

# Lubrizol PIBSA as an Alternative Emulsifier to Achieve High-Performance Metalworking Fluids

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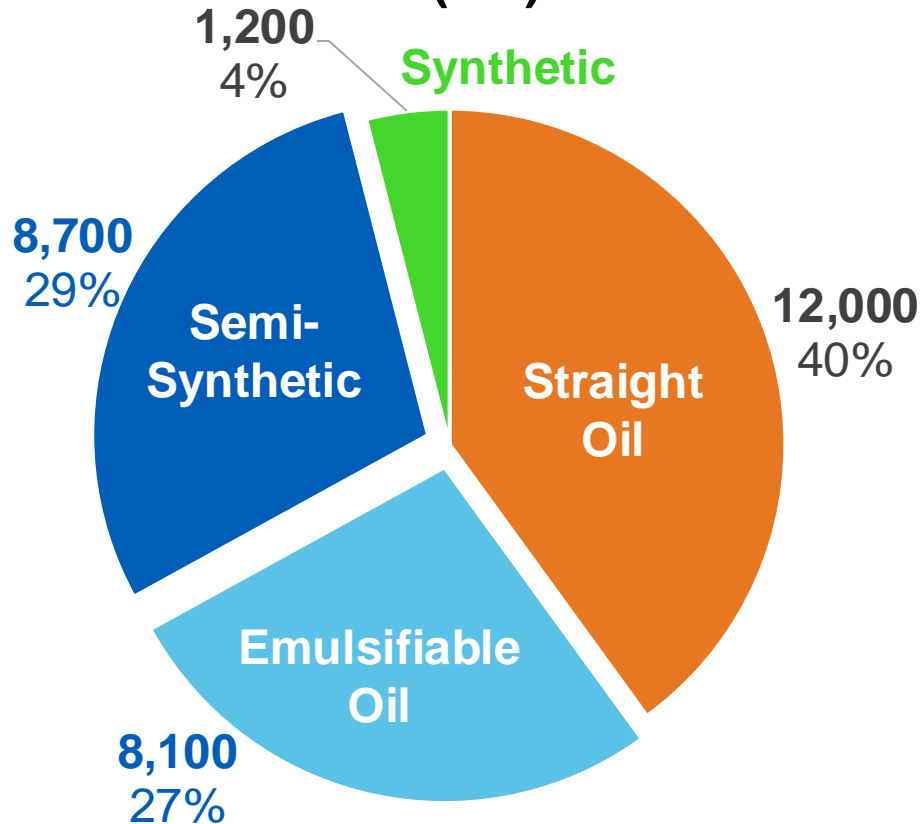
# Outline

- **SECTION I: Introduction to PIBSA**
  - South American Metal Removal Fluid & Additives Market
  - Metalworking Emulsifiers
  - PIBSA: What Is It and Why Choose It?
  - PIBSA vs Sodium Sulfonates
- **SECTION II: Formulating with PIBSA**
  - General Guidance and Best Practices
  - Model Semisynthetic Formula and Performance
- **SECTION III: Benefits of Lubrizol PIBSA**
  - PIBSA Product Line

