





Healthcare Team



**Plastic Technologies**  
For Safe & Effective Medical Devices



**THERMOPLASTIC ELASTOMERS • STRUCTURAL • WEAR**  
**CONDUCTIVE • COLOR • FLAME RETARDANT**




**Low Friction Plastic Technology for Single-Use Drug Delivery Devices**


**August 2015**

RTP Company Corporate Headquarters • 580 East Front Street • Winona, Minnesota 55987 USA  
website: [www.rtpcompany.com](http://www.rtpcompany.com) • email: [rtp@rtpcompany.com](mailto:rtp@rtpcompany.com) • Winman Corporation • +1 320-259-2514

TELEPHONE:

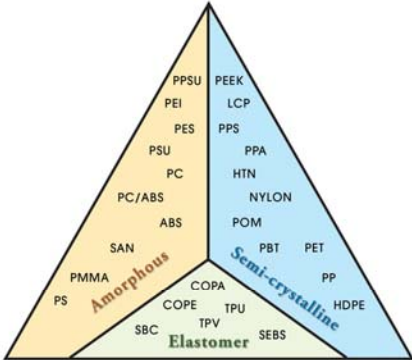
U.S.A.	SOUTH AMERICA	MEXICO	EUROPE	SINGAPORE	CHINA
+1 507-454-6900	+55 11 4193-8772	+52 81 8134-0403	+33 380-253-000	+65 6863-6580	+86 512-6283-8383





## MEDICAL GRADE MATERIALS

YOUR GLOBAL COMPOUNDER OF CUSTOM ENGINEERED THERMOPLASTICS



**PLASTIC TECHNOLOGIES**

Color	Structural	Conductive	Friction & Wear	Flame Retardant	Elastomer
-------	------------	------------	-----------------	-----------------	-----------

**MEDICAL PORTFOLIO**

Bio-compatible Compounds	Change Management	Medical Grade Resins	Laser Marking & Welding	Tribology Test Results	Sheet & Film
--------------------------	-------------------	----------------------	-------------------------	------------------------	--------------

Known bio-compatible database

**Unmatched Resin & Additive Selection**


- Virtually all resins
- Thousands of additives
- Unbiased material selection


**Biocompatibility**

- RTP pre-tested
- Internal list known compounds

**Formulation Control and Change Management**

- Traceability
- ISO 9001 Certified





## Drivers Of This Study

YOUR GLOBAL COMPOUNDER OF CUSTOM ENGINEERED THERMOPLASTICS

- **No industry wide standard test is recognized to characterize start up friction.**
- **Friction is a complex situation with temperature, force, sterilization, UV degradation, human skin oil and shelf life causing “sticktion” concerns.**
- **External lubrication is messy, imprecise and very difficult to evenly spread, clean and QC.**
- **Quality is vital; the device must work the first and only time it is used.**



## INTERNAL LUBRICATION SOLVES MANY PROBLEMS

YOUR GLOBAL COMPOUNDER OF CUSTOM ENGINEERED THERMOPLASTICS

### Improved Selection of Materials

- Tribological data driven decisions
- Improve SPEED to correct solution

### Eliminate Secondary Lubricant

- Low start-up friction
- Eliminate squeaks
- Improve quality & consistency
- Fewer rejects, faster cycle times
- Reduce finished part cost



### Technology Combinations Possible

- Can be combined with laser marking, color, UV stabilization etc.



## INTERNAL LUBRICATION EXAMPLES

YOUR GLOBAL COMPOUNDER OF CUSTOM ENGINEERED THERMOPLASTICS

Lubricated/glass filled PC cover slides.



Lubricated HDPE Vs PC

Lubricated lead screws and slides – easy quiet smooth operation



High speed gears – eliminate 2<sup>nd</sup> lubrication step

Development of a New Friction Test Method

**INTERNAL PLASTIC  
LUBRICATION TESTING  
OVERVIEW**



**FRICITION STUDY OBJECTIVES**

YOUR GLOBAL COMPOUNDER OF CUSTOM ENGINEERED THERMOPLASTICS

- Develop a tribology test to measure **start up** friction to better predict performance
- Characterize plastic on plastic friction behavior to provide effective friction pairing
- Eliminate stick slip phenomenon
- Demonstrate internally lubricated plastic performance

