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Innovative Chemistry for Lubricants

Biobased Lubricant Technology Opportunities in Forestry: Saw Guide and Chain Oil Packages SGP-567 and CO-545

Functional Products Inc.

www.functionalproducts.com

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Market Assessment

- Saw Guide Oil: 3 – 5 million gallons in North America
- Multiple types of chains (Sharp Chain, Green Chain): unknown, but overall volume is likely much greater than SGO
- "Small" overall market size has eliminated major additive companies from investing in specific additive packages designated and tested for these applications
- Primarily a regional demand business

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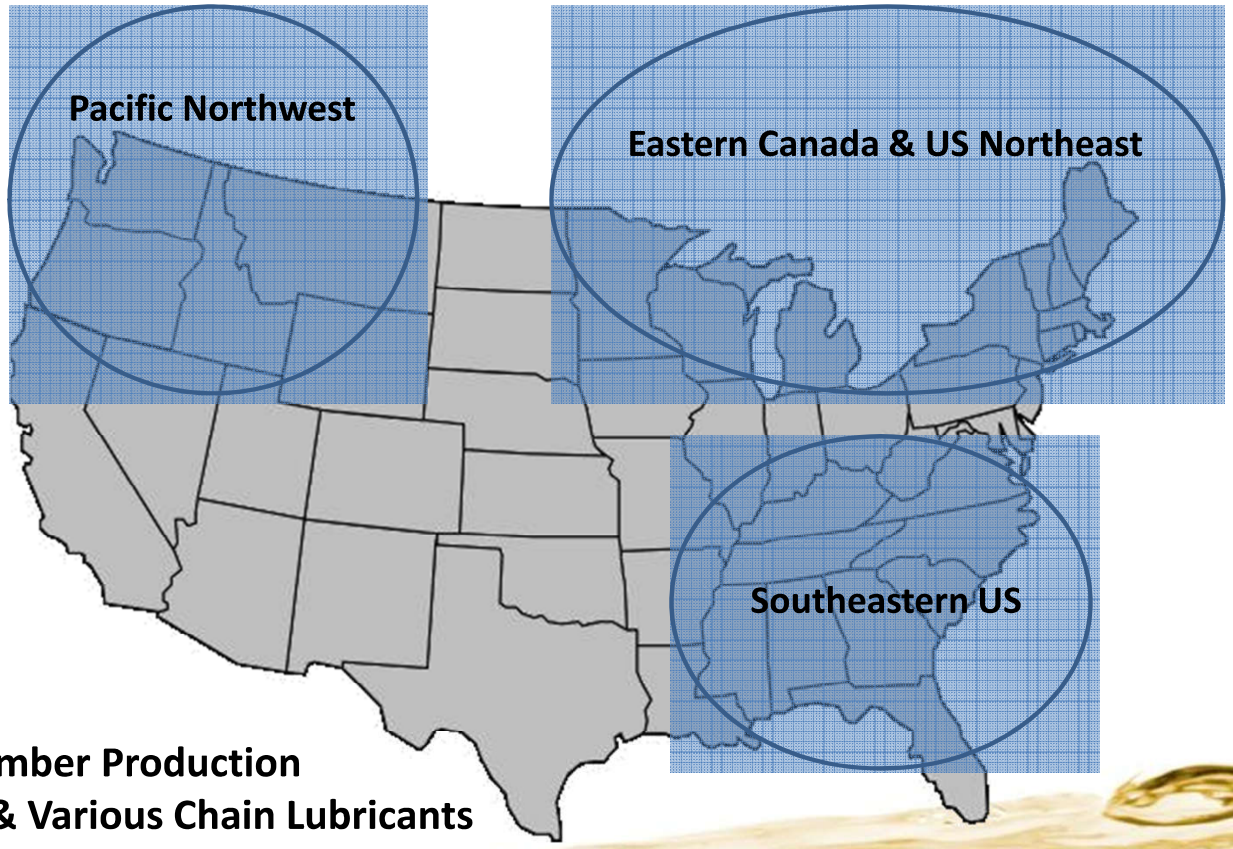
Primary Market Areas



Forestry/Lumber Production
Saw Guide & Various Chain Lubricants

- Saw Guide SGP-567 and Sharp Chain Oils CO-545
  - Used in multiple areas inside lumber mills
  - Represent unique niche lubrication applications in forestry
  - Traditionally served with conventional mineral oil formulations

- Ecological factors and new lubrication technology bring about the transition towards biobased formulations

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The Case for Biobased Lubricants

- Improved biobased technology – results in superior performance
- Both applications are “total or high fluid loss” leading to contamination concerns
- Properly formulated biobased products for these applications may be better lubricants than their petroleum based counterparts

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The Case for Biobased Lubricants

- Distinct finished products
  - Saw Guide Oils of varying viscosity grades and degrees of tackiness
  - Chain Lubricant specific to a variety of chain only applications

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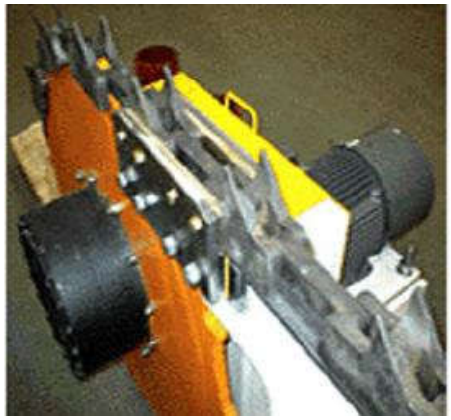
Forestry Applications