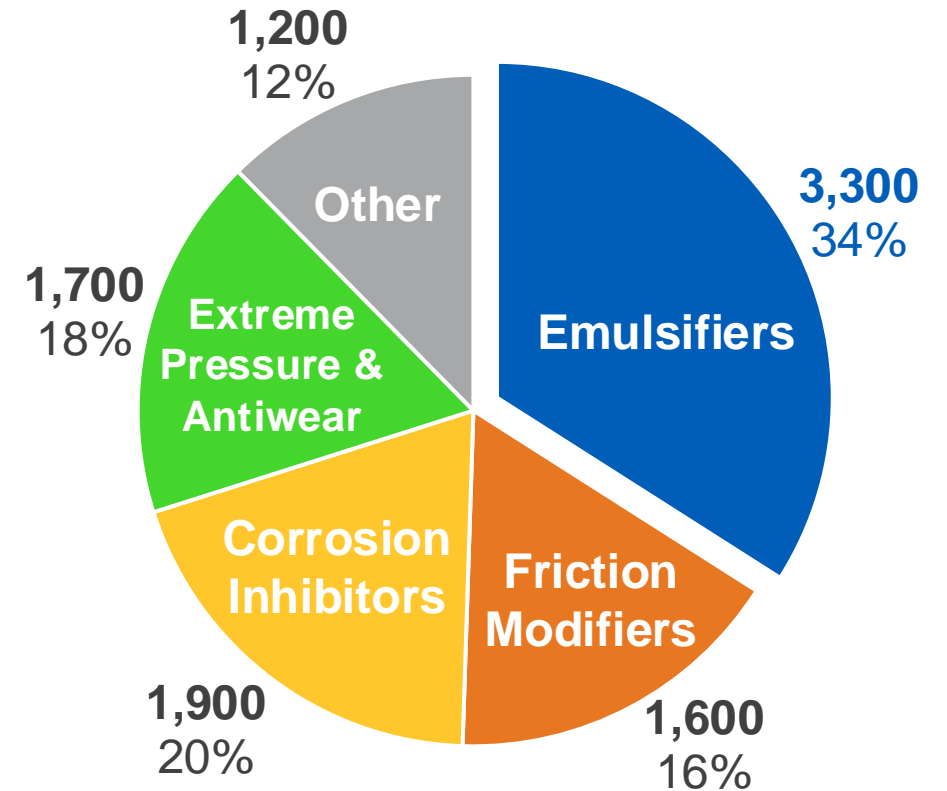
# SECTION I: Introduction to PIBSA

# South American Metal Removal Fluids & Additives (2020)

**Metal Removal Fluids by Fluid Type (MT)**



**Metal Removal Fluid Additives by Function (MT)**



Emulsifiers account for a third of all metal removal additives

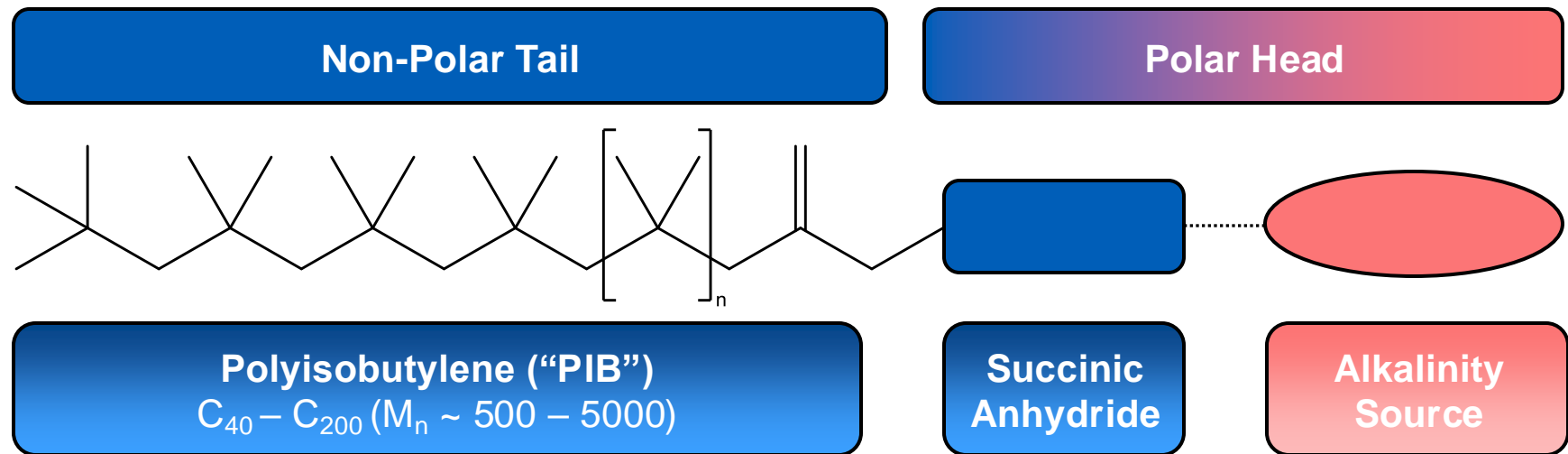
# Metalworking Emulsifiers

	Performance	Cost
Fatty Acid Salts (e.g., TOFA)	—	\$
Sorbitan Esters		
Alkanolamides		
Sodium Sulfonates (Natural & Synthetic)		
<b>PIBSA</b>		
Ether Carboxylates		
Alcohol Alkoxylates	+	\$\$\$

Choosing the right emulsifier system is key: must balance performance, cost, etc.

