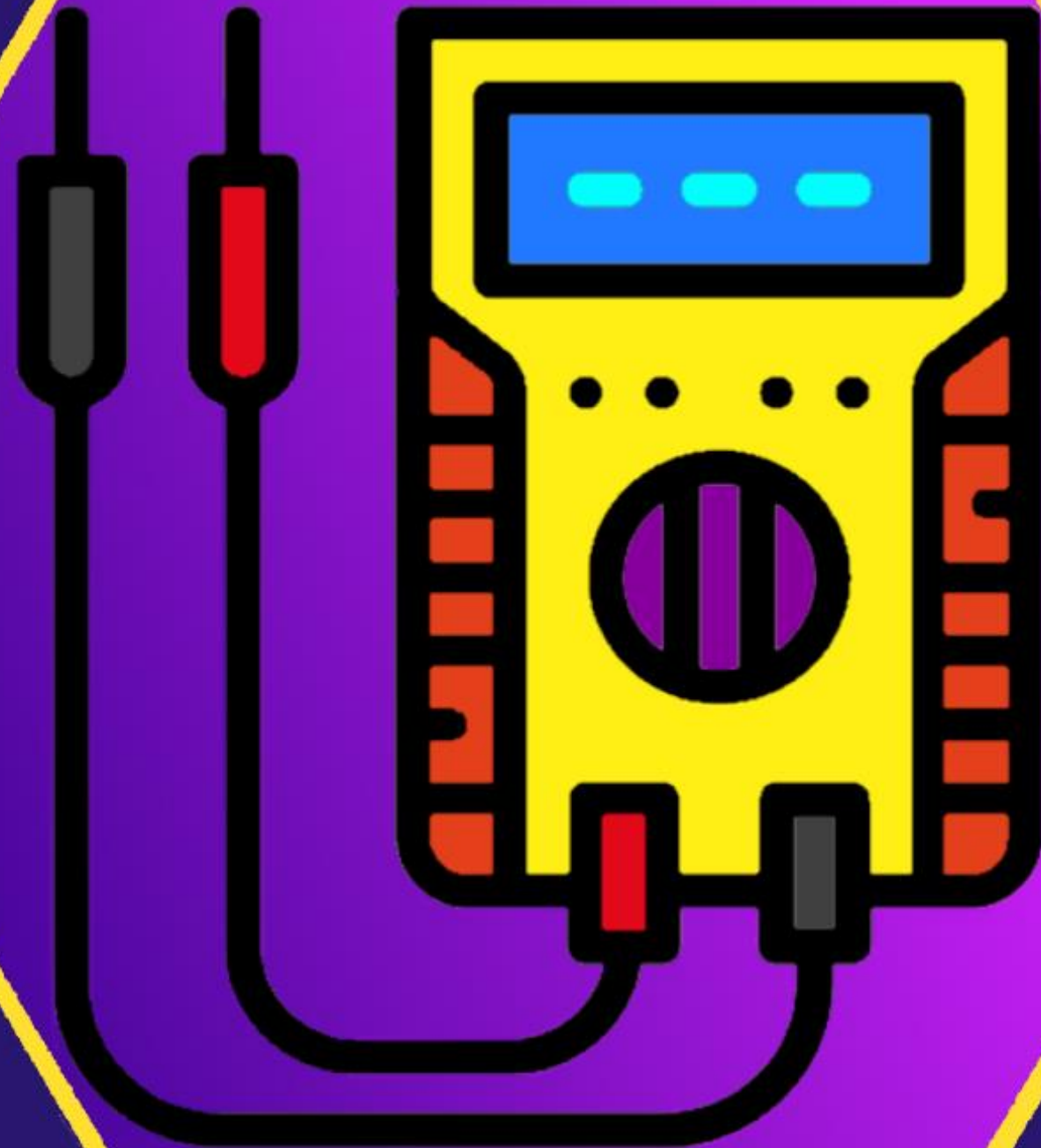


# Electrical Testing



**HARRINGTON  
ELECTRIC CO.**



**EPS™**

# Electrical Testing



## INTRODUCTIONS

**Keith Bushik**  
*Sales Manager*



**David Ross**  
*EPM+ Specialist*



# Electrical Testing



## WHY: Reasons to Perform Electrical Testing

### **PERSONNEL SAFETY**

*Avoidance of Shock, Burns or Electrocution*

### **ACCEPTANCE TESTING**

*For New or Modified Equipment*

### **FAILURE AVOIDANCE**

*Extend Equipment Life-Cycle*

### **INSURANCE COMPLIANCE**

*Effect on Premiums*



# Electrical Testing



## **WHAT:** Types of Electrical Testing



**VISUAL INSPECTION**

**CABLE TESTING**

**TRANSFORMER TESTING**

**SWITCH & CIRCUIT BREAKER TESTING**

**RELAY & SOLID-STATE DEVICE TESTING**



# Electrical Testing



## CABLE TESTING

**HI-POTENTIAL**

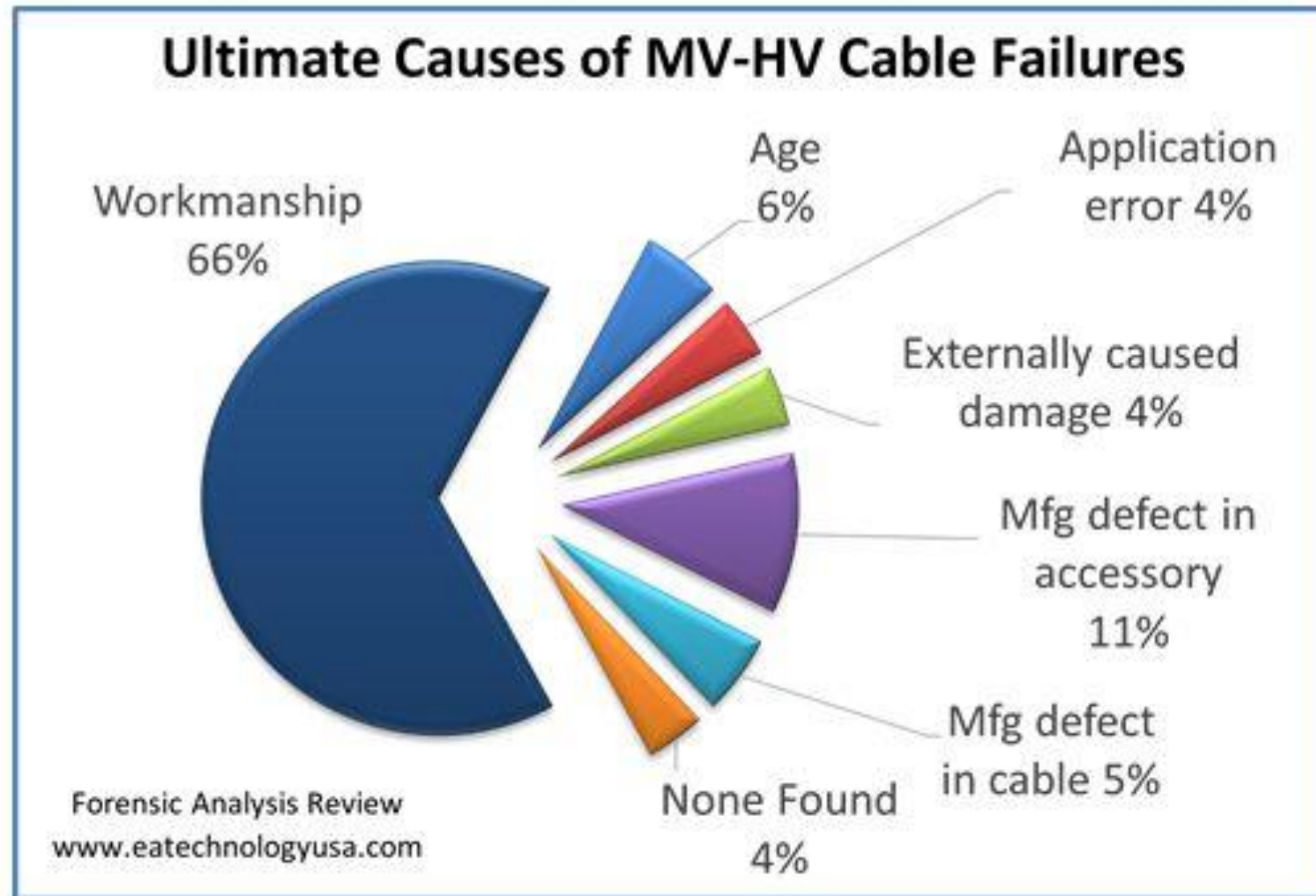
