

# Annual Turbine Oil Analysis Report

Erie Power

Lake Road Generating

03/07/2019



## Turbine Oil Condition

Lubricant Health	Critical
Contamination	Normal
Turbine Wear	Normal
Varnish Potential	Normal

Plant: Lake Road Generating  
 Address: 153 Highway 48 North  
 Strongsville, OH 44149  
 Contact: Jack Boilerman

Machine Name:	Unit 6C Steam Turbine		
Unit Id:	290T451		
Sample Date:	02/21/2019	Received Date:	02/27/2019
Report Date:	03/07/2019	Lab Number:	2469802
Analyst:	HMV	Sample Number:	56-1-13
Lube Type:	GST 32	Machine Type:	Steam Turbine
Machine Manuf.:	GENERAL ELECTRIC	Machine Model:	D11 Reheat Combined-Cycle

### Problems:

This sample failed the demulsibility test.

### Recommendation:

This sample failed the demulsibility test indicating that it does not readily separate from water, which is a critical function for steam turbine lubricants. Consider increasing sampling frequency in order to closely monitor water content.

## Test Data Summary Table

Date		<b>02/21/2019</b>	08/01/2018	07/25/2017	07/07/2016	01/26/2015	06/25/2014	05/22/2013
Lab No	Reference	<b>2469802</b>	2302249	2010748	1731230	1410285	1294740	994674
Hours		Unknown	Unknown	Unknown	Unknown	Unknown	0	0
Event		<b>N/A</b>	N/A	N/A	N/A	N/A	N/A	N/A

## SPECTROSCOPIC ANALYSIS (Reported in ppm) ASTM D5185 MOD

Wear Metals	Iron	<40	<b>0</b>	0	0	0	0	0
	Copper	<25	<b>0</b>	0	0	0	0	0
	Lead	<25	<b>0</b>	0	0	0	0	1
	Aluminum	<35	<b>0</b>	0	0	0	0	0
	Tin	<25	<b>1</b>	1	0	0	0	0
	Nickel	<15	<b>0</b>	0	0	0	0	0
	Chromium	<15	<b>0</b>	0	0	0	0	0
	Titanium	n/a	<b>0</b>	0	0	0	0	0
	Vanadium	n/a	<b>0</b>	0	0	0	0	0
	Silver	n/a	<b>0</b>	0	0	0	0	0
Additives	Calcium	0	<b>0</b>	0	0	0	0	0
	Magnesium	0	<b>0</b>	0	0	0	0	0
	Phosphorus	0	<b>2</b>	4	5	4	4	6
	Zinc	0	<b>0</b>	0	0	0	0	2
	Barium	0	<b>0</b>	0	0	0	0	0
	Molybdenum	0	<b>0</b>	0	0	0	0	0
Contam.	Silicon	<25	<b>0</b>	0	0	0	0	0
	Boron	<25	<b>0</b>	0	0	0	0	3
	Sodium	<25	<b>0</b>	0	0	0	0	0
	Potassium	<25	<b>0</b>	6	0	1	2	3

## PHYSICAL PROPERTIES

Viscosity @ 40C	32	<b>31.0</b>	31.1	31.3	31.1	31.2	30.9	30.7
Acid Number	<0.2	<b>0.01</b>	0.01	0.02	0.01	0.01	0.06	0.03

## FTIR TURBINE METHOD (Indexing Numbers) IWI-110

Thermal Event Acid	1	<b>6</b>	5	4	5	3	4	11
Acid Oxidation	14	<b>22</b>	20	22	25	21	21	19
Ester	20	<b>8</b>	8	9	11	10	10	9
Aromatic Additive	0	<b>0</b>	0	0	0	0	0	0
Base Oil Aromatic	0	<b>0</b>	0	0	0	0	0	0
Amine Antioxidants	58	<b>62</b>	60	62	60	56	58	64
Phenolic Antioxidants	63	<b>41</b>	37	42	40	40	41	40

## PARTICLE COUNT (Reported in particles per ml) ISO 4406.99

ISO CODE	18/16/14	<b>14/13/9</b>	14/13/9	15/13/9	16/14/10	15/13/9	15/13/9	15/14/10
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## CONTAMINATION

Water %	<0.05	<b>0.0015</b>	0.0026	0.0018	0.0002	0.0010	0.0020	0.0020
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## ADDITIONAL TESTS

