What Does a Good Electrical Maintenance Program Look Like?

Gary Walls: President

Utilities Instrumentation Service

References

Coache, Christopher D. *NFPA 70E: Standard for Electrical Safety in the Workplace*. NFPA, 2017.

Hickman, Palmer, and Tim Crnko. *Electrical Safety Related Work Practices:Based on NFPA 70E 2018 Edition*. Alliance, 2018.

NFPA 70B: Recommended Practice for Electrical Equipment Maintenance. National Fire Protection Association, 2015.

Richard, Melissa. *Standard for Acceptance Testing Specifications for Electrical Power Equipment and Systems*. InterNational Electrical Testing Association, 2017.

Tanz, Jayne. *Standard for Maintenance Testing Specifications for Electrical Power Equipment and Systems*. InterNational Electrical Testing Association (NETA), 2015.

Goals Today

- What is Maintenance?
- Why have an Electrical Maintenance Program (EMP)?
- Electrical preventative maintenance program outline
- Questions

What is Maintenance?

- Auto Preventative Maintenance
  - Oil
  - Filters
  - Tires
  - Wiper Blades
  - Washing
  - Windows
  - Seats / Floor


Water
Your lawn care
Weed / Feed
Mow
Trim

Electrical Systems

- Switchgear and Switchboard Assemblies
- Transformers
- Cables
- Switches
- Circuit Breakers
- Protective Relays
- Instrument Transformers

Electrical Systems Continued…

- Metering Devices
- Grounding Systems
- Motor Control Centers
- Direct – Current Systems, Batteries
- Capacitors and Reactors
- Emergency Systems, Engine Generator

Why?

- Safety
- Reliability
- Insurance

Maintenance Considerations

- Example : Abnormal Environmental Conditions Require More Maintenance

Courtesy of Eaton Corporation

- "Silver whiskers" are caused by a contaminated environment, and the lack of maintenance led to control power transformer failure on this medium voltage switchgear.

Maintenance Considerations

- Example : Important to Verify Proper Operation of Electrical Equipment

- Lack of maintenance can lead to bus failure as dirt, moisture, and contaminants cause tracking.

Courtesy of Eaton Corporation


H1


DANGER


X
Y
DANGER

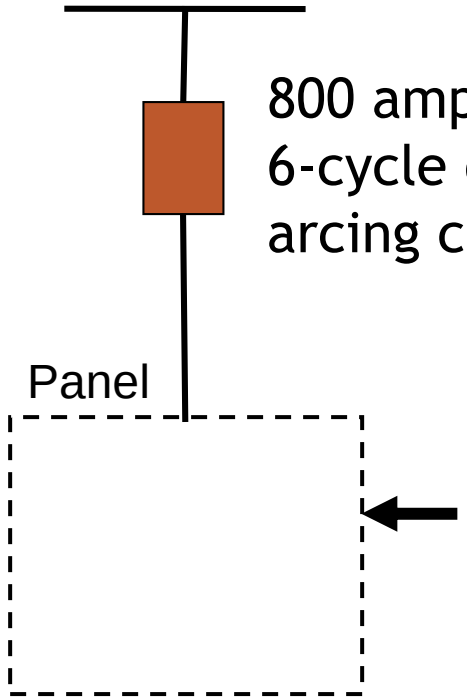
Maintenance Considerations

- Condition of Maintenance
  - Improper or lack of maintenance on an OCPD can lead to higher incident energy than the arc flash risk assessment determines
  - IEEE paper *"Prioritize Circuit Breaker and Protective Relay Maintenance Using Arc Flash Hazard Assessment"*
    - In the study of a specific industrial facility, if the closest upstream circuit breaker or relay did not operate and the next higher level upstream OCPD cleared the arcing fault, in approximately $^{2}/_{3}$ of the cases, the Electrical Worker would not have adequate arc rated PPE.

Maintenance Considerations

- OCPD Maintenance Can Affect Arc-Flash Hazard (continued)

22.6 kA Symmetrical
Available Fault Current
at 480 volts, 3-phase



What happens if…
Lack of maintenance causes the OCPD to clear in **30** cycles rather than 6 cycles?

The actual arc-flash hazard would be much greater than the calculated arc-flash hazard.

