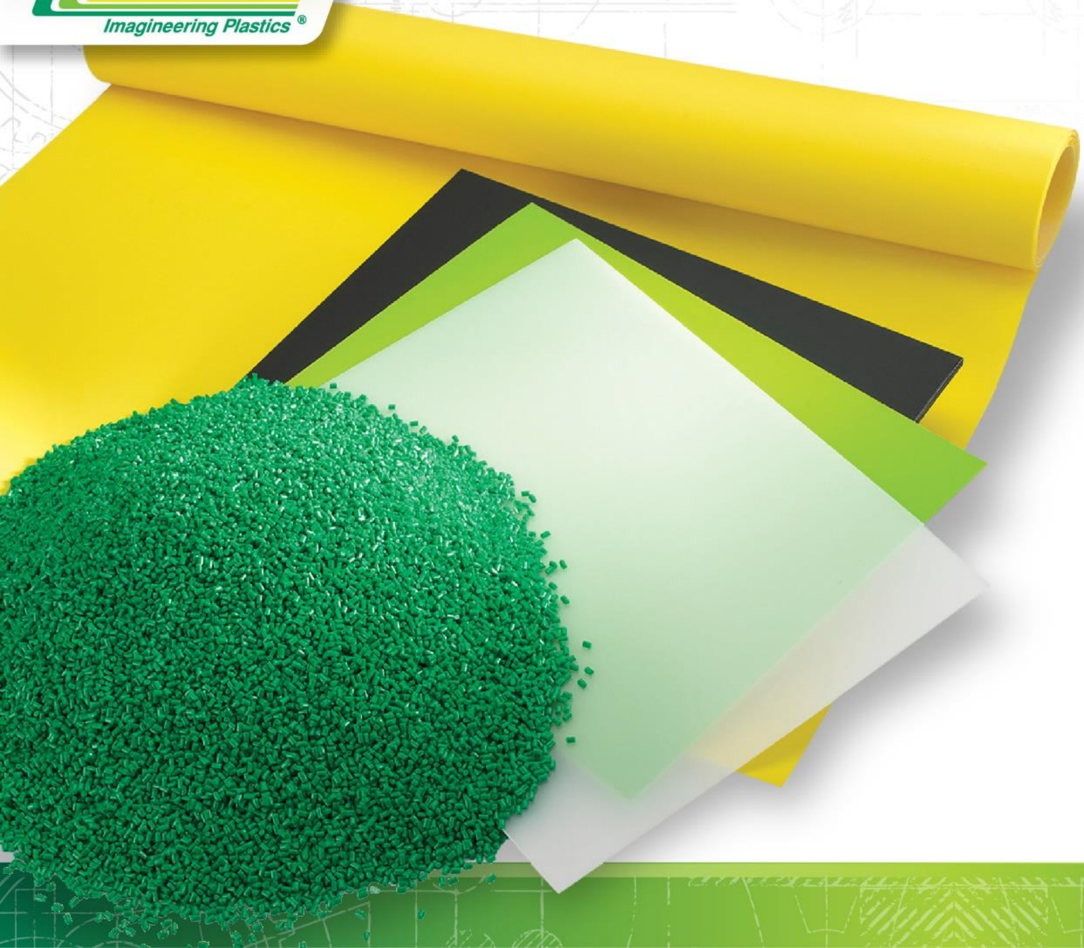


What, WEAR, and When

Sarah Goettler

Product Development Engineer - Wear

“My application is wearing out!”

Fatigue?

?

Chemical Attack?

?

Abrasion?

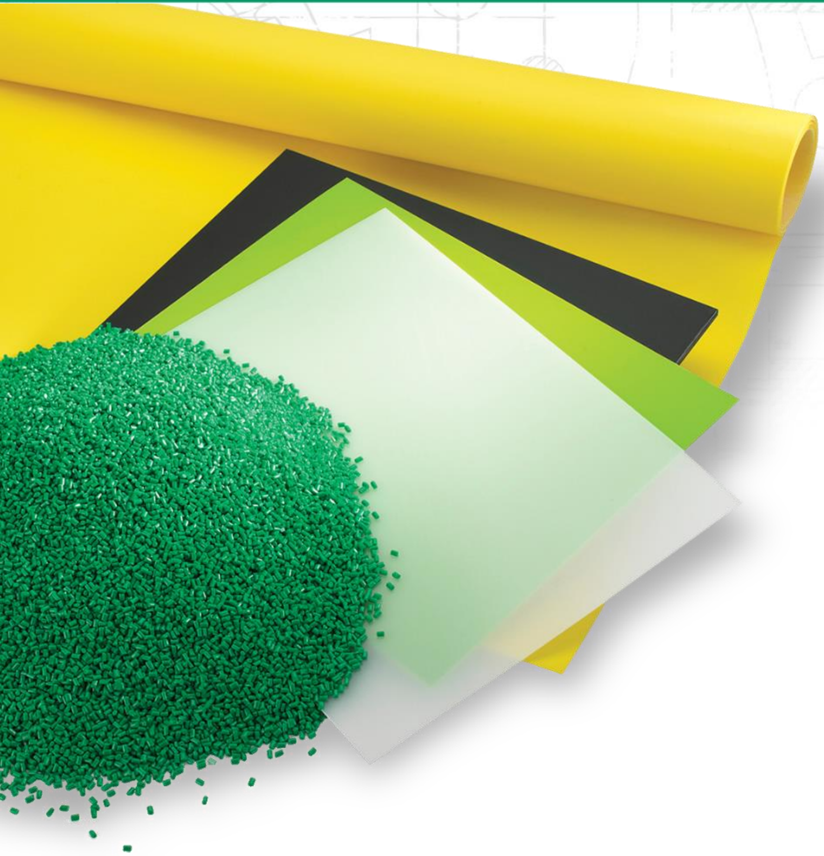
?

Weather/UV Resistance?

?

AGENDA

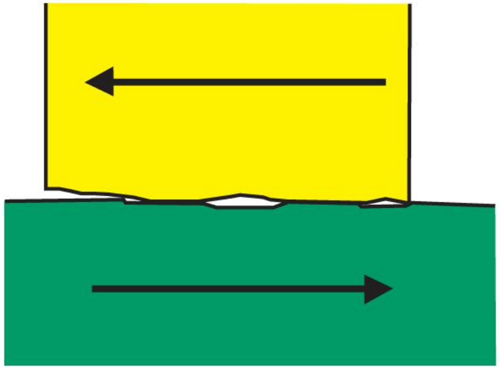
I. What is Wear?
II. Test Methods
III. Additive Technologies
IV. Friction Modification



WHAT IS WEAR?

