Physical Properties Table

Resin	Max. Use Temp. °C	HDT Temp. °C[1]	Brittleness Temp. °C[13]	Melting Point (°C)	Glass Transition Temp. (°C)[20]	Clarity	Microwavability[2]
ABS	86 to 90	75 to 98	0	210 to 230	105 to 109	Transparent to Opaque	--
ACL	120	177	-55	210 to 220	-83 & 100	Opaque	Marginal[3]
COC	70	70	-40	N/A	90	Transparent	Marginal[3]
ECTFE	150	116	<-76	242	85	Translucent	Yes
EPDM	146	<20	-68	N/A	-45	Opaque	Yes
EPR	145	< 20	-90	N/A	-54	Opaque	Yes
ETFE	150	104	-105	265	N/A	Translucent	Yes
FEP	205	70	-270	275	N/A	Translucent	Marginal[3]
FEP 890	205	70	-75	275	N/A	Transparent	Marginal[3]
FLPE	120	65	-100	125 to 138	-25	Translucent	No
HDPE	120	65	-100	125 to 138	-25	Translucent	No
HIPS	90	87	20	N/A	130	Opaque	Marginal[3]
LDPE	80	45	-100	85 to 125	-25	Translucent	Yes
LLDPE 489 Tubing	79	47	-73	85 to 125	-25	Translucent	Marginal[3]
Modified PPE	121	138	-40	240 to 320	164	Opaque	--
PBS	90	72	20	N/A	87-93	Transparent	Marginal [3]
PC	135	138	-135	N/A	154	Transparent	Marginal [3]
PEI	171	210	<20	N/A	215	Transparent Amber	Yes
Permanox®	174	127	-10	233	N/A	Transparent	Yes
PES	180	>200	-100	N/A	350 to 390	Transparent Amber	--
PET	65	21	-40	240 to 275	70	Transparent	Marginal[3]
PETG	70	70	-40	265	81	Transparent	Marginal[3]
PFA	260	73	-270	302 to 310	-80 & 90	Transparent	Yes
PFA 870 Tubing	260	73	-268	302 to 310	-80 & 90	Transparent	Yes
PMMA	50	79 - 107	20	85 to 105	N/A	Transparent	No
PMP	153 - 174	93 - 127	0 to 20	235	N/A	Transparent	Yes
PP	135	107	0	160 to 176	-20 to -5	Translucent	Yes
PP 689 Tubing	121	100	-4	160 to 176	-20 to -5	Translucent	Yes
PPCO	121	90	-40	150 to 175	-20	Translucent	Marginal[3]
PS	90	96	20	N/A	74 to 110	Transparent	No
PSF	165	174	-100	N/A	185 to 195	Transparent	Yes
PTFE/TFE	260	121	-100	320 to 330	120 to 130	Opaque	Yes
PURS 280 Tubing	85	32	-73	87 to 140	-30 to 0	Transparent Amber	No
PVC 180 Tubing	71	-32	-32	N/A	75 to 105	Transparent	Yes[19]
PVC 380 Tubing	79	-32	-32	N/A	75 to 105	Transparent	Yes[19]
PVC 980 Tubing	82	-32	-21	N/A	75 to 105	Transparent	No
PVDF	150	139	-62	141 to 178	-60 to -20	Translucent	Marginal[3]
ResMer™	130 to 150	200 to 300	20	200 to 270	90 to 110	Opaque	Marginal[3]
SAN	85	98	20	108	N/A	Transparent	Yes
SILI 50/65 Tubing	232	-46	-62	N/A	-130 to -120	Translucent	Yes
Silicone Gaskets	204	-46	-68	N/A	-130 to -120	Transparent to Opaque	Yes
Thermanox®	65	38	-60	220 to 240	80	Transparent	Marginal[3]
TPE	121	<23	<-50	N/A	N/A	Transparent to Opaque	Yes
XLPE	65	59	-118	N/A	N/A	Translucent	No
Tritan™	95	99	-40	282	108	Transparent	Marginal[3]

For abbreviations and footnotes, please see page 626-627.