125 inches

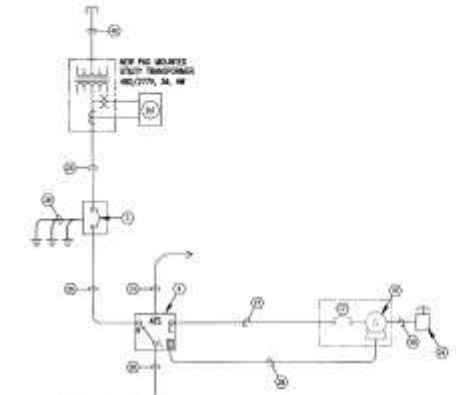
29 cal/cm^2

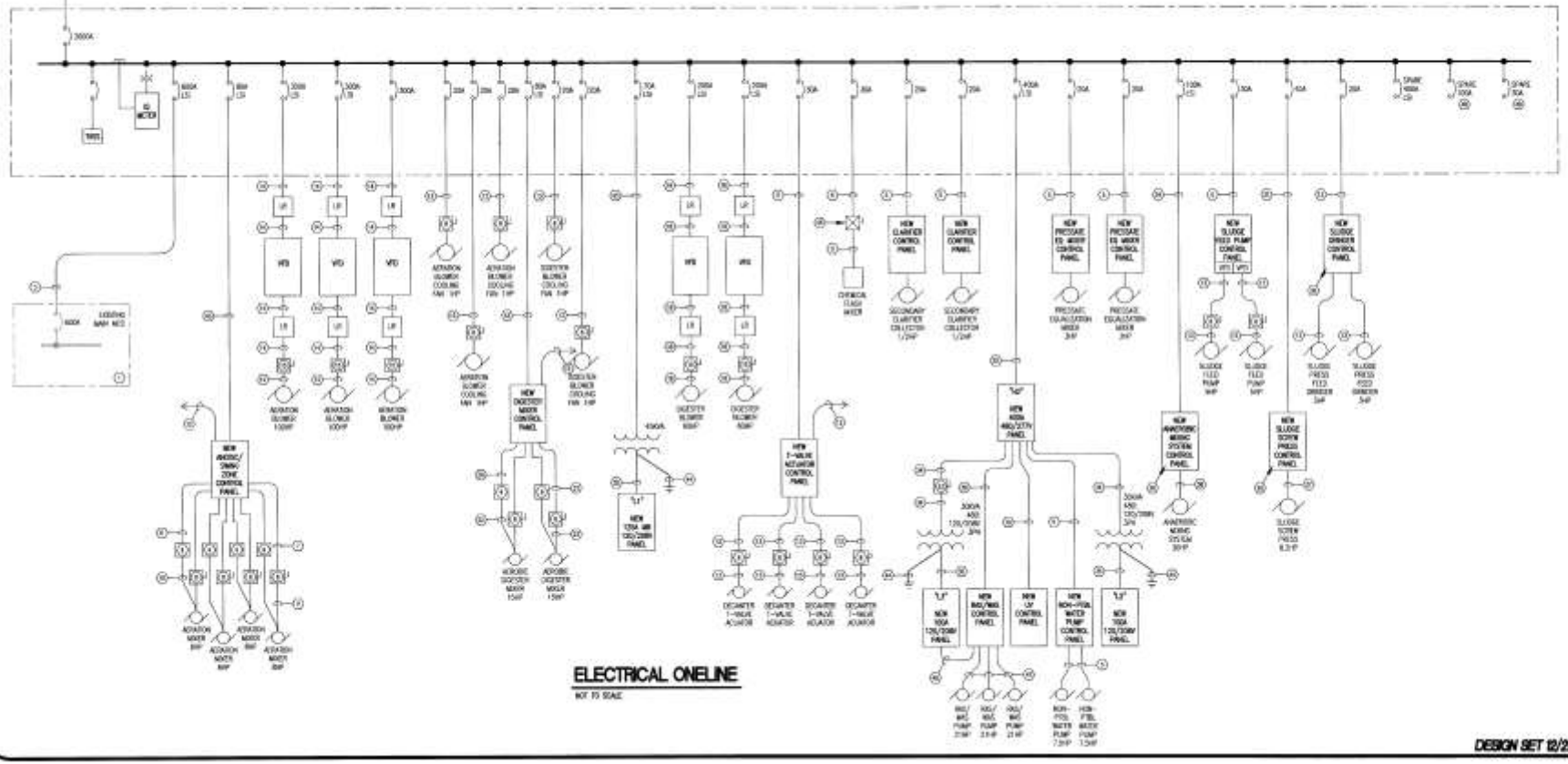
Arc Flash Hazard Analysis for This Panel
Incident Energy: **5.8** cal/cm^2 at 18 inches
AFPB: **47** inches

Maintenance Considerations

- The Value of Electrical Safety-Related Maintenance
  - *NFPA 70E* Scope includes addressing safety-related maintenance requirements
  - New *NFPA 70E* definition:

    "**Maintenance, Condition of**. The state of the electrical equipment considering the manufacturers' instructions, manufacturers' recommendations, and applicable industry codes, standards, and recommended practices."





