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Business Case for Routine Fresh Oil Analysis

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Benefits Statement

Fresh oil testing is critical for effective Condition Monitoring.

Beyond the significance of setting baseline reference to aid oil analysis reports interpretation, it is relevant in establishing operators' confidence that the right oil is in use.

The case-studies of this presentation share how unconnected Companies operating independently achieved total combined cost-avoidance savings of **>K$250**, just by making Fresh Oil Testing part of their New Oil Receiving Procedure from Vendors.

Situation

Ordinarily new oil is perceived fresh and ready for use. A lot of operators in the Industry will not see any need to send sample of fresh oil for Lab analysis.

1. Justifiably, there has not been any machinery contact so elemental wear analysis is meaningless.
2. Furthermore, given that the oil batch was received not too long and warehoused indoor, it is illogical to think of oil degradation or contamination.

Machine wears and degrading condition of lube oil are two vital information that oil analysis provides, so why do oil analysis for freshly supplied oil?

The under listed case studies provide convincing justifications.

Case Study 1

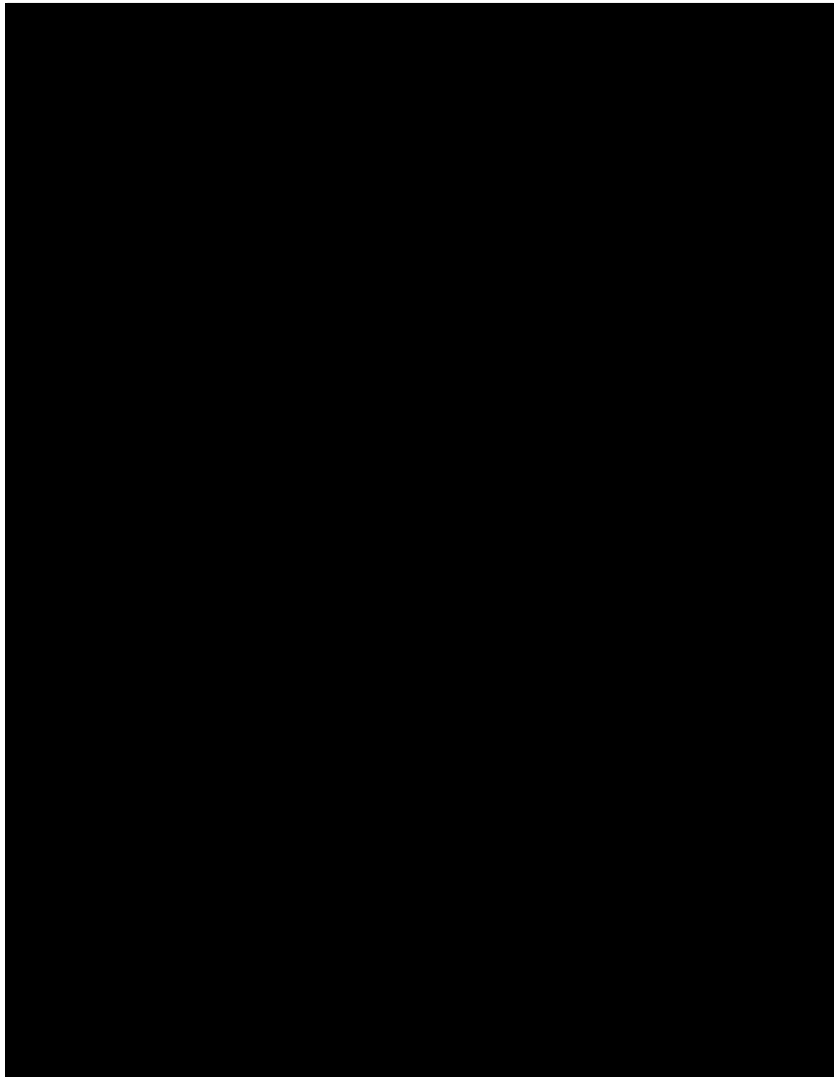
Operators of a Paper Mills in Nigeria observed sluggish movement of the plunger and ram, soon after the lubrication service of a Hydraulic Press. The entire maintenance procedure was reviewed and seemed correctly implemented by competent technicians. The freshly filled in-service hydraulic was least suspect.

By agreeing to fresh oil analysis, wrong oil application was immediately detected which successfully saved Hydraulic System failure, with consequential Production downtime and costly repairs.

Case Study 1: *Oil Analysis Report*
Paper Mill 2 Disperger Unit

1. Sept. 4, 2014, in-service Hydraulic Oil (ISO VG 68) for the Disperger Unit was replaced in scheduled lubrication service.
2. Soon after, Operators observed sluggish response in the performance of the hydraulic system of that Unit. Oct. 25, 2014 oil sampling was ordered for more investigations.
3. Oil analysis report revealed wrong lubricant application, ISO VG 220 was put instead.
4. Follow-up Mtce action was to drain, flush out the ISO VG 220 oil and replace with proper ISO VG 68.
5. Expected normal hydraulic performance of the Disperger Unit was restored.

Obviously, an inexperienced operator had filled an ISO VG 220 oil instead of OEM specified ISO VG 68.



Case Study 2

A manufacturing company with long-term contract to produce metal cans for most brewery companies in Nigeria was saved from the embarrassment of paying huge sums as contract penalties, in addition to costly engine repairs and production downtime while shutdown lasted. The entire production plant and support facilities of that company are powered by in-house generated electricity from Two(2) Natural Gas Engines.

Fortunately, those engines were placed on routine oil analysis provided by Petrosave Laboratory.

1. It was noticed at some point that Lab results were getting out of known trend. In-service oil viscosities significantly dropped while the TBN rose much higher than earlier fresh oil baseline reference. OEM specified mono-grade SAE 40 and LA (Low Ash) oil.
2. Operational checks revealed that production processes were as before; engine load and other running conditions continued to average the same.
3. Lube oil brand remained unchanged.

On further root cause investigation, the Company agreed to fresh oil analysis. The gas engines are supposed to be running on Mobil Pegasus 705 and empty drums from recent lubrication service attest to that. However, analysis of fresh oil samples revealed oil properties appreciably different from those of OEM specified GEO.

Case Study 2a: *Oil Analysis Report*

Note: samples of In-service Gas Engine Oil taken from **GG1** before and including May, 2013 showed steady trend of viscosities lower than its reference Fresh Oil.