WHAT IS WEAR

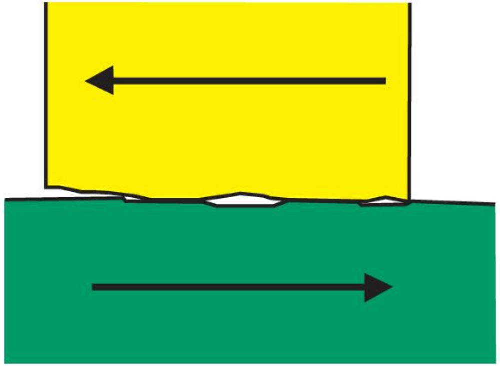
Wear – Sliding wear of thermoplastic compounds against a contact surface (steel, aluminum, other thermoplastics, etc.)



WEAR MECHANISMS

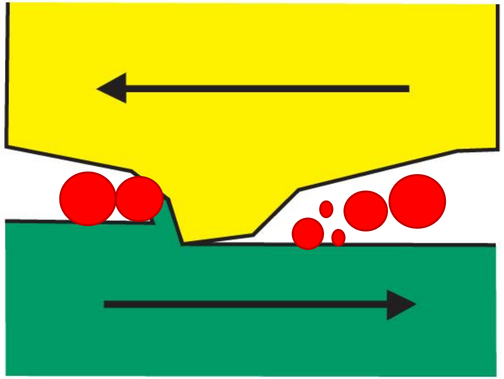
Adhesive Wear

- Characterized by transfer of material caused by frictional heat



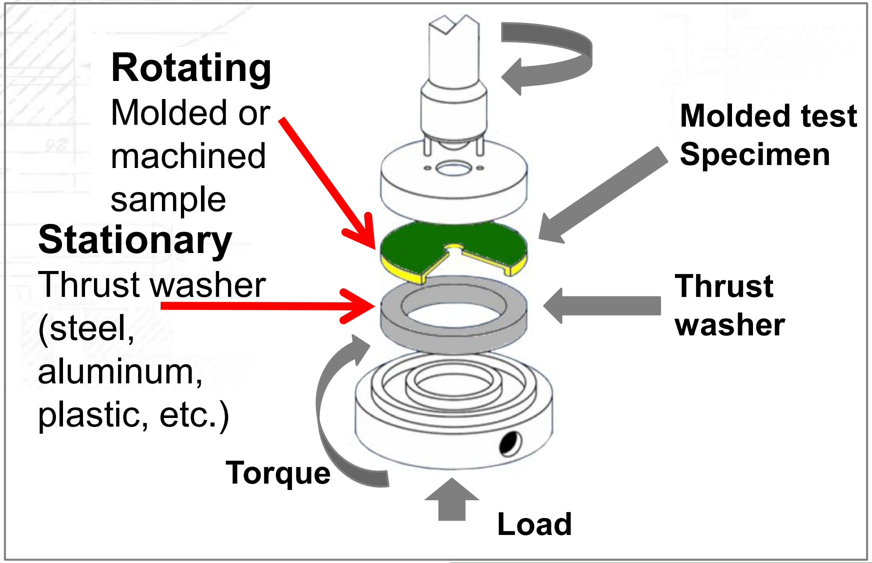
Three Body
Abrasive Wear

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

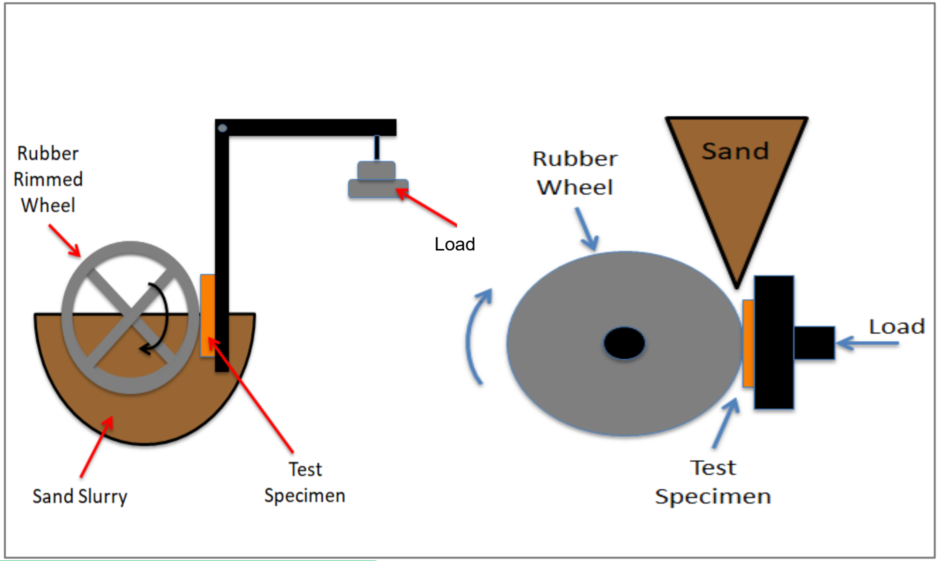


TESTING DIFFERENCES

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-min/ft-lb-hr) · 10^{-10} or (mm^3/N-m) · 10^{-8}*

