PIB HANDLING GUIDELINES

Polyisobutylene

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TPC Group is committed to protecting people and the environment through a comprehensive product stewardship program. The Company conducts its operations and manages its products in a safe, reliable, environmentally responsible and efficient manner. In accordance with this commitment, TPC Group has created this easy-to-use, customer-friendly guide for polyisobutylene (PIB). Please use this guide, at your convenience, in conjunction with TPC Group's product-specific Safety Data Sheet and Technical Data Sheets to find the answers to commonly asked questions regarding specific information about this product.

SCOPE

This document is designed to provide published reference data and published recommendations for the safe storage and handling of polyisobutylene. **See List of Published References and related Disclaimer on Page 7.** TPC Group is committed to safety in the production, handling, and use of our products and this information should be used in conjunction with good engineering and operating practices to minimize the chance of an incident or injury. Among other sources, this document is based upon the American Petroleum Institute recommended practices for protection against ignition and the National Fire Protection Association recommended practices on static electricity.

I. Products and Selected Typical Properties

		Flash Point		
Product	**Viscosity (cSt @ 100°C)**	**PMCC (closed cup), minimum**	**PMCC (closed cup), Nominal**	**COC (open cup), minimum**
TPC-545	5 - 15	120°C (266°F)	123°C (284°F)	130°C (284°F)
TPC-175	75-95	130°C (266°F)	140°C (284°F)	140°C (284°F)
TPC-595	175-205	135°C (275°F)	148°C (299°F)	185°C (365°F)
TPC-1105	190-240	135°C (275°F)	146°C (295°F)	185°C (365°F)
TPC-1160	625-685	135°C (275°F)	165°C (329°F)	210°C (410°F)
TPC-5230	1500-1700	135°C (275°F)	170°C (338°F)	210°C (410°F)
TPC-1285	3000-3400	-	193°C (379°F)	210°C (410°F)
TPC-1350	4000-4500	-	190°C (374°F)	210°C (410°F)

Polyisobutylene volume resistivity = 50×10^{14} Ω-cm [4].

II. Handling Guidelines

Similar to most hydrocarbon liquids, at temperatures above 100°C (212°F), vessels containing polyisobutylene can have small amounts of hydrocarbon in the vapor space.[1,2,3] The hydrocarbon concentration will vary depending on the product grade, temperature and vessel configuration. Vessels should be properly grounded and the vapor space protected from possible sources of ignition.

STORAGE TEMPERATURES AND CONDITIONS

For prolonged storage, temperatures should be kept as low as possible and not exceed the recommended storage temperatures listed in the table below.

Product	Recommended Storage Temperatures
TPC-545	180-210°F
TPC-175	180-210°F
TPC-595	200-230°F
TPC-1105	200-230°F
TPC-1160	200-230°F
TPC-5230	220-250°F
TPC-1285	240-270°F
TPC-1350	240-270°F

Exposure to air should be minimized and a nitrogen pad is recommended to minimize the chance of product oxidation. Heat exchanger surface temperatures should not exceed 300°F to prevent localized product degradation. Any heating of the product should be done to maximize mixing and minimize the chance of localized hot spots. For instance, heating of the product by use of a circulation pump and heater system is preferable to in-tank or on-tank heaters.

LOADING AND UNLOADING TEMPERATURES AND CONDITIONS

Prior to loading, ensure that the truck tank wagon or railcar is properly grounded and the vapor space is protected from possible sources of ignition. It is recommended to add a nitrogen pad the truck tank wagon or railcar before and after loading or offloading. The product temperatures during loading should not exceed the recommended loading temperatures listed in the table below. Overheating of PIB may result in premature thermal degradation of the product.

