STRUCTURAL • ELASTOMERS • WEAR • COLOR
CONDUCTIVE • FLAME RETARDANT • FILM/SHEET

Wear Resistant Thermoplastic Compounds

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RTP Company

Agenda

- RTP Company Introduction
- Definitions & Test Methods
- Morphology
- Additive Technologies
- Application examples

RTP Co.
Imagineering Plastics®

GLOBALIZATION STRATEGY

YOUR GLOBAL COMPOUNDER OF CUSTOM ENGINEERED THERMOPLASTICS

Asia **United States** **France**

- Scalability: Develop your solution on a small scale and produce your solution at larger quantities
- Plant-to-plant consistency
- Identical machinery, processing, QA testing

ISO 9001 REGISTERED FACILITIES

- ISO 9001:2008 Registered Facilities
- Worldwide technical support
- Local customer service: real people, real time

PRODUCT FAMILIES

YOUR GLOBAL COMPOUNDER OF CUSTOM ENGINEERED THERMOPLASTICS

Imagineering Plastics®

STRUCTURAL

WEAR RESISTANT

CONDUCTIVE

ELASTOMERS

FLAME RETARDANT

COLOR

FILM/SHEET

Compounds formulated to meet your needs

Definitions

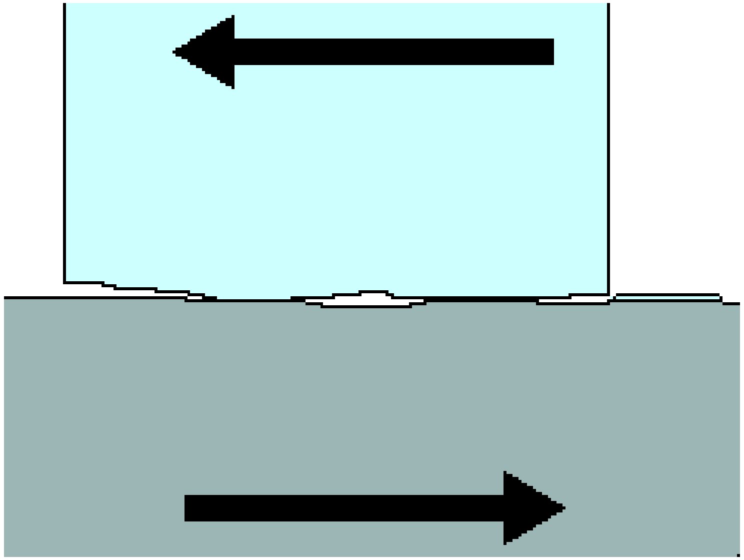
Tribology Definition

The Science of the mechanisms of friction, lubrication, and wear of interacting surfaces that are in relative motion.

Adhesive Wear

The primary mechanism for thermoplastic wear.

Characterized by transfer of material from one part to the other caused by frictional heat.

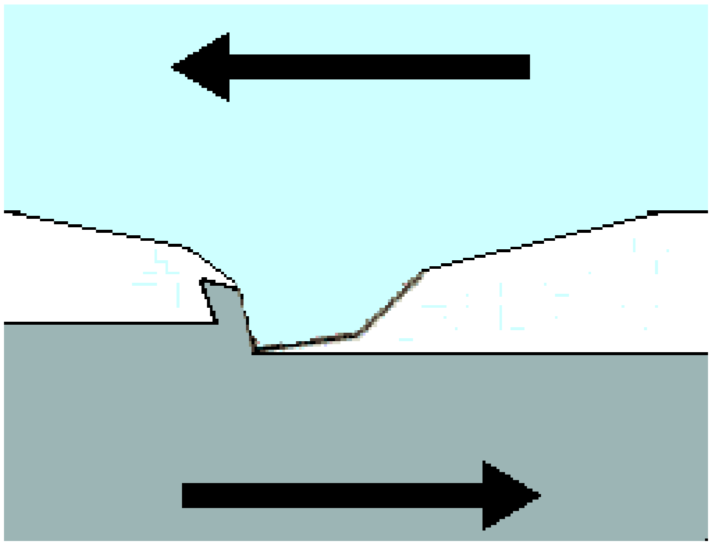


Abrasive wear

Caused by a hard material scraping or abrading away at a softer material.

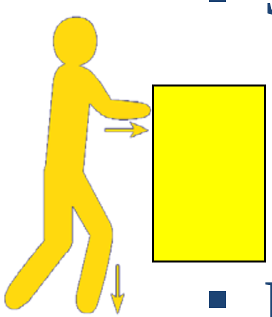
Characterized by grooves cut or gouged into the surface.

- Three Body



Coefficient of Friction (μ)

- Friction is the natural resistance to the sliding motion of one surface over another

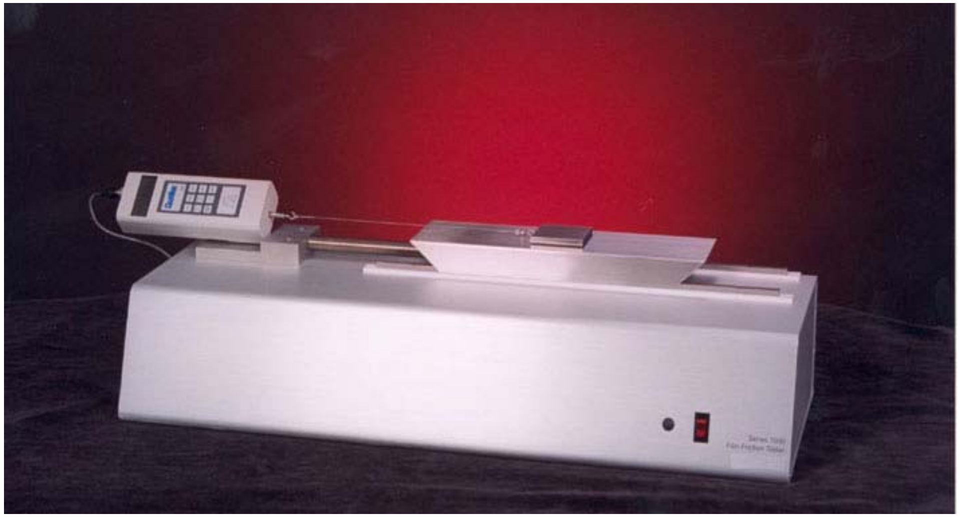


- **Static Coefficient of Friction (μ_s) = Fx/Fy**
  - Fx = Force to initiate motion
  - Fy = Normal force holding surfaces together
- **Dynamic Coefficient of Friction (μ_k) = Fx/Fy**
  - Fx = Force to sustain motion
  - Fy = Normal force holding surfaces together

