HARRINGTON

Industrial Plastics, Inc.

ENGINEERING HANDBOOK

For Industrial Plastic Piping Systems

TABLE OF CONTENTS

Harrington's corporate office in Chino, CA

MATERIAL DESCRIPTION

POLYVINYLS

PVC (POLYVINYL CHLORIDE) has a relatively high tensile strength and modulus of elasticity and therefore is stronger and more rigid than most other thermoplastics. The maximum service temperature is 140°F for Type 1. PVC has excellent chemical resistance to a wide range of corrosive fluids, but may be damaged by ketones, aromatics, and some chlorinated hydrocarbons. It has proved an excellent material for process piping (liquids and slurries), water service, and industrial and laboratory chemical waste drainage. Joining methods are solvent welding, threading (Schedule 80 only), or flanging.

CPVC (CHLORINATED POLYVINYL CHLORIDE) is particularly useful for handling corrosive fluids at temperatures up to 210°F. In chemical resistance, it is comparable to PVC. It weighs about one-sixth as much as copper, will not sustain combustion (self-extinguishing), and has low thermal conductivity. Suggested uses include process piping for hot, corrosive liquids; hot and cold water lines in office buildings and residences; and similar applications above the temperature range of PVC. CPVC pipe may be joined by solvent welding, threading, or flanging.

POLYOLEFINS

POLYPROPYLENE (HOMOPOLYMER) is the lightest thermoplastic piping material, yet it has considerable strength, outstanding chemical resistance, and may be used at temperatures up to 180°F in drainage applications. Polypropylene is an excellent material for laboratory and industrial drainage piping where mixtures of acids, bases, and solvents are involved. It has found wide application in the petroleum industry where its resistance to sulfur-bearing compounds is particularly useful in salt water disposal line, chill water loops, and demineralized water. Joining methods are coil fusion and socket heat welding.

COPOLYMER POLYPROPYLENE is a copolymer of propylene and polybutylene. It is made of high molecular weight copolymer polypropylene and possesses excellent dielectric and insulating properties because of its structure as a non-polar hydrocarbon polymer. It combines high chemical resistance with toughness and strength at operating temperatures from freezing to 200°F. It has excellent abrasion resistance and good elasticity, and is joined by butt and socket fusion.

POLYETHYLENE, although its mechanical strength is comparatively low, polyethylene exhibits very good chemical resistance and is generally satisfactory when used at temperatures below 120°F. Types I and II (low and medium density) polyethylene are used frequently in tanks, tubing, and piping. Polyethylene is excellent for abrasive slurries. It is generally joined by butt fusion.

FLUOROPOLYMERS

PVDF (POLYVINYLIDENE FLUORIDE) is a strong, tough, and abrasion-resistant fluoroplastic material. It resists distortion and retains most of its strength to 280°F. As well as being ideally suited to handle wet and dry chlorine, bromine, and other halogens, it also withstands most acids, bases, and organic solvents. PVDF is not recommended for strong caustics. It is most widely recognized as the material of choice for high purity piping such as deionized water. PVDF is joined by thermal butt, socket, or electrofusion.

HALAR is a durable copolymer of ethylene and chlorofluoroethylene with excellent resistance to a wide variety of strong acids, chlorine, solvents, and aqueous caustics. Halar has excellent abrasion resistance, electric properties, low permeability, temperature capabilities from cryogenic to 340°F, and radiation resistance. Halar has excellent application for high purity hydrogen peroxide and is joined by thermal butt fusion.

TEFLON

There are three members of the Teflon family of resins.

PTFE TEFLON is the original Teflon resin developed by DuPont in 1938. This fluoropolymer offers the most unique and useful characteristics of all plastic materials. Products made from this resin handle liquids or gases up to 500°F. The unique properties of this resin prohibit extrusion or injection molding by conventional methods. When melted PTFE does not flow like other thermoplastics and it must be shaped initially by techniques similar to powder metallurgy. Normally PTFE is an opaque white material. Once sintered it is machined to the desired part.

FEP TEFLON was also invented by DuPont and became a commercial product in 1960. FEP is a true thermoplastic that can be melt-extruded and fabricated by conventional methods. This allows for more flexibility in manufacturing. The dielectric properties and chemical resistance are similar to other Teflons, but the temperature limits are -65°F to a maximum of 300°F. FEP has a glossy surface and is transparent in thin sections. It eventually becomes translucent as thickness increases. FEP Teflon is the most transparent of the three Teflons. It is widely used for its high ultraviolet light transmitting ability.

Caution: While the Teflon resin family has great mechanical properties and excellent temperature resistance, care must be taken when selecting the proper method of connections for your piping system. Generally, Teflon threaded connections will handle pressures to 120 PSIG. Loose ferrule connections are limited to 60 PSIG at ambient temperatures. Teflon loses it's ability to bear a load at elevated temperatures quicker than other thermoplastics. When working with the PTFE products shown in this catalog external ambient temperatures ranging from -60°F to 250°F (-51°C to 121°C) may be handled safely. Fluid or gas temperatures inside the product should be limited to -60 to 400°F (-51°C to 204°C) unless otherwise noted. Always use extreme care when working with chemicals at elevated temperatures.

MATERIAL DESCRIPTION

PFA TEFLON, a close cousin of PTFE, was introduced in 1972. It has excellent melt-processability and properties rivaling or exceeding those of PTFE Teflon. PFA permits conventional thermoplastic molding and extrusion processing at high rates and also has higher mechanical strength at elevated temperatures to 500°F. Premium grade PFA Teflon offers superior stress and crack resistance with good flex-life in tubing. It is generally not as permeable as PTFE.

DURAPLUS

ABS (ACRYLONITRILE-BUTADIENE-STYRENE)

There are many possibilities for polymer properties by combining these resins. For our purposes we will limit it to two products. One is the less expensive ABS resin used in drain, waste, and vent applications. The other resin for more stringent industrial applications has a different combination of the three polymers that make up the copolymer. The Duraplus product is made from this copolymer and has outstanding impact resistance even at low temperatures. The product is very tough and abrasion resistant. Temperature range is 40°F to 176°F.

RYTON (PPS) POLYPHENYLENE SULFIDE remains quite stable during both long and short term exposure to high temperatures. The high tensile strength and flexural modulus typical of PPS compounds, decrease with an increase in temperature. PPS is also highly resistant to chemical attack. Relatively few chemicals react to this material even at high temperatures. Its broad range of chemical resistance is second only to that of Teflon (PTFE). Ryton is used primarily for precision pump parts.

ELASTOMERS

VITON (FLUOROCARBON) is inherently compatible with a broad spectrum of chemicals. Because of this extensive chemical compatibility which spans considerable concentration and temperature ranges, Viton has gained wide acceptance as a sealing for valves, pumps, and instrumentation. Viton can be used in most applications involving mineral acids, salt solutions, chlorinated hydrocarbons, and petroleum oils.

EPDM (EPT) is a terpolymer elastomer made from ethylene-propylene diene monomer. EPDM has good abrasion and tear resistance and offers excellent chemical resistance to a variety of acids and alkalies. It is susceptible to attack by oils and is not recommended for applications involving petroleum oils, strong acids, or strong alkalies.

HYTREL is a multipurpose polyester elastomer similar to vulcanized thermoset rubber. Its chemical resistance is comparable to Neoprene, Buna-N and EPDM; however, it is a tougher material and does not require fabric reinforcement as do the other three materials. Temperature limits are -10°F minimum to 190°F maximum. This material is used primarily for pump diaphragms.

THERMOSETS

FIBERGLASS REINFORCED PLASTICS (FRP) including epoxy, polyester, and vinylester have become a highly valuable process engineering material for process piping.

FRP has been accepted by many industries because it offers the following significant advantages:
(a) moderate initial cost and low maintenance; (b) broad range of chemical resistance; (c) high strength-to-weight ratio; (d) ease of fabrication and flexibility of design; and (e) good electrical insulation properties.

EPOXY pipe and fittings have been used extensively by a wide variety of industries since 1960. It has good chemical resistance and excellent temperatures to pressure properties (to 300°F). Epoxy has been used extensively for fuel piping and steam condensate return lines.

POLYESTER pipe and fittings have been used by the industry since 1963. It has a proven resistance to most strong acids and oxidizing materials. It can be used in applications up to 200°F. Polyester is noted for its strength in both piping and structural shapes.

VINYLESTER resin systems are recommended for most chlorinated mixtures as well as caustic and oxidizing acids up to 200°F. Vinylester for most service has superior chemical resistance to epoxy or polyester.

NYLONS are synthetic polymers that contain an amide group. Their key characteristics are: (a) excellent resistance and low permeation to fuels, oils, and organic solvent, including aliphatic, aromatic, and halogenated hydrocarbons, esters, and ketones; (b) outstanding resistance to fatigue and repeated impact; and (c) wide temperature range from -30°F to 250°F.

Caution: Acids will cause softening, loss of strength, rigidity, and eventual failure.

POLYURETHANES

There are essentially two types of polyurethanes: polyester based and polyether based. Both are used for tubing applications.

POLYESTER based is the toughest of the two, having greater resistance to oil and chemicals. It does not harden when used with most oils, gasoline, and solvents. Polyurethane is extremely resistant to abrasives making it ideal for slurries, solids and granular material transfer. Temperature limit is 170°F.

Caution: Polyester based polyurethanes may be subject to hydrolysis under certain conditions, high relative humidity at elevated temperatures, aerated water, fungi, and bacteria. Where these potentials exist, we recommend polyether-based polyurethane.

POLYETHER-based polyurethane possesses better low temperature properties, resilience and resistance to hydrolytic degradation than the polyester previously discussed.

MATERIAL DESCRIPTION

Accelerated testing indicates that polyether-based polyurethanes have superior hydrolytic stability as compared to polyester based material. Made with no plasticizers and with a low level of extractables, polyether is ideal for high purity work. It will not contaminate laboratory samples and is totally non-toxic to cell cultures. Compared with PVC tubing, polyurethanes have superior chemical resistance to fuels, oils, and some solvents. Its excellent tensile strength and toughness make it suitable for full vacuums. This tubing can withstand temperatures from -94°F to 200°F.

PTBP

Polybutylene terephthalate is a little known specialty material belonging to the polyimide group; It has excellent mechanical properties and good mechanical stress properties under corrosive environments. PTBP is used mainly for valve actuators, and bonnet assemblies.

INDUSTRY STANDARDS

The standards referenced herein, like all other standards, are of necessity minimum requirements. It should be recognized that two different plastic resin materials of the same kind, type, and grade will not exhibit identical physical and chemical properties. Therefore, the plastic pipe purchaser is advised to obtain specific values or requirements from the resin supplier to assure the best application of the material not covered by industry specifications; this suggestion assumes paramount importance.

ANSI

American National Standards Institute, Inc.
655 15th St. N.W.
300 Metropolitan Square
Washington, DC 20005
Phone (202) 639-4090

ANSI PRESSURE CLASSES

ANSI Class 125 means 175 PSIG at 100°F
ANSI Class 150 means 285 PSIG at 100°F
ANSI Class 300 means 740 PSIG at 100°F
ANSI A119.2 - 1963
ANSI B72.2 - 1967
ANSI B31.8 - 1968
ANSI Z21.30 - 1969

The following ASTM standards have been accepted by ANSI and assigned the following designations.

Table 1

ANSI Designation	ASTM Designation	ANSI Designation	ASTM Designation
B72.1	D 2239	B 72.11	D 2412
B72.2	D 2241	B 72.12	D 2446
B72.3	D 2282	B 72.13	D 2447
B72.4	D 1503	B 72.16	D 2564
B72.5	D 1527	B 72.17	D 2657
B72.6	D 1598	B 72.18	D 2661
B72.7	D 1785	B 72.19	D 2662
B72.8	D 2104	B 72.20	D 2672
B72.9	D 2152	B 72.22	D 2740
B72.10	D 2153	B 72.23	D 2235

ASTM

American Society of Testing and Materials
1916 Race Street
Philadelphia, Pennsylvania 19103

Plastic Pipe Specifications:

D 1785		Polyvinyl chloride (PVC) plastic pipe, schedules 40, 80, and 120
F 441		Chlorinated poly (vinyl chloride)(CPVC) plastic pipe, schedules 40 and 80
D 2241		Polyvinyl chloride (PVC) plastic pipe (SD - PR)
D 2513		Thermoplastic gas pressure pipe, tubing and fittings
D 2665		PVC plastic drain, waste, and vent pipe and fittings
D 2672		Bell-ended PVC pipe
D 2729		PVC sewer pipe and fittings
D 2846		Chlorinated (CPVC) plastic hot water distribution system
D 2949		3” thin wall PVC plastic drain, waste, and vent pipe and fittings
D 3034		Type PSM PVC sewer pipe and fittings

Plastic Pipe Fittings Specifications:

D 2464	Threaded PVC plastic pipe fittings, Schedule 80
F 437	Threaded chlorinated polyvinyl chloride (CPVC) plastic pipe fittings, Schedule 80
D 2466	Socket-type PVC plastic type fittings, Schedule 40
D 2467	Socket-type PVC plastic type fittings, Schedule 80
F 439	Socket-type chlorinated polyvinyl chloride (CPVC) plastic pipe fittings Schedule 80
D 3036	PVC plastic pipe lined couplings, socket type

Plastic Pipe Solvent Cement Specifications

D 2564	Solvent cements for PVC plastic pipe and fittings
F 493	CPVC solvent cement

Plastic Lined Steel Piping Specifications:

ASTM A-587	Standard specification for electric-welded low carbon steel pipe for the chemical industry
ASTM A-53	Standard specification for pipe, steel, black and hot-dipped, zinc-coated, welded and seamless
ASTM A-105	Standard specification for forgings, carbon steel, for piping components
ASTM A-125	Standard specification for steel springs, helical, heat-treated
ASTM A-126	Standard specifications for gray iron castings for valves, flanges, and pipe fittings
ASTM A-395	Standard specification for ferritic ductile iron pressure retaining castings for use at elevated temperatures
ASTM A-216	Standard specification for carbon steel castings suitable for fusion welding for high temperature service
ASTM A-234	Standard specification for piping fittings of wrought carbon steel and alloy steel for moderate and elevated temperatures
ANSI B-16.1	Cast iron pipe flanges and flanged fittings Class 25, 125, 150, 250 and 800
ANSI B-16.42	Ductile iron pipe flanges and flanged fittings Class 150 and 300

INDUSTRY STANDARDS

ANSI B-16.5	Steel pipe flanges and flanged fittings Class 150, 300, 400, 600, 900, 1500 and 2500
A-587	Standard specification for electric-welded low carbon steel pipe for the chemical industry
A-53	Standard specification for pipe, steel black and hot-dipped, zinc-coated, welded and seamless
A-105	Standard specification for forgings, carbon steel, for piping components
A-125	Standard specification for steel springs, helical, heat-treated
A-126-73	Standard specification for gray iron castings for valves, flanges, and pipe fittings
A-395-77	Standard specification for ferritic ductile iron pressure retaining castings for use at elevated temperatures
A-216-77	Standard specification for carbon steel castings suitable for fusion welding for high temperature service

Methods of Test Specifications:

D	256	Test for impact resistance of plastics and electrical insulating materials
D	543	Test for resistance of plastics to chemical reagents
D	570	Test for water absorption of plastics
D	618	Conditioning plastics and electrical insulating materials for testing
D	621	Tests for deformation of plastics under load
D	635	Test for flammability of self-supporting plastics
D	638	Test for tensile properties of plastics
D	648	Test for deflection temperature of plastics under load
D	671	Tests for repeated flexural stress of plastics
D	757	Test for flammability of plastics, self-extinguishing type
D	790	Test for flexural properties of plastics
D	883	Nomenclature relating to plastics
D	1180	Test for bursting strength of round, rigid plastic tubing
D	1598	Test for time to failure of plastic pipe under long-term hydrostatic pressure
D	1599	Test for short-time rupture strength of plastic pipe, tubing and fittings
D	2122	Determining dimensions of thermoplastic pipe and fittings
D	2152	Test for quality of extruded PVC pipe by acetone immersion
D	2412	Test for external loading properties of plastic pipe by parallel-plate loading
D	2444	Test for impact resistance of thermoplastic pipe and fittings by means of a tup (falling weight)
D	2837	Obtaining hydrostatic design basis thermoplastic pipe materials
D	2924	Test for external pressure resistance of plastic pipe

RECOMMENDED PRACTICES

D	2153	Calculating stress in plastic pipe under internal pressure
D	2321	Underground installation of flexible thermoplastic sewer pipe
D	2657	Heat joining of thermoplastic pipe and fittings
D	2749	Standard definitions of terms relating to plastic pipe fittings
D	2774	Underground installation of thermoplastic pressure pipe
D	2855	Making solvent cemented joints with PVC pipe and fittings

ASTM STANDARDS FOR PLASTIC MATERIALS REFERENCED IN PLASTIC PIPE, FITTINGS, AND CEMENT STANDARDS

D	1784	PVC compounds and CPVC compounds

BOCA

Building Officials Conference of America
1313 East 60th Street
Chicago, Illinois 60637

BOCA Basic Plumbing Code

INDUSTRY STANDARDS

Table 2

Group	Commercial Standard or Product Standard	ASTM Standard or Tentative Specification
A	PS10	D2104
B	PS11	D2238
C	PS12	D2447
D	PS18	D1527
E	PS19	D2282
F	PS21	D1785
G	PS22	D2241
H	CS228	D2852
I	CS270	D2661
J	CS272	D2665

COMMERCIAL AND PRODUCT STANDARDS

Supt. of Documents
U.S. Government Printing Office
Washington, DC 20402

CS 272 — PVC-DWV pipe and fittings

PS 21 — PVC plastic pipe (Schedules 40, 80, 120) supersedes CS 207-60

PS 22 — PVC plastic pipe (SDR) supersedes CS 256

CSA

Canadian Standards Association
178 Rexdale Boulevard
Rexdale, Ontario, Canada

B 137.0 — Defines general requirements and methods of testing for thermoplastic pressure pipe

B 137.3 — Rigid polyvinyl chloride (PVC) pipe for pressure applications

B 137.4 — Thermoplastic piping systems for gas service

B 137.14 — Recommended practice for the installation of thermoplastic piping for gas service

B 181.2 — Polyvinyl chloride drain, waste, and vent pipe and pipe fittings

B 181.12 — Recommended practice for the installation of PVC drain, waste, and vent pipe fittings

B 182.1 — Plastic drain and sewer pipe and pipe fittings for use underground

B 182.11 — Recommended practice for the installation of plastic drain and sewer pipe and pipe fittings

DEPARTMENT OF AGRICULTURE

U.S. Department of Agriculture
Soil Conservation Service
Washington, DC 20250

SCS National Engineering Handbook, Section 2, Part 1, Engineering Practice Standards

SCS432-D — High pressure underground plastic irrigation pipelines

SCS432-E — Low head underground plastic irrigation pipelines

DEPARTMENT OF DEFENSE MILITARY STANDARDS

Commanding Officer
Naval Publications and Forms Center
5108 Tabor Avenue
Philadelphia, Pennsylvania 19120

MIL-A-22010A(1) — Adhesive solvent-type, polyvinyl chloride amendment

MIL-C-23571A(YD) — Conduit and conduit fittings, plastic, rigid

MIL-P-14529B — Pipe, extruded, thermoplastic

MIL-P-19119B(1) — Pipe, plastic, rigid, unplasticized, high impact, polyvinyl chloride

MIL-P-22011A — Pipe fittings, plastic, rigid, high impact, polyvinyl chloride, (PVC) and poly 1, 2 dichlorethylene

MIL-P-28584A — Pipe and pipe fittings, glass fiber reinforced plastic for condensate return lines

MIL-P-29206 — Pipe and pipe fittings glass fiber reinforced plastic for liquid petroleum lines

DOT - OTS

Department of Transportation, Hazardous Materials Regulation Board, Office of Pipeline Safety, Title 49, Docket OPS-3 and amendments, Part 192. Transportation of Natural Gas and Other Gas by Pipeline: Minimum Federal Safety Standards, Federal Register, Vol, 35, No. 161, Wednesday, August 19, 1980. Amendments to date are 192-1, Vol. 35, No. 205, Wednesday, October 21, 1970; 19-2, Vol. 35, No. 220, Wednesday, November 11, 1970; and 192-3, Vol. 35, No. 223, Tuesday, November 17, 1970.

FEDERAL SPECIFICATIONS

Specifications Activity
Printed Materials Supply Division
Building 197, Naval Weapons Plant
Washington, DC 20407

L-P-320a — Pipe and fittings, plastic (PVC, drain, waste, and vent)

L-P-1036(1) — Plastic rod, solid, plastic tubes and tubing, heavy walled; polyvinyl chloride

INDUSTRY STANDARDS

FHA

Architectural Standards Division
Federal Housing Administration
Washington, DC 20412

FHA UM-41	PVC plastic pipe and fittings for domestic water service
FHA UM-49	ABS and PVC plastic drainage and vent pipe and fittings, FHA 4550.49
FHA UM-53a	Polyvinyl chloride plastic drainage, waste and vent pipe and fittings
FHA MR-562	Rigid chlorinated polyvinyl chloride (CPVC) hi/temp water pipe and fittings
FHA MR-563	PVC plastic drainage and vent pipe and fittings
FHA Minimum	Property standards interim revision No. 31

IAPMO

International Association of Plumbing and Mechanical Officials
5032 Alhambra Avenue
Los Angeles, California 90032

Uniform Plumbing Code

IAPMO IS8	Solvent cemented PVC pipe for water service and yard piping
IAPMO IS9	PVC drain, waste, and vent pipe and fittings
IAPMO IS10	Polyvinyl chloride (PVC) natural gas yard piping
IAPMO PS27	Supplemental standard to ASTM D2665; polyvinyl chloride (PVC) plastic drain, waste, and vent pipe and fittings

(NOTE: IS = installation standard; PS = property standard)

NSF

National Sanitation Foundation
School of Public Health
University of Michigan
Ann Arbor, Michigan 48106

NSF Standard No. 14: Thermoplastic Materials, Pipe, Fittings, Valves, Traps, and Joining Materials

NSF Seal of Approval: Listing of Plastic Materials, Pipe, Fittings, and Appurtenances for Potable Water and Waste Water (NSF Testing Laboratory).

NSPI

National Swimming Pool Institute
2000 K Street, N.W.
Washington, DC 20006

T.R.-19 The Role of Corrosion-Resistant Materials in Swimming Pools, Part D, The Role of Plastics in Swimming Pools.

PHCC

National Association of Plumbing-Heating-Cooling Contractors
1016 20th Street, N.W.
Washington, DC 20036
National Standard Plumbing Code

SBCC

Southern Building Code Congress
1166 Brown-Marx Building
Birmingham, Alabama 35203
SBCC Southern Standard Plumbing Code

SIA

Sprinkler Irrigation Association
1028 Connecticut Avenue, N.W.
Washington, DC 20036
Minimum Standards for Irrigation Equipment

WUC

Western Underground Committee, W.H. Foote
Los Angeles Department of Water and Power
P.O. Box 111
Los Angeles, California 90054
Interim Specification 3.1: Plastic Conduit and Fittings

UL

Underwriters Laboratories, Inc.
207 East Ohio Street
Chicago, Illinois 60611

UL 651	Rigid Nonmetallic Conduit (September 1968)
UL 514	Outlet Boxes and Fittings (March 1951 with Amendments of 22-228-67)

INDUSTRY STANDARDS

NEMA

National Electrical Manufacturers' Association
2101 "L" St. N.W.
Washington, DC 20037

Type 1 — General Purpose - Indoor: This enclosure is intended for use indoors, primarily to prevent accidental contact of personnel with the enclosed equipment in areas where unusual service conditions do not exist. In addition, they provide protection against falling dirt.

Type 2 — Dripproof - Indoor: Type 2 dripproof enclosures are for use indoors to protect the enclosed equipment against falling non-corrosive liquids and dirt. These enclosures are suitable for applications where condensation may be severe such as encountered in cooling rooms and laundries.

Type 3 — Dusttight, Raintight, Sleet (Ice) Resistant Outdoor: Type 3 enclosures are intended for use outdoors to protect the enclosed equipment against windblown dust and water. They are not sleet (ice) proof.

Type 3R — Rainproof and Sleet (Ice) Resistant Outdoor: Type 3R enclosures are intended for use outdoors to protect the enclosed equipment against rain and meet the requirements of Underwriters Laboratories Inc., Publication No. UL 508, applying to "Rainproof Enclosures." They are not dust, snow, or sleet (ice) proof.

Type 3S — Dusttight, Raintight, and Sleet (Ice) Proof-Outdoor: Type 3S enclosures are intended for use outdoors to protect the enclosed equipment against windblown dust and water and to provide for its operation when the enclosure is covered by external ice or sleet. These enclosures do not protect the enclosed equipment against malfunction resulting from internal icing.

Type 4 — Watertight and Dusttight - Indoor and Outdoor: This type is for use indoors or outdoors to protect the enclosed equipment against splashing and seepage of water or streams of water from any direction. It is sleet-resistant but not sleet-proof.

Type 4X — Watertight, Dusttight and Corrosion-Resistant - Indoor and Outdoor: This type has same provisions as Type 4 and, in addition, is corrosion-resistant.

Type 5 — Superseded by Type 12 for Control Apparatus.

Type 6 — Submersible, Watertight, Dusttight, and Sleet (Ice) Resistant - Indoor and Outdoor: Type 6 enclosures are intended for use indoors and outdoors where occasional submersion is encountered, such as in quarries, mines, and manholes. They are required to protect equipment against a static head of water of 6 feet for 30 minutes and against dust, splashing or external condensation of non-corrosive liquids, falling or hose directed lint and seepage. They are not sleet (ice) proof.

Type 7 — Class I, Group A, B, C, and D-Indoor Hazardous Locations - Air-Break Equipment: Type 7 enclosures are intended for use indoors, in the atmospheres and locations defined as Class 1 and Group A, B, C or D in the National Electrical Code. Enclosures must be designed as specified in Underwriters' Laboratories, Inc. "Industrial Control Equipment for Use in Hazardous locations," UL 698. Class I locations are those in which flammable gases or vapors may be present in explosive or ignitable amounts. The group letters A, B, C, and D designate the content of the hazardous atmosphere under Class 1 as follows:

Group A
Atmospheres containing acetylene.

Group B
Atmospheres containing hydrogen or gases or vapors of equivalent hazards such as manufactured gas.

Group C
Atmospheres containing ethyl ether vapors, ethylene, or cyclopropane.

Group D
Atmospheres containing gasoline, hexane, naphtha, benzene, butane, propane, alcohols, acetone, lacquer solvent vapors and natural gas.

INDUSTRY STANDARDS

Type 8 — Class I, Group A, B, C or D - Indoor Hazardous Locations Oil-immersed Equipment: These enclosures are intended for indoor use under the same class and group designations as Type 7, but are also subject to immersion in oil.

Type 9 — Class II, Group E, F and G - Indoor Hazardous Locations - Air-Break Equipment: Type 9 enclosures are intended for use indoors in the atmospheres defined as Class II and Group E, F, or G in the National Electrical Code. These enclosures shall prevent the ingress of explosive amounts of hazardous dust. If gaskets are used, they shall be mechanically attached and of a non-combustible, nondeteriorating, verminproof material. These enclosures shall be designed in accordance with the requirements of Underwriters' Laboratories, Inc. Publication No. UL 698. Class II locations are those in which combustible dust may be present in explosive or ignitable amounts. The group letter E,F, and G designate the content of the hazardous atmosphere as follows:

Group E
Atmosphere containing metal dusts, including aluminum, magnesium, and their commercial alloys.

Group F
Atmospheres containing carbon black, coal, or coke dust.

Group G
Atmospheres containing flour, starch, and grain dust.

Type 10 — Bureau of Mines: Enclosures under Type 10 must meet requirements of Schedule 2G (1968) of the Bureau of Mines, U.S. Department of the Interior, for equipment to be used in mines with atmospheres containing methane or natural gas, with or without coal dust.

Type 11 — Corrosion-Resistant and Dripproof-Oil-Immersed - Indoor: Type 11 enclosures are corrosion-resistant and are intended for use indoors to protect the enclosed equipment against dripping, seepage, and external condensation of corrosive liquids. In addition, they protect the enclosed equipment against the corrosive effects of fumes and gases by providing for immersion of the equipment in oil.

Type 12 — Industrial Use - Dusttight and Driptight - Indoor: Type 12 enclosures are intended for use indoors to protect the enclosed equipment against fibers, flyings, lint, dust and dirt, and light splashing, seepage, dripping and external condensation of non-corrosive liquids.

Type 13 — Oiltight and Dusttight - Indoor: Type 13 enclosures are intended for use indoors primarily to house pilot devices such as limit switches, foot switches, pushbuttons, selector switches, pilot lights, etc., and to protect these devices against lint and dust, seepage, external condensation, and spraying of water, oil or coolant. They have oil-resistant gaskets.

HAZARDOUS (CLASSIFIED) LOCATIONS IN ACCORDANCE WITH FACTORY MUTUAL ENGINEERING CORP.

The National Electrical Code and the Canadian Electrical Code divide hazardous locations into three "classes" according to the nature of the hazard: Class I, Class II, and Class III. The locations in each of these classes are further divided by "divisions" according to the degree of the hazard.

Class I, Division 1 locations are those in which flammable gases or vapors are or may be present in sufficient quantities to produce an ignitable mixture (continuously, intermittently, or periodically).

Class I, Division 2 locations are those in which hazardous mixtures may frequently exist due to leakage or maintenance repair.

Class I, Division 3 are those in which the breakdown of equipment may release concentration of flammable gases or vapors which could cause simultaneous failure of electrical equipment.

For purposes of testing, classification and approval of electrical equipment atmospheric mixtures are classified in seven groups (A through G) depending on the kind of material involved.

Class II locations are classified as hazardous because of the presence of combustible dusts.

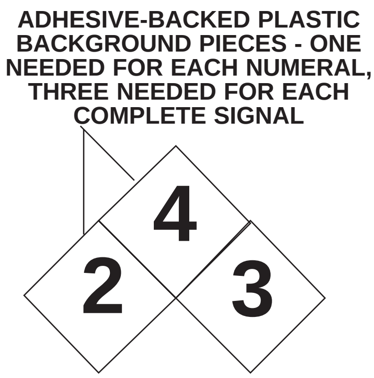
Class III locations are hazardous because of the presence of combustible fibers or flyings in textile processes.

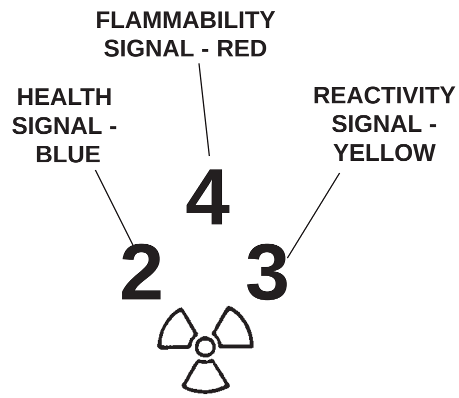
There are similar divisions and groups for Class II and Class III as those described for Class I. For specifics or further details contact Harrington's Technical Services department.

INDUSTRY STANDARDS

HAZARDOUS MATERIAL SIGNALS

Hazardous Material Signals based on the National Fire Protection Association Code number 704M and Federal Standard 313. This system provides for identification of hazards to employees and to outside emergency personnel. The numerical and symboled system shown here are the standards used for the purpose of safeguarding the lives of those who are concerned with fires occurring in an industrial plant or storage location where the fire hazards of material may not be readily apparent.





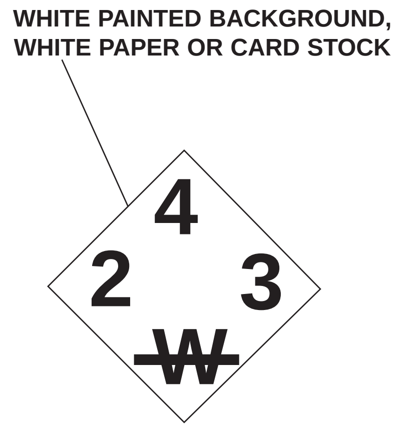


Figure 1. For use where specified color background is used with numerals of contrasting colors.

Figure 2. For use where a white background is necessary.

Figure 3. For use where a white background is used with painted numerals, or for use when the signal is in the form of sign or placard.

Table 4 - ARRANGEMENT AND ORDER OF SIGNALS - OPTIONAL FORM OF APPLICATION

DISTANCE AT WHICH SIGNALS MUST BE LEGIBLE	MINIMUM SIZE OF SIGNALS REQUIRED
50 FEET	1”
75 FEET	2”
100 FEET	3”
200 FEET	4”
300 FEET	6”

NOTE:
This shows the correct spatial arrangement and order of signals used for identification of materials by hazard.

IDENTIFICATION OF MATERIALS BY HAZARD SIGNAL ARRANGEMENT

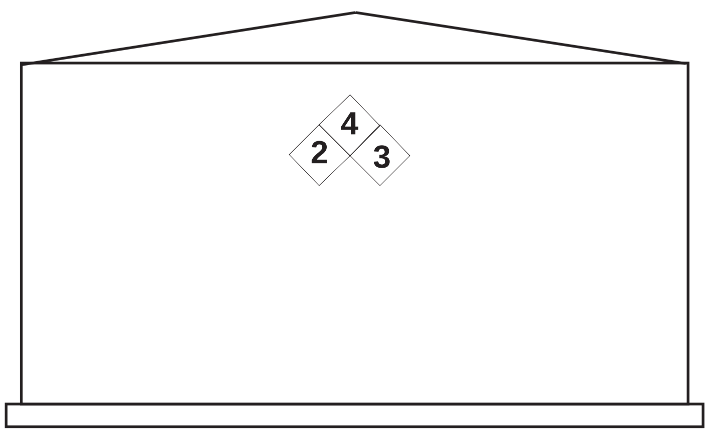


Figure 4. Storage Tank

This is a system for the identification of hazards to life and health of people in the prevention and control of fires and explosions in the manufacture and storage of materials.

The basis for identification are the physical properties and characteristics of materials that are known or can be determined by standard methods. Technical terms, expressions, trade names, etc., are purposely avoided as this system is concerned only with the identification of the involved hazard from the standpoint of safety.

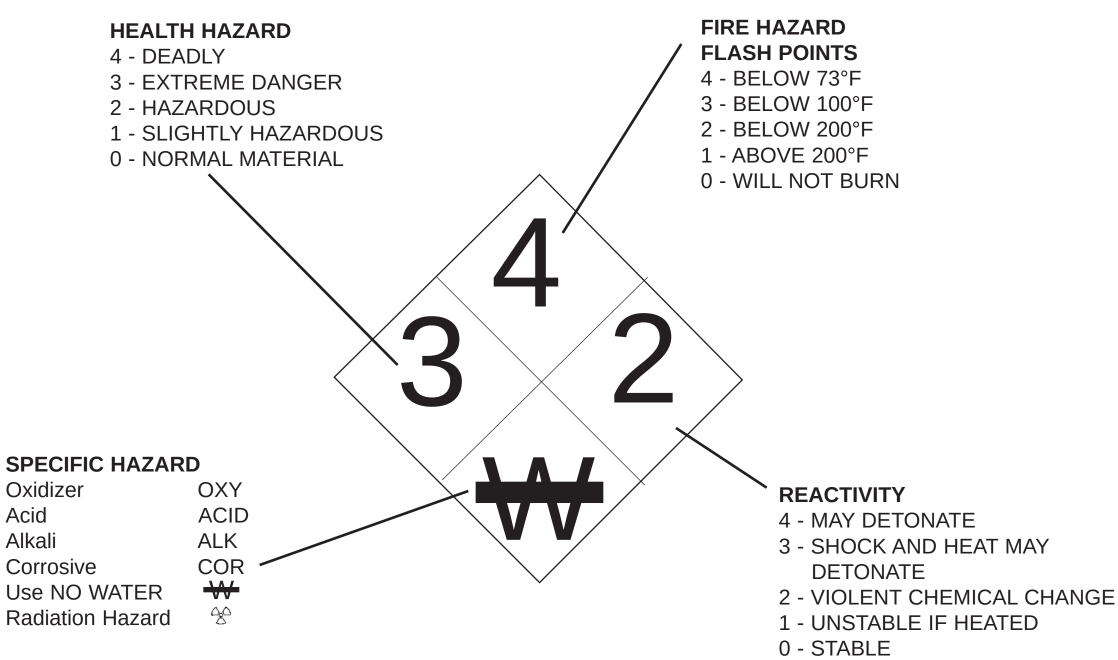
The explanatory material on this page is to assist users of these standards, particularly the person who assigns the degree of hazard in each category.

INDUSTRIAL STANDARDS

INDUSTRY STANDARDS

Table 5 IDENTIFICATION OF THE FIRE AND HEALTH HAZARDS OF MATERIALS

IDENTIFICATION OF HEALTH HAZARDS COLOR CODE: BLUE		IDENTIFICATION OF FLAMMABILITY COLOR CODE: RED		IDENTIFICATION OF REACTIVITY COLOR CODE: YELLOW	
SIGNAL	TYPE OF POSSIBLE INJURY	SIGNAL	SUSCEPTIBILITY OF MATERIALS TO BURNING	SIGNAL	SUSCEPTIBILITY TO RELEASE OF ENERGY
4	Materials which on very short exposure could cause death or major residual injury even though prompt medical treatment were given.	4	Materials which will rapidly or completely vaporize at atmospheric pressure and normal ambient temperature, or which are readily dispersed in air and which will burn readily.	4	Materials which in themselves are readily capable of detonation or of explosive decomposition or reaction at normal temperatures and pressures.
3	Materials which on short exposure could cause serious, temporary or residual injury even though prompt medical treatment were given.	3	Liquids and solids that can be ignited under almost all ambient temperature conditions.	3	Materials which in themselves are capable of detonation or of explosive reaction but require a strong initiating source or which must be heated under confinement before initiation or which react explosively with water.
2	Material which on intense or continued exposure could cause temporary incapacitation or possible residual injury unless prompt medical treatment is given.	2	Materials that must be moderately heated or exposed to relatively high ambient temperatures before ignition can occur.	2	Materials which in themselves are normally unstable and readily undergo violent chemical change but do not detonate. Also materials which may react violently with water or which may form potentially explosive mixtures with water.
1	Materials which on exposure would cause irritation but only minor residual injury, even if no treatment is given.	1	Materials that must be preheated before ignition can occur.	1	Materials which, in themselves, are normally stable, but which can become unstable at elevated temperatures and pressures or which may react with water with some release of energy but not violently.
0	Materials which on exposure under fire conditions would offer no hazard beyond that of ordinary combustible material.	0	Materials that will not burn.	0	Materials, which in themselves are normally stable, even under fire exposure conditions, and which are not reactive with water.



INDUSTRY STANDARDS

Government regulatory agencies

DEPARTMENT OF COMMERCE
National Institute
of Standards and Technology
Public and Business Affairs Div.
Building 101, Room A903
Gaithersburg, MD 20889
Ph#: 301/975-2762
Fax: 301/926-1630

The National Institute of Standards and Technology (NIST) focuses on tasks vital to the country's technology infrastructure that neither industry nor the government can do separately.

NIST works to promote U.S. economic growth by working with industry to develop and apply technology, measurements, and standards.

Part of the Commerce Department's Technology Administration, NIST has four major programs that reflect U.S. industry's diversity and multiple needs. These programs include the Advanced Technology Program; Manufacturing Extension Partnership; Laboratory Research and Services; and the Baldrige National Quality Program.

DEPARTMENT OF ENERGY
Consumer Affairs
1000 Independence Avenue SW
Washington, DC 20585
Ph#: 202/586-5373
Fax: 202/586-0539

The Department of Energy is entrusted to contribute to the welfare of the nation by providing the technical information and scientific and educational foundation for technology, policy, and institutional leadership necessary to achieve efficiency in energy used, diversity in energy sources, a more productive and competitive economy, improved environmental quality, and a secure national defense.

DEPARTMENT OF THE INTERIOR
1849 C Street NW
Washington, DC 20240
Ph#: 202/208-3100
Fax: 202/208-6950

As the nation's principal conservation agency, the Department of the Interior's responsibilities include: encouraging and providing appropriate management, preservation and operation of the nation's public lands and natural resources; developing and using resources in an environmentally sound manner; carrying out related scientific research and investigations in support of these objectives; and carrying out trust responsibilities of the U.S. government with respect to American Indians and Alaska Natives.

It manages more than 440 million acres of federal lands.

DEPARTMENT OF LABOR
Office of Information and Public Affairs
200 Constitution Avenue, NW
Washington, DC 20210
Ph#: 202/219-7316
Fax: 202/219-8699

The Department of Labor's principal mission is to help working people and those seeking work.

The department's information and other services, particularly in job training and labor law enforcement, benefit and affect many other groups, including employers, business organizations, civil rights groups and government agencies at all levels as well as the academic community.

DEPARTMENT OF TRANSPORTATION
Office of Public Affairs
400 Seventh Street SW, Room 10414
Washington, DC 20590
Ph#: 202/366-4570
Fax: 202/366-6337

The Department of Transportation ensures the safety of all forms of transportation; protects the interests of consumers; conducts planning and research for the future; and helps cities and states meet their local transportation needs.

The Department of Transportation Is composed of 10 operating administrations, including the Federal Aviation Administration; the Federal Highway Administration; the Federal Railroad Administration; the Federal Transit Administration; the National Highway Traffic Safety Administration; the Maritime Administration; the St. Lawrence Seaway Development Corp.; the U.S. Coast Guard; the Research and Special Programs Administration; and the Bureau of Transportation Statistics.

DEPARTMENT OF THE TREASURY
Bureau of Alcohol, Tobacco and Firearms
Liaison and Public Information
650 Massachusetts Avenue NW
Room 8290
Washington, DC 20226
Ph#: 202/927-8500
Fax: 202/927-8112

The Bureau of Alcohol, Tobacco and Firearms (ATF) is an agency of the U.S. Department of the Treasury.

ATF's responsibilities are law enforcement; regulation of the alcohol, tobacco, firearms and explosives industries; and ensuring the collection of taxes on alcohol, tobacco, and firearms.

ATF's mission is to curb the illegal traffic in and criminal use of firearms; to assist federal, state and local law enforcement agencies in reducing crime and violence; to investigate violations of federal explosive laws; to regulate the alcohol, tobacco, firearms and explosives industries; to assure the collection of all alcohol, tobacco and firearm tax revenues; and to suppress commercial bribery, consumer deception, and other prohibited trade practices in the alcoholic beverage industry.

ENVIRONMENTAL PROTECTION AGENCY
Communication, Education and Public Affairs
401 M Street SW
Washington, DC 20460
Ph#: 202/260-2090 Public Information Center
Mail Code 3404
Ph#: 202/260-2080
Fax: 202/260-6257
Chemical Control
401 M St. SW
Washington DC 20460
Ph#: 202/260-3749
Fax: 202/260-8168
Chemical Emergency Preparedness and Prevention 401 M St. SW Washington, DC 20460 Ph#: 202/ 260-8600 Fax: 202/260-7906

The Environmental Protection Agency (EPA) is an independent agency in the executive branch of the U.S. government. EPA controls pollution through a variety of activities, which includes research, monitoring, standards setting, and enforcement.

The Environmental Protection Agency supports research and antipollution efforts by state and local governments as well as by public service institutions and universities.

INDUSTRIAL STANDARDS

INDUSTRY STANDARDS

Government regulatory agencies

FEDERAL AVIATION ADMINISTRATION
800 Independence Avenue, SW
Washington, DC 20591
Ph#: 800/FAA-SURE
FAA Consumer Hotline

The Federal Aviation Administration (FAA) provides a safe, secure and efficient global aerospace system that contributes to national security and the promotion of U.S. aerospace.

As the leading authority in the international aerospace community, FAA is responsive to the dynamic nature of customer needs, economic conditions and environmental concerns.

FOOD AND DRUG ADMINISTRATION Office of Public Affairs Public Health Service Department of Health & Human Services
5600 Fishers Lane (HFI-40)
Rockville, MD 20857
Ph#: 301/443-3170
Consumer Affairs

The Food and Drug Administration (FDA) works to protect, promote, and enhance the health of the American people by ensuring that foods are safe, wholesome, and sanitary; human and veterinary drugs, biological products and medical devices are safe and effective; cosmetics are safe; electronic products that emit radiation are safe; regulated products are honestly, accurately, and informatively represented; these products are in compliance with the law and the FDA regulations; and non-compliance is identified and corrected and any unsafe and unlawful products are removed from the marketplace.

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION
300 E Street SW
Washington, DC 20546
Ph#: 202/358-0000
Fax: 202/358-3251

The National Aeronautics and Space Administration explores, uses and enables the development of space for human enterprise; advances scientific knowledge and understanding of the Earth, the solar system and universe; uses the environment of space for research; and researches, develops, verifies and transfers advanced aeronautics, space and related technologies.

NATIONAL INSTITUTE FOR OCCUPATIONAL SAFETY AND HEALTH
Public Affairs
200 Independence Avenue SW
Washington, DC 20201
Ph#: 202/260-8519
Fax: 202/260-1898

The National Institute for Occupational Safety and Health (NIOSH) was established by the Occupational Safety and Health Act of 1970. NIOSH is part of the Centers for Disease Control and Prevention and is the federal institute responsible for conducting research and making recommendations for the prevention of work-related illnesses and injuries.

The Institute's responsibilities include: investigating potentially hazardous working conditions as requested by employers or employees; evaluating hazards in the workplace; creating and disseminating methods for preventing disease, injury, and disability; conducting research and providing scientifically valid recommendations for protecting workers; and providing education and training to individuals preparing for or actively working in the field of occupational safety and health.

NIOSH identifies the causes of work related diseases and injuries and the potential hazards of new work technologies and practices. It determines new ways to protect workers from chemicals, machinery, and hazardous working conditions.

NATIONAL TRANSPORTATION SAFETY BOARD
490 L'Enfant Plaza SW
Washington, DC 20594
Ph#: 202/382-6600

The National Transportation Safety Board is an independent federal accident investigation agency that also promotes transportation safety.

The board conducts safety studies; maintains official U.S. census of aviation accidents; evaluates the effectiveness of government agencies involved in transportation safety; evaluates the safeguards used in the transportation of hazardous materials; and evaluates the effectiveness of emergency responses to hazardous material accidents.

NUCLEAR REGULATORY COMMISSION
Office of Public Affairs
Washington, DC 20555
Ph#: 301/415-8200
Fax: 301/415-2234

The Nuclear Regulatory Commission regulates the civilian uses of nuclear materials in the United States to protect the public health and safety, the environment, and the common defense and security.

The mission is accomplished through licensing of nuclear facilities and the possession, use and disposal of nuclear materials; the development and implementation of requirements governing licensed activities; and inspection and enforcement to assure compliance.

OCCUPATIONAL SAFETY AND HEALTH ADMINISTRATION
Office of Information and Consumer Affairs
200 Constitution Avenue NW, Room N3647
Washington, DC 20210
Ph#: 202/2198151
Fax: 202/219-5986

The Occupational Safety and Health Administration (OSHA) sets and enforces workplace safety and health standards with a goal of ensuring safe and healthful working conditions for all Americans.

OSHA issues standards and rules for safe and healthful working conditions, tools, equipment, facilities, and processes.

OCCUPATIONAL SAFETY AND HEALTH REVIEW COMMISSION
Office of Public Information
One Lafayette Center
1120 20th Street, NW, Ninth Floor
Washington, DC 20036-3419
Ph#: 202/606-5398
Fax: 202/606-5050

The Occupational Safety and Health Review Commission is an independent federal agency that serves as a court to provide decisions in workplace safety and health disputes arising between employers and the Occupational Safety and Health Administration in the department of labor.

U.S. COAST GUARD
Hazard Materials Standards Branch
2100 Second Street SW
Washington, DC 20593-0001
Ph#: 202/267-2970
Fax: 202/267-4816

The U.S. Coast Guard is the United States' primary maritime law enforcement agency as well as a federal regulatory agency and one of the armed forces.

The U.S. Coast Guard duties include aids to navigation; defense operations; maritime pollution preparedness and response; domestic and international ice breaking operations in support of commerce and science; maritime law enforcement; marine inspection and licensing; port safety and security; and search and rescue.

INDUSTRY STANDARDS

Chemical Industry Trade Associations

ADHESIVES MANUFACTURERS ASSOCIATION
1200 19th Street NW, Suite 300
Washington, DC 20036
Ph#: 202/857-1127
Fax: 202/857-1115

The Adhesives Manufacturers Association (AMA) is a national organization comprised of major U.S. companies engaged in the manufacturing, marketing, and selling of formulated adhesives or formulated adhesives coatings to the industrial marketplace. Associate members supply raw materials to the industry.

AIR & WASTE MANAGEMENT ASSOCIATION
1 Gateway Center, 3rd Floor
Pittsburgh, PA 15222
Ph#: 412/232-3444
Fax: 412/232-3450
Membership Department

The Air & Waste Management Association is a non-profit, technical and educational organization with 17,000 members in 58 countries. Founded in 1907, the association provides a neutral forum in which all viewpoints of an environmental issue (technical, scientific, economic, social, political, and health-related) receive equal consideration. The association serves its members and the public by promoting environmental responsibility and providing technical and managerial leadership in the fields of air and waste management.

AMERICAN ACADEMY OF ENVIRONMENTAL ENGINEERS (AAEE)
130 Holiday Court, Suite 100
Indianapolis, MD 21401
Ph#: 301/261-8958 (Washington, DC)

This organization certifies environmental engineers.

AMERICAN BOILER MANUFACTURERS ASSOCIATION
950 N. Glebe Road, Suite 160
Arlington, VA 22203
Ph#: 703/522-7350
Fax: 703/522-2665

The mission of the American Boiler Manufacturers Association is to improve services to the public; to be proactive with government in matters affecting the industry; to promote safe, economical, and environmentally friendly services of the industry; and to carry out other activities recognized as lawful for such organizations.

THE AMERICAN CERAMIC SOCIETY
P.O. Box 6136
Westerville, OH 43086-6136
Ph#: 614/890-4700
Fax: 614/899-6109
Customer Service: 614/794-5890

The American Ceramic Society is the headquarters for the professional organization for ceramic engineers.

AMERICAN CHEMICAL SOCIETY (ACS)
1155 Sixteenth Street NW
Washington, DC 20036
Ph#: 202/872-4600
Fax: 202/872-6337

ACS has 149,000 members. The members are chemists, chemical engineers, or people who have degrees in related fields.

AMERICAN COKE AND COAL CHEMICALS INSTITUTE
1255 23rd Street NW
Washington, DC 20037
Ph#: 202/452-1140
Fax: 202/466-4949

The ACCI's mission is to represent the interests of the coke and coal chemicals industry by communicating positions to legislative and regulatory officials, cooperating with all government agencies having jurisdiction over the industry, providing a forum for the exchange of information, and discussion of problems and promoting the use of coke and its byproducts in the marketplace.

AMERICAN CONFERENCE OF GOVERNMENTAL INDUSTRIAL HYGIENISTS (ACGIH)
Kemper Woods Center
1330 Kemper Meadow Drive, Suite 600
Cincinnati, OH 45240
Ph#: 513/742-2020
Fax 513/742-3355

The ACGIH is an organization of more than 5,500 industrial hygienists and occupational health and safety professionals devoted to the technical and administrative aspects of worker health and safety.

AMERICAN CROP PROTECTION ASSOCIATION
1156 15th Street NW, Suite 400
Washington, DC 20005
Ph#: 202/872-3869
Fax: 202/463-0474

ACPA is the trade association for the manufacturers and formulators/distributors representing virtually all of the active ingredients manufactured, distributed, and sold in the United States for agricultural uses, including herbicides, insecticides, and fungicides.

AMERICAN INSTITUTE OF MINING, METALLURGICAL AND PETROLEUM ENGINEERS (AIME)
345 E. 47th Street
New York, NY 10017
Ph#: 212/705-7695
Fax: 212/371-9622

AIME serves as the unifying forum for the Member Societies, which include the Society for Mining, Metallurgy and Exploration; The Minerals, Metals & Materials Society; Iron and Steel Society; Society of Petroleum Engineers; and the AIME Institute Headquarters.

AMERICAN NATIONAL STANDARDS INSTITUTE, INC.
(ANSI) 11 W. 42nd Street, 13th Floor
New York, NY 10036
Ph#: 212/642-4900
Fax: 212/302-1286
The Sales Department

ANSI is an approval entity in the United States for the voluntary standards effort.

AMERICAN PETROLEUM INSTITUTE (API)
1220 L Street NW
Washington, DC 20005
Ph#: 202/682-8000
Fax: 202/682-8232

The American Petroleum Institute (API) is the U.S. petroleum industry's primary trade association. API provides public policy development and advocacy, research, and technical services to enhance the ability of the petroleum industry to meet its mission.

AMERICAN SOCIETY OF BREWING CHEMISTS
3340 Pilot Knob Road
St. Paul, MN 55121
Ph#: 612/454-7250
Fax: 612/454-0766
Member Services Representative

A non-profit organization that publishes scientific books and journals.

AMERICAN SOCIETY OF HEATING, REFRIGERATING AND AIR CONDITIONING ENGINEERS (ASHRAE)
1791 Tullie Circle NE
Atlanta, GA 30329
Ph#: 404/636-8400
Fax: 404/ 321-5478
Customer Service: 800/527-4723

ASHRAE is an engineering society whose members are engineers specializing in heating, refrigerating, and air conditioning. It serves members through meetings and publications.

INDUSTRY STANDARDS
Chemical Industry Trade Associations

AMERICAN SOCIETY OF MECHANICAL ENGINEERS (ASME)
345 E 47th Street
New York, NY 10017-2392
Ph#: 212/705-7722
Fax: 212/705-7674
Member Services

This organization provides classes and networking, and also serves its members by providing information about technology and solutions to the problems of an increasingly technological society.

AMERICAN SOCIETY FOR NONDESTRUCTIVE TESTING (ASNT)
1711 Arlingate Lane
P.O. Box 28518
Columbus, OH 43228-0518
Ph#: 614/274-6003
Fax: 614/274-6899

A non-profit organization that has 10,000 members worldwide. It sells technical books as well as providing testing for certification for non-destructive testing. This organization also publishes a monthly magazine.

AMERICAN SOCIETY FOR QUALITY CONTROL (ASQC)
P.O. Box 3005
Milwaukee, WI 53201-3005
Ph#: 414/272-8575
Fax: 414/272-1734
Customer Service: 800/ 248-1946

This organization facilitates continuous improvement and increased customer service by identifying, communicating, and promoting the use of quality concepts and technology. The ASQC carries out a variety of professional, educational, and informational programs.

AMERICAN SOCIETY OF SAFETY ENGINEERS
1800 E. Oakton
Des Plaines, IL 60018-2187
Ph#: 847/699-2929
Membership Department, extensions 231, 228, or 254
Fax: 847/296-3769

This is the oldest and largest organization servicing safety engineers. It has more than 32,000 members and 139 local chapters. The society provides safety education seminars, technical publications, and a monthly magazine among other services.

AMERICAN SOCIETY FOR TESTING & MATERIALS (ASTM)
100 Barr Harbor Drive
W. Conshohocken, PA 19428
Ph#: 610/832-9500
Fax: 610/832-9555
Membership Department

This non-profit organization deals with 132 different committees, and provides materials and tests different standards.

CHEMICAL MANUFACTURERS ASSOCIATION (CMA)
1300 Wilson Boulevard
Arlington, VA 22209
Ph#: 703/741-5000
Fax: 703/741-6095

CMA is one of the oldest trade associations in North America. The CMA is also the focal point for the chemical industry's collective action on legislative, regulatory, and legal matters at the international, national, state and local levels.

CHLORINE INSTITUTE
2001 L Street NW #506
Washington, DC 20036
Ph#: 202/775-2790
Fax: 202/223-7225

This organization supports the chloralkaline industry and serves as a public service for safety and health.

COMPOSITES FABRICATORS ASSOCIATION
8201 Greensboro Drive, Suite 300
McLean, VA 22102
Ph#: 703/610-9000
Fax: 703/610-9005

The Composites Fabricators Association provides educational services including seminars, video training tapes, publications, a monthly technical magazine, and an annual convention. It offers free technical, government, and regulatory service to its members.

COSMETIC, TOILETRY AND FRAGRANCE ASSOCIATION
1101 17th Street NW, Suite 300
Washington, DC 200364702
Ph#: 202/331-1770
Fax: 202/331-1969

The Cosmetic, Toiletry and Fragrance Association is the leading trade association for the personal care product industry, representing the majority of U.S. personal care product sales. The industry trade association was founded in 1894.

FEDERATION OF SOCIETIES FOR COATINGS TECHNOLOGY
492 Norristown Road
Blue Bell, PA 19422
Ph#: 610/940-0291
Fax: 610/940-0292

This is a trade association for the paint industry.

HAZARDOUS MATERIALS ADVISORY COUNCIL
1101 Vermont Avenue NW, Suite 301
Washington, DC 20005-3521
Ph#: 202/289-4550
Fax: 202/289-4074

Incorporated in 1978, the Hazardous Materials Advisory Council (HMAC) is an international, non-profit organization devoted to promoting regulatory compliance and safety in the transportation of hazardous materials, substances, and wastes.

ISA
P.O. Box 12277
67 Alexander Drive
Research Triangle Park, NC 27709
Ph#: 919/549-8411
Fax: 919/549-8288
Brian Duckett, Meetings Manager

ISA develops standards for the instrumentation and control field.

METAL FINISHING SUPPLIERS' ASSOCIATION
801 N. Cass Avenue, Suite 300
Westmont, IL 60559
Ph#: 708/887-0797
Fax: 708/887-0799

MFSA is an organization representing 175 member companies who are suppliers of equipment, chemicals, and services to the metal finishing industry.

NACE INTERNATIONAL
National Association of Corrosion Engineers
P.O. Box 218340
Houston, TX 77218-8340
Ph#: 713/492-0535
Fax: 713/492-8254

This organization provides a number of services to its members: the selling of books, publications, magazines, classes, seminars and symposiums are among some of those services.

NATIONAL ASSOCIATION OF CHEMICAL RECYCLERS
1900 M. Street NW, Suite 750
Washington, DC 20036
Ph#: 202/296-1725
Fax: 202/296-2530

INDUSTRY STANDARDS
Chemical Industry Trade Associations

NATIONAL ASSOCIATION OF PRINTING INK MANUFACTURERS, INC. (NAPIM)
Heights Plaza, 777 Terrace Avenue
Hasbrouck Heights, NJ 07604
Ph#: 201/288-9454
Fax: 201/288-9453

The National Association of Printing Ink Manufacturers is a trade association whose purpose it is to represent the printing ink industry in the United States and to provide direction to management in the areas of environmental issues, business management, government regulations, and regulatory compliance.

NATIONAL FIRE PROTECTION ASSOCIATION (NFPA)
1 Batterymarch Park
Quincy, MA 02269-9101
Ph#: 617/770-3000
Fax: 617/770-0700
Member Services

Fire protection standards and manuals. Services and interpretation of standards are available to members only.

PHARMACEUTICAL RESEARCH AND MANUFACTURERS OF AMERICA
1100 Fifteenth Street NW, Suite 900
Washington, DC 20005
Ph#: 202/845-3400
Fax: 202/835-3414

The Pharmaceutical Research and Manufacturers of America (PhRMA) represents the country's largest research based pharmaceutical and biotechnology companies. Investing nearly $16 billion a year in discovering and developing new medicines. PhRMA companies are the source of nearly all new drug discoveries worldwide.

PROCESS EQUIPMENT MANUFACTURERS' ASSOCIATION
111 Park Place
Falls Church, VA 22046-4513
Ph#: 703/538-1796
Fax: 703/241-5603

The Process Equipment Manufacturers' Association is an organization of firms and corporations engaged in the manufacture of process equipment such as agitators, mixers, crushing, grinding and screening equipment, vacuum and pressure filters, centrifuges, furnaces, kilns, dryers, sedimentation and classification devices, and waste treatment equipment.

PULP CHEMICALS ASSOCIATION, INC
15 Technology Parkway South
Norcross, GA 30092
Ph#: 770/446-1290
Fax: 770/446-1487

The Pulp Chemicals Association Inc. is an international trade association serving the common goals of its membership. Any person, firm or corporation who manufactures chemical products derived from the pulp and forest products industries is eligible for membership.

RUBBER MANUFACTURERS ASSOCIATION
1400 K Street NW, Suite 900
Washington, DC 20005
Ph#: 202/682-4800
Fax: 202/682-4854

The Rubber Manufacturers Association is a trade association representing the rubber and tire industry in North America.

SOAP AND DETERGENT ASSOCIATION 475 Park Avenue, S.
New York, NY 10016
Ph#: 212/725-1262
Fax: 212/213-0685

This is a national, non-profit trade association that represents the manufacturers of soaps and detergents.

SOCIETY FOR THE ADVANCEMENT OF MATERIAL AND PROCESS ENGINEERING (SAMPE)
P.O. Box 2459
Covina, CA 91722
Ph#: 818/33-0616
Fax: 818/332-8929

SAMPE is a global, member-governed, volunteer, not-for-profit organization, which supplies information on advanced state-of-the-art materials and process opportunities for career development within the materials and process industries.

SOCIETY OF PLASTICS ENGINEERS
14 Fairfield Drive
Brookfield, CT 06804-0403
Ph#: 203/775-0471
Fax: 203/775-8490

This society deals with education, holds seminars and conferences, and produces magazines and journals. Membership of 37,500 worldwide individuals in all areas of the plastics industry, in 70 countries.

THE SOCIETY OF THE PLASTICS INDUSTRY INC.
1275 K Street NW, Suite 400
Washington, DC 20005
Ph#: 202/371-5200
Fax: 202/371-1022

VALVE MANUFACTURERS ASSOCIATION OF AMERICA (VMA)
1050 17th Street NW, Suite 280
Washington, DC 20036
Ph#: 202/331-8105
Fax: 202/296-0378

WANER ENVIRONMENT FEDERATION
601 Wythe Street
Alexandria, VA 22314-1994
Ph#: 703/684-2400
Fax: 703/684-2450
Member Services

CHEMICAL RESISTANCE GUIDE

The chemical resistance data provided here on the following pages has been assembled from a wide variety of sources in our industry. This information is based on practical field experience and actual laboratory testing conducted by the manufacturers of various plastic resins and finished products. Keep in mind that this information should only be used as a guideline for recommendations and not a guarantee of chemical resistance. Some performance variations may be noticed between homopolymers and copolymers as well as emulsion and suspension type resins of the same general type. In addition, actual service conditions including temperature, concentration, and contaminant's will affect variances in chemical resistance.

In assembling the chemical resistance data presented here, several sources were checked. When conflicts were uncovered, we took a conservative approach and used the lower of two or more ratings. In addition, special consideration was given to the material as supplied by a particular vendor; i.e., our polyethylene ratings are based on information provided by tank manufacturers rather than pipe suppliers. This was done primarily because of the volume of tanks supplied as compared to polyethylene pipe.

In an attempt to make the recommendations more meaningful, we have given the maximum recommended use temperature for each plastic and elastomer in the specific chemicals listed. Lacking complete data in many cases we did leave those in question as blanks. Where a material is unsuitable for a specific chemical an “X” is used.

Metals are listed as:

A = Excellent
B = Good, minor effect
C = Fair, needs further tests
X = Unsuitable

To the best of our knowledge, the information contained in this publication is accurate. However, we do not assume any liability whatsoever for the accuracy or completeness of such information. Moreover, there is a need to reduce human exposure to many materials to the lowest physical limits in view of possible long term adverse effects. To the extent that any hazards may have been mentioned in this publication, we neither suggest nor guarantee that such hazards are the only ones which exist. Final determination of the suitability of any information or product for the use contemplated by any user, the manner of that use and whether there is any infringement of patents, is the sole responsibility of the user. We recommend that anyone intending to rely on any recommendation or use any equipment, processing technique, or material mentioned in this publication should satisfy themselves as to such suitability, and that they meet all applicable safety and health standards. We strongly recommend the user seek and adhere to manufacturers' or suppliers' current instructions for handling each material they use.

USE OF THE CHEMICAL RESISTANCE TABLES

The aggressive agents are classified alphabetically according to their most common designation. Further descriptions include trivial or common names as trade names.

If several concentrations are given for a particular material, the physical data, in general, relates to the pure product that is 100% concentration.

In listing the maximum use temperature for each plastic type in a given chemical, it can in general be assumed that the resistance will be no worse at lower temperatures.

HOW TO SELECT THE CORRECT MATERIAL:

1. Locate the specific chemical in the system or found in the surrounding atmosphere using the alphabetical chart of chemicals.

2. Select the material with a maximum use temperature that matches or exceeds the need. The Harrington philosophy has always been to suggest the least costly material that will do the job.

3. Where a material or elastomer appears to be marginal compared to the requirements, we encourage a call to our technical service group.

EXAMPLES:

1. Methylene chloride: in the tables PVDF, Halar, or Teflon are the only materials suitable. Carbon steel works well for chlorinated hydrocarbons of this sort and that would be our choice unless there was another reason to justify the higher cost of the PVDF, Teflon or Halar.

2. Sodium hypochlorite, 15% at 100°F, PVC is good to 140°F and is the least expensive of the materials available.

3. For nitric acid 40% ambient temperature, the tables recommend either CPVC or polypropylene at 73°F. In most cases CPVC will be the economical choice. Note that PVDF is rated for higher temperature use.

NOTE: The ratings shown for carbon and ceramic pump seals are approximate. Please contact your local Harrington service center for a recommendation on your specific application.