PetroSave Integrated Services Limited

Gas Engine Oil Analysis Report

Client Information

Company Name:	GZ Industry Ltd.	Client Contact:	Mr. Samir Khan
Company Address:	Agbara Factory	Department:	Maintenance - Power Plant
	Agbara Industrial Estate	Mobile Phone No.:	08077691610
	Lagos	Email Address:	samir.khan@gzican.com
			jose.sebastian@gzican.com
		Equipment Operator/Driver:	-

Equipment Information

Equipment Type:	Gas Engine Generator [1.8 MW]	Component:	Engine
Equipment ID Ref.	Gen #1 [S/N: 085619/01]	Make/Model:	JENBACHER / J612GSE
Equipment Make:	JENBACHER	Lube Oil in use:	Pegasus 705
Equipment Year of Manufacture:	-	Oil Brand:	Mobil
Equipment Location:	Gas Plant, Agbara Factory	Oil Weight:	SAE 40

	Fresh Oil Sample	Condemning Limit	Used Oil Samples - Trend of Actual Laboratory Tests						Condition
			19 November 2012	10 December 2012	31 December 2012	25 January 2013	09 April 2013	02 May 2013	OK / Caution / Critical
			272/GZI/GGE#1/16	342/GZI/GGE#1/17	378/GZI/GGE#1/18	450/GZI/GGE#1/19	748/GZI/GGE#1/20	835/GZI/GGE#1/21	
Engine Operating Hours									
Oil Sample [Hrs]	0	-	2,148	2,653	3,139	3,726	5,302	5,731	
Cumm. Engine [Hrs]	-	-	15,539	16,044	16,530	17,117	18,693	19,122	
Lube Oil Properties									
Appearance [Clear, Turbid or Dark]	Clear		Dark	Dark	Dark	Dark	Dark	Dark	
Viscosity @ 40C [cSt]	126.6	+/-25%	117.5	125	123.5	116.4	100.7	98.6	Caution
Viscosity @ 100C [cSt]	13.3	+/-20%	12.6	13.2	13.1	12.6	11.4	11.2	Caution
TAN [mgKOH/g]	0.1	4	1.2	1.2	0.9	1.2	1.8	1.9	OK
TBN [mgKOH/g]	5.6	2.8	4.7	4.6	4.6	4.7	4.7	4.7	OK
Insolubles [%]	0%	1%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	OK
Nitration [A/cm]	0	25	0	0	0	0	2.3	0	OK
Oxidation [A/cm]	0	25	3.2	3.9	3.6	4.3	4.3	4.8	OK
Water in Oil [%]	0.00%	0.20%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	OK
Glycol [%]	0.00%	0.02%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	OK
Elemental Analysis									
Wear Metals									
Aluminum, Al [ppm]	0	15	2	0	0	0	0	1	OK
Copper, Cu [ppm]	0	15	16	20	20	30	68	65	Critical
Chromium, Cr [ppm]	0	5	0	0	4	0	0	0	OK
Lead, Pb [ppm]	0	30	0	0	0	0	0	0	OK
Iron, Fe [ppm]	0	20	0	0	0	0	0	0	OK
Tin, Sn [ppm]	0	10	0	3	5	0	6	10	Critical
Contaminant Metals									
Silicon, Si [ppm]	0	25	0	0	0	0	0	0	OK
Sodium, Na [ppm]	0	8	0	0	0	2	4	5	OK
Potassium, K [ppm]	0	10	0	0	0	0	0	0	OK
Additive Metal									
Molybdenum [ppm]	0	10	0	0	0	0	0	0	OK

Diagnostics:

Low Oil Viscosity - causes include Wrong top-up with lighter oil, VI improver sheardown for multi-grades

High Level of Copper - causes include Bearings, Wrist Pin Bushings, Cam Bushings, Valve Train Bushings, Thrust Washers, Oil Coolers, Oil Pipings, Governors & Oil Pump, Oil Additives

High Level of Tin - causes include Surface coating of Pistons, Overlay of Bearings and Bushings

Service Engineer's Comment:

Low oil viscosity is most probably from use of SAE 30 oil blend; the increasing presence of Tin (a sacrificial metal) may be associated to increased frictional wears from using a low viscosity oil. Note that SAE 40 is the approved oil grade by Jenbarcher. High Copper level continues; possibly from leaching of Oil Cooler/Pipings. For now all other wear metals within limits. Subsequent oil sampling/analysis to monitor trend.

Case Study 2b: *Oil Analysis Report*

Note: samples of In-service Gas Engine Oil taken from **GG2** before and including May, 2013 showed steady trend of viscosities lower than its reference Fresh Oil.

PetroSave Integrated Services Limited

Gas Engine Oil Analysis Report

Client Information

Company Name:	GZ Industry Ltd.	Client Contact:	Mr. Samir Khan
Company Address:	Agbara Factory Agbara Industrial Estate Lagos	Department: Mobile Phone No.: Email Address:	Maintenanoe - Power Plant 08077881810 samir.khan@gzican.com jose.sebastian@gzican.com
		Equipment Operator/Driver:	-

Equipment Information

Equipment Type:	Gas Engine Generator [1.8 MW]	Component:	Engine
Equipment ID Ref.	Gen #2 [S/N: 0856197/01]	Make/Model:	JENBACHER / J612GSE
Equipment Make:	JENBACHER	Lube Oil in use:	Pegasus 705
Equipment Year of Manufacture:	-	Oil Brand:	Mobil
Equipment Location:	Gas Plant, Agbara Factory	Oil Weight:	SAE 40

	Fresh Oil Sample	Condemning Limit	Used Oil Samples - Trend of Actual Laboratory Tests						Condition
			19 November 2012	10 December 2012	31 December 2012	25 January 2013	09 April 2013	02 May 2013	OK / Caution / Critical
			273/GZ/GGE#2/16	343/GZ/GGE#2/17	378/GZ/GGE#2/18	461/GZ/GGE#2/19	749/GZ/GGE#2/20	836/GZ/GGE#2/21	
Engine Operating Hours									
Oil Sample [Hrs]	0	-	2,087	2,592	3,086	3,643	5,295	5,793	
Cumm. Engine [Hrs]	-	-	15,965	16,470	16,963	17,521	19,173	19,671	
Lube Oil Properties									
Appearance [Clear, Turbid or Dark]	Clear		Dark	Dark	Dark	Dark	Dark	Dark	
Viscosity @ 40C [cSt]	126.6	+/-25%	111.2	120.5	120	114.4	100.4	100.2	
Viscosity @ 100C [cSt]	13.3	+/-20%	12.2	12.9	12.8	12.2	11.3	11.3	
TAN [mgKOH/g]	0.1	4	1.1	1.1	1.2	1.3	1.5	1.6	
TBN [mgKOH/g]	5.6	2.8	4.8	4.6	4.7	4.9	4.9	4.8	
Insolubles [%]	0%	1%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	
Nitration [A/cm]	0	25	0	0	0	0	0	0	
Oxidation [A/cm]	0	25	2.6	3.4	3	3.7	4.5	4.8	
Water in Oil [%]	0.00%	0.20%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	
Glycol [%]	0.00%	0.02%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	
Elemental Analysis									
Wear Metals									
Aluminum, Al [ppm]	0	15	2	0	0	0	0	0	
Copper, Cu [ppm]	0	15	37	45	40	59	38	34	
Chromium, Cr [ppm]	0	5	0	0	0	0	0	0	
Lead, Pb [ppm]	0	30	0	0	0	0	0	0	
Iron, Fe [ppm]	0	20	0	0	0	0	0	0	
Tin, Sn [ppm]	0	10	4	6	7	7	8	7	
Contaminant Metals									
Silicon, Si [ppm]	0	25	0	0	0	0	0	0	
Sodium, Na [ppm]	0	8	4	0	0	2	2	8	
Potassium, K [ppm]	0	10	0	0	0	0	5	12	
Additive Metal									
Molybdenum [ppm]	0	10	0	0	0	0	0	0	

