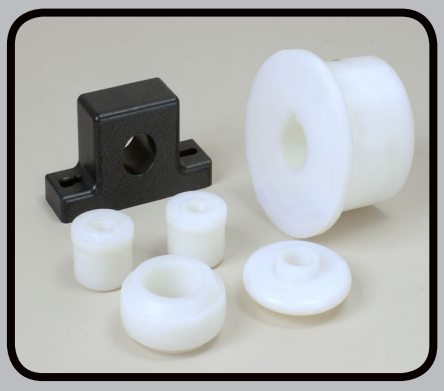
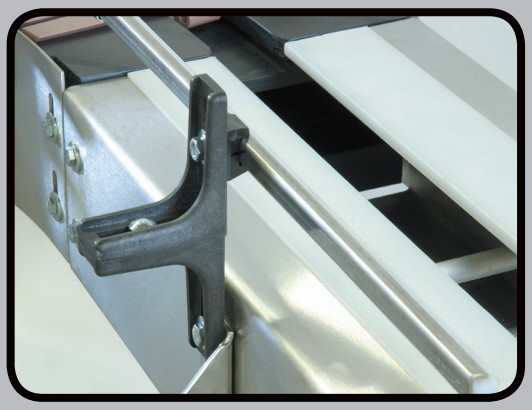
ARTEK

DURAVAR® UHMW-PE

ULTRA-HIGH MOLECULAR WEIGHT POLYETHYLENE




TECHNICAL GUIDELINES

Distributed by: Polymershapes

WELCOME TO ARTEK

Manufacturer of Duravar® Ultra-High Molecular Weight Polyethylene

DEPENDABLE QUALITY • RELIABLE SUPPORT • FAITHFUL SERVICE

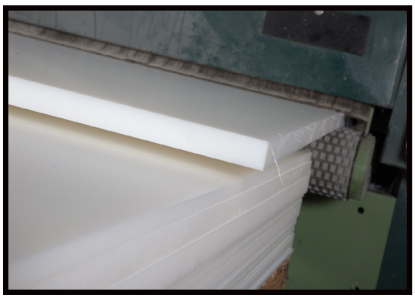
Utilizing Duravar® UHMW-PE Successfully?

There are many industrial application areas where Duravar® UHMW-PE Products are solving inherent operational problems of abrasive wear, impact failure, and material hang-up. Duravar has quickly become known in the industry as "The Material of Choice" to solve the day to day problems that plague the material handling industry.

This collection of technical information is designed to provide a quick reference to Sales Representatives, Design Engineers and Maintenance Personnel involved in researching, specifying, designing and installing Duravar UHMW-PE to minimize downtime, extend equipment life and reduce overall maintenance costs.

This Technical Guideline Brochure includes information on Duravar UHMW-PE:

- Duravar UHMW-PE Physical Properties Chart
- Duravar UHMW-PE Chemical Resistance Chart
- Duravar UHMW-PE Characteristics Reports
- Duravar UHMW-PE Machining Guidelines
- Duravar UHMW-PE Expansion & Contraction
- Duravar UHMW-PE Profile & Component Design Criteria
- Duravar UHMW-PE Profile & Component Design Checklist



Do not hesitate to contact the Artek Team for additional application and technical data not provided in this Guideline Brochure. The Artek Team is ready to assist you in resolving your application problems.

WELCOME TO ARTEK

Manufacturer of Duravar® Ultra-High Molecular Weight Polyethylene

Technical Guidelines - Table of Contents

Commitment To Quality, Support and Service

Artek Inc., a manufacturer of Ultra-High Molecular Weight Polyethylene was incorporated in 1985 with a purpose to produce and sell a quality, high performance polymer called Duravar UHMW-PE. Artek continuously strives to satisfy the customer needs, and is committed to meeting their daily challenges by providing dependable quality, reliable support and faithful service.

Thank You for being a part of the "Artek Team"

DURAVAR®
Specifications & Approvals

Ultra-High Molecular Weight Polyethylene

The following is a brief listing of the most common specifications and approvals Duravar UHMW material currently meets when utilizing Premium UHMW Polymer Resins.

ASTM	Duravar UHMW utilizing Premium Ultra-High Molecular Weight Resins is in compliance with ASTM (D-4020) UHMW Molding and Extrusion Materials and ASTM (D-6712-01) UHMW Solid Plastic Shapes
FDA	Duravar UHMW utilizing Premium UHMW Polymer Resins is in compliance with FDA regulations as listed in the Federal Register under the Food, Drug, and Cosmetic Act of 1958, as amended for food contact use in accordance with 21 CRF177.1520 and meets the requirements of specifications 2.1 and 2.2 of the regulation provided it is used as unmodified.
FEDERAL	Duravar UHMW utilizing Premium UHMW Polymer Resins is in compliance with (L-P-390C) Plastic, Molding and Extrusion Material, Polyethylene and Copolymers (Low to High Density)
ISO	Duravar UHMW utilizing Premium UHMW Polymer Resins is in compliance with ISO#11542-1/2 for molding and extrusion materials.
MILITARY	(MIL-P-23536) Plastic Sheets, Virgin and Borated Polyethylene. (MIL-P-21922) Plastics Rods and Tubes Polyethylene. (MIS-31836) Missle Command Specification for UHMW.
OSHA	Duravar UHMW utilizing Premium UHMW Polymer Resins is not considered hazardous, as defined by the OSHA Hazard Communication Standard 29 CFR 1910.1200.
UL	There is no current listing for Duravar UHMW utilizing Premium UHMW Polymer Resins. However, previous UL-94 testing resulted in a V-2 rating for unmodified UHMW Resin and a V-0 rating with sufficient flame retardant additives.
USDA	Duravar UHMW utilizing GUR® 4000 Series Resins has USDA approval for direct contact with meat and poultry in food handling applications.
3-A	Duravar UHMW, utilizing Premium UHMW Polymer Resins, in Virgin Natural color, comply with the 3-A Sanitary Standards for Multiple Use Plastic Materials, when used in accordance with industry recommendations.