- Thermoplastics Are Unique
  - Static friction is typically less than dynamic friction
    - Can Lead To Slip/Stick
  - Too large of difference leads to squeaking

ASTM D1894 Friction Test

- Sled Test
  - Coefficient of Friction Testing
  - Does not determine wear resistance
- Can Show Slip/Stick



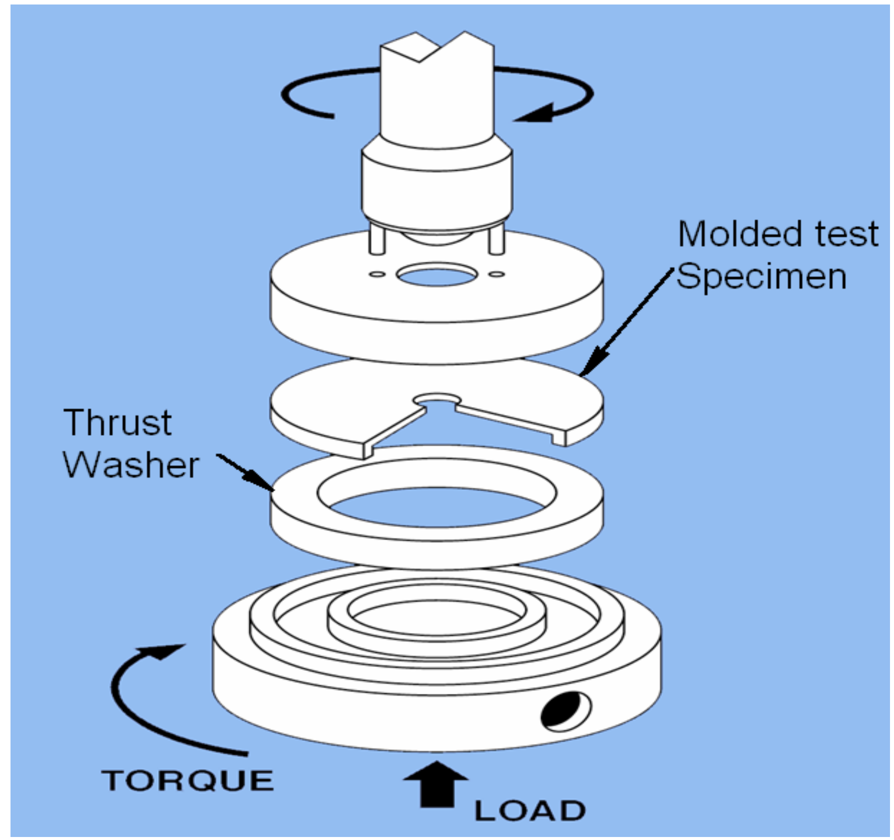
ASTM D3702 Wear Test

Standard conditions

- Steel Thrust Washer
- 40 psi: 50 ft/min (2000 PV)
- Ambient Temp
- 100 hour test

Counter-surface (thrust washer) material, pressure, velocity and temperature are all adjustable

The best use of this test is to perform comparative screening of multiple candidate materials



ASTM D3702 Wear Tester

Calculating Wear Factor (K)

Wear Factor (K)

$$K = W/(F \times V \times T)$$

K = Wear Factor: (in^3-min/ft-lb-hr)·10E-10 or (mm^3/N-m)·10E-8

F = Force: lb or N

V = velocity: ft/min or m/sec

T = Elapsed Time: hr or sec

W = volume wear: in^3 or mm^3

Wear factor per unit pressure can be calculated by multiplying the standard wear factor value by 0.35in^2.

K_P = Wear Factor: (in^5·min/ft-lb-hr)·10E-10

(Some companies report wear factors this way)

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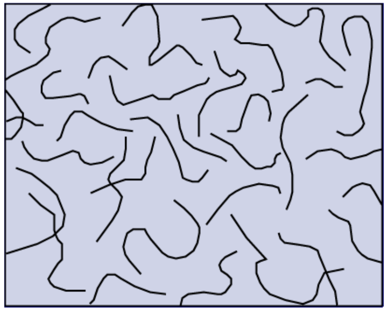
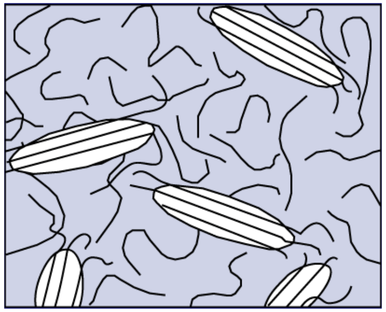
Additive Technologies

Morphology Characteristics

	Amorphous	Semi-Crystalline
Low Shrinkage	X	
Low Warpage	X	
Tight Tolerances	X	
Transparency	X	
Mold Flow Ease		X
Chemical Resistance		X
Response to Reinforcement		X
Wear Resistance		X