Saw Guide array



Sharp Chain links

Green Chain

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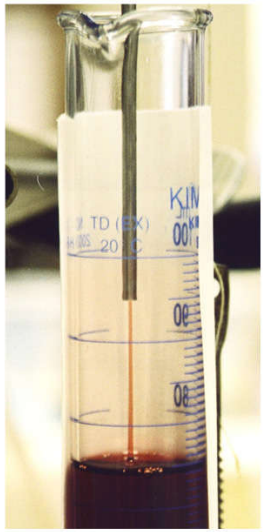
Benefits of Biobased Saw Guide using SGP-567 Oils over Conventional Formulations	
Excellent tackiness	Equivalent tack in biobased formulation using Functional V-584 and conventional formulations
Low friction	Coefficient of friction lower in biobased formulations
Available in several viscosity grades (68, 100 and 150)	All ISO grades can be met using Functional V-515 and Functional V-584 biobased thickener
Good demulsibility	ASTM D1401
Superior rust protection	ASTM D665 A/B plus improved humidity/salt fog performance using Functional SGP-567 XRP
Dispersancy/Cleaning	Solvency important to reduce pitch buildup
Low temperature handling	Pour point of -30°C in canola oil with added pour point depressant
AW/EP characteristics	Increased weld load in biobased formulation, acceptable wear scar in both biobased and conventional

Measuring Tack

This is not a scientific measurement of tackiness

Measuring Tack: Ductless Siphon Test



- Fluid is drawn through a standardized capillary via controlled vacuum
- Initial capillary position is below the fluid surface
- Fluid level within the cylinder drops as siphoning occurs
- A uniform string of viscoelastic fluid is formed
- Measurements of string length are objective vs. entirely subjective

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Rating Tack by String Length

- Starting formulations available for:

	String Length
Tacky Saw Guide Oil	50 - 65
Very Tacky Saw Guide Oil	65 - 80
Exceptionally Tacky Saw Guide Oil	> 80

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Starting Point Saw Guide Formulation: Biobased Very Tacky ISO 100 and 150

Component	Name	Treat Rate (%)
Tackifier	Functional V-584	7-11
Thickener	Functional V-515	8-11
Performance Additive Package	Functional SGP-567	1.5
Base Oil	Canola Oil	Balance

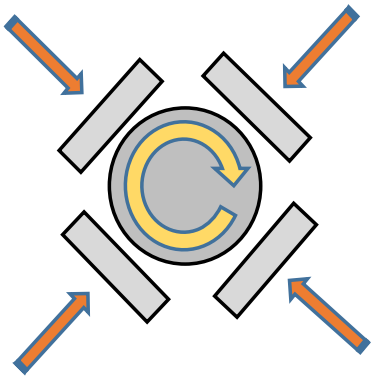
Functional Products has identified a unique bench test that provides relevant data to forestry applications

- Performance measurements
  - Wear scar
  - Coefficient of friction (C of F)
  - Specimen and fluid temperature (°F)
  - Torque

Bench Test Parameters

- **Speed – 600 RPM**
- **Rotating pin against machined bars**
  - **Bars – C 1137 steel**
- **Duration – Variable**