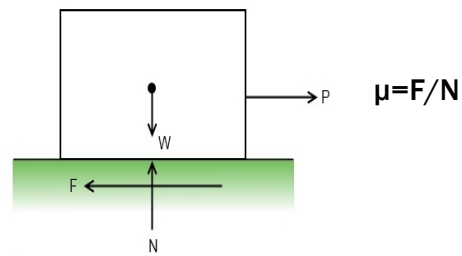


## FRICION TERMS AND DEFINITIONS

YOUR GLOBAL COMPOUNDER OF CUSTOM ENGINEERED THERMOPLASTICS

### Coefficient of Friction ( $\mu$ )

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



## TYPES of SLIDING FRICTION

YOUR GLOBAL COMPOUNDER OF CUSTOM ENGINEERED THERMOPLASTICS

### Static Coefficient of Friction ( $\mu_s$ )



- Static Coefficient of Friction ( $\mu_s$ ) =  $F_x/F_y$ 
  - $F_x$  = Force to *initiate* motion
  - $F_y$  = Normal force holding surfaces together

### Dynamic Coefficient of Friction ( $\mu_k$ )



- Dynamic Coefficient of Friction ( $\mu_k$ ) =  $F_x/F_y$ 
  - $F_x$  = Force to *sustain* motion
  - $F_y$  = Normal force holding surfaces together



## OPTIMAL PERFORMANCE

YOUR GLOBAL COMPOUNDER OF CUSTOM ENGINEERED THERMOPLASTICS

### OPTIMIZED PERFORMANCE is

– **Lowest Static Coefficient of Friction** - ( $\mu_s$ )

- Easy initiation of movement

### **AND**

– **Lowest Glide Factor** =  $\mu_s - \mu_k$

- Glide Factor is the difference between  $\mu_s$  and  $\mu_k$
- Elimination of stick-slip



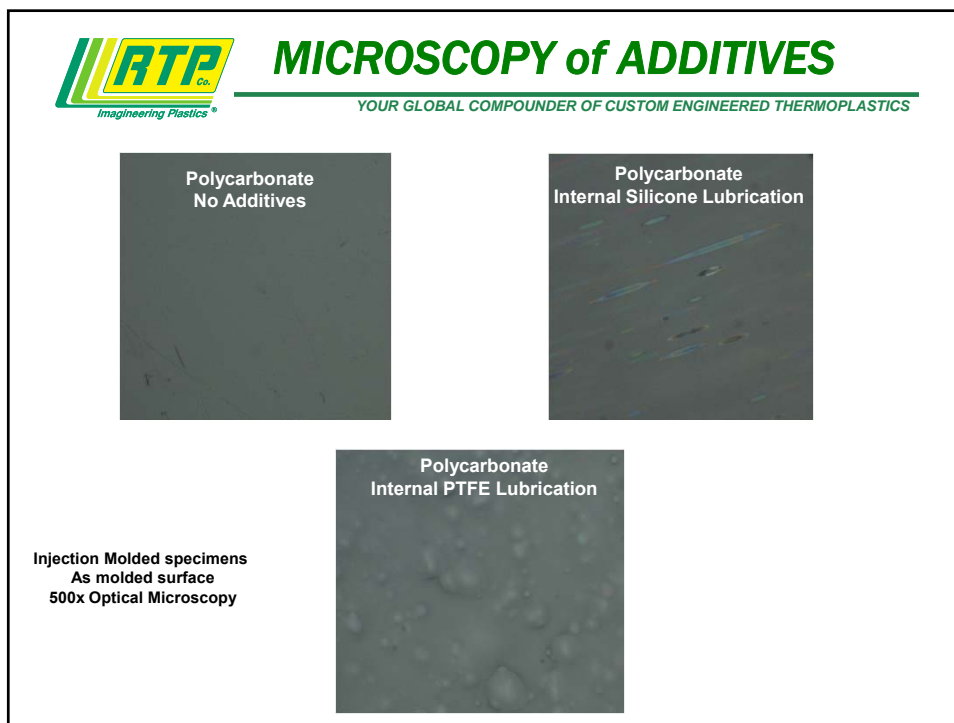
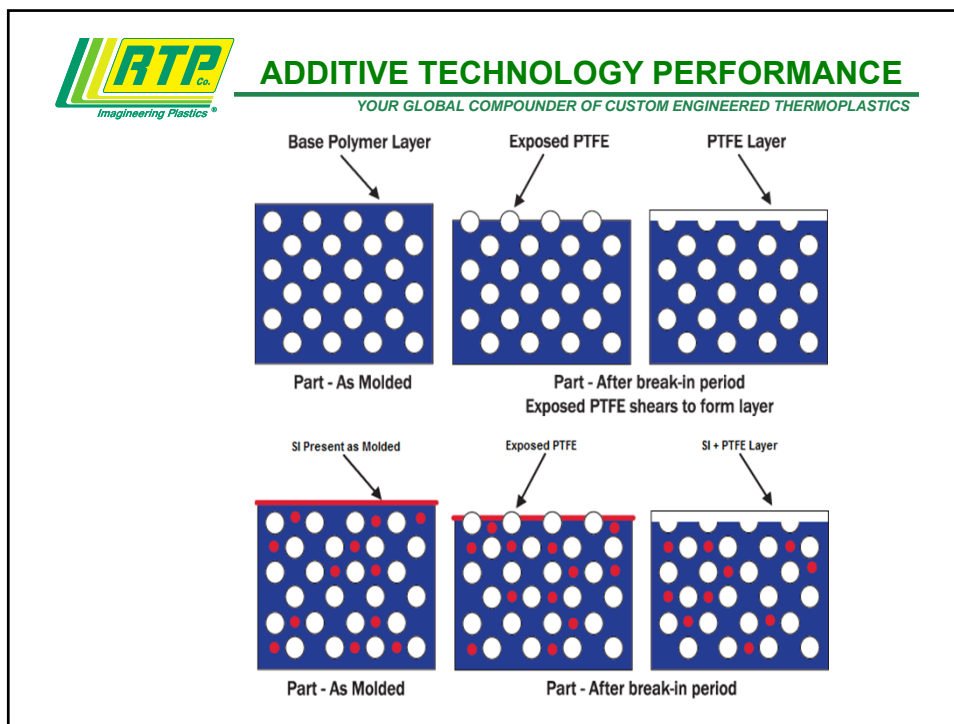
**MUST HAVE BOTH MEASUREMENTS IN TANDEM**