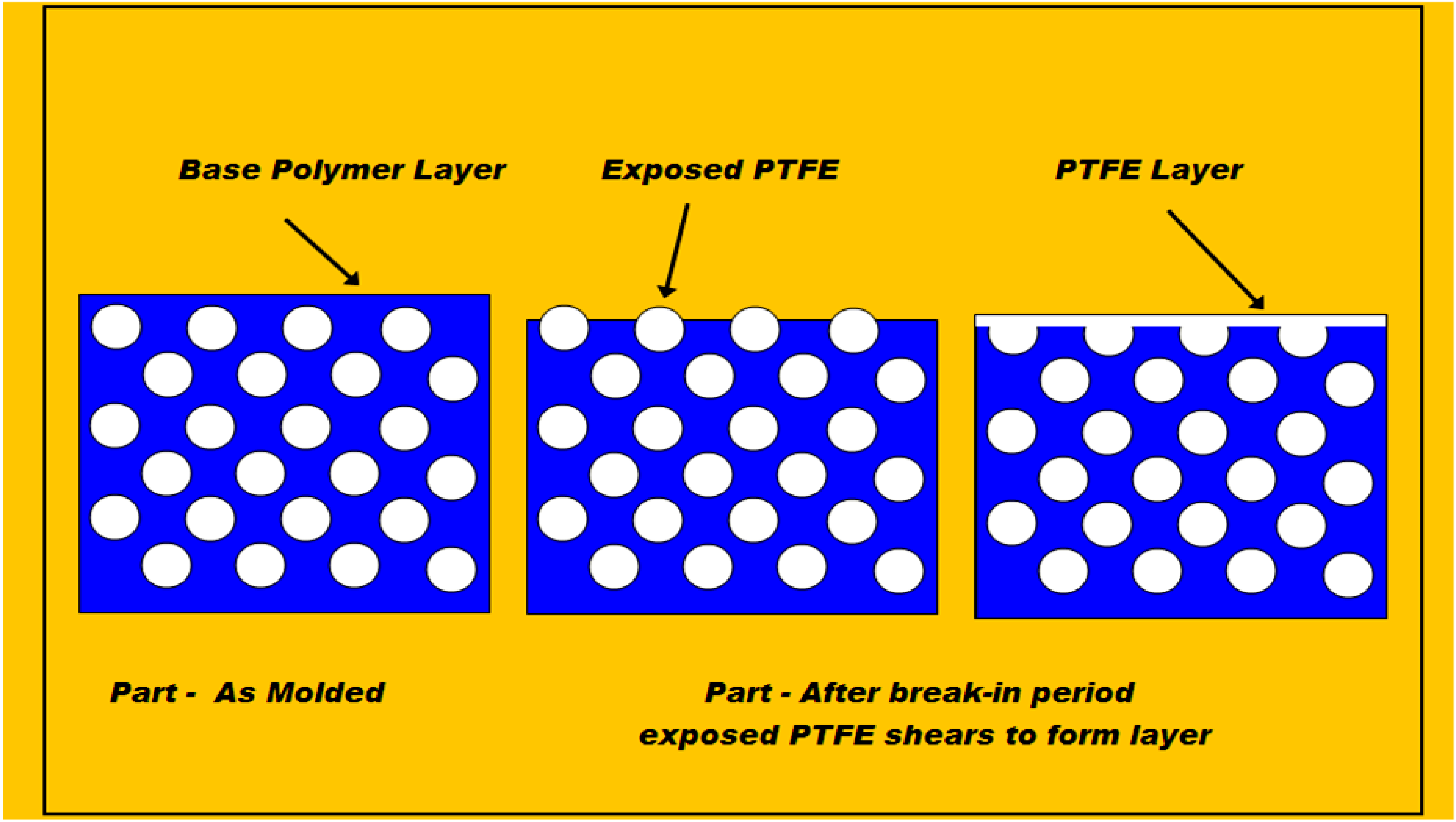
1. PTFE – Polytetrafluoroethylene (10-20%)

- Workhorse additive – solid white powder
- Homogeneously distributed throughout the polymer matrix
- Forms a lubricious layer at polymer surface – Requires a "Break-in" period
- Compatible with nearly all thermoplastic resins

Drawbacks

- Fluorine content
- Die plate-out
- Relatively high loadings

PTFE Mechanism



Application

- **Automotive Seat Adjustment Lever**
  - Needs good strength, stiffness and wear resistance. (Structural, wear, precolor)
  - Glass fiber reinforced PTFE lubricated and precolored PPA.

2. Silicone – Polydimethylsiloxane (1-3%)

- Boundary lubricant which migrates to the surface over time
- Migration rate is viscosity dependent
- Excellent friction reducer
- Best in high speed/low load applications
- Used with PTFE to eliminate "Break-in" period

Drawbacks

- Limited use in decorated parts
  - Poor adhesion of paint or print inks
- Bad for electrical applications
  - Can foul contacts

