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Thermoplastics Piping for the Transport of Chemicals

THERMOPLASTIC PIPING FOR THE TRANSPORT OF CHEMICALS

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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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 and its 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.

While the effect of each individual chemical is specific, some chemicals can be grouped into categories based on similar reactions. For example, water 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 specific 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

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

polyvinyl chloride at 73 °F is not suitable for use with ethyl acetate, it is suitable for the higher molecular weight butyl acetate.

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. In some cases, combinations of chemicals may have a synergistic effect on a thermoplastic material where individual chemicals do not. Lastly, the resistance of a particular plastic to a specific chemical generally decreases with temperature increase, with stress increase, and decreases with cyclical variations of temperature or applied stress.

TYPES OF CHEMICAL ATTACK ON PLASTICS

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

In the case of solubility or permeation, physical properties may be affected, but the polymer molecule structure itself is not chemically changed, degraded or destroyed. In solubility 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, it is not always possible to remove a solvating chemical from the plastic, and in such cases, effects relating to chemical solvation may be permanent.

Sometimes the polymer itself may not be soluble, but it may contain a compounding ingredient that may be soluble in the chemical, and 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 could compromise the purity of a fluid such as potable water inside the pipe, and in gas or vapor transmission service, there may be a very slight loss of contents through the pipe wall. Lastly, a permeating chemical may be entrained in the material and be released when heat fusion or solvent cement joining is performed. Heat fusion or solvent cement joining may be unreliable if performed on permeated pipes.

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).

However, direct chemical attack is not always detrimental. For example, PEX materials are deliberately crosslinked using chemical or irradiation methods. While crosslinking enhances certain mechanical properties of PEX materials, it may preclude the use of heat fusion to join PEX piping.

The chemical resistance of the various plastic types varies 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 1404 to PE 3408, 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, and processing of the plastic in such a way that its full chemical resistance is developed. In general, the less compounding ingredients used the better the chemical resistance. Most plastic pipe compounds covered by current ASTM specifications and product standards use a minimum of compounding ingredients, except for the Type II PVC's and CAB plastics. The Type II PVC's contain impact modifiers which are less susceptible to chemical attack than monomeric plasticizers such as those used in PVC cable insulation, film and sheeting compounds, and in CAB plastics. 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.

Some newer piping products utilize a multi-layered (composite) construction, that is, the pipe wall is constructed of layers of different materials. Both thermoplastic and non-thermoplastic materials are used for the layers. Examples are PE/AL/PE, and PEX/AL/PEX pipes where there is a mid-wall aluminum layer. An all thermoplastic composite pipe has PVC, ABS, and PVC layers. Layered composite material pipes may have chemical resistance that differs from the chemical resistance of the individual materials.

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.

CHEMICAL RESISTANCE DATA FOR THERMOPLASTIC PIPING IN NON-PRESSURE (GRAVITY-FLOW) 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 information on similar testing, or information on previous installations under similar field conditions.

I. A thermoplastic pipe that is subjected to several chemicals may or may not be affected by the chemical combination. 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.

II. 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.

III. 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.

IV. The following chemical resistance information has been obtained from numerous sources. It is 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) were not available. Therefore, this information is best used only for comparison of different thermoplastic materials.

V. 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	acrilonitrile-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.

Plastics at Maximum Operating Temperature (F)

Chemicals and Formula	Concentration	ABS	CPVC	PP	PVC	PE	PB	PVDF	PEX	PA 11	PK
Acetaldehyde $\text{CH}_3 \text{CHO}$		---	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 $\text{CH}_3 \text{CONH}_2$	5%	120	---	140	---	140	---	---	140	---	---
Acetic Acid $\text{CH}_3 \text{COOH}$	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 $(\text{CH}_3 \text{CO})_2 \text{O}$	---	N	N	73	N	73	140	N	73	C to 68	---
Acetone	5%	N	N	73	N	C to	140	R to	C to	C to	---

Plastics at Maximum Operating Temperature (F)

