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Chemical Resistance of Thermoplastics Piping Materials



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CHEMICAL RESISTANCE OF THERMOPLASTICS PIPING MATERIALS

Foreword

This report was developed and published with the technical help and financial support of the members of the PPI (Plastics Pipe Institute, Inc.). The members have shown their interest in quality products by assisting independent standards-making and user organizations in the development of standards, and also by developing reports on an industry-wide basis to help engineers, code officials, specifying groups, and users.

The purpose of this technical report is to provide information on the transport of various chemicals using thermoplastic piping materials.

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This report has been developed as an informative guide on resistance of thermoplastic piping materials to chemical attack. It is divided into two main sections: (1) a discussion of chemical resistance and general considerations for end use applications and (2) a listing of chemical resistance data (table) for several thermoplastic piping materials applicable to non-pressure applications. Determination of suitability for specific applications under stress (pressurized service) is beyond the scope of this report.

SECTION I: CHEMICAL RESISTANCE IN GENERAL

Thermoplastic materials generally are resistant to attack from many chemicals which makes them suitable for use in many process applications. The suitability for use in a particular process piping application is a function of:

- I. Material
 - A. The specific plastic material: ABS, CPVC, PP, PVC, PE, PB, PVDF, PEX¹, PA11, PK
 - B. The specific plastic material physical properties as identified by its cell classification according to the appropriate ASTM material specification.
- II. Product and Joint System
 - A. Piping product dimensions, construction, and composition (layers, fillers, etc.).
 - B. Joining system. Heat fusion and solvent cementing do not introduce different materials into the system. Mechanical joints can introduce gaskets such as elastomers, or other thermoplastic or non-thermoplastic materials used as mechanical fitting components.
 - C. Other components and appurtenances in the piping system.
- III. Use Conditions - Internal and External
 - A. Chemical or mixtures of chemicals, and their concentrations.
 - B. Operating temperature — maximum, minimum, and cyclical variations.
 - C. Operating pressure or applied stress — maximum, minimum and cyclical variations.
 - D. Life-cycle information — such as material cost, installation cost, desired service life, maintenance, repair and replacement costs, etc.

¹ Once cross-linked, PEX is no longer considered a thermoplastic material; however, it is included in this report as convenience for the reader.

Types of Chemical Attack on Plastics

In general, chemicals that affect plastics do so in one of two ways. One effect is chemical solvation or permeation; the other is direct chemical attack.

Chemical Solvation or Permeation

In the case of solvation or permeation, physical properties may be affected, but the polymer molecule structure itself is not chemically changed, degraded or destroyed. In solvation or permeation, gas, vapor or liquid molecules pass through the polymer, typically without damaging the plastic material itself. If the solvating chemical can be removed completely, the plastic is generally restored to its original condition. However, removal of the chemical is not always possible, and, in such cases, these chemical solvation effects may be permanent.

Sometimes the polymer itself may not be soluble, but it may contain a soluble compounding ingredient that may be extracted from the polymer compound. This is rare because such extractable ingredients are either not used in pipe compounds, or they are chemically bonded to the molecular polymer matrix and in such small amounts that they cannot be leached out to any significant extent.

Permeation may do little if any harm to the material, but it may have application-related effects. The permeating chemical may transfer into a fluid on the other side of the pipe. In general, thermoplastic pipes should not be used where a permeating chemical in the environment surrounding the pipe could compromise the purity of a fluid, such as potable water inside the pipe (See also PPI *Statement N* on Pipe Permeation). In gas or vapor transmission service, there may be a very slight loss of contents through the pipe wall. Lastly, a permeating chemical entrained in the material may be released when heat fusion or solvent cement joining is performed. Thus, heat fusion or solvent cement joining may be unreliable if performed on permeated pipes.

