Online Partial Discharge Testing

Emerson Network Power | Electrical Reliability Services

January 28, 2013

Purchase Order No.: MA S09010 Job 74753 WR 0037
ERS Job No. 3167064

Prepared for:

EC Company
PO Box 10286
Portland, OR 97296

Testing Location:

Portland State University
617 SW Montgomery Street
Portland, OR 97201

Submitted By:

Shane T. Smith
Field Engineer

Reviewed by:

Steven Nollette
Supervising Engineer

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1 EXECUTIVE SUMMARY

1.1 OVERVIEW

During this project permanent sensors attached to medium voltage cable terminations and temporary sensors at other equipment locations were utilized to check for the presence of partial discharge (PD). Points at which sensors were attached are documented in this report, and are referred to as points of attachment (POA). The following color codes are used in this report to categorize PD severity:

Red	Significant PD detected, immediate action recommended
Orange	Intermediate levels of PD detected, take action as feasible, retest in 6 months recommended
Yellow	Moderate levels of PD detected, retest in 12-18 months recommended
Green	Non-significant levels of PD detected, retest in 36 months recommended

1.2 FINDINGS

During this project 33 POAs were tested. A summary of findings is shown below. Appendix B provides a complete listing of the results for each POA.

Red	Significant PD was detected at one (1) POA
Orange	Intermediate levels of PD were detected at twenty-five (25) POAs
Yellow	Moderate levels of PD were detected at four (4) of the POAs
Green	Non-significant levels of PD were detected at three (3) POAs

1.3 RECOMMENDATIONS

Significant levels of PD were detected at POA 18. This POA was located at the line side termination of the Chiller Bus Disconnect in Cramer Hall. ERS recommends that PSU consider inspecting/replacing this cable/termination at the earliest opportunity. See Section 5 for additional information.

Recommendations regarding the 25 POAs where intermediate, and the 4 POAs where moderate levels of PD were detected, are provided in Section 5.

2 OBJECTIVES

The purpose of this project was to detect and characterize PD levels occurring on or within medium voltage (MV) power distribution circuits. Evaluation of partial discharge data and the trending of that data over time provide powerful condition assessment information. Trended data can contribute significantly to decisions regarding repair, replacement, and remaining life.

3 SERVICE DESCRIPTION

This project was initiated by Mr. Richard Grabill of EC Company. Data acquisition was conducted by Electrical Reliability Services Field Engineer Mr. Shane Smith between January 2, 2013 and January 3, 2013.

4 PROCEDURES

4.1 TEST POINTS

Test locations were identified as a Points of Attachment (POAs) and uniquely numbered. Each of the phase cables were also identified. Photos of the POA locations were taken and are kept with the project information located in the ERS office file. The POA numbering system is shown in Appendix B.

4.2 PD DETECTION – OVERVIEW

At this location, HFCT sensors are permanently attached to medium voltage cable terminations to check for the presence of partial discharge (PD). These sensors are connected via coax cable to a digital oscilloscope that is used to detect and record the PD signals.

4.3 PD DETECTION – SENSORS

Split-core radio frequency current transformers (HFCTs) have been permanently attached near cable terminations to the ground or drain wires (generally one per phase) which are connected to the metallic shields of the medium voltage cables. HFCT measurements are recorded in units of picoCoulombs (pC). Where necessary, other sensor locations can be used. Alternate locations might include placing an HFCT around the cable (but below the stress cone connection) or around a grouped shield ground conductor. Such alternative placements would depend upon the cable configuration and options for safe placement of the sensor. HFCT sensors detect high frequency (capacitive) currents as they flow to ground over the cable's metallic shield and the ground

conductor. These high frequency currents (signals) are produced primarily by PD occurring in voids within the cable or terminations. The HFCTs provide a voltage (millivolt) output which is converted to picoCoulombs (pC) by software installed on the oscilloscope.
In addition to the use of the sensors described above, a radio frequency detector called a Transient Earth Voltage (TEV) detector, is attached to the enclosure steel. In cases where it is unsafe to attach HFCTs to the shield drain wires and cases where the project scope calls for only the use TEV detectors, no HFCTs were used. TEV sensors can be magnetically attached to the enclosure surface. TEV sensors detect airborne signals produced by PD occurring within the switchgear or other equipment enclosure. Such signals are produced primarily by surface tracking, corona or terminations. The TEV sensors produce a voltage (millivolt) output which is converted to decibels (dB) by software installed on the oscilloscope.