DURAVAR®
Physical Properties Table
Ultra-High Molecular Weight Polyethylene

Typical Physcial Properties	Test Method	U/M	Value
Physical Properties			
Intrinsic Viscosity (IV)	ASTM D-4020	DL/GM	28 - 30
Density	ASTM D-792	GM/CM3	0.935 - 0.945
Hardness	ASTM D-2240	SHORE D	67
Water Absorption	ASTM D-570	%	Nil
Mechanical Properties			
Yield Strength	ASTM D-638	psi	> 3000
Tensile at Break	ASTM D-638	psi	> 5500
Elongation at Break	ASTM D-638	%	> 190
Tensile Modulus	ASTM D-638	psi	> 119,000
Flexural Modulus	ASTM D-790B	psi	> 109,000
Izod Impact	ASTM D-256A	---	No Break
Tensile Impact	ASTM D-1822	ft-lbs/in	> 700
Abrasion Index	SAND SLURRY	Steel = 100	10
Coefficient of Friction - Static (Polished Steel)	ASTM D-1894	---	.15 - .20
Coefficient of Friction - Dynamic (Polished Steel)	ASTM D-1894	---	.10 - .14
Thermal Properties			
Coefficient of Linear Thermal Expansion	ASTM D-696	in/in/F°	7.8×10^{-5}
Application Temperature - Maximum	ASTM D-648	°F	< 200°
Application Temperature - Minimum	ASTM D-648	°F	> -400°
Melting Range	DSC	°F	> 278°
Electrical Properties			
Dielectric Constant	ASTM D-150	---	2.30 - 2.35
Dissipation Factor	ASTM D-150	---	$< 5 \times 10^{-3}$
Static Decay Time	FTS-101C	Seconds	---
Volume Resistivity	ASTM D-257	ohms-cm	1017
Surface Resistivity	ASTM D-257	ohms	1017

DURAVAR®
Chemical Resistance Chart

Ultra-High Molecular Weight Polyethylene

Duravar UHMW is almost completely inert to chemical attacks. At room temperature, it is unaffected by a large number of solvents. At higher temperatures, Duravar UHMW is dissolved by solvents such as aromatic and halogenated hydrocarbons and decahydronphthalene.

Substance	Resistance	Substance	Resistance	Substance	Resistance
Acetate Solvents Pure	+	Ammonium Sulfate	+	Caustic Potash	+
Acetaldehyde	/	Amyl Acetate	+	Caustic Soda	+
Acetic Acid	+	Aniline	+	Chlorinated Water	+
Aceitic Acid Glacial	+	Antimony Trichloride 10%	+	Chlorine Dry 100%	/
Acetic Anhydride Boiling	+	Aqua Regia	/	Chlorine Wet 10%	/
Acetone	+	Barium Chloride 30%	+	Chloroacetic Acid	-
Acid Mine Water	+	Barium Sulfate 10%	+	Chlorobenzene	/
Alcohols General	+	Barium Sulfide	+	Chloroform	/
Alcohol Amyl	+	Beer	+	Chlorosulfonic Acid	-
Alcohol Butyl (Butanol)	+	Benzene	/	Chromic Acid Concentrated	+
Alcohol Ethyl (Ethanol)	+	Benzene Sulfonic Acid	+	Citric Acid Concentrated	+
Allyl Alcohol	+	Benzoic Acid	+	Citric Acid Dilute	+
Allyl Chloride	+	Benzyl Alcohol	+	Copper Sulfate	+
Aluminum Chloride 10%	+	Borax	+	Cottonseed Oil	+
Aluminum Chloride 100%	+	Boric Acid 10%	+	Creosote	+
Aluminum Fluoride	+	Butyric Acid Concentrated	+	Cresol M Crude	+
Aluminum Potassium Sulfate	+	Butyl Acetate	+	Crude Oil	+
Aluminum Sulfate 100%	+	Butyl Phthalate	+	Cupric Chloride 10%	+
Aluminum Sulfate Boiling	-	Calcium Bisulfite	+	Cyclohexane	+
Amines	+	Calcium Chloride Saturated	+	Cyclohexanol	+
Ammonia 100% Anhydrous	+	Calcium Hydroxide 30%	+	Cyclohexanone	+
Ammonia Aqueous	+	Calcium Hypochlorite 100%	+	Detergent	+
Ammonium Carbonate 10%	+	Carbonic Acid (Phenol)	+	Dibutyl Phthalate	+
Ammonium Chloride Saturated	+	Carbide Dioxide	+	Dichloroethane	/
Ammonium Hydroxide	+	Carbon Disulfide	-	Dichloroethylene	-
Ammonium Nitrate	+	Carbon Tetrachloride	/	Diesel Fuel	+
Ammonium Persulfate	+	Carbonic Acid 10%	+	Diethyl Ether	+

+ = Specimen is Resistant	Swelling < 3% or alternatively weight loss < 0.5%. Break elongation not significantly altered.
/ = Specimen has Limited Resistance	Swelling 3 - 8% or alternatively weight loss 0.5-5% and/or break elongation decreased by < 50%
- = Not Resistant	Swelling > 8% or alternatively weight loss > 5% and/or break elongation decreased by > 50%

* Denotes No Information Available

DURAVAR®
Chemical Resistance Chart

Ultra-High Molecular Weight Polyethylene

Duravar UHMW is almost completely inert to chemical attacks. At room temperature, it is unaffected by a large number of solvents. At higher temperatures, Duravar UHMW is dissolved by solvents such as aromatic and halogenated hydrocarbons and decahydronphthalene.

Substance	Resistance	Substance	Resistance	Substance	Resistance
Diisobutylene	+	Heptane	+	Magnesium Hydroxide	+
Dimethyl Aniline	+	Hexane	+	Magnesium Sulfate	+
Dimethyl Formamide	+	Hydraulic Fluid Petroleum	+	Malic Acid	+
Dioane	+	Hydraulic Fluid Synthetic	+	Manganese Chloride	+
Ethers	/	Hydrobromic Acid 37%	+	Mercuric Chloride	+
Ethyl Acetate	+	Hydrochloric Acid >20%	+	Mercury	+
Ethyl Benzene	+	Hydrocyanic Acid	+	Methyl Alcohol Methonal	*
Ethyl Ether	-	Hydrofluoric Acid >40%	+	Methyl Ethyl Keytone	+
Ethylene Chloride	/	Hydrofluosilicic Acid 10%	+	Methylene Chloride	/
Ethylene Diamine	+	Hydrofluorosilicic Acid 10%	+	Milk	+
Ethylene Dichloride	/	Hydrogen Gas	+	Mineral Oil	+
Ethylene Glycol	+	Hydrogen Peroxide 100%	+	Molasses	+
Fatty Acids	+	Hydrogen Sulfide Wet or Dry	+	Monochlorobenzene	/
Ferric Chloride Concentrated	+	Iodine	+	Monochloroacetic Acid	-
Ferrous Chloride	+	Isooctane	+	Naphthalene	+
Fluoboric Acid	+	Isopropyl Alcohol	+	Nickel Chloride	+
Fluosilic Acid 10%	+	Isopropyl Ether	+	Nickel Nitrate	+
Fluorine Gas Wet: Dry NR	/	Keytones	/	Nickel Sulfate	+
Formaldehyde	+	Lactic Acid	+	Nitric Acid 10-30%	+
Formic Acid	+	Lard	+	Nictric Acid 50%	+
Furfural	+	Lead Acetate	+	Nitrobenzene	+
Gallic Acid	+	Lead Nitrate	+	Oils Mineral, Olive, Vegetable	+
Gasoline Unleaded	+	Lime Sulfur	+	Oleic Acid	+
Gelatin	+	Linseed Oil	+	Oxalic Acid	+
Glucose	+	Lubricating Oil	+	Oxygen	+
Glue	+	Lye	+	Ozone	/
Glycerine	+	Magnesium Chloride	+	Paraffin	+

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DURAVAR®
Chemical Resistance Chart

Ultra-High Molecular Weight Polyethylene

Duravar UHMW is almost completely inert to chemical attacks. At room temperature, it is unaffected by a large number of solvents. At higher temperatures, Duravar UHMW is dissolved by solvents such as aromatic and halogenated hydrocarbons and decahydronphthalene.

