



What, WEAR, and When



Sarah Goettler

*Product Development
Engineer - Wear*

“My application is wearing out!”

Fatigue?

?

***Chemical
Attack?***

?

Abrasion?

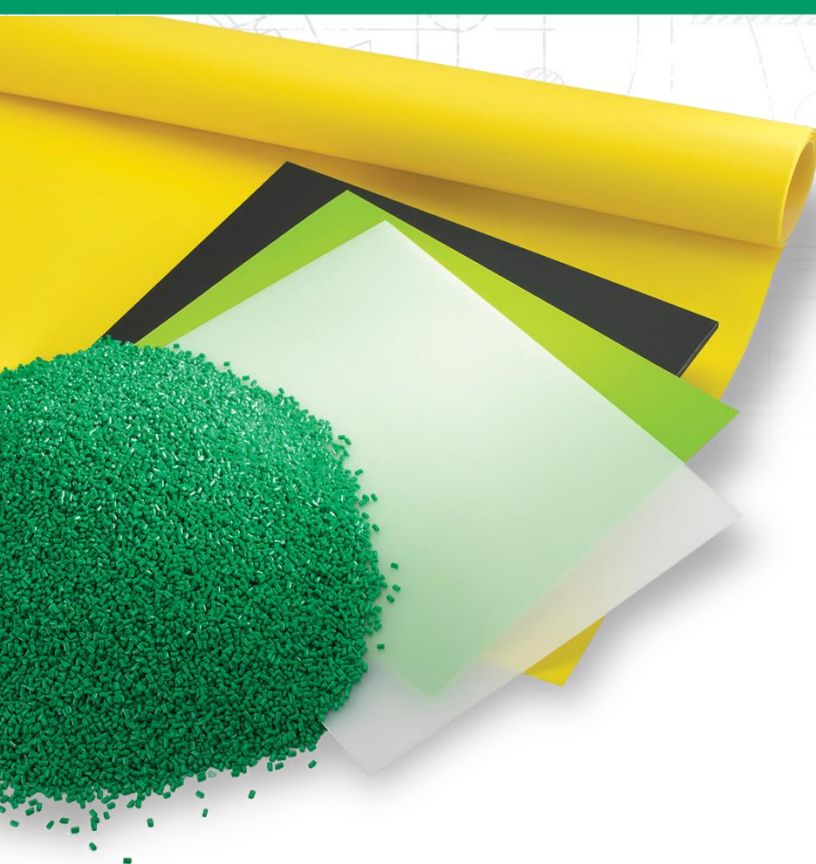
?

***Weather/UV
Resistance?***

?

AGENDA

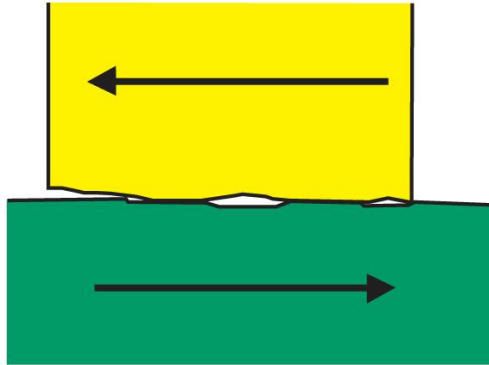
- I. What is Wear?
- II. Test Methods
- III. Additive Technologies
- IV. Friction Modification



WHAT IS WEAR?

WHAT IS WEAR

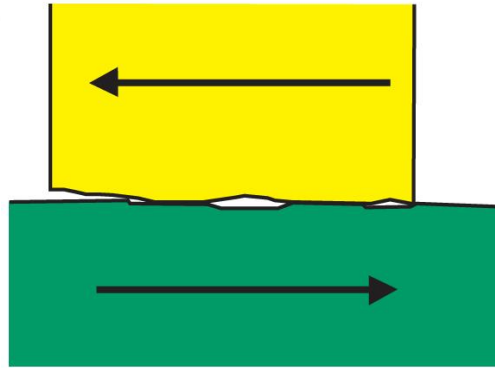
Wear – Sliding wear of thermoplastic compounds against a contact surface (steel, aluminum, other thermoplastics, etc.)



WEAR MECHANISMS

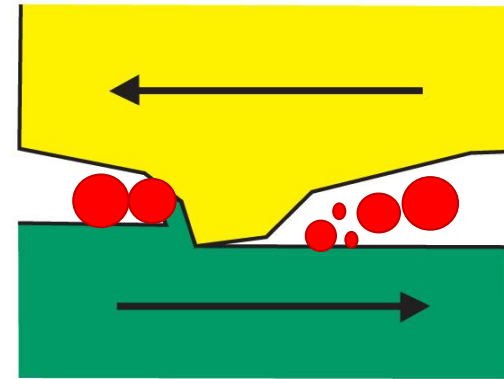
Adhesive Wear

- Characterized by transfer of material caused by frictional heat



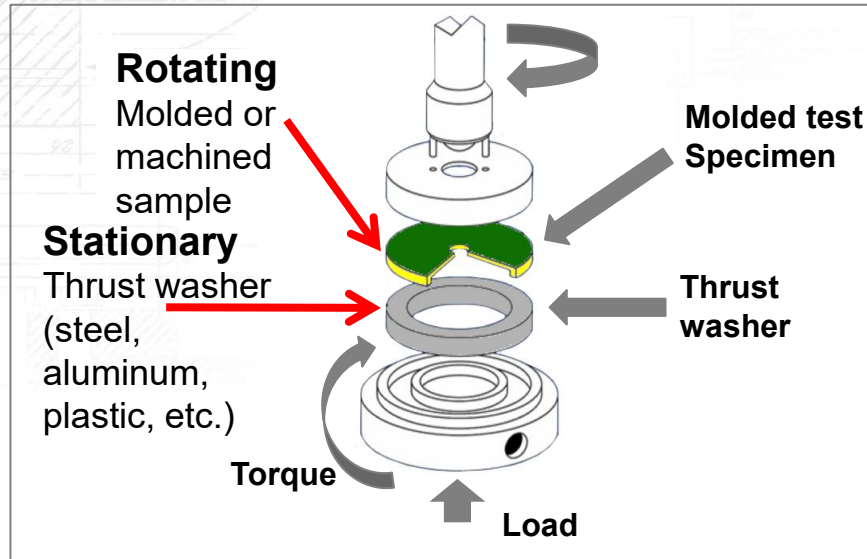
Three Body Abrasive Wear

- Caused by a hard material scraping away at a softer material

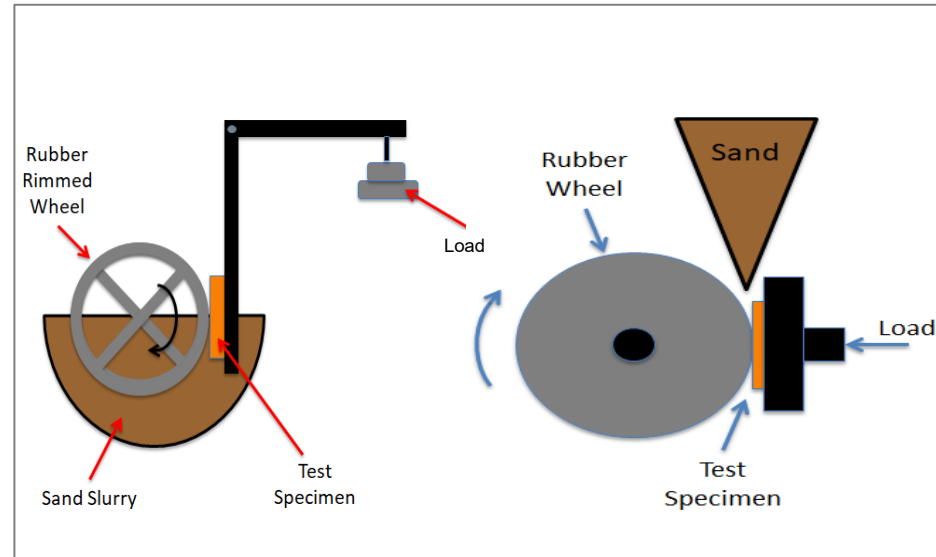


TESTING DIFFERENCES

Thrust Washer **Wear** ASTM D3702



Sand Slurry and Dry Sand **Abrasion** ASTM G105 ASTM G65



Best used for comparative screening

WEAR TESTING

Wear factor (K): Used to quantify wear resistance.

