tricresyl phosphate (SpRB)	$H_3C\text{-}C_6H_5\text{-}O)_3PO_4$		technically pure	20	-	-	-	+	+			+	-	O	-	-
				40				+						-		
				60				+	O							
				80												
				100												
				120												
				140												
Triethanolamine (SpRB)	$N(CH_2\text{-}CH_2\text{-}OH)_3$	Fp. *21	technically pure	20	O	-	-	+	+	+		O	-	O	-	-
				40						+						
				60												
				80												
				100												
				120												
				140												
Triethylamine (SpRB)	$N(CH_2\text{-}CH_3)3$	89	technically pure	20	-	-	-	+	+	O		-	-	-	-	-
				40						-						
				60												
				80												
				100												
				120												
				140												
Trifluoro acetic acid (SpRB)	$F_3C\text{-}COOH$		up to 50%	20	-	-	-	+	+	+		O	-	-	-	-
				40						O						
				60												
				80												
				100												
				120												
				140												
Trioctyl phosphate (SpRB)	$(C_8H_{17})_3\ PO_4$		technically pure	20	-	-	-	+	+	O		+	-	O	-	-
				40				+	O							
				60												
				80												
				100												
				120												
				140												
Turpentine oil (SpRB)			technically pure	20	+	-	-	O	-	+		-	+	O	-	-
				40	O			O					+			
				60									+			
				80												
				100												
				120												
				140												
Urea (SpRB)	$H_2N\text{-}CO\text{-}NH_2$	Fp.*, 133	up to 30%, aqueous	20	+	+	+	+	+	+		+	+	+	+	+
				40	+	+	+	+	+	+		+	+	+	+	+
				60	O	+		+	+	+		+	+	+	+	+
				80		O				+						
				100						O						
				120												
				140												
Urine				20	+	+	+	+	+	+		+	+	+	+	+
				40	+	+	+	+	+	+		+	+	+	+	+
				60	O	+		+	+	+		+	+	+	+	+
				80						+						
				100						+						
				120												
				140												

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Aggressive Media					Chemical Resistance											
Medium	Formula	Boiling point °C	Concentration	Temperature °C	PVC	CPVC	ABS	PE	PP-H	PVDF (SYGEF)		EPDM	FPM	NBR	CR	CSM
Vaseline			technically pure	20	O	O	-	+	O	+		-	+	+	-	-
				40	-					+			+	+		
				60				-	-	+			+	+		
				80						+			+	+		
				100						+			+	+		
				120						+			+			
				140												
Vegetable oils				20	O	-	-	+	+	+		-	+	+	O	O
				40						+						
				60						+						
				80												
				100												
				120												
				140												
Vegetable oils and fats (SpRB)				20	+	O	-	+	+	+		-	+	+	O	O
				40	O			O	+	+			+	+	O	O
				60					O	+			+	+	-	-
				80						+						
				100						+						
				120												
				140												
Vinegar	see wine vinegar															
Vinyl acetate	CH_2=CHOOCCH$_3$	73	technically pure	20	-	-	-	+	+	+		+	-	-	-	-
				40				+		-						
				60					O							
				80												
				100												
				120												
				140												
Vinyl chloride	CH_2=CHCl	-14	technically pure	20	-	-	-	-	-	+		-	+	-	-	
				40						+						
				60												
				80												
				100												
				120												
				140												
Viscose spinning solution				20	+	-	-	+	+	+			+	-	O	+
				40	+			+	+	+		+	+		O	+
				60	+			+	+	+		+	+		-	+
				80												
				100												
				120												
				140												
Waste gases containing - Alkaline				20	+	+		+	+	+		+	+	+	+	+
				40	+	+		+	+	O		+	+	+	+	+
				60	+	+		+	+	-		+	+	+	+	O
				80		+			+			+	O			-
				100									-			
				120												
				140												
Waste gases containing - Carbon oxides			all	20	+	+		+	+	+		+	+	+	+	+
				40	+	+		+	+	+		+	+	+	+	+
				60	+	+		+	+	+		+	+	+	+	+
				80		+			+	+		+	+			+
				100						+			+			
				120						+						
				140												

(Courtesy George Fischer Engineering Handbook)

Aggressive Media					Chemical Resistance											
Medium	Formula	Boiling point °C	Concentration	Temperature °C	PVC	CPVC	ABS	PE	PP-H	PVDF (SYGEF)		EPDM	FPM	NBR	CR	CSM
Waste gases containing -			all	20	+	+		+	+	+		+	+	O	+	+
Hydrochloric acid				40	+	+		+	+	+		+	+	-	+	+
				60	+	+		+	O	+		+	+		+	+
				80		+				+		O	+			+
				100						+			+			
				120						+						
				140												
Waste gases containing -			traces	20	+	+		+	+	+		+	+	+	+	+
Hydrogen fluoride (SpRB)				40	+	+		+	+	+		+	+	O	+	+
				60	+	+		+	+	+		O	+	-	O	+
				80		+				+			+			
				100						+						
				120												
				140												
Waste gases containing -			traces	20	+	+		+	+	+		+	+	O	+	+
Nitrous gases				40	+	+		+	+	+		+	+	-	+	+
				60	+	+		+	O	+		+	+		O	+
				80		+				+		O	+			O
				100						+			O			
				120												
				140												
Waste gases containing -			traces	20	+	+		+	+	+		+	+	O	+	+
Sulphur dioxide				40	+	+		+	+	+		+	+	-	+	+
				60	+	+		+	+	+		+	+		+	+
				80		+			+	+		+	+			+
				100						+			+			
				120						+						
				140												
Waste gases containing -			traces	20	+	+		+	+	+		+	+	O	+	+
Sulphur trioxide (SpRB)				40	+	+		+	+	+		+	+	-	+	+
				60	+	+		+	O	+		+	+		+	+
				80		+				+		O	+			
				100						+						
				120												
				140												
Waste gases containing -			all	20	+	+		+	+	+		+	+	O	+	+
Sulphuric acid				40	+	+		+	+	+		+	+	-	+	+
				60	+	+		+	+	+		+	+		+	+
				80		+			O	+		O	+			+
				100						+			+			
				120						+						
				140												
Water	H_2O	100		20	+	+	+	+	+	+			+	+	+	+
- distilled				40	+	+	+	+	+	+		+	+	+	+	+
- deionised				60	+	+	+	+	+	+		O	+	+	+	+
				80		+			+	+		-	+	+		+
				100					+	+			+	+		
				120						+			+			
				140												
Water, condensed				20	+	+	+	+	+	+			+	+	+	+
				40	+	+	+	+	+	+		+	+	+	+	+
				60	O	+	+	+	+	+		O	+	+	+	+
				80		+			+	+			+	O		+
				100						+						
				120						+						
				140												

(Courtesy George Fischer Engineering Handbook)

Aggressive Media					Chemical Resistance											
Medium	Formula	Boiling point °C	Concentration	Temperature °C	PVC	CPVC	ABS	PE	PP-H	PVDF (SYGEF)		EPDM	FPM	NBR	CR	CSM
Water, drinking,				20	+	+	+	+	+	+			+	+	+	+
chlorinated				40	+	+	+	+	+	+		+	+	+	+	+
				60	+	+	+	+	+	+		O	+	+	+	+
				80					+	+			+	O		+
				100					+	+			+			
				120						+						
				140												
Water, waste water				20	+	+	+	+	+	+			+	+	+	+
without organic solvent				40	+	+	+	+	+	+		+	+	+	+	+
and surfactants				60		+	+	+	+	+		O	+	+	+	+
				80		+			+	+			+	+		+
				100						+				O		
				120						+						
				140												
Wax alcohol (SpRB)	$C_{31}H_{63}OH$		technically pure	20	+	O	-	O	O	+		+	+	+	+	-
				40	+			-	-	+		+	+	+	+	
				60	+					+		+	+	+	+	
				80												
				100												
				120												
				140												
Wine vinegar (SpRB)			usual commercial	20	+	o	O	+	+	+		+	O	-	O	+
				40	+			+	+	+			-		-	O
				60	+			+	+	+						-
				80					+	+						
				100						+						
				120												
				140												
Wines, red and white			usual commercial	20	+	O	+	+	+	+		+	+	+	+	+
				40			+	+	+	+						
				60				+	+	+						
				80						+						
				100						+						
				120												
				140												
Xylene	$C_6H_4(CH_3)_2$	138?	technically pure	20	-	-	-	-	-	+		-	+	-	-	-
		144		40						+			O			
				60						O			-			
				80						-						
				100												
				120												
				140												
yeasts			all, aqueous	20	+	+	+	+	+	+		+	+	+	+	+
				40	+	+		+	+	+		+	+	+	+	+
				60		+		+	+	+						
				80		+				+						
				100												
				120												
				140												
Zinc salts	$ZnCl_2$, $ZnCO_3$, $Zn(NO_3)_2$, $ZnSO_4$		all, aqueous	20	+	+	+	+	+	+			+	+	+	+
				40	+	+	+	+	+	+		+	+	O	+	+
				60	O	+		+	+	+		+	+	-	+	+
				80						+						
				100						+						
				120						+						
				140												

(Courtesy George Fischer Engineering Handbook)

Aggressive Media					Chemical Resistance											
Medium	Formula	Boiling point °C	Concentration	Temperature °C	PVC	CPVC	ABS	PE	PP-H	PVDF (SYGEF)		EPDM	FPM	NBR	CR	CSM
Zinccarbonate				20	+	+	+	+	+	+		+	+			
				40	+	+		+	+	+		+	+			
				60	+	+		+	+	+		+	+			
				80		+			+	+		+	+			
				100						+						
				120												
				140												
Zincchloride			saturated	20	+	+	+	+	+	+		+	+			
				40	+	+		+	+	+		+	+			
				60	+	+		+	+	+		+	+			
				80		+			+	+			+			
				100						+						
				120												
				140												
Zincnitrate	$Zn(NO_3)_2$		saturated	20	+	+	+	+	+	+		+	+			
				40	+	+		+	+	+		+	+			
				60	+	+		+	+	+		+	+			
				80		+			+	+			+			
				100						+						
				120												
				140												
Zincoxide			Suspension	20						+						
				40						+						
				60						+						
				80						+						
				100						+						
				120												
				140												
Zincphosphate			saturated	20	+	+	O	+	+	+		+	+			
				40	+	+		+	+	+		+	+			
				60	+	+		+	+	+		+	+			
				80		+			+	+			+			
				100						+						
				120												
				140												
Zincstearate			Suspension	20	-	-	-	+	+	+		+	O			
				40				+	+	+		+				
				60				+	+	+		+				
				80					+	+						
				100						+						
				120												
				140												
Zincsulfate	$ZnSO_4$			20	+	+		+	+	+		+	+			
				40	+	+		+	+	+		+	+			
				60	+	+		+	+	+		+	+			
				80		+			+	+		+	+			
				100						+			+			
				120												
				140												
1-Chloropentan	$C_5H_{11}Cl$			20	-	-	-									
				40												
				60												
				80												
				100												
				120												
				140												