# What is PIBSA?

- **PIBSA** = **P**oly**i**sob**u**tylene **S**uccinic **A**nhydride
- Made by reacting polyisobutylene with maleic anhydride
  - Derived from readily available feedstocks
  - Not a by-product of another process
- PIBSA is reacted with a source of alkalinity to make an emulsifier



# Why Choose PIBSA?

- Performance
  - Established in metalworking industry
  - Soluble in naphthenic, paraffinic, and synthetic base oils
  - Excellent emulsion quality
  - Excellent hard water stability
  - Low foaming tendency
  - Low susceptibility to biologicals (highly branched, S-free)
- Manufacture and availability
  - Global manufacturing
  - Key chemistry in engine-oil dispersants (large volume material)
  - Not a by-product of another process (first-intent)
  - Consistent quality
  - Excellent availability – no interruptions in supply

PIBSA offers a high-performance, long-term solution

# Comparing PIBSA vs Natural Sodium Sulfonate

Attribute	Natural Sodium Sulfonate	PIBSA
Cost	Moderate	Low-moderate
Security of Additive Supply	Can be volatile	Secure
Consistency	Can be variable	Good
Susceptibility to Biologicals	Medium (linear, contains Sulfur)	Low (highly branched, S-free)
Emulsification Efficiency	Moderate	Good
Hard Water Stability	Poor	Good
Corrosion Protection	Good	Moderate
Foam Tendency	Moderate	Low
Ease of Use	Used as-is	Must neutralize with base
Waste Treatment	Acid / alum	Acid / alum

Color Key:

Good

Medium

Poor

PIBSA offers many benefits over sodium sulfonates



# PIBSA vs Natural Sodium Sulfonate: Hard Water Stability

## Sulfonate



- 5% wt/wt emulsifiable oil emulsions
- Similar formulas except for PIBSA vs. Sulfonate primary emulsifier
- Hardness values in ppm as  $\text{CaCO}_3$
- Aged 48 hours