ELECTRICAL ONELINE

NOT TO SCALE

ELECTRICAL KEYED NOTES:

1. EXISTING MAIN MCC, SEE SHEET E8.
2. NEW 2000A, LSIG, 65KAIC, SERVICE ENTRANCE 100% RATED CIRCUIT BREAKER.
3. (2) SETS OF 4-#350, 1-#1 GND IN 3"C.
4. NEW 2000A, DELAYED TRANSITION, BY-PASS ISOLATION TRANSFER SWITCH.
5. 3-#10, 1-#10 GND IN 1"C.
6. 2-#14 (OVERTEMP), 2-#14 (LEAK SEAL), 1-#14 GND IN 3/4"C. TYPICAL OF (4).
7. 3-#12, 1-#12 GND IN 3/4"C. TYPICAL OF (4).
8. 30A, NON-FUSED, NEMA 4X DISCONNECT.
9. 8"x8"x4" NEMA 4X TERMINAL BOX WITH BACK PLATE AND TERMINAL SETUP FOR CABLE TRANSITION.
10. SENSOR CABLE WITH MIXER MOTOR, TYPICAL OF (4).
11. POWER CORD, FURNISHED WITH MIXER, INSTALLED BY CONTRACTOR, TYPICAL OF (4).
12. SCADA MONITORING, SEE SCADA AND AREA SPECIFIC DRAWING.
13. 3-#12, 1-#12 GND IN 3/4"C.
14. 3-#2/0 XHHW-2, 1-#6 GND IN 2"C.
15. 200A, NON-FUSED, NEMA 4X DISCONNECT.
16. EXISTING 500KW DIESEL GENSET.
17. EXISTING 800A GENERATOR BREAKER.
18. 3-#2 XHHW-2, 1-#6 GND IN 1-1/4"C.
19. 4-#6, 1-#10 GND IN 1-1/4"C.
20. 2-#14 (OVERTEMP), 2-#14 (LEAK SEAL), 1-#14 GND IN 3/4"C. TYPICAL OF (2).
21. 3-#12, 1-#12 GND IN 3/4"C. TYPICAL OF (2).
22. SENSOR CABLE, TYPICAL OF (2).
23. POWER CORD, FURNISHED WITH MIXER, INSTALLED BY CONTRACTOR, TYPICAL OF (2).
24. NEW EMERGENCY SHUTDOWN, MOUNT REMOTE FROM GENSET ON EQUIPMENT RACK.
25. (3) SETS OF 4-#600 CU IN 3"C., WITH (4) SPARE 3" CONDUITS. OR (6) SETS OF 4-#600 AL IN 3"C., WITH (4) SPARE 3" CONDUITS.
26. (5) SETS OF 4-#600 CU, 1-#250 CU GND IN 3-1/2"C. OR (6) SETS OF 4-#600 AL, 1-#250 CU GND IN 3-1/2"C.
27. (2) SETS OF 4-#500 CU, 1-#1/0 CU GND IN 3-1/2"C. OR (4) SETS OF 4-#250 AL, 1-#1/0 CU GND IN 2-1/2"C.
28. 2-#10 CU, 1-#10 CU GND IN 1"C. GENERATOR INITIATION CIRCUIT.
29. 2-#14 CU, 1-#14 CU GND IN 3/4"C.
30. CONTROL PANEL SUPPLIED WITH EQUIPMENT. CONTRACTOR TO COMPLETE ALL CONNECTIONS.
31. 2-#14 ATS/STATUS, 1-#14 GND, TO BLOWER CONTROL PANEL.
32. 4-#600 CU, 1-#3 CU GND IN 4"C.
33. 60A, NON-FUSED, NEMA 4X DISCONNECT.
34. 3-#6 CU, 1-#10 CU GND IN 1"C.
35. 4-#1 CU, 1-#6 CU GND IN 1-1/2"C.
36. 3-#1/0 CU, 1-#6 CU GND IN 2"C.
37. 3-#8 CU, 1-#10 CU GND IN 1"C.
38. 3-#1 CU, #1-6 CU GND IN 1-1/2"C.
39. #4/0 BARE CU BONDED TO (3) 3/4"x10' COPPER CLAD GROUND ROD, SEPARATED BY 10' MINIMUM. SEE GROUNDING DETAIL.
40. (2) 6" PVC; SEE SITE DRAWING.
41. 60A LINE REACTOR - W/E, RL SERIES, NEMA 1 ENCLOSURE.
42. 20A LINE REACTOR - W/E, RL SERIES, NEMA 1 ENCLOSURE.
43. 3-#6, 1-#6 GND IN 1"C.
44. GROUNDING ELECTRODE, #8 CU IN 1"C. SEE GROUNDING DETAIL.
45. NEMA 4X, SIZE 1, FUSED, COMBINATION MOTOR STARTER, WITH HAND-OFF SWITCH, PUSH TO TEST LED LAMPS, GREEN="ON", RED="OFF", WITH ELECTRONIC OVERLOADS, 120V CONTROL POWER TRANSFORMER.
46. 2-#12, 1-#12 GND IN 3/4"C.
47. 3-#6, 1-#8 GND IN 3/4" C.
48. FURNISH & INSTALL (2) SPARE 100A BREAKERS.
49. FURNISH & INSTALL (4) SPARE 30A BREAKERS.