**VLF – VERY LOW FREQUENCY**

**TAN DELTA**

**PARTIAL DISCHARGE**



# Electrical Testing





# Electrical Testing



## TRANSFORMER TESTING



# Electrical Testing



## **TRANSFORMER TESTING**

**INSULATION TESTING (MEGGER)**

**WINDING RESISTANCE**

**TRANSFORMER TURNS RATIO**

**POWER FACTOR**

**TRANSFORMER OIL SAMPLING**

**SFRA – SWEEP FREQUENCY RESPONSE ANALYSIS**



# Electrical Testing



## TRANSFORMER OIL SAMPLING



Date Printed 4/20/2017

TC# 1

Customer 3800000 Thomas Steel Strip Corporation  
Sub-Name SUB #2

City Warren, OH  
Unit No. PS-T-1

Location OUTDOOR/GROUND  
Other

### NAMEPLATE DATA

Manufacturer	SUNBELT	Equipment Type	TRANSFORMER
Manufacture Date		Transformer Class	OA/FFA
Serial No.	ST109958596	Impedance %	7.05
KVA Rating	5,000	Phase/Cycle	3/60
High Voltage	23,000	Liquid Type	OIL
Low Voltage	2,400	Gallons	1,445
Weight	37,420	Other Access	EXPLOSION VENT

### ADDITIONAL EQUIPMENT

Radiators	Yes	Conservator Tank	No
Fans	No	LTC Compartment	No
Water Cooled	No	Bushing Location	Top
Oil Pumps	No	Breather	N2 Blanket
Top FPV (inch)	1.00 Valve	Hose Length (feet)	50