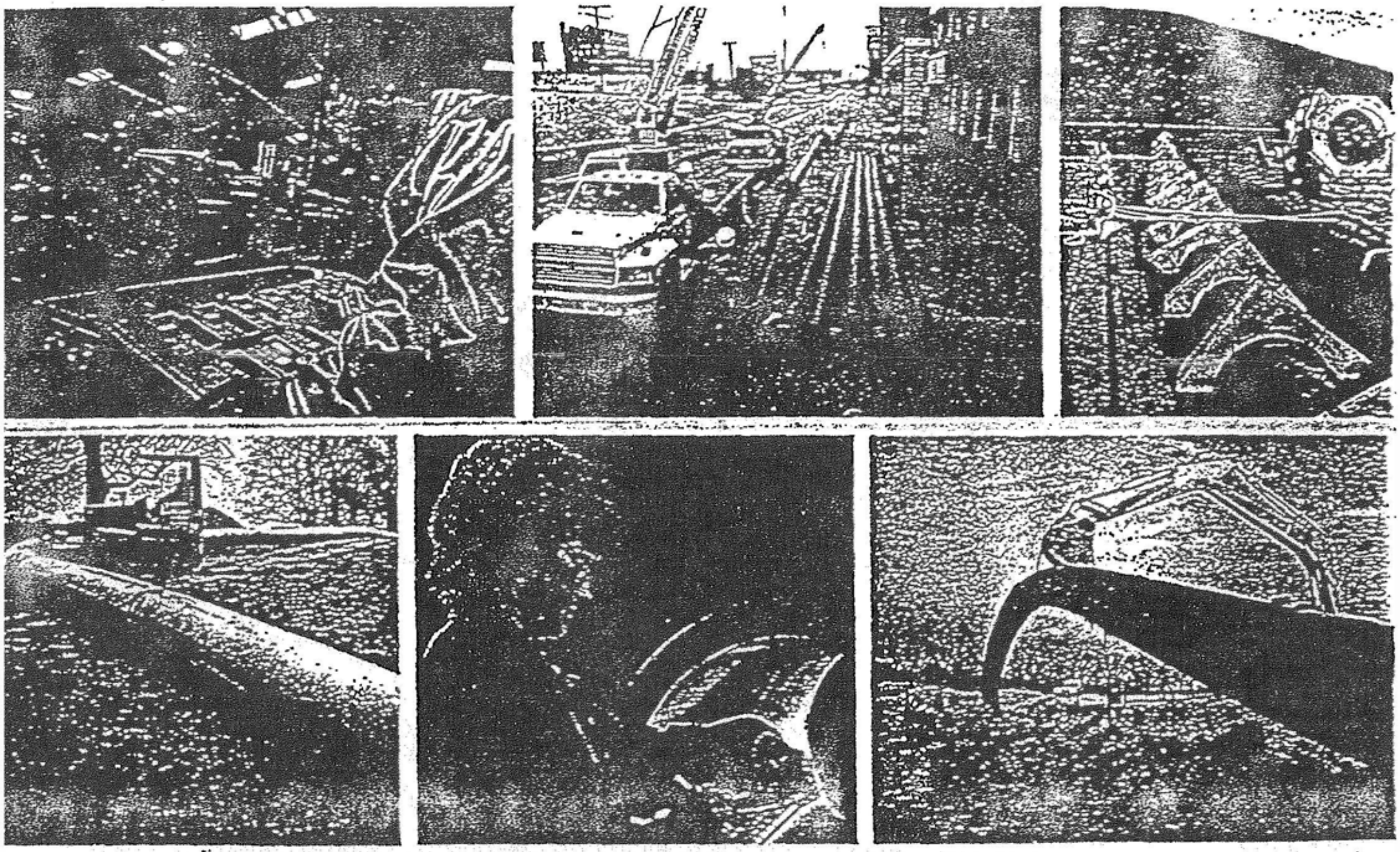
(Courtesy George Fischer Engineering Handbook)

Aggressive Media					Chemical Resistance											
Medium	Formula	Boiling point °C	Concentration	Temperature °C	PVC	CPVC	ABS	PE	PP-H	PVDF (SYGEF)		EPDM	FPM	NBR	CR	CSM
1,1,2-Trifluoro, 1,2,2-Trichloroethane (Freon 113) (SpRB)	$FCl_2C\text{-}CClF_2$	47	technically pure	20	+		-			+			+	+	+	+
				40	+											
				60												
				80												
				100												
				120												
				140												

(Courtesy George Fischer Engineering Handbook)

DRISCOPIPE

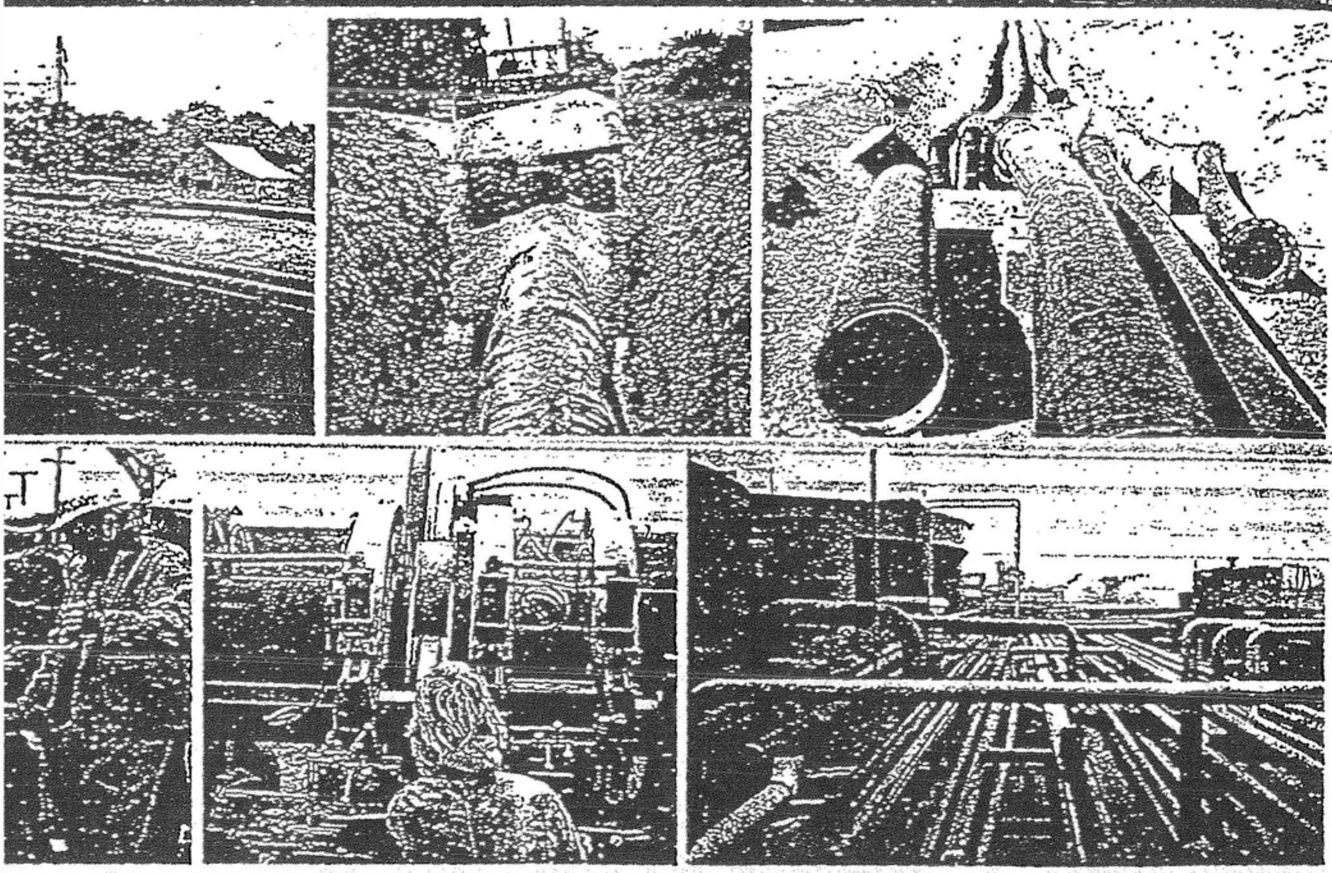
Engineering Characteristics



PHILLIPS 66

Contents

Photographs shown are typical Driscopipe installations.



DRISCOPIPE

Driscopipe® Engineering Characteristics

Introduction

Driscopipe high density polyethylene piping systems offer the modern engineer the opportunity to take advantage of the unusual characteristics of these materials and use them to solve many old problems and to design systems for applications where traditional materials are either unsuitable or too expensive. When compared to the older traditional piping materials, Driscopipe polyethylene piping systems offer a new freedom in environmental design, extended service life, significant savings for installation labor and equipment costs, and reduced maintenance for pipeline systems where operating conditions are within the pressure and temperature capabilities of the material.

This brochure outlines the Engineering Characteristics of Driscopipe high density polyethylene pipe and fittings and points out many of the advantages and benefits to be realized through the use of these systems. The discussion is directed primarily toward the large diameter (3" through 54") Driscopipe 8600 and Driscopipe 1000 Industrial and Municipal product lines. However, these engineering characteristics are also typical of other Driscopipe polyethylene product lines.

Physical Properties

Driscopipe 8600 is manufactured from Marlex M-8000 very high molecular weight high density PE 3408 resin. Pipe and fittings made from Marlex M-8000 are extremely tough and durable, and possess exceptional long term strength. Marlex M-8000 is a proprietary product and is extruded only by Phillips Driscopipe, Inc.

Driscopipe 1000 is manufactured from Marlex TR-480, a PE 3408 polyethylene pipe resin in a molecular weight range which permits the pipe to be extruded by conventional methods. In this respect, Driscopipe 1000 is comparable to other extra high molecular weight, high density, PE 3408 polyethylene pipes commercially available in North America.

Sheets detailing typical physical properties for Driscopipe 1000 and Driscopipe 8600 are available upon request.

Long Term Hydrostatic Strength

One of the outstanding engineering characteristics of Driscopipe high density polyethylene pipe is its long term hydrostatic strength under various thermal and environmental conditions. Life expectancy is conservatively estimated to be in excess of 50 years using the standard design basis. This strength is determined by standardized methods and procedures which the plastic pipe industry has used for many years to evaluate the long term strength of all types of plastic pipe.

Pipe hoop stress versus time to failure plots of long term hydrostatic pressure data for thermoplastic pipe have been studied and analyzed for many years. The mathematical equations used to evaluate the test data and extrapolate values to longer periods of time were chosen after careful evaluation of more than 1,000 sets of long term test data representing more than 400 plastic pipe compounds. Continued testing on new compounds and extended testing of older compounds have proven the validity of these test methods. Actual data from more than 11½ years (100,000 hours) of continuous testing shows the industry methods to be slightly conservative in that actual values are slightly higher than those calculated by the industry-accepted ASTM method.

The reduction in strength which occurs with time, as indicated by the stress-life curves, does not represent a strength degradation of the material but is more in the nature of a relaxation effect. Plastic pipe samples which have been on test for periods up to 70,000 hours have been de-pressurized and checked for permanent reduction of strength by using the quick-burst test. No loss has been found when compared to samples previously quick-burst from the same test lot.

All evidence confirms that the methods used to predict the long term strength of plastic pipe are sound methods. Through the years, these policies and procedures, used to develop recommended hydrostatic design strengths, have influenced manufacturers to research and develop improved piping products such as Driscopipe 8600 and Driscopipe 1000.

Typical calculated long term strengths are shown below:

Long Term Strength @ 73.4°F(23°C)

Time	Hoop Stress, psi
100,000 hrs. (11.43 yrs.)	1635
438,000 hrs. (50 yrs.)	1604
500,000 hrs. (57 yrs.)	1601
1,000,000 hrs. (114 yrs.)	1586

The 114-year long term strength has been included to show more about the nature of the method used by the industry to evaluate the long term strength of plastic pipe and to illustrate the very slow reduction in strength as time progresses.

Long term hoop stresses for design purposes are normally selected at a level which is much lower than the long term strength of the materials. This ensures that the pipe is operating in a hoop stress range where creep (relaxation) of the materials is nil and assures service life in excess of 50 years. Design stress levels are discussed further in the next section.