Physical Properties Table, continued

Resin	Sterilization [4]					Specific Gravity	Flexibility
	Autoclaving	EtO Gas	Dry Heat	Radiation	Disinfectants		
ABS	No	Yes	No	Yes	Some	1.05 to 1.16	Rigid
ACL	Yes [5]	Yes	No	No	Some	1.42 to 1.61	Rigid
COC	Yes	Yes	No	Yes	Some	1.03	Rigid
ECTFE	Yes	Yes	No	Yes	Yes	1.68	Rigid
EPDM	Yes	Yes	No	No	Some	0.86	Moderate to Excellent
EPR	Yes	Yes	No	No	Some	0.86	Moderate to Excellent
ETFE	Yes	Yes	No	Yes	Yes	1.7	Rigid
FEP	Yes	Yes	Yes	No	Yes	2.15	Excellent
FEP 890	Yes	Yes	Yes	No	Yes	2.17	Rigid
FLPE	No	Yes	No	Yes	Yes	0.95	Moderate
HDPE	No	Yes	No	Yes	Yes	0.95	Moderate
HIPS	No	Yes	No	Yes	Some	1.04	Rigid
LDPE	No	Yes	No	Yes	Yes	0.92	Good
LLDPE 489 Tubing	No	Yes	No	No	Some	0.92	Moderate
Modified PPE	Yes	Yes	No	Yes	Some	1.08	Rigid
PBS	No	Yes	No	Yes	Some	0.91 to 1.01	Rigid
PC	Yes [5]	Yes	No	Yes	Some	1.20	Rigid
PEI	Yes	Yes	Yes	Yes	Yes	1.28	Rigid
Permanox®	Yes	Yes	Yes	No	Yes	0.84	Rigid
PES	Yes	Yes	Yes	Yes	Some	1.37	Rigid
PET	No	Yes	No	Yes	Some	1.33	Moderate
PETG	No	Yes	No	Yes	Some	1.27	Moderate
PFA	Yes	Yes	Yes	No	Yes	2.17	Excellent
PFA 870 Tubing	Yes	Yes	Yes	No	Yes	2.15	Rigid
PMMA	No	No	No	Yes	Some	1.19	Rigid
PMP	Yes	Yes	Marginal	No	Yes	0.835	Rigid
PP	Yes	Yes	No	No	Yes	0.9	Rigid
PP 689 Tubing	Yes	Yes	No	No	Some	0.9	Rigid
PPCO	Yes	Yes	No	No	Yes	0.9	Moderate
PS	No	Yes	No	Yes	Some	1.05	Rigid
PSF	Yes	Yes	Yes	Yes	Yes	1.24	Rigid
PTFE/TFE	Yes	Yes	Yes	No	Yes	2.2	Rigid
PURS 280 Tubing	No	Yes	No	No	Some	1.18	Moderate
PVC 180 Tubing	Yes [14]	Yes	No	No	Some	1.19	Excellent
PVC 380 Tubing	Yes [14]	Yes	No	No	Some	1.2	Excellent
PVC 980 Tubing	No	Yes	No	No	Some	1.2	Moderate
PVDF	Yes	Yes	No	Yes	Yes	1.78	Rigid
ResMer™	Yes	Yes	No	Yes	Some	1.15 to 1.50	Rigid
SAN	No	Yes	No	Yes	No	1.07	Rigid
SILI 50/65 Tubing	Yes	Yes	Yes	Yes	Some	1.15	Excellent
Silicone Gaskets	Yes	Yes	Yes	Yes	Yes	1.1 to 1.5	Moderate to Excellent
Thermanox®	No	Yes	No	Yes	Some	1.3	Moderate
TPE	Yes	Yes	No	Yes	Some	0.9	Moderate to Excellent
XLPE	No	Yes	No	Yes	Yes	0.93	Rigid
Tritan™	No	Yes	No	Yes	Some	1.18	Moderate

For abbreviations and footnotes, please see page 626-627.