CHEMICAL RESISTANCE GUIDE

CHEMICAL	FORMULAS	APPROX. SP.GRAVITY @ 100% CONC.		PLASTIC														ELASTOMER				SEAL		METAL			
				PVC	CPVC	POLYPROPYLENE (PP)	POLYVINYLIDENE FLUORIDE (PVDF)	POLYETHYLENE (PE)	POLYETHYLENE-CROSS LINKED (XLPE)	DURAPLUS ABS	RYTON	HALAR	PEEK	TEFLON	EPOXY	VINYLESTER	POLYSULFONE	VITON	EPDM	NEOPRENE	BUNA N (NITRILE)	CARBON	CERAMIC	304 STAINLESS STEEL	316 STAINLESS STEEL	TITANIUM	HASTELLOY C
Acetaldehyde	CH_3CHO	-	-	X	X	100	120	X	X	X	200	-	-	350	150	X	X	100	200	X	X	A	A	A	A	A	A
Acetaldehyde, Aqueous	-	40	-	X	X	100	120	X	X	-	200	-	-	350	150	X	X	100	200	X	X	A	A	A	A	A	A
Acetamide	CH_3CONH_2	-	-	-	-	100	73	150	-	-	-	-	-	-	-	-	-	200	200	X	100	-	A	B	A	-	-
Acetate Solvents, Crude	-	-	-	X	X	-	78	-	-	X	-	-	-	350	-	-	-	X	X	X	X	A	A	B	A	-	B
Acetate Solvents, Pure	-	-	-	X	X	-	X	-	-	X	-	-	-	350	-	-	-	X	X	X	X	-	-	B	A	-	-
Acetic Acid*	CH_3COOH	5	-	140	140	200	140	X	140	68	200	250	-	350	150	200	-	X	200	100	-	-	-	A	A	A	A
Acetic Acid*	CH_3COOH	10	-	140	140	200	140	X	140	68	200	250	-	350	150	200	-	180	200	X	X	-	-	A	A	A	A
Acetic Acid*	CH_3COOH	20	-	140	140	200	140	X	140	X	200	250	-	350	X	200	-	180	200	X	X	-	-	A	A	A	A
Acetic Acid*	CH_3COOH	30	-	140	140	200	140	X	140	X	200	250	-	350	-	100	-	180	200	-	-	-	-	A	A	A	A
Acetic Acid*	CH_3COOH	50	-	100	100	200	100	X	140	X	200	250	-	350	X	100	-	180	200	X	X	-	-	A	A	A	A
Acetic Acid*	CH_3COOH	60	-	73	73	150	100	X	140	X	200	-	-	350	X	X	-	180	100	X	X	-	-	A	A	A	A
Acetic Acid*	CH_3COOH	80	-	X	X	140	73	X	70	X	200	212	-	350	X	X	-	180	100	X	X	-	-	A	A	A	A
Acetic Acid*, Glacial	CH_3COOH	100	1.0	110	110	180	180	X	70	X	200	212	300	350	X	X	-	X	73	X	X	A	A	A	A	A	A
Acetic Anhydride	$(CH_3CO)_2O$	-	5	X	X	73	90	X	X	X	200	73	-	-	X	X	-	X	200	X	X	A	A	-	-	-	-
Acetic Ether (See Ethyl Acetate)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Acetol (Hydroxy 2 Propanone)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	A	A	A	A	A
Acetone	CH_3COCH_3	-	-	X	X	-	-	-	-	-	200	150	-	-	-	-	-	-	-	-	-	-	-	A	A	A	A
Acetonitrile (Methyl Cyanide)	CH_3CN	-	-	X	X	X	150	X	X	X	200	212	-	400	X	X	-	X	-	X	X	-	-	A	A	A	A
Acetophenone	$C_6H_5COCH_3$	-	0.8	X	X	150	200	-	-	X	200	121	-	400	120	X	-	X	-	-	X	-	-	A	A	-	B
Acetyl Acetone	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Acetyl Benzene	$C_6H_5COCH_3$	-	-	X	X	73	73	-	-	X	-	-	-	-	X	X	-	X	-	X	X	-	-	-	A	-	-
Acetyl Bromide	-	-	1.0	X	X	-	-	-	-	X	-	-	-	-	X	X	-	X	-	X	X	-	-	-	A	-	-
Acetyl Chloride (dry)	$C_6H_5COCH_3$	-	3	-	-	-	100	X	X	X	200	150	-	-	X	X	-	-	X	-	-	-	-	-	A	-	-
Acetyl Oxide	CH_3COBr	-	-	-	-	-	-	-	-	X	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Acetyl Propane	CH_3COCL	-	-	X	X	130	100	-	-	X	-	-	-	200	-	-	-	X	-	X	X	-	-	A	A	-	-
Acetylene	$(CH_3CO)_2O$	-	-	100	100	-	200	-	-	-	200	150	-	-	-	-	-	-	-	-	-	A	A	-	A	-	B
Acetylene Dichloride	CLHC:CHLC	-	-	X	X	-	X	-	-	X	-	-	-	300	-	-	-	150	-	-		-	-	-		-	-
Acetylene Tetrachloride	$(CHCL_2)_2$	-	-	-	-	-	-	-	-	X	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Acid Mine Water	-	-	-	100	150	150	250	-	-	-	200	-	-	350	-	-	-	-	-	-	-	-	-	-	-	-	-
Acrylic Acid	$CH_2CHCOOH$	-	-	X	X	X	100	X	X	X	-	212	-	170	X	X	-	-	-	-	-	-	-	-	-	-	-
Acrylic Emulsions*	-	-	-	-	-	-	-	X	70	-	-	-	-	-	-	-	-	X	X	X	X	-	-	A	-	-	A
Acrylonitrile	H_2CCHCN	-	-	X	X	73	100	140	140	X	-	73	-	350	100	X	-	250	200	160	180	A	A	B	-	-	B
Adipic Acid Aqueous	-	-	-	140	180	100	250	140	140	-	-	150	-	350	-	-	-	-	-	-	-	-	-	A	A	A	A
Alcohol (See Ethyl Alcohol)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Alcohol, Allyl	-	-	-	80	80	140	200	100	140	X	-	-	-	250	200	100	-	200	70	100	180	-	-	A	-	-	A
Alcohol, Amyl	$C_5H_{11}OH$	-	-	100	100	170	250	140	140	X	200	250	-	400	200	100	-	190	200	140	140	-	-	A	-	-	A
Alcohol, Benzyl	$C_6H_5CH_2OH$	-	-	X	X	140	180	-	-	X	-	250	-	-	-	-	-	140	X	140	X	-	-	A	-	-	A
Alcohol, Butyl	-	-	-	140	180	180	240	140	140	X	200	250	-	250	200	100	-	100	180	140	140	-	-	A	-	-	A
Alcohol, Diacetone	-	-	-	X	-	73	73	-	-	X	-	150	-	350	-	-	-	X	70	X	-	-	-	A	-	-	A
Alcohol, Ether	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Alcohol, Ethyl	C_2H_5OH	-	-	140	*	180	750	140	140	X	-	250	-	300	180	-	-	170	170	170	200	A	A	A	-	-	A
Alcohol, Hexyl	-	-	-	100	70	70	-	-	-	X	-	73	-	-	-	-	-	160	X	70	70	A	A	A	-	-	A
Alcohol, Isobutyl	$(CH_3)_2CHCH_2OH$	-	-	-	-	-	250	-	-	X	-	-	-	300	180	100	-	140	140	70	70	A	A	A	-	-	A
Alcohol, Isopropyl	$(CH_3)_2CHOH$	-	-	140	*	150	230	140	140	X	-	250	-	300	180	100	-	200	140	70	200	A	A	A	-	-	-
Alcohol, Methyl	CH_3OH	-	-	140	150	150	230	140	140	X	-	250	-	300	150	-	-	100	100	140	140	A	A	A	-	-	A
Alcohol, Octyl	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	A	A	-	-	-	-
Alcohol, Polyvinyl	-	-	-	140	180	180	250	-	-	68	-	-	-	280	150	100	-	210	100	-	-	A	A	A	-	-	-
Alcohol, Propargyl	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	A	A	-	-	-	-
Alkanes	-	-	-	140	100	100	250	-	-	-	-	-	-	300	-	-	-	210	X	X	X	-	-	A	-	-	-
Alkazene	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Allyl Aldehyde	-	-	-	-	-	-	-	-	-	X	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Allyl Bromide	C_3H_5Br	-	-	X	-	-	-	-	-	X	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Allyl Chloride	C_3H_5CL	-	-	X	X	100	200	100	-	X	-	250	-	350	-	-	-	100	X	X	X	-	-	A	-	-	-
Alum (See Aluminum Sulfate)	$AL_2(SO_4)_3$	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

CHEMICAL RESISTANCE

HARRINGTON

CHEMICAL RESISTANCE GUIDE

PLASTIC | ELASTOMER | SEAL | METAL

CHEMICAL	FORMULAS		APPROX. SP.GRAVITY @ 100% CONC.	PVC	CPVC	POLYPROPYLENE (PP)	POLYVINYLIDENE FLUORIDE (PVDF)	POLYETHYLENE (PE)	POLYETHYLENE-CROSS LINKED (XLPE)	DURAPLUS ABS	RYTON	HALAR	PEEK	TEFLON	EPOXY	VINYLESTER	POLYSULFONE	VITON	EPDM	NEOPRENE	BUNA N (NITRILE)	CARBON	CERAMIC	304 STAINLESS STEEL	316 STAINLESS STEEL	TITANIUM	HASTELLOY C
Alum, Ammonium	-	-	-	140	140	200	220	140	140	176	200	250	-	400	270	200	-	180	-	X	180	-	-	-	-	-	-
Alum, Chrome	-	-	-	120	160	180	250	140	140	176	-	150	-	-	270	200	-	180	140	80	180	-	-	B	-	-	-
Alum, Potassium	$ALK(SO_4)_2$	-	-	140	140	180	280	140	140	176	200	250	-	400	270	200	-	180	200	80	180	-	-	A	-	-	-
Aluminum, Acetate	-	-	-	100	100	100	250	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Aluminum,	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Ammonium Sulfate	-	-	-	-	-	200	220	-	-	176	-	250	-	-	-	-	-	80	-	140	140	-	-	-	-	-	-
Aluminum, Bromide	$ALBr_3$	-	-	-	-	-	250	-	-	176	-	-	-	-	-	-	-	180	-	-	140	-	-	-	-	-	-
Aluminum, Chloride	$ALCL_3$	-	-	140	170	170	140	140	140	176	200	250	-	210	-	200	-	180	210	200	200	A	A	C	-	-	-
Aluminum, Citrate	-	-	-	-	-	-	-	140	140	-	-	-	-	-	180	180	-	-	-	-	-	-	-	-	-	-	-
Aluminum, Fluoride	ALF_3	-	-	140	160	200	280	160	-	176	-	250	-	-	-	-	-	180	-	200	200	-	-	-	-	-	-
Aluminum, Formate	$AL(HCOO)_3$	-	-	140	180	180	250	-	-	-	-	-	-	280	-	-	-	250	210	160	180	-	-	B	-	-	-
Aluminum, Hydroxide	$AL(OH)_3$	-	-	140	180	180	250	-	-	176	-	250	-	250	-	-	-	180	150	160	180	-	-	-	A	B	-
Aluminum, Nitrate	$AL(NO_3)_3$	-	-	140	180	180	200	140	140	176	-	250	-	210	250	180	-	200	200	200	200	A	A	-	-	-	-
Aluminum, Phosphate	$ALPO_4$	-	-	-	-	-	-	140	140	176	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Aluminum, Potassium Sulfate	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
(Known as Potash Alum)	-	-	-	140	140	180	280	140	140	176	-	250	-	400	270	200	-	-	200	150	180	-	-	-	-	-	-
Aluminum, Salts	-	-	-	-	-	-	-	140	140	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Aluminum, Sulfate	$AL_2(SO_4)_3$	10	-	140	180	180	280	-	-	176	-	250	-	250	270	300	-	-	210	160	200	A	A	-	-	A	A
Amines	-	15	-	-	-	-	-	-	-	176	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Ammonia	NH_3	25	-	140	180	180	210	-	-	176	200	-	-	250	-	-	-	70	-	-	140	-	-	-	-	-	-
Ammonia	NH_3	99	-	140	180	180	210	-	-	176	200	-	-	250	-	-	-	-	-	-	-	-	-	-	-	-	-
Ammonia, Gas	NH_3	-	-	X	X	100	180	-	-	-	200	-	-	250	-	-	-	X	120	-	180	-	-	A	A	-	A
Ammonia, Anhydrous	-	-	-	X	X	180	250	160	-	-	200	-	-	400	X	-	-	-	-	200	180	C	A	-	-	-	-
Ammonium Hydroxide	NH_4OH	-	-	140	X	180	250	150	-	176	-	300	200	400	150	100	-	X	200	80	X	-	-	-	A	-	A
Ammonium, Nitrate	NH_4NO_3	-	-	140	190	180	250	140	140	176	200	250	-	350	230	200	-	X	200	160	180	-	-	-	-	-	-
Ammonium Phosphate	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Monobasic		-	-	140	180	180	250	140	140	176	200	250	-	250	200	150	-	180	120	140	100	-	-	A	-	-	A
Tribasic	-	-	-	140	180	180	250	140	140	-	-	-	-	250	200	150	-	180	200	140	100	-	-	A	-	-	A
Ammonium, Acetate	-	-	-	140	180	180	-	-	-	-	-	150	-	350	-	-	-	X	140	X	-	-	-	B	-	-	-
Ammonium, Alum (See Aluminum Ammonium Sulfate)		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Ammonium, Bichromate	$(NH_4)_2Cr_2O_7$	-	-	73	-	-	250	-	-	-	-	-	-	-	-	-	-	70	100	100	100	-	-	-	-	-	-
Ammonium, Bifluoride	NH_4HF_2	-	-	140	180	180	250	-	-	-	-	250	-	300	-	-	-	140	-	X	80	-	-	A	-	-	-
Ammonium, Bisulfide	NH_4HS	-	-	140	180	-	250	-	-	-	-	250	-	300	-	-	-	-	-	-	180	-	-	-	-	-	-
Ammonium, Carbonate	NH_4HCO_3	-	-	140	180	200	250	140	140	68	-	250	-	250	180	100	-	200	200	200	200	-	-	A	-	-	-
Ammonium, Casenite	-	-	-	-	-	-	-	140	140	-	-	-	-	-	180	100	-	-	-	-	-	-	-	-	-	-	-
Ammonium, Chloride	NH_4CL	-	-	140	180	180	250	140	140	176	-	250	-	250	270	200	-	220	-	200	180	A	A	B	-	-	-
Ammonium, Dichromate	$(NH_4)_2Cr_2O_7$	-	-	73	-	-	250	-	-	-	-	73	-	-	-	-	-	70	100	100	100	-	-	-	-	-	-
Ammonium, Fluoride	NH_4F	10	-	100	-	180	250	-	-	176	-	250	-	-	-	-	-	140	-	200	100	-	-	-	-	-	-
Ammonium, Fluoride	NH_4F	20	-	100	-	180	250	-	-	176	-	-	-	-	-	150	-	140	-	-	100	-	-	-	-	-	-
Ammonium, Fluoride	NH_4F	25	-	X	-	-	-	-	-	176	-	250	-	-	-	-	-	140	-	200	100	-	-	-	-	-	-
Ammonium, Fluoride	NH_4F	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Ammonium, Hydroxide	NH_4OH	-	-	140	X	180	250	150	-	176	-	300	-	400	150	100	-	X	200	80	X	A	A	A	-	-	A
Ammonium,	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Metaphosphate	-	-	-	140	180	-	-	140	140	-	-	250	-	-	200	150	-	180	-	200	200	-	-	-	-	-	-
Ammonium, Nitrate	NH_4NO_3	-	-	140	180	180	160	140	140	176	-	400	-	250	230	200	-	180	-	200	180	A	A	A	-	-	-
Ammonium, Oxalate	$(NH_4)_2C_2O_4$	-	-	-	-	-	-	140	140	-	-	-	-	-	-	-	-	-	-	-	-	A	-	-	-	-	-
Ammonium, Persulfate	$(NH_4)_2S_2O_8$	-	-	140	150	180	200	140	140	176	-	150	-	-	-	180	73	76	-	200	200	-	-	X	A	-	-
Ammonium, Phosphate	$NH_4H_2PO_4$	-	-	140	180	180	250	140	140	176	-	250	-	250	200	150	-	180	-	200	200	A	A	A	-	-	-
Dibasic	$(NH_4)_2HPO_4$	-	-	140	180	180	250	140	140	-	-	-	-	300	-	200	150	180	210	100	100	A	A	A	-	-	-
Monobasic	$NH_4H_2PO_4$	-	-	140	180	180	250	140	140	-	-	-	-	-	350	200	150	190	210	100	100	A	A	A	-	-	A
Tribasic	-	-	-	140	180	180	250	140	140	-	-	-	-	-	200	150	-	190	210	100	100	A	A	A	-	-	A
Ammonium, Salts	-	-	1.8	140	180	180	250	140	140	-	-	-	-	350	200	150	-	180	210	160	180	A	A	B	-	-	-
Ammonium, Sulfate	$(NH_4)_2SO_4$	-	1.8	140	180	180	250	140	140	176	200	250	-	-	350	200	150	180	210	160	140	A	A	B	-	-	A
Ammonium, Sulfide	$(NH_4)_2S$	-	1.3	140	180	180	250	140	140	-	-	250	-	-	350	200	150	-	210	160	140	-	-	B	-	-	-

CHEMICAL RESISTANCE

CHEMICAL RESISTANCE GUIDE

CHEMICAL	FORMULAS	APPROX. SP.GRAVITY @ 100% CONC.		PLASTIC													ELASTOMER					SEAL		METAL			
				PVC	CPVC	POLYPROPYLENE (PP)	POLYVINYLIDENE FLUORIDE (PVDF)	POLYETHYLENE (PE)	POLYETHYLENE-CROSS LINKED (XLPE)	DURAPLUS ABS	RYTON	HALAR	PEEK	TEFLON	EPOXY	VINYLESTER	POLYSULFONE	VITON	EPDM	NEOPRENE	BUNA N (NITRILE)	CARBON	CERAMIC	304 STAINLESS STEEL	316 STAINLESS STEEL	TITANIUM	HASTELLOY C
Ammonium, Thiocyanate	NH_4SCN	-	1.3	140	180	-	280	140	140	176	-	-	-	-	300	150	100	200	180	140	150	-	-	A	-	-	A
Ammonium, Thiosulfate	$(NH_4)_2S_2O_3$	-	0.86	140	180	-	250	140	140	-	-	-	-	-	300	150	100	200	180	140	150	A	A	A	-	-	-
Amyl, Acetate	$CH_3COOC_5H_{11}$	-	0.86	X	X	X	180	X	X	X	200	150	-	400	140	100	X	X	70	X	X	A	A	A	A	A	A
Amyl, Alcohol (See Alcohol Amyl)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Amyl Bromate	-	-	-	-	-	-	-	-	-	X	-	-	-	-	250	-	-	X	X	-	70	-	-	-	-	-	-
Amyl Bromide	-	-	0.8	-	-	-	250	-	-	X	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Amyl Chloride	-	-	1.02	X	X	X	240	X	X	X	-	250	-	-	100	100	X	68	X	X	X	A	A	B	B	-	-
Aniline	$C_6H_5NH_2$	-	1.02	X	X	100	200	X	70	X	200	121	-	400	250	X	X	140	70	X	X	A	A	A	-	-	-
Aniline Chlorohydrate	-	-	-	X	X	-	140	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Aniline Hydrochloride	$C_6H_5NH_2HCL$	20	-	X	X	100	140	-	-	-	-	-	-	400	X	140	-	180	-	-	-	-	-	X	X	A	X
Anisole	$C_2H_5OCH_3$	-	1	-	-	-	-	-	-	X	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Anthraquinone Sulfonic Acid	-	-	-	100	180	X	240	100	-	X	-	150	-	400	-	-	-	180	-	-	-	-	-	-	-	-	-
Anti-Freeze (See Ethylene Glycol)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Antichlor		-		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Antimony Chloride (See	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Antimony Trichloride)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Antimony Pentachloride	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	150	-	-	-	-	-	-	-	-	-	-
Antimony Trichloride	$SbCL_3$	-	-	140	180	180	100	140	140	-	-	-	-	-	250	200	-	190	140	140	140	-	-	X	X	-	-
Aqua Ammonia (see Ammonia Hydroxide)		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Aqua Regia	80% HCL /20% HNO_3	-	-	X	X	X	200	X	X	X	X	250	-	380	X	X	150	140	X	X	X	-	X	X	-	-	C
Aroclor 1248	-	-	-	-	-	X	-	X	-	-	-	-	-	300	-	-	-	-	-	-	-	A	-	-	-	-	-
Aromatic Hydrocarbons	-	-	-	X	X	68	40	-	-	X	-	-	-	-	250	-	-	180	X	X	X	A	-	-	-	-	-
Arsenic Acid	H_3AsO_4	80	-	100	180	140	210	140	140	-	-	250	-	-	250	180	-	210	150	160	160	A	A	A	A	-	A
Aryl Sufonic Acid	-	-	-	X	X	X	X	-	-	X	-	-	-	-	-	-	180	-	-	-	-	-	-	-	-	-	-
Asphalt	-	-	-	X	X	140	250	-	-	X	200	-	-	-	250	-	-	180	X	X	70	-	A	A	-	-	-
Aviation Fuel	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	250	-	160	X	X	150	-	-	-	-	-	-
Aviation Turbine Fuel	-	-	-	-	-	-	-	-	-	X	-	-	-	250	180	50	180	-	-	-	-	-	-	-	-	-	-
Baking Soda (See	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Sodium Bicarbonate)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Barium Acetate	-	-	-	-	-	-	-	140	140	-	-	-	-	-	-	180	150	-	-	-	-	-	-	-	-	-	-
Barium Carbonate	$BACO_3$	-	4.3	140	180	180	250	140	140	176	-	250	-	400	240	200	200	250	250	160	200	-	-	B	-	-	-
Barium Chloride	$BaCL_2$	-	3.1	140	180	180	250	140	140	176	200	250	-	400	-	200	200	300	250	160	200	-	-	B	-	-	-
Barium Cyanide	$Ba(CN)_2$	-	-	-	-	-	-	140	140	-	200	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Barium Hydrate	$Ba(OH)_2$	-	-	-	-	-	-	140	140	-	0	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Barium Hydroxide	$Ba(OH)_2$	-	2.2	140	180	180	250	140	140	176	200	250	-	400	-	200	150	200	200	140	200	A	A	A	-	-	-
Barium Nitrate	$Ba(NO_3)_2$	-	-	80	180	140	250	140	140	176	200	73	-	400	250	-	-	300	200	140	200	A	A	A	-	-	-
Barium Salts	-	-	4.4	140	180	180	250	140	140	-	-	-	-	-	250	200	180	250	200	140	200	A	A	A	-	-	-
Barium Sulfate	$BaSO_4$	-	4.3	140	180	180	250	140	140	176	200	-	-	400	-	200	200	200	200	150	200	A	B	A	A	A	A
Barium Sulfide	BaS	-	-	140	180	200	280	150	-	-	-	250	-	400	-	200	180	250	140	150	200	A	A	A	A	-	-
Beer	-	-	-	140	180	180	250	-	-	68	-	250	-	400	-	200	-	200	200	140	200	A	A	A	A	A	A
Beet Sugar Liquid	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	A	A	-	-	-	-
Beet Sugar Liquors	-	-	1.0	100	150	180	230	-	-	-	-	150	-	-	80	180	-	180	-	80	80	-	-	-	-	-	-
Benzaldehyde	C_6H_5CHO	-	5	X	X	73	120	X	X	X	X	122	-	400	X	X	-	-	-	-	-	A	A	A	A	A	A
Benzalkonium Chloride	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Benzene	C_6H_6	-	0.9	X	X	100	150	X	X	X	200	-	-	350	180	X	-	140	X	X	X	A	A	A	B	A	B
Benzene Sulfonic Acid	$C_6H_5SO_3H$	10	-	100	180	180	100	150	-	X	-	150	-	400	220	200	-	140	-	-	-	-	-	-	-	-	-
Benzene Sulfonic Acid	-	100	-	X	X	X	73	X	-	X	-	-	-	400	-	-	-	-	-	-	-	-	-	-	-	-	-
Benzoic Acid	C_6H_5COOH	-	1.3	180	180	250	250	150	140	-	-	250	-	400	200	200	-	180	-	140	-	-	-	A	B	A	A
Benzol (see Benzene)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Benzyl Alcohol (see	-	-	1.05	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Alcohol, Benzyl)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	250	-	-	-	-	-	-	-	-	-
Benzyl Benzoate	-	-	1.1	-	-	-	-	-	-	X	200	-	-	-	-	-	-	100	X	X	X	-	-	B	-	-	B
Benzyl Chloride	$C_6H_5CH_2CL$	-	6.8	-	-	73	250	-	-	X	200	-	-	400	-	73	-	200	X	-	X	-	-	-	-	-	-
Bismuth Carbonate	$(BiO)_2CO_3$	-	-	140	180	180	250	-	-	-	-	73	-	400	-	-	-	180	-	-	-	-	-	-	-	-	-

CHEMICAL RESISTANCE

HARRINGTON

CHEMICAL RESISTANCE GUIDE

PLASTIC | ELASTOMER | SEAL | METAL

CHEMICAL	FORMULAS		APPROX. SP.GRAVITY @ 100% CONC.	PVC	CPVC	POLYPROPYLENE (PP)	POLYVINYLIDENE FLUORIDE (PVDF)	POLYETHYLENE (PE)	POLYETHYLENE-CROSS LINKED (XLPE)	DURAPLUS ABS	RYTON	HALAR	PEEK	TEFLON	EPOXY	VINYLESTER	POLYSULFONE	VITON	EPDM	NEOPRENE	BUNA N (NITRILE)	CARBON	CERAMIC	304 STAINLESS STEEL	316 STAINLESS STEEL	TITANIUM	HASTELLOY C
Black Liquor	-	-	-	140	190	140	200	120	-	100	-	250	-	400	200	150	-	180	-	80	180	-	-	-	-	-	-
Bleach (See Sodium Hypochlorite)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Borax, Sodium Borate	$Na_2B_4O_7$	-	1.4	140	180	180	250	140	140	176	-	250	-	400	250	200	-	180	-	200	180	A	A	A	A	A	-
Boric Acid	H_3BO_3	-	-	140	190	180	250	140	140	176	-	250	-	400	230	200	-	200	210	X	180	A	A	B	-	A	A
Brake Fluid	-	-	-	-	-	-	-	-	-	-	-	-	-	300	-	-	-	X	140	-	X	-	-	-	-	-	A
Brewery Slop	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	150	-	A	A	-	-	-	-
Brine	-	-	-	140	190	180	280	140	140	176	-	-	-	-	270	200	-	300	250	-	180	A	A	A	-	-	-
Bromic Acid	$HBrO_3$	-	-	140	190	140	200	150	-	X	-	250	-	400	150	-	-	70	70	-	-	-	-	-	-	-	A
Bromine Dry	Br_2	-	-	-	-	X	200	X	X	X	-	-	-	-	X	X	-	X	-	-	-	-	-	-	-	-	-
Bromine Gas, Wet	-	-	3.1	-	-	-	-	X	X	X	X	-	-	-	-	-	-	X	-	X	-	X	-	-	-	-	-
Bromine Liquid	-	-	-	X	X	X	140	X	X	X	X	150	-	400	X	-	-	190	X	X	X	-	-	-	-	-	-
Bromine Water	-	-	-	100	X	X	180	X	-	X	X	250	-	X	-	-	-	100	X	X	X	-	-	X	X	A	A
Bromobenzene	C_6H_5Br	-	-	X	X	-	150	-	-	X	-	73	-	-	-	-	-	150	X	-	X	-	-	-	-	-	-
Bromotoluene	$C_6H_5CH_2Br$	-	-	X	X	X	180	-	-	X	-	121	-	-	-	-	-	-	-	140	-	-	-	-	-	-	-
Butadiene Gas	-	-	0.8	140	-	X	250	X	-	-	-	-	-	-	150	-	-	190	X	140	X	-	-	A	-	-	A
Butane	C_4H_{10}	-	-	100	70	70	200	X	-	-	200	250	-	400	100	-	-	180	X	-	140	-	-	A	A	-	B
Butanediol (Butylene glycol)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Butanol (See Alcohol, Butyl)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Butter	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	A	A	-	-
Buttermilk	-	-	-	-	-	-	-	-	-	68	-	-	-	-	-	-	-	-	-	X	-	-	-	A	A	-	-
Butyl Acetate	-	-	0.9	-	-	-	-	X	70	X	-	73	-	-	150	X	-	X	-	-	X	-	-	-	-	-	-
Butyl Acrylate Saturated	-	-	-	-	-	-	-	-	-	X	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Butylamine	$C_4H_9NH_2$	-	-	X	X	X	X	X	-	X	200	-	-	350	-	-	-	-	-	-	-	-	-	-	-	-	-
Butylbenzene	$C_6H_5C(CH_3)_3$	-	-	-	-	-	-	-	-	X	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Butyl Benzoate	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Butyl Bromide	C_4H_9Br	-	-	-	-	-	230	-	-	X	-	-	-	250	-	-	-	100	-	-	-	-	-	-	-	-	-
Butyl Butyrate (Butyl Butanoate)	-	-	-	-	-	-	-	-	-	X	-	-	-	-	-	-	-	-	-	-	-	-	-	A	-	-	A
Butyl Carbitol	-	-	-	-	-	-	-	-	-	X	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Butyl Cellosolve (Ethylene	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Glycol Monobutyl Ether)	-	-	-	-	-	-	-	-	-	X	-	73	-	-	150	X	-	-	-	-	-	-	-	-	-	-	-
Butyl Chloride (Chlorobutane)	-	-	-	-	-	X	250	-	-	X	-	-	-	350	-	-	100	-	-	-	-	-	-	B	-	-	B
Butyl Ether	$C_4H_9OC_4H_9$	-	-	X	X	X	100	-	-	X	200	-	-	140	-	-	X	X	X	100	-	-	-	-	-	-	-
Butyl Formate	$HCOOC_4H_9$	-	-	-	-	-	-	-	-	X	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Butyl Mercaptan	C_4H_9SH	-	-	-	-	-	230	-	-	X	-	-	-	350	-	-	-	-	-	-	-	-	-	-	A	-	-
Butyl Phenol	-	-	-	X	X	X	210	-	-	X	-	250	-	400	-	-	-	-	-	-	-	-	-	-	-	-	-
Butyl Phthalate	-	-	-	X	X	100	180	-	-	X	200	-	-	200	-	-	X	-	-	X	-	-	-	-	-	-	-
Butyl Stearate	-	-	-	-	-	-	250	-	-	-	-	73	-	250	-	-	190	100	X	100	-	-	-	A	-	-	-
Butylene (Liquified	-	-	-	-	-	X	250	-	-	-	-	-	-	250	-	-	140	X	X	100	-	A	-	A	-	-	-
Petroleum Gas)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Butyraldehyde	-	-	-	-	-	-	-	-	-	X	-	-	-	-	150	-	X	X	X	X	-	-	-	A	-	-	A
Butyric Acid	-	-	-	X	100	180	220	X	-	X	-	250	-	-	200	180	70	X	X	X	-	X	-	B	-	A	A
Cadmium Cyanide	$Cd(CN)_2$	-	-	140	180	-	-	140	140	-	-	150	-	-	-	-	-	-	70	-	-	-	-	-	-	-	-
Cadmium Salts	-	-	-	-	-	-	-	140	140	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Caffeine Citrate	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Calamine	-	-	3.5	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Calcium Acetate	-	-	-	140	180	180	250	140	140	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Calcium Bisulfide	$Ca(HS)_2$	-	-	120	160	200	210	140	X	-	-	250	-	400	-	-	180	X	100	140	-	A	A	B	-	A	A
Calcium Bisulfite	$Ca(HSO_3)_2$	-	-	100	140	200	210	-	-	-	-	250	-	210	270	200	180	X	100	100	-	-	A	-	-	-	-
Calcium Carbonate	$CaCO_3$	-	2.7	140	200	200	250	140	-	176	-	250	-	300	-	200	180	140	100	100	-	A	A	A	A	A	A
Calcium Chlorate	$Ca(CLO_3)_2$	-	2.7	140	180	200	250	140	-	176	-	250	-	400	200	200	180	140	73	73	-	A	-	A	A	-	B
Calcium Chloride	$CaCL_2$	-	2.1	140	200	200	250	140	140	176	200	250	-	350	270	200	180	200	150	100	-	A	A	B	B	A	A
Calcium Cyanide	$CaCN_2$	-	-	-	-	-	-	140	140	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Calcium Hydroxide	$Ca(OH)_2$	-	2.3	140	180	210	250	140	-	176	-	250	-	400	100	180	200	180	70	140	-	A	A	A	A	A	A
Calcium Hypochlorite	$Ca(OCL)_2$	-	2.3	140	180	180	200	140	140	100	-	250	-	380	150	200	180	100	X	X	-	A	A	B	-	-	B

CHEMICAL RESISTANCE

HARRINGTON

CHEMICAL RESISTANCE GUIDE

				PLASTIC													ELASTOMER					SEAL		METAL			
CHEMICAL	FORMULAS		APPROX. SP.GRAVITY @ 100% CONC.	PVC	CPVC	POLYPROPYLENE (PP)	POLYVINYLIDENE FLUORIDE (PVDF)	POLYETHYLENE (PE)	POLYETHYLENE-CROSS LINKED (XLPE)	DURAPLUS ABS	RYTON	HALAR	PEEK	TEFLON	EPOXY	VINYLESTER	POLYSULFONE	VITON	EPDM	NEOPRENE	BUNA N (NITRILE)	CARBON	CERAMIC	304 STAINLESS STEEL	316 STAINLESS STEEL	TITANIUM	HASTELLOY C
Calcium Nitrate	$Ca(NO_3)_2$	-	1.82	140	180	180	250	140	140	140	200	250	-	400	250	200	-	210	180	100	180	-	-	A	-	-	-
Calcium Oxide	CaO	-	-	140	180	180	250	140	-	150	-	250	-	400	-	-	-	-	210	160	180	-	-	A	-	-	-
Calcium Phosphate	$CaH_4(PO_4)_2$	-	2.3	-	-	-	-	140	140	-	-	-	-	-	150	-	-	-	-	-	-	-	-	-	-	-	-
Calcium Sulfate	$CaSO_4$	-	2.9	140	180	180	210	140	140	150	200	250	-	400	250	200	-	200	210	150	180	A	A	A	A	A	B
Calcium Sulfide	CaS	-	-	140	140	180	180	140	140	-	-	-	-	400	200	200	-	200	150	100	150	-	-	-	-	-	-
Calcium Thiosulfate	CaS_2O_3	-	1.87	-	-	-	-	140	140	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Calgon (Sodium	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Hexametaphosphate)	-	-	-	-	-	-	-	140	140	-	-	-	-	-	-	-	-	-	-	-	-	A	A	-	-	-	-
Cane Sugar Liquors	-	-	-	140	180	140	250	140	-	150	-	150	-	350	-	-	-	200	250	150	150	A	A	A	A	-	A
Caprylic Acid (Octanic Acid)	$CH_3(CH_2)_6COOH$	-	-	140	180	150	220	-	-	X	-	150	-	350	X	200	-	-	-	-	-	A	A	-	-	-	-
Carbinol (See Alcohol, Methyl)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Carbolic Acid (see Phenol)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Carbon Bisulfide (see	-	-	-	-	-	-	-	-	-	X	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Carbon Disulfide)	CS_2	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	A
Carbon Dioxide (wet or dry)	CO_2	-	-	140	180	180	250	140	140	90	-	250	-	350	200	200	-	210	170	150	180	-	-	A	A	A	A
Carbon Disulfide	CS_2	-	-	X	X	X	68	X	X	X	200	73	-	400	73	X	-	180	X	X	X	A	B	A	A	-	A
Carbon Monoxide	CO	-	-	140	180	180	250	140	140	140	-	150	-	400	200	200	-	180	-	200	180	A	A	A	A	-	-
Carbon Tetrachloride	CCL_4	-	1.6	X	X	X	140	X	X	X	-	250	-	350	150	-	-	190	X	X	X	A	A	A	C	A	A
Carbonic Acid	H_2CO_3	-	-	140	210	210	250	140	140	-	-	250	-	350	180	140	-	200	210	70	180	A	A	A	A	-	A
Casein	-	-	-	-	-	-	50	-	-	-	-	-	-	250	-	-	-	180	180	-	-	-	-	-	-	-	-
Castor Oil	-	-	0.95	140	*	150	250	140	140	140	-	250	-	350	220	200	-	140	140	100	140	-	-	A	A	-	A
Catsup	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	A	A	-	A
Caustic Lime -Calcium Hydroxide	$Ca(OH)_2$	-	-	140	180	200	250	-	-	176	-	250	-	250	100	180	-	210	210	70	140	A	A	A	-	-	A
Caustic Potash (Potassium	-	-	-	-	-	-	-	-	-	176	-	250	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Hydroxide)	KOH	-	2.04	140	180	200	140	-	-	-	-	-	-	200	180	150	-	X	200	150	70	-	-	A	-	-	-
Caustic Soda (Sodium	-	-	-	-	-	-	-	-	-	176	-	250	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Hydroxide)	$NaOH$	-	2.13	140	180	200	100	X	140	-	-	-	-	250	120	100	-	X	200	140	180	-	-	A	-	-	-
Cellosolve (See Butyl Cellosolve)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Cetyl Alcohol	$C_{16}H_{33}OH$	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Chloral Hydrate (knockout drops)	$CCL_3CH(OH)_2$	-	1.9	140	160	X	200	-	-	-	-	121	-	200	-	-	-	X	-	-	X	-	-	-	C	-	-
Chloroacetic Acid	$CH_2CLCOOH$	X	-	-	X	-	-	X	X	X	-	212	-	300	100	200	-	X	-	X	X	-	-	C	C	-	-
Chloric Acid	$HClO_3$	20	-	140	180	140	-	-	-	-	-	-	-	140	-	-	-	100	-	-	-	-	-	C	X	-	A
Chloric Acid	$HClO_3$	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	X	-	-	-
Chlorinated Glue	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Chlorine Dioxide	CLO_2	15	-	73	73	X	200	-	-	X	-	150	-	140	X	150	-	140	X	X	X	-	-	-	X	-	-
Chlorine Gas Dry	CL_2	-	-	X	X	X	250	X	X	X	-	212	-	350	X	150	-	140	X	X	X	A	A	-	-	-	-
Chlorine Gas Wet	-	-	-	X	X	X	-	X	X	X	-	212	-	-	X	200	-	140	X	X	X	-	-	A	-	-	A
Chlorine Liquid	-	-	-	X	X	X	200	X	X	X	-	212	-	400	-	-	-	140	-	-	X	-	-	C	-	-	A
Chlorine Water	-	-	-	140	180	-	250	-	-	-	-	212	-	400	-	200	-	180	73	X	X	C	A	-	-	-	-
Chlorosulfonic Acid	$CLSO_2OH$	6	1.77	X	X	X	X	X	X	-	X	73	-	180	-	X	-	X	X	X	X	-	-	X	-	-	-
Chlorox Bleach	$NaOCL:H_2O$	5.5	-	140	140	140	140	140	140	-	-	212	-	350	X	150	-	140	100	73	73	-	-	X	B	X	-
Chocolate Syrup	-	-	-	-	-	100	-	-	-	-	-	-	-	-	-	-	-	100	-	100	-	-	-	-	A	-	B
Chrome Alum (Chr. Potass. Sulf.)	$CrK(SO_4)_2$	-	-	73	73	140	200	140	140	176	-	-	-	210	200	200	-	210	140	160	150	-	-	A	-	-	-
Chromic Acid	H_2CrO_4	5	2.8	140	180	140	250	140	140	X	200	250	-	400	X	200	-	180	73	X	-	X	C	B	A	-	-
Chromic Acid	H_2CrO_4	10	-	140	180	140	250	140	140	X	200	212	-	400	X	100	-	180	73	X	-	X	-	A	-	-	A
Chromic Acid	H_2CrO_4	20	-	140	180	X	250	140	140	X	200	212	-	400	X	100	-	140	73	X	-	X	-	B	B	-	A
Chromic Acid	H_2CrO_4	30	-	100	180	X	200	100	140	X	200	212	-	400	X	X	-	300	-	-	140	X	-	B	-	-	A
Chromic Acid	H_2CrO_4	50	-	X	73	-	180	100	140	X	200	212	-	350	X	X	-	300	-	-	140	X	-	C	B	A	B
Chromium Alum.	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Citric Acid	-	-	1.54	140	180	180	240	140	140	176	200	250	-	200	250	200	-	200	200	200	200	-	-	-	-	-	-
Citric Oils	-	-	-	-	-	-	-	-	-	-	200	-	-	-	-	-	-	-	-	-	-	A	A	-	-	-	-
Cobalt Chloride	$CoCL_2$	-	3.35	-	-	100	-	-	-	176	-	-	-	-	-	-	-	-	X	-	-	-	-	-	-	-	-
Coconut Oil	-	-	-	-	-	100	250	140	140	-	200	250	-	250	-	-	-	340	-	-	200	-	-	-	-	-	-
Cod Liver Oil	-	-	-	-	-	-	-	-	-	-	200	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

CHEMICAL RESISTANCE

HARRINGTON

CHEMICAL RESISTANCE GUIDE

PLASTIC | ELASTOMER | SEAL | METAL

CHEMICAL	FORMULAS		APPROX. SP.GRAVITY @ 100% CONC.	PVC	CPVC	POLYPROPYLENE (PP)	POLYVINYLIDENE FLUORIDE (PVDF)	POLYETHYLENE (PE)	POLYETHYLENE-CROSS LINKED (XLPE)	DURAPLUS ABS	RYTON	HALAR	PEEK	TEFLON	EPOXY	VINYLESTER	POLYSULFONE	VITON	EPDM	NEOPRENE	BUNA N (NITRILE)	CARBON	CERAMIC	304 STAINLESS STEEL	316 STAINLESS STEEL	TITANIUM	HASTELLOY C
Coffee	-	-	-	-	-	-	-	-	-	-	200	-	-	-	-	-	-	200	140	-	100	A	A	A	A	-	-
Coke Oven Gas	-	-	-	X	-	-	230	-	-	X	-	250	-	400	-	-	-	180	-	180	X	A	A	A	A	-	-
Cola Concentrates	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	A	A	-	-	-	-
Copper Acetate	$Cu(C_2H_3O_2)_2$	-	-	73	-	73	250	-	-	-	-	-	-	250	180	180	-	X	150	X	73	-	A	B	A	-	B
Copper Carbonate	$Cu_2(OH)_2CO_3$	-	-	140	170	180	250	140	-	176	-	150	-	350	-	-	-	190	210	-	-	-	A	A	-	-	-
Copper Chloride	$CuCL_3$	-	3.4	140	190	180	250	-	-	176	-	300	-	350	250	200	-	200	210	160	180	-	A	C	C	A	A
Copper Cyanide	$Cu(CN)_2$	-	-	140	190	180	200	140	-	176	-	300	-	300	220	200	-	190	200	160	180	A	A	A	A	B	A
Copper Fluoborate	-	-	-	100	190	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Copper Fluoride	CuF_2	-	2.9	140	170	140	250	140	-	176	-	300	-	350	-	-	-	190	210	140	70	-	A	-	-	-	-
Copper Nitrate	$Cu(NO_3)_2$	-	2.3	140	140	180	210	140	-	176	-	300	-	350	250	200	-	200	210	160	70	-	A	A	-	-	-
Copper Salts	-	-	-	140	140	180	210	140	140	-	-	-	-	350	220	200	-	210	200	140	140	-	A	-	-	-	-
Copper Sulfate	$CuSO_4$	-	2.3	140	180	180	210	140	140	176	200	300	-	350	220	200	-	210	200	140	140	-	A	A	-	-	-
Copper Sulfate	$CuSO_4$	5	-	140	180	180	210	140	140	176	200	300	-	350	220	200	-	210	200	140	140	A	A	A	-	-	-
Corn Oil	-	-	-	73	180	100	250	-	-	X	-	-	-	400	-	-	-	200	X	200	180	-	A	A	-	-	-
Corn Syrup	-	-	-	140	73	150	250	-	-	-	-	-	-	400	220	180	-	210	100	100	100	-	A	A	-	-	-
Cottonseed Oil	-	-	-	140	180	180	250	X	140	X	200	-	-	400	-	-	-	300	X	150	180	-	A	A	-	-	-
Cream	-	-	-	-	190	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Creosol	$CH_3C_6H_4OH$	-	1.05	X	-	X	180	X	70	-	200	-	-	400	-	-	-	100	X	X	X	A	A	A	-	-	-
Creosote	-	-	-	X	X	-	-	-	-	X	-	-	-	400	-	-	-	100	X	X	70	-	-	-	-	-	-
Cresols	-	-	-	X	X	X	180	-	-	X	200	-	-	400	-	-	-	100	X	X	X	-	-	A	-	-	-
Cresylic Acid	-	-	-	X	X	X	150	-	-	X	-	150	-	-	X	X	-	200	X	X	X	A	A	A	-	-	-
Croton Aldehyde	$CH_3CHCHCHO$	-	-	X	X	73	180	-	-	X	-	73	-	210	-	-	-	100	-	-	X	-	-	A	-	-	-
Crude Oil	-	-	-	140	X	73	250	-	-	-	200	250	-	350	250	200	-	300	X	70	70	-	-	A	-	-	-
Cryolite	Na_3ALF_6	-	-	140	190	180	250	-	-	-	-	-	-	300	-	-	-	200	100	100	70	-	-	-	-	-	-
Cupric Cyanide (See	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Copper Cyanide)	$Cu(CN)_2$	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Cupric Fluoride	CuF_2	-	-	140	-	180	250	-	-	176	-	-	-	250	250	-	-	200	210	-	-	-	-	-	-	-	-
Cupric Nitrate	$Cu(NO_3)_2$	-	-	140	170	180	250	140	-	176	-	-	-	-	-	-	-	200	210	160	180	-	A	-	-	-	-
Cupric Salts	-	-	-	140	170	150	250	-	-	-	-	-	-	-	-	-	-	200	210	-	180	-	A	-	-	-	-
Cupric Sulfate (See	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Copper Sulfate)	$CuSO_4$	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Cutting Oil	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Cyanic Acid (Isocyanic Acid)	HN=C=O	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	X	-	-	-	-	-	A	A	-	-
Cyclohexane	-	-	-	X	X	X	210	X	-	X	-	250	-	400	150	120	-	180	X	X	X	A	A	A	A	-	-
Cyclohexanol	C_6H_{12}	-	0.94	X	X	100	210	140	-	X	-	121	-	400	150	-	-	180	-	-	-	-	-	-	-	-	-
Cyclohexanone	$C_6H_{11}OH$	-	0.95	X	X	X	100	X	X	X	200	121	-	400	X	100	-	X	X	-	X	-	-	-	-	-	-
Decalin	$C_6H_{10}O$	-	-	X	X	180	250	-	-	X	-	-	-	-	-	-	-	73	X	X	X	-	-	-	-	-	-
Decanal	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Decane	$CH_3(CH_2)_8CH_3$	-	-	-	-	-	250	-	-	-	-	-	-	250	-	-	-	100	X	X	X	-	-	-	-	-	-
Detergents	-	-	-	140	180*	180	250	X	140	-	200	250	-	400	180	150	-	210	200	160	180	A	A	-	A	-	-
Detergents, Heavy Duty	-	-	-	140	180*	150	150	X	140	-	-	250	-	400	180	150	-	180	-	-	180	A	A	-	-	-	-
Developers (Photo)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Dextrin, Starch Gum	-	-	-	140	200	180	250	140	140	176	-	250	-	400	-	-	-	210	200	200	180	-	-	-	A	-	-
Dextrose (Glucose)	-	-	-	140	200	180	250	140	140	176	-	250	-	400	-	-	-	210	200	70	180	-	-	-	A	-	-
Diacetone Alcohol	-	-	-	X	X	100	100	-	-	-	-	121	-	350	-	-	-	X	70	X	X	-	-	-	A	-	A
Diallyl Phthalate	-	-	-	-	-	-	-	-	-	X	-	-	-	-	180	180	-	-	-	-	-	-	-	-	-	-	-
Diazo Salts	-	-	-	140	190	180	240	140	140	-	-	-	-	350	-	-	-	-	-	-	-	-	-	-	-	-	-
Dibenzyl Ether	-	-	-	X	X	X	100	-	-	X	-	-	-	-	-	-	-	-	X	X	-	-	-	-	-	-	-
Dibutylamine	$(C_4H_9)_2NH$	-	-	-	-	-	-	-	-	X	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Dibutyl Ether	-	-	-	-	-	-	100	-	-	X	-	73	-	350	-	-	-	X	X	X	68	-	-	-	-	-	-
Dibutyl Phthalate	$C_6H_4(COOC_4H_9)_2$	-	-	X	X	73	150	-	-	X	-	73	-	350	180	180	-	X	70	X	X	-	-	-	A	-	-
Dibutyl Sebacate	-	-	-	-	-	-	-	-	-	X	-	212	-	-	-	-	-	X	-	-	-	-	-	-	-	-	-
Dicalcium Phosphate	$CaHPO_4$	-	-	-	-	-	-	-	-	-	-	-	-	-	150	120	-	-	-	-	-	-	-	-	-	-	-
Dichlorethane (ethylene dichloride)	$ClCH_2CH_2CL$	-	-	X	X	X	210	X	X	X	-	73	-	400	-	-	-	150	-	X	-	C	A	-	A	-	-

CHEMICAL RESISTANCE

CHEMICAL RESISTANCE GUIDE

PLASTIC — ELASTOMER — SEAL — METAL

CHEMICAL	FORMULAS		APPROX. SP.GRAVITY @ 100% CONC.	PVC	CPVC	POLYPROPYLENE (PP)	POLYVINYLIDENE FLUORIDE (PVDF)	POLYETHYLENE (PE)	POLYETHYLENE-CROSS LINKED (XLPE)	DURAPLUS ABS	RYTON	HALAR	PEEK	TEFLON	EPOXY	VINYLESTER	POLYSULFONE	VITON	EPDM	NEOPRENE	BUNA N (NITRILE)	CARBON	CERAMIC	304 STAINLESS STEEL	316 STAINLESS STEEL	TITANIUM	HASTELLOY C
Dichlorobenzene	$C_6H_4CL_2$	-	-	X	X	100	140	-	-	X	-	121	-	350	120	X	-	150	X	X	X	-	-	-	B	-	-
Dichlorethylene	CLHC:CHCL	-	1.25	X	X	X	120	-	-	X	-	73	-	350	-	-	-	190	X	X	X	-	-	-	-	-	-
Dichloroisopropyl (Ether)	-	-	-	X	X	X	100	-	-	X	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Dichloromethane	CH_2CL_2	-	-	X	X	X	100	-	-	X	-	-	-	-	-	-	-	-	X	X	X	A	A	-	-	-	-
Diesel Fuel	-	-	-	72	72	100	250	-	70	X	200	250	-	400	250	150	-	190	X	X	100	A	A	-	-	-	-
Diethanolamine	-	-	1.1	X	X	-	-	-	-	104	-	-	-	100	X	X	-	-	-	-	70	-	-	-	-	-	-
Diethyl Cellosolve	-	-	-	-	-	80	280	-	-	X	-	250	-	-	-	-	-	200	X	100	140	-	-	A	-	-	-
Diethylether (Ether)	$(C_2H_5)_2O$	-	-	X	X	100	100	73	-	X	-	73	-	400	100	X	-	X	X	X	X	-	-	-	-	-	-
Diethyl Ketone	$C_2H_5COC_2H_5$	-	-	X	X	-	-	-	-	X	-	-	-	-	-	X	-	X	-	X	200	-	-	-	-	-	-
Diethyl Oxide (Ether)	$(C_2H_5)_2O$	-	-	-	-	-	-	-	-	X	-	73	-	-	-	-	-	X	X	X	X	-	-	-	-	-	-
Diethylamine	$(C_2H_5)_2NH$	-	-	X	X	100	100	-	-	X	-	73	-	400	-	-	-	X	120	X	X	-	-	-	A	-	-
Diethylbenzene	$C_6H_4(C_2H_5)_2$	-	-	X	X	X	-	-	-	X	-	-	-	-	-	-	-	150	X	X	X	-	-	-	A	-	-
Diethylene Glycol	-	-	-	140	200	180	280	-	-	X	-	-	-	350	200	180	-	200	-	150	140	A	A	-	A	A	-
Diethylenetriamine	-	-	-	-	-	80	100	-	-	-	-	-	-	400	X	X	-	-	-	-	-	-	-	-	-	-	-
Diglycolic Acid	$O(CH_2COOH)_2$	-	-	140	190	100	80	-	-	-	-	73	-	400	-	-	-	-	-	-	-	-	-	-	A	-	-
Dimethyl Phthalate	-	-	-	X	X	X	68	-	-	X	-	212	-	-	100	100	-	200	-	-	-	-	-	-	-	-	-
Disobutyl Ketone	-	-	-	X	X	-	140	-	-	X	-	-	-	-	-	-	-	X	X	-	70	-	-	-	-	-	-
Diisobutylene	C_8H_{16}	-	-	-	-	-	180	-	-	-	200	-	-	250	-	-	-	140	X	-	-	-	-	-	A	-	-
Diisooctyl Phthalate	-	-	-	-	-	-	-	-	-	X	200	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Diisopropyl Ketone	-	-	-	-	-	-	68	-	-	-	-	73	-	70	-	-	-	X	70	-	-	-	-	-	-	-	-
Dimethylbenzene	$C_6H_4(CH_3)_2$	-	-	X	X	X	140	-	-	X	-	-	-	250	-	-	-	100	X	X	X	-	-	-	-	-	-
Dimethyl Ether	CH_3OCH_3	-	0.66	X	X	-	-	-	-	X	-	-	-	-	-	-	-	-	-	X	-	-	-	-	-	-	-
Dimethylformamide	$HCON(CH_3)_2$	10	0.95	X	X	120	X	100	-	X	-	-	-	140	-	-	-	X	-	-	-	-	-	-	A	-	-
Dimethyl Ketone (see Acetone)	CH_3COCH_3	-	-	X	X	-	-	-	-	X	-	-	-	-	-	-	-	X	-	X	X	-	-	-	-	-	-
Dimethyl Phthalate	$C_6H_4(COOCH_3)_2$	-	-	X	X	100	100	-	-	X	-	73	-	350	100	100	-	200	-	X	X	-	-	-	A	-	-
Dimethylamine	$(CH_3)_2NH$	-	-	X	X	-	-	-	-	X	-	73	-	-	X	X	-	X	X	-	-	-	-	-	-	-	-
Dioctyl Phthalate	-	-	-	X	X	X	73	X	X	X	200	73	-	-	-	-	-	-	-	X	X	-	-	-	A	-	-
Dioxane	-	-	-	X	X	73	X	73	-	X	200	150	-	350	-	-	-	X	-	X	X	-	-	-	A	A	A
Dioxolane	-	-	1.07	-	-	-	-	-	-	-	-	-	-	-	-	-	-	X	X	-	-	-	-	-	-	-	-
Diphenyl (Dowtherm)	-	-	1	-	-	-	-	-	-	X	200	-	-	350	120	120	-	300	X	150	X	-	-	-	-	-	-
Diphenyl Ether (See Diphenyl Oxide)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Diphenyl Oxide	$(C_6H_5)_2O$	-	-	-	-	-	-	-	-	X	-	-	-	-	120	-	-	100	X	X	X	A	A	-	A	-	-
Dipropylene Glycol	-	-	1.25	140	180	120	280	-	-	X	-	-	-	-	200	150	-	250	210	160	180	A	A	-	A	-	-
Disodium Methylarsonate	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Disodium Phosphate	-	-	-	140	180	180	180	140	140	-	-	300	-	350	-	-	-	80	210	80	100	-	-	A	-	-	-
Distilled Water	HOH	-	-	140	210	180	250	140	140	176	-	300	-	350	250	200	-	-	250	250	180	-	-	A	-	-	-
Divinylbenzene	-	-	-	X	X	X	X	-	-	X	-	73	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Dolomite	$CaMg(CO_3)_2$	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Dowtherm (See Diphenyl)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Dry Cleaning Solvents	-	-	-	X	X	73	250	X	X	-	-	-	-	350	120	X	-	200	X	X	X	-	-	A	-	A	-
Epichlorohydrin	-	-	-	X	X	80	220	-	-	X	200	-	-	350	-	-	-	X	X	-	X	-	-	-	-	A	-
Epsom Salts	$MgSO_4$	-	-	140	200	180	280	140	140	176	-	250	-	300	270	200	-	200	180	160	180	140	-	A	-	-	-
Esters (General)	-	-	-	X	X	X	100	-	-	-	-	-	-	350	100	-	-	-	-	-	-	-	-	-	-	-	-
Ethane	C_2H_6	-	-	73	73	X	280	-	-	-	-	-	-	350	-	-	-	-	X	-	-	-	-	A	-	-	-
Ethanol (see Alcohol, Ethyl)	C_2H_5OH	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Ethanolamine	-	-	1.02	X	X	X	X	-	-	-	200	-	-	100	-	-	-	-	100	-	68	-	-	A	-	-	-
Ethers	-	-	-	X	X	X	100	-	-	-	200	-	-	350	-	-	-	X	X	X	X	-	-	A	A	-	-
Ethyl Acetate	$CH_3COOL_2H_5$	-	-	X	X	100	100	X	X	X	200	121	-	350	150	X	-	X	70	X	X	A	A	A	A	-	-
Ethyl Acetoacetate	-	-	-	X	X	-	120	-	-	X	-	73	-	350	-	-	-	X	-	-	X	-	-	-	-	-	-
Ethyl Acrylate	-	-	-	X	X	73	120	-	-	X	-	121	-	350	-	-	-	X	-	X	X	-	-	-	C	-	-
Ethyl Alcohol	C_2H_5OH	-	0.8	140	180	180	250	120	140	X	-	250	-	300	180	80	-	180	170	70	180	-	-	A	A	-	-
Ethylbenzene	$C_6H_5C_2H_5$	-	-	X	X	X	140	-	-	X	-	-	-	300	-	-	-	70	X	X	X	-	-	-	-	-	-
Ethyl Bromide	C_2H_5BR	-	-	X	X	X	180	X	X	X	-	-	-	350	-	-	-	-	70	70	-	-	-	A	-	-	-
Ethyl Butyrate	$C_3H_7CO_2C_2H_5$	-	-	X	X	-	-	-	-	X	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

CHEMICAL RESISTANCE

HARRINGTON

CHEMICAL RESISTANCE GUIDE

PLASTIC | ELASTOMER | SEAL | METAL

CHEMICAL	FORMULAS	APPROX. SP.GRAVITY @ 100% CONC.		PVC	CPVC	POLYPROPYLENE (PP)	POLYVINYLIDENE FLUORIDE (PVDF)	POLYETHYLENE (PE)	POLYETHYLENE-CROSS LINKED (XLPE)	DURAPLUS ABS	RYTON	HALAR	PEEK	TEFLON	EPOXY	VINYLESTER	POLYSULFONE	VITON	EPDM	NEOPRENE	BUNA N (NITRILE)	CARBON	CERAMIC	304 STAINLESS STEEL	316 STAINLESS STEEL	TITANIUM	HASTELLOY C
Ethyl Cellosolve	-	-	-	-	-	-	-	-	-	X	-	-	-	-	150	X	-	-	-	-	-	-	-	-	-	-	-
Ethyl Chloride (Chlroethane)	C_2H_5CL	-	0.92	X	X	X	250	X	X	X	200	250	-	350	X	X	-	140	70	70	X	A	A	A	-	-	-
Ethyl Ether	$(C_2H_5)_2O$	-	-	X	X	X	100	X	X	X	200	121	-	200	100	X	-	X	X	X	X	-	-	A	A	-	-
Ethyl Formate	$HCOOC_2H_5$	-	-	X	X	X	X	-	-	X	-	73	-	200	-	-	-	X	70	-	X	-	-	-	-	-	-
Ethyl Hexanol	-	-	-	-	-	-	250	-	-	-	-	-	-	250	-	-	-	-	X	X	-	-	-	-	-	-	-
Ethyl Sulfate	$(C_2H_5)_2SO_4$	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	X	-	-	X	-	-	X	-	-	-
Ethylcellulose	-	-	-	-	-	-	-	-	-	176	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Ethylene Bromide	$(CH_2)_2Br_2$	-	-	X	X	X	150	X	X	X	-	250	-	400	-	-	-	73	X	X	X	-	-	A	A	B	A
Ethylene Chlorohydrin	$(CH_2)_2CLOH$	-	-	X	X	140	150	X	X	X	-	73	-	-	150	100	-	150	-	-	X	-	-	-	-	-	-
Ethylene Diamine	$(CH_2)_2(NH_2)_2$	-	-	X	X	190	90	100	-	-	-	73	-	350	X	X	-	150	-	80	150	-	-	-	A	-	-
Ethylene Dichloride	$CLCH_2CH_2CL$	-	1.25	X	X	X	200	X	X	X	-	73	-	-	120	X	-	150	X	X	X	C	A	A	-	-	-
(Dichloroethane)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Ethylene Glycol	CH_2OHCH_2OH	-	1.12	140	*	180	200	140	140	176	200	250	-	400	270	200	-	300	180	150	200	-	-	A	-	-	-
Ethylene Oxide	$(CH_2)_2O$	-	0.9	X	X	X	200	70	70	X	-	250	-	400	X	X	-	X	X	X	X	-	-	-	-	-	-
Fatty Acids	-	-	-	140	140	140	250	X	140	-	-	250	-	250	230	200	-	180	X	-	180	-	-	-	-	-	-
Ferric Acetate (Iron	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Acetate, Basic)	$Fe(C_2H_3O_2)_2OH$	-	-	-	-	-	-	140	140	-	-	-	-	-	200	180	-	X	-	-	X	-	-	-	-	-	-
Ferric Chloride	$FeCL_3$	-	2.9	140	190	180	250	140	140	X	200	250	-	400	220	200	-	210	200	160	180	A	A	X	X	A	C
Ferric Hydroxide	$Fe(OH)_3$	-	-	140	180	180	-	140	-	-	-	-	-	250	-	-	-	180	180	100	180	-	-	-	-	-	-
Ferric Nitrate	$FeNO_3$	50	1.7	140	190	180	250	140	140	176	-	250	-	400	220	200	-	180	180	100	100	-	-	B	A	-	-
Ferric Sulfate	$Fe(SO_4)_3$	-	3.1	140	180	180	250	140	140	68	-	250	-	400	220	200	-	190	210	200	180	C	A	B	-	-	-
Ferrous Chloride	$FeCL_2$	-	3.2	140	180	180	250	140	140	-	200	250	-	400	220	200	-	200	200	80	200	A	A	X	X	A	A
Ferrous Nitrate	-	-	-	140	180	180	250	140	-	-	-	250	-	0	220	200	-	200	180	200	200	-	-	-	-	-	-
Ferrous Sulfate	$FeSO_4$	-	1.9	140	190	180	280	140	140	140	-	250	-	400	220	200	-	200	180	200	200	A	A	A	A	B	A
Fish Solubles	-	-	-	140	190	180	250	X	140	140	-	-	-	400	-	-	-	-	-	-	200	-	-	-	-	-	-
Fluoboric Acid	HBF_4	-	1.8	140	190	140	200	140	140	-	-	73	-	400	200	200	-	200	160	100	170	-	-	B	-	-	-
Fluorine Gas, wet	F_2	-	-	X	X	X	80	X	X	X	-	73	-	250	X	X	-	X	-	-	-	X	-	-	-	-	-
Fluorine, Liquid	F_2	-	-	X	X	X	-	X	X	X	-	-	-	X	X	X	-	100	X	X	X	X	-	X	-	-	A
Fluosilicic Acid (Hydro-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Fluosilic Acid)	H_2SiF_6	25	1.11	X	170	180	210	140	140	176	200	250	-	250	-	100	-	200	140	140	140	A	X	B	-	-	A
Formaldehyde	HCHO	-	-	140	150	150	140	X	70	-	200	121	-	250	150	150	-	X	140	140	X	-	-	A	-	-	-
Formaldehyde	HCHO	35	0.82	140	150	150	140	X	70	-	200	121	-	250	150	150	-	X	140	-	X	-	-	A	-	-	-
Formaldehyde	HCHO	50	-	140	100	73	140	X	-	-	-	73	-	250	-	-	-	X	140	80	X	A	-	A	-	-	-
Formic Acid	HCOOH	25	-	100	120	100	210	X	140	X	-	212	-	300	X	100	-	100	200	100	X	-	-	A	-	-	-
Freon 11 (MF)	CCL_3F	-	1.22	72	72	73	250	-	-	-	200	121	-	250	-	-	-	180	X	200	180	-	-	A	A	-	-
Freon 113 (TF)	CL_3CCF_3	-	-	-	-	-	250	-	-	-	200	121	-	250	-	-	-	70	X	130	73	-	-	-	A	-	-
Freon 114	$C_2CL_2F_4$	-	-	-	-	-	250	-	-	-	200	121	-	250	-	-	-	100	X	130	100	-	-	-	A	-	-
Freon 12	CL_2CF_2	-	-	-	-	-	250	70	70	-	200	121	-	250	-	-	-	180	73	200	180	-	-	-	-	-	-
Freon 12 (Wet)	CL_2CF_2	-	-	-	-	-	-	-	-	-	X	-	-	250	-	-	-	-	-	-	-	-	-	-	-	-	-
Freon 22	$HCClF_2$	-	-	X	X	73	150	-	-	-	200	121	-	X	-	-	-	X	X	130	X	-	-	A	A	-	A
Freon TF	-	-	-	-	-	-	-	-	-	68	200	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Fructose	-	-	-	140	190	180	250	140	140	176	200	-	-	400	220	200	-	180	75	160	180	-	-	A	-	-	-
Fruit Juice	-	-	-	140	190	180	250	140	140	-	200	121	-	400	-	-	-	210	-	200	180	-	-	A	-	-	-
Fruit Pulp	-	-	-	140	190	180	250	140	140	-	200	-	-	400	-	-	-	210	-	200	180	-	-	-	-	-	-
Fuel Oil	-	-	-	-	-	X	250	X	70	X	200	-	-	400	220	180	-	80	X	140	200	-	-	A	A	B	A
Fumaric Acid (Boletic Acid)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Furan	-	-	-	-	-	-	X	-	-	-	200	-	-	-	-	-	-	X	X	-	X	-	-	-	-	-	-
Furfural (Ant Oil) Bran Oil	-	-	0.94	X	X	X	80	X	X	X	200	121	-	400	X	X	-	X	-	200	X	-	-	A	-	-	-
Furfuryl Alcohol	-	-	1.2	-	-	-	-	-	-	X	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Gallic Acid	-	-	-	140	190	73	100	X	140	-	-	121	-	400	-	-	-	190	70	70	70	-	-	A	-	-	-
Gas, Natural	CH_4	-	-	140	190	73	250	-	-	-	-	250	-	400	-	-	-	180	-	-	200	-	-	-	-	-	-
Gasoline, Leaded	-	-	-	100	-	X	250	X	70	X	200	250	-	400	230	150	-	180	X	80	180	-	-	A	-	-	-
Gasoline, Sour	-	-	-	140	150	X	250	X	70	X	200	250	-	400	230	150	-	180	X	80	200	-	-	A	-	-	-
Gasoline, Unleaded (1. Dry)	-	-	-	70	-	X	280	X	70	X	200	250	-	400	250	150	-	180	X	200	200	-	-	A	-	-	-