## LOW FRICTION ADDITIVES

YOUR GLOBAL COMPOUNDER OF CUSTOM ENGINEERED THERMOPLASTICS









## RESIN PAIRS INVESTIGATED

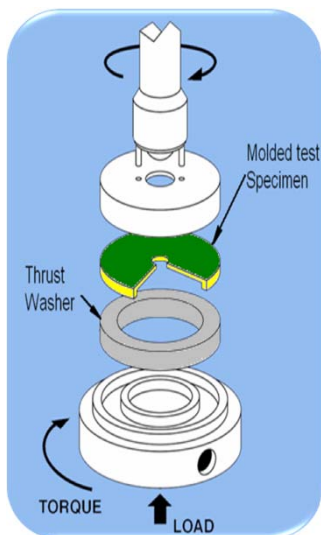
YOUR GLOBAL COMPOUNDER OF CUSTOM ENGINEERED THERMOPLASTICS

<u>PC Against POM</u>	<u>PC against PC</u>	<u>POM against POM</u>
"Standard" Viscosity Silicone	"Standard" Viscosity Silicone	"Standard" Viscosity Silicone
Low Viscosity Silicone	Low Viscosity Silicone	Low Viscosity Silicone
Blended Viscosity Silicone	Blended Viscosity Silicone	Blended Viscosity Silicone
PFPE	PFPE	PFPE
APWA Plus	APWA Plus	
<u>PBT against PC-ABS</u>	<u>ABS against ABS</u>	<u>PC against HDPE</u>
"Standard" Viscosity Silicone	"Standard" Viscosity Silicone	"Standard" Viscosity Silicone
APWA Plus	APWA Plus	PFPE
APWA Plus/Silicone	APWA Plus/Silicone	
PFPE	PFPE	



## DESCRIPTION OF NEW FRICTION TEST METHOD

YOUR GLOBAL COMPOUNDER OF CUSTOM ENGINEERED THERMOPLASTICS



### Modified ASTM D3702 Thrust Washer Test

- Specimens Injection molded per ASTM dimensions
- Oscillating friction measurement

#### Test Method

1. Initial oscillating friction measurement - 30° sweep angle at 0.5 Hz frequency for 10 cycles (Initial friction measurement)
2. Standard rotation - 30 minutes single direction rotation (25 ft/min, 20psi, 500PV)
3. Final oscillating friction measurement 30° sweep angle at 0.5 Hz frequency for 10 cycles (Final friction measurement)





## NEW FRICTION TEST OUTPUT

YOUR GLOBAL COMPOUNDER OF CUSTOM ENGINEERED THERMOPLASTICS

### Test Outputs:

- Initial static friction coefficient, Initial dynamic friction coefficient
- RMS dynamic friction coefficient over 30 min wear test
- Final static friction coefficient, final dynamic friction coefficient

