INDUSTRIAL
CASE STUDIES

830045

The Royal Purple® Advantage

TECHNICAL BENEFITS

INTRODUCTION

The industrial and racing markets associate outstanding quality and superior performance with Royal Purple. This reputation has been earned through Royal Purple's relentless pursuit of excellence in lubrication.

Royal Purple formulates the most advanced lubricants available on the market today. If you currently use Royal Purple's products, you already know this. If you do not, they offer the opportunity to greatly improve the reliability and efficiency of your equipment and to lower your operating costs.

SUPERIOR PRODUCTS, SUPERIOR PERFORMANCE

Lubricants are typically viewed as a commodity, where low price and service issues dominate purchase decisions. Therefore, oil companies seeking large market share have a great incentive to keep manufacturing costs low and little incentive to upgrade lubricant quality.

Royal Purple recognizes that lubricants are not a commodity. Reliable operation of rotating equipment critically depends upon the quality of the lubricant used. Lubricant performance directly and significantly affects how long, how reliable, how efficient and at what cost (i.e. parts, labor, downtime, number of oil changes and energy costs) your equipment will operate. Therefore, Royal Purple will always provide you with the highest quality lubricants available anywhere.

CASE STUDIES

CASE HISTORY QUADREX

RESULTS OF TEST WITH ROYAL PURPLE QUADREX SUPPLIED BY ELMAR FOR THE BIOGAS PLANT IN THE COMPANY AGRICOLA DALLA COSTA

APPLICATION: electric energy production in a Biogas plant using gas derived from animal, vegetable and feeding waste.

ENGINE TYPE: Jenbacher 316 detuned and limited , with a total production per hour of 600 kW. The Engine has a major overhaul every 30.000 h.

OIL IN USE: *mono-grade mineral oil* with an oil change interval every 1.600-1.800 h. the engine uses roughly 750/800 lt for each oil change and top off's.

TEST OIL: ROYAL PURPLE QUADREX 40HB (14TBN).

OBJECTIVES OF TEST

- test Quadrex for longer duration in service
- test for lower oil consumption
- verify greater engine efficiency
- calculate ROI to compensate the higher price of the oil based on the 3 above factors.

TEST DESCRIPTION

Together with the company Elmar, we decided to test Quadrex in a Jenbacher 316 that was installed at Agricola Dalla Costa (the engine chosen for the test had just be overhauled after 30.000 hours in service).

For the first 1.755 h the mineral oil for gas was used to get the baseline data of the engine in service.

The time period for the test was like so:
- start test: 08/04/2016
- end test: 28/12/2016
- Change oil to Quadrex
- monitor the quality of the oil by oil analysis with Mecoil
- samples taken at 500 , 1.902, 2.559, 2.863, 3.242 and 3.984 hours
- verification of the oil consumption and the energy produced with Dalla Costa

QUADREX HOURS IN SERVICES	COMMENTS ON OIL ANALYSIS
500	all values OK, silicon increased from 7 to 22 ppm
1.902	all values OK, silicon increased to 66 ppm
2.559	all values OK silicon stable, TAN increased, but TBN always more than double
2.863	all values OK, TAN slightly increased, TBN always more than double
3.242	all values OK, silicon increased to 76 ppm
3.984	all values OK, TBN increased due to top off of new oil at roughly 3.400 hours

CONSIDERATIONS ON THE OIL ANALYSIS

The incrementation in the silicon values was due to some changes in the quality of the gas. Thanks to the synthetic solvency, high TBN number and the high film strength of the Quadrex oil the incrementation of the TAN even over 3 did not create any problems in the quality of the oil and helped to maintain the engine clean even after 4.274 hours in service (Test ended and oil was changed). *Quadrex could have remained in service in the engine for even more than 4.500 hours.*

RESULTS OF TEST WITH ROYAL PURPLE QUADREX SUPPLIED BY ELMAR FOR THE BIOGAS PLANT IN THE COMPANY AGRICOLA DALLA COSTA

RESULTS (CALCULATED BASED ON THE WORSE WORKING CONDITIONS FOR QUADREX AND THE BEST WORKING CONDITIONS FOR THE *MONO-GRADE MINERAL OIL*)

OIL	MONO-GRADE MINERAL OIL	ROYAL PURPLE QUADREX
hours in service	1.800	4.274
total quantity of oil used	750 lt	1.200 lt (6 drums)
average oil consumption	0,41 lt	0,28 lt

hours in service +137%

Oil consumption -32%

INCREASED EFFICIENCY

The hourly energy production was calculated over a long period based on the progressive data shared during the test . This method was able to account for any positive or negative changes in the gas quality or any problems in the functioning of the production plant.

OIL	MONO-GRADE MINERAL OIL	ROYAL PURPLE QUADREX
period in service	04/01/2016 – 22/06/2016	23/06/2016 - 28/12/2016
energy produced	0,482 MWh	0,514 MWh

energy produced +6,23%

the results obtains are based on many factors, one being some adjustments to better the quality of the gas

> *Since we started using Quadrex gas engine oil the engine starts up much easier.*

Owner of the biogas plant at Dalla Costa

Valve inspection after 1.500 hours running on Quadrex.

All of the test data and oil analysis data are available upon request.

Renox srl
Via del Bosco, 12
60012 Trecastelli (AN) - Italy

tel. +39 071 7950558
fax +39 071 7952727

renox@renox.com
www.renox.com

Cooling Tower Drive

Energy Savings and Reliability Improvement

THE PERFORMANCE OIL THAT OUTPERFORMS®

GENERAL INFORMATION

Type of CTW Drive

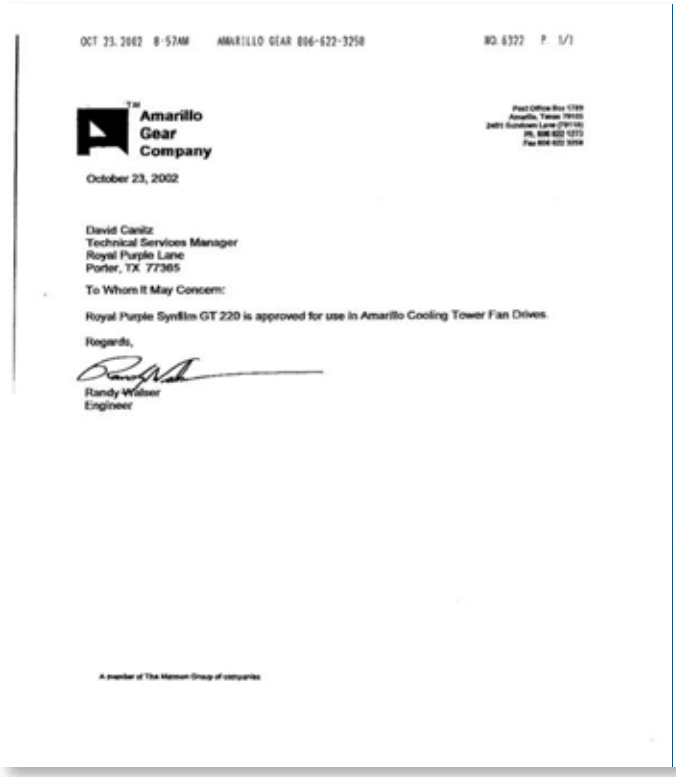
- Right Angle Gear Drive
  - Single Reduction
  - Double Reduction

Character of CTW Drive:

- Helical Gears
- Parallel Shafts
- Smooth Transmission Through Mesh
- Run Quiet Constant Reduce Speed

Sumitomo Drive Technologies · Amarillo Gear Company LLC · Marley · Hansen Transmissions

THE PERFORMANCE OIL THAT OUTPERFORMS®



OCT 23. 2002 8:57AM AMARILLO GEAR 806-622-3250 NO. 6322 P. 1/1

Amarillo Gear Company

Post Office Box 1789
Amarillo, Texas 79105
2401 Sundown Lane (79110)
Ph. 806-622-1273
Fax 806-622-3250

October 23, 2002

David Canitz
Technical Services Manager
Royal Purple Lane
Porter, TX 77365

To Whom It May Concern:

Royal Purple Synflim GT 220 is approved for use in Amarillo Cooling Tower Fan Drives.

Regards,

Randy Widner
Engineer

A member of The Manson Group of companies

***RECOMMENDED MINERAL OILS**

AMBIENT TEMPERATURE AT GEAR DRIVE	20° F to 120° F (-7° C to 49° C)
AGMA LUBRICANT NUMBER	5
ISO GRADE	220
Atlantic Richfield Co. Chevron Oil Co. Cities Service Oil Co. Conoco Exxon Company Gulf Oil Corp. Mobil Oil Corp. Pennzoil Phillips Petroleum Co. Shell Oil Co. Sun Oil Co. Texaco Inc. Total	Duro 220 Rando HD 220 Citgo Pacemaker 220 Hydroclear Multipurpose R & O Oil 220 Teresstic 220 Harmony 220 DTE Oil BB Pennrotbell TO 220 Magnus 220 Morlina SD 220 Sunvis 9220 Regal 220 R & O, Code 1531 Cartec 220

*LIST OF BRAND NAMES IS FOR PURPOSE OF IDENTIFYING TYPES AND IS NOT TO BE CONSTRUED AS EXCLUSIVE RECOMMENDATIONS.

***RECOMMENDED SYNTHETIC LUBRICANTS**

AMBIENT TEMPERATURE AT GEAR DRIVE	-20° F to 150° F (-29° C to 66° C)
AGMA LUBRICANT NUMBER	5S
ISO GRADE	220
Chevron Oil Co. Conoco Mobil	Clarity 220 Synthetic Syncon 220 – R & O Oil SHC 630 SHC 630*

LUBRICATION: Use only Rust and Oxidation Inhibited Gear Oils in accordance with AGMA (American Gear Manufacturers Association). Standard 9005-E02 (or most recent edition of the standard). For general operating conditions, use a lubricant having an AGMA lubricant number of 5. Gear oils containing Extreme Pressure (EP) additives are not recommended, and should never be used on gear drives equipped with the nonreverse option.

If the gear drive is started when the ambient temperature is below 20° F (-7° C), use a lube oil heater or a recommended synthetic oil. Lube oil heaters and synthetic oil are extra cost accessories that can be ordered with new gear drives or installed in the field.

SYNTHETIC LUBRICANTS: Synthetic lubricants offer advantages of extended service life, a broader operational temperature range, reduced friction, and the ability to maintain a higher film strength which can extend the service life of the gear drive. When the operating temperature exceeds 180° F (82° C) or the gear drive is started when the ambient temperature is below 20° F (-7° C), a synthetic lubricant is recommended. Synthetic lubricants can be made of various base stocks which are incompatible with certain gear drive components. Therefore, any synthetic lubricant not listed in this bulletin should be approved by Amarillo Gear Company. Do not use synthetic lubricants made from ester base stocks. Change intervals for synthetic lubricants should not be extended beyond the change interval for mineral oils without a comprehensive monitoring program.

CHANGE INTERVAL: The original oil should be replaced after 500 hours of operation or four weeks, whichever comes first. It is recommended that the oil be drained when it is at or near operating temperature. Refill the drive with the recommended type and amount of lubricant.

Normally the oil should be changed every 2500 hours or every six months, whichever comes first. Shorter change intervals of two or three months may be required if the gear drive is subjected to unusual operating conditions such as very moist atmosphere, rapid temperature changes, consistent high operating temperature or any conditions that tend to contaminate the oil or promote the formulation of sludges and deposits inside the gear case.

The vertical and horizontal shafts are equipped with grease lubricated dual seals. Relubrication is not required.

OIL CAPACITY

SINGLE REDUCTION DRIVES

MODEL	GALLONS	LITERS
65A	.5	2
85	1	4
110	2	8
135	3	11
155	5.5	21
175	5.5	21

DOUBLE REDUCTION DRIVES

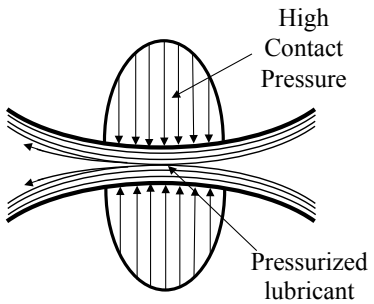
MODEL	GALLONS	LITERS
1308	6	23
1110	8.5	32
1311	14	53
1712	21	80
1712.5	22	83
1713A	24	91
1814	31	117
2016	53	201

Amarillo® Gear Company LLC

SYNFILM GT® | HIGH PERFORMANCE MULTI-PURPOSE INDUSTRIAL OIL

Features and Benefits:

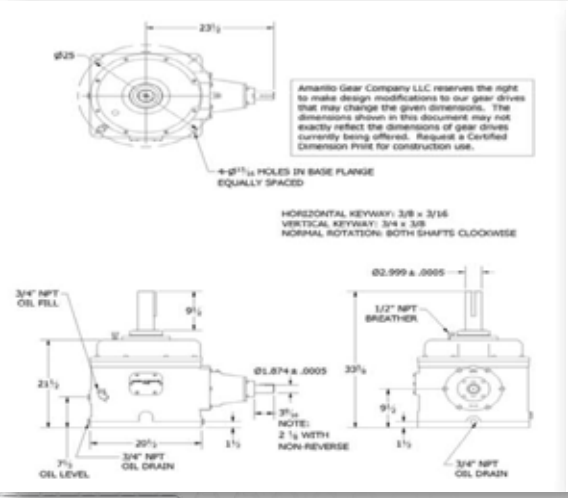
- High Performance Multi-purpose Industrial Oils
- Synerlec® Additive Technology
- Available in ISO VG 32, 46, 68, 100, 150, 220, 320, 460, 680
- Synthetic Oil for Long Life, Superior Film Strength
- High Viscosity Index - Holds Viscosity at Higher Temperatures
- Gears Run Smoother and Quieter
- Increased Lubricity - Extreme Energy Efficiency
- Rapidly Separates from Water
- Lowers Gearbox Temperatures
- Suitable for All Gearbox Types and Bearings



ROYAL PURPLE SYNTHETIC OIL

THE PERFORMANCE OIL THAT OUTPERFORMS®

OPERATION AND MAINTENANCE INSTRUCTION



Amarillo Series Model 175 Fan Drive

Ratings:

Service Horsepower Ratings (HP) at (Service Factor = 2.0)									
Input(RPM)	Nominal Ratio								
	5.5	6.0	6.5	7.0	7.5	8.0	8.5	9.0	9.5
1750	126	112	105	100	80	60	60	60	50
1450	104	92	87	83	66	50	50	50	41
1160	84	74	70	66	53	40	40	40	33

Thrust:
Vertical Shaft Down Thrust Capacity: 5150 lbs.

Oil Capacity:
ISO Grade 220/ AGMA Lubricant Number 5 or 5S. Extreme Pressure additives are not recommended.
Capacity: 5.5 Gallons/21 Liters

Weight:
Domestic Shipping Weight: 855 lbs.
Weight with Export Boxing: 940 lbs.

Shipping Info:
Export Box Dimensions (L x W x H): 40in x 27in x 41in.

ADDITIONAL INFORMATION

Survey Conditions:

- All units are fixed speed.
- All surveys were operated at normal speed.

Factors that were not calculated in the savings:

- Longer service life of the equipment due to improved lubrication, reduced friction, increased component protection.
- Reduced maintenance requirements, longer component life, less replacement parts and labor.
- Increase in Lubricant Life, based on oil analysis.

TIMELINE FOR IMPLEMENTATION

Timeline to Implement Royal Purple at CTW Fan Area

No.	Topics	by	Apr-15				May-15				Jun-15				Jul-15				Aug-15			
			W1	W2	W3	W4	W1	W2	W3	W4	W1	W2	W3	W4	W1	W2	W3	W4	W1	W2	W3	W4
1	Approach / Issue	CTT		7																		
2	Before Change Lubricant - Unit B by Collect: 2.1. Amp / Volt / PF	CTT				27																
3	Change Oil & After01 - Unit B by Collect: 2.1. Amp / Volt / PF					28	9															
4	After02 - Unit B by Collect: Amp/Volt/PF	CTT					4		22													
5	After03 - Unit B by Collect: Amp/Volt/PF	CTT														9	17					
6	Conclusion / Re-Approach	CTT															17					
8	Before Change Lubricant - Unit H by Collect Amp	CTT																24	7			
9	Change Oil & After01 - Unit H by Collect Amp	CTT																			18	25
10	After02 - Unit H by Collect Amp	CTT																				
11	After03 - Unit H by Collect Amp	CTT																				
12	After04 - Unit H by Collect Amp	CTT																				
13	After05 - Unit H by Collect Amp	CTT																				
14	Used Oil Sampling for Analysis	CTT																				
15	After06 - Unit H by Collect Amp	CTT																				
16	After07 - Unit H by Collect Amp	CTT																				
17	Conclusion																					

OILS CHANGEOVER

THE PERFORMANCE OIL THAT OUTPERFORMS®

INNOVEK COOLING TOWERS, CELL H

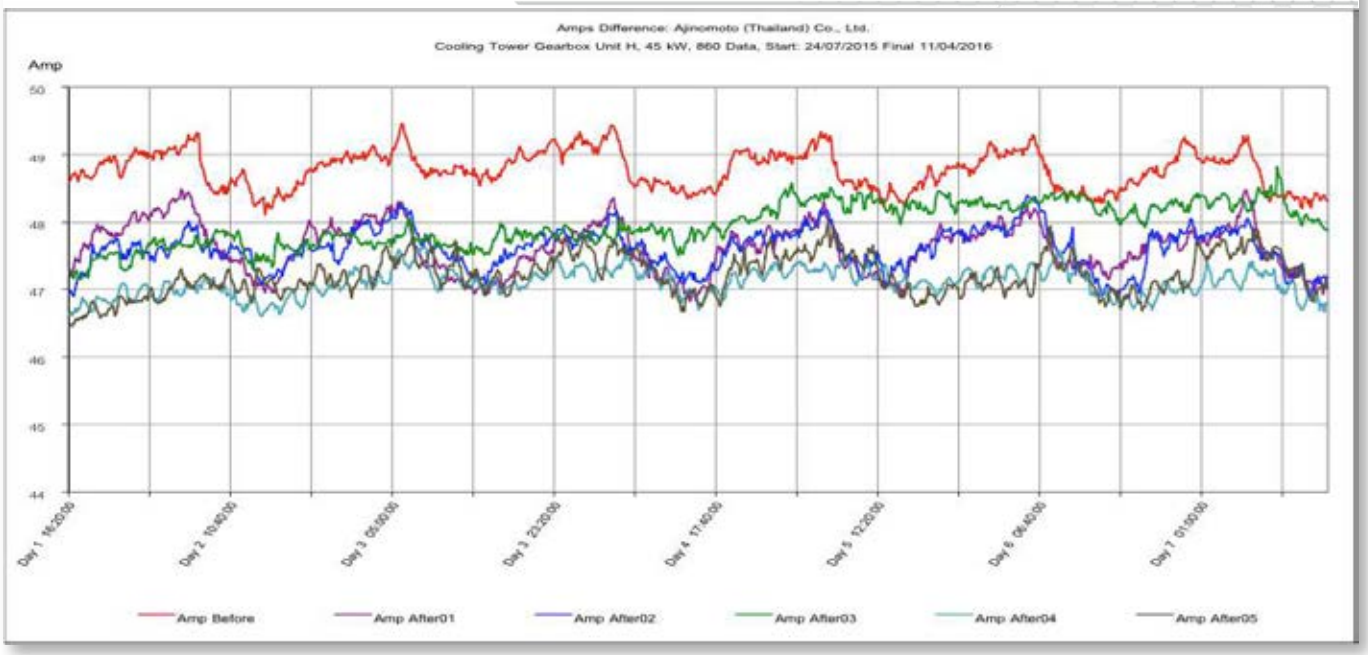
Purpose of Trial: Achieve Operating Costs Reduction Through Energy Saving
Using Royal Purple's Premium Synthetic Lubricant

Trial Equipment: Amarillo FD175 (Unit H), Driven by: Electric Motor, 45 kW, Input 1,750 rpm
380V 3PhaseServiced: N/A hrs Energy Cost: 3.50 THB/Unit
Oil Capacity: 21 Liters Oil Serviced: 3,600 hrs

Before Change: Aug 08, 2015 **After Change:** Sep 28 2015 to 11 Apr 2016
Existing Oil: Mobilgear 600 XP 220 (Mineral) **New Oil:** Royal Purple Synfilm GT 220

Trial Result:	**Existing Oil**	**RP Synfilm GT 220**	
kW (Amps)	32.10 (48.78)	31.19 (47.39)	(2.85 % Reduction)
kWh/Month	23,112 kwh	22,456.8 kwh	
Cost/Month	80,892 THB	78,598.8 THB	
Annual Cost (330 Days)	889,812 THB	864,586.8 THB	
SAVINGS with Energy Efficient Lubricant		**2,293.2 THB/Month.**	**25,225.2 THB/Year**

INNOVEK COOLING TOWERS, CELL H



SUMMARY OF SAVINGS FOR MANAGEMENT

Decreasing Electric Motor Current by 3.0%

Based on the same oil usage life at 12 months

	Oil cost per year	
Before Upgrade	55,500.00	THB
After upgrade	106,074.00	THB

Estimate Gear oil cost , : Mobilgear 220 @ TH
Mobil SHC 630 @ THB350/litre
Royal Purple Synergy 220 @ THB426/litre

3.Return of economy comparison

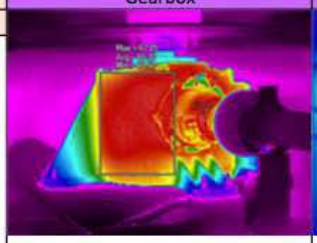
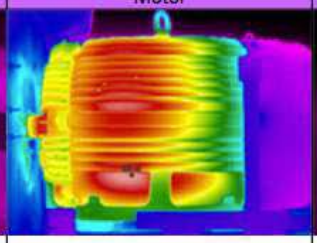
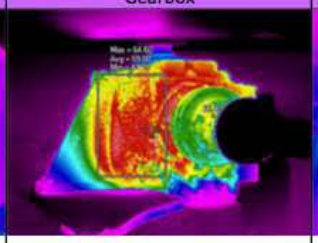
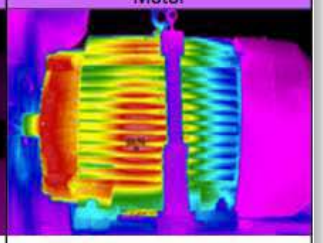
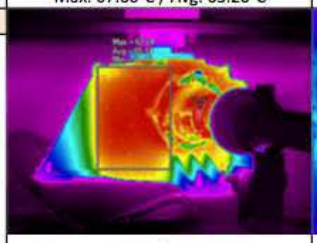
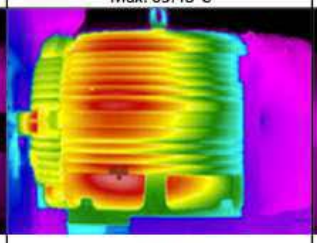
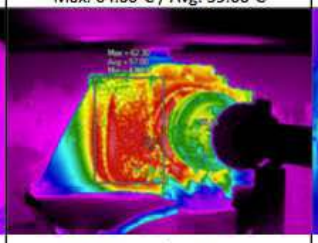
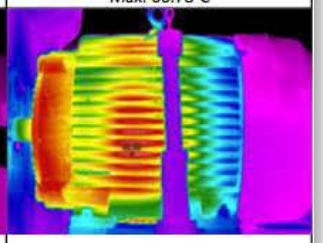
Description	Unit	Mobil ISO VG 220	Synergy/Synfilm GT 220
Gear oil investment	THB	55,500.00	106,074.00
Energy saving	THB/year	Non	321,499.21
Profits (Bonus) after Free Lubricant Cost	THB	Non	215,425.21
Return of investment within	Months	Non	3.63

CONDITION-BASED MONITORING

Used Oil Analysis

CONDITION-BASED MONITORING

Thermography Inspection

Date	CTW #B I RP Synergy 220		CTW #C I RP Synergy 220	
	Gearbox	Motor	Gearbox	Motor
07/07/2017				
	Max. 67.60°C / Avg. 65.20°C	Max. 65.48°C	Max. 64.60°C / Avg. 59.00°C	Max. 66.78°C
08/15/2017				
	Max. 68.97°C / Avg. 65.14°C	Max. 66.63°C	Max. 62.30°C / Avg. 57.00°C	Max. 62.59°C

CONTACT US

For questions or more information please contact one of the Royal Purple Thailand Team.

Suphasit C. - Technical Sales, 099 251 7997
suphasit@chiengthai.com

Yuttaphume K. - Technical Sales, 087 905 8185
yuttaphume@chiengthai.com

THE PERFORMANCE OIL THAT OUTPERFORMS®

ROYAL PURPLE® SYNTHETIC OIL

Steel Plant : Rayong, Thailand Land - Cooling Tower

Energy Savings and Lubrication Improvement

THE PERFORMANCE OIL THAT OUTPERFORMS®

ENERGY SAVINGS AND LUBRICATION IMPROVEMENT

The Equipment Information : Mechanical

Application	: Cooling Tower – Single Reduction Fan Drive
Machine No.	: Cooling Tower No.2
Manufacturer	: Amarillo Gear Company (Texas, USA)
Model	: F155 (Serial No. 328215)
Impellers	: 6 pcs

ROYAL PURPLE® SYNTHETIC OIL

THE PERFORMANCE OIL THAT OUTPERFORMS®

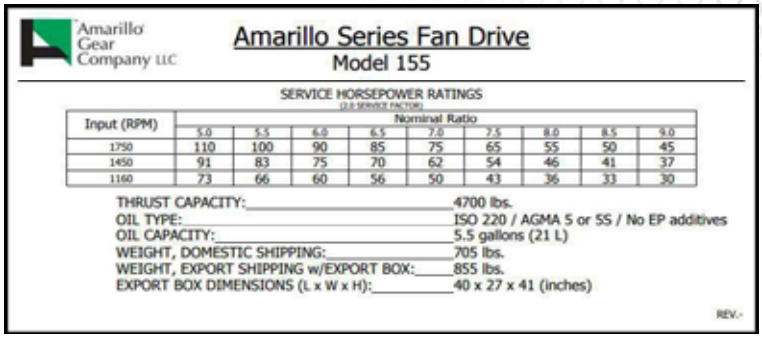
ENERGY SAVINGS AND LUBRICATION IMPROVEMENT

The Equipment Information : Electrical

Driven by : Siemens Motor, 45 kW (82 Amp)
Volt : 400V / 3Phase3Wire
Breaker Position : NFB-05, M-3-2 Cooling Tower Circuit Breaker
Energy Cost : **3.5** THB/Unit (Approx.)

ENERGY SAVINGS AND LUBRICATION IMPROVEMENT

The Equipment Information : Lubrication



Amarillo Gear Company LLC

Amarillo Series Fan Drive
Model 155

SERVICE HORSEPOWER RATINGS
(1.0 SERVICE FACTOR)

Input (RPM)	Nominal Ratio								
	5.0	5.5	6.0	6.5	7.0	7.5	8.0	8.5	9.0
1750	110	100	90	85	75	65	55	50	45
1450	91	83	75	70	62	54	46	41	37
1160	73	66	60	56	50	43	36	33	30

THRUST CAPACITY: 4700 lbs.
OIL TYPE: ISO 220 / AGMA 5 or 5S / No EP additives
OIL CAPACITY: 5.5 gallons (21 L)
WEIGHT, DOMESTIC SHIPPING: 705 lbs.
WEIGHT, EXPORT SHIPPING w/EXPORT BOX: 855 lbs.
EXPORT BOX DIMENSIONS (L x W x H): 40 x 27 x 41 (inches)
REV.-

Oil Capacity : 21 Liters (Not include piping)
OEM Oil Spec : ISO 220 / AGMA 5 or 5S / No EP additives
Oil Serviced : 816 hrs. (on 18 May 2018)
Oil Change Interval : **6** Months (Last Change 14 Apr 2018)
Existing Oil Type : **Shell Morlina 220 (Mineral Oil)**
Oil Analysis : No

ROYAL PURPLE SYNTHETIC OIL
THE PERFORMANCE OIL THAT OUTPERFORMS

***RECOMMENDED MINERAL OILS**

AMBIENT TEMPERATURE AT GEAR DRIVE	20° F to 120° F (-7° C to 49° C)
AGMA LUBRICANT NUMBER	5
ISO GRADE	220
Atlantic Richfield Co. Chevron Oil Co. Cities Service Oil Co. Conoco Exxon Company Gulf Oil Corp. Mobil Oil Corp. Pennzoil Phillips Petroleum Co. Shell Oil Co. Sun Oil Co. Texaco Inc. Total	Duro 220 Rando HD 220 Citigo Pacemaker 220 Hydroclear Multipurpose R & O Oil 220 Teresstic 220 Harmony 220 DTE Oil BB Pennzbell TO 220 Magnus 220 Morlina SD 220 Sunvis 9220 Regal 220 R & O, Code 1531 Carter 220

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AMBIENT TEMPERATURE AT GEAR DRIVE	-20° F to 150° F (-29° C to 66° C)
AGMA LUBRICANT NUMBER	5S
ISO GRADE	220
Chevron Oil Co. Conoco Mobil	Clarity 220 Synthetic Syncon 220 – R & O Oil SHC 630 SHC 630*

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The vertical and horizontal shafts are equipped with grease lubricated dual seals. Relubrication is not required.

OIL CAPACITY

SINGLE REDUCTION DRIVES

MODEL	GALLONS	LITERS
65A	.5	2
85	1	4
110	2	8
135	3	11
155	5.5	21
175	5.5	21

DOUBLE REDUCTION DRIVES

MODEL	GALLONS	LITERS
1008	6	23
1110	8.5	32
1311	14	53
1712	21	80
1712.5	22	83
1713A	24	91
1814	31	117
2016	53	201

Amarillo® Gear Company LLC

OCT 23. 2002 8:57AM AMARILLO GEAR 806-622-3250 NO. 6322 P. 1/1

Amarillo Gear Company

Post Office Box 1789
Amarillo, Texas 79105
2401 Sundown Lane (79118)
Ph. 806 622 1273
Fax 806 622 3258

October 23, 2002

David Canitz
Technical Services Manager
Royal Purple Lane
Porter, TX 77365

To Whom It May Concern:

Royal Purple Synfilm GT 220 is approved for use in Amarillo Cooling Tower Fan Drives.

Regards,

Randy Walser
Engineer

A member of The Mannon Group of companies

***RECOMMENDED MINERAL OILS**

AMBIENT TEMPERATURE AT GEAR DRIVE	20° F to 120° F (-7° C to 49° C)
AGMA LUBRICANT NUMBER	5
ISO GRADE	220
Atlantic Richfield Co. Chevron Oil Co. Cities Service Oil Co. Conoco Exxon Company Gulf Oil Corp. Mobil Oil Corp. Pennzoil Phillips Petroleum Co. Shell Oil Co. Sun Oil Co. Texaco Inc. Total	Duro 220 Rando HD 220 Citigo Pacemaker 220 Hydroclear Multipurpose R & O Oil 220 Teresstic 220 Harmony 220 DTE Oil BB Pennzbell TO 220 Magnus 220 Morlina SD 220 Sunvis 9220 Regal 220 R & O, Code 1531 Carter 220

*LIST OF BRAND NAMES IS FOR PURPOSE OF IDENTIFYING TYPES AND IS NOT TO BE CONSTRUED AS EXCLUSIVE RECOMMENDATIONS.

***RECOMMENDED SYNTHETIC LUBRICANTS**

AMBIENT TEMPERATURE AT GEAR DRIVE	-20° F to 150° F (-29° C to 66° C)
AGMA LUBRICANT NUMBER	5S
ISO GRADE	220
Chevron Oil Co. Conoco Mobil	Clarity 220 Synthetic Syncon 220 – R & O Oil SHC 630 SHC 630*

LUBRICATION: Use only Rust and Oxidation Inhibited Gear Oils in accordance with AGMA (American Gear Manufacturers Association), Standard 9005-E02 (or most recent edition of the standard). For general operating conditions, use a lubricant having an AGMA lubricant number of 5. Gear oils containing Extreme Pressure (EP) additives are not recommended, and should never be used on gear drives equipped with the nonreverse option.

If the gear drive is started when the ambient temperature is below 20° F (-7° C), use a lube oil heater or a recommended synthetic oil. Lube oil heaters and synthetic oil are extra cost accessories that can be ordered with new gear drives or installed in the field.

SYNTHETIC LUBRICANTS: Synthetic lubricants offer advantages of extended service life, a broader operational temperature range, reduced friction, and the ability to maintain a higher film strength which can extend the service life of the gear drive. When the operating temperature exceeds 180° F (82° C) or the gear drive is started when the ambient temperature is below 20° F (-7° C), a synthetic lubricant is recommended. Synthetic lubricants can be made of various base stocks which are incompatible with certain gear drive components; therefore, any synthetic lubricant not listed in this bulletin should be approved by Amarillo Gear Company. Do not use synthetic lubricants made from ester base stocks. Change intervals for synthetic lubricants should not be extended beyond the change interval for mineral oils without a comprehensive monitoring program.

CHANGE INTERVAL: The original oil should be replaced after 500 hours of operation or four weeks, whichever comes first. It is recommended that the oil be drained when it is at or near operating temperature. Refill the drive with the recommended type and amount of lubricant.

Normally the oil should be changed every 2500 hours or every six months, whichever comes first. Shorter change intervals of two or three months may be required if the gear drive is subjected to unusual operating conditions such as very moist atmosphere, rapid temperature changes, consistent high operating temperature or any conditions that tend to contaminate the oil or promote the formulation of sludge and deposits inside the gear case.

The vertical and horizontal shafts are equipped with grease lubricated dual seals. Relubrication is not required.

OIL CAPACITY

SINGLE REDUCTION DRIVES

MODEL	GALLONS	LITERS
65A	.5	2
85	1	4
110	2	8
135	3	11
155	5.5	21
175	5.5	21

DOUBLE REDUCTION DRIVES

MODEL	GALLONS	LITERS
1008	6	23
1110	8.5	32
1311	14	53
1712	21	80
1712.5	22	83
1713A	24	91
1814	31	117
2016	53	201

Amarillo® Gear Company LLC

ENERGY SAVINGS AND LUBRICATION IMPROVEMENT

Power Consumption Comparison Condition

⇩

Avg. Amp

⇩

Cal. kW

⇩

Cal. SEC

1.Use Dent Elite Pro – power data logger collected data only "**Amp**"

2.Calulation kW by fixed Volt = 400 V, PF = 0.86 and actual Avg Amp 3 Phase with formula

P (Kw) = 1.732 x PF x **I(Amp)** x V(volt) / 1000
Unit = kW x Hrs
Cost = Unit x **3.5** (THB)

3.Calculation % Saving by formula

% Saving = [(kW.Before – kW.After) / kW.Before] x 100

4.Comparision Specific Energy Consumption **(SEC)** head to head by Average kW/hr of same operating condition

TIMELINE FOR IMPLEMENTATION

Timeline to Implement Royal Purple at Cooling Tower Gear Box No.2

No.	Topic	By	Time																													
			Mar-18				Apr-18				May-18				Jun-18				Jul-18				Aug-18				Sep-18						
			W1	W2	W3	W4	W1	W2	W3	W4	W1	W2	W3	W4	W1	W2	W3	W4	W1	W2	W3	W4	W1	W2	W3	W4	W1	W2	W3	W4	W1	W2	W3	W4
1	Approach / Issue	CTT			16																											
2	Change PTT Gear Oil EP320 New Oil							14																								
3	Before Collect Data									27					4																	
	3.1 Amp / Volt / PF / kW (Service Oil 816 hrs)	CTT												18	4																	
	3.2 Thermal Image	CTT								27		14			4																	
4	Change Royal Purple Oil																19															
5	Test Peak Load Start - Stop	CTT															19															
6	After Collect Data																19									10						
	6.1 Amp / Volt / PF / kW (Service Oil 840 hrs)	CTT																				24				9						
	6.2 Thermal Image	CTT															19		6		16					10						
7	1st Conclusion	CTT																														
8	Thermal Image Monitoring	CTT	Every 3 Month																													
9	Used Oil Analysis	CTT	On May 2019																													
10	Final Conclusion	CTT	On June 2019																													

Service Oil 34 Day

Service Oil 35 Day

THE PERFORMANCE OIL THAT OUTPERFORMS

ENERGY SAVINGS AND LUBRICATION IMPROVEMENT

Data Before Record

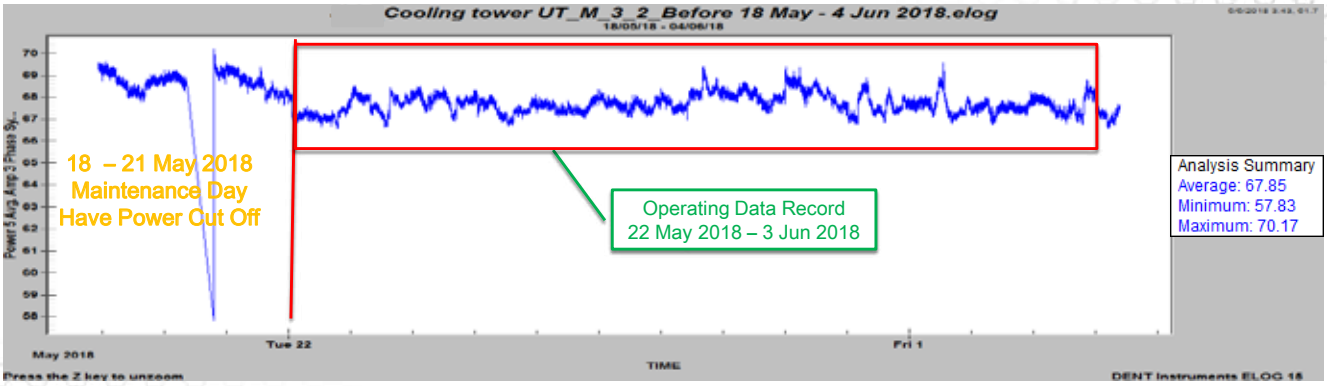
Shell

Data Before

THE PERFORMANCE OIL THAT OUTPERFORMS

ENERGY SAVINGS AND LUBRICATION IMPROVEMENT

Data Before Record Condition

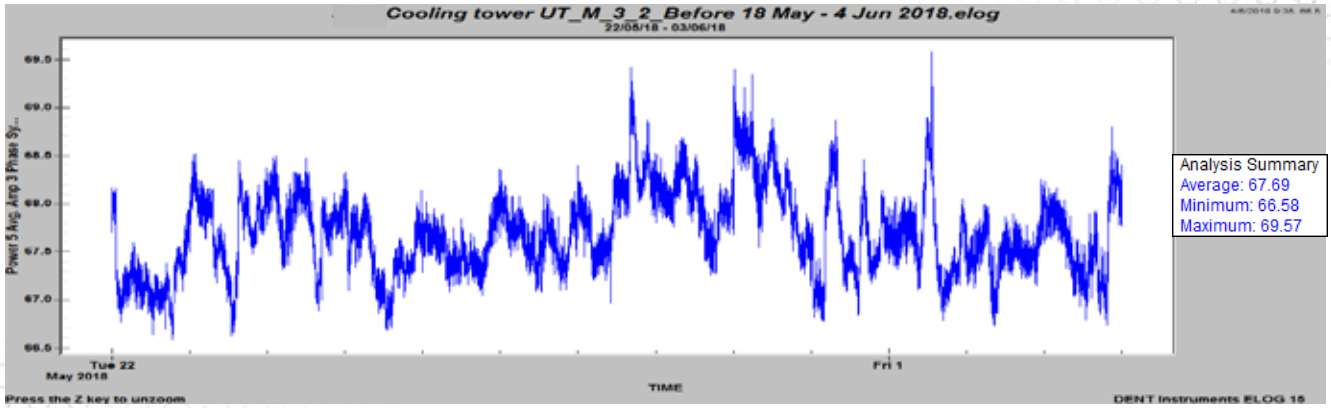


Record Interval	: 1 Minute
Service Oil	: 816 – 1,248 hrs. (34 - 52 day)
Data Before Record Since	: 18 May 2018 – 4 Jun 2018 (18 Day – 23,070 Data)
Data Before Analysis	: **22 May 2018 – 00.00.00 am to 3 Jun 2018 – 23.59.59 pm (13 Operating Day – 18,719 Data)**

THE PERFORMANCE OIL THAT OUTPERFORMS

ENERGY SAVINGS AND LUBRICATION IMPROVEMENT

Data Amp Before OP Day 22 May – 3 Jun 2018

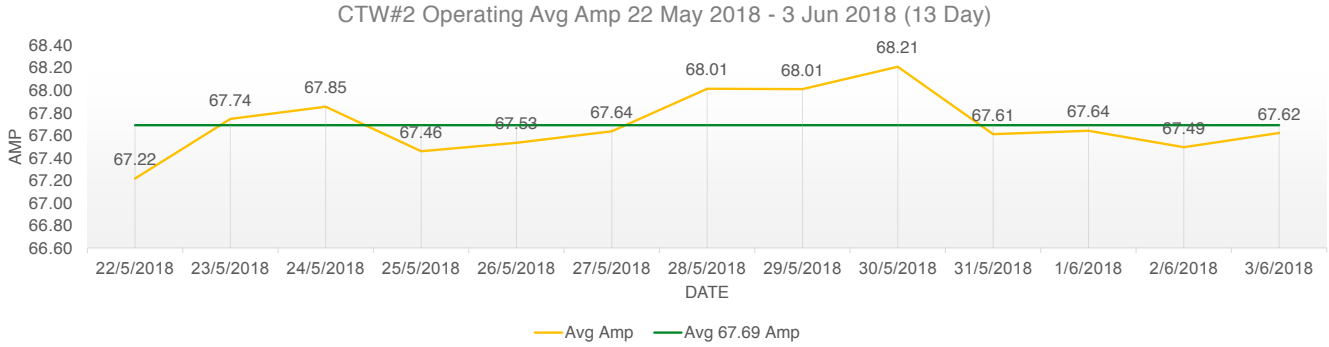


Actual Motor Operating : **Average 67.69 A** or **82.55%** (100%@ 82A)
Min 66.58 A , Max 69.57 A

Amp Fluctuate from Average : **4.42%**

ENERGY SAVINGS AND LUBRICATION IMPROVEMENT

Data Avg. Amp Before Analysis



Average Amp used = **67.69 A**

Average Power Energy Used (P)
= (1.732 x Amp. x Volt x Cos Ø) / 1000
= (1.732 x **67.69 A** x 400 V x 0.86) / 1000
= **40.33 kW/hr**

ENERGY SAVINGS AND LUBRICATION IMPROVEMENT

Data Avg. Operating Cost Before

Operating Energy Consumption Cost

Cal. = 40.33 kW * 3.5 THB/Unit

or **= 141.155** THB/hr.