Direct Chemical Attack

Direct chemical attack occurs when exposure to a chemical causes a chemical alteration of the polymer molecules by chain scission, crosslinking, oxidation or substitution reactions. Direct chemical attack may cause profound, irreversible changes that cannot be restored by removal of the chemical. Examples of this type of attack are 50% chromic acid at 140 °F on PVC, aqua regia on PVC at 73 °F, 95% sulfuric acid at 73 °F on PE and wet chlorine gas on PVC and PE. Direct chemical attack frequently causes a severe reduction of mechanical physical properties such as tensile strength, ductility, and impact resistance, and susceptibility to cracking from applied stress (stress cracking).

Chemical resistance may vary greatly from one plastic material to another (i.e., PVC, ABS, PE, etc.), and also among different cell classifications of the same plastic type (e.g. PVC 1120 to PVC 2110, PE 3608 to PE 4710, etc.). There may also be slight variations among commercial products having the same cell classification.

The chemical resistance of plastic piping is basically a function of the chemical resistance of the thermoplastic material, in addition to additives and other ingredients in the final compound. In general, the less inert compounding ingredients used the better the chemical resistance. Thermoplastic pipes with significant filler percentages may be susceptible to chemical attack where an unfilled material may be affected to a lesser degree or not at all.

Other Considerations

Chemical Families

While the effect of each individual chemical is specific, some chemicals can be grouped into general categories based on similarities in chemical characteristics (acids, bases, alcohols, etc.). For example, water-based (aqueous) solutions of neutral inorganic salts generally have the same effect on thermoplastic piping materials as water alone; thus, sodium chloride, potassium alum, calcium chloride, copper sulfate, potassium sulfate and zinc chloride solutions have the same effect as water. However, at elevated temperatures and/or high concentrations, some oxidizing salt solutions may attack some plastic materials.

Further, with organic chemicals in a specific series such as alcohols, ketones, or acids, etc., as the molecular weight of the organic chemical series increases, the chemical resistance of a particular plastic material to members of the specific organic chemical series frequently also increases. Thus, while one type of polyvinyl chloride at 73 °F is not suitable for use with ethyl acetate, it is suitable for the higher molecular weight butyl acetate.

Accelerating factors (concentration, temperature, stress)

Generally, the resistance of a particular plastic to a specific chemical decreases with an increase in concentration. For example, at 73°F polyethylene pipe can be used to carry 70% sulfuric acid but is not satisfactory for 95% sulfuric acid.

Also, the resistance of a particular plastic to a specific chemical generally decreases as temperature increases, generally decreases with increasing applied stress, and generally decreases where temperature or applied stress are varied or cycled. These effects can be greater overall in combination.

Combinations of Chemicals

In some cases, combinations of chemicals may have a synergistic effect on a thermoplastic material where the individual chemicals do not. It cannot be

assumed that an individual chemical's lack of effect would apply for combinations that include several chemicals. When the possible combined effect of several chemicals is unknown, the material should be tested in the complete chemical mixture(s) in question.

Multi-Layered (Composite) Piping

Some piping products utilize a multi-layered (*composite*) construction, in which the pipe wall is constructed of layers of different materials. The layers may consist of both thermoplastic and non-thermoplastic – for example, PE/AL/PE and PEX/AL/PEX pipes, which contain a mid-wall aluminum layer. An all-thermoplastic composite pipe may contain PVC, ABS, and PVC layers. Layered composite material pipes may have chemical resistance that differs from the chemical resistance of the individual materials.

Rate of Chemical Attack

Chemicals that attack plastics do so at a certain rate, some slowly and some more quickly. But usually, any chemical attack is increased when temperature or stress are increased, or when temperature or stress are varied. The particular rate must be taken into consideration in the life-cycle evaluation for a particular application. It has been observed in some chemical plants that while a particular application may have a relatively short service life, the overall life-cycle cost may be economically feasible and justifiable. Each combination of material cost, installation cost and service life must be evaluated and judged on its own merits.

In some cases involving a slow rate of chemical attack, particularly when the application will be pressurized, simple immersion data, like that represented in the following resistance tables, may not adequately characterize performance throughout the intended design life. Longer-term testing to replicate service conditions is advisable to fully measure the effects of these chemicals.