Lower Value = Better wear resistance!

$$K = \frac{W}{F \times V \times T}$$

K = Wear factor: $(in^3 \cdot min / ft \cdot lb \cdot hr) \cdot 10^{-10}$ or $(mm^3 / N \cdot m) \cdot 10^{-8}$

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

F = Force: lb or N

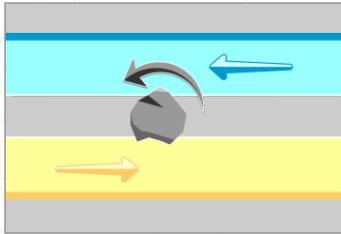
V = Velocity: ft/min or m/sec

T = Elapsed time: hr or sec

100 Hour Test!

ABRASION VS SCRATCH

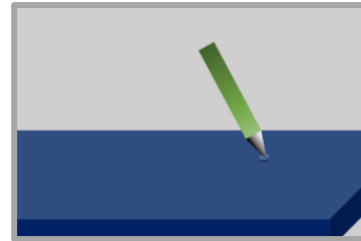
Abrasion



- Abrasive Wear
- Affects part functionality
- Test methods evaluate weight loss

Solution: Abrasion Resistance (ABR)
Compounds

Scratch and Mar

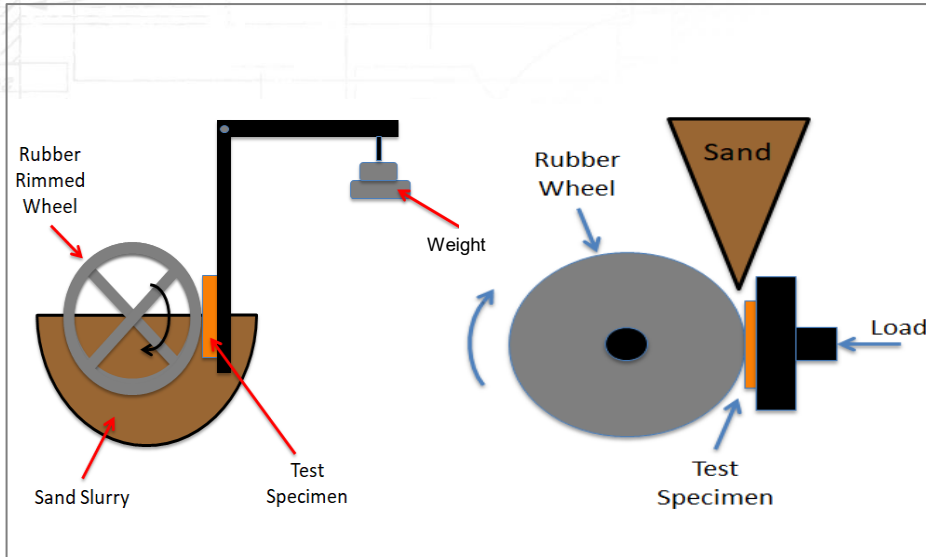


- Primarily aesthetic
- Alters surface quality
- Test methods evaluate scratch severity

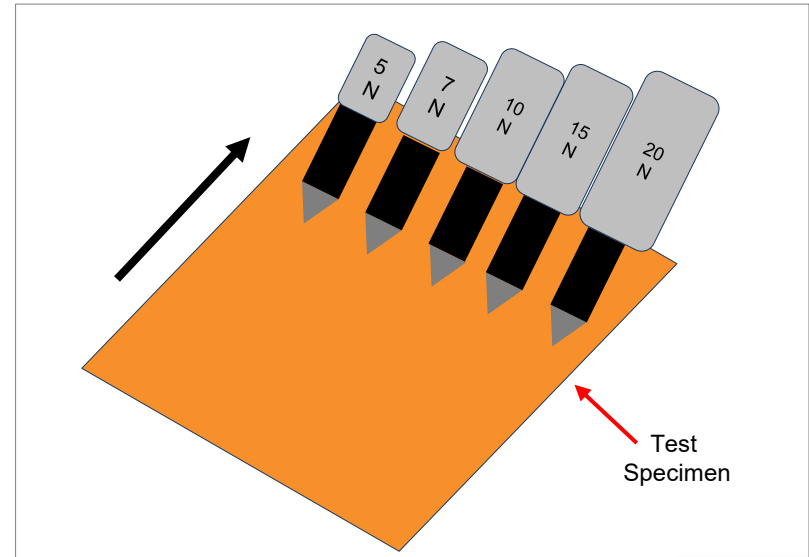
Solution: Surface Protection (SPR)
Compounds

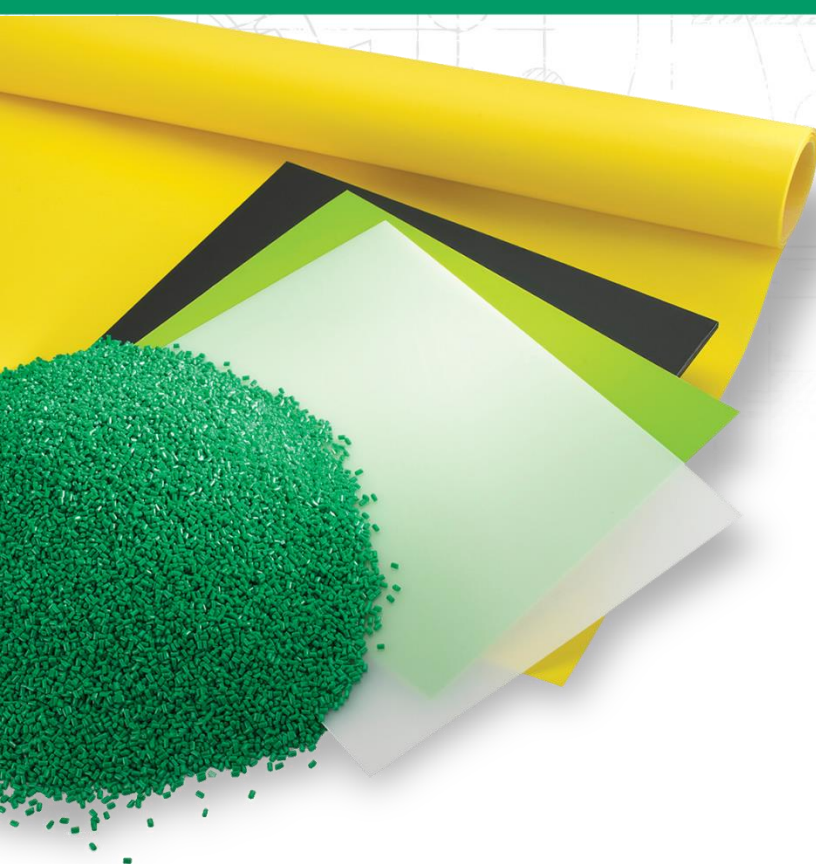
ABRASION TEST VS SCRATCH TEST

Sand Slurry and Dry Sand Abrasion



Multi-Finger (5 Finger) Scratch





ADDITIVE TOOLBOX

ADDITIVE TECHNOLOGIES

APWA



PTFE



Silicone Fluid



Solid Additives



Fibers



ADDITIVE TECHNOLOGIES

PTFE – Polytetrafluoroethylene

- Workhorse additive for wear resistance
- Compatible with nearly all thermoplastic resins

Limitations

- Fluorine content (PFAS)
- Die plate-out
- Relatively high loadings



ADDITIVE TECHNOLOGIES

All Polymeric Wear
Alloy (APWA) vs.