Substance	Resistance	Substance	Resistance	Substance	Resistance
Perchloroethylene	/	Silver Cyanide	+	Sulfur Chloride	*
Perchloric Acid 10%	+	Silver Nitrate	+	Sulfur Dioxide Gas Wet or Dry	+
Petroleum	+	Soap Solutions	+	Sulfuric Acid 10-60%	+
Petroleum Ether	+	Sodium Acetate 60%	+	Sufluric Acid 80%	+
Phosphoric Acid 10-100%	+	Sodium Benzoate 10%	+	Sulfuric Acid 100%	+
Phosphorus	+	Sodium Bicarbonate	+	Sulfuric Acid Fuming Oleum	/
Phosphorus Trichloride	+	Sodium Bichromate	+	Tallow	+
Photographic Solutions	+	Sodium Bisulfate	+	Tannic Acid	+
Phthalic Acid	+	Sodium Bisulfite	+	Tartaric Acid 10%	+
Potassium Acetate 50%	+	Sodium Borate	+	Tetrachloroethylene	/
Potassium Aluminum Sulfate	+	Sodium Carbonate	+	Tetrahydrofuran	/
Potassium Bicarbonate 60%	+	Sodium Chloride	+	Tetrahydronaphthalene	+
Potassium Bichromate 5%	+	Sodium Cyanide	+	Thionyl Chloride	/
Potassium Bromide 10%	+	Sodium Dichromate	+	Toluene	+
Potassium Carbonate	+	Sodium Hydroxide	+	Tomato Juice	+
Potassium Chlorate	+	Sodium Hypochlorite	+	Transformer Oil	+
Potassium Chloride	+	Sodium Metaphosphate	+	Trichloroethylene	-
Potassium Dichromate 5%	+	Sodium Nitrate	+	Triethanolamine	+
Potassium Hydroxide	+	Sodium Perborate	+	Trisodium Phosphate	+
Potassium Iodide	/	Sodium Peroxide	+	Turpentine	+
Potassium Nitrate 10%	+	Sodium Phosphates	+	Urea	+
Potassium Permanganate	+	Sodium Silicate	+	Urine	+
Potassium Sulfate	+	Sodium Sulfate	+	Varnish	+
Propane	+	Sodium Sulfide	+	Vinegar	+
Propyl Alcohol	+	Sodium Sulfite 90%	+	Vinyl Acetate	*
Pyridine	+	Sodium Thiosulfate	+	Whiskey	+
Pyroligneous Acid	+	Sodium Tetraborate	+	White Spirits	+
Rosin	+	Stearic Acid	+	Wine	+
Salt Brine	+	Sulfate Liquor Black	+	Xylene	/
Sea Water	+	Sulfate Liquor Green	+	Zinc Chloride	+
Shellac	+	Sulfur	+	Zinc Sulfate	+

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- = Not Resistant	Swelling > 8% or alternatively weight loss > 5% and/or break elongation decreased by > 50%

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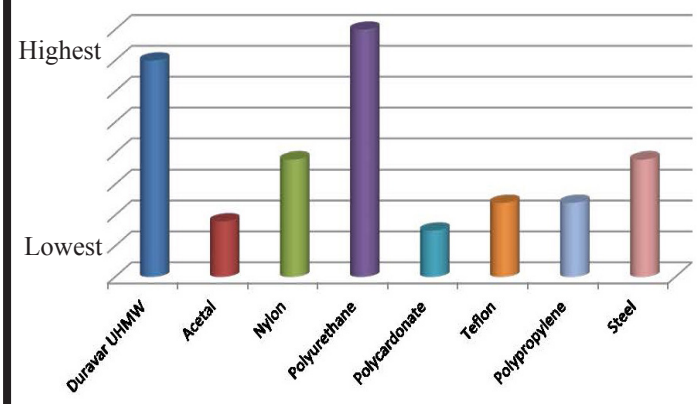
DURAVAR®
Characteristics Report I
Ultra-High Molecular Weight Polyethylene



High Abrasion Resistance of UHMW-PE

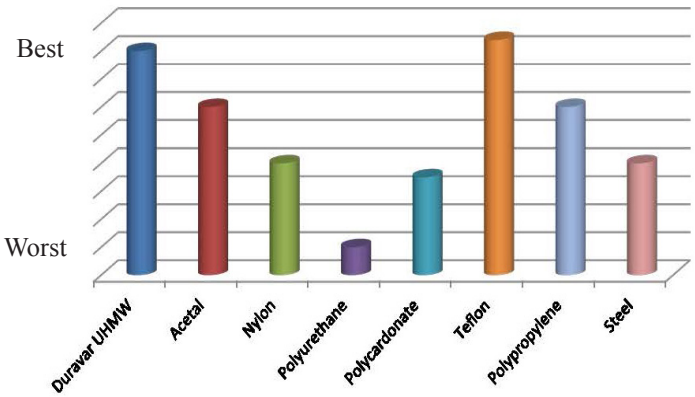
Duravar resists extreme sliding and scouring types of abrasion wear. Actual case studies show it will outwear steel 4 to 6 times depending on application extremes.

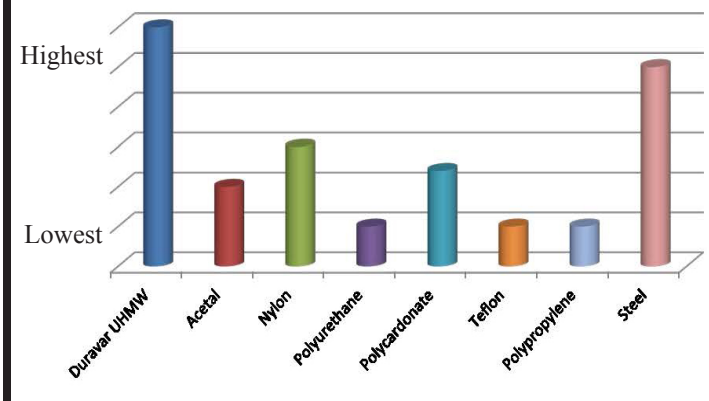
The excellent wearing power of Duravar UHMW helps extend equipment life, reduce maintenance and minimize over-all costs.

Low Coefficient of Friction of UHMW-PE

Duravar UHMW is extremely slippery. It promotes smooth and consistent material flow, even under freezing conditions.

The self lubricating properties of Duravar UHMW promotes sliding movement of dry materials where lubricants are not acceptable, as in food processing.