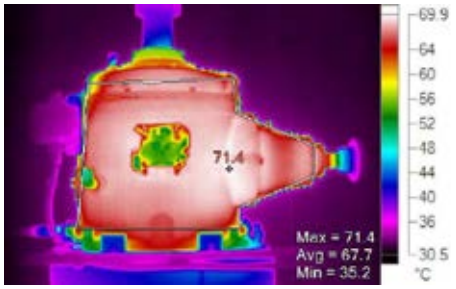
or **= 3,387.72** THB/Day (24 hr)

or **= 101,631.60** THB/Month (30 Day)

or **= 1,219,579.20** THB/Year !!!!

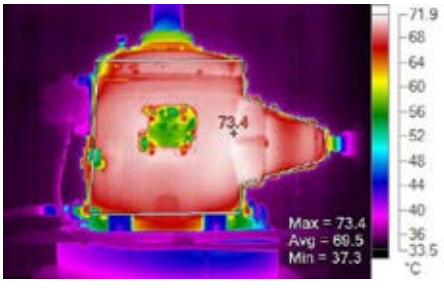
LUBRICATION IMPROVEMENT

Before Thermal Image Monitoring



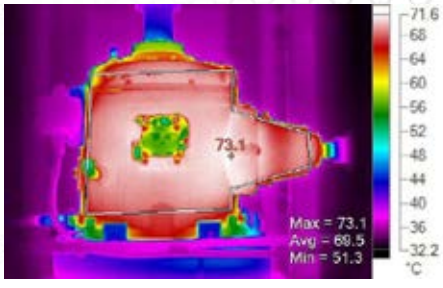
IR_03896.IS2
4/27/2018 3:22:19 PM

Max. = 71.40°C
Avg. = 67.70°C



IR_03998.IS2
5/14/2018 12:16:46 PM

Max. = 73.40°C
Avg. = 69.50°C

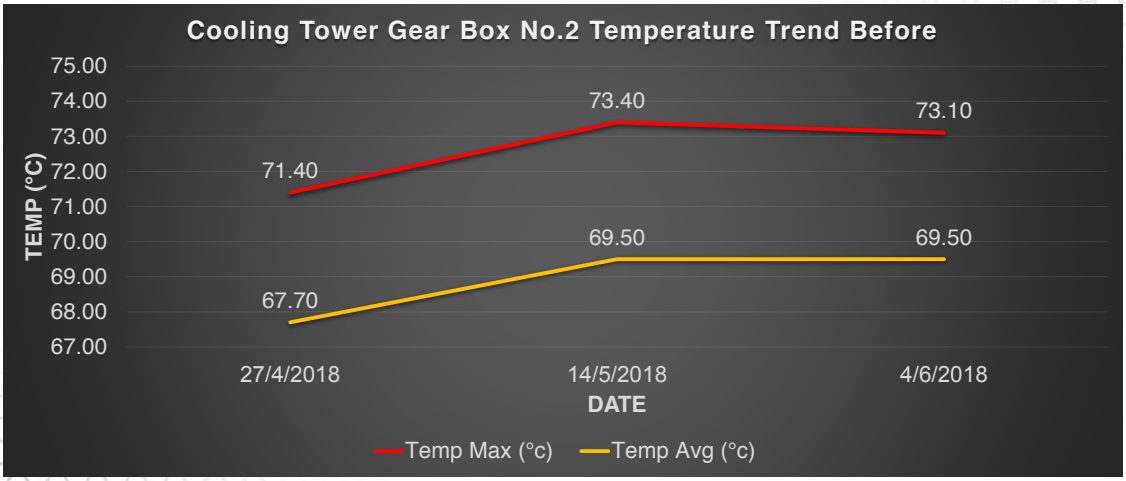


IR_04146.IS2
6/4/2018 9:42:08 AM

Max. = 73.10°C
Avg. = 69.50°C

LUBRICATION IMPROVEMENT

Before Thermal Image Monitoring



THE PERFORMANCE OIL THAT OUTPERFORMS

OILS CHANGEOVER

Date 19 June 2018

Shell

OIL

ROYAL PURPLE SYNTHETIC OIL

Oil Change

THE PERFORMANCE OIL THAT OUTPERFORMS

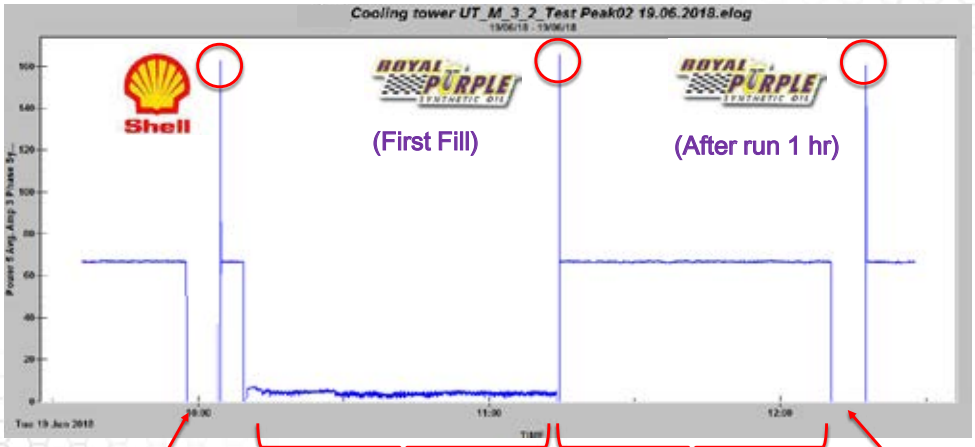
OILS CHANGEOVER

Date 19 June 2018

THE PERFORMANCE OIL THAT OUTPERFORMS

OILS CHANGEOVER

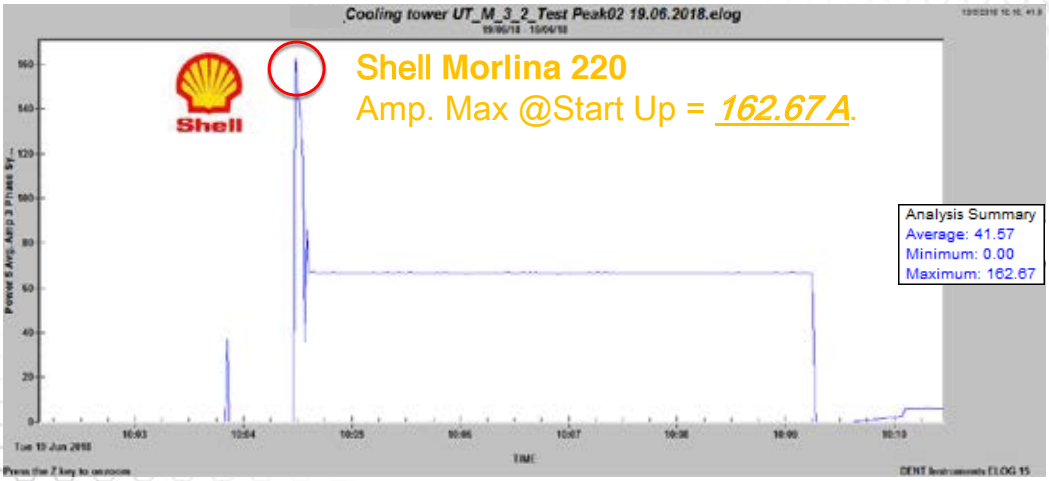
Date 19 June 2018 – Peak Load Start



THE PERFORMANCE OIL THAT OUTPERFORMS

OILS CHANGEOVER

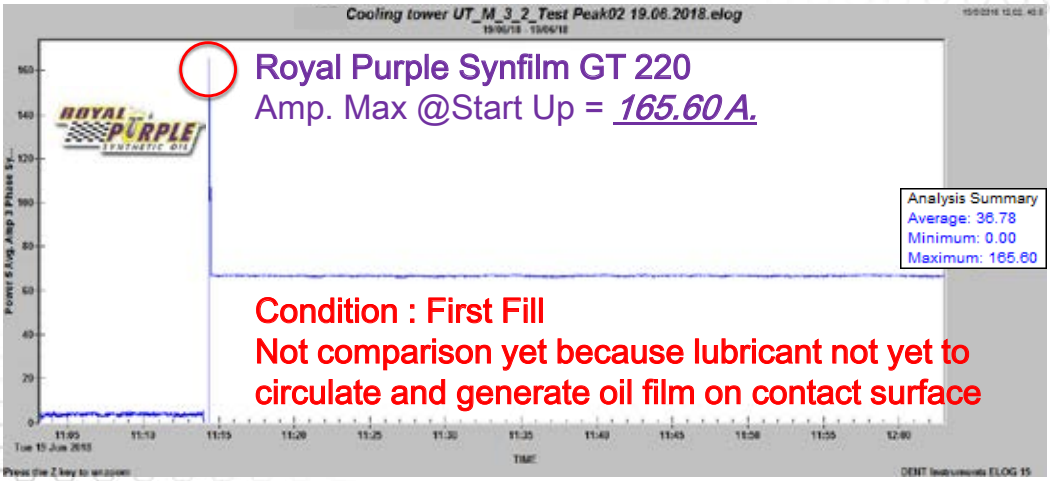
Date 19 June 2018 – Peak Load Start



THE PERFORMANCE OIL THAT OUTPERFORMS

OILS CHANGEOVER

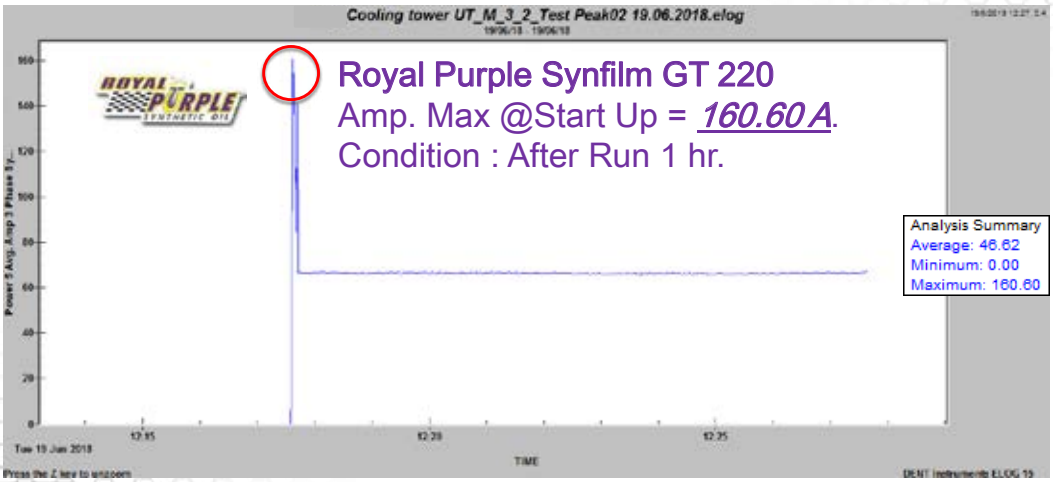
Date 19 June 2018 – Peak Load Start



THE PERFORMANCE OIL THAT OUTPERFORMS

OILS CHANGEOVER

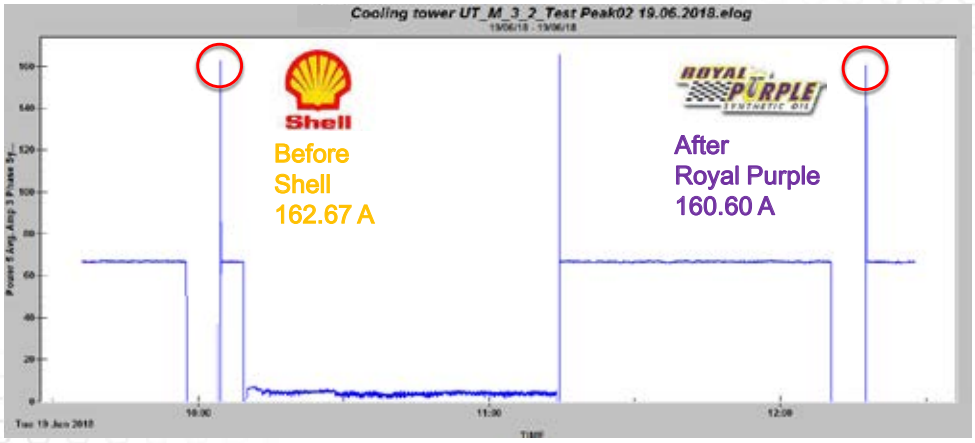
Date 19 June 2018 – Peak Load Start



THE PERFORMANCE OIL THAT OUTPERFORMS®

OILS CHANGEOVER

Date 19 June 2018 – Peak Load Start



Peak Load Start Reduction 1.27% !!!

THE PERFORMANCE OIL THAT OUTPERFORMS®

ENERGY SAVINGS AND LUBRICATION IMPROVEMENT

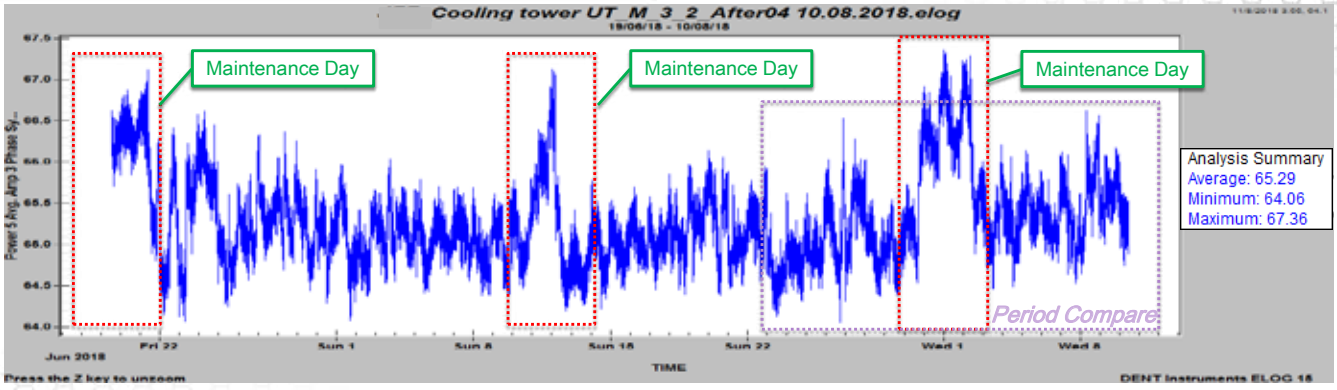
Data After Record

Data After

THE PERFORMANCE OIL THAT OUTPERFORMS

ENERGY SAVINGS AND LUBRICATION IMPROVEMENT

Data After Record Condition

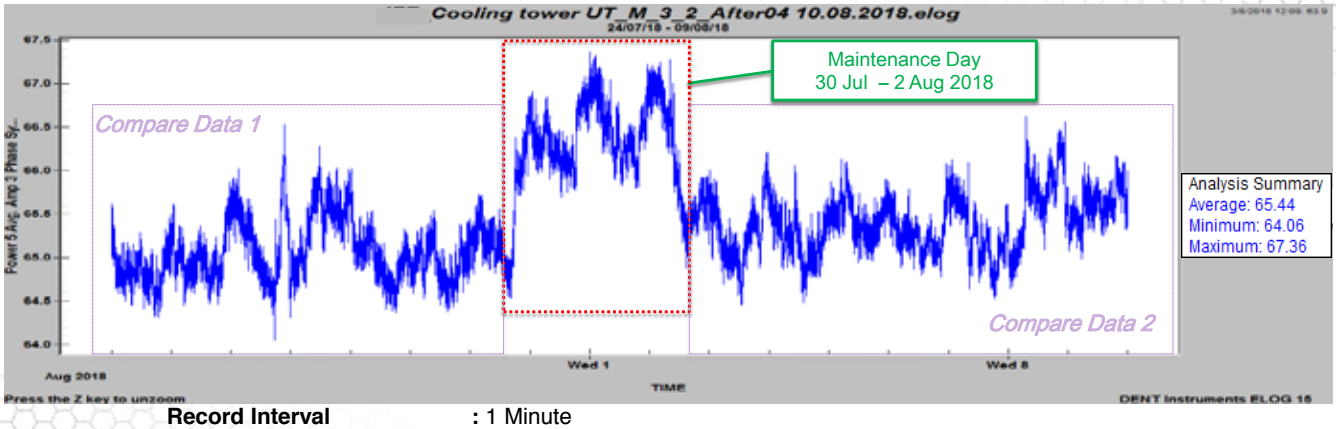


Record Interval	**:** 1 Minute
Service Oil	**:** 1 - 1,248 hrs. (1 - 52 day)
Data After Record Since	**:** 19 Jun 2018 – 10 Aug 2018 (52 Day – 74,794 Data)
Data After Analysis	**: 24 July 2018 – 00.00.00 am to 9 Aug 2018 – 23.59.59 am (14 Operating Day – 20,159 Data)**

THE PERFORMANCE OIL THAT OUTPERFORMS

ENERGY SAVINGS AND LUBRICATION IMPROVEMENT

Data After Record Condition

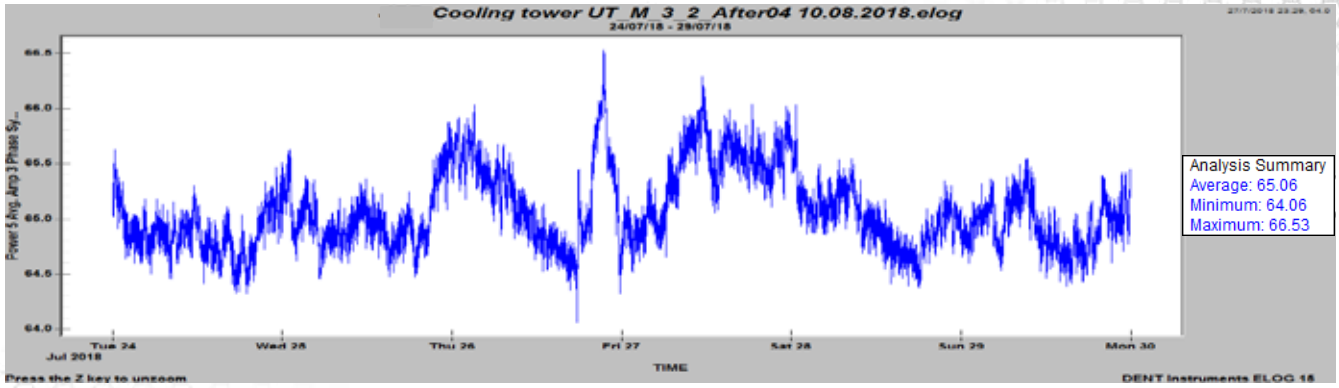


Record Interval : 1 Minute
Service Oil : 840 - 1,248 hrs. (35 - 52 day)
Data After Analysis : **24 Jul 2018 – 00.00.00 am to 9 Aug 2018 – 23.59.59 pm**
(13 Operating Day – 18,719 Data) *Not include* Maintenance Day Condition
(30 July 2018 – 00.00.00 am to 2 Aug 2018 – 23.59.59 pm)

THE PERFORMANCE OIL THAT OUTPERFORMS®

ENERGY SAVINGS AND LUBRICATION IMPROVEMENT

Data Amp After Record (Compare Data 1)

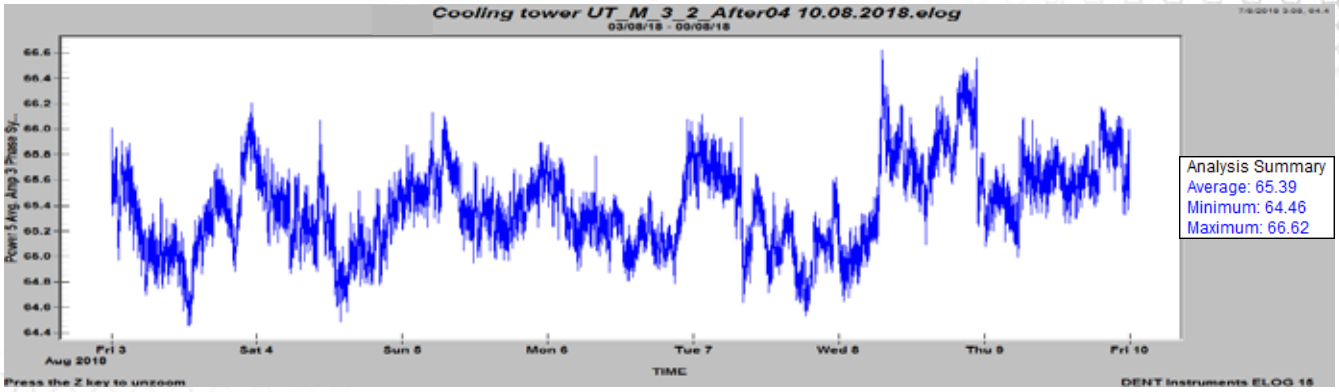


Data After Analysis (Compare Data1) : **24 Jul 2018 – 00.00.00 am to 29 Jul 2018 – 23.59.59 pm**
Actual Motor Operating : **Average 65.06 A** or **79.34%** (100%@ 82A)
Min 64.06 A , Max 66.53 A
Amp Fluctuate from Average : **3.79%**

THE PERFORMANCE OIL THAT OUTPERFORMS®

ENERGY SAVINGS AND LUBRICATION IMPROVEMENT

Data Amp After Record (Compare Data 2)

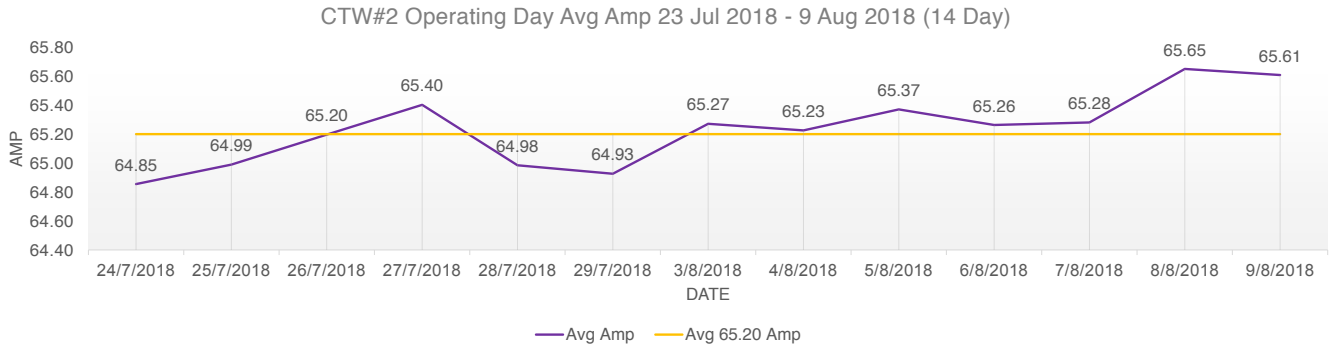


Data After Analysis (Compare Data1) : **3 Aug 2018 – 00.00.00 am to 9 Aug 2018 – 23.59.59 pm**
Actual Motor Operating : **Average 65.39 A** or **79.74%** (100%@ 82A)
Min 64.46 A , Max 66.62 A

Amp Fluctuate from Average : **3.30%**

ENERGY SAVINGS AND LUBRICATION IMPROVEMENT

Data Avg. Amp Before Analysis



Average Amp used = **65.20 A**

Average Power Energy Used (P) = (1.732 x Amp. x Volt x Cos Ø) / 1000
= (1.732 x **65.20 A** x 400 V x 0.86) / 1000
= **38.85 kW/hr**

ENERGY SAVINGS AND LUBRICATION IMPROVEMENT

Data Avg. Operating Cost After

Operating Energy Consumption Cost

Cal. = 38.85 kW * 3.5 THB/Unit

or **= 135.975** THB/hr.

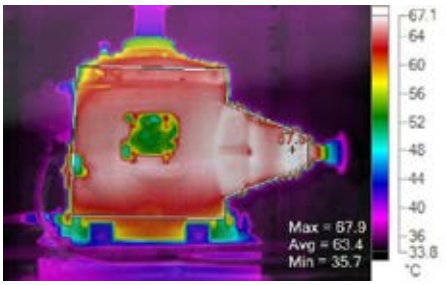
or **= 3,263.40** THB/Day (24 hr)

or **= 97,902.00** THB/Month (30 Day)

or **= 1,174,824.00** THB/Year !!!!

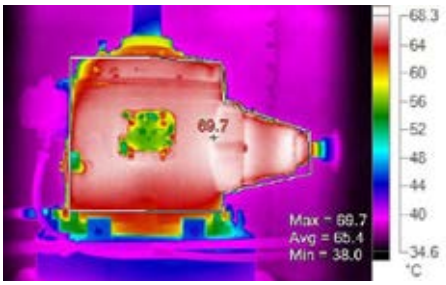
LUBRICATION IMPROVEMENT

After Thermal Image Monitoring



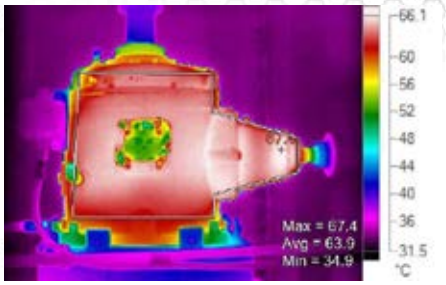
IR_04554.IS2
6/7/2018 2:45:59 PM

Max. = 67.90°C
Avg. = 63.40°C



IR_04657.IS2
23/7/2018 3:02:11 PM

Max. = 69.70°C
Avg. = 65.40°C

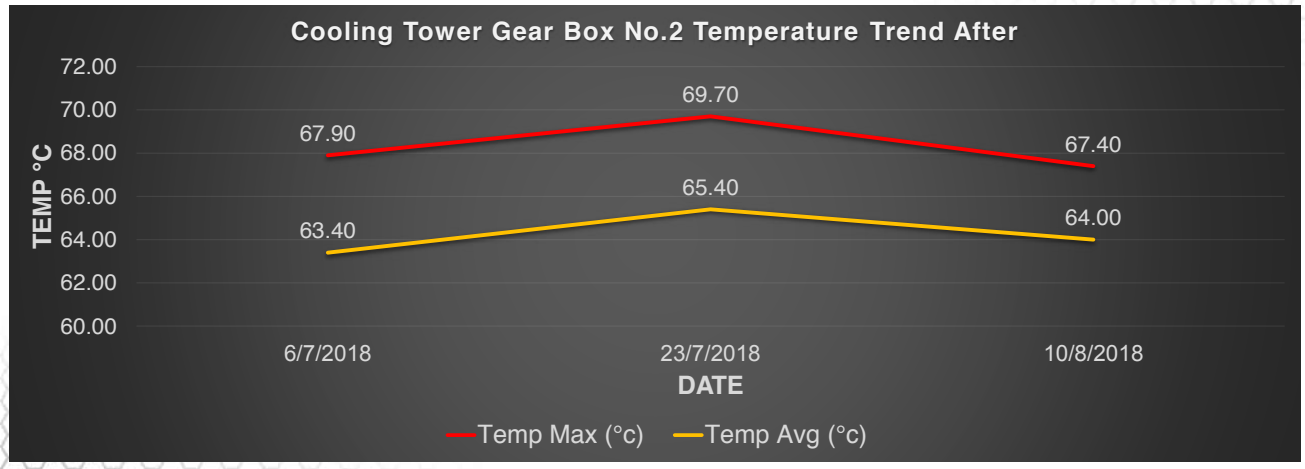


IR_00157.IS2
10/8/2018 10:59:29 AM

Max. = 67.40°C
Avg. = 64.00°C

LUBRICATION IMPROVEMENT

After Thermal Image Monitoring



THE PERFORMANCE OIL THAT OUTPERFORMS®

ENERGY SAVINGS AND LUBRICATION IMPROVEMENT

COMPARISONS ANALYSIS

Shell

Comparisons

Before & After

ROYAL PURPLE SYNTHETIC OIL

THE PERFORMANCE OIL THAT OUTPERFORMS®

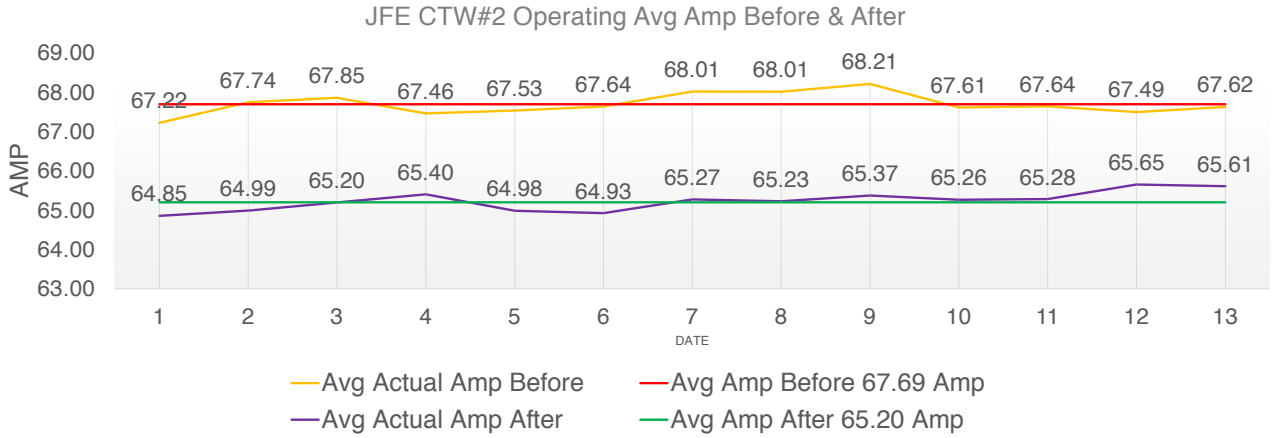
ENERGY SAVINGS AND LUBRICATION IMPROVEMENT

COMPARISONS ANALYSIS

Topic	Before	After	Difference (%)
Time Record	22 May – 3 Jun 2018	24 Jul - 9 Aug 2018	-
Data Quantity	18,719	18,719	-
Oil	Shell Morlina 220	RP Synfilm GT 220	-
Avg. Amp	67.69	65.20	2.49 (- 3.68%)
Avg. Cal. kWh	40.33	38.85	1.48 (- 3.68%)
Avg. Max Operating Temp (°C)	72.63	68.33	4.30 (- 5.92%)
Operating Cost : Cal @ 3.5 THB/Unit			
Hr	141.15	135.97	5.18
Day	3,387.72	3,263.40	124.32
Month	101,631.60	97,902.00	3,729.60
Year	1,219,579.20	1,174,824.00	44,755.20

ENERGY SAVINGS AND LUBRICATION IMPROVEMENT

COMPARISONS ANALYSIS

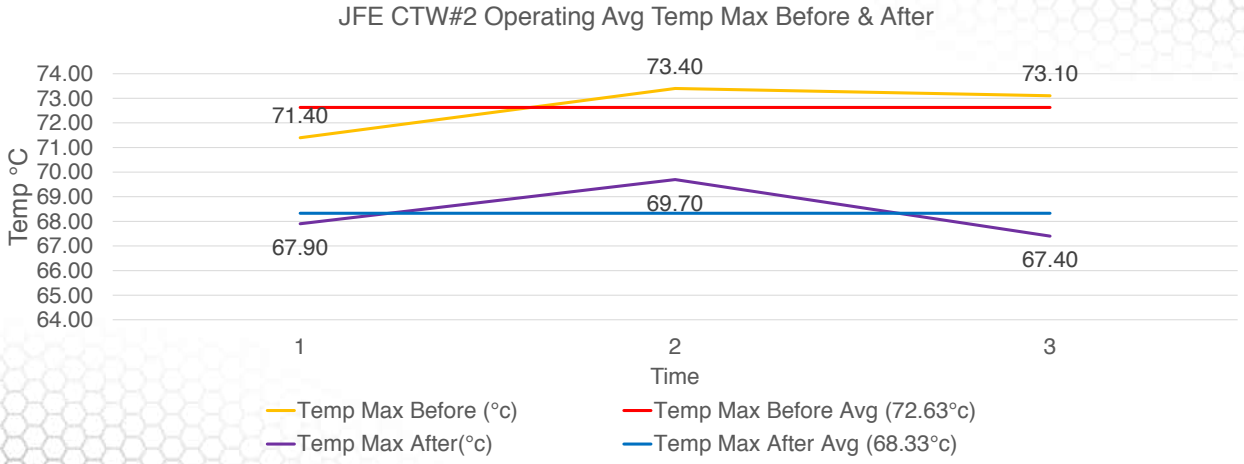


Amp. Reduction 3.68% !!!

THE PERFORMANCE OIL THAT OUTPERFORMS

ENERGY SAVINGS AND LUBRICATION IMPROVEMENT

COMPARISONS ANALYSIS



Temp. Reduction 5.92% !!!

ENERGY SAVINGS AND LUBRICATION IMPROVEMENT

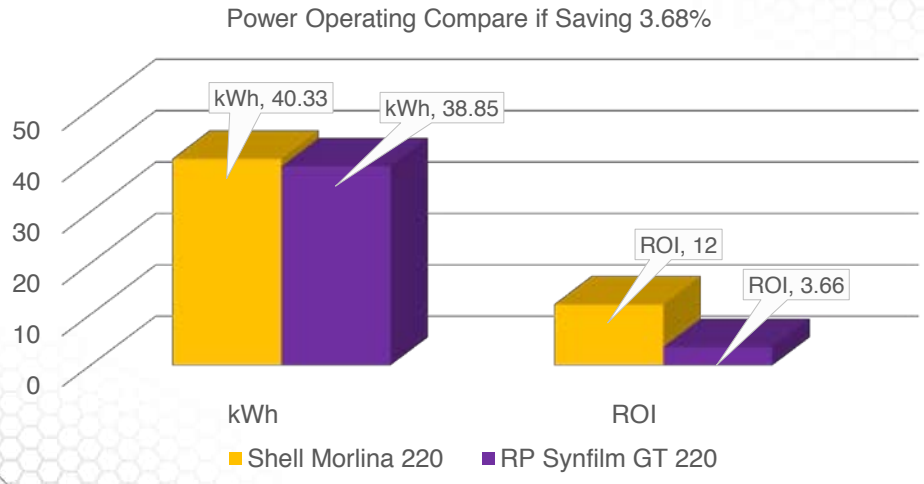
ECONOMICS SAVINGS CALCULATION

Time	Oil	Avg. kWh	Diff
[Before] 22 May – 3 Jun 2018	Shell Morlina 220	40.33	-1.48
[After] 19 Jun - 6 Jul 2018	RP Synfilm GT 220	38.85	

- **Savings (only due to Electric Consumption) = 3.68%**
  1.48 kWh X 24 hrs X 360 days (12 Months) = 12,787.20 unit/year
  12,787.20 X 3.5 Bath = 44,755.20 THB/year
- **Cost of Royal Purple Oil (23 Liter) = 14,950 THB**
- **Return Of Investment with RP Synfilm GT 220 = 4.01 Month !!!**

ENERGY SAVINGS AND LUBRICATION IMPROVEMENT

ECONOMICS SAVINGS CALCULATION

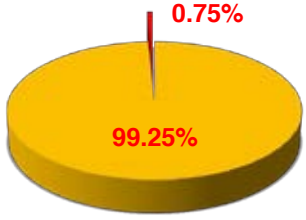


THE PERFORMANCE OIL THAT OUTPERFORMS

ENERGY SAVINGS AND LUBRICATION IMPROVEMENT

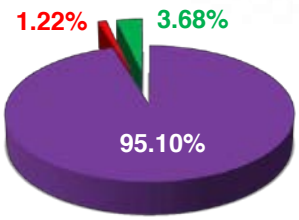
THE BIG PICTURE OF TCO

The Big Picture **Before**



Shell Lubricant Cost (Approx. 200THB/L)
= 23L * 200THB/L * 2
= 9,200 THB / Year
= 0.754 % of Energy operating cost
(1,219,579.20 THB/Year)

The Big Picture **After**



Profit Up 2.46% !!!

Royal Purple Lubricant Cost (650 THB/L)
= 23L * 650THB/L
= 14,950 THB / Year
= 1.22 % of Existing Energy operating cost
Energy Saving = 44,755.30 THB
= 3.68% of Existing Energy operating cost

THE PERFORMANCE OIL THAT OUTPERFORMS

ENERGY SAVINGS AND LUBRICATION IMPROVEMENT

OTHER ADVANTAGE BENEFIT

Reduction CO_2 Equivalent (Carbon Handprint)
= 12,787.20 unit/year X 0.6093 kg.CO2/kWh
= 7,791.24 kg.CO_2/year

Decrease
- Operating Max Temperature Avg. ***4.30 °C (5.92%)***
- Shock Load / Peak Load Start ***1.27%***
- Waste Disposal **23 Liter/year**
- Maintenance Job & Labor Cost & Time

Increase
- Machine Reliability
- Life of machine components
- Oil Change Interval from **6 month to 12 month**

THE PERFORMANCE OIL THAT OUTPERFORMS®

ROYAL PURPLE® SYNTHETIC OIL

Tough Jobs
Require Tough Solution.

THE PERFORMANCE OIL THAT OUTPERFORMS®

ARGOS CEMENT PLANT

CARTAGENA - COLOMBIA

2015

Product: Royal Purple – Max Chain

Climbing rack limestone reduction of power consumption, increases loading capacity 40% and reduces noise by 70%. And the material does not stick to the chain.

