

Analysis of Blending Data Used In the Condensate EQ Model

For

**Canadian Association of Petroleum
Producers**

By

Advantage Insight Group Inc

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www.cti-advantage.com

Executive Summary

The Equalization Steering Committee in their role to oversee the Condensate Equalization has requested Advantage Insight Group Inc to confirm the applicability of the current condensate equalization constants. These constants were based on analysis of blending data obtained from a series of laboratory analysis. This data has not been reviewed since 2001.

The main objective of this study is to establish whether or not the current data base should be changed or expanded.

Based on the already accepted industry methodology, two samples of heavy crude, thermal produced heavy oil sample (Cold Lake) and a conventional produced heavy oil sample (Nexen), were blended with 6 different diluents:

- Fort Saskatchewan (CFT)
- Rimbey (CRM)
- Peace River (CPR)
- Pembina (CPM)
- CRW
- PetroCanada (CPC)

Three target density blends were prepared for each of the heavy crude and diluent pairings; 912 kg/m³, 930 kg/m³ and 940 kg/m³. The viscosity for each blend density mixed was measured at 7°C, 12°C, 20°C, 30°C and 40°C.

The data was statistically analyzed. The error distribution was reviewed to assess the consistency between the predicted and the measured values. The results indicated that the 2006 data was more consistent than the data from 2001. The correlation on all of the data was good.

It was concluded that the data of 2006 is consistent with the data from 2001. Due to the scatter in the data there would have been a 6 to 8 cent reduction in the density penalty if only 2006 blend data had been used. However there would have been a change of less than 1 cent in the density penalty if a larger set of data including both 2001 and 2006 had been used.

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1 Introduction

In 2001, the Equalization Steering Committee adopted a condensate density equalization system that was based on the value of the condensate as a bitumen diluent.

When bitumen is shipped by pipeline it must meet both density and viscosity specifications. Normally diluent/bitumen blends are limited by the viscosity of the blend, not the density. However, density is easily measured and is a much more convenient proxy for the blending characteristics of a blend. To allow the use of density as a proxy for blend efficiency, blends of representative diluent and representative bitumen were prepared and the viscosity behavior of these blends was analyzed to arrive at generalized blending correlations. Using statistical techniques, this viscosity data was then merged to provide generalized relationships that were suitable for valuing each condensate's blend efficiency based on its density.

In 2006, the Equalization Steering Committee requested that the laboratory blend data be reviewed to ensure that the blending relationships that had been observed in 2001 still reflected the current diluent/bitumen blending behavior.

The scope of this report is to re-evaluate the condensate equalization constants based on a new set of laboratory blend data and the already accepted model for the industry methodology.

2 Scope and Laboratory analysis

The Equalization Steering Committee selected several condensate streams to be blended with two representative bitumen streams. A thermally produced heavy oil sample (Cold Lake) and a conventionally produced heavy oil sample (Nexen), were blended with 6 different diluents.

As in 2001, each crude was mixed with each diluent to produce three blends of approximately 940 Kg/m³, 930 Kg/m³ and 912 Kg/m³. Each blend was analyzed for viscosity (ASTM D7042) at 7°C, 12°C, 20°C, 30°C and 40°. Appendix 1 contains the Laboratory results provided for this study.

In 2006 it was concluded that the significant streams in the condensate pool had changed so a slightly revised condensate slate as examined. Table 1 summarizes the streams used in 2001 and 2006 new set of data:

Table 1 2001 and 2006 Condensate and Bitumen Sources

Condensates 2001	Density, kg/m³	Condensates 2006	Density, kg/m³
Fort Saskatchewan (CFT)	670.8	Fort Saskatchewan (CFT)	676.3
Rimbey (CRM)	682.8	Rimbey (CRM)	715.2
Peace River (CPR)	763.8	Peace River (CPR)	739.6
Pembina (CPM)	768.1	Pembina (CPM)	773.4
CRW Jun 3	730.7	CRW	727.2
Swan Hills	828.6	PetroCanada (CPC)	757.2
CRW Jun 1	720.6		
Amoco (CAM)	714.8		
West Pembina	799.7		
Total Blends	54	Total Blends	36
Heavy Streams			
Cold Lake Bitumen	1005.7	Cold Lake Bitumen	997.2
Lloyd Kerrobert Bitumen	976.4	Nexen Plover Lake	984.6

3 Data analysis

A linear viscosity/temperature plot was generated for each Crude/Condensate blend as per ASTM D341. Appendix 2 shows the data analysis and viscosity/temperature plot for each of the crude/condensate blends.

The blend/temperature data was linearly regressed to obtain the 350 cSt density/temperature relationship for each crude/condensate pair. The following expression is obtained:

Equation 1
$$\rho_{blend} = Slope * T_{reference} + Intercept$$

Table 2 summarizes the slope and intercept that was calculated from each of the regressions as well as the quality of the regression. The high R Square value for each of the regressions indicates that the viscosity data is linear over the range of values indicated.

Appendix 3 shows the plot of density vs. temperature for each crude/condensate blend.

Table 2 350cSt Viscosity Blends Density vs. Temperature Correlation Summary - Data 2006

Condensate		Cold Lake			Nexen Blends		
Stream	Density, Kg/m3	Slope	Intercept	R square	Slope	Intercept	R square
CFT-0488	676.3	1.38701	908.4348	0.9990	1.225389	915.4466	0.9999
CRM-0482	715.2	1.25236	914.2953	0.9999	1.168499	918.1293	1.0000
CRW-675	727.2	1.23879	914.6688	0.9984	1.170814	917.6339	0.9999
CPR-0822	739.6	1.23077	915.3531	0.9953	1.161862	918.2300	1.0000
CPC-475	757.2	1.08093	923.6149	1.0000	1.050757	924.4989	0.9999
CPM-478	773.4	1.19867	915.9908	0.9999	1.139727	919.2878	1.0000

Table 3 shows the slope and intercept that was calculated for each of the blends done in 2001 as well as the quality of those regressions. The 2001 data appears

reasonably consistent with the 2006 data considering the differences in individual stream densities.

Table 3 350cSt Viscosity Blend Density vs. Temperature Correlation Summary - Data 2001

Condensate		Cold Lake			LLK		
Stream	Density, Kg/m3	Slope	Intercept	R square	Slope	Intercept	R square
Fort Saskat.(CFT)	670.8	1.349	896.5	0.9994	1.098	920.1	0.9999
Rimbey (CRM)	682.8	1.355	900.5	0.9993	1.249	918.2	0.9979
Amoco (CAM)	714.8	1.273	906.5	0.9997	1.239	921.0	0.9984
Peace River(CPR)	764.2	1.186	910.4	0.9904	1.251	920.0	0.9994
Pembina (CPM)	768.3	1.221	908.4	0.9995	1.142	921.5	0.9989
West Pembina	799.7	1.180	908.7	1.0000	1.195	918.8	0.9991
Valhalla ¹	811.6	1.479	901.6	0.9974	1.453	914.1	0.9940
Swan Hills	828.6	1.087	913.8	0.9998	1.139	919.9	0.9976
CRW Jun 1	720.6	1.302	903.9	0.9994	1.186	919.9	0.9990
CRW Jun 3	730.7	1.268	905.4	0.9992	1.164	920.4	0.9999

Using the data presented in Table 2 and Table 3, an equation for the minimum blend density that would achieve the required viscosity at pipeline reference temperature was developed for each bitumen.

The Slopes and Intercepts from **Equation 1** were regressed vs. condensate density (Table 2 and Table 3) obtaining the following relationships:

$$Slope = a_1 * \rho_{condensate} + b_1$$

$$Intercept = a_2 * \rho_{condensate} + b_2$$

Equation 1 then takes the form of:

$$\text{Equation 2} \quad \rho_{blend} = (a_1 * \rho_{condensate} + b_1) * T_{reference} + (a_2 * \rho_{condensate} + b_2)$$

¹ Excluded from calculation as per analysis 2001

Where:

ρ_{blend} = the required blend density to achieve the 350 cSt blend viscosity at pipeline reference temperature expressed in kg/m³.

$\rho_{condensate}$ = the condensate density used in the blend expressed in kg/m³.

$T_{reference}$ = the pipeline reference temperature expressed in Celsius.

Four cases were analyzed:

Case 1 - Using only 2006 data.

Case 2 - Using 2006 data excluding PC.

Case 3 - Using all 2006 data and 2001 data (excluding Valhalla condensate).

Case 4 - Using 2006 data excluding PC 2001 data (excluding Valhalla condensate).

Appendix 4 shows with more detail the calculation of the coefficient values for each of the cases. The following figure shows the comparison of the effect on the Condensate density penalty for each of the cases.

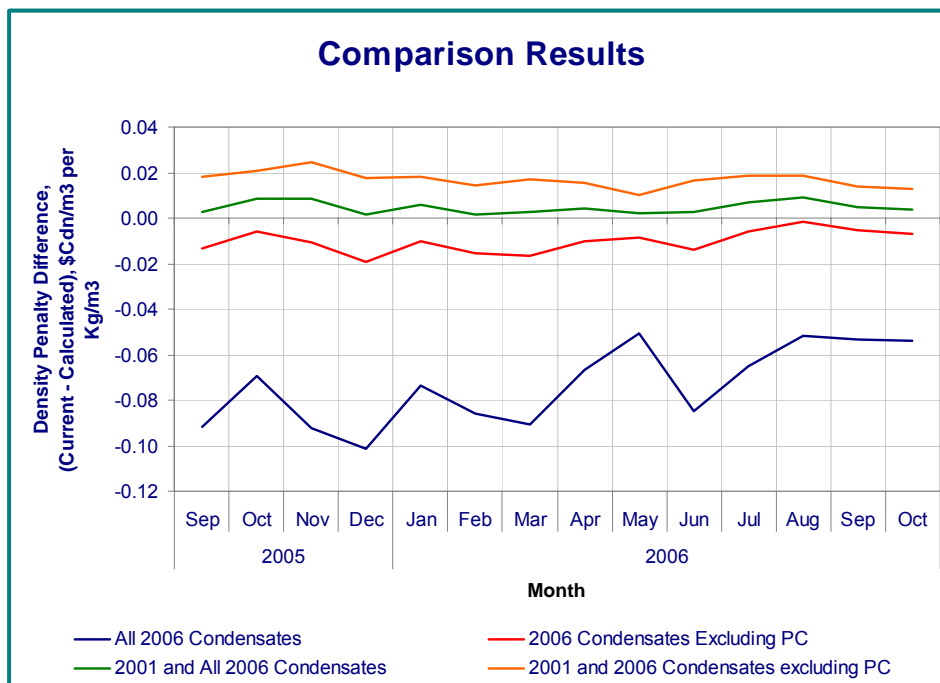


Figure 1 Comparison Cases – Effect of Coefficients in Condensate Density Penalty

It is possible to predict the blend density using Equation 2 with the laboratory information and compare it with the measured density at 15 °C using the coefficients calculated for each case. R square or coefficient of determination can be calculated with the following expression:

Equation 3
$$r^2 = 1 - \frac{\sum (\rho_{measured} - \rho_{predicted})^2}{\sum (\rho_{measured} - \bar{\rho})^2}$$

Where

$\rho_{measured}$ = Measured density, kg/m³

$\rho_{predicted}$ = Predicted density, kg/m³

$\bar{\rho}$ = Mean density

Table 4 presents the summary of coefficient of determination or R square obtained for each of the studied cases. More detail is presented in Appendix 4

Table 4 Density prediction Summary of R square

Case	R square
2001 Data	0.8487
Case 1: Only 2006 data	0.7820
Case 2: Using 2006 data excluding PC	0.8217
Case 3: Using all 2006 data and 2001 data	0.9041
Case 4: Using 2006 data excluding PC 2001 data	0.8994

From the above table, it was concluded that the coefficients obtained when using all 2006 and 2001 data provide a better representation of the data.

Table 5 Model coefficients using 2001 and 2006 Data

	Slope vs. Condensate Density			Intercept vs. Condensate Density		
	a1	b1	R square	a2	b2	R square
Cold Lake Blends	-0.00174	2.52645	0.77947	0.08222	849.09899	0.29120
LLK Blends	-0.00058	1.60790	0.20725	0.02055	904.23302	0.16961

4 Conclusions

- The data of 2006 appears to be consistent with the data from 2001
- Because of the scatter in the data there would be a 6 to 8 cent reduction in the density penalty if only 2006 blend data were used
- There would have be a change of less than 1 cent in the density penalty if a larger set of data including both 2001 and 2006 were used.
- The sets of coefficients obtained when including 2006 data provide an improved estimate of the blend density that satisfies the viscosity of 350 cSt.

5 Appendices

5.1 Appendix 1 Laboratory results



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Diluent Blending Project
for
CAPP / Advantage Insight Group

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SAMPLE ID Various
PROJECT Diluent Blending Study

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Scope of Test

CAPP / Advantage Insight group requested Core Laboratories prepare various diluent – bitumen blends to target densities. The bitumen, diluent and prepared blends were subject to density and viscosity characterization.

Sample Descriptions

<u>Sample</u>	<u>Description</u>
Bitumen	Imperial Cold Lake
Bitumen	Nexen Plover Lake 16-9 Battery
Diluent	CRW-675 June 8 th 2006
Diluent	CPC-475 Petro Canada Condensate, June 8 th 2006
Diluent	CPR-0822 Peace Condensate, June 9 th 2006
Diluent	CFT-0488 Fort Saskatchewan Condensate, June 8 th 2006
Diluent	CRM- 0482 Rimbey Condensate, June 8 th 2006
Diluent	CPM-478 Pembina Condensate, June 8 th 2006

Procedure

The bitumen was characterized by measuring density, total sulphur and viscosity at 30°C, 40°C and 50°C. Each diluent was characterized by measuring its density, Reid Vapour Pressure, C30+ Hydrocarbon Composition, Boiling Range Distribution by Gas Chromatography (Simulated Distillation), and viscosity at 7°C, 12°C, 20°C, 30°C, 40°C. Diluents were kept in a freezer (- 12 °C) until needed. Blends were prepared by accurately weighing the bitumen and diluent on an analytical balance. The masses of each component required to achieve a target densities were calculated utilizing API 2509C and API 12.3 shrinkage methodologies, each blend was vigorously agitated on a paint shaker for 15 minutes. The blends were then allowed to settle for 4 hours prior to density and viscosity measurements. The time between preparation and analysis was kept constant at 4 to 6 hours to reduce aging effects.



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The industry standard procedures utilized for characterization are listed below.