DESIGN SET 12/21

CONSULTANT:

SIMS-DURKIN ASSOCIATES ENGINEERING COMPANY

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INDIANAPOLIS, INDIANA 46234
317.209.4000 (FAX) 317.322.4120
INFO@SIMS-DURKIN.COM
WEB SIMS-DURKIN.COM

REVISIONS:

DATE	DESCRIPTION	BY

APPROVED BY:

TRIAD ASSOCIATES INC.
5838 LAWTON LOOP EAST DRIVE
INDIANAPOLIS, INDIANA 46216
PHONE: 317-377-8330 FAX: 317-377-8341

DESIGNED FOR:

THE CITY OF KENDALLVILLE
NOBLE COUNTY, INDIANA

SHEET TITLE:

WASTEWATER TREATMENT PLANT IMPROVEMENTS PROJECT
ELECTRICAL ONELINE

JOB NUMBER: 2015124	
SCALE: AS NOTED	CHECKED BY:
PLOT SCALE: 1=1	PLOT DATE:
DRAWN BY: ASZ	DATE: DEC., 2019
DESIGNED BY:	
DRAWING NAME: E11 - ELECTRICAL ONELINE	

SHEET NO.

E11

Electrical Systems

- Switchgear and Switchboard Assemblies
- Transformers
- Cables
- Switches
- Circuit Breakers
- Protective Relays
- Instrument Transformers

Electrical Systems Continued…

- Metering Devices
- Grounding Systems
- Motor Control Centers
- Direct – Current Systems, Batteries
- Capacitors and Reactors
- Emergency Systems, Engine Generator

EMP Outline

- System Designs
- Acceptance & Commissioning Testing
- EMP
  - Energized Maintenance
  - Outage Maintenance

Main Parts of an EMP Program

- Responsible and Qualified Personnel
- Survey and analysis of electrical equipment and systems to determine maintenance requirements and priorities
- Programmed routine inspections and suitable tests
- Accurate analysis of inspection and test reports so that proper corrective measures can be prescribed
- Performance of necessary work
- Concise but complete records

Frequency of Maintenance Tests

- NETA recognizes that the ideal maintenance program is reliability-based, unique to each plant and to each piece of equipment. In the absence of this information and in response to requests for a maintenance timetable, NETA's Standards Review Council presents the following time-based maintenance schedule and matrix.

- One should contact a NETA Accredited Testing Company for a reliability-based evaluation.

- The following matrix is to be used in conjunction with Appendix B, Inspections and Tests. Application of the matrix is recognized as a guide only.

- Specific condition, criticality, and reliability must be determined to correctly apply the matrix. Application of the matrix, along with the culmination of historical testing data and trending, should provide a quality electrical preventive maintenance program.

MAINTENANCE FREQUENCY MATRIX				
		EQUIPMENT CONDITION		
		POOR	AVERAGE	GOOD
EQUIPMENT REQUIREMENT	LOW	1.0	2.0	2.5
	MEDIUM	0.50	1.0	1.5
	HIGH	0.25	0.50	0.75

APPENDIX B

Frequency of Maintenance Tests (*continued*)

Inspections and Tests Frequency in Months (Multiply These Values by the Factor in the Maintenance Frequency Matrix)				
Section	**Description**	**Visual**	**Visual & Mechanical**	**Visual & Mechanical & Electrical**
7.1	Switchgear & Switchboard Assemblies	12	12	24
7.2	Transformers			
7.2.1.1	Small Dry-Type Transformers	2	12	36
7.2.1.2	Large Dry-Type Transformers	1	12	24
7.2.2	Liquid-Filled Transformers	1	12	24
	Sampling	–	–	12
7.3	Cables			
7.3.1	Low-Voltage, Low-Energy	–	–	–
7.3.2	Low-Voltage, 600-Volt Maximum	2	12	36
7.3.3	Medium- and High-Voltage	2	12	36
7.4	Metal-Enclosed Busways	2	12	24
	Infrared Only	–	–	12
7.5	Switches			
7.5.1.1	Air, Low-Voltage	2	12	36
7.5.1.2	Air, Medium-Voltage, Metal-Enclosed	–	12	24
7.5.1.3	Air, Medium- and High-Voltage Open	1	12	24
7.5.2	Oil, Medium-Voltage	1	12	24
7.5.3	Vacuum, Medium-Voltage	1	12	24
7.5.4	Medium-Voltage, SF_6	1	12	24
7.5.5	Cutouts	12	24	24
7.6	Circuit Breakers			
7.6.1.1	Air, Insulated-Case/Molded-Case	1	12	36
7.6.1.2	Air, Low-Voltage Power	1	12	36
7.6.1.3	Air, Medium-Voltage	1	12	36
7.6.2	Oil, Medium-Voltage	1	12	36
	Sampling	–	–	12
7.6.2	Oil, High-Voltage	1	12	12
	Sampling	–	–	12
7.6.3	Vacuum, Medium-Voltage	1	12	24
7.6.4	SF_6	1	12	12
7.7	Circuit Switchers	1	12	12
7.8	Network Protectors	12	12	24

Annex I Maintenance Intervals

This annex is not a part of the recommendations of this NFPA document but is included for informational purposes only.

