

# **WEIDMANN**

## **TRANSFORMER/RECTIFIER FLEET CONDITION ASSESSMENT**

for

**NWL Transformers**

**January 4, 2010**

**Written by:**

**Norman Field  
Senior Engineer  
Weidmann Diagnostic Solutions**

## **EXECUTIVE SUMMARY**

A Transformer/Rectifier Fleet Condition Assessment was performed for a fleet of 64 Electrostatic Precipitator (ESP) Transformer/Rectifiers (T/Rs), operated by [REDACTED]. This project evaluated the selected fleet of transformer/rectifiers in terms of their condition as interpreted from studying their insulating oil test results.

All 64 T/Rs belonged to "Unit 4" ESPs at the [REDACTED]. Specifically, there are eight ESPs (namely 4A1, 4A2, 4A3, 4A4, 4B1, 4B2, 4B3, and 4B4) each being supplied power from eight T/Rs (designated A through H), totalling sixty-four T/Rs. The transformer/rectifier condition assessment included a review of dissolved gas-in-oil analyses and general oil quality tests, from two points in time. One set of test results were from oil samples taken on 11/6/2009 and tested by the Weidmann Diagnostic Solutions lab in Bensalem, PA. A second set of test results were from 9/13/2007 and tested by the [REDACTED] oil lab at the [REDACTED]. Using this information, an "Electrostatic Precipitator Transformer/Rectifier Oil Analysis and Diagnostic Evaluation" report was created for each T/R (copies provided herein). Each report provided diagnostic statements regarding the condition of the T/R, and summarized this condition by producing a condition code of either "Normal," "Caution," or "Warning." A summary of the condition codes for each T/R, sorted by severity, is provided herein.

It is important to note that the Diagnostic Evaluation of each T/R took into account not only the results of the most recent oil tests for the samples taken on 11/6/2009, but also the results of the older oil tests for the samples taken on 9/13/2007. This was accomplished by using the dissolved gas-in-oil analysis results from both dates to calculate a rate of change (in parts-per-million per month) for each of the combustible gasses. While knowing the actual gas concentrations in the oil at a given point in time is informative, it is the rate of change of these gas concentrations over time that allow interpretation to be made as to whether there is an active problem inside the T/R or not.

**SUMMARY OF RESULTS**

The following pages of this section show two tables. The first is a listing of all 64 T/Rs sorted by their designation code (for example, "4A1A") and shows the corresponding Condition Code and comments about the condition. The second table is the same list but sorted by Condition Code and then by severity of gassing, for ease of identification of the T/Rs with poorest condition.

SAMPLE

**Table 1: T/Rs sorted by Designation Code**

T/R	Condition Code	Comments
4A1A	Normal	Resample oil in 6 months.
4A1B	Caution	Resample oil in 3 months. High gas concentration.
4A1C	Caution	Resample oil in 3 months. High gas concentration.
4A1D	Normal	Resample oil in 6 months.
4A1E	Normal	Resample oil in 6 months.
4A1F	Normal	Resample oil in 6 months.
4A1G	Warning	Consider internal inspection. Resample oil in 1 month. Very high gas concentration. Abnormal gas increase. Indication of overheating.
4A1H	Normal	Resample oil in 6 months.
4A2A	Normal	Resample oil in 6 months.
4A2B	Normal	Resample oil in 6 months.
4A2C	Normal	Resample oil in 6 months.
4A2D	Normal	Resample oil in 6 months.
4A2E	Normal	Resample oil in 6 months.
4A2F	Caution	Resample oil in 3 months. Very high gas concentration. Indication of overheating.
4A2G	Caution	Resample oil in 3 months. High gas concentration. Indication of overheating.
4A2H	Caution	Resample oil in 3 months. High gas concentration.
4A3A	Normal	Resample oil in 6 months.
4A3B	Caution	Resample oil in 3 months. Very high gas concentration. Indication of overheating.
4A3C	Caution	Resample oil in 3 months. High gas concentration. Indication of overheating. Dielectric breakdown strength low.
4A3D	Caution	Resample oil in 3 months. High gas concentration. Indication of overheating.
4A3E	Caution	Resample oil in 3 months. Moisture very excessive. Dielectric breakdown strength very low.
4A3F	Caution	Resample oil in 3 months. Very high gas concentration. Indication of overheating. Moisture excessive.
4A3G	Normal	Resample oil in 6 months.
4A3H	Warning	Consider internal inspection. Resample oil in 1 month. Very high gas concentration. Abnormal gas increase. Moisture very excessive. Interfacial tension low. Dielectric breakdown strength low. Acid high.
4A4A	Caution	Resample oil in 3 months. High gas concentration. Indication of overheating.
4A4B	Normal	Resample oil in 6 months.