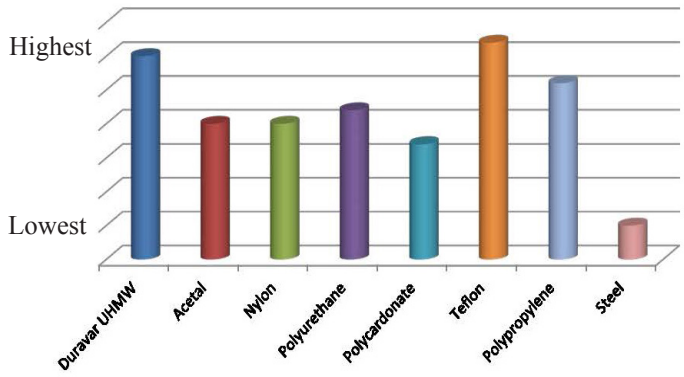
High Impact Strength of UHMW-PE

Duravar resists repeated direct impact blows better than most other engineered plastic materials.

Over time, Duravar work-hardens from the repeated pounding and tumbling abuse received in the material handling process.

From ambient conditions to cryogenic temperatures, Duravar maintains great impact strength.

DURAVAR®
Characteristics Report I
Ultra-High Molecular Weight Polyethylene



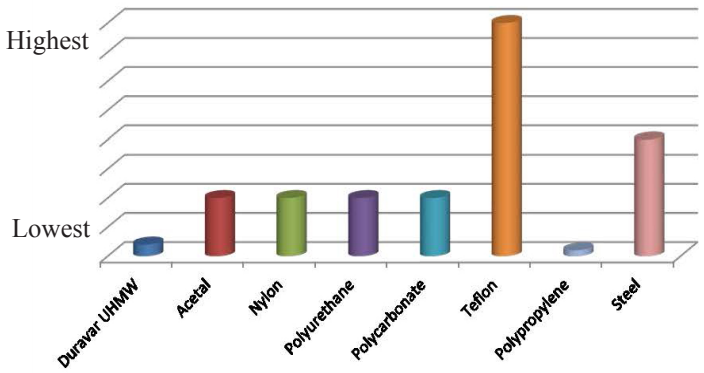
Chemical Resistance of UHMW-PE

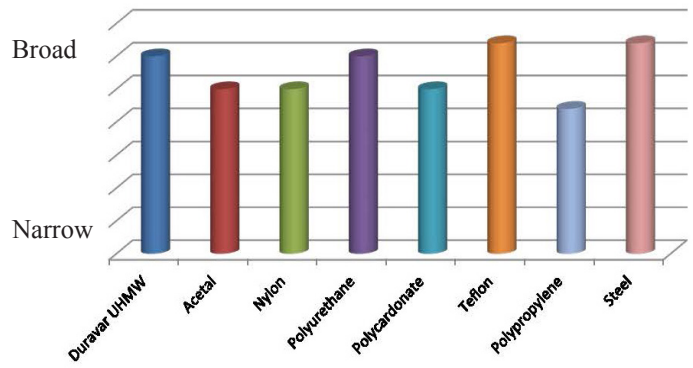
Duravar UHMW is almost completely inert to chemical attacks. At room temperature, it is unaffected by a large number of solvents. Duravar UHMW is dissolved by solvents such as aromatic and halogenated hydrocarbons and decahydronphthalene.

Check out the expanded chemical resistance chart listed on pages 6 through 8.

Cost Effectiveness of UHMW-PE

When compared to other engineering materials, the combination of excellent physical properties of High Abrasion Resistance, Low Coefficient of Friction, Excellent Impact Resistance, and Self-Lubricating/Non-Stick Properties make UHMW-PE the cost effective solution in resolving Industrial Application problems.





Operating Temperature Range of UHMW-PE

In application, Virgin Natural UHMW-PE can operate at a continuous temperature up to 180° F and in applications with intermittent temperature spikes up to 220° F. Enhanced formulations are available that allow UHMW-PE to perform in applications where the temperature ranges up to 300°F. UHMW-PE also performs very well in colder temperature applications and does not demonstrate signs of degradation at cryogenic temperatures (-452°F).

DURAVAR®
Characteristics Report II
Ultra-High Molecular Weight Polyethylene

DYNAMIC COEFFICIENT OF FRICTION ON POLISHED STEEL					
PROPERTIES	UHMW-PE	NYLON 6	NYLON 6/6	PTFE	ACETAL
Dry	0.10 - 0.22	0.15 - 0.40	0.15 - 0.40	0.04 - 0.25	0.15 - 0.35
Water	0.05 - 0.10	0.14 - 0.19	0.04 - 0.08	0.04 - 0.08	0.10 - 0.20
OIL	0.05 - 0.08	0.02 - 0.11	0.04 - 0.05	0.04 - 0.05	0.05 - 0.10

DEFORMATION UNDER COMPRESSION - %								
	PSI	Initial Loading					Permanent Deformation After Removal of Load	
Temp °F	Compression	10 Min.	100 Min.	1000 Min.	1 Day	56 Days	After 1 Min.	After 24 Hrs.
68°	282	1.5	1.7	1.8	1.9	2.4	0.9	0.6
	570	2.4	2.5	2.7	3.0	4.0	1.8	1.2
	850	3.0	4.0	4.5	5.0	5.1	2.7	1.8
	1140	4.0	5.0	6.0	7.0	7.5	3.6	2.4
	1420	5.0	6.5	7.5	8.0	9.0	4.5	2.9
	1700	7.0	7.5	8.0	10.0	11.0	5.4	3.5
122°	282	1.6	1.8	2.0	2.5	2.6	1.3	0.8
	570	2.6	3.0	3.5	4.0	5.0	2.7	1.5
	850	4.5	5.0	5.5	6.0	7.5	4.1	2.3
	1140	6.0	7.0	8.0	9.0	11.0	5.5	3.1
	1420	7.5	9.0	10.0	11.0	14.0	6.9	3.9
	1700	9.0	11.0	12.0	13.0	16.0	8.2	4.7
176°	282	2.5	3.0	3.5	4.0	4.5	1.6	1.1
	570	5.0	5.5	6.0	6.5	8.0	3.2	2.3
	850	7.5	8.0	9.0	10.0	12.0	4.8	3.5
	1140	10.0	11.0	12.5	14.0	15.5	6.4	4.6
	1420	12.5	14.0	15.5	17.0	20.0	8.1	5.8
	1700	15.0	17.0	18.0	20.5	24.0	9.7	6.9

DURAVAR®
Characteristics Report III

Ultra-High Molecular Weight Polyethylene

Information Provided By Various UHMW - PE Resin Suppliers and Processors

The phenomenal abrasion resistance and low coefficient of friction of Ultra-High Molecular Weight Polyethylene makes it the leading candidate for resisting premature wear in slide abrasion applications. The traditional Sand-Slurry Test, utilized by many industries to measure wear, provides ample evidence of the remarkable wear properties of UHMW-PE.