<u>Test</u>	<u>Method</u>
Density	ASTM D-5002 / ASTM D-4052 / ASTM D-7042
Sulfur	ASTM D-4294
Viscosity	ASTM D-445 / ASTM D-7042 / ASTM D-341
RVP	ASTM D-5191

Bitumen Characterization

Imperial Cold Lake Bitumen

Viscosity

Temperature (°C)	Dynamic Viscosity (cP.)	Kinematic Viscosity (cSt.)
30	18642	18870
40	6082	6195
50	2328	2386
7 (Extrapolated)	525000	524000
12 (Extrapolated)	227800	228000
20 (Extrapolated)	58190	69000

Measured Density @ 15.0°C..... 997.2 kg/m³

API Gravity @ 15.6°C..... 10.3

Total Sulfur 3.97 Wt%



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Nexen Plover Lake 16-9 Battery Sales Oil Viscosity

Temperature (°C)	Dynamic Viscosity (cP.)	Kinematic Viscosity (cSt.)
30	4217	4324
40	1613	1665
50	735.4	764.0
7 (Extrapolated)	67900	68600
12 (Extrapolated)	33800	34300
20 (Extrapolated)	12400	12600

Measured Density @ 15.0°C..... 984.6 kg/m³

API Gravity @ 15.6°C..... 12.1

Total Sulfur 3.05 Wt%



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Diluent Characterization

CRW-675 June 8th, 2006
 Viscosity

Temperature (°C)	Dynamic Viscosity (cP.)	Kinematic Viscosity (cSt.)
7	0.6759	0.9221
12	0.6344	0.8698
20	0.5619	0.7774

Measured Density @ 15.0°C (on July 11th, 2006)..... 727.2 kg/m³

API Gravity @ 15.6°C..... 62.9

RVP 72 kPa

Simulated Distillation.....Page 10

Hydrocarbon Composition.....Page 11



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CPC-475 PetroCanada Condensate June 8th, 2006
 Viscosity

Temperature (°C)	Dynamic Viscosity (cP.)	Kinematic Viscosity (cSt.)
7	0.7133	0.7627
12	0.6675	0.7591
20	0.6054	0.7524

Measured Density @ 15.0°C (on July 11th, 2006)..... 757.2

API Gravity @ 15.6°C..... 55.2

RVP 7.8 kPa

Simulated Distillation.....Page 12

Hydrocarbon Composition.....Page 13



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CPR 0822 Peace Condensate June 8th, 2006

Viscosity

Temperature (°C)	Dynamic Viscosity (cP.)	Kinematic Viscosity (cSt.)
7	0.7756	1.0411
12	0.7219	0.9737
20	0.6063	0.8262

Measured Density @ 15.0°C (on July 11th, 2006)..... 739.6 kg/m³

API Gravity @ 15.6°C..... 59.6

RVP 80 kPa

Simulated Distillation.....Page 14

Hydrocarbon Composition.....Page 15



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CFT 0488 Fort Saskatchewan Condensate June 8th, 2006

Viscosity

Temperature (°C)	Dynamic Viscosity (cP.)	Kinematic Viscosity (cSt.)
7	0.3745	0.5495
12	0.3464	0.5114
20	0.3117	0.4653

Measured Density @ 15.0°C (on July 11th, 2006)..... 676.3

API Gravity @ 15.6°C..... 77.5

RVP 88 kPa

Simulated Distillation.....Page 16

Hydrocarbon Composition.....Page 17



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CRM-0482 Rimby Condensate June 8th , 2006
 Viscosity

Temperature (°C)	Dynamic Viscosity (cP.)	Kinematic Viscosity (cSt.)
7	0.5388	0.7472
12	0.5029	0.7009
20	0.4467	0.6295

Measured Density @ 15.0°C (on July 11th, 2006)..... 715.2 kg/m³

API Gravity @ 15.6°C..... 66.2

RVP 71 kPa

Simulated Distillation.....Page 18

Hydrocarbon Composition.....Page 19



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CPM-478 Condensate June 8th, 2006

Viscosity

Temperature (°C)	Dynamic Viscosity (cP.)	Kinematic Viscosity (cSt.)
7	1.3210	1.6933
12	1.2161	1.5669
20	1.0637	1.3818

Measured Density @ 15.0°C (on July 11th, 2006)..... 773.4 kg/m³

API Gravity @ 15.6°C..... 51.3

RVP 52 kPa

Simulated Distillation.....Page 20

Hydrocarbon Composition.....Page 21



LABORATORY TEST RESULTS

JOB NUMBER: 52137-2006-4335

CUSTOMER: CAPP / Advantage Insight Group

SAMPLE I.D: **CRW - 675**

LABORATORY I.D.: 52137-06-4335-1

DATE SAMPLED: June 8, 2006

TEST DESCRIPTION	RESULT	LIMITS	UNITS	TEST METHOD	DATE	TECH
Simulated Distillation			°C	ASTM D-2887	06/11/02	BH
I.B.P.	-3.4					
5% Off	26.1					
10% Off	30.0					
15% Off	35.0					
20% Off	35.9					
25% Off	58.2					
30% Off	63.4					
35% Off	69.3					
40% Off	83.1					
45% Off	90.1					
50% Off	98.1					
55% Off	103.9					
60% Off	115.8					
65% Off	126.0					
70% Off	140.7					
75% Off	159.9					
80% Off	187.9					
85% Off	235.2					
90% Off	302.1					
95% Off	391.4					
F.B.P.	512.3					

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HYDROCARBON LIQUID ANALYSIS

Operator: EnCana Resources

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Well: CRW - 675

File: 52137-2006-4335-1-276

Sample Point: Spot Sample

Date: 2006 11 07

Analysis of C₃₀₊ Fraction

Boiling Point: Range (° C)	Component	Carbon Number	Mole Fraction	Mass Fraction	Liq. Vol. Fraction
-161.7	Methane	C ₁	Trace	Trace	Trace
- 88.9	Ethane	C ₂	0.0003	0.0001	0.0002
- 42.2	Propane	C ₃	0.0041	0.0018	0.0025
- 11.7	Iso Butane	C ₄	0.0061	0.0035	0.0045
- 0.6	Normal Butane	C ₄	0.0428	0.0245	0.0301
27.8	Iso Pentane	C ₅	0.1397	0.0992	0.1142
36.1	Normal Pentane	C ₅	0.1504	0.1068	0.1217
36.1- 68.9	Hexanes	C ₆	0.1382	0.1172	0.1269
68.9- 98.3	Heptanes	C ₇	0.0902	0.0889	0.0930
98.3-125.6	Octanes	C ₈	0.0664	0.0746	0.0760
125.6-150.6	Nonanes	C ₉	0.0394	0.0497	0.0496
150.6-173.9	Decanes	C ₁₀	0.0268	0.0375	0.0368
173.9-196.1	Undecanes	C ₁₁	0.0218	0.0316	0.0288
196.1-215.0	Dodecanes	C ₁₂	0.0139	0.0221	0.0198
215.0-235.0	Tridecanes	C ₁₃	0.0099	0.0170	0.0151
235.0-252.2	Tetradecanes	C ₁₄	0.0085	0.0158	0.0139
252.2-270.6	Pentadecanes	C ₁₅	0.0070	0.0141	0.0123
270.6-287.8	Hexadecanes	C ₁₆	0.0052	0.0113	0.0097
287.8-302.8	Heptadecanes	C ₁₇	0.0042	0.0097	0.0083
302.8-317.2	Octadecanes	C ₁₈	0.0038	0.0095	0.0079
317.2-330.0	Nonadecanes	C ₁₉	0.0032	0.0083	0.0070
330.0-344.4	Eicosanes	C ₂₀	0.0026	0.0070	0.0059
344.4-357.2	Heneicosanes	C ₂₁	0.0027	0.0077	0.0064
357.2-369.4	Docosanes	C ₂₂	0.0020	0.0061	0.0050
369.4-380.0	Tricosanes	C ₂₃	0.0019	0.0060	0.0049
380.0-391.1	Tetracosanes	C ₂₄	0.0016	0.0052	0.0043
391.1-401.7	Pentacosanes	C ₂₅	0.0014	0.0049	0.0039
401.7-412.2	Hexacosanes	C ₂₆	0.0013	0.0046	0.0037
412.2-422.2	Heptacosanes	C ₂₇	0.0012	0.0043	0.0036
422.2-431.7	Octacosanes	C ₂₈	0.0010	0.0038	0.0031
431.7-441.1	Nonacosanes	C ₂₉	0.0009	0.0037	0.0028
441.1 PLUS	Triacotanes Plus	C ₃₀₊	0.0070	0.0293	0.0231
80.0	Benzene	C ₆ H ₆	0.0144	0.0111	0.0090
110.6	Toluene	C ₇ H ₈	0.0277	0.0251	0.0207
136.1-138.9	Ethylbenzene, p + m-Xylene	C ₈ H ₁₀	0.0225	0.0235	0.0195
144.4	o-Xylene	C ₈ H ₁₀	0.0045	0.0047	0.0038
168.9	1,2,4 Trimethylbenzene	C ₉ H ₁₂	0.0061	0.0072	0.0058
48.9	Cyclopentane	C ₅ H ₁₀	0.0151	0.0104	0.0100
72.2	Methylcyclopentane	C ₆ H ₁₂	0.0320	0.0265	0.0253
81.1	Cyclohexane	C ₆ H ₁₂	0.0290	0.0240	0.0221
101.1	Methylcyclohexane	C ₇ H ₁₄	0.0432	0.0417	0.0388
	TOTAL		1.0000	1.0000	1.0000



LABORATORY TEST RESULTS

JOB NUMBER: 52137-2006-4335

CUSTOMER: CAPP / Advantage Insight Group

SAMPLE I.D: **CPC - 475 Petro Canada Condensate**

LABORATORY I.D.: 52137-06-4335-2

DATE SAMPLED: June 8, 2006

TEST DESCRIPTION	RESULT	LIMITS	UNITS	TEST METHOD	DATE	TECH
Simulated Distillation			°C	ASTM D-2887	06/11/02	BH
I.B.P.	69.1					
5% Off	85.8					
10% Off	91.0					
15% Off	94.0					
20% Off	98.2					
25% Off	103.1					
30% Off	103.8					
35% Off	107.1					
40% Off	113.2					
45% Off	117.0					
50% Off	119.4					
55% Off	123.4					
60% Off	126.3					
65% Off	132.7					
70% Off	135.2					
75% Off	140.2					
80% Off	143.1					
85% Off	147.3					
90% Off	151.8					
95% Off	162.4					
F.B.P.	206.3					

CORE LABORATORIES

2810 - 12th Street N.E.

CALGARY, ALBERTA T2E 7P7



HYDROCARBON LIQUID ANALYSIS

Operator: EnCana Resources

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Well: CPC - 475

File: 52137-2006-4335-2-277

Sample Point: Spot Sample

Date: 2006 11 07

Analysis of C₃₀₊ Fraction

Boiling Point: Range (° C)	Component	Carbon Number	Mole Fraction	Mass Fraction	Liq. Vol. Fraction
-161.7	Methane	C ₁	0.0000	0.0000	0.0000
- 88.9	Ethane	C ₂	0.0000	0.0000	0.0000
- 42.2	Propane	C ₃	0.0000	0.0000	0.0000
- 11.7	Iso Butane	C ₄	0.0000	0.0000	0.0000
- 0.6	Normal Butane	C ₄	0.0000	0.0000	0.0000
27.8	Iso Pentane	C ₅	Trace	Trace	Trace
36.1	Normal Pentane	C ₅	0.0002	0.0001	0.0002
36.1- 68.9	Hexanes	C ₆	0.0112	0.0088	0.0097
68.9- 98.3	Heptanes	C ₇	0.2003	0.1822	0.1952
98.3-125.6	Octanes	C ₈	0.2504	0.2597	0.2707
125.6-150.6	Nonanes	C ₉	0.1653	0.1925	0.1966
150.6-173.9	Decanes	C ₁₀	0.0492	0.0636	0.0638
173.9-196.1	Undecanes	C ₁₁	0.0095	0.0127	0.0118
196.1-215.0	Dodecanes	C ₁₂	0.0044	0.0064	0.0059
215.0-235.0	Tridecanes	C ₁₃	0.0014	0.0022	0.0020
235.0-252.2	Tetradecanes	C ₁₄	0.0003	0.0006	0.0005
252.2-270.6	Pentadecanes	C ₁₅	Trace	Trace	Trace
270.6-287.8	Hexadecanes	C ₁₆	0.0000	0.0000	0.0000
287.8-302.8	Heptadecanes	C ₁₇	0.0000	0.0000	0.0000
302.8-317.2	Octadecanes	C ₁₈	0.0000	0.0000	0.0000
317.2-330.0	Nonadecanes	C ₁₉	0.0000	0.0000	0.0000
330.0-344.4	Eicosanes	C ₂₀	0.0000	0.0000	0.0000
344.4-357.2	Heneicosanes	C ₂₁	0.0000	0.0000	0.0000
357.2-369.4	Docosanes	C ₂₂	0.0000	0.0000	0.0000
369.4-380.0	Tricosanes	C ₂₃	0.0000	0.0000	0.0000
380.0-391.1	Tetracosanes	C ₂₄	0.0000	0.0000	0.0000
391.1-401.7	Pentacosanes	C ₂₅	0.0000	0.0000	0.0000
401.7-412.2	Hexacosanes	C ₂₆	0.0000	0.0000	0.0000
412.2-422.2	Heptacosanes	C ₂₇	0.0000	0.0000	0.0000
422.2-431.7	Octacosanes	C ₂₈	0.0000	0.0000	0.0000
431.7-441.1	Nonacosanes	C ₂₉	0.0000	0.0000	0.0000
441.1 PLUS	Triacontanes Plus	C ₃₀₊	0.0000	0.0000	0.0000
80.0	Benzene	C ₆ H ₆	0.0058	0.0041	0.0034
110.6	Toluene	C ₇ H ₈	0.0503	0.0421	0.0356
136.1-138.9	Ethylbenzene, p + m-Xylene	C ₈ H ₁₀	0.0648	0.0625	0.0530
144.4	o-Xylene	C ₈ H ₁₀	0.0230	0.0222	0.0185
168.9	1,2,4 Trimethylbenzene	C ₉ H ₁₂	0.0063	0.0069	0.0057
48.9	Cyclopentane	C ₅ H ₁₀	Trace	Trace	Trace
72.2	Methylcyclopentane	C ₆ H ₁₂	0.0292	0.0223	0.0218
81.1	Cyclohexane	C ₆ H ₁₂	0.0262	0.0200	0.0188
101.1	Methylcyclohexane	C ₇ H ₁₄	0.1022	0.0911	0.0868
	TOTAL		1.0000	1.0000	1.0000



LABORATORY TEST RESULTS

JOB NUMBER: 52137-2006-4335

CUSTOMER: CAPP / Advantage Insight Group

SAMPLE I.D: **CPR - 0488 Peace Condensate**

LABORATORY I.D.: 52137-06-4335-3

DATE SAMPLED: June 9, 2006

TEST DESCRIPTION	RESULT	LIMITS	UNITS	TEST METHOD	DATE	TECH
Simulated Distillation			°C	ASTM D-2887	06/11/02	BH
I.B.P.	-4.7					
5% Off	25.8					
10% Off	27.3					
15% Off	35.5					
20% Off	58.6					
25% Off	68.3					
30% Off	75.3					
35% Off	85.7					
40% Off	93.2					
45% Off	102.7					
50% Off	108.1					
55% Off	118.4					
60% Off	128.2					
65% Off	142.4					
70% Off	161.2					
75% Off	182.8					
80% Off	220.2					
85% Off	271.0					
90% Off	331.1					
95% Off	411.8					
F.B.P.	507.8					

CORE LABORATORIES

2810 - 12th Street N.E.