CHEMICAL RESISTANCE GUIDE

				PLASTIC													ELASTOMER					SEAL		METAL			
CHEMICAL	FORMULAS		APPROX. SP.GRAVITY @ 100% CONC.	PVC	CPVC	POLYPROPYLENE (PP)	POLYVINYLIDENE FLUORIDE (PVDF)	POLYETHYLENE (PE)	POLYETHYLENE-CROSS LINKED (XLPE)	DURAPLUS ABS	RYTON	HALAR	PEEK	TEFLON	EPOXY	VINYLESTER	POLYSULFONE	VITON	EPDM	NEOPRENE	BUNA N (NITRILE)	CARBON	CERAMIC	304 STAINLESS STEEL	316 STAINLESS STEEL	TITANIUM	HASTELLOY C
Gelatin	-	-	-	140	190	180	250	-	140	176	200	212	-	300	-	-	-	180	200	200	180	-	-	A	A	-	-
Gin	-	-	-	140	190	120	250	X	70	X	200	250	-	300	-	-	-	-	-	-	-	-	-	-	A	-	-
Gluconic Acid	-	50	-	-	-	-	-	-	-	-	-	-	-	-	180	100	-	-	-	-	-	-	-	-	-	-	-
Glucose	$C_6H_{12}O_6$	-	-	140	190	180	280	140	140	176	200	250	-	400	220	200	-	300	250	160	180	-	-	A	A	-	-
Glue	-	-	-	140	190	120	-	-	-	-	-	-	-	250	-	-	-	250	100	160	140	-	-	A	-	-	-
Glycerine (see Glycerol)	$C_3H_5(OH)_3$	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	A	A	-	A
Glycerol (Glycyl Alcohol)	$C_3H_5(OH)_3$	-	1.3	140	190	180	280	X	140	176	200	-	-	400	300	200	-	250	200	160	70	-	-		-	-	A
Glycolic Acid (see	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Hydroxyacetic Acid)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	A	A	-	B
Glycols	-	-	-	140	190	120	250	X	140	-	200	250	-	300	250	200	-	250	200	160	140	-	-	A	-	-	-
Glyoxal	OHCCHO	30	1.26	-	-	-	-	-	-	-	-	-	-	120	-	-	-	-	-	70	X	-	-	A	-	-	-
Gold (Auric Cyanide)	$Au(CN)_4$	-	-	-	-	-	-	-	-	-	-	-	-	250	-	-	-	180	-	140	140	-	-	-	-	-	-
Grape Juice	-	-	-	140	140	-	250	-	140	-	-	-	-	250	-	-	-	210	140	160	180	-	-	A	-	-	-
Grape Sugar	-	-	-	140	140	140	250	140	140	-	-	-	-	250	-	-	-	210	140	160	180	-	-	A	-	-	-
Grease	-	-	-	-	-	-	-	70	140	-	-	-	-	-	-	-	-	200	X	100	150	-	-	A	-	-	-
Green Liquor (Alkaline pulp)	-	-	-	100	140	150	-	100	-	120	-	-	-	-	180	X	-	70	-	140	140	-	-	A	-	-	-
Helium	He	-	-	140	190	73	150	-	-	X	-	-	-	-	-	-	-	-	150	70	150	-	-	-	-	-	-
Heptane	$CH_3(CH_2)_5CH_3$	-	-	100	150	73	250	-	-	X	200	250	-	300	200	180	-	340	X	200	180	-	-	-	-	-	-
Hexane	$CH_3(CH_2)_4CH_3$	-	0.66	X	72	73	250	X	70	X	200	250	-	300	150	120	-	340	X	80	180	-	-	A	-	-	-
Hexene	-	-	0.67	X	X	X	-	-	-	-	-	-	-	300	-	-	-	-	X	X	70	-	-	A	-	-	-
Hexyl Alcohol (Hexanol)	$C_6H_{11}OH$	-	-	140	190	73	180	-	-	-	-	73	-	250	-	-	-	250	-	X	140	-	-	-	-	-	-
Honey	-	-	-	140	190	180	300	140	140	-	-	-	-	400	-	-	-	210	150	140	150	-	-	-	-	-	-
Hydraulic Oil	-	-	-	-	-	X	-	-	70	-	-	-	-	300	250	200	-	250	X	70	160	-	-	A	-	-	-
Hydraulic Oil (synthetic)	-	-	-	-	-	X	-	-	-	-	200	-	-	300	250	200	-	250	X	X	X	-	-	-	-	-	-
Hydrazine	H_2NNH_2	-	1	X	X	X	200	-	140	-	-	-	-	250	-	-	-	X	70	X	70	-	-	A	-	-	-
Hydrobromic Acid	HBr	48	1.5	140	180	180	250	140	140	-	-	-	-	250	100	120	-	190	140	X	X	-	-	A	-	-	-
Hydrobromic Acid	HBr	20	-	140	180	180	250	140	140	-	-	-	-	250	100	120	-	190	140	X	X	-	B	C	X	-	-
Hydrobromic Acid	HBr	48	-	140	180	180	250	140	140	-	-	-	-	400	100	120	-	190	140	X	X	-	-	C	-	-	-
Hydrochloric Acid (Dry Gas)	HCL	-	-	-	-	-	-	-	-	-	X	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Hydrochloric Acid	HCL	10	-	140	180	160	250	140	140	176	X	-	-	400	150	200	-	200	150	80	X	-	-	-	X	-	-
Hydrochloric Acid	HCL	20	-	140	180	160	250	140	140	176	X	-	-	400	120	200	-	200	100	80	180	-	-	X	-	-	-
Hydrochloric Acid	HCL	25	-	140	180	160	250	140	140	104	X	-	-	400	X	150	-	200	100	X	X	-	-	-	X	-	-
Hydrochloric Acid	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
(Muriatic Acid)	HCL	37	1.19	140	180	160	210	140	140	68	X	212	-	400	X	150	-	200	100	X	X	A	C	X	X	-	-
Hydrocyanic Acid	-	-	-	-	-	-	-	-	-	-	-	250	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
(Prussic Acid)	HCN	-	-	140	160	140	250	140	140	120	-	-	-	400	-	-	-	190	200	X	200	A	A	A	A	-	-
Hydrocyanic Acid	HCN	10	-	140	140	140	250	140	140	-	-	-	-	400	-	-	-	190	200	X	200	-	-	A	-	-	-
Hydrofluoric Acid	HF	10	-	100	X	150	250	70	140	-	-	-	-	300	X	-	-	150	100	70	-	-	-	-	-	-	-
Hydrofluoric Acid	HF	20	-	100	X	150	250	70	140	-	-	-	-	300	X	X	-	150	100	70	X	B	C	C	-	-	A
Hydrofluoric Acid	HF	30	-	100	X	120	250	70	140	-	-	212	-	300	X	-	-	200	100	X	X	-	-	C	-	-	A
Hydrofluoric Acid	HF	40	-	68	X	120	250	70	140	-	-	212	-	300	X	X	-	200	70	X	X	-	-	C	-	-	A
Hydrofluoric Acid	HF	50	-	68	X	100	250	70	140	-	-	212	-	300	X	X	-	200	X	X	X	-	-	C	-	-	A
Hydrofluoric Acid	HF	65	-	X	X	100	200	-	140	-	-	-	-	250	X	X	-	100	X	X	X	-	-	-	-	-	-
Hydrofluoric Acid	HF	75	0.99	X	X	100	200	-	140	-	-	-	-	250	X	X	-	100	X	X	X	X	X	X	-	-	-
Hydrofluosilicic Acid	H_2SiF_6	-	-	73	73	180	250	140	140	176	-	250	-	300	-	100	-	200	140	X	170	-	-	X	-	-	-
Hydrofluosilicic Acid	H_2SiF_6	20	-	73	73	180	250	140	140	176	-	-	-	300	-	100	-	200	140	X	170	-	-	X	-	-	-
Hydrogen	H	-	-	140	X	180	280	140	140	176	200	250	-	300	-	-	-	200	250	200	180	-	-	A	-	-	-
Hydrogen Chloride Gas Dry	HCL	-	1.27	73	-	140	180	140	-	-	-	-	-	300	150	150	-	70	-	70	-	-	-	-	-	-	-
Hydrogen Cyanide	HCN	-	-	140	190	150	280	-	-	-	-	250	-	300	-	-	-	150	100	200	70	-	-	A	-	-	-
Hydrogen Fluoride	HF	-	-	X	X	73	200	-	-	-	-	-	-	250	-	-	-	180	X	X	X	-	-	X	-	-	-
Hydrogen Peroxide	H_2O_2	5	-	140	160	180	250	140	140	68	X	73	-	250	X	150	-	180	100	-	-	-	-	-	-	-	-
Hydrogen Peroxide	H_2O_2	10	-	140	160	73	250	140	140	68	X	-	-	250	X	150	-	180	100	X	X	A	A	C	-	-	-
Hydrogen Peroxide	H_2O_2	30	-	140	73	X	250	140	140	68	X	-	-	250	X	150	-	200	100	X	X	-	-	-	-	-	-
Hydrogen Peroxide	H_2O_2	50	-	100	X	X	250	-	-	-	X	121	-	250	X	-	-	200	X	X	X	-	-	-	-	-	-

CHEMICAL RESISTANCE

HARRINGTON

CHEMICAL RESISTANCE GUIDE

PLASTIC / ELASTOMER / SEAL / METAL

CHEMICAL	FORMULAS		APPROX. SP.GRAVITY @ 100% CONC.	PVC	CPVC	POLYPROPYLENE (PP)	POLYVINYLIDENE FLUORIDE (PVDF)	POLYETHYLENE (PE)	POLYETHYLENE-CROSS LINKED (XLPE)	DURAPLUS ABS	RYTON	HALAR	PEEK	TEFLON	EPOXY	VINYLESTER	POLYSULFONE	VITON	EPDM	NEOPRENE	BUNA N (NITRILE)	CARBON	CERAMIC	304 STAINLESS STEEL	316 STAINLESS STEEL	TITANIUM	HASTELLOY C
Hydrogen Peroxide	H_2O_2	90	-	X	X	X	68	-	-	-	X	121	-	400	X	-	-	100	X	X	X	-	-	-	-	-	-
Hydrogen Peroxide	H_2O_2	-	-	X	X	X	68	-	-	-	X	-	-	400	-	-	-	100	X	X	X	-	-	-	-	-	-
Hydrogen Phosphide	-	-	-	-	-	-	-	-	-	-	-	121	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
(See Phosphine)	PH_3	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Hydrogen Sulfide	H_2S	-	-	140	190	150	280	140	140	-	-	-	-	400	250	180	-	180	100	X	100	-	-	-	A	-	B
Hydrogen Sulfide (Aq Sol)	H_2S	-	1.19	140	180	150	200	140	140	-	200	121	-	400	250	180	-	140	100	X	100	A	A	A	A	-	B
Hydrogen Sulfide (dry)	H_2S	-	-	140	180	150	80	140	140	-	-	250	-	400	250	180	-	180	100	X	100	-	A	A	A	-	B
Hydroquinone	$C_6H_4(OH)_2$	-	-	140	190	150	250	140	140	X	-	212	-	400	-	-	-	180	X	X	70	-	-	-	-	-	-
Hydroxyacetic Acid	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
(Glycolic Acid)	$CH_2OHCOOH$	-	1.27	140	190	150	100	-	-	-	-	-	-	400	-	-	-	X	-	X	70	-	-	-	-	-	-
Hydroxyacetic Acid	-	1	-	140	190	150	100	-	-	-	-	-	-	400	-	-	-	X	-	X	70	-	-	-	-	-	-
Hydroxylamine Sulfate	$(NH_2OH)_2H_2SO_4$	-	-	140	190	120	150	-	-	-	-	-	-	-	-	-	-	-	70	70	-	-	-	-	-	-	-
Hypochlorous Acid	HOCL	-	10	140	180	120	250	140	140	-	-	250	-	400	-	-	-	180	70	X	X	-	-	X	X	B	B
Ink	-	-	-	-	-	-	-	X	140	-	-	-	-	-	-	-	-	70	70	70	70	-	-	A	-	-	-
Iodine Solution	I_2	0	-	X	X	X	150	X	X	X	-	212	-	400	120	100	-	180	70	X	70	-	-	C	-	-	-
Isobutyl Alcohol (see	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Alcohol, Isobutyl)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Isoctane	-	-	0.7	72	72	73	250	-	-	X	-	73	-	-	-	-	-	190	X	70	70	-	-	A	-	-	-
Isophorone	-	-	0.92	X	X	-	180	-	-	X	-	-	-	-	-	-	-	X	X	-	-	-	-	-	-	-	-
Isopropanol-see Alcohol,Isopropyl	-	-	-	140	140	140	250	X	140	X	-	250	-	300	180	100	-	140	140	70	70	-	-	A	-	-	-
Isopropyl Acetate	$(CH_3)_2CHOH$	-	0.92	X	-	-	-	-	-	X	-	-	-	200	-	-	-	X	70	X	X	-	-	B	-	-	-
Isopropyl Alcohol (See	$CH_3COOCH(CH_3)_2$	-	-	-	-	-	-	-	-	X	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Alcohol, Isopropyl)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Isopropyl Chloride (See	$(CH_3)_2CHOH$	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Chlorpropene)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Isopropyl Ether	$CH_3CHCLCH_3$	-	0.72	X	X	X	130	-	-	X	-	73	-	140	-	-	-	X	X	X	70	-	-	A	-	-	-
Jet Fuel JP-3	-	-	-	-	-	-	-	-	-	X	200	-	-	200	250	180	-	190	X	X	70	-	-	A	-	-	-
Jet Fuel JP-4	-	-	-	140	72	X	250	-	-	X	200	250	-	400	250	180	-	300	X	X	200	-	-	A	-	-	-
Jet Fuel JP-5	-	-	-	140	72	X	250	-	-	X	200	250	-	400	250	180	-	300	X	X	200	-	-	A	-	-	-
Kerosene	-	-	0.81	140	72	X	250	X	70	X	200	250	-	400	250	180	-	300	X	X	200	-	-	A	-	-	-
Ketone	-	-	-	X	X	100	100	X	X	X	200	-	-	350	-	X	-	X	X	X	X	-	-	A	-	-	-
Kraft Liquor	-	-	-	140	190	73	70	140	-	100	-	-	-	400	-	-	-	100	-	70	70	-	-	A	-	-	-
Lacquer	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	X	X	X	X	-	-	A	-	-	-
Lacquer Thinner	-	-	-	X	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	X	X	-	-	A	-	-	-
Lactic Acid (Milk Acid)	-	-	1.2	100	120	180	140	X	140	68	200	-	-	400	230	200	-	210	70	70	X	-	-	A	-	-	-
Lard	-	-	-	140	190	73	250	-	140	-	-	-	-	250	-	-	-	190	X	70	140	-	-	A	-	-	-
Lard Oil	-	-	-	140	190	73	48	-	140	-	-	250	-	250	-	-	-	190	X	70	140	-	-	A	-	-	-
Latex	-	-	-	-	-	-	-	-	-	-	-	-	-	-	220	200	-	70	70	100	70	-	-	-	-	-	-
Lauric Acid	$CH_3(CH_2)_{10}COOH$	-	0.83	140	190	150	230	140	-	140	-	212	-	400	220	200	-	100	-	-	70	-	-	-	-	-	-
Lauryl Chloride	$C_{12}H_{25}CL$	-	-	140	72	X	250	X	-	120	-	212	-	400	-	-	-	200	140	-	70	-	-	-	-	-	-
Lead Acetate (Sugar of Lead)	$Pb(C_2H_3O_2)_2$	-	-	140	190	180	250	140	140	176	-	250	-	400	250	200	-	X	210	160	70	-	-	B	B	A	B
Lead Chloride	$PbCL_2$	-	5.88	140	140	140	250	-	-	176	-	250	-	400	-	-	-	210	140	70	100	-	-	-	-	-	-
Lead Nitrate	$Pb(NO_3)_2$	-	4.53	140	180	180	210	-	-	176	-	250	-	400	220	200	-	210	180	-	-	-	-	-	-	-	-
Lead Sulfate	$PbSO_4$	-	6.39	140	190	150	100	150	-	176	-	250	-	400	-	-	-	80	210	140	200	-	-	-	B	-	B
Lemon Oil	-	-	-	72	72	X	250	-	-	-	-	212	-	400	-	-	-	200	-	100	140	A	-	-	-	-	-
Levulinic Acid	-	-	-	-	-	-	-	-	-	-	-	-	-	-	220	200	-	-	-	-	-	-	-	-	-	-	-
Ligroin (Benzene)	-	-	-	X	X	X	200	-	-	X	-	-	-	250	-	-	-	100	X	70	100	-	-	A	-	-	-
Lime (Calcium Oxide)	CaO	-	-	-	-	-	-	-	-	176	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Lime-Sulfur Solution	-	-	-	140	190	10	150	-	-	-	-	121	-	-	-	-	-	190	210	100	X	-	-	-	-	-	-
Linoleic Acid (Linolic Acid)	-	-	0.91	140	190	73	250	X	-	-	-	212	-	400	-	-	-	70	X	X	70	-	-	-	-	-	-
Linseed Oil (Flaxseed Oil)	-	-	-	140	190	150	250	X	70	X	-	212	-	400	250	100	-	250	70	70	180	-	-	-	-	-	-
Lithium Bromide	LiBr	-	3.46	140	190	-	230	-	-	-	-	121	-	400	-	-	-	200	-	200	140	-	-	-	-	-	-
Lithium Chloride	LiCL	-	-	140	190	-	250	-	-	-	-	-	-	400	230	200	-	140	100	-	70	-	-	A	-	-	-
LPG	-	-	-	-	-	-	-	-	-	-	200	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

CHEMICAL RESISTANCE

HARRINGTON

CHEMICAL RESISTANCE GUIDE

				PLASTIC													ELASTOMER					SEAL		METAL			
CHEMICAL	FORMULAS		APPROX. SP.GRAVITY @ 100% CONC.	PVC	CPVC	POLYPROPYLENE (PP)	POLYVINYLIDENE FLUORIDE (PVDF)	POLYETHYLENE (PE)	POLYETHYLENE-CROSS LINKED (XLPE)	DURAPLUS ABS	RYTON	HALAR	PEEK	TEFLON	EPOXY	VINYLESTER	POLYSULFONE	VITON	EPDM	NEOPRENE	BUNA N (NITRILE)	CARBON	CERAMIC	304 STAINLESS STEEL	316 STAINLESS STEEL	TITANIUM	HASTELLOY C
Lubricants	-	-	-	-	-	-	-	-	-	-	200	250	-	-	-	-	-	-	-	-	-	A	A	A	-	-	-
Lubricating Oil	-	-	-	140	190	73	250	X	X	-	200	250	-	350	250	200	-	180	X	70	180	A	A	-	-	-	-
Lye Solution (See Sodium	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Hydroxide & Potassium	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Hydroxide)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Machine Oil	-	-	-	140	190	120	210	X	-	-	-	-	-	400	-	-	-	140	-	-	140	-	-	A	-	-	-
Magnesium Acetate	$(MgOOCCH_3)_2$	-	1.42	-	-	-	-	140	140	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Magnesium Carbonate	$MgCO_3$	-	3	140	180	180	210	140	140	176	-	250	-	400	220	200	-	210	170	140	180	-	-	A	-	-	-
Magnesium Chloride	$MgCL_2$	-	2.3	140	190	180	280	140	140	176	200	250	-	400	270	200	-	180	180	170	180	-	-	-	-	-	-
Magnesium Citrate	$MgHC_6H_5O_7$	-	-	140	180	180	250	140	140	-	-	-	-	400	-	-	-	210	180	-	180	-	-	-	-	-	-
Magnesium Hydroxide	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	A
(Milk of Magnesia)	$Mg(OH)_2$	-	2.36	140	190	180	250	140	-	176	200	250	-	400	270	150	-	230	170	160	180	A	A	A	A	-	-
Magnesiun Nitrate	$Mg(NO_3)_2$	-	2.03	140	190	180	250	140	140	176	-	250	-	400	250	200	-	230	140	160	70	-	A	A	-	-	-
Magnesium Oxide	MgO	-	3.6	-	-	-	-	-	-	176	-	-	-	-	-	-	-	-	140	160	140	-	A	-	-	-	-
Magnesium Sulfate	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	A
(Epsom Salts)	$MgSO_4$	-	2.6	140	190	180	250	140	140	176	-	250	-	400	270	200	-	200	180	160	180	A	A	A	-	-	-
Maleic Acid	-	-	1.59	140	190	180	250	70	70	-	-	212	-	400	220	200	-	200	70	X	X	A	A	-	-	-	-
Maleic Anhydride	-	-	0.93	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	X	X	X	A	A	-	-	-	-
Malic Acid (Apple Acid)	-	-	1.6	140	190	73	250	-	-	-	-	212	-	400	-	-	-	200	X	70	100	-	A	B	B	-	B
Manganese Sulfate	$MnSO_4$	-	2.11	140	180	180	250	-	-	-	-	-	-	400	-	-	-	230	180	160	140	-	-	-	-	-	-
Mash	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Mayonnaise	-	-	-	-	-	-	-	-	-	-	-	-	-	400	-	-	-	-	-	-	180	-	-	A	-	-	-
Melamine (Trizane)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Mercuric Chloride	$HgCL_2$	-	5.4	140	190	180	250	140	-	X	-	212	-	400	220	200	-	190	210	140	140	-	-	X	-	-	-
Mercuric Cyanide	$Hg(CN)_2$	-	4	140	180	180	250	140	-	X	-	212	-	400	-	-	-	70	70	70	140	-	-	A	-	-	-
Mercuric Nitrate	$Hg(NO_2)_2$	-	4.3	140	180	180	250	140	-	-	-	-	-	-	-	-	-	70	-	70	-	-	-	-	-	-	-
Mercuric Sulfate	$HgSO_4$	-	6.47	140	180	180	230	-	-	-	-	212	-	300	-	-	-	70	70	-	70	-	-	-	-	-	-
Mercurous Chloride	Hg_2CL_2	-	6.99	-	-	-	-	-	-	-	-	212	-	400	220	200	-	200	100	140	100	-	-	-	-	-	-
Mercurous Nitrate	$HgNO_3$	-	4.79	140	190	120	250	-	-	-	-	212	-	400	-	-	-	200	100	140	100	-	-	-	B	-	C
Mercury (Quicksilver)	Hg	-	13.6	140	190	150	250	140	140	68	-	250	-	400	270	200	-	200	70	100	100	-	-	A	A	A	A
Methacrylic Acid Glacial	-	-	1.02	X	X	-	-	-	-	X	-	-	-	-	X	X	-	-	-	-	-	-	-	-	-	-	-
Methane (Methyl Hydride)	CH_4	-	-	140	72	120	280	-	-	-	-	212	-	400	250	200	-	300	X	200	180	-	-	A	-	-	-
Methanesulfonic Acid	CH_3SO_3H	-	1.48	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Methanol (See Alcohol, Methyl)	-	-	0.8	140	210	180	250	X	140	X	-	250	-	400	150	-	-	X	100	140	140	-	-	A	A	-	-
Methoxyethyl Oleate	-	-	0.9	-	-	-	-	-	-	X	-	73	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Methyl "Cellosolve"	-	-	-	X	X	73	250	-	-	X	-	212	-	400	-	-	-	X	70	70	X	-	-	A	-	-	-
Methyl Acetate	$CH_3CO_2CH_3$	-	0.92	X	X	68	100	-	-	X	-	-	-	-	-	-	-	X	-	X	X	-	-	A	-	-	-
Methyl Acetone	-	-	-	-	-	-	-	-	-	X	-	-	-	-	-	-	-	X	-	X	X	-	-	A	-	-	-
Methyl Acrylate	-	-	-	-	-	-	100	-	-	X	-	-	-	300	-	-	-	X	70	X	X	-	-	A	-	-	-
Methyl Alcohol	CH_3OH	-	-	140	210	180	250	X	140	X	-	250	-	400	150	-	-	100	100	140	140	A	A	A	-	-	-
Methyl Benzene (See Toluene)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Methyl Bromide	CH_3Br	-	1.73	X	X	X	250	X	X	X	-	250	-	350	-	-	-	180	X	X	X	-	-	-	-	-	-
Methyl Butanol (See	-	-	-	-	-	-	-	-	-	X	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Alcohol, Amyl)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Methyl Butyl Ketone	$CH_3COC_4H_9$	-	0.83	X	X	X	100	-	-	X	-	-	-	400	-	-	-	X	70	X	X	A	A	A	-	-	-
Methyl Chloride	-	-	-	-	-	-	-	-	-	X	-	250	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
(Chloromethane)	CH_3CL	-	1.3	X	X	X	250	X	X	X	-	-	-	400	X	X	-	150	X	X	X	-	-	A	A	-	C
Methyl Chloroform	-	-	-	-	-	-	-	-	-	X	-	11	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
(Trichloroethane)	-	-	-	X	X	X	120	-	-	-	-	-	-	-	X	X	-	80	X	X	X	-	-	A	-	-	-
Methyl Ether (See	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Dimethyl Ether)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Methyl Ethyl Ketone (MEK)	$CH_3COC_2H_5$	-	0.82	X	X	73	X	X	X	X	200	121	-	-	100	X	-	X	70	X	X	A	A	-	B	-	-
Methyl Formate	$HCOOCH_3$	-	0.98	-	-	-	-	-	-	X	-	73	-	-	-	-	-	X	100	70	X	-	-	-	-	-	-
Methyl Isobutyl Alcohol	-	-	-	-	-	-	-	-	-	X	-	-	-	-	180	120	-	-	-	-	-	-	-	-	-	-	-

HARRINGTON

CHEMICAL RESISTANCE GUIDE

CHEMICAL	FORMULAS	CONC.	APPROX. SP.GRAVITY @ 100%	PVC	CPVC	POLYPROPYLENE (PP)	POLYVINYLIDENE FLUORIDE (PVDF)	POLYETHYLENE (PE)	POLYETHYLENE-CROSS LINKED (XLPE)	DURAPLUS ABS	RYTON	HALAR	PEEK	TEFLON	EPOXY	VINYLESTER	POLYSULFONE	VITON	EPDM	NEOPRENE	BUNA N (NITRILE)	CARBON	CERAMIC	304 STAINLESS STEEL	316 STAINLESS STEEL	TITANIUM	HASTELLOY C
				PLASTIC											ELASTOMER			SEAL		METAL							
Methyl Isobutyl Ketone	-	-	0.8	X	X	X	X	-	-	X	200	73	-	400	150	X	-	X	-	X	X	A	A	A	-	-	-
Methyl Isopropyl Ketone	$CH_3COCH(CH_3)_2$	-	0.82	X	X	X	X	-	-	X	-	-	-	400	-	-	-	X	-	X	X	A	A	A	-	-	-
Methyl Methacrylate	-	-	0.94	X	X	X	100	-	-	X	-	121	-	300	100	X	-	X	X	X	X	A	A	-	-	-	-
Methyl Propanol	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Methyl Salicylate	-	-	-	-	-	-	-	-	-	X	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
(Wintergreen Oil)	-	-	1.18	72	72	73	70	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Methyl Sulfate	-	-	-	72	72	X	-	-	-	-	-	250	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Methylamine	CH_3NH_2	-	-	X	X	X	X	-	-	X	-	73	-	400	-	-	-	100	70	70	X	-	-	A	-	-	-
Methylene Bromide	CH_2Br_2	-	2.47	X	X	X	150	-	-	X	-	73	-	350	-	-	-	70	X	X	X	-	-	-	-	-	-
Methylene Chloride	CH_2CL_2	-	1.34	X	X	X	100	X	X	X	-	73	-	350	X	X	-	X	X	X	X	A	A	A	-	-	-
Methylene Iodine	CH_2I_2	-	3.33	X	X	X	200	-	-	-	-	73	-	350	-	-	-	200	-	-	-	-	-	-	-	-	-
Methylhexane	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Methylisobutyl Carbinol	-	-	-	72	72	120	150	-	-	X	-	-	-	200	120	-	-	70	70	70	70	-	-	-	-	-	-
Methylmethacryate	-	-	-	-	-	-	180	-	-	-	-	-	-	150	100	X	-	X	X	X	X	-	-	-	-	-	-
N-Methyl Pyrrolidone	-	-	-	X	X	X	X	X	X	X	-	-	-	200	X	X	-	X	X	X	X	-	-	-	A	-	-
Methylsulfuric Acid	CH_3HSO_4	-	1.35	140	190	120	70	-	-	-	-	121	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Milk	-	-	-	140	190	180	280	140	140	176	-	212	-	400	-	-	-	190	190	150	140	A	A	A	-	-	-
Mineral Oil	-	-	-	140	190	72	250	X	70	-	200	250	-	400	270	200	-	300	X	70	140	-	-	A	-	-	-
Molasses	-	-	-	140	190	180	250	140	140	176	-	121	-	400	-	-	-	300	100	150	140	A	A	-	-	-	-
Monochloracetic Acid	-	-	-	-	-	-	-	-	-	X	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
(See Chloracetic Acid)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Monochlorobenzene	-	-	-	-	-	-	-	-	-	X	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
(Chlorobenzene)	C_6H_5CL	-	-	X	X	X	140	X	X	-	-	-	-	400	-	-	-	70	X	X	X	-	-	A	-	-	-
Monoethanolamine	$HOCH_2CH_2NH_2$	-	-	X	X	150	X	-	-	-	-	-	-	100	-	-	-	190	70	X	150	-	-	-	A	-	-
Morpholine	$C_{17}H_{19}NO_3$	-	1	-	-	-	75	-	-	-	X	-	-	200	-	-	-	X	70	X	X	-	-	B	-	-	-
Motor Oil	-	-	-	140	190	X	250	X	70	-	200	250	-	250	-	-	-	250	X	-	180	-	-	A	-	-	-
Mustard	-	-	-	140	190	150	250	-	-	-	-	-	-	400	-	-	-	150	150	X	100	-	-	A	-	-	-
Naphtha	-	-	-	140	-	100	210	X	X	X	200	-	-	400	230	180	-	150	X	X	140	-	-	A	-	-	-
Naphthalene (Tar Camphor)	$C_{10}H_8$	-	1.15	X	X	X	200	X	X	X	200	-	-	400	200	200	-	170	X	X	X	-	-	A	-	-	-
Natural Gas	-	-	-	140	73	73	250	-	-	-	-	121	-	300	-	-	-	190	X	140	140	-	-	A	-	-	-
Neon	Ne	-	-	190	140	180	250	-	-	176	-	-	-	300	-	-	-	200	190	150	140	-	-	A	-	-	-
Nickel	Ni	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Nickel Acetate	-	-	1.74	180	140	180	210	140	140	-	-	73	-	-	-	-	-	X	70	-	70	-	-	-	-	-	-
Nickel Chloride	$NiCL_2$	-	3.5	140	180	180	250	140	140	176	-	250	-	400	270	200	-	210	210	160	180	-	-	A	-	-	-
Nickel Cyanide	$Ni(CN)_2$	-	-	-	-	-	-	140	140	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Nickel Nitrate	$Ni(NO_3)_2$	-	2.1	140	180	180	250	140	140	176	-	250	-	400	220	200	-	250	210	200	180	-	-	-	-	-	-
Nickel Sulfate	$NiSO_4$	-	3.7	140	180	180	250	140	140	176	-	250	-	400	-	-	-	180	210	200	200	-	-	-	-	-	A
Nicotine	$C_{10}H_{14}N_2$	-	-	140	180	X	100	X	140	-	-	121	-	400	-	-	-	-	-	X	X	-	-	A	-	-	-
Nicotine Acid (See Niacin)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Nitric Acid	HNO_3	10	-	140	180	180	250	100	140	68	X	250	-	400	X	100	-	190	X	X	X	C	B	A	-	-	-
Nitric Acid	HNO_3	20	-	140	180	140	210	140	140	X	X	-	-	400	X	100	-	190	X	X	X	X	C	-	-	-	-
Nitric Acid	HNO_3	30	-	X	73	120	150	70	70	X	X	212	-	400	X	-	-	190	X	X	X	X	-	-	-	-	-
Nitric Acid	HNO_3	40	-	X	73	73	150	70	70	X	X	212	-	400	X	-	-	73	X	X	X	X	-	-	-	-	-
Nitric Acid	HNO_3	50	-	X	73	73	120	X	X	X	X	121	-	350	X	-	-	100	X	X	X	X	-	A	-	-	-
Nitric Acid	HNO_3	70	-	X	X	X	100	X	X	X	X	121	-	300	X	-	-	X	X	X	X	X	-	A	-	-	-
Nitric Acid Concentrate	HNO_3	-	1.5	X	X	X	73	X	X	X	X	-	-	300	X	-	-	X	X	X	X	X	-	A	-	-	-
Nitric Acid Fuming (Red)	HNO_3	-	-	X	X	X	X	-	-	X	X	-	-	300	-	-	-	X	-	-	-	-	-	-	-	-	-
Nitrobenzene (Oil of Mirbane)	$C_6H_5NO_2$	-	1.2	X	X	73	140	X	X	X	X	121	-	400	-	-	-	70	X	X	X	A	-	A	-	-	-
Nitroethane	$CH_3CH_2NO_2$	-	1.13	-	-	-	68	-	-	X	-	-	-	200	-	-	-	X	-	X	X	-	-	-	-	-	-
Nitrogen	N	-	-	-	-	-	-	-	-	176	200	-	-	-	-	-	-	190	-	140	140	-	A	A	-	-	-
Nitrogen Dioxide	NO_2	-	-	-	-	-	140	-	-	-	-	-	-	400	-	-	-	-	-	-	-	-	-	-	-	-	-
Nitrogen Sulutions	-	-	-	-	-	-	-	-	-	-	-	-	-	-	150	100	-	-	-	-	-	-	-	-	-	-	-
Nitroglycerine	-	-	1.6	X	X	X	120	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Nitromethane	CH_3NO_2	-	-	-	-	-	100	-	-	-	X	-	-	180	-	-	-	-	70	X	X	-	-	-	-	-	-

CHEMICAL RESISTANCE GUIDE

				PLASTIC												ELASTOMER					SEAL		METAL			
CHEMICAL	FORMULAS		APPROX. SP.GRAVITY @ 100% CONC.	PVC	CPVC	POLYPROPYLENE (PP)	POLYVINYLIDENE FLUORIDE (PVDF)	POLYETHYLENE (PE)	POLYETHYLENE-CROSS LINKED (XLPE)	DURAPLUS ABS	RYTON	HALAR	PEEK	TEFLON	EPOXY	VINYLESTER	POLYSULFONE	VITON	EPDM	NEOPRENE	BUNA N (NITRILE)	CARBON	CERAMIC	304 STAINLESS STEEL	316 STAINLESS STEEL	TITANIUM	HASTELLOY C
Nitrous Oxide	N_2O	-	-	100	140	X	X	X	-	-	-	121	-	400	-	-	-	80	-	X	X	-	A	-	-	-	-
Ocenol (Oleyl Alcohol)	-	-	140	100	140	100	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Octane	C_8H_{18}	-	-	X	X	X	250	73	-	-	-	-	-	400	-	-	-	68	X	-	70	-	A	-	-	-	-
Octanoic (Caprylic Acid)	$CH_3(CH_2)_6COOH$	-	0.91	-	-	-	250	-	-	X	-	-	-	400	-	-	-	-	-	-	X	-	A	-	-	-	-
Octylamine	$CH_3(CH_2)_7NH_2$	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Oils	-	-	-	140	190	120	250	140	-	140	-	-	-	400	-	200	-	-	-	-	100	-	-	-	-	-	-
Oils, Aniline	-	-	-	X	X	100	120	-	-	-	-	-	-	250	-	-	-	X	140	X	X	A	A	-	-	-	A
Oils, Anise	-	-	-	-	-	-	-	-	-	-	-	-	-	300		-	-	-	-	-	-	A	A	-	-	-	-
Oils, Bay	-	-	-	-	-	-	-	-	70	-	-	-	-	300	-	-	-	140	-	-	-	A	A	-	-	-	-
Oils, Bone	-	-	-	-	-	-	-	-	70	-	-	-	-	300	-	—	-	140	-	-	-	A	A	-	-	-	-
Oils, Castor	-	-	-	-	*	-	-	-	70	-	-	-	-	300		-	-	140	-	-	-	A	A	-	-	-	-
Oils, Cinnamon	-	-	-	-	-	-	-	-	70	-	-	-	-	300	-	-	-	X	-	-	-	A	A	-	-	-	-
Oils, Citric	-	-	-	-	-	72	-	-	70	-	-	-	-	300	-	-	-	140	-	-	-	A	A	-	-	-	-
Oils, Clove	-	-	-	-	-	72	-	-	70	-	-	-	-	300	-		-	-	-	-	140	A	A	-	-	-	-
Oils, Coconut	-	-	-	140	72	150	250	-	70	-	-	-	-	350	-	—	-	140	X	100	70	A	A	-	-	-	-
Oils, Cod Liver	-	-	-	-	-	72	-	-	70	-	-	-	-	300	-	-	-	140	108	100	140	A	A	-	-	-	-
Oils, Corn	-	-	-	68	68	100	-	250	70	X	-	-	-	250	-	-	-	140	X	X	140	A	A	-	-	-	-
Oils, Cotton Seed	-	-	-	140	-	150	-	250	70	X	-	-	-	300	-	-	-	140	X	X	180	A	A	-	-	-	-
Oils, Creosote	-	-	-	X	X	X	-	-	70	X	-	-	-	300	-	-	-	73	X	X	73	A	A	-	-	-	-
Oils, Crude Sour	-	-	-	140	-	73	-	250	70	-	-	-	-	250	250	200	-	180	X	-	70	A	A	-	-	-	-
Oils, Diesel Fuel	-	-	-	72	72	73	-	250	70	X	-	-	-	300	250	180	-	140	X	X	100	A	A	-	-	-	-
Oils, Fuel	-	-	-	140	-	73	-	250	70	X	-	-	-	300	250	180	-	140	X	X	100	A	A	-	-	-	-
Oils, Linseed	-	-	-	140	*	180	-	250	70	X	-	-	-	300	250	100	-	220	X	70	180	A	A	-	-	-	-
Oils, Mineral	-	-	-	140	*	100	-	250	70	-	-	-	-	300	270	200	-	300	X	70	140	A	A	-	-	-	-
Oils, Olive	-	-	-	140	*	180	-	250	70	X	-	-	-	300	220	200	-	150	-	140	140	A	A	-	-	-	-
Oils, Pine	-	-	-	140	-	-	-	-	70	X	-	-	-	300	150	150	-	70	-	-	70	A	A	-	-	-	-
Oils, Silicone	-	-	-	-	-	150	250	-	70	-	-	-	-	350	-	-	-	190	140	70	140	A	A	A	A	-	-
Oils, Vegetable	-	-	-	-	*	73	250	-	70	-	-	250	-	350	90	200	-	200	X	70	200	A	A	A	A	-	-
Oleic Acid (Red Oil)	-	-	0.9	140	190	73	250	-	-	-	-	212	-	250	200	200	-	190	70	70	100	-	-	A	A	A	-
Oleum (Fuming Sulfuric Acid)	H_2SO_4	100	-	X	X	X	X	X	X	X	-	73	-	200	X	X	-	73	X	X	X	-	-	A	-	A	-
Orange Extract	-	+	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Oxalic Acid	-	-	1.7	73	73	150	150	140	-	110	-	121	-	400	270	200	-	180	150	100	X	-	-	A	A	A	-
Oxygen Gas	O_2	-	-	73	180	150	-	-	-	150	-	250	-	400	-	-	-	180	200	200	100	-	-	A	A	A	-
Ozonized Water	O_3	-	-	73	73	X	250	X	X	X	-	250	-	400	-	-	-	220	180	80	X	-	-	A	A	A	-
Palmitic Acid	-	-	0.84	140	72	180	240	70	70	-	-	212	-	400	220	200	-	190	70	X	100	-	-	A	-	-	-
Palmitic Acid	-	10	-	X	72	180	240	70	70	-	-	-	-	400	220	200	-	190	70	X	100	-	-	A	-	-	-
Paraffin	-	70	-	120	X	120	-	X	-	-	-	121	-	400	-	-	-	250	X	73	140	-	-	A	A	-	-
Pentane (Amyl Hydride)	$CH_3(CH_2)_3CH_3$	-	-	-	-	-	-	-	-	X	-	-	-	400	-	-	-	100	X	70	100	-	-	A	-	A	-
Peracetic Acid	CH_3COOOH	-	-	X	X	X	-	70	-	-	-	-	-	400	-	-	-	100	-	-	-	-	-	-	-	-	-
Perchloric Acid	$HCLO_4$	10	1.8	140	140	100	-	-	-	-	-	121	-	400	-	-	-	70	70	70	X	-	-	A	-	-	-
Perchloric Acid	$HCLO_4$	40	-	X	X	X	140	X	X	-	-	121	-	400	X	X	-	180	70	X	X	-	-	B	-	-	-
Perchloroethylene	CL_2CCCL_2	70	1.6	X	X	X	150	-	X	X	200	-	-	-	120	X	-	200	X	X	X	-	-	A	-	-	-
Petrolatum (Petroleum Jelly)	-	-	-	140	190	120	-	-	-	176	-	-	-	300	-	-	-	100	X	140	100	-	-	A	-	-	-
Petroleum (Sour)	-	-	-	100	150	73	250	X	70	-	200	121	-	300	250	200	-	180	X	X	180	-	-	-	-	-	-
Petroleum Oils	-	-	-	140	150	73	-	-	70	-	200	121	-	-	250	200	-	180	X	100	180	-	-	-	-	-	-
Phenols (Carbolic Acid)	C_6H_5OH	-	1.1	X	72	73	200	X	-	X	200	121	-	350	X	X	-	200	70	X	X	A	X	A	-	A	-
Phenyl Acetate	$C_6H_5OOCCH_3$	100	1.07	-	-	-	-	-	-	X	-	-	-	-	-	-	-	X	-	X	X	-	-	-	-	-	-
Phenylhydrazine	$C_6H_5NHNH_2$	-	1.1	X	X	X	100	X	X	X	-	73	-	400	-	-	-	180	X	X	X	-	-	-	-	-	-
Phosgene Gas	$COCL_2$	-	-	X	X	X	X	X	X	-	-	-	-	350	-	-	-	X	-	X	X	-	-	-	-	-	-
Phosgene Liquid	-	-	1.39	X	X	X	-	X	-	-	-	-	-	-	-	-	-	X	-	X	X	-	-	-	-	-	-
Phosphoric Acid	H_3PO_4	-	1.8	140	190	180	140	140	140	68	X	250	-	400	100	200	-	200	100	120	X	-	-	A	-	-	-
Phosphoric Acid	H_3PO_4	10	-	140	190	180	140	140	140	68	X	250	-	400	100	200	-	200	100	70	X	-	-	A	-	-	-
Phosphoric Acid	H_3PO_4	20	-	140	190	180	140	140	140	68	X	250	-	400	100	200	-	200	70	70	X	-	-	A	-	-	-
Phosphoric Acid	H_3PO_4	40	-	140	190	180	250	140	140	-	X	250	68	300	100	200	-	200	70	X	X	-	-	A	-	-	-

CHEMICAL RESISTANCE

CHEMICAL RESISTANCE GUIDE

				PLASTIC														ELASTOMER				SEAL		METAL			
CHEMICAL	FORMULAS	APPROX. SP.GRAVITY @ 100% CONC.		PVC	CPVC	POLYPROPYLENE (PP)	POLYVINYLIDENE FLUORIDE (PVDF)	POLYETHYLENE (PE)	POLYETHYLENE-CROSS LINKED (XLPE)	DURAPLUS ABS	RYTON	HALAR	PEEK	TEFLON	EPOXY	VINYLESTER	POLYSULFONE	VITON	EPDM	NEOPRENE	BUNA N (NITRILE)	CARBON	CERAMIC	304 STAINLESS STEEL	316 STAINLESS STEEL	TITANIUM	HASTELLOY C
Phosphoric Acid	H_3PO_4	80	-	140	190	180	250	70	70	-	X	250	68	350	100	200	-	200	70	X	X	-	-	A	-	-	-
Phosphoric Acid	H_3PO_4	85	-	140	-	180	200	70	70	X	X	250	-	350	100	200	-	200	70	X	X	-	-	A	-	-	-
Phosphoric Acid	H_3PO_4	100	1.8	-	-	-	-	-	-	X	X	-	-	350	-	-	-	100	70	X	X	-	-	A	-	-	-
Phosphoric Acid Crude	H_3PO_4	-	1.83	-	-	-	-	-	-	-	X	-	-	250	-	-	-	100	70	X	X	-	-	-	-	-	-
Phosphorus Oxychloride	$POCL_3$	-	1.68	73	73	X	200	X	X	X	-	-	-	250	X	-	-	-	-	X	-	-	-	X	X	-	B
Phosphorus Red	-	-	-	70	68	68	250	-	-	-	-	-	-	350	-	X	-	-	-	-	-	-	-	A	-	-	-
Phosphorus Trichloride,dry	PCL_3	-	1.57	X	X	X	250	X	X	X	200	-	-	300	-	-	-	150	100	X	X	-	-	-	-	-	-
Phosphorus Yellow	-	-	-	68	68	68	250	-	-	-	-	73	-	350	-	-	-	-	-	-	-	-	-	-	-	-	-
Photographic Developer	-	-	-	140	190	150	250	X	140	-	-	-	-	350	-	-	-	190	-	100	-	A	A	-	-	-	-
Photographic Solutions	-	-	-	140	190	150	250	X	140	-	-	121	—	400	-	-	-	180	-	200	200	-	-	-	-	-	-
Phthalic Acid	-	-	-	-	-	-	-	-	-	-	-	-	68	400	-	-	-	-	-	-	-	-	-	-	-	-	-
(Terephthalic Acid)	$C_6H_4(COOH)_2$	-	1.59	X	X	X	200	-	-	-	-	-	-	-	-	-	-	140	100	X	X	-	-	A	A	-	B
Phthalic Anhydride	$C_6H_4(CO)_2O$	-	1.53	X	X	X	-	-	-	X	-	-	-	350	220	200	-	-	-	-	-	-	-	-	-	-	-
Pickle Brine	-	-	-	140	180	140	250	-	-	-	-	-	-	-	-	-	-	70	100	X	100	-	-	-	-	-	-
Pickling Solutions	-	-	-	140	180	180	250	X	140	-	-	-	-	400	-	-	-	-	X	X	X	-	-	-	-	-	-
Picric Acid	$C_6H_2(NO_2)_3OH$	-	1.77	X	X	73	70	X	100	-	-	73	-	400	100	100	-	190	140	200	X	-	-	A	-	-	A
Pine Oil	-	-	1.48	-	-	-	-	-	-	X	-	-	-	400	150	150	-	70	X	X	70	-	-	A	-	-	-
Plating Solutions,	-	-	-	-	-	-	-	-	-	-	-	-	-	300	-	-	-	-	-	-	-	-	-	-	-	-	-
Antimony	-	-	-	140	190	250	240	140	140	-	-	-	-	-	-	-	-	140	-	100	100	-	-	A	-	-	-
Plating Solutions, Arsenic	-	-	-	140	190	150	240	140	140	-	-	-	-	300	-	-	-	100	-	100	100	-	-	A	-	-	-
Plating Solutions, Brass	-	-	-	140	180	180	240	140	140	-	-	121	-	300	-	-	-	150	70	200	180	-	X	B	-	-	-
Plating Soltuions, Bronze	-	-	-	140	180	180	200	140	140	-	-	121	-	250	-	-	-	70	70	100	-	-	-	A	-	-	-
Plating Solutions, Cadmium	-	-	-	140	180	X	240	140	140	-	-	121	-	250	-	-	-	180	70	200	180	-	-	A	-	-	-
Plating Solutions, Chrome	-	-	-	140	180	X	250	140	140	-	-	121	-	250	-	-	-	250	-	100	X	-	-	A	-	-	-
Plating Solutions, Copper	-	-	-	140	180	180	210	140	140	-	-	121	-	250	-	-	-	180	70	80	180	-	-	-	-	-	-
Plating Solutions, Gold	-	-	-	100	180	X	250	140	140	-	-	121	-	250	-	-	-	180	70	80	180	-	-	-	-	-	-
Plating Solutions, Indium	-	-	-	140	180	120	200	140	140	-	-	-	-	350	-	-	-	100	-	130	-	-	-	-	-	-	-
Plating Solutions, Iron	-	-	-	140	180	140	200	140	140	-	-	-	-	400	-	-	-	-	-	X	180	-	-	-	-	-	-
Plating Solutions, Lead	-	-	-	140	180	140	250	140	140	-	-	121	-	350	-	-	-	180	70	100	180	-	-	-	-	-	-
Plating Solutions, Nickel	-	-	-	140	140	140	250	140	140	-	-	121	-	350	-	-	-	180	70	200	180	-	-	A	-	-	-
Plating Solutions, Rhodium	-	-	-	140	140	140	250	140	140	-	-	121	-	350	-	-	-	180	-	80	180	-	-	-	-	-	-
Plating Solutions, Silver	-	-	-	140	100	180	250	140	140	-	-	121	-	350	-	-	-	180	70	100	180	-	-	A	-	-	-
Plating Solutions, Tin	-	-	-	140	180	180	250	140	140	-	-	121	-	350	-	-	-	180	100	100	180	-	-	-	C	-	-
Plating Solutions, Zinc	-	-	-	140	180	180	250	140	140	-	-	121	-	350	-	-	-	180	70	200	180	-	-	-	-	-	-
Polyethylene Glycol	-	-	-	140	180	180	250	-	-	-	-	121	-	350	150	-	-	200	100	-	-	-	-	-	-	-	-
Polyvinyl Acetate	-	-	1.19	-	-	-	250	-	-	-	-	-	-	350	150	100	-	68	-	200	68	-	-	-	-	-	-
Emulsion	-	-	-	-	-	-	-	-	-	68	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Polyvinyl Alcohol	$(CH_2CHOH)_2$	-	-	140	140	180	250	-	-	-	-	-	-	400	150	100	-	140	-	-	100	-	-	-	-	-	-
Potash (Potassium	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
(Carbonate)	K_2CO_3	-	-	140	180	180	250	-	-	176	-	-	-	400	100	150	-	200	-	-	150	-	-	-	-	-	-
Potassium Acetate	$KC_2H_3O_2$	-	1.6	70	180	100	250	-	-	-	-	-	-	400	-	-	-	68	100	-	68	-	-	-	-	-	-
Potassium Alum	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
(Aluminum Potassium	-	-	-	140	180	180	250	140	140	-	-	250	-	400	270	200	-	200	180	160	180	-	-	-	-	-	-
Sulfate)	-	-	-	-	-	-	-	-	-	176	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Potassium Bicarbonate	$KHCO_3$	-	2.2	140	200	180	250	-	-	176	-	-	-	400	100	150	-	200	170	160	70	A	A	A	-	-	-
Potassium Bichromate	-	-	-	-	-	-	-	-	-	-	-	212	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
(see Potassium Dichromate)	$K_2Cr_2O_7$	-	2.7	140	180	180	250	-	-	-	-	-	-	300	200	200	-	250	170	-	180	-	-	-	-	-	-
Potassium Bisulfate	$KHSO_4$	-	-	140	180	180	250	-	-	176	-	212	-	300	-	-	-	200	170	140	180	-	-	-	-	-	-
Potassium Bromate	$KBrO_3$	-	3.3	140	180	180	250	-	-	176	-	-	-	350	-	-	-	220	-	140	180	-	-	-	-	-	-
Potassium Bromide	KBr	30	2.7	140	180	180	250	-	-	176	-	250	-	300	220	200	-	200	150	160	180	-	-	-	-	-	-
Potassium Carbonate	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
(Potash)	K_2CO_3	-	2.4	140	180	180	250	-	-	176	-	250	-	300	100	150	-	200	160	160	180	-	-	A	-	-	-
Potassium Chlorate Aqueous	$KCLO_3$	30	2.3	140	180	180	250	-	-	176	-	250	-	300	-	-	-	180	140	100	100	-	-	-	A	-	-
Potassium Chloride	KCl	-	2.0	140	180	180	250	-	-	176	200	250	-	350	200	200	-	200	200	140	180	-	-	-	-	-	-

CHEMICAL RESISTANCE

HARRINGTON

CHEMICAL RESISTANCE GUIDE

				PLASTIC													ELASTOMER					SEAL		METAL			
CHEMICAL	FORMULAS		APPROX. SP.GRAVITY @ 100% CONC.	PVC	CPVC	POLYPROPYLENE (PP)	POLYVINYLIDENE FLUORIDE (PVDF)	POLYETHYLENE (PE)	POLYETHYLENE-CROSS LINKED (XLPE)	DURAPLUS ABS	RYTON	HALAR	PEEK	TEFLON	EPOXY	VINYLESTER	POLYSULFONE	VITON	EPDM	NEOPRENE	BUNA N (NITRILE)	CARBON	CERAMIC	304 STAINLESS STEEL	316 STAINLESS STEEL	TITANIUM	HASTELLOY C
Potassium Chromate	K_2CrO_4	-	2.7	140	180	180	250	-	-	-	-	250	-	-	-	-	-	100	170	70	140	A	X	-	-	-	-
Potassium Copper	-	-	-	-	-	-	-	-	-	-	-	250	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Cyanide	KCuCN	-	-	140	180	200	250	-	-	-	-	-	-	350	-	-	-	200	140	-	140	-	-	-	-	-	-
Potassium Cyanide	KCN	-	1.5	140	180	180	250	-	-	176	-	-	-	350	230	180	-	190	140	160	180	C	A	A	-	-	-
Potassium Dichromate	$K_2Cr_2O_7$	10	2.7	140	180	180	250	-	-	176	-	250	-	350	200	200	-	180	170	160	180	-	-	-	-	-	-
Potassium Ferricyanide	$K_3Fe(CN)_6$	-	-	140	180	140	250	-	-	176	-	250	-	350	220	200	-	140	140	150	70	-	-	-	-	-	-
Potassium Ferrocyanide	$K_4Fe(CN)_6$	-	1.9	140	180	140	250	-	-	176	-	250	-	350	220	200	-	180	140	200	180	-	-	-	-	-	-
Potassium Fluoride	KF	-	2.5	140	180	180	250	-	-	176	-	250	-	350	-	-	-	180	140	-	180	-	-	-	-	-	-
Potassium Hydroxide	KOH	-	2.0	-	-	-	-	-	-	176	-	-	-	-	-	-	-	-	200	160	70	-	-	A	-	-	-
(Caustic Potash)	-	-	-	-	-	-	-	-	-	-	-	250	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Potassium Hydroxide	KOH	25	-	140	180	180	140	-	-	176	200	-	-	350	100	120	-	-	200	160	100	-	-	A	-	-	-
Potassium Hydroxide	KOH	10	-	140	180	100	X	-	-	176	200	250	-	350	-	-	-	-	200	160	70	-	-	A	-	-	-
Potassium Hypochlorite	KHOCL	-	-	140	180	73	250	X	-	-	-	250	-	300	-	-	-	100	70	X	X	-	-	A	-	-	-
Potassium Iodide	KI	-	3.12	140	180	180	48	-	-	176	-	-	-	350	-	-	-	100	140	160	80	-	-	-	-	-	-
Potassium Nitrate (Salt Peter)	KNO_3	-	2.1	140	180	150	250	-	-	176	-	-	-	350	270	200	-	180	210	200	180	-	-	A	-	-	A
Potassium Perbotate	-	-	-	140	180	180	250	-	-	-	-	-	-	350	-	-	-	-	-	70	70	-	-	-	-	-	-
Potassium Perchlorate	$KCLO_4$	-	2.5	140	180	180	250	-	-	-	-	-	-	350	-	-	-	150	140	X	X	-	-	-	-	-	-
Potassium Permanganate	$KMNO_4$	20	2.7	140	*	120	250	-	-	-	200	73	-	350	X	150	-	150	210	100	X	A	A	B	B	-	B
Potassium Persulfate	$K_2S_2O_8$	-	2.5	140	180	120	250	-	-	-	-	300	-	400	-	180	-	200	210	140	X	A	A	-	A	-	-
Potassium Phosphate	K_2HPO_4	-	-	-	180	-	-	-	-	-	-	121	-	400	180	100	-	140	100	100	100	-	-	-	-	-	-
Potassium Salts	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Potassium Sulfate	K_2SO_4	-	2.7	140	180	180	250	-	-	176	-	-	-	400	250	180	-	200	180	140	140	A	A	-	-	-	-
Potassium Sulfide	K_2S	-	1.8	100	120	-	250	-	-	-	-	250	-	300	-	-	-	100	-	70	100	-	-	-	-	-	-
Potassium Thiosulfate	$K_2S_2O_3$	-	-	-	-	-	-	-	-	176	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Propane (Dimethyl- Methane)	C_3H_8	-	-	72	72	73	250	-	-	X	-	-	-	300	150	100	-	300	X	70	100	-	-	-	-	-	-
Propanol (see Alcohol, Propyl)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Propargyl Alcohol	$HC:CCH_2OH$	-	-	72	72	120	150	-	-	-	-	-	-	350	-	-	-	140	-	X	X	-	-	-	-	-	-
Propyl Acetate	$C_3H_7OOCCH_3$	-	0.89	-	-	-	100	-	-	X	-	73	-	140	-	-	-	X	70	X	100	-	-	-	-	-	-
Propyl Alcohol	$CH_3CH_2CH_2OH$	-	0.8	120	160	150	150	-	-	X	-	250	-	400	-	-	-	200	140	200	-	-	-	-	-	-	-
Propylene	$CH_3CH:CH_2$	-	0.51	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	X	-	-	-	-	-	-
Propylene Dichloride	$CH_3CHCLCH_2CL$	-	1.58	X	X	X	150	-	-	X	-	-	-	400	-	-	-	70	X	X	100	-	-	-	-	-	-
Propylene Glycol	$CH_3CHOHCH_2OH$	-	1.0	-	-	-	250	X	140	-	-	-	-	400	200	-	-	200	-	100	X	-	-	-	-	-	-
Pyridine	$N(CH)_4CH$	-	1.0	X	X	73	X	-	-	X	200	-	-	350	-	-	-	X	70	X	80	-	-	-	B	-	-
Pyrogallic Acid (Pyrogallol)	$C_6H_3(OH)_3$	-	1.47	73	-	-	150	-	-	-	-	121	-	350	-	-	-	80	-	200	-	-	-	-	-	-	-
Quaternary Ammonium	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Salts	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	A	A	-	-	-	-
Rayon Coagulating Bath	-	-	-	140	180	73	73	X	140	-	-	-	-	-	-	-	-	-	-	-	X	-	-	-	-	-	-
Rhodan Salts (Thiocyanates)	-	-	-	140	140	140	250	-	-	-	-	-	-	-	-	-	-	180	-	-	-	-	-	-	-	-	-
Rosins	-	-	-	-	-	-	-	-	-	-	-	-	-	350	-	-	-	-	-	-	-	-	-	-	-	-	-
Rum	-	-	-	100	100	100	-	-	-	-	-	-	-	-	-	-	-	70	-	-	-	-	-	-	-	-	-
Rust Inhibitors	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Salad Dressings	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	A	A	-	-	-	-
Salicylaldehyde	C_6H_4OHCHO	-	1.17	X	X	-	140	-	-	-	-	73	-	200	-	-	-	-	-	-	-	-	-	-	-	-	-
Salicylic Acid	$C_6H_4(OH)(COOH)$	-	1.44	-	-	-	210	-	-	-	-	-	-	250	-	-	-	200	-	-	68	A	A	-	-	-	-
Saline Solutions (Brine)	-	-	-	140	190	180	250	140	140	-	-	250	-	400	200	-	-	280	250	160	180	-	-	B	-	-	-
Salt Brine	-	-	-	140	190	180	250	140	140	-	-	250	-	400	200	-	-	280	250	160	180	A	A	B	-	-	B
Sea Water	-	-	-	140	190	180	250	140	140	176	-	250	-	400	200	-	-	280	250	160	180	A	A	C	-	-	A
Salenic Acid	H_2SeO_4	-	22.6	140	190	73	70	70	70	-	-	-	-	350	-	-	-	-	-	-	-	-	-	-	-	-	A
Sewage	-	-	-	140	180	180	250	-	-	-	-	-	-	350	-	-	-	180	140	140	150	A	A	A	-	-	-
Shellac Bleached	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Shellac Orange	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Salicic Acid	SiO_2H_2O	-	-	140	180	180	250	140	140	-	-	-	-	250	-	-	-	200	140	140	180	-	-	-	-	-	-
Silicone Oil	-	-	-	140	150	150	250	-	-	-	-	73	-	350	-	-	-	190	140	70	140	A	A	A	-	-	-
Silver Bromide	AgBr	-	6.47	-	-	-	-	140	140	-	-	-	-	-	-	-	-	-	-	-	-	A	-	-	-	-	-