Transformer/Rectifier Fleet Condition Assessment

T/R	Condition Code	Comments
4A4C	Caution	Resample oil in 3 months. Moisture very excessive. Dielectric breakdown strength low.
4A4D	Normal	Resample oil in 6 months.
4A4E	Normal	Resample oil in 6 months.
4A4F	Caution	Resample oil in 3 months. Moisture very excessive.
4A4G	Normal	Resample oil in 6 months.
4A4H	Caution	Resample oil in 3 months. Moisture very excessive. Interfacial tension low.
4B1A	Normal	Resample oil in 6 months.
4B1B	Normal	Resample oil in 6 months.
4B1C	Normal	Resample oil in 6 months.
4B1D	Normal	Resample oil in 6 months.
4B1E	Caution	Resample oil in 3 months. Interfacial tension very low.
4B1F	Warning	Consider internal inspection. Resample oil in 1 month. Very high gas concentration. High gas increase.
4B1G	Normal	Resample oil in 6 months.
4B1H	Caution	Resample oil in 3 months. High gas concentration.
4B2A	Normal	Resample oil in 6 months.
4B2B	Normal	Resample oil in 6 months.
4B2C	Caution	Resample oil in 3 months. High gas concentration. Indication of overheating.
4B2D	Normal	Resample oil in 6 months.
4B2E	Caution	Resample oil in 3 months. High gas concentration. Indication of overheating.
4B2F	Caution	Resample oil in 3 months. High gas concentration. Indication of overheating.
4B2G	Caution	Resample oil in 3 months. Very high gas concentration.
4B2H	Caution	Resample oil in 3 months. High gas concentration.
4B3A	Normal	Resample oil in 6 months.
4B3B	Normal	Resample oil in 6 months.
4B3C	Caution	Resample oil in 3 months. High gas concentration. Indication of overheating.
4B3D	Warning	Consider internal inspection. Resample oil in 1 month. Very high gas concentration. Abnormal gas increase. Strong indication of overheating.
4B3E	Caution	Resample oil in 3 months. High gas concentration. Moisture very excessive.
4B3F	Caution	Resample oil in 3 months. High gas concentration. Indication of overheating.
4B3G	Caution	Resample oil in 3 months. High gas concentration. Indication of overheating.
4B3H	Normal	Resample oil in 6 months.
4B4A	Caution	Resample oil in 3 months. High gas concentration. Indication of overheating.

## Transformer/Rectifier Fleet Condition Assessment

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<b>T/R</b>	<b>Condition Code</b>	<b>Comments</b>
4B4B	Normal	Resample oil in 6 months.
4B4C	Normal	Resample oil in 6 months.
4B4D	Normal	Resample oil in 6 months.
4B4E	Caution	Resample oil in 3 months. Very high gas concentration. Indication of overheating.
4B4F	Caution	Resample oil in 3 months. High gas concentration. Indication of overheating. Moisture excessive.
4B4G	Caution	Resample oil in 3 months. Moisture very excessive. Dielectric breakdown strength low.
4B4H	Caution	Resample oil in 3 months. High gas concentration. Indication of overheating. Moisture very excessive. Dielectric breakdown strength low.

