

Polyurethane vs Rubber Caster Wheels:

Materials Science and Performance Analysis for Industrial Applications

Abstract

Polyurethane caster wheels exhibit superior resistance to grease, oil, cutting, chunking, and abrasive wear compared to conventional rubber wheels due to fundamental differences in polymer chemistry and mechanical properties. However, this material superiority creates a performance paradox: polyurethane wheels support 2–3× higher static loads than equivalent rubber wheels but sacrifice rollability, floor protection, and thermal management. This white paper examines the tribology, material science, mechanics, ergonomics, and molecular mechanisms underlying polyurethane’s advantages and limitations, providing engineering justification for material selection in industrial caster applications.

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1 Executive Summary

This comprehensive analysis covers tribology, material science, mechanics, and ergonomics of polyurethane and rubber caster wheels. Key findings demonstrate that polyurethane's molecular structure provides exceptional chemical and abrasion resistance while introducing thermal management challenges that limit continuous rolling applications.

2 Chemical Resistance Mechanisms

2.1 Molecular Structure Comparison

Polyurethane backbone: Polyurethane contains urethane linkages ($-\text{NH}-\text{CO}-\text{O}^-$) connecting polymer segments, formed through reaction between polyols and diisocyanates. This creates a polar polymer with hydrogen bonding capability.

Rubber backbone: Conventional rubber consists of hydrocarbon chains (polyisoprene, polybutadiene, EPDM) with no polar functional groups. This creates a non-polar polymer structure.

2.2 Why Polyurethane Resists Oil and Grease

2.2.1 Solubility Parameter Analysis

Materials dissolve in solvents with similar polarity (like dissolves like). Hildebrand solubility parameters (δ):

- Mineral oil/grease: $\delta \approx 16.0\text{--}17.5 \text{ MPa}^{1/2}$ (non-polar)
- Rubber: $\delta \approx 16.5\text{--}17.0 \text{ MPa}^{1/2}$ (non-polar, excellent match)
- Polyurethane: $\delta \approx 19.0\text{--}21.0 \text{ MPa}^{1/2}$ (polar, poor match)

Thermodynamic consequence: When solubility parameters closely match ($\Delta\delta < 2$), significant swelling occurs. When mismatched ($\Delta\delta > 3$), minimal interaction occurs.

Rubber-oil interaction:

- $\Delta\delta \approx 0.5\text{--}1.5$ (thermodynamically favorable)
- Oil molecules diffuse into rubber matrix
- Swelling: 50–200% volume increase
- Mechanical properties degrade catastrophically
- Bond failure (tire-to-core separation) within weeks

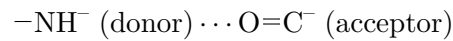
Polyurethane-oil interaction:

- $\Delta\delta \approx 2.5\text{--}4.5$ (thermodynamically unfavorable)
- Oil molecules repelled by polar urethane groups
- Swelling: 5–15% volume increase

- Mechanical properties maintained
- Bond integrity preserved for months to years

2.3 Hydrogen Bonding Network

Polyurethane's urethane linkages create hydrogen bonds between polymer chains:



Effect on chemical resistance:

- Increases cohesive energy density
- Reduces free volume for oil penetration
- Creates polar domains that repel non-polar contaminants
- Maintains dimensional stability under chemical exposure

Critical difference: Oil molecules cannot disrupt polyurethane's strong hydrogen bonding network, preventing swelling and property loss.

2.4 Animal Fat Resistance

Animal fats (triglycerides) consist of long hydrocarbon chains with slight polarity from ester groups.