PTFE Break-In Period with Silicone

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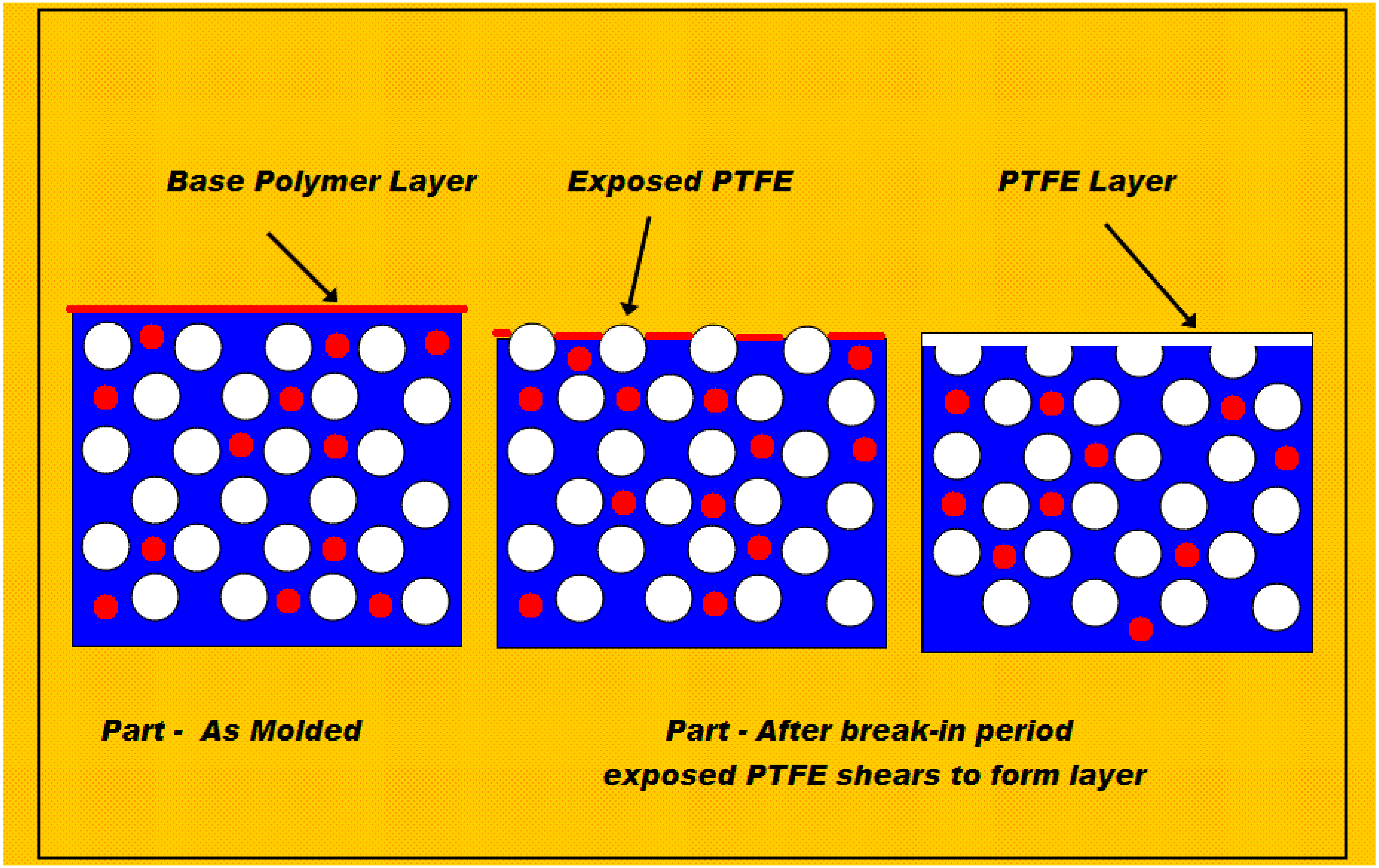
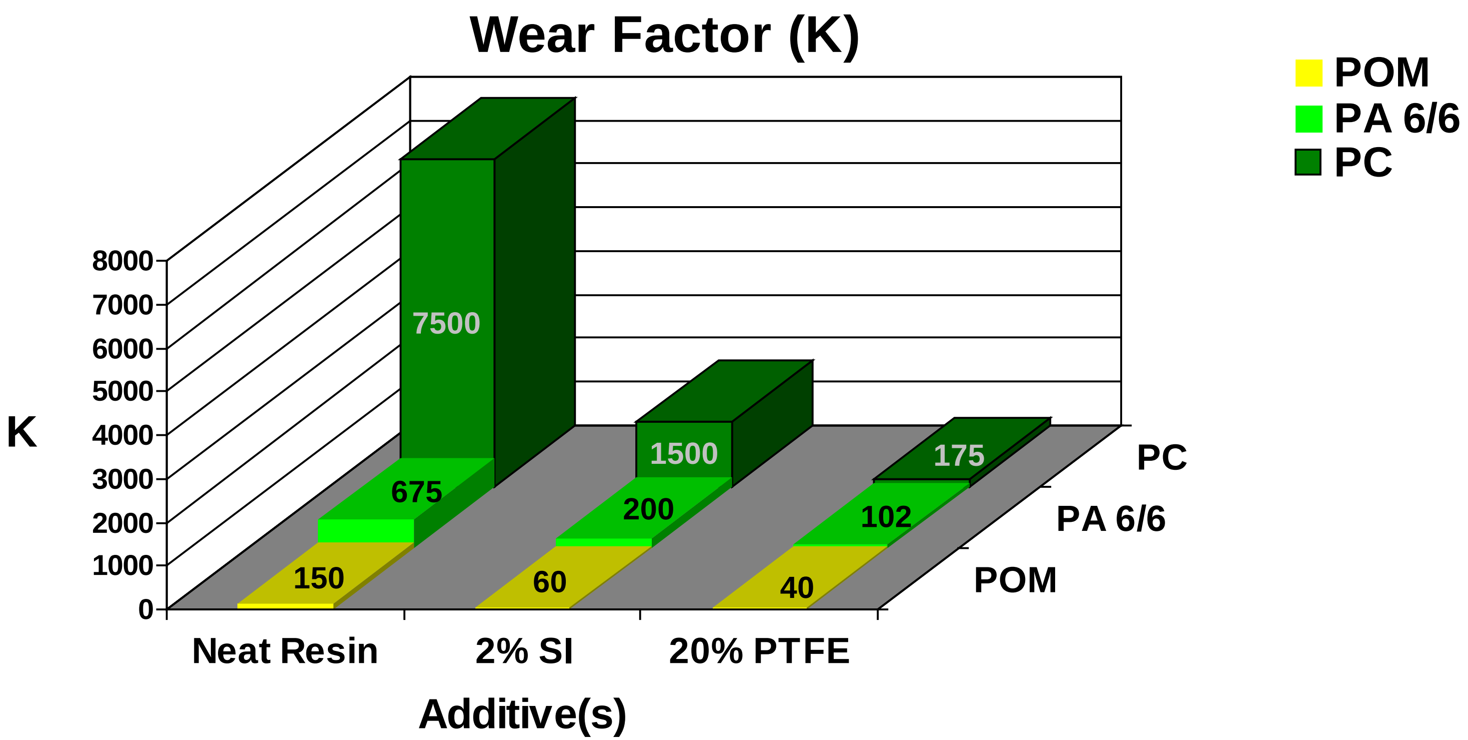


- **Food Handling conveyor rollers**
  - Antimicrobial, low friction. (Antimicrobial, Wear)
  - PTFE and silicone lubricated POM with antimicrobial additive

Wear of POM, PA 6/6 and PC



Values per ASTM D3702 test method vs C1018 Steel

- **Wear Factor Units: (in^3min/ft/lb/hr)E-10**

3. Graphite Powder (5-15%)

- Aqueous environments
- Excellent temperature resistance
- Black (Charcoal Gray) color

4. Molybdenum Disulfide – MoS2 (1-5%)

- Nucleating agent in nylons: creates harder surface
- High affinity to metal: smoother mating metal surface = lower wear

Drawbacks

- Limited use
- Dark color limits colorability
- Sloughing type additives

- **Water Meter Valve**
  - Dimensional stability, potable water contact - NSF listed. (Structural, Wear)
  - Graphite lubricated SAN & PS

1. Glass Fiber (5-50%)

- Improved bearing capabilities and wear resistance
- Low cost

Drawbacks

- Extremely abrasive to mating surface

2. Carbon Fiber (5-50%)

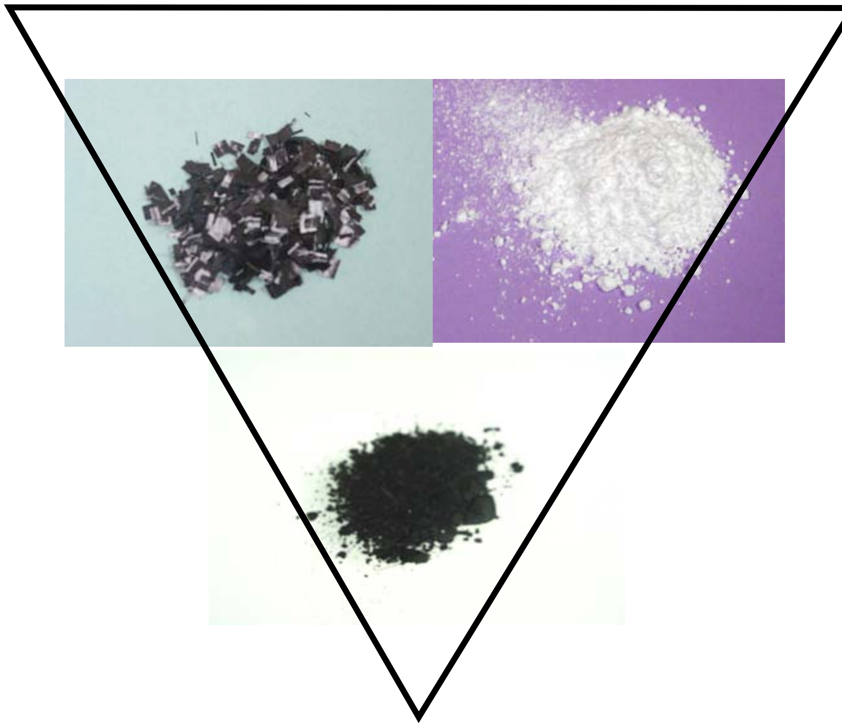
- Greatly improved bearing capabilities
- Electrically and thermally conductive
- Less abrasive than glass