Chemicals and Formula	Concentration	ABS	CPVC	PP	PVC	PE	PB	PVDF	PEX	PA 11	PK
CH ₃ COCH ₃						73		212	73	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	---	---
Acrylonitrile H ₂ C:CHCN	---	---	N	---	N	140	---	---	140	---	---
Adipic Acid COOH(CH ₂) ₄ COOH	sat'd	---	180	140	140	140	73	R to 176	140	---	---
Allyl Alcohol CH ₂ = CHCH ₂ OH	96%	---	C to 73	140	R to 73	140	140	---	N	---	---
	--	---	N	---	N 73	C to 73	---	140	C to 73	---	---
CH ₂ Cl	Liquid	---	---	---	---	---	---	R to 68	---	---	---
Aluminum Ammonium	sat'd	---	180	140	140	140	---	---	140	---	---

Plastics at Maximum Operating Temperature (F)

Chemicals and Formula	Concentration	ABS	CPVC	PP	PVC	PE	PB	PVDF	PEX	PA 11	PK
Sulfate (Alum) $\text{Al}(\text{NH}_4)(\text{SO}_4)_2 \cdot 12\text{H}_2\text{O}$											
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 $\text{Al}(\text{OH})_3$	sat'd	160	180	180	140	140	140	R to 212	140	---	N
Aluminum Nitrate $\text{Al}(\text{NO}_3)_3 \cdot 9\text{H}_2\text{O}$	sat'd	---	180	180	140	140	140	R to 212	140	---	---
Aluminum Oxychloride	--	---	180	180	140	---	140	---	---	---	---
Aluminum Potassium Sulfate (Alum) $\text{AlK}(\text{SO}_4)_2 \cdot 12\text{H}_2\text{O}$	sat'd	160	180	140	140	140	---	R to 212	140	---	---
Aluminum Sulfate (Alum) $\text{Al}_2(\text{SO}_4)_3$	sat'd 20%	160 ---	180 ---	140 ---	140 ---	140 ---	C to 73 ---	R to 212 ---	140 ---	194 ---	--- R to 73
Amonia Gas NH_3	100%	N	N	140	140	140	140	---	140	140	---
Amonia Liquid NH_3	100%	160	N	140	N	140	73	---	140	140	---
Amonia Acetate $\text{NH}_4(\text{C}_2\text{H}_3\text{O}_2)$	sat'd	120	180	73	140	140	---	R to 212	140	---	---

Plastics at Maximum Operating Temperature (F)

Chemicals and Formula	Concentration	ABS	CPVC	PP	PVC	PE	PB	PVDF	PEX	PA 11	PK	
Amonium Bifluoride NH ₄ HF ₂	sat'd	---	180	180	140	---	140	---	140	---	---	
Amonium Bisulfide (NH ₄)HS	---	---	---	---	140	---	---	---	---	---	---	
Amonium Carbonate (NH ₄)HCO ₃ o (NH ₄) CO ₂ NH ₂	sat'd	---	180	212	140	140	140	R to 248	140	---	---	
Amonium Chloride NH ₄ Cl	sat'd	120	180	212	140	140	140	R to 212	140	---	---	
Amonium Dichromate (NH ₄) ₂ Cr ₂ O ₇	--	---	73	---	73	---	---	---	---	---	---	
Amonium Fluoride NH ₄ F	10%	120	180	212	140	140	---	R to 212	140	---	---	
	25%	120	180	212	C to 140	140	73	---	140	---	---	
Amonium Hydroxide NH ₄ OH	10%	120	N	212	140	140	140	---	140	---	N	
	30%	---	---	---	---	R to 140	---	---	R to 140	---	---	
	Conc.	---	---	---	---	---	---	---	194	---	---	
Amonium sphate	Sat'd	--	-- 212	R to 140	R to 140	R to 140	R to 248	R to	R to 140	---	---	
Amonium Nitrate NH ₄ NO ₃	sat'd	120	180	212	140	140	140	R to 212	140	---	---	
Amonium Persulphate (NH ₄) ₂ S ₂ O ₈	---		---	180	140	140	140	140	R to 212	140	---	---