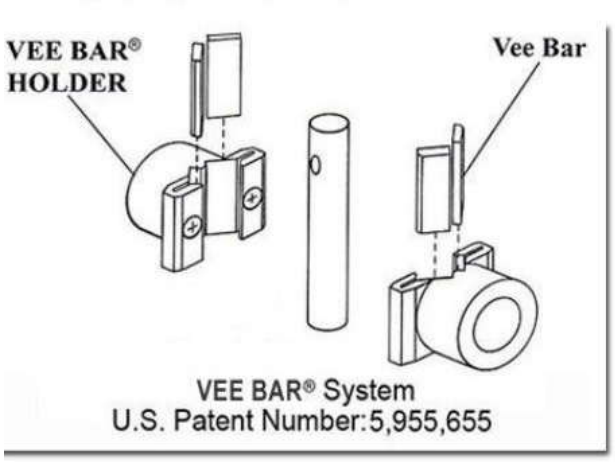
Test



Directed load

Bench Test Parameters

PTI Epsilon Linear Precision Test Machine – a modified Pin and Vee test



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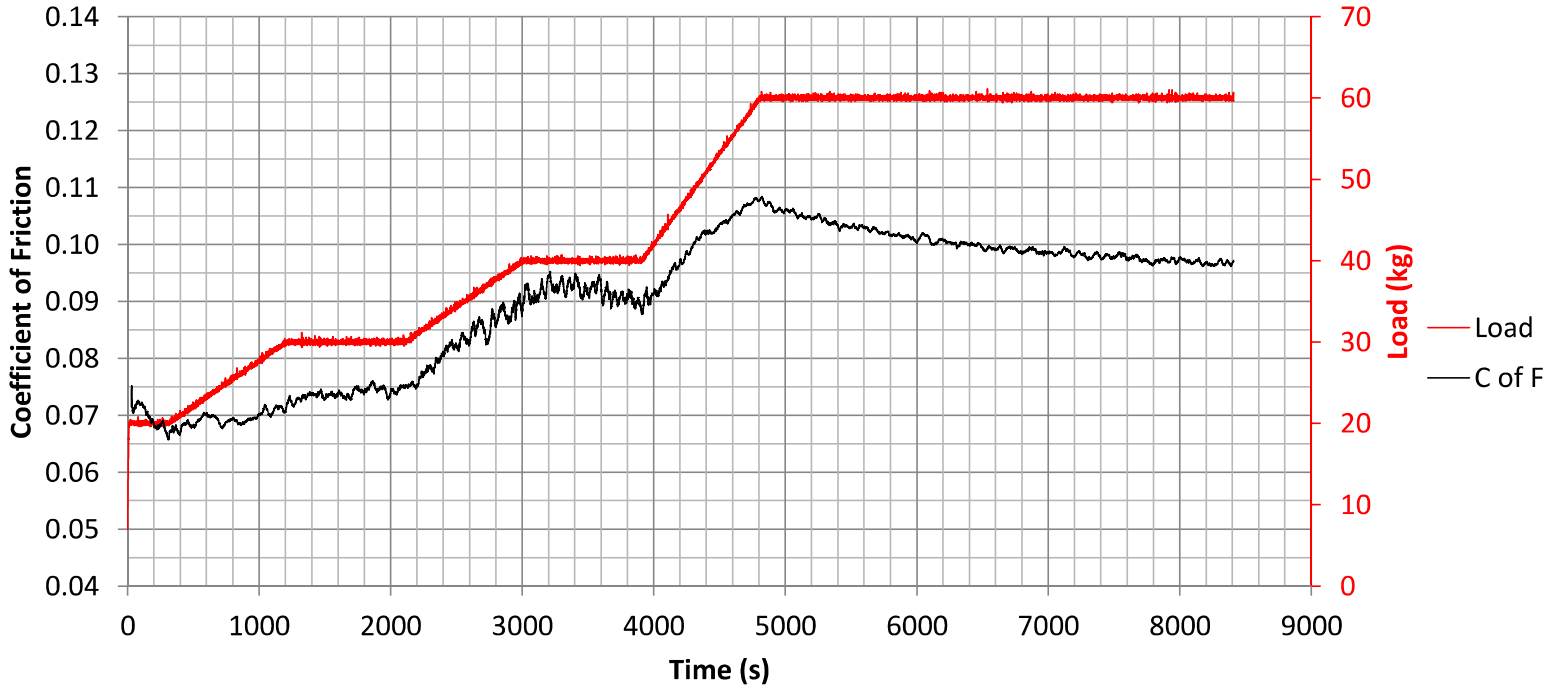
Ramp Up and Staged Load Test: ISO 150 Exceptionally Tacky with SGP-567



15 min ramp up between stages: 5 min at 20 kg, 15 min at 30 kg, 15 min at 40 kg, 60 min at 60 kg.

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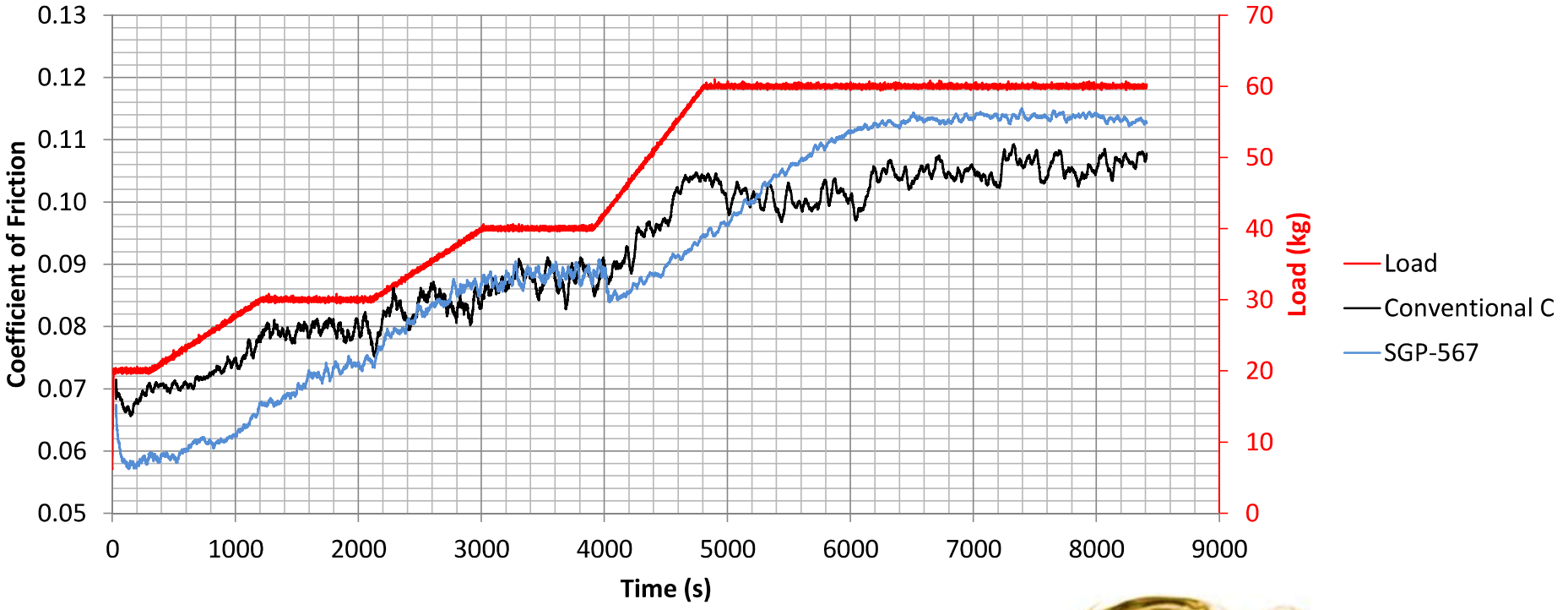
Ramp Up and Staged Load Test: ISO 100 Tacky Saw Guide Oils



15 min ramp up between stages: 5 min at 20 kg, 15 min at 30 kg, 15 min at 40 kg, 60 min at 60 kg.