SECTION 2: CHEMICAL RESISTANCE DATA FOR THERMOPLASTIC PIPING IN NON-PRESSURE APPLICATIONS AND DATA TABLE

When thermoplastic pipes come into contact with chemical agents, it is important to know how the pipe may be affected. For gravity flow or non-pressure applications, where the pipe is not subject to continuous internal pressure or thermal stress, chemical immersion test data may provide suitable information. The pipe manufacturer may have additional data from similar tests, or information on previous installations under similar field conditions.

The following table provides resistance data, with the following cautions:

- I. *Data Sources.* The following chemical resistance information has been obtained from numerous sources. The data are based primarily on plastic material test specimens that have been immersed in the chemical, and to a lesser degree, on field-experience. In most cases, detailed information on the test conditions (such as exposure time), and on test results (such as change in weight, change in volume, and change in strength) was not available. Therefore, this information is best used only for comparison of different thermoplastic materials.
- II. *Combinations of Chemicals.* Chemicals that individually do not have an effect may affect the pipe if combined with certain other chemicals. The listings that follow do not address chemical combinations.
- III. *Composite Piping.* Layered composite piping may have chemical resistance that differs from that of the individual materials in the layers. The listings that follow are not applicable to layered composite piping products.
- IV. *Applicability to fiberglass, filled materials.* The listings that follow are not applicable to composite piping products such as reinforced epoxy resin (fiberglass) pipes, or to thermoplastic pipes containing significant percentages of filler materials.
- V. *Concentrations.* Where no concentrations are given, the relatively pure material is indicated, except in the case of solids where saturated aqueous solutions are indicated.

NOTE: *Even though indicated as acceptable with certain temperature limitations, the use of PVC piping with liquid hydrocarbons such as gasoline and jet fuels should be limited to short-term exposure such as secondary containment systems. This piping is not recommended for long-term exposure to liquid hydrocarbons.*

Resistance Codes

The following code is used in the data table:

<u>Code</u>	<u>Meaning</u>	<u>Typical Result</u>
140	Plastic type is generally resistant to temperature (°F) indicated by code.	Swelling < 3% or weight loss < 0.5% and elongation at break not significantly changed.
R to 73	Plastic type is generally resistant to temperature (°F) indicated by code and may have limited resistance at higher temperatures.	Swelling < 3% or weight loss < 0.5% and elongation at break not significantly changed.
C to 73	Plastic type has limited resistance to temperature (°F) indicated by code and may be suitable for some conditions.	Swelling 3-8% or weight loss 0.5-5% and/or elongation at break decreased by < 50%.
N	Plastic type is not resistant.	Swelling > 8% or weight loss > 5% and/or elongation at break decreased by > 50%.
—	Data not available.	

Plastic Materials Identification

ABS	acrylonitrile-butadiene-styrene
CPVC	chlorinated polyvinyl chloride
PP	polypropylene
PVC	polyvinyl chloride
PE	polyethylene
PB	polybutylene
PVDF	poly vinylidene fluoride
PEX	crosslinked polyethylene
PA11	polyamide 11
PK	polyketone

CHEMICALS THAT DO NOT NORMALLY AFFECT THE PROPERTIES OF AN UNSTRESSED THERMOPLASTIC MAY CAUSE COMPLETELY DIFFERENT BEHAVIOR (SUCH AS STRESS CRACKING) WHEN UNDER THERMAL OR MECHANICAL STRESS (SUCH AS CONSTANT INTERNAL PRESSURE OR FREQUENT THERMAL OR MECHANICAL STRESS CYCLES). UNSTRESSED IMMERSION TEST CHEMICAL RESISTANCE INFORMATION IS APPLICABLE ONLY WHEN THE THERMOPLASTIC PIPE WILL NOT BE SUBJECT TO MECHANICAL OR THERMAL STRESS THAT IS CONSTANT OR CYCLES FREQUENTLY.