Plastics at Maximum Operating Temperature (F)

Chemicals and Formula	Concentration	ABS	CPVC	PP	PVC	PE	PB	PVDF	PEX	PA 11	PK
Amonium Phosphate (Monobasic) NH ₄ H ₂ PO ₄	all	120	180	212	140	140	140	R to 248	140	---	---
Amonium Sulfate (NH ₄) ₂ SO ₄	Sat'd.	120	180	212	140	140	140	R to 212	140	---	---
	20%	---	---	---	---	---	---	---	---	---	R to 73
Amonium Sulfide (NH ₄) ₂ S	dilute	120	180	212	140	140	140	---	140	---	---
	Sat'd.	---	---	---	---	140	---	---	---	---	---
Amonium 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	73 194	C to ---
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 to 73
Aniline t ₂	--	N	N	---	N	73	C to 140	R to 68	C to	---	N 140
Aniline Chlorohydrate	--	---	N	---	N	C to 73	N	---	C to 73	---	---

Plastics at Maximum Operating Temperature (F)

Chemicals and Formula	Concentration	ABS	CPVC	PP	PVC	PE	PB	PVDF	PEX	PA 11	PK
Aniline Hydrochloride $C_6H_5NH_2 \cdot HCl$	sat'd	---	N	---	N	140	N	---	140	---	---
Anthraquinone $C_6H_5(CO)_2C_6H_5$	--	---	180	---	140	C to 73	C to 73	---	C to 73	---	---
Anthraquinone Sulfonic Acid $C_{14}H_7O_2 \cdot SO_3H \cdot H_2O$	--	---	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	N 73	C to	N 73	N	C to	N 194	---	---
Arsenic Acid $H_3AsO_4 \cdot 1/2H_2O$	80%	---	180	140	140	140	140	R to 248	140	---	---
Aryl Sulfonic Acid $C_6H_5SO_3H$	--	---	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 $BaCl_2 \cdot 2H_2O$	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

Plastics at Maximum Operating Temperature (F)

Chemicals and Formula	Concentration	ABS	CPVC	PP	PVC	PE	PB	PVDF	PEX	PA 11	PK
	30%	---	---	---	---	R to 140	---	---	R to 140	---	---
Barium Nitrate $\text{Ba}(\text{NO}_3)_2$	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 $\text{C}_6\text{H}_5\text{CHO}$	10%	N	R to 73	73	R to 73	73	C to 73	---	73	R to 104	---
	99%	---	---	---	---	---	---	---	---	---	C to 73
Benzene C_6H_6	--	N	N	N	N	C to 120	N	C to 122	R to 68	---	---
Benzene Sulfonic Acid $\text{C}_6\text{H}_5\text{SO}_3\text{H}$	10%	---	180	180	140	R to 73	---	---	R to 73	---	---
	10%+	---	N	---	N	---	---	---	---	---	---
Benzoic Acid $\text{C}_6\text{H}_5\text{COOH}$	all	160	180	73	140	140	140	---	R to 248	---	---
Benzoyl Chloride	Sat. Sol.	---	---	---	---	---	---	C to 68	---	---	---
Benzyl Alcohol $\text{C}_6\text{H}_5\text{CH}_2\text{OH}$	--	---	N	120	N	140	---	R to 122	140	R to 68	---

Plastics at Maximum Operating Temperature (F)

Chemicals and Formula	Concentration	ABS	CPVC	PP	PVC	PE	PB	PVDF	PEX	PA 11	PK
Benzyl Chloride		---	---	---	---	---	---	---	R to 140	---	---
Bismuth Carbonate (BiO) ₂ CO	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 o10H 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	---	180	N	140	N	C to	R to	N	---	---

Plastics at Maximum Operating Temperature (F)