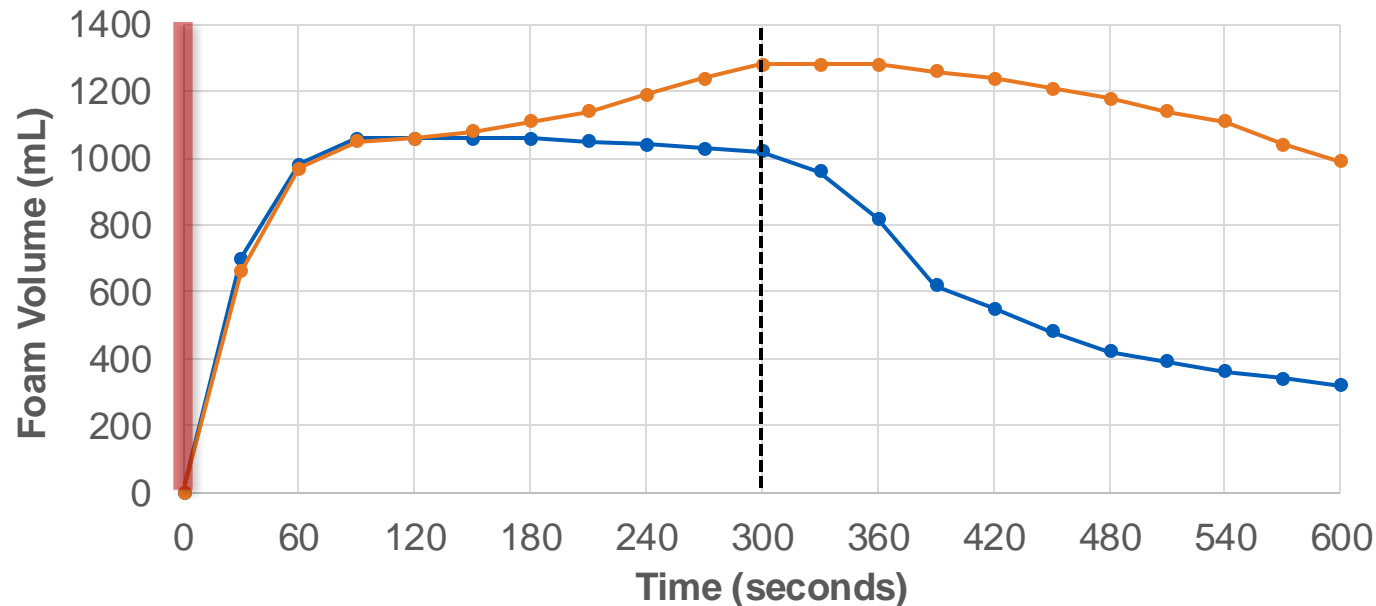
## PIBSA



***PIBSA-based emulsion remains stable in very hard water***

# PIBSA vs Natural Sodium Sulfonate: Foam Behavior

- Lubrizol in-house recirculating foam test (pump on 5 minutes, pump off 5 minutes)
- No defoamer or antifoam
- 5% wt/wt semisynthetic concentrate
- 7.5 °dH (~135 ppm) water (17 : 3 Ca<sup>2+</sup>/Mg<sup>2+</sup> mix)



***PIBSA formula builds less foam, breaks more quickly***

**PIBSA**



**Sulfonate**



# PIBSA vs Natural Sodium Sulfonate: Case Study

Identical semisynthetic formulations  
aside from sulfonate vs PIBSA

Component	Sulfonate	PIBSA
Group II base oil	27	27
450 MW natural sodium sulfonate	7	
PIBSA emulsifier		7
Water	42	42
Rest of formula	24	24
	100	100



5% wt/wt emulsions  
65 °dH (~1070 ppm) water  
(17 : 3 Ca<sup>2+</sup>/Mg<sup>2+</sup> mix)

***PIBSA provides  
same or better  
performance  
relative to sodium  
sulfonate***

# SECTION II

## Formulating with PIBSA

# Guidance for Formulation with PIBSA

- PIBSA requires neutralization with source of alkalinity to make an emulsifier
- Blending procedure can impact product performance
  - Type of neutralizing base
  - Blend temperature
  - Blend duration
- If replacing sodium sulfonate, less PIBSA can typically be used
  - Start at 60 – 70% PIBSA relative to the amount of sodium sulfonate typically used
  - Adjust as necessary

Formulating with PIBSA as primary emulsifier is possible!

# Guidance on PIBSA Reaction Conditions

	Potassium Hydroxide	Primary Amine
Lubrizol Preference	Preferred	Alternative
Blend temperature	50 – 60 °C	70 – 80 °C
Blend duration	60 – 90 minutes	90 – 120 minutes

- Step 1: Dilute PIBSA in oil until well dispersed (other acids can be added)
- Step 2: Blend according to above recommendations
- Step 3: Complete blend as usual; additional amines can be added after PIBSA reaction is complete

# Model Semisynthetic Formula Using PIBSA

- Semi-synthetics are higher value fluid type for metal removal operations
  - Benefit: provide good balance of lubricity, cooling, and cleanliness
  - Challenge: more formulation complexity
- Difficult to formulate to achieve desired performance:
  - Concentrate stability
  - Hard water emulsion stability
  - Foaming behavior
  - Corrosion protection
- Choosing the right emulsifier system is key to success

# Model Semisynthetic Formula Using PIBSA

Component	Formula	Blend Step
Base oil	26	A
<b>PIBSA (ADDCONATE® H)</b>	7	
Fatty acids	3	
Potassium hydroxide (45% in water)	2	B
Alkanolamine mixture	3	C
Nonionic co-emulsifiers	3	
Corrosion inhibitors	12	
Boundary lubricants	2	
Couplers	1	
Biocides	3	
Water	38	
<b>SUM:</b>	<b>100</b>	