WHEN THE PIPE WILL BE SUBJECT TO A CONTINUOUS APPLIED MECHANICAL OR THERMAL STRESS OR TO COMBINATIONS OF CHEMICALS, TESTING THAT DUPLICATES THE EXPECTED FIELD CONDITIONS AS CLOSELY AS POSSIBLE SHOULD BE PERFORMED ON REPRESENTATIVE SAMPLES OF THE PIPE PRODUCT TO PROPERLY EVALUATE PLASTIC PIPE FOR USE IN THIS APPLICATION.

May not be fully applicable to pressurized applications

Plastics at Maximum Operating Temperature (F)

Chemical (Formula)	Concentration	ABS	CPVC	PP	PVC	PE	PB	PVDF	PEX	PA 11	PK
Acetaldehyde CH ₃ CHO	--	---	N	140	N	C to 73	C to 73	---	C to 140	C to 176	R to 73
	Aq. Of 40%	---	N	---	C to 73	R to 73	---	N	R to 73	---	---
Acetamide CH ₃ CONH ₂	5%	120	---	140	---	140	---	---	140	---	---
Acetic Acid CH ₃ COOH	vapor	120	180	180	140	140	140	---	140	---	---
	5%	---	---	---	---	---	---	---	---	---	R to 176
	10%	---	---	---	---	---	---	R to 248	140	R to 176	---
	25%	N	180	180	140	140	140	---	140	---	---
	40%	---	---	---	---	---	---	R to 140	R to 176	---	---
	50%	---	---	---	---	---	---	R to 140	R to 176	C to 68	---
	60%	N	N	180	73	73	73	R to 104	73	---	---
	80%	---	---	---	---	---	---	R to 104	---	---	---
	85%	N	N	120	73	73	73	---	73	---	---
	glacial	N	N	120	73	73	73	R to 104	R to 68	---	---
Acetic Anhydride (CH ₃ CO) ₂ O	---	N	N	73	N	73	140	N	73	C to 68	---
Acetone CH ₃ COCH ₃	5%	N	N	73	N	C to 73	140	R to 212	C to 73	C to 140	---
	10%	---	---	---	---	---	---	R to 122	---	---	---
	100%	---	---	---	---	---	---	---	---	---	R to 73 C to 122
Acetophenone C ₆ H ₅ COCH ₃	---	N	---	120	---	73	---	R to 68	73	---	---
Acetyl Chloride CH ₃ COCl	---	N	N	---	N	---	---	N	---	---	---
Acetylene HC≡CH	gas 100%	73	N	73	N	73	C to 73	---	73	140	---
Acetylnitrile	---	---	N	---	N	---	---	---	---	---	---
Acrylic Acid H ₂ C=CHCOOH	97%	---	N	---	N	140	---	---	140	---	---

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Chemical (Formula)	Concentration	ABS	CPVC	PP	PVC	PE	PB	PVDF	PEX	PA 11	PK
Acrylonitrile $H_2C=CHC\equiv N$	---	---	N	---	N	140	---	---	140	---	---
Adipic Acid $COOH(CH_2)_4COOH$	sat'd	---	180	140	140	140	73	R to 176	140	---	---
Allyl Alcohol $CH_2=CHCH_2OH$	96%	---	C to 73	140	R to 73	140	140	---	N	---	---
Allyl Chloride $CH_2=CHCH_2Cl$	--	---	N	---	N	C to 73	---	140	C to 73	---	---
	Liquid	---	---	---	---	---	---	R to 68	---	---	---
Aluminum Ammonium Sulfate (Alum) $AlNH_4(SO_4)_2 \cdot 12H_2O$	sat'd	---	180	140	140	140	---	---	140	---	---
Aluminum Chloride Aqueous $AlCl_3$	sat'd	160	180	180	140	140	140	R to 212	140	---	---
Aluminum Fluoride Anhydrous AlF_3	sat'd	160	180	180	73	140	140	R to 212	140	---	---
Aluminum Hydroxide $Al(OH)_3$	sat'd	160	180	180	140	140	140	R to 212	140	---	N
Aluminum Nitrate $Al(NO_3)_3 \cdot 9H_2O$	sat'd	---	180	180	140	140	140	R to 212	140	---	---
Aluminum Oxychloride	--	---	180	180	140	---	140	---	---	---	---
Aluminum Potassium Sulfate (Alum) $AlK(SO_4)_2 \cdot 12H_2O$	sat'd	160	180	140	140	140	---	R to 212	140	---	---
Aluminum Sulfate (Alum) $Al_2(SO_4)_3$	sat'd	160	180	140	140	140	C to 73	R to 212	140	194	---
	20%	---	---	---	---	---	---	---	---	---	R to 73
Ammonia Gas NH_3	100%	N	N	140	140	140	140	---	140	140	---
Ammonia Liquid NH_3	100%	160	N	140	N	140	73	---	140	140	---
Ammonium Acetate CH_3COONH_4	sat'd	120	180	73	140	140	---	R to 212	140	---	---
Ammonium Bifluoride NH_4HF_2	sat'd	---	180	180	140	---	140	---	140	---	---
Ammonium Bisulfide $(NH_4)HS$	---	---	---	---	140	---	---	---	---	---	---
Ammonium Carbonate $(NH_4)_2CO_3$	sat'd	---	180	212	140	140	140	R to 248	140	---	---
Ammonium Chloride NH_4Cl	sat'd	120	180	212	140	140	140	R to 212	140	---	---