SAMPLE

**Table 2: T/Rs sorted by Condition Code and Severity of Gassing**

T/R	Condition Code	Comments
4B1F	Warning	Consider internal inspection. Resample oil in 1 month. Possible internal arcing activity. Very high gas concentration. High gas increase.
4A3H	Warning	Consider internal inspection. Resample oil in 1 month. Possible arcing activity. Very high gas concentration. Abnormal gas increase. Moisture very excessive. Interfacial tension low. Dielectric breakdown strength low. Acid high.
4A1G	Warning	Consider internal inspection. Resample oil in 1 month. Possible arcing activity. Very high gas concentration. Abnormal gas increase. Indication of overheating.
4B3D	Warning	Consider internal inspection. Resample oil in 1 month. Very high gas concentration. Abnormal gas increase. Strong indication of overheating.
4B2G	Caution	Resample oil in 3 months. Very high gas concentration.
4A3F	Caution	Resample oil in 3 months. Very high gas concentration. Indication of overheating. Moisture excessive.
4A3B	Caution	Resample oil in 3 months. Very high gas concentration. Indication of overheating.
4A2F	Caution	Resample oil in 3 months. Very high gas concentration. Indication of overheating.
4B4E	Caution	Resample oil in 3 months. Very high gas concentration. Indication of overheating.
4B3F	Caution	Resample oil in 3 months. High gas concentration. Indication of overheating.
4B2E	Caution	Resample oil in 3 months. High gas concentration. Indication of overheating.
4B4A	Caution	Resample oil in 3 months. High gas concentration. Indication of overheating.
4B2F	Caution	Resample oil in 3 months. High gas concentration. Indication of overheating.
4B2C	Caution	Resample oil in 3 months. High gas concentration. Indication of overheating.
4A3C	Caution	Resample oil in 3 months. High gas concentration. Indication of overheating. Dielectric breakdown strength low.
4A3D	Caution	Resample oil in 3 months. High gas concentration. Indication of overheating.
4A4A	Caution	Resample oil in 3 months. High gas concentration. Indication of overheating.

## Transformer/Rectifier Fleet Condition Assessment

T/R	Condition Code	Comments
4B3G	Caution	Resample oil in 3 months. High gas concentration. Indication of overheating.
4B3C	Caution	Resample oil in 3 months. High gas concentration. Indication of overheating.
4B4H	Caution	Resample oil in 3 months. High gas concentration. Indication of overheating. Moisture very excessive. Dielectric breakdown strength low.
4A2G	Caution	Resample oil in 3 months. High gas concentration. Indication of overheating.
4A1C	Caution	Resample oil in 3 months. High gas concentration.
4B3E	Caution	Resample oil in 3 months. High gas concentration. Moisture very excessive.
4B2H	Caution	Resample oil in 3 months. High gas concentration.
4B1H	Caution	Resample oil in 3 months. High gas concentration.
4A1B	Caution	Resample oil in 3 months. High gas concentration.
4B4F	Caution	Resample oil in 3 months. High gas concentration. Indication of overheating. Moisture excessive.
4A4C	Caution	Resample oil in 3 months. Moisture very excessive. Dielectric breakdown strength low.
4A3E	Caution	Resample oil in 3 months. Moisture very excessive. Dielectric breakdown strength very low.
4B1E	Caution	Resample oil in 3 months. Interfacial tension very low.
4A4F	Caution	Resample oil in 3 months. Moisture very excessive.
4A4H	Caution	Resample oil in 3 months. Moisture very excessive. Interfacial tension low.
4B4G	Caution	Resample oil in 3 months. Moisture very excessive. Dielectric breakdown strength low.
4A2H	Caution	Resample oil in 3 months. High gas concentration.
4B1C	Normal	Resample oil in 6 months.
4B3H	Normal	Resample oil in 6 months.
4A1E	Normal	Resample oil in 6 months.
4A2B	Normal	Resample oil in 6 months.
4A2E	Normal	Resample oil in 6 months.
4A2A	Normal	Resample oil in 6 months.
4A3G	Normal	Resample oil in 6 months.
4A1A	Normal	Resample oil in 6 months.
4B4D	Normal	Resample oil in 6 months.
4A3A	Normal	Resample oil in 6 months.
4B4B	Normal	Resample oil in 6 months.
4A4B	Normal	Resample oil in 6 months.
4B3A	Normal	Resample oil in 6 months.
4A2D	Normal	Resample oil in 6 months.
4B2D	Normal	Resample oil in 6 months.
4B1B	Normal	Resample oil in 6 months.