Product	Recommended Loading Temperatures	Heat Exchanger Maximum Surface Temperature
TPC-545	190-230°F	300°F (~50 psig steam)
TPC-175	190-230°F	300°F (~50 psig steam)
TPC-595	230-250°F	300°F (~50 psig steam)
TPC-1105	230-250°F	300°F (~50 psig steam)
TPC-1160	230-250°F	300°F (~50 psig steam)
TPC-5230	230-250°F	300°F (~50 psig steam)
TPC-1285	270-290°F	330°F (~100 psig steam)
TPC-1350	270-290°F	330°F (~100 psig steam)

RAIL CAR HEATING TEMPERATURES

Rail cars can be heated using no more than 100 psig steam if nitrogen is also sparged into the car to help circulate the product. If no nitrogen is used, steam pressure should be limited to 50 psig.

STATIC REDUCTION[1]

General

Polyisobutylene is different than many common liquids as it both generates and then holds a static electrical charge. The discharge of this static could provide an ignition source during transfer and loading operations. Electrical bonding and grounding does not guarantee protection from discharges generated from the surface of a low conductivity liquid such as polyisobutylene. However, static discharges can be minimized by taking steps to reduce static accumulation and discharge.

Product Flow Rates[1]

The flow of liquid through piping generates a static charge. Pipe flow velocity limits should be observed to minimize static charge accumulation. The initial loading velocity should not exceed 1 m/s until the fill outlet in the truck tank wagon or railcar is submerged to prevent spraying and turbulence. The maximum loading rate should not exceed 7 meters per second (23 feet per second) or the value 0.5/d m/s (d = inside pipe diameter in meters), whichever is less.

Velocities and Flow Rates[1]

Pipe Size	**Inside Diameter**		**Velocities**		**Flow Rate**	
	Inches	**Millimeters**	**ft/s**	**m/s**	**GPM**	**Liters/s**
1.5	1.610	40.90	3.28	1.00	21	80
			22.97	7.00	146	553
2	2.067	52.50	3.28	1.00	34	129
			22.97	7.00	240	908
3	3.068	77.90	3.28	1.00	76	288
			22.97	7.00	529	2002
4	4.026	102.30	3.28	1.00	130	492
			22.97	7.00	911	3448
6	6.065	154.10	3.28	1.00	295	1117
			22.97	7.00	1539	5825

Flow-through Filters and Screens[1]

Charge generation greatly increases if a filter is placed in a piping system. A filter can produce from 10 to 200 times more charge than is produced in the same system without filtration. When the pore or screen size of the filter is larger than 300 microns (less than 50 mesh per inch), it is unlikely that hazardous levels of electrostatic charge will be generated in the filter/screen. When the pore or screen size is less than 150 microns (more than 100 mesh per inch) a hazardous charge level is likely to be generated, particularly if the filter or screen is partially plugged. For polyisobutylene which has very low conductivity (less than 2 pS/m) and high viscosity (greater than 30 centistokes) at the lowest intended operating temperature, longer residence times downstream of small pore size filters and screens may be appropriate. In these cases, an increase in residence time should be considered. If at all possible, use a filter at least 150 microns or larger.

Charge Relaxation Time[1]

After filling a vessel, an extended charge relaxation time of at least 15 minutes should be observed before introducing or withdrawing sampling, gauging, or temperature measurement devices or closing manway covers to allow static accumulation to dissipate. Charge relaxation time is the time for a charge to dissipate to e^{-1} (approximately 37%) of the original value. In general, for hydrocarbon liquids, relaxation time constant is approximated by the relationship:

$$\tau \equiv 18/\sigma$$

Where: $\tau \equiv$ relaxation time in seconds,
$\sigma \equiv$ electrical conductivity of the liquid in p*S*/m.