Argos personnel installing hoses and sprinklers

Chains lubricated with used oil (**cost 0**, they user whatever lubricant left overs or used lubricant). Without load 5,8 Amps, with load up to 18 Amps

Chains lubricated with Royal Purple MaxChain (**cost $$**) Without load 3,6 Amps, with load up to 7,2 Amps, 40% less power consumption.

After Royal Purple:

- No chain derailment
- 40% less power consumption
- Less maintenance needed
- 35% more load capacity
- 70% less noise

Energy Audit
Kaeser DS 201 Compressor
Equipment 3A

Grand Haven Board of Light and Power
J.B. Sims Generating Station

SUPERIOR LUBRICATION DELIVERS RESULTS

PURPOSE OF TEST: TO SHOW REDUCED ELECTRICAL CONSUMPTION THROUGH THE USE OF SUPERIOR LUBRICATION.

EQUIPMENT TESTED: **Kaeser DS 201 Compressor / Set as Primary Compressor (Base Load)**
480 Volt connection measuring Current and Voltage

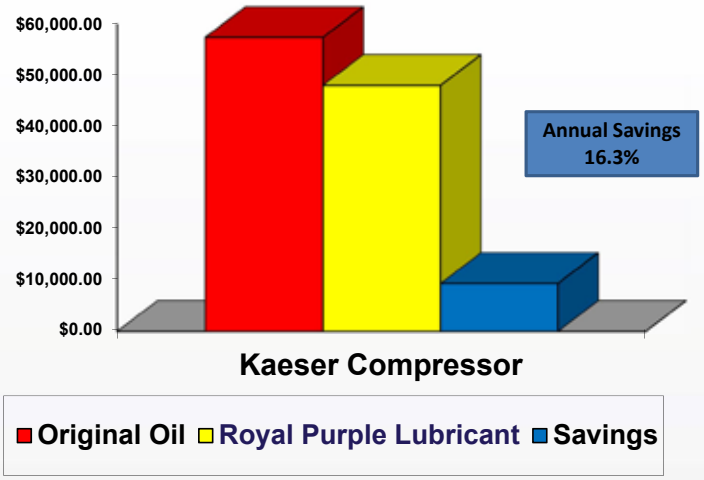
Test Date of the Competitive Lubrication: July 11, 2016
Test Date of Royal Purple Synfilm GT 46: August 29, 2016

LUBRICANT: AC-8000P (Chemlube 228) **LUBRICANT:** Royal Purple Synfilm GT 46
APPLIED: Reservoir

RESULTS:	**Original Oil**	**Royal Purple Synfilm GT**	
KILOWATT HOURS	130.9 kwh	108.7 kwh	**(16.3% Reduction)**
KILOWATT HOURS/Month	95,775.9 kwh	80,164.1 kwh	
COST Elapsed @ $0.0525/KWH	$4.24	$4.03	
COST PER MONTH@ $0.0525/KWH	$4,788.79	$4,008.20	
ANNUAL COST	$57,465.48	$48,098.40	
SAVINGS with ENERGY EFFICIENT LUBRICANTS		**$780.59 per month $9,367.08 per year**	

The tested Kaeser Compressor is representative of a normal base load unit with no known mechanical or electrical issues. Estimated Annual Electrical Savings for this unit are $9,367.08 or a 16.3% reduction as compared to the competitive lubricant.

SUPERIOR LUBRICATION DELIVERS RESULTS



SUMMARY – KAISER COMPRESSOR

Superior Lubricants Save Energy

The Kaeser Compressor was not known to have mechanical or electrical issues at the time the Energy Audit was conducted..

The survey did show an estimated average annual savings of $9,367.08 or 16.3% comparing the Competitive Oil to Royal Purple Synfilm GT.

Royal Purple Synfilm GT showed a reduction in **Total Energy Elapsed** during the data collection in kilowatt/hour, when compared to the Competitive Oil. **Total Energy Elapsed** reduction of **(-16.3%)**

Conclusion:
The Kaeser Compressor worked less to generate the same amount of work with Royal Purple Synfilm GT filled to the proper level in the system reservoir.

SURVEY CONDITIONS

Survey Conditions:

Unit is a Kaeser DS 201 Rotary Screw Air Compressor with over 90,000 operational hours. The unit was set-up as the Primary compressor during testing. The unit was shutdown and the connections were made to the contactor in the main power box. After terminations were achieved, the connections were confirmed, Left to right C-3, B-2 and A-1. The Compressor was started and allowed to run for data collection. Data was collected over a 30 minute time period to achieve the most realistic data possible. The compressor did load and unload multiple times during the data collection process. On July 11, 2016, the competitive test date, the ambient temperature was 78 degrees with 70% humidity. On August 29, 2016, the Royal Purple Synfilm GT test, the ambient temperature was 80 degrees with 67% humidity. During the test oil temperatures were collected from the compressor digital readout. The competitive oil temperature was 189.9 degrees and with Royal Purple Synfilm GT the oil temperature dropped to 179 degrees.

SURVEY CONDITIONS

Energy cost estimated at $0.05 per kwh on a 30 Day Month. Annual cost estimates are $0.05 per kwh on a 12 month basis using 30 days per month.

Givens:

Work required of the Compressor to generate air is directly related to the torque through the system and coefficient of friction of the dynamic moving components. A reduction in energy needed to generate air is related to the coefficient of friction between the components. A reduction in electrical energy will indicate reduced coefficient of friction and improved lubrication of the components.

Factors that were not calculated in the savings:

- Longer Service Life of the equipment due to Improved Lubrication
- Reduction of Friction, Heat and Equipment Wear
- Reduced Maintenance Requirements, Replacement Parts and Labor
- Increase in Lubricant Life based on Oil Analysis

Superior Lubricants Save Energy

All Royal Purple Lubricants are formulated to protect with High Film Strength proprietary formulations.

Royal Purple's high film strength prevents metal to metal contact even at heavy loads.

Preventing metal to metal contact reduces parasitic loss, returns some lost efficiency and prevents wear.

Royal Purple Lubricants can greatly extend Lubricant life in equipment and recommends changing oil based on quality oil analysis reporting.

Superior Lubricants Save Energy

Royal Purple would like to thank Mike Kellogg, Facilities Maintenance Supervisor, and Shawn Kuck, Procurement, at J.B. Sims Generating Station for their allowance and participation in completing this safe and successful Royal Purple Synfilm GT trial and Energy Audit on the sites Kaeser DS 201 Rotary Screw Compressor.

For questions or more information please contact:
John Koch, Senior Regional Manager
Calumet Branded Products
jkoch@royalpurple.com
713-376-8187

Or

Matthew Leggett, Certified MLT-1 Lubrication Specialist
ProSeal Service Group
mleggett@prosealsg.com
616-723-6392

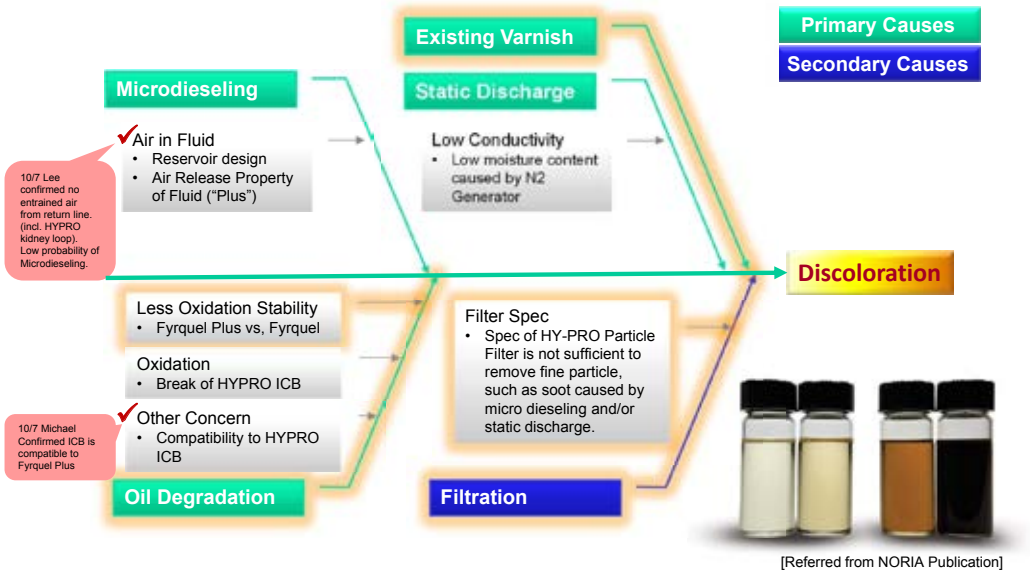
Prepared for Interim Report on March 16, 2017

Combined Cycle Power Plant

Status of Major Lube/Hydraulic Oil Systems

	System	Fluid Information	Previous Status	Action taken in 2015 and 2016	Status Today
Steam Turbine	Hydraulic	Fyrquel EHC Phosphate Ester Based Synthetic Fluids [ISO-VG220] 220 gal. (830 litter)	▪ Concern with Varnish deposits ▪ Experienced several operational issues caused by hydraulic valve sticking	In 2015 ▪ Chemical Flushing ▪ Upgrade to Fyrquel EHC "Plus". ▪ Installed HY-PRO Varnish Removal Filter for Kidney Loop Filtration.	▪ Significant discoloration has been observed. ▪ Oil cleanliness is still acceptable, but concern of operational issues in the future.
	Lubrication	Chevron GST-32 Mineral Based R&O Turbine Oil [ISO-VG32] 4,800 gal. (18,200 litter)	▪ Concern with Varnish deposits, but no significant problem experienced ▪ Rust on the Ceiling of reservoir.	▪ Nothing to be conducted	▪ No practical solution has been found.
Gas Turbine	Lubrication & Hydraulic (Common)	Chevron GST-32 Mineral Based R&O Turbine Oil [ISO-VG32] 6,200 gal. (23,500 litter)	▪ Concern with Varnish deposits ▪ Experienced several operational issues caused by hydraulic valve sticking	In 2015 ▪ Installed HY-PRO Varnish Removal Filter for Kidney Loop Filtration. In 2016 ▪ Upgrade to Royal Purple – PAO Synthetic	▪ Oil cleanliness is acceptable. ▪ Temperature decrease at thrust bearing has been observed.

Fluid Discoloration – Fishbone Analysis

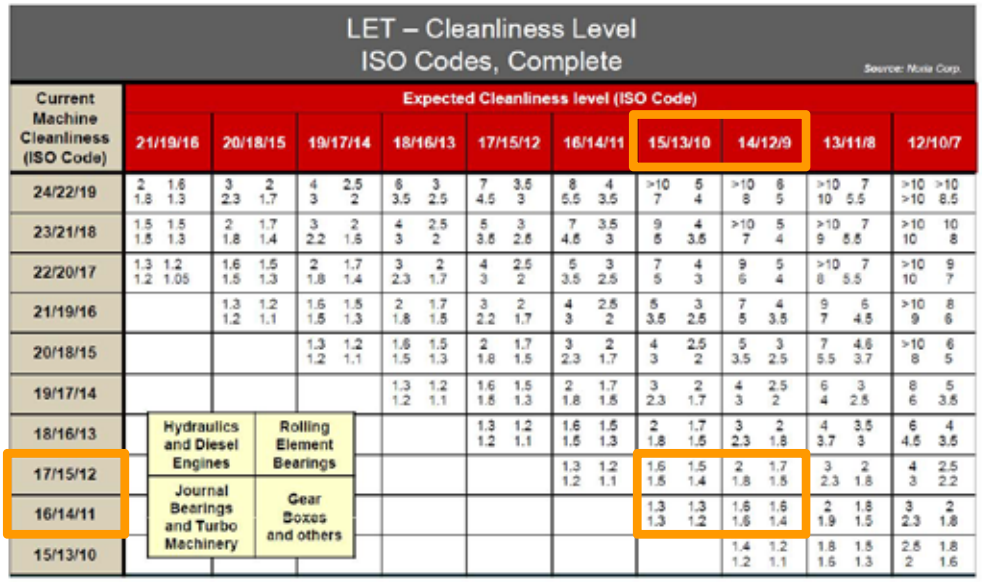


[Referred from NORIA Publication]

Fluid Discoloration – Summery and Recommendation

- Potential Causes
  1) Primary Causes
     - Micro-dieseling — Unlikely : Confirmed no entrained air from return line
     - Static Discharge — Unlikely : Tulsa is humid enough
     - Existing Varnish — Possibly : System is too large...
     - Oil Degradation
       - Oxidation — Possibly : PEs has less oxidation stability than others
       - ICB Incompatibly — Unlikely : Confirmed with HY-PRO
  2) Secondary Causes (not Root Cause)
     - Poor Filtration — Possibly : HY-PRO's particle filter may not be sufficient to remove fine particle.
- Recommendation
  - Because cleanliness is still acceptable, we can wait and see for a while.
    (#1-HPU : 17/15/12, #2-HPU : 16/15/11, #3-HPU : 17/16/12)
  - If cleanliness is getting worse clearly, it's time to consider to use the better particle filter.
    - "Miracle Boy" demonstrated to improve the cleanliness from **"16/15/11"** to **"14/13/9"** under steady state condition.
      ➔60% longer life time can be anticipated…

Life Extension Table for Cleanliness



LET – Cleanliness Level
ISO Codes, Complete

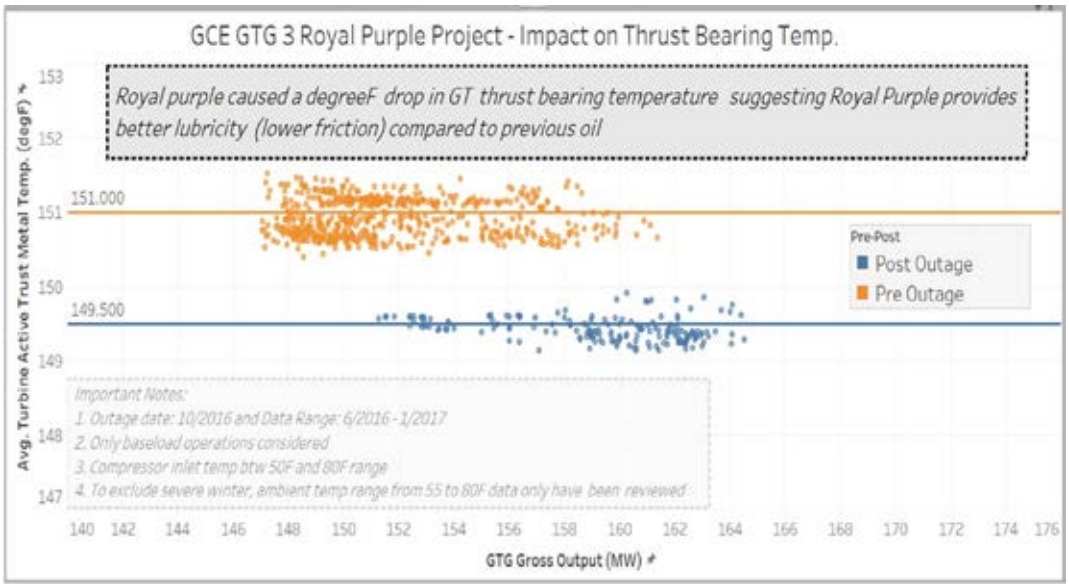
Source: Noria Corp.

Current Machine Cleanliness (ISO Code)	Expected Cleanliness level (ISO Code)									
	21/19/16	20/18/15	19/17/14	18/16/13	17/15/12	16/14/11	15/13/10	14/12/9	13/11/8	12/10/7
24/22/19	2 1.6 1.8 1.3	3 2 2.3 1.7	4 2.5 3 2	6 3 3.5 2.5	7 3.5 4.5 3	8 4 5.5 3.5	>10 5 7 4	>10 6 8 5	>10 7 10 5.5	>10 >10 >10 8.5
23/21/18	1.5 1.5 1.5 1.3	2 1.7 1.8 1.4	3 2 2.2 1.6	4 2.5 3 2	5 3 3.6 2.6	7 3.5 4.6 3	9 4 6 3.5	>10 5 7 4	>10 7 9 5.6	>10 10 10 8
22/20/17	1.3 1.2 1.2 1.05	1.6 1.5 1.5 1.3	2 1.7 1.8 1.4	3 2 2.3 1.7	4 2.5 3 2	5 3 3.5 2.5	7 4 5 3	9 5 6 4	>10 7 8 5.5	>10 9 10 7
21/19/16		1.3 1.2 1.2 1.1	1.6 1.5 1.5 1.3	2 1.7 1.8 1.5	3 2 2.2 1.7	4 2.5 3 2	5 3 3.5 2.5	7 4 5 3.5	9 6 7 4.5	>10 8 9 6
20/18/15			1.3 1.2 1.2 1.1	1.6 1.5 1.5 1.3	2 1.7 1.8 1.5	3 2 2.3 1.7	4 2.5 3 2	5 3 3.5 2.5	7 4.6 5.5 3.7	>10 6 8 5
19/17/14				1.3 1.2 1.2 1.1	1.6 1.5 1.5 1.3	2 1.7 1.8 1.5	3 2 2.3 1.7	4 2.5 3 2	6 3 4 2.5	8 5 6 3.5
18/16/13		Hydraulics and Diesel Engines / Rolling Element Bearings			1.3 1.2 1.2 1.1	1.6 1.5 1.5 1.3	2 1.7 1.8 1.5	3 2 2.3 1.8	4 3.5 3.7 3	6 4 4.5 3.5
17/15/12		Journal Bearings and Turbo Machinery / Gear Boxes and others				1.3 1.2 1.2 1.1	1.6 1.5 1.5 1.4	2 1.7 1.8 1.5	3 2 2.3 1.8	4 2.5 3 2.2
16/14/11							1.3 1.3 1.3 1.2	1.6 1.6 1.6 1.4	2 1.8 1.9 1.5	3 2 2.3 1.8
15/13/10								1.4 1.2 1.2 1.1	1.8 1.5 1.5 1.3	2.5 1.8 2 1.6

Long Term Recommendations

- Overall Status
  - Overall oil condition has been stable at level of "18/16/13" cleanliness since Royal Purple in-service.
  - No "Varnish" related problem has occurred since in-service.
  - Temperature decrease at thrust bearing has been observed. But too soon for a full evaluation.
- Long Term Recommendations
  - Oil Analysis : Monitoring the following items;
    - Oil Cleanliness (Particle Count)
    - Acid Number
    - KF Water %
    - Membrane Patch Colorimetery etc.
  - Visual Inspection – If you have any opportunities.
    - Varnish Deposit (Hydraulic valves/spools, Bathtub ring in the reservoir, etc.)
    - Bearing Conditions (Wear condition, Varnish deposit, etc.)
  - Cleanliness
    - Higher level of cleanliness can be expected. Based on my experience.
      "14/13/11" is achievable target for the utility-spec Gas Turbine application.
      ➔2 times or more longer life time can be anticipated…
    - If cleanliness is getting worse clearly, it's time to consider to use the better particle filter.

Temperature Decrease at Thrust Bearing



Life Extension Table for Cleanliness

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24/22/19	2 1.6 1.8 1.3	3 2 2.3 1.7	4 2.5 3 2	6 3 3.5 2.5	7 3.5 4.5 3	8 4 5.5 3.5	>10 5 7 4	>10 6 8 5	>10 7 10 5.5	>10 >10 >10 8.5
23/21/18	1.5 1.5 1.8 1.3	2 1.7 1.8 1.4	3 2 2.2 1.6	4 2.5 3 2	5 3 3.8 2.8	7 3.5 4.8 3	9 4 5 3.5	>10 5 7 4	>10 7 9 5.5	>10 10 10 8
22/20/17	1.3 1.2 1.2 1.05	1.6 1.5 1.5 1.3	2 1.7 1.8 1.4	3 2 2.3 1.7	4 2.5 3 2	5 3 3.5 2.5	7 4 5 3	9 5 6 4	>10 7 8 5.5	>10 9 10 7
21/19/16		1.3 1.2 1.2 1.1	1.6 1.5 1.5 1.3	2 1.7 1.8 1.5	3 2 2.2 1.7	4 2.5 3 2	5 3 3.5 2.5	7 4 5 3.5	9 6 7 4.5	>10 8 9 6
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18/16/13	Hydraulics and Diesel Engines	Rolling Element Bearings			1.3 1.2 1.2 1.1	1.6 1.5 1.6 1.3	2 1.7 1.8 1.5	3 2 2.3 1.8	4 3.5 3.7 3	6 4 4.6 3.5
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16/14/11	Journal Bearings and Turbo Machinery	Gear Boxes and others					1.3 1.3 1.3 1.2	1.6 1.6 1.6 1.4	2 1.8 1.9 1.5	3 2 2.3 1.8
15/13/10								1.4 1.2 1.2 1.1	1.8 1.5 1.6 1.3	2.5 1.8 2 1.6

Life Extension Table for Moisture

LEM - MOISTURE Level									
Current Moisture Level, ppm	Life Extension Factor								
	2	3	4	5	6	7	8	9	10
50,000	12,500	6,500	4,500	3,125	2,500	2,000	1,500	1,000	782
25,000	6,250	3,250	2,250	1,563	1,250	1,000	750	500	391
10,000	2,500	1,300	900	625	500	400	300	200	156
5,000	1,250	650	450	313	250	200	150	100	78
2,500	625	325	225	156	125	100	75	50	39
1,000	250	130	90	63	50	40	30	20	16
500	125	65	45	31	25	20	15	10	8
260	63	33	23	16	13	10	8	5	4
100	25	13	9	6	5	4	3	2	2

1% water = 10,000 ppm. • Estimated life extension for mechanical systems utilizing mineral-based fluids.

Example: By reducing average fluid moisture levels from 2500 ppm to 156 ppm, machine life (MTBF) is extended by a factor of 5.

What time shall we meet at ...

Energy Audit
Atlas Copco Compressor
Equipment “C”

Covanta Kent
Grand Rapids, MI

SUPERIOR LUBRICATION DELIVERS RESULTS

PURPOSE OF TEST: TO SHOW REDUCED ELECTRICAL CONSUMPTION THROUGH THE USE OF SUPERIOR LUBRICATION.

EQUIPMENT TESTED: **Atlas Copco Compressor / Set as Primary Compressor (Base Load)**
480 Volt connection measuring Current and Voltage

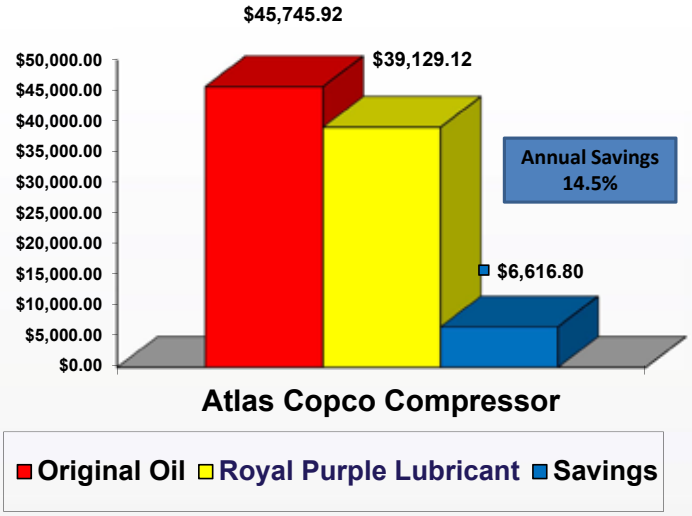
Test Date of the Competitive Lubrication: July 11, 2016
Test Date of Royal Purple Synfilm GT 46: August 29, 2016

LUBRICANT: AirLube Plus 10 (Chemlube Plus 10)
APPLIED: Reservoir

RESULTS:	**Original Oil**	**Royal Purple Synfilm GT**	
KILOWATT HOURS	94.07 kwh	78.61 kwh	**(14.5% Reduction)**
KILOWATT HOURS/Month	76,243.3 kwh	65,215.3 kwh	
COST Elapsed @ $0.05/KWH	$1.74	$1.49	
COST PER MONTH@ $0.05/KWH	$3,812.16	$3,260.76	
ANNUAL COST	$45,745.92	$39,129.12	
SAVINGS with ENERGY EFFICIENT LUBRICANTS		**$551.40 per month $6,616.80 per year**	

The tested Atlas Copco Compressor is representative of a normal base load unit with no known mechanical or electrical issues. Estimated Annual Electrical Savings for this unit are $6,616.80 or a 14.5% reduction as compared to the competitive lubricant.

SUPERIOR LUBRICATION DELIVERS RESULTS



SUMMARY – ATLAS COPCO COMPRESSOR

Superior Lubricants Save Energy

The Atlas Copco Compressor was not known to have mechanical or electrical issues at the time the Energy Audit was conducted.

The survey did show an estimated average annual savings of $6,616.80 or 14.5% comparing the Competitive Oil to Royal Purple Synfilm GT.

Royal Purple Synfilm GT showed a reduction in **Total Energy Elapsed** during the data collection in kilowatt/hour, when compared to the Competitive Oil. **Total Energy Elapsed** reduction of **(-14.5%)**

Conclusion:
The Atlas Copco Compressor worked less to generate the same amount of work with Royal Purple Synfilm GT filled to the proper level in the system reservoir.

SURVEY CONDITIONS

Survey Conditions:
Unit is a Atlas Copco Rotary Screw Air Compressor. The unit was set-up as the Primary compressor during testing. The unit was shutdown and the connections were made to the contactors in the units main disconnect. After terminations were achieved, the connections were confirmed, left to right were A-1, B-2 and C-3. The Compressor was started and allowed to run for data collection. Data was collected over a 30 minute time period to achieve the most realistic data possible. The compressor did load and unload multiple times during the data collection process.

On July 11, 2016 the competitive test data was collected with an ambient temperature of 71F degrees with a relative humidity of 85%.

On August 29, 2016 the Royal Purple Synfilm GT test data was collected with an ambient temperature of 71F degrees with a relative humidity of 87%.

During the test oil temperatures were collected with a temperature gun pointed at the main oil reservoir. The competitive oil temperature was 180.5F degrees and with Royal Purple Synfilm GT the oil temperature dropped to 161.5F degrees.

SURVEY CONDITIONS

Energy cost estimated at $0.05 per kwh on a 30 Day Month. Annual cost estimates are $0.05 per kwh on a 12 month basis using 30 days per month.

Givens:
Work required of the Compressor to generate air is directly related to the torque through the system and the coefficient of friction of the dynamic moving components. A reduction in energy needed to generate air is related to the coefficient of friction between the moving components. A reduction in electrical energy will indicate reduced coefficient of friction and improved lubrication of the components.

Factors that were not calculated in the savings:
- Longer Service Life of the Equipment due to Improved Lubrication.
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Royal Purple Lubricants can greatly extend Lubricant life in equipment and recommends changing oil based on quality oil analysis reporting.

Superior Lubricants Save Energy

Royal Purple would like to thank Randy Inman, Plant Manager, and Jerry Smith, Operations/Maintenance Manager at Covanta Kent for their allowance and participation in completing this safe and successful Royal Purple Synfilm GT trial and Energy Audit on the sites Atlas Copco "C" Rotary Screw Compressor.

For questions or more information please contact:
John Koch, Senior Regional Manager
Calumet Branded Products
jkoch@royalpurple.com
713-376-8187

Or

Matthew Leggett, Certified MLT-1 Lubrication Specialist
ProSeal Service Group
mleggett@prosealsg.com
Cell: (616) 723-6392

FLORIDA TECHNICAL PRODUCTS, INC.

"IMPROVING RELIABILITY THROUGH INNOVATION"

Combined Cycle Power Plant

Tampa Florida

Power Generation Division

Oil Analysis Evaluation Report

3A & 3B Circulator Motors

Synfilm GT ISO 150

Presented by:

Florida Technical Products, Inc.

Kevin C. Hamilton - (904) 813-6211 - kevin@floridatechnicalproducts.com

FLORIDA TECHNICAL PRODUCTS, INC.
"IMPROVING RELIABILITY THROUGH INNOVATION"

August 16, 2017

[redacted]

Dear Mr. [redacted]:

The following information is in regards to the oil analysis results dated 05/01/2017 for the samples collected from the oil reservoirs on your 3A & 3B Circulator Motors. Per the information that you provided to me at the time the lab results were forwarded, both of these units were filled with our Royal Purple Synfilm GT ISO 150 approximately 4 years ago and have been in continuous operation ever since. This equates to approximately 35,040 hours of continuous operation for the oil in the units.

I submitted the results of the analysis from both units to Chris Barker, Tech Services Department Manager, as well as Willie Carter, Ph. D, Vice President of Research & Development at Royal Purple headquarters in Porter Texas. After reviewing the results the following collaborative consensus was reached:

> "(We) discussed the oil analysis reports and we don't think doing anything to the oil is necessary. The magnesium is depleted, and this is the marker for the rust and oxidation inhibitor additive, but that does not indicate that the oil is no longer providing R&O protection. In our experience, the RP lubricant can continue to function excellently even though the magnesium is completely gone. Keep in mind that Synerlec[1] also provides additional oxidation resistance for the oil. We do recommend better filtration for the oil if possible, though. The ISO cleanliness numbers are fairly high.
>
> In summary, the viscosity is in spec, the TAN is good and there are no wear metals or other indicators that there are equipment problems."

Based on this evaluation I don't see any reason to change the oil at this time. Once your new bulk fluid transport & filter carts are delivered I do recommend using the cart designated for use with the Synfilm GT ISO 150 product be used to filter the existing oil to

[1] Synerlec®, Royal Purple's proprietary, additive lubricant technology, is the cornerstone of RP's entire product line. It creates an ionic bond that adheres to metal parts to provide continuous protection even at start-up and strengthens the oil to provide unparalleled performance and protection.

FLORIDA TECHNICAL PRODUCTS, INC.
"IMPROVING RELIABILITY THROUGH INNOVATION"

reduce the number of particulates evidenced by the reported ISO cleanliness level for each unit. Installing a 5-micron filter element on the cart and circulating the oil through the system should reduce the ISO cleanliness to the levels experienced with fresh RP oil out of the drum. Once the carts are delivered with their respective tote racks I will schedule a time to come meet with you and your maintenance staff on how to properly execute this procedure.

If you have any questions or additional concerns regarding the information and statements made within this letter please do not hesitate to contact me directly. Thank you again for the opportunity to work with you in your facility and for your continued business and support.

Sincerely,

Kevin C. Hamilton
Florida Technical Products, Inc.
(904) 813 - 6211
kevin@floridatechnicalproducts.com

ROYAL PURPLE® SYNTHETIC OIL

SYNFILM® GT
MULTI-PURPOSE INDUSTRIAL OIL

BEYOND SYNTHETIC™

Synfilm GT is Royal Purple's most versatile lubricant. In the appropriate viscosity grade, it is recommended for use in gas and steam turbines, centrifugal compressors, pumps, vacuum pumps, blowers, bearings, gears, worm gears, etc. Synfilm GT should be considered instead of Synfilm when oil reservoir temperatures exceed 200˚F, improved low temperature fluidity is desired or when a viscosity grade is not available in Synfilm.

Synfilm GT is a long life, high film strength, energy efficient, synthetic lubricant that significantly increases bearing life and equipment reliability. Synfilm GT gains its performance advantages over competing mineral and synthetic oils through its superior blend of synthetic base oils plus Royal Purple's proprietary Synerlec additive technology. This unique additive technology is proven to make equipment run smoother, cooler, quieter, longer and more efficiently.

Synfilm GT typically is used to upgrade from conventional, low film strength, R&O and lightly formulated circulating oils that rely primarily on their viscosity to protect equipment against wear. Synfilm GT also excels in replacing premium EP and Synthetic gear oils in demanding gear and bearing service.

Synfilm GT 32, 46, 68, 100, 150, 220, 320 and 460 are NSF certified for H2 service.

SYNERLEC® ADDITIVE TECHNOLOGY MAKES THE DIFFERENCE!

Synthetic oils enable Royal Purple to make superior lubricants, but it is Royal Purple's advanced Synerlec additive technology that gives Royal Purple's lubricants their amazing performance advantages. Synerlec additive technology truly is beyond synthetic.

Synerlec additive technology forms a tough, slippery, synthetic film on all metal surfaces. This proprietary film significantly improves lubrication: first, by increasing the oil film's thickness, and second, by increasing the oil film's toughness, both of which help to prevent metal-to-metal contact. It displaces moisture from metal surfaces and protects all metals against rust and corrosion. It also fortifies the oil against the detrimental effects of heat, which causes oil to oxidize.

PERFORMANCE ADVANTAGES

- **High Film Strength**
  Synfilm GT protects bearings far beyond the ability of other turbine oils, carrying significantly greater loads.
- **Rapidly Separates from Water**
  Synfilm GT rapidly and completely separates from water, which is easily drained from the bottom of the oil reservoir.
- **Saves Energy**
  Synfilm GT has an extremely low coefficient of friction that is proven to save energy over conventional oils. In rotating equipment these savings frequently exceed the total cost of the oil within several months, making what was once an oil expense a profit.
- **Extremely Clean**
  Synfilm GT is packaged in new poly containers and has a typical ISO 4406 Cleanliness Level of 14/13/11 (ISO 32, 46 and 68 only). This is up to 250 times cleaner than other new oils delivered in steel drums or by bulk delivery.
- **Reduces Bearing Vibrations**
  The tough oil film of Synfilm GT coupled with its ability to micro-polish contacting bearing elements provides superior bearing lubrication.
- **Longer Oil Life**
  Synfilm GT has outstanding oxidation stability that greatly extends oil change intervals while keeping equipment clean.
- **Excellent Corrosion Protection**
  Synfilm GT's tough oil film forms an ionic bond on metal surfaces, which acts as a preservative oil during shutdown and provides instant lubrication at startup.
- **Synthetic Solvency**
  Synfilm GT's natural solvency cleans up dirty equipment and keeps it clean.
- **Compatible with Seals**
  Synfilm GT has excellent seal compatibility.
- **Compatible with Other Oils**
  Synfilm GT can be mixed with most mineral and synthetic oils. (It is not compatible with silicone or glycol synthetics).
- **Environmentally Responsible**
  Synfilm GT components are TSCA listed and meet EPA, RCRA and OSHA requirements. Synfilm GT extends oil drain intervals, eliminates premature oil changes, decreases the amount of oil purchased and disposed of and conserves energy.

Royal Purple LLC / One Royal Purple Lane / Porter, TX 77365 / 281.354.8600 / royalpurpleindustrial.com

THE PERFORMANCE OIL **THAT OUTPERFORMS®**

REVISED 01 / 27 / 2014

SYNFILM® GT
MULTI-PURPOSE INDUSTRIAL OIL

TYPICAL PROPERTIES*	ASTM METHOD	ISO GRADE 10	22	32	46	68	100	150	220	320	460	680
Viscosity	D-445											
cSt @ 40°C		10	22	32	46	68	100	150	220	320	460	680
cSt @ 100°C		<2.0	4.5	6.0	7.7	10.1	13.1	17.3	22.4	28.8	36.5	47.9
Viscosity Index	D-2270	106	120	135	136	133	129	126	124	122	120	121
Flash Point, °F	D-92	355	350	455	455	485	475	465	445	445	455	455
Pour Point, °F	D-6892	-60	-71	-38	-38	-38	-44	-44	-44	-40	-44	-38
Copper Corrosion Test	D-130											
3 Hrs @ 100°C		1A	1A	1A	1A	1A	1A	1A	1A	1A	1A	1A
24 Hrs @ 100°C		1A	1A	1A	1A	1A	1A	1A	1A	1A	1A	1A
Rust Test	D-665											
Fresh Water		PASS	PASS	PASS	PASS	PASS	PASS	PASS	PASS	PASS	PASS	PASS
Salt Water		PASS	PASS	PASS	PASS	PASS	PASS	PASS	PASS	PASS	PASS	PASS
Foam Test, Seq II	D-892											
Initial/Final/Time(sec)		28/0/6	10/0/2	8/0/2	6/0/1	10/0/5	10/0/5	12/0/7	8/0/4	6/0/3	4/0/1	0/0/0
Demulsibility Test	D-1401											
Mins @ 130°F		10	10	5	5	5	---	---	---	---	---	---
Mins @ 180°F		---	---	---	---	---	5	10	10	15	10	10
Cincinnati Millicron "A"	D-2070											
Corrosion / Oxidation		PASS	PASS	PASS	PASS	PASS	PASS	PASS	PASS	PASS	PASS	PASS
ISO Cleanliness Level	ISO 4406	**	**	14/13/11	14/13/11	14/13/11	N/A	N/A	N/A	N/A	N/A	N/A
Dry Air Oxidation	D-2893											
312 Hrs @ 100°C,												
% Viscosity Increase	0	0	0	0	0	0	0	0	0	0	0	0
Precip. No. (% Solids)	0	0	0	0	0	0	0	0	0	0	0	0
Density, lbs/g	D-4052	6.90	6.99	7.04	7.08	7.12	7.19	7.24	7.27	7.32	7.35	7.38

*Properties are typical and may vary

Note: Synfilm GT's solvency cleans wear metals and deposits left behind by previous oils. These wear metals and deposits can become soluble in the new oil, causing abnormally high values on used oil analysis until equipment is clean.

Royal Purple LLC / One Royal Purple Lane / Porter, TX 77365 / 281.354.8600 / royalpurpleindustrial.com

THE PERFORMANCE OIL **THAT OUTPERFORMS®**

REVISED 01 / 27 / 2014

Report Issue Date: July 7, 2017 **Report Printed Date:** July 7, 2017

FLORIDA POWER AND LIGHT CO.

Oil Analysis Severity Summary

N = Normal	O = Observe	M = Moderate	MH = Moderate High	S = Severe

Lab Number	Name	Description	Date	Severity
669648	3A CIRCULATOR	OIL RESERVOIR	05/01/2017	O
669649	3B CIRCULATOR	OIL RESERVOIR	05/01/2017	O

Report Issue Date: July 7, 2017 **Report Printed Date:** July 7, 2017

FLORIDA POWER AND LIGHT CO.

Oil Analysis Severity Report

Lab Number: 669648 **Name:** 3A CIRCULATOR **Date:** 05/01/2017 **Severity:** Observe

Recommended Action:
Please provide ISO lube grade for the lubricant used in this unit. Continue sampling at frequent intervals to track condition.

Data Interpretation:
Certain particle count values are higher than desired and have been flagged for observation.

Lab Number: 669649 **Name:** 3B CIRCULATOR **Date:** 05/01/2017 **Severity:** Observe

Recommended Action:
Please provide ISO lube grade for the lubricant used in this unit. Continue sampling at frequent intervals to track condition.

Data Interpretation:
Certain particle count values are higher than desired and have been flagged for observation.

FLORIDA POWER AND LIGHT CO.

Severity: (O) - Observe

Oil Analysis Data Sheet Report

Sample ID: 3A CIRCULATOR **Description:** OIL RESERVOIR

Manufacturer: **Oil Type:** **Grade:**

Lab Number / Sample Date		Units	669648 05/01/17
WEAR ELEMENTS			
Iron	Fe	ppm	1
Chromium	Cr	ppm	0
Molybdenum	Mo	ppm	0
Aluminum	Al	ppm	0
Copper	Cu	ppm	0
Lead	Pb	ppm	0
Tin	Sn	ppm	0
Silver	Ag	ppm	0
Nickel	Ni	ppm	0
Vanadium	V	ppm	0
Titanium	Ti	ppm	0
Manganese	Mn	ppm	0
Cadmium	Cd	ppm	0
CONTAMINANT ELEMENTS			
Silicon	Si	ppm	2
Sodium	Na	ppm	0
Boron	B	ppm	0
ADDITIVE ELEMENTS			
Magnesium	Mg	ppm	0
Calcium	Ca	ppm	0
Barium	Ba	ppm	0
Phosphorus	P	ppm	0
Zinc	Zn	ppm	0
NON-METALLIC CONTENT			
Water		% vol	Nil
Solids		% vol	<0.1
LUBE DATA			
Viscosity @ 40'C		cSt	151.4
Total Acid Number		mg KOH/g	0.14
PARTICLE COUNT			
4		/ml	**36325**
6		/ml	**5399**
14		/ml	20
20		/ml	1
30		/ml	0
40		/ml	0
ISO Code 4/6/14 um			**22/20/11**
INFRARED			
Hydroxy			0.000
Antiwear Loss			0.595
Oxidation			4.931
Nitration			5.763

FLORIDA POWER AND LIGHT CO.

