



Additizing Biodiesel for Cold Flow Performance

**Presented
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Introduction

- m The growing interest in Biodiesel and Biodiesel/Diesel Fuel blends for winter has resulted in an increase in Cold Flow Additive usage.
- m Cold Flow Additives for Biodiesel sometimes referred to as Biodiesel flow improvers (BDFI).
 - q Improve the cold flow properties as measured by the CFPP (Cold filter plugging point-ASTM D6371), LTFT (Low Temperature Flow Test – ASTM D4539) and PP (Pour point-ASTM D97).
 - q BDFIs can also arrest, or at least greatly reduce, settling of crystals which form in FAME when stored above or below its CP (Cloud point). Wax settling procedures can evaluate this performance.
 - q BDFIs can be used in concentrated or diluted forms to cover a wide range of handling conditions.

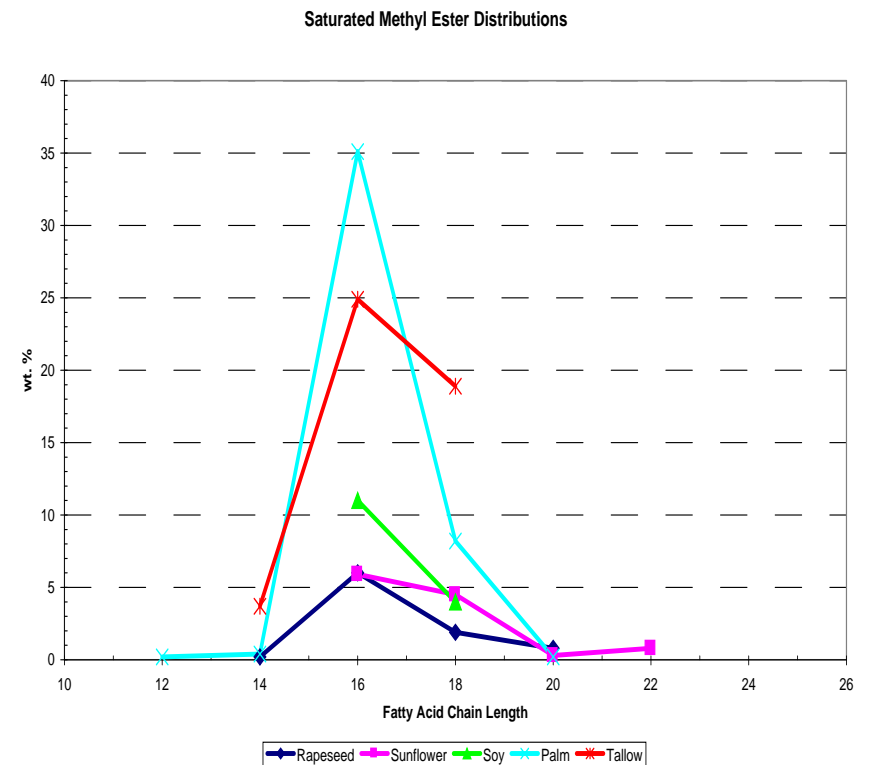
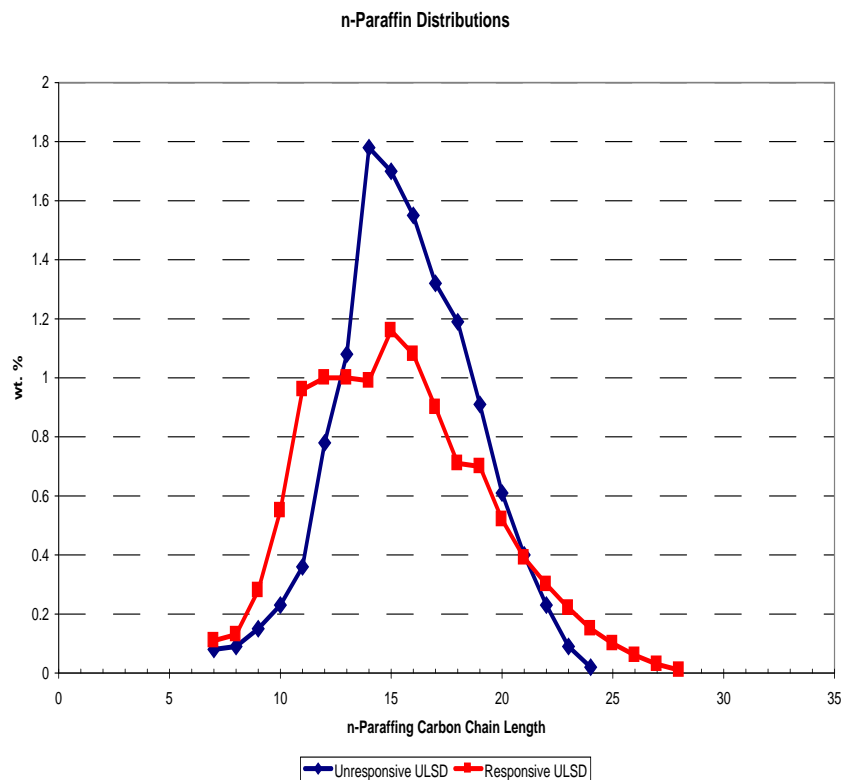
Factors Affecting the Successful Use of Cold Flow Additives in Biodiesel and Biodiesel Blends with Diesel Fuel