Bottom FPV (inch)	2.00 Valve	Service Online	Yes
InsulationType	55C	Power Available	No

### VISUAL INSPECTION

DATE	LEVEL	SAMPLE TEMP	TOP TEMP	P/V	PAINT	LEAKS
05/08/14	NORMAL	19	35	1.50	FAIR	NONE
05/15/15	NORMAL	24	38	1.50	FAIR	NONE
05/05/16	NORMAL	12	28	1.00	FAIR	NONE
03/30/17	NORMAL	12	24	1.00	POOR	NONE

### FIELD SERVICE

DATE	SERVICE
------	---------

### LIQUID SCREEN TEST DATA

DATE	SERVICE	ACID	IFT	DIEL 877	DIEL 1816	GAP	COLOR	SP. GRAV.	VISUAL	SEDIMENT
05/20/10		0.020 AC	38.8 AC	46 AC			0.75 AC	0.870 AC	CLEAR AC	NONE AC
05/18/11		0.020 AC	40.8 AC	42 AC			1.00 AC	0.880 AC	CLEAR AC	NONE AC
06/05/12		0.020 AC	39.6 AC	33 AC			1.00 AC	0.880 AC	CLEAR AC	NONE AC
06/03/13		0.020 AC	40.2 AC	41 AC			1.00 AC	0.880 AC	CLEAR AC	NONE AC
05/08/14		0.020 AC	40.3 AC	38 AC			1.00 AC	0.880 AC	CLEAR AC	NONE AC
05/15/15		0.020 AC	40.0 AC	38 AC			1.00 AC	0.875 AC	CLEAR AC	NONE AC
05/05/16		0.020 AC	40.8 AC	56 AC			0.75 AC	0.880 AC	CLEAR AC	NONE AC
03/30/17		0.020 AC	40.5 AC	38 AC			1.00 AC	0.880 AC	CLEAR AC	NONE AC