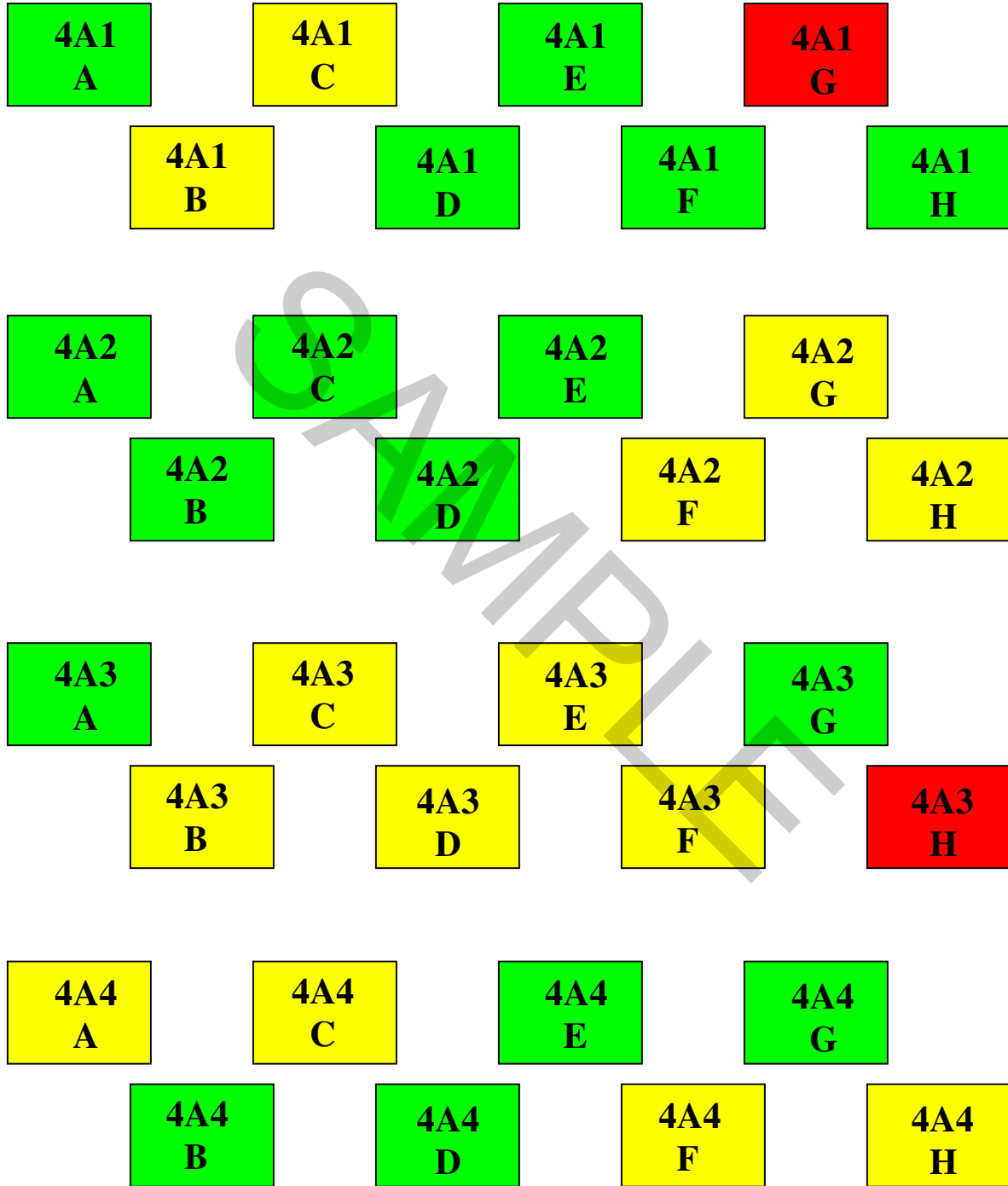
## Transformer/Rectifier Fleet Condition Assessment

