MATERIAL DESCRIPTION

POLYVINYLS

PVC (POLYVINYL CHLORIDE) is, by far, the most common plastic material used for plastic pipe. Its basic properties are chemical inertness, corrosion and weather resistance, high strength to weight ratio, electrical and thermal insulators. The service temperature is 140°F. PVC has been used successfully for 40 years in such areas as chemical processing, industrial plating, chilled water distribution, deionized water, and chemical drainage. Care should be taken to avoid using with Ketones, Chlorinated Hydrocarbons, and Aromatic Solvents. 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 nonpolar 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 Generally described in three classifications according to the relative degree of branching (side chain formation) in their molecular structures and density.

Low Density Polyethylene (LDPE) has more extensive branching resulting in less compact molecular structures and lower mechanical strength, than other Polyethylenes. Good for temperatures to 140°F and is frequently used for food handling equipment, brine tanks and dispensing equipment. It may be hot gas welded if required.

High Density Polyethylene (HDPE) has minimal branching, which makes it more rigid and less permeable than LDPE. Good for temperatures to 160°F and is frequently used for abrasion resistant piping, caustic storage tanks, and control tubing. It may be hot gas welded.

Cross-Linked High Density Polyethylene (XLPE) is a three dimensional Polymer of extremely high molecular weight with individual molecular chains bonded together using heat plus chemicals or radiation. This structure provides superior environmental stress-crack resistance and extremely high impact strength. Cross-linked Polyethylene becomes a thermoset material after manufacturing and cannot be hot gas welded. Good for temperatures to 160°F with most common uses including large tanks for outdoor service.

All Polyethylene have excellent chemical resistance to a wide range of common chemicals. Avoid strong oxidizing agents and solvents.

FLUOROPLASTICS

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® (ECTFE) ETHYLENE CHLOROTRIFLUORO ETHYLENE) 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.

PTFE (POLYTETRAFLUORETHYLENE)

There are three members of the PTFE family of resins. 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.

MATERIAL DESCRIPTION

FEP (FLUORINATED ETHYLENE PROPYLENE) 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 PTFE, 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 is the mostly transparent and is widely used for its high ultraviolet light transmitting ability.

PFA (PERFLUOROALKOXY) is similar to PTFE and FEP. It has excellent melt-processability and properties rivaling or exceeding those of PTFE. 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 offers superior stress and crack resistance with good flex-life in tubing. It is generally not as permeable as PTFE.

ETFE (TEFZEL®, ETHYLENE TETRAFLUORO-ETHYLENE) Tefzel® combines the mechanical toughness with outstanding chemical resistance that approaches PTFE. Effective from -20°F to 300°F, Tefzel is known for its processability and high energy radiation resistance.

ABS (ACRYLONITRILE-BUTADIENE-STYRENE)
Identifies a broad family of engineering thermoplastics with a range of performance characteristics. The copolymeric system can be blended to yield the optimum balance of properties suited to a selected end use. Acrylonitrile imparts chemical resistance and rigidity. Butadiene endows the product with impact strength and toughness, while Styrene contributes to ease of processing.

RYTON® (PPS) POLYPHENYLENE SULFIDE PPS exhibits outstanding high temperature stability, inherent flame resistance and good chemical resistance. Because of its high crystallinity and dimensional stability, PPS is used extensively for molded pump and valve components. Relatively few chemicals react with PPS, even at temperatures up to 200°F. PPS is compatible with such hostile environments as esters, ketones, alcohols, bases and hydrocarbons.

SULFONE POLYMERS

Polysulfone is a tough, clear thermoplastic used in corrosive environments. It has a temperature range to 300°F. Polysulfone has high resistance to acids, alkali, and salt solution but is attacked by ketones, chlorinated hydrocarbons and aromatic hydrocarbons. Polysulfone has found wide usage as flowmeters and sight gauges.

ELASTOMERIC MATERIALS

VITON® (FLUOROELASTOMER) 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. Its maximum temperature limit is 250°F.

EPDM (ETHYLENE PROPYLENE TERPOLYMER) 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. Its maximum temperature limit is 212°F

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.

NITRILE (BUNA-N) Nitrile rubber is a copolymer of butadiene and acrylonitrile. In addition to its excellent elastomeric properties, it is resistant to aliphatic hydrocarbons and aromatic solvents. Its maximum temperature is 212°F.

HYPALON® This is the DuPont name for its elastomer of chlorosulfonated polyethylene used for valve seats and seals. Its maximum temperature limit is 212°F.