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Plastics at Maximum Operating Temperature (F)

Chemical (Formula)	Concentration	ABS	CPVC	PP	PVC	PE	PB	PVDF	PEX	PA 11	PK
Ammonium Dichromate (NH ₄) ₂ Cr ₂ O ₇	--	---	73	---	73	---	---	---	---	---	---
Ammonium Fluoride NH ₄ F	10%	120	180	212	140	140	---	R to 212	140	---	---
	25%	120	180	212	C to 140	140	73	---	140	---	---
Ammonium Hydroxide NH ₄ OH	10%	120	N	212	140	140	140	---	140	---	N
	30%	---	---	---	---	R to 140	---	---	R to 140	---	---
	Conc.	---	---	---	---	---	---	---	194	---	---
Ammonium Metaphosphate	Sat'd	--	--	R to 212	R to 140	R to 140	R to 140	R to 248	R to 140	---	---
Ammonium Nitrate NH ₄ NO ₃	sat'd	120	180	212	140	140	140	R to 212	140	---	---
Ammonium Persulfate (NH ₄) ₂ S ₂ O ₈	---	---	180	140	140	140	140	R to 212	140	---	---
Ammonium Phosphate (Monobasic) NH ₄ H ₂ PO ₄	all	120	180	212	140	140	140	R to 248	140	---	---
Ammonium Sulfate (NH ₄) ₂ SO ₄	Sat'd.	120	180	212	140	140	140	R to 212	140	---	---
	20%	---	---	---	---	---	---	---	---	---	R to 73
Ammonium Sulfide (NH ₄) ₂ S	dilute	120	180	212	140	140	140	---	140	---	---
	Sat'd.	---	---	---	---	140	---	---	---	---	---
Ammonium Thiocyanate NH ₄ SCN	50-60%	120	180	212	140	140	140	R to 212	73	---	---
Amyl Acetate CH ₃ COOC ₅ H ₁₁	--	N	N	N	N	73	---	R to 122	73	C to 194	---
Amyl Alcohol C ₅ H ₁₁ OH	--	---	N	---	N	140	140	R to 212	R to 140	---	---
	100%	---	---	---	---	---	C to 140	---	---	---	---
n-Amyl Chloride CH ₃ (CH ₂) ₃ CH ₂ Cl	--	N	N	N	N	C to 73	---	---	C to 73	---	---
Anisole C ₇ H ₈ O	--	---	---	---	---	---	---	---	---	---	C to 73
Aniline C ₆ H ₅ NH ₂	--	N	N	---	N	73	C to 140	R to 68	C to 140	---	N
Aniline Chlorohydrate	--	---	N	---	N	C to 73	N	---	C to 73	---	---