Drawbacks

- High cost
- Black color

1. 10/10/10 – Carbon fiber/Graphite Powder/PTFE

- Typical additive package for high load bearing applications.
- Prevalent in hi temp resin systems
- PPS, PEEK and PPA versions available from RTP
- Available from some resin producers



- **AC Compressor Scroll Seal**
  - High temperature, chemical and wear resistance
  - Carbon fiber reinforced and PTFE/Graphite lubricated PEEK

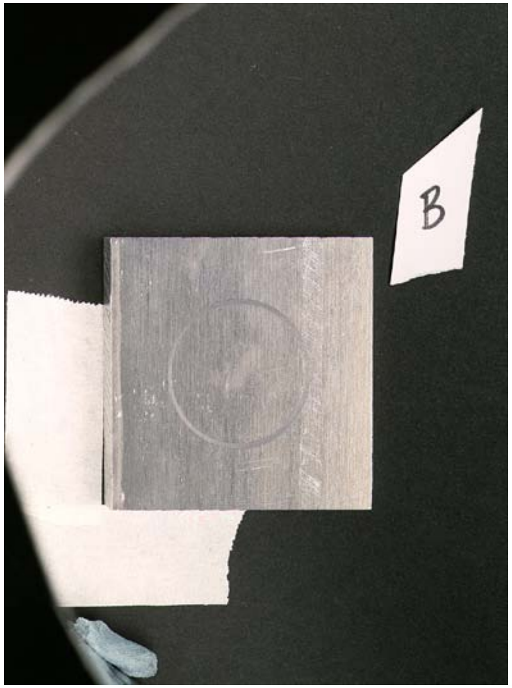
3. Aramid Fiber (5-20%)

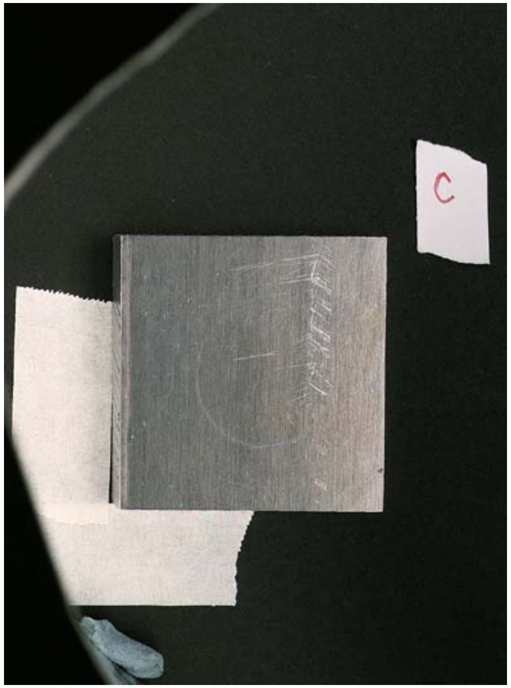
- Very gentle to mating material
- Improves wear and friction

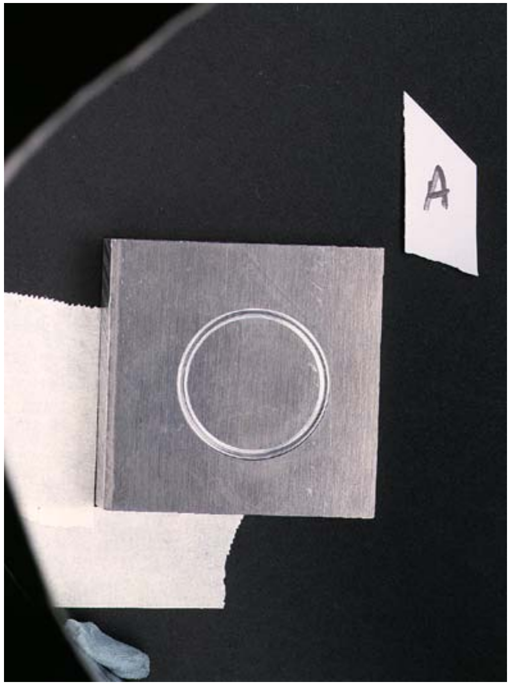
Drawbacks

- Difficult to process
- Minimal physical property enhancement
- High cost

Fibers vs. Metal







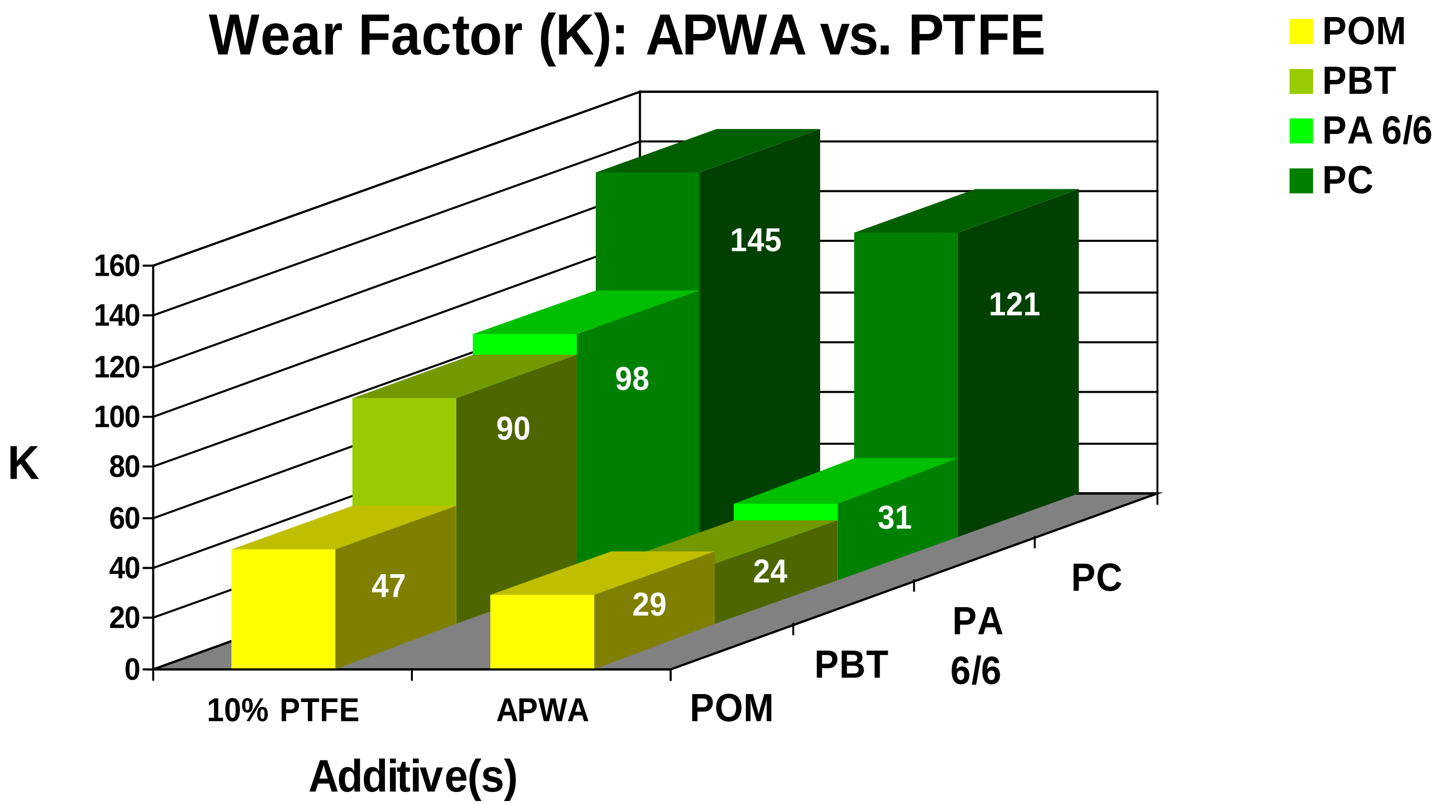
APWA – All Polymeric Wear Additive (5-15%)