Severity: (O) - Observe

Oil Analysis Data Sheet Report

Sample ID: 3A CIRCULATOR **Description:** OIL RESERVOIR

Manufacturer: **Oil Type:** **Grade:**

Lab Number / Sample Date	Units	669648 05/01/17	
Oxidation/Sulfate		25.700	

Recommended Action:

Please provide ISO lube grade for the lubricant used in this unit. Continue sampling at frequent intervals to track condition.

Data Interpretation:

Certain particle count values are higher than desired and have been flagged for observation.

FLORIDA POWER AND LIGHT CO.

Severity: (O) - Observe

Oil Analysis Data Sheet Report

Sample ID: 3B CIRCULATOR **Description:** OIL RESERVOIR

Manufacturer: **Oil Type:** **Grade:**

Lab Number / Sample Date		Units	669649 05/01/17
WEAR ELEMENTS			
Iron	Fe	ppm	2
Chromium	Cr	ppm	0
Molybdenum	Mo	ppm	0
Aluminum	Al	ppm	0
Copper	Cu	ppm	0
Lead	Pb	ppm	0
Tin	Sn	ppm	0
Silver	Ag	ppm	0
Nickel	Ni	ppm	0
Vanadium	V	ppm	0
Titanium	Ti	ppm	0
Manganese	Mn	ppm	0
Cadmium	Cd	ppm	0
CONTAMINANT ELEMENTS			
Silicon	Si	ppm	2
Sodium	Na	ppm	0
Boron	B	ppm	0
ADDITIVE ELEMENTS			
Magnesium	Mg	ppm	0
Calcium	Ca	ppm	0
Barium	Ba	ppm	0
Phosphorus	P	ppm	0
Zinc	Zn	ppm	0
NON-METALLIC CONTENT			
Water		% vol	Nil
Solids		% vol	<0.1
LUBE DATA			
Viscosity @ 40'C		cSt	156.4
Total Acid Number		mg KOH/g	0.30
PARTICLE COUNT			
4		/ml	**62803**
6		/ml	2339
14		/ml	14
20		/ml	1
30		/ml	0
40		/ml	0
ISO Code 4/6/14 um			**23/18/11**
INFRARED			
Hydroxy			0.000
Antiwear Loss			0.680
Oxidation			6.891
Nitration			6.333

FLORIDA POWER AND LIGHT CO.

Severity: (O) - Observe

Oil Analysis Data Sheet Report

Sample ID: 3B CIRCULATOR **Description:** OIL RESERVOIR

Manufacturer: **Oil Type:** **Grade:**

Lab Number / Sample Date	Units	669649 05/01/17	
Oxidation/Sulfate		26.920	

Recommended Action:

Please provide ISO lube grade for the lubricant used in this unit. Continue sampling at frequent intervals to track condition.

Data Interpretation:

Certain particle count values are higher than desired and have been flagged for observation.

Energy Savings from Royal Purple Lubrication

FRAC TECH SERVISES

Cat Engine Serial R1S00820 Data from Royal Purple Lubricant Trial

THE PERFORMANCE OIL THAT OUTPERFORMS

Energy Savings Presentation

PURPOSE OF TEST: TO SHOW ENERGY SAVINGS THROUGH THE USE OF SUPERIOR QUALITY LUBRICATION.

EQUIPMENT TESTED: **Cat Engine Serial Number R1S00820**
Transmission Serial Number PCJ01511
DATE OF INITIAL TESTING: September 3, 2014 **LUBRICANT: Original Lubricant**

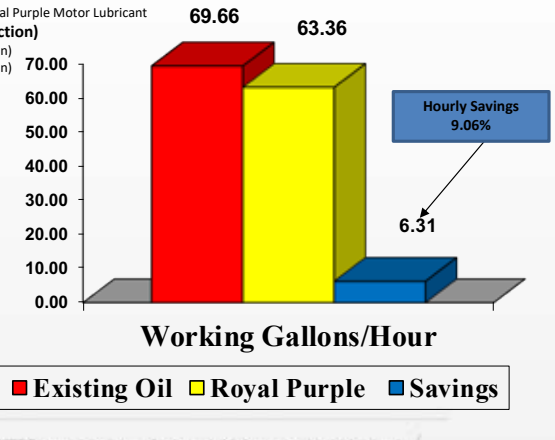
DATE OF FINAL TESTING: November 25, 2014 **LUBRICANT: Royal Purple**

RESULTS:

	Existing Oil	Royal Purple	
Engine Hours	4285.00	5076.00	791.00 with Royal Purple Motor Lubricant
Work fuel/hour	**69.66 gal/hr**	**63.36 gal/hr**	**(9.06% Reduction)**
Idle fuel/hour	9.94 gal/hr	9.87 gal/hr	(0.74% Reduction)
Average (work and idle) fuel/hour	32.43 gal/hr	30.45 gal/hr	(6.12% Reduction)

SAVINGS with ENERGY EFFICIENT LUBRICANTS:

The unit is a representative of like equipment, Fuel Savings estimates are 6.31 gallons per hour of engine work time less idle hours. Resulting in a savings of 9.06 % per hour per unit while unit is performing work.
(Engine pumping excluding idle hours)



FRAC TECH

THE PERFORMANCE OIL THAT OUTPERFORMS

Energy Savings Presentation

PURPOSE OF TEST: TO SHOW ENERGY SAVINGS THROUGH THE USE OF SUPERIOR QUALITY LUBRICATION.

EQUIPMENT TESTED: **Cat Engine Serial Number R1S00820**
Transmission Serial Number PCJ01511

DATE OF INITIAL TESTING: September 3, 2014 **LUBRICANT: Original Lubricant**

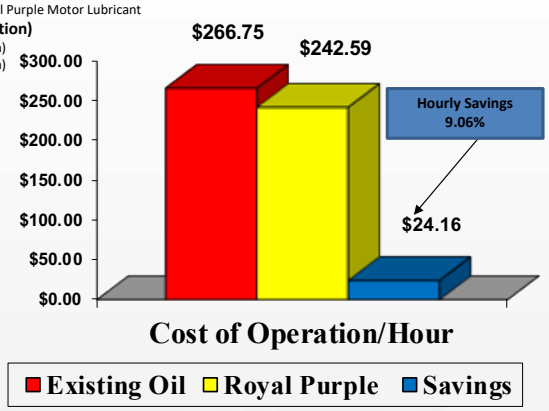
DATE OF FINAL TESTING: November 25, 2014 **LUBRICANT: Royal Purple**

RESULTS:

	Existing Oil	Royal Purple	
Engine Hours	4285.00	5076.00	791.00 with Royal Purple Motor Lubricant
Cost of Work fuel/hour	**$266.75**	**$242.59**	**(9.06% Reduction)**
Cost of Idle fuel/hour	$38.07	$37.79	(0.74% Reduction)
Cost of Average (wk&idle) fuel/hour	$124.17	$116.58	(6.12% Reduction)

SAVINGS with ENERGY EFFICIENT LUBRICANTS:

The unit is a representative of like equipment, Fuel Savings estimates are $24.16 per hour of engine work time less idle hours. Resulting in a savings of 9.06 % per hour per unit while unit is performing work. (Engine pumping excluding idle hours)



FRAC TECH

THE PERFORMANCE OIL THAT OUTPERFORMS

Energy Savings Presentation

PURPOSE OF TEST: TO SHOW ENERGY SAVINGS THROUGH THE USE OF SUPERIOR QUALITY LUBRICATION.

EQUIPMENT TESTED: **Cat Engine Serial Number R1S00820**
Transmission Serial Number PCJ01511

DATE OF INITIAL TESTING: September 3, 2014 **LUBRICANT: Original Lubricant**

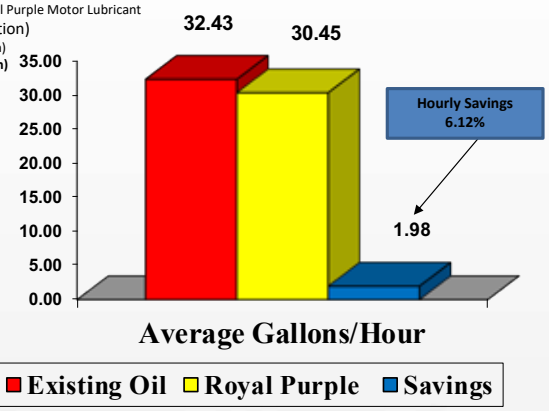
DATE OF FINAL TESTING: November 25, 2014 **LUBRICANT: Royal Purple**

RESULTS:

	Existing Oil	Royal Purple	
Engine Hours	4285.00	5076.00	791.00 with Royal Purple Motor Lubricant
Work fuel/hour	69.66 gal/hr	63.36 gal/hr	(9.06% Reduction)
Idle fuel/hour	9.94 gal/hr	9.87 gal/hr	(0.74% Reduction)
Average (work and idle) fuel/hour	**32.43 gal/hr**	**30.45 gal/hr**	**(6.12% Reduction)**

SAVINGS with ENERGY EFFICIENT LUBRICANTS:

The unit is a representative of like equipment under normal operating conditions, Fuel Savings estimates are 1.98 gallons per hour. Resulting in a savings of 6.12% per hour per unit. (Engine pumping including idle time)



FRAC TECH

THE PERFORMANCE OIL THAT OUTPERFORMS

Energy Savings Presentation

PURPOSE OF TEST: TO SHOW ENERGY SAVINGS THROUGH THE USE OF SUPERIOR QUALITY LUBRICATION.

EQUIPMENT TESTED: **Cat Engine Serial Number R1S00820**
Transmission Serial Number PCJ01511

DATE OF INITIAL TESTING: September 3, 2014 **LUBRICANT: Original Lubricant**

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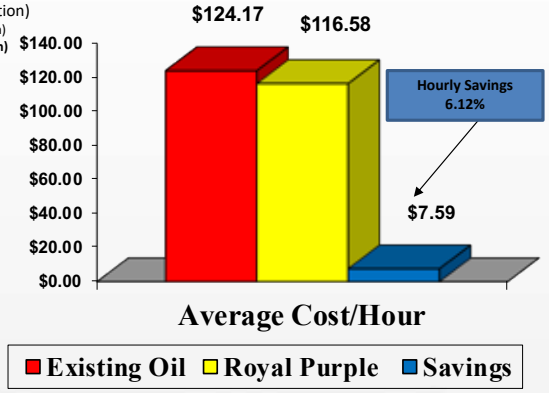
Cost of Work fuel/hour	$266.75	$242.59	(9.06% Reduction)
Cost of Idle fuel/hour	$38.07	$37.79	(0.74% Reduction)
Cost of Average (wk&idle) fuel/hour	**$124.17**	**$116.58**	**(6.12% Reduction)**

SAVINGS with ENERGY EFFICIENT LUBRICANTS:

The unit is a representative of like equipment, Fuel Savings estimates are $7.59 per hour of engine running during the 791.00 hours with Royal Purple. Resulting in a savings of 6.12 % per hour per unit while unit is in normal service. (100 hours--$198.31 Savings)



FRAC TECH

THE PERFORMANCE OIL THAT OUTPERFORMS

Summary

Superior Lubricants Save Energy

The data showed an estimated annual savings of $23,870 or 6.12% comparing the Original Oil average fuel consumption per hour to Royal Purple Lubricant. This savings was calculated by the idle hours and the work hours fuel consumption.

Royal Purple Lubricant showed savings when engine is running under load performing “work” of $24.16 per hour or 9.06%. This savings was calculated by the work hours and work fuel consumption.

Data indicates fuel consumption is reduced, fuel costs are reduced, by using Superior Lubricants in equipment.

THE PERFORMANCE OIL THAT OUTPERFORMS

Case Study

Korean Petrochemical Solves Malfunction of Hydraulic System on Reciprocating Pump; Catalyst Injection Pump Using Royal Purple CLEAN AND FLUSH 46

Background

This customer is one of the largest petrochemicals with 3 operations in Republic of Korea and has produced basic petrochemical materials; HDPE, LDPE, LLDPE, PP, EG, SM, PIA, PET, etc. The trouble and malfunction of the hydraulic system on reciprocating pump occurred right after Turn Around finished and changed to new oil.

Challenge

They have 5 reciprocating pump skids and 4 skids were installed in 1997 and another skid; No.5 was installed in 2012. They haven't had any type of flushing process after installation in 1997, 2012 respectively and have changed to new oil every year during Turn Around; Overhaul. When they faced a trouble and malfunction of hydraulic system, finding an exact cause of a malfunction was difficult because there were several causes, which are related lubrication part, mechanical part and electrical part, etc. They decided to start from lubrication part to solve trouble and malfunction because this is easier to troubleshoot rather than any other option.

Solution

The petrochemical's rotating machinery department selected Royal Purple to solve their trouble immediately using CLEAN AND FLUSH 46. The following is the information on the reciprocating pump specification.

Pump Maker	UHDE PUMP
Pump Type	Plunger Type Reciprocating Pump
Proper Use	Catalyst Injection Pump
Lube Oil	Shell Tellus S2 M46
Oil Reservoir Vol.	Approx. 250 Liters

Royal Purple's CLEAN AND FLUSH 46 is a safe, effective and inexpensive product for cleaning sludge and varnish from equipment while in service. The flushing condition was as follows:

Use	Oil Circulation System Cleaner for Removal of Sludge & Varnish
Dilution Ratio	15% (15% - 25% Recommended)
Flushing Time	64 Hours
Filter	HY-PRO 89L26-3MB (3 Micron)

Oil samples had been collected to check a change of oil cleanliness and varnish before, during and after flushing procedure with CLEAN AND FLUSH 46 and the flushing performance had been achieved very satisfactory while in service. During the flushing procedure, off-line filtration equipped with 3 micron has been installed and had not experienced filter pressure drop due to a large capacity of filter.

The following is showing a change of oil cleanliness and varnish potential index, MPC value and those numbers had been dropped down in a short period of flushing time, 60 hours.

Date	2015. 11. 13	2015. 11. 17	2015. 12. 29	2015. 12. 31	2016. 01. 08
Remarks	Before Filtering	After Filtering	Flushing w/ C&F (26 hrs)	Flushing w/ C&F (60 hrs)	Operation (200 hrs)
ISO4406	21/19/14	**20/19/16**	17/14/11	16/14/11	**16/14/11**
NAS1638	11	**11**	7	6	**6**
MPC	17.9	**22.4**	23.1	23.6	**7.2**
Remarks	New Oil (N.O)	N.O	N.O w/ CF	N.O w/ CF	Drain & Refill N.O

Results

Royal Purple LLC (CLEAN AND FLUSH 46, Oil Circulation System Cleaner) allowed the Korean customer to solve their trouble and malfunction of the hydraulic system on reciprocating pump by not have to purchase an expensive competitor's product, to replace mechanical, electrical parts and to input any other manpower. In addition, flushing plan with CLEAN AND FLUSH 46 is going to help the petrochemical establish a flushing process for their valuable equipment.

Case Study Jan-16

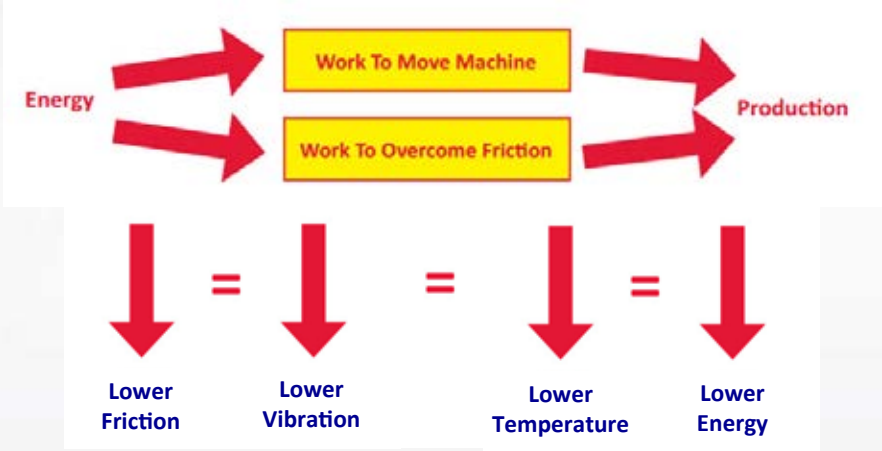
ENERGY SAVING THROUGH THE USE OF ROYAL PURPLE SYNTHETIC OIL

COOLING TOWER GEARBOX

THE PERFORMANCE OIL THAT OUTPERFORMS

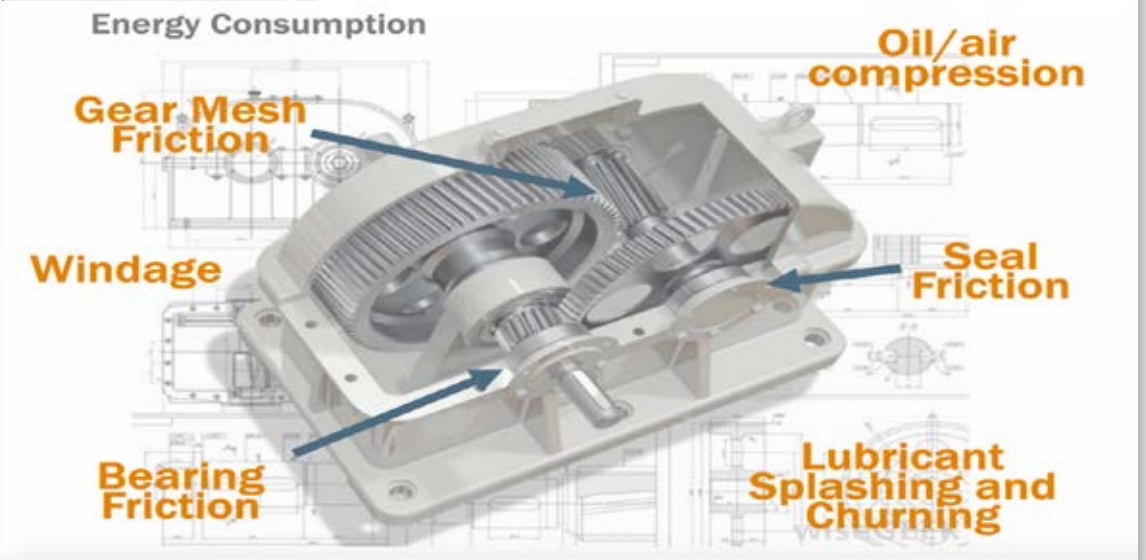
FRICTIONAL ENERGY

E (energy) = W (work) + Q (heat)



THE PERFORMANCE OIL THAT OUTPERFORMS

FRICTIONAL ENERGY



THE PERFORMANCE OIL THAT OUTPERFORMS

GENERAL INFORMATION:

Type of CTW Gearboxes:

- Single Reduction
- Double Reduction

Character of CTW Gearboxes:

- Helical Gears
- Parallel Shafts
- Smooth Transmission through mesh
- Run Quiet Constant Reduce Speed

Hansen® TRANSMISSIONS

Sumitomo Drive Technologies

Amarillo Gear Company LLC

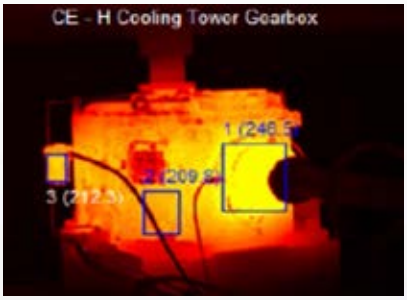
Marley®

THE PERFORMANCE OIL THAT OUTPERFORMS

LUBRICATION AND LUBRICANT

Purpose of Lubricant in a Gearbox:

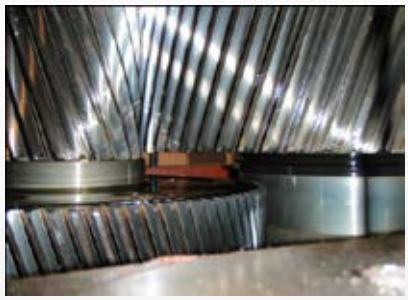
- Carry the Load
- Remove Heat
- Control Friction
- Protect Against Corrosion
- Remove Contaminants



LUBRICATION AND LUBRICANT

Lubrication Requirement:

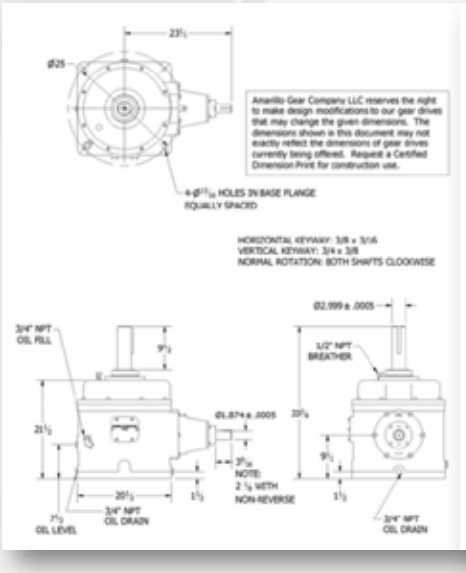
- Clean Target:17/15/12
- Dry Target: <=400 ppm
- Cool Target: 70-80 C
- Non-EP Gear Oil
- ISO VG 150 or 220



THE PERFORMANCE OIL THAT OUTPERFORMS

EQUIPMENT SURVEY

EQUIPMENT SURVEY



Amarillo Series Model 175 Fan Drive

Ratings:

Service Horsepower Ratings (HP) at (Service Factor = 2.0)									
Input(RPM)	Nominal Ratio								
	5.5	6.0	6.5	7.0	7.5	8.0	8.5	9.0	9.5
1750	126	112	105	100	80	60	60	60	50
1450	104	92	87	83	66	50	50	50	41
1160	84	74	70	66	53	40	40	40	33

Thrust:
Vertical Shaft Down Thrust Capacity: 5150 lbs.

Oil Capacity:
ISO Grade 220/ AGMA Lubricant Number 5 or 5S. Extreme Pressure additives are not recommended.
Capacity: 5.5 Gallons/21 Liters

Weight:
Domestic Shipping Weight: 855 lbs.
Weight with Export Boxing: 940 lbs.

Shipping Info:
Export Box Dimensions (L x W x H): 40in x 27in x 41in.

MECHANICAL CONDITIONS

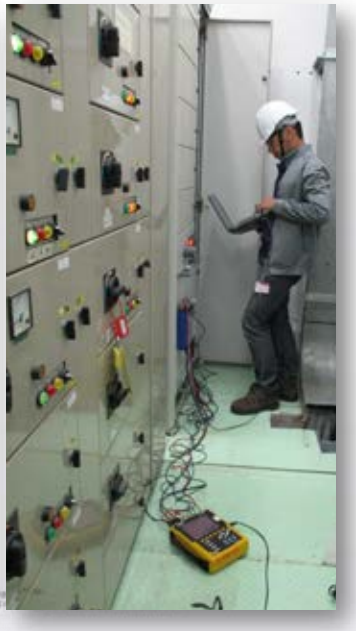
THE PERFORMANCE OIL THAT OUTPERFORMS

ENERGY AUDIT

THE PERFORMANCE OIL THAT OUTPERFORMS

ENERGY AUDIT

DATA LOGGER EQUIPMENT AT ELECTRIC CONTROL ROOM



TIMELINE TO IMPLEMENT

Timeline to Implement Royal Purple at CTW Fan Area

No.	Topics	by	Apr-15				May-15				Jun-15				Jul-15				Aug-15			
			W1	W2	W3	W4	W1	W2	W3	W4	W1	W2	W3	W4	W1	W2	W3	W4	W1	W2	W3	W4
1	Approach / Issue	CTT		7																		
2	Before Change Lubricant - Unit B by Collect: 2.1. Amp / Volt / PF	CTT				27																
3	Change Oil & After01 - Unit B by Collect: 2.1. Amp / Volt / PF					28	9															
4	After02 - Unit B by Collect: Amp/Volt/PF	CTT					4		22													
5	After03 - Unit B by Collect: Amp/Volt/PF	CTT														9	17					
6	Conclusion / Re-Approach	CTT															17					
8	Before Change Lubricant - Unit H by Collect Amp	CTT																24	7			
9	Change Oil & After01 - Unit H by Collect Amp	CTT																			18	25
10	After02 - Unit H by Collect Amp	CTT																				
11	After03 - Unit H by Collect Amp	CTT																				
12	After04 - Unit H by Collect Amp	CTT																				
13	After05 - Unit H by Collect Amp	CTT																				
14	Used Oil Sampling for Analysis	CTT																				
15	After06 - Unit H by Collect Amp	CTT																				
16	After07 - Unit H by Collect Amp	CTT																				
17	Conclusion																					

INNOVEK COOLING TOWERS
SYSTEM B, CELL H

Purpose of Trial: **Achieve operating costs reduction through energy saving using Royal Purple's Premium Synthetic Lubricant**

Trial Equipment: Amarillo FD175 (Unit H), Driven by: Electric Motor, 45 kW, Input 1,750 rpm
380V 3PhaseServiced: N/A hrs Energy Cost: 3.50 THB/Unit
Oil Capacity: 21 Liters Oil Serviced: 3,600 hrs

Before Change: Aug 08, 2015 **After Change:** Sep 28 2015 to 11 Apr 2016

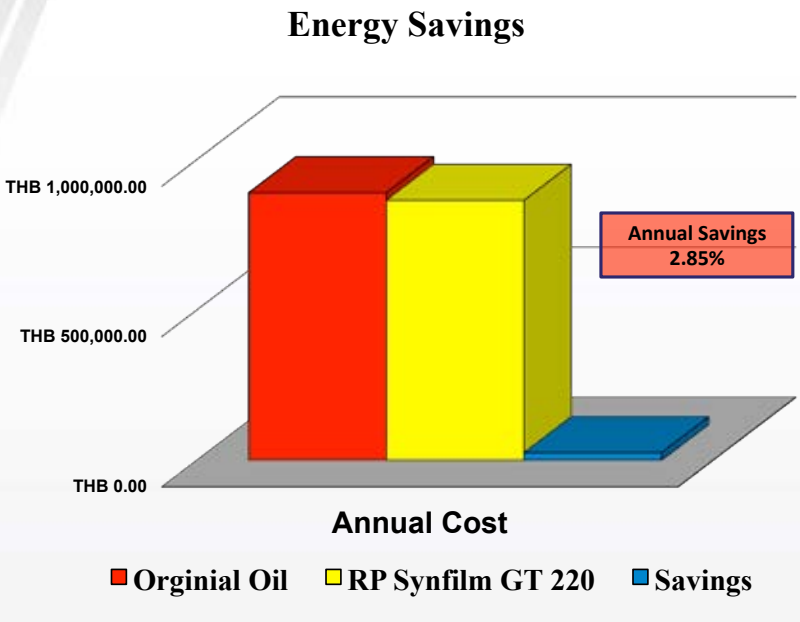
Existing Oil: Mobilgear 600 XP 220 (Mineral) **New Oil:** Royal Purple Synfilm GT 220

Trial Result:	**Existing Oil**	**RP Synfilm GT 220**
kW (Amps)	32.10 (48.78)	31.19 (47.39) (2.85 % Reduction)
kWh/Month	23,112 kwh	22,456.8 kwh
Cost/Month	80,892 THB	78,598.8 THB
Annual Cost (330 Days)	889,812 THB	864,586.8 THB
SAVINGS with Energy Efficient Lubricant	**2,293.2 THB/Month.**	**25,225.2 THB/Year**

Remark: CTW Motor of Unit H run at 68-70% of full Rated Load

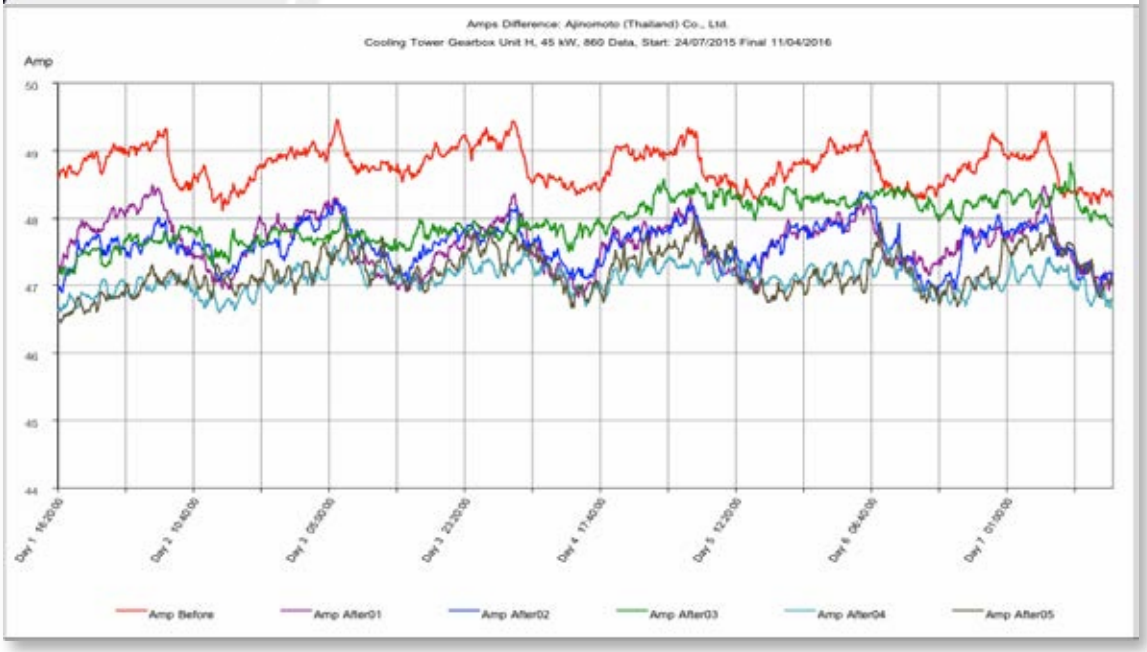
THE PERFORMANCE OIL THAT OUTPERFORMS

SUMMARY

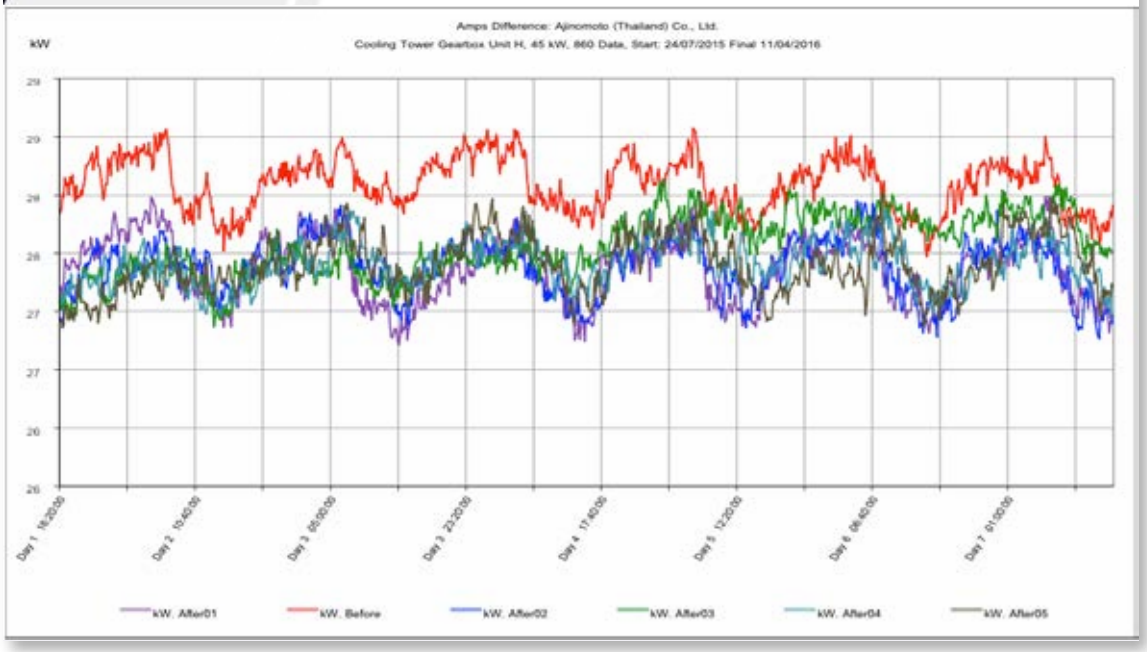


THE PERFORMANCE OIL THAT OUTPERFORMS

INNOVEK COOLING TOWERS
SYSTEM B, CELL H



INNOVEK COOLING TOWERS
SYSTEM B, CELL H



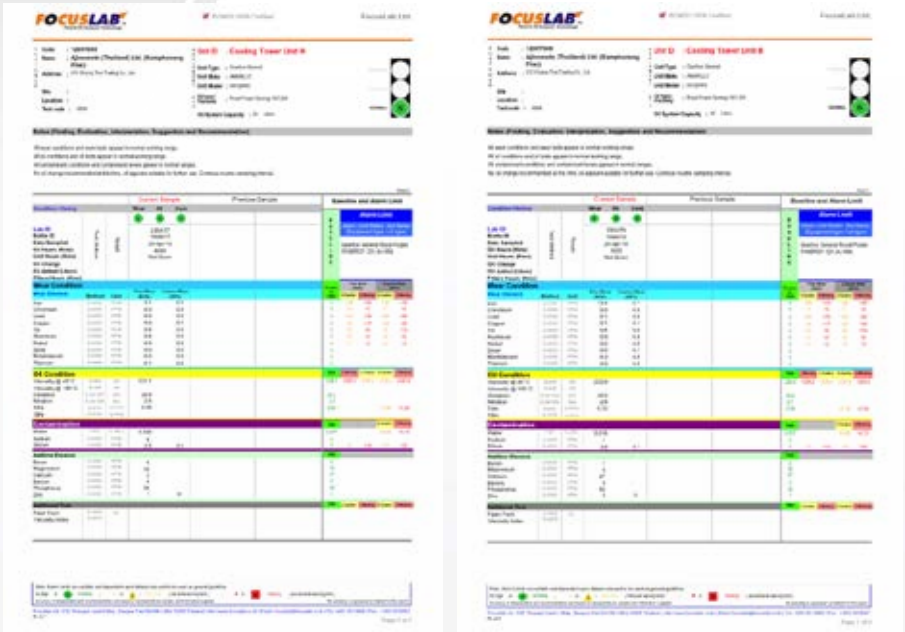
INNOVEK COOLING TOWERS
6 CELLS

Cooling Tower Gearbox - Amarillo A27, 55 kW, 38 Liter

Machine Unit	Date of Measurement	Amperage (Amps)		Saving		Remark
		Before	After	(Amp)	(%)	
1. CTW Fan Unit A						
1.1 Before Change	22-10-2015 to 29-10-2015	81.10				Mobil SHC 630
1.2 After Change 01	21-03-2016 to 29-03-2016	81.10	80.47	0.63	0.78	
2. CTW Fan Unit B						
1.1 Before Change	22-10-2015 to 29-10-2015	101.50				
1.2 After Change 01	21-03-2016 to 29-03-2016	101.50	95.54	5.96	5.87	
1. CTW Fan Unit C						
1.1 Before Change	24-07-2015 to 07-08-2015	96.64				
1.2 After Change 01	29-03-2016 to 04-03-2016	96.64	93.53	3.11	3.22	
1. CTW Fan Unit D						
1.1 Before Change	08-10-2015 to 16-10-2015	99.45				
1.2 After Change 01	22-12-2015 to 30-12-2016	99.45	97.35	2.10	2.11	
1.3 After Change 02	04-04-2016 to 11-04-2016	99.45	97.05	2.40	2.41	
1. CTW Fan Unit E						
1.1 Before Change	08-10-2015 to 16-10-2015	95.27				
1.2 After Change 01	22-12-2015 to 30-12-2016	95.27	93.90	1.37	1.44	
1.3 After Change 02	04-04-2016 to 11-04-2016	95.27	95.50	-0.23	-0.24	
1. CTW Fan Unit F						
1.1 Before Change	16-10-2015 to 20-10-2015	99.52				
1.2 After Change 01	30-12-2015 to 06-01-2016	99.52	101.88	-2.36	-2.37	Low Level
1.3 After Change 02	29-03-2016 to 04-04-2016	99.52	99.09	0.43	0.43	

Summary			
	Energy	13.90	Amp
		9.15	kW
		23054.03	kWh/Month
		253594.31	kWh/Year

LUBE OIL MONITORING



THE PERFORMANCE OIL **THAT OUTPERFORMS**

Superior Lubricants Save Energy

All Royal Purple Lubricants are formulated to protect component due to their unique high film strength

Royal Purple's high film strength prevents metal to metal contact even at heavy loads

Preventing metal to metal contact reduces parasitic loss, returns some lost efficiency and prevents wear

Royal Purple Lubricants are manufactured to extreme cleanliness levels ensuring longer oil and component life

Royal Purple Lubricants can greatly extend Lubricant life in equipment and elongate lubrication intervals by changing oil based on quality oil analysis reporting

Superior Lubricants Save Energy

For questions or more information please contact one of the Royal Purple Thailand Team.

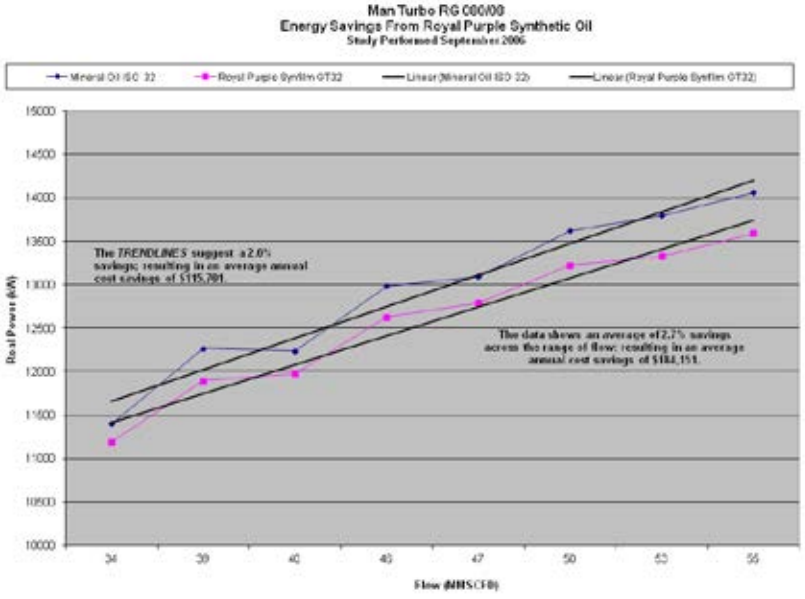
Yuttaphume Keattra, Technical Sales, 087 905 8185, yuttaphume@belraythai.com

Kirana Keawkongtao Technical Sales, 085 865 1963, kirana@belraythai.com

Case Study: Energy Efficiency Improvement

MAN Turbo CO2 Compressor
Integral Gear
8 Stage
19,700 Hp
26,400 RPM max pinion speed
2700 PSIG Discharge

Energy Savings From Synthetic Oil



JMF Consulting

Engine Family QSK50	**Core Report**	
ESN 33201940		
Unit #	Title: Universal Oil Test	
First Rebuild		
Engine Hour	Author: Mike Foster	
	Date: 3-1-16	
	Repair Location: **Cummins Dallas**	

SUMMARY

Purpose:

To compare 15/40 multi-viscosity oil against Royal Purple using a QSK-50 engine rated at 2500 HP. The engine ran four hours with 15/40 oil first. The oil and filters were drained. The engine was filled with Royal Purple and then ran another four hour test pulling the same load at the same RPM as the first test.