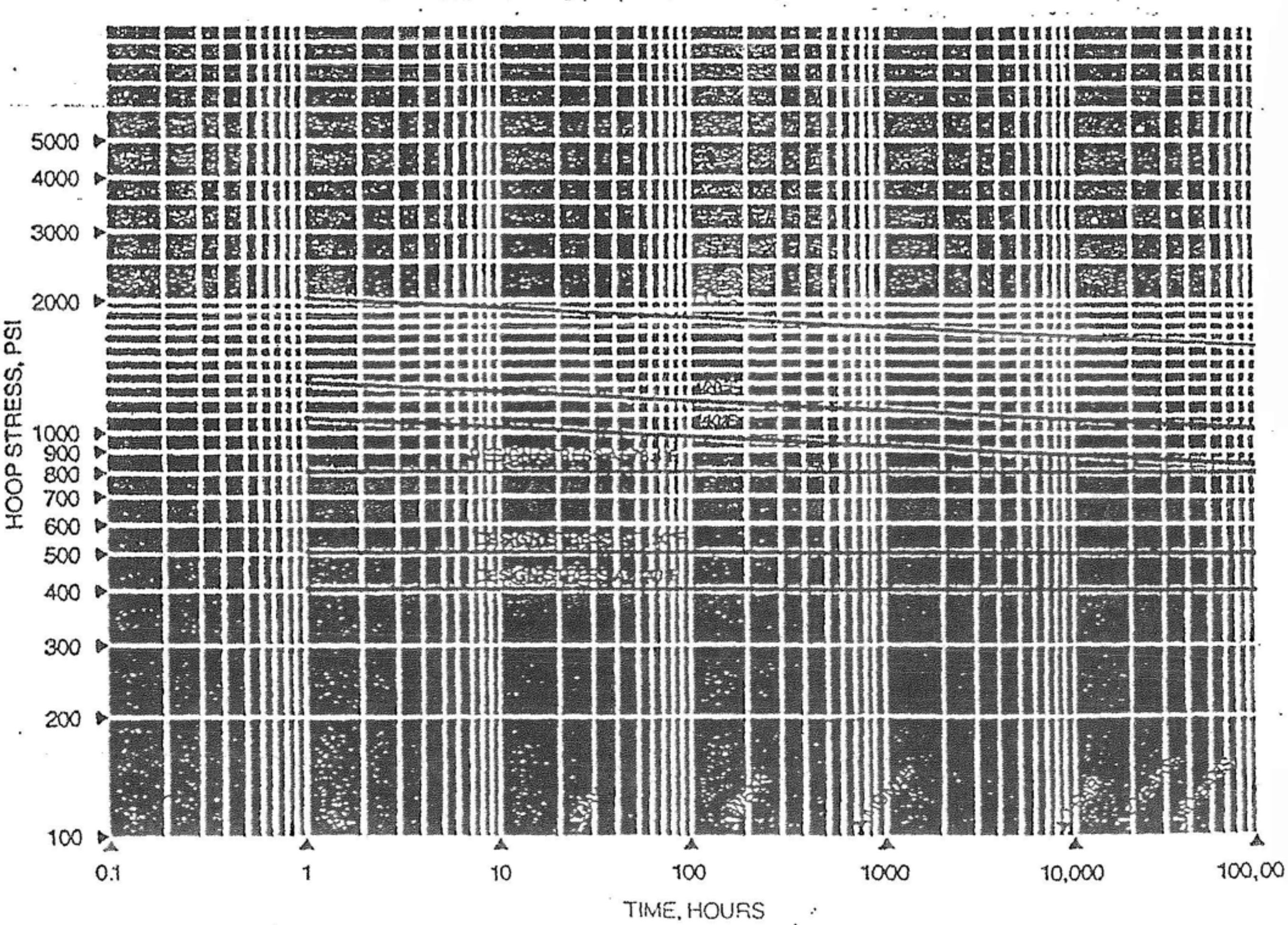
The long term hydrostatic tests are conducted by using ASTM standard test procedures which may be applied to all types of plastic pipe (ASTM D 1598 Test for Time-to-Failure of Plastic Pipe Under Constant Internal Pressure). Stress-life tests are conducted by using numerous pipe samples which are filled with water (or other environmental fluids) and subjected to a controlled pressure at a controlled temperature.

Samples are held on test until they fail. The pressure, temperature and time-to-failure data from all samples are used to calculate and plot stress-life curves for the particular type pipe being tested (ASTM D 2837 Obtaining Hydrostatic Design Basis for Thermoplastic Pipe Materials). This data is then used to predict the probable safe life of the pipe at various stress levels (working pressures) and various temperatures. Because it is not practical to test at all temperature levels, these tests are generally conducted at temperatures of 73.4°F and one or more higher temperatures such as 100°F, 120°F and 140°F.

These stress-life curves give a relationship of the expected life span of the pipe when subjected to various internal stress levels (working pressures) at various temperatures. By comparing stress-life curves, one can compare relative long term performance ability of different plastic pipes. Stress-life curves for Driscopipe 8600 and Driscopipe 1000 are shown in Figure 1.

Figure 1

Stress-Life of Driscopipe® 8600 and Driscopipe® 1000



These stress-life curves were obtained using water as the test medium. However, years of laboratory testing and field experience have shown that these same curves may be used to design Driscopipe systems for natural gas, salt water, sewage and hundreds of other industrial and municipal fluids, mixtures and effluents. The long term strength of Driscopipe indicated by these curves must be de-rated in some environmental circumstances, such as in the presence of liquid hydrocarbons or abrasive fluids, although the pipe is very suitable for use in these environments. An outstanding engineering advantage of Driscopipe is its exceptionally long term service life in the presence of internal and external corrosive service conditions.

Design Pressure Ratings

Since plastic pipe was introduced in the late 50s, the safety factor for design of water systems at standard temperature has been 2 to 1. The 2:1 design factor which was officially adopted by the plastic pipe industry in 1963, was based on allowances for many sources of variation. The guiding principle has always been to make the selection on a conservative basis but not to be unreasonably conservative.

The sources of variation for which allowances are made include ... variation in test methods and procedures among laboratories ... variation among lots of the same compound ... variation of lots of pipe from the compound in different plants and from different extruders ... variation in compounds of the same general class ... variations in handling and installation techniques ... variation in operating pressures (water hammer and surge) ... a strength-time allowance to give service life well beyond 50 years ... and, finally, the great unknown. Each of the factors was judged to reduce the 100,000 hour design strength by 5%-10% or 20% ... for a total of 100% ... or a design factor of 2:1. This is why polyethylene pipe, with a designated 100,000 hour strength of 1600 psi at 73.4°F, has a hydrostatic design strength of 800 psi hoop stress.

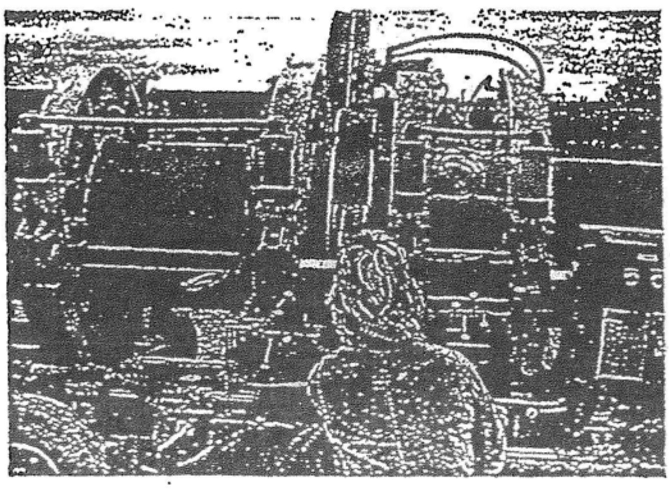
The design pressures for Driscopipe are determined by the following equation, adopted internationally by the industry for this purpose:

$$P = \frac{2S}{SDR-1} \times F \quad \text{or} \quad P = 2S\frac{t}{D-t} \times F$$

Where:
- D = Specified Outside Diameter, Inches
- P = Design Pressure, psi
- S = Long Term Hydrostatic Strength, psi, at the design temperature
- t = Minimum Wall Thickness, Inches
- F = Service Design Factor
- SDR = Standard Dimension Ratio of D/t

The traditional Service Design Factor for water at standard temperature (73.4°F) is one-half (.5). The Service Design Factor for oil or liquid hydrocarbons is 0.25 @ 73°F. The service design factor may be adjusted by the design engineer to reflect the particular conditions anticipated for the application. The temperature selected for design should consider both internal and external conditions. The design temperature should be based on the temperature of the pipe itself. For practical purposes, it is safer to design to the highest temperature.

The design service factor for water may also be used for solutions of inorganic salts, alkaline fluids, non-oxidizing acids, low concentrations of oxidizing acids and many other solutions. See the discussion on chemical resistance for more information.



All standard design pressure ratings shown in Driscopipe literature are based on water at 73.4°F temperature; ie, a safety factor of 2:1 based on the long term hydrostatic strength of the material. Driscopipe is applicable at pressures from 0 to 265 psi and temperatures from below 32°F up to 180°F. Standard Dimension Ratios (SDR) are available from SDR 32.5 to SDR 7.0

Flow Characteristics

Driscopipe polyethylene has excellent flow characteristics as compared to traditional materials. An extremely smooth interior surface offers low resistance to flow. It maintains these excellent flow properties throughout its service life in most applications due to the inherent chemical and abrasion resistance of the material. Because of smooth walls and the non-wetting characteristic of polyethylene, higher flow capacity and less friction loss is possible with Driscopipe. In many cases this higher flow capacity may permit the use of smaller pipe at a lower cost.

A "C" factor of 155 is commonly used in the Hazen-Williams formula for calculating flow in pressure applications. For gravity flow, an "n" factor of .009 is used in Manning's formula.

Experimental test data regarding pumping and pressure drop through Driscopipe is available upon request. This study compares the flow through 8" Driscopipe with and without internal fusion beads using clear water. It also includes flow data for some clay-water slurries and clay-water-sand slurries. Velocities up to 20 fps are studied. Data includes determination of Hazen-Williams "C" factor, Reynolds number, boundry drag, relative roughness, sand grain roughness and friction loss at various velocities.

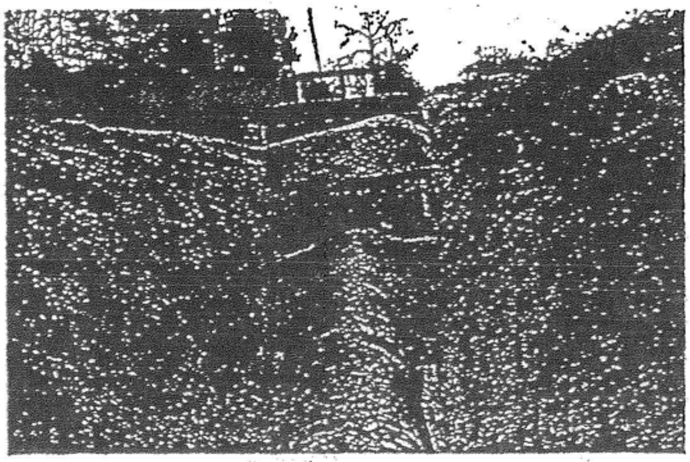
Lightweight – Flexible

The inherent light weight and flexibility of Driscopipe provides many cost saving benefits related to handling, storage, hauling, unloading, stringing, joining and installation. Because of its light weight, Driscopipe can be moved, handled and placed in the ditch with smaller and less expensive construction equipment. Usually, manpower requirements are also reduced.

Driscopipe weighs less than water; it has a specific gravity of .955-.957. Because it will float, it can be joined in long strings and easily towed into position on job sites where water is encountered. The combination of light weight and flexibility provides opportunity to fusion join the pipe in a convenient work area and pull it into position in difficult work areas where terrain or other obstacles present installation problems. The pipe can be joined above ground and rolled or lowered into the trench thus allowing the use of smaller trench widths and eliminating the necessity of placing men and equipment inside the trench. Such installation methods can dramatically reduce the time required for installation in many instances.

The flexibility of Driscopipe allows it to be curved over, under and around obstacles and to make elevation and directional changes, thus eliminating fittings and reducing installation costs. The pipe can be cold bent as it is installed to a radius of 20-40 times the pipe diameter. This flexibility and the butt fusion joining method make Driscopipe ideally suited for inserting it inside older piping systems to renew and renovate such systems at a much lower cost than would be possible otherwise.

Pipe flexibility and toughness also allow small diameter Driscopipe to be plowed-in or pulled-in with suitable equipment.



Toughness — "Ductile PE Pipe"

Overall "toughness" of Driscopipe is an important characteristic of the pipe which is derived from many of the chemical and physical properties of the material as well as the extrusion method. The pipe is ductile. It flexes, bends and absorbs impact loads over a wide temperature range of −180°F up to +180°F. This inherent resiliency and flexibility allow the pipe to absorb surge pressures, vibration and stresses caused by soil movement. Driscopipe can be deformed without permanent damage and with no adverse effect on long term service life. It is flexible for contouring to installation conditions. The toughness of Driscopipe is one of its outstanding engineering characteristics leading to innovative piping design.