CHEMICAL RESISTANCE GUIDE

PLASTIC | ELASTOMER | SEAL | METAL

CHEMICAL	FORMULAS		APPROX. SP.GRAVITY @ 100% CONC.	PVC	CPVC	POLYPROPYLENE (PP)	POLYVINYLIDENE FLUORIDE (PVDF)	POLYETHYLENE (PE)	POLYETHYLENE-CROSS LINKED (XLPE)	DURAPLUS ABS	RYTON	HALAR	PEEK	TEFLON	EPOXY	VINYLESTER	POLYSULFONE	VITON	EPDM	NEOPRENE	BUNA N (NITRILE)	CARBON	CERAMIC	304 STAINLESS STEEL	316 STAINLESS STEEL	TITANIUM	HASTELLOY C
Silver Cyanide	$AgCN$	-	3.95	140	180	180	250	140	140	-	-	250	-	350	-	-	-	140	140	70	X	-	-	-	-	-	-
Silver Nitrate	$AgNO_3$	-	4.32	140	180	180	280	140	140	-	-	250	-	350	-	-	-	250	200	160	140	A	A	A	-	-	-
Silver Salts	-	-	-	140	180	180	280	140	140	-	-	-	-	350	-	-	-	140	140	100	-	-	-	A	-	-	-
Silver Sulfate	Ag_2SO_4	-	5.45	140	180	140	250	140	140	-	-	250	-	250	-	-	-	200	170	100	100	-	-	-	-	-	-
Soap Solutions	-	-	-	140	180	180	280	X	140	-	-	121	-	350	-	-	-	200	200	140	180	A	A	A	-	-	-
Soda Ash (Sodium Carbonate)	Na_2CO_3	-	1.55	140	180	180	280	-	-	176	-	250	-	400	100	150	-	250	140	140	140	-	-	A	-	-	-
Sodium	Na	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Sodium Acetate	$NaC_2H_3O_2$	-	1.5	140	180	180	250	140	140	176	-	250	-	350	220	200	-	X	170	200	X	A	A	A	-	-	A
Sodium Alum	-	-	-	140	180	180	250	140	140	-	-	250	-	350	-	-	-	210	160	140	180	-	-	-	-	-	-
Sodium Aluminate	$Na_2AL_2O_4$	-	-	-	-	-	-	-	-	176	-	-	-	-	-	-	-	200	200	140	180	A	A	-	-	A	A
Sodium Benzoate	C_6H_5COONa	-	-	140	180	180	250	140	140	-	-	250	-	300	200	180	-	200	210	-	140	-	-	-	-	-	-
Sodium Bicarbonate	$NaHCO_3$	-	2.2	140	180	180	280	140	140	176	200	250	-	400	250	150	-	300	210	160	180	A	A	-	-	A	A
Sodium Bichromate (see	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Sodium Dichromate)	$Na_2Cr_2O_7$	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Sodium Bisulfate	$NaHSO_4$	-	2.4	140	180	180	280	140	140	176	200	250	-	250	250	200	-	250	200	140	180	A	A	-	-	A	-
Sodium Bisulfite	$NaHSO_3$	-	1.5	140	180	180	250	140	140	176	200	250	-	350	-	-	-	250	200	140	180	-	-	-	-	A	A
Sodium Borate (Borax)	$Na_2B_4O_7$	-	1.7	100	180	200	250	140	140	176	-	-	-	300	-	-	-	180	140	200	180	A	A	-	-	A	A
Sodium Bromate	$NaBrO_3$	-	3.34	-	-	-	-	140	140	176	-	-	-	-	140	-	-	-	-	-	-	-	-	-	-	-	-
Sodium Bromide	$NaBr$	-	3.2	140	180	180	250	-	-	176	-	250	-	300	250	200	-	250	210	70	70	-	-	-	-	A	-
Sodium Carbonate (Soda Ash)	Na_2CO_3	-	1.55	140	180	180	250	-	-	176	200	250	-	350	100	150	-	200	140	200	200	B	A	-	-	A	A
Sodium Chlorate	$NaCLO_3$	-	2.5	100	180	180	250	-	-	176	-	250	-	350	-	180	-	180	140	70	180	A	A	-	-	A	-
Sodium Chloride (Salt)	$NaCL$	-	2.2	140	180	180	280	140	140	176	200	250	-	350	270	200	-	200	140	160	140	-	-	-	-	B	A
Sodium Chlorite	$NaCLO_2$	25	-	140	180	73	140	-	-	-	-	212	-	400	-	-	-	X	X	-	X	-	-	-	-	-	-
Sodium Chromate	Na_2CrO_4	-	-	-	-	-	200	-	-	-	200	-	-	-	-	-	-	70	70	70	70	-	-	-	-	A	-
Sodium Cyanide	$NaCN$	-	-	140	170	180	250	-	-	176	-	250	-	350	230	200	-	200	140	140	140	-	-	-	-	A	-
Sodium Dichromate	$Na_2Cr_2O_7$	-	2.5	140	140	140	250	-	-	176	200	121	-	350	200	200	-	200	140	70	140	-	-	-	-	-	-
Sodium Ferricyanide	$Na_3Fe(CN)_6$	-	1.5	140	180	150	250	-	-	176	-	-	-	300	270	200	-	140	140	-	70	-	-	A	-	-	-
Sodium Ferrocyanide	$Na_4Fe(CN)_6$	-	1.5	140	180	150	250	-	-	176	-	-	-	350	270	200	-	140	140	-	70	-	-	-	-	-	-
Sodium Fluoride	NaF	-	2.6	140	180	180	250	-	-	176	-	250	-	350	-	-	-	140	140	70	70	-	-	A	-	-	-
Sodium Hydrosulfide	$NaSH$	-	-	-	-	-	-	-	-	-	-	250	-	-	120	-	-	-	-	-	-	-	-	-	-	-	-
Sodium Hydrosulfite	$Na_2S_2O_6$	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Sodium Hydroxide	$NaOH$	15	-	140	180	180	150	X	140	176	200	250	-	400	120	100	-	100	210	160	140	-	-	A	-	-	-
Sodium Hydroxide	$NaOH$	20	-	140	180	180	73	X	140	176	200	-	-	350	120	100	-	100	210	160	100	-	-	A	-	-	-
Sodium Hydroxide	$NaOH$	30	-	140	180	180	X	X	140	176	200	212	-	350	120	100	-	100	210	160	100	-	-	A	-	-	-
Sodium Hydroxide	$NaOH$	50	2.1	140	180	180	X	X	140	176	200	212	-	350	150	X	-	X	180	160	X	-	-	A	-	-	-
Sodium Hydroxide	$NaOH$	70	-	140	180	180	X	X	140	176	-	-	-	350	-	-	-	X	70	100	X	-	-	-	-	-	-
Sodium Hydroxide Conc.	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
(Caustic Soda)	$NaOH$	-	-	140	180	120	X	X	140	176	-	-	-	70	-	-	-	X	100	X	X	-	-	-	-	-	-
Sodium Hypochlorite (Bleach)	$NaOCL$	-	-	140	180	120	100	140	140	X	X	250	-	300	X	150	-	140	70	X	X	-	-	A	-	-	-
Sodium Hypochlorite Conc	$NaOCL$	15	-	140	100	72	100	-	-	X	X	-	-	300	X	-	-	180	X	70	X	-	-	-	-	-	-
Sodium Hyposulfate	$Na_2S_2O_3$	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Sodium Iodide	NaI	-	-	-	-	-	280	-	-	-	-	121	-	-	-	-	-	-	-	160	-	-	-	-	-	-	-
Sodium Metaphosphate	$(NaPO_3)n$	-	-	140	180	150	250	-	-	68	-	250	-	-	-	-	-	180	70	100	150	-	-	A	-	-	-
Sodium Metasilicate	Na_2SiO_3	-	-	140	180	180	250	-	-	176	-	-	-	350	-	-	-	200	-	-	170	-	-	-	-	-	-
Sodium Nitrate	$NaNO_3$	-	2.3	140	180	180	250	-	-	-	-	-	-	400	270	200	-	210	200	190	170	A	A	A	-	-	-
Sodium Nitrate	$NaNO_3$	-	2.2	140	180	180	250	-	-	176	-	250	-	400	270	200	-	200	170	140	X	A	A	A	-	-	-
Sodium Palmitate	-	-	-	140	180	120	250	-	-	-	-	-	-	400	-	-	-	-	-	-	-	-	-	-	-	-	-
Sodium Perborate	$NaBO_3$	-	-	140	180	180	250	-	-	-	-	-	-	350	-	-	-	180	70	200	200	-	-	A	-	-	-
Sodium Perchlorate	$NaCLO_4$	-	2.02	140	180	180	250	-	-	-	-	73	-	350	-	-	-	-	-	-	70	-	-	-	-	-	-
Sodium Peroxide	Na_2O_2	10	2.8	140	180	180	200	-	-	-	-	250	-	350	-	-	-	180	140	200	200	-	-	A	-	-	-
Sodium Phosphate Acid	Na_2HPO_4	-	1.7	140	180	140	280	-	-	-	-	250	-	350	-	-	-	200	170	140	140	-	-	A	-	-	-
Sodium Phosphate Alkaline	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
(Mono Basic	NaH_2PO_4	-	2.04	140	180	180	250	-	-	-	-	250	-	350	-	-	-	200	170	140	140	-	-	A	-	-	-
Sodium Phosphate Neutral (Tri Basic)	Na_3PO_4	-	1.62	140	180	180	250	120	-	-	200	250	-	350	-	-	-	200	170	140	140	-	-	-	-	-	-

CHEMICAL RESISTANCE

HARRINGTON

CHEMICAL RESISTANCE GUIDE

CHEMICAL RESISTANCE

CHEMICAL	FORMULAS		APPROX. SP.GRAVITY @ 100% CONC.	PVC	CPVC	POLYPROPYLENE (PP)	POLYVINYLIDENE FLUORIDE (PVDF)	POLYETHYLENE (PE)	POLYETHYLENE-CROSS LINKED (XLPE)	DURAPLUS ABS	RYTON	HALAR	PEEK	TEFLON	EPOXY	VINYLESTER	POLYSULFONE	VITON	EPDM	NEOPRENE	BUNA N (NITRILE)	CARBON	CERAMIC	304 STAINLESS STEEL	316 STAINLESS STEEL	TITANIUM	HASTELLOY C
Sodium Polyphosphate	-	-	-	140	180	180	250	120	-	-	200	-	-	350	-	-	-	200	150	140	140	A	A	A	-	-	-
Sodium Silicate (Water Glass)	Na_2OSiO_2	-	-	140	180	180	250	-	-	176	200	250	-	350	220	200	-	200	200	140	140	A	A	A	-	-	-
Sodium Sulfate	Na_2SO_4	-	2.7	140	180	150	280	140	140	176	200	250	-	400	270	200	-	200	140	140	140	A	A	A	-	-	-
Sodium Sulfide	Na_2S	50	1.4	140	180	180	250	140	140	-	200	250	-	350	-	150	-	200	140	140	140	A	A	A	-	-	-
Sodium Sulfite	Na_2SO_3	-	2.6	140	180	180	250	140	140	176	-	250	-	350	200	200	-	200	140	140	140	A	A	A	A	-	B
Sodium Tetraborate	$Na_2B_4O_7$	-	-	140	180	120	250	140	140	176	-	-	-	300	-	-	-	140	100	100	70	A	A	A	-	-	-
Sodium Thiocyanate	NaSCN	-	-	140	140	140	240	140	140	-	-	-	-	250	200	180	-	180	140	-	100	A	A	-	-	-	-
Sodium Thiosulfate (HypO)	$Na_2S_2O_3$	-	1.7	140	180	180	250	140	140	176	200	250	-	350	150	200	-	200	-	160	200	A	A	-	B	-	-
Sorghum	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Soy Sauce	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Soybean Oil	-	-	-	140	180	180	250	X	70	-	-	-	-	250	-	-	-	200	X	70	140	A	A	A	-	-	-
Stannic Chloride (Tin Chloride)	Na_2SnCL_6	-	2.3	140	180	150	280	-	-	-	-	250	-	350	250	200	-	200	100	X	140	A	A	C	X	-	-
Stannic Salts	-	-	-	140	180	150	280	-	-	-	-	-	-	350	250	200	-	200	100	X	140	-	-	C	X	-	-
Stannous Chloride (Tin Salts)	$SnCL_2$	-	-	140	180	180	250	-	-	-	-	250	-	350	220	200	-	200	100	X	140	-	-	C	A	-	-
Starch (Amylum)	-	-	1.51	140	180	180	250	140	140	176	-	121	-	350	-	-	-	200	140	140	170	A	A	A	-	-	-
Stearic Acid	-	-	0.84	140	180	120	250	-	-	176	-	121	-	350	220	200	-	80	X	70	200	-	-	A	A	-	-
Stoddard Solvent (Dry	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Cleaning Solvent)	-	-	-	X	X	70	250	-	-	X	200	250	-	300	-	-	-	180	X	X	180	A	A	A	B	-	-
Strontium Carbonate	$SrCO_3$	-	3.62	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Styrene	$C_6H_5CH{:}CH_2$	-	0.9	X	X	X	200	-	-	X	-	-	-	250	100	180	-	X	X	X	X	-	-	A	-	-	-
Succinic Acid (Butaned-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
ioic Acid)	-	-	1.55	140	170	150	150	-	-	-	-	212	-	200	-	-	-	70	70	-	70	-	-	A	-	-	-
Sugar Solutions	-	-	-	140	200	180	270	-	-	-	-	-	-	350	220	180	-	200	140	140	100	-	-	-	-	-	-
Sulfamic Acid	HSO_3NH_2	25	2.1	-	180	X	X	-	-	176	-	-	-	-	100	180	-	-	-	-	-	-	-	-	-	-	-
Sulfate Liquors (Paper Pulp)	-	-	-	140	190	150	150	-	-	-	-	73	-	200	-	-	-	80	70	140	80	-	-	A	-	-	-
Sulfonated Detergents	-	-	-	140	190	150	200	-	-	-	-	-	-	300	-	-	-	100	-	-	-	-	-	-	-	-	-
Sulfur	S	0	-	-	73	-	248	70	70	68	-	212	-	350	-	-	-	73	X	80	X	-	-	A	A	-	A
Sulfur Dioxide	SO_2	-	-	-	-	-	-	-	-	X	200	-	-	-	180	200	-	-	-	-	-	-	-	-	-	-	-
Sulfite Liquor (Sulfite	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-		-	-	-
Paper Process)	-	-	-	140	180	180	250	-	-	-	-	73	-	-	150	200	-	140	140	70	70	-	-	A	-	-	-
Sulfur Chloride	S_2CL_2	-	1.69	140	-	X	250	-	-	-	-	73	-	-	X	X	-	180	X	X	X	-	-	C	-	-	-
Sulfur Dioxide Dry	SO_2	-	-	140	180	180	250	70	70	X	-	212	-	300	X	200	-	100	70	X	X	-	-	A	-	-	-
Sulfur Dioxide Wet	SO_2	-	-	100	150	180	250	70	70	X	-	121	-	300	-	-	-	140	140	X	X	-	-	A	-	-	-
Sulfur Slurries	-	-	-	140	180	X	250	-	-	-	-	-	-	350	-	-	-	200	X	70	X	-	-	A	-	-	-
Sulfur Trioxide Dry	SO3	-	-	X	X	X	X	-	-	-	-	-	-	-	X	X	-	150	X	X	X	-	-	B	-	-	-
Sulfuric Acid	H_2SO_4	10	-	140	180	180	250	140	140	176	200	212	-	350	100	200	-	200	140	100	100	A	A	X	X	X	A
Sulfuric Acid	H_2SO_4	30	-	140	180	150	250	140	140	176	200	212	-	350	100	180	-	200	140	100	100	-	-	X	X	X	A
Sulfuric Acid	H_2SO_4	50	-	140	180	150	200	140	140	68	200	212	-	350	100	180	-	200	140	100	100	-	-	X	X	X	A
Sulfuric Acid	H_2SO_4	60	-	140	180	140	200	X	70	X	200	212	-	350	*	120	-	200	140	100	X	-	-	X	X	X	A
Sulfuric Acid	H_2SO_4	70	-	140	180	140	200	X	70	X	200	212	-	350	X	X	-	200	140	X	X	-	-	X	X	X	B
Sulfuric Acid	H_2SO_4	80	-	140	180	X	200	X	70	X	200	212	-	350	X	X	-	200	70	X	X	-	-	X	C	X	B
Sulfuric Acid	H_2SO_4	90	-	73	150	X	200	X	70	X	200	212	-	350	X	X	-	200	X	X	X	-	-	X	C	X	B
Sulfuric Acid	H_2SO_4	95	-	X	150	X	180	X	70	X	200	212	-	350	X	X	-	200	X	X	X	-	-	C	B	X	B
Sulfuric Acid	H_2SO_4	98	1.84	X	100	X	140	X	X	X	200	212	-	350	X	X	-	200	X	X	X	-	-	C	B	X	B
Sulfuric Acid	H_2SO_4	100	-	X	X	X	X	X	X	X	-	-	-	-	X	X	-	100	X	X	X	-	-	C	B	X	B
Sulfurous Acid	H_2SO_3	-	1.03	140	170	170	250	140	-	-	-	212	-	350	-	-	-	180	X	X	X	-	-	A	B	-	B
Sulfuryl Chloride	SO_2CL_2	-	1.67	-	-	-	-	-	-	-	-	-	-	-	-	-	-	X	-	-	-	-	-	-	-	-	B
Syrup (Sucrose in water)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Tall Oil	-	-	-	140	180	180	250	X	70	-	-	250	-	250	200	200	-	300	X	70	200	-	-	A	B	-	-
Tallow (Animal Fat)	-	-	0.86	-	-	-	-	X	70	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Tannic Acid	$C_{76}H_{52}O_{46}$	-	-	140	200	180	250	X	140	-	-	212	-	250	225	200	-	100	70	100	100	-	-	A	B	-	-
Tanning Liquors	-	-	-	140	190	73	68	-	-	-	-	212	-	250	-	-	-	200	-	70	180	A	A	A	B	-	-
Tar	-	-	-	X	X	-	250	-	-	-	-	250	-	250	-	-	-	190	X	70	X	-	-	A	-	-	-
Tartaric Acid (DihydroxySuccinic Acid)	-	-	1.8	140	180	140	250	140	140	176	-	212	-	250	250	200	-	180	X	180	70	-	-	A	-	-	-

HARRINGTON

CHEMICAL RESISTANCE GUIDE

CHEMICAL	FORMULAS			PLASTIC													ELASTOMER					SEAL		METAL			
			APPROX. SP.GRAVITY @ 100% CONC.	PVC	CPVC	POLYPROPYLENE (PP)	POLYVINYLIDENE FLUORIDE (PVDF)	POLYETHYLENE (PE)	POLYETHYLENE-CROSS LINKED (XLPE)	DURAPLUS ABS	RYTON	HALAR	PEEK	TEFLON	EPOXY	VINYLESTER	POLYSULFONE	VITON	EPDM	NEOPRENE	BUNA N (NITRILE)	CARBON	CERAMIC	304 STAINLESS STEEL	316 STAINLESS STEEL	TITANIUM	HASTELLOY C
Tertiary Butyl Alcohol	-	-	-	68	68	68	250	-	-	X	-	-	-	250	-	-	-	70	-	-	X	-	-	A	-	-	-
Tetrachlorethane	$CHCL_2CHCL_2$	-	-	X	X	X	250	-	-	X	-	-	-	350	-	-	-	70	X	X	X	-	-	A	-	-	-
Tetraethyl Lead	$Pb(C_2H_5)_4$	-	1.65	72	72	73	250	-	-	-	-	250	-	350	-	-	-	150	X	X	X	-	-	-	-	-	-
Tetrahydrofuran	-	-	-	X	X	X	X	X	X	X	200	X	-	350	120	100	-	X	X	X	X	-	-	-	X	-	-
Tetralin (Tetrahydro-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Naphthalene)	$C_{10}H_{12}$	-	-	X	X	X	-	X	X	X	-	-	-	300	-	-	-	68	X	X	X	-	-	-	-	-	-
Thionyl Chloride	$SOCL_2$	-	1.64	X	X	X	X	X	X	X	-	121	-	350	X	X	-	73	X	X	X	-	-	X	X	-	-
Thread Cutting Oils	-	-	-	140	72	120	150	-	-	-	-	250	-	400	-	-	-	70	X	-	70	-	-	B	B	-	-
Titanium Tetrachloride	$TiCL_4$	-	-	X	X	X	X	-	-	-	-	-	-	400	-	-	-	150	X	X	X	-	-	C	C	A	C
Titanous Sulfate	$Ti_2(SO_4)_3$	-	1.47	140	180	180	250	-	-	-	-	-	-	350	-	-	-	-	-	-	-	-	-	-	-	-	-
Toluene	$CH_3C_6H_5$	-	0.9	X	X	X	150	X	X	X	200	121	-	350	150	X	-	70	X	X	-	A	A	A	A	A	A
Tomato Juice	-	-	-	140	180	150	250	70	140	68	200	-	-	400	-	-	-	200	200	100	150	-	-	C	B	-	B
Toxaphene-Xylene	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Transformer Oil (Liquid	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Insulators) Mineral Oil Type	-	-	-	140	190	73	200	X	70	176	-	212	-	400	150	X	-	180	X	100	180	-	-	A	-	-	-
Tributyl Phosphate	$(C_4H_9)_3PO_4$	-	-	X	X	70	100	-	-	X	-	73	-	400	-	-	-	X	70	X	X	A	A	-	-	A	-
Trichloroacetic Acid	CCL_3COOH	-	1.6	73	72	120	100	-	-	-	200	121	-	400	-	-	-	180	70	70	70	-	-	X	X	B	-
Trichloroethane (Methyl	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Chloroform)	$CHCL_2CH_2CL$	-	-	X	X	X	-	-	-	X	-	-	-	350	-	-	-	-	X	X	X	-	-	-	-	A	-
Trichloroethylene	$CHCL:CCL_2$	-	1.1	X	X	68	170	X	X	X	-	73	-	350	120	X	-	200	X	X	X	-	-	-	-	A	-
Trichloropropane	-	-	1.39	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	X	-	-	-	-	-	A	-
Tricresyl Phosphate (TCP)	$(CH_3C_6H_4O)_3PO$	-	1.16	X	X	-	-	-	-	X	-	212	-	-	-	-	-	-	-	X	X	-	-	-	-	A	-
Triethanolamine	$(HOCH_2CH_2)_3N$	-	1.12	X	X	X	X	-	-	73	-	73	-	-	150	X	-	X	70	70	70	-	-	C	C	A	-
Triethyl Phosphate	$(C_2H_5)_3PO_4$	-	0.73	-	-	-	-	-	-	X	200	73	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Triethylamine	$(C_2H_5)_3N$	-	-	73	72	72	70	-	-	-	-	121	-	-	100	X	-	200	73	70	140	-	-	-	-	-	-
Trimethylpropane	$(CH_2OH)_3C_3H_5$	-	-	73	-	-	250	-	-	-	-	-	-	300	-	-	-	200	-	150	150	-	-	-	-	-	-
Trisodium Phosphate	Na_3PO_4	-	-	140	180	180	250	-	-	-	-	250	-	350	-	-	-	180	70	200	200	-	-	A	-	-	-
Turbine Oil	-	-	-	72	72	70	-	-	-	-	-	-	-	350	-	-	-	140	X	X	68	A	A	A	-	-	-
Turpentine	$C_{10}H_{16}$	-	0.9	X	X	X	250	X	X	X	200	250	-	300	150	X	-	180	X	X	100	-	-	A	A	-	B
Urea	$CO(NH_2)_2$	-	1.3	140	180	180	250	X	140	176	-	212	-	250	200	150	-	180	140	140	140	-	-	-	-	-	-
Urine	-	-	-	140	180	180	250	140	140	68	-	121	-	350	-	-	-	180	140	140	100	-	-	A	-	-	-
Vanilla Extract (Vanillin)	-	-	-	-	-	-	-	X	140	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Varnish	-	-	-	-	-	-	250	-	-	68	-	-	-	250	-	-	-	68	X	X	68	-	-	A	-	-	-
Vaseline	-	-	-	140	180	180	250	-	-	176	-	121	-	400	-	-	-	70	X	140	140	-	-	-	-	-	-
Vegetable Oil	-	-	-	140	150	140	200	-	70	-	-	-	-	400	-	-	-	300	140	200	100	-	-	A	A	-	B
Vinegar (4-8% Acetic Acid)	-	-	-	140	180	140	200	140	140	68	200	212	-	400	200	200	-	180	140	200	X	-	-	A	B	-	C
Vinyl Acetate	-	-	0.93	X	X	-	250	-	-	X	-	73	-	350	150	X	-	X	70	X	X	-	-	A	A	-	-
Vinyl Chloride	$CH_2:CHCL$	-	-	X	X	-	-	-	-	X	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Vinyl Ether	$CH_2:CHOCH:CH_2$	-	0.77	X	X	X	-	-	-	X	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Water Acid Mine	-	-	-	140	180	150	280	-	-	-	200	250	-	400	-	-	-	180	250	160	180	A	A	A	A	-	A
Water Deionized	H_20	-	-	140	180	180	280	140	140	176	200	250	-	400	250	180	-	140	250	160	180	A	A	A	-	-	A
Water Demineralized	H_20	-	-	140	180	180	280	140	140	176	200	250	-	400	250	200	-	180	250	160	200	A	A	A	-	-	A
Water Distilled	H_20	-	-	140	180	180	280	140	140	176	200	250	-	400	250	200	-	140	250	160	180	A	A	A	-	-	A
Water Potable	H_20	-	-	140	180	180	280	140	140	176	200	250	-	400	270	200	-	140	250	160	180	A	A	A	-	-	A
Water Salt	H_20	-	-	140	180	180	280	140	140	-	200	250	-	400	270	200	-	180	250	160	180	A	A	B	-	-	A
Water Sewage	H_20	-	-	140	180	180	280	140	140	-	200	250	-	400	250	200	-	180	250	160	180	A	A	A	-	-	A
Whey	-	-	-	-	-	-	-	-	-	-	200	-	-	-	-	-	-	-	-	-	-	A	A	-	-	-	-
Whiskey	-	-	0.9	140	180	180	250	X	140	X	200	250	-	350	-	-	-	180	200	200	180	A	A	A	-	-	-
White Acid	NH_4HF_2HF	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	A	A	-	-	-	-
White Liquor	-	-	-	140	180	180	250	-	-	-	-	212	-	350	100	150	-	180	-	140	140	A	A	B	B	-	-
Wines	-	-	-	140	180	140	250	140	140	-	-	212	-	300	-	-	-	180	170	200	180	A	A	A	A	-	-
Xenon	Xe	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Xylene	$C_6H_4(CH_3)_2$	-	0.9	X	X	X	250	X	X	X	200	-	200	350	150	X	-	180	X	X	X	A	A	-	-	-	-
Yeast	-	-	-	-	-	-	-	-	-	68	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

CHEMICAL RESISTANCE

HARRINGTON

CHEMICAL RESISTANCE GUIDE

PLASTIC | ELASTOMER | SEAL | METAL

CHEMICAL	FORMULAS		APPROX. SP.GRAVITY @ 100% CONC.	PVC	CPVC	POLYPROPYLENE (PP)	POLYVINYLIDENE FLUORIDE (PVDF)	POLYETHYLENE (PE)	POLYETHYLENE-CROSS LINKED (XLPE)	DURAPLUS ABS	RYTON	HALAR	PEEK	TEFLON	EPOXY	VINYLESTER	POLYSULFONE	VITON	EPDM	NEOPRENE	BUNA N (NITRILE)	CARBON	CERAMIC	304 STAINLESS STEEL	316 STAINLESS STEEL	TITANIUM	HASTELLOY C
Zeolite	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Zinc Acetate	$Zn(C:_2H_3O_2)_2$	-	1.7	140	180	180	250	140	140	-	-	-	-	350	180	-	-	70	180	160	-	-	-	-	-	-	-
Zinc Carbonate	$ZnCO_3$	-	4.45	-	-	-	-	140	140	176	-	-	-	-	-	-	-	-	-	-	100	A	A	-	-	-	-
Zinc Chloride	$ZnCL_2$	-	2.9	140	190	180	250	140	140	X	200	250	-	350	250	200	-	200	180	160	70	A	A	-	-	-	-
Zinc Chromate	$ZnCrO_4$	-	3.4	-	-	-	-	140	140	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Zinc Nitrate	$Zn(NO_3)_2$	-	2.06	140	190	180	250	140	140	176	-	250	-	350	-	-	-	200	180	100	140	-	-	-	-	-	-
Zinc Phosphate	$Zn_3(PO_4)_2$	-	4	-	-	-	-	140	140	176	-	-	-	-	180	200	-	-	-	-	-	-	-	-	-	-	-
Zinc Salts	-	-	-	140	190	180	250	140	140	-	-	-	-	350	-	-	-	200	180	-	140	-	-	-	-	-	-
Zinc Sulfate	$ZnSO_4$	-	2	140	190	180	50	140	140	176	-	250	-	400	250	200	-	200	180	140	140	A	A	-	-	-	-

* Caution: Further testing needed, suspect with certain stress levels.

The Teflon included in the tables is PFA or PTFE which are similar in chemical resistance and temperature. For data on FEP Teflon, please call Harrington's technical service department.

NOTE: Recent studies have shown that surfactants and detergents even in trace quantities can adversely affect the performance of certain thermoplastics in applications like sodium hydroxide, e.g. cross-linked polyethylene and CPVC.

MIXED CHEMICALS

Table 6

CHEMICALS	CONCENTRATION (%)	PVC*	CPVC*	PP*	PVDF*	TEFLON*	VITON*	EPT*
Sulfuric Add Chromic Add Sodium Silicon–fluoride	0.7 250 g/l 1	140	176	_	248	248	_	_
Sulfuric Add Hydrofluoric Acid	20 10	140	140	_	248	248	104	104
Sulfuric Acid Hydrofluoric Add	25 15	140	140	_	248	248	_	_
Sulfuric Add Nitric Acid Chlorine Gas	75 5 Little	140	176	104	176	248	_	_
Sulfuric Acid Sulfurous Acid	75 4	140	176	176	248	248	104	140
Sulfuric Acid Spelter Manganese Sulfate	150 g/l 80 2	140	176	176	248	248	176	176
Sodium Sulfide Sulfuric Acid Formaldehyde	225 g/l 225 g/l 50	104	176	176	212	212	212	140

NOTE: * Temperature at °F.

MIXED CHEMICALS

Table 6 (cont'd)

CHEMICALS	CONCENTRATION (%)	PVC*	CPVC*	PP*	PVDF*	TEFLON*	VITON*	EPT*
Hydrochloric Acid Allyl Chloride	36 12 PPM	104	104	140	248	248	176	104
Hydrochloric Acid Benzene	36 54 PPM	140	176	176	248	248	140	68
Hydrochloric Acid Chlorobenzene	18 490 PPM	140	176	176	248	248	140	68
Hydrochloric Acid Chlorobenzene	36 890 PPM	104	—-	104	212	248	104	—-
Hydrofluoric Acid Chromium Sulfate Sodium Silico-fluoride	220 g/l 1 g/l 12 g/l	140	176	—-	248	248	—-	—-
Hydrofluoric Acid Sodium Silico-fluoride Oxalic Acid	350 g/l 17 g/l 1 g/l	104	104	—-	248	248	—-	—-
Hydrochloric Acid Ferrous Chloride	35 28	—-	—-	—-	248	248	—-	176
Hydrochloric Acid Hydrofluoric Acid	10 15	140	140	—-	248	248	—-	—-
Hydrochloric Acid Hydrofluoric Acid	18 20	140	176	—-	248	248	—-	—-
Hydrochloric Acid Nitric Acid	20 50	140	140	—-	68	248	248	—-
Hydrochloric Acid Ortho-chlorophenal	36 170 PPM	140	140	140	248	248	176	104
Hydrochloric Acid Sulfuric Acid	36 g/l 98 g/l	68	68	—	176	248	—-	—-
Hydrochloric Acid Sulfuric Acid	20 5	140	176	176	248	248	176	176
Hydrochloric Acid Sulfuric Acid	36 98	140	176	176	248	248	—-	—-
Hydrofluoric Acid Ammonium Fluoride	250 g/l 8 g/l	140	140	—-	248	248	—-	—-

NOTE: * Temperature at °F

MIXED CHEMICALS

Table 6 (cont'd)

CHEMICALS	CONCENTRATION (%)	PVC*	CPVC*	PP*	PVDF*	TEFLON*	VITON*	EPT*
Hydrochloric Acid Ferric Chloride	25 28	140	212	212	248	248	176	176
Hydrochloric Acid Ferrous Chloride	20 28	—-	—-	—-	248	248	176	176
Nitric Acid Hydrofluoric Acid	15 3	140	140	140	248	248	—-	—-
Nitric Acid Hydrofluoric Acid	15 5	140	104	104	248	248	176	104
Nitric Acid Hydrofluoric Acid	15 10	140	68	104	248	248	—-	—-
Nitric Acid Hydrofluoric Acid	15 15	140	68	104	248	248	—-	—-
Nitric Acid Hydrofluoric Acid	5 20	140	176	—-	248	248	—-	—-
Nitric Acid Sulfuric Acid	50 100g 50 100g	68	68	68	248	248	—-	—-
Sulfuric Acid Chromic Acid	2 1	140	176	68	248	248	104	68
Sulfuric Acid Chromic Acid	10 10	104	104	—-	248	248	104	68
Sulfuric Acid Chromic Acid	10 25	104	104	—-	248	248	68	—-
Sulfuric Acid Chromic Acid	4 g/l 400 g/l	140	140	—-	248	248	—-	—-
Sulfuric Acid Chromic Acid Phosphoric Acid	15 5 80	140	176	—-	248	248	140	104
Sulfuric Acid Chromic Acid Water	2 10 80	140	176	—-	248	248	104	—-

NOTE: *Temperature at °F

RELATIVE PROPERTIES

TABLE 7

Table 7

MATERIAL	SPECIFIC GRAVITY ASTM-D792	WATER ABSORPTION %/24 hrs at 73°F ASTM - D570	TENSILE STRENGTH psi at 73°F ASTM - D638	MODULUS OF ELASTICITY IN TENSION psi @ 73°F x 10 ASTM - D638 "E"	FLEXURAL STRENGTH psi ASTM - D790	IZOD IMPACT 78° ft. lbs/in. notched ASTM - D256	COMPRESSIVE STRENGTH psi ASTM - D695 "o"	POISSON'S RATIO "V"
STEEL Gr. B	7.86	—-	60,000	290	—-	32	—-	.33
ALUMINUM 3003	2.73	—-	16,000	100	—-	20	—-	.33
COPPER	8.94	—-	30,000	170	—-	43	—-	—-
(PVC) POLYVINYL CHLORIDE TYPE 1	1.38	.05	7,940	4.2	14,500	.65	9,600	.35-.38
(CPVC) CHLORINATED POLYVINYL CHLORIDE	1.55	.05	8,400	4.2	15,800	3.0	9,000- 22,000	.35-.38
(PP) POLYPROPYLENE NON PPFR (PPFR) POLYPROPYLENE FLAME RETARDANT	.905	.02	5,000	1.7-2.5	7,000	1.3	5,500- 8,000	.38-.40
(PROLINE) POLYPROPYLENE/ POLYBUTYLENE COPOLYMER	.905	.02	5,800	1.1	2,900	4.7	7,000	.34-4.0
(RYTON) POLYPHYLENE SULFIDE 40% GLASS FIBER REINFORCED	1.6	.05	19,500	1.6	29,000	1.4	21,000	—-
(PVDF) POLYVINYLIDENE FLUORIDE	1.75- 1.78	.04	5,000 - 7,000	2.13	12,180	2.8	10,500	.38
POLYETHYLENE LD PE - LOW DENSITY	.925	.01	2,300	.14-.38	—-	9.0	—-	—-
HALAR	1.69	.04	4,500	2.40	---	No Break	---	0.3-0.4
DURAPLUS (ABS)	1.06	---	5,500	2.40	---	8.5	6,150	---
HD PE - HIGH DENSITY	.965	.01	4,500	.6-1.8	7,000	4.0	3,600	—-
XL PE - CROSS LINK PE	1.28	.02	3,000	—-	5,000	2.0	4,000	—-
TEFLON (PTFE) POLYTETRAFLUORETHYLENE	2.14	.02	2,600	1.0	81,000	No Break	3,500	—-
TEFLON (PFA) PERFLUOROALKOXY	2.2	0.0	2,000- 5,000	.58	—-	3.0	1,700	—-
TEFLON (FEP) FLUORINATED ETHYLENE PROPYLENE	2.1	0.0	2,700- 3,100	.50	—-	No Break	2,200	—-
EPOXY FIBERGLASS	1.6	.05-.20	10,000	1.35	10,000	1.0	25,000	—-
VINYLESTER FIBERGLASS	1.6	.02	10,500	1.4	15,600	2.5	18,000	—
POLYSULFONE	1.24	0.3	10,200	3.6	15,400	1.3	—-	—-

RELATIVE PROPERTIES

TABLE 8

Table 8

MATERIAL	WORKING STRESS @ 73° FM, psi "S"	COEFFICIENT OF LINEAR EXPANSION in/(in °F) x 10^5 ASTM - D696 "e"	THERMAL EXPANSION inches per 10-F change per 100' of pipe	RESISTANCE TO HEAT °F Continous	HEAT DISTORTION 66 psi ASTM - D648	HEAT DISTORTION TEMP °F at 264 psi ASTM - D648	THERMAL CONDUCTIVITY BTU/hr/sq. ft/°F/in. ASTM - C177 "K"	BURNING RATE ASTM - D635	LIMITED OXYGEN index (%) ASTM - D2863-70	BURNING CLASS UL 94	SURFACE BURNING OF BLDG. MATERIALS E-84: FLAME	SURFACE BURNING OF BLDG. MATERIALS E-84: SMOKE
STEEL Gr. B	20,000	.06	1/16"	750°	—-	—-	290	—-	—	—-		
ALUMINUM 3003	—-	—-	5/32"	400°	—-	—	1450	—-	—-	—-		
COPPER	——	—-	1/8"	400°	—-	—-	2610	—-	—-	—-		
(PVC) POLYVINYL CHLORIDE TYPE 1	2,000	3.0	1/3"	140°	173	160	1.2	*	43	V-0	15	850
(CPVC) CHLORINATED POLYVINYL CHLORIDE	2,000	3.8	1/2"	210°	238	221	.95	*	60	V-0	10	295
(PP) POLYPROPYLENE NON PPFR	725-800	5.0	5/8"	180°	220	125-140	1.2	Slow	17	V-2	119	791
(PPFR) POLYPROPYLENE FLAME RETARDANT											115	412
(PROLINE) POLYPROPYLENE/ POLYBUTYLENE COPOLYMER	800	8.33	1"	200°	—-	—-	1.2	Slow	—-	V-2	110	515
(RYTON) POLYPHYLENE SULFIDE 40% GLASS FIBER REINFORCED	—-	—-	1/2"	200°	—-	485	1.5 -0.91	*	—-	V-0	—-	—-
(PVDF) POLYVINYLIDENE FLU-ORIDE	2,300	6.6-8.7	1"	280°	284	195	1.32	*	44	V-0	—-	—-
POLYETHYLENE LD PE - LOW DENSITY	—-	10.0-22.0	1-1/4"	140°	100-121	90-105	2.3	Very Slow	—-	V-1	—-	—-
HD PE - HIGH DENSITY	—-	7.2	7/8"	160°	175-196	110-130	3.5	VerySlow	226	V-1	—-	—-
XL PE - CROSS LINK PE	—-	—-	—-	180°	180	120	—-	Slow	—-	V-1	—-	—-
TEFLON (PTFE) POLYTETRAFLUORETHYLENE	—-	10.0	2/3"	500°	250	—-	6.0	*	95	V-0	—-	—-
(PFA) PERFLUOROALKOXY	—-	7.6	0.9"	500°	—-	—-	1.3	*	95	V-0	—-	—-
TEFLON (FEP) FLUORINATED ETHYLENE PROPYLENE	—-	8.3-10.5	1/3"	300°	158	—-	6.0	*	95	V-0	—-	—-
EPOXY FIBERGLASS	—-	4.0-10.0	1/10"	300°	—-	300	1.7	*	—-	V-0	—-	—-
VINYLESTER FIBERGLASS	—-	—-	1/10"	200°	—-	200	2.0		—-	V-0	—-	—-
POLYSULFONE	—-	3.1	—-	300°	—-	345	1.8		33	V-0	—-	—-
HALAR	—-	4.4-9.2	1"	300°	195	151	1.07	*	60	V-O	—-	—-
DURAPLUS (ABS)	—-	5.6	5/8"	176°	194	223	1.7	*	—-			

* Self-Extinguishing

HARRINGTON

SYSTEMS ENGINEERING DATA FOR THERMOPLASTIC PIPING

INTRODUCTION

In the engineering of thermoplastic piping systems to comply with the Uniform Building Code, Uniform Fire Code, Uniform Mechanical Code, and Uniform Plumbing Code, it is necessary to have not only a working knowledge of piping design, but also an awareness of the unique properties of thermoplastics. The selection of the proper piping material is based upon **S T A M P:**

1. **S**ize
2. **T**emperature
3. **A**pplication
4. **M**edia
5. **P**ressure

Size of piping is determined by carrying capacity of the piping selected. Carrying capacity and friction loss are discussed on pages 50-58.

Temperature refers to the temperature of the liquid being piped and is the most critical factor in selecting plastic piping. Refer to the Continuous Resistance To Heat column in the Relative Properties tables on pages 40-41 to select an appropriate plastic material. Temperature of media must not exceed continuous resistance to heat. Temperature also refers to the maximum and minimum media or climactic conditions which the piping will experience. These maximum and minimum temperatures directly affect chemical resistance, expansion and contraction, support spacing, pressure rating, and most other physical properties of the piping material. These different considerations are discussed separately later.

Application asks what the pipe is being designed to do. Above or below ground, in a building or outside, drainage or pumped, in a floor trench or in a ceiling, high purity, short-/or long-term application, FDA requirement, flame and smoke spread required, and double containment required are all questions which should be answered.

Media is the liquid being contained and its concentration. Specific gravity, percent of suspended solids, and crystallization should be determined. Consult with the chemical resistance chart on pages 18-38 to make a selection based on liquid, concentration, and temperature.

Pressure is the pressure within the piping. Pressure is directly affected by temperature, wall thickness, diameter, and method of joining being employed. Refer to the Temperature-Pressure charts on pages 44-48 to conform the desired installation. Pressure inside the pipe may be less than the surrounding soil or atmospheres such as in vacuum or deep burial applications, and collapse pressure of piping must be determined from tables on page 49.

If more than one material meets the **STAMP** criteria, cost of material, personal preferences, and additional safety considerations are used to determine the right material for the service.

After piping, fitting, valve, and gasket materials are chosen for the service being considered, engineering the piping system begins with calculations for:

1. Pressure Ratings
2. Water Hammer
3. Temperature-Pressure Relationships
4. Flow Rate and Friction Loss Characteristics
5. Dimensional and Weight Data

It must be noted that storage, handling, and use of gaseous, liquid, and solid hazardous production material (HPM), as defined and discussed in the Uniform Building Code and Uniform Fire Code, requires very careful consideration and compliance to provide piping systems that comply with the law and are safe to man and the environment.

PRESSURE RATINGS OF THERMOPLASTICS

DETERMINING PRESSURE-STRESS-PIPE RELATIONSHIPS

ISO EQUATION

Circumferential stress is the largest stress present in any pressurized piping system. It is this factor that determines the pressure that a section of pipe can withstand. The relationship of stress, pressure, and pipe dimensions is described by the ISO (International Standardization Organization) equation. In various forms this equation is:

$$P = \frac{2S}{R-1} = \frac{2St}{D_0 - t} \qquad \frac{2S}{P} = \frac{D_0}{t} - 1$$

$$\frac{2S}{P} = R - 1 \qquad S = \frac{P(R-1)}{2}$$

Where:

P = Internal Pressure, psi
S = Circumferential Stress, psi
t = Wall Thickness, in.
D_0 = Outside Pipe Diameter, in.
$R = D_0/t$

LONG-TERM STRENGTH

To determine the long-term strength of thermoplastic pipe, lengths of pipe are capped at both ends (see Figure 5) and subjected to various internal pressure, to produce circumferential stresses that will produce failure in from 10 to 10,000 hours. The test is run according to ASTM D-1598 - Standard Test for Time-to-Failure of Plastic Pipe Under Long-Term Hydrostatic Pressure.

The resulting failure points are used in a statistical analysis (outlined in ASTM D-2837, see page 6) to determine the characteristics of the regression curve that represents the stress/time-to-failure relationship for the particular thermoplastic pipe compound under test.

SYSTEMS ENGINEERING DATA FOR THERMOPLASTIC PIPING

This curve is represented by the equation:

$$\text{Log} = a + b \log S$$

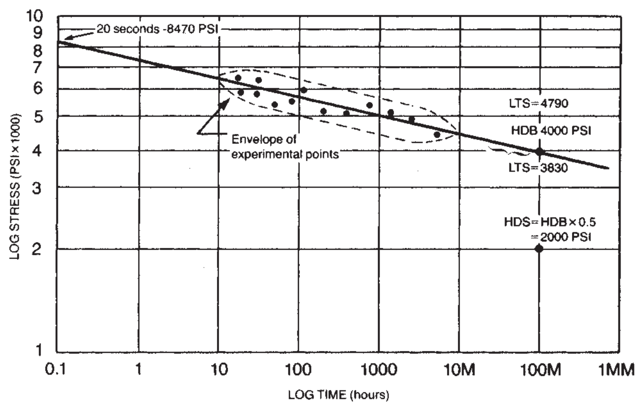
Where:

a and b are constants describing the slope and intercept of the curve, and T and S are time-to-failure and stress, respectively.

The regression curve may be plotted on a log-log paper, as shown in Figure 6, and extrapolated from 10,000 to 100,000 hours (11.4 years). The stress at 100,000 hours is known as the Long-Term Hydrostatic Strength (LTHS) for that particular thermoplastic compound. From this (LTHS) the Hydrostatic Design Stress (HDS) is determined by applying the service factor multiplier, as described below.

FIGURE 6

REGRESSION CURVE - STRESS/TIME-TO-FAILURE FOR PVC TYPE 1

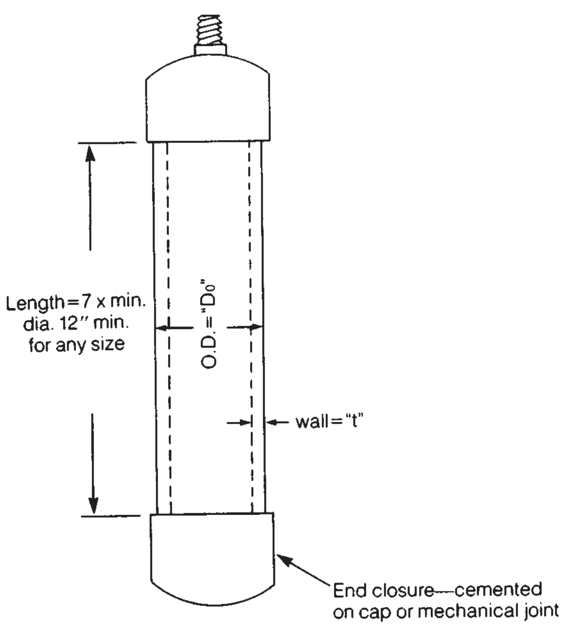


SERVICE FACTOR

The Hydrostatic Stress Committee of the Plastics Pipe Institure (PPI) has determined that a service (design) factor of one-half the hydrostatic design basis would provide an adequate safety margin for use with water to ensure useful plastic-pipe service for a long period of time. While not stated in the standards, it is generally understood within the industry that this "long period of time" is a minimum of 50 years.

FIGURE 5

LONG-TERM STRENGTH TEST PER ASTM D1598



Pipe test specimen per ASTM D1598 for "Time-to-Failure of Plastic Pipe Under Long-Term Hydrostatic Pressure"

SYSTEMS ENGINEERING DATA FOR THERMOPLASTIC PIPING

The standards for plastic pipe, using the 0.5 service factor, require that the pressure rating of the pipe be based upon this hydrostatic design stress, again calculated with the ISO equation.

While early experience indicated that this service factor, or multiplier, of 0.5 provided adequate safety for many if not most uses, some experts felt that a more conservative service factor of 0.4 would better compensate for water hammer pressure surges, as well as for slight manufacturing variations and damage suffered during installation.

The PPI has issued a policy statement officially recommending this 0.4 service factor. This is equivalent to recommending that the pressure rating of the pipe should equal 1.25 times the system design pressure for any particular installation. Based upon this policy, many thousands of miles of thermoplastic pipe have been installed in the United States without failure.

It is best to consider the actual surge conditions, as outlined later in this section. In addition, substantial reductions in working pressure are advisable when handling aggressive chemical solutions and in high-temperature service.

Numerical relationships for service factors and design stresses of PVC are shown in Table 9.

Table 9
SERVICE FACTORS AND HYDROSTATIC DESIGN STRESS
(Hydrostatic design basis equals 4000 PSI)

SERVICE FACTOR	HDS
0.5	2000 psi (13.8 MPa)
0.4	1600 psi (11 MPa)

Material: PVC Type I & CPVC

TEMPERATURE-PRESSURE AND MODULUS RELATIONSHIPS

Temperature Derating

Pressure ratings for thermoplastic pipe are generally determined in a water medium at room temperature (73°F). As the system temperature increases, the thermoplastic pipe becomes more ductile, increases in impact strength, and decreases in tensile strength. The pressure ratings of thermoplastic pipe must therefore be decreased accordingly.

The effects of temperature have been exhaustively studied and correction (derating) factors developed for each thermoplastic piping compound. **To determine the maximum operating pressure at any given temperature, multiply the pressure rating at ambient shown in Table 10 by the temperature correction factor for that material shown in Table 11. Attention must also be given to the pressure rating of the joining technique, i.e., threaded system normally reduces pressure capabilities substantially.**

Table 10
MAXIMUM OPERATING PRESSURES (PSI) AT 73°F AMBIENT
BASED UPON A SERVICE FACTOR OF .5

NOMINAL SIZE	PVC & CPVC SCHEDULE 40 SOLVENT WELD	PVC & CPVC SCHEDULE 80 SOLVENT WELD	PVC & CPVC SCHEDULE 80 THREADED	POLYPROPYLENE*(PP) PPRO-SEAL	POLYPROPYLENE*(PP) PROLINE SDR 11	POLYPROPYLENE*(PP) PROLINE SDR 32	PVDF SUPER PROLINE SDR 11	PVDF SUPER PROLINE SDR 32	PVDF SCHEDULE 80 SOCKET FUSION	PVDF SCHEDULE 80 THREADED
1/4	780	1130	—-	N/A	N/A	N/A	N/A	N/A	N/A	N/A
3/8	620	920	—-	N/A	N/A	N/A	N/A	N/A	N/A	N/A
1/2	600	850	420	150	160	45	230	N/A	975	290
3/4	480	690	340	150	160	45	230	N/A	790	235
1	450	630	320	150	160	45	230	N/A	725	215
1-1/4	370	520	260	N/A	160	45	230	N/A	600	180
1-1/2	330	471	240	150	160	45	230	N/A	540	160
2	280	400	200	150	160	45	230	N/A	465	135
2-1/2	300	425	210**	N/A	160	45	N/A	160	N/A	N/R
3	260	375	190**	N/A	160	45	N/A	160	430	N/R
4	220	324	160**	N/A	160	45	N/A	160	370	N/R
6	180	280	N/R	N/A	160	45	N/A	160	N/A	N/R
8	160	250	N/R	N/A	160	45	N/A	160	N/A	N/A
10	140	230	N/R	N/A	160	45	N/A	160	N/A	N/A
12	130	230	N/R	N/A	160	45	N/A	160	N/A	N/A

—- = Data not available at printing; N/R = Not Recommended; N/A = Not Available (not manufactured)
* Threaded Polypropylene is not recommended for pressure applications and Fuseal drainage systems are not pressure rated.
**For threaded joints properly backwelded.
NOTE: The pressure ratings in this chart are based on water and are for pipe and fittings only. Systems that include valves, flanges, or other weaker items will require derating the entire system.

SYSTEMS ENGINEERING DATA FOR THERMOPLASTIC PIPING

Table 11
TEMPERATURE CORRECTION FACTORS

OPERATING TEMPERATURES °F	FACTORS					
	PVC	CPVC	POLYPROPYLENE		POLYVINYLIDENE FLUORIDE	
			PPRO-SEAL NATURAL	PROLINE	SUPER PROLINE	SCHEDULE 80
73	1.00	1.00	1.00	1.00	1.00	1.00
80	.88	.94	.93		.95	.93
90	.75	.86	.83		.87	.87
100	.62	.78	.74	.64	.80	.82
110	.50	.71	.66			.76
120	.40	.64	.58		.68	.71
130	.30	.57	.51			.65
140	.22	.50	.40	.40	.58	.61
150	N/R	.43	.38			.57
160	N/R	.37	.35		.49	.54
180	N/R	.25	.23	.28	.42	.47
200	N/R	.18	.14	.10	.36	.41
210	N/R	.16	.10	N/R		.38
220	N/R	N/R	N/R	N/R		.35
240	N/R	N/R	N/R	N/R	.25	
250	N/R	N/R	N/R	N/R		.28
280	N/R	N/R	N/R	N/R	.18	.22

FLANGED SYSTEMS

FLANGED SYSTEMS
Maximum pressure for any flanged system is 150 psi. At elevated temperatures the pressure capability of a flanged system must be derated as shown in Table 12.

Design Pressure - Pressure rating at 73°F x temperature correction factor.

Table 12 - MAXIMUM OPERATING PRESSURE (PSI) FOR FLANGED SYSTEMS

OPERATING TEMPERATURE °F	PVC*	CPVC*	PP**	PVDF
100	150	150	150	150
110	135	145	140	150
120	110	135	130	150
130	75	125	118	150
140	50	110	105	150
150	N/R	100	93	140
160	N/R	90	80	133
170	N/R	80	70	125
180	N/R	70	50	115
190	N/R	60	N/R	106
200	N/R	50	N/R	97
210	N/R	40	N/R	90
240	N/R	N/R	N/R	60
280	N/R	N/R	N/R	25

N/R = Not Recommended
* PVC and CPVC flanges sizes 2-1/2 through 3-/and 4-inch threaded must be backwelded for the above pressure capability to be applicable.
** Threaded PP flanges size 1/2 through 4 inch as well as the 6” back welded socket flange are not recommended for pressure applications (drainage only).

PRESSURE RATINGS

PVC LARGE DIAMETER FABRICATED FITTINGS AT 73°F 10" THROUGH 24"

The following tables indicate the working pressure recommended by the manufacturer for large diameter PVC fabricated fittings. These fittings are not generally recommended for high pressure applications. Pressure capabilities are not necessarily the same as the rating of the pipe from which they are fabricated. Be sure pressure to temperature correction factors are considered when system design calls for temperatures above 73°F.

Water hammer and surge pressure are the two most critical elements in large-diameter design. Keeping velocities below 5 feet per second and working pressures to these guidelines will give years of trouble-free service.

Table 13
90° ELBOW

NOMINAL SIZE (IN.)	SCHEDULE 40		SCHEDULE 80	
	WT. (LBS.)	PSI RTG	WT. (LBS.)	PSI RTG
10	22	140	34	230
12	30	130	50	230
14	40	130	70	220
16	56	130	100	220
18	90	100	93	125
20	121	50	125	75
24	202	50	208	75

Table 14
COUPLING

NOMINAL SIZE (IN.)	SCHEDULE 40		SCHEDULE 80	
	WT. (LBS.)	PSI RTG	WT. (LBS.)	PSI RTG
10	9	140	15	230
12	15	130	23	230
14	19	130	33	220
16	29	130	54	220
18	33	100	53	160
20	45	50	74	75
24	77	50	110	75

Table 15
TEE

NOMINAL SIZE (IN.)	SCHEDULE 40		SCHEDULE 80	
	WT. (LBS.)	PSI RTG	WT. (LBS.)	PSI RTG
10	28	140	44	230
12	41	130	69	230
14	54	130	95	220
16	78	130	139	220
18	115	100	156	160
20	153	50	204	75
24	231	50	338	75

Table 16
45° ELBOW

NOMINAL SIZE (IN.)	SCHEDULE 40		SCHEDULE 80	
	WT. (LBS.)	PSI RTG	WT. (LBS.)	PSI RTG
10	15	140	24	230
12	21	130	36	230
14	30	130	52	220
16	42	130	75	220
18	47	100	71	160
20	62	50	95	75
24	103	50	159	75

Table 17
REDUCING TEE

NOMINAL SIZE (IN.)	SCHEDULE 40		SCHEDULE 80	
	WT. (LBS.)	PSI RTG	WT. (LBS.)	PSI RTG
10 x 8	23	140	32	230
10 x 6	21	140	30	230
10 x 4	18	140	28	230
12 x 10	32	130	55	220
12 x 8	30	130	49	220
12 x 6	26	130	47	220
12 x 4	24	130	45	220
14 x 12	46	100	70	160
14 x 10	39	100	66	160
14 x 8	36	100	59	160
16 x 14	68	100	118	160
16 x 12	61	100	105	160
16 x 10	54	100	90	160
16 x 8	49	100	82	160
18 x 16	82	100	132	160
18 x 14	73	100	116	160
20 x 18	104	75	160	100
20 x 16	98	75	156	100
24 x 20	162	50	251	75

PRESSURE RATINGS

PVC LARGE DIAMETER FABRICATED FITTINGS AT 73°F 10" THROUGH 24"

Table 18
CONCENTRIC REDUCER

NOMINAL SIZE (IN.)	SCHEDULE 40	
	WT. (LBS.)	PSI RTG
10 x 8	9	140
10 x 6	22	140
10 x 4	23	140
12 x 10	15	130
12 x 8	31	130
12 x 6	34	130
14 x1 2	23	130
14 x 10	36	130
16 x 14	32	130
16 x 12	54	130
18 x 16	46	100
20 x 18	45	100
24 x 20	87	100

Table 19
BUSHING (SPIG x SOC)

NOMINAL SIZE (IN.)	SCHEDULE 40	
	WT. (LBS.)	PSI RTG
10 x 8	11	140
10 x 6	16	140
10 x 4	20	140
12 x 10	15	130
12 x 8	26	130
12 x 6	31	130
14 x 12	24	100
16 x 14	22	100
16 x 12	46	100
16 x 10	61	100
16 x 8	72	100
18 x 16	30	100
20 x 18	33	100
24 x 20	55	100

Table 20
EXTENDED BUSHING

NOMINAL SIZE (IN.)	SCHEDULE 40	
	WT. (LBS.)	PSI RTG
10 x 8	11	140
12 x 10	19	130
14 x 12	28	130
16 x 14	38	130

Table 21
MALE ADAPTOR

NOMINAL SIZE (IN.)	SCHEDULE 40	
	WT. (LBS.)	PSI RTG
6	6	25
8	7	25
10	8	25
12	14	25

Table 22
FEMALE ADAPTOR

NOMINAL SIZE (IN.)	SCHEDULE 40	
	WT. (LBS.)	PSI RTG
6	6	25
8	7	25
10	8	25
12	14	25

PRESSURE RATINGS

PVC LARGE DIAMETER FABRICATED FITTINGS AT 73°F

Table 23
CROSS

NOMINAL SIZE (IN.)	SCHEDULE 40		SCHEDULE 80	
	WT. (LBS.)	PSI RTG	WT. (LBS.)	PSI RTG
3	2	240	5	260
4	3	220	7	240
6	13	160	22	240
8	22	160	30	240
10	38	140	62	230
12	58	130	95	230
14	74	130	129	220
16	107	130	190	220
18	117	100	185	160
20	158	50	247	75
24	267	50	413	75

Table 24
FLANGE (BLIND)

NOMINAL SIZE (IN.)	SCHEDULE 40		SCHEDULE 80	
	WT. (LBS.)	PSI RTG	WT. (LBS.)	PSI RTG
10	16	25	32	75
12	21	25	42	75
14	26	25	52	75
16	33	25	66	75
18	36	25	72	75
20	44	25	88	75
24	57	25	114	75

Table 25
CAP

NOMINAL SIZE (IN.)	SCHEDULE 40		SCHEDULE 80	
	WT. (LBS.)	PSI RTG	WT. (LBS.)	PSI RTG
10	5	140	14	230
12	7	130	17	230
14	23	130	35	220
16	32	130	49	220
18	38	100	54	160
20	49	50	69	75
24	74	50	108	75

Table 26
IPS PIPE DIMENSION TABLE

NOMINAL PIPE SIZE (IN.)	O.D.	SCHEDULE 40		SCHEDULE 80	
		AVERAGE I.D.	MINIMUM WALL	AVERAGE I.D.	MINIMUM WALL
1	1.315	1.033	.133	.935	.179
1-1/4	1.660	1.364	.140	1.256	.191
1-1/2	1.900	1.592	.145	1.476	.200
2	2.375	2.049	.154	1.913	.218
3	3.500	3.042	.216	2.864	.300
4	4.500	3.998	.237	3.786	.337
5	5.563	5.047	.258	4.813	.375
6	6.625	6.013	.280	5.709	.432
8	8.625	7.943	.322	7.565	.500
10	10.750	9.976	.365	9.492	.593
12	12.750	11.890	.406	11.294	.687
14	14.000	13.126	.437	12.440	.780
16	16.000	15.000	.500	14.200	.900
CLASS 100				CLASS 160	
18	18.000	17.120	.440	16.614	.693
20	20.000	19.022	.489	18.460	.770
24	24.000	22.870	.585	22.152	.924

SYSTEMS ENGINEERING DATA
FOR THERMOPLASTIC PIPING

Table 27

MODULUS OF ELASTICITY ($x10^5$) PSI VS. TEMPERATURE

MATERIAL	TEMPERATURE, °F								
	73	90	110	140	170	200	210	250	280
PVC	4.20	3.85	3.40	3.00	—-	—-	—-	—-	—-
CPVC	4.23	4.10	3.70	3.27	2.93	2.40	2.26	—-	—-
PP Fuseal	2.00	1.30	.097	.074	0.61	0.55	0.53	—-	—-
PP Pressure	1.50	1.34	1.18	0.96	0.77	0.59	0.53	—-	—-
PVDF	2.13	1.66	1.37	1.04	0.80	0.61	0.55	0.37	0.29

EXTERNAL PRESSURES - COLLAPSE RATING

Thermoplastic pipe is frequently specified for situations where uniform external pressures are applied to the pipe, such as in underwater applications. In these applications, the collapse rating of the pipe determines the maximum permissible pressure differential between external and internal pressures. The basic formulas for collapsing external pressure applied uniformly to a long pipe are:

1. For thick wall pipe where collapse is caused by compression and failure of the pipe material:

$$Pc = \frac{o}{2Do^2}(Do^2 - Di^2)$$

2. For thin wall pipe where collapse is caused by elastic instability of the pipe wall:

$$Pc = \frac{2cE}{1-v^2}\left(\frac{t}{Dm}\right)^3$$

Where:

Pc = Collapse Pressure (external minus internal pressure), psi
o = Compressive Strength, psi
E = Modulus of elasticity, psi
v = Poisson's Ratio
Do = Outside Pipe Diameter, in.
Dm = Mean Pipe Diameter, in.
Di = Inside Pipe Diameter, in.
t = Wall Thickness, in.
c = Out-of-Roundness Factor, Approximately 0.66

Choice of Formula - By using formula 2 on thick-wall pipe, an excessively large pressure will be obtained. It is therefore necessary to calculate, for a given pipe size, the collapse pressure using both formulas and use the lower value as a guide to safe working pressure. For short-term loading conditions, the values of E, o and v from the relative properties charts shown on pages 40-41 will yield reasonable results. See individual materials charts for short-term collapse pressures at 73°F. For long-term loading conditions, appropriate long-term data should be used.

SHORT-TERM COLLAPSE PRESSURE

Thermoplastic pipe is often used for suction lines or in applications where external pressures are applied to the pipe, such as in heat exchangers, or underwater loading conditions. The differential pressure rating of the pipe between the internal and external pressures is detemined by derating collapse pressures of the pipe. The differential pressure rating of the pipe is determined by derating the short-term collapse pressures shown in Table 28.

Collapse pressures must be adjusted for temperatures other than for room temperature. The pressure temperature correction chart (Table 28) used to adjust pipe pressure ratings may be used for this purpose. (See note below table).

Table 28

SHORT-TERM COLLAPSE PRESSURE IN PSI AT 73°F

	1/2	3/4	1	1-1/4	1-1/2	2	3	4	6	8	10	12
SCHEDULE 40 PVC	2095	1108	900	494	356	211	180	109	54	39	27	22
SCHEDULE 80 PVC	2772	2403	2258	1389	927	632	521	335	215	147	126	117
SCHEDULE 80 CPVC - IPS	2772	2403	2258	1389	927	632	521	335	215	147	126	117
SCHEDULE 80 PRESSURE POLYPROPYLENE - IPS	1011	876	823	612	412	278	229	147	94	65	55	51
SCHEDULE 80 PVDF - IPS	2936	1576	1205	680	464	309	255	164	105	72	61	57
PROLINE PRO 150	40	40	40	40	40	40	40	40	40	40	40	40
PROLINE PRO 45	1.6	1.6	1.6	1.6	1.6	1.6	1.6	1.6	1.6	1.6	1.6	1.6
SUPER PROLINE	202	99	92	44	41	22	5.8	5.8	5.8	5.8	5.8	5.8

NOTE: These are short-term ratings; long-term ratings should be reduced by 1/3 to 1/2 of the short-term ratings.

Vacuum Service - All sizes of Schedule 80 thermoplastic pipe are suitable for vacuum service up to 140°F and 30 inches of mercury. Solvent-cemented joints are recommended for vacuum applications when using PVC. Schedule 40 PVC will handle full vacuum up to 24" diameter.

Laboratory tests have been conducted on Schedule 80 PVC pipe to determine performance under vacuum at temperatures above recommended operating conditions. Pipe sizes under 6 inches show no deformation at temperatures to 170°F and 27 inches of mercury vacuum.

The 6 inch pipe showed slight deformation at 165°F, and 20 inches of mercury. Above this temperature, failure occurred due to thread deformation.

TABLE 29

CARRYING CAPACITY AND FRICTION LOSS FOR SCHEDULE 80 THERMOPLASTIC PIPE

(Independent variables: Gallons per minute and nominal pipe size O.D.

Dependent variables: Velocity, friction head and pressure drop per 100 feet of pipe, interior smooth .)

GALLONS PER MINUTE	VELOCITY FEET PER SECOND	FRICTION HEAD FEET	FRICTION LOSS POUNDS PER SQUARE INCH	VELOCITY FEET PER SECOND	FRICTION HEAD FEET	FRICTION LOSS POUNDS PER SQUARE INCH	VELOCITY FEET PER SECOND	FRICTION HEAD FEET	FRICTION LOSS POUNDS PER SQUARE INCH	VELOCITY FEET PER SECOND	FRICTION HEAD FEET	FRICTION LOSS POUNDS PER SQUARE INCH	VELOCITY FEET PER SECOND	FRICTION HEAD FEET	FRICTION LOSS POUNDS PER SQUARE INCH	VELOCITY FEET PER SECOND	FRICTION HEAD FEET	FRICTION LOSS POUNDS PER SQUARE INCH	VELOCITY FEET PER SECOND	FRICTION HEAD FEET	FRICTION LOSS POUNDS PER SQUARE INCH	VELOCITY FEET PER SECOND	FRICTION HEAD FEET	FRICTION LOSS POUNDS PER SQUARE INCH
	1/2 IN.			3/4 IN.			1 IN.			1-1/4 IN.			1-1/2 IN.			2 IN.			2-1/2 IN.			3 IN.		
1	1.48	4.02	1.74	0.74	0.86	0.37																		
2	2.95	8.03	3.48	1.57	1.72	0.74	0.94	0.88	0.38	0.52	0.21	0.09	0.38	0.10	0.041									
5	7.39	45.23	19.59	3.92	9.67	4.19	2.34	2.75	1.19	1.30	0.66	0.29	0.94	0.30	0.126	0.56	0.10	0.040	0.39	0.05	0.022	0.25	0.02	0.009
7	10.34	83.07	35.97	5.49	17.76	7.69	3.28	5.04	2.19	1.82	1.21	0.53	1.32	0.55	0.24	0.78	0.15	0.065	0.54	0.07	0.032	0.35	0.028	0.012
10				7.84	33.84	14.65	4.68	9.61	4.16	2.60	2.30	1.00	1.88	1.04	0.45	1.12	0.29	0.13	0.78	0.12	0.052	0.50	0.04	0.017
15	4 IN.			11.76	71.70	31.05	7.01	20.36	8.82	3.90	4.87	2.11	2.81	2.20	0.95	1.68	0.62	0.27	1.17	0.26	0.11	0.75	0.09	0.039
20	0.57	0.04	0.017				9.35	34.68	15.02	5.20	8.30	3.59	3.75	3.75	1.62	2.23	1.06	0.46	1.56	0.44	0.19	1.00	0.15	0.065
25	0.72	0.06	0.026	5 IN.			11.69	52.43	22.70	6.50	12.55	5.43	4.69	5.67	2.46	2.79	1.60	0.69	1.95	0.67	0.29	1.25	0.22	0.095
30	0.86	0.08	0.035	0.54	0.03	0.013	14.03	73.48	31.82	7.80	17.59	7.62	5.63	7.95	3.44	3.35	2.25	0.97	2.34	0.94	0.41	1.49	0.31	0.13
35	1.00	0.11	0.048	0.63	0.04	0.017				9.10	23.40	10.13	6.57	10.58	4.58	3.91	2.99	1.29	2.73	1.25	0.54	1.74	0.42	0.18
40	1.15	0.14	0.061	0.72	0.04	0.017				10.40	29.97	12.98	7.50	13.55	5.87	4.47	3.83	1.66	3.12	1.60	0.69	1.99	0.54	0.23
45	1.29	0.17	0.074	0.81	0.06	0.026	6 IN.			11.70	37.27	16.14	8.44	16.85	7.30	5.03	4.76	2.07	3.51	1.99	0.86	2.24	0.67	0.29
50	1.43	0.21	0.091	0.90	0.07	0.030	0.63	0.03	0.013	13.00	45.30	19.61	9.38	20.48	8.87	5.58	5.79	2.51	3.90	2.42	1.05	2.49	0.81	0.35
60	1.72	0.30	0.13	1.08	0.10	0.043	0.75	0.04	0.017				11.26	28.70	12.43	6.70	8.12	3.52	4.68	3.39	1.47	2.99	1.14	0.49
70	2.01	0.39	0.17	1.26	0.13	0.056	0.88	0.05	0.022							7.82	10.80	4.68	5.46	4.51	1.95	3.49	1.51	0.65
75	2.15	0.45	0.19	1.35	0.14	0.061	0.94	0.06	0.026							8.38	12.27	5.31	5.85	5.12	2.22	3.74	1.72	0.74
80	2.29	0.50	0.22	1.44	0.16	0.069	1.00	0.07	0.030							8.93	13.83	5.99	6.24	5.77	2.50	3.99	1.94	0.84
90	2.58	0.63	0.27	1.62	0.20	0.087	1.13	0.08	0.035	8 IN.						10.05	17.20	7.45	7.02	7.18	3.11	4.48	2.41	1.04
100	2.87	0.76	0.33	1.80	0.24	0.10	1.25	0.10	0.043							11.17	20.90	9.05	7.80	8.72	3.78	4.98	2.93	1.27
125	3.59	1.16	0.50	2.25	0.37	0.16	1.57	0.16	0.068	0.90	0.045	0.019							9.75	13.21	5.72	6.23	4.43	1.92
150	4.30	1.61	0.70	2.70	0.52	0.23	1.88	0.22	0.095	1.07	0.05	0.022	10 IN.						11.70	18.48	8.00	7.47	6.20	2.68
175	5.02	2.15	0.93	3.15	0.69	0.30	2.20	0.29	0.12	1.25	0.075	0.033										8.72	8.26	3.58
200	5.73	2.75	1.19	3.60	0.88	0.38	2.51	0.37	0.16	1.43	0.09	0.039	0.90	0.036	0.015							9.97	10.57	4.58
250	7.16	4.16	1.81	4.50	1.34	0.58	3.14	0.56	0.24	1.79	0.14	0.61	1.14	0.045	0.02	12 IN.						12.46	16.00	6.93
300	8.60	5.83	2.52	5.40	1.87	0.81	3.76	0.78	0.34	2.14	0.20	0.087	1.36	0.07	0.03									
350	10.03	7.76	3.36	6.30	2.49	1.08	4.39	1.04	0.45	2.50	0.27	0.12	1.59	0.085	0.037	1.12	0.037	0.016						
400	11.47	9.93	4.30	7.19	3.19	1.38	5.02	1.33	0.58	2.86	0.34	0.15	1.81	0.11	0.048	1.28	0.05	0.022						
450				8.09	3.97	1.72	5.64	1.65	0.71	3.21	0.42	0.18	2.04	0.14	0.061	1.44	0.06	0.026						
500				8.99	4.82	2.09	6.27	2.00	0.87	3.57	0.51	0.22	2.27	0.17	0.074	1.60	0.07	0.030						
750							9.40	4.25	1.84	5.36	1.08	0.47	3.40	0.36	0.16	2.40	0.15	0.065						
1000							12.54	7.23	3.13	7.14	1.84	0.80	4.54	0.61	0.26	3.20	0.26	0.11						
1250										8.93	2.78	1.20	5.67	0.92	0.40	4.01	0.40	0.17						
1500										10.71	3.89	1.68	6.80	1.29	0.56	4.81	0.55	0.24						
2000													9.07	2.19	0.95	6.41	0.94	0.41						
2500													11.34	3.33	1.44	8.01	1.42	0.62						
3000																9.61	1.99	0.86						
3500																11.21	2.65	1.15						
4000																12.82	3.41	1.48						

CARRYING CAPACITY AND FRICTION LOSS FOR SCHEDULE 40 THERMOPLASTIC PIPE

(Independent variables: Gallons per minute and nominal pipe size O.D.