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

F = Force: *lb or N*

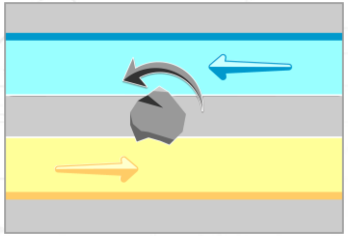
V = Velocity: *ft/min or m/sec*

T = Elapsed time: *hr or sec*

100 Hour Test!

ABRASION VS SCRATCH

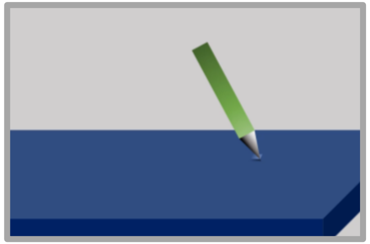
Abrasion



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

Solution: Abrasion Resistance (ABR) Compounds

Scratch and Mar

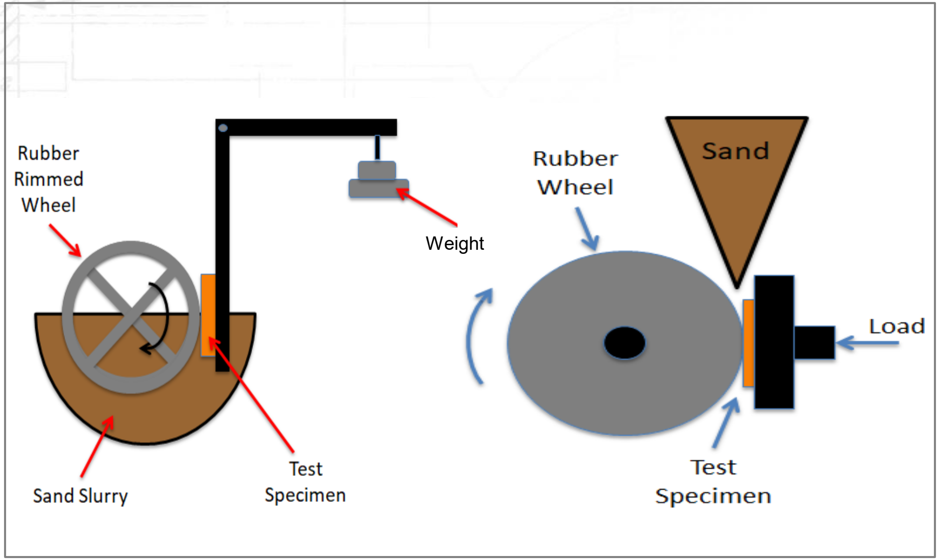


- Primarily aesthetic
- Alters surface quality
- Test methods evaluate scratch severity

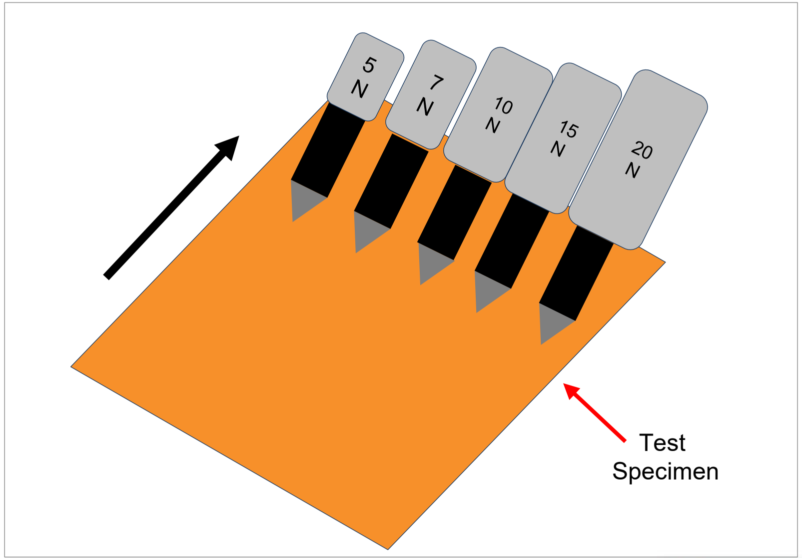
Solution: Surface Protection (SPR) Compounds

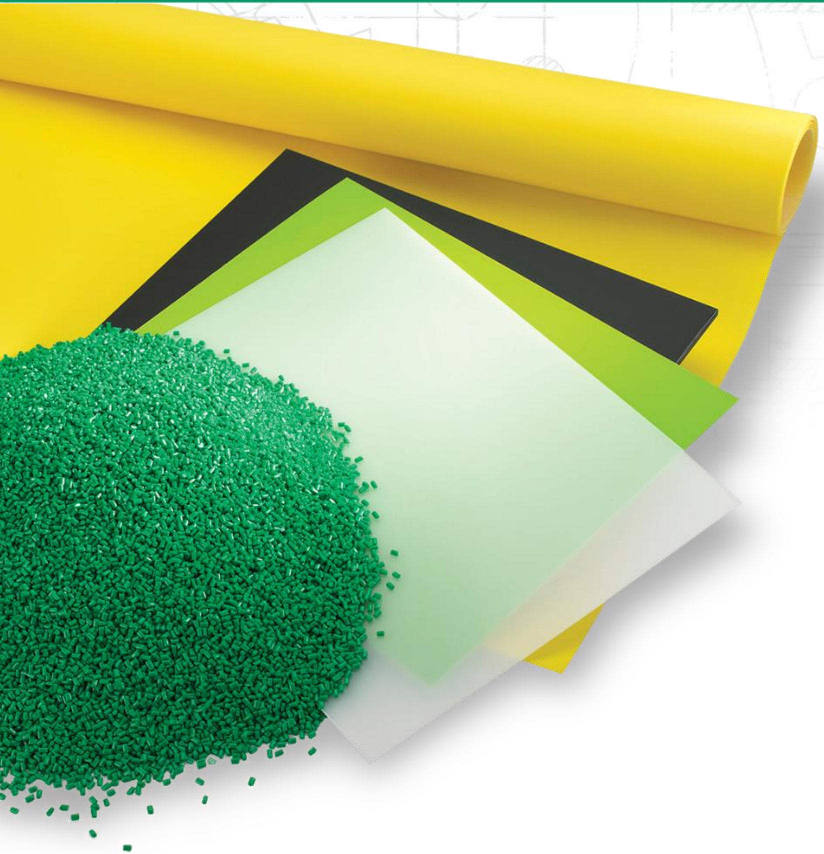
ABRASION TEST VS SCRATCH TEST

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

APWA

PTFE

WEAR ADDITIVE COMPARISON

APWA

- ✓ PFAS-Compliant
- ✓ Halogen-free Ingredients
- ✓ Clean Processing and Handling
- ✓ REACH Compliant
- ✓ Low specific gravity