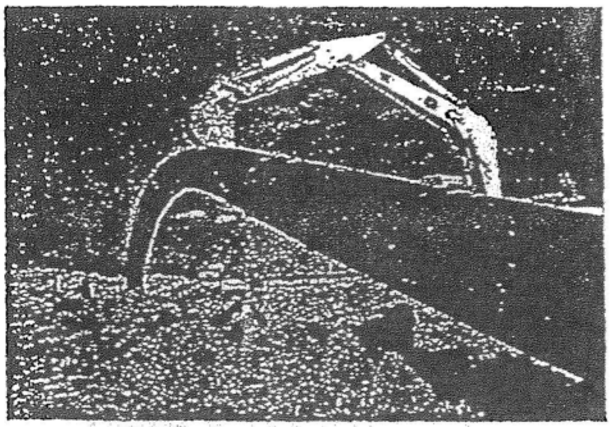
Even though "toughness" has become generally recognized by the industry as a highly desirable characteristic ... there is no standard test which can be used to directly compare the "toughness" among polyethylenes ... as well as among the different plastic materials which are considered suitable for piping.

A "toughness" test has not been devised is simply because it is influenced by so many of the physical and chemical properties of the material. The extreme toughness of Driscopipe has been noted as one of its outstanding features since its introduction to the industry ... yet to explain "toughness", many properties are discussed and demonstrated. To obtain a complete evaluation of the toughness of a plastic material, it is necessary to see demonstrations of tests and to conduct some tests in person in order to compare it with materials which are more familiar, such as cast iron, steel, cement, copper, etc.

Toughness is related to ... Environmental Stress Crack Resistance (ESCR) ... Notch sensitivity ... Resistance to secondary stresses from external loading ... Impact strength ... Tear strength ... Flexibility ... Kink resistance ... Abrasion and scratch resistance ... Flexural strength ... Elongation ... Chemical resistance ... Tensile strength ... Ductility ... Creep resistance ... Temperature resistance ... Density ... Molecular weight ... and the thermoplastic nature of the material. Part of the toughness of any polyethylene material can be attributed to its flexibility, flexural strength and impact resistance as compared to the more rigid thermoplastic materials such as PVC. Polyethylene is ductile and will elongate many times more than PVC. Consequently, it will absorb more impact without damage or failure. PE will flex or elongate and stress relieve itself rather than rupture. Generally, impact strength is greater for the higher molecular weight PE resins. Impact resistance is also important from the standpoint of a piping system being able to absorb energy imposed on it by external forces.

The expansive force of water freezing inside Driscopipe will not damage it.

ESCR is one of the properties closely related to "toughness" and has been studied as a possible means to define and measure toughness. The exceptional resistance of Driscopipe 8600 to environmental stress cracking as compared to other PE materials is discussed further in the next section.



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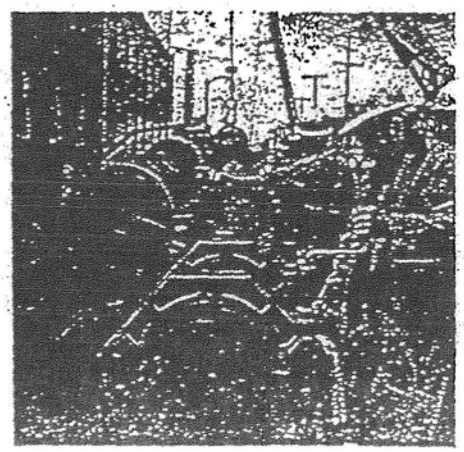
Driscopipe 8600 is unique and differs from Driscopipe 1000 and from all other polyethylene pipes. Driscopipe 8600 exhibits a superior toughness which gives the pipe the highest impact strength, highest tear strength and lowest notch sensitivity of any polyethylene pipe currently available. Driscopipe 8600 offers the highest resistance to cuts, scratches and abrasions which occur when handling and installing the pipe.

These properties are maintained throughout its temperature range without a loss of ductility or reduced resistance to notch sensitivity. Driscopipe has been successfully installed in numerous arctic applications. Some of these applications have included direct burial in the unstable arctic permafrost.

To learn more of the relative toughness of Driscopipe 8600, we encourage you to take a piece of pipe with a butt fusion joint and try to tear it up without using sharp tools. Pound it flat with a sledge hammer ... slam it against a corner of angle iron ... run over it with a truck ... then do the same with steel, copper, PVC, cast iron and the less rugged PEs. It's not very scientific ... but we believe you'll be convinced that Driscopipe 8600 has extremely high toughness. We have evaluated Driscopipe many times in laboratory and field test experiments to demonstrate and prove this toughness.

- One excellent indicator of the relative toughness of Driscopipe 8600, as compared to other polyethylene pipe materials, can be observed in the ASTM Standard Test for determination of flow rate of the thermoplastic materials.

  When Driscopipe 8600 is heated to 190°C (374°F) to measure the flow rate, it requires 432.5 pounds/sq. in. force, applied for 10 minutes, to flow 1½ grams of 8600 material through the orifice of the test unit! Other commercially available polyethylene pipe materials will flow 10 to 20 times this amount under the same conditions.
- When Driscopipe 8600 is heated to 475-500°F to melt it for fusion joining, it requires 150 pounds pressure per square inch of material to make the melted surfaces flow together. This is another indicator of toughness. Other commercially available polyethylene pipe materials require about one-half that amount of pressure and some competitive pipes require less than 25 psi!
- Driscopipe 8600 has been pressure tested for long periods at temperatures up to 140°F and performance requirements at these high temperatures can be used in purchase specifications to assure that the user is getting the highest performing polyethylene pipe.



Environmental Stress Crack Resistance

The most recent ASTM specification written to identify polyethylene plastic pipe and fittings materials is ASTM D 3350, "Polyethylene Plastics Pipe and Fittings Materials", adopted in 1974. This specification uses six (6) properties to classify PE material ... one of these is ESCR.

ASTM D 3350 lists three cell limits for ESCR classification which use the ESCR test outlined in ASTM D 1693, Test Method for Environmental Stress Cracking of Ethylene Plastics. The cell limits are:

Cell Classification Limit	Test Condition ASTM D 1693	Test Duration Hours	Percent of Failures Allowed	Test Temp. °C
1	A	48	50	50°
2	B	24	50	50°
3	C	192	20	100°

Minimum Notch for A is .020"; for B and C is .012". Minimum Thickness for A is .120"; for B and C is .070". A and B use a diluted aqueous solution reagent, C uses full strength reagent.

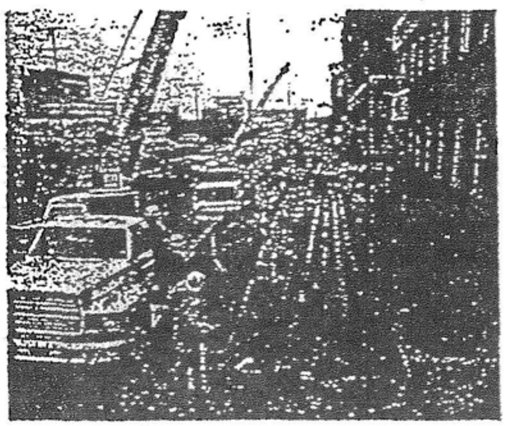
This method of testing for ESCR was first written in 1959 and was developed primarily to evaluate polyethylene as a jacketing material for power and communications cable. Although the method requires the use of laboratory compression molded specimens rather than pipe, it became the generally accepted method for evaluating ESCR of PE materials used for piping. Its wide use was responsible for its inclusion in ASTM D 3550 to describe one of the six primary properties of a PE pipe material.

The test method, ASTM D-1693, is an accelerated test method to determine the resistance of a polyethylene material to environmental stress cracking. It is a measure of the ability of the polyethylene to withstand secondary stress loadings. These loadings are typically thought of as low-level, long-term, external stresses which may act upon the polyethylene pipe in field installations.

Under conditions of the test, high local multiaxial stresses are developed through the introduction of a controlled imperfection (notch). The notched sample is subjected to an elevated temperature bath of a surface active agent. Environmental stress cracking has been found to occur most readily under such conditions.

A note in the test specifications states that, generally, low density (Type I) polyethylenes are tested under Condition A, medium and high density (Type II and Type III) polyethylenes are generally tested under Condition B and high density resins with high melt viscosity, such as pipe grade P34, are tested under Condition C.

As pipe grade polyethylenes have improved, the testing requirements of ASTM D-1693 have become less stringent for P34 pipe grade polyethylenes such as Driscopipe 8600 and Driscopipe 1000. As a result, a more severe stress crack resistance test has been developed to evaluate high density polyethylene pipe. The ASTM F-1248 stress crack resistance test method was developed by a gas distribution company for quality control purposes and is often referred to as Ring ESCR since it tests actual produced pipe ring samples rather than molded specimens.



ASTM F-1248 utilizes rings cut from a pipe sample. The rings are notched on one side and compressed between parallel plates until the distance between the plates is three times the specified pipe minimum wall thickness. The compressed ring samples are subjected to an elevated temperature bath of a surface active agent and visibly inspected for crack formation or propagation.

The Ring ESCR test provides useful information regarding the different polyethylene pipe grade materials. Driscopipe 8600 shows no tendency for sample failures when tested in excess of 10,000 hours. This further reinforces the unique ability of Driscopipe 8600 to provide the highest degree of resistance to the external stresses inherent to a pipeline installation.

Driscopipe 1000, an extra high molecular weight HDPE pipe, will exhibit a ring ESCR of $F_{50} > 1000$ hours. Other lower molecular weight pipes may exhibit lower F_{50} values.

Chemical Corrosion Resistance

The outstanding resistance of Driscopipe to attack by most chemicals makes it suitable to transport these chemicals or to be installed in an environment where these chemicals are present. Factors which determine the suitability and service life of each particular application include the specific chemical and its concentration, pressure, temperature, period of contact and service conditions which may introduce stress concentrations in the pipe or fittings.

Driscopipe is, for all practical purposes, chemically inert within its temperature use range. This advantageous engineering characteristic is one of the primary reasons for the wide use of Driscopipe in industrial applications. It does not rot, rust, pit, corrode or lose wall thickness through chemical or electrical reaction with the surrounding soil, whether acid, alkaline, wet or dry. It neither supports the growth of, nor is affected by, algae, bacteria or fungi and is resistant to marine biological attack. It contains no ingredients which make it attractive to rodents, gophers, etc.

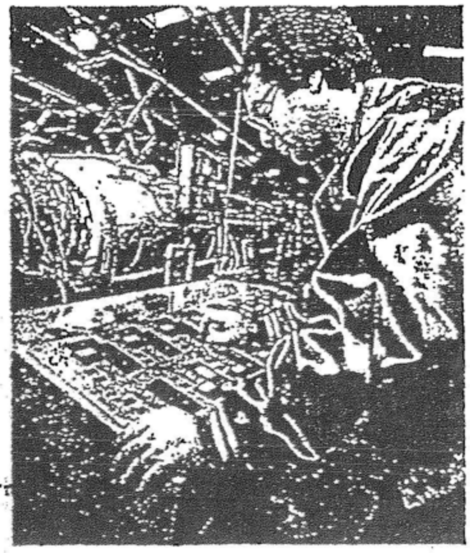
Information relative to the resistance of Driscopipe to a wide range of chemicals is shown in the following tables. This information is based on results of immersion tests (usually 3 months) at various temperatures. Changes in tensile strength and elongation are evaluated at a rapid strain rate to emphasize any strength decay in the material.

Most acids, bases and other chemicals can be transported by Driscopipe using the same design parameters as would apply to water, natural or manufactured gas and water solutions of inorganic salts. Strong oxidizing agents such as fuming sulfuric acid may adversely affect the pipe, depending upon concentration, temperature and period of contact. In many cases, such as gravity flow waste lines, these chemicals can be handled because of dilution and intermittent flow.