Demulsibility	40-40-0 (30)	<b>4-20-56 (30)</b>	5-13-62 (30)	12-17-51 (30)	6-33-41 (30)	4-21-55 (30)	5-22-53 (30)	40-40-0 (20)
Color		<b>&lt;3.5</b>	<3.5	<3.5	<3.5	<3.5	<3.5	<3.0
Foam Test (Sec.)	<250 s	<b>410 / 0 / 240</b>	360 / 0 / 175	420 / 0 / 191	180 / 0 / 82	110 / 0 / 136	320 / 0 / 132	180 / 0 / 69
RPVOT (Mins.)	>200	<b>1294</b>	1174	1257	1006	1605	1140	1690
Rust	Pass	<b>PASS</b>	PASS	PASS	PASS	PASS	PASS	PASS

## VARNISH POTENTIAL ANALYSIS

Ultra Centrifuge	<3	<b>1</b>	1	1	1	1	1	2
MPC Value	< 23	<b>1</b>	1	2	4	1	2	14
Ruler Amine %	N/A	<b>N/A</b>	N/A	N/A	N/A	N/A	N/A	N/A
Ruler Phenolic %	100%	<b>55</b>	60	69	64	57	53	69
Ruler ZDDP %	N/A	<b>N/A</b>	N/A	N/A	N/A	N/A	N/A	N/A

**Discussion of test results:****Spectroscopic Analysis by ASTM D5185 MOD**

SPECTROSCOPIC ANALYSIS (Reported in ppm) ASTM D5185 MOD								
Date		02/21/2019	08/01/2018	07/25/2017	07/07/2016	01/26/2015	06/25/2014	05/22/2013
Lab No	Reference	2469802	2302249	2010748	1731230	1410285	1294740	994674
Wear Metals	Iron	<40	0	0	0	0	0	0
	Copper	<25	0	0	0	0	0	0
	Lead	<25	0	0	0	0	0	1
	Aluminum	<35	0	0	0	0	0	0
	Tin	<25	1	1	0	0	0	0
	Nickel	<15	0	0	0	0	0	0
	Chromium	<15	0	0	0	0	0	0
	Titanium	n/a	0	0	0	0	0	0
	Vanadium	n/a	0	0	0	0	0	0
	Silver	n/a	0	0	0	0	0	0
Additives	Calcium	0	0	0	0	0	0	0
	Magnesium	0	0	0	0	0	0	0
	Phosphorus	0	2	4	5	4	4	6
	Zinc	0	0	0	0	0	0	2
	Barium	0	0	0	0	0	0	0
	Molybdenum	0	0	0	0	0	0	0
Contam.	Silicon	<25	0	0	0	0	0	0
	Boron	<25	0	0	0	0	0	3
	Sodium	<25	0	0	0	0	0	0
	Potassium	<25	0	6	0	1	2	3

Spectroscopic analysis quantifies the presence of metals in parts per million (ppm). The reported elements may be associated with machine wear, contamination or oil additives.

*Wear Metals - All wear metal levels are low and do not indicate any abnormal wear modes.*

*Additives - The levels of additive metals in this sample are consistent with the oil type listed.*

*Contaminants - No significant levels of contaminant metals were found.*

**Demulsibility by ASTM D1401**

ADDITIONAL TESTS								
Date		02/21/2019	08/01/2018	07/25/2017	07/07/2016	01/26/2015	06/25/2014	05/22/2013
Lab No	Reference	2469802	2302249	2010748	1731230	1410285	1294740	994674
Demulsibility	40-40-0 (30)	4-20-56 (30)	5-13-62 (30)	12-17-51 (30)	6-33-41 (30)	4-21-55 (30)	5-22-53 (30)	40-40-0 (20)

Demulsibility tests the oil's ability to separate from water. A turbine oil should fully separate from water in 30 minutes, with a passing result defined as less than 3 ml of emulsion after 30 minutes.

*This sample failed demulsibility with 56 ml of emulsion remaining after 30 minutes. This is a failing result and indicates that this lubricant does not readily separate from water.*

**Acid Number by ASTM D974 MOD**

PHYSICAL PROPERTIES								
Date		02/21/2019	08/01/2018	07/25/2017	07/07/2016	01/26/2015	06/25/2014	05/22/2013
Lab No	Reference	2469802	2302249	2010748	1731230	1410285	1294740	994674
Acid Number	<0.2	0.01	0.01	0.02	0.01	0.01	0.06	0.03

Acid Number (AN) is an indicator of oil health. As the oil oxidizes, acidic byproducts are generated within the oil. As the oil's ability to resist oxidation drops, more of these byproducts are generated causing the AN to increase. A sharp increase in acid number can indicate that the oil is approaching the end of its useful life.

*The acid number for this sample was 0.01 which is considered an acceptable result for this lubricant.*

**Viscosity by ASTM D445 MOD**

PHYSICAL PROPERTIES								
Date		02/21/2019	08/01/2018	07/25/2017	07/07/2016	01/26/2015	06/25/2014	05/22/2013
Lab No	Reference	2469802	2302249	2010748	1731230	1410285	1294740	994674
Viscosity @ 40C	32	31.0	31.1	31.3	31.1	31.2	30.9	30.7

Viscosity is a measure of lubricant's resistance to flow. Changes in viscosity indicate improper servicing, dilution, contamination or lubricant breakdown in service. Test results are reported in centistokes (cSt) at 40 C.