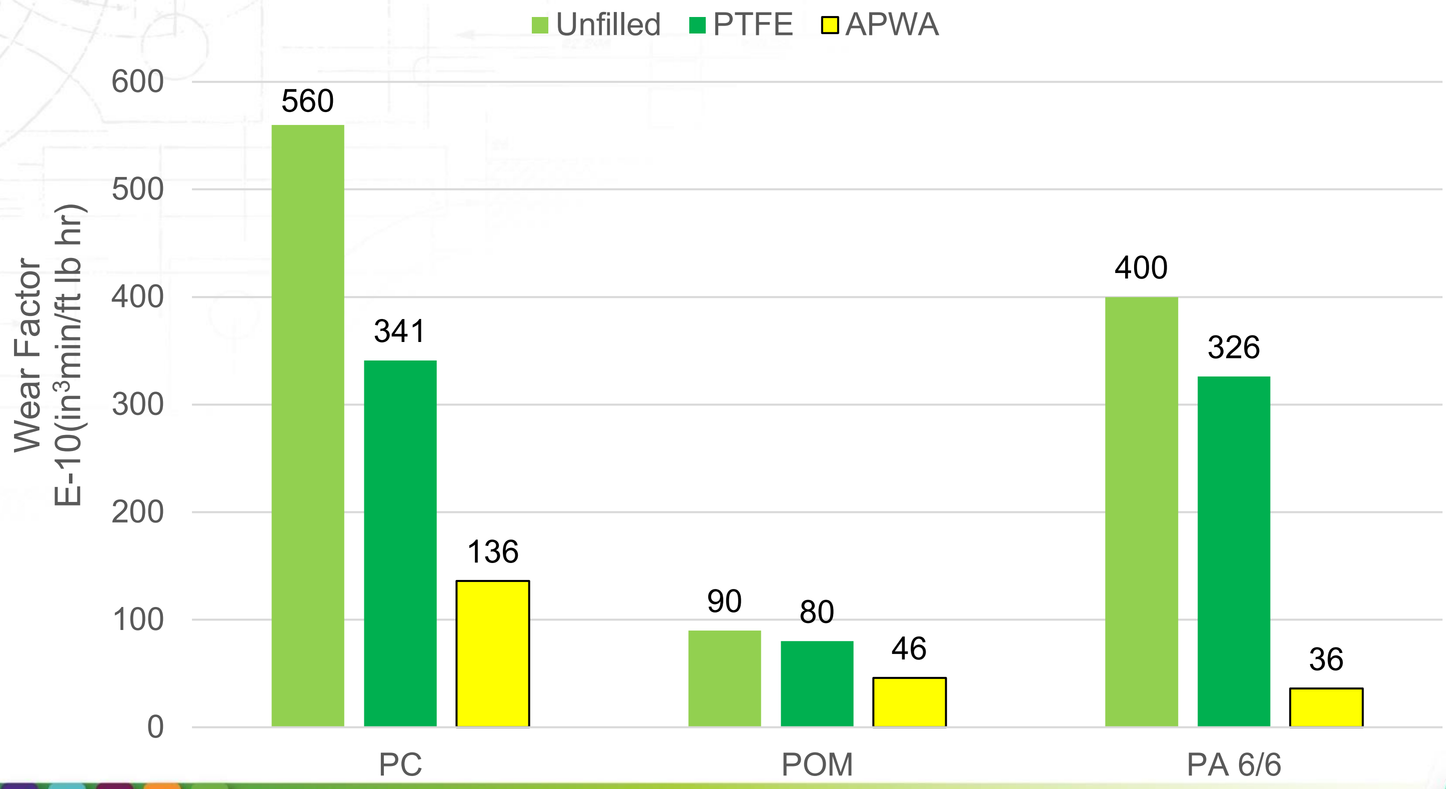
APWA and PTFE

- ✓ Colorable Compounds
- ✓ Excellent Wear Performance
- ✓ RoHS Compliant Ingredients

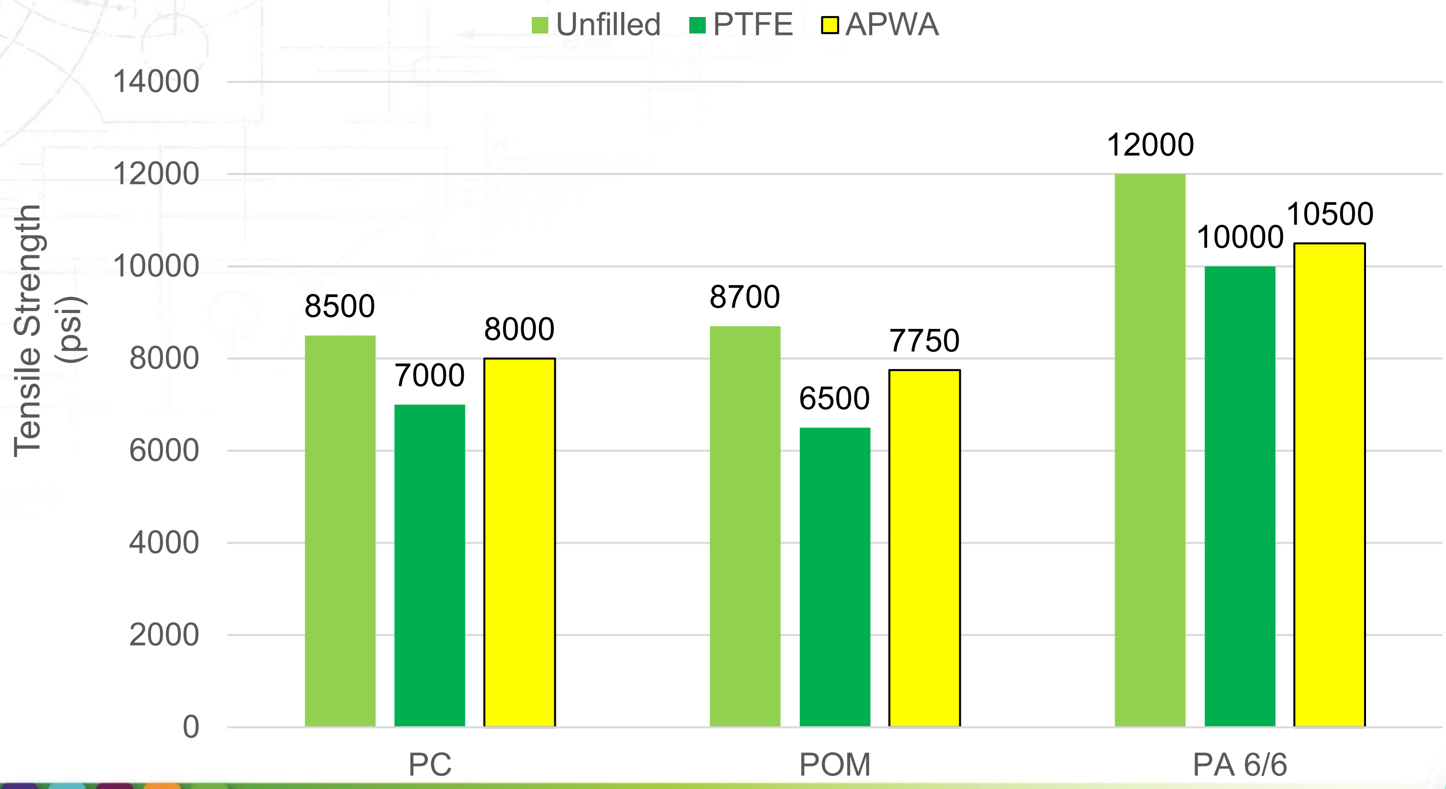
PTFE

- ✓ Forever Chemical (PFAS)
- ✓ Proven Track Record
- ✓ Effective for High Temp/High Load Systems
- ✓ Effective in Nearly all Resin Systems
- ✓ Long History as Industry Standard