CALGARY, ALBERTA T2E 7P7



HYDROCARBON LIQUID ANALYSIS

Operator: EnCana Resources

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Well: CPR - 0822

File: 52137-2006-4335-3-278

Sample Point: Spot Sample

Date: 2006 11 07

Analysis of C₃₀₊ Fraction

Boiling Point: Range (° C)	Component	Carbon Number	Mole Fraction	Mass Fraction	Liq. Vol. Fraction
-161.7	Methane	C ₁	0.0007	0.0001	0.0003
- 88.9	Ethane	C ₂	0.0007	0.0002	0.0004
- 42.2	Propane	C ₃	0.0102	0.0042	0.0061
- 11.7	Iso Butane	C ₄	0.0092	0.0050	0.0065
- 0.6	Normal Butane	C ₄	0.0601	0.0327	0.0409
27.8	Iso Pentane	C ₅	0.0949	0.0641	0.0750
36.1	Normal Pentane	C ₅	0.1157	0.0782	0.0905
36.1- 68.9	Hexanes	C ₆	0.1295	0.1043	0.1149
68.9- 98.3	Heptanes	C ₇	0.0936	0.0878	0.0933
98.3-125.6	Octanes	C ₈	0.0724	0.0775	0.0800
125.6-150.6	Nonanes	C ₉	0.0447	0.0537	0.0543
150.6-173.9	Decanes	C ₁₀	0.0329	0.0439	0.0436
173.9-196.1	Undecanes	C ₁₁	0.0267	0.0368	0.0340
196.1-215.0	Dodecanes	C ₁₂	0.0168	0.0254	0.0231
215.0-235.0	Tridecanes	C ₁₃	0.0125	0.0205	0.0185
235.0-252.2	Tetradecanes	C ₁₄	0.0107	0.0190	0.0169
252.2-270.6	Pentadecanes	C ₁₅	0.0089	0.0172	0.0151
270.6-287.8	Hexadecanes	C ₁₆	0.0066	0.0138	0.0119
287.8-302.8	Heptadecanes	C ₁₇	0.0053	0.0118	0.0101
302.8-317.2	Octadecanes	C ₁₈	0.0050	0.0118	0.0101
317.2-330.0	Nonadecanes	C ₁₉	0.0042	0.0104	0.0088
330.0-344.4	Eicosanes	C ₂₀	0.0034	0.0087	0.0074
344.4-357.2	Heneicosanes	C ₂₁	0.0035	0.0095	0.0080
357.2-369.4	Docosanes	C ₂₂	0.0027	0.0076	0.0065
369.4-380.0	Tricosanes	C ₂₃	0.0025	0.0075	0.0062
380.0-391.1	Tetracosanes	C ₂₄	0.0021	0.0065	0.0054
391.1-401.7	Pentacosanes	C ₂₅	0.0019	0.0063	0.0051
401.7-412.2	Hexacosanes	C ₂₆	0.0018	0.0059	0.0050
412.2-422.2	Heptacosanes	C ₂₇	0.0016	0.0055	0.0046
422.2-431.7	Octacosanes	C ₂₈	0.0013	0.0049	0.0039
431.7-441.1	Nonacosanes	C ₂₉	0.0013	0.0048	0.0040
441.1 PLUS	Triacotanes Plus	C ₃₀₊	0.0087	0.0347	0.0278
80.0	Benzene	C ₆ H ₆	0.0131	0.0096	0.0079
110.6	Toluene	C ₇ H ₈	0.0295	0.0255	0.0213
136.1-138.9	Ethylbenzene, p + m-Xylene	C ₈ H ₁₀	0.0273	0.0271	0.0228
144.4	o-Xylene	C ₈ H ₁₀	0.0050	0.0050	0.0041
168.9	1,2,4 Trimethylbenzene	C ₉ H ₁₂	0.0078	0.0088	0.0072
48.9	Cyclopentane	C ₅ H ₁₀	0.0126	0.0083	0.0081
72.2	Methylcyclopentane	C ₆ H ₁₂	0.0327	0.0258	0.0250
81.1	Cyclohexane	C ₆ H ₁₂	0.0299	0.0236	0.0220
101.1	Methylcyclohexane	C ₇ H ₁₄	0.0500	0.0460	0.0434
	TOTAL		1.0000	1.0000	1.0000



LABORATORY TEST RESULTS

JOB NUMBER: 52137-2006-4335

CUSTOMER: CAPP / Advantage Insight Group

SAMPLE I.D.: CFT - 0488 Fort Saskatchewan Condensate

LABORATORY I.D.: 52137-06-4335-4

DATE SAMPLED: June 8, 2006

TEST DESCRIPTION	RESULT	LIMITS	UNITS	TEST METHOD	DATE	TECH
Simulated Distillation			°C	ASTM D-2887	06/11/02	BH
I.B.P.	4.4					
5% Off	26.0					
10% Off	26.6					
15% Off	26.9					
20% Off	27.3					
25% Off	28.2					
30% Off	35.3					
35% Off	35.7					
40% Off	36.1					
45% Off	36.5					
50% Off	56.8					
55% Off	59.4					
60% Off	68.2					
65% Off	69.5					
70% Off	82.6					
75% Off	88.1					
80% Off	98.0					
85% Off	106.2					
90% Off	125.6					
95% Off	164.5					
F.B.P.	339.6					

CORE LABORATORIES

2810 - 12th Street N.E.

CALGARY, ALBERTA T2E 7P7



HYDROCARBON LIQUID ANALYSIS

Operator: EnCana Resources

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Well: CFT - 0488

File: 52137-2006-4335-4-279

Sample Point: Spot Sample

Date: 2006 11 07

Analysis of C₃₀₊ Fraction

Boiling Point: Range (° C)	Component	Carbon Number	Mole Fraction	Mass Fraction	Liq. Vol. Fraction
-161.7	Methane	C ₁	0.0000	0.0000	0.0000
- 88.9	Ethane	C ₂	Trace	Trace	Trace
- 42.2	Propane	C ₃	Trace	Trace	Trace
- 11.7	Iso Butane	C ₄	0.0006	0.0004	0.0005
- 0.6	Normal Butane	C ₄	0.0417	0.0296	0.0341
27.8	Iso Pentane	C ₅	0.2553	0.2248	0.2425
36.1	Normal Pentane	C ₅	0.2762	0.2431	0.2593
36.1- 68.9	Hexanes	C ₆	0.1414	0.1487	0.1509
68.9- 98.3	Heptanes	C ₇	0.0545	0.0667	0.0653
98.3-125.6	Octanes	C ₈	0.0261	0.0364	0.0347
125.6-150.6	Nonanes	C ₉	0.0125	0.0196	0.0183
150.6-173.9	Decanes	C ₁₀	0.0080	0.0139	0.0128
173.9-196.1	Undecanes	C ₁₁	0.0083	0.0149	0.0127
196.1-215.0	Dodecanes	C ₁₂	0.0033	0.0065	0.0055
215.0-235.0	Tridecanes	C ₁₃	0.0021	0.0044	0.0037
235.0-252.2	Tetradecanes	C ₁₄	0.0016	0.0037	0.0030
252.2-270.6	Pentadecanes	C ₁₅	0.0011	0.0028	0.0022
270.6-287.8	Hexadecanes	C ₁₆	0.0007	0.0019	0.0015
287.8-302.8	Heptadecanes	C ₁₇	0.0005	0.0014	0.0012
302.8-317.2	Octadecanes	C ₁₈	0.0004	0.0012	0.0010
317.2-330.0	Nonadecanes	C ₁₉	0.0003	0.0009	0.0008
330.0-344.4	Eicosanes	C ₂₀	0.0002	0.0006	0.0005
344.4-357.2	Heneicosanes	C ₂₁	0.0002	0.0007	0.0006
357.2-369.4	Docosanes	C ₂₂	0.0001	0.0005	0.0003
369.4-380.0	Tricosanes	C ₂₃	0.0001	0.0004	0.0003
380.0-391.1	Tetracosanes	C ₂₄	0.0001	0.0003	0.0003
391.1-401.7	Pentacosanes	C ₂₅	0.0001	0.0003	0.0003
401.7-412.2	Hexacosanes	C ₂₆	0.0001	0.0003	0.0003
412.2-422.2	Heptacosanes	C ₂₇	Trace	Trace	Trace
422.2-431.7	Octacosanes	C ₂₈	Trace	Trace	Trace
431.7-441.1	Nonacosanes	C ₂₉	Trace	Trace	Trace
441.1 PLUS	Triacotanes Plus	C ₃₀₊	0.0003	0.0017	0.0012
80.0	Benzene	C ₆ H ₆	0.0220	0.0210	0.0160
110.6	Toluene	C ₇ H ₈	0.0188	0.0211	0.0163
136.1-138.9	Ethylbenzene, p + m-Xylene	C ₈ H ₁₀	0.0094	0.0122	0.0094
144.4	o-Xylene	C ₈ H ₁₀	0.0017	0.0022	0.0017
168.9	1,2,4 Trimethylbenzene	C ₉ H ₁₂	0.0016	0.0024	0.0018
48.9	Cyclopentane	C ₅ H ₁₀	0.0229	0.0196	0.0176
72.2	Methylcyclopentane	C ₆ H ₁₂	0.0307	0.0315	0.0282
81.1	Cyclohexane	C ₆ H ₁₂	0.0275	0.0282	0.0243
101.1	Methylcyclohexane	C ₇ H ₁₄	0.0296	0.0355	0.0309
	TOTAL		1.0000	1.0000	1.0000



LABORATORY TEST RESULTS

JOB NUMBER: 52137-2006-4335

CUSTOMER: CAPP / Advantage Insight Group

SAMPLE I.D: **CRM - 0482 Rimbey Condensate**

LABORATORY I.D.: 52137-06-4335-5

DATE SAMPLED: June 8, 2006

TEST DESCRIPTION	RESULT	LIMITS	UNITS	TEST METHOD	DATE	TECH
Simulated Distillation			°C	ASTM D-2887	06/11/02	BH
I.B.P.	4.1					
5% Off	26.3					
10% Off	27.1					
15% Off	35.0					
20% Off	36.1					
25% Off	57.3					
30% Off	60.0					
35% Off	68.9					
40% Off	69.7					
45% Off	83.5					
50% Off	89.2					
55% Off	97.9					
60% Off	103.5					
65% Off	113.0					
70% Off	119.4					
75% Off	134.9					
80% Off	146.0					
85% Off	169.7					
90% Off	214.0					
95% Off	305.2					
F.B.P.	493.0					

CORE LABORATORIES
2810 - 12th Street N.E.
CALGARY, ALBERTA T2E 7P7



HYDROCARBON LIQUID ANALYSIS

Operator: EnCana Resources

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Well: CRM - 0482

File: 52137-2006-4335-5-280

Sample Point: Spot Sample

Date: 2006 11 07

Analysis of C₃₀₊ Fraction

Boiling Point: Range (° C)	Component	Carbon Number	Mole Fraction	Mass Fraction	Liq. Vol. Fraction
-161.7	Methane	C ₁	Trace	Trace	Trace
- 88.9	Ethane	C ₂	0.0003	0.0001	0.0002
- 42.2	Propane	C ₃	0.0024	0.0011	0.0015
- 11.7	Iso Butane	C ₄	0.0031	0.0019	0.0024
- 0.6	Normal Butane	C ₄	0.0440	0.0267	0.0324
27.8	Iso Pentane	C ₅	0.1477	0.1113	0.1263
36.1	Normal Pentane	C ₅	0.1378	0.1038	0.1166
36.1- 68.9	Hexanes	C ₆	0.1693	0.1522	0.1628
68.9- 98.3	Heptanes	C ₇	0.1011	0.1058	0.1090
98.3-125.6	Octanes	C ₈	0.0649	0.0774	0.0777
125.6-150.6	Nonanes	C ₉	0.0373	0.0500	0.0491
150.6-173.9	Decanes	C ₁₀	0.0233	0.0346	0.0334
173.9-196.1	Undecanes	C ₁₁	0.0174	0.0267	0.0240
196.1-215.0	Dodecanes	C ₁₂	0.0102	0.0171	0.0152
215.0-235.0	Tridecanes	C ₁₃	0.0066	0.0120	0.0105
235.0-252.2	Tetradecanes	C ₁₄	0.0055	0.0109	0.0094
252.2-270.6	Pentadecanes	C ₁₅	0.0043	0.0092	0.0079
270.6-287.8	Hexadecanes	C ₁₆	0.0031	0.0073	0.0061
287.8-302.8	Heptadecanes	C ₁₇	0.0025	0.0061	0.0052
302.8-317.2	Octadecanes	C ₁₈	0.0022	0.0057	0.0048
317.2-330.0	Nonadecanes	C ₁₉	0.0018	0.0050	0.0041
330.0-344.4	Eicosanes	C ₂₀	0.0015	0.0042	0.0035
344.4-357.2	Heneicosanes	C ₂₁	0.0014	0.0043	0.0035
357.2-369.4	Docosanes	C ₂₂	0.0010	0.0033	0.0026
369.4-380.0	Tricosanes	C ₂₃	0.0009	0.0031	0.0024
380.0-391.1	Tetracosanes	C ₂₄	0.0008	0.0026	0.0022
391.1-401.7	Pentacosanes	C ₂₅	0.0007	0.0025	0.0020
401.7-412.2	Hexacosanes	C ₂₆	0.0006	0.0023	0.0018
412.2-422.2	Heptacosanes	C ₂₇	0.0005	0.0021	0.0016
422.2-431.7	Octacosanes	C ₂₈	0.0004	0.0018	0.0013
431.7-441.1	Nonacosanes	C ₂₉	0.0004	0.0017	0.0013
441.1 PLUS	Triacotanes Plus	C ₃₀₊	0.0030	0.0133	0.0104
80.0	Benzene	C ₆ H ₆	0.0175	0.0143	0.0114
110.6	Toluene	C ₇ H ₈	0.0353	0.0340	0.0276
136.1-138.9	Ethylbenzene, p + m-Xylene	C ₈ H ₁₀	0.0269	0.0298	0.0244
144.4	o-Xylene	C ₈ H ₁₀	0.0034	0.0038	0.0030
168.9	1,2,4 Trimethylbenzene	C ₉ H ₁₂	0.0063	0.0079	0.0063
48.9	Cyclopentane	C ₅ H ₁₀	0.0163	0.0119	0.0113
72.2	Methylcyclopentane	C ₆ H ₁₂	0.0296	0.0260	0.0244
81.1	Cyclohexane	C ₆ H ₁₂	0.0290	0.0255	0.0231
101.1	Methylcyclohexane	C ₇ H ₁₄	0.0397	0.0407	0.0373
	TOTAL		1.0000	1.0000	1.0000



LABORATORY TEST RESULTS

JOB NUMBER: 52137-2006-4335

CUSTOMER: CAPP / Advantage Insight Group

SAMPLE I.D: **CPM - 478 Pembina Condensate**

LABORATORY I.D.: 52137-06-4335-7

DATE SAMPLED: June 8, 2006

TEST DESCRIPTION	RESULT	LIMITS	UNITS	TEST METHOD	DATE	TECH
Simulated Distillation			°C	ASTM D-2887	06/11/02	BH
I.B.P.	-3.1					
5% Off	27.5					
10% Off	57.3					
15% Off	68.7					
20% Off	77.3					
25% Off	90.7					
30% Off	98.4					
35% Off	109.3					
40% Off	118.9					
45% Off	133.7					
50% Off	144.3					
55% Off	162.0					
60% Off	178.5					
65% Off	204.5					
70% Off	234.9					
75% Off	266.4					
80% Off	302.6					
85% Off	344.1					
90% Off	393.4					
95% Off	454.6					
F.B.P.	543.2					

CORE LABORATORIES

2810 - 12th Street N.E.