**Step A:** Blend ADDCONATE® H and fatty acids in oil, heat to 55-60 °C for 30 minutes.

**Step B:** Add potassium hydroxide (45%) and blend at 55-60 °C for 30-60 minutes.

**Step C:** Blend rest of formula as usual



# PIBSA Semisynthetic: Concentrate Stability

Temperature:

-18 °C

0 °C

20 °C

50 °C

65 °C

photo at  
storage  
temp

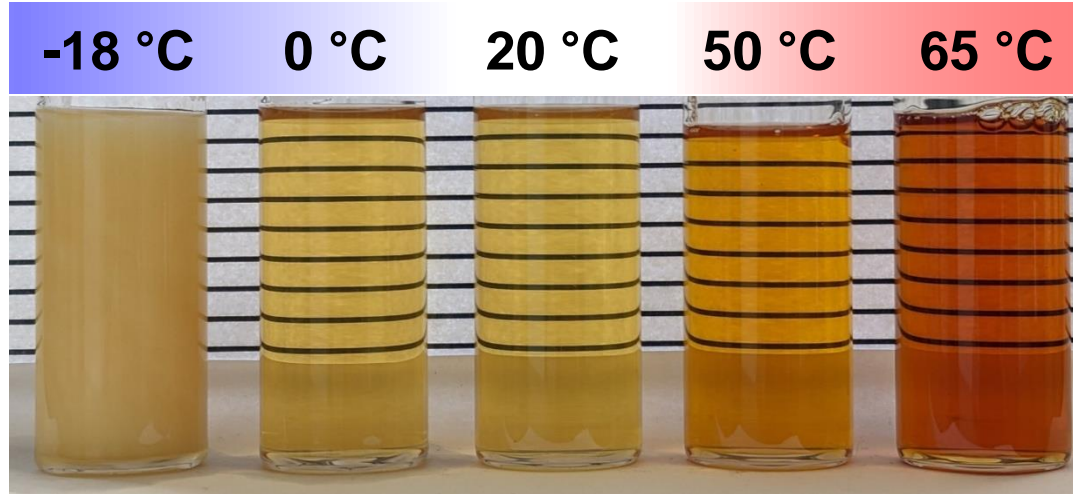


photo after  
equilibrate  
at 20 °C



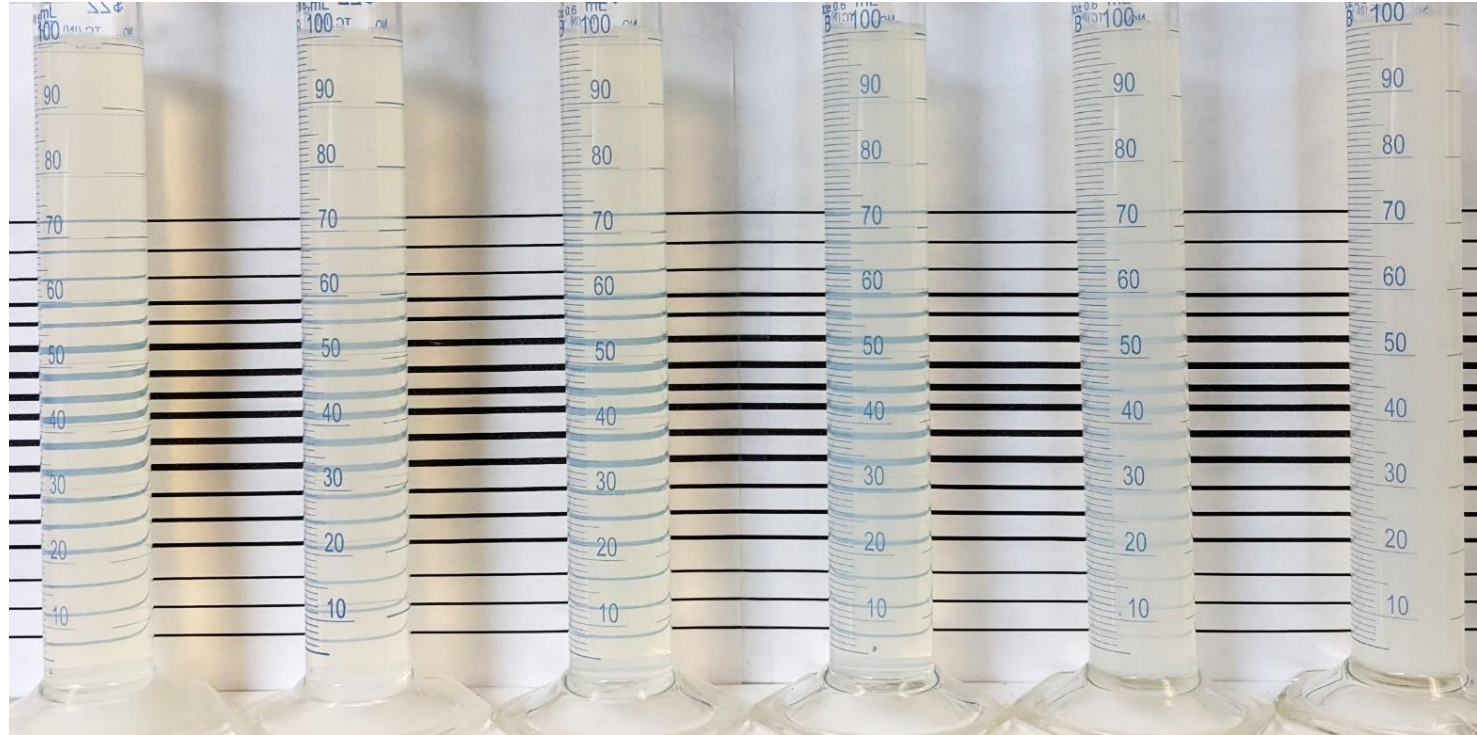
- Concentrate stored at temperatures shown for four weeks
- Darkening at high temperatures due to amine components