- Alloys with host polymer
- Excellent Plastic vs. Plastic performance (Great for business machines)
- Completely halogen free
- Physical properties maintained
- No die plate-out
- Specific gravity benefits (more parts per lb or kg)

Drawbacks

- Limited thermal resistance
- Higher cost
- Not FDA

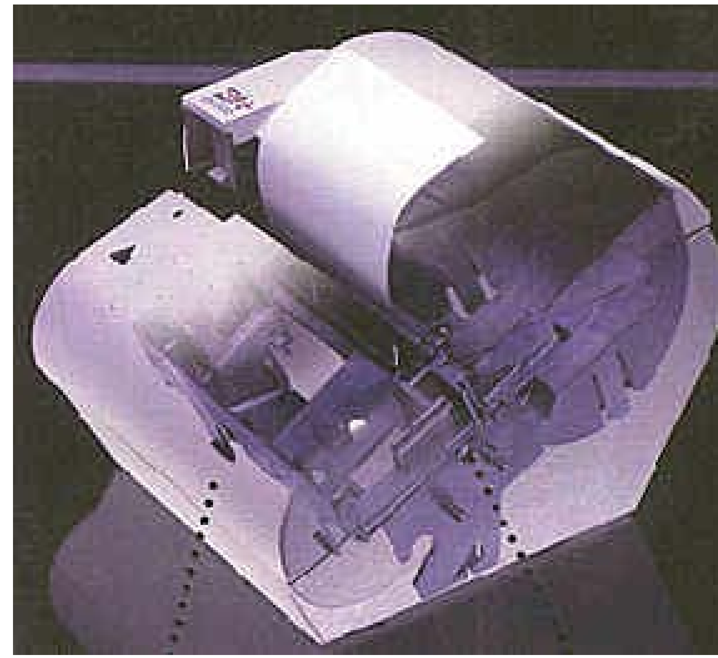
APWA Plastic vs. Plastic wear



Values per ASTM D3702 test method.

- **PV = 1000 ft·lb/in^{2}min**
- **Wear Factor Units: (in^{3}min/ft/lb/hr)E-10**

- **Thermal Printer Frame**
  - High Impact, ESD, wear resistance. (Conductive, Structural, Wear)
  - Impact modified, conductive PC with APWA for improved wear resistance



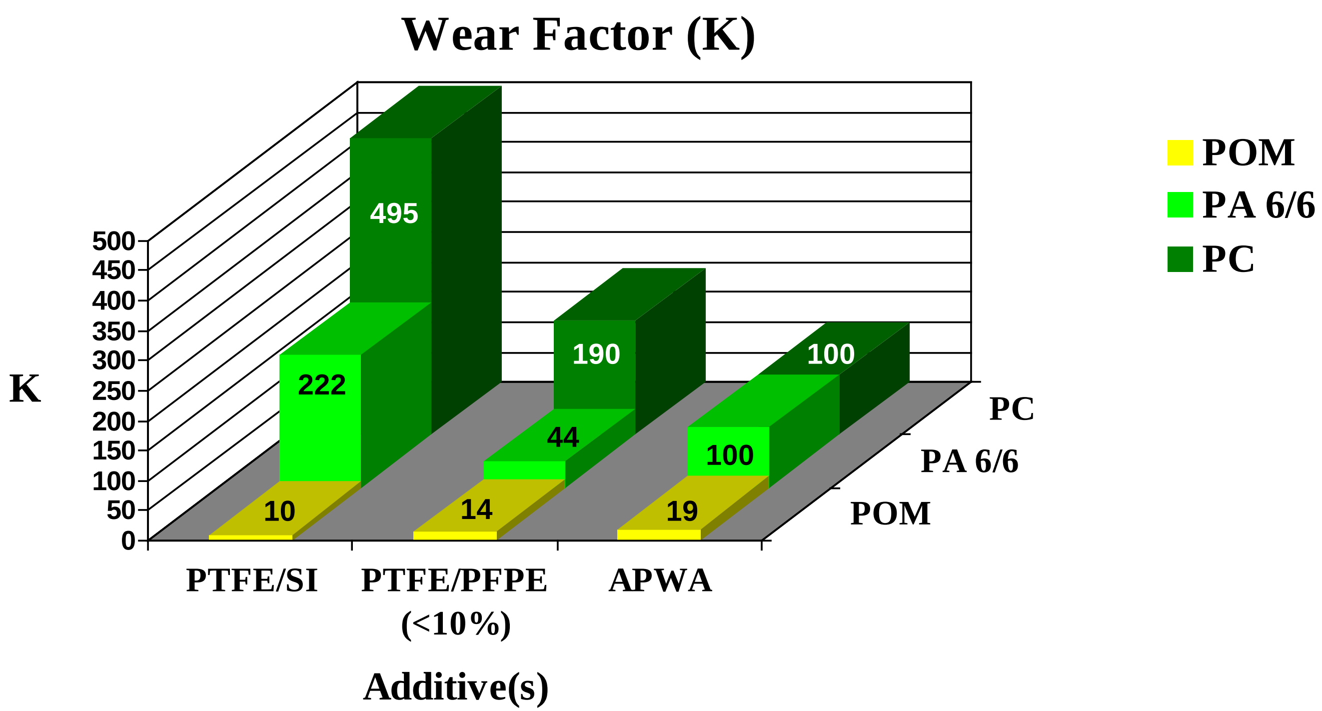
PFPE – Perfluoropolyether Oil (< 1%)