Rubber failure mechanism:

- Non-polar portions penetrate rubber matrix
- Volume expansion 30–100%
- Ester groups react with unsaturated C=C bonds in rubber
- Catastrophic property degradation

Polyurethane resistance:

- Polar urethane groups repel hydrocarbon chains
- Minimal swelling (<10%)
- No reactive double bonds (saturated backbone)
- Properties maintained throughout exposure

Performance comparison in food processing environment:

- Rubber tire separation: 2–8 weeks
- Polyurethane functional life: 12–36 months

3 Cutting and Chunking Resistance

3.1 Tear Strength Fundamentals

Fracture mechanics parameter (tearing energy):

$$G_c = \text{Energy required to propagate crack through material}$$

Material comparison:

| Property | Rubber | Polyurethane |
|-----------------------|--------------------------|--------------------------|
| Tensile strength | 25–30 MPa | 35–55 MPa |
| Tear strength (Die C) | 50–100 kN/m | 80–150 kN/m |
| Fracture toughness | 3–5 MPa·m ^{1/2} | 5–8 MPa·m ^{1/2} |

Table 1: Mechanical property comparison

Polyurethane exhibits 50–100% higher tear strength despite lower ultimate elongation.

3.2 Phase-Separated Microstructure

Rubber (vulcanized):

- Homogeneous network with random sulfur crosslinks
- Crosslink density: 1–5 per 100 carbons
- Soft, extensible, but lacks reinforcing structure

Polyurethane (cast):

- Phase-separated morphology:
 - Hard segments: Rigid urethane domains (high T_g)
 - Soft segments: Flexible polyol chains (low T_g)
- Hard domains act as physical crosslinks AND reinforcing fillers
- Domain size: 5–20 nm
- Hard phase volume: 20–40%

3.3 Crack Propagation Resistance

When sharp object contacts tire:

Rubber response:

- Soft network stretches easily
- Low modulus allows deep penetration
- Once crack initiates, propagates rapidly through compliant matrix

- Result: Easy cutting, material removal

Polyurethane response:

- Hard domains act as crack arrestors
- Crack must fracture through rigid phase (high energy) OR deflect around domains (longer path)
- Phase boundaries create tortuous crack propagation
- Result: 3–5× more energy required to cut

Quantitative comparison:

Energy to cut 1 mm² cross-section:

- Rubber: 0.5–1.0 J/mm²
- Polyurethane: 2.0–4.0 J/mm²

3.4 Chunking Resistance Under Impact

Chunking: Loss of tread material from impact with sharp objects or severe deformation.

Critical material properties:

Modulus (load distribution):

- Rubber: 2–5 MPa (soft, localizes stress)
- Polyurethane: 10–50 MPa (stiff, distributes stress over larger volume)

Higher modulus reduces peak stress concentration, preventing localized fracture.

Hardness (penetration resistance):

- Rubber: 40–60 Shore A
- Polyurethane: 90–95 Shore A to 60–65 Shore D

Harder material resists gouging and penetration damage.

Practical failure scenario (metal edge impact):

Rubber: Soft material deforms around edge, high local strain (>700%), material tears, chunk removed.

Polyurethane: Stiff material distributes load, lower strain (<400%), hard domains arrest cracks, material recovers intact.

Result: Polyurethane maintains tread integrity under abuse conditions that destroy rubber.

4 Abrasive Wear Resistance

4.1 Wear Mechanisms

- **Two-body abrasion:** Wheel slides on rough floor (concrete asperities)
- **Three-body abrasion:** Loose particles (sand, metal filings) trapped between wheel and floor

4.2 Archard Wear Equation

Fundamental wear relationship:

$$V = K \times \frac{F_n \times s}{H}$$

Where:

- V = wear volume
- K = wear coefficient (material dependent)
- F_n = normal force
- s = sliding distance
- H = hardness

Critical insight: Wear inversely proportional to hardness.

Hardness comparison:

- Rubber (60 Shore A): $H \approx 8\text{--}10$ MPa
- Polyurethane (95 Shore A): $H \approx 25\text{--}30$ MPa
- Polyurethane (65 Shore D): $H \approx 150\text{--}180$ MPa

At identical loading, polyurethane experiences 3–20× less wear due to hardness advantage alone.

4.3 Phase-Separated Composite Behavior

Polyurethane's microstructure creates composite-like wear resistance:

- Hard phase resists abrasive particle penetration
- Soft phase provides toughness, prevents brittle fracture
- Phase boundaries deflect and blunt crack propagation
- Effective wear resistance = Hard phase hardness + Soft phase toughness

This combination cannot be achieved in homogeneous rubber.