Tests were conducted with a variety of materials for a period of 24 hours at a speed of 1,750 rpm. in a 50/50 sand/water slurry. Carbon Steel was assigned an abrasion rating of 100, based on the volume of material lost during the test; results of the materials tested are displayed below by performance rank. The lower the figure, the better the wear properties of the material tested. The following chart clearly indicates the superior abrasion resistance of components made with UHMW-PE.

Abrasion Resistance

Product	Result	Product	Result	Product	Result
UHMW-PE	15	Polycarbonate	96	Polysulfone	300
Nylon 6-6	31	Carbon Steel	100	Yellow Brass	400
Polyurethane (D-70)	37	Polyacetal	110	LDPE	530
PTFE	72	Polypropolene	190	Maple Wood	690
Stainless Steel (304)	84	Phosphor Bronze	190	Neoprene Rubber (hard)	800
HDPE	86	Phenolic Laminate LE	200	Hickory Wood	950

Coefficient of Friction

UHMW-PE has a lower coefficient of friction than glass. Together with its self-lubricating properties, it is an ideal candidate for sliding contact applications.

Materials	Static	Kinetic	Test Method
Mild Steel vs. Mild Steel	0.30 - 0.40	0.25 - 0.35	---
Mild Steel vs. UHMW-PE	0.15 - 0.20	0.12 - 0.20	ASTM D-1894
UHMW-PE vs. UHMW-PE	0.20 - 0.30	0.20 - 0.30	---

Duravar®
Machining Guidelines I - Options
Ultra-High Molecular Weight Polyethylene

When machining Duravar UHMW, it is important to use sharp tools to create a high quality surface finish. Carbide tipped wood or metal cutting tools are recommended for machining Duravar.

Planing: Duravar UHMW - PE Flat Stock

Duravar UHMW flat stock can be successfully planed utilizing Standard Wood Planers or Metal Shapers. When using sharp Carbide Tipped Blades, either devices can be operated at high speeds.

Turning: Duravar UHMW - PE Round Stock

Duravar UHMW can be turned without difficulty on conventional Wood-Working or Metal-Working Lathes. Cooling is not usually necessary, but adequate care is required to assure the removal of all chips. When cutting depth is excessive, compressed air or water spray may be required to minimize local heat build-up. Tool speed, feed rates, and tool type will determine the surface finish.

Milling: Duravar - UHMW - PE Components

Standard machines can be employed in fabricating shapes from Duravar UHMW stock. Milling equipment with horizontal, vertical, angle, and arc-milling devices, promote economical production on a large scale. Milling tools with coarse pitch are recommended for best possible chip removal.

Cutting: Duravar - UHMW - PE Flat & Bar Stock

Duravar UHMW can be cut with standard Band Saws and Circular Saws. A sharp wide-tooth spacing of 1/8" to 3/16" is recommended to allow chip removal during the cutting process. Band Saws are preferable for cutting heavy cross-sections since the blade carries off heat, thus promoting higher cutting speeds with no auxiliary cooling. When using Circular Saws for fabrication, Tungsten Carbide Blades are recommended. Typically, high cutting speeds produce a cleaner saw cut finish.

Drilling: Duravar - UHMW - PE Components

Twist Drills are most commonly used when drilling Duravar UHMW, but for larger diameter holes, circular cutters are acceptable. Providing allowances for good chip removal will minimize local overheating of the tool and material in most cases. If cooling is necessary at high cutting speeds, it can be achieved with compressed air or water spray. If coolants are not used, the drill should be removed from the hole frequently to clean out the chips and prevent overheating.

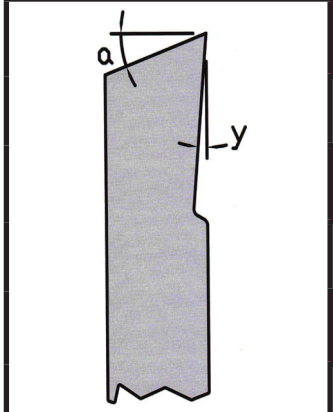
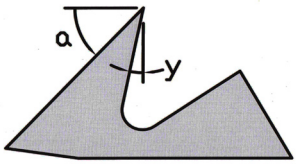
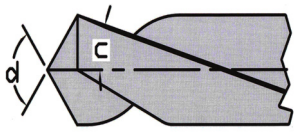
DURAVAR®

Machining Guidelines II - Tooling

Ultra-High Molecular Weight Polyethylene

Duravar UHMW - PE is available in a full range of standard blocks, sheets, and rod stock configurations for fabricating and machining into an array of dimensionally stable component parts. It can be easily cut, milled, turned, planed, or drilled on equipment used for wood or metal fabricating.

Recommended Machining & Tool Geometry for Duravar UHMW - PE

Tool Geometry	Machining Method	Cutting Speed ft./min	Feed Rate in./rev.	Rake Angle y, °	Clearance Angle a, °
	**Planing Operations**				
		8,000 - 12,000	0.012 - 0.030	20	15 - 20
	Turning Operations				
		600 - 1,300	0.004 - 0.020	0 - 25	5 - 30
	Milling Operations				
		600 - 12,000	0.010 - 0.030	10 - 15	10 - 20
	**Cutting Operations**				
	Band	3,000 - 6,000	0.0008 - 0.0040 (1)	5 - 8	15
	Circular	3,000 - 13,000	0.0008 - 0.0040 (1)	0 - 15	10 - 15
	**Drilling Operations (2) Hole Diameter in.**				
	< 0.8	150 - 500	0.004 - 0.012	60	10 - 20
	0.8 - 1.6	150 - 500	0.004 - 0.012	120	10 - 15
	> 1.6	150 - 500	0.004 - 0.012	140	10 - 15

* Helix Angle y^2 at the Chisel Edges
** Clearance Angle Measured at the Chisel Edges

Notations: *(1) in./tooth* *(2) Helix Angle (c), 10 - 30 °* *(3) Angle of Point (d), °*

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Machining Guidelines III - Common Causes

Ultra-High Molecular Weight Polyethylene

Machining Difficulties & Causes

Drilling

Difficulty	Common Cause
Tapered Hole	1. Incorrectly Sharpened Drill Bit 2. Insufficient Clearance 3. Feed Too Heavy
Burnt, Melted Surface	1. Incorrectly Sharpened Drill Bit 2. Feed Too Light 3. Drill Bit Dull
Chipping of Surfaces	1. Feed Too Heavy 2. Clearance Too Great 3. Too Much Rake
Chatter	1. Too Much Clearance 2. Feed Too Light 3. Too Much Rake
Spiral Lines On Inside Diameter	1. Feed Too Heavy 2. Drill Bit Not Centered 3. Drill Bit Ground Off-Center
Oversize Hole	1. Drill Bit Ground Off-Center 2. Web Too Thick 3. Insufficient Clearance 4. Feed Rate Too Heavy
Undersize Hole	1. Drill Bit Dull 2. Too Much Clearance 3. Point Angle Too Small
Holes Not Concentric	1. Spindle Speed Too Slow 2. Drill Speed Too Heavy At Start 3. Drill Bit Not Sharpened Correctly
Burr at Cut-Off	1. Cut-Off Tool Dull 2. Drill Bit Does Not Pass Completely Through Material
Rapid Dulling of Drill Bit	1. Feed Too Light 2. Spindle Speed Too Fast 3. Insufficient Cooling Lubrication