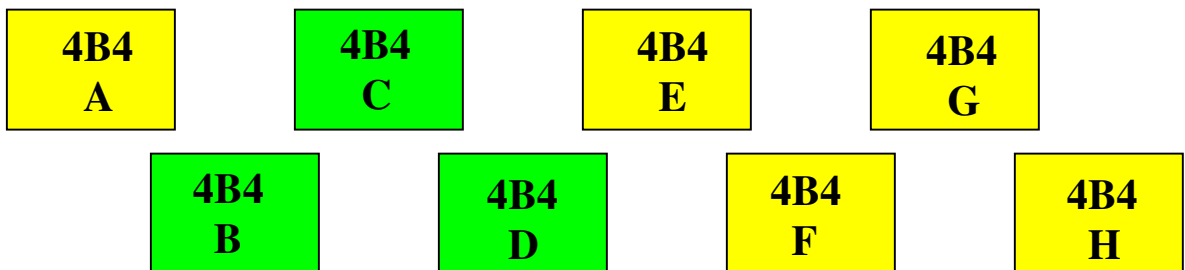
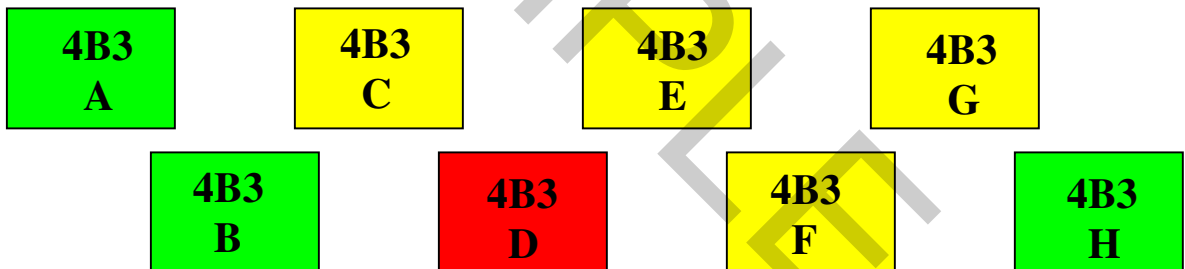
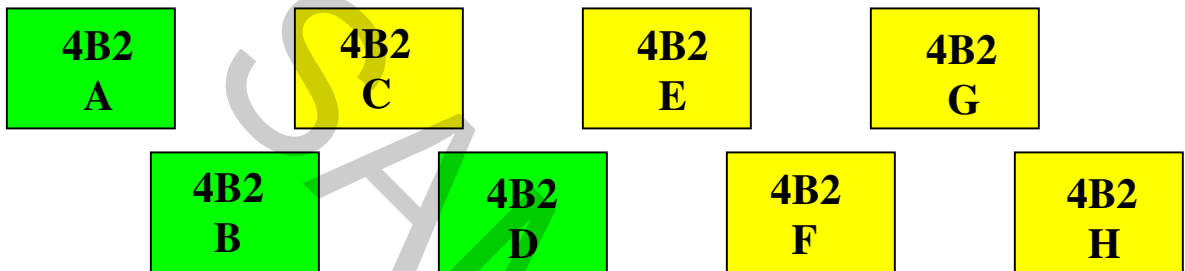
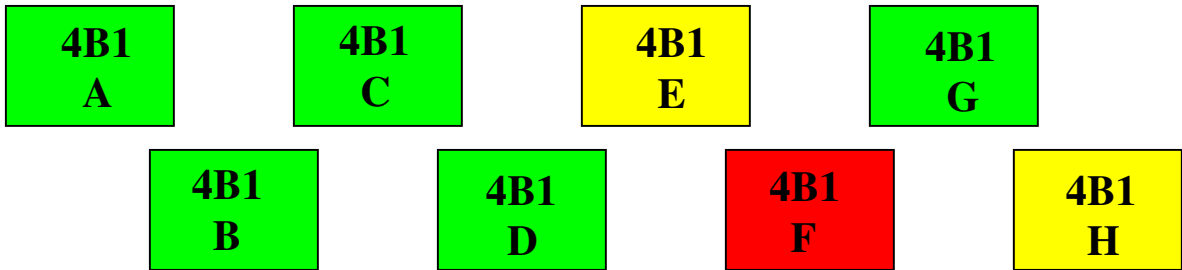
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<b>T/R</b>	<b>Condition Code</b>	<b>Comments</b>
4B4C	Normal	Resample oil in 6 months.
4A1F	Normal	Resample oil in 6 months.
4A1H	Normal	Resample oil in 6 months.
4B2A	Normal	Resample oil in 6 months.
4B2B	Normal	Resample oil in 6 months.
4A1D	Normal	Resample oil in 6 months.
4B1A	Normal	Resample oil in 6 months.
4A4E	Normal	Resample oil in 6 months.
4B1D	Normal	Resample oil in 6 months.
4B1G	Normal	Resample oil in 6 months.
4A2C	Normal	Resample oil in 6 months.
4A4D	Normal	Resample oil in 6 months.
4A4G	Normal	Resample oil in 6 months.
4B3B	Normal	Resample oil in 6 months.