CALGARY, ALBERTA T2E 7P7



HYDROCARBON LIQUID ANALYSIS

Operator: EnCana Resources

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Well: CPM - 478

File: 52137-2006-4335-7-282

Sample Point: Spot Sample

Date: 2006 11 07

Analysis of C₃₀₊ Fraction

Boiling Point: Range (° C)	Component	Carbon Number	Mole Fraction	Mass Fraction	Liq. Vol. Fraction
-161.7	Methane	C ₁	Trace	Trace	Trace
- 88.9	Ethane	C ₂	0.0004	0.0001	0.0002
- 42.2	Propane	C ₃	0.0060	0.0021	0.0032
- 11.7	Iso Butane	C ₄	0.0065	0.0030	0.0041
- 0.6	Normal Butane	C ₄	0.0328	0.0152	0.0198
27.8	Iso Pentane	C ₅	0.0591	0.0340	0.0414
36.1	Normal Pentane	C ₅	0.0728	0.0419	0.0505
36.1- 68.9	Hexanes	C ₆	0.1129	0.0777	0.0890
68.9- 98.3	Heptanes	C ₇	0.0965	0.0771	0.0853
98.3-125.6	Octanes	C ₈	0.0805	0.0733	0.0789
125.6-150.6	Nonanes	C ₉	0.0553	0.0566	0.0596
150.6-173.9	Decanes	C ₁₀	0.0449	0.0510	0.0528
173.9-196.1	Undecanes	C ₁₁	0.0403	0.0473	0.0455
196.1-215.0	Dodecanes	C ₁₂	0.0279	0.0358	0.0341
215.0-235.0	Tridecanes	C ₁₃	0.0219	0.0305	0.0287
235.0-252.2	Tetradecanes	C ₁₄	0.0197	0.0299	0.0276
252.2-270.6	Pentadecanes	C ₁₅	0.0165	0.0271	0.0248
270.6-287.8	Hexadecanes	C ₁₆	0.0126	0.0223	0.0202
287.8-302.8	Heptadecanes	C ₁₇	0.0102	0.0192	0.0173
302.8-317.2	Octadecanes	C ₁₈	0.0094	0.0188	0.0168
317.2-330.0	Nonadecanes	C ₁₉	0.0079	0.0166	0.0147
330.0-344.4	Eicosanes	C ₂₀	0.0064	0.0140	0.0124
344.4-357.2	Heneicosanes	C ₂₁	0.0067	0.0155	0.0136
357.2-369.4	Docosanes	C ₂₂	0.0050	0.0122	0.0106
369.4-380.0	Tricosanes	C ₂₃	0.0047	0.0119	0.0103
380.0-391.1	Tetracosanes	C ₂₄	0.0039	0.0102	0.0089
391.1-401.7	Pentacosanes	C ₂₅	0.0035	0.0097	0.0083
401.7-412.2	Hexacosanes	C ₂₆	0.0031	0.0090	0.0076
412.2-422.2	Heptacosanes	C ₂₇	0.0028	0.0084	0.0071
422.2-431.7	Octacosanes	C ₂₈	0.0024	0.0075	0.0063
431.7-441.1	Nonacosanes	C ₂₉	0.0023	0.0074	0.0062
441.1 PLUS	Triacotanes Plus	C ₃₀₊	0.0178	0.0603	0.0504
80.0	Benzene	C ₆ H ₆	0.0130	0.0081	0.0070
110.6	Toluene	C ₇ H ₈	0.0318	0.0234	0.0204
136.1-138.9	Ethylbenzene, p + m-Xylene	C ₈ H ₁₀	0.0321	0.0272	0.0238
144.4	o-Xylene	C ₈ H ₁₀	0.0061	0.0052	0.0044
168.9	1,2,4 Trimethylbenzene	C ₉ H ₁₂	0.0113	0.0108	0.0093
48.9	Cyclopentane	C ₅ H ₁₀	0.0113	0.0063	0.0064
72.2	Methylcyclopentane	C ₆ H ₁₂	0.0288	0.0193	0.0195
81.1	Cyclohexane	C ₆ H ₁₂	0.0264	0.0177	0.0172
101.1	Methylcyclohexane	C ₇ H ₁₄	0.0465	0.0364	0.0358
	TOTAL		1.0000	1.0000	1.0000
			125.4	0.7606	



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Cold Lake – CRW-675 Blend Characterization

Target Density 940 kg/m³

Diluent Concentration..... 17.89 Mass %

.....23.00 Volume %

Measured Density @ 15.0°C..... 939.7 kg/m³

Temperature (°C)	Dynamic Viscosity (cP.)	Kinematic Viscosity (cSt.)
7	925.4	979.5
12	612.8	650.8
20	336.0	358.8
30	176.5	489.8
40	101.3	109.8

Target Density 930 kg/m³

Diluent Concentration..... 20.87 Mass %

.....26.56 Volume %

Measured Density @ 15.0°C..... 930.3 kg/m³

Temperature (°C)	Dynamic Viscosity (cP.)	Kinematic Viscosity (cSt.)
7	481.6	514.9
12	331.3	335.3
20	190.9	206.0
30	106.9	116.2
40	64.23	70.32



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Cold Lake – CRW-675 Blend Characterization

Target Density 912 kg/m³

Diluent Concentration.....26.89 Mass %

.....33.53 Volume %

Measured Density @ 15.0°C..... 911.1 kg/m³

Temperature (°C)	Dynamic Viscosity (cP.)	Kinematic Viscosity (cSt.)
7	155.9	170.2
12	114.3	125.1
20	71.37	78.66
30	44.66	49.94
40	29.16	32.74

Cold Lake – CPC-475 Blend Characterization

Target Density 940 kg/m³

Diluent Concentration.....20.36 Mass %

.....25.19 Volume %

Measured Density @ 15.0°C..... 939.6 kg/m³

Temperature (°C)	Dynamic Viscosity (cP.)	Kinematic Viscosity (cSt.)
7	579.5	613.6
12	396.6	421.2
20	226.1	241.5
30	125.0	134.4
40	74.22	80.44



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Cold Lake – CPC-475 Blend Characterization

Target Density 930 kg/m³

Diluent Concentration.....24.33 Mass %

.....29.75 Volume %

Measured Density @ 15.0°C..... 928.0 kg/m³

Temperature (°C)	Dynamic Viscosity (cP.)	Kinematic Viscosity (cSt.)
7	265.1	284.2
12	189.3	203.6
20	114.3	123.7
30	68.34	74.46
40	43.11	47.32

Target Density 912 kg/m³

Diluent Concentration.....31.20 Mass %

.....37.39 Volume %

Measured Density @ 15.0°C..... 909.2 kg/m³

Temperature (°C)	Dynamic Viscosity (cP.)	Kinematic Viscosity (cSt.)
7	83.96	91.83
12	63.97	70.21
20	42.46	46.90
30	28.02	31.19
40	19.22	21.56



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Cold Lake – CFT-0488 Blend Characterization

Target Density 940 kg/m³

Diluent Concentration..... 14.11 Mass %

..... 19.50 Volume %

Measured Density @ 15.0°C..... 940.4 kg/m³

Temperature (°C)	Dynamic Viscosity (cP.)	Kinematic Viscosity (cSt.)
7	1117	1182
12	753.8	799.8
20	405.2	432.4
30	208.4	224.0
40	117.2	128.0

Target Density 930 kg/m³

Diluent Concentration..... 16.73 Mass %

..... 22.86 Volume %

Measured Density @ 15.0°C..... 927.6 kg/m³

Temperature (°C)	Dynamic Viscosity (cP.)	Kinematic Viscosity (cSt.)
7	517.2	554.5
12	353.6	380.4
20	202.2	218.8
30	112.1	122.2
40	66.70	73.51



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Cold Lake – CFT-0488 Blend Characterization

Target Density 912 kg/m³

Diluent Concentration.....21.61 Mass %

.....28.90 Volume %

Measured Density @ 15.0°C..... 907.8 kg/m³

Temperature (°C)	Dynamic Viscosity (cP.)	Kinematic Viscosity (cSt.)
7	180.5	197.7
12	130.5	143.4
20	80.17	88.68
30	49.04	55.23
40	31.68	35.58

Cold Lake – CPR-0822 Blend Characterization

Target Density 940 kg/m³

Diluent Concentration..... 18.76 Mass %

.....23.74 Volume %

Measured Density @ 15.0°C..... 940.5 kg/m³

Temperature (°C)	Dynamic Viscosity (cP.)	Kinematic Viscosity (cSt.)
7	926.0	979.4
12	614.2	651.7
20	337.2	359.9
30	177.2	190.5
40	101.2	109.6



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Cold Lake – CPR-0822 Blend Characterization

Target Density 930 kg/m³

Diluent Concentration.....22.08 Mass %

.....27.65 Volume %

Measured Density @ 15.0°C..... 930.6 kg/m³

Temperature (°C)	Dynamic Viscosity (cP.)	Kinematic Viscosity (cSt.)
7	469.2	501.6
12	323.8	347.2
20	186.9	201.6
30	105.1	114.2
40	63.23	69.21

Target Density 912 kg/m³

Diluent Concentration.....28.63 Mass %

.....35.11 Volume %

Measured Density @ 15.0°C..... 911.2 kg/m³

Temperature (°C)	Dynamic Viscosity (cP.)	Kinematic Viscosity (cSt.)
7	146.9	160.3
12	108.1	118.4
20	67.97	74.89
30	42.77	47.49
40	28.00	31.33



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Cold Lake – CRM-0482 Blend Characterization

Target Density 940 kg/m³

Diluent Concentration..... 16.70 Mass %

.....21.84 Volume %

Measured Density @ 15.0°C..... 939.5 kg/m³

Temperature (°C)	Dynamic Viscosity (cP.)	Kinematic Viscosity (cSt.)
7	879.4	931.1
12	585.1	621.5
20	322.5	344.6
30	170.2	183.1
40	98.04	106.3

Target Density 930 kg/m³

Diluent Concentration..... 19.73 Mass %

.....25.52 Volume %

Measured Density @ 15.0°C..... 927.5 kg/m³

Temperature (°C)	Dynamic Viscosity (cP.)	Kinematic Viscosity (cSt.)
7	424.7	455.3
12	293.5	315.7
20	170.3	184.3
30	96.35	105.1
40	58.29	64.05



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Cold Lake – CRM-0482 Blend Characterization

Target Density 912 kg/m³

Diluent Concentration.....25.44 Mass %

.....32.24 Volume %

Measured Density @ 15.0°C..... 908.2 kg/m³

Temperature (°C)	Dynamic Viscosity (cP.)	Kinematic Viscosity (cSt.)
7	139.8	153.1
12	102.9	113.1
20	64.83	71.68
30	40.79	45.45
40	26.76	30.06

Cold Lake – CMP-478 Blend Characterization

Target Density 940 kg/m³

Diluent Concentration.....22.30 Mass %

.....27.01 Volume %

Measured Density @ 15.0°C..... 937.5 kg/m³

Temperature (°C)	Dynamic Viscosity (cP.)	Kinematic Viscosity (cSt.)
7	758.6	804.8
12	507.4	540.0
20	281.8	301.7
30	150.3	162.1
40	86.73	94.22



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Cold Lake – CMP-478 Blend Characterization

Target Density 930 kg/m³

Diluent Concentration..... 26.43 Mass %

..... 31.65 Volume %

Measured Density @ 15.0°C..... 926.9 kg/m³

Temperature (°C)	Dynamic Viscosity (cP.)	Kinematic Viscosity (cSt.)
7	375.6	402.9
12	261.4	281.4
20	153.0	165.7
30	87.48	95.44
40	53.19	58.46

Target Density 912 kg/m³

Diluent Concentration..... 34.04 Mass %

..... 39.96 Volume %

Measured Density @ 15.0°C..... 910.9 kg/m³

Temperature (°C)	Dynamic Viscosity (cP.)	Kinematic Viscosity (cSt.)
7	135.4	147.8
12	100.6	110.3
20	64.53	71.20
30	41.56	46.78
40	26.68	29.92



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Nexen Plover Lake – CRW-675 Blend Characterization

Target Density 940 kg/m³

Diluent Concentration..... 14.75 Mass %
 18.99 Volume %

Measured Density @ 15.0°C..... 939.2 kg/m³

Temperature (°C)	Dynamic Viscosity (cP.)	Kinematic Viscosity (cSt.)
7	796.6	843.5
12	530.4	563.5
20	292.5	316.6
30	154.0	165.9
40	88.10	95.52

Target Density 930 kg/m³

Diluent Concentration..... 17.77 Mass %
 22.64 Volume %

Measured Density @ 15.0°C..... 930.6 kg/m³

Temperature (°C)	Dynamic Viscosity (cP.)	Kinematic Viscosity (cSt.)
7	439.0	469.2
12	302.0	323.8
20	173.7	187.4
30	97.30	105.7
40	58.26	63.77



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Nexen Plover Lake – CRW-675 Blend Characterization

Target Density 912 kg/m³

Diluent Concentration.....23.56 Mass %
29.45 Volume %

Measured Density @ 15.0°C..... 913.5 kg/m³

Temperature (°C)	Dynamic Viscosity (cP.)	Kinematic Viscosity (cSt.)
7	153.0	166.6
12	112.1	122.4
20	69.88	76.80
30	43.38	48.04
40	28.11	31.37

Nexen Plover Lake – CPC-475 Blend Characterization

Target Density 940 kg/m³

Diluent Concentration.....16.45 Mass %
20.38 Volume %

Measured Density @ 15.0°C..... 940.7 kg/m³

Temperature (°C)	Dynamic Viscosity (cP.)	Kinematic Viscosity (cSt.)
7	625.9	661.8
12	421.9	447.6
20	236.8	252.7
30	128.1	137.6
40	74.73	80.91



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Nexen Plover Lake – CPC-475 Blend Characterization

Target Density 930 kg/m³

Diluent Concentration..... 20.55 Mass %
 25.16 Volume %

Measured Density @ 15.0°C..... 929.9 kg/m³

Temperature (°C)	Dynamic Viscosity (cP.)	Kinematic Viscosity (cSt.)
7	280.3	299.8
12	198.3	212.8
20	118.2	127.6
30	69.51	75.60
40	43.23	47.36

Target Density 912 kg/m³

Diluent Concentration..... 28.00 Mass %
 33.59 Volume %

Measured Density @ 15.0°C..... 911.1 kg/m³

Temperature (°C)	Dynamic Viscosity (cP.)	Kinematic Viscosity (cSt.)
7	85.45	93.27
12	64.84	71.02
20	42.76	47.12
30	27.91	31.00
40	19.00	21.26



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Nexen Plover Lake – CFT-0488 Blend Characterization

Target Density 940 kg/m³

Diluent Concentration..... 11.42 Mass %
 15.80 Volume %
 Measured Density @ 15.0°C..... 940.2 kg/m³

Temperature (°C)	Dynamic Viscosity (cP.)	Kinematic Viscosity (cSt.)
7	923.0	976.3
12	608.2	645.5
20	330.8	353.1
30	171.6	184.5
40	96.89	105.0

Target Density 930 kg/m³

Diluent Concentration..... 14.13 Mass %
 19.32 Volume %
 Measured Density @ 15.0°C..... 929.9 kg/m³

Temperature (°C)	Dynamic Viscosity (cP.)	Kinematic Viscosity (cSt.)
7	458.7	490.6
12	314.8	337.8
20	180.8	195.2
30	100.6	109.5
40	60.06	65.80



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Nexen Plover Lake – CFT-0488 Blend Characterization

Target Density 912 kg/m³

Diluent Concentration..... 19.08 Mass %
25.55 Volume %

Measured Density @ 15.0°C..... 911.9 kg/m³

Temperature (°C)	Dynamic Viscosity (cP.)	Kinematic Viscosity (cSt.)
7	159.0	173.4
12	116.0	127.0
20	72.00	79.29
30	44.60	49.49
40	28.81	32.23

Nexen Plover Lake – CPR-0822 Blend Characterization

Target Density 940 kg/m³

Diluent Concentration..... 15.29 Mass %
19.37 Volume %

Measured Density @ 15.0°C..... 941.1 kg/m³

Temperature (°C)	Dynamic Viscosity (cP.)	Kinematic Viscosity (cSt.)
7	887.0	937.3
12	584.9	620.2
20	318.8	340.0
30	166.1	178.4
40	94.09	101.8



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Nexen Plover Lake – CPR-0822 Blend Characterization

Target Density 930 kg/m³

Diluent Concentration..... 18.81 Mass %
23.57 Volume %

Measured Density @ 15.0°C..... 931.1 kg/m³

Temperature (°C)	Dynamic Viscosity (cP.)	Kinematic Viscosity (cSt.)
7	436.7	466.5
12	300.7	322.2
20	173.2	186.8
30	96.90	105.2
40	58.04	63.50

Target Density 912 kg/m³

Diluent Concentration..... 25.54 Mass %
31.35 Volume %

Measured Density @ 15.0°C..... 912.7 kg/m³

Temperature (°C)	Dynamic Viscosity (cP.)	Kinematic Viscosity (cSt.)
7	141.1	153.7
12	103.8	113.5
20	65.05	71.55
30	40.74	45.16
40	26.57	29.67



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Nexen Plover Lake – CRM-0482 Blend Characterization