Introduction

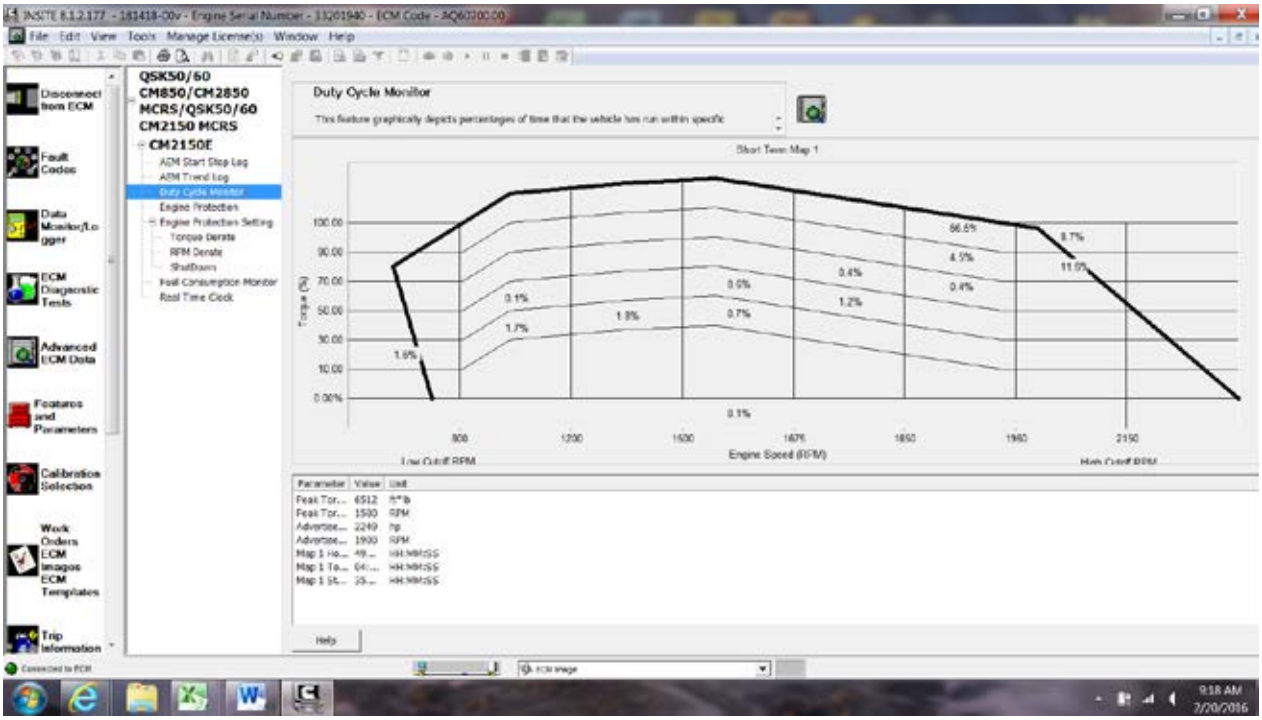
Engine Information			
ESN	33201940		
Rebuild Timeline	Repair		
Rated Power	2500		
Total Fuel Used			
Avg HP			
Avg Engine Load			
Avg Engine RPM			
	Installed	Functional	Size
Oil Reserve	N/A	N/A	N/A
Centinel	N/A	N/A	N/A
Prelube	X	X	Rolling

Customer Information	
Work Order #	181418
Customer	Universal
Customer Site	Cleburne
OEM	Engine Dyno
Model	Fracturing Pump
Unit #	
Application	Oil & Gas
Date in Service	
Failure Date	
Engine Hours	3586 hr
Unit Hours	

Observations:

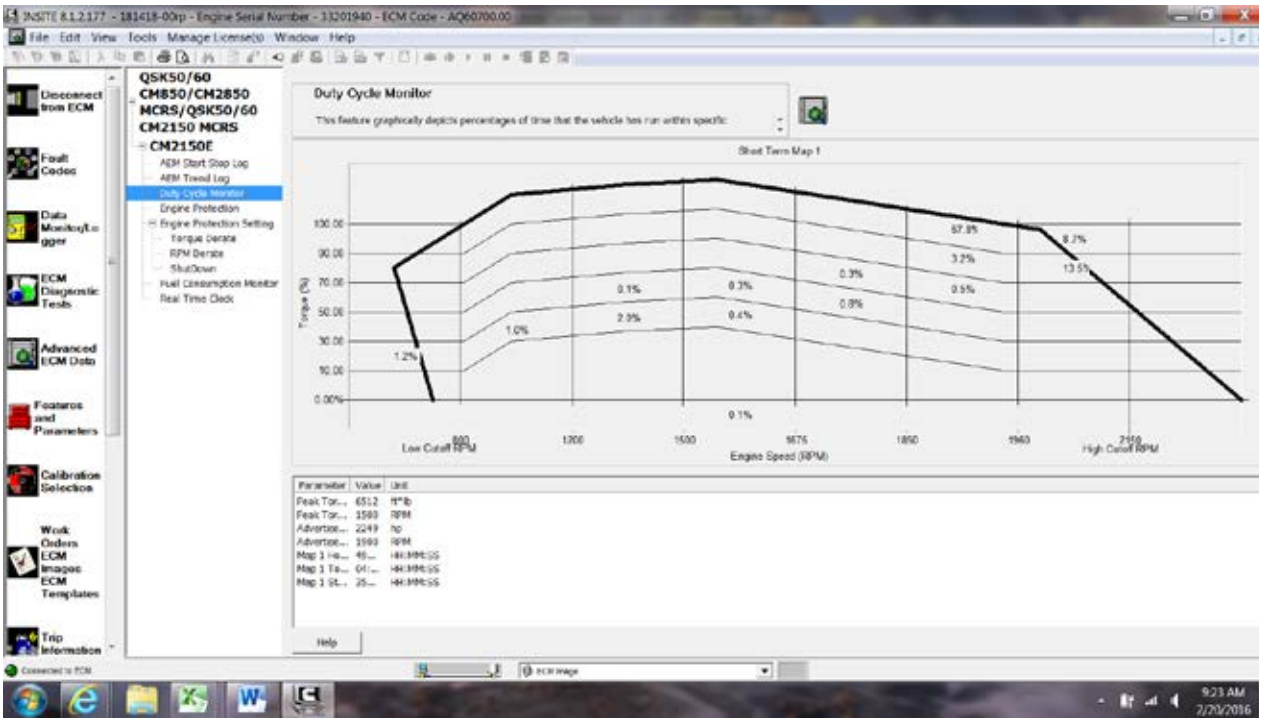
Duty Cycle Map:

The map was cleared for each test. It is showing the engine ran 66.5% of the time, pulling rated horsepower. The engine was running using Multi-Viscosity oil.



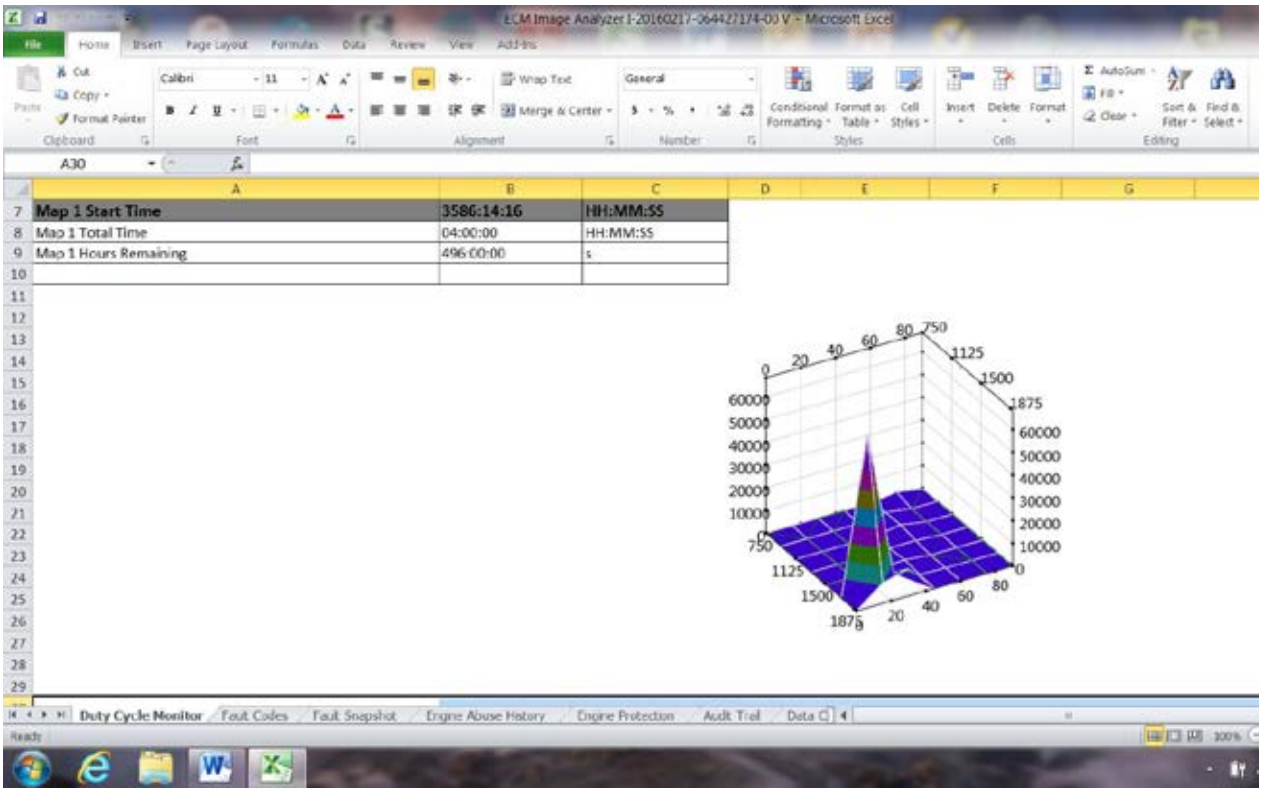
Duty cycle Map:

The map is using Royal Purple oil. The engine ran four hours at 67.8% of the time at rated horsepower.

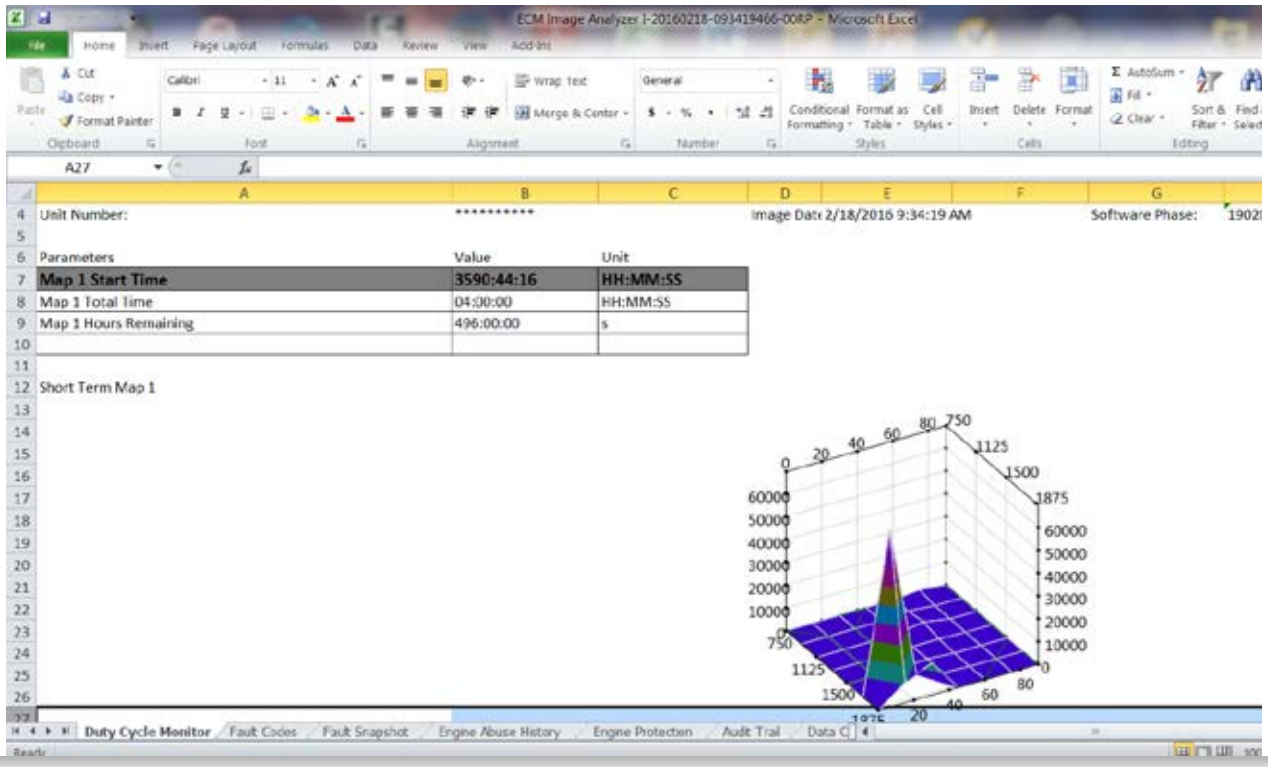


Duty Cycle:

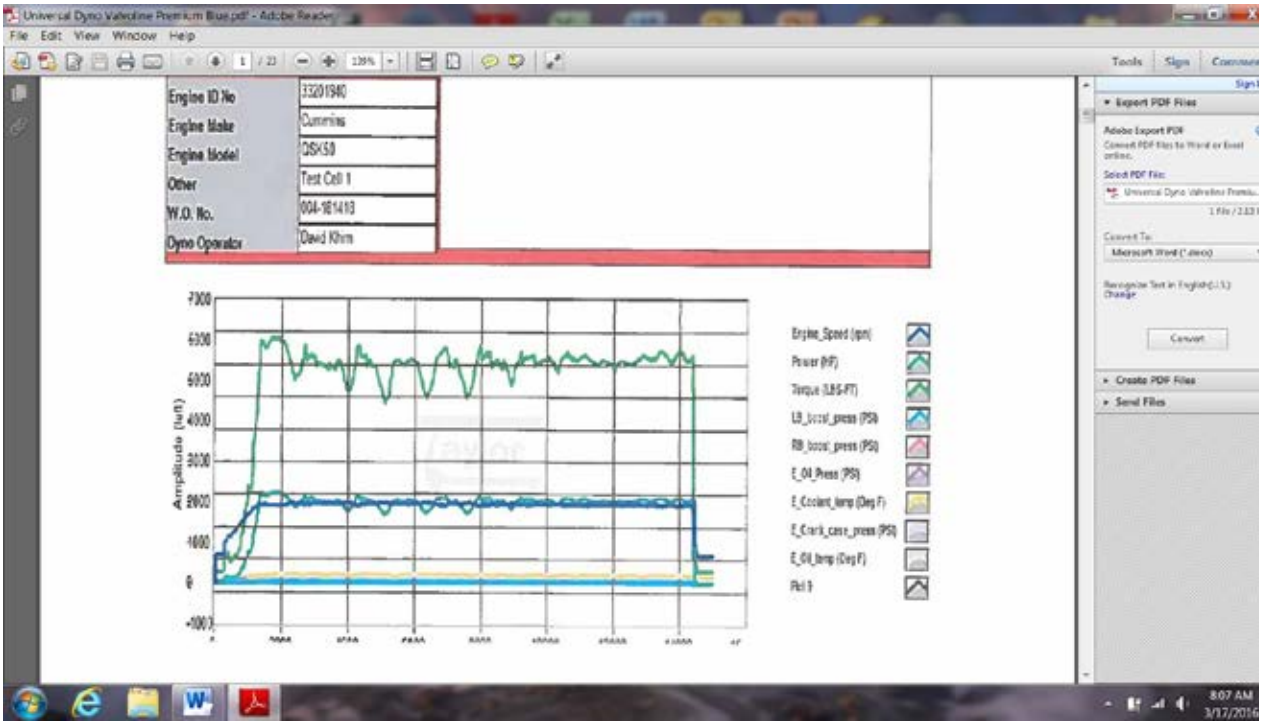
This map is showing the engine ran four hours using Multi-Viscosity oil.



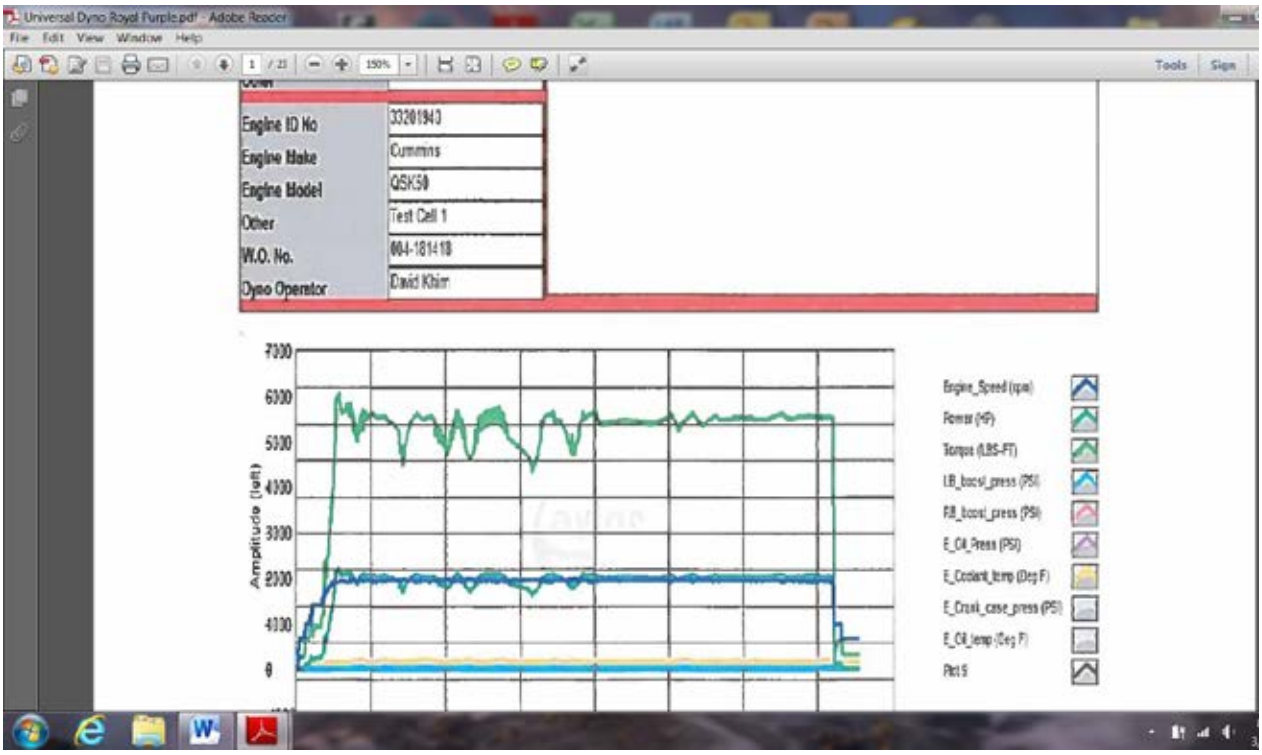
Duty Cycle Map:
This is the engine running four hours with Royal Purple



Dyno Report:
The engine ran using Multi-Viscosity oil under the same load and speed as Royal Purple



Dyno Report:
The engine was run using Royal Purple under the same load and speed as the Multi-Viscosity oil



Samples of the Dyno Report:

The full dyno report is available. This is samples of the dyno report. The first sample is toward the beginning. The second is around the middle and third is toward the end of each run.

MV

Timestamp seconds	Englne_Speeel (rpm)	Power(HP)	forque IL.BS-FT}	LB_boostJ> IRB_boost_p rea(PSI)	,,...(PSI)	E_OIl_Press (PSI)	E_Coolant_temp(DegF)	E_Crank_case_presa PSI)	E_Oll_temp (DegF)
9868.40	1956.12	2047.16	5495.55	39.34	38.89	59.16	179.60	0.02	223.53

RP

Timestamp seconds	Englne_Speed(rpm)	Power (HP)	Torque (LBS.fl')	LB_boost._p ms(PSI)	RB_boost_p 111fl (PS1)	E_OIl_Press (PSI)	E_Coolant_temp (DegF)	E_Crank_case_press (PSIJ PSI)	E_Oll_temp (DegF)
9883.40	1956.12	2050.84	5507.15	39.03	38.8	58.58	179.80	0.02	223.53

MV is the Multi-Viscosity oil. RP is Royal Purple. The engine speed is the same. Power and torque is higher with Royal Purple. The oil pressure is lower.

MV

Timestamp seconds	Englne_Spe (rpm)	Power(HP)	Torque (LBS-FT)	LB_boost_press (PSI)	RB_boost_prrasa (PSI)	E_OIl_Press (PSI)	E_Cool1nt_temp(DegF)	E_Crank_case___prns (PSI)	E_Oll_temp (DegF)
10290.40	1963.50	1979.92	5295.82	38.00	37.48	64.38	179.60	0.04	224.32

RP

Timestamp seconds	Englne_Speed(rpm)	Power (HP)	Torque (LBS.fl')	LB_boost._p ms(PSI)	RB_boost_p 111fl (PS1)	E_OIl_Press (PSI)	E_Coolant_temp (DegF)	E_Crank_case_press (PSIJ	E_Oll_temp (DegF)
10288.40	1957.50	1994.88	5353.41	38.80 1	38.13	59.74	179.60	0.04	223.53

This sample was taken from the middle of the dyno report. The RPM is the same from both runs. The horsepower and torque is higher using the Royal Purple oil. The oil pressure remains lower.

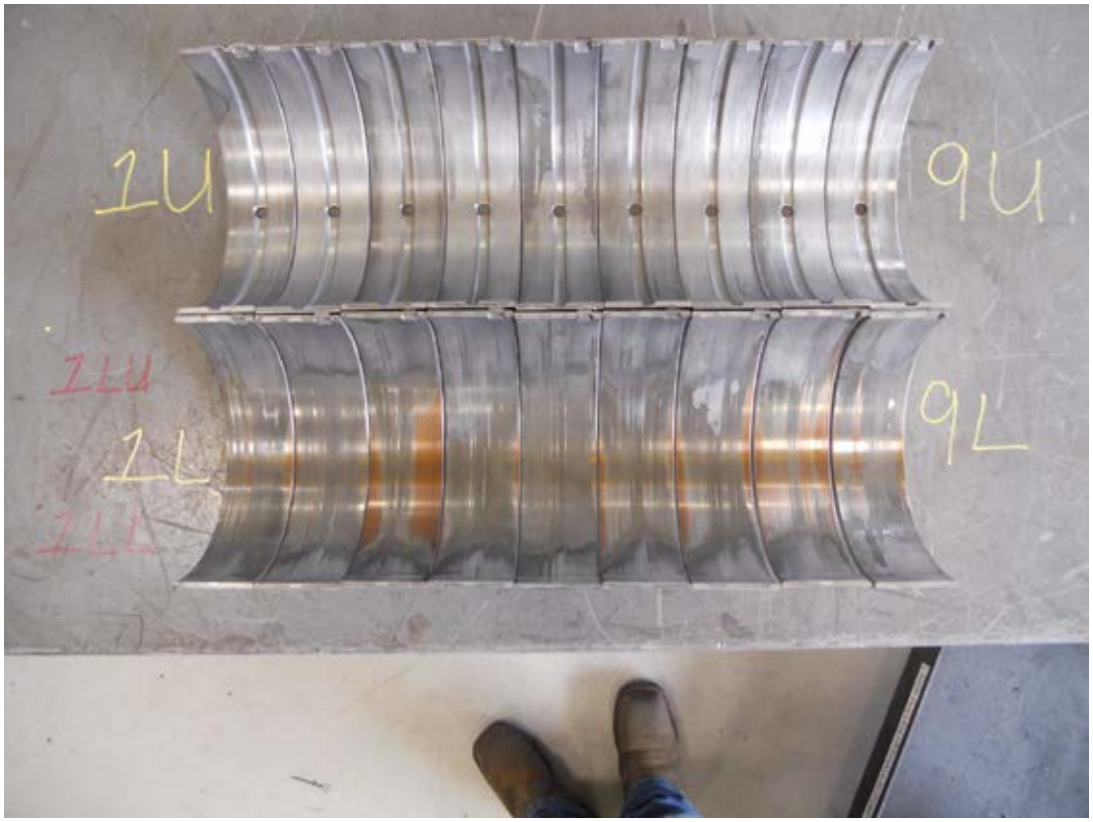
MV

Timestamp seconds	Englne_Spe (rpm)	Power(HP)	Torque (LBS-FT)	LB_boost_press (PSI)	RB_boost_prrasa (PSI)	E_OIl_Press (PSI)	E_Cool1nt_temp(DegF)	E_Crank_case___prns (PSI)	E_Oll_temp (DegF)
11417.00	1952,75	2030.35	5460.52	39.29	39.01	60.90	181.40	J.04	225.05

RP

Timestamp seconds	Englne_Speeel (rpm)	Power(HP)	forque IL.BS-FT}	LB_boostJ> IRB_boost_p rea(PSI)	,,...(PSI)	E_OIl_Press (PSI)	E_Coolant_temp(DegF)	E_Crank_case_presa PSI)	E_Oll_temp (DegF)
12315.60	1951.00	2052.38	5525.45	39.60	39.36	58.00	179.60	0.02	224.04

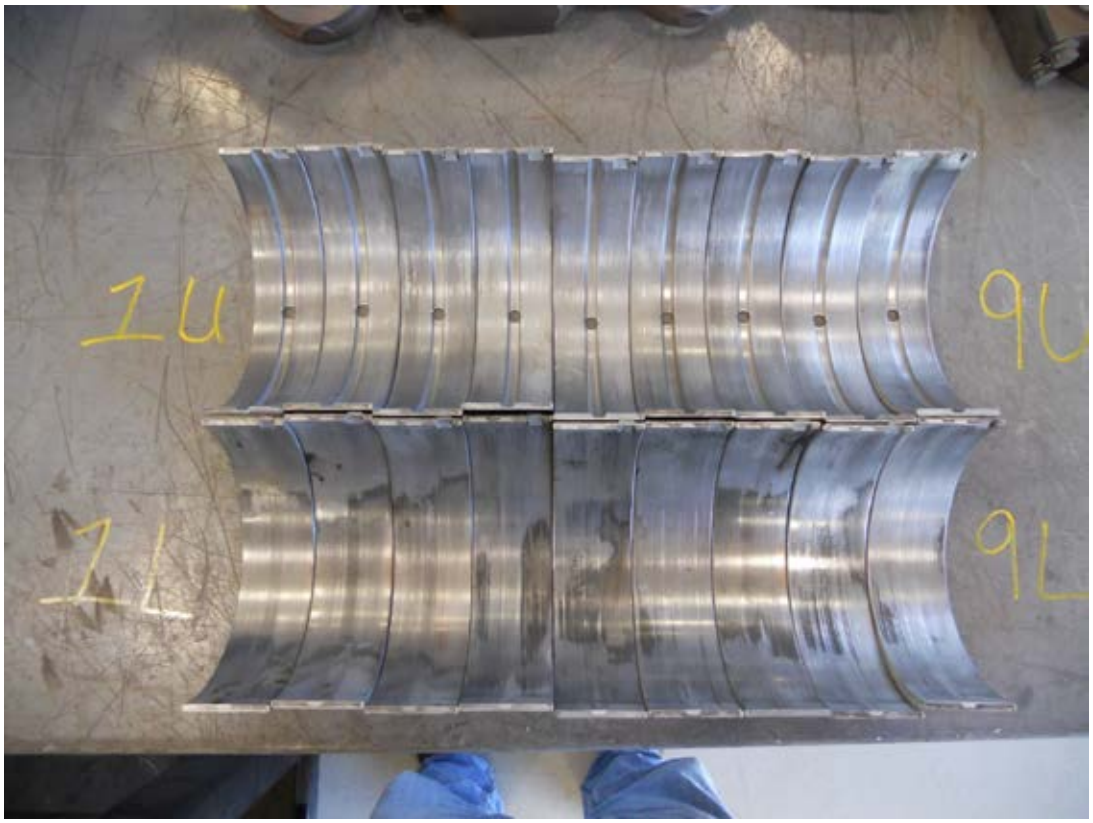
Bearing wear comparison:
Main bearings after using 15/40 Multi-Viscosity oil.



QSK-50 Comparison:

Engine came in for scheduled rebuild with 17,000 hours using 15/40 Multi-Viscosity oil. Main bearings are made of multi-layers of metal. This picture shows at least three different metals exposed from wear. The bottom half of the bearings will show more wear because of the load of the crankshaft and pistons in the engine. The top half of the bearing is showing no wear.

Bearing Wear Comparison:
Royal Purple oil



Universal Engine came in for a scheduled rebuild with 23,000 hours using Royal Purple oil. The bottom half of the bearings show less wear with more hours compared to the top picture.

Conclusion:

Most engine wear happens at startup. The reason is the engine relies on the film of oil that is left after you shut the engine down. When you restart the engine it has no oil pressure for a few seconds. You can see the wear differences in the two sets of main bearings. Both sets of main bearings came from high hour rebuilds, but the bearings that came from the engine with Royal Purple show less wear than the bearings with multi-viscosity oil. The four hour dyno run also shows less oil pressure, more power and higher torque using Royal Purple. All of these factors contribute to friction. The less friction you have the better performance and a longer life of the engine.

Proven Value Report

Clean and Flush / Royal Purple
Hydraulic System in Reciprocating Pump

CALUMET
SPECIALTY PRODUCTS PARTNERS, L.P.

Proven Value Report

Lotte Chemical / Petrochemical Industry / Korea

Application Details

- ✓ Catalyst Injection pump
- ✓ Reciprocating type pump
- ✓ EVA process (Ethylene Vinyl Acetate process)

Application Issues

- ✓ New oil change during annual T/A
- ✓ Malfunction of hydraulic system when start-up after T/A
- ✓ Running off-line filtration but no resolution in terms of oil cleanliness

UHDE Pump
2 Pumps on Skid / 5 Skids
EVA Process

ROYAL PURPLE SYNTHETIC OIL

CALUMET SPECIALTY PRODUCTS PARTNERS, L.P. FORTUNE 500

Proven Value Report

Lotte Chemical / Petrochemical Industry

Royal Purple Product Proposal

- ✓ CLEAN AND FLUSH 46
  - Oil Circulation System Cleaner

Application Requirements

- ✓ Resolve malfunction of hydraulic system of reciprocating pump immediately
- ✓ Improve cleanliness and reduce varnish potential index, MPC
- ✓ Stable running without any troubles

Hydraulic Oil

- ✓ Shell Tellus S2 M46

Cleaning/Flushing Condition

- ✓ Dilution Ratio: 15%
- ✓ Cleaning Time: 64 Hours
- ✓ Off-line Filter: HY-PRO 89L26-3MB (3 micron)

Customer Benefit & Cost Savings

- ✓ Excellent cleaning/flushing results
- ✓ Improve oil cleanliness and reduce MPC
- ✓ Very safe, effective cleaning during operation without equipment down
- ✓ If shut down, production loss above USD 100K per hour, normally need 6-8 hours for repair hydraulic components with USD 5K

Proven Value Report

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Especialistas en lubricación industrial

Energy efficiency test

In an electric motor by using high performance lubricants into the speed reduction gearbox

Success story in the industry

CIR-e3 Portable analyzer for energy audits

FLENDER reductor

The test took place in an environmentally committed paper industry that produces cartonboard for many different types of customers (food industry, pharmaceutical etc.): **BARCELONA CARTONBOARD**, formerly **STORA ENSO**.

It is a customer of Lubritec since more than 20 years, by selling lubricants as well as lubricating services.

The purpose of the test is showing the **ENERGY SAVINGS** in an electrical motor by using a high performance **ROYAL PURPLE** gear oil in the FLENDER speed reductor, in comparison with a another high efficiency oil (PAG) of a premium manufacturer.

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ABOUT THE TEST: the idea

The test consists of a comparison of the energy consumption of an electrical motor, in a similar period of time and production output, between a premium polyglycol gear oil and a polyalphaolefin **ROYAL PURPLE SYNERGY 220**.

The average consumption is recorded minute by minute in a memory card of the portable analyzer installed during the whole test.

Furthermore we take reductor housing temperatures through a thermography camera, at the same day time, if possible, to check the heat dissipated by the speed reductor.

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ABOUT THE TEST: the idea

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ABOUT THE TEST: the steps

On the 5th of August BARCELONA CARTONBOARD did an scheduled maintenance stop:

- Our mechanics emptied the FLENDER reductor and they filled it again with the same CLP-PG 220 oil, **brand new**. The aim was to start the test with 0 working hours.
- At the same time we installed the portable analyzer to the electrical feeding source of the inverter, and two days later we checked that the data were properly recorded. That was the real starting point of the test.

On the scheduled maintenance stop of the 2nd of September, the PG-oil in use was emptied, the reductor was cleaned and filled it up with **ROYAL PURPLE SYNERGY 220**.

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ABOUT THE TEST: the results

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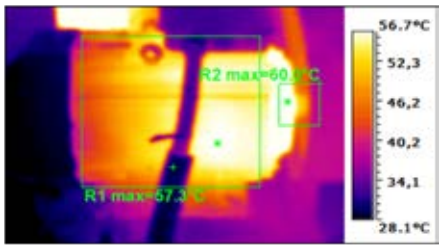
THERMOGRAPHY: MOTOR 24ME001



DIA Y HORA	LUBRICANTE: PG-220	R.P. SYNERGY 220
14/08/15 - 09:10	70,7	
18/08/15 - 15:15	70,7	
21/08/15 - 12:15	67,4	
25/08/15 - 10:00	56,6	
28/08/15 - 13:15	70,4	
01/09/15 - 12:05	73,7	
04/09/15 - 11:00		65,4
08/09/15 - 12:05		55,3
18/09/15 - 13:25		56,4
22/09/15 - 12:10		67,1
25/09/15 - 12:30		58,3
29/09/15 - 13:10		64,4
MEDIA	68,25	61,15

RECORDED TEMPERATURE

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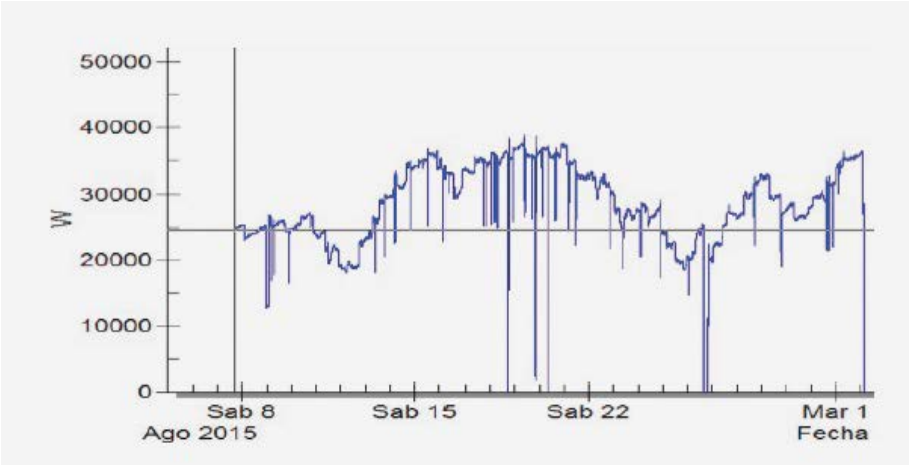
GRAPHICAL COMPARATIVE OF THE ENERGY CONSUMPTION

From 7th August 2015 to 1st September 2015



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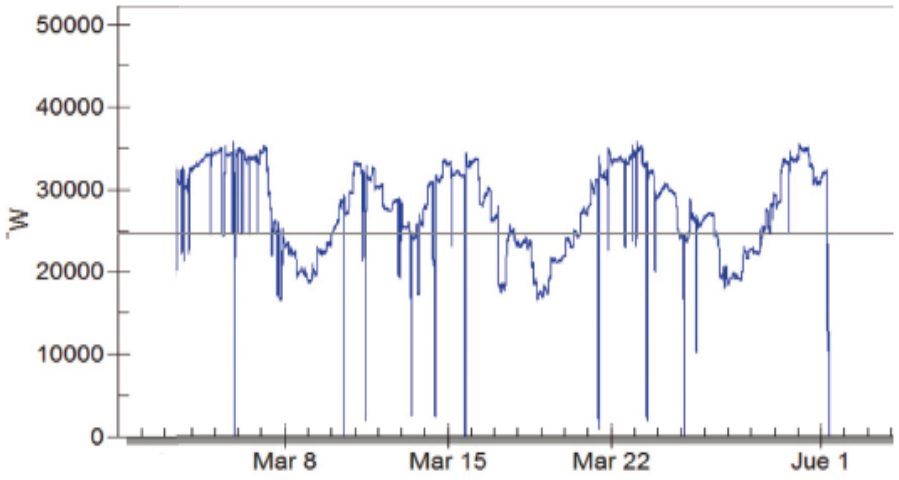
GRAPHICAL COMPARATIVE OF THE ENERGY CONSUMPTION

From 2d September to 1st October 2015 with
ROYAL PURPLE SYNERGY 220



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PRODUCTION DATA

	AUGUST	SEPTEMBER
Production hours	606,31	681,31
Average power consumption (kW)	28,49	27,19
Consumption (KWxh)	17.273,77	18.522,37

Power savings **4,57 %**

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CONCLUSIONS

1. Reduction in electricity consumption by 4.57 %, which means, multiplied by the rest of equal or similar equipment, an annual save over 20.000 €
2. Reduction of the CO_2 emissions: 48.165 kg of CO_2 throughout its lifetime.
3. Decreasing of temperature of 7°C
4. The test was done in a short period of time, always with brand new oils. The results of an oil analysis of the CLP-PG 220 gear oil, used in the first part of the test, showed no presence of any wear particles, prior to fill it up with **ROYAL PURPLE SYNERGY 220.** Therefore the gear box was working properly and the results showed a superior performance of the **ROYAL PURPLE** oil.
5. The test keeps running now in order to determine the lifetime of the **ROYAL PURPLE SYNERGY 220** vs. its competitor, that achieved roughly 57.000 working hours.

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The test was conducted and supevised by

Ismael Cabaco
Services manager

Eduard Pujol
Services technician

Javier Romera
Services technician

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Energy Savings on an Escalator from Superior Lubrication for

ThyssenKrupp

Neiman Marcus

Garden State Plaza
1 Garden State Plaza
Paramus, NJ 07652

SUPERIOR LUBRICATION DELIVERS RESULTS

PURPOSE OF TEST: TO SHOW REDUCED ELECTRICAL CONSUMPTION THROUGH THE USE OF SUPERIOR LUBRICATION.

EQUIPMENT TESTED: Montgomery Escalator
480 Volt connection measuring Current and Voltage/Compressor set as main compressor

DATE OF INITIAL TESTING: September 15, 2016

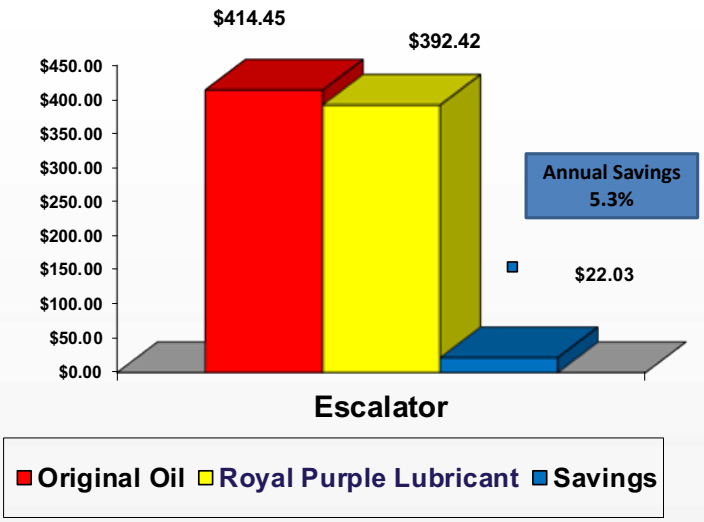
LUBRICANT: Elevator Gear Oil **LUBRICANT:** Royal Purple Synfilm GT
APPLIED: Gearbox and Chain Lubricant

RESULTS:	**Original Oil**	**Royal Purple Synfilm GT**	
KILOWATT HOURS	94.55 kwh	89.53 kwh	(5.3% Reduction)
KILOWATT HOURS/Month	8289.1 kwh	7848.4 kwh	
COST Elapsed @ $0.05/KWH	$.05	$.04	
COST PER MONTH@ $0.05/KWH	$414.45	$392.43	
ANNUAL COST	$4,973.40	$4,709.16	

SAVINGS with ENERGY EFFICIENT LUBRICANTS **$22.02 per month $264.24 per year per escalator. 4 escalators in Neiman Marcus equates to an annual savings of $1,056.96.**

The unit is representative of the normal operating compressor on site with no known mechanical or electrical issues. Electrical Savings Estimates for this unit is $264.24 per year or 5.3% reduction.