NEOPRENE A chlorinated synthetic rubber used primarily as a seating and sealing material in valves, its maximum temperature limit is 212°F.

NATURAL RUBBER This is a high molecular weight polymer isoprene derived from the Hevea tree. It is used as diaphragm and sealing material because of its elastomeric properties and resistance to abrasion. Its maximum temperature limit is 212°F.

THERMOSETS

FRP (FIBERGLASS REINFORCED PLASTICS) OR RTRP (REINFORCED THERMOSETTING RESIN PIPE)
FRP piping is a highly valuable engineering material for process piping and vessels. It has been accepted by many industries because it offers the following significant advantages, (1) moderate initial cost and low maintenance (2) broad range of chemical resistance (3) high strength-to-weight ratio (4) ease of fabrication and flexibility of design and (5) good electrical insulation properties.

MATERIAL DESCRIPTION

Epoxy glass fiber pipe exhibits all the above mentioned characteristics as well as performance temperatures to 300°F. Epoxy piping is commonly used in the oil, mining and chemical industries. New application in the geothermal and steam condensate systems have also proven successful.

Vinylester resins are epoxy-based thermosetting resins that are cured by free radical polymerization similar to the curing mechanism of conventional polyester resins. Physical properties are tensile strength, elongation and fatigue resistance very close to those of the premiums aromatic amine cured epoxies. Chemical resistance represents the best of two worlds; the excellent alkali resistance of the epoxy and the acid and oxidation chemical resistance of the polyester.

INDUSTRY STANDARDS

Because plastic piping and plastic lined metallic piping are used for so many applications and because the requirements for each application are somewhat different, numerous standards and a variety of joining systems have been developed. Additional standards are being prepared and will be added to this list in future revisions as they become available.

The standards referenced herein, like all other standards, are of necessity minimum requirements. It should be recognized that two different plastic resin materials even though 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 for the aforementioned tests from the resin supplier to assure optimum pipe from a particular material. In case of a 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/Primer Specifications

D	2564	Solvent cements for PVC plastic pipe and fittings
F	493	CPVC solvent cement
F	656	Primers for PVC/CPVC pipe and fitting joints

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

INDUSTRY STANDARDS

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
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

INDUSTRY STANDARDS

BOCA

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

BOCA Basic Plumbing Code

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)

Table 3 - PIPE O.D.s

U.S. (ANSI)		EUROPE (ISO)			
NOMINAL BORE INCHES	ACTUAL OD INCHES	DN (NOMINAL BORE)		d (ACTUAL OD)	
		MM	IN.	MM	IN.
1/8	.405	6	(.236)	10	(.394)
1/4	.540	8	(.315)	12	(.472)
3/8	.675	10	(.394)	15	(.630)
1/2	.840	15	(.591)	20	(.787)
3/4	1.050	20	(.787)	25	(.984)
1	1.315	25	(.984)	32	(1.260)
1 1/4	1.660	32	(1.260)	40	(1.575)
1 1/2	1.900	40	(1.575)	50	(1.969)
2	2.375	50	(1.969)	63	(2.480)
2 1/2	2.875	65	(2.559)	75	(2.953)
3	3.500	80	(3.150)	90	(3.543)
4	4.500	100	(3.937)	110	(4.331)
5	5.563	125	(4.921)	140	(5.512)
6	6.625	150	(5.906)	160	(6.299)
8	8.625	200	(7.874)	225	(8.858)
10	10.750	250	(9.843)	280	(11.024)
12	12.750	300	(11.811)	315	(12.402)

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 noncorrosive 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 your Corr Tech representative.

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.

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

ADHESIVE-BACKED PLASTIC BACKGROUND PIECES - ONE NEEDED FOR EACH NUMERAL, THREE NEEDED FOR EACH COMPLETE SIGNAL

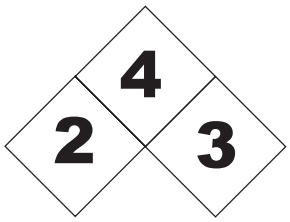


Figure 1. For use where specified color background is used with numerals of contrasting colors.

FLAMMABILITY SIGNAL- RED

HEALTH SIGNAL- BLUE

REACTIVITY SIGNAL- YELLOW

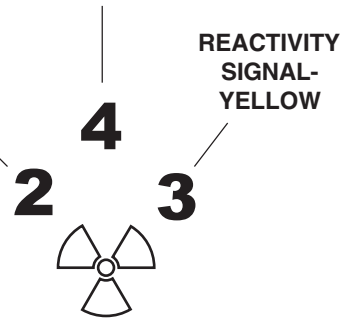


Figure 2. For use where a white background is necessary.