Diagnostics:

Low Oil Viscosity - causes include Wrong top-up with lighter oil, VI improver sheardown for multi-grades

High Level of Copper - causes include Bearings, Wrist Pin Bushings, Cam Bushings, Valve Train Bushings, Thrust Washers, Oil Coolers, Oil Pipings, Governors & Oil Pump, Oil Additives

High Level of Tin - causes include Surface coating of Pistons, Overlay of Bearings and Bushings

High Level of Sodium - causes include Oil additive constituent, Coolant additive, Road Salt/Dirt, Grease

High Level of Potassium - cause include Coolant additive, Trace element in fuel

Service Engineer's Comment:

Low oil viscosity is most probably from use of low SAE oil blend; the increasing presence of Tin (a sacrificial metal) can be associated to increased frictional wears from using a low viscosity oil. High Copper level continues; possibly from leaching of Oil Cooler/Pipings. For now all other wear metals within limits. This gas engine should be investigated for coolant ingress as indicated by presence of "Coolant markers" - Sodium and Potassium; proactive maintenance action is advised. Subsequent oil sampling/analysis to monitor trend.

Case Study 2c: *Oil Analysis Report*

Sample of fresh Gas Engine Oil taken May, 2013 showed that fresh oil quality was off specification.

1. Gas engines do run pretty hot, therefore lower SAE oil will compromise the expected oil film protection at heated operating temperature.
2. Furthermore, high TBN oil created a grim prospect for excessive ash deposits with associated problems.

PetroSave
Integrated Services Limited

Fresh Oil Analysis Report

Client Information

Company Name:	GZ Industry Ltd.	Client Contact:	Mr. Samir Khan
Company Address:	Agbara Factory	Department:	Maintenance - Power Plant
	Agbara Industrial Estate	Mobile Phone No.:	08077691610
		Email Address:	samir.khan@gzican.com
Date:	02-May-13		jose.sebastian@gzican.com

Test	Units		Fresh Oil Sample Drum	Mobil Pegasus 705 Website PDS Info
Color	Visual		Gold-yellow	Gold-yellow
SAE Grade	-		30	40
Viscosity @ 40C	cSt		85.3	126.2
Viscosity @ 100C	cSt		10.2	13.2
Specific Gravity [SG] @ 15C	kg/m^3		884	887
Total Base Number [TBN]	mgKOH/g		6.3	5.6
Total Acid Number [TAN]	mgKOH/g		0.4	NA
Flash Point	°C		190	252
Water	% vol		Nil	Nil

Comments

Reviewing critical oil properties of the fresh oil sample provided and matched against Mobil website information for Pegasus 705; it is safe to conclude that Sample **DOES NOT MEET** the product formulation properties of Mobil Pegasus 705.

Case Study 2d: *Oil Analysis Report*

1. Company Procurement, contracted a new Oil Vendor, certified as Authorized Distributor of Mobil Industrial lubricants.
2. The new Vendor supplied the upgrade GEO Mobil Pegasus 805; recently launched at that time
3. Sample of fresh Gas Engine Oil taken in July, 2013 from randomly selected new oil drum, showed that fresh oil quality was within specification.

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Fresh Oil Analysis Report

Client Information

Company Name:	GZ Industry Ltd.	Client Contact:	Mr. Samir Khan
Company Address:	Agbara Factory Agbara Industrial Estate	Department: Mobile Phone No.: Email Address:	Maintenance - Power Plant 07046180713 samir.khan@gzican.com
Date:	23-Jul-13		jose.sebastian@gzican.com

Test	Units		Fresh Oil Sample Drum - Batch No. C3200023	Mobil Pegasus 805 2001 year Website PDS Info
Color	Visual		Clear, Light Brown	NA
SAE Grade	-		40	40
Viscosity @ 40C	cSt		122.6	130.0
Viscosity @ 100C	cSt		13.0	13.5
Viscosity Index, VI	-		100	99
Specific Gravity [SG] @ 15C	kg/m^3		889	890
Total Base Number [TBN]	mgKOH/g		6.2	6.2
Total Acid Number [TAN]	mgKOH/g		0.3	NA
Flash Point	°C		185	262
Water	% vol		Nil	Nil

NA - Not Available

Comments

1. Reviewing critical oil properties of the fresh oil sample provided and matched against Mobil website information for Pegasus 805; it is safe to conclude that Sample **MEETS** the product formulation properties of Mobil Pegasus 805.
2. It is essential to note that website Product Data information is only a guide as to the typical properties of the lubricant; however, slight but acceptable variations often occur in actual lubricant batch produced at that point in time. Such variation may be driven by the specifications of the base stock oil available to the LOBP (Lube Oil Blending Plant) at that point in time.

Case Study 2e: *Oil Analysis Report*

1. Lubrication Service was done to flush the fake oil and crankcase for this Gas Engine refilled with genuine Mobil Pegasus 805.
2. Samples of In-service Gas Engine Oil taken from **GG1** beginning July, 2013 showed In-service oil properties are getting normalized.

PetroSave Integrated Services Limited

Gas Engine Oil Analysis Report

Client Information

Company Name:	GZ Industry Ltd.	Client Contact:	Mr. Samir Khan
Company Address:	Agbara Factory Agbara Industrial Estate Lagos	Department:	Maintenance - Power Plant
		Mobile Phone No.:	07046180713
		Email Address:	samir.khan@gzican.com jose.sebastian@gzican.com
		Equipment Operator/Driver:	-

Equipment Information

Equipment Type:	Gas Engine Generator [1.8 MW]	Component:	Engine
Equipment ID Ref.	Gen #1 [S/N: 0868186/01]	Make/Model:	JENBACHER / J612GSE
Equipment Make:	JENBACHER	Lube Oil in use:	Pegasus 706
Equipment Year of Manufacture:	-	Oil Brand:	Mobil
Equipment Location:	Gas Plant, Agbara Factory	Oil Weight:	SAE 40