SUPERIOR LUBRICATION DELIVERS RESULTS



SUMMARY – ESCALATOR

Superior Lubricants Save Energy

Escalator was not known to have mechanical or electrical issues at the time of the data collection dates.

The survey did show an estimated average annual savings of $264.36 per escalator or 5.3% comparing the Original Oil to Royal Purple Synfilm GT.

Royal Purple Synfilm GT showed a reduction in **Total Energy Elapsed** during the data collection in kilowatt/hour, when compared to the Original Oil. **Total Energy Elapsed** reduction of **(-5.3%)**

Conclusion:
The Escalator worked less with Royal Purple Synfilm GT filled to proper level in the reservoir.

SURVEY CONDITIONS

Survey Conditions:
Unit is a Montgomery Escalator located within Neiman Marcus in Paramus, NJ. All surveys were ran with this unit set-up as the primary unit. The unit was shutdown and the connections were made to the contactor in the units main feed panel. After terminations were achieved, the connections were confirmed, Left to right were A-1, B-2 and C-3. The Escalator was started and allowed to run to collect data. Data was collected over 30 minutes to try to get as realistic data as possible. The escalator was running the entire time while attempting to collect data. On September 15, 2016, ambient temperature was 70 degrees with 85% humidity and on November 03, 2016, ambient temperature was 70 degrees with 87% humidity . These escalators are located within Neiman Marcus and therefore, ambient temperature was the actual temperature inside the store itself.

SURVEY CONDITIONS

Cost estimated at $0.05 per kwh on a 30 Day Month. Annual cost estimates are $0.05 per kwh on a 12 month at 30 days per month.

Givens:
Work required of this escalator is directly related to the coefficient of friction of the dynamic moving components. A reduction in energy needed to run the unit is related to the coefficient of friction between the components. A reduction in electrical energy will indicate reduced coefficient of friction and improved lubrication of the components.

Factors that were not calculated in the savings:
Longer service life of the equipment due to improved lubrication, reduction of friction
Reduced maintenance requirements, Replacement parts and Labor
Increase in Lubricant Life, based on oil analysis

Superior Lubricants Save Energy

All Royal Purple Lubricants are formulated to protect with high film strength

Royal Purple's high film strength prevents metal to metal contact even at heavy loads

Preventing metal to metal contact reduces parasitic loss, returns some lost efficiency and prevents wear

Royal Purple Lubricants can greatly extend Lubricant life in equipment and recommends changing oil based on quality oil analysis reporting

Superior Lubricants Save Energy

Royal Purple would like to thank Kenneth Dominguez for scheduling the work to complete the safe and successful Royal Purple Synfilm GT trial and data collection on the escalator.

For questions or more information please contact:
John Koch, Senior Regional Manager
Calumet Branded Products
jkoch@royalpurple.com
713-376-8187

Summary Report

Royal Purple Engine Oil, Durability and Performance Testing with the City of New York Department of Sanitation

Written and Submitted By:

Christopher Barker, Royal Purple LLC
Gary Galati, V.A.G., Inc. dba Performance Lubricants

Executive Summary

In September of 2010, evaluation of Royal Purple premium synthetic engine oils by the City of New York Department of Sanitation (DSNY) in sanitation truck diesel engines began. The evaluation was performed in two phases. Phase one of the evaluation was to determine the durability and useful oil life of the Royal Purple engine oil in the DSNY sanitation trucks. The minimum target oil life was 750 hours. The testing included 13 separate trucks with periodic oil sampling and used oil analysis performed to determine the condition of the engine oil. All units successfully operated to engine oil life far exceeding the 750 hour target with the maximum life recorded as 1,900+ operating hours. Phase two of the evaluation concerned engine oil performance of two different Royal Purple synthetic SAE 15W-40 engine oil formulations. Performance was measured on the DSNY chassis dynamometer. Two sanitation trucks were chosen and baseline dynamometer tests were performed with the currently used engine oil installed. After this, the Royal Purple candidate oils were installed and the evaluation procedure was begun. Dynamometer testing was scheduled to be performed approximately every 300 hours of truck operation, and results were compared to baseline dynamometer tests performed on the currently used engine oil. Over the course of the 900+ hour evaluation, emissions remained in the required range of the EPA certification, while showing an improvement in fuel economy in the DSNY drive cycle, as anticipated.

Background

The City of New York Department of Sanitation (DSNY) is tasked with continuous improvement with respect to reducing the environmental impact of the municipal fleet. The mandate has allowed DSNY to evaluate many new technologies intended to reduce vehicle emissions and/or improve the fuel economy of the vehicles in the fleet. Historically, the new technologies have included additional or replacement vehicle hardware, while lubricants had not been evaluated for the potential improvements in environmentally friendly operation of the vehicle. The initial meeting between Royal Purple Distributor, Performance Lubricants, and DSNY took place on July 15, 2010, at the Queens, NY headquarters. Spiro Kattan and George Johnson participated in the meeting along with Glenn Goldstein from Emisstar and Gary Galati of Performance Lubricants. It was decided an evaluation of Royal Purple 15W40 engine oil might be appropriate in designated units based in the local borough. In September 2010, DSNY senior management agreed to an evaluation of Royal Purple diesel engine oils in the DSNY fleet.

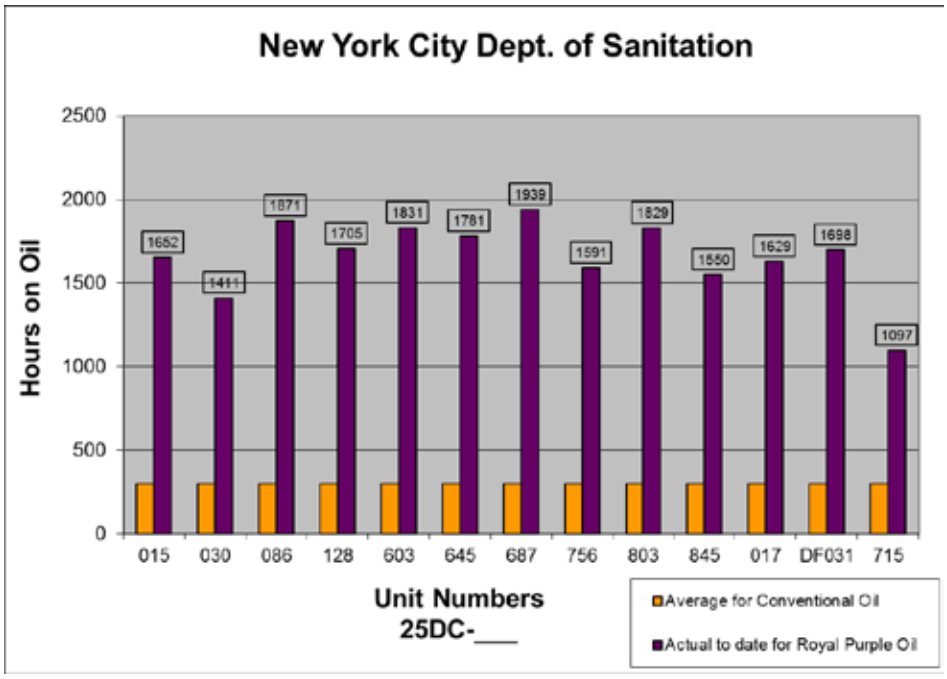
Phase I

The overall test objective was to determine if the oil stability would enable an extended drain interval without sacrificing performance. The project target interval was 750+ hours. Achieving the objective would present a savings to DSNY in the amount of oil required for purchase each year, substantially reduce the volume of used oil to handle and dispose of annually, and reduce the time and associated labor cost for preventive oil service maintenance.

Thirteen (13) units based in the Queens area were selected for the evaluation (25DC-015, 25DC-030, 25DC-086, 25DC-128, 25DC-603, 25DC-645, 25DC-687, 25DC-756, 25DC-803, 25DC-845, 25DF-017, 25DF-031, and 25DC-715. Six drums of oil (total of 330-gallons) were provided “gratis” and shipped in early October for the evaluation. Oil was installed in all thirteen units beginning in late October, 2010 through early January, 2011. The units were deployed in their normal city and borough runs for trash pickup and disposal. Periodic oil analysis testing was performed to determine oil degradation and its capability to remain stable

in such an operating environment. Two oil samples were taken at each interval, one analyzed in-house and the second sample by an outside third party laboratory, Wear-Check, located in Cary, NC.

The 13 test units successfully operated in a range of 1097 hours up to 1939 hours before the oil was drained. At the point of drain, a final oil sample was taken for analysis. In every case, the report indicated that the oil remained suitable for continued use. Final TBN numbers ranged from a low of 5.1 to 8.6. Since the initial TBN of Royal Purple 15W-40 engine oils is typically 10 to 10.5, the remaining neutralization ability of the oil, as indicated by oil analysis, can be considered to be 51% - 86% of new/unused oil.



Viscosity of the used oil is also a factor in determining the condition of the lubricant. In all units, the engine oil retained a serviceable viscosity even with as high as 1,900+ hours of use. Furthermore, all wear metals measured also remained in a normal and acceptable range when compared to a standard 300-mile oil drain interval. A tabulated summary of the used oil analysis results, including viscosity, TBN, and wear metal values, is included in the Appendix. Based on continued good vehicle reliability and the excellent used oil analysis results, it was evident that the Royal Purple oil could withstand the operational rigors of DSNY and that there was an opportunity for significant savings by extending oil-drain intervals without jeopardizing engine performance.

Phase II

After a successful Phase I of testing, whereby the Royal Purple synthetic oil was able to significantly and safely extend the potential for oil drain intervals, it was decided to enter into a Phase II of testing, utilizing the services of the DSNY in-house dynamometer to measure fuel flow and emissions. The dynamometer testing and measurements were scheduled for the standard 300-hour interval plus a 600 and 900 hour interval to ascertain if performance was in fact sustainable over an extended oil service interval.

Two trucks were selected for the test, Unit #25DD-205 and #25DD-012, both Class 8 refuse trucks with identical drive train components and of the same manufacturer. The particular units were also chosen based on similar accumulated operational hours. A baseline oil sample of the currently used engine oil was taken at the time of the typical oil change interval. Two formulations of Royal Purple 15W-40 diesel engine oil were utilized, a special formulation designated as "DSNY Special" and the current API CJ-4 licensed formulation.

The DSNY Special 15W-40 oil was installed in Unit #25-DD205 on June 10, 2014 at 3969 unit hours. An initial drain of the Royal Purple (clean-out drain) was performed on August 26, 2014 at 4252 hours (283 hours on the oil). The intent of the clean-out drain is to remove deposits and any residual effect of the previous conventional oil. The unit was re-filled with new Royal Purple DSNY Special oil and performance measurements for the WV and NY Sanitation operational cycles; dynamometer evaluations were scheduled for 300, 600, and 900 operational hours. The actual evaluations occurred on November 7, 2014 (4538/286 hrs), February 26, 2015 (4964/712 hrs), and May 20, 2015 (5277/1,025 hrs). An oil sample was also taken at each measurement point in the test.

The same procedure was carried out for Unit #25DD-012 utilizing the API CJ-4 licensed 15W-40 engine oil. Installation of Royal Purple took place on September 30, 2014 at 3445 unit hours. The clean-out drain completed on January 5, 2015 (3722/277 hrs), with dynamometer evaluations scheduled for 300, 600, and 900 operational hours. The actual dynamometer performance evaluations occurred on March 11, 2015 (4134/412 hrs), July 7, 2015 (4436/714 hrs) and October 27, 2015 (4766/ 1,044 hrs).

At all three of the dynamometer performance evaluations, emissions remained within a normal range with actual improvement in some areas. In addition, stable or improved fuel efficiency was observed in both units, particularly when focusing on the more significant NYC Sanitation driving cycle. For unit #25DD-205 with the DSNY Special 15W-40 oil, the more significant NYC drive cycle showed a 3.2% fuel improvement at the end of the testing. Unit #25DD-012, using the API CJ-4 15W-40 oil, showed a 9.1% fuel economy improvement in the NYC drive cycle and an overall average fuel improvement of 6.45% was observed. Summary tables of these results are shown below.

25DD-205 / QW2								
Task #	**Date**	**Target** (hrs.)	**Actual** (hrs.)	**Emissions**	**Description**	**Action**	**Action**	**Action**
1	6/10/14	-------	3969	**Test #1**	Baseline w/CJ-4	Fill w/RP 15W-40 (special)	Replace Oil Filters	Oil Sample
2	8/26/14	4269	4252	**-------**	RP Clean Out	Fill w/RP 15W-40 (special)	Replace Oil Filters	Oil Sample
3	11/7/14	4569	4538	**Test #2**	-------	-------	Replace Oil Filters	Oil Sample
4	2/26/15	4838	4964	**Test #3**	-------	-------	Replace Oil Filters	Oil Sample
5	5/20/15	5264	5277	**Test #4**	-------	-------	Replace Oil Filters	Oil Sample
25DD-012 / QW2								
Task #	**Date**	**Target**	**Actual**	**Emissions**	**Description**	**Action**	**Action**	**Action**
1	9/30/14	-------	3445	Test #1	Baseline w/CJ-4	Fill w/RP 15W-40 (CJ-4)	Replace Oil Filters	Oil Sample
2	1/5/15	3745	3722	-------	RP Clean Out	Fill w/RP 15W-40 (CJ-4)	Replace Oil Filters	Oil Sample
3	3/11/15	4022	4134	Test #2	-------	-------	Replace Oil Filters	Oil Sample
4	7/7/15	4434	4436	Test #3	-------	-------	Replace Oil Filters	Oil Sample
5	10/27/15	4736	4766	Test #4	-------	-------	Replace Oil Filters	Oil Sample

DSNY Unit #25DD-012, Royal Purple 15W-40 API CJ-4								
Test Cycle	Test Condition	THC (g/mi)	CO (g/mi)	NO_x (g/mi)	CO_2 (kg/mi)	CH_4 (g/mi)	NMHC (g/mi)	F.E. (mpg)
NYC	Base	0.09	0.56	6.7	3.0	0.05	0.06	3.3
	300 hrs	0.05	0.40	7.6	3.0	0.02	0.04	3.4
	600 hrs	0.05	0.68	12	2.9	0.00	0.06	3.5
	900 hrs	0.05	0.74	15	2.8	0.00	0.07	3.6
WVU	Base	0.03	0.19	6.4	3.5	0.02	0.02	2.9
	300 hrs	0.03	0.15	8.9	3.6	0.01	0.03	2.8
	600 hrs	0.03	0.54	12	3.5	0.00	0.05	2.9
	900 hrs	0.04	0.40	15	3.4	0.00	0.06	3.0
Overall	Base	0.06	0.37	6.6	3.3	0.03	0.04	3.1
	300 hrs	0.04	0.28	8.3	3.3	0.01	0.04	3.1
	600 hrs	0.04	0.61	12	3.2	0.00	0.06	3.2
	900 hrs	0.05	0.57	15	3.1	0.00	0.06	3.3

DSNY Unit #25DD-205, Royal Purple 15W-40 DSNY Special								
Test Cycle	Test Condition	THC (g/mi)	CO (g/mi)	NO_x (g/mi)	CO_2 (kg/mi)	CH_4 (g/mi)	NMHC (g/mi)	F.E. (mpg)
NYC	Base	0.01	0.49	6.4	3.3	0.01	0.01	3.1
	300 hrs	0.02	0.61	7.0	3.3	0.00	0.02	3.1
	600 hrs	0.04	7.5	8.4	3.2	0.00	0.05	3.1
	900 hrs	0.09	3.8	11	3.2	0.00	0.10	3.2
WVU	Base	0.03	0.32	5.7	3.8	0.01	0.03	2.7
	300 hrs	0.03	0.17	6.9	3.8	0.00	0.04	2.6
	600 hrs	0.044	8.6	10	3.9	0.00	0.06	2.6
	900 hrs	0.111	5.2	13	3.9	0.00	0.13	2.6
Overall	Base	0.02	0.40	6.1	3.6	0.01	0.02	2.9
	300 hrs	0.02	0.39	6.9	3.6	0.00	0.03	2.9
	600 hrs	0.04	8.1	9.3	3.5	0.00	0.05	2.9
	900 hrs	0.10	4.5	12	3.5	0.00	0.11	2.9

As anticipated, this is consistent with our experience from road trials and laboratory test results for heavy duty diesel engines. The data history indicates a fuel improvement range between 2- 5%, with an overall average of approximately 3%.

Conclusion and Recommendations

Through both phases of the engine oil evaluation, under the direct observation and administration by DSNY staff and maintenance personnel, the Royal Purple premium synthetic diesel engine oils have proven to provide the performance and protection, as well as possess the durability and reliability to allow DSNY to make further reductions to the environmental impact of the municipal fleet. Results from Phase I and Phase II show that Royal Purple 15W-40 diesel engine oils are the environmentally friendly engine oil by allowing safe, extended oil change intervals, thereby reducing environmentally hazardous waste products, and by improving vehicle fuel economy. The evaluation also shows Royal Purple 15W-40 premium synthetic diesel engine oils to be the economic engine oil choice by reducing overall annualized cost of engine lubricant and fuel, and by reducing required maintenance labor hours and waste disposal fees. The table below shows operational cost savings provided by switching the fleet to Royal Purple premium synthetic engine oils. The fuel saving section shows three scenarios based on historical typical fuel economy improvements, and actual fuel economy improvements observed during the dynamometer testing.

New Oil	Units	Current Drain Interval	Annual Hours	Avg. # Drains per Year	Gallons per Drain	Annual Gallons of New Oil	Cost per Gallon	Total Cost of Oil	Savings
Conventional Oil	2300	300	1050	3.50	11	88,550	$6.24	$552,552.00	x
Royal Purple	2300	900	1050	1.17	11	29,601	$20.00	$592,020.00	($39,468.00)
Used Oil	**Units**	**Current Drain Interval**	**Annual Hours**	**Avg. # Drains per Year**	**Gallons per Drain**	**Annual Gallons of Oil**	**Reduction of Used Oil**	**Per Gal Disposal Cost**	**Savings**
Conventional Oil	2300	300	1050	3.50	11	88,550	x	x	x
Royal Purple	2300	900	1050	1.17	11	29,517	59,033	0.75	$44,275.00
Labor	**Units**	**Avg. # Drains per Year**	**Labor per Drain**	**Total Labor Cost**					
Conventional Oil	2300	3.50	$90.00	$724,500.00					
Royal Purple	2300	1.17	$90.00	$242,190.00					$482,310.00
Fuel	**Units**	**Gallons per Hour**	**Annual Hours**	**Total Gal per Year**	**Reduced Gal of Fuel**	**Fuel Cost per Gal**			
Conventional Oil	2300	2	1050	4,830,000	x	x			
Royal Purple									
Typical - 2.70%	2300	1.946	1050	4,699,590	130,410	1.65			$215,176.50
25DD-205 DSNY Cycle - 3.23%	2300	1.936	1050	4,675,440	154,560	1.65			$255,024.00
25DD-012 DSNY Cycle - 9.10%	2300	1.818	1050	4,390,470	439,530	1.65			$725,224.50
Total Savings									
Typical									$702,293.50
25DD-205 DSNY Cycle									$742,141.00
25DD-012 DSNY Cycle									$1,212,341.50

Appendix

Phase I Oil Analysis Results

Unit #	Install Date	Oil Type	Sample Date	Hours	Silicon	Potas.	Sodium	Fuel (%)	Water (%)	Iron	Nickel	Chrom.	Titanium	Copper	Alum.	Tin	Lead	Soot (%)	Visc @100°	Sulf.	Oxid.	TBN
25DC-015	30-Nov-10	CI	14-Mar-11	617	7.8	0	3.6	<2.0	<0.1	8.9	0.5	0.3	0.7	2.7	3.6	0	0	0.1	13.73	72	68	12.0
25DC-015			23-Jun-11	968	9.3	7.3	4.5	<2.0	<0.1	14.0	0.8	0.5	0.5	32	4.7	0	3.5	0.2	13.89	72	68	10.9
25DC-015																						
25DC-015			27-Sep-11	1298	11.0	1.7	3.8	<2.0	<0.1	18.0	1.8	0.6	0	78	4.2	1.1	1.6	0.4	13.5	86	80	9.1
25DC-015			20-Jan-12	1652	10.0	1.5	5.2	<2.0	<0.1	30.0	2.9	0.8	0	111	5.7	2.1	1.4	0.4	13.66	78	68	8.8
25DC-030	2-Dec-10	CI	17-Mar-11	600	6.3	0	3.9	<2.0	<0.1	9.4	1.6	0.3	0.7	23	3.6	0	0	0.2	13.67	72	68	11.6
25DC-030			23-Jun-11	865	9.1	0	4.7	<2.0	<0.1	16.0	4.5	0.7	0.5	101	4.5	0	1.1	0.3	12.83	80	76	7.8
25DC-030			27-Jun-11	1000	9.0	<2	6.0	N/A	<0.1	7.0	N/A	4.0	N/A	94	3.0	<2	<2	0.7	13.2	N/A	N/A	8.0
25DC-030			28-Sep-11	1161	9.0	1.7	4.1	<2.0	<0.1	19.0	4	0.7	0	148	4.2	1.9	0.8	0.5	13.19	89	80	8.8
25DC-030			20-Jan-12	1411	11.0	0	5.2	<2.0	<0.1	27.0	6.1	1	0.4	187	5.7	0	3.3	0.6	13.31	80	68	8.1
25DC-086	1-Dec-10	CI	18-Mar-11	502	6.2	0	3.7	<2.0	<0.1	10.0	0.7	0.2	0.7	3.3	3.5	0	0	0.2	13.48	66	60	12.3
25DC-086			23-Jun-11	710	7.6	0	3.9	<2.0	<0.1	19.0	1.5	0.5	0.5	4.3	4.5	0	0	0.3	12.97	72	64	11.5
25DC-086			27-Jun-11	500	8.0	<2	2.0	N/A	<0.1	6.0	N/A	6.0	N/A	17	4.0	<2	<2	0.6	13.4	N/A	N/A	9.6
25DC-086			28-Sep-11	1213	9.8	2.2	4.3	<2.0	<0.1	35.0	2.4	0.7	0	23	6	1.8	2	0.8	13.36	91	84	8.8
25DC-086			3-May-12	1768	11.0	1.3	10	<2.0	<0.1	59.0	3.8	1.1	0	103	8.4	2	2	1	13.14	89	84	8.1
25DC-086			27-Jun-12	1871	11.0	<2	5	N/A	<0.1	47.0	N/A	2	N/A	148	10	7	6	1.8	12.7	N/A	7.5	8.5
25DC-128	17-Nov-10	CJ	17-Mar-11	600	6.2	0	5.8	<2.0	<0.1	9.6	0.6	0.3	0.5	226	2.9	0	0	0.2	13.43	55	64	8.7
25DC-128			23-Jun-11	1001	9.1	0	7.3	<2.0	<0.1	15.0	1.4	0.4	0.4	269	4.1	0	0.3	0.4	13.36	53	68	5.5
25DC-128			29-Jun-11	0	10.0	<2	16.0	N/A	<0.1	6.0	N/A	<2	N/A	160	5.0	2	<2	0.9	13.3	N/A	N/A	7.0
25DC-128			29-Sep-11	1295	11.0	1.6	7.1	<2.0	<0.1	20.0	2.2	0.5	0	254	4	1.2	1.2	0.9	13.04	72	84	6.3
25DC-128			20-Jan-12	1705	13.0	0	9.3	<2.0	<0.1	35.0	3.4	0.9	0.3	273	6	0	1.7	1.2	12.63	72	88	5.7
25DC-603	25-Oct-10	CJ	9-Mar-11	656	8.0	4.6	5.6	<2.0	<0.1	9.5	1.1	0.3	0.6	100	2.8	0	0	0.3	13.12	61	72	9.2
25DC-603			23-Jun-11	1072	11.0	0	2.7	<2.0	<0.1	15.0	2.1	0.5	0.4	137	3.5	0	0.3	0.5	13	66	76	8.1
25DC-603			27-Jun-11	0	13.0	<2	4.0	N/A	<0.1	4.0	N/A	4.0	N/A	123	3.0	<2	<2	1	8.3	N/A	N/A	6.7
25DC-603			30-Sep-11	1288	14.0	1.7	2.9	<2.0	<0.1	24.0	3.1	0.6	0	157	4.1	2.9	1.7	0.9	12.84	80	96	6.3
25DC-603			2-May-12	1664	17.0	1.1	4.8	<2.0	<0.1	74.0	5.7	1.4	0	165	5.9	5.9	4.1	1.8	12.93	100	129	7.4
25DC-603			27-Jun-12	1831	29.0	<2	18	N/A	<0.1	62.0	N/A	3	N/A	129	10	12	8	2.4	13.3	N/A	12.5	5.6
25DC-645	28-Oct-10	CJ	15-Mar-11	593	7.9	0	2.4	<2.0	<0.1	11.0	1.3	0.4	0.5	19	2.3	0	1.6	0.2	13.3	58	72	8.3
25DC-645			23-Jun-11	927	11.0	0.9	2.7	<2.0	<0.1	17.0	2.5	0.5	0.4	26	2.5	0	0	0.3	13.2	61	76	7.8
25DC-645			27-Jun-11	500	10.0	<2	<2	N/A	<0.1	7.0	N/A	<2	N/A	31	3.0	4	<2	0.9	13.2	N/A	N/A	6.4
25DC-645			10-May-12	1636	16.0	1.1	4.5	<2.0	<0.1	61.0	5.6	1.2	0	33	5.8	4	3.8	0.8	13.07	72	88	6.2
25DC-645			27-Jun-12	1781	16.0	<2	<2	N/A	<0.1	49.0	N/A	7	N/A	38	10.0	13	9	1.6	9.7	N/A	11.1	5.1
25DC-687	3-Nov-10	CJ	14-Mar-11	670	8.3	5.6	2.5	<2.0	<0.1	9.6	1.4	0.3	0.6	9.1	2.2	0	0	0.1	12.93	61	76	8.6
25DC-687			23-Jun-11	1085	11.0	0	3.3	<2.0	<0.1	17.0	2	0.4	0.5	10	2.9	0	3	0.3	12.92	64	88	4.7
25DC-687			27-Jun-11	500	9.0	<2	<2	N/A	<0.1	8.0	N/A	<2	N/A	12	2.0	<2	3	0.8	12.1	N/A	N/A	5.5
25DC-687			30-Oct-11	1478	15.0	0	4.1	<2.0	<0.1	29.0	2.3	0.6	0.5	12	3.2	0	9.6	0.7	13.11	86	108	6.2
25DC-687			21-Jan-12	1939	14.0	1	4.1	<2.0	<0.1	54.0	3.8	1	0	15	3.8	5.1	11	0.8	13.59	75	92	6.0

Unit #	Install Date	Oil Type	Sample Date	Hours	Silicon	Potas.	Sodium	Fuel (%)	Water (%)	Iron	Nickel	Chrom.	Titanium	Copper	Alum.	Tin	Lead	Soot (%)	Visc @100°	Sulf.	Oxid.	TBN
25DC-756	9-Nov-10	CJ	17-Mar-11	600	7.8	0	2.5	<2.0	<0.1	9.4	2.6	0.3	0.5	137	2.8	0	0	0.1	13.13	61	76	8.8
25DC-756			12-Jul-11	878	9.3	0	2.4	<2.0	<0.1	12.0	3.5	0.5	0.3	134	3.1	0	0	0.2	12.98	64	80	8.1
25DC-756			29-Jun-11	500	9.0	<2	<2	N/A	<0.1	5.0	N/A	3	N/A	120	4.0	2	<2	0.6	<3	N/A	N/A	6.7
25DC-756			27-Sep-11	1212	12.0	1.4	2.6	<2.0	<0.1	21.0	4.7	0.7	0	149	3.9	1.8	2	0.5	12.7	75	100	6.5
25DC-756			22-Jan-12	1591	13.0	0.9	3.9	<2.0	<0.1	33.0	5.7	0.9	0	143	4.7	3.6	3.4	0.5	13	61	80	7.0
25DC-803	14-Oct-10	CJ	18-Mar-11	726	18.0	2.7	2.3	<2.0	<0.1	18.0	4.7	0.5	0.5	206	3.4	0	0	0.4	12.96	66	88	9.0
25DC-803			23-Jun-11	1031	22.0	0	3.2	<2.0	<0.1	27.0	6.8	0.8	0.4	209	4	0	0.8	0.7	12.76	69	92	5.2
25DC-803			29-Jun-11	0	30.0	<2	<2	N/A	<0.1	12.0	N/A	<2	N/A	145	4.0	<2	2	1.2	<3	N/A	N/A	6.3
25DC-803			26-Sep-11	1267	25.0	2.6	3	<2.0	<0.1	38.0	7.2	1.1	0	207	4.5	1.7	4.3	1.1	12.54	86	116	6.1
25DC-803			21-Jan-12	1829	26.0	0	4.4	<2.0	<0.1	73.0	11	1.8	0.4	201	5.5	0	6.5	1.6	12.52	86	116	5.6
25DC-845	21-Oct-10	CJ	10-Mar-11	449	15.0	1.9	2.6	<2.0	<0.1	13.0	3.6	0.4	0.5	305	3.1	0	0	0.3	13.22	64	80	8.2
25DC-845			23-Jun-11	824	19.0	0	3.3	<2.0	<0.1	18.0	5.8	0.5	0.5	282	4	0	1.3	0.5	13.06	66	84	5.1
25DC-845			27-Jun-11	500	25.0	<2	<2	N/A	<0.1	6.0	N/A	<2	N/A	138	4.0	3	<2	0.9	<3	N/A	N/A	6.1
25DC-845			28-Sep-11	1385	23.0	2	2.7	<2.0	<0.1	27.0	7.1	0.8	0	274	4.1	1.6	3.6	1	12.66	80	104	6.0
25DC-845			21-Jan-12	1550	24.0	1.7	3.9	<2.0	<0.1	46.0	8.9	1.1	0	284	5.3	3.3	5.3	1.3	12.61	86	124	5.1
25DF-017	13-Jan-11	CI	10-Mar-11	331	8.1	7.2	3.4	<2.0	<0.1	6.4	1.2	0.3	0.7	3.1	2.7	0	2.8	0.1	13.07	69	72	12.8
25DF-017			23-Jun-11	747	14.0	7.9	4.4	<2.0	<0.1	14.0	2.5	0.4	0.6	8.8	3.9	0	5.3	0.3	13.38	80	80	10.8
25DF-017			29-Jun-11	500	20.0	14	22.0	N/A	<0.1	11.0	N/A	8.0	N/A	28	12.0	2	10	0.7	13.6	N/A	N/A	8.3
25DF-017			26-Sep-11	1176	16.0	2.4	3.8	<2.0	<0.1	24.0	4.4	0.6	0	17	3.6	1.8	8.5	0.6	13.05	100	96	8.2
25DF-017			21-Jan-12	1629	19.0	0	5	<2.0	<0.1	42.0	7.2	1	0.5	30	4.7	0	16	0.8	12.96	102	100	7.0
1551-DF031	16-Dec-10	CI	15-Mar-11	470	9.0	0	3.1	<2.0	<0.1	13.0	1.5	0.5	0.6	7.5	3.1	0	5.5	0.1	13.06	78	84	12.1
1551-DF031			23-Jun-11	668	11.0	0	3.6	<2.0	<0.1	20.0	3.1	0.6	0.4	25	3.4	0	2.5	0.3	12.56	89	92	10.4
1551-DF031			29-Jun-11	0	11.0	<2	14.0	N/A	<0.1	9.0	N/A	3.0	N/A	45	4.0	5	6	0.7	<3	N/A	N/A	7.9
1551-DF031			26-Sep-11	987	13.0	2.2	3.7	<2.0	<0.1	30.0	3.8	0.8	0	37	3.7	1.7	4.9	0.6	12.92	97	100	8.7
25-DF031			**20-Jan-12**	**1095**	**14.0**	**0**	**5.4**	**<2.0**	**<0.1**	**46.0**	**4.7**	**1.1**	**0.4**	**65**	**5.2**	**0**	**9.8**	**0.9**	**12.93**	**102**	**108**	**7.6**
1551-DF031			9-May-12	1522	15.0	10	50	N/A	<0.1	64.0	5.1	1.3	0	73	5.5	3.2	7.9	N/A	12.92	100	120	6.5
25DF-031			27-Jun-12	1698	14.0	<2	<2	N/A	0.1	64.0	N/A	8	N/A	86	9	10	13	1.9	11.6	N/A	15.2	6.8
25DC715	7-Oct-10	CJ	7-Jul-11	812	12.0	1.1	3	<2.0	<0.1	15.0	1.9	0.4	0.5	28	5.1	0	1.2	0.2	12.88	61	72	8.1
25DC715			28-Sep-11	**1111**	15.0	1.2	1.2	<2.0	<0.1	6.4	1.4	0.3	0	5.5	1.9	1.4	1.3	0.2	13.75	58	72	9.4
25DC715			20-Jan-12	**622?**	8.9	0	2.1	<2.0	<0.1	12.0	2.8	0.3	0.3	9.7	3.2	0	2.8	0.4	13.09	58	68	8.2
25DC715			3-May-12	1090	9.2	0.9	2.4	<2.0	<0.1	18.0	3.4	0.5	0	12	4.3	2.9	1.2	0.3	13.13	47	52	7.9
25DC715			27-Jun-12	1097	9.0	<2	<2	N/A	<0.1	13.0	N/A	<2	N/A	32	8	<2	3	1.2	13.4	N/A	6	6.8

Phase II Oil Analysis Results

Product		RP 15W-40 CJ-4		Out of Spec			
Customer		DSNY		Critical			
Unit ID		25DD-012		Baseline	- not for comparison with Typicals		
NOTE: All values in the Typical column are nominal, batch to batch variation the rule							
Sample Oil Hours, Scheduled			Baseline	Clean Out	300 hr	600 hr	900 hr
Sample Oil Hours, Actual				0	412 hr	714 hr	1,044 hr
Lab Sample #			14103103	15011900	15040900	15072801	15121500
Test	Unit	Typicals					
cSt@ 40°C	cSt	≈105	99.12	92.55	91.35	89.15	88.64
cSt@ 100°C	cSt	≈15	13.58	13.29	13.24	12.93	12.84
Visc. Index		≈146	137	144	145	144	143
Total Base No.	mgKOH/gm	9.3 Min	8	8.8	7.4	5.3	3.3
Iron	ppm	<1	16	7	8	11	21
Copper	ppm	<1	1	2	2	2	4
Lead	ppm	<1	<1	<1	<1	<1	6
Titanium	ppm	<1	<1	<1	<1	<1	<1
Chromium	ppm	<1	<1	<1	<1	<1	<1
Cadmium	ppm	<1	<1	<1	<1	<1	<1
Nickel	ppm	<1	1	<1	<1	1	1
Aluminum	ppm	<1	1	2	2	3	3
Tin	ppm	<1	<1	<1	<1	<1	2
Calcium	ppm	2050-2400	1240	2360	2567	2556	2476
Magnesium	ppm	<1	808	67	14	16	11
Phosphorus	ppm	1000-1200	1107	1059	1073	1031	1079
Silicon	ppm	<1	5	6	5	5	12
Sodium	ppm	<1	4	11	11	6	15
Barium	ppm	<1	<1	<1	<1	<1	<1
Boron	ppm	<1	3	64		<1	<1
Antimony	ppm	<1	<1	<1	<1	<1	<1
Vanadium	ppm	<1	<1	<1	<1	<1	<1
Molybdenum	ppm	<1	45	3	<1	2	1
Manganese	ppm	<1	<1	<1	<1	<1	<1
Zinc	ppm	1200-1400	1316	1248	1286	1404	1339

Product		RP 15W-40 DSNY		Out of Spec			
Customer		DSNY		Critical			
Unit ID		25DD-205		Baseline	- not for comparison with Typicals		
NOTE: All values in the Typical column are nominal, batch to batch variation the rule							
Sample Oil Hours, Scheduled			Baseline	Clean Out	300 hr	600 hr	900 hr
Sample Oil Hours, Actual				0	286 hr	712 hr	1,025 hr
Lab Sample #			14061101	14100100	14120303	15032300	15061003
Test	Unit	Typicals					
cSt@ 40°C	cSt	≈108	94.39	98.03	97.96	98.84	97.4
cSt@ 100°C	cSt	≈15	13.09	13.74	13.69	13.81	13.58
Visc. Index		≈145	137	141	141	141	140
Total Base No.	mgKOH/gm	10.0 Min	7.2	9.8	9.9	8.7	7.3
Iron	ppm	<1	7	7	8	18	23
Copper	ppm	<1	2	3	5	12	27
Lead	ppm	<1	<1	<1	<1	2	2
Titanium	ppm	<1	<1	<1	<1	<1	<1
Chromium	ppm	<1	<1	<1	<1	<1	<1
Cadmium	ppm	<1	<1	<1	<1	<1	<1
Nickel	ppm	<1	<1	<1	<1	<1	<1
Aluminum	ppm	<1	2	3	3	4	4
Tin	ppm	<1	1	<1	3	<1	<1
Calcium	ppm	3000-3500	1139	3216	3485	3454	3377
Magnesium	ppm	<1	755	77	17	20	16
Phosphorus	ppm	1100-1275	1025	1193	1264	1254	1211
Silicon	ppm	<1	6	5	4	8	9
Sodium	ppm	<1	15	4	8	11	9
Barium	ppm	<1	<1	<1	<1	<1	<1
Boron	ppm	<1	8	<1	<1	5	<1
Antimony	ppm	<1	<1	<1	<1	<1	<1
Vanadium	ppm	<1	<1	<1	<1	<1	<1
Molybdenum	ppm	110-130	43	112	109	123	119
Manganese	ppm	<1	<1	<1	<1	<1	<1
Zinc	ppm	1250-1470	1264	1386	1458	1473	1421

OPPD

Case Studies and Equipment Trends

Jesse Jaspers
Vision Industrial Sales

The Economical Case for Using Royal Purple Lubricants

Over the past three and a half years, Vision Industrial Sales and Royal Purple Lubricants have worked hand-in-hand with personnel at OPPD to promote a world-class lubrication and equipment reliability program at OPPD Nebraska City. Not only has the Nebraska City plant benefited from greatly increased lubrication performance compared to the products that they were using previously, but also the training and customer service that has been offered as an integral part of the reliability program.

Lubrication Performance

For years, Royal Purple lubricants have been making news worldwide because of the huge performance gains and cost savings that are made when switching from a competitor's product. OPPD has had the opportunity to see these results in their own equipment as well, and the data to show some of these the cost savings is included in this report. The performance comes from the combination of very clean, dry synthetic base oils, and Synerlec, the fine-tuned additive chemistry that is proprietary to Royal Purple. Some competitors have resorted to up-front pricing wars, splitting hairs regarding mineral vs. synthetic as a direct performance indicator, touting viscosity index as a major performance indicator, and other marketing material that leaves out the most important fact – that a lubrication's proven performance (or lack thereof) in your equipment will always be the most important factor in choosing a lubricant. Royal Purple synthetic lubricants have an incredible track record of showing positive results, and OPPD is now reaping the benefits of those results.

Royal Purple's proprietary Synerlec additive technology separates metal surfaces by creating a thicker, tenacious oil film than is created by the viscosity alone, it provides a tougher oil film on opposing surfaces, and over a period of time it micro-polishes those surfaces in order to reduce metal to metal contact and further increase the separation capabilities of the lubricant film. Synslide additive in Royal Purple gear oils takes Synerlec to another level with increased protection against boundary lubrication. Results from the performance of Synslide in Royal Purple Thermyl Glyde gear oil have been well documented on the Dravo Bucket Wheel Reclaimer Gearbox in which wear was reduced by over 98% from the Mobilgear SHC 632, Mobil's synthetic gear oil. Results from this application are included in this report.

