

# eastec®

MAY 14-16, 2019

EASTERN STATES EXPOSITION  
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# **Tooling Life in the Age of Regulation — Meeting both tooling efficiency and regulatory demand — Life after chlorinated paraffins**

Hoon Kim, Senior Principal R&D Scientist, BASF-Chemetall

## BASF – We create chemistry



- + Our chemistry is used in almost all industries
- + We combine economic success, social responsibility and environmental protection
- + Sales 2017: €64,457 million
- + EBIT 2017: €8,522 million
- + Employees (as of December 31, 2017): 115,490
- + 6 Verbund sites and 347 other production sites

## BASF Segments at a glance — Chemetall's position



### Chemicals

Petrochemicals  
Monomers  
Intermediates



### Performance Products

Dispersions & Pigments  
Care Chemicals  
Nutrition & Health  
Performance Chemicals



### Functional Materials & Solutions

Catalysts  
Construction Chemicals  
**Coatings**  
Performance Materials



### Agricultural Solutions

Crop Protection



### Oil & Gas

Oil & Gas



## BASF Coatings Division at a glance



### OEM coatings

- E-coat
- Primer
- Basecoat
- Clearcoat



### Refinish coatings

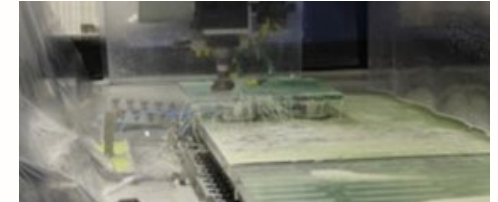
- Sealer
- Primer
- Basecoat
- Clearcoat



### Decorative paints

For interior and exterior use:

- Wall
- Wood
- Metal
- Specific use



### Surface Treatment

- Anodizing
- Cleaners
- Coil Coatings
- Conversion Coatings & Thin Film
- Glass Processing Products
- Lubricants
- Metalworking Fluids
- Non-Destructive Testing
- Maintenance Products
- Paint Detack & Paint Strippers

## Chemetall at a glance



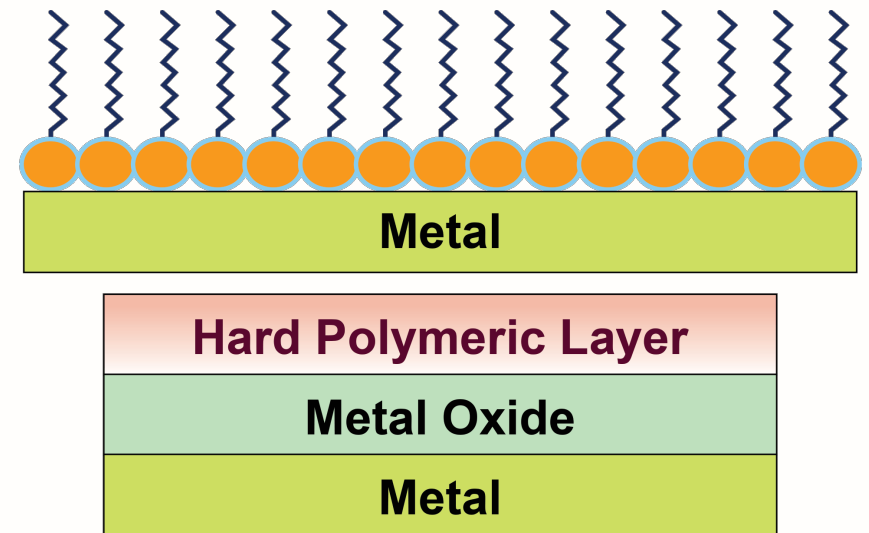
We are the Surface Treatment global business unit of the Coatings division of BASF, operating under the Chemetall brand, a leading supplier of applied surface treatments and services for metal, plastic, and glass substrates in a vast range of industries and end markets.

- ⊕ Headquarters: Frankfurt am Main Germany
- ⊕ Facilities: 40+ worldwide\*
- ⊕ Production sites: 20+ on all continents\*