	Fresh Oil Sample	Condemning Limit	Used Oil Samples - Trend of Actual Laboratory Tests						Condition (OK / Caution / Critical)
			02 May 2013 835/GZI/GGE#1/21	31 May 2013 986/GZI/GGE#1/22	22 July 2013 1460/GZI/GGE#1/23	13-Sep-13 1764/GZI/GGE#1/24	08 October 2013 1851/GZI/GGE#1/25	28 October 2013 1916/GZI/GGE#1/26	
Engine Operating Hours									
Oil Sample [Hrs]	0	-	5,731	1,163	627	1,776	2,319	2,804	
Cumm. Engine [Hrs]	-	-	19,122	19,571	20,587	21,736	22,279	22,764	
Lube Oil Properties									
Appearance [Clear, Turbid or Dark]	Clear		Dark	Dark	Dark	Dark	Dark	Dark	
Viscosity @ 40C [cSt]	122.6	+/-25%	98.6	100.7	146.9	137.6	140.6	139.9	OK
Viscosity @ 100C [cSt]	13	+/-20%	11.2	11.4	14.7	14.1	14.3	14.2	OK
TAN [mgKOH/g]	0.3	4	1.9	2.1	1	1.6	1.6	1.8	OK
TBN [mgKOH/g]	6.2	3.1	4.7	4.4	5.3	4.6	4.6	4.5	OK
Insolubles [%]	0%	1%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	OK
Nitration [A/cm]	0	25	0	0	10.2	6.1	3.5	3.3	OK
Oxidation [A/cm]	0	25	4.8	4.2	3.3	5.2	6	6.6	OK
Water in Oil [%]	0.00%	0.20%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	OK
Glycol [%]	0.00%	0.02%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	OK
Elemental Analysis									
Wear Metals									
Aluminum, Al [ppm]	0	15	1	3	2	2	3	0	OK
Copper, Cu [ppm]	0	15	65	73	17	30	25	25	Critical
Chromium, Cr [ppm]	0	5	0	3	0	4	0	2	OK
Lead, Pb [ppm]	0	30	0	0	0	0	0	0	OK
Iron, Fe [ppm]	0	20	0	0	0	0	2	2	OK
Tin, Sn [ppm]	0	10	10	7	4	10	2	5	OK
Contaminant Metals									
Silicon, Si [ppm]	0	25	0	0	0	0	0	0	OK
Sodium, Na [ppm]	0	8	5	5	4	7	0	0	OK
Potassium, K [ppm]	0	10	0	0	0	0	0	0	OK
Additive Metal									
Molybdenum [ppm]	0	10	0	0	0	0	0	0	OK

Diagnostics:

High Level of Copper - causes include Bearings, Wrist Pin Bushings, Cam Bushings, Valve Train Bushings, Thrust Washers, Oil Coolers, Oil Pipings, Governors & Oil Pump, Oil Additives

Service Engineer's Comment:

Copper at critical level persists and occuring alone; leaching of Oil Cooler is suspected. Reoccuring High Copper alerts should be reviewed with Jenbarcher Engineers and appropriate maintenance actions taken. Current High Copper condition if left unattended, could "mask" other sources of copper eg. should bearing wears occur. Oil is ok for continued use. Subsequent oil sampling/analysis to monitor trend.

Case Study 2f: *Oil Analysis Report*

1. Lubrication Service was done to flush the fake oil and crankcase for this Gas Engine refilled with genuine Mobil Pegasus 805.
2. Samples of In-service Gas Engine Oil taken from **GG2** beginning July, 2013 showed In-service oil properties are getting normalized.

Obviously an unscrupulous oil vendor had supplied much cheaper competitive multi-grade DEO filled into new empty drums, then labeled and supplied as Mobil Pegasus 705.

That discovery kick-started a change process which made fresh oil analysis an essential step in that company's new oil receiving procedure.

PetroSave Integrated Services Limited

Gas Engine Oil Analysis Report

Client Information

Company Name:	GZ Industry Ltd.	Client Contact:	Mr. Samir Khan
Company Address:	Agbara Factory Agbara Industrial Estate Lagos	Department:	Maintenance - Power Plant
		Mobile Phone No.:	07046180713
		Email Address:	samir.khan@gzican.com jose.sebastian@gzican.com
		Equipment Operator/Driver:	-

Equipment Information

Equipment Type:	Gas Engine Generator [1.8 MW]	Component:	Engine
Equipment ID Ref.	Gen #2 [S/N: 0866187/01]	Make/Model:	JENBACHER / J612GSE
Equipment Make:	JENBACHER	Lube Oil in use:	Pegasus 706
Equipment Year of Manufacture:	-	Oil Brand:	Mobil
Equipment Location:	Gas Plant, Agbara Factory	Oil Weight:	SAE 40

	Fresh Oil Sample	Condeming Limit	Used Oil Samples - Trend of Actual Laboratory Tests						Condition
			02 May 2013 836/GZI/GGE#2/21	31 May 2013 987/GZI/GGE#2/22	22 July 2013 1461/GZI/GGE#2/23	13 September 2013 1765/GZI/GGE#2/24	08 October 2013 1852/GZI/GGE#2/25	28 October 2013 1917/GZI/GGE#2/26	OK / Caution / Critical
Engine Operating Hours									
Oil Sample [Hrs]	0	-	5,793	1,272	2,426	705	1,303	1,788	
Cumm. Engine [Hrs]	-	-	19,671	20,137	21,291	22,192	22,790	23,275	
Lube Oil Properties									
Appearance [Clear, Turbid or Dark]	Clear		Dark	Dark	Dark	Dark	Dark	Dark	
Viscosity @ 40C [cSt]	126.6	+/-25%	100.2	101.3	102.1	137.1	141.4	143.2	
Viscosity @ 100C [cSt]	13.3	+/-20%	11.3	11.4	11.5	14.1	14.4	14.5	
TAN [mgKOH/g]	0.1	4	1.6	1.6	2.3	1	1.3	1.6	
TBN [mgKOH/g]	5.6	3.1	4.8	4.6	4	5.4	5.1	4.8	
Insolubles [%]	0%	1%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	
Nitration [A/cm]	0	25	0	0	4.6	4.5	2.3	2.9	
Oxidation [A/cm]	0	25	4.8	0	5.7	0	2.6	4.2	
Water in Oil [%]	0.00%	0.20%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	
Glycol [%]	0.00%	0.02%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	
Elemental Analysis									
Wear Metals									
Aluminum, Al [ppm]	0	15	0	0	3	0	2	0	
Copper, Cu [ppm]	0	15	34	62	52	12	45	99	
Chromium, Cr [ppm]	0	5	0	0	0	0	0	0	
Lead, Pb [ppm]	0	30	0	4	4	0	0	0	
Iron, Fe [ppm]	0	20	0	0	2	0	0	0	
Tin, Sn [ppm]	0	10	7	8	9	2	0	5	
Contaminant Metals									
Silicon, Si [ppm]	0	25	0	0	0	0	0	0	
Sodium, Na [ppm]	0	8	8	3	38	945	3	3	
Potassium, K [ppm]	0	10	12	6	0	0	0	0	
Additive Metal									
Molybdenum [ppm]	0	10	0	3	0	0	0	0	