### Delta value

- Difference between static and dynamic coefficients of friction
- Delta values are calculated from the initial routine and the final routine
- Low delta values are desired to lower "sticktion"



## SPECIMEN PREPARATION

YOUR GLOBAL COMPOUNDER OF CUSTOM ENGINEERED THERMOPLASTICS

### Specimens Molded in-house per ASTM D3702 Thrust Washer dimensions

### Specimen Care:

- Important to mold consistent surfaces
- Important to observe care throughout molding, assembly, and testing
- Clean dirt free environment is important
- Contaminant free molding environment





## SPECIMEN HANDLING

YOUR GLOBAL COMPOUNDER OF CUSTOM ENGINEERED THERMOPLASTICS

### Specimens Must Be Clean:

- Gloves must be used to eliminate human skin oil contamination.
- Specimens stored in sealed bags.

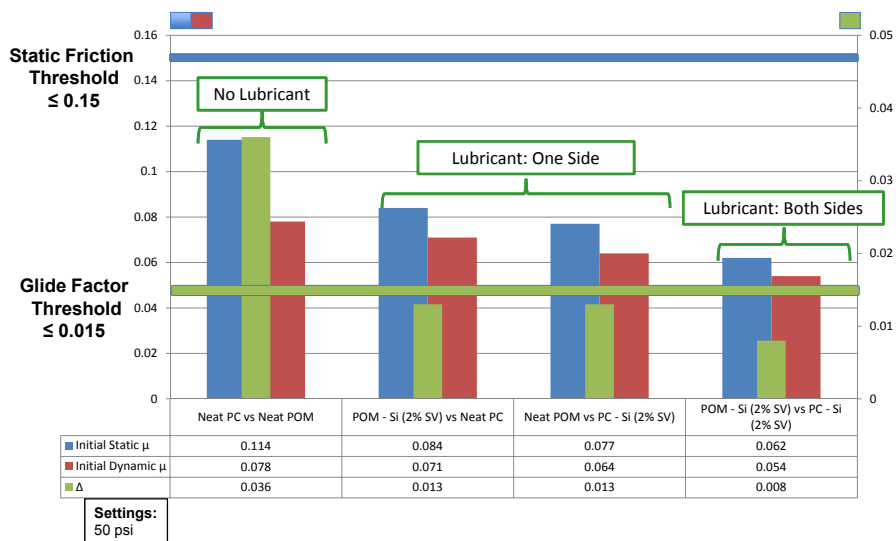
### Handling Methods for Production

- Fingerprints on devices can cause variation in friction performance and attract contaminants.
- Dirt increases friction.