## Outline

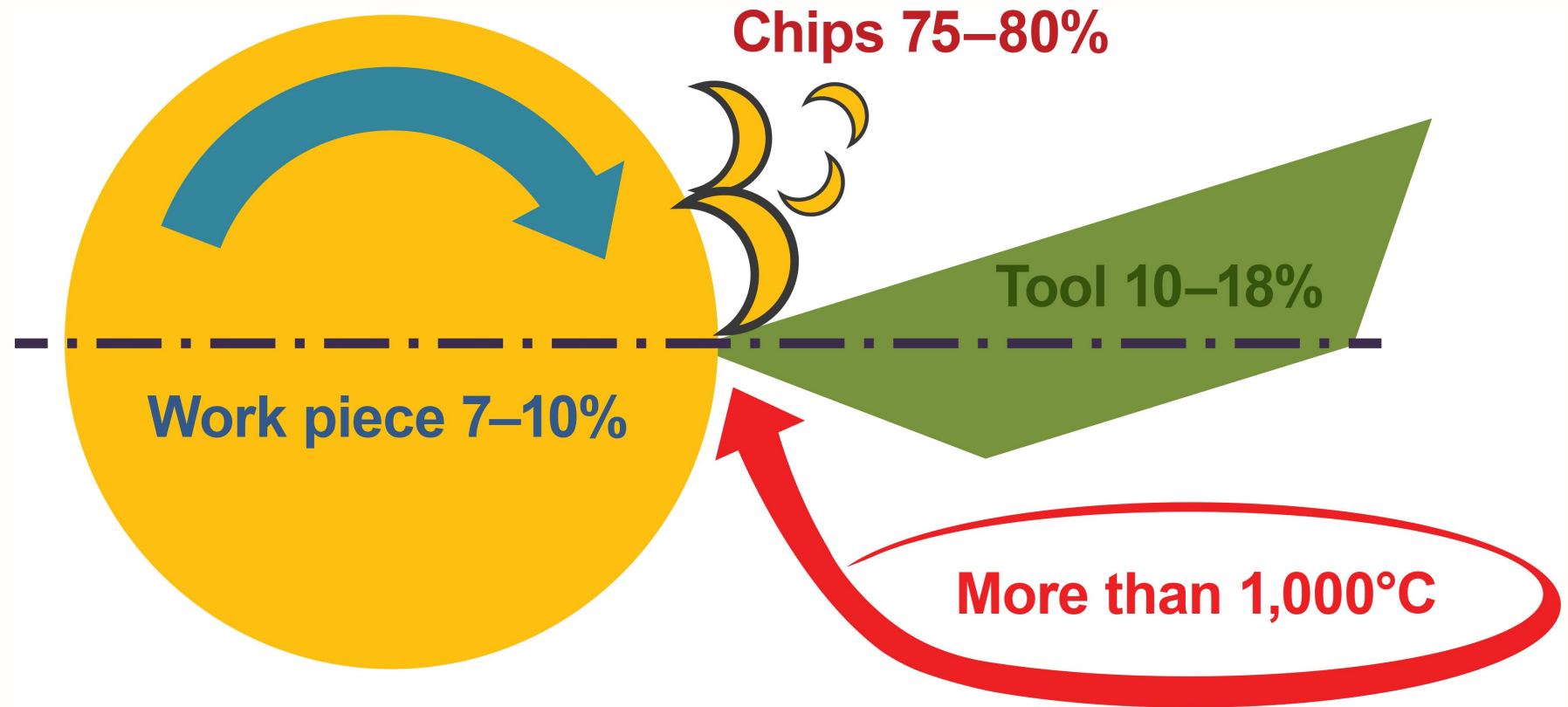


- 1) Metalworking Fluids Overview
- 2) Semi-Synthetic formulation
- 3) Lubricity Enhancer vs. EP Agent
- 4) New EP Technology: Chlorinated Paraffin Alternative
- 5) Summary and Acknowledgement



# Metalworking Fluids Overview

*Heat!!! How to minimize.*



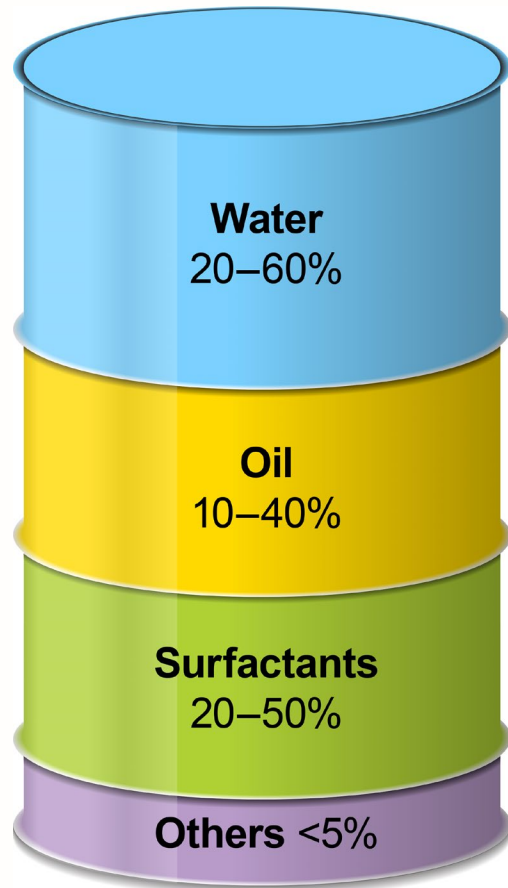
+ Lubrication

+ Cooling

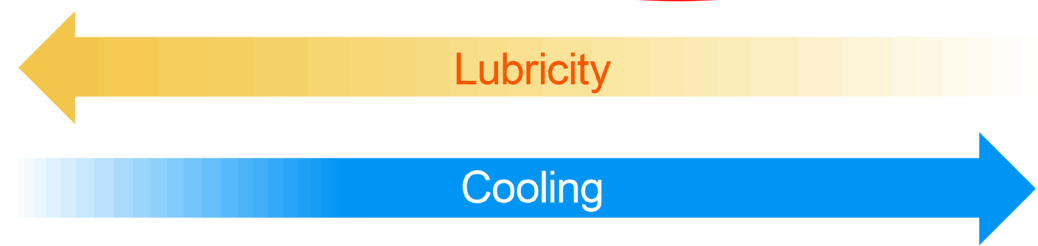
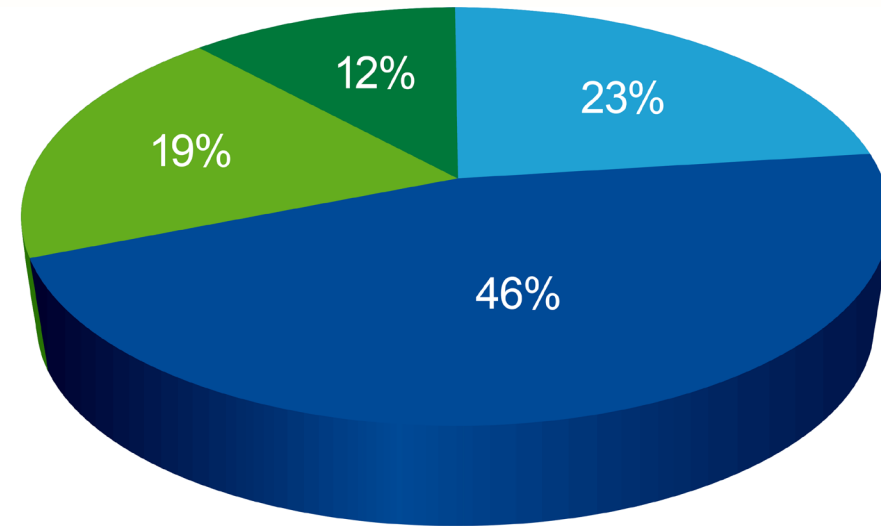
+ Chip Removal