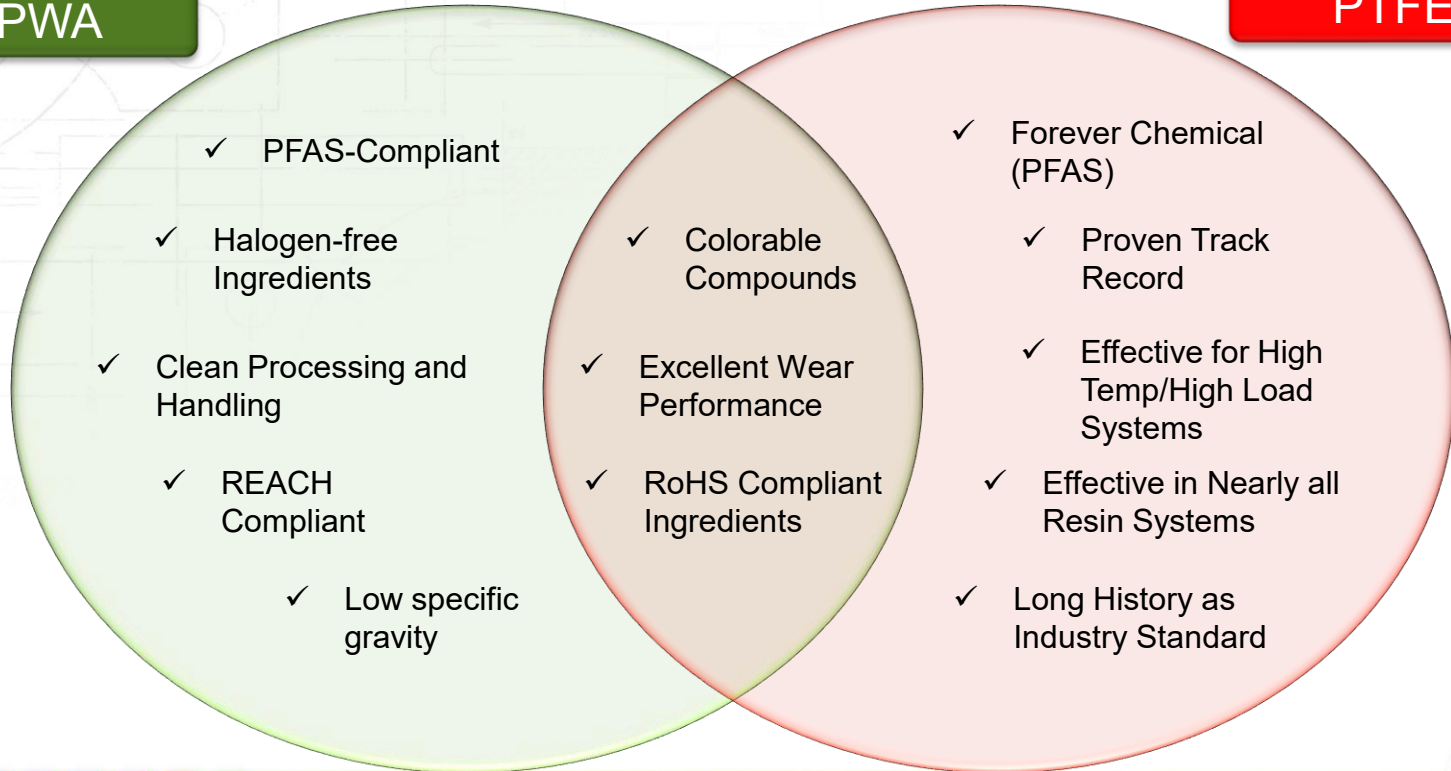
PTFE



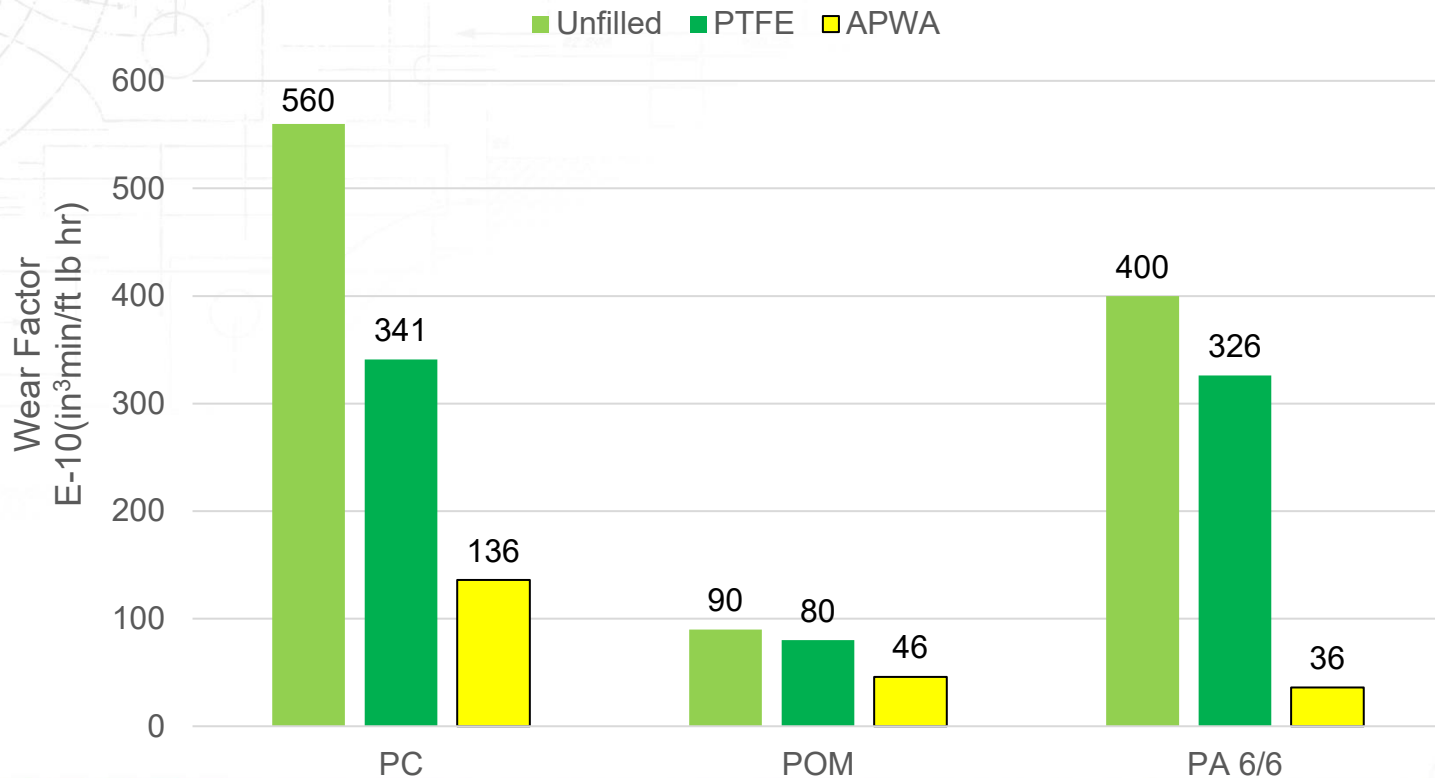
WEAR ADDITIVE COMPARISON

APWA

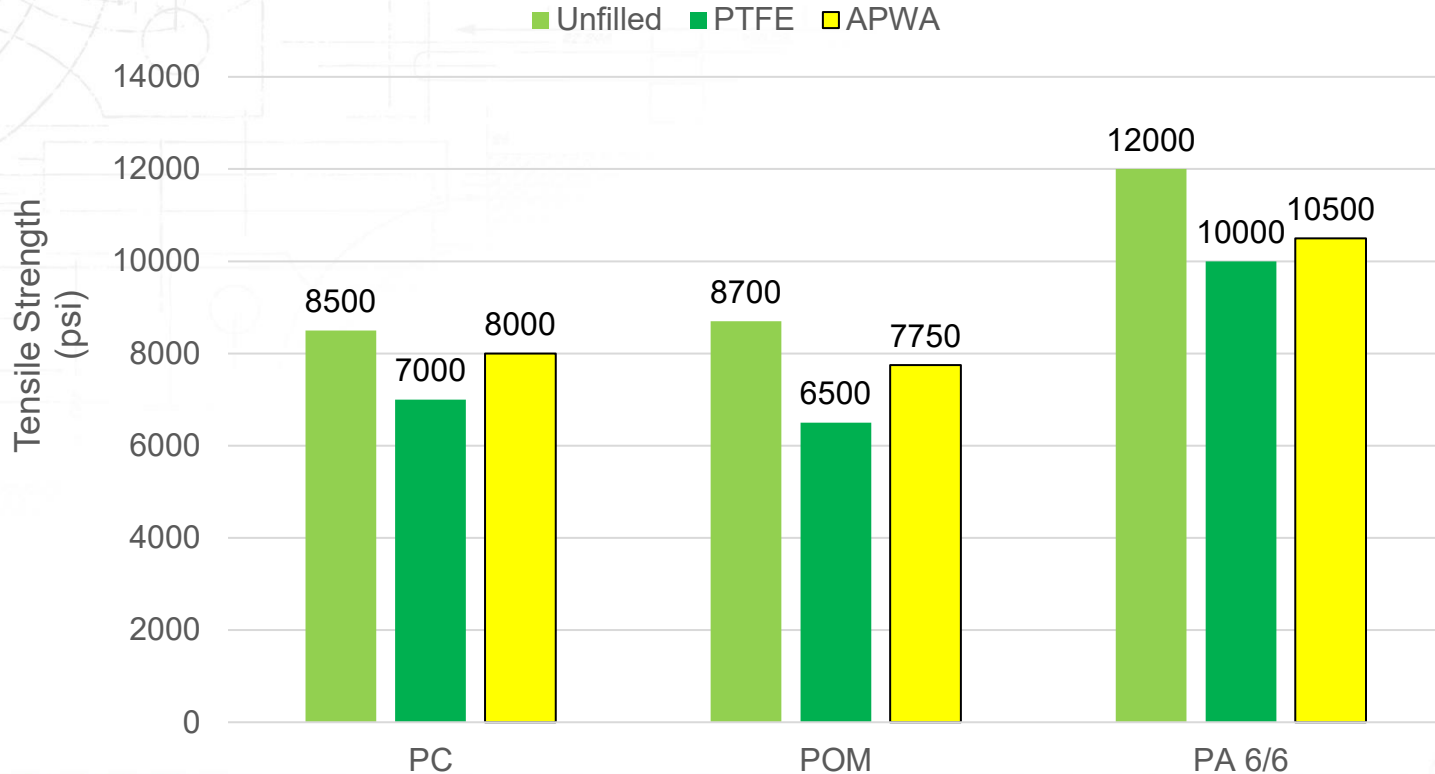
PTFE



APWA VS PTFE WEAR



APWA VS PTFE TENSILE STRENGTH



APPLICATION EXAMPLE

Leaf Spring Tip Inserts