SAMPLE

A pictorial representation of the Condition Codes for each T/R, grouped by their corresponding precipitator, follows. A red color represents a “Warning” condition code, yellow a “Caution” condition code, and green a “Normal” condition code.





### **CONCLUSIONS**

Out of the sixty-four T/Rs, four had a Condition Code of “Warning” as of 11/6/2009. These four T/Rs were given this condition assessment due to their severity of gas concentrations and active gassing rates. It is highly recommended to immediately resample the oil from these T/Rs for updated DGA and GOQ testing. Internal inspection of these T/Rs should also be seriously considered.

Another thirty T/Rs received a Condition Code of “Caution.” While these T/Rs did not have sufficiently high gassing rates to be classified as “Warning,” they did have higher than normal gas concentrations in most cases. In a few cases, the T/Rs were given a “Caution” designation due to their poor GOQ test results, and not as a result of the DGA figures. It is recommended that the oil from these thirty T/Rs is resampled within three months from the previous sampling for updated DGA and GOQ testing.

A final thirty T/Rs received a Condition Code of “Normal.” These T/Rs did not have high gassing rates nor did they have higher than normal gas concentrations, nor oil quality problems. It is recommended that the oil from these thirty T/Rs is resampled within six months from the previous sampling for updated DGA and GOQ testing.

**ELECTROSTATIC PRECIPITATOR TRANSFORMER/RECTIFIER Oil Analysis & Diagnostic Evaluation**

NWL Transformers  
312 Rising Sun Road  
Bordentown, NJ 08505

Location: [REDACTED]  
Serial No.: 4A1A  
Bank / Phase: -  
LTC Compartment: Transformer/Rectifier  
Breathing Type: Sealed  
Fluid: Mineral Oil  
Gallons: -

Mfr.: General Electric  
Year: -

Account No.: 444  
Customer ID: -  
Order No.: 321245  
Control No.: 6086332  
Date Received: 11/9/2009  
Date Reported: 12/14/2009