I.1 Introduction. This annex provides, in Table I.1, an initial guideline for maintenance intervals for equipment. It should be stressed that environmental or operating conditions of a specific installation should be considered and might dictate a different frequency of maintenance than suggested in this annex *(see 8.2.5)*. Chapter 22 and Annex H deal specifically with the maintenance of equipment that, by nature of its application, necessitates long intervals between shutdowns. It should be noted that maintenance, inspection, and test methods for equipment that can operate for long periods are essentially the same as for equipment that might be shut down frequently. However, the recommended work should be performed with more care and diligence to obtain the desired reliability for service to loads that can operate continuously for months or years.

Table I.1 Interval Guidelines

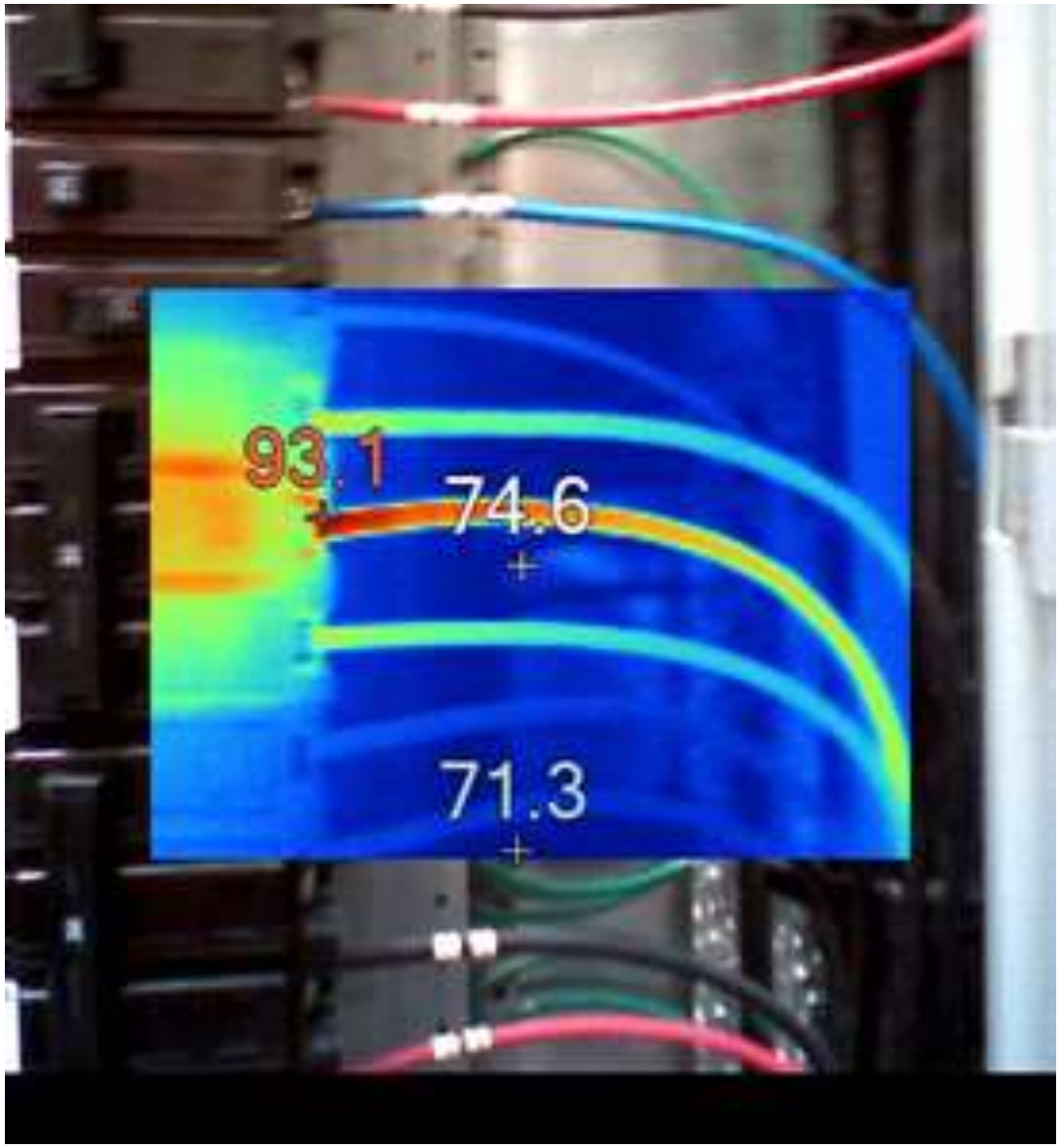
Item/Equipment	Task/Function	Interval	Reference
Substations (Outdoor)	Infrared scanning	Annually	21.17
Insulators	Visual inspection	4–6 months	9.1.2.1
	Corona detection	4–6 months	9.1.2.2
	Electrical tests	As indicated by other PM	21.9
Conductors	Visual inspection of connections	4–6 months	9.1.3
	Check connections for tightness	As indicated by other PM	9.1.3
Air-disconnecting switches	Visual inspection	4–6 months	9.1.4.2
	Operation check	Annually	9.1.4.3
	Contact inspection	Annually	9.1.4.3
Grounding equipment	Visual inspection	Annually	9.1.5
	Check connections for tightness	1–2 years	9.1.5
	Electrical test	3 years	21.13, 21.14, 21.15
Enclosures	Security/operational check	1–3 months	9.1.6
Switchgear Assemblies	Infrared scanning	Annually	21.17
Enclosures	Security/operational check		9.2.4
	Outdoor	1–3 months	
	Indoor	6 months	
	Visual inspection		9.2.5 through 9.2.6.2
	Outdoor	1–3 months	
	Indoor	6 months	
Ventilation	Visual inspection	1–3 months	9.2.8
Space heaters	Operational check	Annually	9.2.7
Insulation	Visual inspection/clean	Annually	9.2.10 through 9.2.14.3
	Electrical tests	2 years	21.9
Air Circuit Breakers, Medium Voltage			
Insulation	Visual inspection/clean	Annually	9.4.2
	Electrical tests	3 years	21.9
Contacts	Visual inspection/clean	Annually	9.4.3.4
	Adjust	Annually	9.4.3.5
	Electrical test	3 years	21.12, 21.16, 21.9.3.2
Arc interrupters	Visual inspection/clean	Annually	9.4.4.3, 9.4.4.4
	Electrical test	3 years	9.4.4.4
	Air-puffer operational check	Annually	9.4.4.5
Operating mechanism	Visual inspection	Annually	9.4.5.2
	Operational check/adjustment	Annually	9.4.5.2
Trip device circuit	Operational check	Annually	9.4.6.3
Air Circuit Breakers, Low Voltage	Visual inspection/clean/adjust	Annually	9.4, 21.9, 21.10.2.5
	Electrical tests	3 years	
Vacuum Circuit Breaker	Visual inspection/clean/adjust	Annually	9.4
	Contact checks/vacuum integrity	3 years	9.5.1, 9.5.2
	Electrical tests	3 years	21.9, 21.10.2.5