Requirements

- Good strength
- Impact resistance
- Reduced squeak/noise
- PTFE-free

Solution

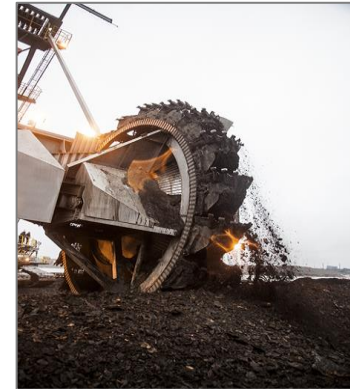
Impact modified PA 6/6 + APWA



ABRASION RESISTANT SOLUTIONS

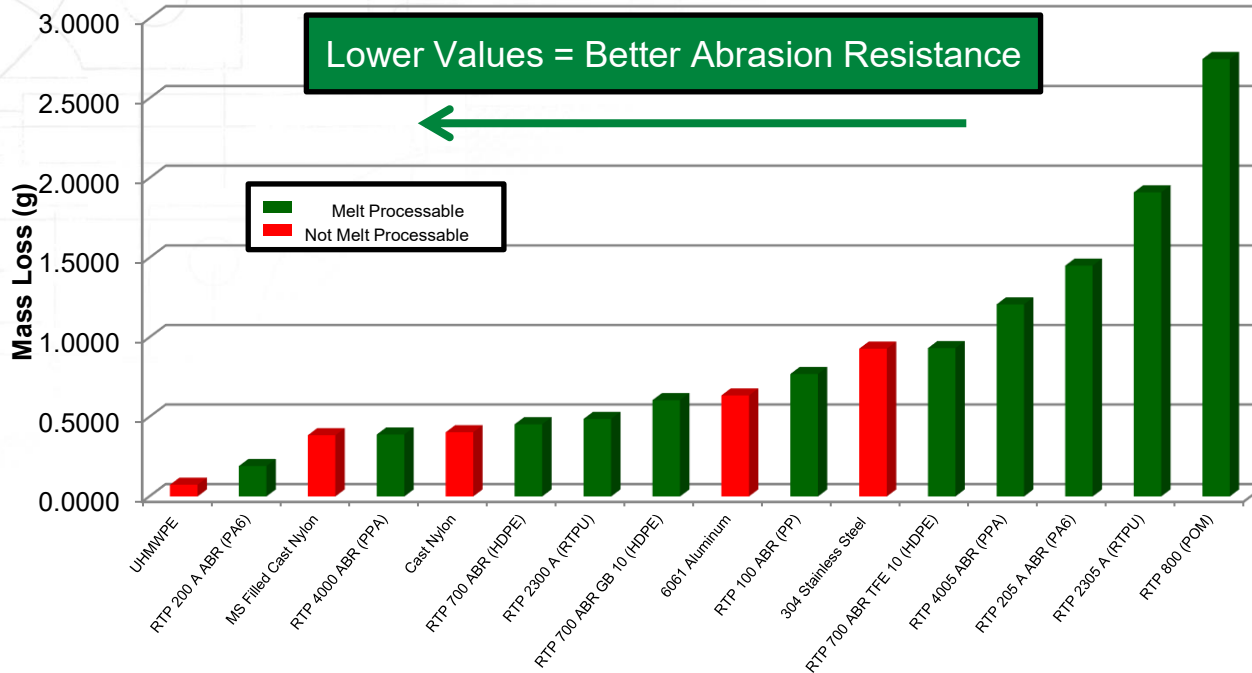
Abrasion Resistant Compounds (ABR)