Target Density 940 kg/m³

Diluent Concentration..... 13.57 Mass %
 17.77 Volume %

Measured Density @ 15.0°C..... 940.4 kg/m³

Temperature (°C)	Dynamic Viscosity (cP.)	Kinematic Viscosity (cSt.)
7	834.4	882.5
12	553.0	586.8
20	303.1	323.5
30	159.0	170.9
40	90.55	98.07

Target Density 930 kg/m³

Diluent Concentration..... 16.77 Mass %
 21.72 Volume %

Measured Density @ 15.0°C..... 929.1 kg/m³

Temperature (°C)	Dynamic Viscosity (cP.)	Kinematic Viscosity (cSt.)
7	406.6	434.8
12	281.1	301.5
20	162.9	175.8
30	91.78	99.79
40	55.31	60.58



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Nexen Plover Lake – CRM-0482 Blend Characterization

Target Density 912 kg/m³

Diluent Concentration.....22.68 Mass %
28.76 Volume %

Measured Density @ 15.0°C..... 911.9 kg/m³

Temperature (°C)	Dynamic Viscosity (cP.)	Kinematic Viscosity (cSt.)
7	134.7	147.0
12	99.39	108.8
20	62.64	68.97
30	39.34	43.65
40	25.76	28.80

Nexen Plover Lake – CMP-478 Blend Characterization

Target Density 940 kg/m³

Diluent Concentration..... 18.32 Mass %
22.21 Volume %

Measured Density @ 15.0°C..... 940.4 kg/m³

Temperature (°C)	Dynamic Viscosity (cP.)	Kinematic Viscosity (cSt.)
7	806.5	852.9
12	534.8	567.4
20	293.2	312.9
30	154.3	165.9
40	87.83	95.10



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Nexen Plover Lake – CMP-478 Blend Characterization

Target Density 930 kg/m³

Diluent Concentration..... 20.40 Mass %
 24.60 Volume %

Measured Density @ 15.0°C..... 930.1 kg/m³

Temperature (°C)	Dynamic Viscosity (cP.)	Kinematic Viscosity (cSt.)
7	388.9	415.9
12	269.4	289.0
20	156.2	168.6
30	88.57	96.29
40	53.32	58.40

Target Density 912 kg/m³

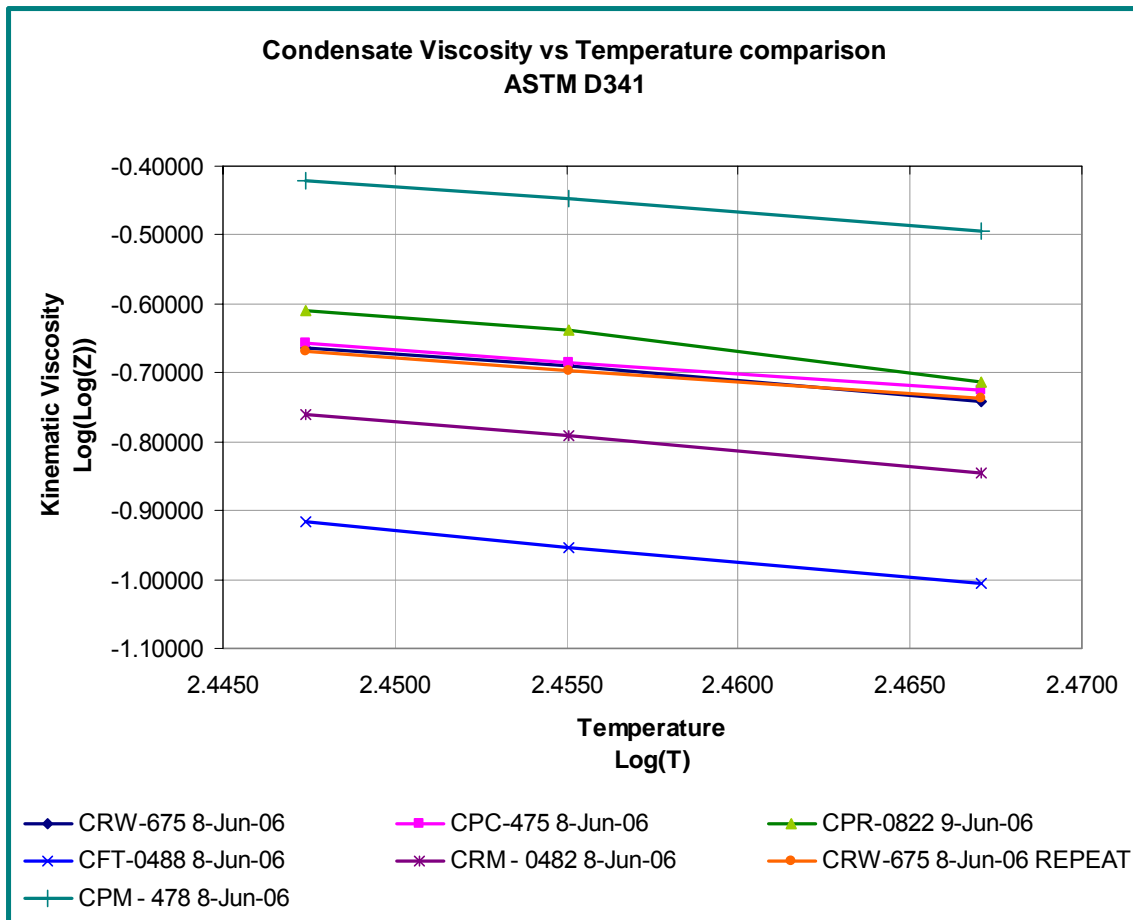
Diluent Concentration..... 30.62 Mass %
 35.97 Volume %

Measured Density @ 15.0°C..... 912.0 kg/m³

Temperature (°C)	Dynamic Viscosity (cP.)	Kinematic Viscosity (cSt.)
7	125.7	137.1
12	93.03	101.8
20	58.86	64.80
30	37.23	41.30
40	24.42	27.30

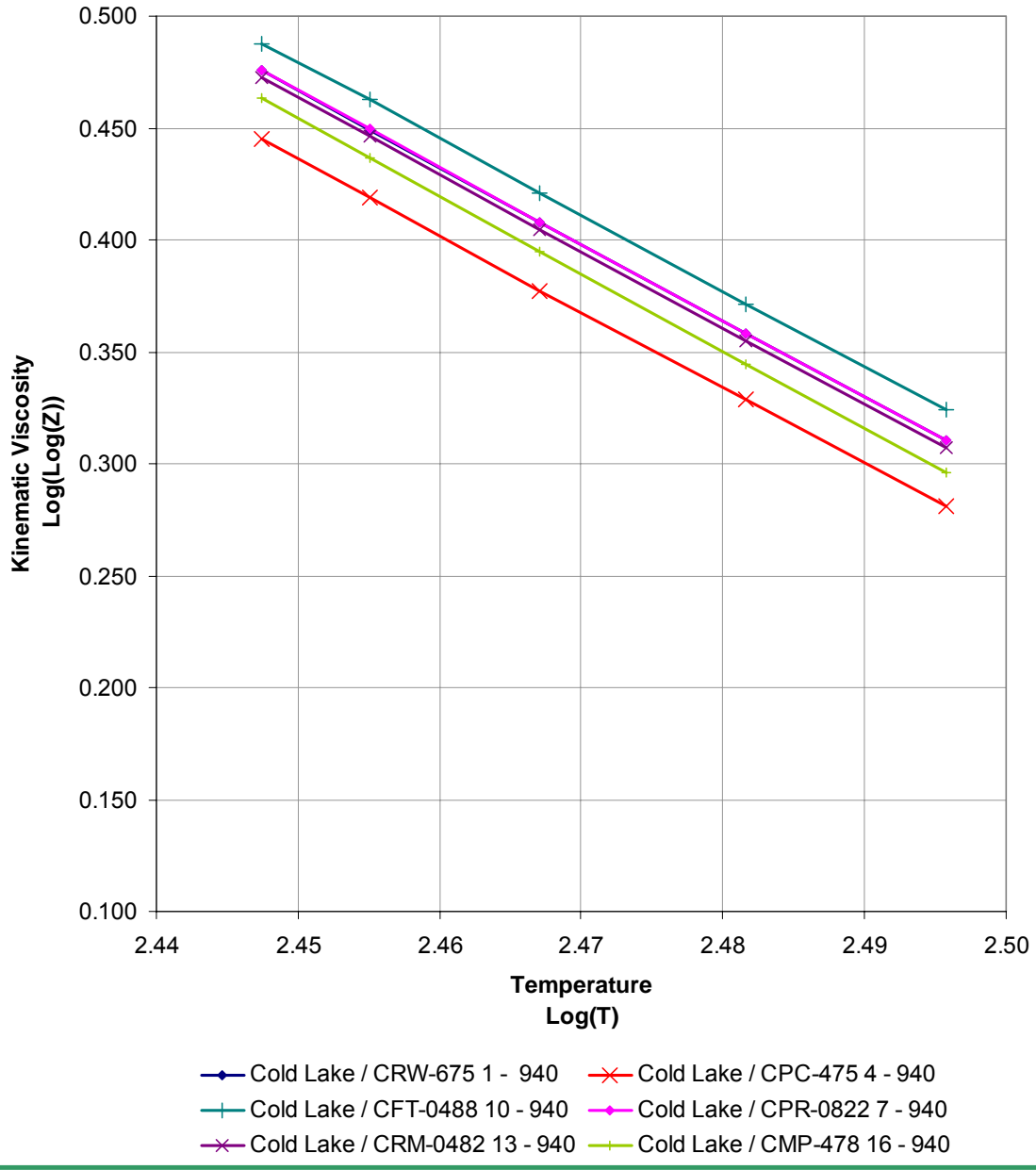
5.2 Appendix 2 Data Analysis – Viscosity vs. Temperature

As per ASTM D341, the following plot compares viscosity vs. temperature for each of the condensates that were used. The value of Z corresponds to a series of calculations based on Kinematic viscosity. ASTM D341 contains further details about this calculation. Linear behaviour is observed.

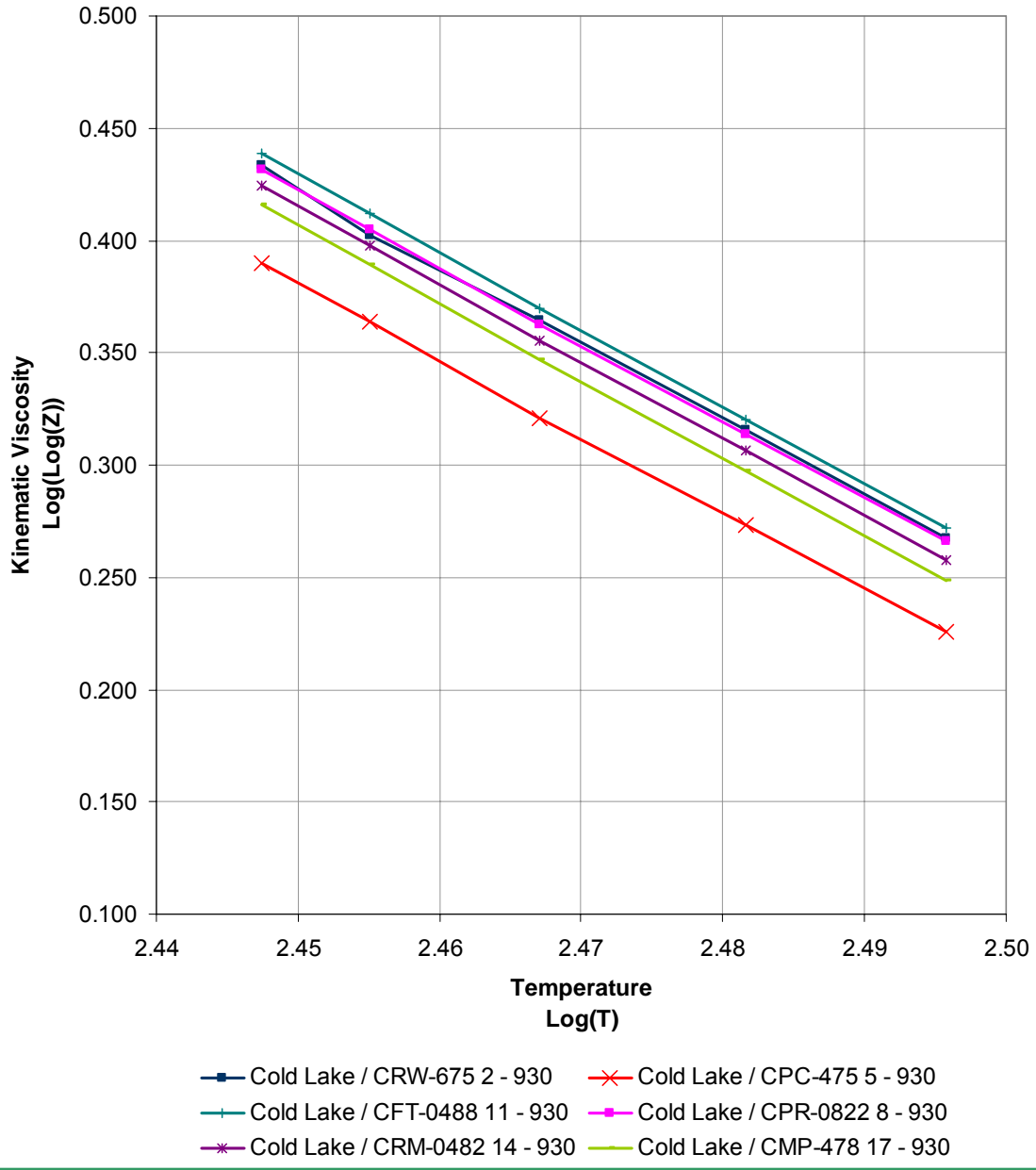


For each of the blends the viscosity vs. temperature was plotted as per ASTM D341. The following figures compare the results for each of the blends.