Coefficient of Friction

- Coefficient of Friction (CoF) is a ratio

  Force required to move a body over a horizontal surface at constant speed under an applied load

$$\text{CoF} \equiv \frac{\text{Lubricant viscosity x speed}}{\text{Force of the perpendicular load against surface}}$$

As the number of asperities on the surface increases, the CoF increases

Less force is required to overcome the applied load when the CoF is lower

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Ramp Up and Staged Load Test

Sample Discription	ISO Grade	Relative Tack	Total Wt. Loss	
Conventional A	150	Tacky (62)	.029 g	
Biobased Unconventional B	150	Tacky (57)	.008 g	
SGP-567 in Canola Oil	150	Tacky (59)	.001 g	Averge of weight loss of Canola oil based formulas with SGP-567 is statistically zero
SGP-567 in Canola Oil	150	Very Tacky (67)	.000 g	
SGP-567 in Canola Oil	150	Exceptionally Tacky (98)	.000 g	

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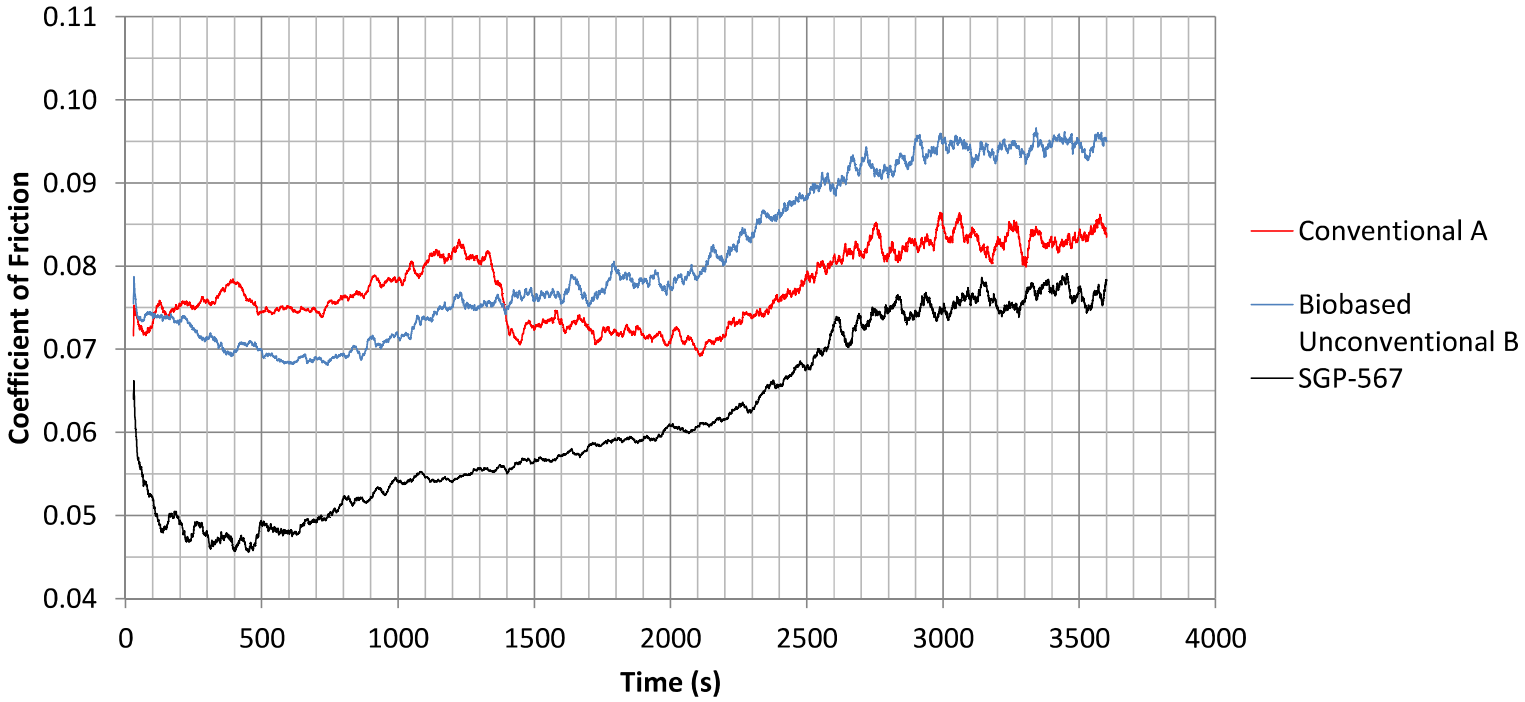
Ramp Up and Staged Load Test: ISO 150 Tacky Formulations