*The viscosity result is acceptable for the fluid in use.*

## FTIR Spectroscopy by Turbine Method IWI-110

ADDITIONAL TESTS								
Date		02/21/2019	08/01/2018	07/25/2017	07/07/2016	01/26/2015	06/25/2014	05/22/2013
Lab No	Reference	2469802	2302249	2010748	1731230	1410285	1294740	994674
Thermal Event Acid	1	6	5	4	5	3	4	11
Acid Oxidation	14	22	20	22	25	21	21	19
Ester	20	8	8	9	11	10	10	9
Aromatic Additive	0	0	0	0	0	0	0	0
Base Oil Aromatic	0	0	0	0	0	0	0	0
Amine Antioxidants	58	62	60	62	60	56	58	64
Phenolic Antioxidants	63	41	37	42	40	40	41	40

FTIR covers the monitoring of base stock degradation, oxidation and additive depletion in machine lubricants, hydraulic fluids, and other fluid types. This test is based on trending of different parameters in various oils and fluids.

*FTIR results show a good correlation to new oil data and do not suggest significant fluid degradation.*

## Particle Count by ISO 4406

ADDITIONAL TESTS								
Date		02/21/2019	08/01/2018	07/25/2017	07/07/2016	01/26/2015	06/25/2014	05/22/2013
Lab No	Reference	2469802	2302249	2010748	1731230	1410285	1294740	994674
ISO CODE	18/16/14	14/13/9	14/13/9	15/13/9	16/14/10	15/13/9	15/13/9	15/14/10
>4 Micron	2500	122	131	181	358	165	192	310
>6 Micron	640	47	51	70	139	64	75	120
>14 Micron	160	3	3	5	10	4	5	9
>50 Micron	0	0	0	0	0	0	0	0
>100 Micron	0	0	0	0	0	0	0	0

Using the fluid flow decay principle, oil is passed through a calibrated screen and particles are classified according to their size in microns. The raw data is then converted to an ISO code using ISO 4406.

*Particle count data for this sample indicates a very low level of particulate contamination and is below the alarm of 18/16/14.*

**Color by ASTM D1500**

ADDITIONAL TESTS								
Date		02/21/2019	08/01/2018	07/25/2017	07/07/2016	01/26/2015	06/25/2014	05/22/2013
Lab No	Reference	2469802	2302249	2010748	1731230	1410285	1294740	994674
Color		<3.5	<3.5	<3.5	<3.5	<3.5	<3.5	<3.0

Color analysis is a simple quantification of the oil's appearance. There are no pass or fail specifications. The results are used as a comparison to new oil or trend data.

**Foam Test by ASTM D892**

ADDITIONAL TESTS								
Date		02/21/2019	08/01/2018	07/25/2017	07/07/2016	01/26/2015	06/25/2014	05/22/2013
Lab No	Reference	2469802	2302249	2010748	1731230	1410285	1294740	994674
Foam Test (Sec.)	<250 s	410 / 0 / 240	360 / 0 / 175	420 / 0 / 191	180 / 0 / 82	110 / 0 / 136	320 / 0 / 132	180 / 0 / 69

Foaming tendency is a measurement of the relative resistance to foaming exhibited by the oil. Air introduced into the oil sample should generate no more than 450 ml of foam after 5 minutes, and the foam should dissipate after a 10 minute settling period and ideally less than 250 seconds.

*This sample generated 410 ml of foam which fully dissipated in 240 seconds. This is considered an acceptable result.*

**Rotating Pressure Vessel Oxidation Test by ASTM D2272**

ADDITIONAL TESTS								
Date		02/21/2019	08/01/2018	07/25/2017	07/07/2016	01/26/2015	06/25/2014	05/22/2013
Lab No	Reference	2469802	2302249	2010748	1731230	1410285	1294740	994674
RPVOT (Mins.)	>200	1294	1174	1257	1006	1605	1140	1690

The RPVOT test accelerates the oxidation process in order to evaluate the oil's remaining ability to resist oxidation, with the result expressed in minutes. Generally, an oil's condemning limit is 25% of new oil value, with an absolute lower limit of 200 minutes.