- m The base diesel fuel must be responsive to Cold Flow Additives.
- m Select the appropriate lab test to demonstrate the desired performance.
- m The Biodiesel must be properly blended into the Diesel Fuel resulting in a homogeneous and stable blend.
- m Cold Flow Additive must also be properly blended into the Biodiesel or Biodiesel/Diesel Fuel blend in order to achieve the desired and expected result.

Diesel Fuel and Biodiesel Response

- m If the base Diesel Fuel in a Biodiesel/ Diesel Fuel blend is unresponsive to Cold Flow Additives then it is highly unlikely that the blend will be responsive.
- m As the Biodiesel proportion in a Biodiesel/Diesel Fuel increases (2 to 20%) the response to Cold Flow Additive will decrease primarily because the wax content increases substantially. This does not necessarily mean that response is unachievable.
- m Like Diesel Fuel, Biodiesel is more responsive to Cold Flow Additive for lower wax containing streams with broader wax distributions.

Typical n-Paraffin and FAME Saturate Distributions



Note the large difference in scales for the y-axes.

Laboratory Tests (I)

- m Selection of the appropriate lab test is not as simple a task as it sounds.
- m Correlation of lab tests with field performance of diesel fuel has developed over many years and selection of the wrong test can result in major field failures.
- m Cloud Point (ASTM D2500) is the most widely used method for estimating vehicle low temperature operability in North America.
 - q It is the most conservative test when applied to hydrocarbon based diesel fuel.
- m CFPP (ASTM D6371) was introduced in Europe in 1965 and correlated to the typical low temperature operability for light duty vehicles when cold flow additives are used.
 - q Recent vehicle testing suggests that CFPP still protects approx. 80-85% of the light duty vehicles
 - q Correlation with vehicle performance limited to about 10°C(18°F) below Cloud Point.
- m LTFT (ASTM D4539) was developed to correlate with the most severe Heavy Duty fuel system design in North America during the early 1980s
 - q The severe fuel delivery design has increased in use since then, so LTFT still appears to be valid for the HD market.

Laboratory Tests (II)

- m Pour Point (ASTM D97) is a directional indicator of low temperature handling and not an absolute measure of performance.
- m Wax Settling is a measure of the tendency for wax to settle under storage conditions below Cloud Point, but above the estimated low temperature limit as measured by other tests such as CFPP or LTFT
 - q Build up of wax in the bottom of vehicle and storage tanks can be problematic over time.
- m Many other tests have been developed and used for estimating low temperature performance for hydrocarbon fuel storage and heating oil including FFFT, IFT, LTS, PFT, EFT, APT to name a few .
- m Industry is beginning to determine how applicable many of these tests are for Biodiesel blends.

Handling and Blending Biodiesel and Diesel Fuel

- m For proper blending both the Biodiesel and Diesel Fuel need to be 'Bright and Clear' with no evidence of precipitation.
 - q Simple mixing without heat may not be sufficient to dissolve any solids that may be present

- m Elevated temperatures (>70°F) are often used in colder climates for Biodiesel storage. There is some evidence that even at these temperatures over time that precipitation may occur, but it may or may not impact performance.