4.4 Coefficient of Friction Impact

Sliding friction coefficients:

- Rubber on concrete: $\mu \approx 0.7\text{--}1.0$ (high adhesion)
- Polyurethane on concrete: $\mu \approx 0.4\text{--}0.6$ (lower adhesion)

Lower friction reduces tangential forces during rolling and sliding, decreasing abrasive wear rate.

4.5 Standardized Abrasion Testing

DIN 53516 Abrasion Test results:

Abrasion loss (mm³):

- Natural rubber: 120–180
- Conventional moldon rubber: 150–250
- Polyurethane (90–95 Shore A): 40–80
- Polyurethane (60–65 Shore D): 15–30

Polyurethane loses 3–10× less material under identical abrasive conditions.

Field performance data:

Rough concrete floor, frequent movement:

- Rubber tire life: 6–12 months
- Polyurethane tire life: 24–48 months

Polyurethane service life is 2–4× longer before tread wear necessitates replacement.

5 The Capacity Paradox

5.1 Static Load Capacity Advantage

Load capacity determined by:

- Compressive strength (resistance to crushing)
- Creep resistance (resistance to permanent deformation)
- Modulus (load distribution efficiency)

Creep compliance (time-dependent deformation):

$$J(t) = \frac{\varepsilon(t)}{\sigma}$$

Where $J(t)$ measures how much material continues deforming under constant stress over time.

Rubber creep behavior:

- Viscoelastic relaxation continues over time
- Permanent set (flat spotting) occurs at 40–60% of ultimate strength
- Crosslinked network allows molecular chain slippage

Polyurethane creep behavior:

- Hard domains lock structure, resist viscous flow
- Creep plateaus after initial deformation
- Permanent set occurs at 70–90% of ultimate strength
- Physical crosslinks remain stable under sustained load

Result: Polyurethane supports 2–3× higher static load without permanent deformation compared to rubber of equivalent size.

5.2 The Rolling Resistance Problem

Critical paradox: High static capacity ≠ High rollable capacity

Rolling resistance equation:

$$F_{\text{roll}} = C_{rr} \times F_{\text{normal}}$$

Where C_{rr} (coefficient of rolling resistance) depends on hysteresis.

Hysteresis (energy loss per deformation cycle):

Rubber:

- Hysteresis: 10–20% energy loss
- High elastic recovery (80–90%)
- Minimal heat generation

Polyurethane:

- Hysteresis: 25–40% energy loss
- Moderate elastic recovery (60–70%)
- Significant heat generation

5.3 Thermal Runaway Mechanism

Heat generation exceeds dissipation capacity:

1. High hysteresis generates heat
2. Temperature increases (+50–80°C)
3. Modulus decreases (material softens)

4. Increased deformation depth
5. More material flexing per revolution
6. Accelerated heat generation
7. Further temperature rise
8. Positive feedback loop → thermal runaway

Consequences:

- Bond strength degrades above 80°C
- Adhesive failure risk (tire-to-core separation)
- Functional failure within hours

This explains the warning: “Do not use any polyurethane wheel in a constant rolling application.”

6 Floor Protection Analysis

6.1 Definition of Floor Protection

Truly floor protective materials must:

- Cushion impacts: Absorb shock energy in tire deformation
- Provide compliance: Distribute load over large contact area
- Offer high resilience: Rapid recovery prevents repeated hammering

6.2 Impact Force Transmission

Impact scenario (wheel drops onto concrete):

Kinetic energy must be absorbed by wheel deformation OR transmitted to floor as damaging force.

Force-deflection relationship:

$$F_{\text{peak}} = \frac{E_{\text{kinetic}}}{\delta_{\text{deformation}}}$$

Where smaller deformation (δ) creates higher peak force.