ATTN: Joe Koszyk  
PO No.: FS090073

Sample Container ID: 53002216  
Project ID: -

ASTM D-3612	Lab Control Number:	6086332	07-4657
	Date Sampled:	11/6/2009	9/13/2007
	WDS Report Number:	321245	GE Report
	Oil Temp. (C):	-	-
	Hydrogen (H2) (ppm):	0	10
	Methane (CH4) (ppm):	1	5
	Ethane (C2H6) (ppm):	0	5
	Ethylene (C2H4) (ppm):	35	65
	Acetylene (C2H2) (ppm):	0	0
	Carbon Monoxide (CO) (ppm):	59	170
	Carbon Dioxide (CO2) (ppm):	1260	2100
	Nitrogen (N2) (ppm):	52710	59000
	Oxygen (O2) (ppm):	25484	30000
	Total Dissolved Gas (ppm):	79549	-
	Total Dissolved Combustible Gas (ppm):	95	235
Equivalent Headspace TCG (%):	0.07	-	
ASTM D-1533B	Moisture In Oil (ppm):	15	44
ASTM D-971	Interfacial Tension (dynes/cm):	29.7	27.4
ASTM D-974	Acid Number (mg KOH/g):	0.079	0.08
ASTM D-1500	Color Number (Relative):	1.5	-
ASTM D-1524	Visual Exam (Relative):	CLR&SPRK	-
ASTM D-1524	Sediment Exam (Relative):	ND	-
ASTM D-1816	Dielectric Breakdown at 1mm (kV):	38	-
Condition Code as of 11/06/2009:		Normal	
Recommended Action:		Resample oil within 6 months.	
Rate of Change Analysis:		All relevant gas concentrations are stable.	
Dissolved-Gas Concentration Analysis:		All gasses within normal limits.	
Dissolved-Gas Ratio Analysis:		Ratio calculations not necessary.	
Physical Evaluation:		Moisture content acceptable. IFT acceptable. Dielectric Breakdown Strength acceptable. Oil clear and sparkling.	

The analyses, opinions or interpretations contained in this report are based upon material and information supplied by the client. Weidmann Diagnostic Solutions does not imply that the contents of the sample received by this laboratory are the same as all such material in the environment from which the sample was taken. Our test results relate only to the sample or samples tested. Any interpretations or opinions expressed represent the best judgement of Weidmann Diagnostic Solutions. Weidmann Diagnostic Solutions assumes no responsibility and makes no warranty or representation, expressed or implied, as to the condition, productivity or proper operation of any equipment or other property for which this report may be used or relied upon for any reason whatsoever.

**ELECTROSTATIC PRECIPITATOR TRANSFORMER/RECTIFIER Oil Analysis & Diagnostic Evaluation**

NWL Transformers  
312 Rising Sun Road  
Bordentown, NJ 08505

Location: XXXXXXXXXX  
Serial No.: 4A1B  
Bank / Phase: -  
LTC Compartment: Transformer/Rectifier  
Breathing Type: Sealed  
Fluid: Mineral Oil  
Gallons: -

Mfr.: General Electric  
Year: -

Account No.: 444  
Customer ID: -  
Order No.: 321245  
Control No.: 6086308  
Date Received: 11/9/2009  
Date Reported: 12/14/2009

ATTN: Joe Koszyk  
PO No.: FS090073

Sample Container ID: 53002588  
Project ID: -

ASTM D-3612	Lab Control Number:	6086308	07-4658
	Date Sampled:	11/6/2009	9/13/2007
	WDS Report Number:	321245	GE Report
	Oil Temp. (C):	-	-
	Hydrogen (H2) (ppm):	3	10
	Methane (CH4) (ppm):	3	5
	Ethane (C2H6) (ppm):	0	5
	Ethylene (C2H4) (ppm):	76	37
	Acetylene (C2H2) (ppm):	0	0
	Carbon Monoxide (CO) (ppm):	200	120
	Carbon Dioxide (CO2) (ppm):	2457	1900
	Nitrogen (N2) (ppm):	53839	56000
	Oxygen (O2) (ppm):	17536	31000
	Total Dissolved Gas (ppm):	74114	-
	Total Dissolved Combustible Gas (ppm):	282	157
Equivalent Headspace TCG (%):	0.24	-	
ASTM D-1533B	Moisture In Oil (ppm):	19	46
ASTM D-971	Interfacial Tension (dynes/cm):	29.8	27.4
ASTM D-974	Acid Number (mg KOH/g):	0.077	0.08
ASTM D-1500	Color Number (Relative):	2.0	-
ASTM D-1524	Visual Exam (Relative):	CLR&SPRK	-
ASTM D-1524	Sediment Exam (Relative):	ND	-
ASTM D-1816	Dielectric Breakdown at 1mm (kV):	41	-
Condition Code as of 11/06/2009:	<b>CAUTION</b>		
Recommended Action:	Resample oil within 3 months.		
Rate of Change Analysis:	All relevant gas concentrations are stable.		
Dissolved-Gas Concentration Analysis:	At least one gas exceeds normal limits.		
Dissolved-Gas Ratio Analysis:	Ratio analysis not used due to overall low gas quantities.		
Physical Evaluation:	Moisture content acceptable. IFT acceptable. Dielectric Breakdown Strength acceptable. Oil clear and sparkling.		