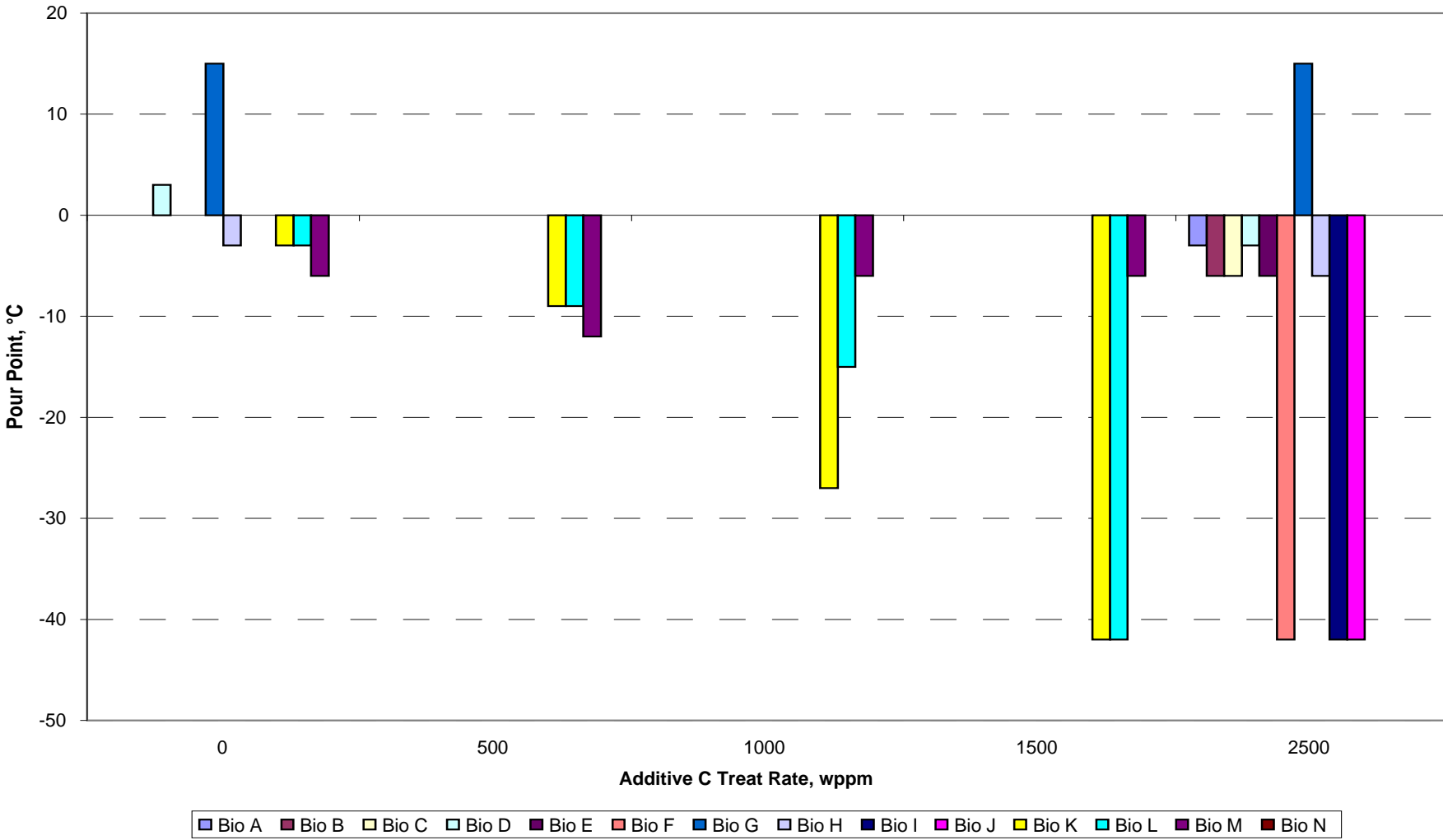
- m Agitation or turbulent flow are required to mix Biodiesel with Diesel Fuel.
 - q Static mixers, impellers or pump-a-rounds are commonly used