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

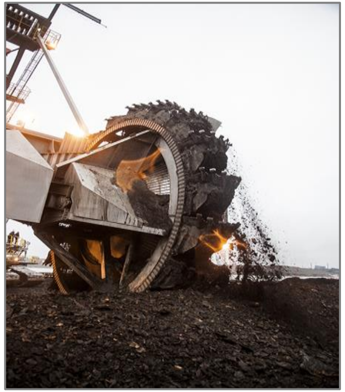
Solution

Impact modified PA 6/6 + APWA

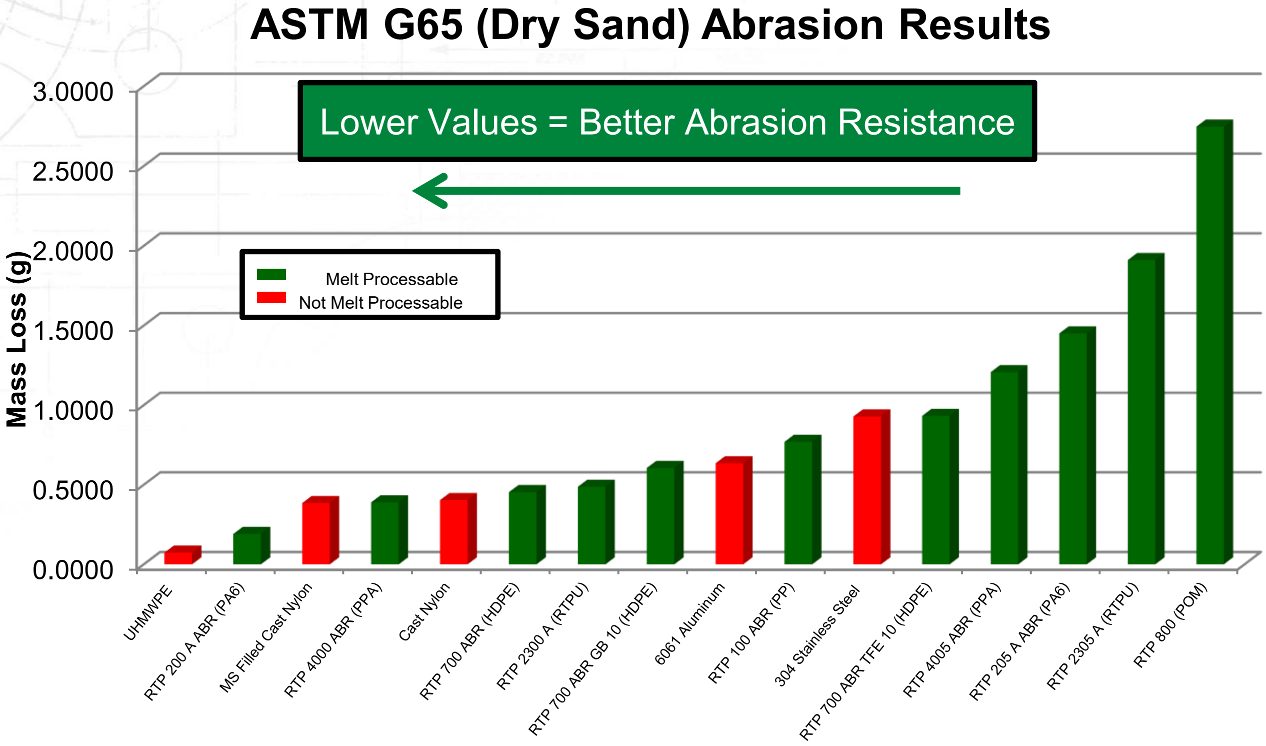
ABRASION RESISTANT SOLUTIONS

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

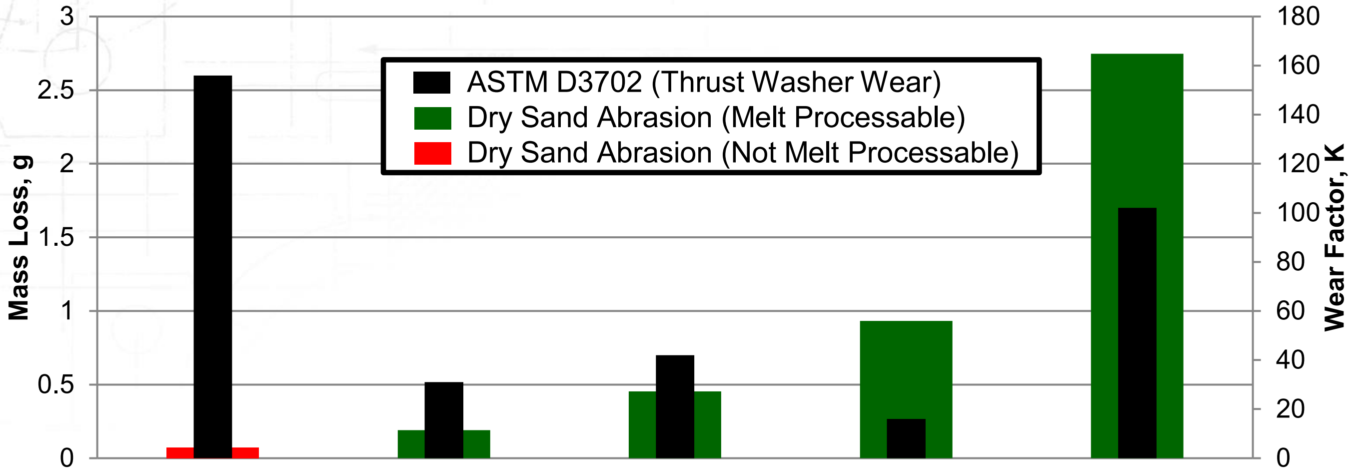


ABRASION TEST RESULTS



Tested per ASTM G65 Dry Sand/Rubber Wheel

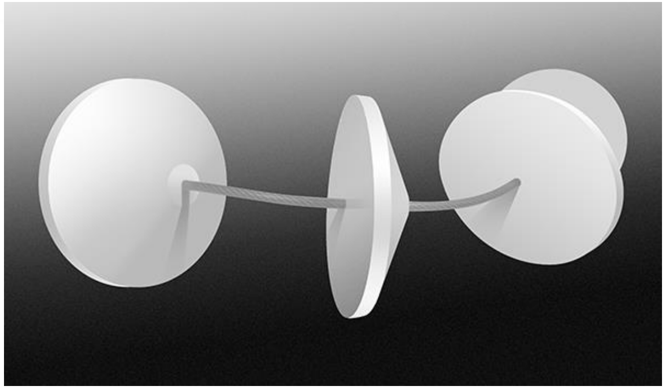
ABRASION VS SLIDING WEAR



	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

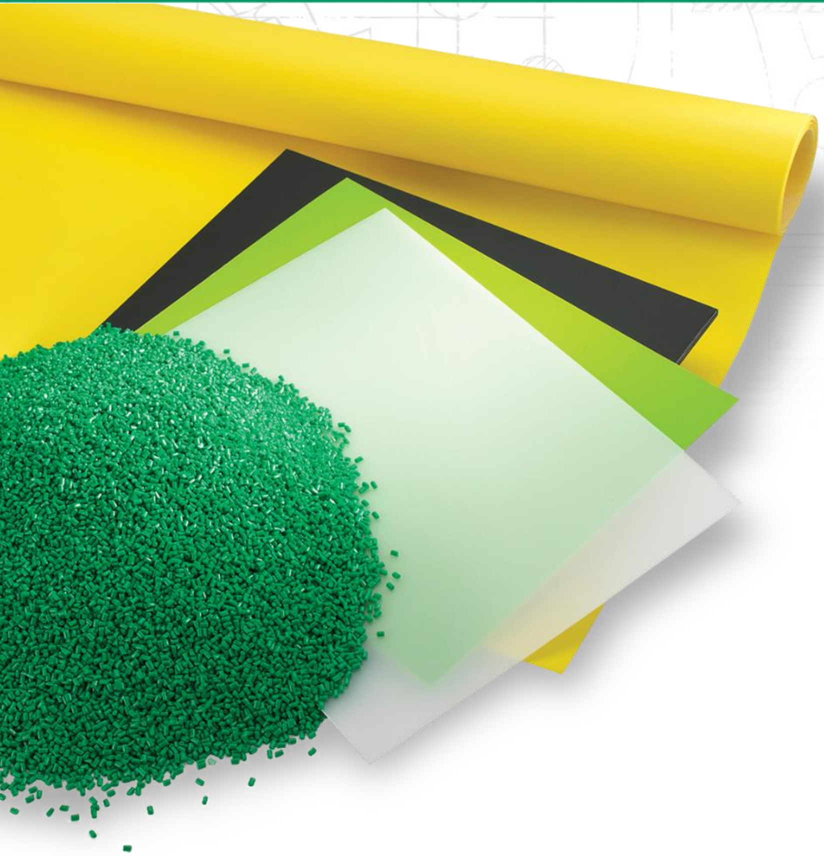
APWA

PTFE

Silicone Fluid

Solid Additives

Fibers

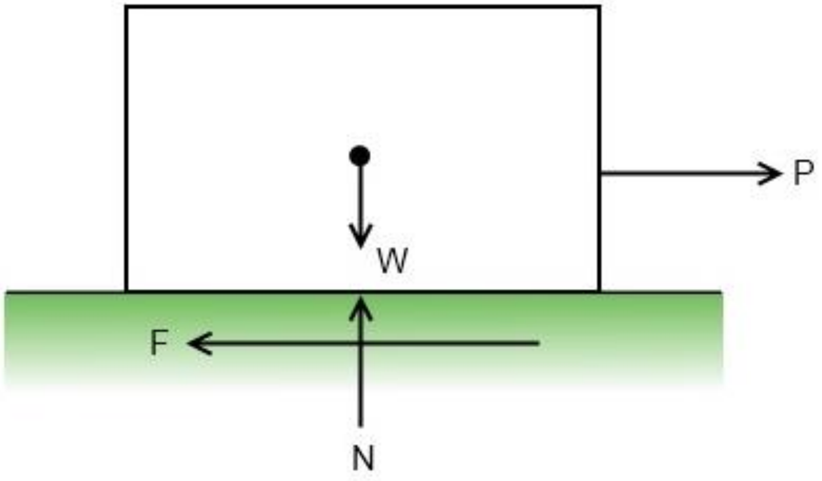


FRICTION MODIFICATION: OPTIMAL POLYMER PAIRS