Some chemicals, such as all types of liquid hydrocarbons, will mechanically absorb into the wall of the pipe and cause a reduction in hoop stress but this does not degrade the material. This effect is temporary if exposure is intermittent. Where exposure is continuous, it is necessary to derate the pressure capability of the pipe for long term service. This includes such products as gasoline, ethyl alcohol, benzene, carbon tetrachloride, crude and refined oils, etc. Where 5-100% hydrocarbon liquids are continuously present in a pressure system, a service design factor of .25 should be used to calculate design pressures instead of the service design factor of .5 used with water.

$$P = \frac{2S}{SDR-1} \times F \quad \text{or} \quad P = 2S\frac{t}{D-t} \times F$$

Where:
- D = Outside Diameter, Inches
- P = Design Pressure, psi
- S = Long Term Hydrostatic Strength, psi, at the design temperature
- t = Minimum Wall Thickness, Inches
- F = Service Design Factor
- SDR = Standard Dimension Ratio of D/t



CHEMICAL RESISTANCE OF DRISCOPIPE

S – Satisfactory
U – Unsatisfactory
M – Marginal
N – Not known

All concentrations are 100% unless noted otherwise.

On reagents marked marginal, chemical attack will be recognized by a loss of physical properties of the pipe which may require a change in design factors.

Reagent	70°F (21°C)	140°F (60°C)
Acetic Acid 1-10%	S	S
Acetic Acid 10-60%	S	M
Acetic Acid 80-100%	S	M
Acetone	M	U
Acrylic Emulsions	S	S
Aluminum Chloride-Dilute	S	S
Aluminum Chloride Conc.	S	S
Aluminum Fluoride Conc.	S	S
Aluminum Sulfate Conc.	S	S
ums (All Types) Conc.	S	S
Ammonia 100% Dry Gas	S	S
Ammonium Carbonate	S	S
Ammonium Chloride Sat'd	S	S
Ammonium Fluoride 20%	S	S
Ammonium Hydroxide 0.88 S.G.	S	S
Ammonium Metaphosphate Sat'd	S	S
Ammonium Nitrate Sat'd	S	S
Ammonium Persulfate Sat'd	S	S
Ammonium Sulfate Sat'd	S	S
Ammonium Sulfide Sat'd	S	S
Ammonium Thiocyanate Sat'd	S	S
Amyl Acetate	M	U
Amyl Alcohol 100%	S	S
Amyl Chloride 100%	N	U
Aniline 100%	S	N
Antimony Chloride	S	S
Aqua Regia	U	U
Barium Carbonate Sat'd	S	S
Barium Chloride	S	S
Barium Hydroxide	S	S
Barium Sulfate Sat'd	S	S
Barium Sulfide Sat'd	S	S
Beer	S	S
Benzene	M	U
Benzene Sulfonic Acid	S	S
Bismuth Carbonate Sat'd	S	S
leach Lye 10%	S	S
Black Liquor	S	S
Borax Cold Sat'd	S	S
Boric Acid Dilute	S	S

Reagent	70°F (21°C)	140°F (60°C)
Boric Acid Conc.	S	S
Bromic Acid 10%	S	S
Bromine Liquid 100%	M	U
Butanediol 10%	S	S
Butanediol 60%	S	S
Butanediol 100%	S	S
Butyl Alcohol 100%	S	S
Calcium Bisulfide	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 BL'GH Sol.	S	S
Calcium Nitrate 50%	S	S
Calcium Sulfate	S	S
Camphor Oil	N	U
Carbon Dioxide 100% Dry	S	S
Carbon Dioxide 100% Wet	S	S
Carbon Dioxide Cold Sat'd	S	S
Carbon Disulfide	N	U
Carbon Monoxide	S	S
Carbon Tetrachloride	M	U
Carbonic Acid	S	S
Castor Oil Conc.	S	S
Chlorine Dry Gas 100%	S	M
Chlorine Moist Gas	M	U
Chlorine Liquid	M	U
Chlorobenzene	M	U
Chloroform	M	U
Chlorosulfonic Acid 100%	M	U
Chrome Alum Sat'd	S	S
Chromic Acid 20%	S	S
Chromic Acid Up to 50%	S	S
Chromic Acid and Sulfuric Acid	S	M
Cider	S	S
Citric Acid Sat'd	S	S
Coconut Oil Alcohols	S	S
Cola Concentrates	S	S
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
Cottonseed Oil	S	S
Crude Oil*	S	M
Cuprous Chloride Sat'd	S	S
Cyclohexanol	S	S
Cyclohexanone	M	U
Detergents Synthetic	S	S
Developers, Photographic	S	S
Dextrin Sat'd	S	S
Dextrose Sat'd	S	S
Dibutylphthalate	S	M
Disodium Phosphate	S	S

Reagent	70°F (21°C)	140°F (60°C)
Diazo Salts	S	S
Diethylene Glycol	S	S
Diglycolic Acid	S	S
Dimethylamine	M	U
Emulsions, Photographic	S	S
Ethyl Acetate 100%	M	U
Ethyl Alcohol 100%	S	S
Ethyl Alcohol 35%	S	S
Ethyl Butyrate	M	U
Ethyl Chloride	M	U
Ethyl Ether	U	U
Ethylene Chloride	U	U
Ethylene Chlorohydrin	U	U
Ethylene Dichloride	M	U
Ethylene Glycol	S	S
Ferric Chloride Sat'd	S	S
Ferric Nitrate Sat'd	S	S
Ferrous Chloride Sat'd	S	S
Ferrous Sulfate	S	S
Fish Solubles	S	S
Fluoboric Acid	S	S
Fluorine	S	U
Fluosilicic Acid 32%	S	S
Fluosilicic Acid Conc.	S	S
Formaldehyde 40%	S	N
Formic Acid 0-20%	S	S
Formic Acid 20-50%	S	S
Formic Acid 100%	S	S
Fructose Sat'd	S	S
Fruit Pulp	S	S
Fuel Oil	S	U
Furfural 100%	M	U
Furfuryl Alcohol	M	U
Gallic Acid Sat'd	S	S
Gas Liquids*	S	M
Gasoline*	M	U
Gin	S	U
Glucose	S	S
Glycerine	S	S
Glycol	S	S
Glycolic Acid 30%	S	S
Grape Sugar Sat'd Aq.	S	S
Hexanol, Tert.	S	S
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
Hydrochloric Acid Conc.	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

*HDPE Resin Service Design Factor for hydrocarbons per the formula on page 3 and 8 is F = 0.25 to compensate for hydrocarbon saturation effects on long term hydrostatic strength.

continued on page 10

continued from page 9

CHEMICAL RESISTANCE OF DRISCOPIPE

Reagent	70°F (21°C)	140°F (60°C)
Hydrogen Peroxide 30%	S	S
Hydrogen Peroxide 90%	S	M
Hydrogen Phosphide 100%	S	S
Hydroquinone	S	S
Hydrogen Sulfide	S	S
Hypochlorus Acid Conc.	S	S
Inks	S	S
Iodine (Alc. Sol.) Conc.	S	U
Lactic Acid 10%	S	S
Lactic Acid 90%	S	S
Latex	S	S
Lead Acetate Sat'd	S	S
Lube Oil*	S	M
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
Mercuric Chloride Sat'd	S	S
Mercuric Cyanide Sat'd	S	S
Mercurous Nitrate Sat'd	S	S
Mercury	S	S
Methyl Alcohol 100%	S	S
Methyl Bromide	M	U
Methyl Chloride	M	U
Methyl Ethyl Ketone 100%	M	U
Methylsulfuric Acid	S	S
Methylene Chloride 100%	M	U
Milk	S	S
Mineral Oils	S	U
Molasses Comm.	S	S
Nickel Chloride Sat'd	S	S
Nickel Nitrate Conc.	S	S
Nickel Sulfate Sat'd	S	S
Nicotine Dilute	S	S
Nicotinic Acid	S	S
Nitric Acid 0-30%	S	S
Nitric Acid 30-50%	S	M
Nitric Acid 70%	S	M
Nitric Acid 95-98%	U	U
Nitrobenzene 100%	U	U
Octyl Cresol	S	U
Oils and Fats*	S	M
Oleic Acid Conc.	S	U
Oleum Conc.	U	U
Orange Extract	S	S
Oxalic Acid Dilute	S	S
Oxalic Acid Sat'd	S	S
Ozone 100%	S	U
Perchloric Acid 10%	S	S
Petroleum Ether	U	U
Phenol 90%	U	U
Phosphoric Acid Up to 30%	S	S
Phosphoric Acid Over 30%	S	S
Phosphoric Acid 90%	S	S
Phosphorous (Yellow) 100%	S	N
Phosphorus Pentoxide 100%	S	N
Photographic Solutions	S	S
Pickling Baths		
Sulfuric Acid	S	S
Hydrochloric Acid	S	S
Sulfuric-Nitric	S	U
Plating Solutions		
Brass	S	S
Cadmium	S	S
Chromium	N	N
Copper	S	S
Gold	S	S
Indium	S	S
Lead	S	S
Nickel	S	S
Rhodium	S	S
Silver	S	S
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 Sat'd	S	S
Potassium Fluoride	S	S
Potassium Hydroxide 20%	S	S
Potassium Hydroxide Conc.	S	S
Potassium Nitrate Sat'd	S	S
Potassium Perborate Sat'd	S	S
Potassium Perchlorate 10%	S	S
Potassium Sulfate Conc.	S	S
Potassium Sulfide Conc.	S	S
Potassium Sulfite Conc.	S	S
Potassium Persulfate Sat'd	S	S
Propargyl Alcohol	S	S
Propyl Alcohol	S	S
Propylene Dichloride 100%	U	U
Propylene Glycol	S	S
Rayon Coagulating Bath	S	S
Sea Water	S	S
Selenic Acid	S	S
Shortening	S	S
Silicic Acid	S	S
Silver Nitrate Sol.	S	S
Soap Solution Any Conc'n	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 Bromide Dilute Sol.	S	S
Sodium Carbonate Con.	S	S
Sodium Carbonate	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	S	S
Sodium Ferrocyanide Sat'd	S	S
Sodium Fluoride Sat'd	S	S
Sodium Hydroxide Conc.	S	S
Sodium Hypochlorite	S	S
Sodium Nitrate	S	S
Sodium Sulfate	S	S
Sodium Sulfide 25%	S	S
Sodium Sulfide Sat'd Sol.	S	S
Sodium Sulfite Sat'd	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	M
Sulfuric Acid 80%	S	U
Sulfuric Acid 96%	M	U
Sulfuric Acid 98%	M	U
Sulfuric Acid, Fuming	U	U
Sulfurous Acid	S	S
Tallow*	S	M
Tannic Acid 10%	S	S
Tanning Extracts Comm.	S	S
Tartaric Acid Sat'd	N	N
Tetrahydrofurane	N	U
Titanium Tetrachloride Sat'd	N	U
Toluene	M	U
Transformer Oil	S	M
Trisodium Phosphate Sat'd	S	S
Trichloroethylene	U	U
Urea Up to 30%	S	S
Urine	S	S
Vinegar Comm.	S	S
Vanilla Extract	S	S
Wetting Agents	S	S
Whiskey	S	N
Wines	S	S
Xylene	M	U
Yeast	S	S
Zinc Chloride Sat'd	S	S
Zinc Sulfate Sat'd	S	S

For additional chemical resistance listings, consult the P.P.I. technical report #TR 19/10-84, Table I and the ISO technical report #ISO/Data 8-1979, Tables I, II, III.

Temperature Characteristics

nce polyethylene is a thermoplastic material, many of its physical and chemical properties are dependent on temperature and will change as the temperature of the material is increased or decreased. However, the exposure of Driscopipe to temperature variations within the recommended operating range does not result in degradation of the material. As these temperature changes are reversed, the material properties also reverse to their original values.

You will note from the information on physical properties that Driscopipe has a brittleness temperature below −180°F and a softening temperature of +257°F. The recommended operating temperature is limited only on the higher temperature side to a range of 140-180°F, dependent upon the pressure of the application and other operating and installation considerations. On the lower temperature side, Driscopipe gains strength without becoming brittle and is ideal for use at sub-zero temperatures.

Driscopipe becomes molten at 400-500°F and temperatures in this range are used to fusion join the piping system. Pipe is extruded at about the same temperature. To protect the material against degradation at the higher temperature, it is chemically stabilized. This stabilizer protects the material against thermal degradation which might otherwise occur during manufacture, outside storage and installation.

Driscopipe has been tested for thousands of hours at elevated temperatures of 140°F and 180°F without thermal degradation. These long term pressure tests at the higher temperatures are used to obtain recommended design strengths for the pipe at these temperatures.