Cold Flow Additive Injection

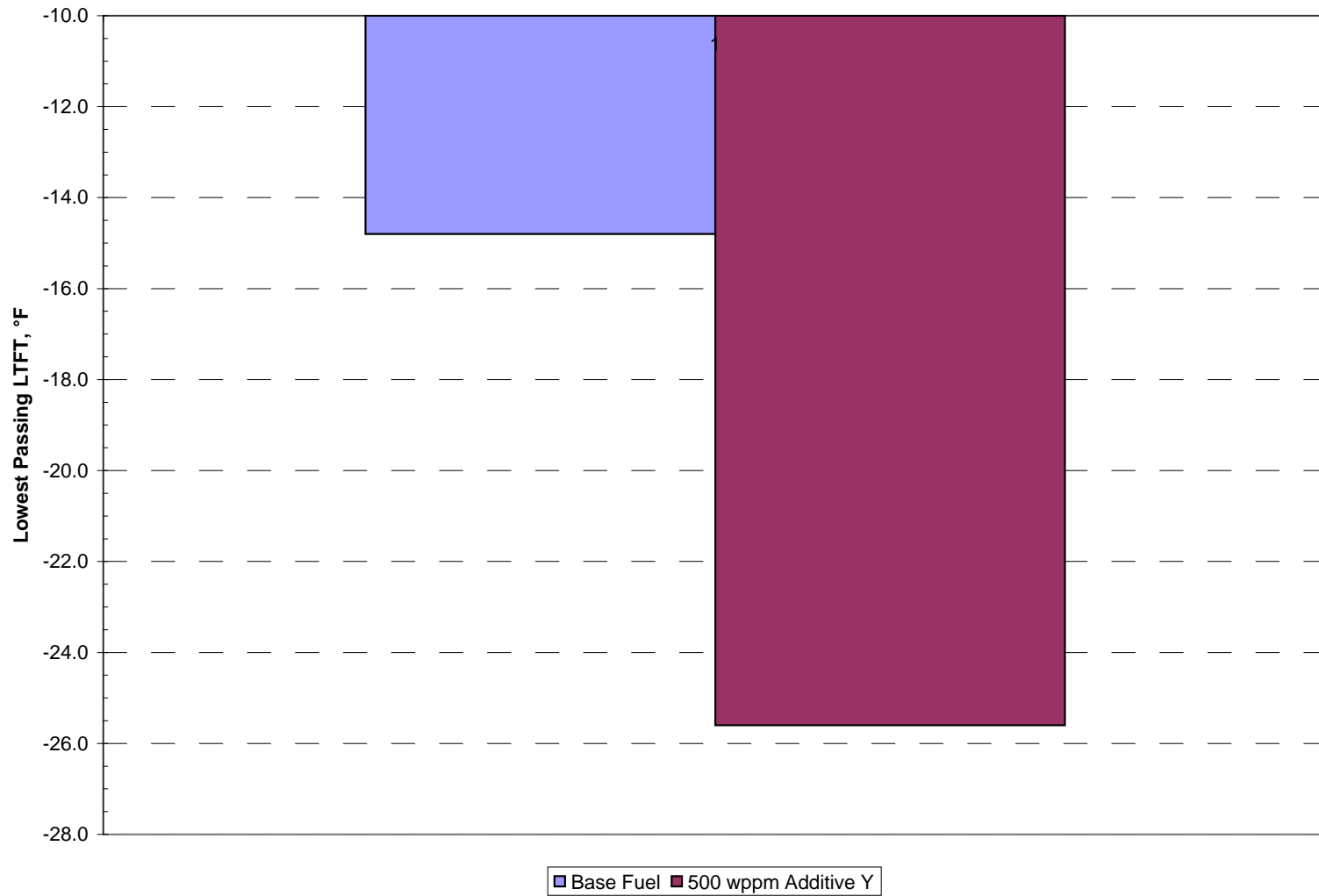
- m The Cold Flow Additive and the fuel must be bright and clear at injection temperature.
- m Some applications may allow or require that additives be injected separately into the Diesel Fuel and Biodiesel portions before combining
 - q Regardless, all components must be bright and clear!
- m The additive should be injected proportionally according to the required treat rate.
- m Viscous additives may cause mixing problems due to large differences between the viscosity of the fuel and the additive
 - q Heating the additive may be the best solution if dilution is not an option.
- m An injection nozzle is recommended .
- m The treated FAME blend should be homogenised by turbulent flow or by using a static mixer which will create turbulent flow.