(continues)

Energized Maintenance

- Infrared Scanning
- Ultrasonic Scanning
- Oil Sampling


96.9
87.5
75.9


93.1
74.6
71.3

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734-424-1200

TRANSFORMER INSPECTION

NETA ACCREDITED COMPANY

CUSTOMER _____ PAGE _____
ADDRESS _____ JOB # _____
USER _____
OWNER REPRESENTATIVE _____ TELEPHONE _____
DATE _____ TEMPERATURE ____ °F HUMIDITY ____ % EQPT. LOCATION _____
SUBSTATION _____ POSITION _____

NAMEPLATE DATA

MANUFACTURER _____ SERIAL NO. _____
SPECIFICATION NO. _____ / / TYPE _____ CLASS _____
PHASE _____ TEMPERATURE RISE ____ °C ____ °C IMPEDANCE ____ % B.I.L. RATING _____ kV BIL ____ kV SEC.
COOLANT _____ CAPACITY _____ / _____ TOTAL WEIGHT _____
WINDING POLARITY _____ WINDING MATERIAL _____ K FACTOR _____
PRIMARY VOLTAGE _____ ○ DELTA ○ WYE RATED CURRENT ____ / ____ / ____ AMPERES
SECONDARY VOLTAGE _____ ○ DELTA ○ WYE RATED CURRENT ____ / ____ / ____ AMPERES
TAP VOLTAGES _____ _____ _____ _____ _____ _____ _____ _____
TAP CONNECTIONS _____ _____ _____ _____ _____ _____ _____ _____
TAP SETTING _____ _____ VOLTS # FANS _____ TAP CHANGER: ○ INTERNAL ○ EXTERNAL DRY TYPE ☐

GAUGES:

COOLANT TEMPERATURE _____ °C MAXIMUM TEMPERATURE _____ °C RESET TEMPERATURE GAUGE ☐
COOLANT LEVEL _____ PRESSURE VACUUM _____ # LCR COUNTER _____
OTHER GAUGES _____

VISUAL INSPECTION:

BUSHINGS _____ SUPPORT INSULATORS _____ CONNECTIONS _____
PAINT _____ RADIATORS _____ FANS _____
NO-LOAD TAP CHANGER _____ LEAKS _____
FAN PUMP CONTROLS _____
ADDITIONAL EQUIPMENT _____
GROUND CONDUCTOR SIZE _____ AWG/kcm NO. OF GROUND CONDUCTORS _____ GROUND CONDUCTOR CONDITION _____