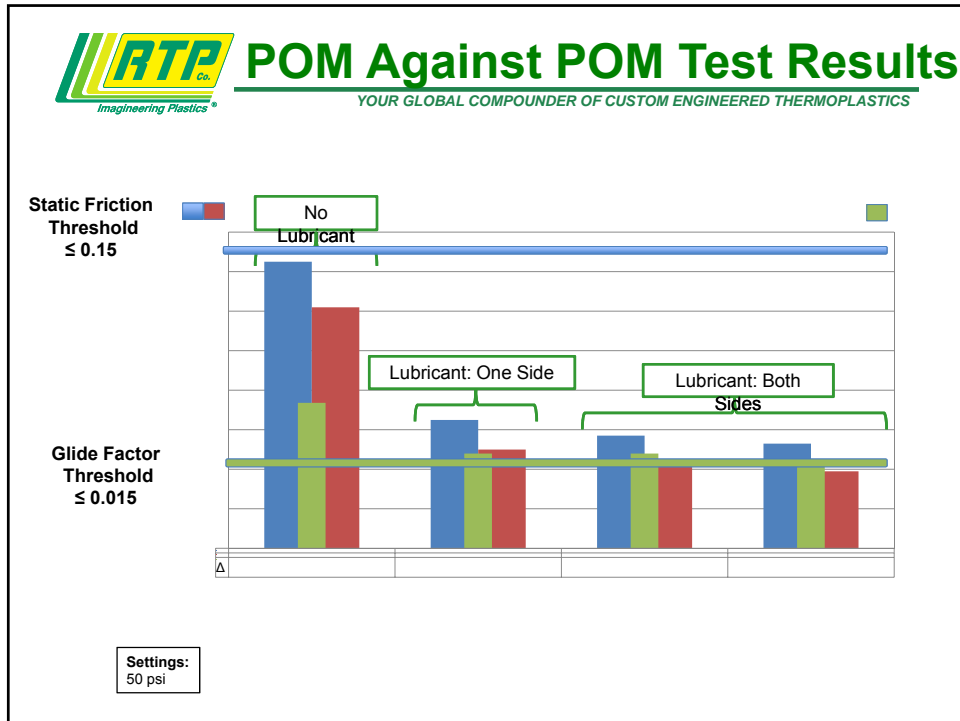


## PC VS POM FRICTION RESULTS

YOUR GLOBAL COMPOUNDER OF CUSTOM ENGINEERED THERMOPLASTICS







**RTP Co.**  
Imagining Plastics®

**SELF vs. SELF OBSERVATIONS**  
YOUR GLOBAL COMPOUNDER OF CUSTOM ENGINEERED THERMOPLASTICS

- **Selecting the optimal “friction pairs” is important.**
- **Self vs self should be avoided unless lubrication is applied.**
- **Internal lubricants reduce friction in self vs self friction pairings.**
- **Topical lubricants can wear off over time.**

~~POM vs POM~~

~~PC vs PC~~



## DISSIMILAR FRICTION PAIR OBSERVATIONS

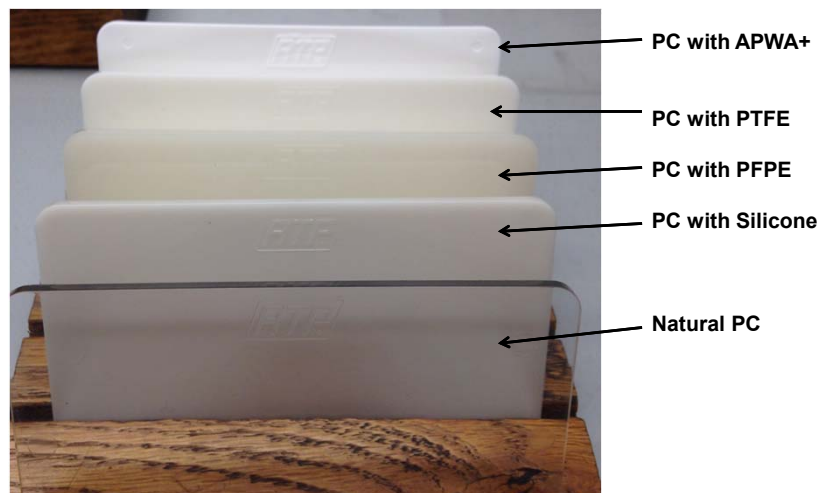
YOUR GLOBAL COMPOUNDER OF CUSTOM ENGINEERED THERMOPLASTICS

- Dissimilar friction pairs show improved low-friction performance over self v self without lubrication.
- **Optimal friction** performance is obtained by adding lubricant to one or both sides of the dissimilar friction pairing.



## INTERNAL LUBRICANTS REDUCE CLARITY

YOUR GLOBAL COMPOUNDER OF CUSTOM ENGINEERED THERMOPLASTICS





## SUMMARY TEST OBSERVATIONS

YOUR GLOBAL COMPOUNDER OF CUSTOM ENGINEERED THERMOPLASTICS

### **Resin Selection** is Key to Achieve Low Friction Performance

1. Lubricated dissimilar friction pairs – best performance
2. Lubricated self v self pairs – good performance
3. Neat dissimilar pairs – poor performance
4. Neat self v self pairs – worst performance

### All **Lubricants** Improve Friction Performance to Some Degree

1. Silicone has very good performance across the resin systems
2. APWA Plus with silicone performs well in some pairs
3. PFPE has acceptable performance in some friction pairs

### **Pressure or Load** Increases Friction Dramatically

1. Internal lubricants become increasingly more important in friction systems with higher loads.
2. Internal lubricants improve consistent operation when higher loads or **variable** loads are present.



## FUTURE INVESTIGATION

YOUR GLOBAL COMPOUNDER OF CUSTOM ENGINEERED THERMOPLASTICS

Expanded friction pair testing

Further silicone investigation

- High concentration silicone loadings at high pressures
- Viscosity/loading level affect on long term aging performance

Cold temperature friction testing for biologics

**RTP Co.** **CONCLUSIONS**  
*Imagining Plastics* YOUR GLOBAL COMPOUNDER OF CUSTOM ENGINEERED THERMOPLASTICS

Low Glide Factor yields optimal device performance

Select material quickly, with confidence

Eliminating external lube lowers production costs

**Speed to Solution - Optimized Performance - Lowest Total Cost**

**RTP Co.**  
Healthcare Team

**Plastic Technologies**  
For Safe & Effective Medical Devices