- Ability to injection mold or extrude the material
 - Greater design freedom and performance properties
 - Elimination of costly secondary operations
- Minimize abrasive wear and provide excellent sliding wear and friction performance
- Non-PFAS



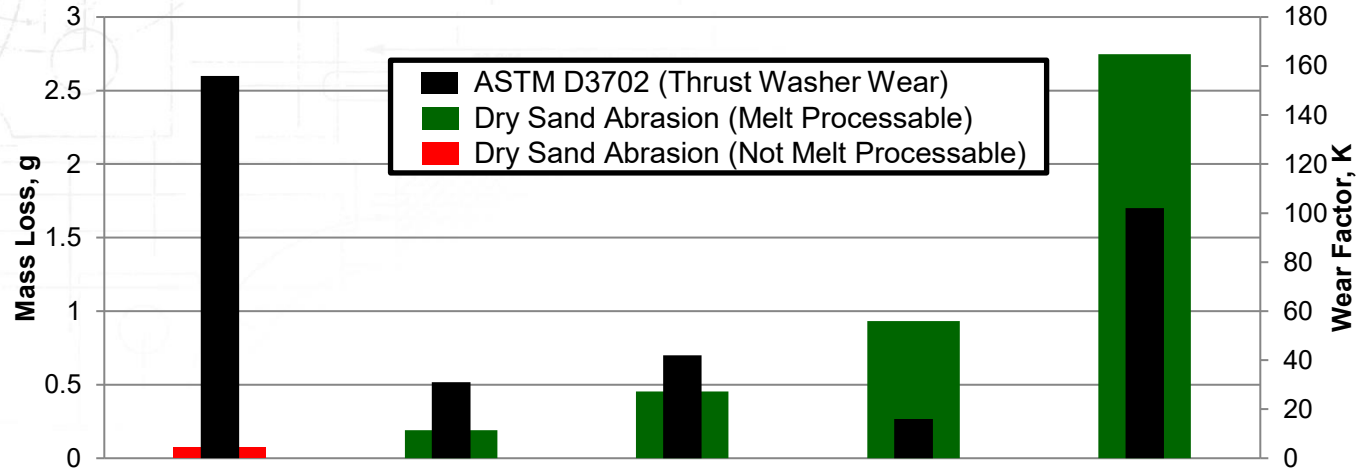
ABRASION TEST RESULTS

ASTM G65 (Dry Sand) Abrasion Results



Tested per ASTM G65 Dry Sand/Rubber Wheel

ABRASION VS SLIDING WEAR



	UHMWPE	PA6 + ABR	HDPE + ABR	PP + ABR	POM
Mass Loss, g ASTM G65; Dry Sand	0.074	0.191	0.454	0.770	2.747
Wear Factor K (in ³ min/ft-lb-hr)*E-10	156	31	42	46	102
Dynamic CoF, μ_k	0.73	0.38	0.24	0.16	0.42

APPLICATION EXAMPLE

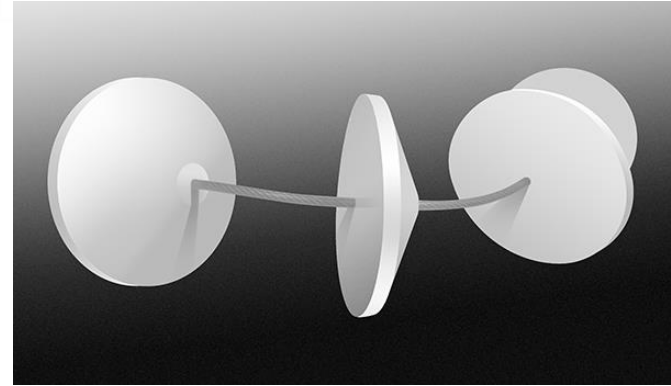
Cable Conveyor

Requirements

- FDA Compliant
- Gentle, low-noise material handling
- Injection moldable
- Abrasion/Wear resistant
- Low friction

Solution

- HDPE + ABR with FDA compliant materials



ADDITIVE TECHNOLOGIES

APWA



PTFE



Silicone Fluid



Solid Additives



Fibers



ADDITIVE TECHNOLOGIES

Reinforcing Fibers and Wear Resistance

Glass Fiber



- Improved bearing capabilities/wear resistance
- Very abrasive

Carbon Fiber



- Higher bearing capabilities
- Excellent thermal resistance
- Conductive
- Less abrasive

Aramid Fiber



- Little strength improvement
- Consistent low friction
- Very gentle to mating surface

