



*Great Lakes Maritime
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Cold Flow Testing of Biodiesel Blends with Additives

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Project Goals/Topics

- Quantify Cold Flow Properties of Biodiesel Blends with Additives
- Methodology
 - Test Procedures
 - Equipment
 - Variables
 - Sample Preparation
 - Number of Tests
- Results

Test Procedures

- Cloud Point (CP)
 - ASTM D2500
 - Temperature at which the smallest observable cluster of wax crystals first appears
- Pour Point (PP)
 - ASTM D97/D6749
 - Lowest temperature at which movement of the test specimen is observed
- Cold Filter Plugging Point (CFPP)
 - ASTM D6371
 - Estimation of the lowest temperature at which a fuel will give trouble-free flow in certain fuel systems

Equipment

- Tanaka MPC-102L CP/PP Tester
 - Minimum Temperature -40°C
(water) -60°C (refrigerated bath)
- Tanaka AFP-102 CFPP Tester
 - Refrigerated Bath Required
 - Minimum CFPP -60°C
- Neslab RTE-7 D1 Refrigerated Bath
 - Temperature Range: -25°C to $+150^{\circ}\text{C}$



Test Variables

- Blend (6 Blends)
 - #2 Diesel (high sulfur)
 - B5, B10, B20, B50, B100 (soy methyl ester)
- Additive
 - 4 different additives
- Additive Loading (3 Loadings)
 - No loading
 - 100% loading
 - Manufacturer's Recommended Amount
 - 200% loading

Additives

- FPPF Deluxe Total Power
- Power Service Diesel Fuel Supplement + Cetane Boost
- AMSOIL Diesel Cold Flow Improver
- Howes Diesel Treat

Additive	Recommended Amount*	Volume Ratio (additive/fuel)
FPPF	1 quart/250 gal.	0.001
Power Service	8 oz./25 gal.	0.0025
AMSOIL	2 oz./5 gal.	0.003125
Howes	1 oz./5 gal.	0.0015625

***Recommended Amount = 100% Loading**

Sample Preparation

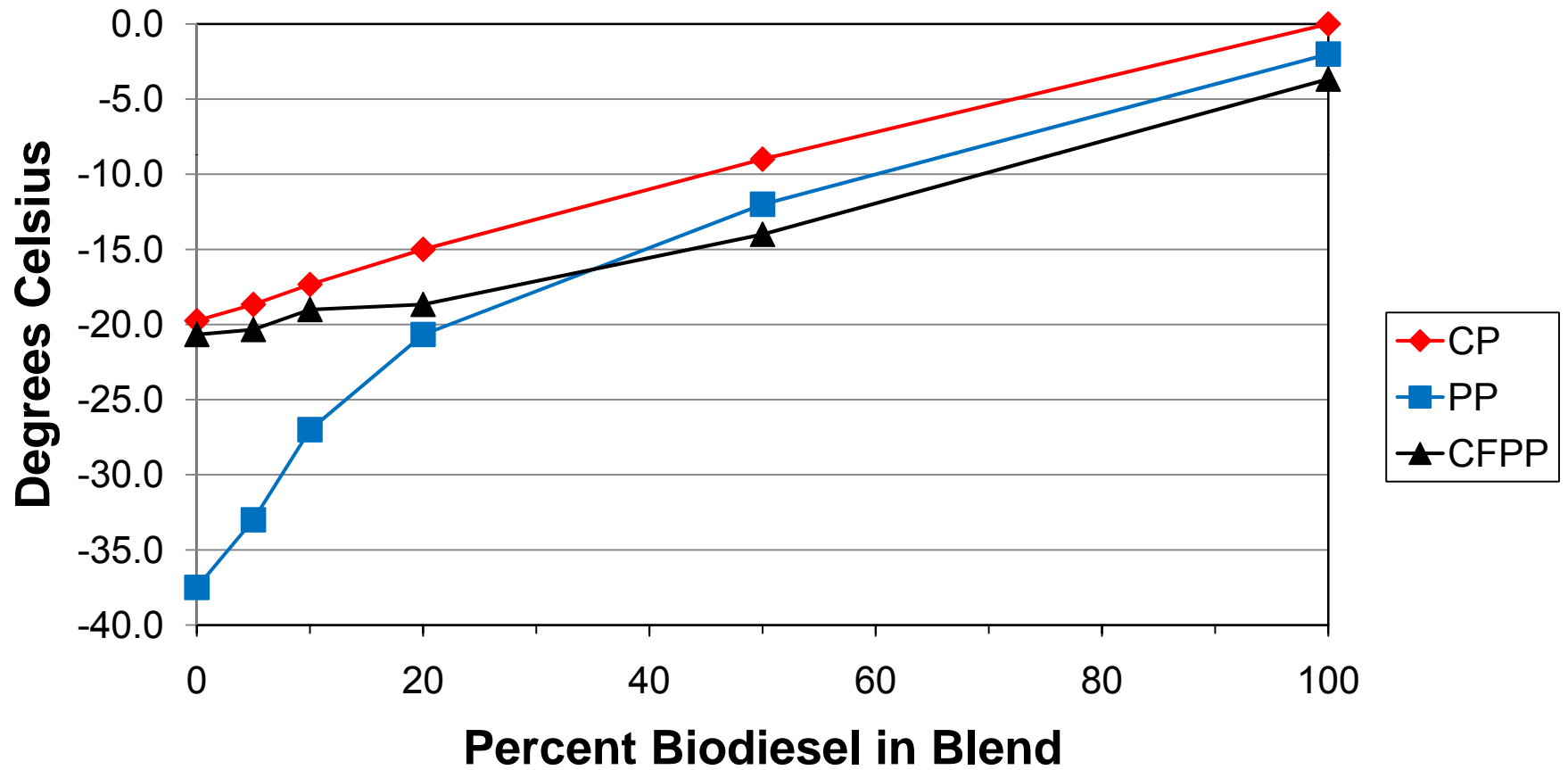
- 300 mL Samples
 - Blend Uncertainties
 - $B5 \pm 0.14$
 - $B10 \pm 0.14$
 - $B20 \pm 0.22$
 - $B50 \pm 0.57$
 - Additive Uncertainties (Volume Ratio)
 - FPPF $\rightarrow 0.001 \pm 2.06E-5$
 - Power Service $\rightarrow 0.0025 \pm 2.36E-5$
 - AMSOIL $\rightarrow 0.003125 \pm 2.54E-5$
 - Howes $\rightarrow 0.0015625 \pm 2.14E-5$