## Semi-synthetic Metalworking Fluids

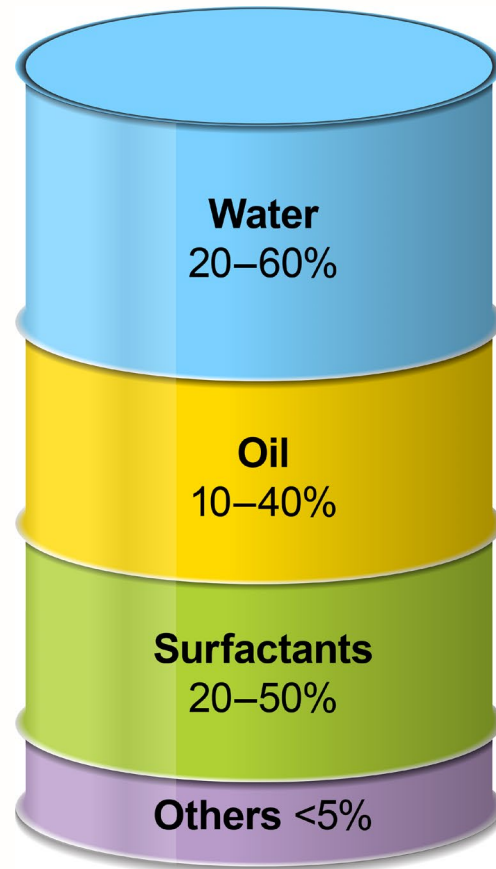


### Metalworking Fluid Types

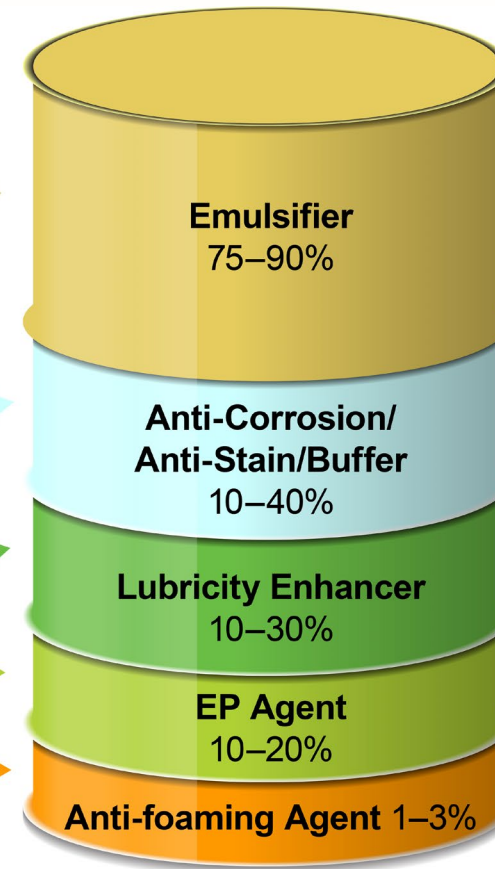


## Semi-synthetic Metalworking Fluids

### Semi-synthetic Formulation



### Surfactant Composition



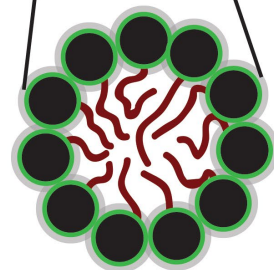
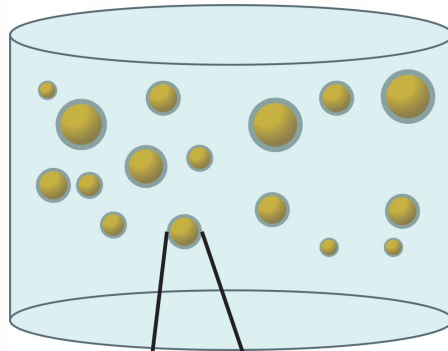
Biocides  
and Coupler



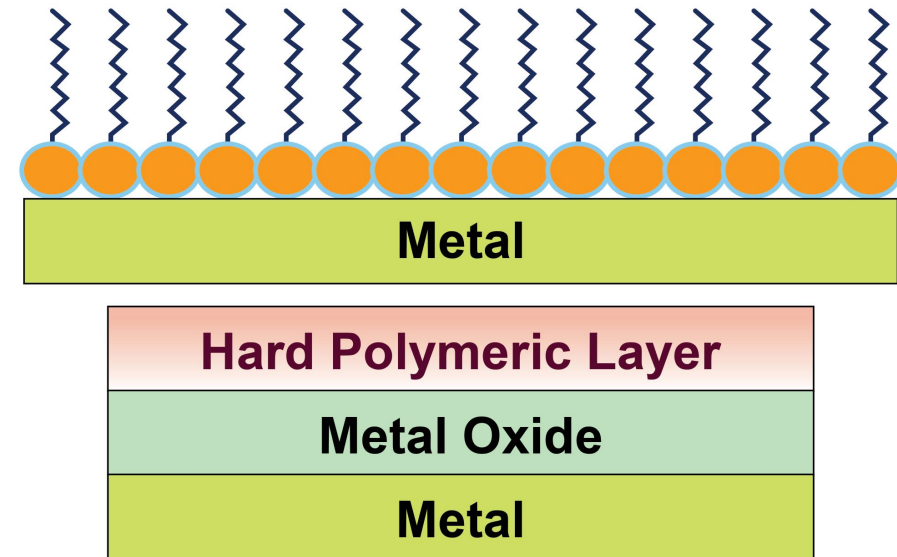
## Major issues in Metalworking Fluids

Different interfaces at different locations: Water/Oil, Metalworking Fluids/Metal

### Emulsion Stability



- 1) Lubricity
- 2) Corrosion
- 3) Microbial Growth



Defoaming/Anti-foaming: Air/Fluid Interface

## Lubricity Enhancers

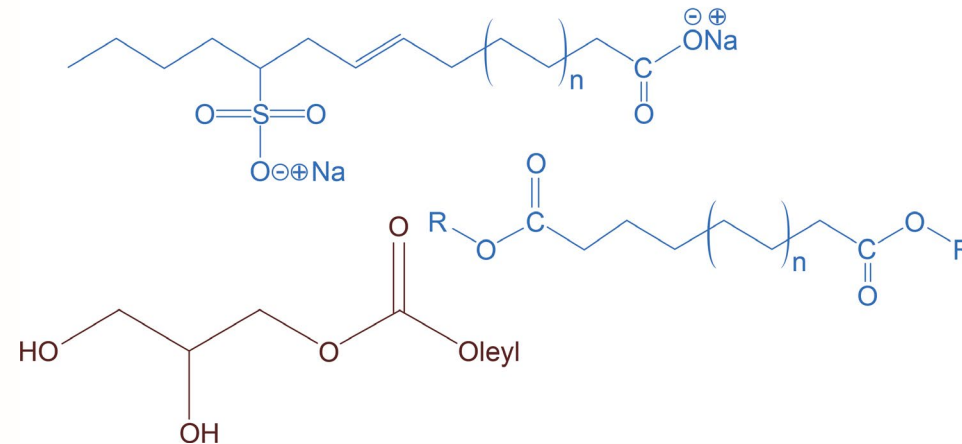
### Lubricity Enhancer Structure, Function, and Chemistry