These proprietary additives also offer superior protection against oxidation, therefore increasing the oil life to several times that of its competitors. OPPD is taking advantage of this increase in oil life in several pieces of equipment. In the Unit 1 fly ash blowers, for example, they have gone from a standard two month oil change on the Mobil lubricant, to over two years on Royal Purple. Though oil analysis was not being utilized prior to the Royal Purple being used, it was determined that if the oil change intervals on Mobil went beyond two months they could plan on repairing the equipment quite often. There has also been no failures since the switch to Royal Purple in these blowers over two years ago. Similar results have been found in the coal mill rollers as well as other equipment in the plant.

Royal Purple's best-selling light bearing and hydraulic oils are filtered to an ISO cleanliness of 14/13/11. This means that the lubricant is showing up at the plant 200 times cleaner than what is typical of competitors' lubricants, specifically those mineral and synthetic oils that are being transported in bulk or (often reused) steel drums. Along with superior wear and corrosion protection, cleanliness is a major reason that our customers see extended equipment life.

Finally, the Royal Purple is able to affect the single largest cost in operating equipment. Energy cost typically dwarfs any maintenance related costs on equipment and it is here where some of the largest returns related to lubrication are realized. Recently, OPPD picked out five fans that were changed from Mobil DTE Heavy Medium to Royal Purple Synfilm GT 68 in the Spring outage of 2011, and through historical trending, were able to determine that they are also consistently seeing these energy savings returns that Royal Purple customers have become accustomed to. Through these savings, it has been shown that even if the competitor were giving their lubricants away, it would cost OPPD a significant amount of money to accept the free oil.

Customer Service

Vision Industrial Sales is the main contact for OPPD personnel, though they also have had access to anyone at Royal Purple including the president and vice president who started the company 27 years ago, in case the need for further assistance arises.

Vision Industrial Sales and Royal Purple have logged well over 500 hours in the last three and a half years in assisting OPPD on-site with their maintenance and reliability program. In this time, several reps from Royal Purple have visited the plant numerous times in order to lend their experience and assistance. Mike Crosby, current manager of Royal Purple, came on site to do a one-day grease training when there were questions on proper greasing procedures. Vision Industrial has also had world-renowned lubrication training resource Ray Thibault on site twice, for two days each time, to bring OPPD personnel up to speed on lubrication and reliability principles. In contrast, it has been widely stated by OPPD personnel that the current local and regional Mobil reps had not been in the plant for *years*, until word got out that Royal Purple was going into some of the equipment in the plant.

Part of the service that Vision Industrial offers is a third-party oil analysis program that OPPD has taken advantage of several times in order to get a more in-depth look at the oil than what the Nebraska City in-house lab offers. Though Royal Purple also has state-of-the-art oil analysis capabilities, a third party is used to erase any doubt of subjectivity. In some cases, OPPD has sent oil samples to be analyzed at Royal Purple for specific purposes, but not typically to obtain a general oil condition analysis.

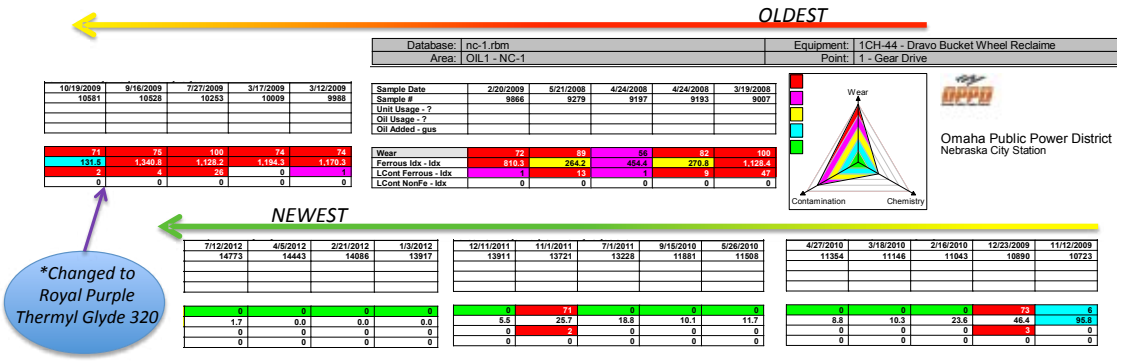
Lubrication Consolidation

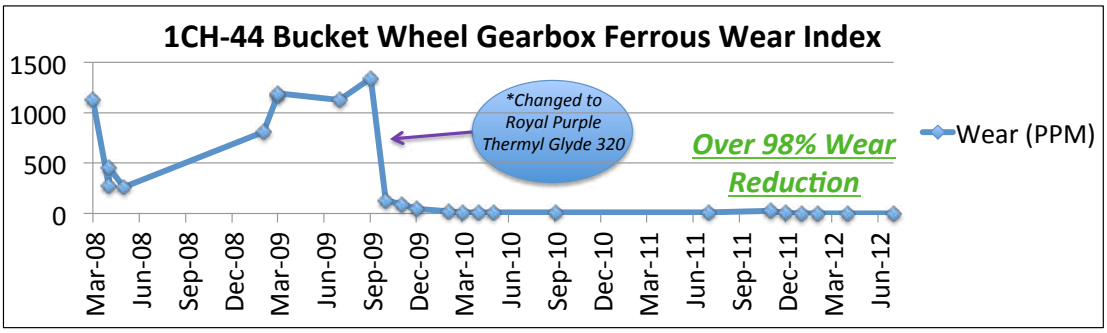
One of the focuses in the plant since Vision Industrial started working with OPPD, is to be as lean on lubrication inventory as possible, and this is achieved through proper planning and lubrication consolidation. Many hours were spent by Vision Industrial logging the proper lubrication in each piece of equipment, and it was determined that as much as 20% of the equipment was not utilizing the proper lubricant viscosity, type, or both. Something that Vision Industrial and Royal Purple strive for is the correct lubricant, in the correct place, at the correct time, in the correct amount. **Through this lubrication audit process, the lubricant storage area was pared down from 22 drums and 30-some odd pails to 14 drums.** Some further consolidation has taken place since the main audit. Since this move to consolidation, Vision Industrial and Royal Purple have helped to create a more optimal lubrication storage area and transport system in order to continually work toward higher equipment reliability and uptime.

Case Study – Dravo Bucket Wheel Reclaimer Gearbox

- The following page shows historical oil analysis on 1CH-44, Dravo Bucket Wheel Reclaimer Gearbox.
- New gearbox was installed early in 2009 with Mobilgear SHC 320 synthetic extreme pressure gear oil and immediately showed *very high* amounts of ferrous (iron) wear through oil analysis, about ten times what is considered acceptable.
- OPPD had a stacking plate type magnetic filtration device on the pressurized lubrication loop of the gearbox for quite some time, at least as long as the new gearbox had been in service. It was always filling up and being overwhelmed with particles the first six months while the Mobilgear was being used.
- Oil analysis prior to 2009 is also shown to highlight that high ferrous wear was typical of previous gearbox which was also lubricated with a Mobilgear product.
- Between late September and Early October 2009, the oil in the gearbox was changed to Royal Purple Thermyl Glyde 320, a synthetic extreme pressure gear oil.
- ***Immediately***, the ferrous wear was arrested and the magnetic filtration device began to catch up to the residual wear that was in the equipment.
- After the wear numbers subsided and steadied out, Vision Industrial helped to introduce an even higher strength magnetic filtration device in order to ensure long-lasting life of the gearbox. Oil analysis since has shown **wear numbers over 98% lower than that of the previous Mobilgear product**.
- **Total replacement cost of this gearbox in the event of failure has been estimated at over $500,000. Based on the extreme wear numbers, it is safe to say that replacement by now would have been very likely had the Thermyl Glyde not been utilized.**

1CH-44 – Dravo Bucket Wheel Reclaimer Gearbox
(Historical OPPD In-House Lab Analysis)





Case Study - Energy Savings in NEC Unit 2 Fans with Royal Purple Lubricants

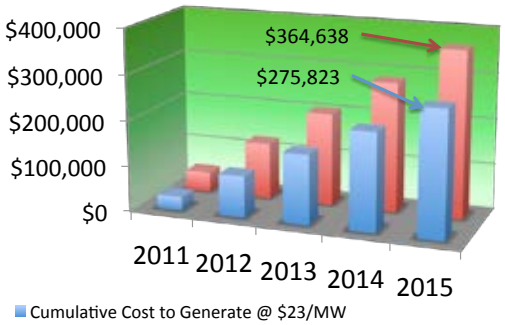
On each of the following five pages are the results of an energy usage and bearing vibration case study on a fan located in Unit 2 at OPPD Nebraska City. **All comparisons are done while equipment is doing equal or more work with the Royal Purple lubricant installed.**

These fans from Unit 2 were chosen as a case study for several reasons:

1. Availability of historical operating data through OPPD's internal instrument and controls system.
2. Known date that the oil was changed from Mobil DTE Heavy Medium to Royal Purple Synfilm GT 68.
3. The work that the fans do can be correlated directly back to the inlet vane position, and therefore are not affected by as many adverse conditions and parameters as other types of equipment. This is important for precise comparison between lubricants.

Vibration

Each fan has exhibited not only a decrease in amps to do the same or slightly more work, but also a ***decrease in average bearing vibration of 14.4%***. A decrease in bearing vibration is directly related to an increase in equipment life. Of the twenty bearings, three exhibited no change, and *only one* increased in average vibration, by 1.25%. This is data alone is enough benefit to justify the upgrade in lubrication.



Energy Savings

Average energy savings across the five fans of about 3.3%.
The cost to lubricate the five fans with Royal Purple was $15,989.
Payback on Total Cost of Royal Purple Approximately Every 90 Days.
Energy Savings Have Paid For Total Cost of Oil About 9 Times Thus Far.

The graph shows the cumulative totals of the cost to generate the energy saved in these fans, and the opportunity cost to sell this "free" energy at peak. Total cost of Royal Purple is subtracted in the first year.

In less than five years, at the end of 2015, the energy cost savings to OPPD from switching these five fans to Royal Purple will be about $275,000.

Turbine Generation and Fan Inlet Vane Position

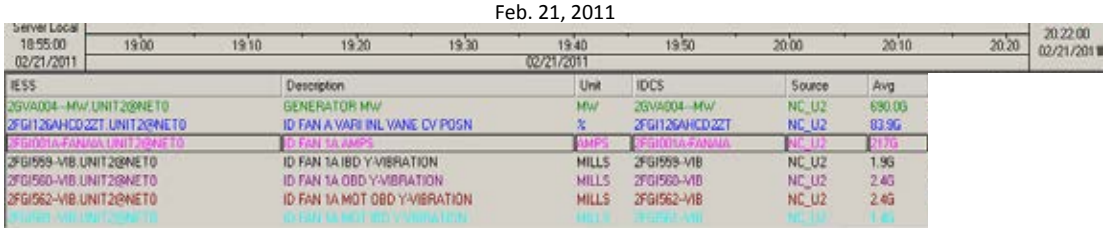
vs.

Electrical Consumption and Bearing Vibration

NEC Unit 2 ID Fan A

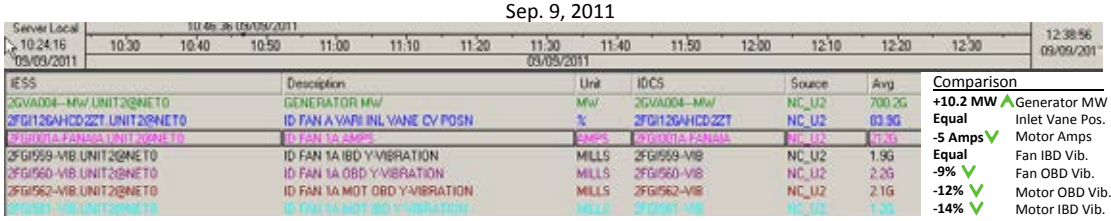
Prior: Mobil DTE Heavy Medium

Feb. 21, 2011



Lubricant Changed to Royal Purple Synfilm GT 68 During Spring Outage 2011

Sep. 9, 2011



Annual Energy Savings to Produce 10.2 MW More With Royal Purple Synfilm GT:

13.2kV*5A*24hr*365day/1000 = ***578.2 MW***

Cost to Generate @ $23/MW = ***$13,297*** Peak Rate Opportunity Cost @ $30/MW = ***$17,345***

Average Bearing Vibration Reduced by 8.75%

Turbine Generation and Fan Inlet Vane Position

vs.

Electrical Consumption and Bearing Vibration

NEC Unit 2 ID Fan B

Prior: Mobil DTE Heavy Medium

Feb. 25, 2011

Lubricant Changed to Royal Purple Synfilm GT 68 During Spring Outage 2011

Sep. 26, 2011

Annual Energy Savings to Run At 1.4% Increased Vane Position and Produce 1.4 MW More With Royal Purple Synfilm GT:

13.2kV*4A*24hr*365day/1000 = ***462.5 MW***

Cost to Generate @ $23/MW = ***$10,638*** Peak Rate Opportunity Cost @ $30/MW = ***$13,875***

Average Bearing Vibration Reduced by 22%

Turbine Generation and Fan Inlet Vane Position

vs.

Electrical Consumption and Bearing Vibration

NEC Unit 2 PA Fan A

Prior: Mobil DTE Heavy Medium

Feb. 21, 2011

IESS	Description	Unit	IDCS	Source	Avg
2GVA004--MW.UNIT2@NET0	GENERATOR MW	MW	2GVA004--MW	NC_U2	690.0G
28YA004AFVD2ZT.UNIT2@NET0	PAF-A INL VANE CDR POS FDBK	%	28YA004AFVD2ZT	NC_U2	53.1G
28YA001A-FANAIA.UNIT2@NET0	PAF A AMPS	AMPS	28YA001A-FANAIA	NC_U2	132G
28YA763-VIB.UNIT2@NET0	PA FAN 1A IBD Y-VIBRATION	MILLS	28YA763-VIB	NC_U2	1.00G
28YA764-VIB.UNIT2@NET0	PA FAN 1A OBD Y-VIBRATION	MILLS	28YA764-VIB	NC_U2	0.72G
28YA766-VIB.UNIT2@NET0	PA FAN 1A MOT OBD Y-VIBRATION	MILLS	28YA766-VIB	NC_U2	0.84G

Lubricant Changed to Royal Purple Synfilm GT 68 During Spring Outage 2011

Sep. 9, 2011

IESS	Description	Unit	IDCS	Source	Avg
2GVA004--MW.UNIT2@NET0	GENERATOR MW	MW	2GVA004--MW	NC_U2	700.4G
28YA004AFVD2ZT.UNIT2@NET0	PAF-A INL VANE CDR POS FDBK	%	28YA004AFVD2ZT	NC_U2	57.7G
28YA001A-FANAIA.UNIT2@NET0	PAF A AMPS	AMPS	28YA001A-FANAIA	NC_U2	125G
28YA763-VIB.UNIT2@NET0	PA FAN 1A IBD Y-VIBRATION	MILLS	28YA763-VIB	NC_U2	0.58G
28YA764-VIB.UNIT2@NET0	PA FAN 1A OBD Y-VIBRATION	MILLS	28YA764-VIB	NC_U2	0.60G
28YA766-VIB.UNIT2@NET0	PA FAN 1A MOT OBD Y-VIBRATION	MILLS	28YA766-VIB	NC_U2	0.84G

Comparison	
+10.4 MW ↑	Generator MW
+8% ↑	Inlet Vane Pos.
-7 Amps ↓	Motor Amps
-42% ↓	Fan IBD Vib.
-17% ↓	Fan OBD Vib.
Equal	Motor OBD Vib.
-4% ↓	Motor IBD Vib.

Annual Energy Savings to Run at 8% Increased Vane Position and Produce 10.4 MW More With Royal Purple Synfilm GT:
13.2kV*7A*24hr*365day/1000 = ***809.4 MW***

Cost to Generate @ $23/MW = ***$18,616*** Peak Rate Opportunity Cost @ $30/MW = ***$24,282***

Average Bearing Vibration Reduced by 15.75%

Turbine Generation and Fan Inlet Vane Position

vs.

Electrical Consumption and Bearing Vibration

NEC Unit 2 PA Fan B

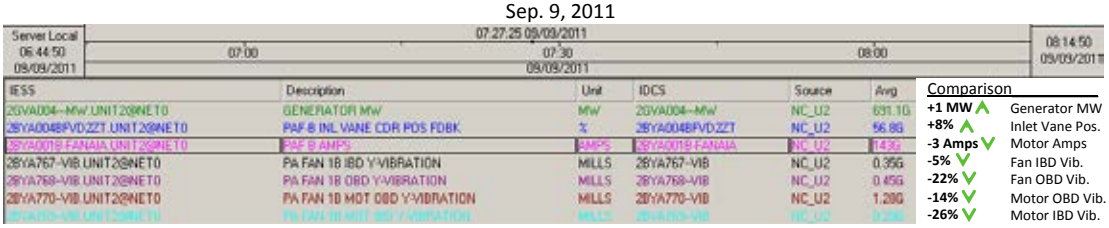
Prior: Mobil DTE Heavy Medium

Feb. 21, 2011

IESS	Description	Unit	IDCS	Source	Avg
2GVA004--MW.UNIT2@NET0	GENERATOR MW	MW	2GVA004--MW	NC_U2	690.1G
28YA004BFVD2ZT.UNIT2@NET0	PAF-B INL VANE CDR POS FDBK	%	28YA004BFVD2ZT	NC_U2	52.3G
28YA001B-FANAIA.UNIT2@NET0	PAF B AMPS	AMPS	28YA001B-FANAIA	NC_U2	146G
28YA767-VIB.UNIT2@NET0	PA FAN 1B IBD Y-VIBRATION	MILLS	28YA767-VIB	NC_U2	0.37G
28YA768-VIB.UNIT2@NET0	PA FAN 1B OBD Y-VIBRATION	MILLS	28YA768-VIB	NC_U2	0.58G
28YA770-VIB.UNIT2@NET0	PA FAN 1B MOT OBD Y-VIBRATION	MILLS	28YA770-VIB	NC_U2	1.49G

Lubricant Changed to Royal Purple Synfilm GT 68 During Spring Outage 2011

Sep. 9, 2011



IESS	Description	Unit	IDCS	Source	Avg
2GVA004--MW.UNIT2@NET0	GENERATOR MW	MW	2GVA004--MW	NC_U2	691.1G
28YA004BFVD2ZT.UNIT2@NET0	PAF-B INL VANE CDR POS FDBK	%	28YA004BFVD2ZT	NC_U2	56.8G
28YA001B-FANAIA.UNIT2@NET0	PAF B AMPS	AMPS	28YA001B-FANAIA	NC_U2	143G
28YA767-VIB.UNIT2@NET0	PA FAN 1B IBD Y-VIBRATION	MILLS	28YA767-VIB	NC_U2	0.35G
28YA768-VIB.UNIT2@NET0	PA FAN 1B OBD Y-VIBRATION	MILLS	28YA768-VIB	NC_U2	0.45G
28YA770-VIB.UNIT2@NET0	PA FAN 1B MOT OBD Y-VIBRATION	MILLS	28YA770-VIB	NC_U2	1.28G

Comparison	
+1 MW ↑	Generator MW
+8% ↑	Inlet Vane Pos.
-3 Amps ↓	Motor Amps
-5% ↓	Fan IBD Vib.
-22% ↓	Fan OBD Vib.
-14% ↓	Motor OBD Vib.
-26% ↓	Motor IBD Vib.

Annual Energy Savings to Run at 8% Increased Vane Position and Produce 1 MW More With Royal Purple Synfilm GT:
13.2kV*3A*24hr*365day/1000 = ***346.9 MW***

Cost to Generate @ $23/MW = ***$7,979*** Peak Rate Opportunity Cost @ $30/MW = ***$10,407***

Average Bearing Vibration Reduced by 16.75%

Turbine Generation and Fan Inlet Vane Position

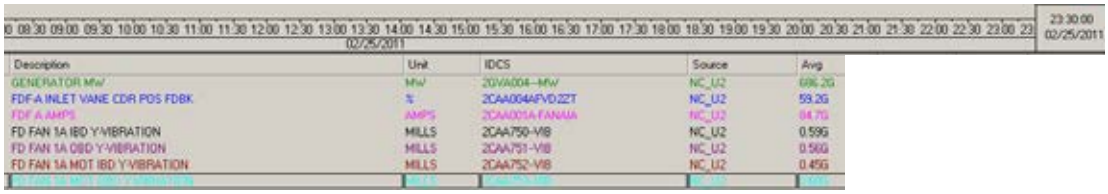
vs.

Electrical Consumption and Bearing Vibration

NEC Unit 2 FD Fan A

Prior: Mobil DTE Heavy Medium

Feb. 25, 2011



Description	Unit	IDCS	Source	Avg
GENERATOR MW	MW	2GVA004--MW	NC_U2	686.2G
FDF A INLET VANE CDR POS FDBK	%	2CAA004AFVD22T	NC_U2	59.2G
FDF A AMPS	AMPS	2CAA001A FANAMA	NC_U2	84.7G
FD FAN 1A IBD Y-VIBRATION	MILLS	2CAA750-VIB	NC_U2	0.59G
FD FAN 1A OBD Y-VIBRATION	MILLS	2CAA751-VIB	NC_U2	0.56G
FD FAN 1A MOT IBD Y-VIBRATION	MILLS	2CAA752-VIB	NC_U2	0.45G

Lubricant Changed to Royal Purple Synfilm GT 68 During Spring Outage 2011

Sep. 13, 2011

Description	Unit	IDCS	Source	Avg
GENERATOR MW	MW	2GVA004--MW	NC_U2	690.1G
FDF A INLET VANE CDR POS FDBK	%	2CAA004AFVD22T	NC_U2	64.1G
FDF A AMPS	AMPS	2CAA001A FANAMA	NC_U2	82.6G
FD FAN 1A IBD Y-VIBRATION	MILLS	2CAA750-VIB	NC_U2	0.51G
FD FAN 1A OBD Y-VIBRATION	MILLS	2CAA751-VIB	NC_U2	0.46G
FD FAN 1A MOT IBD Y-VIBRATION	MILLS	2CAA752-VIB	NC_U2	0.43G

Comparison	
+3.9 MW ^	Generator MW
+7.6% ^	Inlet Vane Pos.
-4.1 Amps v	Motor Amps
-14% v	Fan IBD Vib.
-18% v	Fan OBD Vib.
-4% v	Motor IBD Vib.
+1.2%	Motor OBD Vib.

Annual Energy Savings to Run at 7.6% Increased Vane Position and Produce 3.9 MW More With Royal Purple Synfilm GT:
13.2kV*4.1A*24hr*365day/1000 = ***474.1 MW***

Cost to Generate @ $23/MW = ***$10,904*** Peak Rate Opportunity Cost @ $30/MW = ***$14,223***

Average Bearing Vibration Reduced by 8.7%

ENERGY SAVING THROUGH
THE USE OF ROYAL PURPLE SYNTHETIC OIL

Water / Process Pump

EQUIPMENTS SURVEY

PETROCHEMICAL PLANT – RAYONG

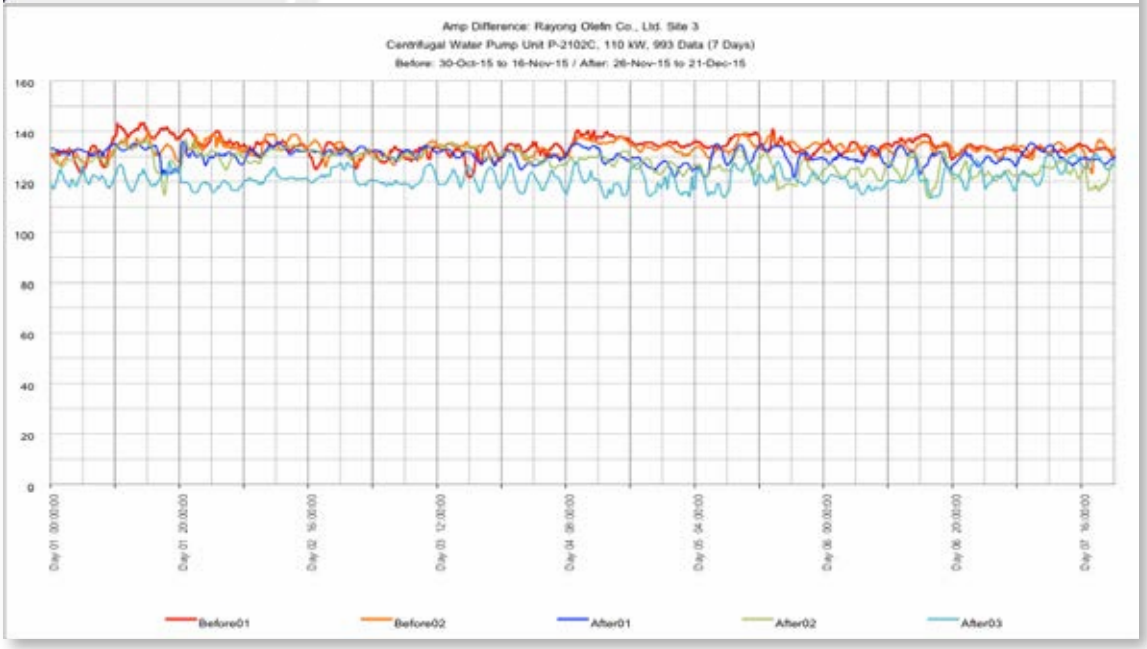
ENERGY AUDIT

DATA LOGGER EQUIPMENT AT ELECTRIC CONTROL ROOM

THE PERFORMANCE OIL THAT OUTPERFORMS

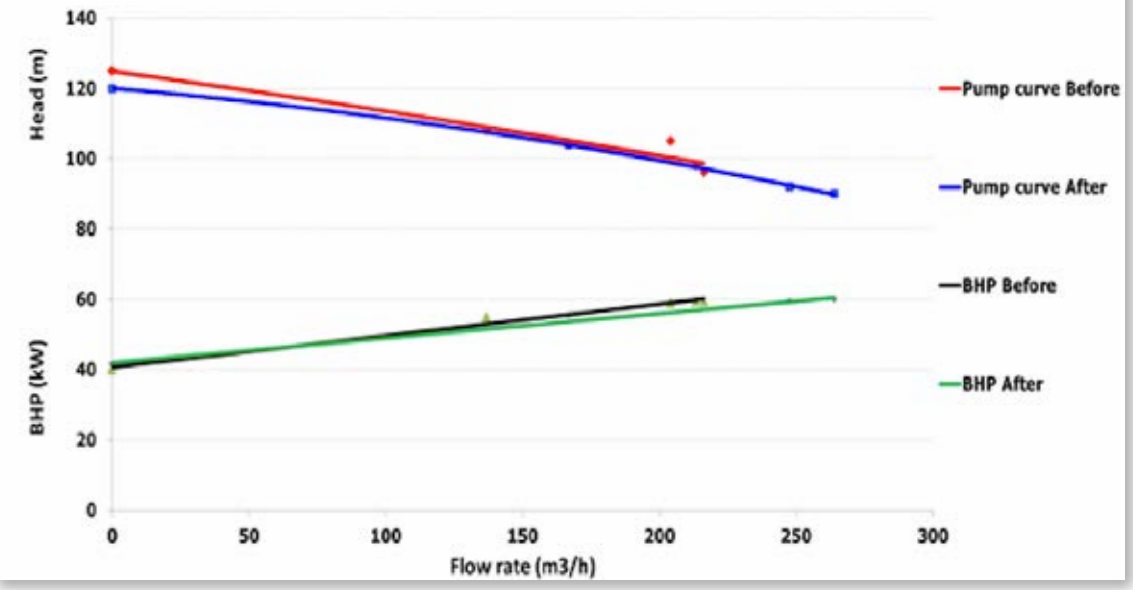
ENERGY MONITORING

FOLLOW – UP AMPS



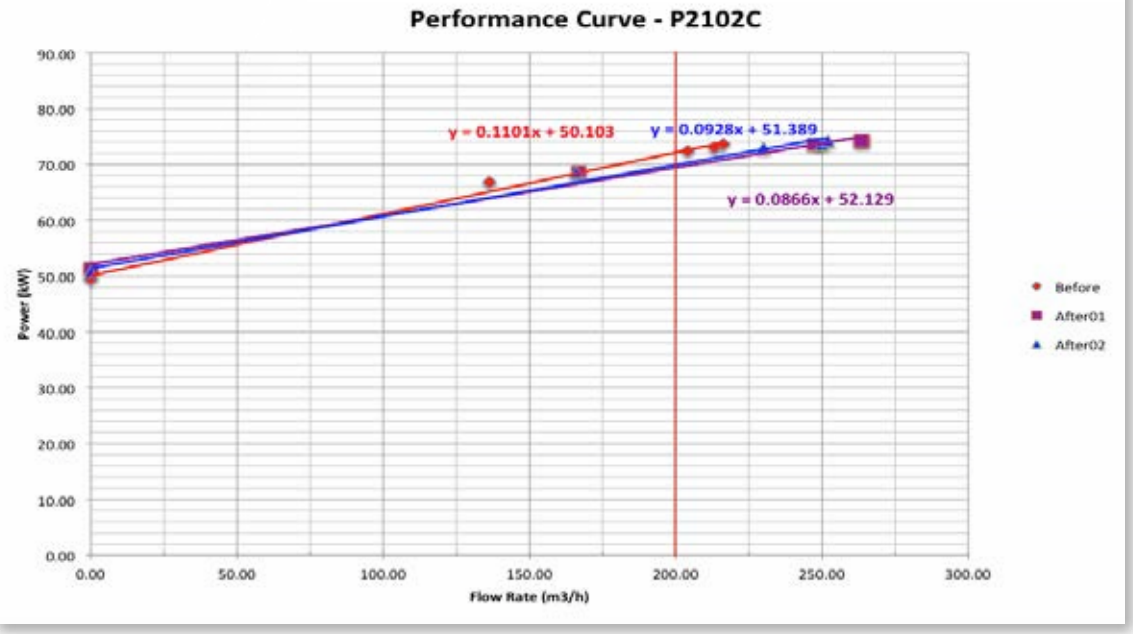
EFFICIENCY MONITORING

PERFORMANCE CURVE



EFFICIENCY MONITORING

PERFORMANCE CURVE



SUMMARY

PURPOSE OF TEST: TO SHOW ENERGY SAVINGS THROUGH THE USE OF SUPERIOR QUALITY LUBRICATION

EQUIPMENT TESTED RAYONG PETROCHEMICAL PLANT – Centrifugal WaterPump P-2102C
Driven by: FUJI Electric Motor, 110 kW, Input 2,970 rpm
380 Volt connection measuring Current and Voltage/Fixed Speed
Serviced: N/A hrs Energy Cost: 3.35 THB/Unit
Capacity: 2.5 Liters
Oil Serviced: 5 Month Other: Temp, Oil and Vibration Monitoring

DATE OF INITIAL TESTING: Oct 30, 2015 **DATE OF FINAL TESTING:** Dec 21, 2015

LUBRICANT: Shell Turbo ISO 46 (Mineral) **LUBRICANT:** Royal Purple Synfilm GT 46

RESULTS:	**Original Oil**	**RP Synfilm GT 46**	
KILOWATT	77.04 kW	74.33 kW	**(3.52% Reduction)**
KILOWATT HOURS/Month	55,468.8 kwh	53,517.6 kwh	
COST per Month	185,820.48 THB	179,283.96 THB	
ANNUAL COST(12 months)	2,229,845.76 THB	2,151,407.52 THB	

SAVINGS with ENERGY EFFICIENT LUBRICANTS **6,536.52 THB/Month or 78,438.24 THB/Year**

E PERFORMANCE OIL **THAT OUTPERFORMS**

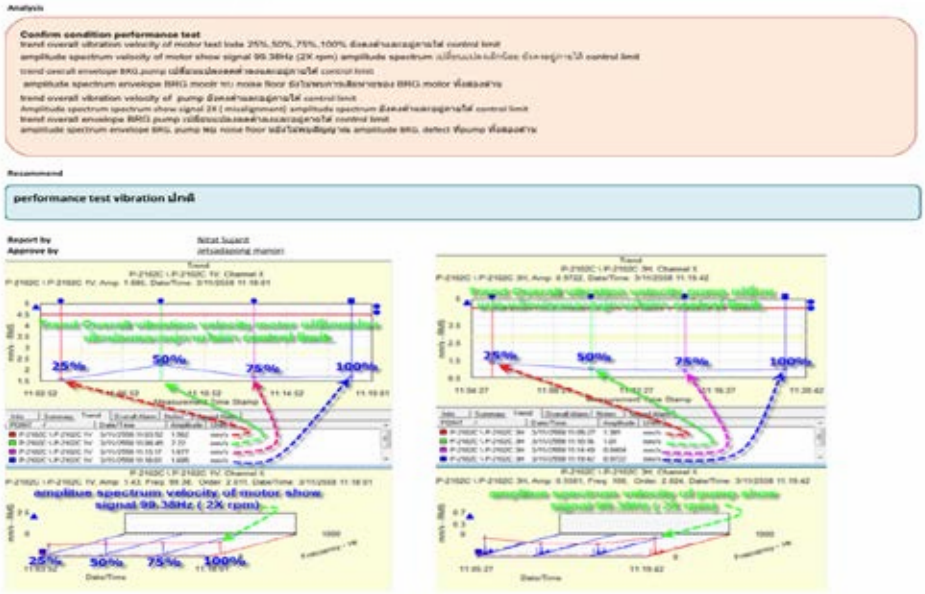
VIBRATION MONITORING

P-2102C Vibration Report

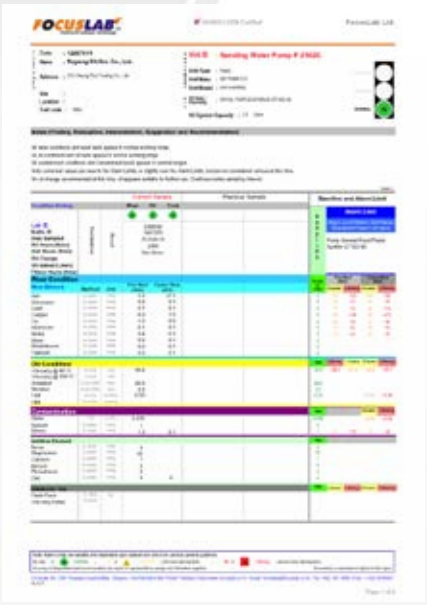
	Date >	8-7-15	27-10-15	3-11-15	3-11-15	3-11-15	3-11-15	26-11-15	26-11-15	26-11-15	26-11-15	ISO 10816 Part 3	
Overall vibration	Speed >(RPM)	-	-	-	-	-	-	-	-	-	-		
	Amp >	120	120	-	-	-	-	-	-	-	-		
	Pressure(kg/cm2)	9.4	10	12	11	11	11	11	11	11	11		
	Flow (ton)	-	-	-	-	-	-	-	-	-	-		
	Position	Routine	Routine	25%	50%	75%	100%	25%	50%	75%	100%	Warning limit	Danger Limit
Motor NDE	1H (mm/s)	1.06	1.19	1.18	1.10	1.07	1.15	1.03	1.03	1.06	1.07	2.8	4.5
	1HACC (Gs)	0.33	0.40	0.21	0.29	0.25	0.24	0.29	0.33	0.39	0.41	2.8	4.5
	1E (Gs)	0.94	1.08	0.72	0.79	0.70	0.66	0.85	1.06	1.01	1.01	3	5
	1V (mm/s)	1.96	1.97	1.58	2.22	1.68	1.69	2.13	1.83	2.23	2.00	2.8	4.5
	1T (deg C)	44	38	37	36	36	36	41	41	42	42	60	80
Motor DE	2H (mm/s)	0.67	0.74	0.73	0.73	0.89	0.73	0.71	0.72	0.73	0.74	2.8	4.5
	2HACC (Gs)	0.27	0.29	0.23	0.39	0.35	0.46	0.24	0.44	0.29	0.36	2.8	4.5
	2E (Gs)	0.89	0.87	0.81	0.95	0.87	0.91	0.67	0.86	0.69	0.62	3	5
	2V (mm/s)	0.68	0.62	0.58	0.49	0.49	0.49	0.54	0.60	0.52	0.52	2.8	4.5
	2A (mm/s)	1.28	1.45	0.86	0.87	0.92	0.91	1.33	1.32	1.20	1.29	2.8	4.5
	2T (deg C)	46	40	39	39	39	38	45	45	45	44	60	80
Pump NDE	3H (mm/s)	0.79	0.84	1.38	1.01	0.99	0.97	1.08	0.86	0.93	0.80	2.8	4.5
	3HACC (Gs)	0.48	0.51	0.56	0.50	0.36	0.47	0.67	0.59	0.55	0.55	2.8	4.5
	3E (gE)	1.66	1.63	2.55	1.54	1.17	1.08	2.29	2.09	1.99	2.05	3	5
	3V (mm/s)	0.79	0.81	1.19	0.70	0.74	0.72	1.01	0.79	0.80	0.79	2.8	4.5
	3T (deg C)	46	41	39	39	39	39	48	48	48	48	60	80
Pump DE	4H (mm/s)	0.63	0.77	1.24	0.75	0.73	0.74	0.89	0.75	0.73	0.73	2.8	4.5
	4HACC (Gs)	0.56	0.60	0.49	0.49	0.37	0.38	0.84	0.76	0.69	0.65	2.8	4.5
	4E (gE)	1.92	2.03	2.28	1.59	1.36	1.32	2.81	2.45	2.23	2.180	3	5
	4V (mm/s)	0.76	0.75	1.14	0.71	0.62	0.68	0.88	0.71	0.75	0.74	2.8	4.5
	4A (mm/s)	0.50	0.50	0.76	0.57	0.56	0.54	0.68	0.51	0.49	0.51	2.8	4.5
	4T (deg C)	46	42	39	39	40	40	47	47	47	47	60	80

Note:
H mean vibration measured in horizontal direction, velocity unit (mm/s)
HACC mean vibration measured in horizontal direction, acceleration unit (g)
V mean vibration measured in vertical direction, velocity unit (mm/s)
A mean vibration measured in axial direction, velocity unit (mm/s)
E mean vibration measured in horizontal direction, unit (gE), with SKF method use in define bearing defect.