Dependent variables: Velocity, friction head and pressure drop per 100 feet of pipe, interior smooth .)

GALLONS PER MINUTE	VELOCITY FEET PER SECOND	FRICTION HEAD FEET	FRICTION LOSS POUNDS PER SQUARE INCH	VELOCITY FEET PER SECOND	FRICTION HEAD FEET	FRICTION LOSS POUNDS PER SQUARE INCH	VELOCITY FEET PER SECOND	FRICTION HEAD FEET	FRICTION LOSS POUNDS PER SQUARE INCH	VELOCITY FEET PER SECOND	FRICTION HEAD FEET	FRICTION LOSS POUNDS PER SQUARE INCH	VELOCITY FEET PER SECOND	FRICTION HEAD FEET	FRICTION LOSS POUNDS PER SQUARE INCH	VELOCITY FEET PER SECOND	FRICTION HEAD FEET	FRICTION LOSS POUNDS PER SQUARE INCH	VELOCITY FEET PER SECOND	FRICTION HEAD FEET	FRICTION LOSS POUNDS PER SQUARE INCH	VELOCITY FEET PER SECOND	FRICTION HEAD FEET	FRICTION LOSS POUNDS PER SQUARE INCH
	1/2 IN.			3/4 IN.			1 IN.			1-1/4 IN.			1-1/2 IN.			2 IN.			2-1/2 IN.			3 IN.		
1	1.13	2.08	0.90	0.63	0.51	0.22																		
2	2.26	4.16	1.80	1.26	1.02	0.44	0.77	0.55	0.24	0.44	0.14	0.06	0.33	0.07	0.03									
5	5.64	23.44	10.15	3.16	5.73	2.48	1.93	1.72	0.75	1.11	0.44	0.19	0.81	0.22	0.09	0.49	0.066	0.029	0.30	0.038	0.016	0.22	0.015	0.007
7	7.90	43.06	13.64	4.43	10.52	4.56	2.72	3.17	1.37	1.55	0.81	0.35	1.13	0.38	0.17	0.69	0.11	0.048	0.49	0.051	0.023	0.31	0.021	0.009
10	11.28	82.02	35.51	6.32	20.04	8.68	3.86	6.02	2.61	2.21	1.55	0.67	1.62	0.72	0.31	0.98	0.21	0.091	0.68	0.09	0.039	0.44	0.03	0.013
15	4 IN.			9.48	42.46	18.39	5.79	12.77	5.53	3.31	3.28	1.42	2.42	1.53	0.66	1.46	0.45	0.19	1.03	0.19	0.082	0.66	0.07	0.030
20	0.51	0.03	0.013	12.65	72.34	31.32	7.72	21.75	9.42	4.42	5.59	2.42	3.23	2.61	1.13	1.95	0.76	0.33	1.37	0.32	0.14	0.88	0.11	0.048
25	0.64	0.04	0.017	5 IN.			9.65	32.88	14.22	5.52	8.45	3.66	4.04	3.95	1.71	2.44	1.15	0.50	1.71	0.49	0.21	1.10	0.17	0.074
30	0.77	0.06	0.026	0.49	0.02	0.009	11.58	46.08	19.95	6.63	11.85	5.13	4.85	5.53	2.39	2.93	1.62	0.70	2.05	0.68	0.29	1.33	0.23	0.10
35	0.89	0.08	0.035	0.57	0.03	0.013				7.73	15.76	6.82	5.66	7.36	3.19	3.41	2.15	0.93	2.39	0.91	0.39	1.55	0.31	0.13
40	1.02	0.11	0.048	0.65	0.03	0.013				8.84	20.18	8.74	6.47	9.43	4.08	3.90	2.75	1.19	2.73	1.16	0.50	1.77	0.40	0.17
45	1.15	0.13	0.056	0.73	0.04	0.017	6 IN.			9.94	25.10	10.87	7.27	11.73	5.08	4.39	3.43	1.49	3.08	1.44	0.62	1.99	0.50	0.22
50	1.28	0.16	0.069	0.81	0.05	0.022	0.56	0.02	0.009	11.05	30.51	13.21	8.08	14.25	6.17	4.88	4.16	1.80	3.42	1.75	0.76	2.21	0.60	0.26
60	1.53	0.22	0.095	0.97	0.07	0.030	0.67	0.03	0.013				9.70	19.98	8.65	5.85	5.84	2.53	4.10	2.46	1.07	2.65	0.85	0.37
70	1.79	0.30	0.13	1.14	0.10	0.043	0.79	0.04	0.017							6.83	7.76	3.36	4.79	3.27	1.42	3.09	1.13	0.49
75	1.92	0.34	0.15	1.22	0.11	0.048	0.84	0.05	0.022							7.32	8.82	3.82	5.13	3.71	1.61	3.31	1.28	0.55
80	2.05	0.38	0.16	1.30	0.13	0.056	0.90	0.05	0.022	8 IN.						7.80	9.94	4.30	5.47	4.19	1.81	3.53	1.44	0.62
90	2.30	0.47	0.20	1.46	0.16	0.069	1.01	0.06	0.026							8.78	12.37	5.36	6.15	5.21	2.26	3.98	1.80	0.78
100	2.56	0.58	0.25	1.62	0.19	0.082	1.12	0.08	0.035	0.65	0.03	0.012				9.75	15.03	6.51	6.84	6.33	2.74	4.42	2.18	0.94
125	3.20	0.88	0.38	2.03	0.29	0.125	1.41	0.12	0.052	0.81	0.035	0.015							8.55	9.58	4.15	5.52	3.31	1.43
150	3.84	1.22	0.53	2.44	0.40	0.17	1.69	0.16	0.069	0.97	0.04	0.017	10 IN.						10.26	13.41	5.81	6.63	4.63	2.00
175	4.48	1.63	0.71	2.84	0.54	0.235	1.97	0.22	0.096	1.14	0.055	0.024										7.73	6.16	2.67
200	5.11	2.08	0.90	3.25	0.69	0.30	2.25	0.28	0.12	1.30	0.07	0.030	0.82	0.027	0.012							8.83	7.88	3.41
250	6.40	3.15	1.36	4.06	1.05	0.45	2.81	0.43	0.19	1.63	0.11	0.048	1.03	0.035	0.015	12 IN.						11.04	11.93	5.17
300	7.67	4.41	1.91	4.87	1.46	0.63	3.37	0.60	0.26	1.94	0.16	0.069	1.23	0.05	0.022									
350	8.95	5.87	2.55	5.69	1.95	0.85	3.94	0.79	0.34	2.27	0.21	0.091	1.44	0.065	0.028	1.01	0.027	0.012						
400	10.23	7.52	3.26	6.50	2.49	1.08	4.49	1.01	0.44	2.59	0.27	0.12	1.64	0.09	0.039	1.16	0.04	0.017						
450				7.31	3.09	1.34	5.06	1.26	0.55	2.92	0.33	0.14	1.85	0.11	0.048	1.30	0.05	0.022						
500				8.12	3.76	1.63	5.62	1.53	0.66	3.24	0.40	0.17	2.05	0.13	0.056	1.45	0.06	0.026						
750							8.43	3.25	1.41	4.86	0.85	0.37	3.08	0.28	0.12	2.17	0.12	0.052						
1000							11.24	5.54	2.40	6.48	1.45	0.63	4.11	0.48	0.21	2.89	0.20	0.087						
1250										8.11	2.20	0.95	5.14	0.73	0.32	3.62	0.31	0.13						
1500										9.72	3.07	1.33	6.16	1.01	0.44	4.34	0.43	0.19						
2000													8.21	1.72	0.74	5.78	0.73	0.32						
2500													10.27	2.61	1.13	7.23	1.11	0.49						
3000																8.68	1.55	0.67						
3500																10.12	2.07	0.90						
4000																11.07	2.66	1.15						

CARRYING CAPACITY & FRICTION LOSS

TABLE 30

HARRINGTON

FOR SERVICE, PLEASE CALL 1-800-877-HIPCO

CARRYING CAPACITY & FRICTION LOSS

TABLE 31

HARRINGTON

CARRYING CAPACITY AND FRICTION LOSS FOR 315 PSI AND SDR 13.5 THERMOPLASTIC PIPE

(Independent variables: Gallons per minute and nominal pipe size O.D.

Dependent variables: Velocity, friction head and pressure drop per 100 feet of pipe, interior smooth .)

GALLONS PER MINUTE	VELOCITY FEET PER SECOND	FRICTION HEAD FEET	FRICTION LOSS POUNDS PER SQUARE INCH	VELOCITY FEET PER SECOND	FRICTION HEAD FEET	FRICTION LOSS POUNDS PER SQUARE INCH	VELOCITY FEET PER SECOND	FRICTION HEAD FEET	FRICTION LOSS POUNDS PER SQUARE INCH	VELOCITY FEET PER SECOND	FRICTION HEAD FEET	FRICTION LOSS POUNDS PER SQUARE INCH	VELOCITY FEET PER SECOND	FRICTION HEAD FEET	FRICTION LOSS POUNDS PER SQUARE INCH	VELOCITY FEET PER SECOND	FRICTION HEAD FEET	FRICTION LOSS POUNDS PER SQUARE INCH	VELOCITY FEET PER SECOND	FRICTION HEAD FEET	FRICTION LOSS POUNDS PER SQUARE INCH	VELOCITY FEET PER SECOND	FRICTION HEAD FEET	FRICTION LOSS POUNDS PER SQUARE INCH
	1/2 IN.			3/4 IN.			1 IN.			1-1/4 IN.			1-1/2 IN.			2 IN.			2-1/2 IN.			3 IN.		
1	0.85	1.03	0.45	0.54	0.34	0.15																		
2	1.69	2.05	0.89	1.07	0.68	0.29	0.68	0.40	0.17	0.42	0.13	0.06	0.32	0.065	0.028	0.20	0.03	0.013						
5	4.22	11.58	5.01	2.68	3.82	1.65	1.69	1.24	0.54	1.05	0.39	0.17	0.80	0.20	0.088	0.51	0.075	0.033	0.35	0.038	0.016	0.24	0.02	0.009
7	5.91	21.24	9.20	3.75	7.01	3.03	2.36	2.28	0.99	1.47	0.72	0.31	1.12	0.37	0.16	0.72	0.125	0.054	0.49	0.053	0.023	0.33	0.03	0.012
10	8.44	40.46	17.52	5.35	13.34	5.78	3.37	4.33	1.87	2.10	1.37	0.59	1.60	0.71	0.31	1.02	0.24	0.10	0.70	0.09	0.039	0.47	0.04	0.017
15	4 IN.			8.03	28.27	12.24	5.06	9.18	3.97	3.15	2.91	1.26	2.40	1.50	0.65	1.53	0.50	0.22	1.04	0.20	0.087	0.70	0.08	0.035
20	0.57	0.04	0.017	10.70	48.17	20.86	6.74	15.64	6.77	4.21	4.96	2.15	3.20	2.55	1.10	2.04	0.85	0.37	1.39	0.34	0.15	0.94	0.13	0.056
25	0.71	0.06	0.026	5 IN.			8.43	23.65	10.24	5.26	7.49	3.24	4.00	3.85	1.67	2.55	1.29	0.56	1.74	0.51	0.22	1.17	0.19	0.082
30	0.85	0.08	0.035	0.56	0.03	0.013	10.11	33.15	14.35	6.31	10.50	4.55	4.80	5.40	2.34	3.06	1.80	0.78	2.09	0.71	0.31	1.41	0.27	0.12
35	0.99	0.11	0.048	0.65	0.04	0.017				7.36	13.97	6.05	5.60	7.19	3.11	3.57	2.40	1.04	2.44	0.95	0.41	1.64	0.36	0.16
40	1.14	0.14	0.060	0.74	0.05	0.022				8.41	17.90	7.75	6.40	9.20	3.98	4.08	3.07	1.33	2.78	1.21	0.52	1.88	0.46	0.20
45	1.28	0.17	0.074	0.84	0.06	0.026	6 IN.			9.46	22.26	9.64	7.20	11.44	4.95	4.59	3.82	1.65	3.13	1.51	0.65	2.11	0.58	0.25
50	1.42	0.21	0.091	0.93	0.07	0.030	0.66	0.03	0.013	10.52	27.05	11.71	8.00	13.91	6.02	5.10	4.64	2.01	3.48	1.83	0.79	2.35	0.70	0.30
60	1.70	0.29	0.13	1.12	0.10	0.043	0.79	0.04	0.017				9.60	19.50	8.44	6.12	6.50	2.81	4.18	2.57	1.11	2.82	0.98	0.42
70	1.99	0.38	0.16	1.30	0.14	0.061	0.92	0.06	0.026							7.14	8.65	3.75	4.87	3.42	1.48	3.29	1.31	0.57
75	2.13	0.44	0.19	1.40	0.16	0.069	0.98	0.07	0.030							7.65	9.83	4.26	5.22	3.88	1.68	3.52	1.49	0.65
80	2.27	0.49	0.21	1.49	0.18	0.078	1.05	0.08	0.035							8.16	11.08	4.80	5.57	4.37	1.89	3.76	1.68	0.73
90	2.56	0.61	0.26	1.67	0.22	0.095	1.18	0.09	0.039							9.18	13.78	5.97	6.27	5.44	2.36	4.23	2.09	0.90
100	2.84	0.74	0.32	1.86	0.27	0.12	1.31	0.11	0.048							10.20	16.75	7.25	6.96	6.61	2.86	4.70	2.54	1.10
125	3.55	1.13	0.49	2.33	0.40	0.18	1.64	0.17	0.074										8.70	10.01	4.33	5.88	3.84	1.66
150	4.26	1.58	0.68	2.79	0.56	0.24	1.97	0.24	0.10										10.44	14.01	6.07	7.04	5.37	2.33
175	4.97	2.10	0.91	3.26	0.75	0.33	2.30	0.32	0.14													8.22	7.15	3.10
200	5.68	2.69	1.16	3.72	0.96	0.42	2.62	0.41	0.18													9.39	9.15	3.96
250	7.10	4.07	1.76	4.66	1.46	0.63	3.28	0.62	0.27													11.74	13.86	6.00
300	8.52	5.69	2.46	5.58	2.03	0.88	3.93	0.87	0.38															
350	9.94	7.58	3.29	6.52	2.70	1.17	4.59	1.16	0.50															
400	11.36	9.70	4.20	7.44	3.46	1.50	5.24	1.48	0.64															
450				8.37	4.31	1.87	5.90	1.84	0.80															
500				9.30	5.24	2.27	6.56	2.23	0.97															
750							9.83	4.73	2.05															
1000							13.11	8.06	3.49															

CARRYING CAPACITY AND FRICTION LOSS FOR 200 PSI AND SDR 21 THERMOPLASTIC PIPE

(Independent variables: Gallons per minute and nominal pipe size O.D.
Dependent variables: Velocity, friction head and pressure drop per 100 feet of pipe, interior smooth .)

GALLONS PER MINUTE	VELOCITY FEET PER SECOND	FRICTION HEAD FEET	FRICTION LOSS POUNDS PER SQUARE INCH	VELOCITY FEET PER SECOND	FRICTION HEAD FEET	FRICTION LOSS POUNDS PER SQUARE INCH	VELOCITY FEET PER SECOND	FRICTION HEAD FEET	FRICTION LOSS POUNDS PER SQUARE INCH	VELOCITY FEET PER SECOND	FRICTION HEAD FEET	FRICTION LOSS POUNDS PER SQUARE INCH	VELOCITY FEET PER SECOND	FRICTION HEAD FEET	FRICTION LOSS POUNDS PER SQUARE INCH	VELOCITY FEET PER SECOND	FRICTION HEAD FEET	FRICTION LOSS POUNDS PER SQUARE INCH	VELOCITY FEET PER SECOND	FRICTION HEAD FEET	FRICTION LOSS POUNDS PER SQUARE INCH	VELOCITY FEET PER SECOND	FRICTION HEAD FEET	FRICTION LOSS POUNDS PER SQUARE INCH
	1/2 IN.			3/4 IN.			1 IN.			1-1/4 IN.			1-1/2 IN.			2 IN.			2-1/2 IN.			3 IN.		
1	0.84	1.00	0.44	0.50	0.28	0.12																		
2	1.67	2.00	0.87	0.99	0.56	0.24	0.60	0.30	0.13	0.37	0.095	0.04	0.29	0.05	0.022	0.18	0.023	0.010						
5	4.17	11.25	4.87	2.47	3.14	1.36	1.50	0.93	0.41	0.93	0.30	0.13	0.71	0.15	0.065	0.45	0.06	0.025	0.31	0.031	0.014	0.20	0.015	0.006
7	5.84	20.66	8.95	3.46	5.76	2.49	2.09	1.70	0.74	1.31	0.54	0.23	0.99	0.28	0.12	0.63	0.081	0.035	0.43	0.044	0.020	0.29	0.021	0.009
10	8.34	39.34	17.03	4.94	10.96	4.75	2.99	3.24	1.40	1.86	1.02	0.44	1.41	0.52	0.23	0.90	0.17	0.074	0.61	0.07	0.03	0.41	0.03	0.013
15	4 IN.			7.40	23.23	10.06	4.49	6.86	2.97	2.79	2.16	0.94	2.12	1.11	0.48	1.35	0.37	0.16	0.92	0.14	0.061	0.62	0.06	0.026
20	0.50	0.03	0.013	9.87	39.57	17.13	5.98	11.68	5.06	3.72	3.68	1.59	2.83	1.89	0.82	1.80	0.63	0.27	1.23	0.25	0.11	0.83	0.09	0.039
25	0.62	0.04	0.017	5 IN.			7.48	17.66	7.65	4.65	5.56	2.41	3.54	2.85	1.23	2.25	0.95	0.41	1.53	0.37	0.16	1.03	0.14	0.061
30	0.75	0.06	0.026	0.49	0.02	0.009	8.97	24.76	10.72	5.58	7.80	3.38	4.24	4.00	1.73	2.71	1.34	0.58	1.84	0.52	0.23	1.24	0.20	0.087
35	0.87	0.08	0.035	0.57	0.03	0.013	10.47	32.94	14.26	6.51	10.37	4.49	4.95	5.32	2.30	3.16	1.78	0.77	2.15	0.70	0.30	1.45	0.27	0.12
40	1.00	0.10	0.043	0.65	0.04	0.017				7.44	13.28	5.75	5.66	6.81	2.95	3.61	2.27	0.98	2.45	0.89	0.39	1.65	0.34	0.15
45	1.12	0.12	0.052	0.74	0.04	0.017	6 IN.			8.37	16.52	7.15	6.36	8.47	3.67	4.06	2.83	1.23	2.76	1.11	0.48	1.86	0.42	0.18
50	1.25	0.15	0.065	0.82	0.05	0.022	0.58	0.02	0.009	9.30	20.08	8.69	7.07	10.29	4.46	4.51	3.44	1.49	3.07	1.35	0.58	2.06	0.51	0.22
60	1.50	0.21	0.091	0.98	0.08	0.035	0.69	0.03	0.013	11.17	28.14	12.18	8.49	14.42	6.24	5.41	4.82	2.09	3.68	1.89	0.82	2.48	0.72	0.31
70	1.75	0.28	0.12	1.14	0.10	0.043	0.81	0.04	0.017				9.90	19.19	8.31	6.31	6.41	2.78	4.29	2.51	1.09	2.89	0.96	0.42
75	1.87	0.32	0.14	1.23	0.11	0.048	0.86	0.05	0.022				10.61	21.80	9.44	6.76	7.29	3.16	4.60	2.85	1.23	3.10	1.09	0.47
80	2.00	0.36	0.16	1.31	0.13	0.056	0.92	0.05	0.022							7.21	8.21	3.55	4.91	3.22	1.39	3.30	1.23	0.53
90	2.25	0.45	0.19	1.47	0.16	0.069	1.04	0.07	0.030	8 IN.						8.12	10.21	4.42	5.52	4.00	1.73	3.72	1.52	0.66
100	2.50	0.54	0.23	1.63	0.19	0.082	1.15	0.08	0.035	0.67	0.03	0.012				9.02	12.41	5.37	6.14	4.86	2.10	4.13	1.85	0.80
125	3.13	0.82	0.36	2.04	0.30	0.13	1.44	0.125	0.054	0.85	0.037	0.015							7.67	7.36	3.19	5.17	2.81	1.22
150	3.75	1.15	0.50	2.45	0.41	0.18	1.73	0.18	0.078	1.02	0.05	0.022							9.20	10.30	4.46	6.19	3.93	1.70
175	4.37	1.54	0.67	2.86	0.55	0.24	2.02	0.24	0.103	1.19	0.065	0.028	10 IN.						10.74	13.72	5.94	7.23	5.23	2.26
200	4.99	1.96	0.85	3.27	0.70	0.30	2.31	0.30	0.13	1.36	0.08	0.035	0.86	0.027	0.012							8.26	6.69	2.90
250	6.24	2.97	1.29	4.09	1.06	0.46	2.89	0.46	0.20	1.70	0.125	0.054	1.10	0.045	0.020	12 IN.						10.33	10.13	4.39
300	7.49	4.16	1.80	4.90	1.48	0.64	3.46	0.63	0.27	2.04	0.18	0.078	1.31	0.06	0.026									
350	8.74	5.54	2.40	5.72	1.98	0.86	4.04	0.85	0.37	2.38	0.24	0.103	1.54	0.08	0.035	1.08	0.036	0.016						
400	9.99	7.09	3.07	6.54	2.53	1.10	4.61	1.08	0.47	2.72	0.30	0.13	1.75	0.10	0.043	1.24	0.04	0.017						
450	11.24	8.82	3.82	7.35	3.14	1.36	5.19	1.34	0.58	3.06	0.37	0.16	1.97	0.13	0.056	1.40	0.06	0.026						
500	12.48	10.72	4.64	8.17	3.82	1.65	5.76	1.63	0.71	3.40	0.45	0.19	2.19	0.15	0.065	1.55	0.07	0.030						
750				12.26	8.09	3.50	8.64	3.46	1.50	5.10	0.96	0.42	3.29	0.33	0.14	2.33	0.14	0.061						
1000							11.53	5.89	2.55	6.80	1.63	0.64	4.38	0.56	0.24	3.11	0.24	0.10						
1250										8.50	2.47	1.07	5.48	0.85	0.37	3.89	0.37	0.16						
1500										10.19	3.45	1.49	6.57	1.18	0.51	4.66	0.51	0.22						
2000										13.59	5.87	2.54	8.76	2.02	0.87	6.22	0.87	0.38						
2500													10.96	3.06	1.33	7.77	1.33	0.57						
3000													13.15	4.27	1.85	9.33	1.85	0.80						
3500																10.88	2.47	1.07						
4000																12.44	3.17	1.37						
4500																13.99	3.93	1.70						

CARRYING CAPACITY AND FRICTION LOSS 160 PSI AND SDR 26 THERMOPLASTIC PIPE

(Independent variables: Gallons per minute and nominal pipe size O.D.

Dependent variables: Velocity, friction head and pressure drop per 100 feet of pipe, interior smooth .)

GALLONS PER MINUTE	VELOCITY FEET PER SECOND	FRICTION HEAD FEET	FRICTION LOSS POUNDS PER SQUARE INCH	VELOCITY FEET PER SECOND	FRICTION HEAD FEET	FRICTION LOSS POUNDS PER SQUARE INCH	VELOCITY FEET PER SECOND	FRICTION HEAD FEET	FRICTION LOSS POUNDS PER SQUARE INCH	VELOCITY FEET PER SECOND	FRICTION HEAD FEET	FRICTION LOSS POUNDS PER SQUARE INCH	VELOCITY FEET PER SECOND	FRICTION HEAD FEET	FRICTION LOSS POUNDS PER SQUARE INCH	VELOCITY FEET PER SECOND	FRICTION HEAD FEET	FRICTION LOSS POUNDS PER SQUARE INCH	VELOCITY FEET PER SECOND	FRICTION HEAD FEET	FRICTION LOSS POUNDS PER SQUARE INCH	VELOCITY FEET PER SECOND	FRICTION HEAD FEET	FRICTION LOSS POUNDS PER SQUARE INCH
		1/2 IN.			3/4 IN.			1 IN.			1-1/4 IN.			1-1/2 IN.			2 IN.			2-1/2 IN.			3 IN.	
1	0.84	1.00	0.43	0.50	0.28	0.12																		
2	1.67	2.00	0.86	0.99	0.56	0.24	0.59	0.29	0.13	0.36	0.085	0.037	0.27	0.02	0.0087	0.17	0.01	0.004						
5	4.17	11.25	4.87	2.47	3.14	1.36	1.48	0.91	0.39	0.90	0.27	0.117	0.68	0.14	0.059	0.44	0.045	0.020	0.30	0.025	0.011	0.20	0.01	0.0045
7	5.84	20.66	8.95	3.46	5.76	2.49	2.08	1.66	0.72	1.25	0.49	0.21	0.96	0.25	0.104	0.61	0.08	0.035	0.42	0.035	0.015	0.28	0.014	0.0063
10	8.34	39.34	17.03	4.94	10.96	4.74	2.96	3.16	1.37	1.79	0.92	0.40	1.36	0.47	0.20	0.87	0.16	0.069	0.59	0.06	0.026	0.40	0.02	0.009
15		4 IN.		7.40	23.23	10.06	4.44	6.69	2.90	2.68	1.96	0.85	2.04	1.00	0.43	1.30	0.33	0.14	0.88	0.13	0.056	0.59	0.05	0.022
20	0.48	0.02	0.009	9.87	39.57	17.13	5.92	11.40	4.94	3.58	3.34	1.45	2.72	1.71	0.74	1.73	0.57	0.25	1.18	0.22	0.095	0.79	0.09	0.039
25	0.60	0.04	0.017		5 IN.		7.40	17.23	7.46	4.47	5.04	2.18	3.40	2.59	1.12	2.16	0.86	0.37	1.47	0.34	0.15	0.99	0.13	0.056
30	0.72	0.05	0.022	0.47	0.02	0.009	8.88	24.15	10.46	5.36	7.07	3.06	4.08	3.63	1.57	2.60	1.21	0.52	1.77	0.47	0.20	1.19	0.18	0.078
35	0.84	0.07	0.030	0.55	0.03	0.013	10.36	32.13	13.91	6.26	9.41	4.07	4.76	4.83	2.09	3.03	1.61	0.70	2.06	0.63	0.27	1.39	0.24	0.10
40	0.96	0.09	0.039	0.63	0.03	0.013				7.15	12.05	5.22	5.44	6.18	2.68	3.46	2.06	0.89	2.35	0.81	0.35	1.59	0.31	0.13
45	1.08	0.11	0.048	0.71	0.04	0.017		6 IN.		8.04	14.98	6.49	6.12	7.69	3.33	3.90	2.56	1.11	2.65	1.00	0.43	1.78	0.38	0.16
50	1.20	0.14	0.061	0.78	0.05	0.022	0.55	0.02	0.009	8.94	18.21	7.88	6.80	9.34	4.04	4.33	3.11	1.35	2.94	1.22	0.53	1.98	0.47	0.20
60	1.44	0.19	0.082	0.94	0.07	0.030	0.66	0.03	0.013				8.16	13.10	5.67	5.19	4.36	1.89	3.53	1.71	0.74	2.38	0.65	0.28
70	1.67	0.25	0.11	1.10	0.09	0.039	0.77	0.04	0.017				9.52	17.42	7.54	6.06	5.80	2.51	4.12	2.27	0.98	2.78	0.87	0.38
75	1.79	0.29	0.13	1.18	0.10	0.043	0.83	0.04	0.017				10.19	19.80	8.57	6.49	6.60	2.86	4.41	2.58	1.12	2.97	0.99	0.43
80	1.91	0.32	0.14	1.25	0.12	0.052	0.88	0.05	0.022				10.87	22.31	9.66	6.92	7.43	3.22	4.71	2.91	1.26	3.17	1.11	0.48
90	2.15	0.40	0.17	1.41	0.14	0.061	0.99	0.06	0.026		8 IN.		12.23	27.75	12.02	7.79	9.25	4.01	5.30	3.62	1.57	3.57	1.38	0.60
100	2.39	0.49	0.21	1.57	0.18	0.078	1.10	0.07	0.030	0.66	0.03	0.012	13.59	33.73	14.61	8.66	11.24	4.87	5.89	4.39	1.90	3.97	1.68	0.73
125	2.99	0.74	0.33	1.96	0.27	0.12	1.39	0.11	0.047	0.83	0.037	0.015							7.36	6.65	2.88	4.96	2.54	1.10
150	3.50	1.04	0.45	2.35	0.37	0.16	1.66	0.16	0.066	0.98	0.04	0.017							8.83	9.31	4.03	5.95	3.56	1.54
175	4.19	1.39	0.60	2.74	0.50	0.22	1.94	0.21	0.091	1.14	0.06	0.026		10 IN.					10.31	12.40	5.37	6.94	4.74	2.05
200	4.79	1.77	0.77	3.13	0.63	0.27	2.21	0.27	0.12	1.30	0.07	0.030	0.83	0.027	0.012							7.93	6.07	2.63
250	5.98	2.68	1.16	3.92	0.96	0.42	2.76	0.41	0.18	1.63	0.11	0.048	1.05	0.04	0.017		12 IN.					9.92	9.18	3.98
300	7.18	3.75	1.62	4.70	1.34	0.58	3.31	0.57	0.25	1.95	0.16	0.069	1.26	0.05	0.022									
350	8.38	5.00	2.17	5.49	1.79	0.77	3.87	0.76	0.33	2.28	0.21	0.091	1.47	0.075	0.033	1.04	0.04	0.017						
400	9.57	6.39	2.77	6.27	2.28	0.99	4.42	0.97	0.42	2.61	0.27	0.12	1.68	0.09	0.039	1.19	0.04	0.017						
450	10.77	7.95	3.44	7.05	2.84	1.23	4.97	1.21	0.52	2.93	0.33	0.14	1.89	0.11	0.048	1.34	0.05	0.022						
500	11.96	9.66	4.18	7.84	3.45	1.49	5.52	1.47	0.64	3.26	0.41	0.18	2.10	0.14	0.061	1.49	0.06	0.026						
750				11.75	7.31	3.17	8.28	3.12	1.35	4.89	0.86	0.37	3.14	0.29	0.13	2.23	0.13	0.056						
1000							11.05	5.31	2.30	6.51	1.47	0.64	4.19	0.50	0.22	2.98	0.22	0.095						
1250										8.15	2.23	0.96	5.27	0.76	0.33	3.73	0.34	0.15						
1500										9.77	3.11	1.35	6.29	1.06	0.46	4.47	0.46	0.20						
2000										13.03	5.30	2.29	8.38	1.81	0.78	5.96	0.79	0.34						
2500													10.48	2.74	1.19	7.45	1.20	0.52						
3000													12.58	3.84	1.66	8.94	1.67	0.72						
3500																10.43	2.22	0.96						
4000																11.92	2.86	1.24						
4500																13.41	3.54	1.53						

CARRYING CAPACITY & FRICTION LOSS

TABLE 33

PROLINE-POLYPROPYLENE 150 FLOW RATES

TABLE 34

GALLONS PER MINUTE	VELOCITY FEET PER SECOND	FRICTION HEAD FEET	FRICTION LOSS POUNDS PER SQUARE INCH	VELOCITY FEET PER SECOND	FRICTION HEAD FEET	FRICTION LOSS POUNDS PER SQUARE INCH	VELOCITY FEET PER SECOND	FRICTION HEAD FEET	FRICTION LOSS POUNDS PER SQUARE INCH	VELOCITY FEET PER SECOND	FRICTION HEAD FEET	FRICTION LOSS POUNDS PER SQUARE INCH	VELOCITY FEET PER SECOND	FRICTION HEAD FEET	FRICTION LOSS POUNDS PER SQUARE INCH	VELOCITY FEET PER SECOND	FRICTION HEAD FEET	FRICTION LOSS POUNDS PER SQUARE INCH	VELOCITY FEET PER SECOND	FRICTION HEAD FEET	FRICTION LOSS POUNDS PER SQUARE INCH	VELOCITY FEET PER SECOND	FRICTION HEAD FEET	FRICTION LOSS POUNDS PER SQUARE INCH	VELOCITY FEET PER SECOND	FRICTION HEAD FEET	FRICTION LOSS POUNDS PER SQUARE INCH
	1/2 IN.			3/4 IN.			1 IN.			1-1/4 IN.			1-1/2 IN.			2 IN.			2-1/2 IN.			3 IN.			4 IN.		
1	1.17	1.27	.55	.68	.35	.15	.39	.09	.04	.24	.02	.01															
2	2.34	4.60	1.99	1.37	1.25	.54	.78	.32	.14	.49	.09	.04	.32	.05	.02												
5	5.84	25.04	10.84	3.42	6.81	2.95	1.95	1.73	.75	1.22	.55	.24	.79	.18	.08	.50	.07	.03	.35	.02	.01	.24	.02	.01			
7	8.18	46.69	20.21	4.79	12.73	5.51	2.72	3.21	1.39	1.71	1.04	.45	1.11	.37	.16	.70	.12	.05	.49	.05	.02	.34	.05	.02			
10	11.70	90.37	39.12	6.85	24.62	10.66	3.89	6.24	2.70	2.45	2.01	.87	1.58	.69	.30	1.00	.23	.10	.70	.09	.04	.49	.07	.03			
15				10.30	52.18	22.59	5.84	13.21	5.72	3.67	4.27	1.85	2.37	1.48	.64	1.49	.49	.21	1.05	.21	.09	.73	.14	.06	.49	.02	.01
20							7.78	22.50	9.74	4.90	7.28	3.15	3.16	2.52	1.09	1.99	.83	.36	1.41	.35	.15	.97	.23	.10	.65	.05	.02
25							9.73	34.00	14.72	6.12	11.02	4.77	3.95	3.79	1.64	2.49	1.25	.54	1.76	.53	.23	1.22	.30	.13	.81	.07	.03
30							11.70	47.66	20.63	7.34	15.43	6.68	4.74	5.31	2.30	2.99	1.73	.75	2.11	.74	.32	1.46	.39	.17	.98	.12	.05
	6 IN.																										
35	.54	.02	.01							8.57	20.54	8.89	5.53	7.09	3.07	3.49	2.31	1.00	2.46	.99	.43	1.70	.53	.23	1.14	.14	.06
40	.62	.05	.02							9.79	26.29	11.38	6.32	9.06	3.92	3.98	2.93	1.27	2.81	1.27	.55	1.94	.65	.28	1.30	.18	.08
45	.69	.05	.02							11.00	32.71	14.16	7.11	11.27	4.88	4.48	3.67	1.59	3.16	1.57	.68	2.19	.79	.34	1.46	.23	.10
50	.77	.07	.03										7.90	13.70	5.93	4.98	4.46	1.93	3.52	1.92	.83	2.43	1.09	.47	1.63	.30	.13
				8 IN.																							
60	.92	.07	.03	.59	.02	.01							9.48	19.20	8.31	5.98	6.26	2.71	4.22	2.68	1.16	2.92	1.46	.63	1.95	.42	.18
70	1.08	.09	.04	.69	.05	.02							11.10	25.64	11.10	6.97	8.32	3.60	4.92	3.56	1.54	3.40	1.87	.81	2.28	.55	.24
80	1.23	.12	.05	.79	.05	.02										7.97	10.65	4.61	5.62	4.55	1.97	3.89	2.31	1.00	2.60	.69	.30
90	1.39	.14	.06	.89	.07	.03										8.96	13.24	5.73	6.33	5.68	2.46	4.38	2.82	1.22	2.93	.88	.38
100	1.54	.16	.07	.98	.07	.03										9.96	16.10	6.97	7.03	6.91	2.99	4.86	4.25	1.84	3.25	1.06	.46
							10 IN.																				
125	1.92	.25	.11	1.23	.09	.04	.79	.02	.01							12.50	24.26	10.50	8.79	10.44	4.52	6.08	5.91	2.56	4.06	1.59	.69
150	2.31	.37	.16	1.48	.12	.05	.95	.05	.02										10.60	14.62	6.33	7.29	7.92	3.43	4.88	2.24	.97
175	2.69	.49	.21	1.72	.16	.07	1.10	.05	.02													8.51	10.14	4.39	5.69	2.98	1.29
200	3.08	.62	.27	1.97	.21	.09	1.26	.07	.03													9.72	15.34	6.64	6.50	3.81	1.65
										12 IN.																	
250	3.85	.92	.40	2.46	.30	.13	1.58	.12	.05	.99	.02	.01										12.20	21.51	9.31	8.13	5.75	2.49
													14 IN.														
300	4.62	1.32	.57	2.95	.44	.19	1.89	.14	.06	1.19	.05	.02	.94	.02	.01										9.75	8.09	3.50
350	5.39	1.73	.75	3.44	.60	.26	2.21	.21	.09	1.39	.07	.03	1.09	.05	.02										11.40	10.72	4.64
400	6.16	2.24	.97	3.94	.74	.32	2.52	.25	.11	1.59	.07	.03	1.25	.05	.02												
																16 IN.											
450	6.93	2.27	1.20	4.43	.92	.40	2.84	.32	.14	1.78	.09	.04	1.40	.07	.03	1.11	.02	.01									
500	7.69	3.37	1.46	4.92	1.13	.49	3.15	.37	.16	1.98	.12	.05	1.56	.07	.03	1.23	.05	.02									
																			18 IN.								
600	9.23	4.71	2.04	5.90	1.59	.69	3.78	.53	.23	2.38	.16	.07	1.87	.09	.04	1.48	.05	.02	1.17	.02	.01						
700	10.80	6.28	2.72	6.89	2.13	.92	4.41	.72	.31	2.78	.23	.10	2.19	.14	.06	1.72	.07	.03	1.36	.05	.02						
800				7.87	2.70	1.17	5.04	.92	.40	3.17	.30	.13	2.50	.16	.07	1.97	.09	.04	1.55	.05	.02						
900				8.85	3.37	1.46	5.67	1.13	.49	3.57	.37	.16	2.81	.21	.09	2.21	.12	.05	1.75	.07	.03						
1000				9.84	4.11	1.78	6.30	1.39	.60	3.97	.44	.19	3.12	.25	.11	2.46	.14	.06	1.94	.07	.03						
2000							12.60	5.01	2.17	7.93	1.62	.70	6.24	.90	.39	4.92	.51	.22	3.89	.30	.13						
2500										9.92	2.47	1.07	7.80	1.36	.59	6.15	.76	.33	4.86	.44	.19						
500																12.30	2.77	1.20	9.72	1.57	.68						
7500																			14.60	3.30	1.43						

PROLINE-POLYPROPYLENE 45 FLOW RATES

FOR SERVICE, PLEASE CALL 1-800-877-HIPCO

TABLE 35

GALLONS PER MINUTE	2 IN.			2-1/2 IN.			3 IN.			4 IN.			6 IN.			8 IN.			10 IN.			12 IN.			14 IN.		
	VELOCITY FEET PER SECOND	FRICTION HEAD FEET	FRICTION LOSS POUNDS PER SQUARE INCH	VELOCITY FEET PER SECOND	FRICTION HEAD FEET	FRICTION LOSS POUNDS PER SQUARE INCH	VELOCITY FEET PER SECOND	FRICTION HEAD FEET	FRICTION LOSS POUNDS PER SQUARE INCH	VELOCITY FEET PER SECOND	FRICTION HEAD FEET	FRICTION LOSS POUNDS PER SQUARE INCH	VELOCITY FEET PER SECOND	FRICTION HEAD FEET	FRICTION LOSS POUNDS PER SQUARE INCH	VELOCITY FEET PER SECOND	FRICTION HEAD FEET	FRICTION LOSS POUNDS PER SQUARE INCH	VELOCITY FEET PER SECOND	FRICTION HEAD FEET	FRICTION LOSS POUNDS PER SQUARE INCH	VELOCITY FEET PER SECOND	FRICTION HEAD FEET	FRICTION LOSS POUNDS PER SQUARE INCH	VELOCITY FEET PER SECOND	FRICTION HEAD FEET	FRICTION LOSS POUNDS PER SQUARE INCH
5	.38	.02	.01																								
7	.53	.07	.03	.37	.02	.01																					
10	.76	.12	.05	.53	.05	.02	.37	.02	.01																		
15	1.13	.23	.10	.80	.12	.05	.55	.05	.02																		
20	1.51	.42	.18	1.07	.18	.08	.74	.07	.03	.50	.02	.01															
25	1.89	.62	.27	1.34	.28	.12	.92	.12	.05	.62	.05	.02															
30	2.27	.88	.38	1.60	.37	.16	1.11	.14	.06	.74	.07	.03															
35	2.64	1.18	.51	1.87	.51	.22	1.29	.21	.09	.87	.07	.03															
40	3.02	1.50	.65	2.14	.65	.28	1.48	.25	.11	.99	.09	.04															
45	3.40	1.87	.81	2.40	.81	.35	1.66	.32	.14	1.12	.12	.05															
50	3.78	2.29	.99	2.67	.97	.42	1.84	.39	.17	1.24	.14	.06															
60	4.53	3.19	1.38	3.20	1.36	.59	2.22	.55	.24	1.49	.21	.09	.70	.02	.01												
70	5.29	4.25	1.84	3.74	1.82	.79	2.59	.74	.32	1.74	.28	.12	.82	.05	.02												
80	6.04	5.43	2.35	4.27	2.38	1.03	2.96	.95	.41	1.99	.37	.16	.94	.07	.03												
90	6.80	6.77	2.93	4.80	2.91	1.26	3.33	1.20	.52	2.23	.44	.19	1.05	.07	.03												
100	7.55	8.22	3.56	5.34	3.53	1.53	3.69	1.43	.62	2.48	.55	.24	1.17	.09	.04												
125	9.44	12.43	5.38	6.68	5.41	2.34	4.62	2.17	.94	3.10	.83	.36	1.46	.14	.06	.93	.02	.01									
150	11.30			8.01	7.48	3.24	5.54	3.07	1.33	3.72	1.16	.50	1.76	.18	.08	1.12	.07	.03									
175				9.35	9.96	4.31	6.47	4.07	1.76	4.34	1.55	.67	2.05	.25	.11	1.31	.07	.03	.84	.02	.01						
200				10.68	12.77	5.53	7.39	5.22	2.26	4.96	1.99	.86	2.34	.32	.14	1.50	.07	.03	.96	.05	.02						
250							9.24	7.88	3.41	6.20	2.98	1.29	2.93	.49	.21	1.87	.12	.05	1.20	.05	.02						
300							11.08	11.04	4.78	7.44	4.18	1.81	3.51	.67	.29	2.24	.16	.07	1.44	.07	.03						
350										8.68	5.59	2.42	4.10	.90	.39	2.62	.23	.10	1.68	.09	.04	1.06	.02	.01			
400										9.93	7.14	3.09	4.68	1.16	.50	2.99	.30	.13	1.92	.14	.06	1.21	.05	.02			
450										11.17	8.87	3.84	5.27	1.43	.62	3.37	.37	.16	2.16	.16	.07	1.36	.05	.02	1.07	.02	.01
500													5.85	1.73	.75	3.74	.44	.19	2.40	.21	.09	1.51	.07	.03	1.19	.05	.02
600													7.02	2.43	1.05	4.49	.60	.26	2.87	.28	.12	1.81	.09	.04	1.43	.05	.02
700													8.19	3.23	1.40	5.24	.83	.36	3.35	.35	.15	2.11	.12	.05	1.66	.07	.03
800													9.36	4.13	1.79	5.98	1.04	.45	3.83	.46	.20	2.41	.14	.06	1.90	.09	.04
900													10.53	5.15	2.23	6.73	1.29	.56	4.31	.60	.26	2.71	.18	.08	2.14	.12	.05
1000													11.70	6.26	2.71	7.48	1.57	.68	4.79	.72	.31	3.02	.23	.10	2.38	.14	.06
2000																14.96	5.71	2.47	9.58	2.56	1.11	6.03	.83	.36	4.75	.46	.20
2500																			11.96	3.88	1.68	7.54	1.27	.55	5.94	.72	.31
5000																									11.88	2.54	1.10
7500																											
10000																											

GALLONS PER MINUTE	16 IN.			18 IN.			20 IN.			24 IN.		
	VELOCITY FEET PER SECOND	FRICTION HEAD FEET	FRICTION LOSS POUNDS PER SQUARE INCH	VELOCITY FEET PER SECOND	FRICTION HEAD FEET	FRICTION LOSS POUNDS PER SQUARE INCH	VELOCITY FEET PER SECOND	FRICTION HEAD FEET	FRICTION LOSS POUNDS PER SQUARE INCH	VELOCITY FEET PER SECOND	FRICTION HEAD FEET	FRICTION LOSS POUNDS PER SQUARE INCH
600	1.12	.02	.01									
700	1.31	.05	.02									
800	1.50	.05	.02									
900	1.68	.07	.03	1.30	.02	.01						
1000	1.87	.07	.03	1.48	.05	.02	1.20	.02	.01			
2000	3.74	.25	.11	2.96	.14	.06	2.39	.09	.04	1.51	.02	.01
2500	4.67	.39	.17	3.69	.23	.10	2.99	.14	.06	1.89	.05	.02
5000	9.35	1.41	.61	7.39	.81	.35	5.98	.49	.21	3.77	.16	.07
7500	14.00	.69	.30	11.00	1.71	.74	8.97	1.02	.44	5.66	.32	.14
10000				14.80	2.91	1.26	12.00	1.73	.75	7.55	.55	.24

SUPER/PROLINE - PVDF FLOW RATES

TABLE 36

GALLONS PER MINUTE	VELOCITY FEET PER SECOND	FRICTION HEAD FEET	FRICTION LOSS POUNDS PER SQUARE INCH	VELOCITY FEET PER SECOND	FRICTION HEAD FEET	FRICTION LOSS POUNDS PER SQUARE INCH	VELOCITY FEET PER SECOND	FRICTION HEAD FEET	FRICTION LOSS POUNDS PER SQUARE INCH	VELOCITY FEET PER SECOND	FRICTION HEAD FEET	FRICTION LOSS POUNDS PER SQUARE INCH	VELOCITY FEET PER SECOND	FRICTION HEAD FEET	FRICTION LOSS POUNDS PER SQUARE INCH	VELOCITY FEET PER SECOND	FRICTION HEAD FEET	FRICTION LOSS POUNDS PER SQUARE INCH	VELOCITY FEET PER SECOND	FRICTION HEAD FEET	FRICTION LOSS POUNDS PER SQUARE INCH	VELOCITY FEET PER SECOND	FRICTION HEAD FEET	FRICTION LOSS POUNDS PER SQUARE INCH	VELOCITY FEET PER SECOND	FRICTION HEAD FEET	FRICTION LOSS POUNDS PER SQUARE INCH
	1/2 IN.			3/4 IN.			1 IN.			1-1/4 IN.			1-1/2 IN.			2 IN.			2-1/2 IN.			3 IN.			4 IN.		
1	1.00	.88	.38	.58	.23	.10	.36	.07	.03	.21	.02	.01															
2	2.00	3.14	1.36	1.17	.85	.37	.71	.25	.11	.42	.07	.03	.27	.02	.01												
5	5.00	17.14	7.42	2.92	4.64	2.01	1.78	1.39	.60	1.06	.39	.17	.67	.14	.06	.41	.05	.02									
7	7.00	31.88	13.80	4.09	8.64	3.74	2.49	2.56	1.11	1.49	.74	.32	.94	.23	.10	.57	.07	.03	.38	.02	.01						
10	10.00	61.91	26.80	5.84	16.72	7.24	3.55	4.99	2.16	2.12	1.43	.62	1.35	.46	.20	.81	.14	.06	.54	.05	.02	.40	.02	.01			
15				8.76	35.34	15.30	5.33	10.56	4.57	3.19	3.03	1.31	2.02	.99	.43	1.22	.30	.13	.81	.12	.05	.60	.05	.02			
20				11.70	60.29	26.10	7.10	17.99	7.79	4.25	5.17	2.24	2.69	1.71	.74	1.62	.49	.21	1.07	.18	.08	.79	.09	.04	.50	.02	.01
25							8.88	27.26	11.80	5.31	7.78	3.37	3.37	2.56	1.11	2.03	.74	.32	1.34	.28	.12	.99	.14	.06	.62	.05	.02
30							10.70	38.12	16.50	6.37	10.93	4.73	4.04	3.60	1.56	2.43	1.04	.45	1.61	.39	.17	1.19	.18	.08	.74	.07	.03
35										7.43	14.55	6.30	4.71	4.80	2.08	2.84	1.39	.60	1.88	.51	.22	1.39	.25	.11	.87	.07	.03
	16 IN.																										
40										8.50	18.62	8.06	5.38	6.14	2.66	3.24	1.80	.78	2.15	.67	.29	1.59	.32	.14	.99	.09	.04
45										9.56	23.10	10.00	6.06	7.65	3.31	3.65	2.22	.96	2.42	.83	.36	1.79	.39	.17	1.12	.12	.05
50	.59	.02	.01							10.62	28.18	12.20	6.73	9.29	4.02	4.05	2.70	1.17	2.69	.99	.43	1.99	.49	.21	1.24	.14	.06
60	.70	.05	.02										8.08	13.01	5.63	4.86	3.79	1.64	3.22	1.39	.60	2.38	.67	.29	1.49	.21	.09
70	.82	.05	.02										9.42	17.30	7.49	5.67	5.04	2.18	3.76	1.85	.80	2.78	.90	.39	1.74	.28	.12
80	.94	.07	.03										10.80	22.18	9.60	6.48	6.44	2.79	4.30	2.38	1.03	3.18	1.13	.49	1.99	.37	.16
				18 IN.																							
90	1.05	.07	.03													7.29	8.02	3.47	4.83	2.96	1.28	3.57	1.41	.61	2.23	.44	.19
100	1.17	.09	.04	.75	.02	.01										8.10	9.75	4.22	5.37	3.58	1.55	4.96	1.71	.74	2.48	.55	.24
125	1.46	.14	.06	.93	.05	.02										10.13	14.74	6.38	6.71	5.43	2.35	5.96	2.61	1.13	3.10	.83	.36
							10 IN.																				
150	1.76	.18	.08	1.12	.07	.03													8.06	7.60	3.29	6.95	3.65	1.58	3.72	1.16	.50
175	2.05	.23	.10	1.31	.07	.03	.96	.02	.01										9.40	10.09	4.37	7.94	4.85	2.10	4.34	1.96	.85
200	2.34	.32	.14	1.50	.09	.04	1.20	.05	.02										10.70	12.94	5.60	9.93	6.19	2.68	4.96	2.98	1.29
										12 IN.																	
250	2.93	.49	.21	1.87	.16	.07	1.44	.07	.03													11.90	20.93	9.06	6.20	4.18	1.81
300	3.51	.67	.29	2.24	.23	.10	1.68	.09	.04																7.44	5.57	2.41
350	4.10	.90	.39	2.62	.30	.13	1.92	.14	.06	1.06	.02	.01													8.68	7.14	3.09
400	4.68	1.13	.49	2.99	.37	.16	2.16	.16	.07	1.21	.05	.02													9.93	8.87	3.84
450	5.27	1.41	.61	3.37	.46	.20	2.40	.18	.08	1.36	.05	.02													11.20	10.79	4.67
500	5.85	1.73	.75	3.74	.58	.25	2.87	.28	.12	1.51	.07	.03															
600	7.02	2.43	1.05	4.49	.81	.35	3.35	.37	.16	1.81	.07	.03															
700	8.19	3.23	1.40	5.24	1.09	.47	3.83	.46	.20	2.11	.12	.05															
800	9.36	4.13	1.79	5.98	1.39	.60	4.31	.60	.26	2.41	.14	.06															
900	10.50	5.15	2.23	6.73	1.73	.75	4.79	.72	.31	2.71	.18	.08															
1000				7.48	2.10	.91	9.58	2.56	1.11	3.02	.23	.10															
2000				15.00	7.60	3.29	12.00	3.88	1.68	6.03	.83	.36															
2500										7.54	1.27	.55															
5000										15.10	4.55	1.97															

CARRYING CAPACITY & FRICTION LOSS

TABLE 37

EQUIVALENT LENGTH OF THERMOPLASTIC PIPE IN FEET

				¼"	½"	¾"	1"	1¼"	1½"	2"	2½"	3"	4"	6"	8"	10"	12"
GLOBE VALVES	Conventional	With no obstruction in flat, bevel, or plug type seat	Fully Open	10.3	17.6	23.3	29.7	39.1	45.6	58.6	69.95	86.9	114.1	171.8	226.1	283.9	338.2
		With wing or pin guided disc	Fully Open	13.7	23.3	30.9	39.3	51.8	60.4	77.5	92.6	115.1	151.0	227.4	299.3	375.8	447.7
	Y-Pattern	(No obstruction in flat, bevel or plug type seat) —With stem 60 degrees from run of pipe line	Fully Open	5.3	9.1	12.0	15.3	20.1	23.5	30.1	36.0	44.7	58.7	88.4	116.4	146.1	174.1
		—With stem 45 degrees from run of pipe line	Fully Open	4.4	7.5	10.0	12.7	16.7	19.5	25.0	29.8	37.1	48.6	73.3	96.4	121.1	144.3
ANGLE VALVES	Conventional	With no obstruction in flat, bevel, plug type seat	Fully Open	4.4	7.5	10.0	12.7	16.7	19.5	25.0	29.8	37.1	48.6	73.3	96.4	121.1	144.3
		With wing or pin guided disc	Fully Open	6.1	10.4	13.7	17.5	23.0	26.8	34.5	41.2	51.1	67.1	101.1	133.0	167.0	199.0
GATE VALVES	Conventional Wedge Disc, Dbl Disc, or Plug Disc		Fully Open	0.4	0.7	0.9	1.1	1.5	1.7	2.2	2.7	3.3	4.4	6.6	8.6	10.9	12.9
			Three-Quarters Open	1.1	1.8	2.4	3.1	4.0	4.7	6.0	7.2	8.9	11.7	17.7	23.3	29.2	34.8
			One-Half Open	4.9	8.3	11.0	14.0	18.4	21.5	27.6	32.9	40.9	53.7	80.9	106.4	133.6	159.2
			One-Quarter Open	27.3	45.7	61.8	78.7	103.5	120.8	155.0	185.2	230.1	302.0	454.9	598.6	751.5	895.4
BALL VALVES	Full Port Design		Fully Open	Same as an equivalent of Sch. 80 Pipe													
FITTINGS	90° Standard Elbow			0.9	1.6	2.1	2.6	3.5	4.0	5.5	6.2	7.7	10.1	15.2	20.0	25.1	29.8
	45° Standard Elbow			0.5	0.8	1.1	1.4	1.8	2.1	2.8	3.3	4.1	5.4	8.1	10.6	13.4	15.9
	90° Long Radius Elbow			0.6	1.0	1.4	1.7	2.3	2.7	4.3	5.1	6.3	8.3	12.5	16.5	20.7	24.7
	90° Street Elbow			1.5	2.6	3.4	4.4	5.8	6.7	8.6	10.3	12.8	16.8	25.3	33.3	41.8	49.78
	45° Street Elbow			0.8	1.3	1.8	2.3	3.0	3.5	4.5	5.4	6.6	8.7	13.1	17.3	21.7	25.9
	Square Corner Elbow			1.7	3.0	3.9	5.0	6.5	7.6	9.8	11.7	14.6	19.1	28.8	37.9	47.6	56.7
	Standard Tee	With Flow through run		0.6	1.0	1.4	1.7	2.3	2.7	4.3	5.1	6.3	8.3	12.5	16.5	20.7	24.7
		With Flow through branch		1.8	4.0	5.1	6.0	6.9	8.1	12	14.3	16.3	22.1	32.2	39.9	50.1	59.7

SLOPE OF HORIZONTAL DRAINAGE PIPING

Horizontal drains are designated to flow at half full capacity under uniform flow conditions so as to prevent the generation of positive pressure fluctuations. A minimum of 1/4" per foot should be provided for 3" pipe and smaller, 1/8" per foot for 4" through 6", and 1/16" per foot for 8" and larger. These minimum slopes are required to maintain a velocity of flow greater than 2 feet per second for scouring action. Table 41 gives the approximate velocities and discharge rated for given slopes and diameters of horizontal drains based on modified Manning Formula for 1/2 full pipe and n = 0.015. The valves for R, R 2/3, A, S, S 1/2 and n are from Tables 38, 39 & 40.

$$Q = A \times \frac{1.486}{n} \times R^{2/3} \times S^{1/2} (7.48 \times 60)$$

Where: Q = Flow in GPM; A = Cross sectional area, sq. ft.; n = Manning coefficient; R = Hydraulic radius of pipe; S = Hydraulic gradient

Table 38

PIPE SIZE (IN.)	$R = \frac{D}{4}$ FEET	$R^{2/3}$	A - CROSS-SECTIONAL AREA FOR FULL FLOW SQ. FT.	A - CROSS-SECTIONAL AREA FOR HALF FULL FLOW SQ. FT.
1-1/2	0.0335	0.1040	0.01412	0.00706
2	0.0417	0.1200	0.02180	0.01090
2-1/2	0.0521	0.1396	0.03408	0.01704
3	0.0625	0.1570	0.04910	0.02455
4	0.0833	0.1910	0.08730	0.04365
5	0.1040	0.2210	0.13640	0.06820
6	0.1250	0.2500	0.19640	0.09820
8	0.1670	0.3030	0.34920	0.17460
10	0.2080	0.3510	0.54540	0.27270
12	0.2500	0.3970	0.78540	0.39270
14	0.3125	0.4610	1.22700	0.61350

Table 39 VALUES OF S AND $S^{1/2}$.

SLOPE INCHES PER FOOT	S FOOT PER FOOT	$S^{1/2}$
1/8	0.0104	0.102
1/4	0.0208	0.144
1/2	0.0416	0.204

Table 40 VALUES OF n.

PIPE SIZE	n
1-1/2"	0.012
2" through 3"	0.013
4"	0.014
5" and 6"	0.015
8" and larger	0.016

Table 41 APPROXIMATE DISCHARGE RATES AND VELOCITIES IN SLOPING DRAINS

	FLOWING HALF FULL DISCHARGE RATE AND VELOCITY							
ACTUAL INSIDE DIAMETER OF PIPE INCHES	1/16 IN./FT. SLOPE		1/8 IN./FT. SLOPE		1/4 IN./FT. SLOPE		1/2 IN./FT. SLOPE	
	DISCHARGE GPM	VELOCITY FPS	DISCHARGE GPM	VELOCITY FPS	DISCHARGE GPM	VELOCITY FPS	DISCHARGE GPM	VELOCITY FPS
1-1/4	-	-	-	-	-	-	3.40	1.78
1-3/8	-	-	-	-	3.13	1.34	4.44	1.90
1-1/2	-	-	-	-	3.91	1.42	5.53	2.01
1-5/8	-	-	-	-	4.81	1.50	6.80	2.12
2	-	-	-	-	8.42	1.72	11.9	2.43
2-1/2	-	-	10.8	1.41	15.3	1.99	21.6	2.82
3	-	-	17.6	1.59	24.8	2.25	35.1	3.19
4	26.70	1.36	37.8	1.93	53.4	2.73	75.5	3.86
5	48.3	1.58	68.3	2.23	96.6	3.16	137.	4.47
6	78.5	1.78	111.	2.52	157.	3.57	222.	5.04
8	170.	2.17	240.	3.07	340.	4.34	480.	6.13
10	308.	2.52	436.	3.56	616.	5.04	872.	7.12
12	500.	2.83	707.	4.01	999.	5.67	1413.	8.02

SYSTEMS ENGINEERING DATA FOR THERMOPLASTIC PIPING

WATER HAMMER

Surge pressures due to water hammer are a major factor contributing to pipe failure in liquid transmission systems. A column of moving fluid within a pipeline, owing to its mass and velocity, contains stored energy. Since liquids are essentially incompressible, this energy cannot be absorbed by the fluid when a valve is suddenly closed.

The result is a high momentary pressure surge, usually called water hammer. The five factors that determine the severity of water hammer are:

1. Velocity (The primary factor in excessive water hammer: see discussion of "Velocity " and "Safety Factor" on page 62).
2. Modulus of elasticity of material of which the pipe is made.
3. Inside diameter of pipe.
4. Wall thickness of pipe.
5. Valve closing time.

Maximum pressure surges caused by water hammer can be calculated by using the equation below. This surge pressure should be added to the existing line pressure to arrive at a maximum operating pressure figure.

$$Ps = V\left(\frac{Et\ 3960}{Et + 3 \times 10^5 Di}\right)^{1/2}$$

Where:

Ps = Surge Pressure. in psi
V = Liquid Velocity, in ft. per sec.
Di = Inside Diameter of Pipe, in.
E = Modulus of Elasticity of Pipe Material, psi
t = Wall Thickness of Pipe, in.

Calculated surge pressure, which assumes instantaneous valve closure, can be calculated for any material using the values for E (Modulus of Elasticity) found in the properties chart, pages 40-41.

Here are the most commonly used surge pressure tables for IPS pipe sizes.