Diagnostics:

High Level of Copper - causes include Bearings, Wrist Pin Bushings, Cam Bushings, Valve Train Bushings, Thrust Washers, Oil Coolers, Oil Pipings, Governors & Oil Pump, Oil Additives

Service Engineer's Comment:

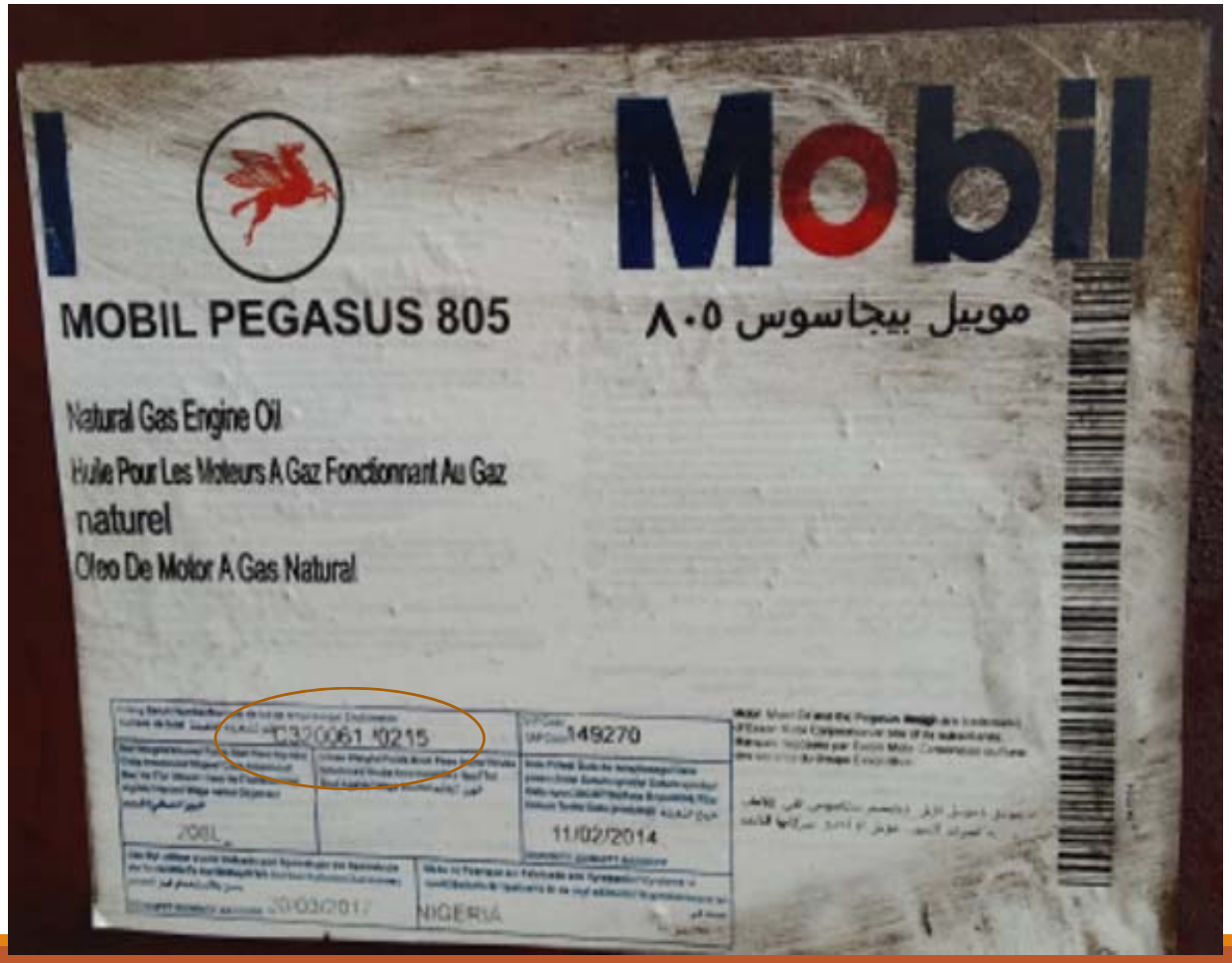
Copper at critical level persists; same comment as for Gas Engine #1 will apply. Oil is ok for continued use. Subsequent oil sampling/analysis to monitor trend.

Case Study 3

A well known Newspaper Company, affiliated to leading UK newspaper, running on Gas Engine opted for oil analysis after 10,000 Run Hrs. Ordinarily, every Gas Engine user (of that brand) is expected to commence with oil analysis program as a key OEM Warranty requirement, the Power Plant of this newspaper considered otherwise but was later compelled to accept oil analysis after series of problems.

1. On the very first visit by the Petrosave Field Service Engineer, in-service oil sample was taken from that Gas Engine while fresh oil sample was also taken from a randomly picked GEO drum in the Oil Store. Every drum is expected to have its Production Batch No. indicated on the stick-on label on top of the drum as well as on the upper side of same drum. However, for this drum the batch numbers on the stick-on label and on the drum side were remarkably different. That was the first alert on the quality content of fresh oil drum.
2. Fresh Oil analysis at Petrosave Laboratory, confirmed the oil did not meet the product formulation properties of Mobil Pegasus 805.
3. Furthermore, investigations by the Newspaper company revealed that contrary to earlier claims, the oil vendor was never an authorized Mobil lubricants distributor.

Local OEM representative, on service contract with this Newspaper, took appropriate steps to immediately flush and replace the in-service oil during Lubrication Service.



Case Study 3: *Different Batch Nos. on a New Oil Drum*

Case Study 3 *Oil Analysis Reports*

PetroSave Integrated Services Limited

Fresh Oil Analysis Report

Client Information

Company Name:	The Guardian Newspaper	Client Contact:	Mr. George M. Oha
Company Address:	Rutam House Apapa-Oshodi Expressway Isolo, Oshodi Expwy Lagos	Department: Mobile Phone No.: Email Address:	Engineering 08033285823, 08025955859 <george.oha@ngrguardiannews.com>
Date:	29-Mar-2017		

Test	Units	Fresh Mobil Pegasus 805 Sample Drum Batch # [Sticker] C320061/0215 Drum Batch # [Drum Side] C280055 Sampled: Mar. 27, 2017	Mobil Pegasus 805 Website PDS Info
Color	Visual	Clear, Brown	NA
SAE Grade	-	30	40
Viscosity @ 40C	cSt	86.9	130.0
Viscosity @ 100C	cSt	10.9	13.5
Viscosity Index, VI	-	110	99
Specific Gravity [SG] @ 15C	kg/m^3	890	890
Total Acid Number [TAN]	mgKOH/g	1.0	NA
Total Base Number [TBN]	mgKOH/g	5.9	6.2
Flash Point [Closed-cup Method]	°C	206	262 #
Water	% vol	Nil	NA

NA - Not Available # - Based on Open-Cup Method

* Note the TAN level of fresh oil is not available as a Product Data Sheet (PDS) information. However, TAN = 0.3 is typical value, which has been measured at Petrosave Lab for several GEO samples, of authentic sources and correctly meeting other Mobil Pegasus 805 published oil parameters.