Since all thermoplastic piping materials are affected by temperature, it is a general practice to characterize these materials at ambient temperature of 23°C (73.4°F). Nearly all ASTM tests relating to physical, mechanical and chemical properties of thermoplastic materials are conducted at this temperature. If a test is conducted, or a property defined, at other than 73.4°F, it is always noted.

One example of the effect of temperature on Driscopipe is the change in long term strength of the material as shown on the stress-life curves. This type behavior is true for all thermoplastics but there are large differences between the performance of specific materials at the higher temperatures.

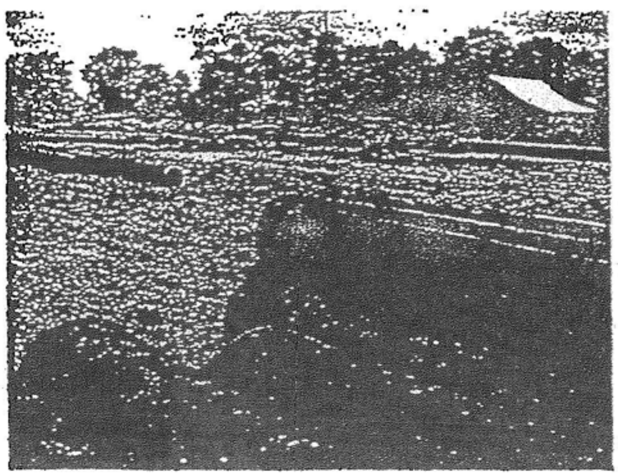
Knowledge of the long term strength of Driscopipe at the various temperatures allows selective design of a system. Accurate interpolations can be made for other temperatures between those which are known when data at three or more temperature levels is available.

Other properties of thermoplastic pipe which change with temperature and can affect system design and installation procedures include the following.

Burst strength – Short term (1 minute) burst tests on Driscopipe at various temperatures show these typical hoop stress values:

Temperature, °F	Hoop Stress, psi
73.4°	3250
32°	4300
0°	5290
−20°	5670
−40°	6385

Driscopipe will quick-burst at a pressure approximately four times greater than the rated operating pressure.



Chemical Resistance – The ability of most thermoplastics to resist degradation in the presence of corrosive chemicals is reduced as temperature increases. This is also true for Driscopipe but to a lesser extent because of its high density and high molecular weight. The effect of temperature on Driscopipe in the presence of various chemicals is shown in the chemical resistance tables.

Flexibility – As temperature is decreased, the flexibility of Driscopipe is also decreased. This has very little effect on installation except that at the lower winter temperatures, coiled pipe becomes more difficult, mechanically, to uncoil and stretch out in the ditch. Although Driscopipe becomes stiffer at low temperature, it can be bent, uncoiled or plowed in with sufficient mechanical power and no damage will occur to the pipe because of bending it at cold temperatures.

Other Physical Properties – There is a slight change with temperature of impact strength, notch sensitivity, flexural modulus, hardness and elongation ... but none are of such extent as to affect design parameters or installation procedures over the normal range of temperatures.

Modulus of Elasticity – Typical values for the variance in modulus of elasticity with temperature change is shown below.

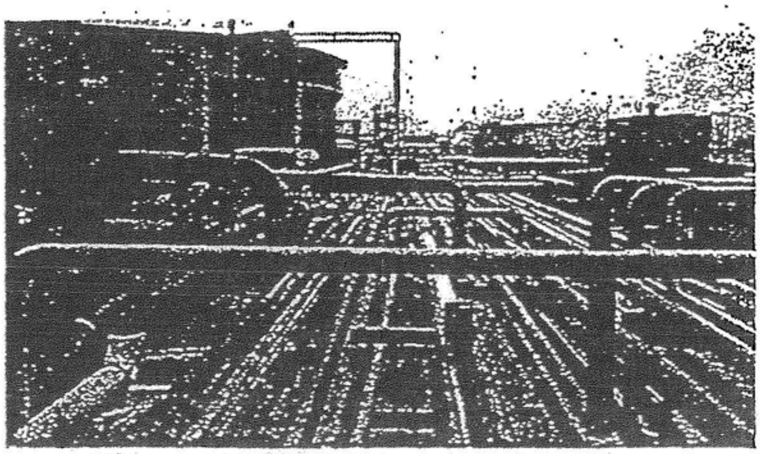
Temperature °F	Modulus of Elasticity, psi
−20°	300,000
0°	260,000
32°	200,000
75°	130,000
100°	105,000
140°	60,000

Thermal Expansion and Contraction – Polyethylene, like other thermoplastics, has a coefficient of expansion higher than metals. This coefficient is usually determined by a standard test method which employs the use of molded specimens. Measurements are made with a quartz dilatometer while the test specimen is held at elevated temperature. Typical coefficient values by this method range from $.75 \times 10^{-4}$ for Driscopipe 8600 to $.83 \times 10^{-4}$ for Driscopipe 1000.

The coefficient of linear expansion may also be determined by measuring the change in length of unrestrained pipe samples at different temperatures. The calculated coefficient is somewhat higher on extruded pipe than on molded test specimens. This appears to be true for all polyethylene pipe. The average coefficient calculated from measurements made on Driscopipe in the temperature range 0°F to 140°F, is 1.2×10^{-4} in/in/°F.

The circumferential coefficient of expansion and contraction for Driscopipe is approximately $.6 \times 10^{-4}$ in/in/°F in the range of 0° to 140°F ... or about ½ the linear coefficient. This circumferential change with temperature rarely presents any problems in system design. There may be need to consider this factor if compression fittings are used.

The expansion or contraction for Driscopipe can be stated in an easy rule of thumb ... the pipe will expand or contract approximately 1.4" per 100 feet for each 10°F change in temperature. Thus a 1000 foot unrestrained line which undergoes a 20°F increase in temperature change will increase in length 28 inches. The relatively large amount of expansion and contraction of plastic pipe generally presents no real problems in installation. The pipe has a relatively low elastic modulus and consequently there is less stress build-up. These stresses, caused by temperature change, are easily dissipated due to the thermoplastic nature of the material which relaxes and adjusts with time.



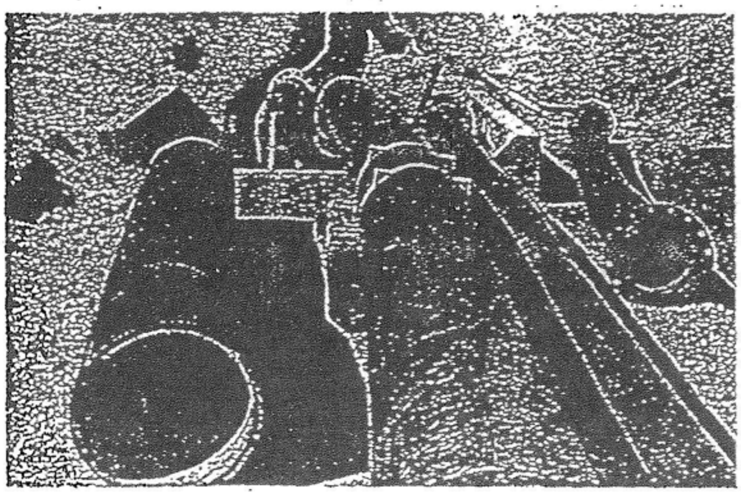
Tests have been conducted wherein the temperature ...re than 100 feet of unrestrained pipe was ...nged 130°F in a period of a few minutes. The total force created by contraction was measured and proved to be about (½) one-half the theoretical calculated value. Thermoplastic materials are unique in their ability to stress-relieve themselves. Actual changes in temperature in most applications take place slowly over an extended period of time. The total stresses imposed will vary but are generally much lower than the calculated values.

Direct buried pipe will generally have ample soil friction and interference to restrain movement of the pipe under normal application temperature changes. It is a good idea to make the final tie-ins on a system at a temperature which is as close to operating temperature as possible. This is particularly true for insert liner systems where there is no soil restraint.

Normal good direct burial installation practices which include snaking the pipe in the ditch, proper backfill and compaction, making the tie-in at the proper temperature, etc. should be used at all times and will substantially reduce the possibility of pull out at tie-in connections on such installations. However, planning the transition tie-in becomes more important when Driscopipe is used for insert renewal inside another pipe because there is no restraint from earth loading. ...contraction of the pipe due to reduction in ...perature is freely transmitted to the transition ...onnection and may result in pull-out if proper design precautions are not taken. In those cases, it may be necessary to provide additional anchoring at the terminations of the insert liner. Concrete anchors poured into undisturbed soil and cast around anchor projections in the Driscopipe line will restrict movement at the end of the line. Anchor projections on the Driscopipe liner can be made by fusing a blind tee into the line or by the use of two reducers, to the next larger size of pipe, fused together in the line.

Thermal Conductivity – This property of Driscopipe is lower than that for metals and can sometimes be exploited in the design of the system. It may eliminate or reduce the need for insulating pipe which carries water or other fluids through freezing temperatures. Thermal Conductivity of Driscopipe is 2.7 BTU per hour per sq. ft. per °F per inch of thickness. The slow heat transfer inhibits freezing and, if normal burial precautions are used, accidental freezing is usually eliminated. If the pipe does freeze, it does not fracture but fluid flow will be stopped. It will resume its function upon thawing. Direct application of intense heat should not be used to thaw a line. Antifreeze compounds such as methanol, isoproponol and ethylene glycol can be used without detrimental effect on the pipe.

Ignition Temperatures – The flash point for high density polyethylene using the Cleveland open cup method (ASTM D92) is 430°F. The flash ignition and self ignition temperatures using ASTM D1929 are 645°F and 660°F.



Weatherability

Two principal factors influence the weathering of plastic pipe in outside above ground applications ... temperature changes caused by seasonal variations and solar heating and solar radiation of ultraviolet rays. Effects of temperature variations on Driscopipe were discussed in the preceding section. Expansion and contraction of a line above ground, due to differential heating, will cause the line to move laterally, particularly if it is empty. This movement can easily be controlled within desired limits through the use of restraints.

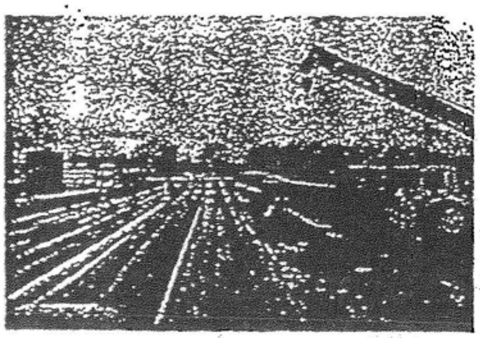
Driscopipe is also protected against degradation caused by ultraviolet rays when exposed to direct sunlight. The material contains 2½% of finely divided carbon black which also accounts for the black color of Driscopipe. Carbon black is the most effective single additive capable of enhancing the weathering characteristic of plastic materials. The protection even relatively low levels of carbon black impart to the plastic is so great that it is not necessary to use other light stabilizers or UV absorbers.

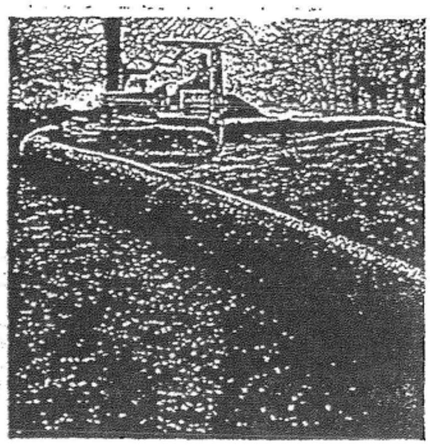
Weatherability tests indicate that Driscopipe can be safely used outside in most climates for periods of many years without danger of loss of physical properties due to UV exposure. Phillips has done extensive testing of polyethylene compounds containing 2 to 3% carbon black and compared these to other UV stabilizers to determine their effectiveness for protection against UV degradation in outdoor exposure. Samples were aged in outdoor exposure in three geographical locations: Phoenix, Arizona, Bartlesville, Oklahoma (Phillips 66 headquarters) and Akron, Ohio. From these actual tests, it was determined that one year exposure in Arizona was equivalent to at least two years in Bartlesville and greater than three and one-half years in Akron.