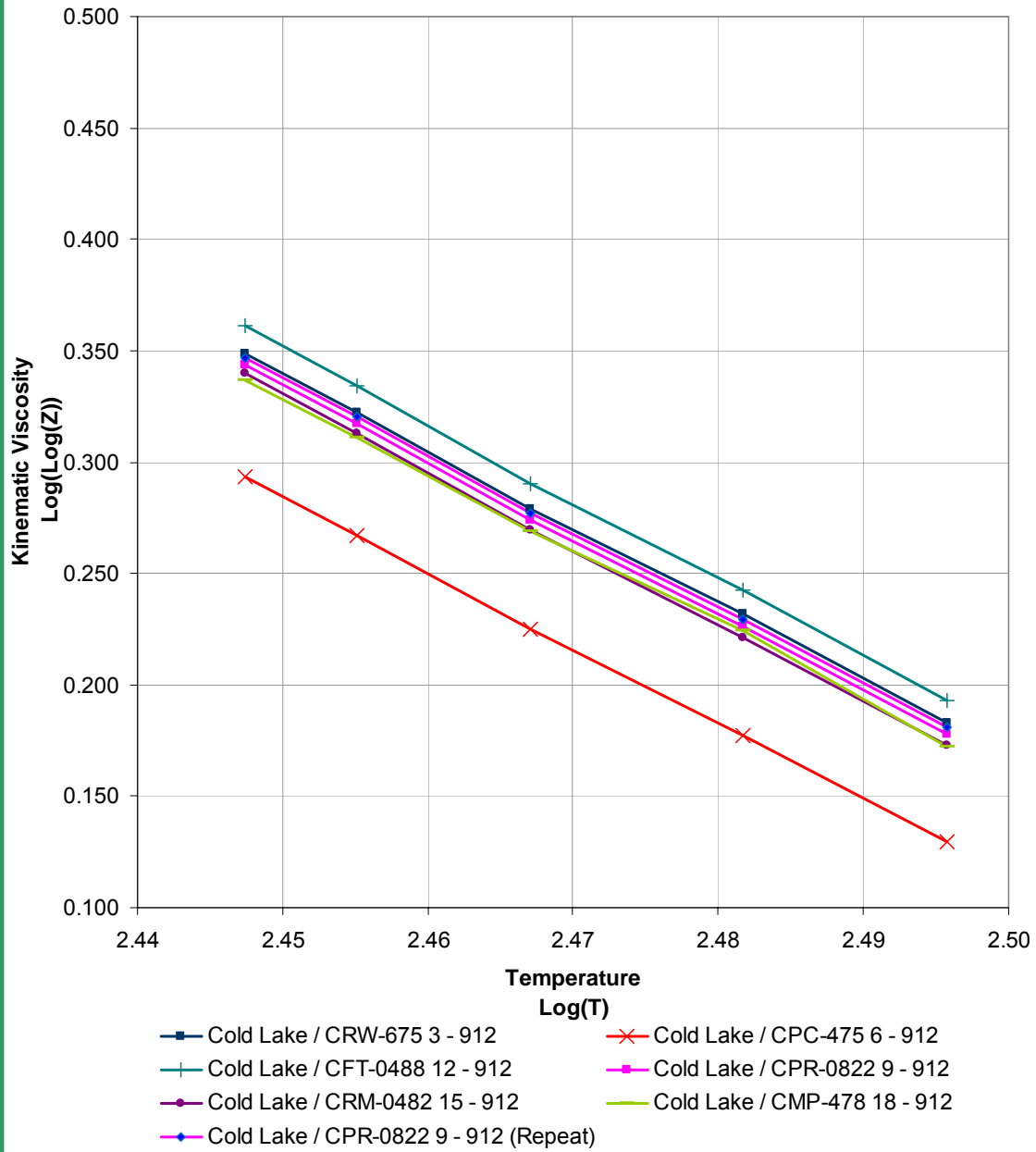
Comparison 940 Kg/m3 blends vs Temperature ASTM D340



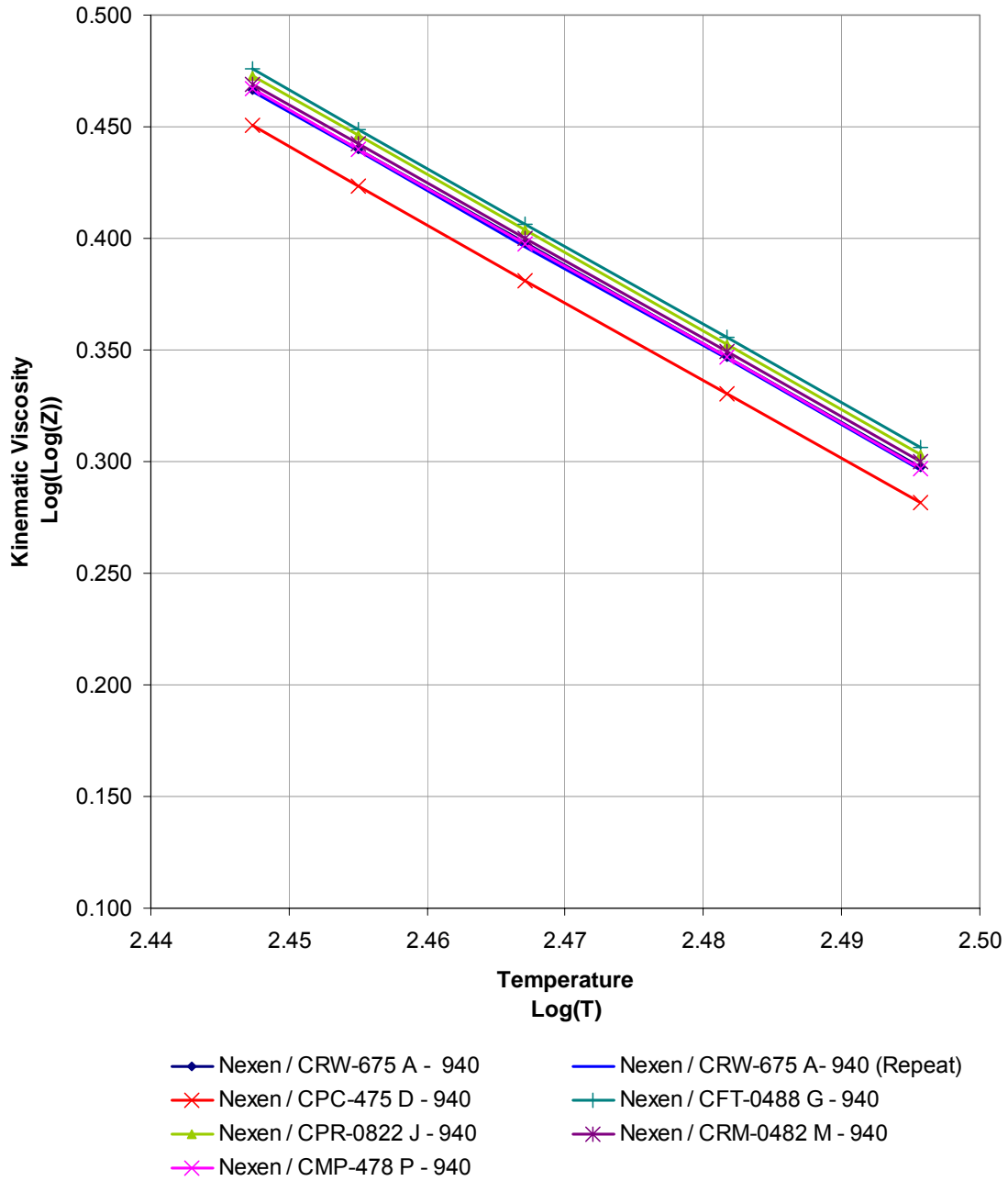
Comparison 930 Kg/m3 blends vs Temperature ASTM D340



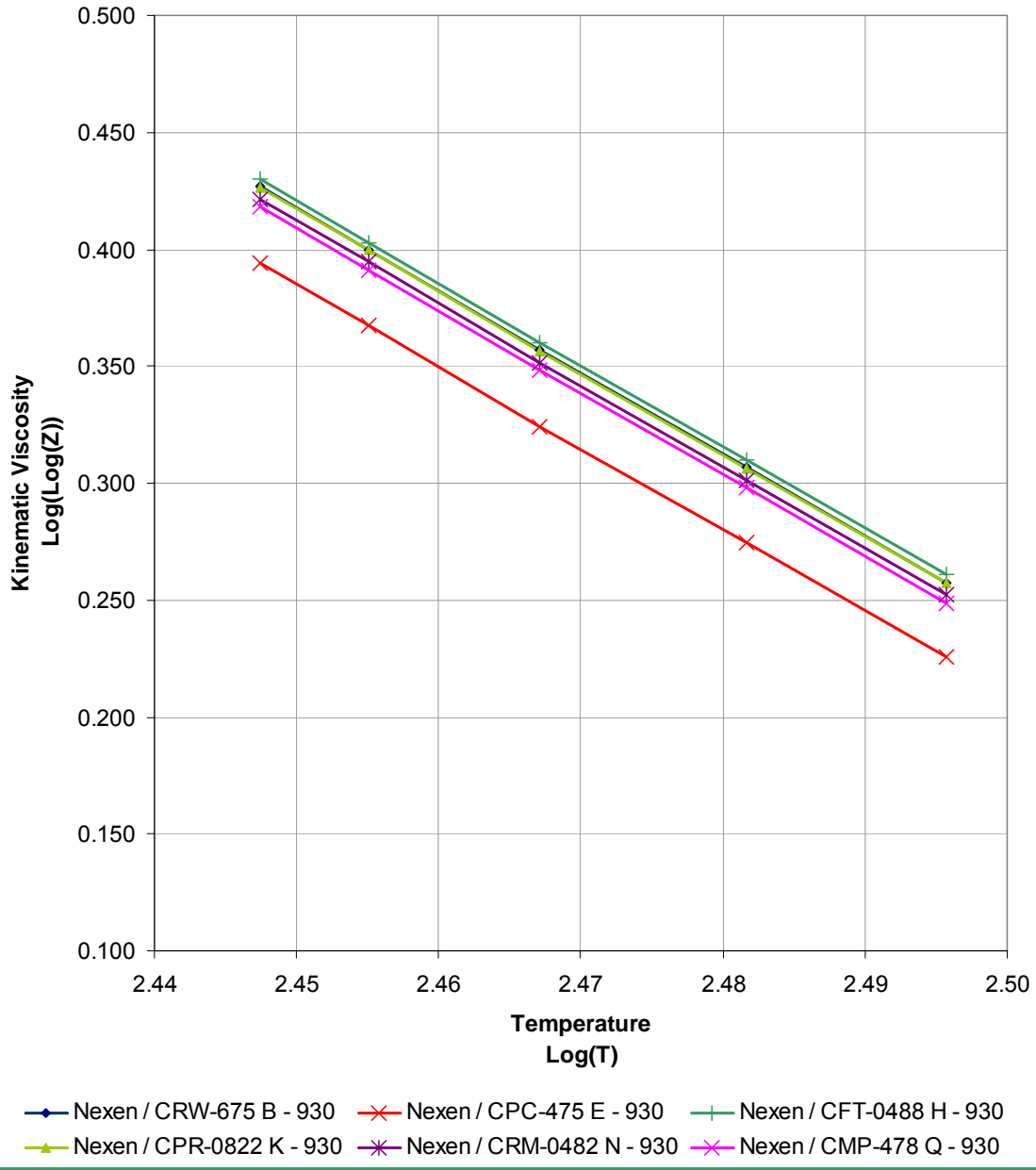
Comparison 912 Kg/m3 blends vs Temperature ASTM D340



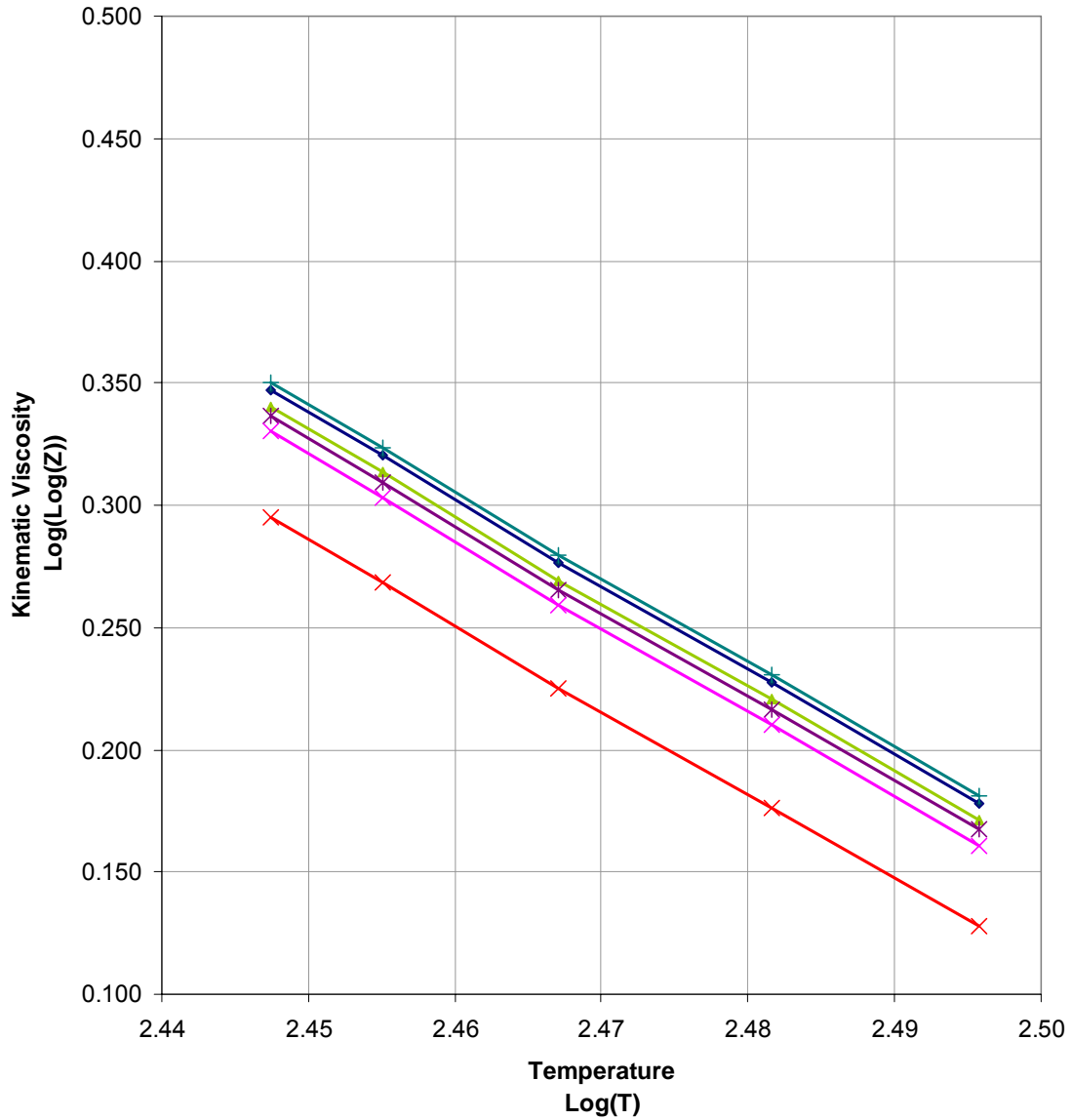
Comparison 940 Kg/m3 blends vs Temperature ASTM D340



Comparison 930 Kg/m3 blends vs Temperature ASTM D340



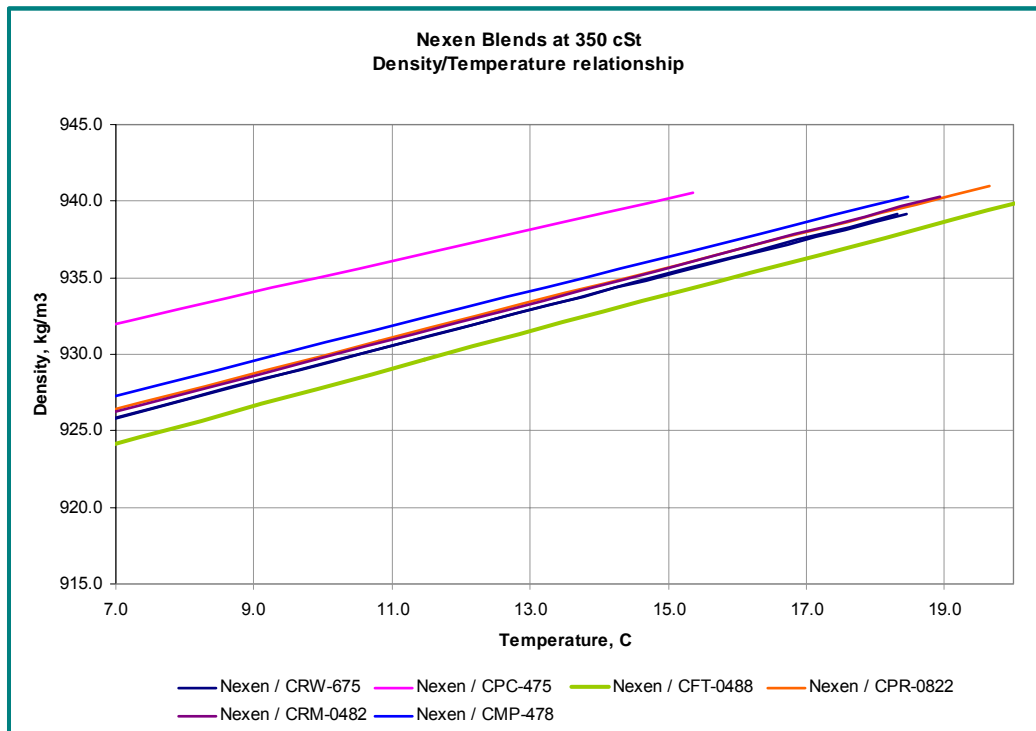
Comparison 912 Kg/m3 blends vs Temperature ASTM D340