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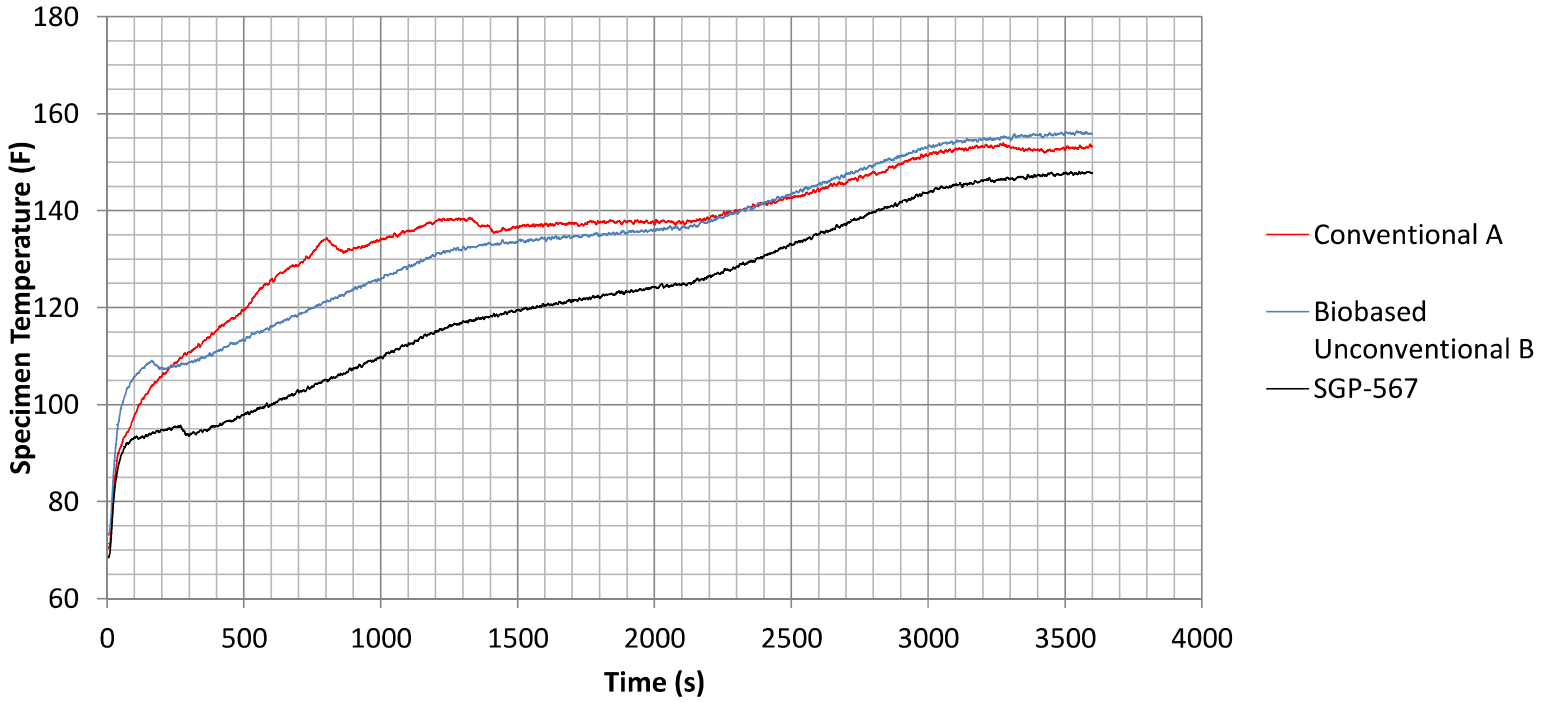
Ramp Up and Staged Load Test: ISO 150 Tacky Formulations



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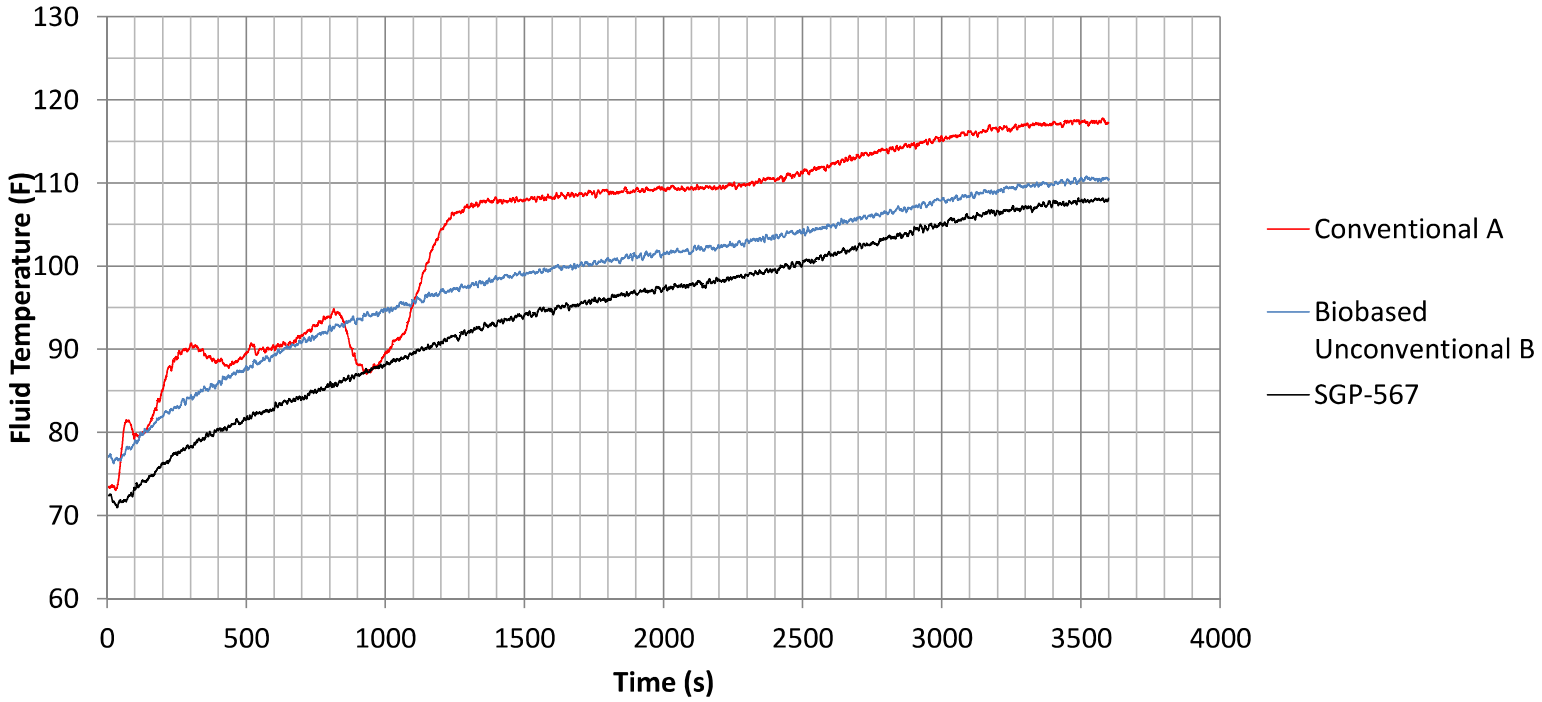
Ramp Up and Staged Load Test: ISO 150 Tacky Formulations