FRICTION DEFINITIONS

Coefficient of Friction (μ)

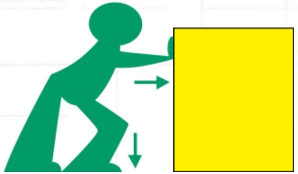
Ratio of the force of friction between two bodies and the force pressing them together



$$\mu = F/N$$

FRICTION DEFINITIONS

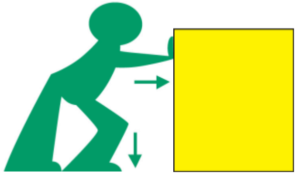
Coefficient of Friction (μ)



Static coefficient of friction (μ_s) = $\frac{Fx}{Fy}$

Fx = Force to *initiate* motion

Fy = Normal force holding surfaces together

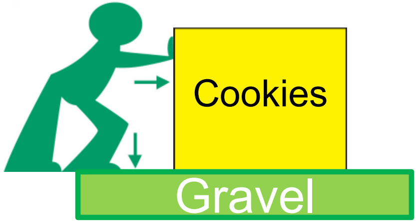


Dynamic coefficient of friction (μ_k) = $\frac{Fx}{Fy}$

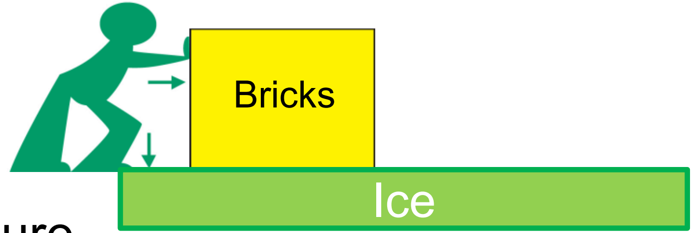
Fx = Force to *sustain* motion

Fy = Normal force holding surfaces together

NOT JUST TWO FRICTION VALUES!