Chemicals and Formula	Concentration	ABS	CPVC	PP	PVC	PE	PB	PVDF	PEX	PA 11	PK
	sat'd						73	176			
Bromobenzene C ₆ H ₅ Br	--	---	---	---	N	---	---	---	---	---	---
Bromotoluene C ₆ H ₅ CH ₂ B ₂	--	---	---	C	N	---	---	---	---	---	---
Butadiene H ₂ C: CHHC: CH ₂	50% Gas	---	180 ---	N ---	140 ---	73 ---	---	---	73 ---	---	---
								212			
Butane C ₄ H ₁₀	50% Gas	---	180 ---	140 ---	140 ---	140 ---	N ---	---	140 ---	---	---
								68			
n-Butanol	Liquid	---	---	---	---	---	---	R to 140	---	---	R to 73
Butyl Acetate CH ₃ COOCH (CH ₃) (C ₂ H ₅)	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 OC ₄ H ₉	--	---	N	---	73	---	---	---	---	---	---
n-Butyl Chloride C ₄ H ₉ Cl	--	N	N	---	---	---	---	---	---	---	---
Butyl Glycol	Liquid	---	---	---	---	---	---	R to 212	---	---	---
Butylene © CH ₃ CH:CHCH ₃	Liquid	---	---	N	140	120	---	---	120	---	---

Plastics at Maximum Operating Temperature (F)

Chemicals and Formula	Concentration	ABS	CPVC	PP	PVC	PE	PB	PVDF	PEX	PA 11	PK
Butyl Phenol $C_4H_9C_6H_9OH$	--		---	N	C to 73	73	73	---	R to 176	---	---
Butyl Phthalate	--	---	N	180	---	---	---	R to 140	---	---	---
Butyl Stearate	--	---	---	---	73	---	---	---	---	---	---
Butynediol $HOCH_2C:CCH_2OH$	--	---	---	---	73	---	---	---	---	---	---
Butyric Acid $CH_3CH_2CH_2COOH$	-- 20% Liquid	N --- ---	N --- ---	180 --- ---	73 --- ---	73 --- ---	73 --- ---	--- R to 212 R to 176	73 --- 73	--- --- ---	--- --- ---
Cadmium Cyanide $Cd(CN)_2$	--	---	180	---	140	---	---	---	---	---	---
Calcium Bisulfide $Ca(HS)_2 \cdot 6H_2O$	--	---	73	---	N	140	---	---	140	---	---
Calcium Bisulfite $Ca(HSO_3)_2$	-- Sat'd	--- ---	180 ---	180 ---	140 ---	N ---	140 ---	--- R to 248	N ---	--- ---	--- ---
Calcium Carbonate $CaCO_3$	Sat'd	---	180	180	140	140	140	R to 248	140	---	---
Calcium Chlorate $Ca(ClO_3)_2 \cdot 2H_2O$	--	---	180	180	140	140	140	R to 248	140	---	---
Calcium Chloride $CaCl_2$	5% Sat'd	--- 120	--- 180	--- 180	--- 140	--- 140	--- 140	--- R to 248	--- R to 176	--- R to 194	R to 176 ---

Plastics at Maximum Operating Temperature (F)

Chemicals and Formula	Concentration	ABS	CPVC	PP	PVC	PE	PB	PVDF	PEX	PA 11	PK
Calcium Hydroxide Ca(OH)_2	--	160	180	180	140	140	140	---	140	---	---
	2%	---	---	---	---	---	---	---	---	---	R to 73
	30%	---	---	---	---	R to 140	---	---	R to 140	---	---
Calcium Hypochlorite Ca(OCl)_2	30%	160	180	140	140	140	140	---	140	---	---
	Sat'd	---	---	---	---	---	---	C to 212	---	---	---
Calcium Nitrate $\text{Ca(NO}_3)_2$	--	---	180	180	140	140	140	---	140	---	---
	50%	---	---	---	---	140	---	R to 212	140	---	---
	Sat'd	---	---	---	---	---	---	R to 176	---	---	---
Calcium Oxide CaO	--	---	180	---	140	140	---	---	140	---	---
Calcium Sulfate CaSO_4	--	100	180	180	140	140	140	R to 212	140	---	---
Calcium Hydrogen Sulphide	>10%	---	---	---	---	---	---	R to 248	---	---	---
Camphor $\text{C}_{10}\text{H}_{16}\text{O}$	--	N	---	73	73	73	---	---	73	---	---
Cane Sugar Liquors $\text{C}_{12}\text{H}_{22}\text{O}_{11}$	--	---	180	180	140	140	150	---	140	---	---
Carbitol	--	---	N	---	73	---	---	---	---	---	---
Carbon Dioxide	Dry	160	180	140	140	140	---	R to	140	---	---