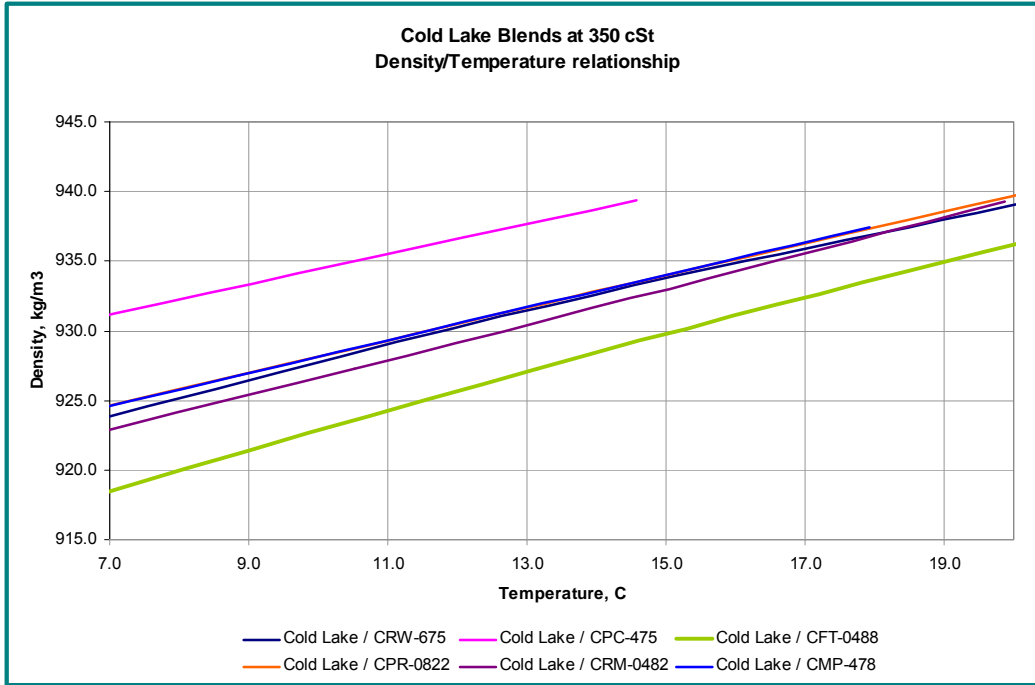
- ◆ Nexen / CRW-675 C - 912
- ✕ Nexen / CPC-475 F - 912
- ◆ Nexen / CFT-0488 I - 912
- ◆ Nexen / CPR-0822 L - 912
- ✕ Nexen / CRM-0482 O - 912
- ✕ Nexen / CMP-478 R - 912

5.3 Appendix 3 Data Analysis – Density vs. Temperature

The 350 cSt Viscosity Blends Density² vs. Temperature for the Cold Lake and LLK plots are shown in the following figures.



² Blend density @ 15°C, was interpolated based on laboratory information received.



The following table summarizes the regression results for the 350 cSt viscosity blends density vs. temperature. A general equation is obtained:

Equation 4
$$\rho_{blend} = Slope * T_{reference} + Intercept$$

The following table summarizes the slopes and intercepts obtained for each pair of Heavy/Condensate.

Table 350cSt Viscosity Blends Density vs. Temperature Correlation Summary - Data 2006

Condensate		Cold Lake			Nexen Blends		
Stream	Density, Kg/m3	Slope	Intercept	R square	Slope	Intercept	R square
CFT-0488	676.3	1.38701	908.4348	0.9990	1.225389	915.4466	0.9999
CRM-0482	715.2	1.25236	914.2953	0.9999	1.168499	918.1293	1.0000
CRW-675	727.2	1.23879	914.6688	0.9984	1.170814	917.6339	0.9999
CPR-0822	739.6	1.23077	915.3531	0.9953	1.161862	918.2300	1.0000
CPC-475	757.2	1.08093	923.6149	1.0000	1.050757	924.4989	0.9999
CMP-478	773.4	1.19867	915.9908	0.9999	1.139727	919.2878	1.0000

5.4 Appendix 4 Model coefficients

As shown in Appendix 3 a 350cSt density/temperature relationship for each crude/condensate was obtained:

Equation 5
$$\rho_{blend} = Slope * T_{reference} + Intercept$$

The Slopes and Intercepts from the 350 cSt viscosity blends density vs. temperature (slope and intercept) were regressed vs. the condensate density obtaining an equation for each bitumen that relates the target density required to meet the 350 cSt pipeline specification with reference temperature and diluent density.

$$Slope = a_1 * \rho_{condensate} + b_1$$

$$Intercept = a_2 * \rho_{condensate} + b_2$$

Equation 5 takes the form of:

Equation 6
$$\rho_{blend} = (a_1 * \rho_{condensate} + b_1) * T_{reference} + (a_2 * \rho_{condensate} + b_2)$$

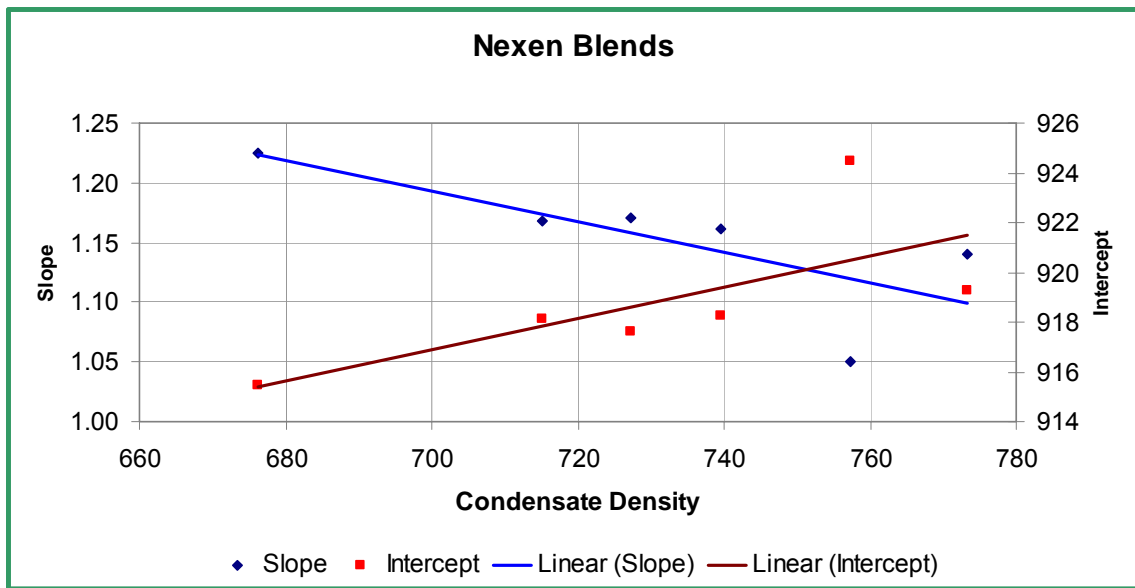
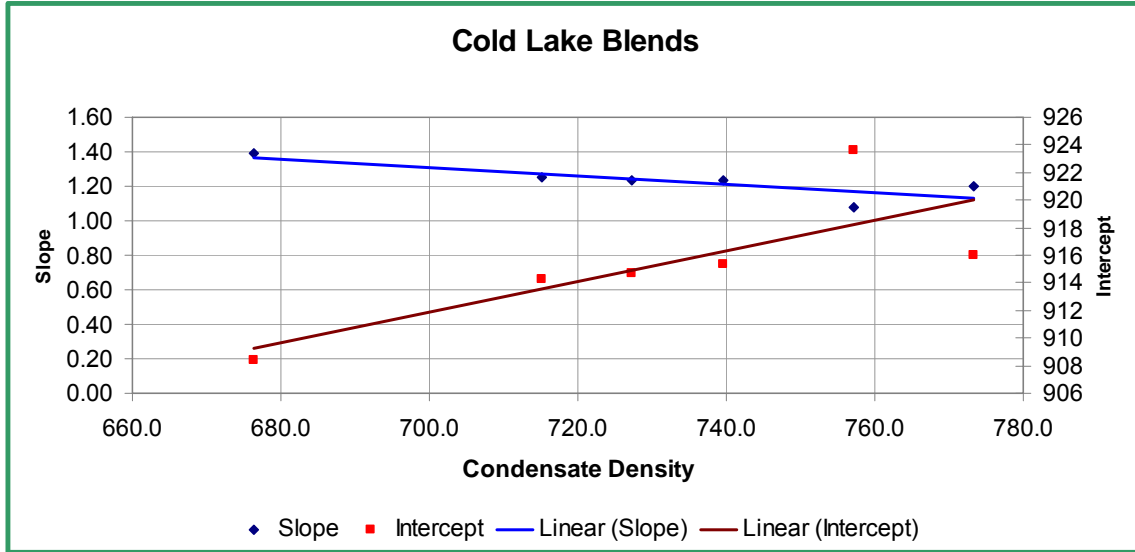
Coefficients a1, b1, a2 and b2 are input in the Condensate EQ model.

Calculation of coefficients was done according to the following cases:

- Case 1 – Using only 2006 data.
- Case 2- Using 2006 data excluding PC.
- Case 3 - Using all 2006 data and 2001 data (excluding Valhalla condensate).
- Case 4 - Using 2006 data excluding PC 2001 data (excluding Valhalla condensate).

Case 1 – Using only 2006 data.

The following figures show the value of the slope and intercept vs. condensate density for Cold Lake and LLK blends.

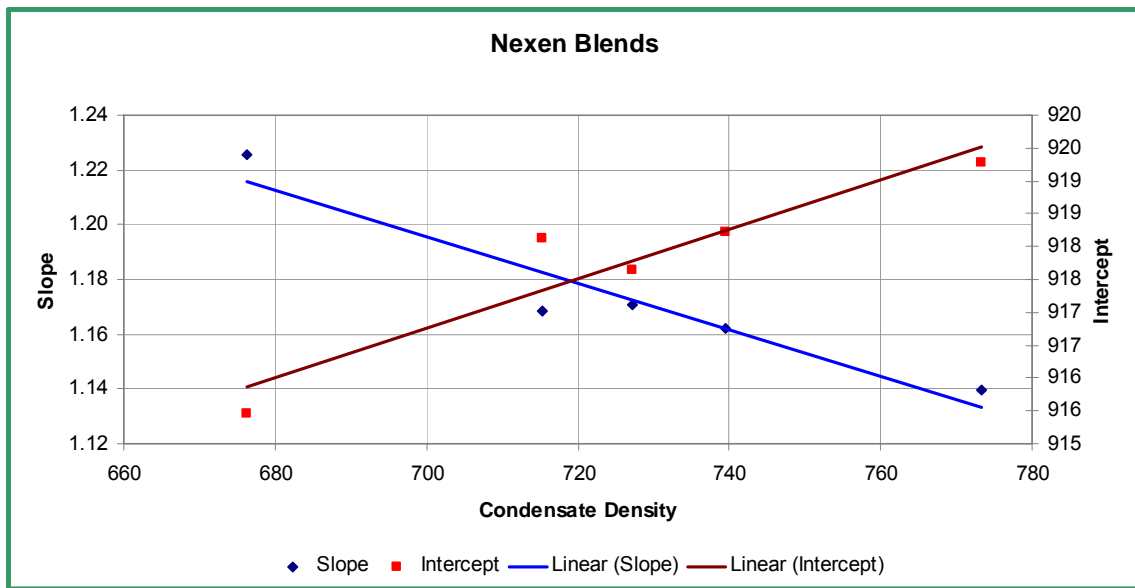
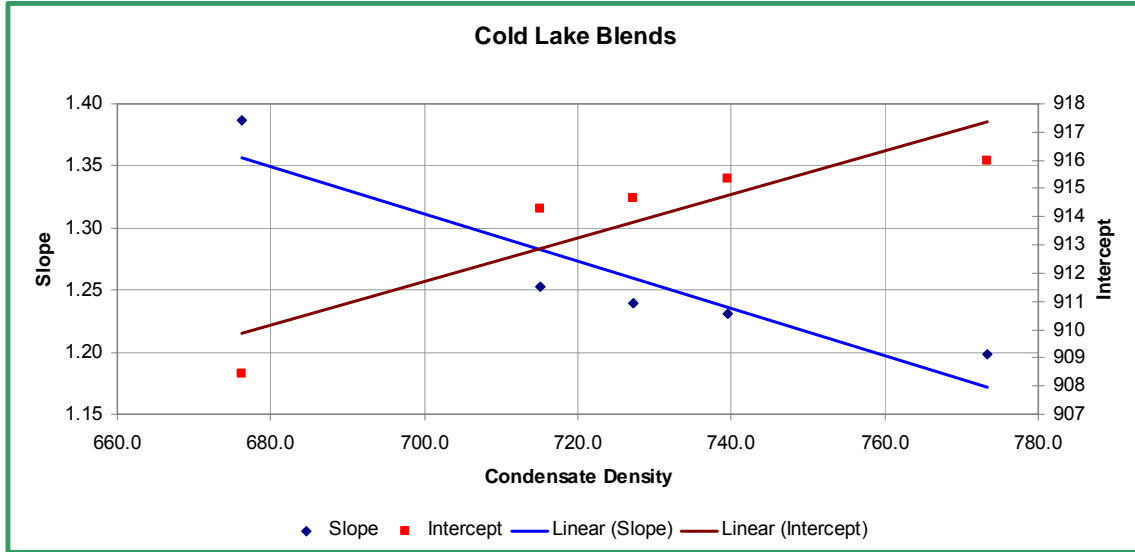


The following table summarizes the values of a1, b1, a2, b2 calculated for each of the bitumen using only 2006 data.

	Slope vs. Condensate Density			Intercept vs. Condensate Density		
	a1	b1	R square	a2	b2	R square
Cold Lake Blends	-0.00244	3.01910	0.71705	0.11029	834.71530	0.59872
LLK Blends	-0.00128	2.08871	0.57647	0.06251	873.14887	0.49303

Case 2- Using 2006 data excluding PC.

The following figures show the value of the slope and intercept vs. condensate density for Cold Lake and LLK blends for this case.