Cutting Off

Difficulty	Common Cause
Melted Surface	1.Tool Dull 2. Insufficient Side Clearance 3. Insufficient Coolant Supply
Rough Finish	1. Feed Too Heavy 2. Tool Improperly Sharpened 3. Cutting Edge Not Honed
Spiral Marks	1. Tool Rubs During Its Retreat (use same fall on cam as rise) 2. Burr On Point Of Tool
Nibs or Burrs at Cut-Off Point	1. Point Angle Not Great Enough 2. Tool Dull or Not Honed 3. Feed Too Heavy
Burrs on Outside Diameter	1. No Chamfer Before Cut-Off 2. Tool Dull

Turning & Boring

Difficulty	Common Cause
Melted Surface	1. Tool Dull or Heel Rubbing 2. Feed Rate Too Slow 3. Spindle Speed Too Fast
Rough Finish	1. Feed Too Heavy 2. Incorrect Clearance Angle 3. Sharp Point On Tool
Burrs at Edge of Cut	1. Tool Dull 2. Insufficient Side Clearance 3. Lead Angle Not Provided on Tool
Chatter	1. Too Much Nose Radius on Tool 2. Tool Not Mounted Solidly Enough 3. Material Not Supported Properly

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Expansion & Contraction I - Calculations

Ultra-High Molecular Weight Polyethylene

Duravar ® Ultra-High Molecular Weight Polyethylene (UHMW-PE) has a High Linear Thermal Expansion/Contraction Rate. Like other engineering polymer materials, Duravar will expand (*grow*) when subjected to increasing temperatures and contract (*shrink*) during decreasing temperatures. Duravar UHMW is cut to size within the Artek facility at an approximate temperature range of 75˚ to 85˚ F. To calculate the expansion (*growth*) or contraction (*shrinkage*) of the Duravar UHMW material at various temperatures, utilize the formulas listed in the example boxes below.

Application Criteria Example:

Item # 1: Material is Duravar Virgin UHMW Flat Stock that is cut to 120" lengths within the Artek facility at a temperature range of 75° to 85° F.

Item # 2: Determine what the expansion length of the 120" long Duravar Flat Stock Material will be if the temperature increases to 110° F during the application. Utilize the Expansion Formula displayed in Chart # 1.

Item # 3: Determine what the contraction length of the 120" long Duravar Flat Stock Material will be if the temperature decreases to 55° F during the application. Utilize the Contraction Formula displayed in Chart # 2.

Expansion Formula: .0001" x Length of Part (in.) x Total Temperature Degree Change

(Expansion Formula) x (Material Length) x (Temperature Increase/Change) = (Expansion Value)

(.0001") x (120") x (30° F) = (+ .360") or (120.36" Long)

Based on the provided data, this 120" Long Duravar Flat Stock Material will expand or grow to a maximum application length of 120.36" Long.

Contraction Formula: .000078" x Length of Part (in.) x Total Temperature Degree Change

(Contraction Formula) x (Material Length) x (Temperature Decrease/Change) = (Expansion Value)

(.0001") x (120") x (-25° F) = (- .234") or (119.76" Long)

Based on the provided data, this 120" Long Duravar Flat Stock Material will contract or shrink to a minimum application length of 119.76" Long.

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Expansion & Contraction II - Reference

Ultra-High Molecular Weight Polyethylene

Duravar UHMW is cut to size in the factory at an approximate temperature range of 75˚ to 85˚ F When subjected to temperatures varied from the base factory temperature, the Duravar UHMW material will grow as the temperature rises and shrinks as the temperature cools. Review the example charts below to determine Duravar's rate of expansion and contraction at various temperatures.

Expansion Example:

0.0001	Expansion Code x Length of Part in Inches x Total Degree Change = Expansion						
Standard Length	**(+) Degree °F 10**	**(+) Degree °F 20**	**(+) Degree °F 30**	**(+) Degree °F 40**	**(+) Degree °F 50**	**(+) Degree °F 60**	**(+) Degree °F 70**
240	0.24	0.48	0.72	0.96	1.20	1.44	1.68
144	0.14	0.29	0.43	0.58	0.72	0.86	1.01
120	0.12	0.24	0.36	0.48	0.60	0.72	0.84
96	0.10	0.19	0.29	0.38	0.48	0.58	0.67
72	0.07	0.14	0.22	0.29	0.36	0.43	0.50
60	0.06	0.12	0.18	0.24	0.30	0.36	0.42
48	0.05	0.10	0.14	0.19	0.24	0.29	0.34

Contraction Example:

0.000078	Contraction Code x Length of Part in Inches x Total Degree Change = Contraction						
Standard Length	**(-) Degree °F -10**	**(-) Degree °F -20**	**(-) Degree °F -30**	**(-) Degree °F -40**	**(-) Degree °F -50**	**(-) Degree °F -60**	**(-) Degree °F -70**
240	(0.19)	(0.37)	(0.56)	(0.75)	(0.94)	(1.12)	(1.31)
144	(0.11)	(0.22)	(0.34)	(0.45)	(0.56)	(0.67)	(0.79)
120	(0.09)	(0.19)	(0.28)	(0.37)	(0.47)	(0.56)	(0.66)
96	(0.07)	(0.15)	(0.22)	(0.30)	(0.37)	(0.45)	(0.52)
72	(0.06)	(0.11)	(0.17)	(0.22)	(0.28)	(0.34)	(0.39)
60	(0.05)	(0.09)	(0.14)	(0.19)	(0.23)	(0.28)	(0.33)
48	(0.04)	(0.07)	(0.11)	(0.15)	(0.19)	(0.22)	(0.26)

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Profile & Component Design I - Check List

Ultra-High Molecular Weight Polyethylene

Application Information:

- What is the function of the part and how does the application operate?
- What are the desirable material properties?
- What is the existing material and why is it being changed out?
- Can the design be revised or simplified?

Electrical Considerations:

- Are Insulation Characteristics a consideration in this application?
- Are Conductivity Characteristics a consideration in this application?
- Are Static Reduction Characteristics a consideration in this application?

Mechanical Considerations:

- Is Abrasion (High Wear Characteristics) a consideration in the application?
- Is Friction (Slippery Surface Characteristics) a consideration in the application?
- Is Impact (Direct or Glancing Blow Characteristics) a consideration in the application?
- Which Dimensions & Tolerances are most critical to the application for optimum performance?

