

UHMW (Ultra High Molecular Weight Polyethylene) Technical Material Specification

1.0 Material Overview & Common Uses

UHMW (Ultra High Molecular Weight Polyethylene) is a linear polyethylene with a molecular weight typically between 3.1 and 5.67 million g/mol, making it one of the toughest and most wear-resistant thermoplastics available. It is characterized by extremely high impact strength, low coefficient of friction (self-lubricating), excellent chemical resistance, and outstanding abrasion resistance, often outperforming steel in sliding wear applications.

- Common industrial applications include: conveyor wear strips, chute liners, guide rails, star wheels, food processing cutting boards, medical prosthetics (e.g., hip and knee joint components), marine dock bumpers, and bulk material handling equipment.
- UHMW is non-toxic, non-stick, and FDA/USDA compliant for direct food contact, making it a staple in food and beverage processing lines.
- It is also used in high-abrasion environments such as mining, aggregate handling, and recycling facilities due to its ability to resist sliding wear and impact.

2.0 Core Technical Properties & Sizing

- Density: 0.930 – 0.945 g/cm³ (typical range for standard grades)
- Molecular Weight: 3.1 – 5.67 million g/mol (UHMW-PE classification)
- Melting Point: 130 – 136 °C (crystalline melting range)
- Continuous Service Temperature: -200 °C to +80 °C (short-term peaks up to +120 °C)
- Tensile Strength at Yield: 20 – 25 MPa (depending on grade and orientation)
- Elongation at Break: 300 – 500% (indicating high ductility)
- Impact Strength (Izod, notched): No break (typical) – exceptionally high impact resistance
- Coefficient of Friction (dynamic, against steel): 0.10 – 0.20 (self-lubricating)
- Abrasion Resistance (Taber, CS-17 wheel, 1000g load): < 20 mg loss per 1000 cycles
- Water Absorption: < 0.01% (24-hour immersion) – virtually zero moisture uptake
- Standard Sheet Sizes: 48" x 96" (1220 mm x 2440 mm), 48" x 120" (1220 mm x 3050 mm), 60" x 120" (1525 mm x 3050 mm)
- Standard Thickness Tolerances (per ASTM D4020): ±0.010" for thicknesses up to 0.250", ±0.015" for 0.251" – 0.500", ±0.020" for 0.501" – 1.000", ±0.030" for 1.001" – 2.000"
- Standard Rod Diameters: 0.250" – 12.000" (6.35 mm – 304.8 mm) with length tolerances of +0.125" / -0.000"
- Hardness (Shore D): 60 – 70 (typical range)
- Flammability Rating: HB (UL 94) – slow burning, self-extinguishing in some grades

3.0 Processing, Machinability & Application

UHMW is considered a challenging material to machine due to its high ductility, low melting point, and tendency to produce long, stringy chips that can wrap around tooling. It is not suitable for conventional injection molding due to its extremely high melt viscosity; it is typically processed by compression molding, ram extrusion, or direct machining from stock shapes.

- Machining requires sharp, polished carbide or high-speed steel (HSS) tooling with positive rake angles ($10^{\circ} - 15^{\circ}$) to minimize heat buildup and prevent melting or smearing.
- Recommended cutting speeds: 200 – 500 SFM (surface feet per minute) for turning and milling; use lower speeds for drilling to avoid heat generation.
- Feed rates: 0.005 – 0.020 inches per revolution (IPR) for turning; 0.002 – 0.010 inches per tooth (IPT) for milling.
- Coolant is generally not required but compressed air or a fine mist coolant can be used to clear chips and reduce heat; avoid flood coolant as it can cause thermal shock and dimensional instability.
- Drilling: Use a $118^{\circ} - 135^{\circ}$ split-point drill bit with a slow helix; peck drilling is recommended to break chips and prevent packing.
- Tapping: Use roll-form taps (thread forming) rather than cutting taps to avoid tearing the material; thread depths should be at least 1.5x the diameter for adequate strength.
- Sawing: Use a fine-tooth (10 – 14 TPI) carbide-tipped blade with a negative rake angle; band saw speeds of 3000 – 5000 FPM are typical.
- Welding: UHMW cannot be welded by conventional hot gas or ultrasonic methods due to its high molecular weight; mechanical fastening (screws, bolts, dovetail joints) or adhesive bonding (using cyanoacrylate or epoxy) is recommended.
- Gluing: Surface preparation is critical – flame treat or corona treat the surface to improve adhesion; use a two-part epoxy or polyurethane adhesive for structural bonds.
- Thermoforming: Not recommended due to extremely high melt viscosity; UHMW is typically machined to final shape rather than formed.