Soft rubber response:

- Deep compression (8–12 mm deflection under impact)
- Absorbs 80–90% of energy in elastic tire deformation
- Peak force low (large denominator in equation)
- Floor experiences minimal stress

- Floor protection: Excellent

Polyurethane response:

- Minimal compression (2–4 mm deflection)
- Absorbs only 40–60% of energy
- Remaining 40–60% transmitted to floor
- Peak force high (small denominator)
- Floor experiences 2.5–4× higher stress
- Floor protection: Moderate

Hard tread (phenolic, metal) response:

- Negligible compression (<1 mm)
- Absorbs <10% of energy
- 90%+ transmitted to floor
- Peak force very high
- Floor damage severe
- Floor protection: None (destructive)

6.3 The “Jack Hammer” Effect

Repeated rolling over rough surfaces:

Each irregularity (crack, pebble, expansion joint) creates impact.

Soft rubber:

- Tire deforms around obstacle
- Energy absorbed gradually
- Slow rebound (high damping)
- Floor experiences distributed force application

Polyurethane:

- Limited deformation
- Wheel “bounces” over obstacle
- Faster rebound (moderate damping)
- Floor experiences sharp, repeated impacts

Long-term floor degradation (10,000 wheel passes):

- Soft rubber: Minimal wear, no cracking
- Polyurethane: Surface erosion, micro-crack initiation
- Hard tread: Severe spalling, structural damage

Practical application guidance:

Polyurethane is less damaging than hard tread wheels but harder than soft rubber. Select based on priority:

- Floor preservation critical → Use rubber
- Chemical resistance critical → Use polyurethane (accept floor wear)
- Maximum floor destruction → Avoid both (use metal)

7 Standing Load Performance

7.1 Viscoelastic Creep Under Constant Stress

Standing load: Constant force applied without movement for extended periods.

All polymers exhibit time-dependent deformation:

$$\varepsilon(t) = \varepsilon_0 + \text{Creep term}$$

Rubber (crosslinked elastomer):

- Covalent sulfur crosslinks prevent infinite flow
- Creep reaches plateau
- Relaxation time: $\tau \approx 10\text{--}100$ hours
- Permanent set at 80% capacity: 5–10% (largely recoverable)

Standard polyurethane (physical crosslinks):

- Hard domains can rearrange under sustained stress
- Soft phase undergoes viscous flow between hard domains
- Relaxation time: $\tau \approx 1\text{--}10$ hours (faster than rubber)
- Permanent set at 80% capacity: 15–30% (partially recoverable)

Flat spotting consequence:

After 24 hours under load:

- Rubber: Minor flat spot, minimal rollability impact
- Standard polyurethane: Pronounced flat spot, severe rollability degradation

General rule: Standard polyurethane NOT suitable for standing loads.

7.2 Extra Heavy Duty Formulation Solution

Material modifications for standing load capability:

Higher durometer formulation:

- Standard: 90–95 Shore A (\approx 45–50 Shore D)
- Extra heavy duty: 60–65 Shore D
- Shore D is different scale measuring harder materials. 65 Shore D \gg 50 Shore D.

Modulus comparison:

- Standard polyurethane: $E \approx$ 25–35 MPa
- Extra heavy duty: $E \approx$ 150–200 MPa
- 5–6 \times higher modulus dramatically reduces creep deformation

Hard segment volume fraction:

- Standard formulation: 25–35% hard phase
- Extra heavy duty: 40–50% hard phase
- More hard phase = more physical crosslinks = superior creep resistance

Structural reinforcement:

- Thicker tire (3/4" vs standard 1/2")
- Extra thick iron core (structural support)
- Combined effect distributes load over larger volume

Standing load performance (1000 lb, 48 hours):

- Standard polyurethane: 20–35% permanent set (severe flat spotting)
- Extra heavy duty: 3–8% permanent set (minimal flat spotting)

Conclusion: Extra heavy duty formulation suitable for standing loads; standard formulation is not.