Comment

1. In spite of minor variations seen in the parameters reported above, it is safe to conclude that the fresh oil sample reasonably **FAILED TO MEET** the product formulation properties of Mobil Pegasus 805. **Not Ok to use.**

PetroSave Integrated Services Limited

Gas Engine Oil Analysis Report

Client Information

Company Name:	The Guardian Newspaper	Client Contacts:	Mr. George M. Oha
Company Address:	Rutam House Apapa-Oshodi Expressway Isolo, Oshodi Expwy Lagos	Department: Mobile Phone Nos.: Email Address: Equipment Operator/Driver:	Engineering 08033285823, 08025955859 <george.oha@ngrguardiannews.com>

Equipment Information

Equipment Type:	Gas Engine Generator (1,095 KW)	Component:	Engine
Equipment ID Ref.	Gen #1 [S/N: 1124559]	Make/Model:	GE-JENBACHER / J320 GS
Equipment Make:	GE-JENBACHER	Lube Oil in use:	Pegasus 805
Equipment Date:	2015	Oil Brand:	Mobil
Equipment Location:	Guardian Newspaper Compound, Isolo	Oil Weight:	SAE 40

	Fresh Oil 1-Aug-15	Condeming Limit	Used Oil Samples - Trend of Actual Laboratory Tests 27-Mar-17 8025/Guardian/GG1/1	Condition OK Caution Critical
Engine Operating Hours				
Oil Sample [Hrs]	0	-	286	
Cumm. Engine [Hrs]	-	-	10,462	
Lube Oil Properties				
Appearance [Clear, Turbid or Dark]	Clear		Dark	
Viscosity @ 40C [cSt]	126.8	+ 25%	86.8	
Viscosity @ 100C [cSt]	13.1	± +3	10.3	
TAN [mgKOH/g]	0.3	+ 2.5	1.8	
TBN [mgKOH/g]	6.2	3.1	5.3	
Soot [%]	0%	2%	0.0%	
Nitration [A/cm]	0	20	6.5	
Oxidation [A/cm]	0	20	2.0	
Water in Oil [%]	0.00%	0.20%	0.00%	
Glycol [%]	0.00%	0.02%	0.00%	
Elemental Analysis				
Wear Metals				
Aluminum, Al [ppm]	0	15	0	
Copper, Cu [ppm]	0	15	0	
Chromium, Cr [ppm]	0	5	0	
Lead, Pb [ppm]	0	20	0	
Iron, Fe [ppm]	0	20	2	
Tin, Sn [ppm]	0	5	0	
Contaminant Metals				
Silicon, Si [ppm]	0	20	0	
Sodium, Na [ppm]	0	20	5	
Potassium, K [ppm]	0	5	3	
Additive Metal				
Molybdenum [ppm]	0	10	7	

Diagnostics:

Low Oil Viscosity - causes include Wrong top-up with lighter oil, VI improver sheardown for multi-grades

Service Engineer's Comment:

All engine wear rates within Limits. Low Oil Viscosity coming from current stock of "questionable" Fresh Mobil Pegasus 805 drums. Immediate ***Lubrication Service*** *using genuine Mobil Pegasus 805 advised. Next oil sampling/analysis advised to monitor trend.*

Case Study 4

In another scenario, the Power Plant of leading cement manufacturing plant in Nigeria was saved from being short-changed in its efforts to replenish its warehouse stock of fresh Turbine grade oil.

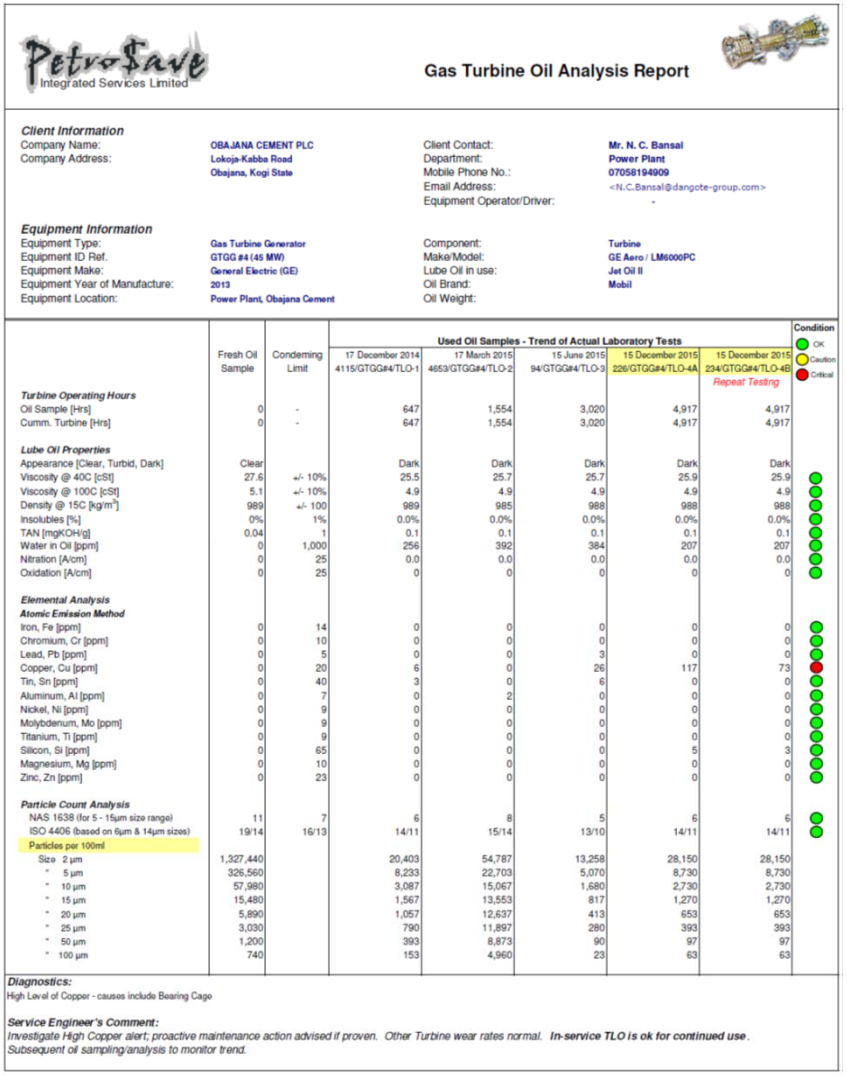
1. The entire cement plant is powered by four (4) aircraft adapted but land-based GE Gas Turbines, lubricated using synthetic aviation grade lubricant.
2. Not long after the lubrication service of one of the Gas Turbines GT4; High Copper was measured for that Turbine which was off trend going by previous results.
3. This situation triggered controversies between the Petrosave Oil Analysis Lab and Power Plant maintenance engineers which resulted to an agreement to investigate the fresh oil quality of the newly stock.
4. Lab analysis revealed that High Copper was from the newly supplied synthetic aviation lubricant.