Plastics at Maximum Operating Temperature (F)

Chemicals and Formula	Concentration	ABS	CPVC	PP	PVC	PE	PB	PVDF	PEX	PA 11	PK
CO ₂	100%							212			
Carbon Dioxide CO ₂	Wet	160	180	140	140	140	140	---	140	---	---
Carbon Disulfide CS ₂	--	N	N	N	N	C to 140	---	---	R to 68	R to 104	---
Carbon Monoxide CO	Gas	---	180	180	140	140	140	R to 140	140	---	---
Carbon Tetrachloride CCl ₄	--	N	N	N	73	C to 73	N	C to 212	C to 68	N	R to 73
Carbonic Acid H ₂ CO ₃	Sat'd	---	185	180	140	140	140	---	140	---	---
Castor Oil	--	---	C to 180	140	140	73	140	---	73	---	---
Caustic Potash KOH	50%	160	180	180	140	140	73	---	140	---	---
Caustic Soda NaOH (Sodium Hydroxide)	40%	160	180	180	140	140	73	---	140	---	---
Cellosolve ClCH ₂ COOH	--	---	N	73	73	C to 120	140	---	C to 120	---	---
Cellosolve Acetate CH ₃ COOCH ₂ CH ₂ OC ₂ H ₅	--	---	N	73	73	---	---	---	---	---	---
Chloral Hydrate CCL ₃ CH (OH) ₂	All	---	180	C to 73	140	120	140	---	120	---	---

Plastics at Maximum Operating Temperature (F)

Chemicals and Formula	Concentration	ABS	CPVC	PP	PVC	PE	PB	PVDF	PEX	PA 11	PK
Chloramine NH ₂ Cl	Dilute	---	N	73	73	73	---	---	73	---	---
Chloric Acid HClO ₃ o7H ₂ O	10%	---	180	73	140	73	---	---	73	---	---
	20%	---	185	73	140	73	---	---	73	---	---
Chlorine Gas (Moisture Content)	0-20 PPM	N	C to 73	N	C to 73	C to 73	---	R to 212	C to 73	---	---
	20-50 PPM	N	N	N	N	C to 73	---	---	C to 73	---	---
	50+ PPM	N	N	N	N	C to 73	---	N	C to 73	---	---
Chlorine	Liquid	N	N	N	N	N	---	---	N	---	N
Chlorinated Water	10 PPM	---	180	180	140	140	140	---	140	---	---
Chlorinated Water	Sat'd	---	180	180	140	C to 120	140	R to 212	C to 120	---	---
Chloroacetic Acid CH ₂ ClCOOH	50%	N	180	C to	140 73	120	N	---	120	---	---
	>10%	---	---	---	---	---	---	R to 140	---	---	---
Chloroacetyl Chloride -- ClCH ₂ COCl		---	---	---	73	---	---	---	---	---	---
Chlorobenzene C ₆ H ₅ Cl	Dry	N	N	73	N	C to 75	N	---	C to 75	---	---
	Liquid	---	---	---	---	---	---	R to 140	R to 68	C to 176	---
Chlorobenzyl Chloride-- ClC ₆ H ₄ CH ₂ Cl		---	N	---	N	C to 120	---	---	C to 120	---	---