Table 42 - SURGE PRESSURE, Ps IN PSI AT 73°F

WATER VELOCITY (FT/SEC)	NOMINAL PIPE SIZE											
	1/2	3/4	1	1-1/4	1-1/2	2	3	4	6	8	10	12
SCHEDULE 40 PVC & CPVC												
1	27.9	25.3	24.4	22.2	21.1	19.3	18.9	17.4	15.5	14.6	13.9	13.4
2	55.8	50.6	48.8	44.4	42.2	38.6	37.8	34.8	31.0	29.2	27.8	26.8
3	83.7	75.9	73.2	66.6	63.3	57.9	56.7	52.2	46.5	43.8	41.7	40.2
4	111.6	101.2	97.6	88.8	84.4	77.2	75.6	69.6	62.0	58.4	55.6	53.6
5	139.5	126.5	122.0	111.0	105.5	96.5	94.5	87.0	77.5	73.0	69.5	67.0
6	167.4	151.8	146.4	133.2	126.6	115.8	113.4	104.4	93.0	87.6	83.4	80.4
SCHEDULE 80 PVC & CPVC												
1	32.9	29.9	28.7	26.2	25.0	23.2	22.4	20.9	19.4	18.3	17.3	17.6
2	65.6	59.8	57.4	52.4	50.0	46.4	44.8	41.8	38.8	36.6	35.6	35.2
3	98.7	89.7	86.7	78.6	75.0	69.6	67.2	62.7	58.2	59.9	53.4	52.8
4	131.6	119.6	114.8	104.8	107.0	92.8	89.6	83.6	77.6	73.2	71.2	70.4
5	164.5	149.5	143.5	131.0	125.0	116.0	112.0	104.5	97.0	91.5	89.0	88.0
6	197.4	179.4	172.2	157.2	150.0	133.2	134.4	125.4	116.4	109.8	106.8	105.6
SCHEDULE 80 POYLPROPYLENE												
1	23.5	20.9	20.0	18.1	17.1	15.9	15.2	14.1	13.1	12.2	11.9	11.8
2	47.0	41.8	40.0	36.2	34.2	31.6	30.4	28.2	26.2	24.4	23,8	23.6
3	70.5	62.7	60.0	54.3	51.3	47.4	45.6	42.3	39.3	36.6	35.7	35.4
4	94.0	83.6	80.0	72.4	68.4	63.2	60.8	56.4	52.4	48.8	47.6	47.2
5	117.5	104.5	100.0	90.5	85.5	79.0	76.0	70.5	65.5	61.0	59.5	59.0
6	141.0	125.4	120.0	108.6	102.6	94.8	91.2	84.6	78.6	73.2	71.4	70.8
SCHEDULE 80 PVDF												
1	25.2	22.6	21.6	19.5	18.5	17.1	16.5	15.3	14.2	13.3	12.9	12.8
2	50.4	45.2	43.2	39.0	37.0	34.2	33.0	30.6	28.9	26.6	25.8	25.6
3	75.6	67.8	64.8	58.5	55.5	51.3	49.5	45.9	42.6	39.9	38.7	38.4
4	100.8	90.4	86.4	78.0	74.0	68.4	66.0	61.2	56.8	53.2	51.6	51.2
5	126.0	118.0	108.0	97.5	92.5	86.5	82.5	76.5	71.0	66.5	64.5	64.0
6	151.2	135.6	129.6	117.0	111.0	102.6	99.0	91.8	85.2	79.8	77.4	76.8
SUPER PROLINE												
1	22.3	19.8	19.6	17.4	17.1	15.5	18.4	12.6	12.5	12.4	12.4	12.4
2	44.5	39.7	39.1	34.7	34.2	30.9	24.8	25.2	24.9	24.8	24.9	24.8
3	66.8	59.5	58.7	52.1	51.4	46.4	37.2	37.7	37.4	37.2	37.3	37.3
4	89.1	79.4	78.3	69.5	68.5	61.8	49.7	50.3	49.9	49.6	49.8	49.7
5	111.3	99.2	97.9	86.9	85.6	77.3	62.1	62.9	62.3	62.0	62.2	62.1
6	133.6	119.0	117.4	104.2	102.7	92.8	74.5	75.5	74.8	74.4	74.6	74.5
PROLINE PRO 150												
1	15.3	14.1	12.9	12.6	12.8	12.8	12.7	12.7	12.8	12.7	12.7	12.7
2	30.7	28.2	25.9	25.3	25.6	25.6	25.5	25.4	25.5	25.5	25.5	25.5
3	46.0	42.3	38.8	37.9	38.4	38.4	38.2	38.2	38.3	38.2	38.2	38.2
4	61.4	56.4	51.8	50.5	51.2	51.2	51.0	50.9	51.0	50.9	51.0	50.9
5	76.7	70.5	64.7	63.2	64.0	64.0	63.7	63.6	63.8	63.7	63.7	63.7
6	92.1	84.6	77.6	75.8	76.8	76.8	76.5	76.3	76.5	76.4	76.5	76.4
PROLINE PRO 45												
1	-	-	-	-	-	7.1	7.0	7.1	7.1	7.0	7.1	7.1
2	-	-	-	-	-	14.2	14.1	14.3	14.2	14.1	14.1	14.1
3	-	-	-	-	-	21.3	21.1	21.4	21.2	21.1	21.2	21.1
4	-	-	-	-	-	28.4	28.1	28.6	28.3	28.2	28.2	28.2
5	-	-	-	-	-	35.5	35.2	35.7	35.4	35.2	35.3	35.3
6	-	-	-	-	-	42.5	42.3	42.8	42.5	42.2	42.4	42.3

NOTE: For sizes larger than 12", call Harrington's Technical Services Group.

SYSTEMS ENGINEERING DATA FOR THERMOPLASTIC PIPING

WATER HAMMER (continued)

However, to keep water hammer pressures within reasonable limits, it is common practice to design valves for closure times considerably greater than 2L/C.

$$T_C > \frac{2L}{C}$$

Where:

T_C = Valve Closure time, sec.
L = Length of Pipe run, ft.
C = Sonic Velocity of the Pressure Wave = 4720 ft. sec.

Another formula which closely predicts water hammer effects is:

$$p = a \frac{w}{144g}$$

which is based on the elastic wave theory. In this text, we have further simplified the equation to:

$$p = Cv$$

Where p = maximum surge pressure, psi
v = fluid velocity in feet per second
C = surge wave constant for water at 73°F

It should be noted that the surge pressure (water hammer) calculated here is a maximum pressure rise for any fluid velocity, such as would be expected from the instant closing of a valve. It would therefore yield a somewhat conservative figure for use with slow closing actuated valves, etc.

For fluids heavier than water, the following correction should be made to the surge wave constant C.

$$C^1 = \frac{(S.G. - 1)\ C + C}{2}$$

Where C^1 = Corrected Surge Wave Constant
S.G. = Specific Gravity or Liquid

For example, for a liquid with a specific gravity of 1.2 in 2" Schedule 80 PVC pipe, from Table 43 = 24.2

$$C^1 = \frac{(1.2 - 1)}{2}(24.2) + 24.2$$

$$C^1 = 2.42 + 24.2$$

$$C^1 = 26.6$$

Table 43 - Surge Wave Correction for Specific Gravity

PIPE SIZE (IN.)	PVC SCH 40	PVC SCH 80	CPVC SCH 40	CPVC SCH 80	POLY-PROPYLENE SCH 80	KYNAR (PVDF) SCH 80
1/4	31.3	34.7	33.2	37.3	—-	—-
3/8	29.3	32.7	31.0	34.7	—-	—-
1/2	28.7	31.7	30.3	33.7	25.9	28.3
3/4	26.3	29.8	27.8	31.6	23.1	25.2
1	25.7	29.2	27.0	30.7	21.7	24.0
1-1/4	23.2	27.0	24.5	28.6	19.8	—-
1-1/2	22.0	25.8	23.2	27.3	18.8	20.6
2	20.2	24.2	21.3	25.3	17.3	19.0
2-1/2	21.1	24.7	22.2	26.0	—-	
3	19.5	23.2	20.6	24.5	16.6	
4	17.8	21.8	18.8	22.9	15.4	
6	15.7	20.2	16.8	21.3		
8	14.8	18.8	15.8	19.8		
10	14.0	18.3	15.1	19.3		
12	13.7	18.0	14.7	19.2		
14	13.4	17.9	14.4	19.2		

Proper design when laying out a piping system will eliminate the possibility of water hammer damage.

The following suggestions will help in avoiding problems:

1) In a plastic piping system, a fluid velocity not exceeding 5ft/sec. will minimize water hammer effects, even with quickly closing valves, such as solenoid valves.

2) Using actuated valves which have a specific closing time will eliminate the possibility of someone inadvertently slamming a valve open or closed too quickly. With pneumatic and air-spring actuators, it may be necessary to place a valve in the air line to slow down the valve operation cycle.

3) If possible, when starting a pump, partially close the valve in the discharge line to minimize the volume of liquid which is rapidly accelerating through the system. Once the pump is up to speed and the line completely full, the valve may be opened.

4) A check valve installed near a pump in the discharge line will keep the line full and help prevent excessive water hammer during pump start-up.

VELOCITY

Thermoplastic piping systems have been installed that have successfully handled water velocities in excess of 10 feet per second. Thermoplastic pipe is not subject to erosion caused by high velocities and turbulent flow, and in this respect is superior to metal piping systems, particularly where corrosive or chemically agressive fluids are involved. The Plastics Pipe Institute has issued the following policy statement on water velocity:

The maximum safe water velocity in a themoplastic piping system depends on the specific details of the system and the operating conditions. **In general, 5 feet per second is considered to be safe.** Higher velocities may be used in cases where the operating characteristics of valves and pumps are known so that sudden changes in flow velocity can be controlled. The total pressure in the system at any time (operating plus surge or water hammer) should not exceed 150 percent of the pressure rating of the system.

SAFETY FACTOR

As the duration of pressure surges due to water hammer is extremely short - seconds, or more likely, fractions of a second - in determining the safety factor the maximum fiber stress due to total internal pressure must be compared to some very short-term strength value. Referring to Figure 6, shown on page 43, it will be seen that the failure stress for very short time periods is very high when compared to the hydrostatic design stress.

The calculation of safety factor may thus be based very conservatively on the 20-second strength value given in Figure 6, shown on page 43 - 8470 psi for PVC Type 1.

A sample calculation is shown below, based upon the listed criteria:

Pipe = 1-1/4" Schedule 80 PVC
O.D. = 1.660: Wall = 0.191
HDS = 2000 psi

The calculated surge pressure for 1-1/4" Schedule 80 PVC pipe at a velocity of 1 ft/sec is 26.2 psi/ft/sec.

SYSTEMS ENGINEERING DATA FOR THERMOPLASTIC PIPING

Water Velocity = 5 feet per second
Static Pressure in System = 300 psi
Total System Pressure = Static Pressure + Surge Pressure:
Pt = P x Ps
= 300 + 5 x 26.2
= 431.0 psi

Maximum circumferential stress is calculated from a variation of the ISO Equation:

$$S = \frac{Pt\ (Do-t)}{2t} = \frac{431(1.660-.191)}{2x.191} = 1657.4$$

$$\text{Safety Factor} = \frac{\text{20 second strength}}{\text{Maximum stress}} = \frac{8470}{1657} = 5.11$$

Table 44 gives the results of safety factor calculations based upon service factors of 0.5 and 0.4 for the 1-1/4" PVC Schedule 80 pipe of the example shown above using the full pressure rating calculated from the listed hydrostatic design-stress.

In each case, the hydrostatic design basis = 4000 psi, and the water velocity = 5 feet per second.

Comparing safety factor for this 1-1/4" Schedule 80 pipe at different service factors, it is instructive to note that changing from a service factor of 0.5 to a more conservative 0.4 increases the safety factor only by 16%.

$$100 \times \left(1 - \frac{3.38}{4.03}\right) = 16\%$$

In the same way, changing the service factor from 0.4 to 0.35 increases the safety factor only by 9%. Changing the service factor from 0.5 to 0.35 increases the safety factor by 24%.

From these comparisons it is obvious that little is to be gained in safety from surge pressures by fairly large changes in the hydrostatic design stress resulting from choice of more conservative service factors.

Table 44

SAFETY FACTORS VS. SERVICE FACTORS - PVC TYPE 1 THERMOPLASTIC PIPE

PIPE CLASS	SERVICE FACTOR	HDS PSI	PRESSURE RATING PSI	SURGE PRESSURE AT 5 FT/SEC	MAXIMUM PRESSURE PSI	MAXIMUM STRESS PSI	SAFETY FACTOR
1-1/4" Sch. 80	0.5	2000	520	131.0	651.0	2503.5	3.38
1-1/4" Sch. 80	0.4	1600	416	131.0	547.0	2103.5	4.03

Pressure rating values are for PVC pipe, and for most sizes are calculated from the experimentally determined long-term strength of PVC extrusion compounds. Because molding compounds may differ in long term strength and elevated temperature properties from pipe compounds, piping systems consisting of extruded pipe and molded fittings may have lower pressure ratings than those shown here, particularly at the higher temperatures. Caution should be exercised in design operating above 100°F.

FRICTION LOSS CHARACTERISTICS OF WATER THROUGH PLASTIC PIPE, FITTINGS AND VALVES

INTRODUCTION

A major advantage of thermoplastic pipe is its exceptionally smooth inside surface area, which reduces friction loss compared to other materials.

Friction loss in plastic pipe remains constant over extended periods of time, in contrast to some other materials where the value of the Hazen and Williams C factor (constant for inside roughness) decreases with time. As a result, the flow capacity of thermoplastics is greater under fully turbulent flow conditions like those encountered in water service.

C FACTORS

Tests made both with new pipe and pipe that had been in service revealed C factor values for plastic pipe between 160 and 165. Thus, the factor of 150 recommended for water in the equation below is on the conservative side. On the other hand, the C factor for metallic pipe varies from 65 to 125, depending upon age and interior roughening. The obvious benefit is that with plastic systems it is often possible to use a smaller diameter pipe and still obtain the same or even lower friction losses.

The most significant losses occur as a result of the length of pipe and fittings and depend on the following factors.

1. Flow velocity of the fluid.

2. The type of fluid being transmitted, especially its viscosity.

3. Diameter of the pipe.

4. Surface roughness of interior of the pipe.

5. The length of the pipeline.

Hazen and Williams Formula

The head losses resulting from various water flow rates in plastic piping may be calculated by means of the Hazen and Williams formula:

$$f = 0.2083 \left(\frac{100}{C}\right)^{1.852} \times \frac{q^{1.852}}{Di^{4.8655}}$$

$$= .0983 \frac{q^{1.852}}{Di^{4.8655}} \text{ for } C = 150$$

$$P = .4335f$$

Where:

f = Friction Head in ft. of Water per 100 ft of Pipe
P = Pressure Loss in psi per 100 ft. of Pipe
Di = Inside Diameter of Pipe, in.
q = Flow Rate in U.S. gal/min
C = Constant for Inside Roughness (C equals 150 thermoplastics)

SYSTEMS ENGINEERING DATA
FOR THERMOPLASTIC PIPING

FLOW OF FLUIDS AND HEAD LOSS CALCULATIONS

Tables, flow charts, or a monograph may be used to assist in the design of a piping system depending upon the accuracy desired. In computing the internal pressure for a specified flow rate, changes in static head loss due to restrictions (valves, orifices, etc.) as well as flow head loss must be considered.

The formula in Table 45 can be used to determine the head loss due to flow if the fluid viscosity and density and flow rate are known. The head loss in feet of fluid is given by:

$$h = \frac{:186\ fLV}{d^2}$$

f, the friction factor, is a funcion of the Reynolds number, adimensionless parameter which indicates the degree of turbulence.

The Reynolds number is defined as: $f = \frac{dVW}{12U}$

Figure 7 below shows the relationship between the friction factor, f, and the Reynolds number, R. It is seen that three distinct flow zones exist. In the laminar flow zone, from Reynolds numbers 0 to 2000, the friction factor is given by the equation:

$$f = \frac{64}{R}$$

Substituting this in the equation for the head loss, the formula for laminar flow becomes:

$$h = \frac{143\ ULV}{Wd^2}$$

Flow in the critical zone, Reynolds numbers 2000 to 4000, is unstable and a surging type of flow exists. Pipe lines should be designed to avoid operation in the critical zone since head losses cannot be calculated accurately in this zone. In addition, the unstable flow results in pressure surges and water hammer which may be excessively high. In the transition zone, the degree of turbulence increases as the Reynolds number increases. However, due to the smooth inside surface of plastic pipe, complete turbulence rarely exists. Most pipe systems are designed to operate in the transition zone.

TABLE 45
FORMULAS FOR HEAD LOSS CALCULATIONS

$$R = \frac{dVw}{12\ u}$$

$$R = \frac{3160\ G}{kd}$$

$$R = \frac{2220B}{kd}$$

$$R = 22,735\ \frac{Qw}{zd}$$

When R = 4000:

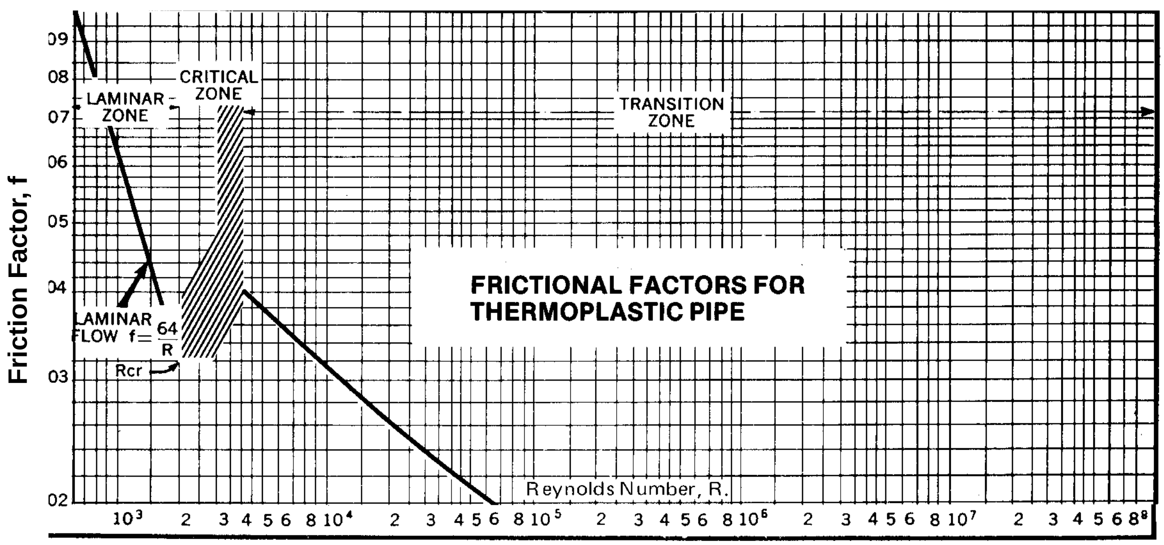
$$h = .186\ \frac{fLV^2}{d}$$

$$h = .0311\ \frac{fLG^2}{d^5}$$

$$P = \frac{fLB^2\ W}{9450d^2}$$

$$P = 43.5\ \frac{fLQ^2\ W}{d^5}$$

SYMBOL	QUANTITY	UNITS
B	flow rate	barrels/hour
d	inside diameter	inches
f	friction factor	dimensionless
G	flow rate	gallons/minute
h	head loss	feet of fluid
k	kinematic viscosity	centistokes
L	length of pipe	feet
P	pressure drop	lbs/in^2
Q	flow rate	$ft^3/sec.$
R	Reynolds number	dimensionless
u	absolute viscosity	lb/ft-sec.
V	velocity	ft./sec.
w	density	lbs/ft^3
z	absolute viscosity	centipoises



MANNING EQUATION

The Manning roughness factor is another equation used to determine friction loss in hydraulic flow. Like the Hazen-Williams C factor, the Manning "n" factor is an empirical number that defines the interior wall smoothness of a pipe. PVC pipe has an "n" value that ranges from 0.008 to 0.012 from laboratory testing. Comparing with cast iron with a range of 0.011 to 0.015, PVC is at least 37.5 percent more efficient, or another way to express this would be to have equal flow with the PVC pipe size being one-third smaller than the cast iron. The following table gives the range of "n" value for various piping materials.

Table 46

PIPE MATERIAL	"n" RANGE
CAST IRON	0.011-0.015
WROUGHT IRON (BLACK)	0.012-0.015
WROUGHT IRON (GALVANIZED)	0.013-0.017
SMOOTH BRASS	0.009-0.013
GLASS	0.009-0.013
RIVETED AND SPIRAL STEEL	0.013-0.017
CLAY DRAINAGE TILE	0.011-0.017
CONCRETE	0.012-0.016
CONCRETE LINED	0.012-0.018
CONCRETE-RUBBLE SURFACE	0.017-0.030
PVC	0.008-0.012
WOOD	0.010-0.013

ABOVE-GROUND INSTALLATION

OF THERMOPLASTIC PIPING

EXPANSION AND CONTRACTION OF PLASTIC PIPE

Plastics, like other piping materials, undergo dimensional changes as a result of temperature variations above and below the installation temperature. In most cases, **piping should be allowed to move unrestrained in the piping support system** between desired anchor points without abrasion, cutting or restriction of the piping. Excessive piping movement and stresses between anchor points must be compensated for and eliminated by installing expansion loops, offsets, changes in direction or teflon bellows expansion joints. (See Figure 7 for installed examples.)

If movement resulting from these dimensional changes is restricted by adjacent equipment, improper pipe clamping and support, inadequate expansion compensation, or by a vessel to which the pipe is attached, the resultant stresses and forces may cause damage to the equipment or piping.

A. Calculating Dimensional Change and Expansion Loop Size

The extent of expansion or contraction (ΔL) is dependent upon the piping material of construction and its coefficient of linear expansion (Y), the length of straight run being considered (L), and the temperature that the piping will possibly experience ($T_1 - T_2$). **The worst possible situations for maximum and minimum temperatures must be considered**. The formula for determining change in pipe length due to temperature change is:

$$\Delta L = \frac{Y (T_1 - T_2)}{10} \times \frac{L}{100}$$

Where: ΔL = Dimensional change due to thermal expansion or contraction (inches).
Y = Expansion coefficient (inches/10°F/100 ft) See Table 47
$(T_1 - T_2)$ = Temperature differential (degrees F)
L = Length of straight pipe run being considered (Feet)

TABLE 47
EXPANSION COEFFICIENT

Material	Y value (in/10°F/100ft)
FRP (Epoxy and Vinylester)	.100
PVC	.360
CPVC	.456
Fuseal (PP) 1-1/2 - 6 in.	.600
Fuseal (PP) 8, 10, 12 in.	.732
Proseal (PP)	.732
Proline (PP)	1.000
Polyethylene (PE)	1.250
Superproline (PVDF)	0.800

Generally, stresses due to expansion and contraction of a piping system can be reduced or eliminated through frequent changes in direction or through the installation of expansion loops. Loops, as depicted in Figure 7, are fabricated with 4 elbows and straight pipe and are much less expensive than teflon expansion joints. The loop sizing formula is as follows:

$$R = 1.44 \sqrt{D \; \Delta L}$$

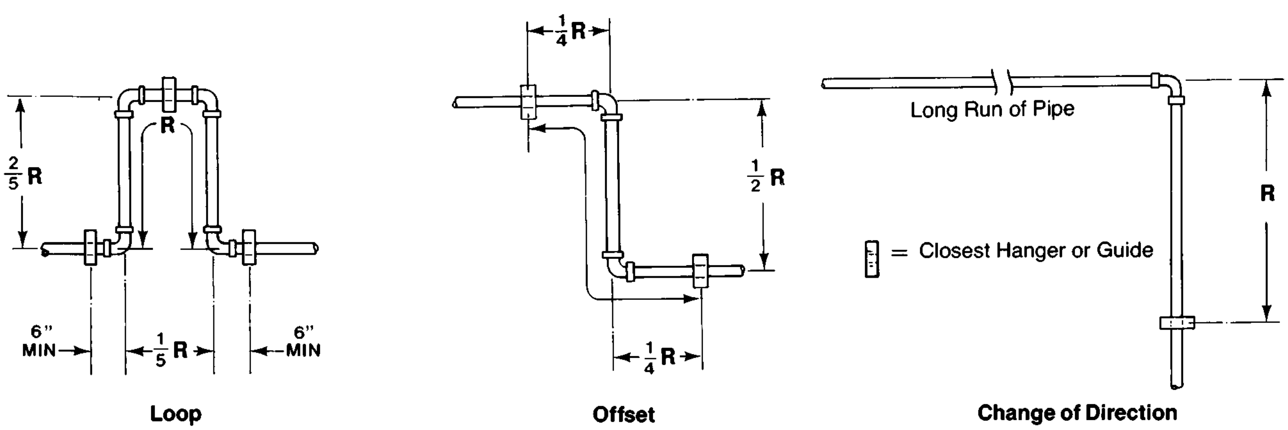
Where: R = Expansion loop leg length in feet
D = Nominal outside diameter (O.D.) of pipe in inches
ΔL = Change in length in inches due to expansion or contraction

EXAMPLE:

How much expansion can be expected in a 300 foot straight run of 6 inch PVC Sch. 80 pipe that will be installed at 80°F, operated at 110°F, and will experience a 50°F minimum in winter and 120°F maximum in summer? How long should the expansion loop legs be to compensate for the resultant expansion and contraction?

$$\Delta L = 0.360 \; \frac{(120-50)}{10} \times \frac{300}{100}$$
$$= 0.360 \times 7.0 \times 3$$
$$= 7.56 \text{ inches change in length}$$
$$R = 1.44 \sqrt{D \; \Delta L}$$
$$= 1.44 \sqrt{6.625 \times 7.56}$$
$$= 1.44 \times 7.08$$
$$= 10.20 \text{ Feet}$$

Figure 7



HARRINGTON

ABOVE-GROUND INSTALLATION
OF THERMOPLASTIC PIPING

THERMAL EXPANSION COMPENSATION

The change in length of thermoplastic pipe with temperature variation should always be considered when installing pipe lines and proviisions made to compensate for this change in length. The following tables have been prepared to assist you in determining this expansion.

Table 48 THERMAL EXPANSION ΔL (in.) - PVC Type 1

TEMP. CHANGE ΔT°F	LENGTH OF RUN IN FEET									
	10	20	30	40	50	60	70	80	90	100
30	.11	.22	.32	.43	.54	.65	.76	.86	.97	1.08
40	.14	.29	.43	.58	.72	.86	1.01	1.15	1.30	1.44
50	.18	.36	.54	.72	.90	1.08	1.26	1.40	1.62	1.80
60	.22	.43	.65	.86	1.08	1.30	1.51	1.72	1.94	2.16
70	.25	.50	.76	1.01	1.26	1.51	1.76	2.02	2.27	2.52
80	.29	.58	.86	1.15	1.44	1.73	2.02	2.30	2.59	2.88
90	.32	.65	.97	1.30	1.62	1.94	2.27	2.59	2.92	3.24
100	.36	.72	1.03	1.44	1.80	2.16	2.52	2.88	3.24	3.60

Example: Highest temperature expected - 120°F
Lowest temperature expected - 50°F
Total change (ΔT) 70°F
Length of run - 40 feet
From 70°F row on PVC chart read 1.01 in. length change (ΔL)
NOTE: Table is based on: ΔL = 12eL(ΔT)
Where e = Coefficient of Thermal Expansion
= 3.0×10^{-5} in./in. °F
L = Length of Run
ΔT = Temperature Change

Table 49 THERMAL EXPANSION ΔL (in.) CPVC Schedule 80

TEMP. CHANGE ΔT°F	LENGTH OF RUN IN FEET									
	10	20	30	40	50	60	70	80	90	100
20	.09	.18	.27	.36	.46	.55	.64	.73	.82	.91
30	.14	.27	.41	.55	.68	.82	.96	1.09	1.23	1.37
40	.18	.36	.55	.73	.91	1.09	1.28	1.46	1.64	1.82
50	.23	.46	.68	.91	1.14	1.37	1.60	1.82	2.05	2.28
60	.27	.55	.82	1.09	1.37	1.64	1.92	2.19	2.46	2.74
70	.32	.64	.96	1.28	1.60	1.92	2.23	2.55	2.87	3.19
80	.36	.73	1.09	1.46	1.82	2.19	2.55	2.92	3.28	3.65
90	.41	.82	1.23	1.64	2.05	2.46	2.87	3.28	3.69	4.10
100	.46	.91	1.37	1.82	2.28	2.74	3.19	3.65	4.10	4.56

Table 50 THERMAL EXPANSION ΔL (in) Copolymer Polypropylene

TEMP. CHANGE ΔT°F	LENGTH OF RUN IN FEET									
	10	20	30	40	50	60	70	80	90	100
20	.15	.29	.44	.59	.73	.88	1.02	1.17	1.32	1.46
30	.22	.44	.66	.88	1.10	1.32	1.54	1.76	1.98	2.20
40	.29	.59	.88	1.17	1.46	1.76	2.05	2.34	2.64	2.93
50	.37	.73	1.10	1.46	1.83	2.20	2.56	2.93	3.29	3.66
60	.44	.88	1.32	1.76	2.20	2.64	3.07	3.51	3.95	4.39
70	.51	1.02	1.54	2.05	2.56	3.07	3.59	4.10	4.61	5.12
80	.59	1.17	1.76	2.34	2.93	3.51	4.10	4.68	5.27	5.86
90	.66	1.32	1.98	2.69	3.29	3.95	4.61	5.27	5.93	6.59
100	.73	1.46	2.20	2.93	3.66	4.39	5.12	5.86	6.59	7.32

Table 51 THERMAL EXPANSION ΔL (in.) - PVDF Schedule 80

TEMP. CHANGE ΔT°F	LENGTH OF RUN IN FEET									
	10	20	30	40	50	60	70	80	90	100
20	.19	.38	.58	.77	.96	1.15	1.34	1.54	1.73	1.92
40	.38	.77	1.15	1.54	1.92	2.30	2.69	3.07	3.46	3.84
50	.48	.96	1.44	1.92	2.40	2.88	3.36	3.84	4.32	4.80
60	.58	1.15	1.73	2.30	2.88	3.46	4.03	4.61	5.18	5.76
70	.67	1.34	2.02	2.69	3.36	4.03	4.70	5.38	6.05	6.72
80	.77	1.54	2.30	3.07	3.84	4.61	5.38	6.14	6.91	7.68
90	.86	1.73	2.59	3.46	4.32	5.18	6.05	6.91	7.78	8.64
100	.96	1.92	2.88	3.84	4.80	5.76	6.72	7.68	8.64	9.60

The following expansion loop and offset lengths have been calculated based on stress and modulus of elasticities at the temperature shown below each chart. To calculate the proper length of loop at other temperatures the following formula may be used:

$$l = \sqrt{\frac{3E(O.D.)\,\Delta L}{2S}}$$

Where:
ΔT = Temperature Change in °F
S = Thermal Stress, psi = e(ΔT)E
E = Modulus of Elasticity (found in relative properties chart on pages 40-41.
ΔL= Length Change in Inches at ΔT (see tables above)
l = Total Length of Loop or Offset

Table 52 EXPANSION LOOPS AND OFFSET LENGTHS, PVC Type 1 Schedule 40 and 80

NOM. PIPE SIZE	AVERAGE O.D.	LENGTH OF RUN IN FEET									
		10	20	30	40	50	60	70	80	90	100
		LENGTH OF LOOP "*l*" IN INCHES									
1/2	.840	11	15	19	22	24	27	29	31	32	34
3/4	1.050	12	17	21	24	27	30	32	34	36	38
1	1.315	14	19	23	27	30	33	36	38	41	43
1-1/4	1.660	15	22	26	30	34	37	40	43	46	48
1-1/2	1.900	16	23	28	33	36	40	43	46	49	51
2	2.375	18	26	32	36	41	45	48	52	55	58
3	3.500	22	31	38	44	49	54	58	63	66	70
4	4.500	25	35	43	50	56	61	66	71	75	79
6	6.625	30	43	53	61	68	74	80	86	91	96
8	8.625	35	49	60	69	78	85	92	98	104	110
10	10.750	39	55	67	77	87	95	102	110	116	122
12	12.750	42	60	73	84	94	103	112	119	126	133

NOTE: Table based on stress and modulus of elasticity at 130°F
ΔT = 50°F
S = 600 psi
E = 3.1×10^{5} psi

ABOVE-GROUND INSTALLATION
OF THERMOPLASTIC PIPING

Table 53
EXPANSION LOOPS AND OFFSET LENGTHS, CPVC Schedule 80

NOM. PIPE SIZE	AVERAGE O.D.	LENGTH OF RUN IN FEET									
		10	20	30	40	50	60	70	80	90	100
		LENGTH OF LOOP "l" IN INCHES									
1/2	.840	15	21	26	30	33	37	39	42	45	47
3/4	1.050	17	22	27	31	34	38	40	43	46	48
1	1.315	19	26	32	37	42	46	49	53	56	59
1-1/4	1.660	21	30	36	42	47	52	56	59	63	67
1-1/2	1.900	23	32	39	45	50	55	59	64	67	71
2	2.375	25	35	43	50	56	62	67	71	75	80
3	3.500	31	43	53	61	68	75	81	86	91	97
4	4.500	35	49	60	69	77	85	92	98	103	109
6	6.625	42	59	73	84	94	103	111	119	125	133
8	8.625	48	67	83	96	107	118	127	135	143	152
10	10.750	54	75	93	107	119	131	142	151	160	169
12	12.750	59	82	101	116	130	143	154	164	174	184

NOTE: Table based on stress and modulus of elasticity at 160°F.
ΔT = 100°F
S = 750 psi
E = 2.91 x 10^5 psi

Table 54
EXPANSION LOOPS AND OFFSET LENGTHS Copolymer Polypropylene

NOM. PIPE SIZE	AVERAGE O.D.	LENGTH OF RUN IN FEET									
		10	20	30	40	50	60	70	80	90	100
		LENGTH OF LOOP "l" IN INCHES									
1/2	.840	18	25	31	36	40	44	47	50	54	57
3/4	1.050	20	28	35	40	45	49	53	56	60	63
1	1.315	22	32	39	45	50	55	59	63	67	71
1-1/4	1.660	25	35	43	50	56	62	66	71	75	79
1-1/2	1.900	27	38	46	54	60	66	71	76	81	85
2	2.375	30	42	52	60	67	74	79	85	90	95
3	3.500	36	52	63	73	81	89	96	103	109	115
4	4.500	41	58	71	83	92	101	109	117	124	131
6	6.625	50	71	87	100	112	123	132	142	151	159
8	8.625	57	81	99	114	128	140	151	162	172	181
10	10.750	64	90	111	128	143	156	169	181	192	202
12	12.750	69	98	121	139	155	170	184	197	209	220

NOTE: Table based on stress and modulus of elasticity at 160°F.
ΔT = 100°F
S = 240 psi
E = .83 x 10^5 lb./in.^{2}

Table 55
EXPANSION LOOPS AND OFFSET LENGTHS, PVDF Schedule 80

NOM. PIPE SIZE	AVERAGE O.D.	LENGTH OF RUN IN FEET									
		10	20	30	40	50	60	70	80	90	100
		LENGTH OF LOOP "l" IN INCHES									
1/2	.840	10	15	18	20	23	25	27	29	31	32
3/4	1.050	11	16	20	23	26	28	30	32	34	36
1	1.315	13	18	22	26	29	31	34	36	38	40
1-1/4	1.660	14	20	25	29	32	35	38	41	41	45
1-1/2	1.900	15	22	27	31	34	38	41	44	44	49
2	2.375	17	24	30	34	38	42	46	49	49	54

NOTE: Table based on stress and modulus of elasticity at 180°F.
ΔT = 100°F
S = 1080 psi
E = 1.04 x 10^5 psi

ABOVE-GROUND INSTALLATION
OF THERMOPLASTIC PIPING

These tables are based on:

F = As = restraining force, lbs.
A = Cross sectional wall area, in.^{2}
S = e(ΔT)E*
e = Coefficient of liner expansion*
E = Modulus of elasticity*
ΔT = Temperature change, °F
*All values are available from relative properties chart on pages 40-41.

Table 56

RESTRAINT FORCE "F" (LB.) - PVC Type 1 Schedule 40 and 80.

PIPE SIZE	SCHEDULE 40 PVC CROSS SECTIONAL WALL AREA (IN^2)	SCHEDULE 40 PVC ΔT = 50°F S = 630 PSI	SCHEDULE 40 PVC ΔT = 100°F S = 1260 PSI	SCHEDULE 80 PVC CROSS SECTIONAL WALL AREA (IN^2)	SCHEDULE 80 PVC ΔT = 50°F S = 630 PSI	SCHEDULE 80 PVC ΔT = 100°F S = 1260 PSI
1/2	.250	155	310	.320	200	400
3/4	.333	210	420	.434	275	550
1	.494	310	6220	.639	405	810
1-1/4	.669	420	840	.882	555	1,110
1-1/2	.800	505	1,010	1.068	675	1,350
2	1.075	675	1,350	1.477	930	1,860
3	2.229	1,405	2,810	3.016	1,900	3,800
4	3.174	2,000	4,000	4.407	2,775	5,550
6	5.581	3,515	7,030	8.405	5,295	10,590
8	8.399	5,290	10,580	12.763	8,040	16,080
10	11.908	7,500	15,000	18.922	11,920	23,840
12	15.745	9,920	19,840	26.035	16,400	32,800

Table 58

RESTRAINT FORCE "F" (LB.) Copolymer Polypropylene Schedule 80

PIPE SIZE	CROSS SECTIONAL WALL AREA (IN^2)	ΔT = 50°F S = 550 PSI	ΔT = 100°F S = 1110 PSI
1/2	.320	147	294
3/4	.434	199	398
1	.639	293	586
1-1/4	.882	404	808
1-1/2	1.068	489	978
2	1.477	663	1,325
3	3.016	1,381	2,276
4	4.407	2,018	4,036
6	8.405	3,899	7,698
8	12.763	5,895	11,690
10	18.922	8,666	17,332
12	26.035	11,929	23,848

Table 57

RESTRAINT FORCE "F" (LB.) CPVC Schedule 80

PIPE SIZE	CROSS SECTIONAL WALL AREA (IN^2)	ΔT = 50°F S = 805 PSI	ΔT = 100°F S = 1610 PSI
1/2	.320	260	520
3/4	.434	350	700
1	.639	515	1,030
1-1/4	.882	710	1,420
1-1/2	1.068	860	1,720
2	1.477	1,190	2,380
3	3.016	2,430	4,860
4	4.407	3,550	7,100
6	8.405	6,765	13,530
8	12.763	10,275	20,550
10	18.922	15,230	30,460
12	26.035	20,960	41,920

Table 59

RESTRAINT FORCE "F" (LB.) PVDF Schedule 80

PIPE SIZE	CROSS SECTIONAL WALL AREA (IN^2)	ΔT = 50°F S = 850 PSI	ΔT = 100°F S = 1700 PSI
1/2	.320	270	540
3/4	.434	370	740
1	.639	540	1,080
1-1/4	.882	750	1,500
1-1/2	1.068	905	1,810
2	1.477	1,255	2,510
3	3.016	2,565	5,130
4	4.407	3,745	7,490

ABOVE-GROUND INSTALLATION

OF THERMOPLASTIC PIPING

A. HANGERS

Plastic piping hangers must allow axial movement between anchor points. Hangers must prevent transverse movement and in conjunction with anchors, prevent point loading of the piping. Figures 8, 9, 10, 11 and 12 on page 70 are examples of types of hangers, anchors and support which may be used. Sleeving plastic piping at horizontal support points with a plastic pipe one pipe size larger which will allow unrestricted movement is recommended. Anchors should be placed at tees, valves, and desired locations to create sections of predictable expansion and contraction in the piping system.

Vertical lines must also be supported at proper intervals so that the fitting at the lower end is not overloaded. The supports should not exert a compressive strain on the pipe such as the double-bolt type. Riser clamps squeeze the pipe and are not recommended. If possible, each clamp should be located just below a coupling or other fitting so that the shoulder of the coupling provides bearing support to the clamp.

B. SUPPORT SPACING OF PLASTIC PIPE

When thermoplastic piping systems are installed above-ground, they must be properly supported to avoid unnecessary stresses and possible sagging.

Horizontal runs require the use of hangers spaced approximately as indicated in tables for individual material shown below. Note that additional support is required as temperatures increase. Continuous support can be accomplished by the use of a smooth structural angle or channel.

Where the pipe is exposed to impact damage, protective shields should be installed.

Tables are based on the maximum deflection of a uniformly loaded, continuously supported beam calculated from:

$$y = .00541 \frac{wL^4}{EI}$$

Where:

- y = Deflection or sag, in.
- w = Weight per unit length, lb/in.
- L = Support spacing, in.
- E = Modulus of elasticity at given temp. lb/in^2
- I = Moment of inertia, in.^{4}

If 0.100 in. is chosen arbitrarily as the permissible sag (y) between supports, then:

$$L^4 = 18.48 \frac{EI}{W}$$

Where:

W = Weight of Pipe + Weight of Liquid, lb./in.

For a pipe $I = \frac{\pi}{64} (Do^4 - Di^4)$

Where:

Do = Outside diameter of the pipe, in.
Di = Inside diameter of the pipe, in.

Then:

$$L = .907 \frac{E}{W} (Do^4 - Di^4)^{1/4} = .976 \frac{E}{W} (Do^4 - Di^4)^{1/4}$$

Table 60

SUPPORT SPACING "L" (FT.) - PVC

TEMP °F	NOMINAL PIPE SIZE 1/2	3/4	1	1-1/4	1-1/2	2	3	4	6	8	10	12
SCHEDULE 40 PVC												
60	4-1/4	4-1/2	5	5-1/2	5-3/4	6-1/4	7-1/2	8-1/4	9-1/2	10-1/2	11-1/2	12-1/2
100	4	4-1/4	4-3/4	5-1/4	5-1/2	6	7	7-3/4	9	10	11	11-3/4
140	3-3/4	4	4-1/2	5	5-1/4	5-3/4	6-3/4	7-1/2	8-1/2	9-3/4	10-1/2	11-1/4
SCHEDULE 80 PVC												
60	4-1/2	4-3/4	5-1/4	5-3/4	6	6-1/2	8	8-3/4	10-1/2	11-1/2	12-3/4	14
100	4	4-1/2	5	5-1/2	5-3/4	6-1/4	7-1/2	8-1/4	10	11	12-1/4	13-1/4
140	3-3/4	4-1/4	4-3/4	5-1/4	5-1/4	6	7	8	9-1/2	10-1/2	11-1/2	12-1/2

Table 61

SUPPORT SPACING "L" (FT.) - CPVC Schedule 80

TEMP °F	NOMINAL PIPE SIZE 1/2	3/4	1	1-1/4	1-1/2	2	3	4	6	8	10	12
73	4	4-1/2	5	5-1/2	5-3/4	6-1/2	7-3/4	8-1/2	10-1/4	11-1/4	12-1/2	13-3/4
100	4	4-1/2	5	5-1/2	5-3/4	6-1/4	7-1/2	8-1/4	10	11	12-1/2	13-1/4
120	4	4-1/4	4-3/4	5-1/4	5-1/2	6-1/4	7-1/2	8-1/4	9-3/4	10-1/2	12	13
140	4	4-1/4	4-3/4	5-1/4	5-1/2	6	7-1/4	8	9-1/2	10-1/2	11-3/4	12-3/4
160	3-3/4	4-1/4	4-1/2	5	5-1/4	5-3/4	7	7-3/4	9-1/4	10-1/4	11-1/2	12-1/2
180	3-3/4	4	4-1/2	5	5-1/4	5-3/4	7	7-1/2	9	10-1/4	11-1/4	12-1/4
210	3-1/2	4	4-1/4	4-3/4	5	5-1/2	6-1/2	7-1/4	8-3/4	9-3/4	10-3/4	11-3/4

ABOVE-GROUND INSTALLATION
OF THERMOPLASTIC PIPING

Table 62
SUPPORT SPACING "L" (FT.) - Polypro Schedule 80

TEMP °F	NOMINAL PIPE SIZE											
	1/2	3/4	1	1-1/4	1-1/2	2	3	4	6	8	10	12
73	3-3/4	4	4-1/2	4-3/4	5	5-1/2	6-1/2	7-1/4	8-1/2	9-1/2	10-1/2	11-1/4
120	3-1/2	3-3/4	4	4-1/2	4-3/4	5	6	6-3/4	8	8-3/4	9-3/4	10-1/2
140	3	3-1/2	3-3/4	4	4-1/4	4-1/2	5-1/2	6	7-1/4	8	8-3/4	9-1/2
160	3	3	3-1/2	3-3/4	4	4-1/4	5-1/4	5-3/4	6-3/4	7-1/2	8-1/4	9
180	2-3/4	3	3-1/4	3-1/2	3-3/4	4	5	5-1/2	6-1/2	7	7-3/4	8-1/2
200	2-1/2	2-3/4	3	3-1/2	3-1/2	4	4-3/4	5-1/4	6	6-3/4	7-1/2	8
212	2-1/2	2-3/4	3	3-1/4	3-1/4	3-3/4	4-1/2	5	5-3/4	6-1/2	7-1/4	7-3/4

Support spacing subject to change with SDR piping systems and different manufacturers' resins. See manufacturers support spacing guide prior to installation.

Table 63
SUPPORT SPACING "L"(FT.) - Proline & Super Proline

PIPE SIZE (IN.)	TEMPERATURE 68°F/ 20°C	86°F/ 30°C	104°F/ 40°C	122°F/ 50°C	140°F/ 60°C	158°F/ 70°C	176°F/ 80°C
1/2	3.0	2.5	2.5	2.0	2.0	2.0	2.0
3/4	3.0	3.0	2.5	2.5	2.5	2.5	2.0
1	3.5	3.0	3.0	3.0	3.0	2.5	2.5
1-1/2	4.0	3.5	3.0	3.0	3.0	3.0	3.0
2	4.5	4.0	4.0	3.5	3.0	3.0	3.0
2-1/2	5.0	4.5	4.0	4.0	3.5	3.0	3.0
3	5.5	5.0	4.0	4.0	4.0	3.5	3.5
4	6.0	5.0	5.0	4.0	4.0	4.0	4.0
6	7.0	6.0	6.0	5.0	5.0	4.5	4.5
8	7.5	7.0	6.0	6.0	5.5	5.0	5.0
10	8.5	7.5	7.0	6.5	6.0	6.0	5.5
12	9.5	8.5	8.0	7.0	7.0	6.5	6.0
14	10.0	8.5	8.0	7.5	7.0	6.5	6.5
16	10.5	9.5	8.5	8.0	7.5	7.0	6.5
18	11.5	10.0	9.0	8.5	8.0	7.5	7.0
20	12.0	10.5	9.5	8.5	8.5	8.0	7.5
24	13.5	11.5	10.0	9.5	8.5	8.0	7.5

This support spacing chart shows spans for polypropylene (PP) SDR 11, PP SDR 17.6, and PVDF pipes. For PP SDR 32, multiply span times .55 for the reduced value.

The support spacing chart shown above is based on liquids with a specific gravity of 1.0. Spacing should be reduced by 10% for liquids having 1.5 specific gravity, 15% for 2.0 s.q., and 20% for 2.5 s.q.

Table 64
SUPPORT SPACING "L" (FT.) - PVDF Schedule 80

TEMP °F	NOMINAL PIPE SIZE											
	1/2	3/4	1	1-1/4	1-1/2	2	3	4	6	8	10	12
68	3-1/2	3-3/4	4-1/4	4-1/2	4-3/4	5-1/4	6-1/2	7	8-1/2	9-1/2	10-1/2	11-1/4
120	3	3-1/4	3-3/4	4	4-1/4	4-3/4	5-3/4	6-1/4	7-1/2	8-1/4	9-1/4	10
160	2-3/4	3	3-1/2	3-3/4	4	4-1/4	5-1/4	5-3/4	6-3/4	7-1/2	8-1/2	9
200	2-1/2	2-3/4	3	3-1/2	3-1/2	4	4-3/4	5-1/4	6-1/4	7	7-3/4	8-1/4
240	2-1/4	2-1/2	2-3/4	3	3-1/4	3-1/2	4-1/4	4-3/4	5-1/2	6-1/4	7	7-1/2
260	2-1/4	2-1/2	2-3/4	3	3-1/4	3-1/2	4	4-1/2	5-1/2	6	6-3/4	7-1/4
280	2	2-1/4	2-1/2	2-3/4	3	3-1/4	4	4-1/4	5-1/4	5-3/4	6-1/2	7

Support spacing subject to change with SDR piping systems and different manufacturers' resins. See manufacturers support spacing guide prior to installation.

NOTE: All tables shown are based in .100 inch SAG between supports.

ABOVE-GROUND INSTALLATION
OF THERMOPLASTIC PIPING

PLASTICS AND FIRE (continued)

The surface burning characteristics of building materials are based upon UBC 42-1 Standards and ASTM E-84 testing to provide flame and smoke spread information of plastic material found on page 41.

All plastics melt before they burn when exposed to an open flame, and generate toxic carbon monoxide, non-toxic carbon dioxide, water vapor by-products, and dense smoke. PVC and CPVC also release toxic hydrogen chloride when burned. PVDF and other fluorocarbons release hydrogen fluoride. ABS, nylon and other nitrogen containing polymers release hydrogen cyanide.

An Underwriters Lab approved kaolin clay thermal insulation cloth, which will fireproof any plastic piping system to a 0 flame spread and 0 smoke spread per ASTM E-84 testing, has been used effectively to meet fire codes.

TABLE 65 FLAME-SPREAD CLASSIFICATION (UBC 1994)

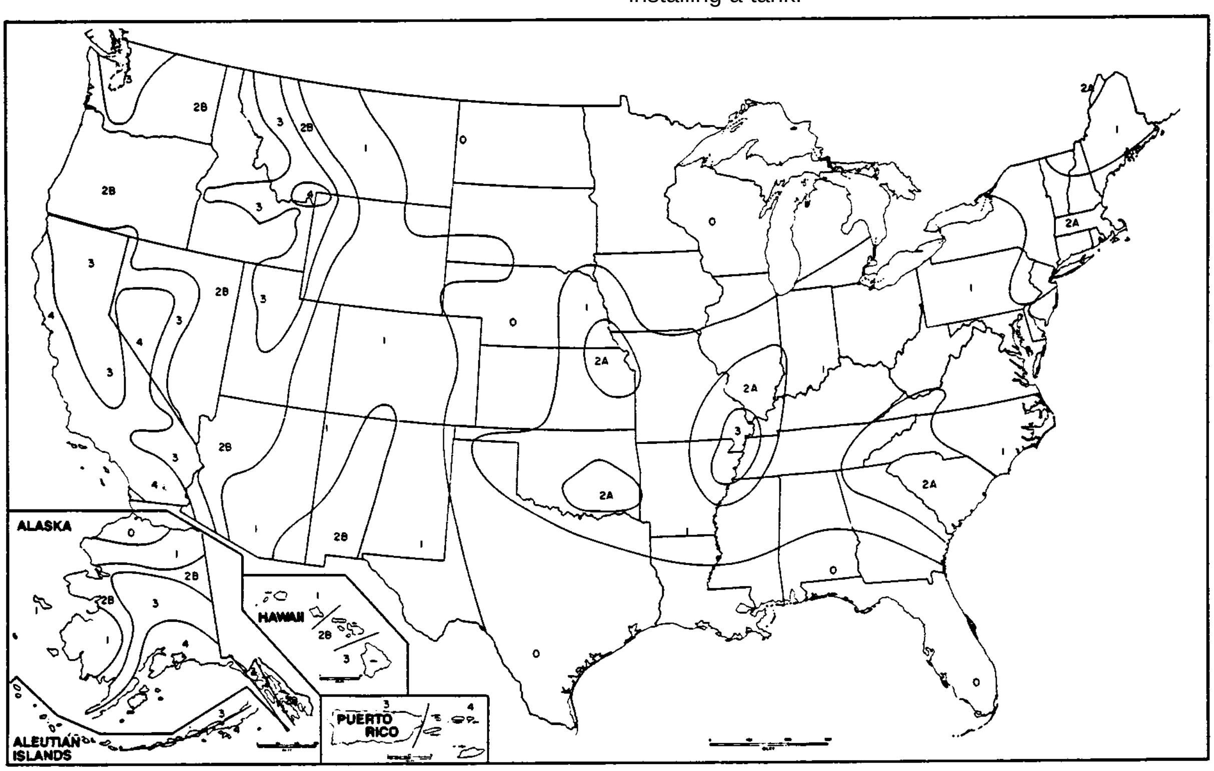
Class	Flame-Spread Index
I	0-25
II	26-75
III	76-200

TABLE 66 MAXIMUM FLAME-SPREAD CLASS (UBC 1994)

Occupancy Group	Description	Enclosed Vertical Exitways	Other Exitways	Rooms or Areas
A	Stadium	I	II	II
E	High Schools	I	II	III
I	Hospital	I	I	II
H-1	High Explosive	I	II	III
H-2	Moderate Explosive			
H-3	High Fire			
H-4	Repair Garage, Not B below			
H-5	Aircraft Repair, Not B below			
H-6	Semiconductor Fab and Research and Development			
H-7	Health Hazards - Highly Corrosive or Toxic			
B-1	Gas Stations	I	II	III
B-2	Office Buildings - No highly flammable or combustible materials			
B-3	Airplane Hangar, No open flame			
B-4	Power Plant, Factories using non-combustible and non-explosive materials			
R-1	Hotel, Apartment	I	II	III
R-3	Houses	III	III	III

SEISMIC DESIGNS FOR STORAGE TANKS

The Uniform Building Code 1994 edition states: "Flat bottom tanks or other tanks with supported bottoms found at or below grade shall be designed to resist the seismic forces calculated using the procedures in Section 2312 (i) for rigid structures considering the entire weight of the tanks and its contents." Seismic forces and wind forces tend to topple a tank. These forces must be calculated by a registered engineer and an approved restraint system utilized when installing a tank.



SEISMIC ZONE MAP OF THE UNITED STATES

ABOVE-GROUND INSTALLATION
OF THERMOPLASTIC PIPING

SUNLIGHT WEATHERING AND PAINTING
Plastic pipe and fittings have varying resistance to weathering. PVC, CPVC, and Polypropylene undergo surface oxidation and embrittlement by exposure to sunlight over a period of several years. The surface oxidation is evident by a change in pipe color from gray to white. Oxidized piping does not lose any of its pressure capability. It does, however, become much more susceptible to impact damage. PVDF is unaffected by sunlight but is translucent when unpigmented.

PVC and CPVC pipe and fittings can be easily protected from ultraviolet oxidation by painting with a heavily pigmented, exterior water base latex paint. The color of the paint is of no particular importance, as the pigment acts as an ultraviolet screen and prevents sunlight damage. White or some other light color is recommended as it helps reduce pipe temperature. The latex paint must be thickly applied as an opaque coating on the pipe and fittings that have been cleaned well and very lightly sanded.

Polypropylene and PVDF pipe and fittings are very difficult to paint properly and should be protected by insulation.

THERMAL EFFECTS ON PLASTICS
The physical properties of thermoplastic piping is significantly related to its operating temperature. As the operating temperature falls, the pipe's stiffness and tensile strength increases, increasing the pipe's pressure capacity and its ability to resist earth-loading deflection. With the drop in temperature, impact strength is reduced.

With an increase in temperature, there is a decrease in pipe tensile strength and stiffness and a reduction in pressure capability, as outlined in the Temperature-Pressure charts on page 44.

THERMAL CONDUCTIVITY, HEAT TRACING AND INSULATION
Plastic piping, unlike metal, is a very poor conductor of heat. Thermal conductivity is expressed as BTU/hr./sq.ft./°F/in. where BTU/hr. or British Thermal Unit per hour is energy required to raise temperature of 1 pound of water (12 gallons ÷ specific gravity) one Fahrenheit degree in one hour. Sq. ft. refers to 1 square foot where heat is being transferred. Inch refers to 1 inch of pipe wall thickness. As pipe wall increases, thermal conductivity decreases.

A comparison to steel, aluminum, and copper can be seen on page 41. Copper, a good conductor of heat, will lose 2,610 BTU/hr per square foot of surface area with a wall thickness of 1 inch. PVC will lose only 1.2 BTU/hr! If wall thickness is reduced to 0.250 inches, the heat loss increases 4 times.

Although plastics are poor conductors of heat, heat tracing of plastic piping may be necessary to maintain a constant elevated temperature of a viscous liquid, prevent liquid freezing, or to prevent a liquid, such as 50% sodium hydroxide, from crystallizing in a pipeline at 68°F. Electric heat tracing with self-regulating, temperature-sensing tape such as Raychem Chemelex Autotrace will maintain a 90°F temperature to prevent sodium hydroxide from freezing. The tape should be S-pattern wrapped on the pipe to allow pipe repairs and to avoid deflection caused by heating one side of the pipe. Heat tracing should be applied directly on the pipe within the insulation, and must not exceed the temperature-pressure-chemical resistance design of the system.

Insulation to further reduce plastic piping heat loss is available in several different forms from several manufacturers. The most popular is a two half foam insulation installed within a snap together with aluminum casing. Insulation can also provide weathering protection and fireproofing to plastic piping and is discussed later.

ULTRA-VIOLET LIGHT STERILIZATION
UV sterilizers for killing bacteria in deionized water are becoming common. The intense light generated will stress crack PVC, CPVC, polypropylene, and PVDF piping over time that is directly connected to the sterilizer. PVDF goes through a cross-linking of H-F causing a discoloration of the fitting and pipe material, and joint stress cracking.

VIBRATION ISOLATION
Plastic piping will conduct vibration from pumping and other sources of resonance frequencies, such as liquid flow through a partially open valve. Vibration isolation is best accomplished using a flanged, teflon, or thin rubber bellows expansion joint installed near the pump discharge or source of vibration. Metallic or thick rubber expansion joints lack the flexibility to provide flange movement and vibration isolation and should not be used in plastic piping systems. The proper bellows expansion joint will also provide for pipe system flexibility against a stationary mounted pump, storage tank, or equipment during an earthquake to reduce pipe breakage.

BELOW-GROUND INSTALLATION
OF THERMOPLASTIC PIPE

INTRODUCTION
Many problems experienced by above-ground plastic piping such as weathering/painting, expansion/contraction, pipe support/hangers, fire, and external mechanical damage are virtually eliminated by proper below-ground installation. The depth and width of trenching, bedding and backfilling, thrust blocking, snaking, air and pressure relief, and size and wall thickness of pipe must be considered.

TRENCHING AND BEDDING
DEPTH
In installing underground piping systems, the depth of the trench is determined by the intended service and by local conditions (as well as by local, state and national codes that may require a greater trench depth and cover than are technically necessary).

Underground pipes are subjected to external loads caused by the weight of the backfill material and by loads applied at the surface of the fill. These can range from static to dynamic loads.

Static loads comprise the weight of the soil above the top of the pipe plus any additional material that might be stacked above ground. An important point is that the load on a flexible pipe will be less than on a rigid pipe buried in the same manner. This is because the flexible conduit transfers part of the load to the surrounding soil and not the reverse. Soil loads are minimal with narrow trenches until a pipe depth of 10 feet is attained.

Dynamic loads are loads due to moving vehicles such as trucks, trains and other heavy equipment. For shallow burial conditions live loads should be considered and added to static loads, but at depths greater than 10 feet, live loads have very little effect.

Pipe intended for potable water service should be buried at least 12 inches below the maximum expected frost penetration.

WIDTH
The width of the trench should be sufficient to provide adequate room for “snaking” 1/2 to 2-1/2 inch nominal diameter pipe from side to side along the trench bottom, as described below, and for placing and compacting the side fills. The trench width can be held to a minimum with most pressure piping materials by joining the pipe at the surface and then lowering it into the trench after adequate joint strength has been obtained.

BEDDING
The bottom of the trench should provide a firm, continuous bearing surface along the entire length of the pipe run. It should be relatively smooth and free of rocks. Where hardpan, ledge rock or boulders are present, it is recommended that the trench bottom be cushioned with at least four (4) inches of sand or compacted fine-grained soils.

SNAKING
To compensate for thermal expansion and contraction when laying small diameter pipe in hot weather, the snaking technique of offsetting 1/2 to 2-1/2 inch nominal diameter pipe with relation to the trench center line is recommended.

A. **1/2 inch to 2-1/2 inch nominal diameter**. When the installation temperature is substantially lower than the operating temperature, the pipe should, if possible, be installed with straight alignment and brought up to operating temperature after joints are properly cured but before backfilling. This procedure will permit expansion of the pipe to be accommodated by a “snaking” action.

When the installation temperature is substantially above the operating temperature, the pipe should be installed by snaking in the trench. For example, a 100-foot length of PVC Type 1 pipe will expand or contract about 3/4 inch for each 20°F temperature change. On a hot summer day, the direct rays of the sun on the pipe can drive the surface temperature up to 150°F. At night, the air temperature may drop to 70°F. In this hypothetical case, the pipe would undergo a temperature change of 80°F and every 100 feet of pipe would contract 3 inches overnight. This degree of contraction would put such a strain on newly cemented pipe joints that a poorly made joint might pull apart.

A practical and economical method is to cement the line together at the side of the trench during the normal working day. When the newly cemented joint has dried, the pipe is snaked from one side of the trench to the other in gentle alternate curves. This added length will compensate for any contraction after the trench is backfilled. See Figure 13.

B. **3 inch and larger nominal diameter** pipes should be installed in straight alignment. Before backfilling to the extent that longitudinal movement is restricted, the pipe temperature should be adjusted to within 15°F of the operating temperature, if possible.

BELOW-GROUND INSTALLATION

OF THERMOPLASTIC PIPING

FIGURE 13

Table shown below gives the required loop length in feet and offset in inches for various temperature variations.

Snaking of thermoplastic pipe within trench to compensate for thermal expansion and contraction.

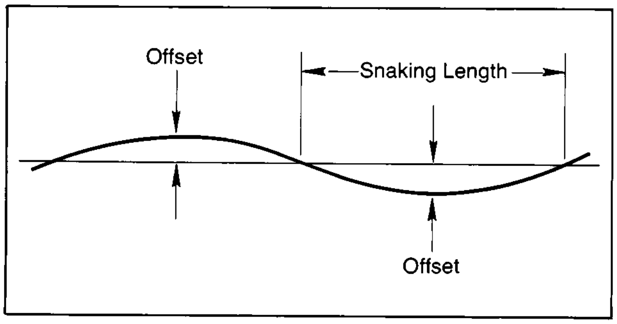
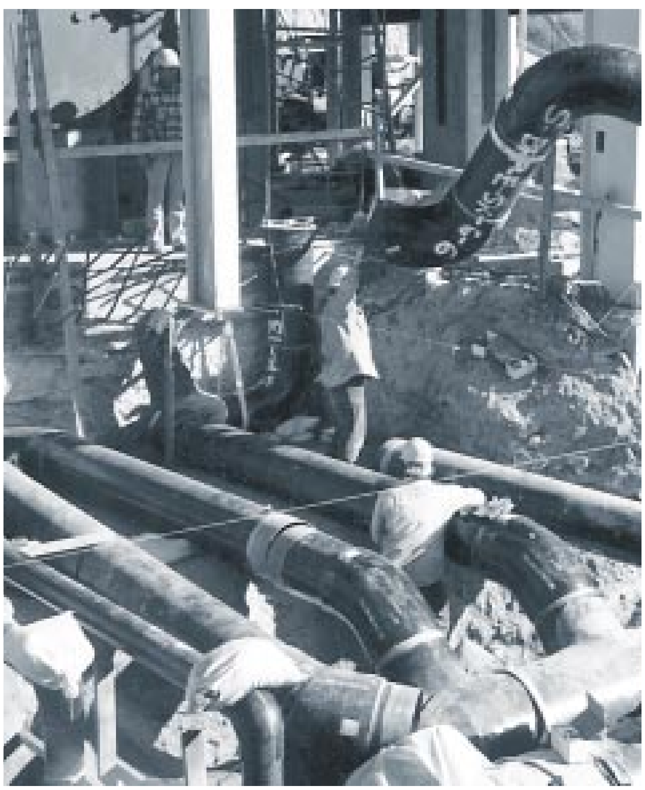


Table 67

SNAKING LENGTH VS. OFFSET (IN.) TO COMPENSATE FOR THERMAL CONTRACTION

SNAKING LENGTH (FT.)	MAXIMUM TEMPERATURE VARIATION (°F) BETWEEN TIME OF CEMENTING AND FINAL BACKFILLING									
	10°	20°	30°	40°	50°	60°	70°	80°	90°	100°
	LOOP OFFSET (IN.)									
20	2.5	3.5	4.5	5.20	5.75	6.25	6.75	7.25	7.75	8.00
50	6.5	9.0	11.0	12.75	14.25	15.50	17.00	18.00	19.25	20.25
100	13.0	18.0	22.0	26.00	29.00	31.50	35.00	37.00	40.00	42.00



DETERMINING SOIL LOADING FOR FLEXIBLE PLASTIC PIPE, SCHEDULE 80

Underground pipes are subjected to external loads caused by the weight of the backfill material and by loads applied at the surface of the fill. These can range from static to dynamic loads.

Static loads comprise the weight of the soil above the top of the pipe plus any additional material that might be stacked above ground. An important point is that the load on a flexible pipe will be less than on a rigid pipe buried in the same manner. This is because the flexible conduit transfers part of the load to the surrounding soil and not the reverse. Soil loads are minimal with narrow trenches until a pipe depth of 10 feet is attained.

Dynamic loads are loads due to moving vehicles such as trucks, trains and other heavy equipment. For shallow burial conditions live loads should be considered and added to static loads, but at depths greater than 10 feet, live loads have very little effect.

Soil load and pipe resistance for other thermoplastic piping products can be calculated using the following formula or using Tables 68 & 69.

$$Wc' = \frac{\Delta X(EI + .061\, E'r^3)80}{r^3}$$

Wc' = Load Resistance of the Pipe, lb./ft.
Δx = Deflection in Inches @ 5% (.05 x I.D.)
E = Modulus of Elasticity
t = Pipe Wall Thickness, in.
r = Mean Radius of Pipe (O.D. -t)/2
E' = Modulus of Passive Soil Resistance, psi
H = Height of Fill Above Top of Pipe, ft.
I = Moment of Inertia $\frac{t^3}{12}$

TABLE 68

LIVE LOAD FOR BURIED FLEXIBLE PIPE (LB/LIN.FT)

PIPE SIZE	H20 WHEEL LOADS FOR VARIOUS DEPTHS OF PIPE (LB./LIN.FT.)				
	2	4	6	8	10
2	309	82	38	18	16
3	442	118	56	32	21
4	574	154	72	42	27
6	837	224	106	61	40
8	1102	298	141	82	53
10	1361	371	176	101	66
12	1601	440	210	120	78

NOTE: H20 wheel load is 16,000 lb./wheel

BELOW-GROUND INSTALLATION

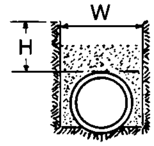
OF THERMOPLASTIC PIPING

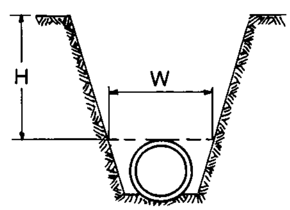
TABLE 69

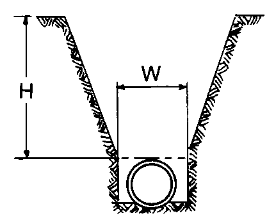
SOIL LOAD AND PIPE RESISTANCE FOR FLEXIBLE THERMOPLASTIC PIPE
PVC Schedule 40 and 80 Pipe

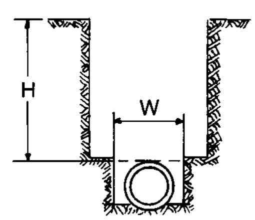
NOM. SIZE (IN.)	Wc' = LOAD RESISTANCE OF PIPE (LB./FT.) SCHEDULE 40 PIPE E'=200	SCHEDULE 40 PIPE E'=700	SCHEDULE 80 PIPE E'=200	SCHEDULE 80 PIPE E'=700	H (FT)	Wc = SOIL LOADS AT VARIOUS TRENCH WIDTHS AT TOP OF PIPE (LB./FT.) 2 FT	3 FT	4 FT	5 FT
1-1/2	1084	1282	2809	2993	10	106	125	136	152
					20	138	182	212	233
					30	144	207	254	314
					40	—	214	269	318
2	879	1130	2344	2581	10	132	156	170	190
					20	172	227	265	291
					30	180	259	317	392
					40	—	267	337	398
2-1/2	1344	1647	3218	3502	10	160	191	210	230
					20	204	273	321	352
					30	216	306	377	474
					40	—	323	408	482
3	1126	1500	2818	3173	10	196	231	252	280
					20	256	336	392	429
					30	266	266	384	469
					40	—	394	497	586
3-1/2	1021	1453	2591	3002	10	223	266	293	320
					20	284	380	446	490
					30	300	426	524	660
					40	—	450	568	670
4	969	1459	2456	2922	10	252	297	324	360
					20	328	432	540	551
					30	342	493	603	743
					40	—	506	639	754
5	896	1511	2272	2861	10	310	370	407	445
					20	395	529	621	681
					30	417	592	730	918
					40	—	625	790	932
6	880	1620	2469	3173	10	371	437	477	530
					20	484	636	742	812
					30	503	725	888	1093
					40	—	745	941	1110
8	911	1885	2360	3290	10	483	569	621	690
					20	630	828	966	1057
					30	656	945	1156	1423
					40	—	970	1225	1445
10	976	2198	2597	3764	10	602	710	774	860
					20	785	1032	1204	1317
					30	817	1177	1405	1774
					40	—	1209	1527	1801
12	1058	2515	2909	4298	10	714	942	919	1020
					20	931	1225	1429	1562
					30	969	1397	1709	2104
					40	—	1434	1811	2136

NOTE 1: Figures are calculated from minimum soil resistance values (E' = 200 psi for uncompacted sandy clay foam) and compacted soil (E' = 700 for side-fill that is compacted to 90% or more of Proctor Density for distance of two pipe diameters on each side of the pipe). If Wc' is less than Wc at a given trench depth and width, then soil compaction will be necessary.
NOTE 2: These are soil loads only and do not include live loads.