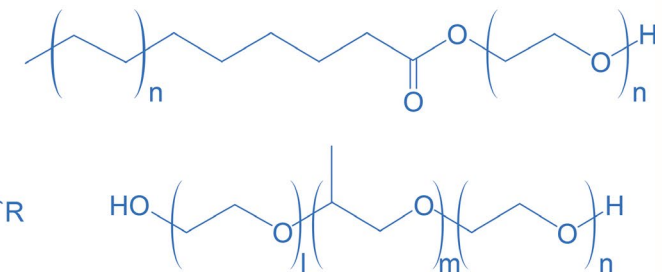
- Form slippery deposits layer by Physi-sorption
- Reduce friction/wear under low temperature mild load conditions
- Reduce EP content

### Dominant chemistries:

#### Sulfonates, Carboxylates



#### Alkoxyates

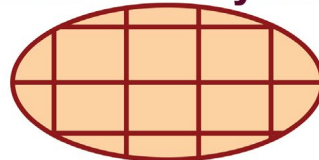




## Antiwear/EP Agents

Extreme Pressure Agent Structure, Function, and Chemistry

**Insoluble Polymer**



**Hard Polymeric Layer**

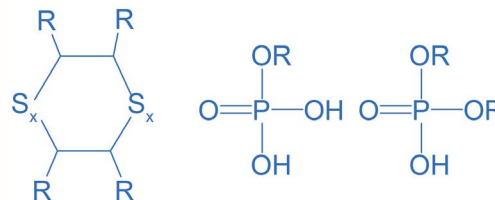
**Metal Oxide**

**Metal**

- P, S, Cl, and B containing compounds
- Form Chemisorbed Hard/Polar Polymeric Film
- Reduce Friction/Wear in boundary lubrication regime

Dominant chemistries:

**P,S,Cl, and B Compounds**

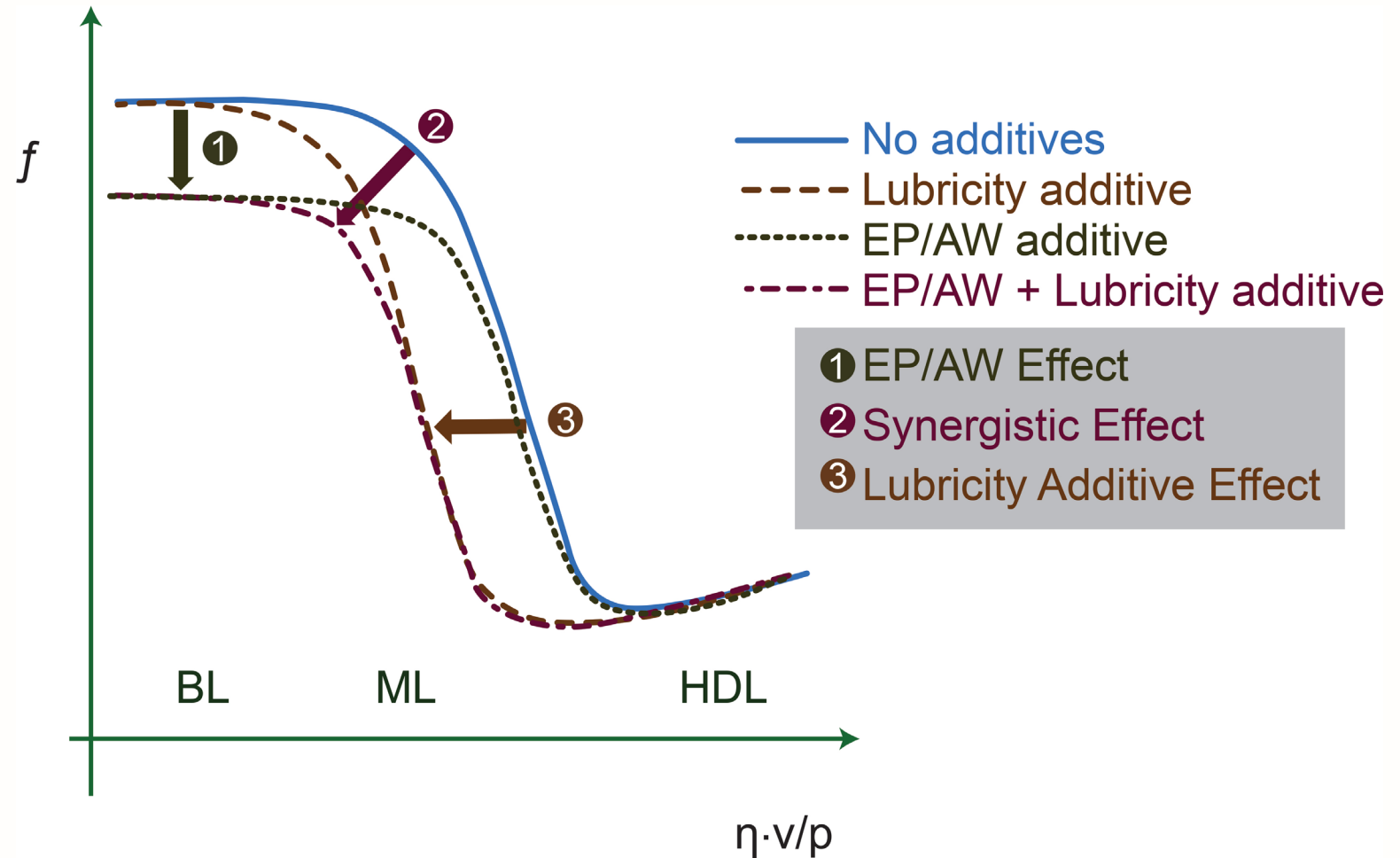


**Metal Complexes**

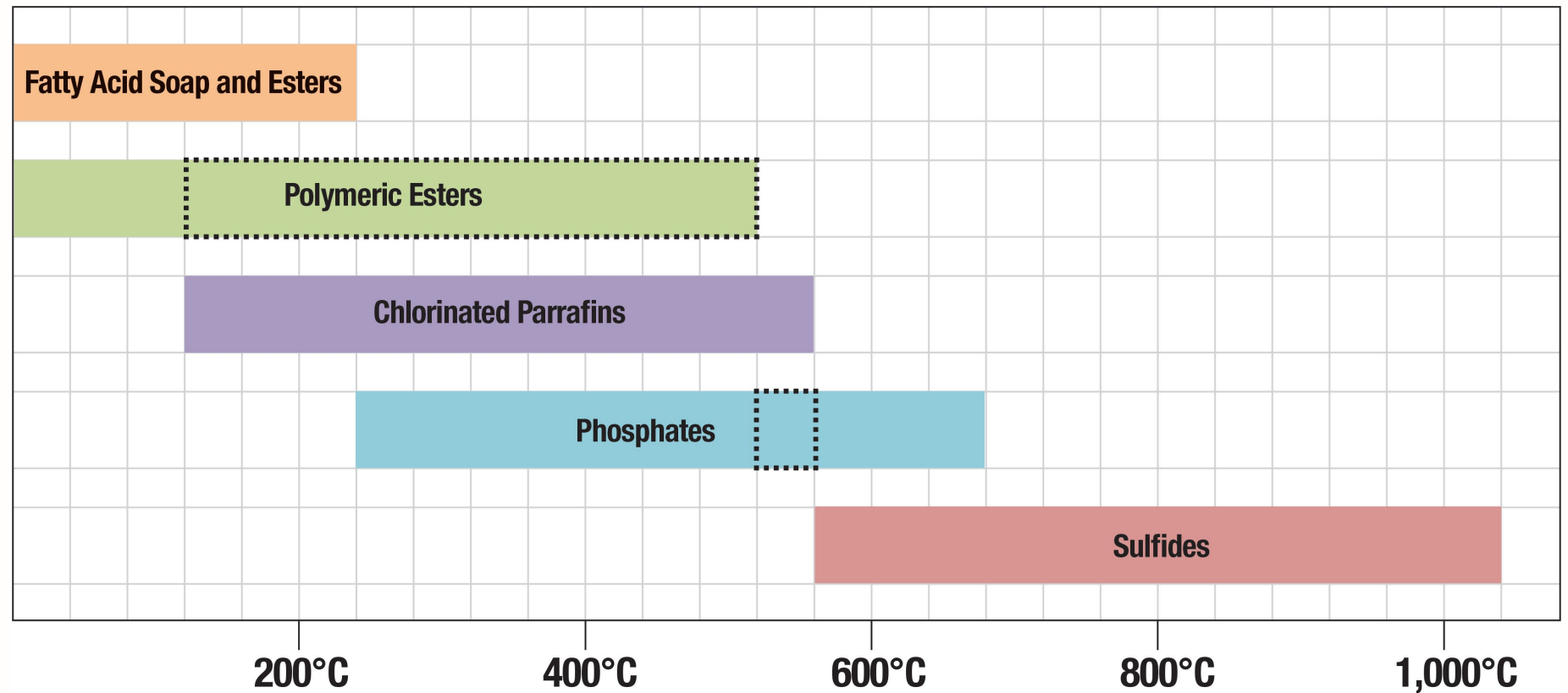
MoS<sub>2</sub>

## Synergistic Effect

Friction Coefficient: Synergistic Effect with Lubricity Additives



# Activation Temperatures & Potential Alternatives



## Chlorinated Paraffin Regulation Update

Chlorinated Paraffin Category	Carbon Chain Length
Short Chain Chlorinated Paraffin (SCCP)	C10–C13
Medium Chain Chlorinated Paraffin (MCCP)	C14–C17
Long Chain Chlorinated Paraffin (LCCP)	C18–C30

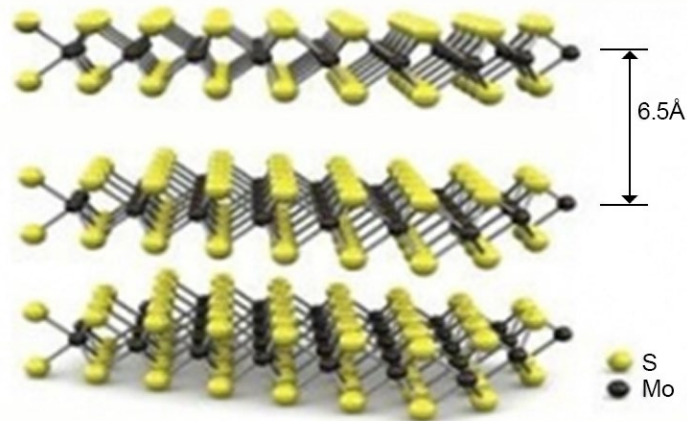


Chlorinated Paraffin Type	Chain Length
SCCP	C10–13
MCCP	C14–17
LCCP	C18–20
vLCCP	C21–30

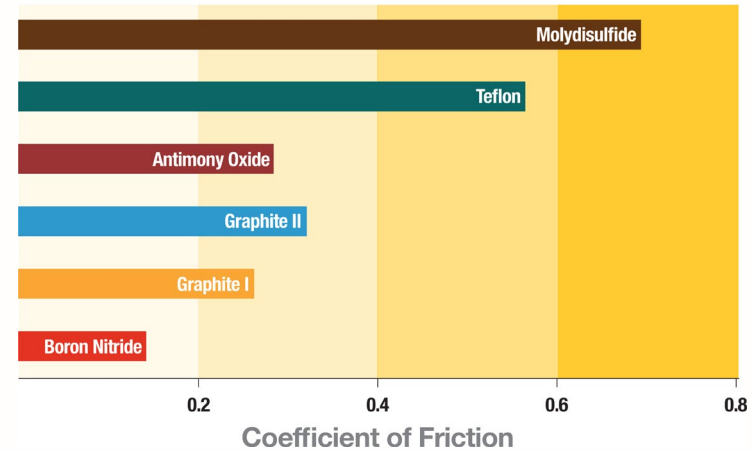
- SCCP (Short Chain CP, C10-C13): Carcinogen in 1994
- MCCP (Medium Chain CP, C14-17): Toxic to aquatic organism in 2005
- LCCP (Long Chain CP, C18-20): Nontoxic
- vLCCP (Very Long Chain CP, C21-30): Classified by EPA



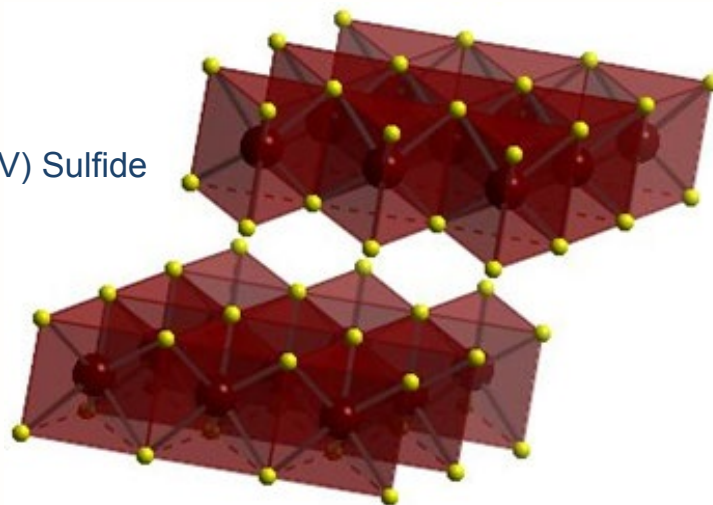
## Potential Alternatives: WS<sub>2</sub> NPs