8 Bond Integrity and Failure Modes

8.1 Polyurethane-to-Core Bonding Methods

Typical bonding approaches:

- **Chemical bonding:** Adhesive primer creates covalent bonds between polyurethane and metal during casting
- **Mechanical bonding:** Textured or knurled core surface provides mechanical interlock
- **Combination method:** Both chemical and mechanical (most common, highest strength)

8.2 Failure Mode 1: Chemical Attack

Aggressive chemicals that compromise bonds:

Strong acids (pH < 2):

- Hydrolyze urethane linkages
- Mechanism: $-\text{NH}-\text{CO}-\text{O}^- + \text{H}^+ \rightarrow$ degradation products
- Bond strength loss: 40–70% over weeks

Strong bases (pH > 12):

- Saponify ester groups (if polyester-based polyurethane)
- Attack adhesive primer chemistry
- Bond strength loss: 50–80% over weeks

Concentrated solvents:

- Swell soft phase, create internal stress
- Stress concentration at bond interface
- Progressive delamination

Note: Oils and greases do NOT chemically attack polyurethane or bonds, but certain oil additives can penetrate to bond line if adhesive primer is incompatible.

8.3 Failure Mode 2: Impact Loading

Stress wave propagation:

Impact \rightarrow Compression wave through tire \rightarrow Reflects at tire-core interface \rightarrow Tensile stress at bond

If tensile stress > bond strength \rightarrow delamination initiates

Repeated impact effects:

- Fatigue crack grows along bond interface
- Progressive failure (days to weeks depending on impact severity)
- Eventually catastrophic separation

8.4 Failure Mode 3: Overloading

Excessive deformation creates shear stress:

Load > 150% rated capacity:

- Tire deforms beyond elastic limit

- Plastic (permanent) deformation
- Residual stress at bond interface
- Time-dependent creep failure
- Bond separates under constant shear load

Critical threshold: Loads exceeding 150% of rating create immediate bond failure risk.

8.5 Failure Mode 4: Heat Buildup

Thermal degradation mechanism:

Source of heat:

- Continuous rolling at high loads
- High hysteresis energy dissipation
- Inadequate heat dissipation

Thermal expansion mismatch:

- Polyurethane: $\alpha \approx 100\text{--}200 \times 10^{-6} / \text{řC}$
- Iron core: $\alpha \approx 12 \times 10^{-6} / \text{řC}$
- Temperature rise creates differential expansion, inducing interface stress

Combined thermal and mechanical stress:

Heat buildup + high load + deformation shear = accelerated bond failure

This explains continuous rolling prohibition:

Continuous operation at full capacity \rightarrow Heat generation (+50–80řC) \rightarrow Bond weakening \rightarrow Shear stress from deformation \rightarrow Bond failure (hours to days)

Safe operation requires:

- Intermittent use (allow cooling between cycles)
- Reduced loading (40–60% capacity for continuous movement)
- Adequate rest periods

9 Temperature Performance Limits

9.1 Lower Temperature Limit (–20řF / –29řC)

Glass transition temperature (T_g) consideration:

Polyurethane soft segment T_g : –50řC to –70řC (remains rubbery at –29řC)

Performance at –20řF:

- Modulus increases 2–3× (material stiffens)
- Flexibility reduced
- Rolling resistance increases (higher hysteresis at low temperature)
- Material remains functional (no brittle fracture)

Hard segments: $T_g \approx +80^\circ\text{C}$ to $+120^\circ\text{C}$ (always glassy, unaffected by cold)

9.2 Upper Temperature Limit (180°F / 82°C)

Soft phase thermal behavior:

- Modulus decreases (softening)
- Hysteresis increases (more energy loss)
- Creep accelerates (time-dependent deformation faster)

Hard phase stability:

- Well below T_g ($+100^\circ\text{C}$ for typical hard segments)
- Maintains structural integrity
- Physical crosslinks stable

Bond degradation threshold:

Most polyurethane-to-metal adhesives degrade at $90\text{--}120^\circ\text{C}$ ($194\text{--}248^\circ\text{F}$).

Operational guidance:

- Intermittent exposure to 150°F: Acceptable (wheel cools between cycles)
- Continuous operation at 180°F: Bond failure risk within hours
- For higher temperatures: Use high temp phenolic wheels (up to 475°F) or metal wheels (up to 700°F with appropriate bearings)

10 Application Selection Matrix

10.1 When Polyurethane Is Superior

Chemical exposure environments:

- Oil/grease contamination on floors
- Animal fat exposure (food processing, commercial kitchens)
- Mild chemical spills (industrial facilities)
- *Advantage:* Maintains properties and bond integrity where rubber fails

High static capacity requirements:

- Heavy loads stored on equipment (intermittent repositioning)
- Infrequent movement of heavy machinery
- Load >300 lbs per caster where rubber would permanently deform
- *Advantage:* 2–3× higher static capacity prevents flat spotting

Abrasive floor surfaces:

- Rough or deteriorated concrete
- Outdoor surfaces (asphalt, uncoated concrete)
- Debris-laden environments (metal shops, fabrication areas)
- *Advantage:* 3–10× longer service life due to abrasion resistance

Cutting/chunking risk:

- Sharp objects on floor (metal edges, broken materials)
- High-impact environments
- Severe mechanical abuse
- *Advantage:* Superior tear strength, phase-separated microstructure resists damage

Cost-sensitive lifecycle applications:

- Extended service requirements (2–4 year replacement cycles)
- High-volume caster installations
- Total cost of ownership optimization
- *Advantage:* Lower lifecycle cost despite moderate initial cost

10.2 When Rubber Is Superior

Manual movement at full rated capacity:

- Hand-pushed carts and equipment
- Ergonomic requirements (OSHA <50 lb push force)
- Frequent repositioning under load
- *Advantage:* Low rolling resistance, minimal heat generation, can operate at 100% rated capacity

Floor protection critical:

- Hardwood, tile, polished concrete, epoxy floors

- Environments where floor damage unacceptable
- Institutional settings (hospitals, schools, offices)
- *Advantage:* True floor protection through cushioning and compliance

Sensitive cargo:

- Vibration-sensitive equipment
- Delicate instruments or materials
- Shock absorption requirements
- *Advantage:* High resilience (80–90%), excellent damping

Continuous rolling applications:

- Conveyor systems
- Production lines with constant movement
- AGVs/AMRs operating >6 hours/day
- *Advantage:* Low hysteresis prevents thermal runaway

Clean, dry environments:

- No chemical exposure
- Controlled facility conditions
- Floor preservation more important than chemical resistance
- *Advantage:* Superior performance where polyurethane's chemical resistance unnecessary

11 Engineering Guidelines for Caster Manufacturers

11.1 Capacity Rating Methodology

Static capacity rating criteria:

- No collapse under maximum rated load
- Permanent deformation <10% after 24–48 hours under load
- Bond integrity maintained
- Material within elastic limit

Critical communication requirement:

Capacity ratings indicate maximum load a caster can safely support under normal operating conditions.

11.2 Manufacturing Specifications for Bond Integrity

To minimize bond failure risk:

Adhesive selection:

- Use urethane-based primers compatible with both polyurethane and core material
- Verify temperature resistance matches application (minimum 100°C for standard duty)
- Chemical compatibility testing for specialized environments

Core preparation:

- Mechanical texturing (knurling, grooving) for interlock
- Surface cleanliness (no oil, oxidation, contaminants)
- Proper primer application (uniform coating, adequate cure time)

Casting parameters:

- Control pour temperature (too hot degrades adhesive, too cold prevents bonding)
- Adequate cure time before demolding (minimum 16–24 hours for most formulations)
- Post-cure conditioning (temperature cycling improves bond strength)

Quality control testing:

- Pull-off adhesion testing (ASTM D4541)
- Thermal cycling (confirm bond survives temperature range)
- Chemical exposure testing (verify resistance to expected contaminants)

11.3 Customer Communication Best Practices

Critical information to provide:

Capacity rating context:

- Clearly state rating is for rolling loads not static loads
- Provide load factor recommendations for manual operation
- Warn against continuous rolling at full capacity

Material limitations:

- Polyurethane NOT suitable for constant rolling
- Heat buildup risk when operated at high loads continuously
- Bond failure mechanisms (chemical, thermal, overload)

Application guidance:

- Load reduction factors for manual movement (40–60%)
- Temperature operating range (–20°F to 180°F)
- Chemical compatibility (excellent for oils/greases, poor for strong acids/bases)

Comparison to rubber:

- Higher static capacity (2–3×)
- Superior chemical and abrasion resistance
- Lower rollability at maximum rated load
- Moderate (not excellent) floor protection

Service life expectations:

