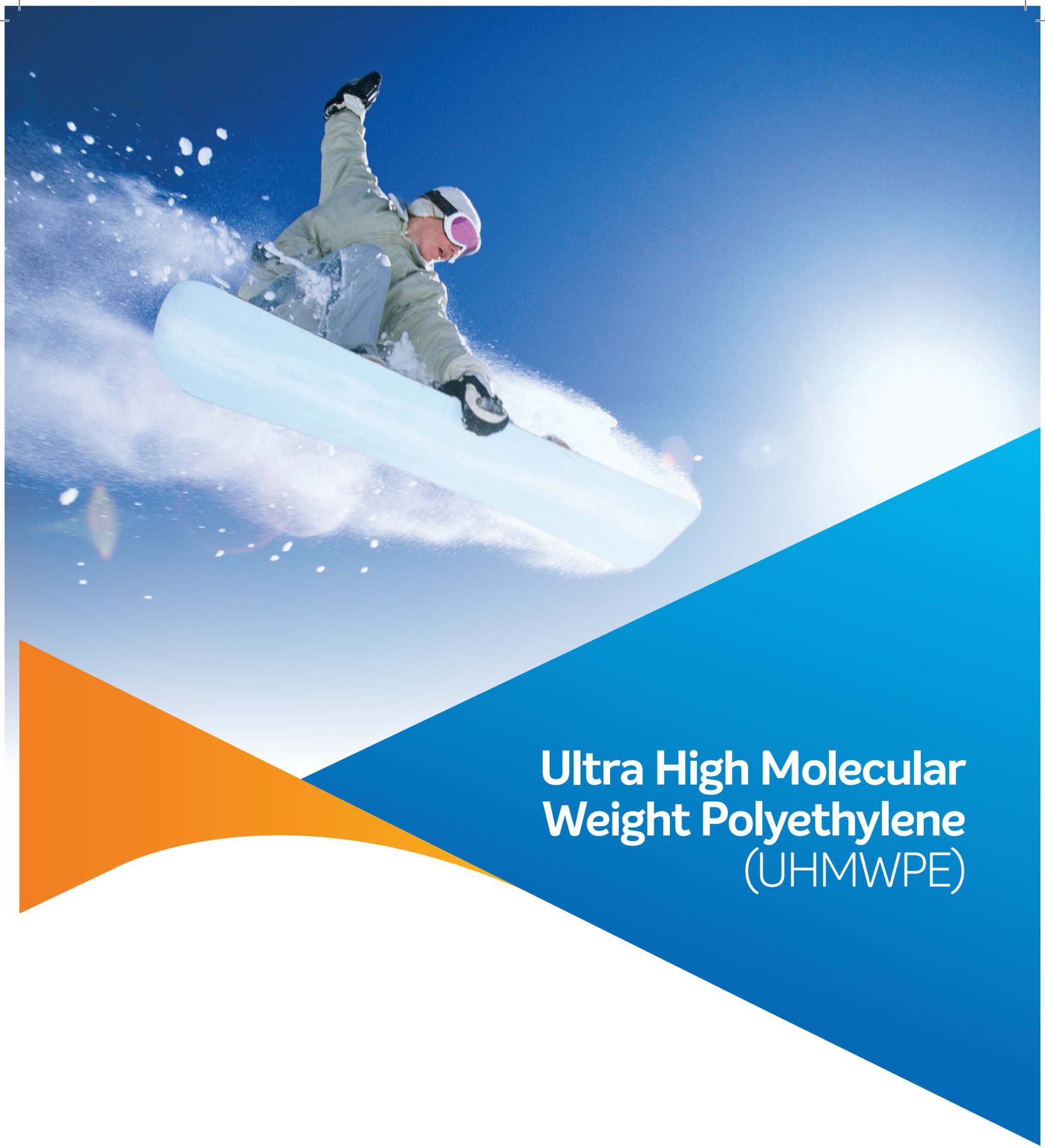


Ultra High Molecular Weight Polyethylene (UHMWPE)