ADDITIVE TECHNOLOGIES

**Fibers protect the polymer, but may be abrasive
against the mating material**



Glass



Carbon



Aramid

Aluminum Contact Surface

APPLICATION EXAMPLE

Laser Printer Fuser Gears

Requirements

- High operating temperatures
- Good strength
- Good wear resistance

Solution

- PPS + Glass Fiber + PTFE



APPLICATION EXAMPLE

Copier Bushings

Requirements

- High heat deflection temperature
- Good wear resistance

Solution

- PPA + Aramid Fiber + PTFE



ADDITIVE TECHNOLOGIES

APWA



PTFE



Silicone Fluid

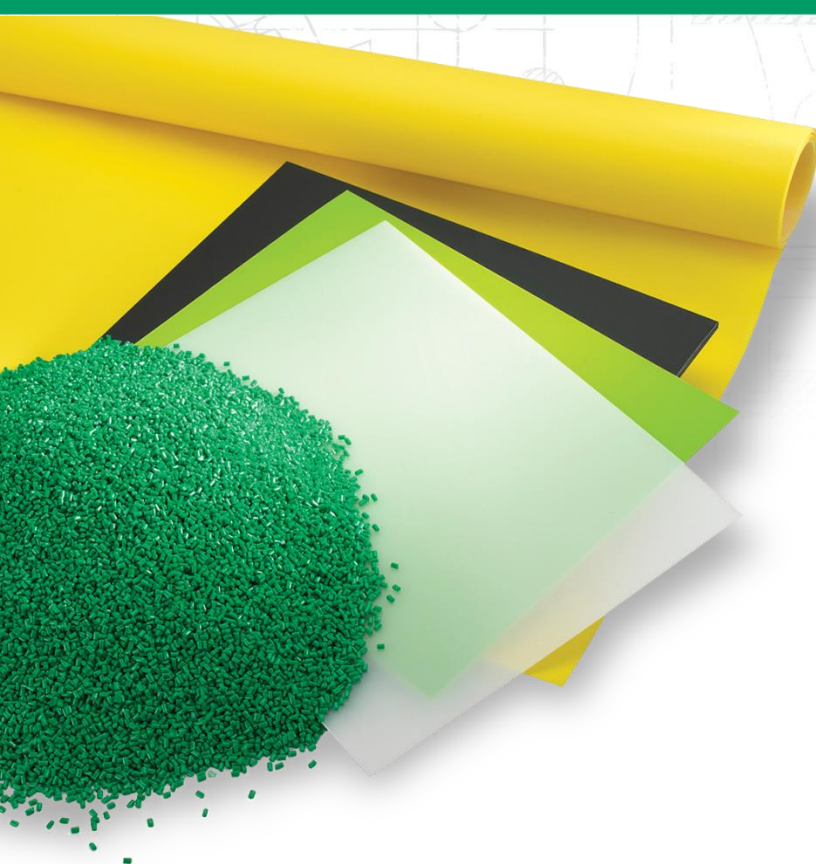


Solid Additives



Fibers



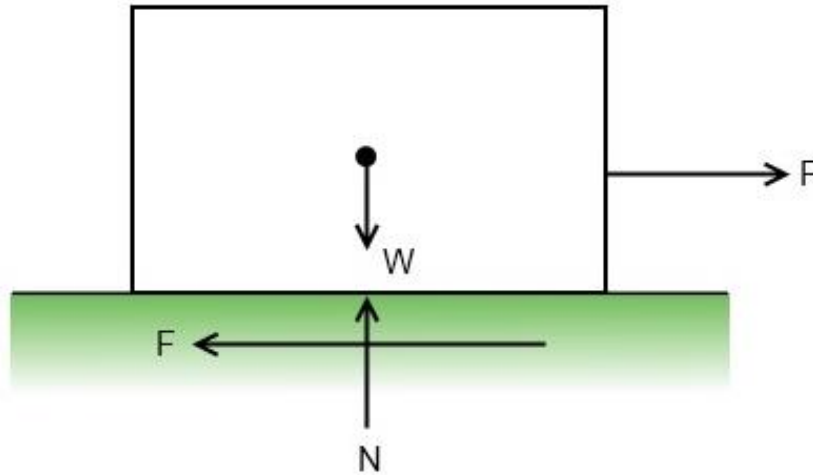


FRICTION MODIFICATION: OPTIMAL POLYMER PAIRS

FRICTION DEFINITIONS

Coefficient of Friction (μ)

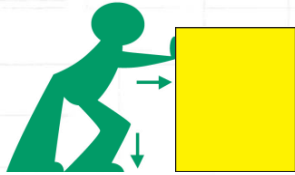
Ratio of the force of friction between two bodies and the force pressing them together



$$\mu = F/N$$

FRICTION DEFINITIONS

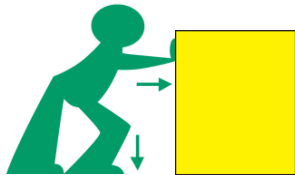
Coefficient of Friction (μ)



Static coefficient of friction (μ_s) = $\frac{F_x}{F_y}$

F_x = Force to *initiate* motion

F_y = Normal force holding surfaces together



Dynamic coefficient of friction (μ_k) = $\frac{F_x}{F_y}$

F_x = Force to *sustain* motion

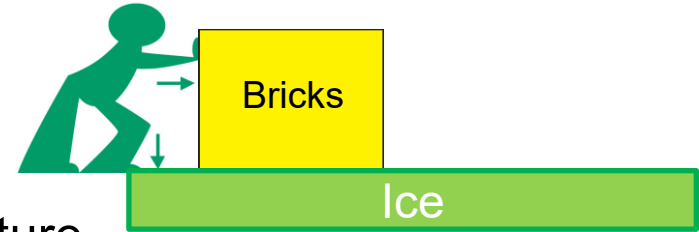
F_y = Normal force holding surfaces together

NOT JUST TWO FRICTION VALUES!

- Friction is dependent on:

- Mating material
- Surface finish
- Pressure/Velocity/Temperature

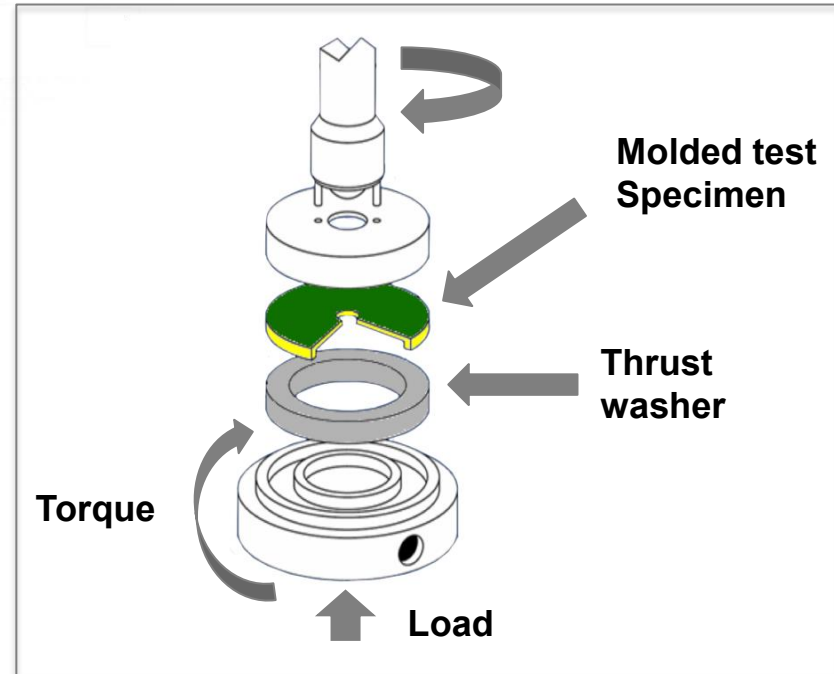
- Most non-plastic materials: $\mu_s > \mu_k$
- Thermoplastics are somewhat unique: $\mu_k > \mu_s$
 - May cause “stick/slip” → squeaking