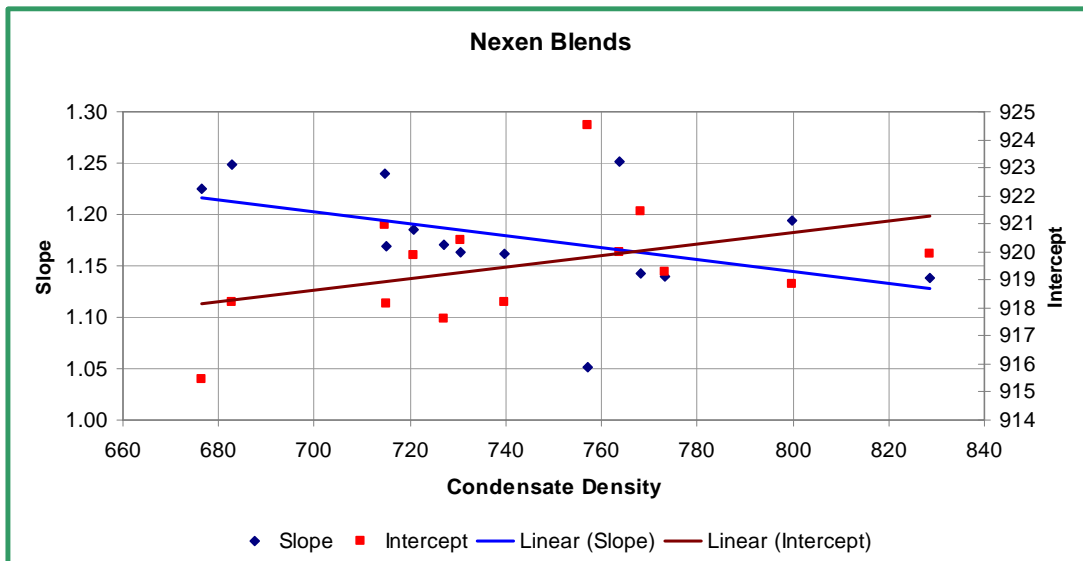
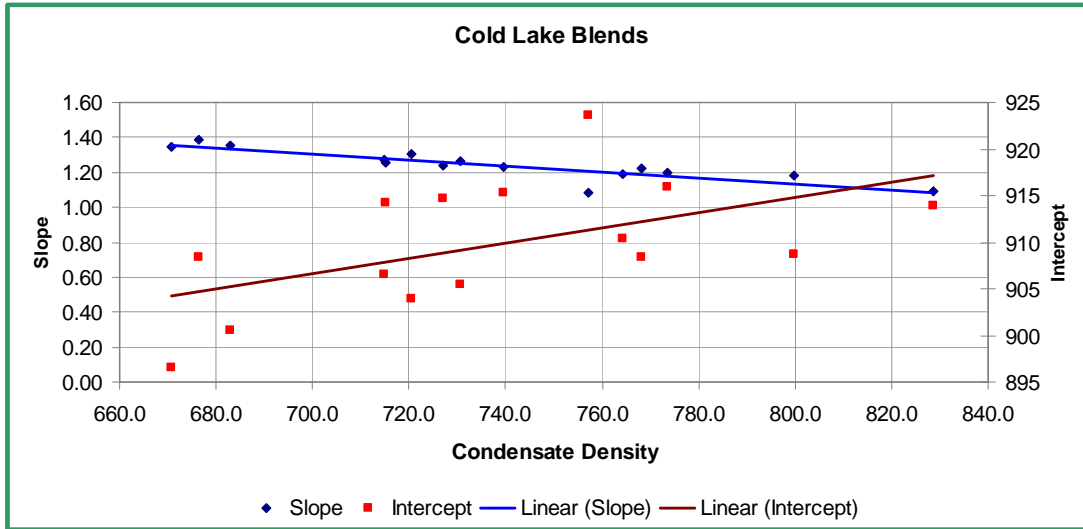


The following table summarizes the values of a1, b1, a2, b2 calculated for each of the bitumen using 2006 data and excluding the PC stream.

	Slope vs. Condensate Density			Intercept vs. Condensate Density		
	a1	b1	R square	a2	b2	R square
Cold Lake Blends	-0.00191	2.64525	0.85756	0.07718	857.68864	0.80846
LLK Blends	-0.00085	1.79360	0.91519	0.03779	890.29871	0.88945

Case 3 - Using all 2006 data and 2001 data (excluding Valhalla condensate).

The values of the slope and intercept vs. condensate density for Cold Lake and LLK blends are shown in the following figures.

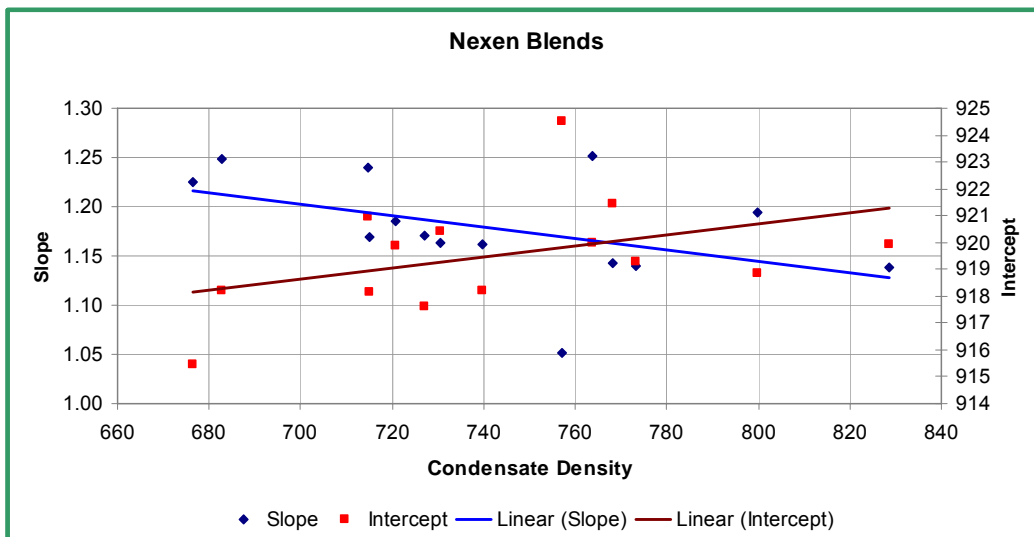
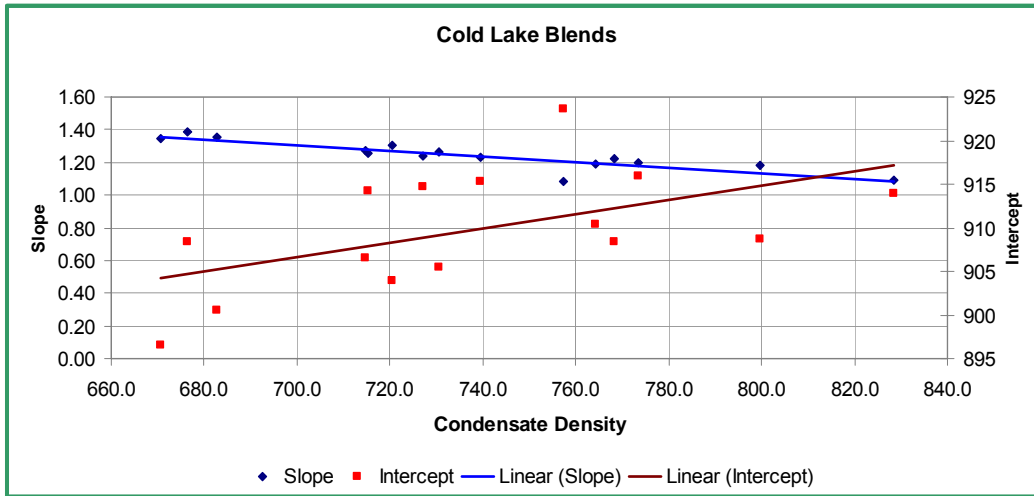


The following table summarizes the values of a1, b1, a2, b2 calculated for each of the bitumen using all 2006 data and 2001 data excluding the Valhalla stream as concluded in the 2001 report.

	Slope vs. Condensate Density			Intercept vs. Condensate Density		
	a1	b1	R square	a2	b2	R square
Cold Lake Blends	-0.00174	2.52645	0.77947	0.08222	849.09899	0.29120
LLK Blends	-0.00058	1.60790	0.20725	0.02055	904.23302	0.16961

Case 4 - Using 2006 data excluding PC 2001 data (excluding Valhalla condensate).

The values of the slope and intercept vs. condensate density for Cold Lake and LLK blends are shown in the following figures.

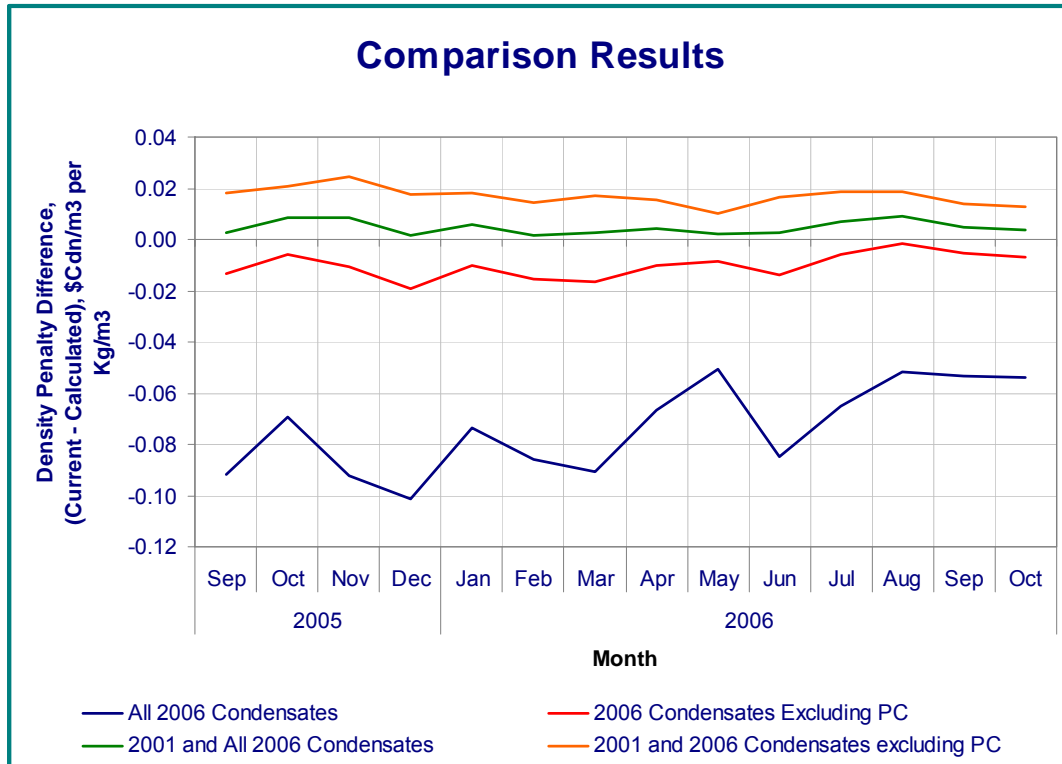


The following table summarizes the values of a1, b1, a2, b2 calculated for each of the bitumen using all 2006 excluding PC data and 2001 data excluding the Valhalla stream.

	Slope vs. Condensate Density			Intercept vs. Condensate Density		
	a1	b1	R square	a2	b2	R square
Cold Lake Blends	-0.00165	2.46643	0.91639	0.07311	854.93179	0.33101
LLK Blends	-0.00050	1.55775	0.28045	0.01737	906.23124	0.22410

Effect on Condensate Equalization

The following figure compares the effect that each of the case would have on the Condensate Equalization penalties.



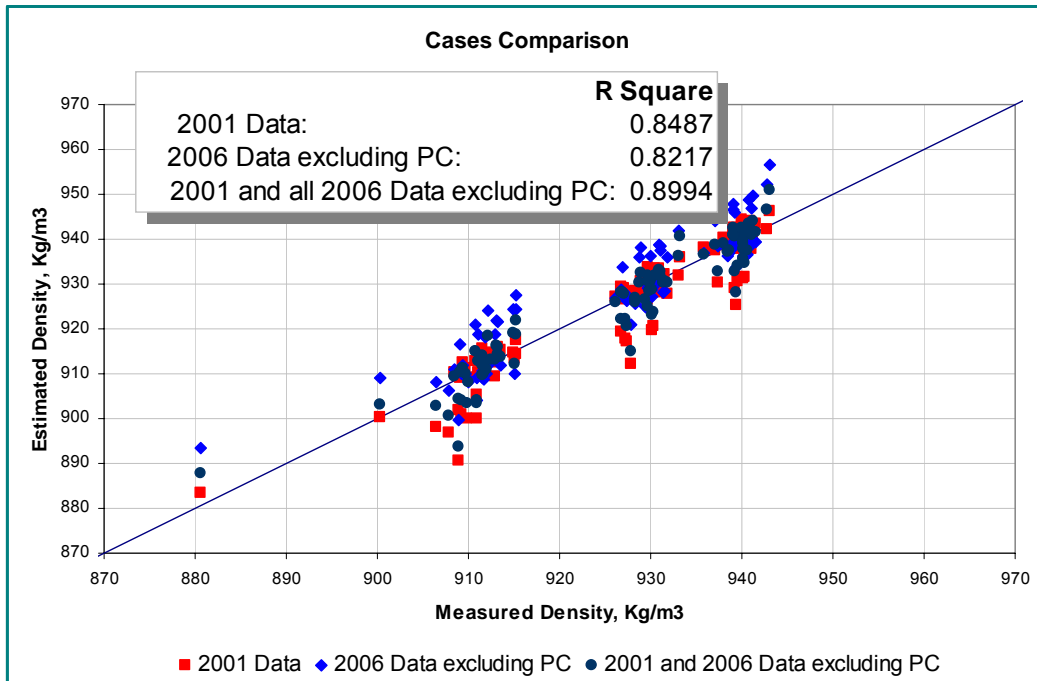
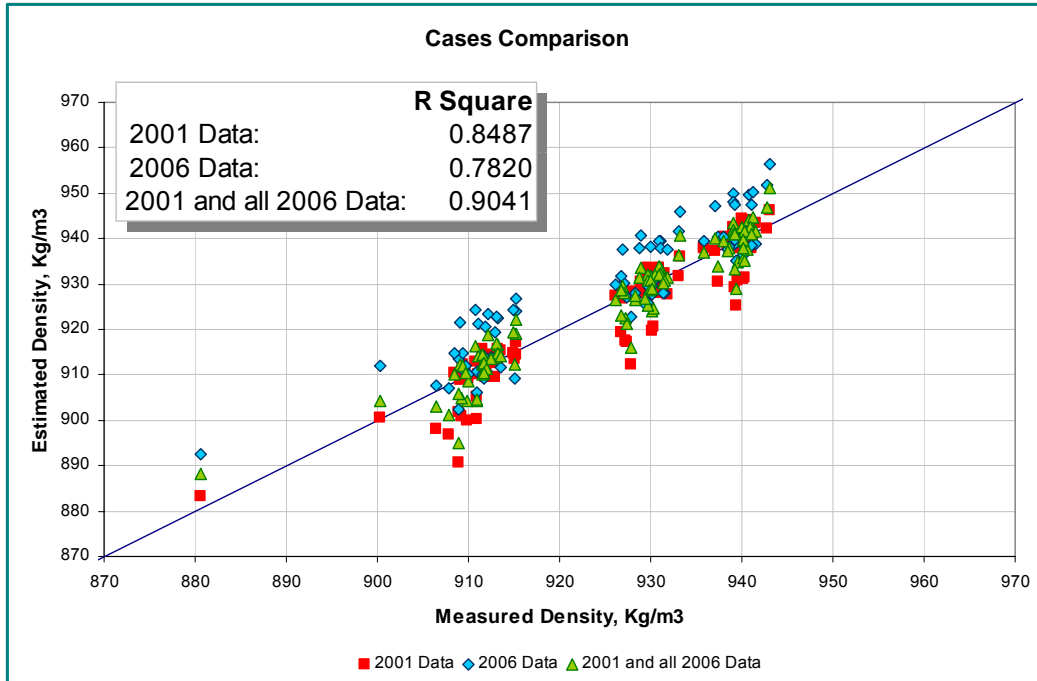
Prediction quality – Coefficient of determination

It is possible to obtain the temperature at which each blend will satisfy the 350cSt interpolating from the ASTM D341 graphics as shown in Appendix 2.

Knowing the temperature and the condensate density, the blend density is then estimated using the coefficients calculated for each case according with the following equation:

$$\rho_{blend} = (a_1 * \rho_{condensate} + b_1) * T_{reference} + (a_2 * \rho_{condensate} + b_2)$$

The following figures show the comparison of the measured density vs. the predicted density for each of the cases as well as with the actual set of coefficients (obtained from 2001 data excluding Valhalla).



2001 and 2006 data offers a better representation of the data. The following figure compares shows the effect of the Petro-Canada stream will make on the predictions.