Appearance Considerations:

- Configuration - Style and/or Shape?
- Color Requirements - Natural, Standard Color, or Color Match?
- Surface Finish Requirements - As Extruded or Machined Acceptable?

Environmental Considerations:

- Operating Temperature Range - Highest Temperature, Lowest Temperature, Lengths of Time?
- Sunlight Exposure - Is the application in direct sunlight, some sunlight, no sunlight?
- Inclement Weather Conditions - Is the application environment Dry or Wet with Direct/Indirect Exposure?
- Chemical Exposure - Do chemicals play a role in the application?

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Profiles & Components II - Design Criteria

Ultra-High Molecular Weight Polyethylene

Company Information	
Company Name :	Origination Date :
Contact Name :	Contact Title :
Address :	
City, State, Zip :	
Phone Number :	Fax Number :
Email Address :	

Please describe the application and requirements of the Extruded Profile or Fabricated Component: _____

_____

_____

Part Name: _____ Part Number: _____

Duravar UHMW Material: Virgin _____ Reprocessed _____ Color Requirement: _____

Estimated Annual Usage: _____ Quantity Per Release: _____

This Profile/Component is a: Prototype_____ Redesign_____ Current Design_____ New Design_____

If this Profile/Component is a current design, why is a change in manufacturer being considered? _____

_____

Design Considerations Required	
Physical Property	Importance
Abrasion Resistance Required?	
Coefficient of Friction Required?	
Impact Resistance Required?	
Moisture Resistance Required?	
Chemical Resistance Required?	
Operating Temperature Required?	
Outside Application Required?	

Sketch Design with Dimension Area Provided - Attach a formal drawing or print to this form if available.

Special Notations: _____

_____

Application Information

Where is Duravar UHMW-PE Utilized?

Duravar UHMW-PE is used in a large variety of industries for many applications to solve the day to day problems incurred during operation. Undoubtedly, there are many other applications and industries other than those cited.

Shipping, Handling & Storing Industry

Wet or frozen materials can be difficult to move. Duravar UHMW-PE prevents wet or frozen material from sticking to equipment. Moisture causes many materials to stick to steel, but with Duravar, they move easily, without hang up. Your rail fleet will operate better with maintenance parts of Duravar, which resists abrasive and corrosive dust environments. Conveyor belt return rollers do not build up with wet or frozen product when they are sleeved with Duravar. Both wet and dry materials discharge faster and more easily from storage equipment lined with Duravar.

Applications:

Chain Guides
V-Roller Sleeves
Chute Liners
Discharge Gates
Chain Idlers
Chain Sprockets
Distributors
Fifth-Wheel Liners
Chain Wear Plates
Rollers
Gates
Yoke Wear Plates
Return Roller Sleeves
Belt Guides
Guides
Coupled Wear Plates

Aggregate - Sand & Gravel Industry

The prime advantage afforded by Duravar UHMW-PE in handling aggregate and sand is that it facilitates the flow of smooth and fine aggregate and wet sand, which would normally stick to metal surfaces. In addition, Duravar will reduce or eliminate corrosion and equipment wear.

Applications:

Bucket Conveyors
Conveyor Belt Rollers
Filter Scrapers
Rope Guides
Shaker Screen Guides
Chain Guides
Belt Scrapers
Filter Wipers
Rope Pulleys
Filter Guide Shoes
Chain Wear Plates
Belt Wiper Blades
Idler Pulleys
Filter Liners
Wear Bars & Plates
Chain Sprockets
Filter Plates
Idler Rollers
Shaker Screen Bar
Wear Guides

Farm Machinery Industry

Because it is often stored outdoors and exposed to the weather, agricultural machinery benefits from self-lubricating, long-lasting parts that do not corrode or freeze, even on rusty shafts and ways. Non-corrosive, non-stick characteristics make Duravar UHMW-PE ideal for contact with seed, feed, fertilizers, and wet harvest products.

Applications:

Belt Guide Rollers
Loader Liners
Chain Guides
Wiper Blades
Belt Idlers & Pulleys
Mixer Paddles
Conveyor Flights
Seals & Bearings
Flow Guides
Star & Bogey Wheels
Bushings & Bearings
Chain-Tensioning Blocks
Chutes & Hoppers
Chain Wear Plates
Sprockets

Solid - Waste Handling Industry

Solid waste is often corrosive and very abrasive, especially if it contains corrosive chemicals, glass and metal scrap. In a solid-wast handling system, moisture is often present, making movement of the material difficult. Duravar UHMW-PE allows the wet waste to slide more easily without sticking. It is more resistant than stainless steel to corrosion from a variety of strong chemicals and its abrasion resistance gives excellent service life. Trucks, trailers, hoppers and bin liners with parts made of Duravar unload quietly.

Applications:

Bucket Liners	*Truck Liners*	*Trailer Liners*	*Bin Liners*
Bulk Conveyor Rollers	*Hopper Liners*	*Chutes*	*Sluices*
Wiper Blades	*Scraper Blades*	*Compactor Surfaces*	*Chain Wear Plate*
Chain Sprockets	*Conveyor Flights*	*Drag Line Bucket Liners*	*Guide Rails*

Ore & Mineral Mining Industry

For direct mining, both surface and underground and processing operations, Duravar UHMW-PE increases productivity by reducing sticking, holdup, and bridging. Its lubricity speeds product flow and movement. Underground mechanical operations are quited with Duravar on areas subject to rubbing and impact. Surfaces lined with it require no lubrication and are virtually unaffected by dust and dirt buildup. Duravar also lessens energy requirements and deadens noise.

Drag bucket liners easily release product and overburden in wet or freezing conditions, and this results in higher bucket output and lower energy costs. Slurry pump parts and pipe liners made of Duravar reduce wear on parts and pipes, increase flow, and cut energy requirements.

Applications:

Guide Belt Scrappers	*Belt Rollers*	*Idlers & Pulleys*	*Sprockets*
Chain Wear Plates	*Scrapers & Wipers*	*Conveyor Bucket Liners*	*Agitators*
Guides & Skirt Boards	*Liners & Plates*	*Impact Pads & Bumpers*	*Shoes & Tracks*

Food & Beverage Handling Industry

Food and Beverage equipment parts are made of Duravar UHMW-PE because of its outstanding abrasion and impact resistance. Use of Duravar UHMW-PE increases the life of handling equipment and also contributes significantly to clean low-maintenance, low-energy, low-cost operations. Duravar has a non-stick surface and parts are self-lubricating, requiring no containment grease or oil.

In addition, they are unaffected by steam cleaning, even when harsh detergents are used. For indoor operations, parts made with Duravar provide the added benefit of reduced noise levels. Duravar meets FDA requirements and is accepted by the USDA for poultry and meat contact.