H = Height of fill above top of pipe, ft.
W = Trench width at top of pipe, ft.

HEAVY TRAFFIC

When plastic pipe is installed beneath streets, railroads, or other surfaces that are subjected to heavy traffic and resulting shock and vibration, it should be run within a protective metal or concrete casing.

HYDROSTATIC PRESSURE TESTING

Plastic pipe is not designed to provide structural strength beyond sustaining internal pressures up to its designed hydrostatic pressure rating and normal soil loads. Anchors, valves, and other connections must be independently supported to prevent added shearing and bending stresses on the pipe.

RISERS
The above piping design rule applies also where pipe is brought out of the ground. Above-ground valves or other connections must be supported independently. If pipe is exposed to external damage, it should be protected with a separate, rigidly supported metal pipe sleeve at the danger areas. Thermoplastic pipe should not be brought above ground where it is exposed to high temperatures. Elevated temperatures can lower the pipes pressure rating below design levels.

LOCATING BURIED PIPE
The location of plastic pipelines should be accurately recorded at the time of installation. Since pipe is a non-conductor, it does not respond to the electronic devices normally used to locate metal pipelines. However, a copper or galvanized wire can be spiraled around, taped to, or laid alongside or just above the pipe during installation to permit the use of a locating device, or use marker tape.

NOTE: For additional information see ASTM D-2774, "Underground Installation of Thermoplastic Pressure Piping."

TESTING THERMOPLASTIC PIPING SYSTEMS
We strongly recommend that all plastic piping systems be hydrostatically tested as described below before being put into service. Water is normally used as the test medium. **Note: Do not pressure test with compressed air or gas! Severe damage or bodily injury can result.**

The water is introduced through a pipe of 1-inch diameter or smaller at the lowest point in the system. An air relief valve should be provided at the highest point in the system to bleed off any air that is present.

The piping system should gradually be brought up to the desired pressure rating using a pressure bypass valve to assure against over pressurization. The test pressure should in no event exceed the rated operating pressure of the lowest rated component in the system such as a 150-pound flange.

INITIAL LOW-PRESSURE TEST
The initial low-pressure hydrostatic test should be applied to the system after shallow back-filling which leaves joints exposed. Shallow back-filling eliminates expansion/contraction problems. The test should last long enough to determine that there are no minute leaks anywhere in the system.

PRESSURE GAUGE METHOD
Where time is not a critical factor, the reading of a regular pressure gauge over a period of several hours will reveal any small leaks. If the gauge indicates leakage, that entire run of piping must then be visually inspected - paying special attention to the joints - to locate the source of the leak.

VISUAL INSPECTION METHOD
After the line is pressurized, it can be visually inspected for leaks without waiting for the pressure gauge to reveal the presence or absence of a pressure drop.

Even though no leaks are found during the initial inspection, however, it is recommended that the pressure be maintained for a reasonable length of time. Checking the gauge several times during this period will reveal any slow developing leaks.

LOCATE ALL LEAKS
Even though a leak has been found and the pipe or joint has been repaired, the low-pressure test should be continued until there is a reasonable certainty that no other leaks are present. Locating and repairing leaks is very much more difficult and expensive after the piping system has been buried. Joints should be exposed during testing.

HIGH-PRESSURE TESTING
Following the successful completion of the low-pressure test, the system should be high-pressure tested for at least 12 hours. The run of pipe should be more heavily backfilled to prevent movement of the line under pressure. Since any leaks that may develop probably will occur at the fitting joints, these should be left uncovered.

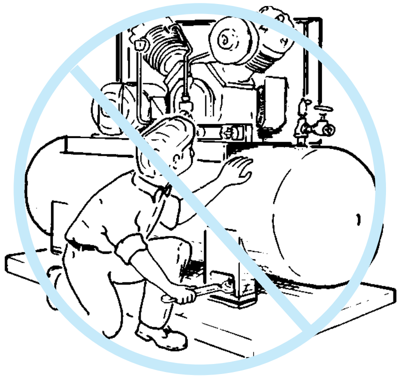
Solvent-cemented piping systems must be fully cured before pressure testing. For cure times, refer to the solvent cementing instruction tables on page 84.

TEST PRESSURE
The test pressure applied should not exceed: (a) the designed maximum operating pressure, (b) the designed pressure rating of the pipe, (c) the designed pressure rating of any system component, whichever is lowest.

SAFETY PRECAUTIONS
(1) Do not test with fluid velocities exceeding 5 ft./sec. since excessive water hammer could damage the system. (2) Do not allow any personnel not actually working on the high-pressure test in the area, in case of a pipe or joint rupture. (3) **Do not test with air or gas.**

TRANSITION FROM PLASTIC TO OTHER MATERIALS
Transitions from plastic piping to metal piping may be made with flanges, threaded fittings, or unions. Flanged connections are limited to 150 psi, and threaded connections are limited to 50% of the rated pressure of the pipe.

NOTE: When tying into a threaded metal piping system, it is recommended that a plastic male thread be joined to a metal female thread. Since the two materials have different coefficients of expansion, the male plastic fitting will actually become tighter within the female metal fitting when expansion occurs.



DO NOT TEST WITH AIR OR COMPRESSED GAS.

TESTING

INSTALLATION OF THERMOPLASTIC PIPING SYSTEMS

HANDLING & STORAGE PLASTIC PIPE

Normal precautions should be taken to prevent excessive mechanical abuse. However, when unloading pipe from a truck, for example, it is unwise to drag a length off the tailgate and allow the free end to crash to the ground. Remember, too, that SCRATCHES AND GOUGES ON THE PIPE SURFACE CAN LEAD TO REDUCED PRESSURE-CARRYING CAPACITY. Standard pipe wrenches should not be used for making up threaded connections since they can deform or scar the pipe. Use strap wrenches instead. When using a pipe vise or chuck, wrap jaws with emery cloth or soft metal.

Pipe should be stored on racks that afford continuous support and prevent sagging or draping of longer lengths. Burrs and sharp edges of metal racks should be avoided. Plastic fittings and flanges should be s˚Á„Bê4˚ÁÂ’∑ «?Ëkÿ4*ùÍ◊∑3)›Ì À1ÀPÔ ˛
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FIELD STACKING
During prolonged field storage of loose pipe, its stacks should not exceed two feet in height. Bundled pipe may be double-stacked providing its weight is distributed by its packaging boards.

HANDLING
Care should be exercised to avoid rough handling of pipe and fittings. They should not be pushed or pulled over sharp projections, dropped or have any objects dropped upon them. Particular care should be taken to avoid kinking or buckling the pipe. Any kinks or buckles which occur should be removed by cutting out the entire damaged section as a cylinder. All sharp edges on a pipe carrier or trailer that could come in contact with the pipe should be padded; i.e., can use old fire hose or heavy rubber strips. Only nylon or rope slings should be used for lifting bundles of pipe; chains are not to be used.

INSPECTION
Before installation, all lengths of pipe and fittings should be thoroughly inspected for cuts, scratches, gouges, buckling, and any other imperfections which may have been imparted to the pipe during shipping, unloading, storing, and stringing. Any pipe or pre-coupled fittings containing harmful or even questionable defects should be removed by cutting out the damaged section as a complete cylinder.

JOINING TECHNIQUES

FOR THERMOPLASTIC PIPE

There are six recommended methods of joining thermoplastic pipe and fittings, each with its own advantages and limitations:

SOLVENT CEMENTING
The most widely used method in Schedule 40 PVC, Schedule 80 PVC and CPVC piping systems as described in ASTM D-2855-93. The O.D. of the pipe and the I.D. of the fitting are primed, coated with special cement and joined together, as described in detail below. Knowledge of the principles of solvent cementing is essential to a good job. These are discussed in the Solvent Welding Instructions Section.
NOTE: The single most significant cause of improperly or failed solvent cement joints is lack of solvent penetration or inadequate primer application.

THREADING
Schedule 80 PVC, CPVC, PVDF, and PP can be threaded with special pipe dyes for mating with Schedule 80 fittings provided with threaded connections. Since this method makes the piping system easy to disassemble, repair, and test, it is often employed on temporary or take-down piping systems, as well as systems joining dissimilar materials. However, threaded pipe must be derated by 50 percent from solvent-cemented systems. **(Threaded joints are not recommended for PP pressure applications.)**

FLANGES
Flanges are available for joining all thermoplastic piping systems. They can be joined to the piping either with solvent-cemented or threaded connections. Flanging offers the same general advantages as threading and consequently is often employed in piping systems that must frequently be dismantled. The technique is limited to **150 psi working pressure.**

BUTT FUSION
This technique us used to connect all sizes of Polypropylene (Proline), PVDF (Super Proline) and large diameter Fuseal. Butt fusion is an easy, efficient fusion method especially in larger diameters.

SOCKET FUSION
This technique is used to assemble PVDF and polypropylene pipe and fittings for high-temperature, corrosive-service applications. (See each material Design Data section for recommended joining technique.)

FUSEAL HEAT FUSION
R & G Sloane's Fuseal is a patented method of electrically fusing pipe and fitting into a single homogenous unit. This advanced technique is used for GSR Fuseal polypropylene corrosive waste-handling systems.

FUSEAL MECHANICAL JOINT
Mechanical Joint polypropylene drainage system is used extensively for accessible smaller sized piping areas. The system, as the name implies, is a mechanical sealed joint that consists of a seal-ring, grab-ring, and nut. It is quick and easy to install and can be disconnected just as easily. You will find it most suitable for under sink and under counter piping.

INSTALLATION OF THERMOPLASTIC PIPING SYSTEMS

BASIC PRINCIPLES OF SOLVENT CEMENTING

SAFETY PRECAUTIONS

Cements contain highly volatile solvents which evaporate rapidly. Avoid breathing the vapors. If necessary, use a fan to keep the work area clear of fumes. Avoid skin or eye contact. Do not use near heat, sparks, or open flame. Do not pressure test with compressed air or gas! Severe damage or bodily injury can result.

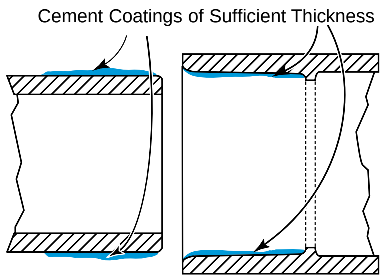
Solvent cementing is a preferred method of joining rigid PVC (Polyvinyl Chloride) and CPVC (Chlorinated Polyvinyl Chloride) pipe and fittings providing a chemically fused joint. The solvent-cemented joint is the last vital link in the installation process. It can mean the success or failure of the whole system. Accordingly, it requires the same professional care and attention that is given to the other components of the system. Experience shows that most field failures of plastic piping systems are due to improperly made solvent-cemented joints.

There are step-by-step procedures on just how to make solvent-cemented joints shown on the following pages. However, we feel that if the basic principles involved are first explained and understood, better quality installation can result with ease. To consistently make good joints, the following basics should be clearly understood by the installer.

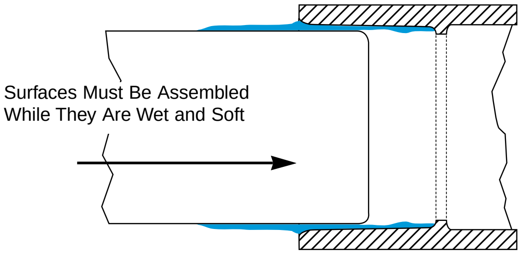
1. The joining surfaces must be clean, then softened and made semi-fluid.
2. Sufficient cement must be applied to fill the gap between pipe and fittings.
3. Assembly of pipe and fittings must be made while the surfaces are still wet and fluid.
4. Joint strength develops as the cement dries. In the tight part of the joint the surfaces will tend to fuse together. In the loose part the cement will bond to both surfaces.

Penetration and softening should be achieved with a suitable primer such as P70. Primer will penetrate and soften the surfaces more quickly than cement alone. Primer also provides a safety factor for the installer, as he can know under various temperature conditions when he has achieved sufficient softening of the material surfaces. For example, in cold weather more time and additional applications of primer will be required.

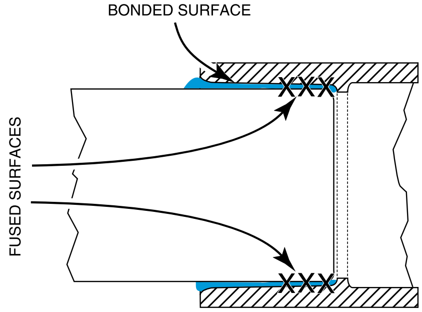
More than sufficient cement to fill the loose part of the joint must be applied. Besides filling the gap, adequate cement layers will penetrate the surface and also remain wet until the joint is assembled. Prove this for yourself. Apply on the top surface of a piece of pipe two separate layers of cement. First, flow on a heavy layer of cement, then alongside it a thin brushed out layer. Test the layers every 15 seconds or so by a gentle tap with your finger. You will note that the thin layer becomes tacky and dries quickly (probably within 15 seconds). The heavy layer will remain wet much longer. Now check for penetration a few minutes after applying these layers. Scrape them with a knife. The thin layer will have achieved little or no penetration, the heavy one much more penetration.



If the cement coating on the pipe and fittings are wet and fluid when assembly takes place, they will tend to flow together and become one cement layer. Also, if the cement is wet the surface beneath them will be soft, and these softened surfaces in the tight part of the joint will tend to fuse together.



As the solvent dissipates, the cement layer and the softened surfaces will harden with a corresponding increase in joint strength. A good joint will take the required pressure long before the joint is fully dry and final strength is obtained. In the tight (fused) part of the joint, strength will develop more quickly than in the loose (bonded) part of the joint. Information about the development of the bond strength of solvent-cemented joints is available on request.



JOINING EQUIPMENT AND MATERIALS

- **Cutting Tool (Saw or Wheel cutter)**
- **Deburring Tool (knife or file)**
- **Applicator Can or Bucket**
- **Solvent Cement**
- **Notched Boards**
- **Rags (nonsynthetic, i.e., cotton)**
- **Cement and Primer Applicators**
- **Purple Primer**
- **Tool Tray**

INSTALLATION OF THERMOPLASTIC PIPING SYSTEMS

SOLVENT CEMENTING INSTRUCTIONS FOR PVC AND CPVC PIPE AND FITTINGS

Before commencing work, this entire section should be studied and thoroughly understood. It is important that workers making joints be knowledgeable of these instructions and follow them carefully. Do not take shortcuts or omit any of the detailed steps.

KNOW YOUR MATERIAL

There are two general types of rigid vinyl materials, PVC and CPVC. Fitting are made of both materials and in both Schedule 40 and Schedule 80 weights.

Because of the difference in socket dimensions between the Schedule 40 and Schedule 80 fittings, more care must be taken with the Schedule 80 fittings and the cure schedules are different. Determine before proceeding with the job which type of vinyl plastic you are working with and which weight of fitting.

HANDLING CEMENTS AND PRIMERS

Cements and primers contain highly volatile solvents which evaporate rapidly. Avoid breathing the vapors. If necessary, use a fan to keep the work area clear of fumes. Avoid skin or eye contact. Keep cans closed when not actually in use. Solvent cements are formulated to be used "as received" in the original containers. If the cement thickens much beyond its original consistency, discard it. Cement should be free flowing, not jelly-like. Do not attempt to dilute it with thinner, as this may change the character of the cement and make it ineffective. Caution: Solvent cement has limited shelf life, usually one year for CPVC and two years for PVC. Date of manufacture is usually stamped on the bottom of the can. Do not use the cement beyond the period recommended by the manufacturer. Always keep solvent cements and primers out of the reach of children.

SELECTION OF CEMENTS, PRIMERS AND APPLICATORS

1. Obtain the correct primer and solvent cement for the product being installed. (See Harrington's Catalog for detailed information on solvent cements and primers.)

PVC

(a) Use #P-70 purple primer for all sizes of PVC pipe and fittings.
(b) Use #710 clear, light-bodied cement with PVC Schedule 40 fittings having an interference fit through 2" size. Not for use on Schedule 80.
(c) Use #705 clear, medium-bodied cement with PVC Schedule 40 fittings having an interference fit though 6" size. Not for use on Schedule 80.
(d) Use #711 gray, heavy-bodied cement with PVC Schedule 80 fittings through 8" and Schedule 40 fittings 6" and 8" size.
(e) Use #719 gray, extra-heavy-bodied cement for Schedule 40, 80, and all class or schedule sizes over 8" size.

CPVC

(a) Use #P-70 purple primer for all sizes of CPVC pipe and fittings except copper tube size CPVC (which requires #P-72 or 729).
(b) Use #714 orange or gray, heavy-bodied cement for all sizes of CPVC pipe and fittings.

2. Obtain the correct primer applicators. (See Harrington's Catalog for applicators.) Generally, the applicator should be about 1/2 the pipe diameter.

(a) Use #DP-75, 3/4" diameter, dauber (Supplied with pint size cans of P-70 primer.) for pipe sizes thru 1 1/4".
(b) Use #DP-150, 1 1/2" diameter, dauber for pipe sizes through 3".
(c) Use #4020 cotton string mop for pipe sizes 4" and larger.

Low VOC 724 cement for hypochlorite service.
Weld-on 724 CPVC low VOC cement is a gray, medium bodied, fast setting solvent cement used for joining CPVC industrial piping through 12" diameter, and is specially formulated for services that include caustics and hypochlorites.

3. Obtain the correct solvent cement applicators. Generally, the applicator should be about 1/2 the pipe diameter.

(a) Use #DP-75 3/4" diameter dauber or a natural bristle brush for pipe sizes 1/2" through 1-1/4"
(b) Use #DP-150 1-1/2" diameter dauber for pipe sizes 3/4" through 3". (1" natural bristle brush may be used for pipe sizes up to 2".).
(c) Use #3020, 2" diameter, "Roll-A-Weld" roller for 3" through 6" pipe sizes.
(d) Use #7020 7" long roller or #4020 large cotton swab for 6" through 12" pipe sizes.
(e) Use extra-large natural bristle paint brush to flow cement onto pipe larger than 12".

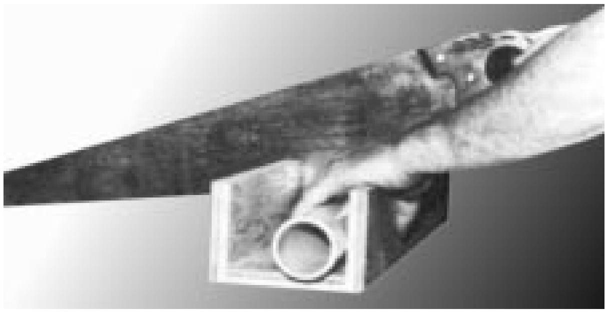
INSTALLATION OF THERMOPLASTIC

INSTALLATION OF THERMOPLASTIC PIPING SYSTEMS

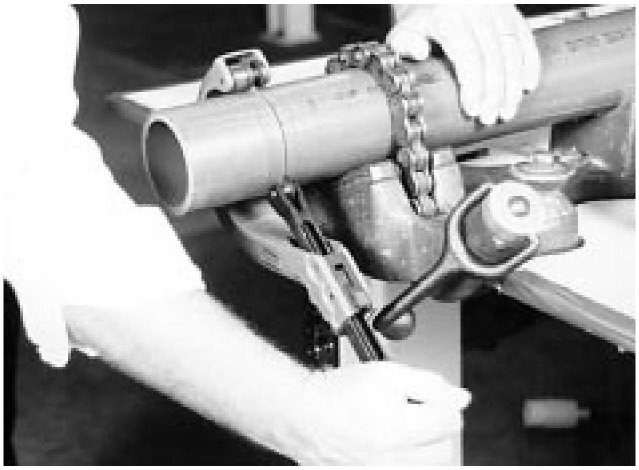
SOLVENT CEMENTING INSTRUCTIONS FOR PVC AND CPVC PIPE AND FITTINGS

PREPARATION

Condition pipe and fittings to the same temperature.



1. Cut pipe square to desired length using a hand saw and miter box or mechanical cutoff saw. A diagonal cut reduces the bonding area in the most effective part of the joint.



2. Plastic tubing cutters may also be used for cutting plastic pipe. However, most produce a raised bead at the end of the pipe. This must be removed with a file, knife, or beveling tool. A raised bead will wipe the cement away when the pipe is inserted into the fitting.

3. Large diameter pipe should be cut and chamfered with appropriate power tools. See Harrington's Products Catalog for tools.

- **For 3/8" to 8" pipe -** 1/16" to 3/32"
- **For 10" to 30" pipe -** 1/4" to 5/8"

4. Chamfer end of the pipe as shown above.

5. Clean and dry pipe and fitting socket of all dirt, moisture, and grease. Use a clean, dry rag.

Check pipe and fitting for fit (dry) before cementing. For proper interference fit, the pipe must go into the fitting 1/3 to 3/4 of the way to the stop. Too tight of a fit is not desirable. You must be able to fully bottom the pipe into the socket after it has been softened with primer. If the pipe and fitting are not out of round, a satisfactory joint can be made if there is a "net" fit. That is, the pipe bottoms in the fitting socket with no interference, but without slop. All pipe and fitting must conform to ASTM or other standards.

INSTALLATION OF THERMOPLASTIC PIPING SYSTEMS

SOLVENT CEMENTING INSTRUCTIONS FOR PVC AND CPVC PIPE AND FITTINGS

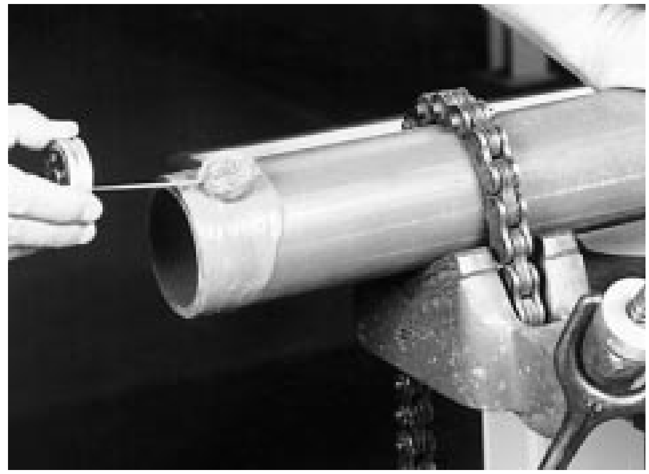
PRIMING

7. The purpose of the primer is to penetrate and soften the surfaces so that they can fuse together. The proper use of the primer and checking of its softening effect provides assurance that the surfaces are prepared for fusion in a wide variety of temperatures and working conditions.

Before starting the installation, we recommend checking the penetration and softening effect of the primer on a scrap piece of the material you will be working with. This should be done where the temperature and environmental conditions are the same as those where the actual installation will take place. The effect of the primer on the surface will vary with both time and temperature. To check for proper penetration and softening, apply primer as indicated in step number 9. After applying primer, use a knife or sharp scraper and draw the edge over the coated surface. Proper penetration has been made if you can scratch or scrape a few thousandths of an inch of the primed surface away.

8. Using the correct applicator as previously mentioned, apply primer freely with a scrubbing motion to the fitting socket, keeping the surface and applicator wet until the surface has been softened. This usually requires 5-15 seconds. More time is needed for hard surfaces (found in belled-end pipe and fittings made from pipe stock) and in cold weather conditions. Redip the applicator in the primer as required.

When the surface is primed, remove any puddles of primer from the socket. Puddles of primer can weaken the pipe and/or joint itself.

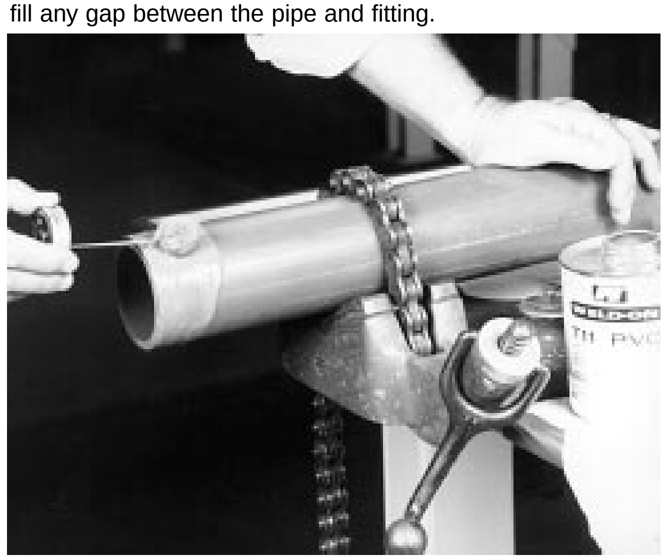


9. Apply the primer to the end of the pipe equal to the depth of the fitting socket. Application should be made in the same manner as was done to the fitting socket. Be sure the entire surface is well dissolved or softened.

10. Apply a second application of primer to the fitting socket and immediately, while the surfaces are still wet, apply the appropriate solvent cement. Time becomes important at this stage. Do not allow cement or primer to dry or start forming film on the surface.

CEMENTING

11. Apply a liberal coat of solvent cement to the male end of the pipe. Flow the cement on with the applicator. **Do not** brush cement out to a thin paint-type layer that will dry in a few seconds. The amount should be more than sufficient to fill any gap between the pipe and fitting.

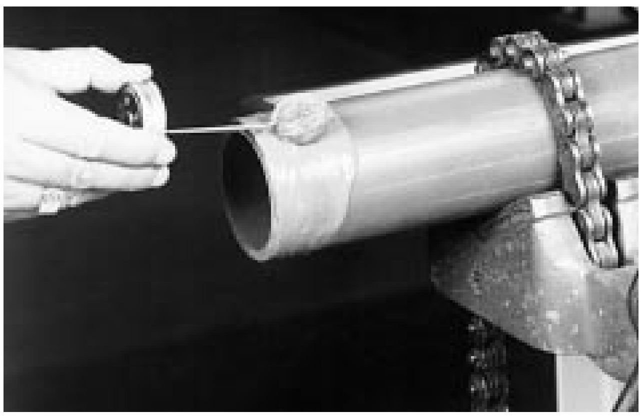


INSTALLATION OF THERMOPLASTIC PIPING SYSTEMS

SOLVENT CEMENTING INSTRUCTIONS FOR PVC AND CPVC PIPE AND FITTINGS

12. Apply a medium layer of solvent cement to the fitting socket; avoid puddling cement in the socket. On bell-end pipe do not coat beyond the socket depth or allow cement to run down in the pipe beyond the bell.

13. Apply a second full, even coat of solvent cement to the male end of the pipe. There must be sufficient cement to fill any gap in the joint. The cement must be applied deliberately but without delay. It may be necessary for two men to work together when cementing three inch and larger pipe.



14. While both the inside of the socket and the outside surface of the male end of the pipe are soft and wet with cement, forcefully bottom the male end of the pipe into the socket. Give the male end of the pipe a one-quarter turn if possible. This will help drive any air bubbles out of the joint. The pipe must go into the bottom of the socket and stay there. Hold the joint together until both soft surfaces are firmly gripped. (Usually less than 30 seconds on small diameter piping, larger sizes will require more time.) Care must be used since the fitting sockets are tapered and the pipe will try to push out of the fitting just after assembly.

When solvent cementing large diameter (8 inch and above) pipe and fittings proper equipment should be used. We recommend using straps and come-alongs as shown. See the tool section of the Harrington catalog.

15. After assembly a properly made joint will normally show a ring or bead of cement completely around the juncture of the pipe and fitting. Any gaps at this point may indicate a defective assembly job, due to insufficient cement or the use of light bodied cement on larger diameters where heavy bodied cement should have been used.

16. Without disturbing the joint, use a rag and remove excess cement from the pipe at the end of the fitting socket. This includes the ring or bead noted earlier. This excess cement will not straighten the joint and may actually cause needless softening of the pipe and additional cure times.

17. Handle newly assembled joints carefully until initial set has taken place. Recommended setting time allowed before handling or moving is related to temperature. See initial set times (Table 70).

18. Allow the joint to cure for adequate time before pressure testing. Joint strength development is very rapid within the first 48 hours. Short cure periods are satisfactory for high ambient temperatures with low humidity, small pipe sizes, and interference-type fittings. Longer cure periods are necessary for low temperatures, large pipe sizes, loose fits, and relatively high humidity. See Table 71 for recommended cure times.

INSTALLATION OF THERMOPLASTIC PIPING SYSTEMS

SOLVENT CEMENTING INSTRUCTIONS FOR PVC AND CPVC PIPE AND FITTINGS

Table 70

INITIAL SET TIMES

TEMPERATURE RANGE DURING INITIAL SET TIME	SET TIME FOR PIPE SIZES 1/2" TO 1 1/4"	SET TIME FOR PIPE SIZES 1 1/2" TO 3"	SET TIME FOR PIPE SIZES 4" TO 8"	SET TIME FOR PIPE SIZES 10" TO 14"	SET TIME FOR PIPE SIZES 16" TO 24"
60° TO 100° F	15 MIN.	30 MIN.	1 HR.	2 HR.	4 HR.
40° TO 59° F	1HR.	2 HR.	4 HR.	8 HR.	16 HR.
0° TO 39° F	3 HR.	6 HR.	12 HR.	24 HR.	48 HR.

* In damp or humid weather allow 50% more cure time.

The following cure schedules are suggested as guides. They are based on laboratory test data and should not be taken to be the recommendation of all cement manufacturers. Individual manufacturers' recommendations for their particular cement should be followed. These cure schedules are based on laboratory test data obtained on net fit joints. (Net fit—in a dry fit the pipe bottoms snugly in the fitting socket without meeting interference.) If a gap joint is encountered in the system, double the following cure times.

Table 71

JOINT CURE SCHEDULE FOR PVC/CPVC PIPE AND FITTINGS

RELATIVE HUMIDITY 60% OR LESS* TEMPERATURE RANGE DURING ASSEMBLY AND CURE TIME	CURE TIME FOR PIPE SIZES 1/2" TO 1 1/4		CURE TIME FOR PIPE SIZES 1 1/2" TO 3"		CURE TIME FOR PIPE SIZES 4" TO 8"		CURE TIME FOR PIPE SIZES 10" TO 14"	CURE TIME FOR PIPE SIZES 16" TO 24"
	Up To 180 psi	Above 180 to 370 psi	Up To 180 psi	Above 180 to 315 psi	Up To 180 psi	Above 180 to 315 psi	Up to 180 psi	Up to 100 psi
60° TO 100° F	1 Hr.	6 Hr.	2 Hr.	12 Hr.	6 Hr.	24 Hr.	24 Hr.	48-72 Hr.
40° TO 59° F	2 Hr.	12 Hr.	4 Hr.	24 Hr.	12 Hr.	48 Hr.	72 hrs	5 Days
0° TO 39° F	8 Hr.	48 Hr.	16 Hr.	96 Hr.	48 Hr.	8 Days	8 Days	10-14 Days

TROUBLESHOOTING AND TESTING SOLVENT CEMENT JOINTS

DO NOT TEST WITH AIR OR COMPRESSED GAS.

DO NOT TAKE SHORTCUTS. Experience has shown that shortcuts from the instructions given above are the cause of most field failures. Don't take a chance.

Solvent cemented joints correctly assembled with good cement under reasonable field conditions should never blow apart when tested, after the suggested cure period under recommended test pressures.

Good solvent cemented joints exhibit a complete dull surface on both surfaces **when cut in half and pried apart.** Leaky joints will show a continuous or an almost continuous series of shiny spots or channels from the bottom to the outer lip of the fitting. No bond occured at these shiny spots. The condition can increase to the point where the entire cemented area is shiny, and the fitting can blow off at this point.

Shiny areas can be attributed to one or a combination of the following causes:

1. Cementing surface not properly primed and dissolved prior to applying solvent cement.
2. Use of too small an applicator for primer or cement in comparison to pipe and fitting diameter.
3. Use of a cement which has partially or completely dried prior to bottoming the pipe into the fitting.
4. Use of jelled cement which will not bite into the pipe and fitting surface due to loss of the prime solvent.
5. Insufficient cement or cement applied only to one surface.
6. Excess gap which cannot be satisfactorily filled.
7. Excess time taken to make the joint after start of the cement application. In many of these cases, as well as condition No. 2, examination will show that it was impossible to bottom the fitting, since the lubrication effect of the cement had dissipated.
8. Cementing with pipe surfaces above 110°F has evaporated too much of the prime solvent.
9. Cementing with cement which has water added by one means or another, or excess humidity conditions coupled with low temperatures.
10. Joints that have been disturbed and the bond broken prior to the firm set, or readjusted for alignment after bottoming.

INSTALLATION OF THERMOPLASTIC PIPING SYSTEMS

SOLVENT CEMENTING INSTRUCTIONS FOR PVC AND CPVC PIPE AND FITTINGS

JOINING PLASTIC PIPE IN HOT WEATHER

There are many occasions when solvent cementing plastic pipe in 95°F temperatures and over cannot be avoided. If special precautions are taken, problems can be avoided. Solvent cements for plastic pipe contain high-strength solvents which evaporate faster at elevated temperatures. This is especially true when there is a hot wind blowing. If the pipe is stored in direct sunlight, surface temperatures may be 20°F to 30°F above the air temperature. Solvents attack these hot surfaces faster and deeper, especially inside the joint. Thus it is very important to avoid puddling inside the socket and to wipe off excess cement outside the joint.

By following our standard instructions and using a little extra care as outlined below, successful solvent cemented joints can be made even in the most extreme hot weather conditions.

JOINING PLASTIC PIPE IN COLD WEATHER

Working in freezing temperatures is never easy, but sometimes the job is necessary. If that unavoidable job includes solvent cementing of plastic pipe, it can be done.

GOOD JOINTS CAN BE MADE AT SUB-ZERO TEMPERATURES

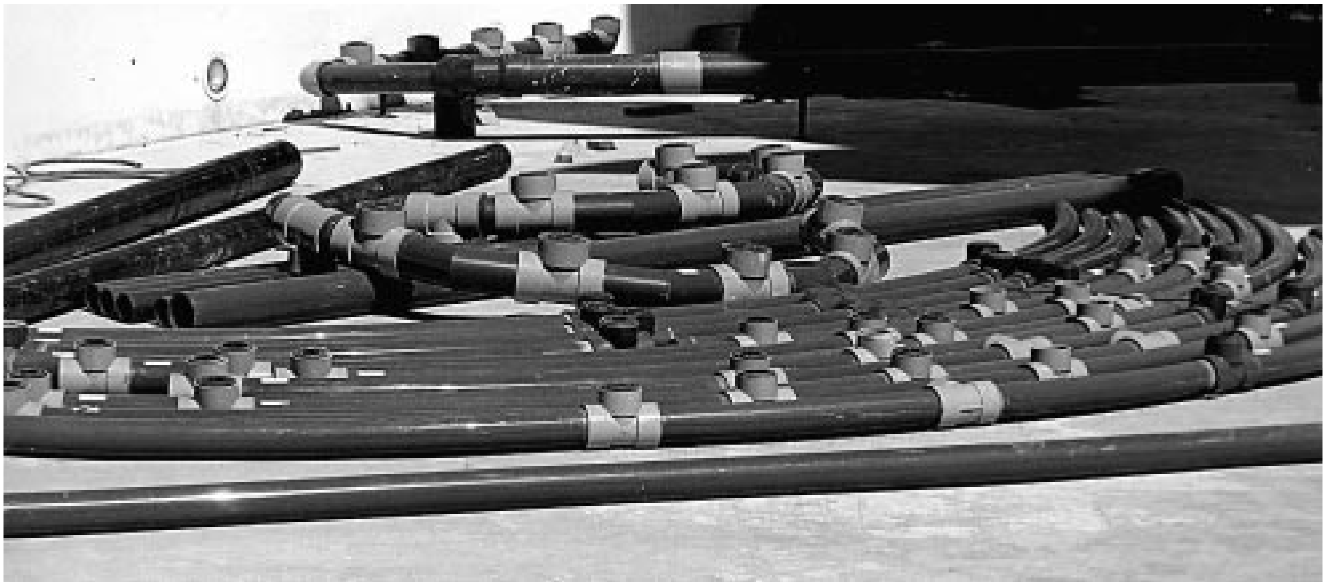
By following our standard instructions and using a little extra care and patience, successful solvent cemented joints can be made at temperatures even as low as -15°F. In cold weather solvents penetrate and soften the surfaces more slowly than in warm weather. Also, the plastic is more resistant to solvent attack. Therefore, it becomes more important to presoften surfaces with primer.

Because solvents evaporate slower in cold weather, a longer cure time will be required. The cure schedule printed in Table 71 already allows a wide margin for safety. For colder weather, simply allow more cure time.

TIPS TO FOLLOW WHEN SOLVENT CEMENTING IN HIGH TEMPERATURES:

1. Store solvent cements and primers in a cool or shaded area prior to use.
2. If possible, store fittings and pipe, or at least the ends to be solvent cemented, in a shady area before cementing.
3. Cool surfaces to be joined by wiping with a damp rag. Be sure that surface is dry prior to applying solvent cement.
4. Try to do the solvent cementing in the cooler morning hours.
5. Make sure that both surfaces to be joined are still wet with cement when putting them together. With large size pipe, more people on the crew may be necessary.
6. Use one of our heavier bodied, high viscosity cements since they will provide a little more working time.
7. Be prepared for a greater expansion-contraction factor in hot weather.

INSTALLATION OF THERMOPLASTIC



INSTALLATION OF THERMOPLASTIC PIPING SYSTEMS

SOLVENT CEMENTING INSTRUCTIONS FOR PVC AND CPVC PIPE AND FITTINGS

TIPS TO FOLLOW IN SOLVENT CEMENTING DURING COLD WEATHER:

1. Prefabricate as much of the system as is possible in a heated working area.
2. Store cements and primers in a warmer area when not in use and make sure they remain fluid.
3. Take special care to remove moisture, including ice and snow.
4. Use extra primer to soften the joining surfaces before applying cement.
5. Allow a longer initial set and cure period before the joint is moved or the system is tested.
6. Read and follow all of our directions carefully before installation.

Regular cements are formulated to have well-balanced drying characteristics and to have good stability in sub-freezing temperatures. Some manufacturers offer special cements for cold weather because their regular cements do not have that same stability.

For all practical purposes, good solvent cemented joints can be made in very cold conditions with our existing products, providing proper care and a little common sense are used.

PHYSICAL DATA
P-70 PRIMER FOR PVC AND CPVC

BOILING POINT (°F) Based on 1st boiling Comp. THF.	151°F	SPECIFIC GRAVITY (H_20=1)	0.870 ±0.010
VAPOR PRESSURE (mm Hg.) THF @ 25	190	PERCENT, VOLATILE BY VOLUME (%)	100%
VAPOR DENSITY (AIR = 1) APPROX.	2.49	EVAPORATION RATE (BUAC = 1) APPROX.	5.5 - 8
SOLUBILITY IN WATER 100%			
APPEARANCE AND ODOR - Purple Color, - Etheral Odor			

FIRE AND EXPLOSION HAZARD DATA

FLASH POINT (Method used) (T.C.C.) 6°F	FLAMMABLE LIMITS	Left 1.8	Used 11.8
EXTINGUISHING MEDIA Dry chemical,Carbondioxide - Foam - Ansul "Purple K" National Aero-O-Foam			
SPECIAL FIREFIGHTING PROCEDURES Close or confined quarters require self contained breathing apparatus. Positive pressure hose mask or airline masks.			
UNUSUAL FIRE AND EXPLOSION HAZARDS Fire hazard because of low flash point, high volatility and heavy vapor.			

PHYSICAL DATA
705 CLEAR OR GRAY CEMENT FOR PVC

BOILING POINT (°F) Based on 1st boiling Comp. THF.	151°F	SPECIFIC GRAVITY (H_20=1)	0.920 ±0.02
VAPOR PRESSURE (mm Hg.) THF @ 25°C	190	PERCENT, VOLATILE BY VOLUME (%) APPROX	85 to 90%
VAPOR DENSITY (AIR = 1) APPROX.	2.49	EVAPORATION RATE (BUAC = 1) APPROX.	5.5 to 8
SOLUBILITY IN WATER Solvent portion PVC resin & filler - Precipates			
APPEARANCE AND ODOR - Clear,Thin syrupy liquid, Etheral odor			

FIRE AND EXPLOSION HAZARD DATA

FLASH POINT (Method used) (T.O.C.)10°F	FLAMMABLE LIMITS	Left 1.8	Used 1.8
EXTINGUISHING MEDIA Dry chemical,Carbondioxide - Foam - Ansul "Purple K" National Aero-O-Foam			
SPECIAL FIREFIGHTING PROCEDURES Close or confined quarters require self contained breathing apparatus. Positive pressure hose mask or airline masks.			
UNUSUAL FIRE AND EXPLOSION HAZARDS Fire hazard because of low flash point, high volatility and heavy vapor.			

PHYSICAL DATA
711 GRAY CEMENT FOR PVC

BOILING POINT (°F) Based on 1st boiling Comp. THF.	151°F	SPECIFIC GRAVITY (H_20=1)	0.958± 0.008
VAPOR PRESSURE (mm Hg.) THF @ 25°C	190	PERCENT, VOLATILE BY VOLUME (%)APPROX.	90%
VAPOR DENSITY (AIR = 1) APPROX.	2.49	EVAPORATION RATE (BUAC = 1) APPROX.	5.0 to 8
SOLUBILITY IN WATER Solvent portion PVC resin & filler - Precipates			
APPEARANCE AND ODOR - Gary color, medium syrupy liquid - Etheral Odor			

FIRE AND EXPLOSION HAZARD DATA

FLASH POINT (Method used) (T.O.C.) 8°F	FLAMMABLE LIMITS % in Air	Left 2.0	Used 11.8
EXTINGUISHING MEDIA Dry chemical, Carbondioxide - Foam - Ansul "Purple K" National Aero-O-Foam			
SPECIAL FIREFIGHTING PROCEDURES Close or confined quarters require self contained breathing apparatus. Positive pressure hose mask or airline masks.			
UNUSUAL FIRE AND EXPLOSION HAZARDS Fire hazard because of low flash point, high volatility and heavy vapor.			

PHYSICAL DATA
719 GRAY CEMENT FOR PVC

BOILING POINT (°F) Based on 1st boiling Comp. THF.	151°F	SPECIFIC GRAVITY (H_20=1)	0.009 ±0.004
VAPOR PRESSURE (mm Hg.) THF @	190	PERCENT, VOLATILE BY VOLUME (%)	80%
VAPOR DENSITY (AIR = 1) APPROX.	2.49	EVAPORATION RATE (BUAC = 1) APPORX. Initial	5 - 8
SOLUBILITY IN WATER Solvent portion PVC resin & filler - Precipates			
APPEARANCE AND ODOR - Gray color, paste like, Etheral Odor			

FIRE AND EXPLOSION HAZARD DATA

FLASH POINT (Method used) (T.C.C.)8°F	FLAMMABLE LIMITS	Left 2	Used 11.8
EXTINGUISHING MEDIA Carbondioxide, Dry chemicals			
SPECIAL FIREFIGHTING PROCEDURES Close or confined quarters require self-contained breathing apparatus. Positive pressure hose mask or airline masks.			
UNUSUAL FIRE AND EXPLOSION HAZARDS Fire hazard because of low flash point, high volatility and heavy vapor.			

PHYSICAL DATA
714 GRAY CEMENT FOR CPVC

BOILING POINT (°F) The lowest boiling point	151°	SPECIFIC GRAVITY (H_20=1)	
VAPOR PRESSURE (mm Hg.) THF @ 25	190	PERCENT, VOLATILE BY VOLUME (%)	85-90%
VAPOR DENSITY (AIR = 1) APPROX.	2.49	EVAPORATION RATE (BUAC = 1) Initially	8.0
SOLUBILITY IN WATER Resin precipates			
APPEARANCE AND ODOR -Gray color, Medium syrupy liquid - Etheral Odor			

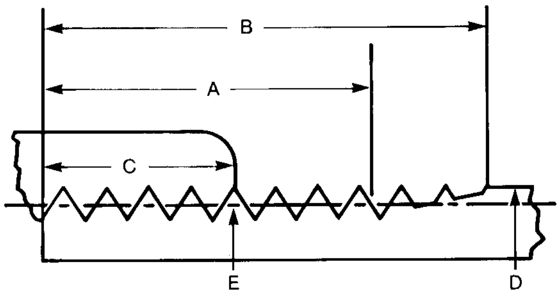
FIRE AND EXPLOSION HAZARD DATA

FLASH POINT (Method used) (T.O.C.) 6°F	FLAMMABLE LIMITS	Left 1.8 %	Used 11.8%
EXTINGUISHING MEDIA Dry chemical, Carbondioxide - Foam - Ansul "Purple K" National Aero-O-Foam			
SPECIAL FIREFIGHTING PROCEDURES Close or confined quarters require self contained breathing apparatus. Positive pressure hose mask or airline masks			
UNUSUAL FIRE AND EXPLOSION HAZARDS Fire hazard because of low flash point, high volatility and heavy vapor.			

Low VOC 724 cement for hypochlorite service

weld-on 724 CPVC low VOC cement is a gray, medium bodied, fast-setting solvent cement used for joining CPVC industrial piping through 12" diameter and is specially formulated for services that include caustics and hypochlorites.

THREADING INSTRUCTIONS PVC - CPVC - PP - PVDF



SCOPE

The procedure presented herein covers threading of all IPS Schedule 80 or heavier thermoplastic pipe. The threads are National Pipe Threads (NPT) which are cut to the dimensions outlined in ANSI B2.1 and presented below:

DO NOT THREAD SCHEDULE 40 PIPE

Table 72

Threading Dimensions

PIPE		THREADS					
NOMINAL PIPE SIZE (IN.)	OUTSIDE DIAMETER D PER INCH	NUMBER OF THREADS (IN.)	NORMAL ENGAGEMENT BY HAND C (IN.)	LENGTH OF EFFECTIVE THREAD A (IN.)	TOTAL LENGTH: END OF PIPE TO VANISH POINT B (IN.)	PITCH DIAMETER AT END OF INTERNAL THREAD E (IN.)	DEPTH OF THREAD MAX. (IN.)
1/4	.540	18	.200	.4018	.5946	.48989	.04444
1/2	.840	14	.320	.5337	.7815	.77843	.05714
3/4	1.050	14	.339	.5457	.7935	.98887	.05714
1	1.315	11-1/2	.400	.6828	.9845	1.23863	.06957
1-1/4	1.660	11-1/2	.420	.7068	1.0085	1.58338	.06957
1-1/2	1.900	11-1/2	.420	.7235	1.0522	1.82234	.06957
2	2.375	11-1/2	.436	.7565	1.0582	2.29627	.06957
2-1/2	2.875	8	.682	1.1375	1.5712	2.76216	.10000
3	3.500	8	.766	1.2000	1.6337	3.38850	.10000
4	4.500	8	.844	1.3000	1.7337	4.38713	.10000

THREADING INSTRUCTIONS PVC - CPVC - PP - PVDF

THREADING EQUIPMENT AND MATERIALS

- Pipe dies
- Pipe vise
- Threading ratchet or power machine
- Tapered plug
- Cutting lubricant (soap and water, soluble machine oil and water)
- Strap wrench
- Teflon tape
- Cutting tools
- Deburring tool

PIPE PREPARATION

Cut pipe square and smooth and remove burrs or raised edges with a knife or file. To ensure square end cuts, a miter box, hold down or jig must be used. The pipe can be easily cut with a power or hand saw, circular or band saw. Smooth cuts are obtained by using fine-toothed cutting blades (16-18 teeth per inch). A circumferential speed of about 6000 ft./min. is suitable for circular saws, band saw speed should be approximately 3000 ft./min. Pipe or tubing cutters can also be used to produce square, smooth cuts, however, the cutting wheel should be specifically designed for plastic pipe. Such a cutter is available from your local service center.

If a hold down vise is used when the pipe is cut, the jaws should be protected from scratching or gouging the pipe by inserting a rubber sheet between the vise jaws and the pipe.

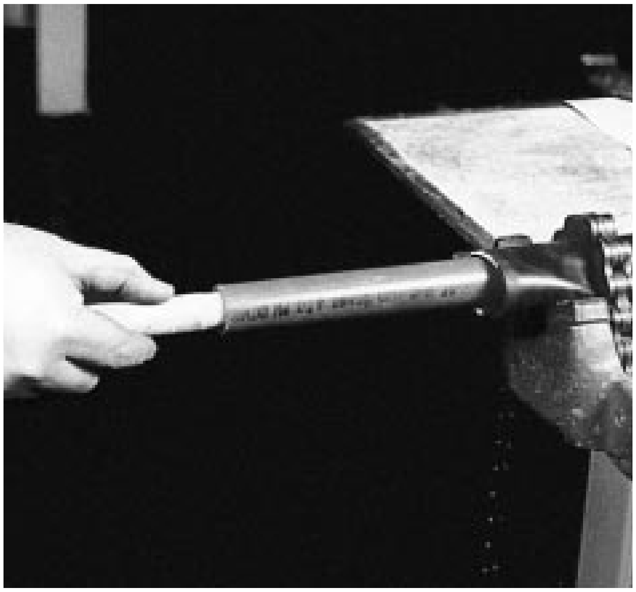
THREADING DIES

Thread-cutting dies should be clean, sharp and in good condition and should not be used to cut materials other than plastics. Dies with a 5° negative front rake are recommended when using power threading equipment and dies with a 5° to 10° negative front rake are recommended when cutting threads by hand.

When cutting threads with power threading equipment, self-opening die heads and a slight chamfer to lead the dies will speed production.

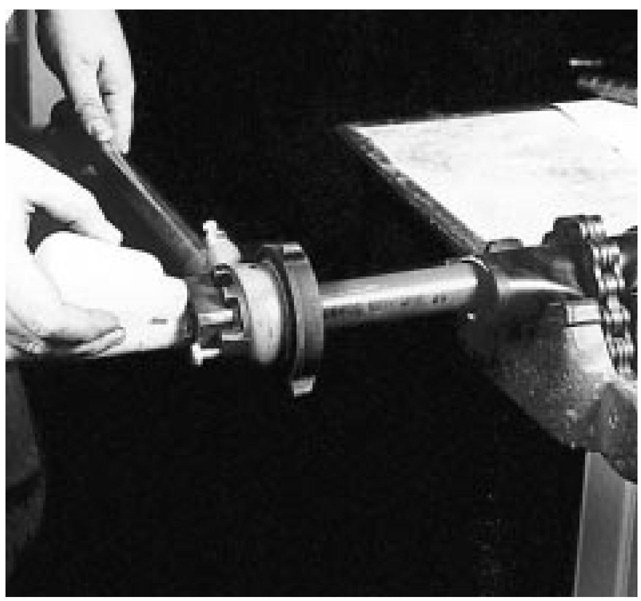
THREADING AND JOINING

1. Hold pipe firmly in a pipe vise. Protect the pipe at the point of grip by inserting a rubber sheet or other material between the pipe and vise.



2. A tapered plug must be inserted in the end of the pipe to be threaded. This plug provides additional support and prevents distortion of the pipe in the threaded area. Distortion of the pipe during the threading operation will result in eccentric threads, non-uniform circumferential thread depth, or gouging and tearing of the pipe wall. See Table 72 for approximate plug O.D. dimensions.

3. Use a die stock with a proper guide that is free of burrs or sharp edges, so the die will start and go on square to the pipe axis.

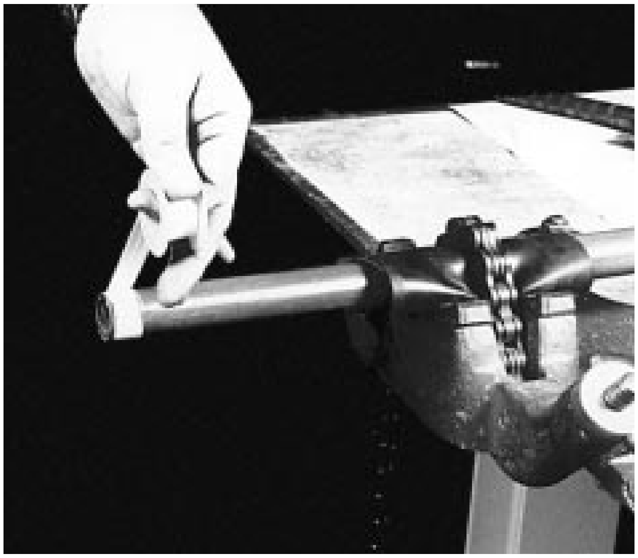


4. Push straight down on the handle avoiding side pressure that might distort the sides of the threads. If power threading equipment is used, the dies should not be driven at high speeds or with heavy pressure. Apply an external lubricant liberally when cutting the threads. Advance the die to the point where the thread dimensions are equal to those listed in Table 72. Do not overthread.

THREADING INSTRUCTIONS PVC - CPVC - PP - PVDF

5. Periodically check the threads with a ring gauge to ensure that proper procedures are being followed. Thread dimensions are listed in Table 72 and the gauging tolerance is +1-1/2 turns.

6. Brush threads clean of chips and ribbons. Then starting with the second full thread and continuing over the thread length, wrap TFE (Teflon) thread tape in the direction of the threads. Overlap each wrap by one-half the width of the tape.



7. Screw the fitting onto the pipe and tighten by hand. Using a strap wrench only, further tighten the connection an additional one to two threads past hand tightness. Avoid excessive torque as this may cause thread damage or fitting damage.

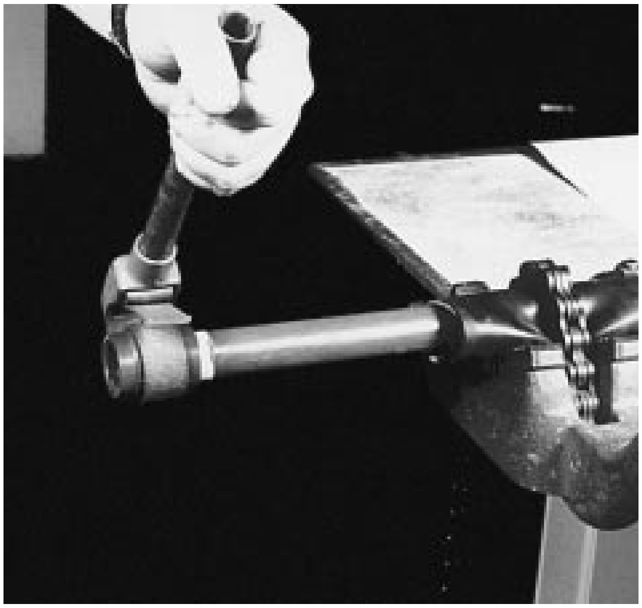


TABLE 73
REINFORCING PLUG DIMENSIONS*

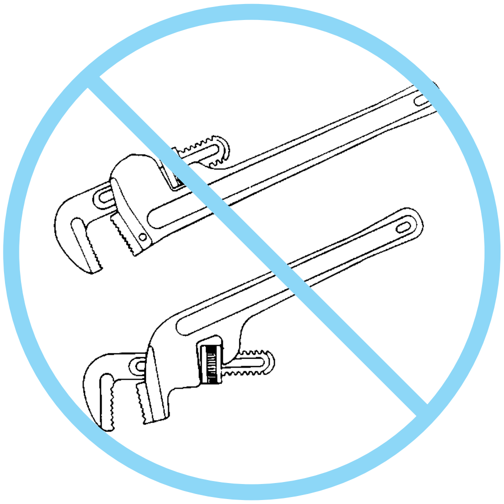
NOMINAL PIPE SIZE (IN.)	PLUG O.D.*
1/2	.526
3/4	.722
1	.935
1-1/4	1.254
1-1/2	1.475
2	1.913
2-1/2	2.289
3	2.864
4	3.786

*These dimensions are based on the median wall thickness and average outside diameter for the respective pipe sizes. Variations in wall thickness and O.D. dimensions may require alteration of the plug dimensions.

PRESSURE TESTING
Threaded piping systems can be pressure tested up to 50% of the pipe's hydrostatic pressure rating as soon as the last connection is made.

Caution: Air or compressed gas is not recommended and should not be used as a media for pressure testing of plastic piping systems.

Caution: Pressure ratings for threaded systems are reduced drastically. Check your application with your local service center prior to installation.



USE STRAP WRENCH ONLY!

INSTALLATION OF THERMOPLASTIC

FLANGED JOINTS

SCOPE

Flanged joints are recommended extensively for plastic piping systems that require periodic dismantling. Flanges and flanged fittings are available in almost all materials and sizes to meet your requirements. Please consult your local service center for the availability of any flanged fitting not shown in this catalog. Flanges are normally assembled to pipe or fittings by solvent welding, threading, or thermal fusion.

Gasket seals between the flange faces should be an elastomeric, full, flat-faced gasket with a hardness of 50 to 70 durometer. Harrington Industrial Plastics can provide neoprene gaskets in the 1/2" through 24" range having a 1/8" thickness. For chemical environments too aggressive for neoprene, other more resistant elastomers should be used.

DIMENSIONS

Bolt circle and number of bolt holes for the flanges are the same as 150 lb. metal flanges per ANSI B16.1. Threads are tapered iron pipe size threads per ANSI B2.1. The socket dimensions conform to ASTMD 2467 which describes one-half through 8" sizes.

PRESSURE RATING

Maximum pressure for any flanged system is 150 psi. At elevated temperatures the pressure capability of a flanged system must be derated as follows:

Table 74

MAXIMUM OPERATING PRESSURE (PSI)

OPERATING TEMPERATURE				
(°F)	PVC*	CPVC*	PP**	PVDF
100	150	150	150	150
110	135	140	140	150
120	110	130	130	150
130	75	120	118	150
140	50	110	105	150
150	NR	100	93	140
160	NR	90	80	133
170	NR	80	70	125
180	NR	70	50	115
190	NR	60	NR	106
200	NR	50	NR	97
250	NR	NR	NR	50
280	NR	NR	NR	25

NR- Not Recommended

* PVC and CPVC flanges sizes 2-1/2, 3 and 4-inch threaded must be back welded for the above pressure capability to be applicable.

** Threaded PP flanges size 1/2 thru 4" as well as the 6" back weld socket flange are not recommended for pressure applications (drainage only).

SEALING

The faces of flanges are tapered back away from the orifice area at a 1/2 to 1 degree pitch so that when the bolts are tightened the faces will be pulled together generating a force in the waterway area to improve sealing.

INSTALLATION TIPS

Once a flange is joined to pipe, the method for joining two flanges together is as follows:

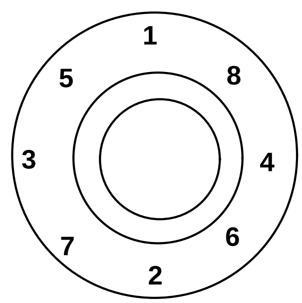
1. Make sure that all the bolt holes of the matching flanges match up. It is not necessary to twist the flange and pipe to achieve this.
2. Insert all bolts.
3. Make sure that the faces of the mating flanges are not separated by excessive distance prior to bolting down the flanges.
4. The bolts on the plastic flanges should be tightened by pulling down the nuts diametrically opposite each other using a torque wrench. Complete tightening should be accomplished in stages and the final torque values in the following table should be followed for the various sizes of flanges. Uniform stress across the flange will eliminate leaky gaskets.

Table 75

FLANGE SIZE (IN.)	RECOMMENDED TORQUE (FT. LBS.)*
1/2-1-1/2	10-15
2-4	20-30
6-8	33-50
10	53-75
12	80-110
14-24	100

*For a well lubricated bolt.

The following tightening pattern is suggested for the flange bolts.



5. If the flange is mated to a rigid and stationary flanged object, or a metal flange, particularly in a buried situation where settling could occur with the plastic pipe, the plastic flange must be supported to eliminate potential stressing.

Note: Flange gasket and low torque gasket sets are available from Harrington Industrial Plastics.

FIBERGLASS REINFORCED PLASTICS (FRP)

FIBERGLASS REINFORCED PLASTICS (FRP)

FRP is a special segment of the corrosion-resistant plastics industry. By combining flexible strands of glass with various thermoset resins, a wide range of performance characteristics can be achieved. Unlike thermoplastic resins, thermoset resins do not return to a liquid state with heat.

The glass can be prepared in a variety of forms which determines the final properties of the glass resin combination. As an example, the glass can be chopped strands in a mat or felt type fabric, yarns, woven fabric, continuous strands, unidirectional or bidirectional fabrics and so on. The choices are almost infinite.

The different types of glass all have different rates of resin absorption. For the most part, every mechanical attribute is enhanced by increasing the volume of glass contained in the plastic thermoset resin. Thus, glass versus resin ratio becomes a key criteria in defining a product for a particular application.

Glass fiber and resin are described as a composite or laminate. When combining glass and resin, it is important to “wet the glass” and this is done by eliminating the trapped air which increases the glass to resin interface. The glass used for FRP is treated with silane or other similar chemistry to enhance the resin's affinity to the glass.

Selecting a specific resin will dictate the performance characteristics of the final FRP product. Chemical resistance, temperature range and mechanical properties are determined by the choice of resin and the glass.

Epoxy resins give exceptional mechanical strength and are very chemically resistant. Epoxies are used for caustics, hydrocarbons, and most organic chemicals. Several catalysts can be used in curing the epoxy resin by a crosslinking of the long polymer chain. The choice of catalyst will determine the properties of the finished FRP product. For example, an anhydride catalyst will give an epoxy product with limited chemical resistance and limited temperature capability. An aromatic amines catalyst, on the other hand, will produce a final product with broad chemical resistance and a temperature range of up to 300° F in certain services.

Primary disadvantages of epoxies are they require long curing times and are best cured using heat to promote complete reaction for all the epoxy sites. Epoxies are, therefore, stronger when the catalyzation is enhanced by heat.

Polyester resins are available in many forms. The two that are relevant to FRP are orthophthalic and isophthalic resins. The former is a non-corrosion resistant resin used in boats, auto bodies, and structural forms. The latter is the chemically resistant resin that is appropriate to our use in handling corrosive fluids. Isophalic polyester is the most economical of all the resin choices for FRP.

Vinylester is a coined word describing a polyester that has been modified by the addition of epoxide reactive sites. The vinylester resin has broad chemical resistance including most acids and weak bases. It is generally the choice for high purity deionized water storage in an FRP vessel.

FRP piping is available from a few major manufacturers as a standard catalog, off-the-shelf product in diameters up to 16 inches. Face to face dimensions for fittings are based on steel and the requirements of American National Standards Institute ANSI B -16.3. Not all fittings meet ANSI requirements unless specified by agreement. FRP flanges are always thicker than steel, so longer bolts are needed.

There are many fabricators who specialize in made-to-order or custom vessels, as well as special made-to-order piping. For FRP piping larger than 16 inch in diameter, it is also made to order. Large diameter FRP pipe can be custom made in sizes even larger than 12 feet.

FRP pipe products are manufactured by several techniques. Filament winding is done using continuous lengths of fiberglass yarn or tape which are wound onto a polished steel mandrel. The glass is saturated with a catalyzed resin as it is being wound onto the mandrel. This process is continued until the desired wall thickness is achieved. The resin polymerizes usually by an exothermic reaction. Depending on the angle at which the glass is applied and the tension, the mechanical properties of the finished product can be affected. Piping and vessels are produced in this manner.

Centrifugal casting involves applying glass and catalyzed resin to the inside of a rotating polished cylindrical pipe. Curing of the glass resin combination forms a finished pipe. The forces of the centrifugal rotating cylinder forces the resin to wet the glass and gives an inherent resin rich and polished outside diameter to the final product. The resin that is in excess of that required to wet the glass forms a pure resin liner. Pipe, both small and larger diameter, as well as tanks, are manufactured by this process.

Applications for FRP have grown since the introduction almost forty years ago of thermoset resins. The following is a list of some of the general advantages of FRP:

- Corrosion resistant
- Lightweight
- High strength-to-weight ratio
- Low resistance to flow
- Ease of installation
- Low cost of installation
- Very low electrical conductivity
- Excellent thermal insulation
- Long service life
- Dimensional stability

Industrial uses for FRP tanks and piping have developed in oil and gas, chemical processing, mining, nuclear, and almost every other industry you can think of.