*The RPVOT result for this sample was 1294 minutes, indicating a healthy antioxidant additive package.*

**Rust Test by ASTM D665 A**

ADDITIONAL TESTS								
Date		02/21/2019	08/01/2018	07/25/2017	07/07/2016	01/26/2015	06/25/2014	05/22/2013
Lab No	Reference	2469802	2302249	2010748	1731230	1410285	1294740	994674
Rust	Pass	PASS	PASS	PASS	PASS	PASS	PASS	PASS

The rust test is an indication of the rust preventing characteristics of inhibited mineral oil in the presence of distilled water. A portion of the sampled oil is mixed with water. A steel test rod is placed in the mixture and is agitated by stirring. The test duration is 4 hours after which the steel rod is inspected for the presence of rust. A passing result is the absence of rust on the steel rod.

*This sample received a result of Pass - Clean indicating excellent rust preventing characteristics.*

**Water by Karl Fisher by ASTM D6304**

CONTAMINATION								
Date		02/21/2019	08/01/2018	07/25/2017	07/07/2016	01/26/2015	06/25/2014	05/22/2013
Lab No	Reference	2469802	2302249	2010748	1731230	1410285	1294740	994674
Water %	<0.05	0.0015	0.0026	0.0018	0.0002	0.0010	0.0020	0.0020

Karl Fischer titration is a direct measurement of water in a lubricating oil. Water is considered to be the most destructive of contaminants causing accelerated oil degradation and corrosion to system components. Also, excessive water in large static reservoirs can lead to microbial growth. The presence of water can severely alter the load carrying capacity of a lubricant.

*The water result for this sample was: 0.0015% (15 ppm). This is considered an acceptable result.*



**Ultra Centrifuge Test**

VARNISH POTENTIAL ANALYSIS								
Date		02/21/2019	08/01/2018	07/25/2017	07/07/2016	01/26/2015	06/25/2014	05/22/2013
Lab No	Reference	2469802	2302249	2010748	1731230	1410285	1294740	994674
Ultra Centrifuge	<3	1	1	1	1	1	1	2

A small amount of oil in a test tube is run for 30 minutes at 17,000 RPM in an ultra centrifuge. By subjecting the sample to significant G-forces, we are able to extract insoluble contaminants that are much too small to be detected by normal particle counting. The amount of the agglomerated material is compared to a rating scale to derive the UC Value (1-8). When the UC Value exceeds 2, a marginal condition is noted. A UC value exceeding 5 is considered to be a critical result.

*This sample received an Ultra Centrifuge rating of 1 indicating an acceptable result.*

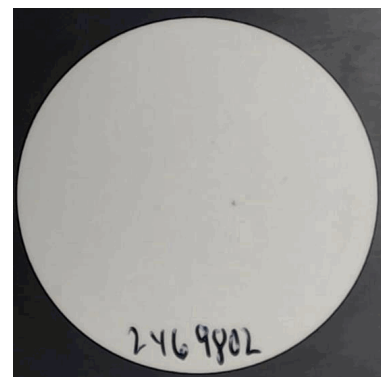


**Membrane Patch Colorimetry**

VARNISH POTENTIAL ANALYSIS								
Date		02/21/2019	08/01/2018	07/25/2017	07/07/2016	01/26/2015	06/25/2014	05/22/2013
Lab No	Reference	2469802	2302249	2010748	1731230	1410285	1294740	994674
MPC Value	< 23	1	1	2	4	1	2	14
L Value		-0.2	0.6	-0.5	-2.0	-1.0	-1.0	-7.0
a Value		-0.1	-0.1	-0.2	0.0	0.0	0.0	0.0
b Value		0.4	-0.2	1.9	3.0	1.0	1.0	12.0

The process of making a patch isolates and agglomerates insoluble by-products associated with varnish. The color of the membrane patch provides a guideline as to the extent of varnish potential. Generally a value over 23 is considered abnormal.

*This sample received a color result of 1. This is below the alarm limit of 23 and is considered to be an acceptable result.*



**RULER**

VARNISH POTENTIAL ANALYSIS									
Date		02/21/2019	08/01/2018	07/25/2017	07/07/2016	01/26/2015	06/25/2014	05/22/2013	
Lab No	New Oil	2469802	2302249	2010748	1731230	1410285	1294740	994674	
Amine	Peak Area	N/A	N/A	N/A					
	Percent Remaining	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Phenolic	Peak Area	8994	5006	5479					
	Percent Remaining	100%	55	60	69	64	57	53	69
ZDDP	Peak Area	N/A	N/A	N/A					
	Percent Remaining	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A

The RULER accurately measures the remaining active antioxidants in the lubricant. Antioxidants are the most important additive components in many lubricants including turbine, hydraulic, compressor and aerospace fluids. The RULER number represents the concentration of the antioxidants monitored relative to a new oil.

*RULER data shows the level of remaining phenolic antioxidants to be 55% of the level present in new oil. This is considered an acceptable result.*