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SGP-567 Biobased Saw Guide Oil Results

- >14% Coefficient of Friction improvement
  - Provides power and energy savings
  - Improves cutting efficiency
- Reductions in both saw and fluid temperatures
- Designed to be environmentally friendly
- Renewable resource platform, (> 90 % non-petroleum derived)

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ASTM B117 Salt Fog: 2.5 Hours Exposure

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ASTM D1748 Humidity Cabinet: Testing in Progress

Formulation	Hours to Failure
Conventional A ISO 150 Tacky	1176
SGP-567 ISO 150 Tacky	>2712
SGP-567 XRP ISO 150 Tacky	>2712

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Biobased Chain Oil

Benefits of Biobased Chain Oils over Conventional Formulations	
Excellent tackiness	Equivalent tack in biobased formulation using V-584 and conventional formulations
Low friction	Coefficient of friction lower in biobased formulations
Single viscosity grade	ISO 46 can be met using V-584
Good rust protection	Good ASTM D665 A/B performance
Excellent wetting	Added synthetic ester for enhanced wetting
AW characteristics	Comparable wear scar in both biobased and conventional
Low temperature handling	Pour point of -30°C in canola oil with added pour point depressant
EP characteristics	Biobased performs better under high load conditions

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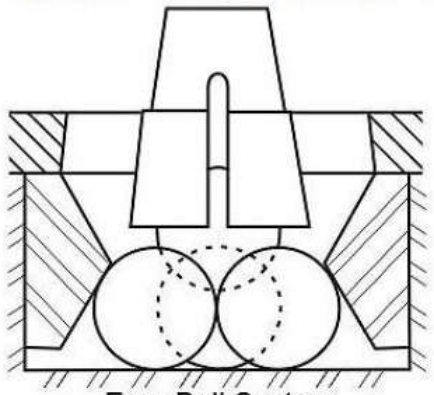
Starting Point Formula: CO-545 ISO 46 Biobased Chain Oil

Component	Name	Treat Rate (%)
Tackifier and Thickener	Functional V-584	3-5
Pour Point Depressant	Functional PD-590	0.3-1.0
Performance Additive Package	Functional CO-545	1-2
Base Fluid	Canola Oil/Synthetic Ester Blend	Balance

Chain Oil Bench Test Parameters

PTI Multi-Four Ball Machine (M-4) – variable load and ball speed


Four Ball System

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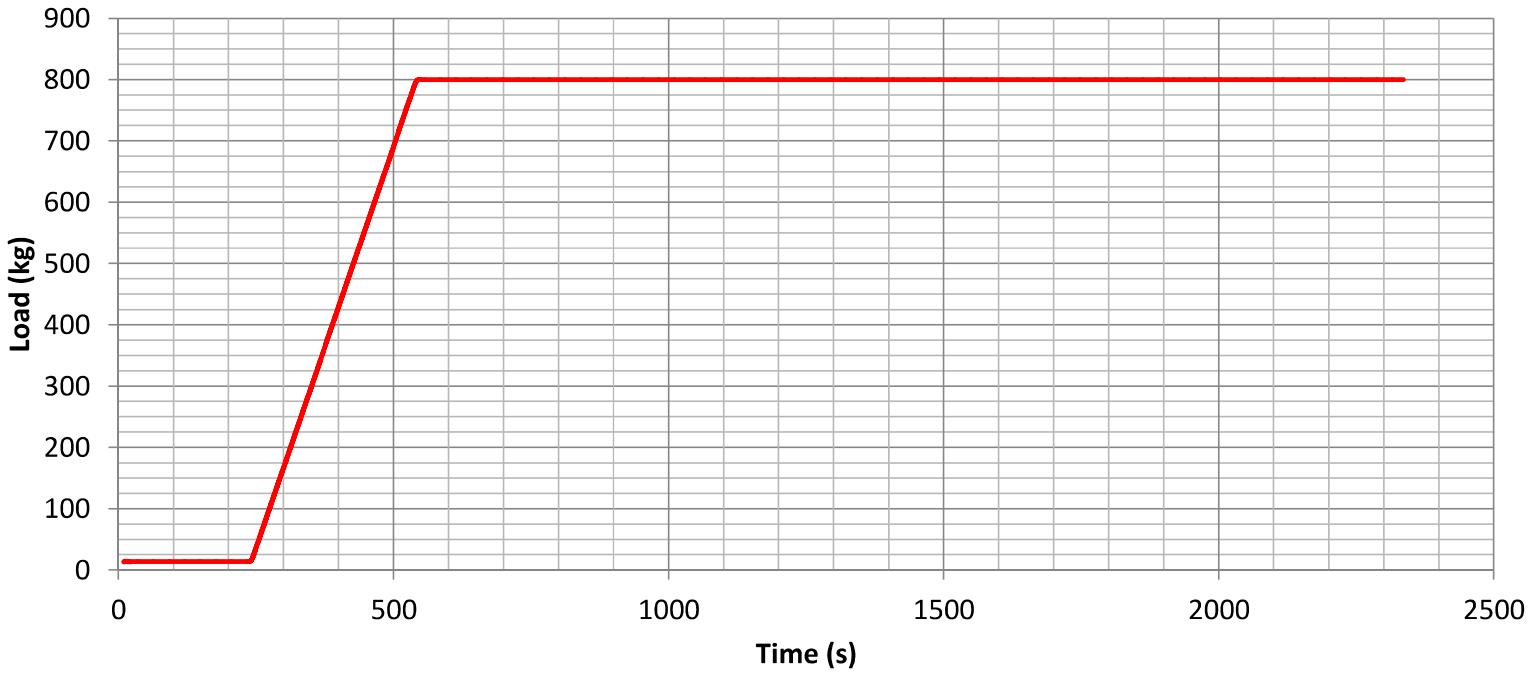
Chain Oil Bench Test Parameters