FIBERGLASS REINFORCED PLASTICS (FRP)

FRP piping is very amenable to the addition of specific additives to achieve certain properties. Antimony trioxide or brominated compounds, for example, can be added to provide excellent fire resistant characteristics. Specifically, designed FRP piping systems are produced for internal pressures up to 3000 PSI. Other FRP piping is used for down hole in the oil field, usually for salt water reinjection. FRP products are one of the most easily modified to meet specific needs, thus the broad range of industrial applications.

As with any piping material, good system design, proper fabrication and correct installation techniques are necessary for long and reliable service life.

Selecting the proper joining method is important for controlling installation costs and being compatible with the nature of the installation.

Butt and wrap is used to join FRP pipe by simply butting two sections of pipe together and overwrapping the joint with multiple layers of fiberglass saturated with the appropriate resin.

Threaded connections are often used for rapid and easy joining. There can be an O-ring gasket used to provide the sealing mechanism.

Bell and spigot joints are used usually with a bonding adhesive or with a gasket.

Flanges are most often used to join FRP pipe to metal or other dissimilar piping materials.

Contact molding is a process of applying fiberglass and resin to the surface of a mold that may be a variety of shapes. This process can be done by hand, spraying, or with an automated system. FRP fittings, vessels, and piping are produced by this method.

Compression molding is a process normally used to manufacture FRP fittings. A mixture of glass and resin is placed inside a mold and with heat and other molding techniques a finished part is produced.

Current standards outline the composition, performance requirements, construction method, design criteria testing and quality of workmanship. The modern standards have their origin in the U.S. Dept. of Commerce Voluntary Standard PS1549. Custom Contact Molded Reinforced Polyester Chemical Resistant Equipment. The ASTMC-582-95 takes the place of PS1569.

The following is a partial listing of ASTM standards for FRP Industrial products.

FIBERGLASS PIPE AND FITTINGS
Specification for:

D 2997 - 95	Centrifugally Cast "Fiberglass" Pipe
D 5421 - 93	Contact Molded "Fiberglass" Flanges
D 5677 - 95	"Fiberglass" Pipe and Pipe Fittings, Adhesive Bonded Joint Type, for Aviation Jet Turbine Fuel Lines
D 5686 - 95	"Fiberglass" Pipe and Pipe Fittings, Adhesive Bonded Joint Type Epoxy Resin, for Condensate Return Lines
D 3517 - 91	"Fiberglass" Pressure Pipe
D 5685 - 95	"Fiberglass" Pressure Pipe Fittings
D 2996 - 95	Filament-Wound"Fiberglass" Pipe
D 4024 - 94	Reinforced Thermosetting Resin (RTR) Flanges

FIBERGLASS TANKS AND EQUIPMENT
Specifications for:

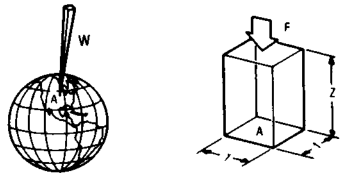
D 4097 - 95a	Contact-Molded Glass-Fiber-Reinforced Thermoset Resin Chemical-Resistant Tanks
C 482 - 95	Contact-Molded Reinforced Thermosetting Plastic (RTP) Laminates for Corrosion Resistant Equipment
D 3982 - 92	Custom Contact-Pressure-Molded Glass-Fiber-Reinforced Thermosetting Resin Hoods
D 3299 - 95a	Filament-Wound Glass-Fiber-Reinforced Thermoset Resin Chemical-Resistant Tanks

There are many special tools used for making field joints. The best policy is to follow the FRP pipe manufacturer's recommendations precisely. Most manufacturers offer the services of a factory person to train or supervise fabrication and installation.

To take maximum advantage of the many advantages of FRP in your corrosive or high purity application, contact your nearest Harrington or Corro-Flo Harrington location, or contact our Technical Services Group in Chino, California, using the number listed on the inside back cover.

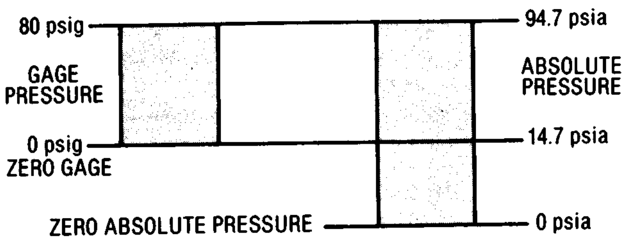
HYDRAULIC FUNDAMENTALS

PRESSURE The basic definition of pressure is force per unit area. As commonly used in hydraulics and in this catalog, it is expressed in pounds per square inch (PSI).



ATMOSPHERIC PRESSURE is the force exerted on a unit area by the weight of the atmosphere. At sea level, the atmospheric standard pressure is 14.7 pounds per square inch.

GAUGE PRESSURE Using atmospheric pressure as a zero reference, gauge pressure is a measure of the force per unit area exerted by a fluid. Units are PSIG.



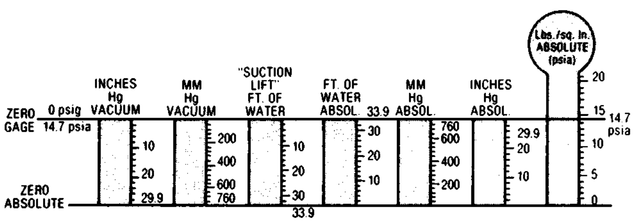
ABSOLUTE PRESSURE is the total force per unit area exerted by a fluid. It equals atmospheric pressure plus gauge pressure. Units are expressed in PSIA.

OUTLET PRESSURE or discharge pressure is the average pressure at the outlet of a pump during operation, usually expressed as gauge pressure (psig).

INLET PRESSURE is the average pressure measured near the inlet port of a pump during operation. It is expressed either in units of absolute pressure (psig) preferably, or gauge pressure (psig).

DIFFERENTIAL PRESSURE is the difference between the outlet pressure and the inlet pressure. Differential pressure is sometimes called Pump Total Differential pressure.

VACUUM OR SUCTION are terms in common usage to indicate pressures in a pumping system below normal atmospheric pressure and are often measured as the difference between the measured pressure and atmospheric pressure in units of inches of mercury vacuum, etc. **It is more convenient to discuss these in absolute terms; that is from a reference of absolute zero pressure in units of psia.**



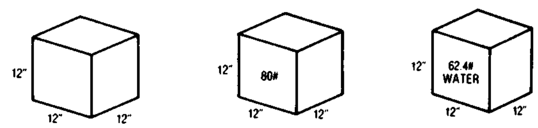
FLUID FUNDAMENTALS Fluids include liquids, gases, and mixtures of liquids, solids, and gases. For the purpose of this catalog, the terms **fluid and liquid** are used interchangeably to mean pure liquids, or liquids mixed with gases or solids which act essentially as a liquid in a pumping application.

DENSITY OR SPECIFIC WEIGHT of a fluid is its weight per unit volume, often expressed in units of pounds per cubic foot, or grams per cubic centimeter.

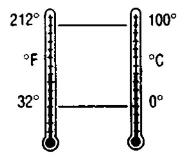
Example: If weight is 80 lb.; density is 80 lb/cu. ft.
The density of a fluid changes with temperature.

SPECIFIC GRAVITY of a fluid is the ratio of its density to the density of water. As a ratio, it has no units associated with it.

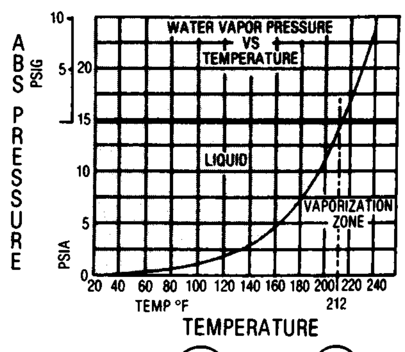
EXAMPLE: Specific gravity is $\frac{80\text{ lb}}{62.4\text{ lb.}}$ or SG = 1.282

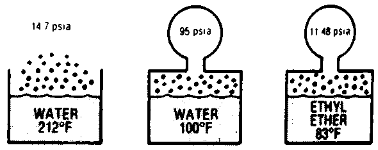


TEMPERATURE is a measure of the internal energy level in a fluid. It is usually measured in units of degrees fahrenheit (°F) or degrees centigrade (°C). The temperature of a fluid at the pump inlet is usually of greatest concern.
See °F-°C conversion chart on page 96.



VAPOR PRESSURE of a liquid is the absolute pressure (at a given temperature) at which a liquid will change to a vapor. Vapor pressure is best expressed in units of psi absolute (psia). Each liquid has its own vapor pressure-temperature relationship.





For example: If 100°F water is exposed to the reduced absolute pressure of .95 psia, it will boil. It will boil, even at 100°F.

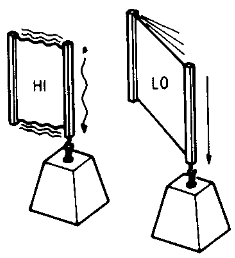
HYDRAULIC FUNDAMENTALS

HYDRAULIC FUNDAMENTALS

VISCOSITY—The viscosity of a fluid is a measure of its tendency to resist a shearing force. High viscosity fluids require a greater force to shear at a given rate than low viscosity fluids.

The CENTIPOISE (cps) is the most convenient unit of absolute viscosity measurement.

Other units of viscosity measurement such as the centistoke (cks) or Staybolt Second Universal (SSU) are measures of Kinematic viscosity where the specific gravity of the fluid influences the viscosity measured. Kinematic viscometers usually use the force of gravity to cause the fluid to flow down a calibrated tube while timing its flow.

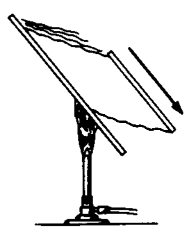


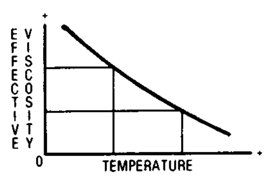
The absolute viscosity, measured in units of centipoise (1/100 of a poise) is used throughout this catalog as it is a convenient and consistent unit for calculation. Other units of viscosity can easily be converted to centipoise:

Kinematic vicscosity x Specific Gravity = Absolute Viscosity
Centistokes x Specific Gravity = Centipoise
SSU x .216 x Specific Gravity = Centipoise

See page 100 for detailed conversion charts

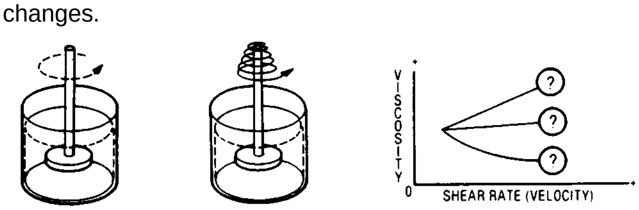
Viscosity unfortunately is not a constant, fixed property of a fluid, but is a property which varies with the conditions of the fluid and the system.





In a pumping system, the most important factors are the normal decrease in viscosity with temperature increase.

And the viscous behavior properties of the fluid in which the viscosity can change as shear rate or flow velocity changes.



EFFECTIVE VISCOSITY is a term describing the real effect of the viscosity of the ACTUAL fluid, at the SHEAR RATES which exist in the pump and pumping system at the design conditions.

Centrifugal pumps are generally not suitable for pumping viscous liquids. When pumping more viscous liquids instead of water, the capacity and head of the pump will be reduced and the horsepower required will be increased.

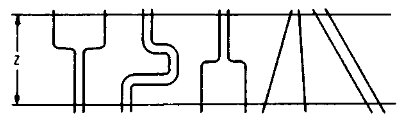
pH value for a fluid is used to define whether the aqueous solution is an acid or base (with values of pH usually between 0 and 14):

1. Acids or acidic solutions have a pH value less than 7.
2. Neutral solutions have pH value of 7 at 25°C (example: pH of pure water = 7).
3. Bases or alkaline solutions have a pH value **greater** than 7.

RELATION OF PRESSURE TO ELEVATION

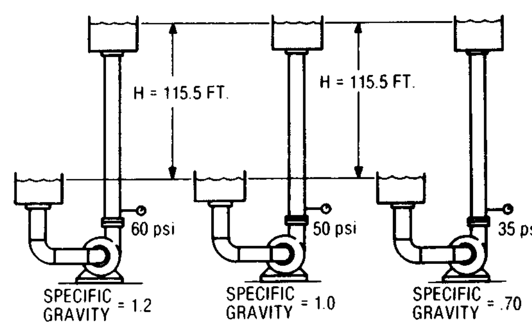
In a static liquid (a body of liquid at rest) the pressure difference between any two points is in direct proportion only to the **vertical** distance between the points.

This pressure difference is due to the weight of the liquid and can be calculated by multiplying the vertical distance by the density (or vertical distance x density of water x specific gravity of the fluid). In commonly used units

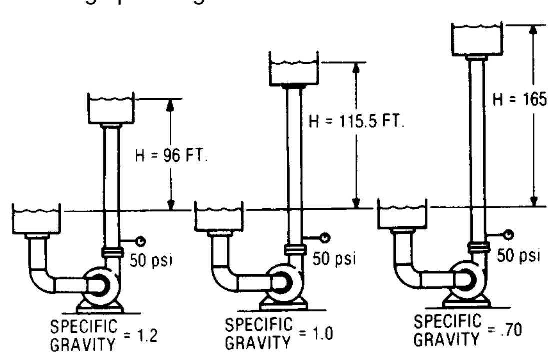


P static (in PSI) - Z (in feet) x 62.4 lbs./cu. ft. x SG / 144 sq. in./sq. ft.

PUMP HEAD-PRESSURE-SPECIFIC GRAVITY—in a centrifugal pump the head developed (in feet) is dependent on the velocity of the liquid as it enters the impeller eye and as it leaves the impeller periphery and therefore, is independent of the specific gravity of the liquid. The pressure head developed (in psi) will be directly proportional to the specific gravity.



Pressure-Head relation of identical pumps handling liquids of differing specific gravities.



Pressure-head relation of pumps delivering same pressure handling liquids of differing specific gravity.

HYDRAULIC FUNDAMENTALS

IMPORTANT PUMP TERMS: The term HEAD is commonly used to express the elevational equivalent of pressure allowing for specific gravity, Generally expressed in feet, head can best be defined by the following equation:

$$\frac{\text{Pounds per square inch x 2.31}}{\text{Specific Gravity}} = \text{Head in feet}$$

The following expressions of HEAD terms are generally accepted as standards throughout the industry.

Static Head • The hydraulic pressure at a point in a fluid when the liquid is at rest.

Friction Head • The loss in pressure or energy due to frictional losses in flow.

Velocity Head • The energy in a fluid due to its velocity, expressed as a head unit.

Pressure Head • A pressure measured in equivalent head units.

Discharge Head • The output pressure of a pump in operation.

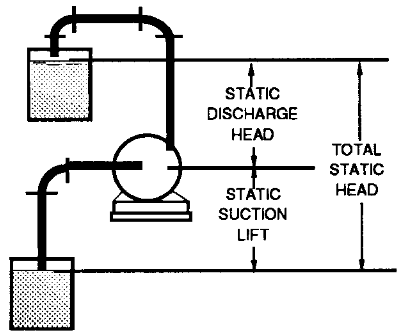
Total Dynamic • The total pressure difference Head between the inlet and outlet of a pump in operation.

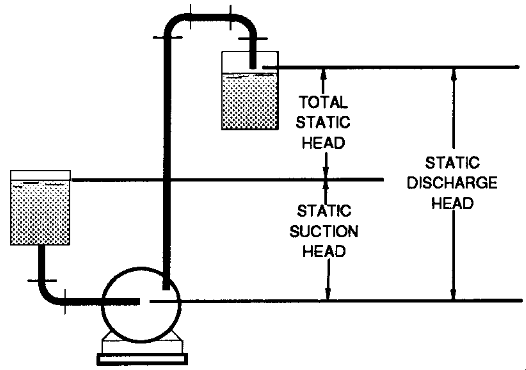
Suction Head • The inlet pressure of a pump when above atmospheric.

Suction Lift • The inlet pressure of a pump when below atmospheric.

FRICTIONAL LOSSES

The nature of frictional losses in a pumping system can be very complex. Losses in the pump itself are determined by actual test and are allowed for in the manufacturers' curves and data. Similarly, manufacturers of processing equipment, heat exchangers, static mixers, etc., usually have data available for friction losses.





Frictional losses due to flow in pipes are directly proportional to the:

- **length of pipe**
- **pipe diameter**
- **flow rate**
- **viscosity of the fluid**

Pipe friction tables have been established by the Hydraulic Institute and many other sources which can be used to compute the friction loss in a system for given flow rates, viscosities, and pipe sizes. Friction loss charts for plastic pipe appear in this catalog on pages 50-58. Tables of equivalent lengths for fittings and valves are on page 58.

NPSH

Fluid will only flow into the pump head by atmospheric pressure or atmospheric pressure plus a positive suction head. If suction pressure at suction pipe is below the vapor pressure of the fluid, the fluid may flash into a vapor. A centrifugal pump cannot pump vapor only. If this happens, fluid flow to the pump head will drop off and cavitation may result.

NET POSITIVE SUCTION HEAD, AVAILABLE (NPSHA) is based on the design of the system around the pump inlet. The average pressure (in psia) is measured at the port during operation, minus the vapor pressure of the fluid at operating temperature. It indicates the amount of useful pressure energy available to fill the pump head.

NET POSITIVE SUCTION HEAD, REQUIRED (NPSHR) is based on the pump design. This is determined by testing of the pump for what pressure energy (in psia) is needed to fill the pump inlet. It is a characteristic which varies primarily with the pump speed and the viscosity of the fluid.

Table 3

PIPE O.D.'S CONVERSION CHART

U.S. (ANSI)		EUROPE (ISO)	
NOMINAL PIPE SIZES (IN.)	ACTUAL O.D. INCHES	d (ACTUAL O.D.) MM	IN.
1/8	.405	10	(.394)
1/4	.540	12	(.472)
3/8	.675	16	(.630)
1/2	.840	20	(.787)
3/4	1.050	25	(.984)
1	1.315	32	(1.260)
1-1/4	1.660	40	(1.575)
1-1/2	1.900	50	(1.969)
2	2.375	63	(2.480)
2-1/2	2.875	75	(2.953)
3	3.500	90	(3.543)
4	4.500	110	(4.331)
5	5.563	140	(5.512)
6	6.625	160	(6.299)
8	8.625	225	(8.858)
10	10.750	280	(11.024)
12	12.750	315	(12.402)

CONVERSION DATA

TABLE 76

CONVERSION OF THERMOMETER READINGS

Degrees centigrade to degrees Fahrenheit

°C	°F	°C	°F	°C	°F	°C	°F
−40	−40.0	+5	+41.0	+40	+104.0	+175	+347
−38	−36.4	6	42.8	41	105.8	180	356
−36	−32.8	7	44.6	42	107.6	185	365
−34	−29.2	8	46.4	43	109.4	190	374
−32	−25.6	9	48.2	44	111.2	195	383
−30	22.0	10	50.0	45	113.0	200	392
−28	18.4	11	51.8	46	114.8	205	401
−26	14.8	12	53.6	47	116.6	210	410
−24	11.2	13	55.4	48	118.4	215	419
−22	7.6	14	57.2	49	120.2	220	428
−20	−4.0	15	59.0	50	122.0	225	437
−19	−2.2	16	60.8	55	131.0	230	446
−18	−0.4	17	62.6	60	140.0	235	455
−17	+1.4	18	64.4	65	149.0	240	464
−16	3.2	19	66.2	70	158.0	245	473
−15	5.0	20	68.0	75	167.0	250	482
−14	6.8	21	69.8	80	176.0	255	491
−13	8.6	22	71.6	85	185.0	260	500
−12	10.4	23	73.4	90	194.0	265	509
−11	12.2	24	75.2	95	203.0	270	518
−10	14.0	25	77.0	100	212.0	275	527
−9	15.8	26	78.8	105	221.0	280	536
−8	17.6	27	80.6	110	230.0	285	545
−7	19.4	28	82.4	115	239.0	290	554
−6	21.2	29	84.2	120	248.0	295	563
−5	23.0	30	86.0	125	257.0	300	572
−4	24.8	31	87.8	130	266.0	305	581
−3	26.6	32	89.6	135	275.0	310	590
−2	28.4	33	91.4	140	284.0	315	599
−1	30.2	34	93.2	145	293.0	320	608
0	32.0	35	95.0	150	302.0	325	617
+1	33.8	36	96.8	155	311.0	330	626
2	35.6	37	98.6	160	320.0	335	635
3	37.4	38	100.4	165	329.0	340	644
4	39.2	39	102.2	170	338.0	345	653

VOLUME

Volume of a pipe is computed by:

V= ID2x7rx Lx3

Where: V = volume (in cubic inches)
ID = inside diameter (in inches)
π = 3.14159
L= length of pipe (in feet)

1 U.S. Gallon . . . . 128 fl. oz. (U.S.)
231 cu. in.
0.134cu. ft.
3.785 litres
.00379 cu. meters
0.833 Imp. gal.
0238 42-gal. barrel
1 Imperial Gallon . . . . 1.2 U.S. gal.
1 Cubic Foot . . . . 7.48 U.S. gal.
0.0283 cu. meter
1 Litre . . . . 0.2642 U.S. gal.
1 Cubic Meter . . . . 35.314 cu. ft.
264.2 U.S. gal.
1 Acre Foot . . . . 43,560 cu. ft.
325,829 U.S. gal.
1 Acre Inch . . . . 3,630 cu. ft.
27,100 U.S. gal.

LENGTH

1 Inch. . . . . 2.54 centimeters
1 Meter . . . . 3.28 ft.
39.37 in.
1 Rod . . . . 16.5 ft.
1 Mile . . . . 5,280 ft. (1.61 kilometers)

WEIGHT

1 U.S. Gallon @ 50°F. . . . . 8.33 lb. x sp. gr.
1 Cubic Foot . . . . 62.35 lb. x sp. gr.
7.48 gal. (U.S.)
1 Cubic Ft. of Water @50°F . . . . 62.41 lb.
1 Cubic Ft. of Water @39.2°F
(39.2°F is water temperature
at its greatest density). . . . . 62.43 lb.
1 Kilogram . . . . 2.2 lb.
1 Imperial Gallon Water . . . . 10.0 lb.
1 Pound . . . . 12 U.S. gal. -sp. gr.
016 cu. ft. sp. gr.

CAPACITY OR FLOW

1 Gallon Per Minute (g.p.m.) . . . . 134 c.f.m.
500 lb. per hr. x sp. gr.
500 lb. Per Hour . . . . 1 g.p.m.÷ sp. gr.
1 Cubic Ft. Per Minute (c.f.m.). . . . . 449 g.p.h.
1 Cubic Ft. Per Second (c.f.s.) . . . . 449 g.p.m.
1 Acre Foot Per Day . . . . 227 g.p.m.
1 Acre Inch Per Hour . . . . 454 g.p.m.
1 Cubic Meter Per Minute . . . . 264.2 g.p.m.
1,000,000 Gal. Per Day . . . . 595 g.p.m.

Brake H.P. = $\frac{\text{(g.p.m.) (Total Head in Ft.) (Specific Gravity)}}{\text{(3960) (Pump Eff.)}}$

CONVERSION DATA

TABLE 77

TO CHANGE	TO	MULTIPLY BY
Atmospheres	PSI (Pounds per Sq. Inch)	14.696
Atmospheres	Feet of Water	33.9
Atmospheres	Inches of Mercury	29.92
Barrels (U.S.L.q.)	Gallons (U.S.)	31.5
Barrels of Oil	Gallons (U.S.)	42
B.T.U.	H.P.Lr	.0003929
Centimeters	Feet	.0328
Centimeters	Inches	.3937
Centimeters/Sec.	Feet/Min.	1.9684
Centimeters/Sec.	Feet/Sec.	.0328
Centipoise	Poises	.01
Centistokes	Stokes	.01
Cubic Centimeters	Cubic Feet	3.5314×10^{-5}
Cubic Centimeters	Cubic Inches	.06102
Cubic Centimeters	Gallons (L.Q.)	.0002642
Cubic Feet	Gallons	7.4805
Cubic Feet	Cubic Inches	1728.
Cubic Feet	Cubic Yards	.03703
Cubic Feet/Min.	G.P.M.	7.4805
Cubic Inches	Gallons	.004329
Cubic Inches	Cubic Centimeters	16.387
Cubic Inches	Cubic Feet	.0005787
Cubic Meters	Gallons (Liq)	264.17
Cubic Meters	Cubic Feet	35.31
Cubic Meters	Cubic Inches	61,023.74
Cubic Meters/Hr.	G.P.M.	4.403
Cubic Yards	Cubic Feet	27
Degrees	Revolution	.00277778
Dynes	Pounds	2.248009×10^{-6}
Dynes/Sq. Cm.	PSI	1.45038×10^{-5}
Fathom	Feet	6
Feet	Centimeters	30.48006
Feet	Meters	.3048006
Feet	Inches	12
Feet	Yards	.3333
Feet of Water	Atmosphere	.02949
Feet of Water	PSI	.433
Feet of Water	Inches of Mercury	.88265
Feet of Water	Pounds per Sq. Ft.	62.5
Feet/Hr.	Miles/Hour	.00018939
Feet/Min.	Meters/Min.	.3048
Feet/Min.	Miles/Hour	.01136
Feet/Sec.	Miles/Hour	.681818
Gallons	Cubic Centimeters	3,785.43

TO CHANGE	TO	MULTIPLY BY
Gallons	Gallons (Imp.)	.83268
Gallons	Cubic Feet	.13368
Gallons	Cubic Inches	231
Gallons	Pound of Water	8.33
Gallons/Min.	Cubic Feet/Min.	.13368
Horsepower	Ft. Lbs./Min.	33,000
Horsepower	Ft. Lbs./Sec.	550
Inches	Feet	.083333
Inches	Meters	.0254
Inches	Millimeters	25.40005
Inches	Mils	1000
Inches of Mercury	Atmosphere	.033327
Inches of Mercury	Feet of Water	1.1309
Inches of Mercury	PSI	.489
Inches of Mercury	Inches of Water	13.6
Inches of Water	Inches of Mercury	.0735
Inches of Water	Pounds per Sq. In.	.0361
Inches of Water	Ounces per Sq. In.	.578
Inches of Water	Pounds per Sq. Ft.	5.2
Kilograms	Pounds (avdp.)	2.2046
Kilograms/Sq. Cm.	PSI	14.2233
Kilograms/Sq. mm.	PSI	1422.33
Liters	Gallons	.264178
Long Tons	Pounds	2240
Meters	Feet	3.2808
Meters	Inches	39.37
Ounces	Pounds	.0625
Ounces per Sq. In.	Inches of Mercury	.127
Ounces per Sq. In.	Inches of Water	1.733
Poise	Centipoise	100
Pounds	Ounces	16
Pounds per Sq. In.	Inches of Water	27.72
Pounds per Sq. In.	Feet of Water	2.31
Pounds per Sq. In.	Inches of Mercury	2.04179
Pounds per Sq. In.	Atmospheres	.06804
Pounds of Water	Gallon	.12004
Square Feet	Square Inches	144
Square Feet	Square Yards	.11111
Square Inches	Square Centimeters	6.4516
Square Inches	Square Feet	.006944
Square Inches	Square Millimeters	645.163
Square Millimeters	Square Inches	.0015499
Square Yards	Square Feet	9
Tons Molasses/Hr.	G.P.M.	2.78

CONVERSION DATA

TABLE 78

Inches	Millimeters
0	0.0000
1/128	0.1984
1/64	0.3969
3/128	0.5953
1/32	0.7937
5/128	0.9921
3/64	1.1906
7/128	1.3890

Convert 3.7643 meters to feet, inches and fractions

3.7643 meters		
3.6556	=	12 ft.
108.70 mm		
107.95	=	4¼ in.
.75	=	1/32″
3.7643 meters	=	12′ – 4-9/32″

Convert 15′ – 6-7/16″ to meters

15′	=	4.5720	meters
6-7/16″	=	.163513	meters
15′ – 6-7/16″	=	4.735513	meters

EQUIVALENT OF COMMON FRACTIONS OF AN INCH

FRACTION	DECIMALS	MILLIMETERS	FRACTION	DECIMALS	MILLIMETERS
1/64	.015625	0.397	33/64	.515625	13.097
1/32	.03125	0.794	17/32	.53125	13.494
3/64	.046875	1.191	35/64	.546875	13.891
1/16	.0625	1.588	9/16	.5625	14.288
5/64	.078125	1.984	37/64	.578125	14.684
3/32	.09375	2.381	19/32	.59375	15.081
7/64	.109375	2.778	39/64	.609375	15.478
1/8	.1250	3.175	5/8	.625	15.875
9/64	.140625	3.572	41/64	.640625	16.272
5/32	.15625	3.969	21/32	.65625	16.669
11/64	.171875	4.366	43/64	.671875	17.066
3/16	.1875	4.762	11/16	.6875	17.462
13/64	.203125	5.159	45/64	.703125	17.859
7/32	.21875	5.556	23/32	.71875	18.256
15/64	.234375	5.953	47/64	.734375	18.653
1/4	.25	6.350	3/4	.7500	19.050
17/64	.265625	6.747	49/64	.765625	19.447
9/32	.28125	7.144	25/32	.78125	19.844
19/64	.296875	7.541	51/64	.796875	20.241
5/16	.3125	7.938	13/16	.8125	20.638
21/64	.328125	8.334	53/64	.828125	21.034
11/32	.34375	8.731	27/32	.84375	21.431
23/64	.359375	9.128	55/64	.859375	21.828
3/8	.3750	9.525	7/8	.8750	22.225
25/64	.390625	9.922	57/64	.890625	22.622
13/32	.40625	10.319	29/32	.90625	23.019
27/64	.421875	10.716	59/64	.921875	23.416
7/16	.4375	11.112	15/16	.9375	23.812
29/64	.453125	11.509	61/64	.953125	24.209
15/32	.46875	11.906	31/32	.96875	24.606
31/64	.484375	12.303	63/63	.984375	25.003
1/2	.5	12.700	1	1.0	25.400

CONVERSION DATA

TABLES 79, 80, & 81

WATER PRESSURE TO FEET HEAD

POUNDS PER SQUARE INCH	FEET HEAD	POUNDS PER SQUARE INCH	FEET HEAD
1	2.31	100	230.90
2	4.62	110	253.98
3	6.93	120	277.07
4	9.24	130	300.16
5	11.54	140	323.25
6	13.85	150	346.34
7	16.16	160	369.43
8	18.47	170	392.52
9	20.78	180	415.61
10	23.09	200	461.78
15	34.63	250	577.24
20	46.18	300	692.69
25	57.72	350	808.13
30	69.27	400	922.58
40	92.36	500	1154.48
50	115.45	600	1385.39
60	138.54	700	1616.30
70	161.63	800	1847.20
80	184.72	900	2078.10
90	207.81	1000	2309.00

NOTE: One pound of pressure per square inch of water equals 2.31 feet of water at 60° F. Therefore, to find the feet head of water for any pressure not given in the table above, multiply the pressure pounds per square inch by 2.31.

FEET HEAD OF WATER TO PSI

FEET HEAD	POUNDS PER SQUARE INCH	FEET HEAD	POUNDS PER SQUARE INCH
1	.43	100	43.31
2	.87	110	47.64
3	1.30	120	51.97
4	1.73	130	56.30
5	2.17	140	60.63
6	2.60	150	64.96
7	3.03	160	69.29
8	3.46	170	73.63
9	3.90	180	77.96
10	4.33	200	86.62
15	6.50	250	108.27
20	8.66	300	129.93
25	10.83	350	151.58
30	12.99	400	173.24
40	17.32	500	216.55
50	21.65	600	259.85
60	25.99	700	303.16
70	30.32	800	346.47
80	34.65	900	389.78
90	38.98	1000	433.00

NOTE: One foot of water at 60° F equals .433 pounds pressure per square inch. To find the pressure per square inch for any feet head not given in the table above, multiply the feet head by .433.

EQUIVALENTS OF PRESSURE AND HEAD

TO OBTAIN MULTIPLY BY	lb./in.^{2}	lb./ft^2	Atmospheres	kg/cm^2	kg/m^2	in. Water (68°F)*	ft. Water (68°F)*	in. Mercury (32°F)**	mm Mercury (32°F)**	Bar ***	Megapascal (MPa)***
lb./in.^{2}	1	144	.068046	.070307	703.070	27.7276	2.3106	2.03602	51.7150	0.06895	.006895
lb./ft.^{2}	.0069445	1	.000473	.000488	4.88241	.1926	.01605	.014139	.35913	.000479	.0000479
Atmospheres	14.696	2116.22	1	1.0332	10332.27	407.484	33.9570	29.921	760	1.01325	.101325
kg/cm^2	14.2233	2048.155	.96784	1	10000	394.38	32.8650	28.959	735.559	.98067	.098067
kg/m^2	.001422	.204768	.0000968	.0001	1	.03944	.003287	.002896	.073556	.000098	.0000098
in. Water*	.036092	5.1972	.002454	.00253	25.375	1	.08333	.073430	1.8651	.00249	.000249
ft. Water*	.432781	62.3205	.029449	.03043	304.275	12	1	.88115	22.3813	.029839	.0029839
in. Mercury**	.491154	70.7262	.033421	.03453	.345.316	13.6185	1.1349	1	25.40005	.033864	.0033864
mm Mercury**	.0193368	2.78450	.0013158	.0013595	13.59509	.53616	.044680	.03937	1	.001333	.0001333
Bar***	14.5038	2088.55	.98692	1.01972	10197.2	402.156	33.5130	29.5300	750.062	1	.10
MPa***	145.038	20885.5	9.8692	10.1972	101972	4021.56	335.130	295.300	7500.62	10	1

* Water at 68° F (20°C) ** Mercury at 32° F (0° C) *** 1 MPa (Megapascal) = 10 Bar = 1,000 N/m^2)

To convert from one set of units to another, locate the given unit in the left hand column, and multiply the numerical value by the factor shown horizontally to the right, under the set of units desired.

CONVERSION DATA

TABLES 82 & 83

Poise = c.g.s. unit of absolute viscosity
Stoke = c.g.s. unit of kinematic viscosity
Centipoise = 0.01 poise
Centistoke = 0.01 stoke
Centipoises = centistokes x density (at temperature under consideration)
Reyn (1 lb. sec. per sq. in.) = 69 x 105 centipoises

VISCOSITY CONVERSION

SAYBOLT UNIVERSAL SSU	STOKES	CENTISTOKES	POISES*	CENTIPOISES*	ENGLER SECONDS	REDWOOD NO. 1 SECONDS	TYPICAL LIQUIDS AT 70°F
31	.010	1.00	.008	.8	54	29	WATER
35	.025	2.56	.020	2.05	59	32.1	KEROSENE
50	.074	7.40	.059	5.92	80	44.3	NO. 2 FUEL OIL
80	.157	15.7	.126	12.6	125	69.2	NO. 4 FUEL OIL
100	.202	20.2	.162	16.2	150	85.6	TRANSFORMER OIL
200	.432	43.2	.346	34.6	295	170	HYDRAULIC OIL
300	.654	65.4	.522	52.2	470	254	SAE 10W OIL
500	1.10	110	.88	88.0	760	423	SAE 10 OIL
1,000	2.16	220	1.73	173	1,500	896	SAE 20 OIL
2,000	4.40	440	3.52	352	3,000	1,690	SAE 30 OIL
5,000	10.8	1,080	8.80	880	7,500	4,230	SAE 50 OIL
10,000	21.6	2,160	17.0	1,760	15,000	8,460	SAE 60-70 OIL
50,000	108	10,800	88	8,800	75,000	43,660	MOLASSES B
100,000	216	21,600	173	17,300	150,000	88,160	MOLASSES C

Kinematic Viscosity (in centistokes) =

$$\frac{\text{Absolute Viscosity (in centipoise)}}{\text{Density}}$$

REYNOLDS NUMBER, R.

Reynolds Number, *R. is* a dimensionless number or ratio of velocity in ft. per sec. times the internal diameter of the pipe in feet times the density in slugs per cu.ft. divided by the absolute viscosity in lb. sec. per sq. ft.

This is equivalent to *R=VD/v* (VD divided by the kinematic viscosity). Reynolds Number is of great significance because

$$R = \frac{VD}{V}$$

it determines the type of flow, either laminar or turbulent, which will occur in any pipe line, the only exception being a critical zone roughly between an *R* of 2000 to 3500. Within this zone it is recommended that problems be solved by assuming that turbulent flow is likely to occur. Computation using this assumption gives the greatest value of friction loss and hence the result is on the safe side.

For those who prefer the greater precision of an algebraic equation, Reynolds Number for a pipe line may also be computed from the following formula:

$$R = \frac{Q}{29.4dv}$$

where Q is in GPM, *d* is inside diameter of pipe in inches, and *V* is kinematic viscosity in ft.^{2}/sec.

PUMPING VISCOUS LIQUIDS WITH CENTRIFUGAL PUMPS

Centrifugal pumps are generally not suitable for pumping viscous liquids. However, liquids with viscosities up to 2000 SSU can be handled with Centrifugal pumps. The volume and pressure of the pump will be reduced according to the following table.

Percent reduction in flow and head and percent increase in power when pumping viscous liquid instead of water are shown in the table below.

VISCOSITY SSU	30	100	250	500	750	1000	1500	2000
Flow Reduction GPM %	–	3	8	14	19	23	30	40
Head Reduction Feet %	–	2	5	11	14	18	23	30
Horsepower increase %	–	10	20	30	50	65	85	100

CONVERSION DATA BAUME

UNITED STATES STANDARD BAUME SCALES
RELATION BETWEEN BAUME DEGREES AND SPECIFIC GRAVITY

TABLE 84

LIQUIDS HEAVIER THAN WATER

$$\text{Formula– sp gr} = \frac{145}{145-\ ^\circ\text{Baume}}$$

BAUME DEGREES	SP GR 60°—60°	BAUME DEGREES	SP GR 60°—60°	BAUME DEGREES	SP GR 60°—60°	BAUME DEGREES	SP GR 60°—60°
0	1.00000	20	1.16000	40	1.38095	60	1.70588
1	1.00694	21	1.16935	41	1.39423	61	1.72619
2	1.01399	22	1.17886	42	1.40777	62	1.74699
3	1.02113	23	1.18852	43	1.42157	63	1.76829
4	1.02837	24	1.19835	44	1.43564	64	1.79012
5	1.03571	25	1.20833	45	1.45000	65	1.81250
6	1.04317	26	1.21849	46	1.46465	66	1.83544
7	1.05072	27	1.22881	47	1.47959	67	1.85897
8	1.05839	28	1.23932	48	1.49485	68	1.88312
9	1.06618	29	1.25000	49	1.51042	69	1.90789
10	1.07407	30	1.26087	50	1.52632	70	1.93333
11	1.08209	31	1.27193	51	1.54255	71	1.95946
12	1.09023	32	1.28319	52	1.55914	72	1.98630
13	1.09848	33	1.29464	53	1.57609	73	2.01389
14	1.10687	34	1.30631	54	1.59341	74	2.04225
15	1.11538	35	1.31818	55	1.61111	75	2.07143
16	1.12403	36	1.33028	56	1.62921	76	2.10145
17	1.13281	37	1.34259	57	1.64773	77	2.13235
18	1.14173	38	1.35514	58	1.66667	78	2.16418
19	1.15079	39	1.36792	59	1.68605	79	2.19697

LIQUIDS LIGHTER THAN WATER

$$\text{Formula– sp gr} = \frac{140}{130+\ ^\circ\text{Baume}}$$

BAUME DEGREES	SP GR 60°—60°	BAUME DEGREES	SP GR 60°—60°	BAUME DEGREES	SP GR 60°—60°	BAUME DEGREES	SP GR 60°—60°
10	1.00000	30	.87500	50	.77778	70	.70000
11	.99291	31	.86957	51	.77348	71	.69652
12	.98592	32	.86420	52	.76923	72	.69307
13	.97902	33	.85890	53	.76503	73	.68966
14	.97222	34	.85366	54	.76087	74	.68627
15	.96552	35	.84848	55	.75676	75	.68293
16	.95890	36	.84337	56	.75269	76	.67961
17	.95238	37	.83832	57	.74866	77	.67633
18	.94595	38	.83333	58	.74468	78	.67308
19	.93960	39	.82840	59	.74074	79	.66986
20	.93333	40	.82353	60	.73684	80	.66667
21	.92715	41	.81871	61	.73298	81	.66351
22	.92105	42	.81395	62	.72917	82	.66038
23	.91503	43	.80925	63	.72539	83	.65728
24	.90909	44	.80460	64	.72165	84	.65421
25	.90323	45	.80000	65	.71795	85	.65117
26	.89744	46	.79545	66	.71428	86	.64815
27	.89172	47	.79096	67	.71066	87	.64516
28	.88608	48	.78652	68	.70707	88	.64220
29	.88050	49	.78212	69	.70352	89	.63927

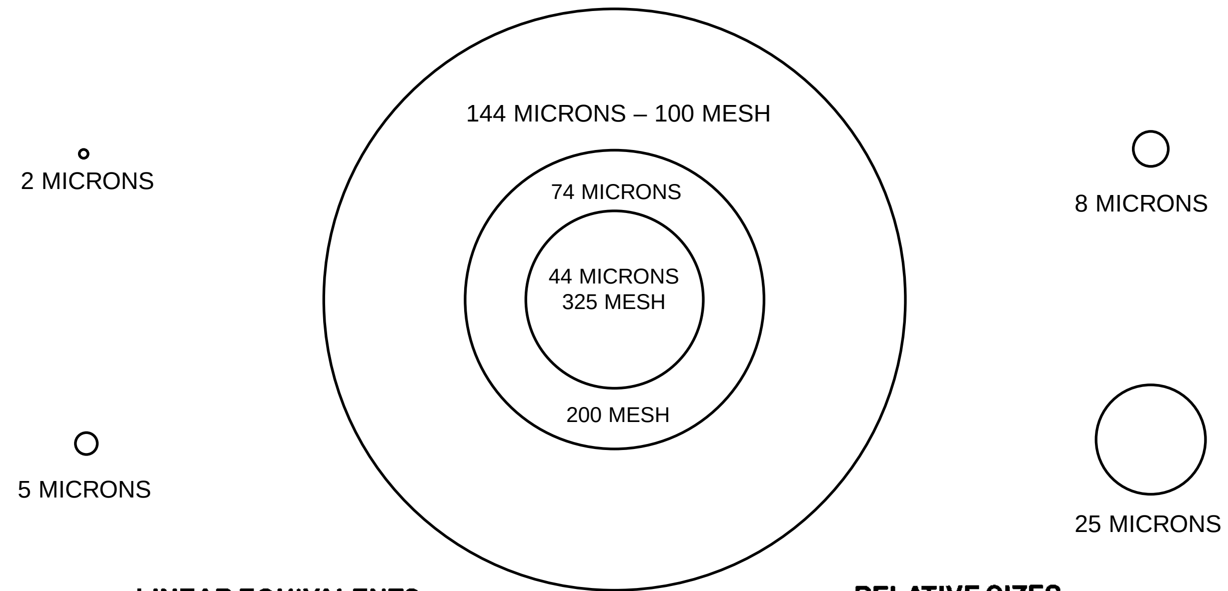
From Circular No. 59 Bureau of Standards.

RELATIVE SIZE OF PARTICLES

TABLE 85

RELATIVE SIZE OF PARTICLES

MAGNIFICATION 500 TIMES



LINEAR EQUIVALENTS

1 INCH	25.4 MILLIMETERS	25,400 MICRONS
1 MILLIMETER	.0394 INCHES	1,000 MICRONS
1 MICRON	$\frac{1}{25,400}$ OF AN INCH	.001 MILLIMETERS
1 MICRON	3.94×10^{-5}	.000039 INCHES

RELATIVE SIZES

LOWER LIMIT OF VISIBILITY (NAKED EYE)	40 MICRONS
WHITE BLOOD CELLS	25 MICRONS
RED BLOOD CELLS	8 MICRONS
BACTERIA (COCCI)	2 MICRONS

COCOA EQUIV. TO 8-10 MICRONS
TALCUM POWDER EQUIV. TO 10 MICRONS
AVG. DIAM. HUMAN HAIR IS 50-70 MICRONS
TABLE SALT EQUIV. TO 100 MICRONS

US AND ASTM STD. SIEVE NO.	ACTUAL OPENING		US AND ASTM STD. SIEVE NO.	ACTUAL OPENING	
	INCHES	MICRONS		INCHES	MICRONS
10	.0787	2000	170	.0035	88
12	.0661	1680	200	.0029	74
14	.0555	1410		.0026	65
16	.0469	1190	230	.0024	62
18	.0394	1000	270	.0021	53
20	.0331	840		.0020	50
25	.0280	710	325	.0017	44
30	.0232	590		.0016	40
35	.0197	500	400	.00142	36
40	.0165	420		.00118	30
45	.0138	350	550	.00099	25
50	.0117	297	625	.00079	20
60	.0098	250		.00059	15
70	.0083	210	1,250	.000394	10
80	.0070	177	1,750	.000315	8
100	.0059	149	2,500	.000197	5
120	.0049	125	5,000	.000099	2.5
140	.0041	105	12,000	.0000394	

PUMP SIZING GUIDELINES

The following worksheet is designed to take you step-by-step through the process of selecting the proper pump for most common applications. There are three major decisions to make when choosing the right pump. They are size, type and best buy for the particular application. Each factor must be weighed carefully and a final selection refined through the process of elimination. The following worksheet will help eliminate many common oversights in design selection. This is a combination of many manufacturers specification request, so it may be photocopied and used by any applications engineer.

I. Sketch the layout of the proposed installation. Trying to pick a pump without a sketch of the system is like a miner trying to work without his lamp. You are in the dark from start to finish. When drawing the system, show the piping, fittings, valves and/or other equipment that may affect the system. Mark the lengths of pipe runs. Include all elevation changes.

II. Determine and study what is to be pumped. All of the following criteria will affect the pump selection in terms of materials of construction and basic design.

What is the material to be pumped and its concentration?____
Is it corrosive?__________yes___________no_____________pH value.
Specific Gravity_________or pounds per gallon___________. Temperature: Min.______Max._______ degrees C. or F.
Viscosity at temperature(s) given above______________in Centipoise or_____________Seconds Saybolt Universal.
Is the material abrasive_____yes ______no. If so, what is the percentage of solid in solution______________and their size range_________________ Min.________________________ Max.________________________
Capacity required (constant or variable)____________________________U.S. Gallons per minute (gpm)__________,
U.S. Gallon per hour (gph)_______,U.S. Gallons per day (gpd)_________,Cubic Centimeters per day (ccpd)_________.

PUMP SIZING GUIDELINES

(continued)

III. Calculating the total pressure requirements.

The Inlet side of the pump

1. What is the material of the inlet piping____ and size_____________?
   (a) What is the total length of the inlet piping, in feet?_____________________
   (b) Fittings Qty. Equivalent length (See page 58)
   ______ ____ x ______________ = ___________
   ______ ____ x ______________ = ___________
   ______ ____ x ______________ = ___________
2. Total length (a+b above) for calculating friction loss ______________
3. Friction loss per 100 foot of pipe (See pages 50 - 58) ________________
4. Total inlet friction loss (use answer from #2 above multiplied by answer in #3 above, then divide the product by 100) ____
5. Static suction lift (See important terms under Hydraulic Fundamentals, pages 93-95)_____________
6. Static suction head _____________ _____________
7. Total inlet head = (4 + 5 - 6 from above)____________
   $NPSH_A$ (Net Positive Suction Head, available) has been calculated to be _____________________.

The Discharge side of the pump

8. What is the material of the discharge piping____________________and the size__________?
   (c) What is the total length of the discharge piping, in feet?_______________
   (d) Fittings Qty. Equivalent length (See page 58)
   ______ ____ x ______________ = ___________
   ______ ____ x ______________ = ___________
   ______ ____ x ______________ = ___________
9. Total length (c+d above) for calculating friction loss ______________
10. Friction loss per 100 foot of pipe (See pages 50 to 58) = ______________
11. Total discharge friction loss (Use answer from #9 above multiplied by answer in #10 above then divide the product by 100) ____
12. Static discharge head (See sketch) Total elevation difference between centerline of the pumps inlet and the point of discharge.____________________________________
13. Add any additional pressure requirements on the system: ie, filters, nozzles or equipment.________PSI____________
14. Total Discharge Head = (11 + 12 + 13 from above)____________
15. Total System Head = (7 + 12 + 13) _____________ in feet.
16. Total Static Head = (5 - 6 + 12 +13) ____________ in feet.
17. Total Friction Loss = (4 + 11) __________________in feet.

IV. Service Cycle

How many hours per day will this pump operate?____________How many days per week will it be used?___________

V. Construction Features

Is a sanitary pump design required?___________yes ________no.
Will the pump be required to work against a closed discharge?________yes________no.
Is it possible for this pumping system to run dry?__________yes________no.
Is a water-jacketed seal required to prevent crystallization on the seal faces?_______yes _______no.
Can the pump be totally isolated, drained, and flushed?_______yes_______no.
Does this application and environment require a chemically resistant epoxy coating? ____________yes____________no
.

VI. Drive Requirements

AC______ or DC______Motor, Voltage____________________ Cycle (Hz)____________Phase________________
Motor enclosure design________Open, ________Totally Enclosed,_________Explosion Proof,___________Sanitary,
Pneumatic (Air Motor)________ Plant air pressure available__________ psig. Volume of air available__________SCFM.

VII. What accessories will be required? Foot Valve____________________, Suction Strainer____________________,
Check Valves ________________,Isolation Valves______________, Pressure Relief Valve_____________________,
Pressure Gauges___________, Flow indicators_________________, Filter/Lubricator/Regulator__________________.

GLOSSARY OF PIPING TERMS

ABRASION RESISTANCE:
Ability to withstand the effects of repeated wearing, rubbing, scraping, etc.

ACCEPTANCE TEST:
An investigation performed on an individual lot of a previously qualified product, by, or under the observation of, the purchaser to establish conformity with a purchase agreement.

ACRYLIC RESINS:
A class of thermoplastic resins produced by polymerization of acrylic acid derivatives.

ACRYLONITRILE - BUTADIENE • STYRENE (ABS):
Plastics containing polymers and/or blends of polymers, in which the minimum butadiene content is 6 percent, the minimum styrene and/or substituted styrene content is 15 percent, and the maximum content of all other monomers is not more than 5 percent, and lubricants, stabilizers and colorants.

ADHESIVE:
A substance capable of holding materials together by surface attachment.

AGING:
The effect of time on materials.

ALKYD RESINS:
A class of thermosetting resins produced by condensation of a poly-based acid or anhydride and a polyhydric alcohol.

ANNEAL:
To prevent the formation of or remove stresses in plastic parts by controlled cooling from a suitable elevated temperature.

BELL END:
The enlarged portion of a pipe that resembles the socket portion of a fitting and that is intended to be used to make a joint by inserting a piece of pipe into it. Joining may be accomplished by solvent cements, adhesives, or mechanical techniques.

BEAM LOADING:
The application of a load to a pipe between two points of support, usually expressed in pounds and the distance between the centers of the supports.

BLISTER:
Undesirable rounded elevation of the surface of a plastic, whose boundaries may be either more or less sharply defined, somewhat resembling in shape a blister on the human skin. A blister may burst and become flattened.

BOND:
To attach by means of an adhesive.

BURNED:
Showing evidence of thermal decomposition through some discoloration, distortion, or destruction of the surface of the plastic.

BURST STRENGTH:
The internal pressure required to break a pipe or fitting. This pressure will vary with the rate of build-up of the pressure and the time during which the pressure is held.

BUTYLENE PLASTICS:
Plastics based on resins made by the polymerization of butane or copolymerization of butene with one or more unsaturated compounds, the butene being in greatest amount of weight.

CELLULOSE:
Chemically a carbohydrate, which is the chief component of the solid structure of plants, wood, cotton, linen, etc. The source of the cellulosic family of plastics.

CELLULOSE ACETATE BUTYRATE:
A class of resins made from a cellulose base. Either cotton tinters or purified wood pulp, by the action of acetic anhydride, acetic acid, and butyric acid.

CEMENT:
A dispersion of solutions of a plastic in a volatile solvent. This meaning is peculiar to the plastics and rubber industries and may or may not be an adhesive composition.

CHEMICAL RESISTANCE:
(1) The effect of specific chemicals on the properties of plastic piping with respect to concentration, temperature, and time of exposure. (2) The ability of a specific plastic pipe to render service for a useful period in the transport of a specific chemical at a specified concentration and temperature.

COALESCENCE:
The union or fusing together of fluid globules or particles to form larger drops or a continuous mass.

COLD FLOW:
Change in dimensions or shape of some materials when subjected to external weight or pressure at room temperature.

COMPOUND:
A combination of ingredients before being processed or made into a finished product. Sometimes used as a synonym for material formulation.

COMPRESSIVE STRENGTH:
The crushing load at failure applied to a specimen per unit area of the resistance surface of the specimen.

CONDENSATION:
A chemical reaction in which two or more molecules combine with the separation of water. Also, the collection of water droplets from vapor onto a cold surface.

COPOLYMER:
The product of simultaneous polymerization of two or more polymerizeable chemicals known as monomers.

CRAZING:
Fine cracks at or under the surface of a plastic.

CREEP:
The unit elongation of a particular dimension under load for a specific time following the initial elastic elongation caused by load application. It is expressed usually in inches per inch per unit of time.

CURE:
To change the properties of a polymeric system into a final, more stable, usable condition by the use of heat, radiation or reaction with chemical additives.

DEFLECTION TEMPERATURE:
The temperature at which a specimen will deflect a given distance at a given load under prescribed conditions of test. See ASTM D648. Formerly called heat distortion.

DEGRADATION:
A deleterious change in the physical properties of a plastic evidenced by impairment of these properties.

GLOSSARY OF PIPING TERMS

DIELECTRIC CONSTANT:
A value that serves as an index of the ability of a substance to resist the transmission of an electrostatic force from one charged body to another, as in a condenser. The lower the value, the greater the resistance. The standard apparatus utilizes a vacuum, whose dielectric constant is 1; in reference to the various materials interposed between the charged terminals have the following values at 20° C : air, 1.00058; glass, 3; benzene, 2.3; acetic aced, 6.2; ammonia, 15.5; ethyl alcohol, 25: glycerol, 56; and counts for its unique behavior as a solvent and in electrolytic solutions. Most hydrocarbons have high resistance (low conductivity). Dielectric constant values decrease as the temperature rises.

DIFFUSION:
The migration or wandering of the particles or molecules of a body of fluid matter away from the main body through a medium or into another medium.

DIMENSION RATIO:
The diameter of a pipe divided by the wall thickness. Each pipe can have two dimension ratios depending upon whether the outside or inside diameter is used. In practice, the outside diameter is used if the standards requirement and manufacturing control are based on this diameter. The inside diameter is used when this measurement is the controlling one.

DRY-BLEND:
A free-flowing compound prepared without fluxing or addition of solvent.

DUROMETER:
Trade name of the Shore Instrument Company for an instrument that measures hardness. The Durometer determines the “hardness of rubber or plastics by measuring the depth of penetration (without puncturing) of a blunt needle compressed on the surface for a short period of time.

ELASTICITY:
That property of plastics materials by virtue of which they tend to recover their original size and like properties.

ELONGATION:
The capacity to take deformation before failure in tension. Expressed as a percentage of the original length.

EMULSION:
A dispersion of one liquid in another, possible only when they are mutually insoluble.

ENVIRONMENTAL STRESS CRACKING:
Cracks that develop when the material is subjected to stress in the presence of specific chemicals.

ESTER:
A compound formed by the reaction between an alcohol and an acid. Many esters are liquids. They are frequently used as plasticizers in rubber and plastic compounds.

EXTRUSION:
Method of processing plastic in a continuous or extended form by forcing heat-softened plastic through an opening shaped like the cross-section of the finished product. This is the method used to produce thermoplastic (PVC) pipe.

FABRICATE:
Method of forming a plastic into a finished article by machining drawing, cementing, and similar operations.

FIBER STRESS:
The unit stress, usually in pounds per square inch (psi) in a piece of material that is subjected to an external load.

FILLER:
A relatively inert material added to a plastic to modify its strength, permanence, working properties or other qualities or to lower costs.

FLAMMABILITY:
The time a specimen will support a flame after having been exposed to a flame for a given period.

FLEXURAL STRENGTH:
The pressure in pounds necessary to break a given sample when applied to the center of the sample which has been supported at its end.

FORMULATION:
A combination of ingredients before being processed or made into a finished product. Sometimes used as a synonym for material or compound.

FORMING:
A process in which the shape of plastic pieces such as sheets, rods, or tubes is changed to a desired configuration.

FUSE:
To join two plastic parts by softening the material through heat or solvents.

GENERIC:
Common names for types of plastic material. They may be either chemical terms or coined names. They contrast with trademarks which are the property of one company.

GRAVES TEAR STRENGTH:
The force required to rupture a specimen by pulling a prepared notched sample.

HARDNESS:
A comparative gauge of resistance to indentation.

HEAT DISTORTION:
The temperature at which a specimen will deflect a given distance at a given load.

HEAT JOINING:
Making a piper joint by heating the edges of the parts to be joined so that they fuse and become essentially one piece with or without the addition of additional material.

HEAT RESISTANCE:
The ability to withstand the effects of exposure to high temperature. Care must be exercised in defining precisely what is meant when this term is used. Descriptions pertaining to heat resistance properties include boilable, washable, cigarette-proof, sterilizable, etc.

HOOP STRESS:
The tensile stress, usually in pounds per square inch (psi) in the circumferential orientation in the wall of the pipe when the pipe contains a gas or liquid under pressure.

HYDROSTATIC DESIGN STRESS:
The estimated maximum tensile stress in the wall of the pipe in the circumferential orientation due to internal hydrostatic pressure that can be applied continuously with a high degree of certainty that failure of the pipe will not occur.

GLOSSARY OF PIPING TERMS

HYDROSTATIC STRENGTH (quick):
The hoop stress calculated by means of the ISO equation at which the pipe breaks due to an internal pressure build-up, usually within 60 to 90 seconds.

IMPACT STRENGTH:
Resistance or mechanical energy absorbed by a plastic part to such shocks as dropping and hard blows.

INJECTION MOLDING:
Method of forming a plastic to the desired shape by forcing heat-softened plastic into a relatively cool cavity where it rapidly solidifies (freezes).

ISO EQUATION:
An equation showing the interrelations between stress, pressure, and dimensions in pipe, namely

$$S \; \frac{P(ID + t)}{2t} \text{ or } \frac{P(OD) - t)}{2t}$$

where S = stress
P = pressure
ID = average inside diameter
OD = average outside diameter
t = minimum wall thickness

JOINT:
The location at which two pieces of pipe or a pipe and a fitting are connected together. The joint may be made by an adhesive, a solvent cement, or a mechanical device such as threads or a ring seal.

KETONES:
Compounds containing the carbonyl group (CO) to which is attached two alkyl groups. Ketones, such as methyl ethyl ketone, are commonly used as solvents for resins and plastics.

LIGHT STABILITY:
Ability of a plastic to retain its original color and physical properties upon exposure to sun or artificial light.

LONGITUDINAL STRESS:
The stress imposed on the long axis of any shape. It can be either a compressive or tensile stress.

LONG-TERM HYDROSTATIC STRENGTH:
The estimated tensile stress in the wall of the pipe in the circumferential orientation (hoop stress) that when applied continuously will cause failure of the pipe at 100,000 hours (11.43 years). These strengths are usually obtained by extrapolation of log-log regression equations or plots.

LUBRICANTS:
A substance used to decrease the friction between solid faces sometimes used to improve processing characteristics of plastic compositions.

MODULUS:
The load in pounds per square inch (or kilos per square centimeter) of initial cross-sectional area necessary to produce a stated percentage elongation which is used in the physical description of plastics (stiffness).

MODULUS OF ELASTICITY:
The ratio of the stress per square inch to the elongation per inch due to this stress.

MOLDING, COMPRESSION:
A method of forming objects from plastics by placing the material in a confining mold cavity and applying pressure and usually heat.

MONOMER:
The simplest repeating structural unit of a polymer. For additional polymers this presents the original unpolymerized compound.

OLEFIN PLASTICS:
Plastics based on resins made by the polymerization of olefins or copolymerization of olefins with other unsaturated compounds, the olefins being in greatest amount by weight. Polyethylene, polypropylene, and polybutylene are the most common olefin plastics encountered in pipe.

ORANGE PEEL:
Uneven surface somewhat resembling an orange peel.

ORGANIC CHEMICAL:
Originally applied to chemicals derived from living organisms, as distinguished from “inorganic” chemicals found in minerals and inanimate substances; modern chemists define organic chemicals more exactly as those which contain the element carbon.

PHENOL RESINS:
Resins made by reaction of a phenolic compound or tar acid with an aldehyde; more commonly applied to thermosetting resins made from pure phenol and formaldehyde.

PLASTIC:
A material that contains as an essential ingredient an organic substance of large molecular weight is solid in its finished state, and at some state in its manufacture or in its processing into finished articles, can be shaped by flow.

PLASTICITY:
A property of plastics and resins which allows the material to be deformed continuously and permanently without rupture upon the application of a force that exceeds the yield value of the material.

PLASTIC CONDUIT:
Plastic pipe or tubing used as an enclosure for electrical wiring.

PLASTIC PIPE:
A hollow cylinder of a plastic material in which the wall thickness is usually small when compared to the diameter and in which the inside and outside walls are essentially concentric.

PLASTIC TUBING:
A particular size of plastics pipe in which the outside diameter is essentially the same as that of copper tubing.

POLYBUTYLENE:
A polymer prepared by the polymerization of butene - 1 as the sole monomer.

POLYETHYLENE:
A polymer prepared by the polymerization of ethylene as the sole monomer.

POLYMER:
A product resulting from a chemical change involving the successive addition of a large number of relatively small molecules (monomer) to form the polymer and whose molecular weight is usually a multiple of that of the original substance.

POLYMERIZATION:
Chemical change resulting in the formation of a new compound whose molecular weight is usually a large multiple of that of the original substance.

GLOSSARY OF PIPING TERMS

POLYPROPYLENE:
A polymer prepared by the polymerization of propylene as the sole monomer.

POLYSTYRENE:
A plastic based on a resin made by polymerization of styrene as the sole monomer.

POLYVINYL CHLORIDE:
Polymerized vinyl chloride, a synthetic resin which, when plasticized or softened with other chemicals, has some rubber like properties. It is derived from acetylene and hydrochloric acid.

PRESSURE:
When expressed with reference to pipe the force per unit area exerted by the medium in the pipe.

STABILIZER:
A chemical substance which is frequently added to plastic compounds to inhibit undesirable changes in the material, such as discoloration due to heat or light.

STIFFNESS FACTOR:
A physical property of plastic pipe that indicates the degree of flexibility of the pipe when subjected to external loads.

STRAIN:
The ratio of the amount of deformation to the length being deformed caused by the application of a load on a piece of material.

STRENGTH:
The mechanical properties of a plastic such as a load or weight carrying ability, and ability to withstand sharp blows. Strength properties include tensile, flexural, and tear strength, toughness, flexibility, etc.

STRESS:
When expressed with reference to pipe, the force per unit area in the wall of the pipe in the circumferential orientation due to internal hydrostatic pressure.

STRESS CRACK:
External or internal cracks in a plastic caused by tensile stresses less than that of its short-time mechanical strength.

STRESS RELAXATION:
The decrease of stress with respect to time in a piece of plastic that is subject to an external load.

STYRENE PLASTICS:
Plastics based on resins made by the polymerization of styrene or copolymerization of styrene with other unsaturated compounds, the styrene being in greatest amount by weight.

STYRENE-RUBBER-PLASTICS:
Compositions based on rubbers and styrene plastics, the styrene plastics being in greatest amount by weight.

SUSTAINED PRESSURE TEST:
A constant internal pressure test for 1000 hours.

TEAR STRENGTH:
Resistance of a material to tearing.

TENSILE STRENGTH:
The capacity of a material to resist a force tending to stretch it. Ordinarily the term is used to denote the force required to stretch a material to rupture, and is known variously as "breaking point," "breaking stress," "ultimate tensile strength," and sometimes erroneously as "breaking strain." In plastics testing, it is the load in pounds per square inch or kilos per square centimeter of original cross-sectional area, supported at the moment of rupture by a piece of test sample on being elongated.

THERMOFORMING:
Forming with the aid of heat.

THERMAL CONDUCTIVITY:
Capacity of a plastic material to conduct heat.

THERMAL EXPANSION:
The increase in length of a dimension under the influence of an increase in temperature.

THERMOPLASTIC:
In a plastic which is thermoplastic in behavior, adj. capable of being repeatedly softened by increase of temperature and hardened by decrease of temperature.

THERMOSETTING:
Plastic materials which undergo a chemical change and harden permanently when heated in processing. Further heating will not soften these materials.

TRANSLUCENT:
Permitting the passage of light, but diffusing it so that objects beyond cannot be clearly distinguished.

TURBULENCE:
Any deviation from parallel flow in a pipe due to rough inner walls, obstructions, or direction changes.

VINYL PLASTICS:
Plastics based on resins made from vinyl monomers, except those specifically covered by other classification, such as acrylic and styrene plastics. Typical vinyl plastics are polyvinyl chloride, or polyvinyl monomers with unsaturated compounds.

VIRGIN MATERIAL:
A plastic material in the form of pellets, granules, powder, floc or liquid that has not been subjected to use or processing other than that required for its original manufacture.

VISCOSITY:
Internal friction of a liquid because of its resistance to shear, agitation or flow.

VOLATILE:
Property of liquids to pass away by evaporation.

WATER ABSORPTION:
The percentages by weight or water absorbed by a sample immersed in water. Dependent upon area exposed and time of exposure.

WELDING:
The joining of two or more pieces of plastic by fusion of the material in the pieces at adjoining or nearby areas either with or without the addition of plastic from another source.

YIELD STRENGTH:
The stress at which a plastic material exhibits a specified limiting permanent set.

YIELD POINT:
The point at which a plastic material will continue to elongate at no substantial increase in load during a short test period.

YIELD STRESS:
The stress at which a plastic material elongates without further increase of stress. Up to this point, the stress/strain relationship is linear (Young's Modules).