VIBRATION MONITORING



LUBE OIL MONITORING



THE PERFORMANCE OIL THAT OUTPERFORMS

SUMMARY

Energy Saving

Existing Mineral Oil:	**77.04**	kW
Royal Purple Synfilm GT:	**74.33**	kW
Royal Purple Savings:	**2.71**	kW
Annual Energy Savings:	**23,414.4**	kWH
	78,438.24	THB

Labor Saving

Existing Mineral Oil: 150 X 2 Times	**1,200.00**	THB
Royal Purple Synfilm GT: 600 X 1 Time	**600.00**	THB
Annual Labor Savings:	**600.00**	THB - Royal Purple Saving

Differences in Oil Purchase Cost

Existing Mineral Oil:		
Estimated Oil Life:	**4,000.00**	hrs
Cost	**150.00**	THB/Liter
Royal Purple Synfilm GT:		
Estimated Oil Life:	**8,000.00**	hrs
Cost	**600.00**	THB/Liter
Annual Oil Cost		
Existing Mineral Oil	**750.00**	THB
Royal Purple Synfilm GT	**1,500.00**	THB
	750.00	THB – Negative Saving for Royal Purple

Total Annual Savings

Power Savings:	**78,438.24**	THB
Labor Savings:	**600.00**	THB
Cost of Oil:	**(750.00)**	THB
Total:	**78,288.24**	THB

THE PERFORMANCE OIL THAT OUTPERFORMS

WHAT'S NEXT

Cooling Water Pump P-2400C




Kirana Keawkongtao: Technical Sales
Tel: +662-726-7300, Mobile: +6685-865-1963
Email: kirana@belraythai.com

Yuttaphume Keattra: Technical Sales
Tel: +662-726-7300, Mobile: +6687-905-8185
Email: yuttaphume@belraythai.com

THE PERFORMANCE OIL THAT OUTPERFORMS

Backup

THE PERFORMANCE OIL THAT OUTPERFORMS

ROYAL PURPLE – BEYOND SYNTHETIC

Comparison Table - Pump Lubricants

Typical Properties / Product	Royal Purple Synfilm GT	Mobil DTE Light	Mobil SHC 624
ISO Viscosity Grade	32	32	32
Base Fluid Type	Synthetic PAO	Mineral Oil	Synthetic PAO
Viscosity, (Base Fluid),ASTM D445			
@ 40 C, cSt	32.0	31.0	32.0
@ 100 C, cSt	6.0	5.5	6.3
Viscosity Index, (Base Fluid),ASTM D2270	135	102	148
Flash Point, ASTM D92, C	235	218	236
Pour Point, ASTM D97, C	-38	-18	-57
Copper Strip Corrosion, ASTM D130			
3 hrs @ 100C, rating	1A	1B	1B
Rust Test, ASTM D665			
Procedure Freash Water & Salt Water	Pass	Pass	Pass
Demulsibility, 1 hour, ASTM D1401			
Oil/water/emulsion, ml/ml/ml	5	N/A	N/A
Foam Test, ASTM D 892, Seq I			
Tendency/stability, ml/ml	N/A	20/0	20/0
Foam Test, ASTM D 892, Seq II			
Initial/Final/Time (sec)	8/0/2	N/A	N/A
Water Seperability, ASTM D 1401			
Min. to 3 ml emulsion @ 54ºC	N/A	15	15
TOST, ASTM D 943, Hours to 2 NN	5,000	N/A	N/A
ISO Cleanliness Level, ISO 4406	14/13/11	N/A	N/A
Density @15° C kg/l, ASTM D 4052	0.843	0.85	0.85
Color	Purple		

THE PERFORMANCE OIL THAT OUTPERFORMS

ROYAL PURPLE – BEYOND SYNTHETIC

Comparison Table - Pump Lubricants

Typical Properties / Product	Royal Purple Synfilm GT	Mobil DTE Heavy Medium	Mobil SHC 626
ISO Viscosity Grade	68	68	68
Base Fluid Type	Synthetic PAO	Mineral Oil	Synthetic PAO
Viscosity, (Base Fluid),ASTM D445			
@ 40 C, cSt	68.0	65.1	68.0
@ 100 C, cSt	10.1	8.7	11.6
Viscosity Index, (Base Fluid),ASTM D2270	133	95	165
Flash Point, ASTM D92, C	251.7	223	225
Pour Point, ASTM D97, C	-38	-15	-51
Copper Strip Corrosion, ASTM D130			
3 hrs @ 100C, rating	1A	1B	1B
Rust Test, ASTM D665			
Procedure Freash Water & Salt Water	Pass	Pass	Pass
Demulsibility, 1 hour, ASTM D1401			
Oil/water/emulsion, ml/ml/ml	5	N/A	N/A
Foam Test, ASTM D 892, Seq I			
Tendency/stability, ml/ml	N/A	50/0	20/0
Foam Test, ASTM D 892, Seq II			
Initial/Final/Time (sec)	10/0/5	N/A	N/A
Water Seperability, ASTM D 1401			
Min. to 3 ml emulsion @ 54ºC	N/A	20	--
TOST, ASTM D 943, Hours to 2 NN	N/A	4500	N/A
ISO Cleanliness Level, ISO 4406	14/13/11	N/A	N/A
Density @15° C kg/l, ASTM D 4052	0.853	0.87	0.86
Color	Purple		

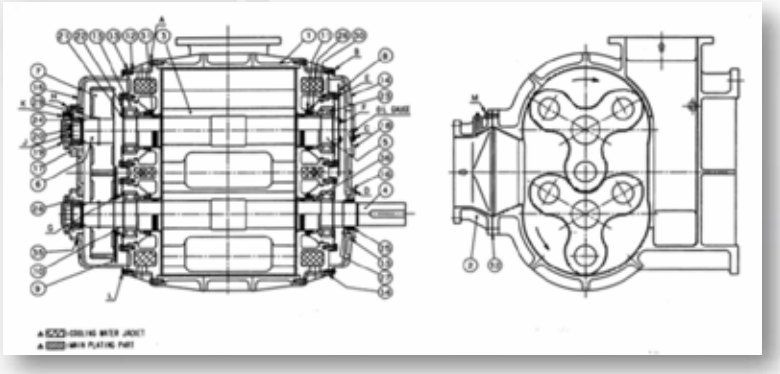
THE PERFORMANCE OIL THAT OUTPERFORMS

ENERGY SAVING THROUGH
THE USE OF ROYAL PURPLE SYNTHETIC OIL

POLYPROPYLENE PLANT

ROOTS BLOWER

250 / 200 KW



SANKO
Sanko Air Plant Ltd.

The Equipment Information:

Machine Type: Rotary Root Blower
Driven by: Motor, 250 /200 kW
Serviced: N/A hrs
Oil Capacity: 18 Liters
Lube Oil Type: Shell Morlina 100

Manufacturer: Sanko Air Plant Ltd.
Volt: 690 Volt, 3Phase3Wire
Energy Cost: 3.35 THB/Unit
Oil Serviced: N/A hrs.
Oil Analysis: Normal

Oil Change Interval: 6 Months
Vibration Analysis: Normal

EQUIPMENTS SURVEY

ENERGY AUDIT – BASELINE AMPS

SUMMARY

Purpose of Trial: **Achieve operating costs reduction through energy saving using Royal Purple's Premium Synthetic Lubricant**

Trial Equipment: Root Blower Unit CM3832C2, Driven Motor: 200 kW, 690V 3Phase, 50 Hz
Serviced: N/A hrs Energy Cost: 3.35 THB/Unit
Capacity: 18 Liters Oil Serviced: N/A hrs.

Before Change: 01 to 10 Feb 2016
Existing Oil: Shell Morlina 100 (Mineral)

After Change: 01 to 08 Mar 2016
New Oil: Royal Purple Synfilm GT 100

Trial Result:	**Existing Oil**	**RP Synfilm GT 100**
Avg. kW (Amps)	101.20 (84.68)	98.90 (82.76)
Avg. Production	29.9555 Ton/hr	30.1558 Ton/hr
SEC	3.38 kW/Ton/hr	3.27 kW/Ton/hr **(3.25% Reduction)**
kWh/Month	73,008 kwh	70,632 kwh
Cost/Month	244,576.8 THB	236,617.2 THB
Annual Cost (330 Days)	2,690,344.8 THB	2,602,789.2 THB

SAVINGS with Energy Efficient Lubricant **7,959.6 THB/Month.** **87,555.6 THB/Year**

THE PERFORMANCE OIL THAT OUTPERFORMS

SUMMARY

Purpose of Trial: **Achieve operating costs reduction through energy saving using Royal Purple's Premium Synthetic Lubricant**

Trial Equipment: Root Blower Unit CM3832C2, Driven Motor: 200 kW, 690V 3Phase, 50 Hz
Serviced: N/A hrs Energy Cost: 3.35 THB/Unit
Capacity: 18 Liters Oil Serviced: N/A hrs.

Before Change: 01 to 10 Feb 2016 **After Change:** 06 to 12 May 2016
Existing Oil: Shell Morlina 100 (Mineral) **New Oil:** Royal Purple Synfilm GT 100

Trial Result:	**Existing Oil**	**RP Synfilm GT 100**
Avg. kW (Amps)	101.20 (84.68)	95.60 (80.00)
Avg. Production	29.9555 Ton/hr	30.5782 Ton/hr
SEC	3.38 kW/Ton/hr	3.13 kW/Ton/hr **(7.42% Reduction)**
kWh/Month	73,008 kwh	67,608 kwh
Cost/Month	244,576.8 THB	226,486.8 THB
Annual Cost (330 Days)	2,690,344.8 THB	2,491,354.8 THB
SAVINGS with Energy Efficient Lubricant		**18,090.0 THB/Month.** **198,990 THB/Year**

SUMMARY

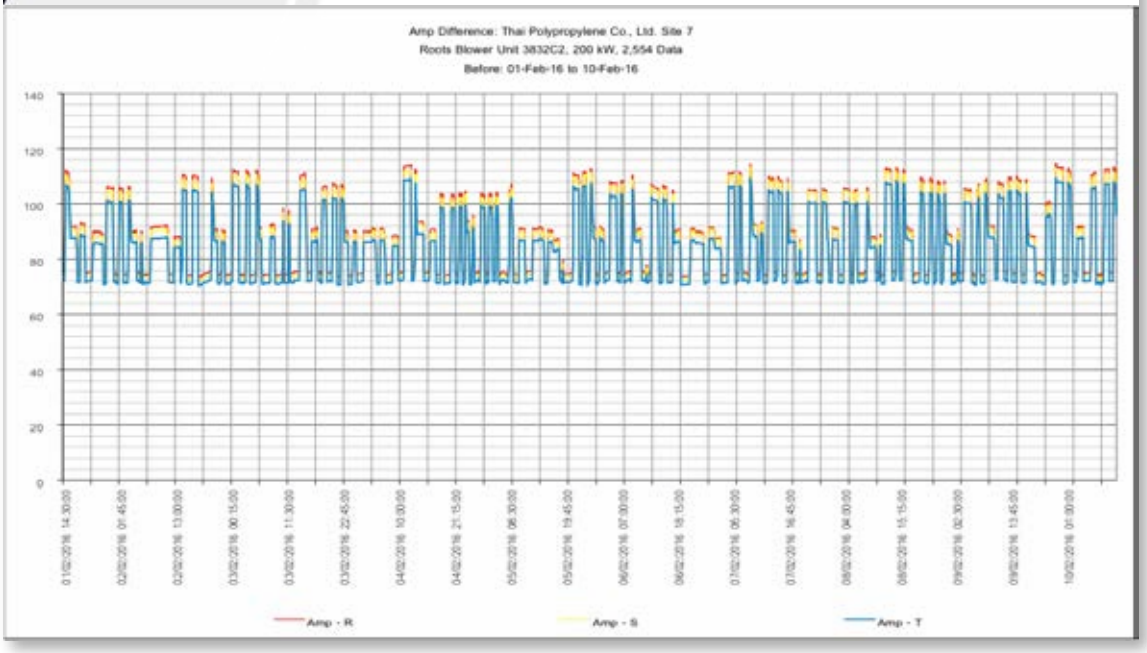
Purpose of Trial: **Achieve operating costs reduction through energy saving using Royal Purple's Premium Synthetic Lubricant**

Trial Equipment: Root Blower Unit CM3832C2, Driven Motor: 200 kW, 690V 3Phase, 50 Hz
Serviced: N/A hrs Energy Cost: 3.35 THB/Unit
Capacity: 18 Liters Oil Serviced: N/A hrs.

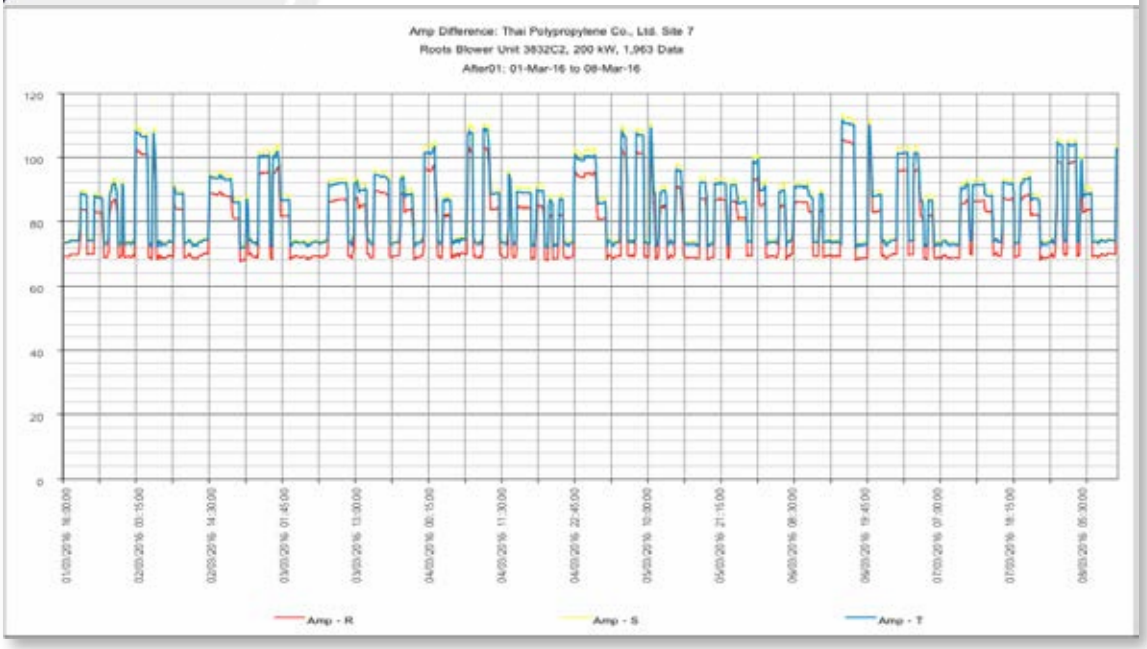
Before Change: 01 to 10 Feb 2016 **After Change:** 23 to 30 Jun 2016
Existing Oil: Shell Morlina 100 (Mineral) **New Oil:** Royal Purple Synfilm GT 100

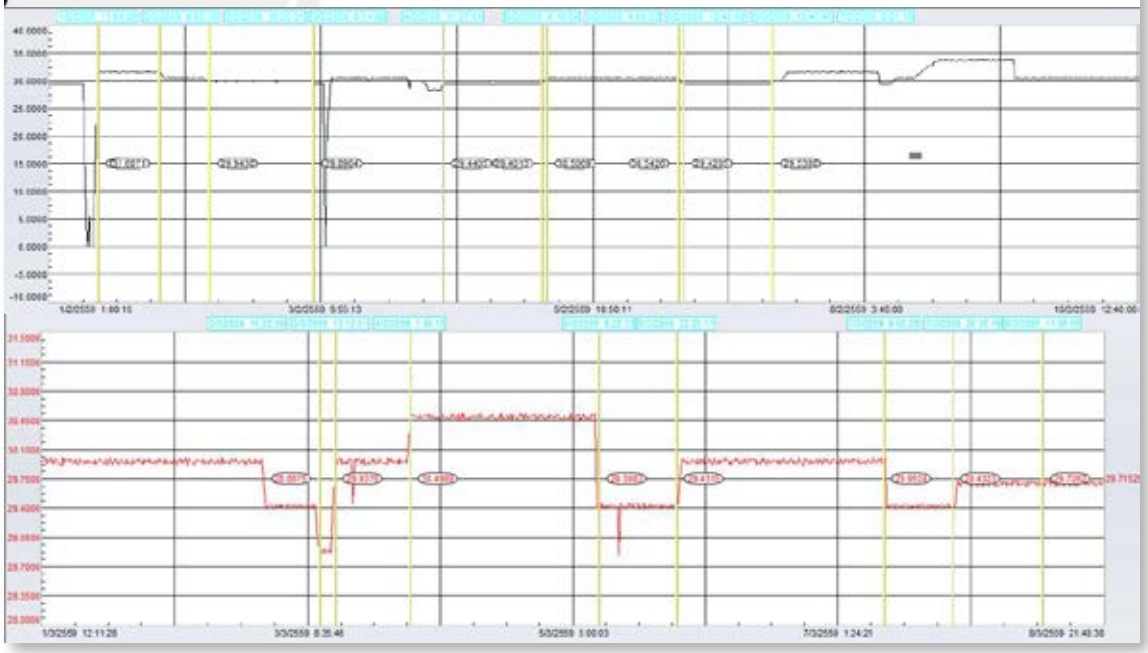
Trial Result:	**Existing Oil**	**RP Synfilm GT 100**
Avg. kW (Amps)	101.20 (84.68)	97.36 (81.47)
Avg. Production	29.9555 Ton/hr	30.3722 Ton/hr
SEC	3.38 kW/Ton/hr	3.21 kW/Ton/hr **(5.47% Reduction)**
kWh/Month	73,008 kwh	69,336 kwh
Cost/Month	244,576.8 THB	232,275.6 THB
Annual Cost (330 Days)	2,690,344.8 THB	2,555,031.6 THB
SAVINGS with Energy Efficient Lubricant		**12,301.2 THB/Month.** **135,313.2 THB/Year**

SUMMARY



SUMMARY





1. ช่วงเวลาก่อนการเปลี่ยนถ่ายน้ำมันเกียร์ประสิทธิภาพสูง

ช่วงเวลา	ระยะเวลารวม	จำนวนข้อมูล	อัตราการผลิตเฉลี่ย	กระแสไฟฟ้าเฉลี่ย	ดัชนีการใช้พลังงาน	กำลังไฟฟ้าเฉลี่ย	ดัชนีการใช้พลังงาน
	(hrs)	(Data)	(Ton/hr)	(Amps)	SEC (Amp/Ton/hr)	(kW)	SEC (kW/Ton/hr)
Period 01	21.92	263	29.9207	83.90	2.80	100.27	3.35
Period 02	20.83	250	29.4209	83.52	2.84	99.81	3.39
Period 03	27.75	333	30.5248	84.39	2.76	100.85	3.30
Average			29.9555	84.68	2.83	101.20	3.38

2. ช่วงเวลาหลังการเปลี่ยนถ่ายน้ำมันเกียร์ประสิทธิภาพสูง ช่วงที่ 1

ช่วงเวลา	ระยะเวลารวม	จำนวนข้อมูล	อัตราการผลิตเฉลี่ย	กระแสไฟฟ้าเฉลี่ย	ดัชนีการใช้พลังงาน	กำลังไฟฟ้าเฉลี่ย	ดัชนีการใช้พลังงาน
		(Data)	(Ton/hr)	(Amps)	SEC (Amp/Ton/hr)	(kW)	SEC (kW/Ton/hr)
Period 01	35.67	428	29.9917	82.25	2.74	98.30	3.28
Period 02	30.67	368	30.5096	83.03	2.72	99.23	3.25
Period 03	33.50	402	29.9661	83.05	2.77	99.25	3.31
Average			30.1558	82.76	2.74	98.90	3.28

3. ช่วงเวลาหลังการเปลี่ยนถ่ายน้ำมันเกียร์ประสิทธิภาพสูง ช่วงที่ 2

ช่วงเวลา	ระยะเวลารวม	จำนวนข้อมูล	อัตราการผลิตเฉลี่ย	กระแสไฟฟ้าเฉลี่ย	ดัชนีการใช้พลังงาน	กำลังไฟฟ้าเฉลี่ย	ดัชนีการใช้พลังงาน
	(Hrs)	(Data)	(Ton/hr)	(Amps)	SEC (Amp/Ton/hr)	(kW)	SEC (kW/Ton/hr)
Period 01	33.33	400	30.5214	79.73	2.61	95.28	3.12
Period 02	37.92	455	30.5214	81.27	2.66	97.12	3.18
Period 03	16.67	200	31.0221	78.69	2.54	94.04	3.03
Period 04	10.92	131	30.2263	78.37	2.59	93.66	3.10
Average			30.5728	80.00	2.62	95.60	3.13

4. ช่วงเวลาหลังการเปลี่ยนถ่ายน้ำมันเกียร์ประสิทธิภาพสูง ช่วงที่ 3

ช่วงเวลา	ระยะเวลารวม	จำนวนข้อมูล	อัตราการผลิตเฉลี่ย	กระแสไฟฟ้าเฉลี่ย	ดัชนีการใช้พลังงาน	กำลังไฟฟ้าเฉลี่ย	ดัชนีการใช้พลังงาน
	(Hrs)	(Data)	(Ton/hr)	(Amps)	SEC (Amp/Ton/hr)	(kW)	SEC (kW/Ton/hr)
Period 03	71.33	856	30.5884	78.97	2.58	94.38	3.09
Period 04	9.58	115	29.9921	79.66	2.66	95.20	3.17
Period 05	51.58	619	30.5362	85.54	2.80	102.23	3.35
Average			30.3722	81.47	2.68	97.36	3.21

SUMMARY

Energy Saving

Existing Mineral Oil:	**101.46**	kW
Royal Purple Synfilm GT:	**96.08**	kW
Royal Purple Savings:	**5.38**	kW
Annual Energy Savings:	**42,609.6**	kWH
	142,742.16	THB

Labor Saving

Existing Mineral Oil: 600 X 2 Times	**1,200.00**	THB
Royal Purple Synfilm GT: 600 X 1 Time	**600.00**	THB
Annual Labor Savings:	**600.00**	THB - Royal Purple Saving

Differences in Oil Purchase Cost

Existing Mineral Oil:		
Estimated Oil Life:	**4,000.00**	hrs
Cost	**150.00**	THB/Liter
Royal Purple Synfilm GT:		
Estimated Oil Life:	**8,000.00**	hrs
Cost	**600.00**	THB/Liter
Annual Oil Cost		
Existing Mineral Oil	**2,700.00**	THB
Royal Purple Synfilm GT	**10,800.00**	THB
	8,100.00	THB – No Saving for Royal Purple

Total Annual Savings

Power Savings:	**142,742.16**	THB
Labor Savings:	**600.00**	THB
Cost of Oil:	**8,100.00**	THB
Total:	**135,242.16**	THB

THE PERFORMANCE OIL THAT OUTPERFORMS

Kirana Keawkongtao: Technical Sales
Tel: +662-726-7300, Mobile: +6685-865-1963
Email: kirana@belraythai.com

Yuttaphume Keattra: Technical Sales
Tel: +662-726-7300, Mobile: +6687-905-8185
Email: yuttaphume@belraythai.com

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Energy Savings Presentation

PURPOSE OF TEST: TO SHOW ENERGY SAVINGS THROUGH THE USE OF SUPERIOR QUALITY LUBRICATION.

EQUIPMENT TESTED: **Schindler Escalator Drive Gearboxes**
Montgomery Kone 60E, Series 498 Gearbox, 12.66:1 Ration
DATE OF INITIAL TESTING: July 24, 2013 **LUBRICANT: Csatrol Tribol 800/680**

DATE OF FINAL TESTING: January 22, 2014 **LUBRICANT: Royal Purple Synfilm GT680**

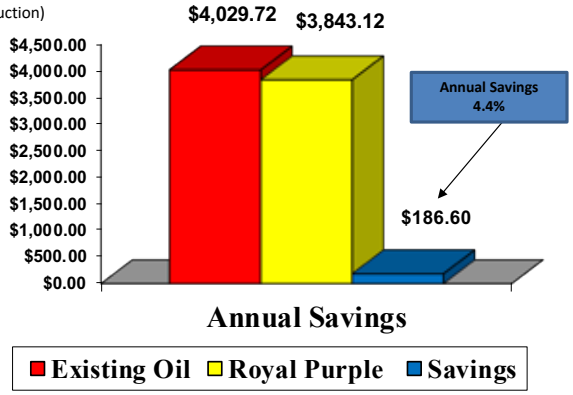
RESULTS:

	Existing Oil	Royal Purple
KILOWATT HOURS/15 MINUTE	1.14659 kwh	1.09602 kwh
KILOWATT HOURS/Month	3,350.3 kwh	3,202.6 kwh
COST PER DAY@ $.10/KWH	$11.17	$10.68
COST PER MONTH@ $.10/KWH	$335.03	$320.26
ANNUAL COST(300 days)	$4,020.36	$3,843.12

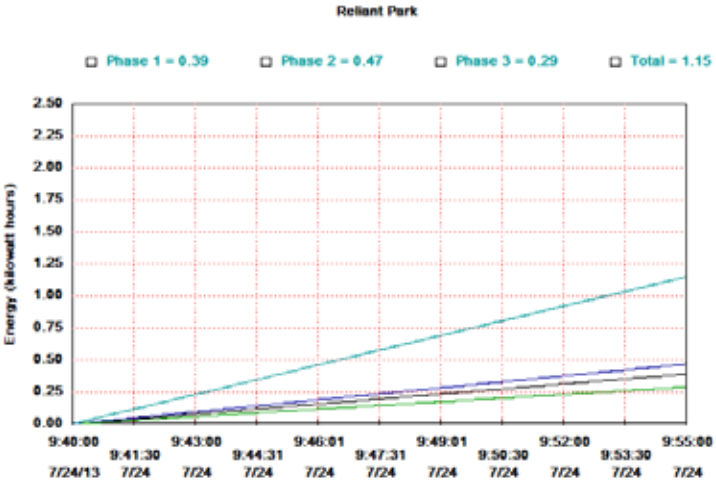
(4.4% Reduction)

SAVINGS with ENERGY EFFICIENT LUBRICANTS:

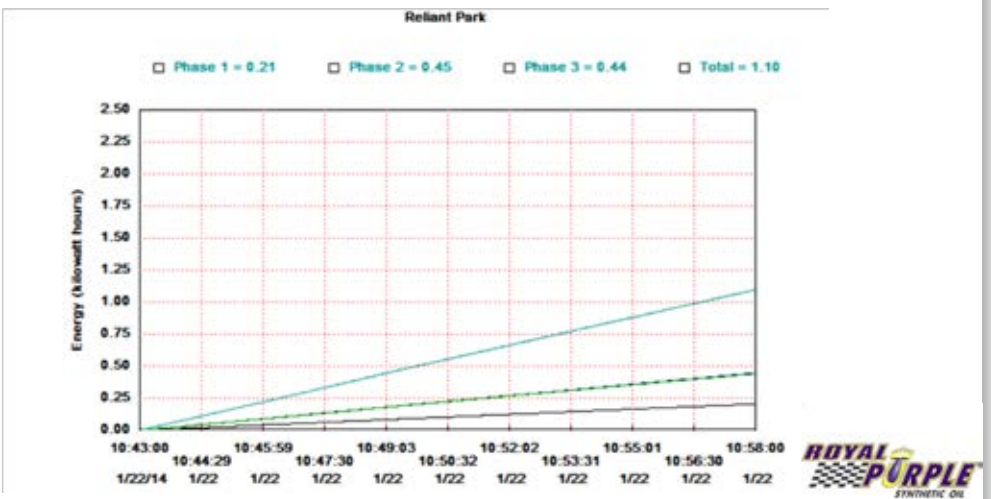
The unit is a representative of the 30+ escalators on site, Electrical Savings estimates are $186.60 per unit per year. (30 units --$5598 per year)



Energy with Existing Oil
Total Energy Consumed during Survey = 1.15 kwh



Energy with Royal Purple
Energy Efficient Lubricants
Total Energy Consumed
during Survey = 1.10 kwh



FLORIDA TECHNICAL PRODUCTS, INC.

"IMPROVING RELIABILITY THROUGH INNOVATION"

Tampa Coal Fire Power Plant

Evaluation Report - Coal Yard Stacker-Reclaimer

Falk Gearbox

Synergy High-Performance Gear Oil

Presented by:

Florida Technical Products, Inc.

Danny D. Hamilton - (904) 703-6057 - dan@floridatechnicalproducts.com

FLORIDA TECHNICAL PRODUCTS, INC.
"IMPROVING RELIABILITY THROUGH INNOVATION"

February 18, 2007

[redacted]

Dear Mr. [redacted]:

The following information is in regards to the impressive performance of Royal Purple's Synergy ISO 220 in the Falk Gearbox for the Stacker-Reclaimer at [redacted]. [redacted] Station is an 1800 MW, coal-fire power generation facility located in Tampa, Florida. The coal is moved from the transportation ships in the bay to south side of the plant through the use of a stacker-reclaimer.

In the spring of 2005 the stacker-reclaimer began to frequently shut down due to a "low oil pressure" shut-off system being triggered. After multiple failed attempts to remedy the cause of the issue, it became a practice at the plant to bypass the automatic shutdown with the manual override switch. This practice continued until December of 2005 when the high-speed pinion froze, knocking multiple teeth off of the gear in the Falk gearbox. [redacted] contacted Falk and was informed that delivery of a new gear would take approximately 12-16 weeks. The unit was experiencing significant vibrations that caused the platform to sway. If the stacker-reclaimer failed during this period then the personnel in the coal yard would be forced to use loaders/dozers to move all of the coal. This would have been an around the clock process until the unit could be fixed.

Having recently introduced Royal Purple to the plant, I was contacted to advise on a possible solution to avoid the catastrophic failure of the stacker-reclaimer. I recommended Royal Purple's Synergy ISO 220 Gear Oil that is fortified with the company's proprietary additive Synslide[1]. The plant ordered 2 x 55 gallon drums of the Synergy product and scheduled an outage. I delivered the product and stayed on site to assist with the conversion. When the gearbox was opened we observed a significant amount of wear metals suspended in the existing oil and noted that 9 teeth were missing from the gear. The gearbox was cleaned and filled with the Royal Purple Synergy Gear Oil.

[1] Synslide is Royal Purple's tough, EP lubricating film, that provides maximum protection under boundary lubrication conditions typically caused by heavily loaded, slow speed and/or shock load conditions.

FLORIDA TECHNICAL PRODUCTS, INC.
"IMPROVING RELIABILITY THROUGH INNOVATION"

After the third day the unit was in service with the Royal Purple product, the vibration the unit was experiencing began to decrease noticeably. The stacker-reclaimer continued to show operational improvement throughout the next 10 weeks. During the 10th week of service [redacted] received notification from Falk that their production facility had burned down and that delivery of the new gear would be delayed from the previous delivery estimate of 12-16 weeks to 12-16 months.

Fortunately for the plant, the Royal Purple Synergy carried the load in the gearbox and allowed the unit to run for the entire length of the lead-time for the new gear. During this period the initial vibrations experienced due to the missing teeth on the gear subsided to levels below that of the unit prior to the initial failure. Due to this documented success Royal Purple is now in all gearboxes in the coal yard at [redacted] Station.

If you have any questions or additional concerns regarding the information and statements made within this letter please do not hesitate to contact me directly. Thank you again for the opportunity to work with you in your facility and for your continued business and support.

Sincerely,

Danny D. Hamilton
Florida Technical Products, Inc.
(904) 703 - 6057
dan@floridatechnicalproducts.com

ROYAL PURPLE® SYNTHETIC OIL

SYNERGY®

HIGH PERFORMANCE GEAR OIL

BEYOND SYNTHETIC™

Synergy is an ultra-tough, long life, EP industrial gear oil proven to make gears run smoother, quieter, cooler and longer without overhauls. Synergy gains its performance advantage over competing mineral and synthetic oils through its superior blend of synthetic base oils plus Synslide additive technology, Royal Purple's unique, proprietary, noncorrosive, EP technology.

Synergy protects gears in severe service applications where other EP oils fail. Synergy is recommended for users looking for longer oil life and significantly improved gear box reliability and performance.

For more information, please request Royal Purple's "Gear Lubrication Manual."

SYNSLIDE® ADDITIVE TECHNOLOGY MAKES THE DIFFERENCE!

Synthetic oils enable Royal Purple to make superior lubricants, but it is Royal Purple's advanced Synslide additive technology that gives Royal Purple's EP lubricants their amazing performance advantages. Synslide additive technology truly is beyond synthetic.

Synslide additive technology, Royal Purple's tough, EP lubricating film, provides maximum protection under boundary lubrication conditions typically caused by heavily loaded, slow speed and/or shock load conditions. This tenacious, slippery film significantly improves lubrication and reduces wear by increasing the oil film thickness and toughness, which helps to prevent metal-to-metal contact in gears and bearings.

Synslide additive technology is noncorrosive to gears and bearings, including case-hardened gears that are easily pitted by conventional sulfur-phosphorus EP oils. Synslide additive technology displaces water from metal surfaces and excels in protecting equipment in wet environments. It also fortifies the oil against the detrimental effects of heat, which causes oil to oxidize.

Note: For Worm Gears, Royal Purple recommends Synergy® Worm Gear Oil or Thermyl-Glyde® Worm Gear Oil.

PERFORMANCE ADVANTAGES

- **High Film Strength**
  Synergy protects gears and bearings beyond the ability of conventional EP gear oils.
- **Shock Load Protection**
  Synergy protects against fatigue failure in gears subjected to sudden shock loads.
- **Rapidly Separates from Water**
  Synergy rapidly and completely separates from water, which is easily drained from the bottom of the oil reservoir.
- **Longer Oil Life**
  Synergy has outstanding oxidation stability that greatly extends oil change intervals while keeping gear boxes clean.
- **Reduces Bearing Vibrations**
  The tough oil film of Synergy coupled with its ability to micro-polish contacting bearing elements provides superior bearing lubrication.
- **Saves Energy**
  The tough oil film of Synergy and low coefficient of friction save energy in gear boxes operating under load.
- **Synthetic Solvency**
  The natural solvency of Synergy cleans up dirty gear boxes and keeps them clean.
- **Compatible with Seals**
  Synergy has excellent compatibility with most seals.
- **Compatible with Other Oils**
  Synergy is compatible with most elastomers and can be mixed with other mineral oils and most synthetic oils. (It is not compatible with silicone or glycol based synthetics).
- **Environmentally Responsible**
  Synergy components are TSCA listed and meet EPA, RCRA and OSHA requirements. Synergy extends oil drain intervals, eliminates premature oil changes, decreases the amount of oil purchased and disposed of and conserves energy.

Royal Purple LLC / One Royal Purple Lane / Porter, TX 77365 / 281.354.8600 / royalpurpleindustrial.com

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REVISED 01 / 27 / 2014

SYNERGY®

HIGH PERFORMANCE GEAR OIL

TYPICAL PROPERTIES*	ASTM METHOD	ISO GRADE 68	100	150	220	320	460	680	1000
SAE Grade	---	75W80	80W85	80W90	90	85W140	140	250	250
AGMA Grade	---	2 EP	3 EP	4 EP	5 EP	6 EP	7 EP	8 EP	8A EP
Viscosity	D-445								
cSt @ 40°C		68	100	150	220	320	460	680	1000
cSt @ 100°C		8.8	12.0	15.7	21.0	25.8	32.7	44.6	58.0
Viscosity Index	D-2270	102	102	101	110	105	104	111	112
Flash Point, °F	D-92	415	460	405	400	435	415	440	390
Pour Point, °F	D-6892	-33	-33	-30	-33	-30	-24	-24	-30
Copper Corrosion Test	D-130								
3 Hrs @ 100°C		1A	1A	1A	1A	1A	1A	1A	1A
Rust Test	D-665								
Fresh Water		PASS	PASS	PASS	PASS	PASS	PASS	PASS	PASS
Salt Water		PASS	PASS	PASS	PASS	PASS	PASS	PASS	PASS
Foam Test, Seq II	D-892								
Initial/Final/Time(sec)		4/0/2	2/0/0	4/0/2	7/0/2	10/0/4	4/0/1	1/0/1	0/0/0
Demulsibility Test	D-1401								
Mins @ 130°F		10	---	---	---	---	---	---	---
Mins @ 180°F		---	5	5	5	10	10	15	10
Cincinnati Millicron "B"	D-2070								
Corrosion / Oxidation		PASS	PASS	PASS	PASS	PASS	PASS	PASS	PASS
Four Ball EP Test	D-2783								
Load Wear Index		58	60	60	72	61	61	61	61
Weld Load, kgf		315	400	400	315	400	400	400	400
Density, lbs/g	D-4052	7.37	7.40	7.41	7.38	7.48	7.51	7.49	7.50

*Properties are typical and may vary

*Note: When changing to Synergy, its solvency cleans wear metals and deposits left behind by previous oils. These wear metals and deposits can cause abnormally high values on used oil analysis until equipment is clean.

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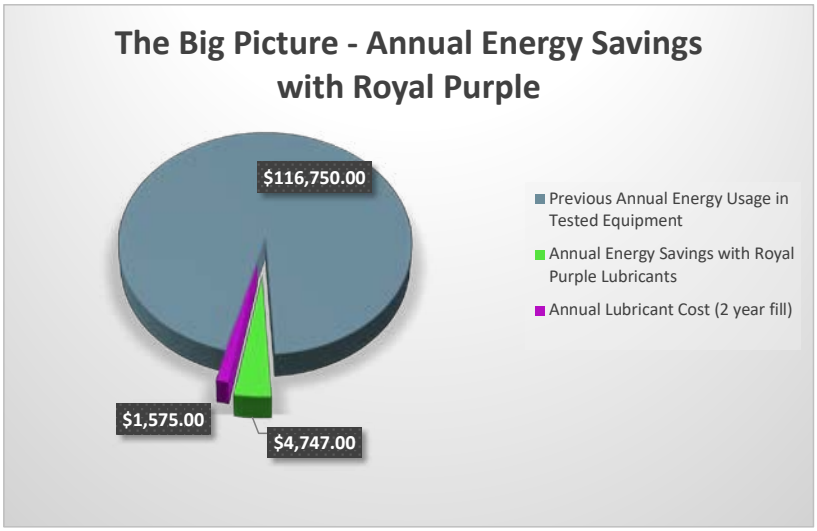
REVISED 01 / 27 / 2014

Energy Savings with Royal Purple Lubricants

Titan Tire
Des Moines, IA

Summary:
Two plant air compressors in the powerhouse, one Atlas Copco and one Gardner Denver, were changed from a competitor's fluid to Royal Purple Synfilm. Energy usage was logged with a Powersight PS3500 power analyzer before changing away from the competitor's products and then again after Royal Purple had been lubricating the equipment for several months. The reason for the extended period between tests was to allow atmospheric conditions to replicate in order to get an accurate before and after comparison. This also allowed the "after" portion of the test to be conducted on the Royal Purple lubricant that had been used in the equipment for a considerable period of time.

Operating parameters were recorded during the before testing and repeated for the after testing so that each piece of equipment was doing the same amount of work or more for the follow-up test. All three legs of voltage and current were logged at a rate of about one data point each second, in order to compile an average over at least a several minute period, over which period the parameters were closely controlled. This average usage was then used to determine monthly and yearly usage and savings.



ROI on **total cost of Royal Purple** lubricants based solely on energy savings:
Every 121 days or over 3 times annually (on two-year oil change, typical in this equipment) compared to previously used lubricants.

Energy cost used: $0.04/kwh

Data

Titan Tire

Operating parameters: Ambient temperature and humidity differences were negligible between tests. Ambient temp was approximately 75F during all tests, controlled by the overhead door opening or the room heater. Header pressure was matched for each test for the duration of the test as well. Air outlet pressure on compressor #1 was steady at 100-101 psi for the duration of the test, and 116 psi on compressor #2 for the duration of the test, both verified at the control panel. Any other measurable variables on the compressors were controlled for the duration of the tests.

Compressor #1 (Atlas Copco 200 HP GA160)

Titan Compressor #1 Before
C:\PowerSight\TitanTireComp#1AtlasCopco GA160Before.psm.log
Test began at 07/21/14 10:12:12
Test ended at 07/21/14 10:22:32

Titan Compressor #1 After
C:\PowerSight\TitanComp#1AtlasCopco GA160After2.log
Test began at 03/27/15 14:32:11
Test ended at 03/27/15 14:34:18

Measurement	Before	After	Units	Change	%Change
Total True Power Ave:	103816.6	98695.4	Watts	-5121.2	-4.9 %
Energy, estimated per month:	75838.3	72667.4	KWH	-3170.9	-4.2 %
Cost, estimated per month:	$3,033.53	$2,906.70	$	-$126.83	-4.2 %
Cost, estimated per year (at $0.040/KWH)	$36402.36	$34,880.40	$	-$1,521.96	-4.2 %

Compressor #2 (Gardner Denver 300 HP)

Titan Compressor #2 Before
C:\PowerSight\TitanComp#2GD300HPBefore.psm.log
Test began at 07/31/14 09:30:53
Test ended at 07/31/14 09:36:10

Titan Compressor #2 After
C:\PowerSight\TitanComp#2GD300HPAfter.log
Test began at 03/27/15 14:53:28
Test ended at 03/27/15 14:59:33

Measurement	Before	After	Units	Change	%Change
Power Ave:	229248.6	220564.7	Watts	-8683.9	-3.8 % Total True
Energy, estimated per month:	167466.7	160672.8	KWH	-6793.9	-4.1 %
Cost, estimated per month:	$6,698.67	$6,426.91	$	-$271.76	-4.1 %
Cost, estimated per year: (at $0.040/KWH)	$80,348.04	$77,122.92	$	-$3,225.12	-4.1 %

ROYAL PURPLE®
SYNTHETIC OIL

ROYAL PURPLE, LLC.
One Royal Purple Lane | Porter, TX 77365

PHONE 281-354-8600
TOLL FREE 888-382-6300
FAX 281-354-7600
WEB royalpurpleindustrial.com

REV. 10/19