Applications:

Bearing Blocks & Seals	*Chute Liners*	*Cable & Chain Guides*	*Chain Wear Plates*
Conveyor Guides	*Dough Bins*	*Conveyor Rollers*	*Filter Press Plates*
Mixer Liners	*Mixer Paddles*	*Overhead Conveyor Wheels*	*Tabletop Guides*
Bearing Shields	*Bottle Fillers*	*Bottle Labeler*	*Bottle Cappers*
Bottle Plates	*Bottle Re-Setter*	*Bumper Blocks*	*Rollers*
Belt Wipers	*Worm Screws*	*Guards & Guides*	*Corner Plates*

Packaging Machinery Industry

Tobacco, cosmetic, pharmaceutical, and drug packaging machines operate cleanly and without contamination from product residue, lubricants, rust or corrosion when they are made with Duravar UHMW-PE parts. Such parts perform many useful functions and reduce operating energy costs and maintenance costs; moving parts need no lubricants; guide parts slide easily without staining or sticking; drive parts outwear those made of stainless steel and cost less; and cleaning with live steam and strong detergents causes no problems. Parts made with Duravar are safe and sanitary and have FDA clearance and USDA acceptance for food contact.

Applications:

Air Conveyor Pipes	*Bearings*	*Bearing Blocks*	*Bearing Seals*
Bumper Blocks	*Cam Guides*	*Chain Covers*	*Chain Guides*
Chain Wear Plates	*Chute Linings*	*Chutes*	*Conveyor Belt Wipers*
Conveyor Guides	*Conveyor Rollers*	*Feed Screws*	*Feeder Arm Tips*
Glue Sealer Surfaces	*Hopper Linings*	*Guide Plates & Rails*	*Rollers*

Aeration, Chemical & Biological Treatment Industry

Duravar UHMW-PE, the most abrasion resistant plastic, is resistant to a wide variety or harsh, chemically corrosive environment such as 80 sulfuric acid, 37% hydrochloric acid, concentrated caustic soda (sodium hydroxide) and concentrated Clorox bleach (sodium hypochlorite). In addition, Duravar has outstanding environment stress-crack resistance. Combine these good corrosion-resistant properties with the low friction, self-lubricating properties of Duravar UHMW-PE and it is obvious that this plastic should be used in wastewater, chemical, and biological treatment equipment.

Applications:

Valve Plugs & Seals	*Valve Liners*	*Pump Housings*	*Gear Pump Gears*
Pump Impellers	*Filter Plates*	*Filter Frames*	*Filter Wiper Blades*
Pipe Fittings	*Tubing*	*Mixer Impellers*	*Mixer Baffles*
Mixer Liners	*Mixer Paddles*	*Doctor Blades*	*Feeder Chutes*
Conveyor Augers	*Flanges & Gaskets*	*Level Indicator Floats*	*Centrifuge Liners*

Forestry Industry

Duravar UHMW-PE's low friction, high resistance to abrasion and exceptional toughness make it a good choice for wear and material flow applications in the sawmill and wood industries. Logs can cause significant wear on conveying equipment and chains & flights can wear out quickly. Holes can also develop in steel pans and chutes. duravar, which outlasts AR steel in most applications, can extend the life of conveying equipment. In addition, Duravar offers sound abatement benefits, where it can reduce the noise of a dragging chain by 20 decibels.

Applications:

Log Conveyor Lines	*Chip & Bark Hoppers*	*Trimmer Sticks*	*Chutes*
Chip Conveyor Liners	*Bumper Blocks*	*Chain Guides*	*Doctor Blades*
Chip Conveyor Flights	*Pulp Paddles*	*Roller Bearings*	*Idlers*
Guide Rollers	*Suction Box Covers & Liners*	*Saw Guides*	*Drag Flights*
Bark Conveyor Liners	*Wood Chip Hoppers*	*Conveyor Flights*	*Sprockets*

Coal Shipping & Storage

Wet or frozen coal is difficult to handle and ship. Duravar UHMW-PE liners keep it from sticking. Antifreeze can make wet coal hard to handle, but Duravar liners prevent handling problems. Conveyor buckets, bin chutes, and railcars lined with Duravar make coal handling more efficient by providing easy release, reducing corrosion and wear, and lowering labor and maintenance costs. In cold weather, wet coal will not cake on the surface of return conveyor belt rollers lined with Duravar.

Coal Machinery

Duravar UHMW-PE can improve machinery life by reducing wear and corrosion. Whenever metal rubs against metal there is noise, friction, and wear. The use of Duravar wear pads will eliminate noise and reduce wear and friction. When two metal surfaces impact, there is noise and potential failure. Duravar UHMW-PE pads can take the impact and eliminate noise and metal fatigue. Chains running on wear plates of Duravar do not require lubrication, the plate does not wear or squeak, and the chain does not wear out.

Coal Mining

For direct mining operations, whether surface or underground, the use of Duravar UHMW-PE will increase productivity by preventing sticking and bridges by speeding movement and flow and by reducing noise and machinery downtime. Machinery maintenance can be reduced by eliminating lubrication requirements. Energy saving can be provided by reducing friction and thermal losses. Slurry pumping can be improved with pipe liners of Duravar UHMW-PE to resist wear and reduce pumping, energy, and noise.

Coal Preparation

Duravar UHMW-PE can provide lower coal preparation costs by reducing sticking and bridging, even with fine wet coal. Liners for processing tanks will reduce corrosion, wear, and sticking. Screening, conveying, and handling operations can be made quieter and more energy-efficient by reducing friction and thermal losses. Slurry streams can be pumped with less energy and virtually no wear losses.

Applications:

Belt Conveyor Rollers
Conveyor Belt Scrapers
Bearings & Bushings
Filter Wipes
Chain Wear Plates
Conveyor Guide
Filter Guide Shoes
Froth Cell Liners
Shaft Protectors
Guides & Skirt Boards
Bucket Liners
Railcar Couplers
Belt Scrapers
Impact Pads
Hydraulic Seals
Filter Plates
Floats
Diffusers
Bin Liners
Wiper Rollers
Chute Liners
Wear Plates
Chain Guides
Chain Tensioning Blocks
Wear Bars
Scrappers
Screen Bars & Guides
Slurry Bars & Guides
Picking Belt Rollers
Idler Sleeves
Gate Guides
Hopper Gates
Guide Strips
Wiper Blades
Conveyor Wheels
Exhaust Nozzles
Flume Liners
Launder Lines
Scrappers Bearings
Rope Guides & Pulleys

Concrete Industry

The major problems in making and handling concrete mixes are flow and clean-up. Duravar UHMW-PE liners can make your concrete mixes flow easily out of the truck, down the chute and into the form. Additionally, UHMW liners make concrete-handling equipment easy to clean up. No chipping or scraping with Duravar. The mix washes off easily even when it sets up.

Applications:

Wiper Blades & Scrapers
Chain Wear Plates
Bunker Linings
Chain Sprockets
Chain & Wear Guides
Wear Bars & Plates
Conveyor & Idler Rollers
Rope Guides & Pulleys

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