Conductivity = 1/resistivity
Polyisobutylene volume resistivity = 50 x 10^{14} Ω-cm
Conductivity = 1/ 50 x 10^{14} Ω-cm = 0.0002 p*S* / cm = 0.02 p*S* /m
τ = 18/ σ = 18 / 0.02 = 900 seconds = 15 minutes

TEMPERATURE VS DENSITY OF POLYISOBUTYLENE BY GRADE

Product	Temp., °F	g/cm^3	lb/gal
TPC545	60	0.8646	7.215122
TPC545	85	0.8564	7.146692
TPC545	110	0.8484	7.079932
TPC545	135	0.8403	7.012337
TPC545	160	0.8322	6.944742
TPC545	175	0.8273	6.903852
TPC545	194	0.8212	6.852947

TPC 545 Density = -0.002702(Temp) + 7.376905

Product	Temp., °F	g/cm^3	lb/gal
TPC175	60	0.8868	7.4007
TPC175	85	0.879	7.3356
TPC175	110	0.8709	7.268
TPC175	135	0.8631	7.2029
TPC175	160	0.8555	7.1395
TPC175	175	0.8509	7.1011
TPC175	194	0.8452	7.0535

TPC 175 Density = -0.002595(Temp) + 7.555209

Product	Temp., °F	g/cm^3	lb/gal
TPC 595	60	0.89357	7.4572
TPC 595	85	0.88601	7.3941
TPC 595	110	0.87848	7.3313
TPC 595	135	0.87098	7.2687
TPC 595	160	0.86351	7.2063
TPC 595	175	0.85904	7.169
TPC 595	194	0.85336	7.1216

TPC 595 Density = -0.002503(Temp) + 7.606962

Product	Temp., °F	g/cm^3	lb/gal
TPC 1105	60	0.89357	7.4572
TPC 1105	85	0.88601	7.3941
TPC 1105	110	0.87848	7.3313
TPC 1105	135	0.87098	7.2687
TPC 1105	160	0.86351	7.2063
TPC 1105	175	0.85904	7.169
TPC 1105	194	0.85336	7.1216

TPC 1105 Density = -0.002503(Temp) + 7.606962

Product	Temp., °F	g/cm^3	lb/gal
TPC1160	60	0.9023	7.5301
TPC1160	85	0.8949	7.4683
TPC1160	110	0.8875	7.4065
TPC1160	135	0.8801	7.3448
TPC1160	160	0.8728	7.2839
TPC1160	175	0.8681	7.2446
TPC1160	194	0.8624	7.1971

TPC 1160 Density = -0.002481(Temp) + 7.679364

Product	Temp., °F	g/cm^3	lb/gal
TPC1285	60	0.9089	7.5851
TPC1285	85	0.90161	7.5243
TPC1285	110	0.89442	7.4643
TPC1285	135	0.88722	7.4042
TPC1285	160	0.88013	7.345
TPC1285	175	0.87583	7.3092
TPC1285	194	0.87044	7.2642

TPC 1285 Density = -0.002394(Temp) + 7.728012

Product	Temp., °F	g/cm^3	lb/gal
TPC1350	60	0.91128	7.605
TPC1350	85	0.90407	7.5448
TPC1350	110	0.8969	7.485
TPC1350	135	0.88976	7.4254
TPC1350	160	0.88265	7.3661
TPC1350	175	0.87841	7.3307
TPC1350	194	0.87303	7.2858

TPC 1350 Density = -0.002382(Temp) + 7.747356

Product	Temp., °F	g/cm^3	lb/gal
TPC5230	60	0.9068	7.5676
TPC5230	85	0.8996	7.5075
TPC5230	110	0.8923	7.4466
TPC5230	135	0.8851	7.3865
TPC5230	160	0.8778	0.73256
TPC5230	175	0.8734	7.2889
TPC5230	194	0.8678	7.2421

TPC 5230 Density = -0.002428(Temp) + 7.713715

References

1. American Petroleum Institute Recommended Practice 2003, *Protection Against Ignitions Arising Out of Static, Lightning, and Stray Currents*, 6th ed., January 2008.
2. NFPA 77: *Recommended Practice on Static Electricity,* National Fire Protection Association, 2014 ed., 2014.
3. DOT/FAA/AR-05/14, *Polymer Flammability*, US Dept. of Transportation, May 2005.
4. Kunal et al., *Journal of Polymer Science: Part B: Polymer Physics,* Vol. 46, 1390–1399 (2008).