Stable concentrate over broad temperature range

# PIBSA Semisynthetic: Hard Water Emulsion Stability

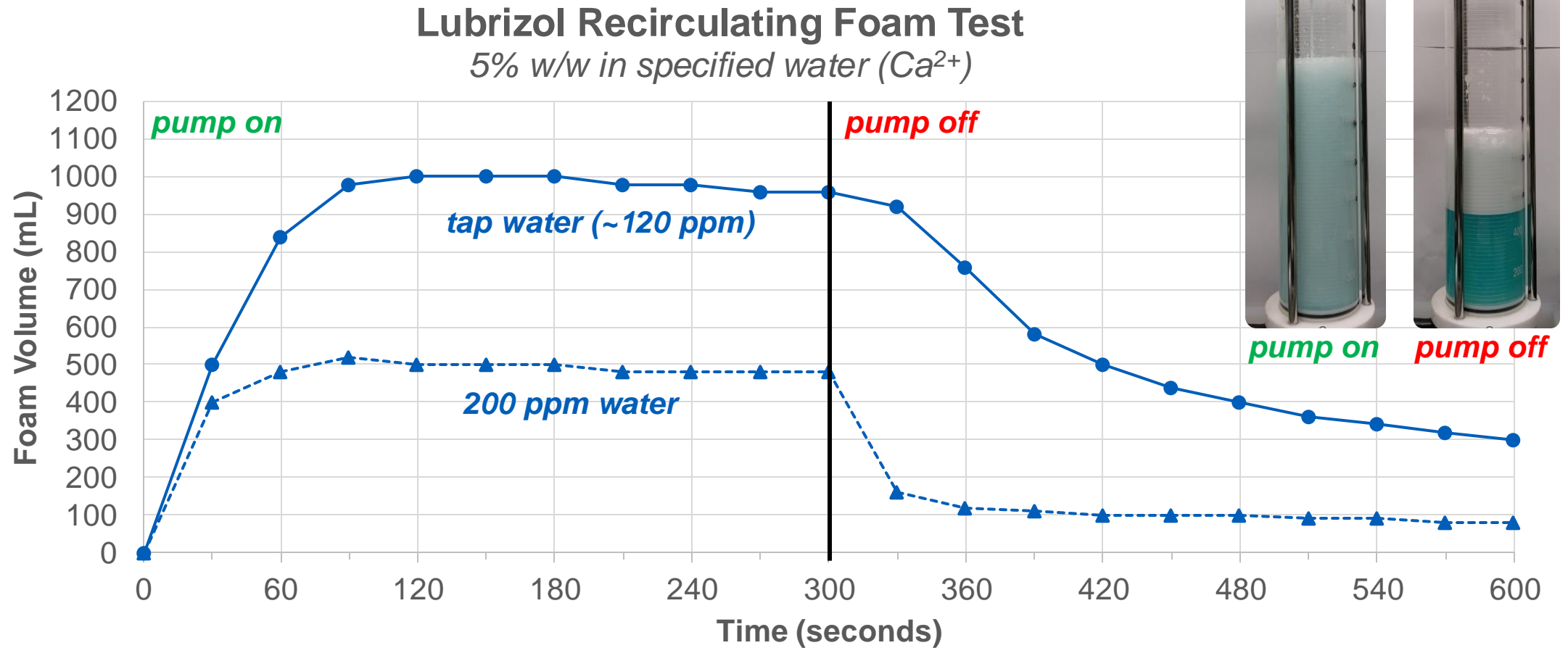
- Emulsion Stability test in soft and hard water
- 5% w/w in specified water ( $\text{Ca}^{2+}$ ). Equilibrate at 20 °C for 72 hours