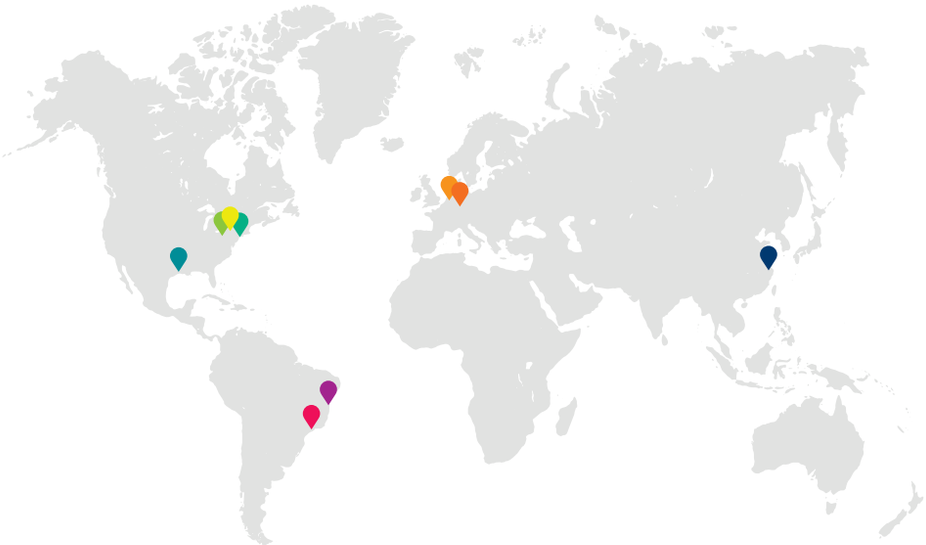
UTEC®

Braskem

UTEC is the trade name of the Ultra High Molecular Weight Polyethylene (UHMWPE) developed and produced by Braskem with our own catalyst and production technology.

UTEC has a molecular weight approximately 10 times higher than High Density Polyethylene (HDPE) resins. The ultra high molecular weight of UTEC results in excellent mechanical properties such as high abrasion resistance, impact strength and low coefficient of friction. These special properties allow the product to be used in high performance applications.

UTEC grades are sold in powder form according to the molecular weight and average particle size. The molecular weight may be in the low range (3 million g/mol), medium range (5 million g/mol), or high range (up to 12 million g/mol). Products with these different molecular weights are available in a range of particle sizes (average diameter approximately 125 µm to 255µm).



UTEC®

Philadelphia, PA, USA UTEC Global Headquarters, Sales Office. **Pittsburgh, PA, USA** Innovation and Technology Center. **Edison, NJ, USA** Warehouse.
La Porte, TX, USA Warehouse and Manufacturing Facility. **Salvador, Brazil** Warehouse and Manufacturing Facility, Sales Office. **Sao Paulo, Brazil** Warehouse.
Frankfurt, Germany Sales Office. **Rotterdam, Netherlands** Sales Office. **Shanghai, China** Distributor.

Impact Strength

UTEC is the best solution compared to other materials because of its remarkable impact strength. Figure 1 compares the impact strength of UTEC with the many other commodity resins and engineering plastics.

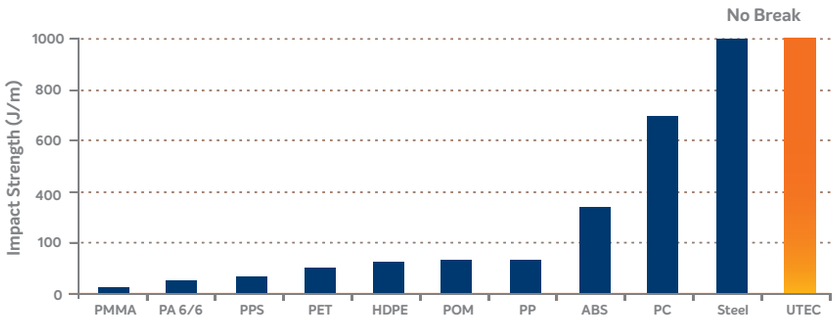


Figure 1 – Notched Izod Impact Strength (ASTM D 256): UTEC vs. other materials.
Data source: HARPER, CHARLES A. Modern Plastics Handbook. 1999.

Coefficient of Friction

UTEC is an excellent material for sliding applications where low coefficient of friction properties are required, working as a self-lubricating material. Figure 2 compares the static and dynamic coefficient of friction of UTEC with other engineering thermoplastics; even without additives, UTEC is still the best performance solution for sliding applications.