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Chemical (Formula)	Concentration	ABS	CPVC	PP	PVC	PE	PB	PVDF	PEX	PA 11	PK
Aniline Hydrochloride C ₆ H ₅ NH ₂ • HCl	sat'd	---	N	---	N	140	N	---	140	---	---
Anthraquinone C ₁₄ H ₈ O ₂	--	---	180	---	140	C to 73	C to 73	---	C to 73	---	---
Anthraquinone Sulfonic Acid C ₁₄ H ₇ O ₂ • SO ₃ • H ₂ O	--	---	180	73	140	140	C to 73	---	C to 73	---	---
Antifreeze	--	---	---	---	---	---	---	---	---	---	R to 73 C to 176
Antimony Trichloride SbCl ₃	sat'd	---	180	140	140	140	140	R to 140	140	---	---
Aqua Regia (Nitrohydrochloric Acid)	--	N	R to 73	N	C to 73	N	N	C to 194	N	---	---
Arsenic Acid H ₃ AsO ₄	80%	---	180	140	140	140	140	R to 248	140	---	---
Aryl Sulfonic Acid C ₆ H ₅ SO ₃ H	--	---	180	---	140	73	---	---	73	---	---
Asphalt	--	---	N	73	N	73	140	---	73	---	---
Barium Carbonate BaCO ₃	sat'd	120	180	140	140	140	140	R to 248	140	---	---
Barium Chloride BaCl ₂ • 2H ₂ O	sat'd	120	180	140	140	140	140	R to 212	140	194	---
Barium Hydroxide Ba(OH) ₂	sat'd	73	180	140	140	140	140	---	R to 212	---	---
	10%	---	---	---	---	---	---	---	---	---	R to 73
	30%	---	---	---	---	R to 140	---	---	R to 140	---	---
Barium Nitrate Ba(NO ₃) ₂	sat'd	73	180	140	73	140	---	---	140	---	---
Barium Sulfate BaSO ₄	sat'd	73	180	140	140	140	140	R to 212	140	---	---
Barium Sulfide BaS	sat'd	73	180	140	140	140	140	---	R to 248	---	---
Beer	--	120	180	180	140	R to 140	140	R to 248	R to 140	68	R to 73
Beet Sugar Liquors	--	---	180	180	140	73	140	---	73	---	---
Benzaldehyde C ₆ H ₅ CHO	10%	N	R to 73	73	R to 73	73	C to 73	---	73	R to 104	---
	99%	---	---	---	---	---	---	---	---	---	C to 73
Benzene C ₆ H ₆	--	N	N	N	N	C to 120	N	C to 122	R to 68	---	---

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Chemical (Formula)	Concentration	ABS	CPVC	PP	PVC	PE	PB	PVDF	PEX	PA 11	PK
Benzene Sulfonic Acid C ₆ H ₅ SO ₃ H	10%	---	180	180	140	R to 73	---	---	R to 73	---	---
	10%+	---	N	---	N	---	---	---	---	---	---
Benzoic Acid C ₆ H ₅ COOH	all	160	180	73	140	140	140	---	R to 248	---	---
Benzoyl Chloride C ₆ H ₅ COCl	Sat. Sol.	---	---	---	---	---	---	C to 68	---	---	---
Benzyl Alcohol C ₆ H ₅ CH ₂ OH	--	---	N	120	N	140	---	R to 122	140	R to 68	---
Benzyl Chloride C ₇ H ₇ Cl	--	---	---	---	---	---	---	---	R to 140	---	---
Bismuth Carbonate (BiO) ₂ CO ₃	Sat'd.	---	180	180	140	140	140	---	140	---	---
Black Liquor	sat'd	---	180	140	140	120	140	---	120	---	---
Bleach	5% Active Cl ₂	---	180	120	140	C to 140	---	---	C to 140	---	R to 73
	12% Active Cl ₂	73	185	120	140	73	140	---	73	---	---
Borax Na ₃ B ₄ O ₇ •10H ₂ O	sat'd	160	180	212	140	140	140	---	140	---	---
Boric Acid H ₃ BO ₃	Sat'd	160	180	212	140	140	140	R to 212	140	---	---
Brake Fluid	--	---	---	140	---	140	---	---	140	---	---
Brine	sat'd	---	180	140	140	140	140	---	140	---	---
Bromic Acid HBrO ₃	Sat'd	---	180	N	140	N	140	R to 212	N	---	---
	10%	---	---	---	---	140	---	---	---	---	---
Bromine Br ₂	Liquid	73	N	N	N	N	N	R to 248	N	N	---
	vapor 25%	---	180	N	140	N	---	---	N	---	---
Bromine Water	cold sat'd	---	180	N	140	N	C to 73	R to 176	N	---	---
Bromobenzene C ₆ H ₅ Br	--	---	---	---	N	---	---	---	---	---	---
Bromotoluene (Benzyl bromide) C ₆ H ₅ CH ₂ Br	--	---	---	C	N	---	---	---	---	---	---
Butadiene H ₂ C=CHCH=CH ₂	50%	---	180	N	140	73	---	---	73	---	---