Estimating Cold Flow Performance

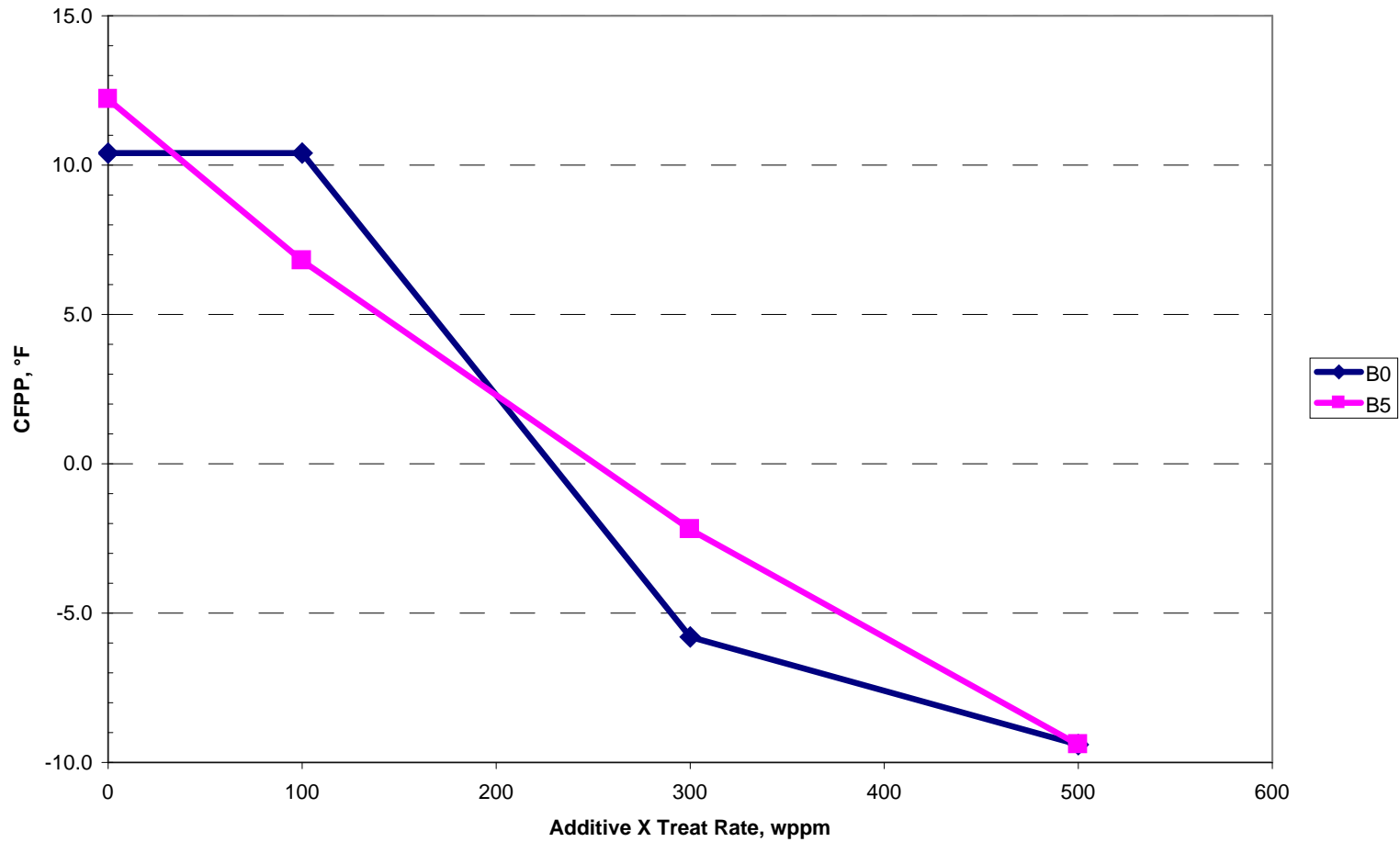
B100 Pour Point Response



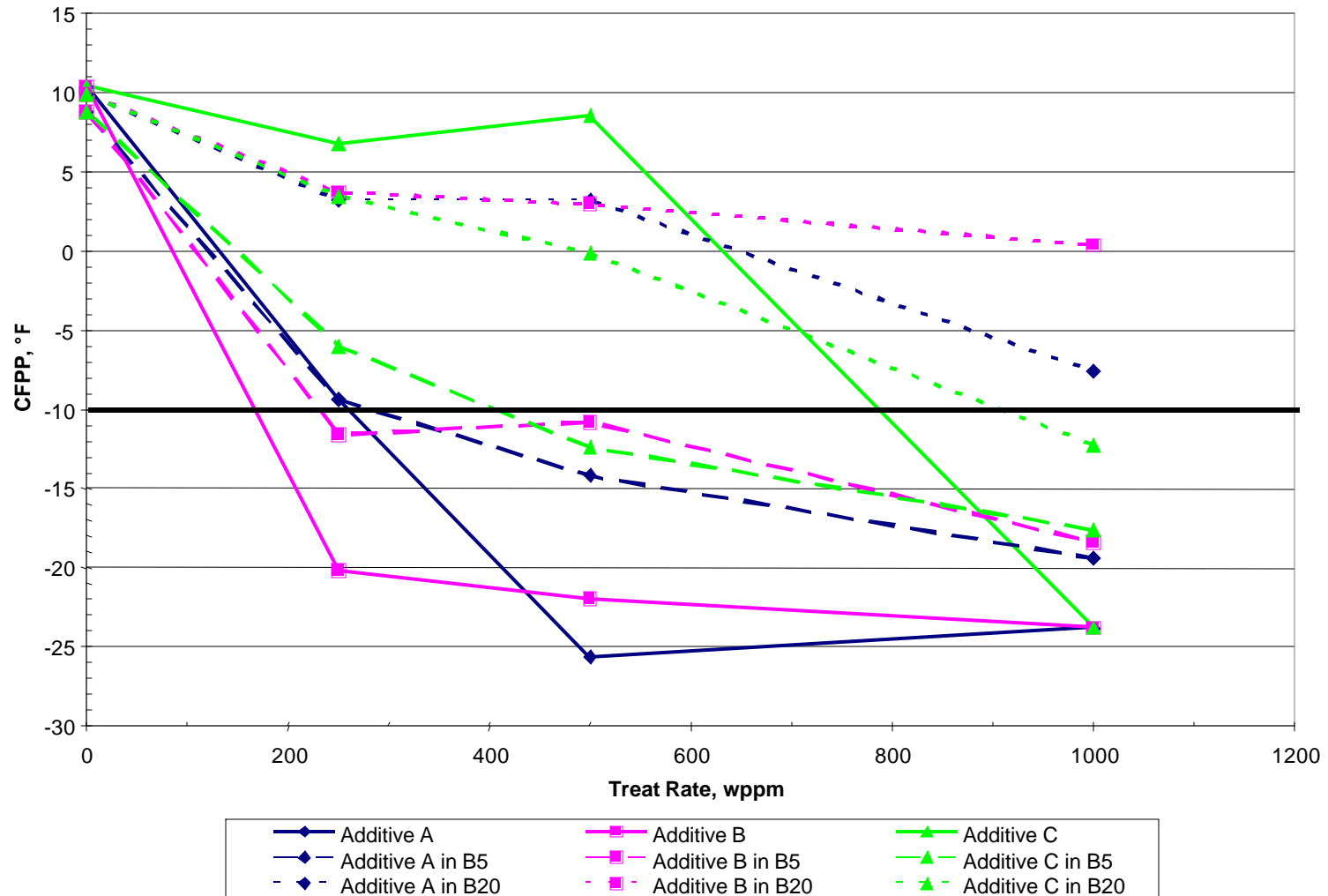
LTFT Response in Soy B2



CFPP Response in Soy B5



CFPP Response in Soy B5 and B20 Diesel Fuel Blends



Wax Anti-Settling

7 day cyclic cooling test (cycled from -3°C to -13°C)

- m Saturated fatty acid esters form crystals at temperatures below the cloud point (in B100 $\geq -4^{\circ}\text{C}$) and settle.
- m The settling can be prevented with the right additive and proper additive injection as shown in the simulation test.
- m Therefore Cold Flow Additives for B100 offer advantages at temperatures below the cloud point.
 - q Homogeneous product, complying with the specification also in winter.
 - q Equally good cold operability for each batch delivered from a storage tank
 - q Also after longer period without driving the cold operability is as good as in every day use.