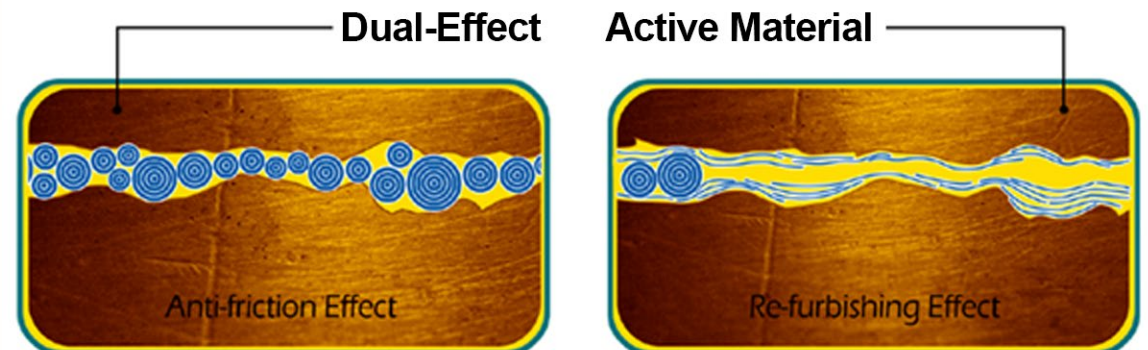
Comparison of Various Solid Lubricant Powders



Tungsten (IV) Sulfide

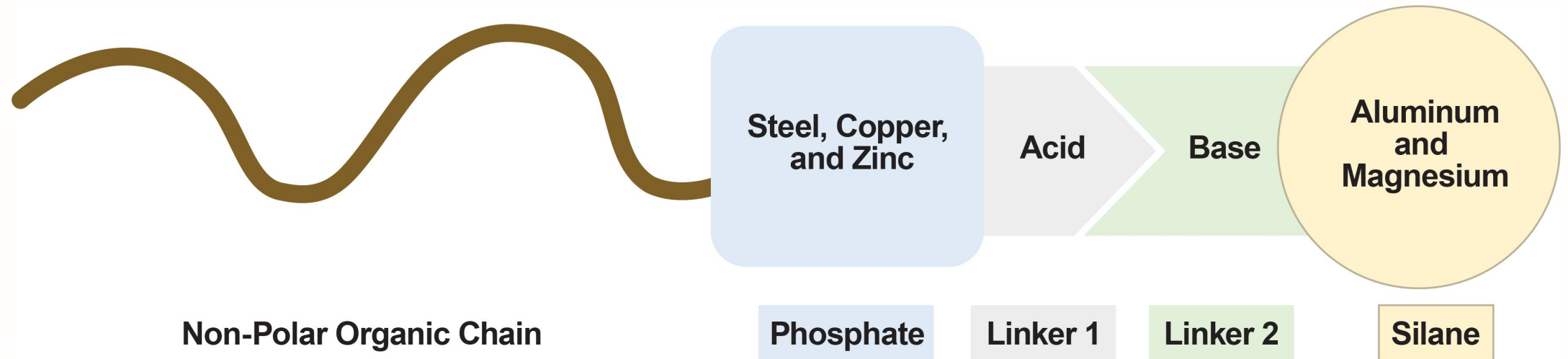


Anti-Friction and Anti-Wear Oil Additive



## Potential Alternatives (New EP):

Phosphate/Silane Combo (PSiEP)



# Property Control: Lubricity (Tapping Torque) EP Agent/Lubricity Enhancer (LE)/Phosphates (PP)

Mixture DOE: 4 Continuous Factors

ID	BASE	EP1	LE1	PP	Torque on Steel	Torque on Aluminum
CP-1	97.0%	0.0%	0.0%	3.0%	198.6	171.6
CP-2	95.5%	1.4%	1.3%	1.8%	187.3	150.0
CP-3	97.0%	0.0%	3.0%	0.0%	212.0	167.3
CP-4	97.0%	1.5%	0.0%	1.5%	202.3	170.0
CP-5	94.0%	1.5%	1.5%	3.0%	<b>180.3</b>	<b>109.6</b>
CP-6	97.0%	3.0%	0.0%	0.0%	191.3	170.6
CP-7	96.0%	0.0%	2.0%	2.0%	192.6	180.3
CP-8	94.0%	0.0%	3.0%	3.0%	192.3	139.3
CP-9	94.0%	3.0%	0.0%	3.0%	185.3	129.6
CP-10	95.5%	1.5%	0.0%	3.0%	192.6	180.3
CP-11	94.0%	3.0%	3.0%	0.0%	<b>171.6</b>	<b>109.0</b>

Baseline with CP (15%) and CFA (8%): 174 on Steel, 176.3 on Aluminum

# Property Control: Lubricity (Tapping Torque) EP Agent/Lubricity Enhancer (LE)/Phosphates (PP)

## DOE: Effect Analysis on Steel

Sorted Parameter Estimates				
Term	Estimate	Std. Error	T Ratio	Prob> t
EP1/0.06	113.66347	2.489004	45.67	0.0139*
Phosphate/0.06	101.54931	2.823685	35.96	0.0177*
(Base-0.94)/0.06	73.121699	2.649316	27.60	0.0231*
LE1/0.06	55.709536	3.063345	18.19	0.0350*
Base*LE1	70.842787	6.577801	10.77	0.0589*
EP1*LE1	66.749562	6.677797	10.00	0.0635*
EP1*Phosphate	-54.68466	6.726463	-8.13	0.0779*
LE1*Phosphate	47.710226	6.360353	7.50	0.0844*
Base*EP1	-9.56205	6.574039	-1.45	0.3834*
Base*Phosphate	1.388672	6.642909	0.21	0.8688*