The analyses, opinions or interpretations contained in this report are based upon material and information supplied by the client. Weidmann Diagnostic Solutions does not imply that the contents of the sample received by this laboratory are the same as all such material in the environment from which the sample was taken. Our test results relate only to the sample or samples tested. Any interpretations or opinions expressed represent the best judgement of Weidmann Diagnostic Solutions. Weidmann Diagnostic Solutions assumes no responsibility and makes no warranty or representation, expressed or implied, as to the condition, productivity or proper operation of any equipment or other property for which this report may be used or relied upon for any reason whatsoever.

**ELECTROSTATIC PRECIPITATOR TRANSFORMER/RECTIFIER Oil Analysis & Diagnostic Evaluation**

NWL Transformers  
312 Rising Sun Road  
Bordentown, NJ 08505

Location: [REDACTED]  
Serial No.: 4A1G  
Bank / Phase: -  
LTC Compartment: Transformer/Rectifier  
Breathing Type: Sealed  
Fluid: Mineral Oil  
Gallons: -

Mfr.: General Electric  
Year: -

Account No.: 444  
Customer ID: -  
Order No.: 321245  
Control No.: 6086305  
Date Received: 11/9/2009  
Date Reported: 12/14/2009

ATTN: Joe Koszyk  
PO No.: FS090073

Sample Container ID: 3001081  
Project ID: -

ASTM D-3612	Lab Control Number:	6086305	07-4659
	Date Sampled:	11/6/2009	9/13/2007
	WDS Report Number:	321245	GE Report
	Oil Temp. (C):	-	-
	Hydrogen (H2) (ppm):	115	10
	Methane (CH4) (ppm):	1165	220
	Ethane (C2H6) (ppm):	893	570
	Ethylene (C2H4) (ppm):	1980	1200
	Acetylene (C2H2) (ppm):	2	3
	Carbon Monoxide (CO) (ppm):	310	230
	Carbon Dioxide (CO2) (ppm):	2803	4200
	Nitrogen (N2) (ppm):	54071	59000
	Oxygen (O2) (ppm):	18475	32000
	Total Dissolved Gas (ppm):	79814	-
Total Dissolved Combustible Gas (ppm):	4465	2223	
Equivalent Headspace TCG (%):	1.27	-	
ASTM D-1533B	Moisture In Oil (ppm):	8	39
ASTM D-971	Interfacial Tension (dynes/cm):	36.2	31.0
ASTM D-974	Acid Number (mg KOH/g):	0.031	0.03
ASTM D-1500	Color Number (Relative):	1.0	-
ASTM D-1524	Visual Exam (Relative):	CLR&SPRK	-
ASTM D-1524	Sediment Exam (Relative):	ND	-
ASTM D-1816	Dielectric Breakdown at 1mm (kV):	46	-
Condition Code as of 11/06/2009:	<b>WARNING</b>		
Recommended Action:	Consider internal inspection of Transformer/Rectifier. Resample oil within 1 month.		
Rate of Change Analysis:	At least one gas has an abnormal rate of increase.		
Dissolved-Gas Concentration Analysis:	At least one gas far exceeds normal limits.		
Dissolved-Gas Ratio Analysis:	Indication of high temperature overheating.		
Physical Evaluation:	Moisture content acceptable. IFT acceptable. Dielectric Breakdown Strength acceptable. Oil clear and sparkling.		

The analyses, opinions or interpretations contained in this report are based upon material and information supplied by the client. Weidmann Diagnostic Solutions does not imply that the contents of the sample received by this laboratory are the same as all such material in the environment from which the sample was taken. Our test results relate only to the sample or samples tested. Any interpretations or opinions expressed represent the best judgement of Weidmann Diagnostic Solutions. Weidmann Diagnostic Solutions assumes no responsibility and makes no warranty or representation, expressed or implied, as to the condition, productivity or proper operation of any equipment or other property for which this report may be used or relied upon for any reason whatsoever.