Physical Properties Table, continued

Resin	Permeability (cc.-mil/100in²-24 hr.-atm)			Permeability (cc.-mm/m²-24 hr.-Bar)			Water Vapor Transmission Rate		Water Adsorbtion (%)
	N_2	O_2	CO_2	N_2	O_2	CO_2	(grams/m²) [15]	(grams/100 in²) [16]	
ABS	--	--	--	--	--	--	--	--	0.3 to 0.7
ACL	0.5	1.0	4.1	0.2	0.4	1.6	--	--	0.6
COC	15,871	5,032	1,742	6,167	1,955	677	40.00	2.58	<0.01
ECTFE	10	25	110	3.9	9.7	42.7	3.2	0.2	<0.1
EPDM	25 - 150	75 - 650	800 - 8000	9.7 - 58	29 - 253	3114 - 3108	--	--	0.05
EPR	25 - 150	75 - 650	800 - 8000	9.7 - 58	29 - 253	3114 - 3108	--	--	0.05
ETFE	30	100	250	12	39	97	1.65	0.11	0.03
FEP	320	750	2,200	124.34	291.41	854.82	6.200	0.40	<0.01
FEP 890	334	1,000	2,251	129.62	388.55	874.63	6.2	0.40	<0.01
FLPE	42	185	580	16	72	225	4.6	0.30	<0.01
HDPE	42	185	580	16	72	225	4.6 - 6.2	0.30 - 0.40	<0.01
HIPS	20 - 25	300 - 400	1,000 - 1,500	7.7 - 9.7	116 - 155	388- 582	1220 - 6102	79 - 394	0.07
LDPE	180	500	2,700	70	194	1,049	15 - 23	1.0 - 1.5	<0.01
LLDPE 489 Tubing	334	1,001	4,670	130	389	1,815	15 - 23	1.0 - 1.5	<0.01
Modified PPE	--	1,000	--	--	389	--	69.70	4.50	0.10 to 0.15
PBS	20 - 25	300 - 400	1,000 - 1,500	7.8 - 9.7	116 - 155	388 - 582	2.20	0.14	0.07 to 0.09
PC	50	300	1,075	19.43	116.57	418	115.00	7.42	0.35
PEI	19	37	171	7.2	14.4	67	5.8	0.37	0.25
Permanox®	8,000	32,000	115,000	3,108	12,434	44,684	6.00	0.39	<0.01
PES	--	--	--	--	--	--	--	--	0.55
PET	0.7 - 1.0	13	70	0.27 - 0.39	5.1	27	18.13	1.17	0.25
PETG	10	25	125	3.9	9.7	49	18.13	1.17	0.13
PFA	291	881	2,260	113	342	878	2.0	0.13	<0.02
PFA 870 Tubing	300	1,084	2,502	117	421	972	2.0	0.13	<0.02
PMMA	2.78	12.4	68	1.08	4.8	26	55.20	3.56	0.35
PMP	8,000	32,000	115,000	3,108	12,434	44,684	775.00	50.00	0.01
PP	48	240	800	18.7	93	311	3.90	0.25	<0.02
PP 689 Tubing	67	417	1,501	26	162	583	3.9	0.25	<0.02
PPCO	45	200	650	17	78	253	4.40	0.28	<0.02
PS	20 - 25	300 - 400	1,000 - 1,500	7.8 - 9.7	116 - 155	388 - 582	1220 - 6102	79 - 394	0.05
PSF	55	300	700	21.40	117	272	--	--	0.3
PTFE/TFE	--	308	--	--	120	--	4.00	0.26	<0.01
PURS 280 Tubing	5.0 - 83	16.7 - 167	66.7 - 417	1.9 - 32.4	6.5 - 65	26 - 162	--	--	1.12
PVC 180 Tubing	8.3 - 33	16.7 - 100	167 - 584	3.2 - 13	2.6 - 39	64.8 - 227	15 - 80	1.0 - 5.2	0.15 to 0.75
PVC 380 Tubing	8.3 - 33	16.7 - 100	167 - 584	3.2 - 13	2.6 - 39	64.8 - 227	15 - 80	1.0 - 5.2	0.15 to 0.75
PVC 980 Tubing	8.3 - 33	16.7 - 100	167 - 584	3.2 - 13	2.6 - 39	64.8 - 227	15 - 80	1.0 - 5.2	0.15 to 0.75
PVDF	9	14	505	3.5	5.4	196	29.76	1.9	0.05
ResMer™	--	--	--	--	--	--	--	--	0.01
SAN	--	--	--	--	--	--	--	--	0.2
SILI 50/65 Tubing	46,116	132,762	335,741	17,918	51,585	130,453	--	--	0.1
Silicone Gaskets	--	--	--	--	--	--	--	--	0.1
Thermanox®	1.60	8.1	38.7	0.62	3.15	15.04	--	--	0.25
TPE	31 - 145	85 - 646	900 - 8634	12.05 - 56	33.03 - 251	350 - 3355	--	--	0.05 to 0.1
XLPE	42	185	580	16	72	225	4.6 - 6.2	0.3 - 0.4	<0.01
Tritan™	--	--	--	--	--	--	--	--	0.43