VECTOR DIAGRAM

PRI. VECTOR: _____
SEC. VECTOR: _____

POST TEST VOLTAGES

NO LOAD SECONDARY VOLTAGE			
X1 - X2	V	X0 - G	V
X1 - X3	V	X0 - X1	V
X2 - X3	V	X0 - X2	V
		X0 - X3	V

COMMENTS: _____
DEFICIENCIES: _____

☐ ACCEPTABLE ☐ NON - ACCEPTABLE

Tested By _____ Tested By _____

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LOW VOLTAGE
POWER CIRCUIT BREAKER TEST

NETA ACCREDITED COMPANY

CUSTOMER _____ PAGE _____

ADDRESS _____ JOB # _____

USER _____

OWNER REPRESENTATIVE _____ TELEPHONE _____

DATE _____ TEMPERATURE _____ °F HUMIDITY _____ % EQPT. LOCATION _____

SUBSTATION _____ POSITION _____

MANUFACTURER _____ SN / SO NO. _____ FRAME SIZE(F) _____

BREAKER TYPE _____ SENSOR TAPS _____ MOUNTING ○ B.I. ○ D.O.

FUSE CAT. NO. _____ CUBICLE CODE _____ THERMAL MEMORY ○ ON ○ OFF

TRIP UNIT TYPE _____ CATALOG NO. _____ ZONE INTLK ☐ TARGETS ☐

DESCRIPTION	INSPECTED	CONDITION	CLEAN/LUBE
CUBICLE AND RACKING DEVICES	☐		
CONTACT FINGERS	☐		
LOADING AND ARCING CONTACTS	☐		
OVERCURRENT DEV. BATTERY	☐		

DESCRIPTION	INSPECTED	CONDITION	CLEAN/LUBE
ARC CHUTES	☐		
AUXILIARY DEVICES	☐		
GROUND CONNECTION	☐		
LOAD CONDUCTOR NO.	Size		Cu ○ Al ○

SETTINGS AS FOUND

RATING PLUG(R) _____ LONG TIME PU _____ x _____ A = _____ A DELAY _____

SENSOR TAP _____ SHORT TIME PU _____ = _____ A DELAY _____ PT ○ IN ○ OUT ○ N/A

GRD. FLT. ○ 3W ○ 4W INST. PU _____ = _____ A ○ ON ○ OFF

GRD. FLT. PU _____ = _____ A ○ ON ○ OFF DELAY _____ PT ○ IN ○ OUT ○ N/A

SETTINGS AS LEFT

RATING PLUG(R) _____ LONG TIME PU _____ x _____ A = _____ A DELAY _____

SENSOR TAP _____ SHORT TIME PU _____ = _____ A DELAY _____ PT ○ IN ○ OUT ○ N/A

GRD. FLT. ○ 3W ○ 4W INST. PU _____ = _____ A ○ ON ○ OFF

GRD. FLT. PU _____ = _____ A ○ ON ○ OFF DELAY _____ PT ○ IN ○ OUT ○ N/A

TCC NO. _____

FUNCTION	TEST AMPERES	CURRENT MULTIPLE	TIME BAND MINIMUM	TIME BAND MAXIMUM	POLE 1 AS FOUND (seconds)	POLE 1 AS LEFT (seconds)	POLE 2 AS FOUND (seconds)	POLE 2 AS LEFT (seconds)	POLE 3 AS FOUND (seconds)	POLE 3 AS LEFT (seconds)
INSTANTANEOUS										
SHORT TIME										
LONG TIME										
GROUND FAULT										

EQUIPMENT TEMPERATURE _____ °C TEMPERATURE CORRECTION FACTOR TO 20°C, TCF _____

INSULATION RESISTANCE	POLE 1 MΩ (P1-P2) READING	POLE 1 MΩ (P1-P2) 20°C	POLE 2 MΩ (P2-P3) READING	POLE 2 MΩ (P2-P3) 20°C	POLE 3 MΩ (P3-P4) READING	POLE 3 MΩ (P3-P4) 20°C
POLE TO POLE						
POLE TO FRAME						
LINE TO LOAD						

POLE RESISTANCE - MILLI-OHMS READING		
POLE 1	POLE 2	POLE 3

CONTROL WIRING			COUNTER READING BEGEND	
READING		20°C		

COMMENTS: _____

DEFICIENCIES: _____

☐ ACCEPTABLE ☐ NON - ACCEPTABLE

Tested By: _____ Tested By: _____

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CABLE HIGH POTENTIAL TEST

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CUSTOMER _____ PAGE _____
ADDRESS _____ JOB # _____
USER _____
OWNER REPRESENTATIVE _____ TELEPHONE _____
DATE _____ TEMPERATURE _____ °F HUMIDITY _____ % EQPT. LOCATION _____
SUBSTATION _____ POSITION _____