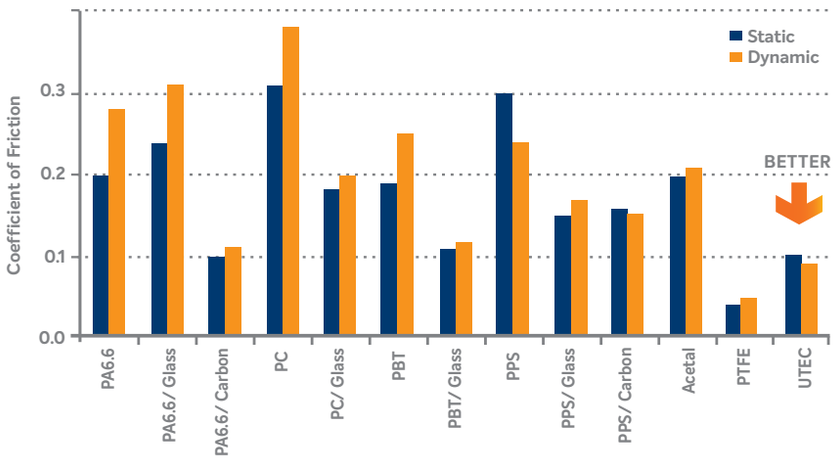


Figure 2 – Static and Dynamic Coefficient of Friction of UTEC and other materials.
Data Source: CRAWFORD, R.J. Plastics Engineering. 3rd edition, 1998.

Industries

- Automotive and Transportation
- Electronics
- Industrial and Heavy Equipment
- Oil and Gas
- Pipe and Mining
- Porous Plastics
- Recreation and Consumer
- Fibers and Textiles
- Material and Food Handling
- Battery Separators

Molecular Chain Length

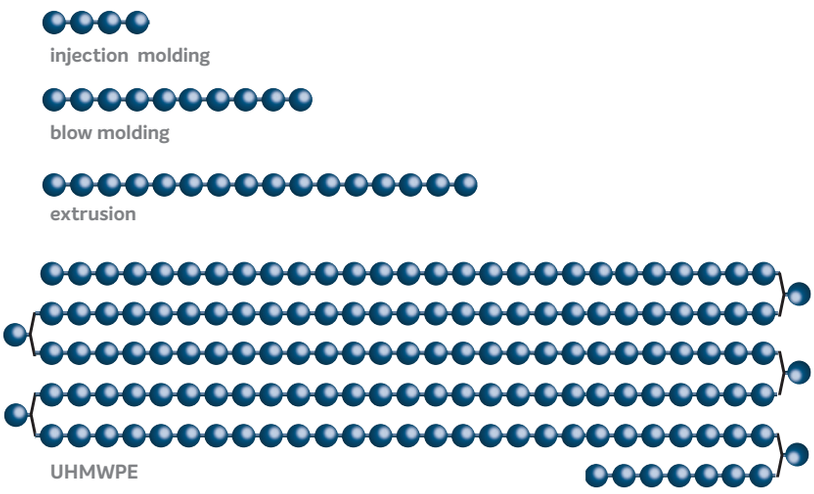
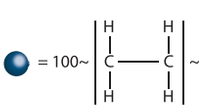


Figure 3 – Comparing relative polymer chain length for different grades of HDPE used in injection molding, blow molding, and extrusion molding with UTEC® UHMWPE polymeric chain.



Chemical Resistance

UTEC is extremely resistant to a wide variety of substances. The material is almost totally inert; therefore, it can be used in the most corrosive or aggressive environments at moderate temperatures. Even at high temperatures, UTEC is resistant to several solvents, except aromatic, halogenated hydrocarbons and strong oxidizing materials, such as nitric acid.

Compatibility tests between a product sample and the chemical environment are strongly recommended to verify satisfactory part performance, at the same conditions, for a period of time equal to the life time expected for each new application. Even substances classified with high attack or absorption characteristics show good practical results.

Figure 4 – Relative abrasion wear of UTEC grades and various materials, STEEL SAE 1020 = 100. The pictures show the tested parts. Measured by Braskem internal sand slurry method.

Abrasion Wear Resistance

Another outstanding UTEC property is the abrasion wear resistance. This makes UTEC suitable for replacing metals in applications that require high abrasion resistance while providing light-weighting benefits.

Figure 4 compares the relative wear resistance of UTEC compared to other materials used in high wear applications such as tubes, liners, silos, containers and other equipment.

In the UHMWPE technology, it is well-known that the abrasion wear decreases with molecular weight as shown in Figure 5.