WHITE PAINTED BACKGROUND, WHITE PAPER OR CARD STOCK

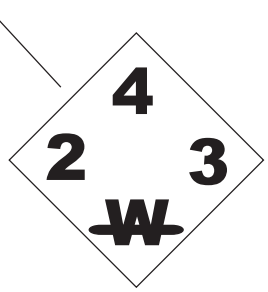


Figure 3. For use where a white background is used with painted numerals, or for use when the signal is in the form of sign or placard.

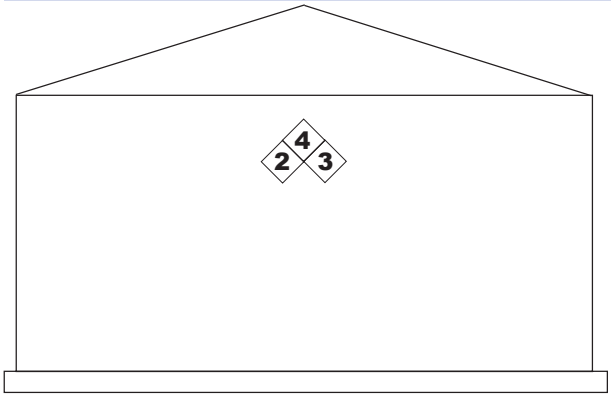


Figure 4. Storage Tank

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"

IDENTIFICATION OF MATERIALS BY HAZARD SIGNAL ARRANGEMENT

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.

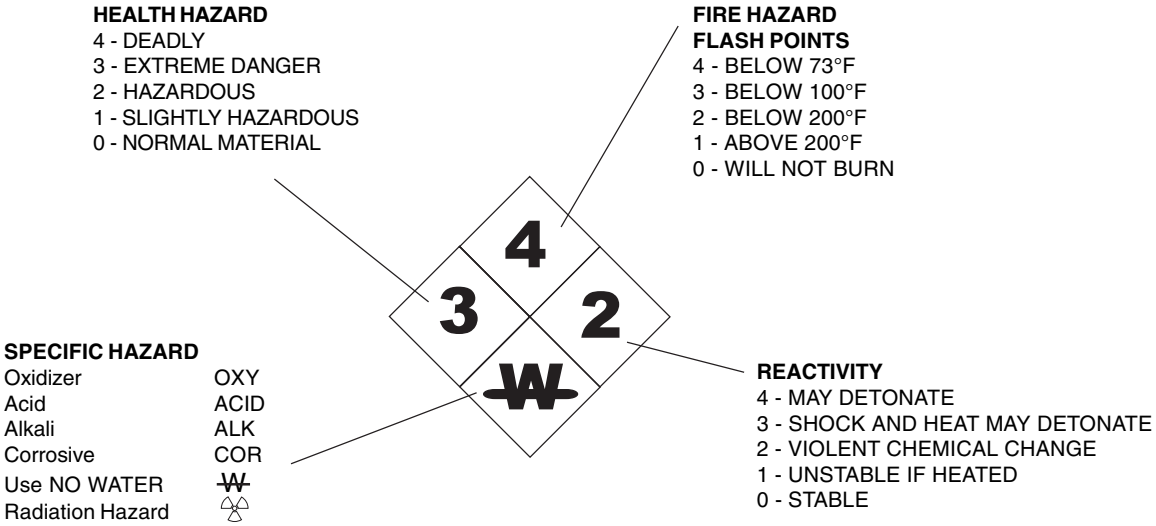
The explanatory material on this page is to assist users of these standards, particularly the person who assigns the degree of hazard in each category.

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

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.



RELATIVE PROPERTIES

TABLE 1

Table 1

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 73° ft. lbs/in. notched ASTM - D256	COMPRESSIVE STRENGTH psi ASTM - D695 "c"	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	.905	.02	5,000	1.7-2.5	7,000	1.3	5,500-8,000	.38-.40
(PPFR) POLYPROPYLENE FLAME RETARDANT								
(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	—
(PTFE) POLYTETRAFLUORETHYLENE	2.14	.02	2,600	1.0	81,000	No Break	3,500	—
(PFA) POLYFLUOROALKOXY	2.2	0.0	2,000-5,000	.58	—	3.0	1,700	—
(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 2

Table 2

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 @6 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	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 FLUORIDE	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	—	—
(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	—	—
(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