For abbreviations and footnotes, please see page 626-627.

Physical Properties Table, continued

Resin	Non-Cytotoxicity [6]	Suitability for Food and Bev. Use [7]	Regulation Part 21 CFR	Refractive Index	Transparency (%)	Haze (%)	Hardness (Rockwell R/M or Shore D/A)	Coeffiecient of Friction (static)
ABS	--	--	--	--	78 to 90	2.5 to 11	93 to 115 R	--
ACL	Yes	Yes [8]	177.2480	1.48 to 1.51	0	--	94 - 120 R	0.07-0.20
COC	Yes	Yes	177-1520	1533	91	--	--	--
ECTFE	Yes	Yes	177.1380	1.4200	--	--	90 R / 75 D	0.19
EPDM	--	Yes [9]	177.2600	--	0	--	45 - 87 A	0.725
EPR	--	Yes [9]	177.2600	--	0	--	45 - 87 A	0.853
ETFE	Yes	Yes	177.1380	1.3580	--	--	50 R	--
FEP	Yes	Yes	177.1550	1.341 to 1.347	96	--	60 D / 25 to 45 R	0.03 to 0.40
FEP 890	--	Yes	177.1550	1.347	96	--	58 D	--
FLPE	Yes	Yes [9]	177.1615	1.5400	--	--	60 to 73 D	0.29
HDPE	Yes	Yes [9]	177.1520	1.5400	--	--	60 to 73 D	0.29
HIPS	Yes	Yes	177.1640	--	0	--	--	--
LDPE	Yes	Yes [9]	177.1520	1.5100	--	--	41 to 46 D	--
LLDPE 489 Tubing	--	Yes [9]	177.1520	1.5100	--	--	50 D	--
Modified PPE	Yes	Yes	177.2460 [17]	--	0	--	115 R to 120 R / 78 M	--
PBS	Yes	Yes	177.1640	1.535 to 1.573	90 to 95	--	53 to 64 D	--
PC	Yes	Yes	177.1580	1.5860	91	--	70 M	0.31
PEI	--	Yes	177.1595	1.4600	58	--	125 R	--
Permanox®	Yes	Yes	177.1520	1.46	94	--	87 R	--
PES	Yes	Yes	177.2440	1.65	90	--	120 to 127 R	88 M
PET	Yes	Yes	177.1315	1.5750	85	--	112 R	0.2 to 0.4
PETG	Yes	Yes [10]	177.1315	1.57	91	--	106 R	--
PFA	Yes	No	--	1.3580	93.5	--	55 D	0.18
PFA 870 Tubing	--	Yes	177.1550	1.3580	93.5	--	60 D	--
PMMA	Yes	Yes	177.1010	1.48 to 1.57	92	--	92 to 100 M	--
PMP	Yes	Yes [11]	177.1520	1.4630	93	2.1	85 R	--
PP	Yes	Yes	177.1520	1.4735 to 1.490	--	--	80-110 R / 70-75 D	0.24
PP 689 Tubing	--	Yes	177.1520	1.4900	--	--	75 D	--
PPCO	Yes	Yes	177.1520	1.4735 to 1.5100	--	--	80-100 R / 70-75 D	0.24
PS	Yes	Yes	177.1640	1.5894	90	--	60 to 90 M	--
PSF	Yes	Yes	177.1655	1.6330	86	--	120 R	0.29
PTFE/TFE	Yes	Yes	177.1550	1.3500	0	--	58 R / 50-65 D	0.04
PURS 280 Tubing	--	No	--	1.5 to 1.6	--	--	85 A	--
PVC 180 Tubing	--	Yes [12]	176.180 / 175.300	1.53 to 1.55	--	--	55 A	--
PVC 380 Tubing	--	Yes [12]	176.180 / 175.300	1.53 to 1.55	--	--	65 A	--
PVC 980 Tubing	--	Yes [12]	176.180 / 175.300	1.53 to 1.55	--	--	65 A	--
PVDF	Yes	Yes	177.2510	1.4200	--	--	78 D	0.3
ResMer™	--	--	--	--	--	--	--	--
SAN	--	Yes	177.1040	1.5700	89	--	125 R	--
SILI 50/65 Tubing	Yes	Yes [9]	177.2600	1.4035	--	--	50 A / 65 A	--
Silicone Gaskets	--	Yes [9]	177.2600	--	0 to 95	--	--	--
Thermanox®	Yes	Yes	177.1315	1.57	91	--	94 M	0.2 to 0.4
TPE	Yes	Yes	177.2600	--	0 to 95	--	--	--
XLPE	Yes	No	--	1.5400	--	--	50 to 70 R	0.1 to 0.2
Tritan™	Yes	Yes	174.5(d)(5) FCN 729	--	90	1	112 R	--