FRICTION TESTING

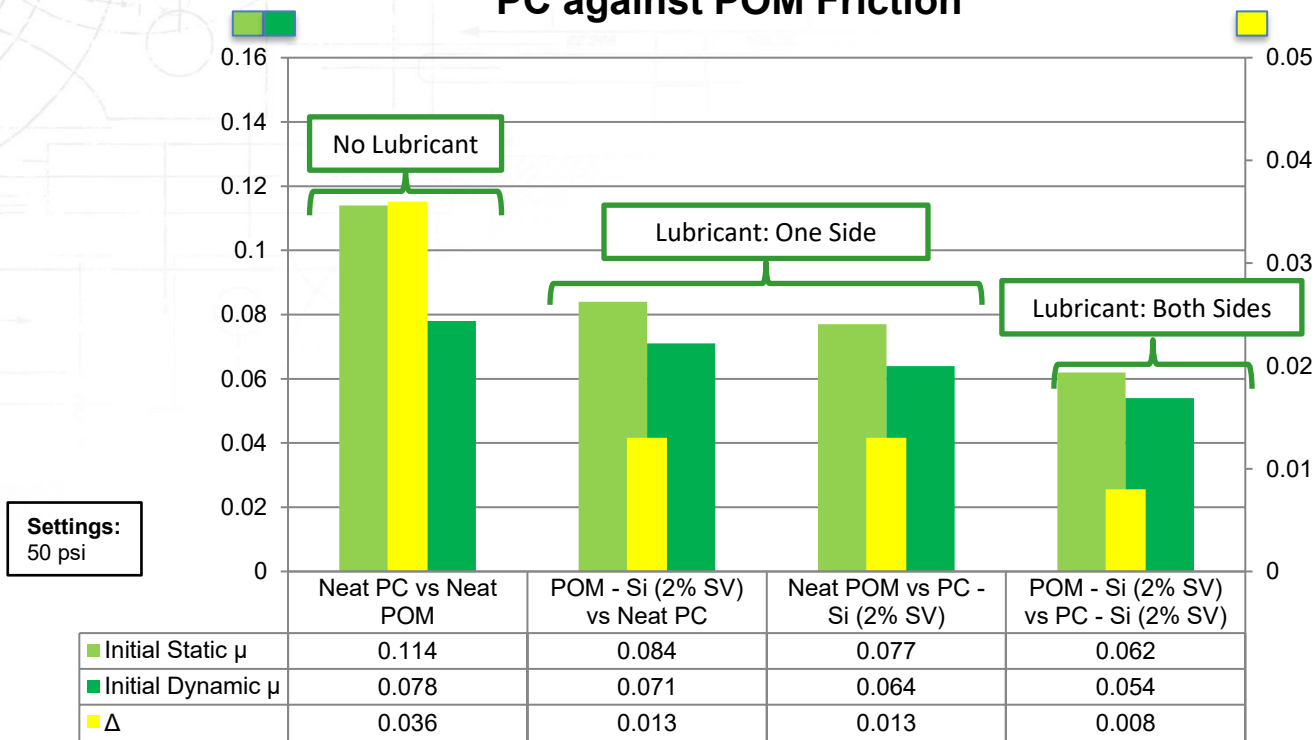
RTP Company Modified ASTM D3702 Friction Test

- Oscillating motion used to measure static friction coefficients
- Used to quantify the difference between μ_s and μ_k to evaluate stick/slip
- Used to generate friction data for optimal pairing material selection



PLASTIC VS PLASTIC FRICTION EXAMPLE

PC against POM Friction



WHEN TO USE WEAR SOLUTION

Drug Delivery Pen Components

Requirements

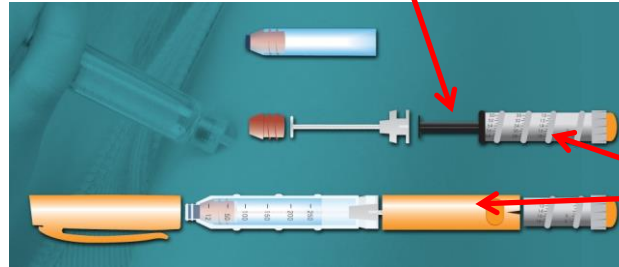
- Good strength
- Dimensional stability
- Eliminate secondary lubricant application
- No stick/slip

Solution(s)

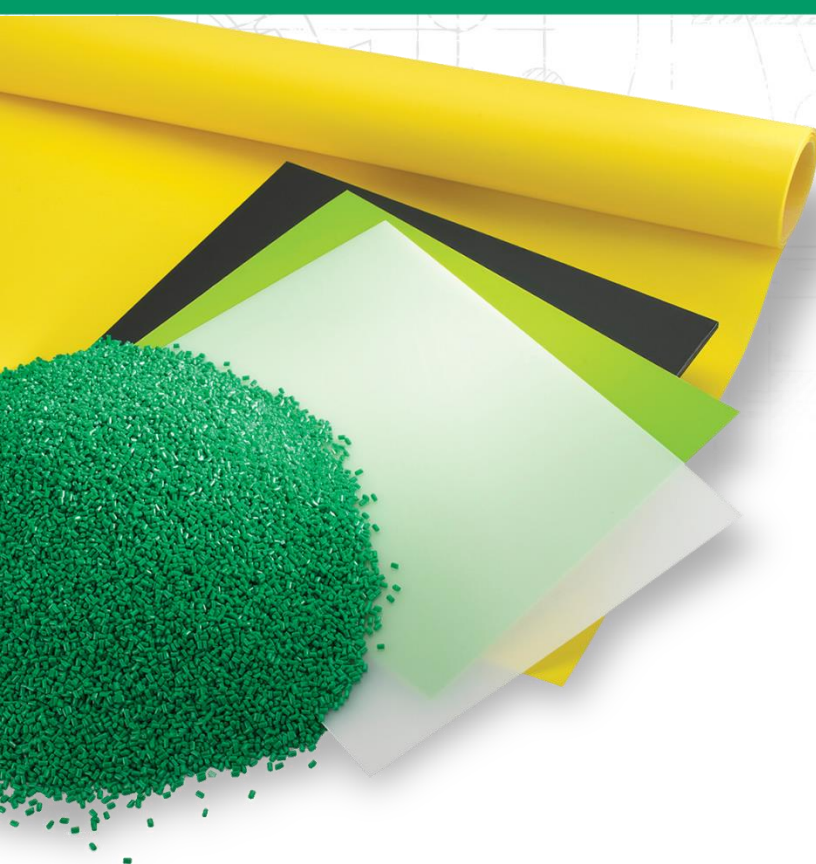
- Optimal plastic “friction pairs”



Fiber reinforced and internally lubricated PC or PBT



Internally lubricated POM or PBT



SUMMARY

WHEN TO USE WEAR SOLUTIONS

Solutions for common issues, including:

Lubrication

Eliminate messy & costly secondary operations



Stiction

Reduce stick/slip phenomenon



Noise

Reduce noise caused by part movement & vibration



Scratch & Mar

Enhance product quality & customer satisfaction



Abrasion

Enhance abrasion resistance



Extreme Conditions

Withstand high temps, pressure, velocity, & more



ADDITIONAL INFORMATION & DATA



Wear and Friction Resistant Thermoplastics

Solutions for Wear, Friction, Abrasion, and Surface Protection Issues



www.rtpcompany.com

Plastic Against Metal Performance: ASTM D-3702

RTP Company Product	Description	Percent per (in)	Velocity (ft/min)	English (in)	Metric (mm)	Wear Factor (in ³ /in)	Wear Factor (mm ³ /mm)
Polycarbonate, 100 (RTP 100 Series)							
RTP 100 ABR	Abrasion Resistant	40 (276)	50 (6,25)	2000	307	70	617
		50 (245)	100 (6,51)	1000	46	175	460
RTP 100 CC	30% GF	40 (276)	50 (6,25)	2000	107	70	215
RTP 100 CC TFE 15	30% GF, 15% PTFE	40 (276)	50 (6,25)	2000	120	70	241
RTP 30105 CC	30% GF, 5% PTFE	40 (276)	50 (6,25)	2000	101	70	203
Nylon 6/6, 100 (RTP 100 Series)							
RTP 200	Unfilled PA 6/6	40 (276)	50 (6,25)	2000	301	70	1811
		50 (245)	100 (6,51)	1000	96	175	591
RTP 200 B2	2% Silicone	40 (276)	50 (6,25)	2000	191	300	384
		50 (245)	100 (6,51)	1000	111	175	344
RTP 200 TFE 5	5% PTFE	40 (276)	50 (6,25)	2000	367	70	1824
		50 (245)	100 (6,51)	1000	407	175	668
RTP 200 TFE 10	10% PTFE	40 (276)	50 (6,25)	2000	341	70	645
		50 (245)	100 (6,51)	1000	171	175	344
RTP 200 TFE 18 B2	18% PTFE, 2% Silicone	40 (276)	50 (6,25)	2000	11	70	22
		50 (245)	100 (6,51)	1000	58	175	118
RTP 200 TFE 20	20% PTFE	40 (276)	50 (6,25)	2000	102	70	255
		50 (245)	100 (6,51)	1000	111	175	22
RTP 300 X 12054 A	AP300™	40 (276)	50 (6,25)	2000	136	70	273
		50 (245)	100 (6,51)	1000	46	175	90
RTP 300 X 12056 B	AP300™ + Silicone	40 (276)	50 (6,25)	2000	21	360	42
		50 (245)	100 (6,51)	1000	81	70	143
RTP 200 ABR	Abrasion Resistant	40 (276)	50 (6,25)	2000	257	70	476
		50 (245)	100 (6,51)	1000	79	175	141
RTP 202 TFE 13 B2	15% GF, 13% PTFE, 2% Silicone	40 (276)	50 (6,25)	2000	8	70	16
		50 (245)	100 (6,51)	1000	15	175	30