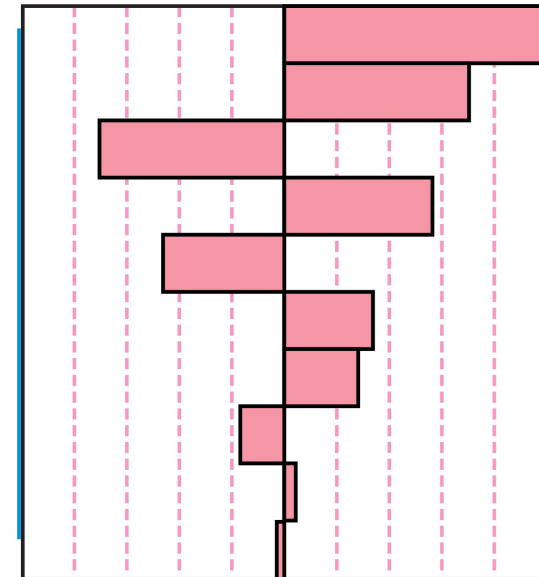
***New EP has a strong effect on Steel***



# Property Control: Lubricity (Tapping Torque) EP Agent/Lubricity Enhancer (LE)/Phosphates (PP)

## DOE: Effect Analysis on Aluminum

Sorted Parameter Estimates				
Term	Estimate	Std. Error	T Ratio	Prob> t
(Base-0.94)/0.06	279.4033	25.23858	11.07	0.0574
EP1*LE1	493.13339	63.61571	7.75	0.0817
Base*Phosphate	-488.048	63.28335	-7.71	0.0821
Phosphate/0.06	168.44556	26.89969	6.26	0.1008
Base*EP1	-322.298	62.62726	-5.15	0.1222
EP1/0.06	88.306246	23.71137	3.72	0.1670
LE1*Phosphate	189.28869	60.59159	3.12	0.1972
Base*LE1	-116.2583	62.6631	-1.86	0.3147
EP1*Phosphate	29.154167	64.07932	0.45	0.7282
LE1/0.06	-10.97553	29.18281	-0.38	0.7710