Number of Tests

- Additive/Loading Effect
 - No Additive (1) + (4 Additives × 2 Loadings)
 - 9 Combinations
- Total Combinations
 - # of Blends (6) × Additive/Loading Effect (9)
 - 54 Combinations
- Each Test Repeated 3 Times
 - Check for Repeatable Results
- **TOTAL NUMBER OF TESTS = 162**

Results

No Additives



Results

Reduction in Cloud Point for 100% Loading

Additive	Reduction in CP (°C)					
	#2	B5	B10	B20	B50	B100
FPPF	-1.8	-0.7	-0.3	-1.3	1.0	1.0
Power Service	-2.8	-3.7	-3.3	0.0	1.0	0.0
AMSOIL	-0.8	-2.3	-1.0	-2.7	-2.0	1.0
Howes	-3.4	-3.3	-3.3	0.0	0.0	0.3

Results

Reduction in Pour Point for 100% Loading

Additive	Reduction in PP (°C)					
	#2	B5	B10	B20	B50	B100
FPPF	>12.5	>17	>23	>29	8.0	2.0
Power Service	>12.5	>17	>23	>29	9.7	2.3
AMSOIL	>12.5	>17	>23	>29	>38	9.7
Howes	>12.5	>17	18.0	10.3	4.0	2.5

Pour Point < -50°C

Results

Reduction in CFPP for 100% Loading

Additive	Reduction in CFPP (°C)					
	#2	B5	B10	B20	B50	B100
FPPF	14.7	14.7	14.3	5.0	-2.0	-1.7
Power Service	11.3	13.7	10.0	6.3	-2.0	-2.3
AMSOIL	13.0	13.7	12.3	13.3	0.0	-2.7
Howes	11.7	12.7	5.7	2.3	-2.0	-2.2

Results

- Repeatability of Test Results
 - Generally within Test Method Specifications
 - Cloud Point $\pm 2^{\circ}\text{C}$
 - Pour Point $\pm 1^{\circ}\text{C}$
 - Cold Filter Plugging Point $\pm 1.76^{\circ}\text{C}$

Conclusions

- B50 and B100 PP Slightly Greater Than CFPP
- Additive Effects (100% Loading)
 - No Noticeable Effect on Cloud Point
 - Agrees with Literature
 - Large Effect on Pour Point
 - Particularly for B20 Blends and Lower
 - AMSOIL Additive Most Effective
 - Significant Effect on CFPP
 - 3 Additives Worked Well for B20 Blends and Lower
- More Tests are Being Conducted
 - 200% Loading