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Plastics at Maximum Operating Temperature (F)

Chemical (Formula)	Concentration	ABS	CPVC	PP	PVC	PE	PB	PVDF	PEX	PA 11	PK
	Gas	---	---	---	---	---	---	R to 212	---	---	---
Butane C ₄ H ₁₀	50%	---	180	140	140	140	N	---	140	---	---
	Gas	---	---	---	---	---	---	R to 68	---	---	---
n-Butanol C ₄ H ₉ OH	Liquid	---	---	---	---	---	---	R to 140	---	---	R to 73
Butyl Acetate CH ₃ COOCH ₂ CH ₂ CH ₂ CH ₃	100%	N	N	C to 73	N	C to 73	C to 73	C to 104	C to 73	R to 194	---
Butyl Alcohol CH ₃ (CH ₂) ₂ CH ₂ OH	--	---	C to 73	180	140	140	140	---	140	C to 104	---
Butyl Cellosolve HOCH ₂ CH ₂ O(CH ₂) ₃ CH ₃	--	---	N	---	73	---	---	---	---	---	---
n-Butyl Chloride C ₄ H ₉ Cl	--	N	N	---	---	---	---	---	---	---	---
Butyl Glycol HOCH ₂ CH ₂ O(CH ₂) ₃ CH ₃	Liquid	---	---	---	---	---	---	R to 212	---	---	---
Butylene © CH ₃ CH=CHCH ₃	Liquid	---	---	N	140	120	---	---	120	---	---
Butyl Phenol C ₄ H ₉ C ₆ H ₄ OH	--	---	---	N	C to 73	73	73	---	R to 176	---	---
Butyl Phthalate C ₁₆ H ₂₂ O ₄	--	---	N	180	---	---	---	R to 140	---	---	---
Butyl Stearate CH ₃ (CH ₂) ₁₆ COO(CH ₂) ₃ CH ₃	--	---	---	---	73	---	---	---	---	---	---
Butynediol HOCH ₂ C≡CCH ₂ OH	--	---	---	---	73	---	---	---	---	---	---
Butyric Acid CH ₃ CH ₂ CH ₂ COOH	--	N	N	180	73	73	73	---	73	---	---
	20%	---	---	---	---	---	---	R to 212	---	---	---
	Liquid	---	---	---	---	---	---	R to 176	73	---	---
Cadmium Cyanide Cd(CN) ₂	--	---	180	---	140	---	---	---	---	---	---
Calcium Bisulfide Ca(HS) ₂ o6H ₂ O	--	---	73	---	N	140	---	---	140	---	---
Calcium Bisulfite Ca(HSO ₃) ₂	--	---	180	180	140	N	140	---	N	---	---
	Sat'd	---	---	---	---	---	---	R to 248	---	---	---
Calcium Carbonate CaCO ₃	Sat'd	---	180	180	140	140	140	R to 248	140	---	---

May not be fully applicable to pressurized applications