Weather-Ometer tests were run under standard conditions as set out in ASTM D 1499-64 and compared with the actual test samples in the three locations described above. From this test work, it was determined, conservatively, that 5000 hours (approximately 7 months) in the Weather-Ometer compares to greater than 42 months exposure in Arizona. Samples containing 2 to 3% carbon black and thermal stabilizers as used in Driscopipe have been tested for greater than 25,000 hours (2.85 years) in the Weather-Ometer without any brittleness or loss of physical properties. This is equivalent to over 17 years in Arizona and over 60 years in Akron, Ohio.

Permeability

The permeability of gases, vapors or liquids through a plastic membrane is generally considered to be an activated diffusion process. That is, the gas, vapor or liquid dissolves in the membrane and then diffuses tc a position of lower concentration. The permeation rate is determined by the functional groups of the permeating molecules and by the density of the plastic ... the higher the density, the lower the permeability. Listed below are typical permeability rates for HDPE.





	Permeability Rate*
Carbon Dioxide	345
Hydrogen	321
Oxygen	111
Helium	247
Ethane	236
Natural Gas	113
Freon 12	95
Nitrogen	53

*Cubic centimeters per day per 100 sq. inches per mil thickness at atmospheric pressure differential.

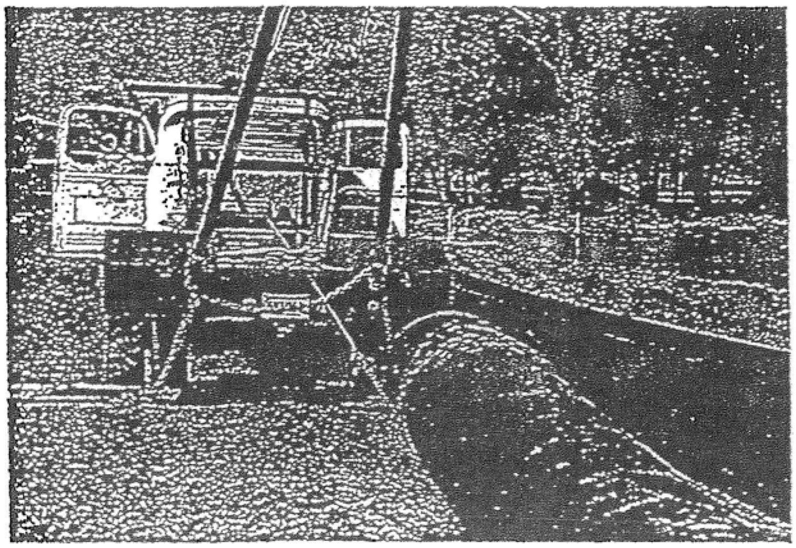
These permeation rates are considered very low. They result in negligible loss of product and create no hazard. For example, polyethylene piping systems are the predominant material used to construct new gas distribution systems and to renew old deteriorated systems. The permeation rate will vary in direct proportion to the differential pressure applied.

If the internal operating pressure is 60 psi, for example, the permeability rate would be approximately 4 times that shown above but volume losses would still be extremely low. Calculated volume loss in one mile of SDR 11 pipe (any size) in one day, for natural gas, would be ¼ of one cubic foot. At 120 psi, it would be ½ cubic foot per day.

Abrasion Resistance

One of the many outstanding characteristics of Driscopipe polyethylene is its resistance to abrasion. The inherent resilience and toughness of Driscopipe allows the mining industry to use this pipe in numerous surface applications where more conventional materials would be unsatisfactory, either because of the terrain encountered or the abrasiveness of the slurry to be moved. Quite often, a Driscopipe system offers substantial economic advantage as a means of transport over more conventional transportation methods used in the mining industry. Some of the more common applications include tailings lines and the transport of gypsum, limestone, sand, slimes and coal.

Due to its unique toughness, as indicated by low melt flow values, Driscopipe 8600 provides improved abrasion resistance over all other polyethylene piping materials. Controlled pipe loop pumping tests have demonstrated that Driscopipe can outlast steel pipe by as much as 4 to 1. One such test, performed by Williams Brothers Engineering, Tulsa, Oklahoma, compared Driscopipe to steel in pumping a coarse particle size magnetite iron ore slurry. At 13½ ft/sec velocity, Driscopipe was better by a factor of 4:1 and at 17 ft/sec by a factor of 3:1.



Heat Fusion Joining

The heat fusion joining technique has a long history of use for joining polyethylene pipe materials. The heat fusion method of joining PE pipe began shortly after the first commercial production of high density polyethylene in the early 1950s ... both developed by Phillips 66.

The integrity and superiority of heat fusion are now recognized universally. The modern day heat fusion joint is the same joint made in 1956 ... only the fusion equipment has evolved to gain efficiency, reliability and convenience. The principles learned on early equipment for making a successful joint are still in use today. Phillips designed, developed and built many models of heat fusion equipment from 1956 until the early 1970s. Since that time, Phillips has guided this development by others. The extensive line of high quality, efficient fusion equipment offered by McElroy Manufacturing, Inc., Tulsa, Oklahoma is one of the results of this long history of development. Phillips pioneered the idea and development of heat fusion and has used it exclusively in every high density polyethylene piping system sold by Phillips since 1956. There are millions of these joints in service today. In fact, 92% of all natural gas distribution pipe to homes, farms and factories is installed with polyethylene pipe and fittings. Heat fusion joints are industry accepted and field proven.

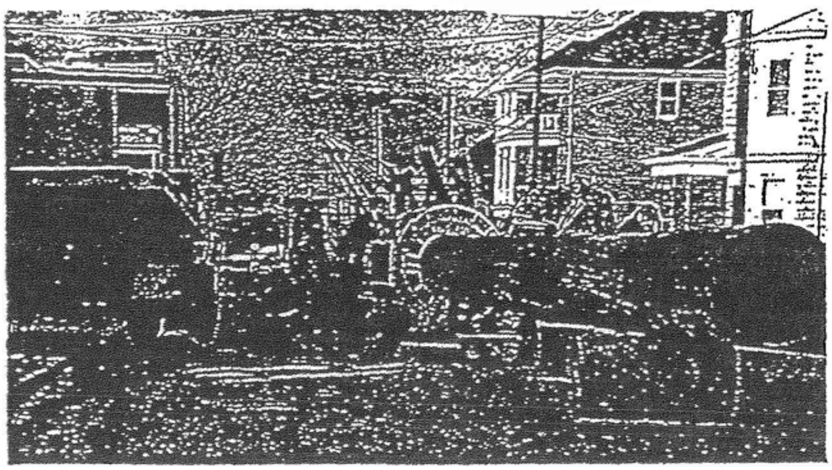
The heat fusion joining system has been so successful that it is the "standard" joining system for polyethylene. There are many reasons ... here are some.

Heat fusion joining ideally meets the requirements for a fast joining method to facilitate all phases of construction work in a safe and reliable manner.

The heat fusion joint is structurally superior to the socket fusion joint by configuration and, therefore, better meets the requirements of service. The heat joint configuration allows it to better disperse stresses initiated by pipe deflection and external loading. Stress concentration is minimized when the joint is placed in a strain and the joint is more "forgiving" when ground settlement occurs. In a socket joint, there is an extremely high ratio of "joint wall" to "pipe wall", resulting in stress intensification from external loading.

The Driscopipe heat fusion joining system is a simple, visual procedure with straight forward instructions. No "timing cycles" are necessary. The visual procedure allows the operator to concentrate on his work rather than a clock. Visually, he knows when the pipe ends have melted to the degree required to fuse them together. Visually, he observes and controls fusion pressure by observing the amount and configuration of the fusion bead as it is formed.

In the course of this work, the fusion operator is faced with a wide variety of job conditions. Changes in air temperature, material temperature, wind velocity, sun exposure, humidity, as well as condition of the terrain and the equipment all influence the joining requirements. Quality work under field conditions is more consistent with a simple, straight-forward, visual procedure.

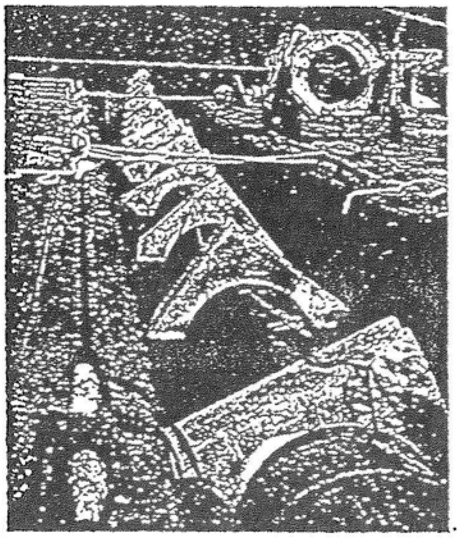


One heat fusion operator, with equipment, typically [illegible]e whole operation himself, sometimes using a [illegible]ond person as a helper. Pipe tolerances, ovality and curvature are no problem and "melt" is easily controlled by the visual procedure.

Heat fusion joints offer a large advantage over socket coupled joints for plow-in installation and for insert renewal applications. Socket coupled pipe requires larger size plow chutes and bore holes. Heat fused pipe one size larger can usually be handled and installed through bore holes and plow chutes selected for socket coupled pipe. Larger sizes of heat fused pipe can be used inside old mains for insert renewal because it does not require the extra space for the coupling.

Heat fusion joints may easily be cut out and re-done. This fact has a bearing on the quantity and quality of training necessary and favorably affects operator attitude toward quality in the field. These joints can be easily cut out and destructively tested in the field to check joining proficiency and equipment condition and it's inexpensive. There is no coupling to destroy and throw away.

The heat fusion joining system is especially effective with Driscopipe 8600. The melt of this material is very viscous and tough. The operator can apply ample pressure to form the heat fusion joint with little danger [illegible]rcing the molten material from between the two [illegible]ds of the joint, as can be done with the softer, less viscous, high density materials.



Driscopipe 8600 can be fusion joined to other polyethylene piping materials when necessary. Special joining techniques are required to achieve good joints. Phillips Driscopipe technical personnel are available to instruct and demonstrate the fusion joining procedure for joining Driscopipe to other polyethylene materials.

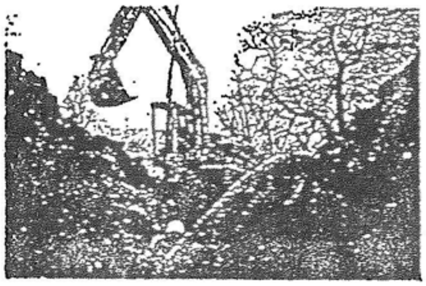
Fatigue Resistance

Driscopipe 8600 very high molecular weight, high density polyethylene has superior resistance to fatigue failure caused by cyclic loading. Independent laboratory tests were conducted to determine the suitability of Driscopipe 8600 for use as the cold water supply pipe and the barge mooring leg of the Mini-OTEC Project (Hawaii, 1979). In that application, 2150′ of 24″ 60 psi Driscopipe 8600 was deployed vertically in a deep ocean trench just offshore Keahole Point and was subject to cyclic distortion caused by wave action, current, and barge motion.

Cyclic tests showed that Driscopipe 8600 very high molecular weight PE could endure more than 100,000 cycles at a stress of 1800 psi without failure. Copies of this test report are avialable upon request.

Driscopipe 1000 offers good fatigue service life also, but not equal to 8600. Neither requires de-rating like PVC AWWA C-900 pipe. In fact, per AWWA C-906 for 4″ to 63″ HDPE pipe, no water hammer or fatigue de-rating factor need be applied to Driscopipe 8600 or Driscopipe 1000 ductile PE pipe.

The Driscopipe performance team offers you innovative solutions to your piping requirements. Contact your nearest Driscopipe Sales Representative. He'll give you personalized technical service, installation assistance and all the cost-saving advantages of a Driscopipe Piping System. Engineered for Performance!



DRISCOPIPE

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A Subsidiary of Phillips 66 Company

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1774-90 A 01

butane may condense and liquefy in the pipe. Such liquefied fuel gasses are known to permeate polyethylene pipe, and result in unreliable heat fusion or electrofusion joints.