ABRASION RESISTANT COMPOUNDS

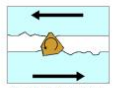
WEAR AND FRICTION RESISTANT PRODUCTS

FEATURES

- Can be injection molded or extruded
- Uniquely offered in a number of resin and additive combinations
- Suitable for both lower and higher volume applications

BENEFITS

- Can be injection molded, unlike other solutions that are limited to compression or ram extrusion
- Eliminates costly secondary processing, thereby reducing overall total cost
- Performance can be further enhanced by utilizing a wide range of resins and additives
- Global availability



Abrasion is typically catastrophic to operating systems due to contamination by extraneous debris.



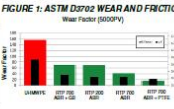
Abrasion Resistant Compounds can be injection molded, offering design freedom and reduced costs for a variety of applications.

RTP Company formulates unique thermoplastic compounds that resist abrasion and are designed specifically for injection molding, offering a whole new way to solve abrasion issues. Substances that cause abrasion are not easily predicted or managed; third party abrasion can generate debris, resulting in system contamination and adverse effects on operations and quality. Typically, abrasion is catastrophic to a system, so minimizing the effects of abrasion is critical.

Abrasion Resistant Compounds from RTP Company can reduce abrasion and provide additional properties to meet even the most challenging application requirements. They are available in multiple resin and additive combinations for extreme design flexibility. Additional functionality such as wear and friction resistance, flame retardancy, and conductivity can be included.

FIGURE 1: ASTM D5702 WEAR AND FRICTION

Wear Factor (1000V)



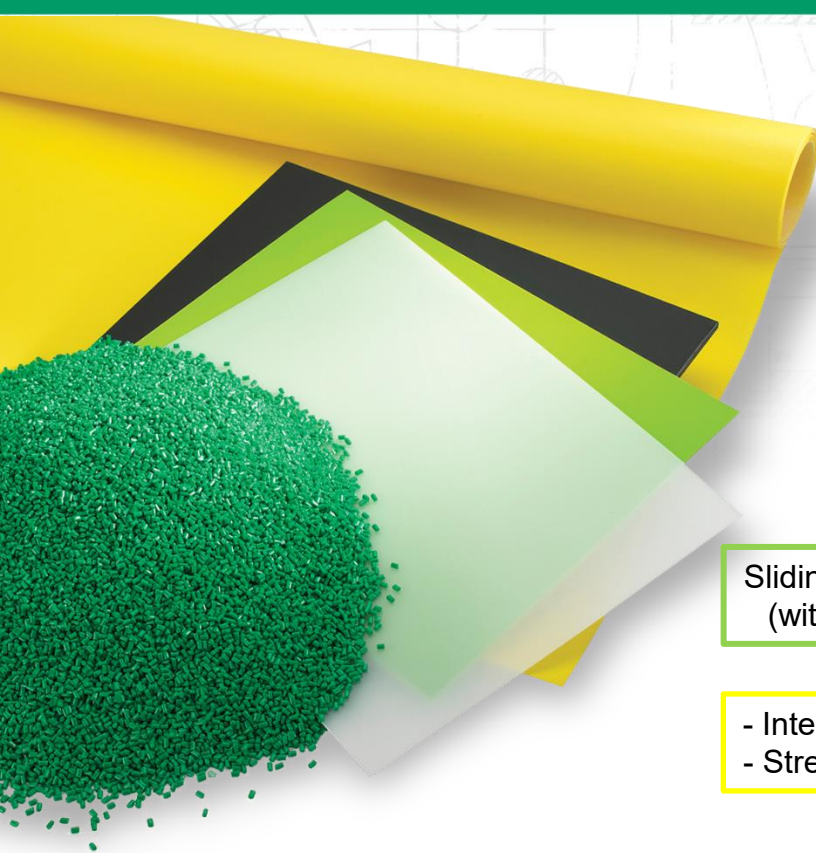
Data from multiple, industry-recognized test methods suggests that RTP Company's Abrasion Resistant Compounds demonstrate abrasion resistance comparable to UHMWPE (Ultra-High Molecular Weight Polyethylene). In addition, these compounds are superior to UHMWPE in wear and friction tests (see Figure 1).

With the added advantage of being injection moldable, our Abrasion Resistant Compounds are not limited to stock shapes that require costly secondary processing, making the design possibilities seemingly endless! Abrasion Resistant Compounds, available from RTP Company, your global compounder of custom engineered thermoplastics!

RTP Company Corporate Headquarters: 380 East First Street, Wichita, Kansas 67202 USA | Website: www.rtpcompany.com | Email: info@rtpcompany.com

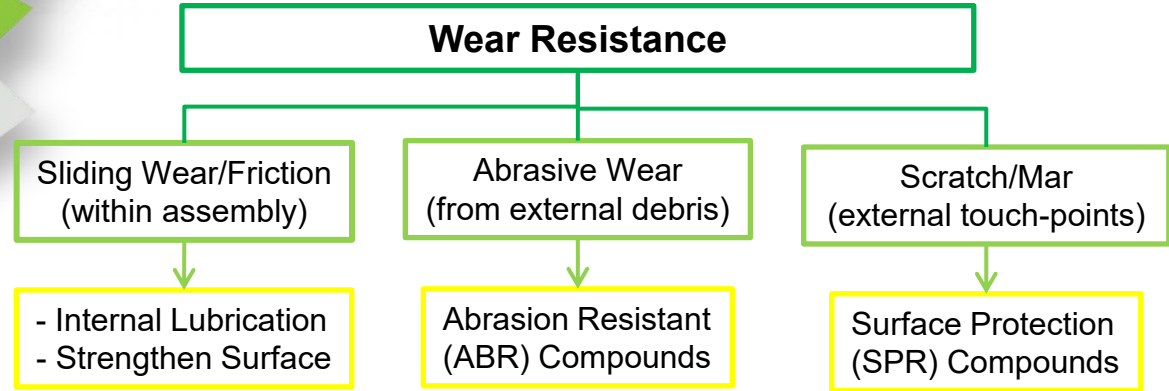
Wichita, Kansas | Wichita, Kansas | Wichita, Kansas | Wichita, Kansas | Wichita, Kansas

Wear factor (K) and friction coefficient (μ_K) for common tribological compounds:
www.rtpcompany.com/info/wear



THANK YOU!

Questions?



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rtpcompany.com

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