RME

Additive A	
Original CP	-5.2
20% Bottom CP	-4.3
Delta CP	0.9
Original CFPP	-20.5
20% Bottom CFPP	-20
Delta CFPP	0.5
Original PP	-36
Additive B	
Original CP	-5
20% Bottom CP	6.5
Delta CP	11.5
Original CFPP	-21
20% Bottom CFPP	-12
Delta CFPP	9
Original PP	-39



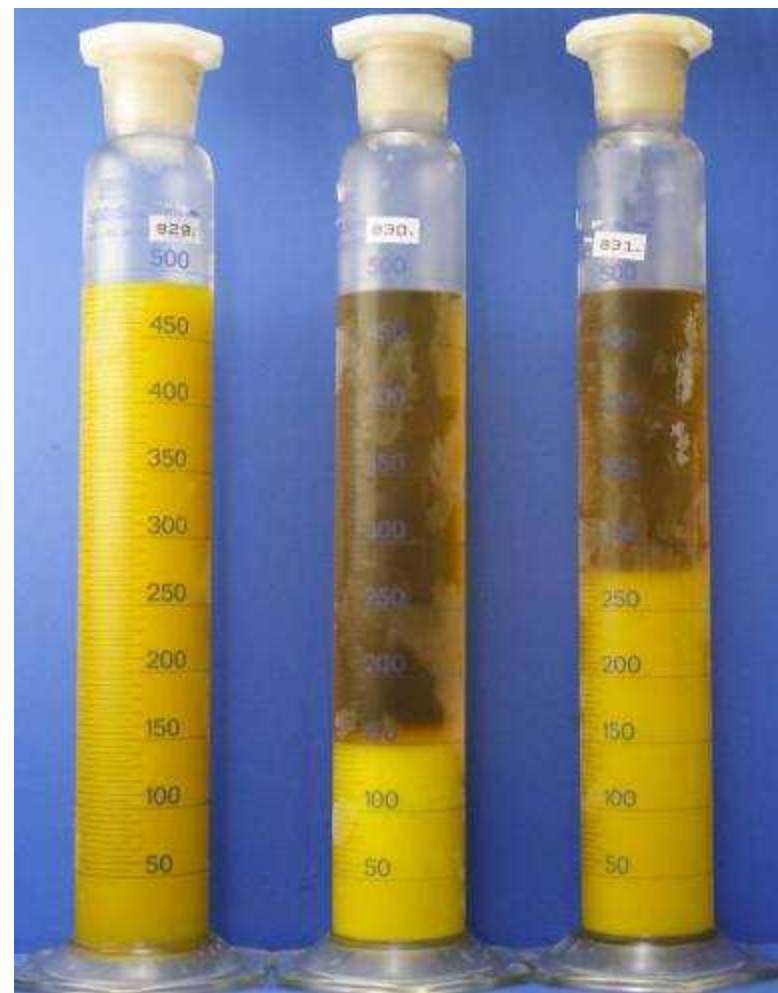
Additive A

Additive B

RME/SME blend (80/20)

Additive C	
Original CP	-4.7°C
20% Bottom CP	-5.3°C
Delta CP	-0.6°C
Original CFPP	-20°C
20% Bottom CFPP	-21°C
Delta CFPP	-1°C
Original PP	-39°C

Additive D	Normal treat rate	Doubled treat rate
Original CP	-3.4°C	-3.4°C
20% Bottom CP	3.4°C	1.6°C
Delta CP	6.8°C	5°C
Original CFPP	-24°C	-10.5°C
20% Bottom CFPP	-1°C	-5°C
Delta CFPP	23°C	5.5°C
Original PP	-39°C	-36°C



Additive C

Additive D

Summary

m Cold Flow Additives can provide valuable performance in Biodiesel and Biodiesel blends

m The level of cold flow performance in the field is dependent on

- q Diesel Fuel response to Cold Flow Additive
- q Proper blending of Diesel Fuel with B100
- q The level of Biodiesel in the finished blend
 - B2 \longrightarrow B20 – Increased severity
- q The saturate level of the B100
 - Higher saturate levels more of a challenge than lower levels
- q Homogeneous introduction of the Cold Flow Additive in the Biodiesel and/or Biodiesel blend
- q Selecting the right evaluation test to correspond with field requirements
 - CFPP ~~— — —~~ \rightarrow Storage
 - CFPP — — — \rightarrow Light Duty Vehicle Performance

m Questions?