In potable water applications, permeating chemicals could affect the pipe or water in the pipe. ANSI/AWWA standards provide the following guidance for potable water applications:

> "The selection of materials is critical for water service and distribution piping where there is likelihood the pipe will be exposed to significant concentrations of pollutants comprised of low molecular weight petroleum products or organic solvents or their vapors. Research has documented that pipe materials such as polyethylene, polybutylene, polyvinyl chloride, and asbestos cement, and elastomers, such as used in jointing gaskets and packing glands, may be subject to permeation by lower molecular weight organic solvents or petroleum products. If water pipe must pass through such a contaminated area or an area subject to contamination, consult with the manufacturer regarding permeation of pipe walls, jointing materials, and so forth, *before* selecting materials for use in that area."[1]

Chemical Attack

A direct chemical attack on the polymer will result in permanent, irreversible polymer damage or chemical change by chain scission, cross-linking, oxidation, or substitution reactions. Such damage or change cannot be reversed by removing the chemical.

Chemical Resistance Information

The following chemical resistance guide, Table 5-1 (next page), presents immersion test chemical resistance data for a wide variety of chemicals.

- ❑ This data may be applicable to gravity flow and low stress applications.
- ❑ It may not be applicable when there is applied stress such as internal pressure, or applied stress at elevated temperature.

Unless stated otherwise, polyethylene was tested in the relatively pure, or concentrated chemical.

It is generally expected that dilute chemical solutions, lower temperatures, and the absence of stress have less potential to affect the material. At higher temperature, or where there is applied stress, resistance may be reduced, or polyethylene may be unsuitable for the application. Further, combinations of chemicals may have effects where individual chemicals may not.

Testing is recommended where information about suitability for use with chemicals or chemical combinations in a particular environment is not available. PLEXCO cannot provide chemical testing services.

1 *ANSI/AWWA C906-90, Section 1.2; ANSI/AWWA C901-96, Section 4.1.*

Table 5-1 Chemical Resistance

Because the particular conditions of each application may vary, Table 5-1 information should be used only as a preliminary guide for PLEXCO and SPIROLITE polyethylene pipe materials. This information is offered in good faith, and is believed to be accurate at the time of publication, but it is offered without any warranty, expressed or implied. Additional information may be required, particularly in regard to unusual or special applications. Determinations of suitability for use in particular chemical or environmental conditions may require specialized laboratory testing.

Additional information on chemical compatibility may be found in PPI TR-19, *Thermoplastic Piping for the Transport of Chemicals.*

Chemical Resistance Key

Key†	*Meaning*
X	resistant (swelling <3% or weight loss <0.5%; elongation at break not substantially changed)
/	limited resistance (swelling 3 - 8% or weight loss 0.5 - 5%; elongation at break reduced by <50%)
—	not resistant (swelling > 8% or weight loss >5%; elongation at break reduced by >50%)
D	discoloration
*	aqueous solutions in all concentrations
**	only under low mechanical stress

† Where a key is not printed in the table, data is not available.

Medium	*73°F*	*140°F*
Acetaldehyde, gaseous	X	/
Acetic acid (10%)	X	X
Acetic acid (100%) (Glacial acetic acid)	X	/D
Acetic anhydride	X	/D
Acetone	X	X
Acetylene tetrabromide	**/ to —	—
Acids, aromatic	X	X
Acrylonitrile	X	X
Adipic acid	X	X
Allyl alcohol	X	X
Aluminum chloride, anhydrous	X	X
Aluminum sulphate	*X	X
Alums	X	X
Ammonia, liquid (100%)	X	X
Ammonium chloride	*X	X
Ammonium flouride, aqueous (up to 20%)	X	X
Ammonium nitrate	*X	X
Ammonium sulphate	*X	X
Ammonium sulfide	*X	X
Amyl acetate	X	X
Aniline, pure	X	X
Anisole	/	—
Antimony trichloride	X	X
Aqua regia	—	—
Barium chloride	*X	X
Barium hydroxide	*X	X

VOLUME 1

Medium	73°F	140°F
Beeswax	X	**/ to —
Benzene	/	/
Benezenesulphonic acid	X	X
Benzoic acid	*X	X
Benzyl alcohol	X	X to /
Borax, all concentrations	X	X
Boric acid	*X	X
Brine, saturated	X	X
Bromine	—	—
Bromine vapor	—	
Butanetriol	X	X
Butanol	X	X
Butoxyl	*X	/
Butyl acetate	X	/
Butyl glycol	X	X
Butyric acid	X	/
Calcium chloride	*X	X
Calcium hypochlorite	*X	X
Camphor	X	/
Carbon dioxide	X	X
Carbon disulphide	/	
Carbon tetrachloride	**/ to —	—
Caustic potash	X	X
Caustic soda	X	X
Chlorine, liquid	—	—
Chlorine bleaching solution (12% active chlorine)	/	—
Chlorine gas, dry	/	—
Chlorine gas, moist	/	—
Clorine water (disinfection of mains)	X	
Chloroacetic acid (mono)	X	X
Chlorobenzene	/	—
Chloroethanol	X	XD
Chloroform	**/ to —	—
Chlorosulphonic acid	—	—
Chromic acid (80%)	X	—D
Citric acid	X	X
Coconut oil	X	/
Copper salts	*X	X
Corn oil	X	/
Creosote	X	XD
Creosol	X	XD
Cyclohexane	X	X
Cyclohexanol	X	X
Cyclohexanone	X	X
Decahydronaphthalene	X	/
Desiccator grease	X	/
Detergents, synthetic	X	X
Dextrin, aqueous (18% saturated)	X	X
Dibutyl ether	X to /	—
Dibutyl phthalate	X	/
Dichloroacetic acid (100%)	X	/D
Dichloroacetic acid (50%)	X	X
Dicliloroacetic acid methyl ester	X	X
Dichlorbenzene	/	—
Diclolorethane	/	/
Dicloroethylene	—	—
Diesel oil	X	/
Diethyl ether	X to /	/
Diisobutyl ketone	X	/ to —
Dimethyl formamide (100%)	X	X to /
Dioxane	X	X
Emulsifiers	X	X
Esters, aliphatic	X	X to /
Ether	X to /	/
Ethyl acetate	/	—
Ethyl alcohol	X	X
Ethyl glycol	X	X
Ethyl hexanol	X	X
Ethylene chloride (dichlorothene)	/	/
Ethylene diamine	X	X
Fatty acids (>C^6)	X	/
Feric chloride*	X	X
Fluorine	—	—
Fluorocarbons	/	—
Fluorosilic acid, aqueous (up to 32%)	X	X
Formaldehyde (40%)	X	X
Formamide	X	X
Formic acid	X	
Fruit juices	X	X
Fruit pulp	X	X
Furfuryl alcohol	X	XD
Gelatine	X	X
Glucose	*X	X
Glycerol	X	X
Glycerol chlorohydrin	X	X
Glycol (conc.)	X	X

Second Edition

Issued 12/98

Medium	73°F	140°F
Glycolic acid (50%)	X	X
Glycolic acid (70%)	X	X
Halothane	/	/
Hydrazine hydrate	X	X
Hydrobromic acid (50%)	X	X
Hydrochloric acid (all concentrations)	X	X
Hydrocyanic acid	X	X
Hydrofluoric acid (40%)	X	/
Hydrofluoric acid (70%)	X	/
Hydrogen	X	X
Hydrogen chloride gas, moist and dry	X	X
Hydrogen peroxide (30%)	X	X
Hydrogen peroxide (100%)	X	
Hydrogen sulfide	X	X
Iodine, tincture of, DAB 7 (German Pharmacopoeia)	X	/D
Isooctane	X	/
Isopropanol	X	X
Isopropyl ether	X to /	—
Jam	X	X
Keotones	X	X to /
Lactic acid	X	X
Lead acetate	*X	X
Linseed oil	X	X
Magnesium chloride	*X	X
Magnesium sulphate	*X	X
Maleic acid	X	X
Malic acid	X	X
Menthol	X	/
Mercuric chloride (sublimate)	X	X
Mercury	X	X
Methanol	X	X
Methyl butanol	X	X
Methyl ethyl ketone	X	/ to —
Methyl glycol	X	X
Methylene chloride	/	/
Mineral oils	X	X to /
Molasses	X	X
Monochloroacetic acid	X	X
Monochloroacetic ethyl ester	X	X
Monochloroacetic methyl ester	X	X
Morpholine	X	X
Naptha	X	/
Naphthalene	X	/
Nickel salts	*X	X

Medium	73°F	140°F
Nitric acid (25%)	X	X
Nitric acid (50%)	/	—
Nitrobenzene	X	/
o-Nitrotoluene	X	/
Octyl cresol	/	—
Oils, ethereal	/	/
Oils, vegetable & animal	X	X to /
Oleic acid (conc.)	X	/
Oxalic acid (50%)	X	X
Ozone	/	—
Ozone, aqueous solution (Drinking water purification)	X	
Paraffin oil	X	X
Perchloric acid (20%)	X	X
Perchloric acid (50%)	X	/
Perchloric acid (70%)	X	—D
Petrol	X	X to /
Petroleum	X	/
Petroleum ether	X	/
Petroleum jelly	**X to /	/
Phenol	X	XD
Phosphates	*X	X
Phosphoric acid (25%)	X	X
Phosphoric acid (50%)	X	X
Phosphoric acid (95%)	X	/D
Phosphorus oxychloride	X	/D
Phosphorus pentoxide	X	X
Phosphorus trichloride	X	/
Photographic developers, commecial	X	X
Phthalic acid (50%)	X	X
Polyglycols	X	X
Potassium bichromate (40%)	X	X
Potassium borate, aqueous (1%)	X	X
Potassium bromate, aqueous (up to 10%)	X	X
Potassium bromide	*X	X
Potassium chloride	*X	X
Potassium chromate, aqueous (40%)	X	
Potassium cyanide	*X	X
Potassium hydroxide (30% solution)	X	X
Potassium nitrate	*X	X
Potassium permanganate	X	XD
Propanol	X	X
Propionic acid (50%)	X	X
Propionic acid (100%)	X	/

VOLUME 1

Medium	73°F	140°F
Propylene glycol	X	X
Pseudocumene	/	/
Pyridine	X	/
Seawater	X	X
Silicic acid	X	X
Silicone oil	X	X
Silver nitrate	X	X
Soduim benzoate	X	X
Sodium bisulphite, weak aqueous solutions	X	X
Sodium carbonate	*X	X
Sodium chloride	*X	X
Sodium chlorite (50%)	X	/
Sodium hydroxide (30% solution)	X	X
Sodium hypochlorite (12% active chlorine)	/	—
Sodium nitrate	*X	X
Sodium silicate	*X	X
Sodium sulfide	*X	X
Sodium thiosulphate	X	X
Spermaceti	X	/
Spindle oil	X to /	/
Starch	X	X
Steric acid	X	/
Succinc acid (50%)	X	X
Sugar syrup	X	X
Sulfates	*X	X
Sulfur	X	X
Sulfur dioxide, dry	X	X
Sulfur dioxide, moist	X	X
Sulfur trioxide	—	—
Sulfuric acid (10%)	X	X
Sulfuric acid (50%)	X	X
Sulfuric acid (98%)	/	—
Sulfuric acid, fuming	—	—
Sulfurous acid	X	X
Sulfuryl chloride	—	
Tallow	X	X
Tannic acid (10%)	X	X
Tartaric acid	X	X
Tetrachloroethane	**X to /	—
Tetrahydrofurane	**X to /	
Tetetrahydronapthalene	X	/
Thionyl chloride	—	—

Medium	73°F	140°F
Thiophene	/	/
Toluene	/	—
Transformer oil	X	/
Tributyl phosphate	X	X
Trichloroacetic acid (50%)	X	X
Trichloroacetic acid (100%)	X	/ to —
Trichloroethylene	**X to /	—
Triethanolamine	X	X
Turpentine, oil of	x to /	/
Tween 20 and 90 (Atlas Chemicals)	X	X
Urea	*X	X
Vinegar (commecial conc.)	X	X
Viscose spinning solutions	X	X
Waste gases containing		
carbon dioxide	X	X
carbon monoxide	X	X
hydrocloric acid (all conc.)	X	X
hydrogen fluoride (traces)	X	X
nitrous vitriol (traces)	X	X
sulfur dioxide (low conc.)	X	X
sulphuric acid, moist (all conc.)	X	X
Water gas	X	X
Xylene	—	—
Yeast, aqueous preparations	X	X
Zinc chloride	*X	X