For abbreviations and footnotes, please see page 626-627.

Physical Properties Abbreviations

Table of Abbreviations

Abbreviation	Name
ACL	Acetal
COC	Cyclic Olefin Copolymer
ECTFE	Ethylene Chlorotrifluoroethylene
EPDM	Ethylene Propylene Diene Monomer Rubber
EPR	Ethylene Propylene Rubber
ETFE	Ethylene Tetrafluoroethylene
FEP	Fluorinated Ethylene Propylene
FLPE	Fluorinated High-density Polyethylene
HDPE	High-density Polyethylene
HIPS	High Impact Polystyrene
LDPE	Low Density Polyethylene
PC	Polycarbonate
PEI	Potheterimide
PET	Polyethylene terephthalate
PETG	Polyethylene terephthalate copolymer
PFA	Perfluoroalkoxy
PMMA	Polymethylmethacrylate
PMP	Polymethylpentene
PP	Polypropylene
PPCO	Polypropylene Copolymer
PPE	Modified Polyphenylene Ether
PS	Polystyrene
PSF	Polysulfone
PURS	Thermoplastic Polyester Polyurethane
PVDF	Polyvinylidenedifluoride
ResMer™	ResMer™ - Glass Filled
SAN	(No Suggestions)
Silicone Gaskets	Silicone - Gaskets, filled - typically red
Silicone 50/65 Tubing	Silicone - Tubing, and unfilled (translucent) o-rings
PTFE / TFE	Tetrafluoroethylene
TPE	Thermoplastic Elastomer
Thermanox®	Proprietary NUNC Resin
Permanox®	Proprietary NUNC Resin
Tritan™	Proprietary CoPolyester

Physical Properties Footnotes

1 *Heat Deflection Temperature is the temperature at which an injection molded bar deflects 0.01 in. when placed under 66 psig (ASTM D648) of pressure. Materials may be used above Heat Deflection Temperatures in non-stress applications; see Max. Use Temp.*

2 *Ratings based on five minute tests using 600 watts of power on exposed, empty labware. CAUTION: Do not exceed Max. Use Temp., or expose labware to chemicals which heating cause to attack the plastic or be rapidly absorbed.*

3 *The plastic will absorb and retain significant amounts of heat resulting in an unexpectedly hot surface.*

4 *STERILIZATION:*

Autoclaving (121°C, 15 psig for 20 minutes) – Clean and rinse items with distilled before autoclaving. (Always completely disengage thread before autoclaving.) Certain chemicals which have no appreciable effect on resins at room temperature may cause deterioration at autoclaving temperatures unless removed with distilled water before hand.