### INHIBITOR CONTENT

DATE	PCT. BY WEIGHT
06/03/13	0.165% QU
05/08/14	0.162% QU
05/15/15	0.167% QU
05/05/16	0.170% QU
03/30/17	0.167% QU

NOTE - STUDIES SHOW THAT A LEVEL OF 0.3% INHIBITOR IS OPTIMUM FOR PRESERVATION OF IN-SERVICE TRANSFORMER OILS. OILS WITH A LEVEL BELOW 0.08% ARE CONSIDERED TO BE UNINHIBITED.

### LIQUID POWER FACTOR

DATE	25 C	100 C
06/03/13	0.031 AC	0.871 AC
05/08/14	0.020 AC	0.759 AC
05/15/15	0.023 AC	0.796 AC
05/05/16	0.026 AC	0.880 AC
03/30/17	0.028 AC	0.668 AC

# Electrical Testing



## TRANSFORMER TESTING



INTELLIGENT TRANSFORMER MANAGEMENT®

Page 2 Date Printed 4/20/2017

TC# 1

Customer 3800000 Thomas Steel Strip Corporation  
Sub-Name SUB #2  
Location OUTDOOR/GROUND

S/N ST109958596  
Mfg. SUNBELT  
Unit No. PS-T-1

Gallons 1,445 High Volt. 23,000  
KVA 5,000 Low Volt. 2,400

### KARL FISCHER TESTING MOISTURE CONTENT EXPRESSED IN PPM

DATE	AVG.		PCT.		MOISTURE BY DRY WEIGHT PCT.
	TEMP	PPM	SATURATION	AC	
06/05/12	27	7	8.8	AC	0.99
06/03/13	29	11	13.8	AC	1.52
05/08/14	24	5	6.9	AC	0.81
05/15/15	29	5	6.3	AC	0.69
05/05/16	17	5	10.3	AC	1.25
03/30/17	17	3	6.2	AC	0.75

#### RECOMMENDATION RETEST 1 YEAR

The moisture content continues to be acceptable based on the equipment and liquid type. Continued normal monitoring is indicated.

### FURAN ANALYSIS EXPRESSED IN PPB

DATE	5H2F	2FOL	2FAL	2ACF	5M2F	TOTAL
06/05/12	ND	ND	5	ND	ND	5
06/03/13	ND	ND	3	ND	ND	3
05/08/14	ND	ND	1	ND	ND	1
05/15/15	ND	ND	1	ND	ND	1
05/05/16	ND	ND	2	ND	ND	2
03/30/17	ND	ND	3	ND	ND	3

#### RECOMMENDATION RETEST 1 YEAR

NO DIAGNOSTIC CHANGES ARE NOTED IN FURAN LEVELS SINCE THE PREVIOUS ANALYSIS. THE CELLULOSIC INSULATION APPEARS TO BE IN GOOD CONDITION.

CALCULATED DP 800 EST. LIFE REMAINING 100%

### ICP METALS-IN-OIL EXPRESSED IN PPM

DATE	ALUMINUM	IRON	COPPER
05/20/10	ND	ND	ND
05/18/11	ND	ND	ND
06/05/12	ND	ND	ND
06/03/13	ND	ND	ND
05/08/14	ND	ND	ND
05/15/15	ND	ND	ND
05/05/16	ND	ND	ND
03/30/17	ND	ND	ND

#### RECOMMENDATION RETEST 1 YEAR

THERE HAS BEEN NO DIAGNOSTIC CHANGE SINCE THE PREVIOUS ANALYSIS. THESE DATA INDICATE NORMAL OPERATION.