- Thermally Stable up to PEEK processing temps
- Differentiates RTP Company from others
- Physical properties maintained
- Minimized die plate-out (improved production efficiencies)
- Synergy with PTFE
- Specific gravity benefits
- Improved fatigue resistance

Drawbacks

- **Limited effectiveness in amorphous resins**
- **Needs PTFE "kick" to deliver optimum friction reduction**

Wear Factor (K) against Steel



Values per ASTM D3702 test method vs. C1018 Steel

- **PV = 2000 ft·lb/in^{2}min**
- **Wear Factor Units: (in^{3}min/ft/lb/hr)E-10**

- **Agricultural Pump**
  - Chemical and Wear Resistance (Structural, Wear)
  - PFPE lubricated PP

Questions

- Thank you for your attention.
- Any questions?

Friction of POM, PA 6/6 and PC

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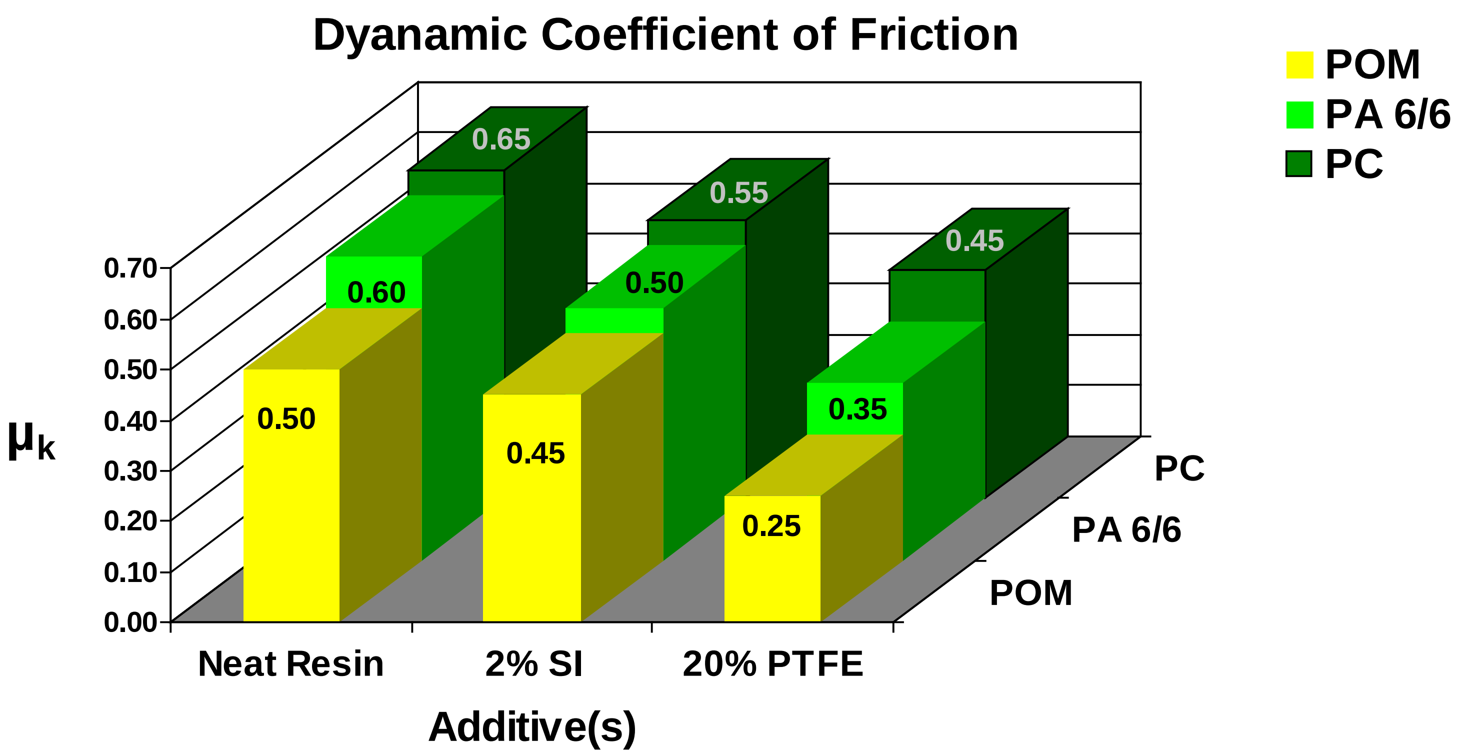