EtO Gas – Ethylene Oxide: 100% EtO, EtO:Nitrogen mixture, EtO:HCFC mixture

Dry Heat – exposure to 160°C for 120 minutes without stress/load on the polymer parts

Disinfectants – Benzalkonium chloride, formalin/formaldehyde, hydrogen peroxide, ethanol, etc.

Radiation – gamma or beta irradiation at 25 kGy (2.5 MRad) with unstabilized plastic.

5 *Sterilizing reduces mechanical strength. Do not use PC vessels for vacuum applications if they have been autoclaved. Refer to Use and Care Guidelines for Nalgene™ Labware, for detailed information on sterilizing.*

6 *"Yes" indicates the resin has been determined to be non-cytotoxic, based on USP and ASTM biocompatibility testing standards utilizing an MEM elution technique with WI38 human diploid lung cell line.*

7 *Resins meet requirements of CFR21 section of Food Additives Amendment of the Federal Food and Drug Act. End users are responsible for validation of compliance for specific containers used in conjunction with their particular applications.*

8 *Acceptable for aqueous foods only, at temperatures up to 121°C / 250°F. Not sanctioned for use with alcoholic or fatty foods at any temperature.*

9 *Acceptable for:*

Nonacid, aqueous products; may contain salt, sugar or both (pH above 5.0)

Dairy products and modifications; oil-in-water emulsions, high or low fat

Moist bakery products with surface containing no free fat or oil

Dry solids with the surfaces containing no free fat or oil (no end-test required) and under all conditions as described in Table 2 of FDA Regulation 177.1520 except condition A - high temperature sterilization (e.g. over 100°C / 212°F)

10 *Acceptable for:*

Alcoholic foods containing not more than 15% (by volume) alcohol; fill and storage temperature not to exceed 49°C (120°F)

Non-alcoholic foods of hot fill to not exceed 82°C (180°F) and 49°C (120°F) in storage.

Not suitable for carbonated beverages or beer or packaging food requiring thermal processing.

11 *Straight-sided jars, beakers and graduated cylinders only.*

12 *Acceptable for aqueous, oil, dairy, acidic, and alcoholic foods up to 71°C/160°F.*

13 *The brittleness temperature is the temperature at which an item made from the resin may break or cracked if dropped. This is not the lowest use temperature if care is exercised in use and handling.*

14 *The tubing will become opaque from absorbed water, see the current NALGENE® Labware catalog information on Autoclaving PVC Tubing for for details.*

15 *WVTR = Water Vapor Transmission rate in g-mm/m² - 24 hr. - 1 Bar at 37°C and 90% Relative Humidity.*

16 *WVTR = Water Vapor Transmission rate in g-mm/100 in² - 24 hr. - 1 Bar at 37°C and 90% Relative Humidity.*

17 *Acceptable for:*

Frozen or refrigerated storage: Ready-prepared foods intended to be reheated in container at time of use

1. Aqueous or oil-in-water emulsion of high- or low-fat.

2. Aqueous, high- or low-free oil or fat.

18 *Will vary based on exact composition*

19 *If microwaved in the prsence of water; the tubing will become opaque from absorbed moisture, see the current Nalgene Labware catalog information on Autoclaving PVC Tubing for details.*

20 *Glass Transition Temperature is the reversible transition in amorphous or semi-amorphous materialsfrom a hard and relatively brittle state into a flexible or rubber-like state without becoming a true liquid.*