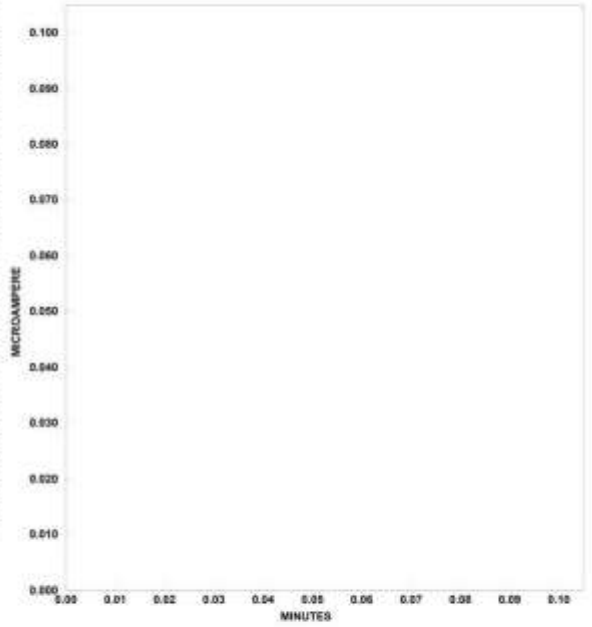
CABLE SOURCE _____ CABLE TERMINATION POINT _____
OPERATING VOLTAGE _____ kV INSTALLED IN _____ LENGTH _____ ft
MANUFACTURER _____ INSULATION TYPE _____ INSULATION THICKNESS _____ mil
SIZE _____ kcmil NO. OF CONDUCTORS _____ CONDUCTOR MATERIAL _____
RATED VOLTAGE _____ kV ○ GROUNDED ○ UNGROUNDED ○ BELTED ○ SHIELDED AGE _____

CONNECTED EQUIPMENT _____

TIME MINUTES	TEST VOLTAGE	PHASE A µA	PHASE B µA	PHASE C µA
0.25				
0.50				
0.75				
1.00				
1.25				
1.50				
1.75				
2.00				
3.00				
4.00				
5.00				
6.00				
7.00				
8.00				
9.00				
10.00				
11.00				
12.00				
13.00				
14.00				
15.00				
16.00				
17.00				
18.00				
19.00				
20.00				
21.00				
22.00				
23.00				
24.00				
25.00				
DECAY TO 5KV, SECS				
SHIELD RESIST.- OHMS				

PHASE IDENTIFICATION

PHASE A PHASE B PHASE C



COMMENTS: _____

DEFICIENCIES: _____

☐ ACCEPTABLE ☐ NON - ACCEPTABLE

TOOLS USED

Tested By _____ Tested By _____ FORM: NETA ED 7/6/01

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INSULATING FLUID EVALUATION

Page: _____
Job Number: _____

DATE: _____ TEMPERATURE _____ °F HUMIDITY _____ % EQPT. LOCATION _____
SUBSTATION _____ POSITION _____

Report Number: Location: Year of Mfg.:
Bank & Phase: kV Rating:
Serial Number: Breathing:
Manufacturer: Cooling:
Equipment Type: Fluid Type:

	Sample Date					
	Laboratory No.					
	Container No.					
	Temperature					
D1533	Moisture	(ppm)				
D971	Interfacial Tension	(dynes/cm)				
D974	Acid Number	(mgKOH/g)				
D1500	Color Number					
D1524	Visual Examination					
D877	Dielectric BV	(kV)				
D1816	Dielectric BV	(kV)				
D924	Power Factor	(% @ 25 C)				
D924	Power Factor	(% @ 100 C)				
D2668	Oxidation Inhibitor	(%)				
D129	Specific Gravity					
D88	Viscosity	(SUS)				
D97	Pour Point	(C)				
D92	Flash Point	(C)				
D92	Fire Point	(C)				
D1807	Refractive Index					
D1275	Corrosive Sulfur					

Insulating Fluid Diagnostics

	ASTM D3487	IEEE Group I	<69	>69<288	>345	IEEE Group II	IEEE Group III
Moisture:	35 max		35 max	25 max	20 max		
Interfacial Tension:	40 min		24 min	36 min	30 min	24 min	16 min
Acid Number:	0.03 max		0.2 max	0.2 max	0.1 max	0.2 max	0.5 max
Color Number:	0.5 max						
Visual Examination:	clear & bright						
Dielectric BV D877:	30 min		26 min	26 min	26 min		
Dielectric BV D1816:	28 min		23 min	26 min	26 min		
Power Factor @ 25 C:	0.05 max						
Power Factor @ 100 C:	0.30 max						
Oxidation Inhibitor:	0.3 max						
Specific Gravity:	0.91 max						
Viscosity @ 40 C:	66 max						
Pour Point:	-40 max						
Flash Point:	145 min						
Fire Point:							
Refractive Index:							
Corrosive Sulfur:	noncorrosive						
Comments:							

COMMENTS:

DEFICIENCIES:

☐ ACCEPTABLE ☐ NON - ACCEPTABLE

Tested By: _____ Tested By: _____

Questions?

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Utilities Instrumentation Service