4.0 Common Defects & Quality Control

- Reject if visible surface cracks, crazing, or stress whitening are present under normal lighting conditions (unaided eye).
- Reject if internal voids or bubbles are detected via ultrasonic testing or visual inspection of cut edges (voids > 1.0 mm diameter are unacceptable).
- Reject if thickness variation exceeds $\pm 0.015"$ for sheets under 0.500" nominal thickness, or $\pm 0.030"$ for sheets over 0.500".
- Reject if surface contamination (oil, grease, mold release) is visible; material must be clean and free of foreign matter.
- Reject if the material exhibits a wavy or uneven surface (warpage) exceeding 0.010" per linear foot when laid on a flat reference surface.
- Reject if the material has a strong odor (indicating degradation or improper processing) or discoloration (yellowing or dark spots).
- Reject if the material fails to meet the specified molecular weight range (3.1 – 5.67 million g/mol) per ASTM D4020 testing.
- Reject if the material shows signs of delamination or separation between layers (common in compression molded sheets).
- Reject if the material has a Shore D hardness below 60 or above 70, indicating incorrect grade or processing.
- Acceptance criteria: All dimensions must be within the tolerances specified in Section 2.0; material must be free of defects listed above; a sample must pass a 180° bend test without cracking (for thicknesses up to 0.250").

5.0 Storage, Handling & WHMIS Guidelines

- Store UHMW sheets and rods in a clean, dry environment at temperatures between 10°C and 30°C ($50^{\circ}\text{F} - 86^{\circ}\text{F}$).

- Relative humidity should be maintained below 60% to prevent surface condensation, which can cause dimensional changes during machining.
- UHMW has an indefinite shelf life under proper storage conditions; no specific shelf life limit applies, but FIFO (First In, First Out) inventory rotation is recommended to avoid prolonged exposure to UV light (which can cause surface degradation).
- Store flat sheets horizontally on a flat, level surface to prevent warping; stack with protective interleaving (e.g., polyethylene film) to avoid surface scratches.
- Rod stock should be stored horizontally on racks with full-length support to prevent bending or sagging.
- WHMIS Classification: UHMW is not classified as a hazardous material under WHMIS 2015 (GHS). It is considered a non-hazardous manufactured article. However, dust generated during machining may be a nuisance particulate.
- WHMIS Hazard Statements: None for solid form. For machining dust: May cause mechanical irritation to eyes and respiratory tract. Combustible dust hazard – fine dust can form explosive mixtures in air if dispersed in sufficient concentration.
- Mandatory PPE during machining: Safety glasses with side shields, dust mask (N95 or higher) if dust is generated, and cut-resistant gloves (e.g., Kevlar or Dyneema) to protect against sharp edges.
- Ventilation: Use local exhaust ventilation (LEV) or a dust collection system when machining to control airborne dust levels below 10 mg/m³ (total dust) per ACGIH TLV.
- Fire safety: UHMW is combustible. Keep away from open flames and high-temperature sources. Use Class A or Class B fire extinguishers (water, foam, dry chemical) in case of fire.
- Spill cleanup: Solid spills are non-hazardous; sweep or vacuum (using an explosion-proof vacuum for fine dust) and dispose of in general waste. Do not flush to drains.
- First aid: For eye contact with dust, flush with water for 15 minutes. For skin contact, wash with soap and water. If dust is inhaled, move to fresh air. Seek medical attention if irritation persists.

Regulatory Disclaimer: This document is a generic technical material specification provided for educational purposes. The end-user assumes all liability for reviewing, adapting, and validating all tolerances, properties, and safety protocols against specific OEM data sheets and local regulations before deployment.