- Friction is dependent on:
  - Mating material
  - Surface finish
  - Pressure/Velocity/Temperature



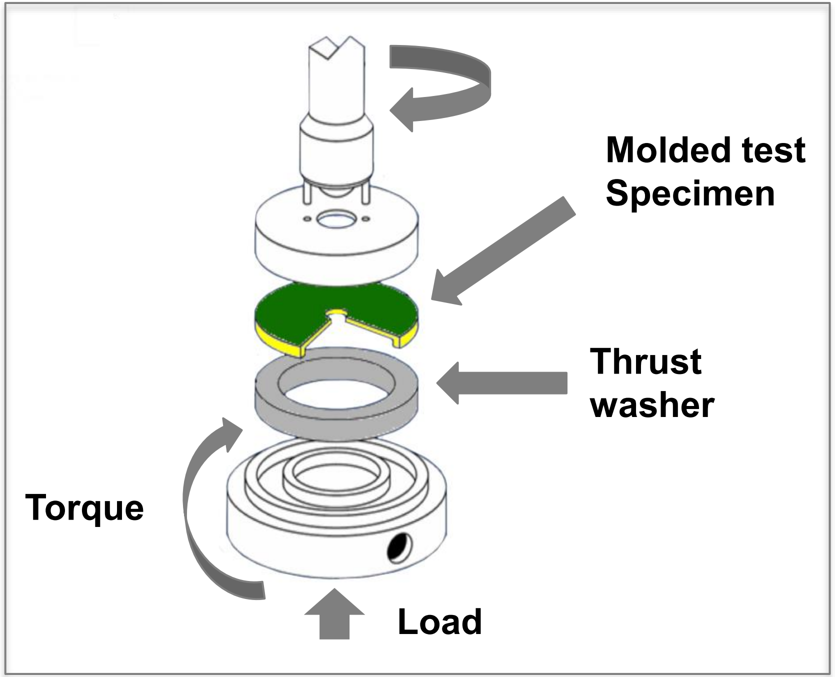
- Most non-plastic materials: $\mu_s > \mu_k$
- Thermoplastics are somewhat unique: $\mu_k > \mu_s$
  - May cause “stick/slip” squeaking

FRICTION TESTING

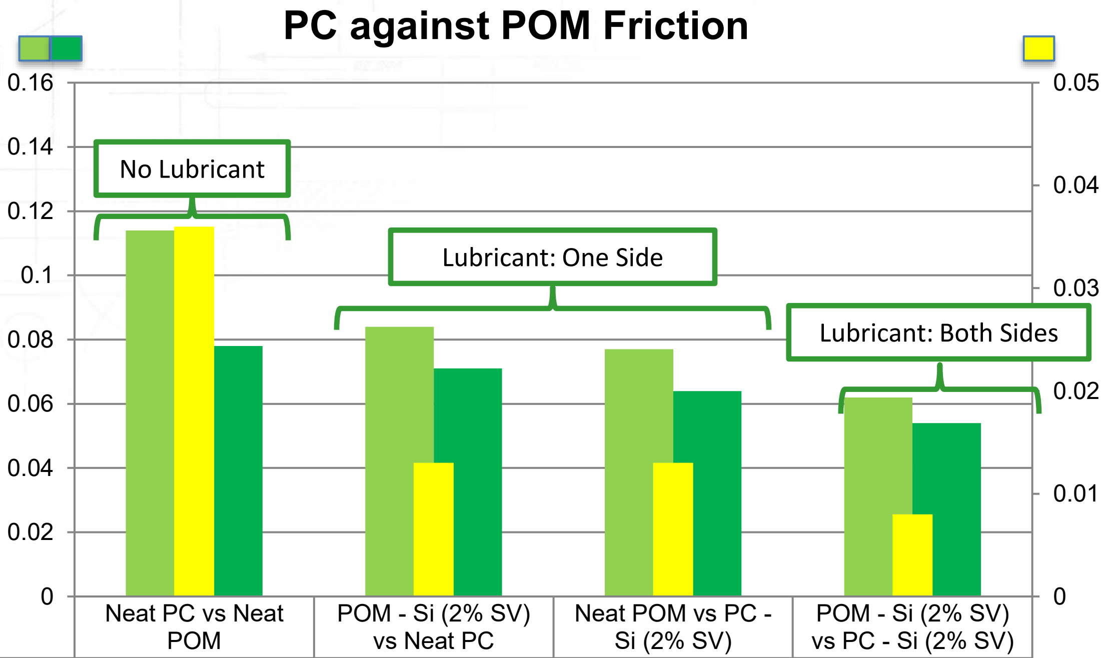
RTP Company Modified ASTM D3702 Friction Test

- 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



	Neat PC vs Neat POM	POM - Si (2% SV) vs Neat PC	Neat POM vs PC - Si (2% SV)	POM - Si (2% SV) vs PC - Si (2% SV)
Initial Static μ	0.114	0.084	0.077	0.062
Initial Dynamic μ	0.078	0.071	0.064	0.054
Δ	0.036	0.013	0.013	0.008

Settings:
50 psi

WHEN TO USE WEAR SOLUTION

Drug Delivery Pen Components

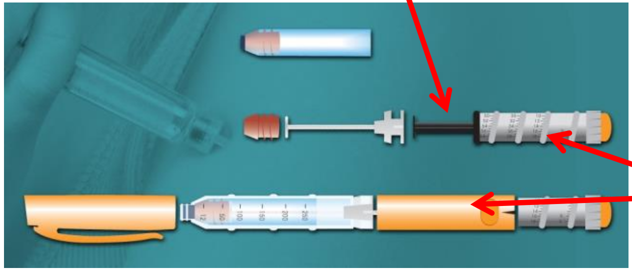
Requirements

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

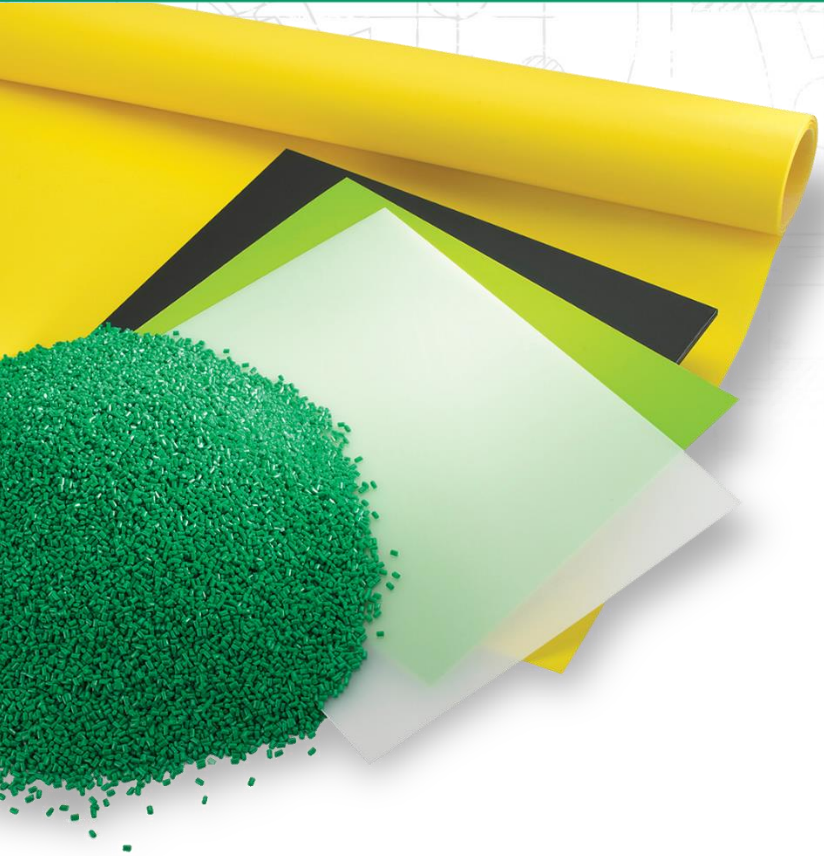
Solution(s)