High Copper created a false alarm for that recently serviced Gas Turbine. Also copper level was rapidly increasing for the other turbines from automated oil make-ups. High Copper, even for Gas Turbine signifies bearing wears, necessitating turbine unit shutdown for needed bearing replacement.

Unscheduled process shutdown for Mtce activity has the potential for remarkable costs in terms of operational downtime, aside from expensive repairs. Without fresh oil analysis, that would have been the case.

Case Study 4:

Copper trends in GT4 Oil Analysis Reports



Petro$ave Integrated Services Limited

Gas Turbine Oil Analysis Report

Client Information

Company Name:	OBAJANA CEMENT PLC	Client Contact:	Mr. N. C. Bansal
Company Address:	Lokoja-Kabba Road Obajana, Kogi State	Department:	Power Plant
		Mobile Phone No.:	07058194909
		Email Address:	<N.C.Bansal@dangote-group.com>
		Equipment Operator/Driver:	-

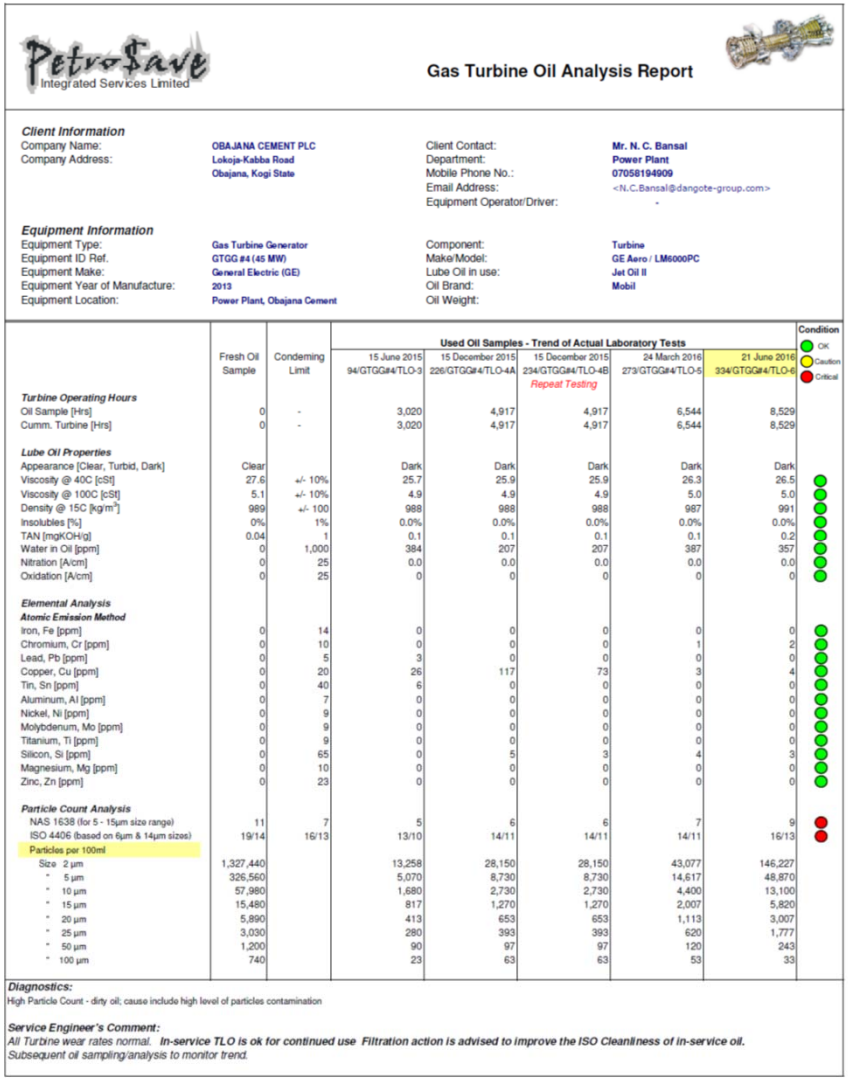
Equipment Information

Equipment Type:	Gas Turbine Generator	Component:	Turbine
Equipment ID Ref.	GTGG #4 (45 MW)	Make/Model:	GE Aero / LM6000PC
Equipment Make:	General Electric (GE)	Lube Oil in use:	Jet Oil II
Equipment Year of Manufacture:	2013	Oil Brand:	Mobil
Equipment Location:	Power Plant, Obajana Cement	Oil Weight:	

	Fresh Oil Sample	Condemning Limit	Used Oil Samples - Trend of Actual Laboratory Tests					Condition
			17 December 2014	17 March 2015	15 June 2015	15 December 2015	15 December 2015	OK / Caution / Critical
			4115/GTGG#4/TLO-1	4653/GTGG#4/TLO-2	94/GTGG#4/TLO-3	226/GTGG#4/TLO-4A	234/GTGG#4/TLO-4B	
							Repeat Testing	
Turbine Operating Hours								
Oil Sample [Hrs]	0	-	647	1,554	3,020	4,917	4,917	
Cumm. Turbine [Hrs]	0	-	647	1,554	3,020	4,917	4,917	
Lube Oil Properties								
Appearance [Clear, Turbid, Dark]	Clear		Dark	Dark	Dark	Dark	Dark	
Viscosity @ 40C [cSt]	27.6	+/- 10%	25.5	25.7	25.7	25.9	25.9	
Viscosity @ 100C [cSt]	5.1	+/- 10%	4.9	4.9	4.9	4.9	4.9	
Density @ 15C [kg/m^3]	989	+/- 100	989	985	988	988	988	
Insolubles [%]	0%	1%	0.0%	0.0%	0.0%	0.0%	0.0%	
TAN [mgKOH/g]	0.04	1	0.1	0.1	0.1	0.1	0.1	
Water in Oil [ppm]	0	1,000	256	392	384	207	207	
Nitration [A/cm]	0	25	0.0	0.0	0.0	0.0	0.0	
Oxidation [A/cm]	0	25	0	0	0	0	0	
Elemental Analysis								
Atomic Emission Method								
Iron, Fe [ppm]	0	14	0	0	0	0	0	
Chromium, Cr [ppm]	0	10	0	0	0	0	0	
Lead, Pb [ppm]	0	5	0	0	3	0	0	
Copper, Cu [ppm]	0	20	6	0	26	117	73	
Tin, Sn [ppm]	0	40	3	0	6	0	0	
Aluminum, Al [ppm]	0	7	0	2	0	0	0	
Nickel, Ni [ppm]	0	9	0	0	0	0	0	
Molybdenum, Mo [ppm]	0	9	0	0	0	0	0	
Titanium, Ti [ppm]	0	9	0	0	0	0	0	
Silicon, Si [ppm]	0	65	0	0	0	5	3	
Magnesium, Mg [ppm]	0	10	0	0	0	0	0	
Zinc, Zn [ppm]	0	23	0	0	0	0	0	
Particle Count Analysis								
NAS 1638 (for 5 - 15µm size range)	11	7	6	8	5	6	6	
ISO 4406 (based on 6µm & 14µm sizes)	19/14	16/13	14/11	15/14	13/10	14/11	14/11	
Particles per 100ml								
Size 2 µm	1,327,440		20,403	54,787	13,258	28,150	28,150	
" 5 µm	326,560		8,233	22,703	5,070	8,730	8,730	
" 10 µm	57,980		3,087	15,067	1,680	2,730	2,730	
" 15 µm	15,480		1,567	13,553	817	1,270	1,270	
" 20 µm	5,890		1,057	12,637	413	653	653	
" 25 µm	3,030		790	11,897	280	393	393	
" 50 µm	1,200		393	8,873	90	97	97	
" 100 µm	740		153	4,960	23	63	63	