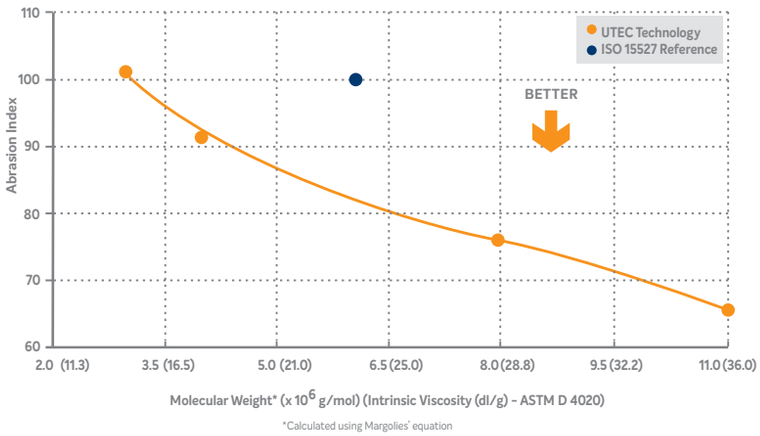


Figure 5 – Abrasion Index (Braskem internal sand slurry method) as a function of the Molecular Weight for the UTEC technology, measured according to ISO 15527 (ISO reference set as 100).

Nomenclature

UTEC® 3 0 4 0 □

- Molecular Weight 10^6 g/mol (Intrinsic Viscosity, dL/g)
  - 3 – 3.0 (14)
  - 4 – 4.5 (19)
  - 5 – 6.0 (24)
  - 6 – 8.0 (28)
  - 9 – 11.0 (36)
- Acid Scavenger and powder flow additive
  - 0 – High level
  - 5 – Low level
  - 1 – Absent
- Bulk Density (g/cm³)
  - 0.4 – 0.5
- Average Particle Size (µm)
  - 0 – 225
  - 1 – 155
- Special Characteristic

Additional Properties

- Elongational Viscosity x Molecular Weight
- Impact Strength x Temperature
- Stress x Strain
- Yield Stress x Temperature
- Specific Enthalpy x Temperature
- Specific Heat x Temperature

Molecular Structure

The UTEC molecular structure has direct impact on its physical and thermal properties as well as processing performance. There are some characterization methods which can be used to measure the molecular weight of polymers. In the case of UHMWPE resins, the viscosity of polymer diluted solutions is widely used for that purpose.

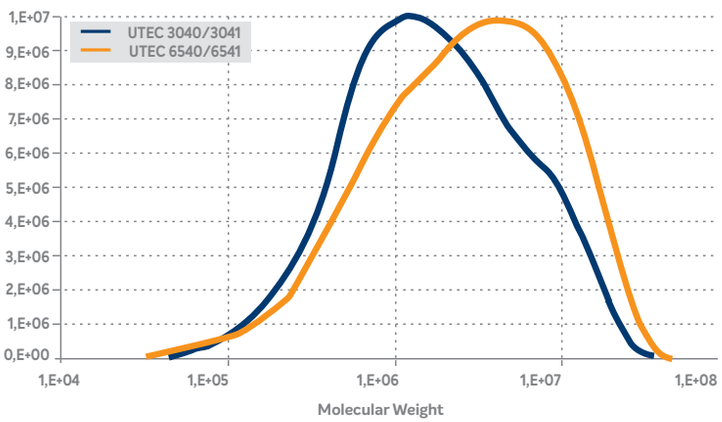
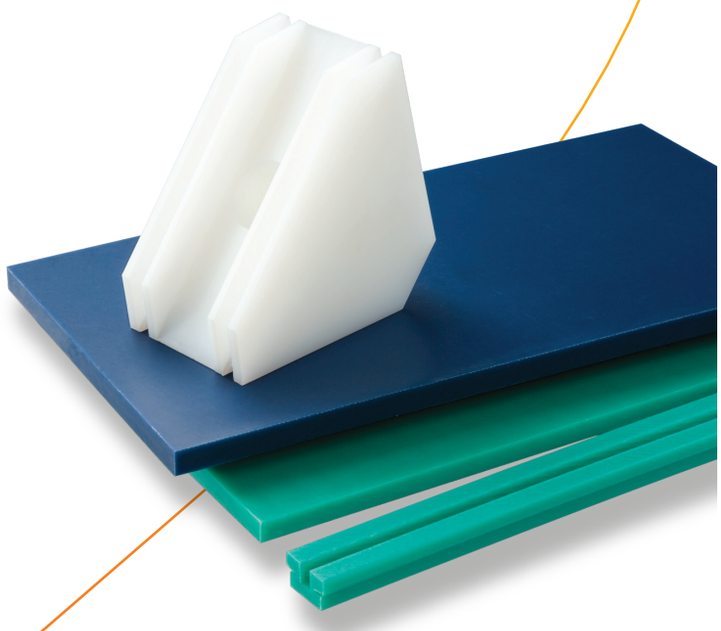


Figure 6 – Typical UTEC technology MWD (Molecular Weight Distribution) curves measured by GPC (Gel Permeation Chromatography) method.