Speed: 10 rpm
5 min ramp up
30 min hold at 800 kg

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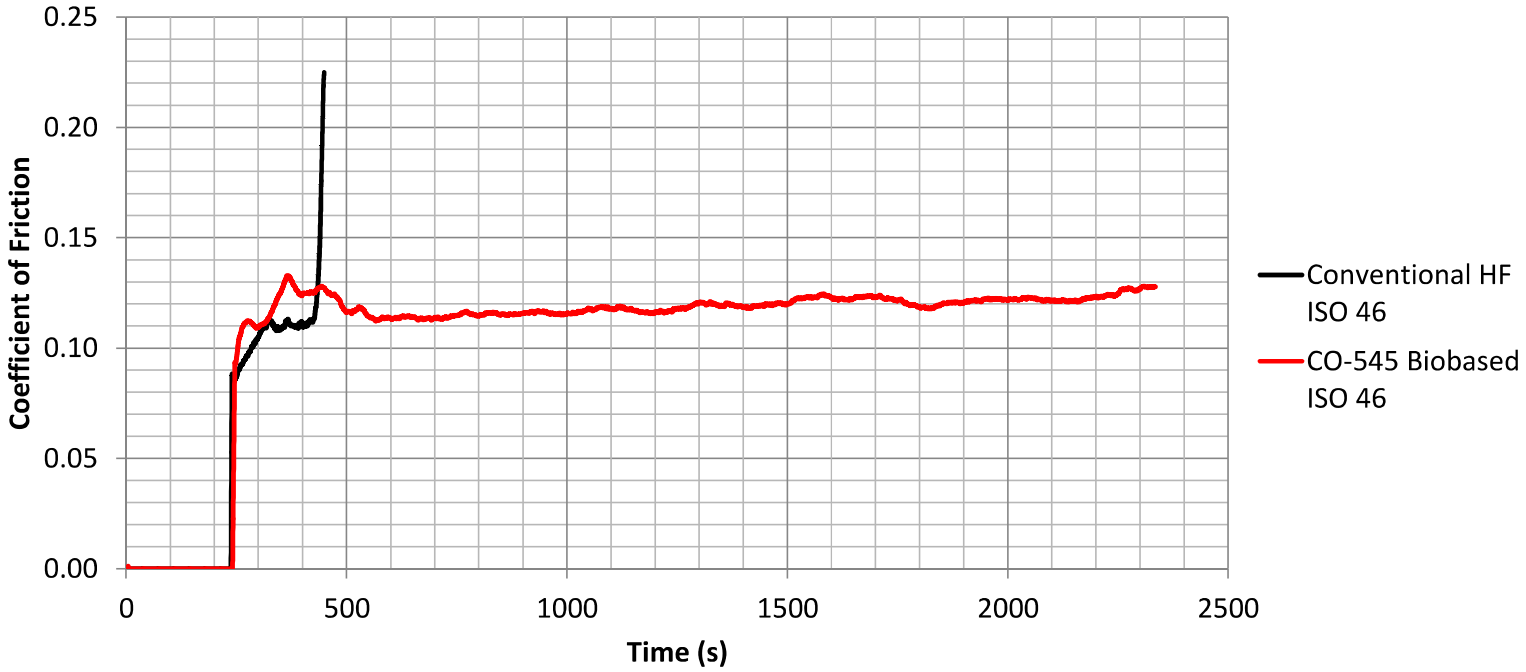
Ramp Up and Staged Load Test: ISO 46 with CO-545



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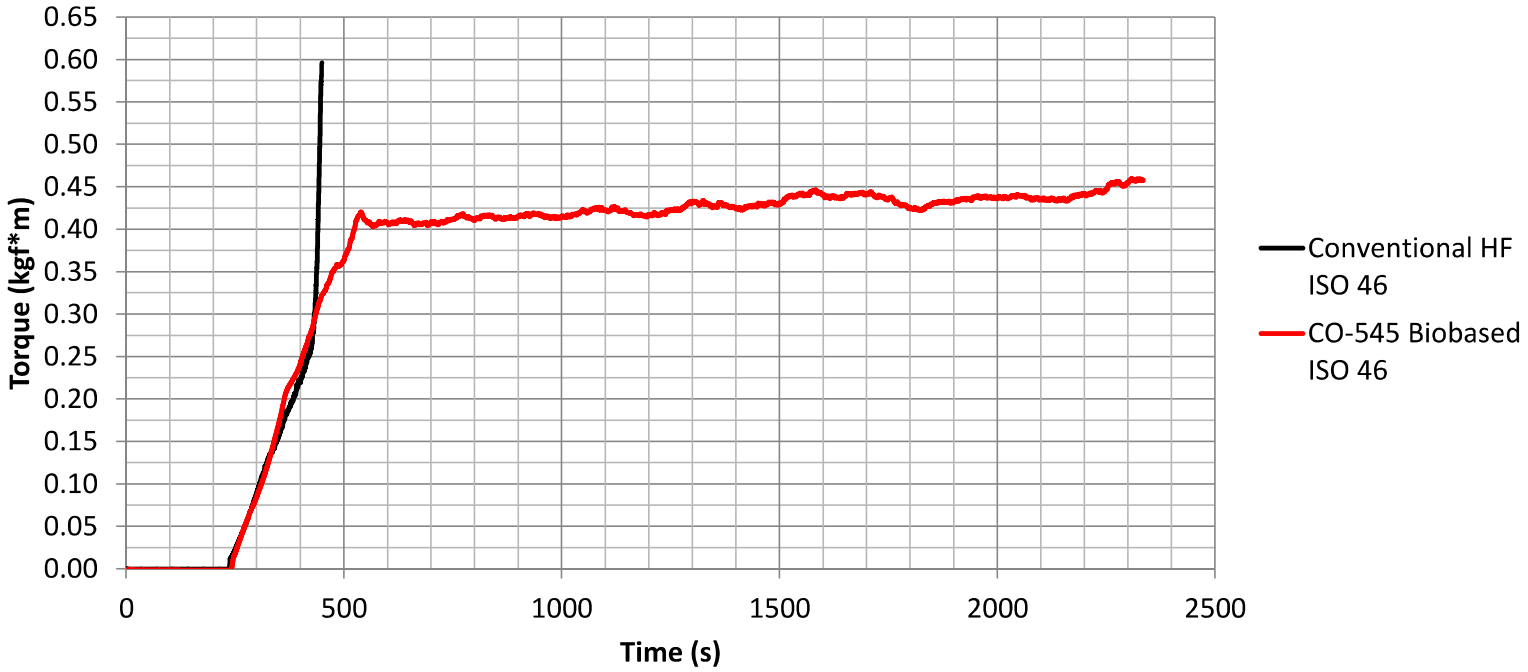