**120 ppm    200 ppm    300 ppm    400 ppm    500 ppm    600 ppm**



Stable emulsions, even in very hard water

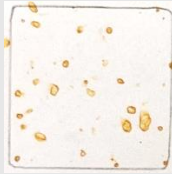

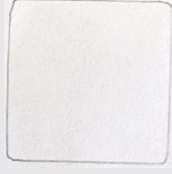
# PIBSA Semisynthetic: Foam Behavior



Relatively low foaming without use of a defoamer or antifoam

# PIBSA Semisynthetic: Corrosion Protection

IP287 Cast Iron Chip Test in 200 ppm water ( $\text{Ca}^{2+}$ )

Dilution (wt/wt)	rust
1%	
2%	
3%	
pH (5% in tap water)	9.3



*Note: Also shows no staining on aluminum (AA319, AA6061, AA7075)*

Good ferrous corrosion protection without sulfonates

# Summary: Formulating with PIBSA

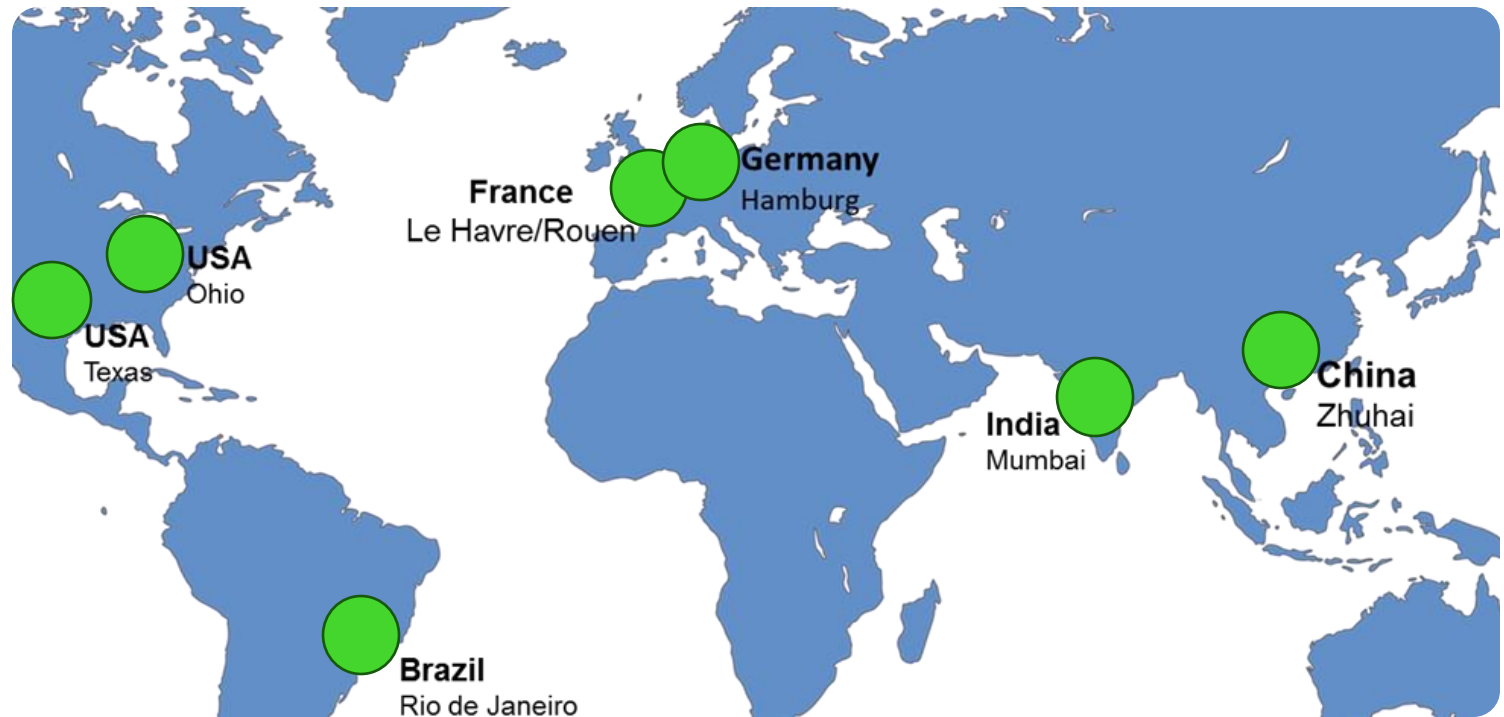
- Additional blend step may be needed to neutralize PIBSA
- Relatively easy to do with common components and mild conditions
- High performance semisynthetic fluid is achievable
  - Excellent concentrate stability
  - Excellent emulsion & hard water stability
  - Low foaming
  - Good ferrous and nonferrous corrosion protection

# SECTION III: Lubrizol's PIBSA Products



# Benefits of Lubrizol PIBSA

- Lubrizol has sold PIBSA as an emulsifier for over 20 years
- Lubrizol is a technical leader in manufacturing and use of PIBSA
- Lubrizol PIBSA supply is global, consistent, and cost-effective
  - Based on readily available materials
  - Not a byproduct of another process
  - Made using a continuous process: quality is consistent over time
  - Typically, lower cost than natural and synthetic sodium sulfonates