- 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

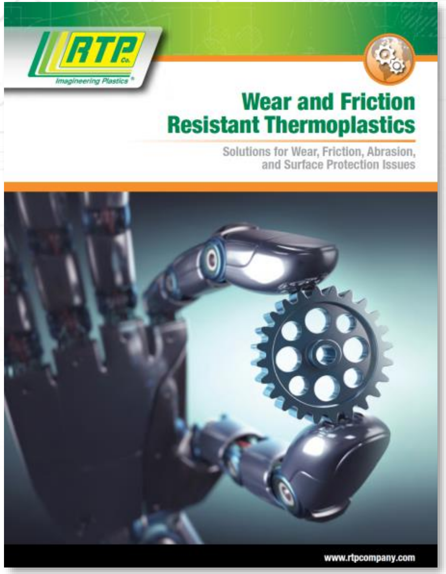
Noise
Reduce noise caused by part movement & vibration

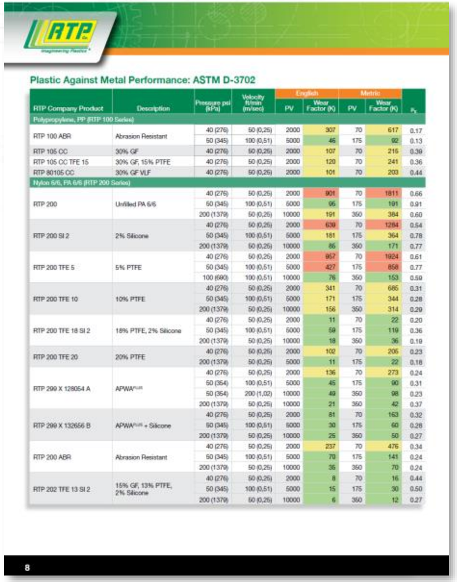
Scratch & Mar
Enhance product quality & customer satisfaction

Abrasion
Enhance abrasion resistance

Extreme Conditions
Withstand high temps, pressure, velocity, & more

ADDITIONAL INFORMATION & DATA





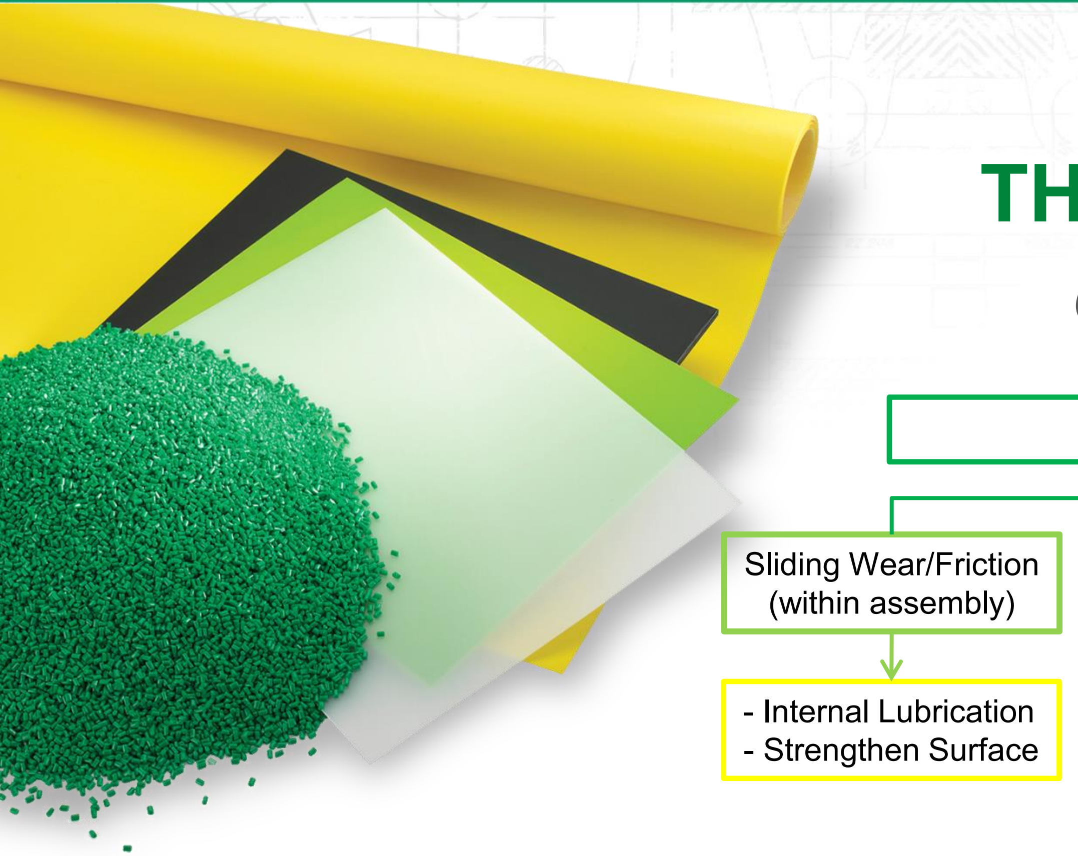
Wear factor (K) and friction coefficient (μ_K) for common tribological compounds:
www.rtpcompany.com/info/wear

THANK YOU!

Questions?

Wear Resistance

- Sliding Wear/Friction (within assembly)
  - Internal Lubrication
  - Strengthen Surface
- Abrasive Wear (from external debris)
  - Abrasion Resistant (ABR) Compounds
- Scratch/Mar (external touch-points)
  - Surface Protection (SPR) Compounds



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