### PCB CONTENT EXPRESSED IN PPM

DATE	1242	1254	1260	OTHER	TOTAL
07/07/06					ND

COLOR LABEL: Green CLASS: NON-PCB

Results in mg/kg  
ND means None Detected  
(<2 mg/kg per ASTM D4059)

### GAS-IN-OIL ANALYSIS GAS CHROMATOGRAPHY EXPRESSED IN PPM

DATE	HYDROGEN		OXYGEN	NITROGEN	METHANE	CARBON MONOXIDE		CARBON DIOXIDE	ETHANE	ETHYLENE	ACETYLENE	TOTAL COMBUST.	TOTAL GAS
	24	75,801				468	4,587		8	20	ND	540	147,418
05/20/10	24	75,801	66,490	20	468	4,587	8	20	ND	540	147,418		
05/18/11	25	11,475	82,517	27	729	6,119	11	21	ND	813	100,924		
06/05/12	44	12,975	74,913	21	540	6,905	8	24	ND	637	95,430		
06/03/13	28	10,787	66,771	27	551	6,237	11	30	ND	647	84,442		
05/08/14	19	11,716	67,593	30	598	6,203	10	25	ND	682	86,194		
05/15/15	20	15,409	70,720	22	471	5,081	12	27	ND	552	91,762		
05/05/16	22	10,590	47,846	22	420	4,871	10	24	ND	498	63,805		
03/30/17	40	21,476	81,925	20	482	5,150	12	40	ND	594	109,145		



# Electrical Testing



## TRANSFORMER TESTING

Report Source      TwoWindingTransformer

Session Test Date    4/23/2018 9:40:27 AM

Nameplate - Two-winding Transformer

Company	Involta	Serial Number	G17302-2
Location	Akron Oh	Special ID	USS-A2
Division	Cleveland	Circuit Designation	USS-A2
Manufacturer	Pioneer Electric	Configuration	D_Y
Year Manufactured	2014	Tank Type	N2 Blanket
Mfr Location	Granby, QC	Coolant	FR3
Phases	Three	Class	
Oil Volume	1370 KG	BIL	95 kV
Weight	4510 KG		
kV	13.8, 0.48	VA Rating	1250, *, *, 1563, kVA

Administration

Test Date	4/23/2018	Test Time:	9:40 AM	Weather	Indoors
Air Temperature	23°C	Apparatus Temperature	43.3°C	Humidity	26 %
Tester	J.R.	Work Order		Date Last Tested	
Verified		Test Set Type	M4100	Date Retested	
Verification Date		Set Top Serial #		Reason	
Last Sheet #		Test Set Model	M4100	Travel Time	
Purchase Order		Ins. Book #		Duration	
Copies		Sheet #		Crew Size	3

Overall Tests

	Insulation	Test kV	mA	Watts	PF*TCF [%]	Corr Fctr	Cap (pF)	FRANK™	Manual
1	CH+CHL	10.004	55.391	4.329	0.782	1	14693.100		
2	CH	10.002	9.513	0.853	0.897	1	2523.390	Good	
3	CHL (Measured)	10.001	45.850	3.472	0.757	1	12161.900	Good	
4	CHL	0	45.878	3.476	0.758	1	12169.710	Good	
5	CL+CHL	0.996	59.747	4.438	0.743	1	15848.550		
6	CL	0.996	13.923	0.894	0.642	1	3693.280	Good	
7	CHL (Measured)	0.995	45.836	3.590	0.783	1	12158.750	Good	
8	CHL	0	45.824	3.544	0.773	1	12155.270	Good	
Winding without Attached Bushing Calculation									
	CH-C1	CH'	9.513	0.853	0.897	1	2523.390		
	CL-C1	CL'	13.923	0.894	0.642	1	3693.280		



# Electrical Testing



## TRANSFORMER TESTING

### Hot Collar Tests

ID	Serial #	Test Mode	Skirt #	Standard			Legacy (GST, optional)			FRANK™	Manual
				Test kV	mA	Watts	Test kV	mA	Watts		
H1	41A05081-1_H1	UST RB	2	10.013	0.033	0.007	*	0.033	*	Good	
H2	41A05081-1_H2	UST RB	2	10.004	0.035	0.008	*	0.035	*	Good	
H3	41A05081-1_H3	UST RB	2	10.004	0.033	0.006	*	0.033	*	Good	