# Lubrizol Metalworking PIBSA-Based Products

	ADDCONATE® H	ADDCONATE® M	LUBRIZOL® 5981	LUBRIZOL® MC5150	LUBRIZOL® 5620B
<b>Emulsifier chemistry</b>	1000 M <sub>n</sub> PIBSA	1000 M <sub>n</sub> PIBSA	1000 M <sub>n</sub> PIBSA	500 M <sub>n</sub> PIBSA	Pre-neutralized PIBSA “Gemini” acid derivative
<b>Mineral Oil Free?</b>	No	No	Yes	Yes	No
<b>Viscosity @ 100°C, cSt</b>	100	90	900	150	90
<b>Features and benefits</b>	General purpose	Improved bloom, compatibility, and lubricity	Mineral oil free	Mineral oil free  Improved emulsification efficiency	“Ready-to-Use”  Excellent hard water stability, low foaming properties

*New products currently in development*



# Summary

- **SECTION I: Introduction to PIBSA**
  - Successfully formulating an emulsified MWF depends on emulsifier system
  - PIBSA is a high-performance alternative to sodium sulfonates
    - Lower foaming tendency
    - Better hard water stability
    - Global manufacturing, first-intent, consistent, high-volume material
- **SECTION II: Formulating with PIBSA**
  - PIBSA needs to be neutralized with an alkaline source
  - PIBSA can be used to successfully formulate a high-performance semisynthetic fluid
- **SECTION III: Benefits of Lubrizol PIBSA**
  - Lubrizol is a world leader in high quality PIBSA-based emulsifiers
  - Multiple PIBSA and PIBSA-based emulsifier products are available. More are on the way!



# ***Lubrizol***

# Thank you!

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