Diagnostics:
High Level of Copper - causes include Bearing Cage

Service Engineer's Comment:
Investigate High Copper alert; proactive maintenance action advised if proven. Other Turbine wear rates normal. ***In-service TLO is ok for continued use.***
Subsequent oil sampling/analysis to monitor trend.



Petro$ave Integrated Services Limited

Gas Turbine Oil Analysis Report

Client Information

Company Name:	OBAJANA CEMENT PLC	Client Contact:	Mr. N. C. Bansal
Company Address:	Lokoja-Kabba Road Obajana, Kogi State	Department:	Power Plant
		Mobile Phone No.:	07058194909
		Email Address:	<N.C.Bansal@dangote-group.com>
		Equipment Operator/Driver:	-

Equipment Information

Equipment Type:	Gas Turbine Generator	Component:	Turbine
Equipment ID Ref.	GTGG #4 (45 MW)	Make/Model:	GE Aero / LM6000PC
Equipment Make:	General Electric (GE)	Lube Oil in use:	Jet Oil II
Equipment Year of Manufacture:	2013	Oil Brand:	Mobil
Equipment Location:	Power Plant, Obajana Cement	Oil Weight:	

	Fresh Oil Sample	Condemning Limit	Used Oil Samples - Trend of Actual Laboratory Tests					Condition
			15 June 2015	15 December 2015	15 December 2015	24 March 2016	21 June 2016	OK / Caution / Critical
			94/GTGG#4/TLO-3	226/GTGG#4/TLO-4A	234/GTGG#4/TLO-4B	273/GTGG#4/TLO-5	334/GTGG#4/TLO-6	
					Repeat Testing			
Turbine Operating Hours								
Oil Sample [Hrs]	0	-	3,020	4,917	4,917	6,544	8,529	
Cumm. Turbine [Hrs]	0	-	3,020	4,917	4,917	6,544	8,529	
Lube Oil Properties								
Appearance [Clear, Turbid, Dark]	Clear		Dark	Dark	Dark	Dark	Dark	
Viscosity @ 40C [cSt]	27.6	+/- 10%	25.7	25.9	25.9	26.3	26.5	
Viscosity @ 100C [cSt]	5.1	+/- 10%	4.9	4.9	4.9	5.0	5.0	
Density @ 15C [kg/m^3]	989	+/- 100	988	988	988	987	991	
Insolubles [%]	0%	1%	0.0%	0.0%	0.0%	0.0%	0.0%	
TAN [mgKOH/g]	0.04	1	0.1	0.1	0.1	0.1	0.2	
Water in Oil [ppm]	0	1,000	384	207	207	387	357	
Nitration [A/cm]	0	25	0.0	0.0	0.0	0.0	0.0	
Oxidation [A/cm]	0	25	0	0	0	0	0	
Elemental Analysis								
Atomic Emission Method								
Iron, Fe [ppm]	0	14	0	0	0	0	0	
Chromium, Cr [ppm]	0	10	0	0	0	1	2	
Lead, Pb [ppm]	0	5	3	0	0	0	0	
Copper, Cu [ppm]	0	20	26	117	73	3	4	
Tin, Sn [ppm]	0	40	6	0	0	0	0	
Aluminum, Al [ppm]	0	7	0	0	0	0	0	
Nickel, Ni [ppm]	0	9	0	0	0	0	0	
Molybdenum, Mo [ppm]	0	9	0	0	0	0	0	
Titanium, Ti [ppm]	0	9	0	0	0	0	0	
Silicon, Si [ppm]	0	65	0	5	3	4	3	
Magnesium, Mg [ppm]	0	10	0	0	0	0	0	
Zinc, Zn [ppm]	0	23	0	0	0	0	0	
Particle Count Analysis								
NAS 1638 (for 5 - 15µm size range)	11	7	5	6	6	7	9	
ISO 4406 (based on 6µm & 14µm sizes)	19/14	16/13	13/10	14/11	14/11	14/11	16/13	
Particles per 100ml								
Size 2 µm	1,327,440		13,258	28,150	28,150	43,077	146,227	
" 5 µm	326,560		5,070	8,730	8,730	14,617	48,870	
" 10 µm	57,980		1,680	2,730	2,730	4,400	13,100	
" 15 µm	15,480		817	1,270	1,270	2,007	5,820	
" 20 µm	5,890		413	653	653	1,113	3,007	
" 25 µm	3,030		280	393	393	620	1,777	
" 50 µm	1,200		90	97	97	120	243	
" 100 µm	740		23	63	63	53	33	

Diagnostics:
High Particle Count - dirty oil; cause include high level of particles contamination

Service Engineer's Comment:
All Turbine wear rates normal. ***In-service TLO is ok for continued use Filtration action is advised to improve the ISO Cleanliness of in-service oil.***
Subsequent oil sampling/analysis to monitor trend.

Implications – Discussion Notes

All of the above Case-studies demonstrate that even fresh oil testing can be strategic in preventing operational downtime and expensive repairs

1. **Case-Study 1**: Fresh oil analysis detected wrong lubricant application; **K$50** estimated as down time & repair costs avoided.
2. **Case-Studies 2 & 3**: Without Fresh oil analysis, it would have been both difficult and belated to know that unscrupulous oil vendors were compromising lube oil quality ; **K$200** is estimated combined savings in avoiding costly downtime & repairs.
3. **Case-Study 4:** elemental analysis of Fresh oil sample prevented False Alarm by detecting unusually high copper metal in the Fresh oil which was not coming from machine wears; no cost estimation was provided by client.

Thank You