### Insulation Resistance

Core Ground Test				
Manufacturer	Pioneer			*
Serial #	G17302-2			*
Connections	Volts	T1 (Mohms)	T2 (Mohms)	PI
Hi to Lo/Ground	10000.00	2040.00	2810.00	1.38
Hi to Ground Guard Lo	10000.00	1605.00	*	*
Lo to Hi/Ground	*	*	*	*
Lo to Ground Guard Hi	1000.00	808.00	*	*
Hi to Lo Guard Ground	*	*	*	*
Core to Ground	*	*	*	*

### Manual Winding Resistance

Manufacturer	Serial Number	Winding		Winding Temperature	Temperature Rise	Factory Resistance (Ohms)	Factory Temperature
		Configuration					
Pioneer	G17302-2	Δ-Y		43.3°C	18.3°C	*	*
High Voltage							
Winding : Tap Position (s)	Phase	Resistance	Units	Calculated Resistance	Correction Factor	Corrected Resistance	Percentage Deviation
HV: 1 (Max V) LV: 16L (Min V)	A	987.4	milli Ohms	*	*	*	*
HV: 1 (Max V) LV: 16L (Min V)	B	990	milli Ohms	*	*	*	*
HV: 1 (Max V) LV: 16L (Min V)	C	991.2	milli Ohms	*	*	*	*
Low Voltage							
Winding : Tap Position (s)	Phase	Resistance	Units	Calculated Resistance	Correction Factor	Corrected Resistance	Percentage Deviation
HV: 1 (Max V) LV: 16L (Min V)	A	466	micro Ohms	*	*	*	*
HV: 1 (Max V) LV: 16L (Min V)	B	485	micro Ohms	*	*	*	*
HV: 1 (Max V) LV: 16L (Min V)	C	496	micro Ohms	*	*	*	*

# Electrical Testing

## TRANSFORMER TESTING



### Excitation Current & Losses Tests

Manufacturer		Type	Steps	Boost %	Buck %	Position Found	Position Left	Oil Volume
DETC			5	*	*	3	3	*
OnLine			33	*	*			*

Winding : Tap Position (s)	Test kV	H1 H2 mA Watts	X	H2 H3 mA Watts	X	H3 H1 mA Watts	X	FRANK™	Manual
HV: 3 LV: 16L (Min V)	10	28.455 284.485	L	38.228 379.555	L	38.448 378.723	L	Good	

### Turns Ratio Tests

Serial Number				HV Winding				LV Winding			
G17302-2				Delta				Wye			
Connections				H1 - H2				H2 - H3			
				X0 - X2				X0 - X3			
Tap	HV [kV]	Tap	LV [kV]	H1 - H3 X1 - X0 Cal	Ratio 1	Ratio 2	Ratio 3	Min. Lim	Max. Lim	FRANK™	Manual
C	13800	C	480	*	49.766	49.781	49.777	49.547	50.045		



# Electrical Testing



## TRANSFORMER TESTING



**Mobile  
Transformer  
Testing Lab**



# Electrical Testing



## SWITCH & CIRCUIT BREAKER TESTING

**INSULATION TESTING**  
(MEGGER)

**DUCTOR TESTING**  
(DLRO METER)

**EXERCISING**



# Electrical Testing



## OVERCURRENT RELAY & SOLID STATE DEVICE TESTING

**Primary  
Injection**



**Secondary  
Injection**

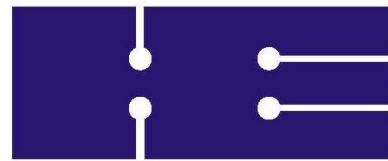


# Electrical Testing



**EPS**<sup>TM</sup>

Electric Power Systems



**HARRINGTON ELECTRIC CO.**

*Thank You for Attending!*