Processing

It is not possible to process UTEC through conventional extrusion methods or injection or blow molding, because this material does not flow even at temperatures above its melting point. UTEC requires special processing techniques, such as RAM extrusion and compression molding. These processes are generally used to produce semi-finished parts such as rods and sheets. UTEC can be sintered into porous parts (filters) and calendered into porous sheets. It can also be gel processed into fibers or for a variety of battery separator applications.

Those semi-finished parts can then be machined into parts for a wide range of applications. It is possible to use the same machining techniques as those used for wood or metal, such as sawing, milling, planing, drilling and turning. Other conversion processesmay also be used.



For more information,
visit **www.braskem.com/utec**

	Control Properties	Intrinsic Viscosity	Molecular Weight *	Average Particle Size D50	Tensile Strength at Break	Double Notched Charpy Impact Strength	Abrasion Index (ISO 15527 refeence set to 100)
	Method	ASTM D 4020	ASTM D 4020 Margolies	Laser Scattering	ASTM D 638 ISO 527	ISO 11542-2	Braskem Internal Method
	Units	dl/g	g/mol * 10^6	µm	MPa	kJ/m^2	-
UTEC	3040	14.0	3.0	225	> 30	> 180	100
		Applications which require high impact strength and some wear resistance – technical parts, RAM extruded/compression molded rods, sheets, profiles, and pipes.					
	3041	14.0	3.0	155	> 30	> 180	100
		Applications which require high impact strength and some wear resistance – technical and porous parts, filters, fibers, RAM extruded/compression molded rods, sheets, profiles, and pipes.					
	4040	18.0	4.0	225	> 30	>1 30	91
		Applications which require a good balance of impact and wear resistance – technical parts and RAM extruded/compression molded rods, sheets, profiles, and pipes.					
	4041	18.0	4.0	155	> 30	> 130	91
		Applications which require a good balance of impact and wear resistance – technical and porous parts, filters, fibers, and RAM extruded/ compression molded rods, sheets, profiles, and pipes.					
	5540	24.0	6.0	225	> 30	>100	82
		Applications which require high wear resistance – technical parts, RAM extruded/compression molded rods, sheets, profiles, and pipes.					
	5541	24.0	6.0	155	> 30	> 100	82
		Applications which require high wear resistance – technical parts, fibers, RAM extruded/compression molded rods, sheets, profiles, and pipes.					
	6540	28.0	8.0	225	> 30	> 100	76
		Applications which require highest wear resistance – technical parts, RAM extruded/compression molded rods, sheets, and profiles.					
	6541	28.0	8.0	155	> 30	> 100	76
		Applications which require highest wear resistance – technical parts, RAM extruded/compression molded rods, sheets, and profiles.					
	6540G	28.0	8.0	255	> 30	> 100	76
		Applications which require highest wear resistance – technical parts, RAM extruded and/or compression molded rods, sheets, and profiles.					
	9540	36.0	11.0	225	> 30	> 100	66
		Applications which require extreme wear resistance – technical parts, RAM extruded and/or compression molded rods, sheets, and profiles.					

Other typical values for all UTEC grades are melting point of 133°C, Bulk density of 0.45 g/mL, Shore D Hardness of 64, Kinetic COF of 0.09, CLTE of 1.5 x 10-4, Specific Heat @ 23°C of 0.48 Cal/g°C, and Specific Melt Enthlapy of 34 cal/g

Braskem does not recommend the use of its products for manufacturing packages, pieces or any other type of product that will be used for storing of or be in contact with parenteral solutions or that will have any type of internal contact with the human body, except when explicitly indicated otherwise.

braskem.com

Every day, Braskem's 8,000 team members work to improve people's lives through sustainable solutions in chemistry and plastics and engage with partners throughout the value chain to advance the circular economy.

With 41 industrial units in Brazil, United States, Mexico and Germany, net revenue of R$58 billion (US$15.8 billion) and exports to around 100 countries, Braskem produces annually over 20 million tons of plastic resins and chemical products.

Braskem is one of the largest global manufacturers of Ultrahigh Molecular Weight Polyethylene (UHMWPE), which is produced under the trade name UTEC. UTEC is the material of choice for high performance applications. UTEC enables industries such as transportation, industrial, material handling, recreational sports, and porous plastics to produce goods that enhance the quality of life for people around the world.

For more information visit www.braskem.com/utec.

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