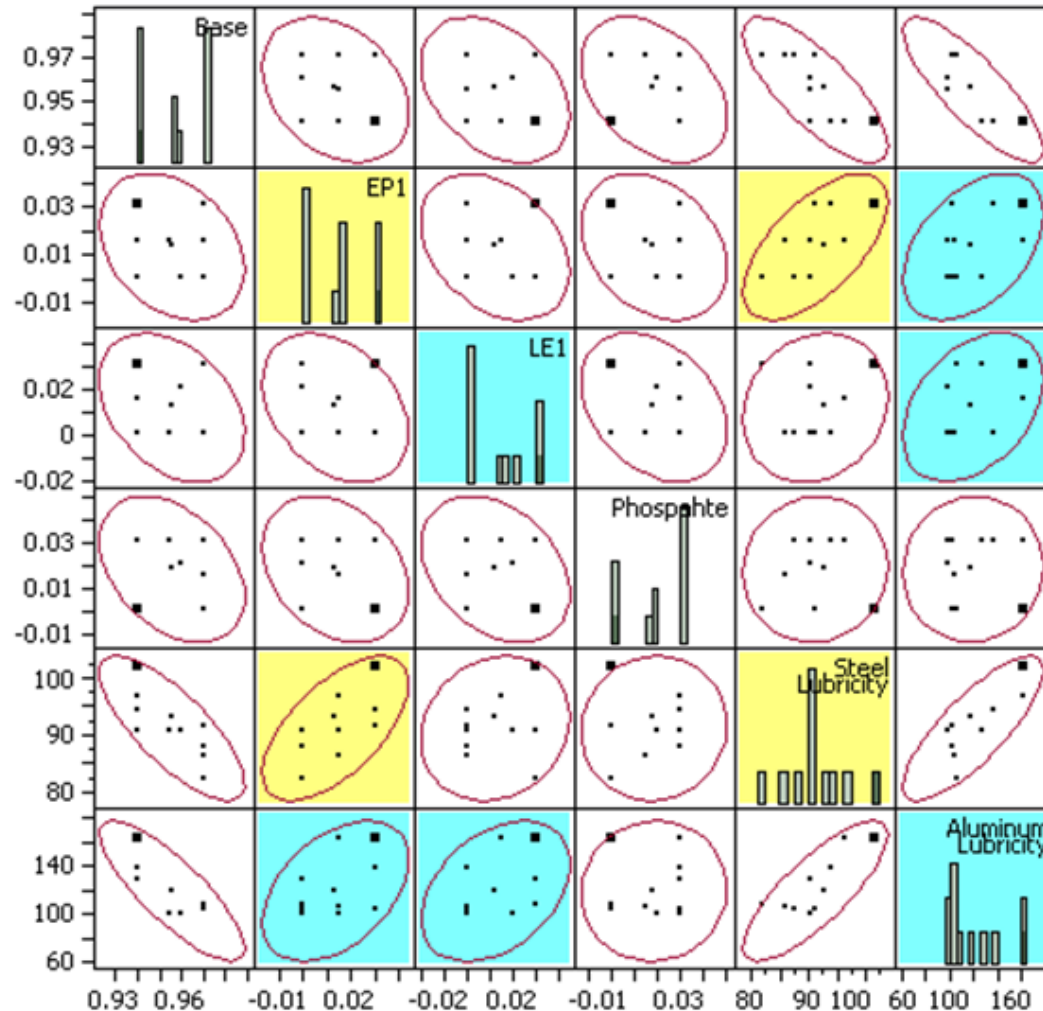


***New EP may have synergistic effect with LE1 on Aluminum***

## Property Control:

EP vs. LE vs. PP vs. Lubricity

### Multi-Variate Analysis (MVA)



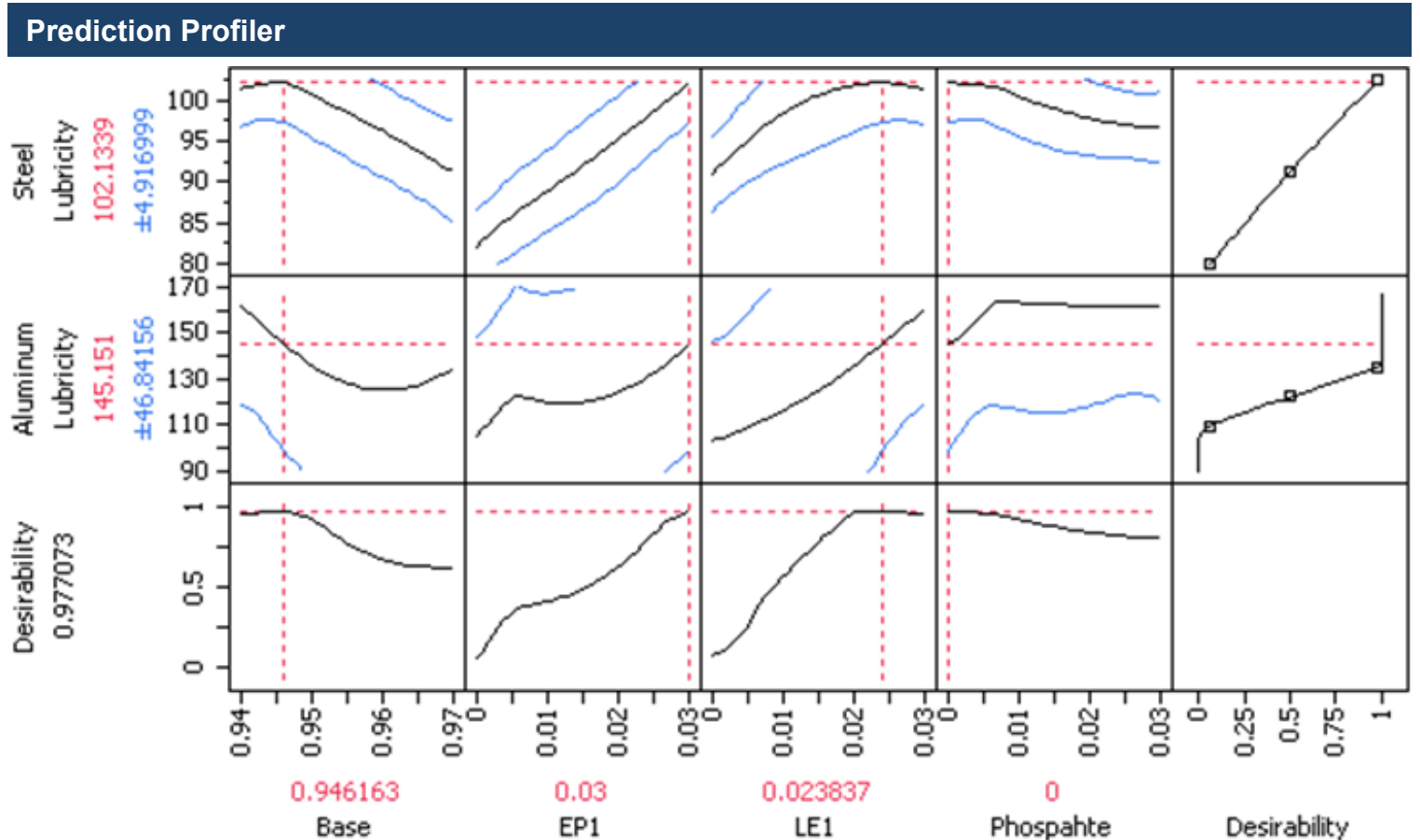
*New EP has correlation with torque on Steel*

*New EP/LE may have correlation with torque on Aluminum*

## Property Control:

Optimal Formulation Prediction

## New Formulation Design



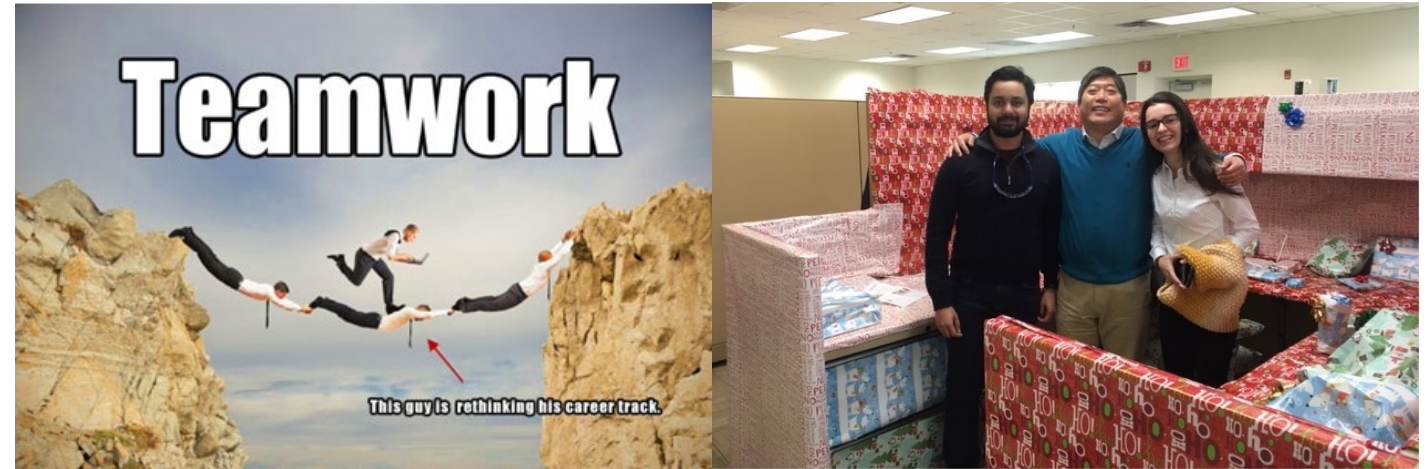
**Computer-designed formulation:**

159 (104% of Baseline) on Steel, 108 (169% of Baseline) on Aluminum

## Summary

<b>Multi-functional Phosphate/Silane Combo EP Technology</b>	
<b>1. Proven Technology</b>	Phosphates are used in zinc and iron pretreatment Silanes are used in aluminum pretreatment
<b>2. Chlorinated Paraffin Free</b>	Eco-friendly and regulation worry free
<b>3. Minimum Phosphorus</b>	Minimize microbial growth by reducing biological food sources
<b>4. Multi-functional</b>	Enhances lubricity as new EP agent in addition to the excellent corrosion/stain protection
<b>5. Simple Preparation and Application</b>	Based on general acid-base organic chemistry and simple drop-in application or minimal formulation adjustment

## Acknowledgement



1. **Mauro Beccaro**, Vice President of Chemetall NA
2. **Stefan Waidelich**, Head of Technology Chemetall NA
3. **Mubarik Chowdhry**, Head of Global Technology
4. **Cyle Ward**, Metalworking Fluids Business Manager
5. **Mark Fretz**, Metalworking Fluids Product Manager
6. **Joana Costa**, Formulation Chemist
7. **Joydeep Nath**, Synthetic Chemist





## Innovation correlates with Family, Colleagues, and People!



Chemistry is simple, but life is not.  
That's why I love chemistry.  
Polymer is long, but life is short.  
That's why I love polymer.

**Thank you very much for your attention!**