Values per ASTM D3702 test method vs C1018 Steel

APWA Plastic vs. Steel wear

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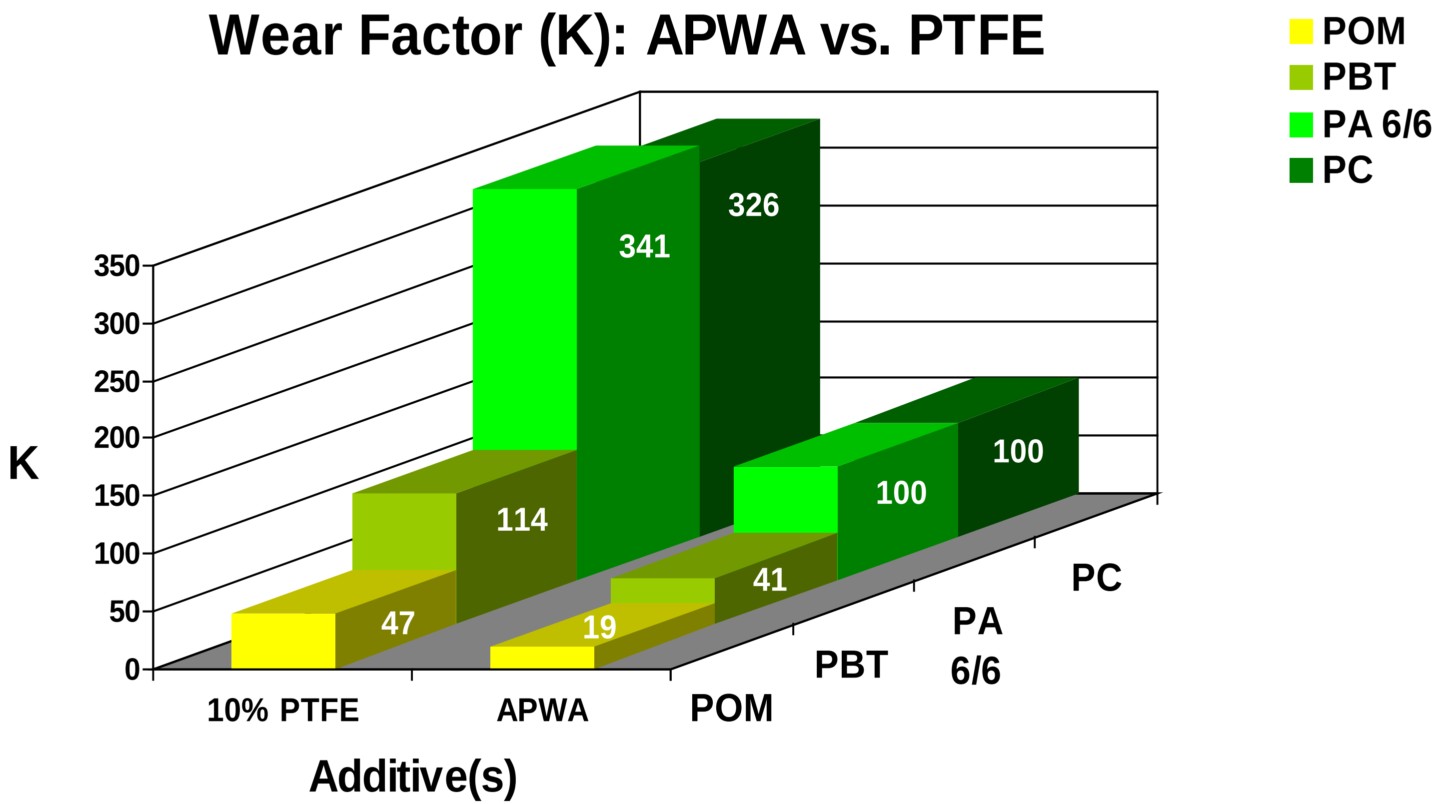
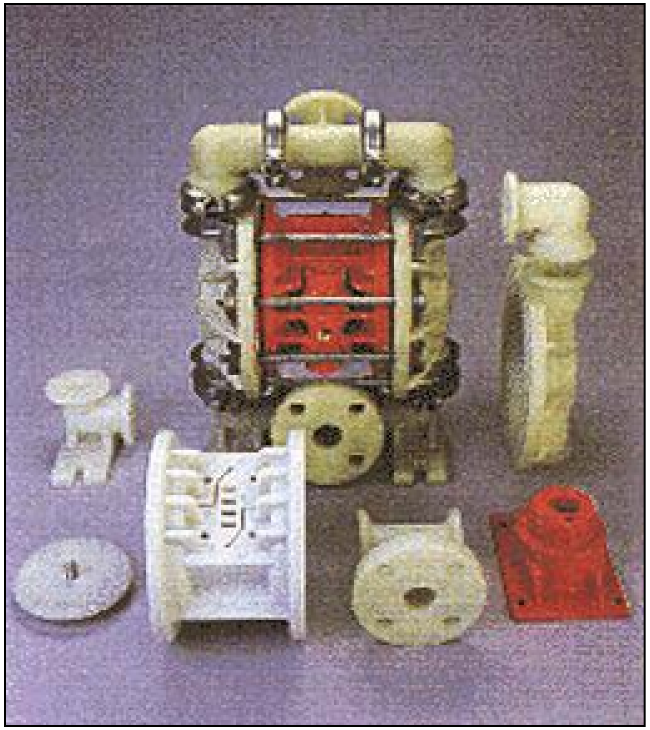


Values per ASTM D3702 test method vs. C1018 Steel.

- PV = 2000 ft·lb/in^{2}min
- Wear Factor Units: (in^{3}min/ft/lb/hr)E-10

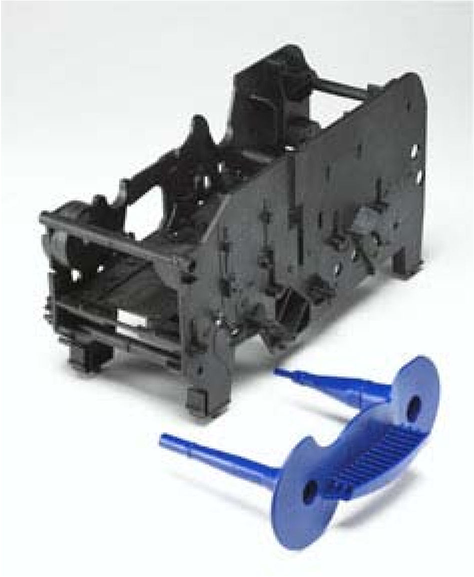
Industrial Application

- **Fluid Handling Pump**
  - Chemical resistance, high strength & stiffness. (Structural, Wear)
  - Glass fiber reinforced, PTFE lubricated PP



Business Machine Application

- **Digital Printer Cartridge Holder**
  - ESD, high strength/stiffness, low friction/wear. (Conductive, Structural, Wear)
  - Carbon fiber reinforced, PTFE lubricated PEI



- Copier Bushings
  - Extremely high temperature resistance (~260° C), wear resistance. (High Temperature, Wear)
  - Aramid fiber reinforced, PTFE lubricated TPI

Physical Property Comparison

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	POM			PA 6/6			PC		
	Unfilled	PTFE (20%)	Silicone (2%)	Unfilled	PTFE (20%)	Silicone (2%)	Unfilled	PTFE (20%)	Silicone (2%)
Specific Gravity	1.41	1.52	1.40	1.14	1.26	1.13	1.19	1.31	1.19
Tensile Strength (psi)	8700	6500	7800	12,000	9500	11,000	8500	7000	8500
Flexural Modulus (psi)	350,000	300,000	350,000	400,000	400,000	400,000	340,000	320,000	350,000
Notched Impact (ft-lb/in)	1.5	1.0	1.5	1.0	1.0	1.0	7.5	3.5	10.5

Testing per ASTM test methods.

Physical Property Comparison

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	POM			PA 6/6			PC		
	PTFE/SI	PTFE /PFPE	APWA	PTFE/SI	PTFE/ PFPE	APWA	PTFE/SI	PTFE/ PFPE	APWA
Specific Gravity	1.44	1.41	1.39	1.19	1.17	1.12	1.24	1.25	1.16
Tensile Strength (psi)	6500	8000	8000	10500	10500	10000	7500	8000	8000
Flexural Modulus (psi)	300,000	340,000	300,000	400,000	400,000	400,000	300,000	330,000	350,000
Notched Impact (ft-lb/in)	1.2	1.5	1.2	1.2	1.2	1.1	7.5	3.5	10.5

Testing per ASTM test methods.