- Chemical environments: 2–4× longer than rubber
- Abrasive floors: 3–10× longer than rubber
- Continuous rolling: Not recommended (rubber superior)

12 Conclusion

Polyurethane caster wheels demonstrate superior performance to rubber in chemical resistance, abrasion resistance, cutting/chunking resistance, and static load capacity due to fundamental materials science advantages:

- **Chemical resistance:** Polar urethane linkages and hydrogen bonding network repel non-polar oils and greases (minimal swelling vs catastrophic rubber failure)
- **Abrasion resistance:** Higher hardness and phase-separated microstructure reduce wear rate by 3–10× compared to rubber
- **Cutting/chunking resistance:** Hard domain crack arrestors and higher tear strength provide 3–5× greater energy requirement for material removal
- **Static capacity:** Superior creep resistance from physical crosslink stability enables 2–3× higher load support without permanent deformation

However, these advantages create performance trade-offs:

- **Rolling resistance:** Higher hysteresis (25–40% vs 10–20%) generates excessive heat at maximum rated capacity, necessitating 40–60% load reduction for manual operation
- **Floor protection:** Moderate deflection (2–4 mm vs 8–12 mm for rubber) provides intermediate floor protection, inferior to soft rubber but superior to hard tread wheels
- **Thermal management:** Heat generation 5–8× higher than rubber at equivalent loading creates bond failure risk in continuous rolling applications

Application selection must balance material advantages against operational limitations:

- Use polyurethane when chemical resistance, abrasion resistance, or high static capacity dominate requirements, accepting reduced rollability and moderate floor protection.
- Use rubber when manual rollability at full capacity, floor protection, or continuous rolling capability are critical, accepting chemical vulnerability and lower static capacity.

Optimal caster performance requires matching material properties to specific application demands through rigorous engineering analysis of environmental, mechanical, and operational factors.

Appendix: FAQ About Polyurethane and Rubber Caster Wheels

What are polyurethane and rubber caster wheels?

Polyurethane wheels are made from a strong, polar plastic that resists chemicals. Rubber wheels, made from natural or synthetic rubber, are stretchy and protect floors but absorb oils.

Which is better for heavy loads?

Polyurethane supports 500–1200 pounds per caster (e.g., 900 pounds for a 5-inch wheel), 2–3× more than rubber (200–400 pounds). Use polyurethane for heavy static loads.

How do wheel width and height affect performance?

Wider wheels (1.25–2 inches) spread weight, reducing floor damage. Taller wheels (5–8 inches) roll over obstacles better. Both materials use similar sizes, but polyurethane handles rough floors longer.

How much weight can polyurethane wheels sustain in a static application?

It depends on the quality of the urethane. A good rule of thumb is to not exceed 65% of the rated capacity of the wheel in a static application to prevent permanent deformation.

Why does rubber fail in oily environments?

Rubber swells 50–200% in oils, softening and separating from the core in weeks. Polyurethane swells only 5–15%, lasting months to years.

Why is polyurethane better for abrasive floors?

Polyurethane's hardness (90–95 Shore A) and microstructure reduce wear by 3–10× (15–80 mm³ loss vs. 120–250 mm³ for rubber), lasting 2–4 years vs. 6–12 months.

When should I use rubber casters?

Use rubber for:

- Delicate floors (hardwood, tile)
- Manual pushing (easy rolling)
- Continuous movement without heat buildup

When should I use polyurethane casters?

Use polyurethane for:

- Oily or greasy environments

- Rough, abrasive floors
- Heavy static loads (e.g., 900 pounds per caster)

Can polyurethane be used for continuous rolling?

Not at full capacity. Polyurethane generates 5–8× more heat than rubber, risking bond failure. Use at 40–60% capacity (e.g., 360–540 pounds for a 900-pound caster) for continuous rolling.

How do I prevent bond failure?

Choose proper adhesives, ensure clean core surfaces, and avoid continuous rolling at high loads. For standing loads, use extra heavy-duty polyurethane (60–65 Shore D).

Where can I get help choosing casters?

Contact a caster supplier's engineering team to match material, capacity, wheel width, and height to your needs.