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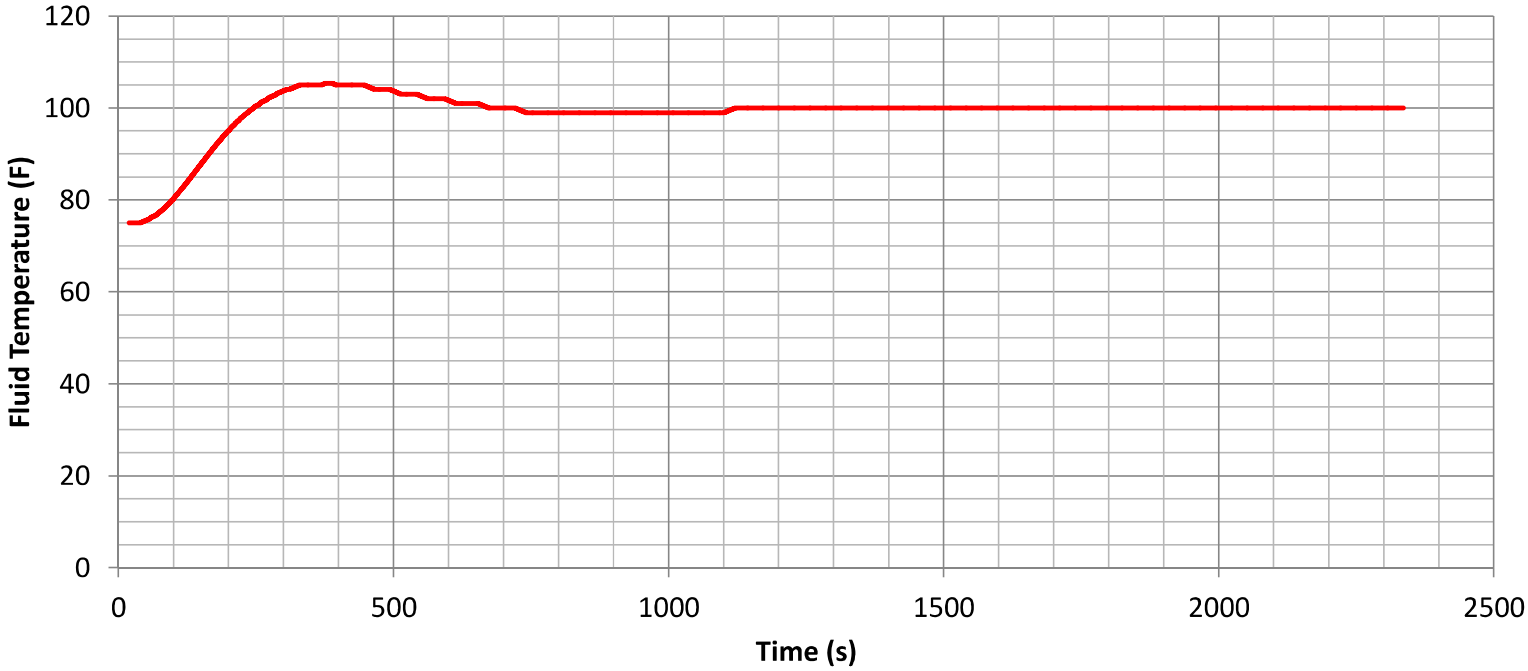
Ramp Up and Staged Load Test: ISO 46 with CO-545



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CO-545 Biobased Chain Oil Results

- Coefficient of Friction improvement
  - Provides power and energy savings
- Stable fluid temperature
- Designed to be environmentally friendly
- Renewable resource platform, (> 90 % non-petroleum derived)

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Advantages of SGP-567 and CO-545 Formulations over Conventional Oils

- Superior performance
  - Improved lubricity
- Lighter color than conventional formulations
- Safer for the environment
  - Renewable base fluids

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Other Biobased Packages

- Functional Products also offers the following packages to formulate the following:
  - Hydraulic fluid – HF-580 or HF-546
  - Open gear oil – GA-502
  - Way oil – WA-64 or WA-60SF
  - Rock drill oil – RD-535 or RD-535CP