4.4 PD DETECTION – DATA ACQUISITION AND ANALYSIS

The PD measurement system incorporates a wideband (0-400 MHz) high-speed Digital Storage Oscilloscope (DSO) to capture high-resolution measurements of PD signals. After collection of the PD signals, a range of analysis software is used to evaluate and categorize the data. The software utilizes a PD “Event Recognition” module to find short duration, high frequency pulses which have a peak of at least twice the standard deviation and classify them. Screen shots of example signals are shown below.

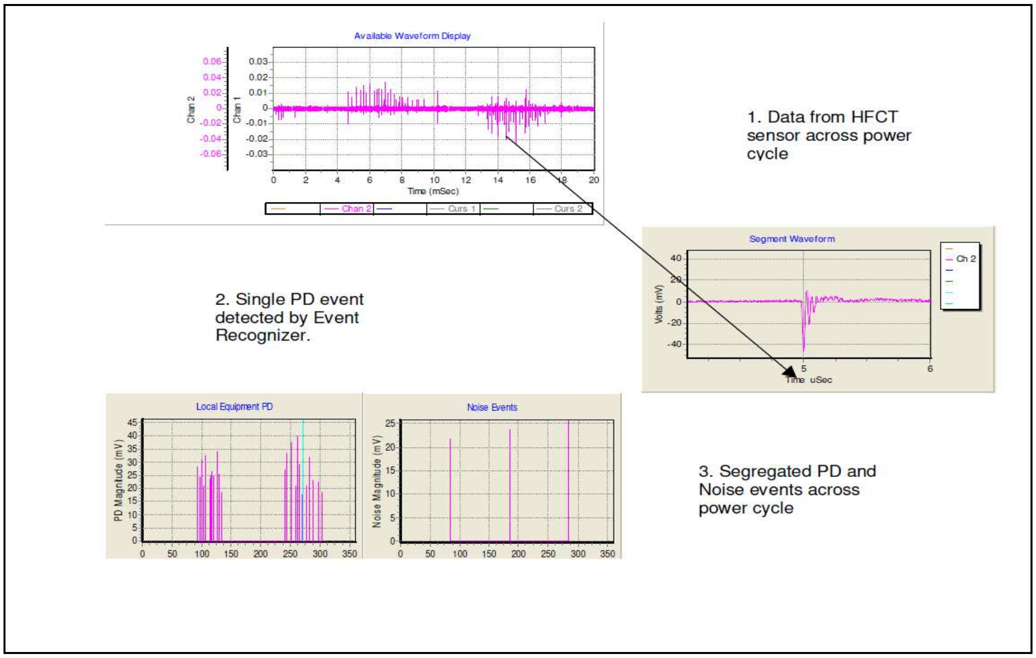


Figure 1 – Screen shots of PD signals.

Signals are analyzed based on pulse magnitude, shape (frequency), and timing (with respect to the 60 cycle phase current), to determine if they represent radio frequency noise or partial discharge signals. The “Event Recognition” software uses algorithms to categorize PD signals into the red, orange, yellow, or green severity categories described in Section 1. This software also categorizes PD signals as “Cable” or “Local.” This categorization helps differentiate between PD that is ”cable” – PD occurring within the cable somewhere along the circuit between terminations, or PD that is “local” – PD occurring in the connected equipment (e.g. switchgear, MCC or transformer) or in the terminations. “Local” PD is detected primarily via the TEV sensors. “Cable” and “Local” PD severity classifications are then assigned based primarily on the magnitude of the PD signal. The following tables show the relationship between PD magnitude and severity category.

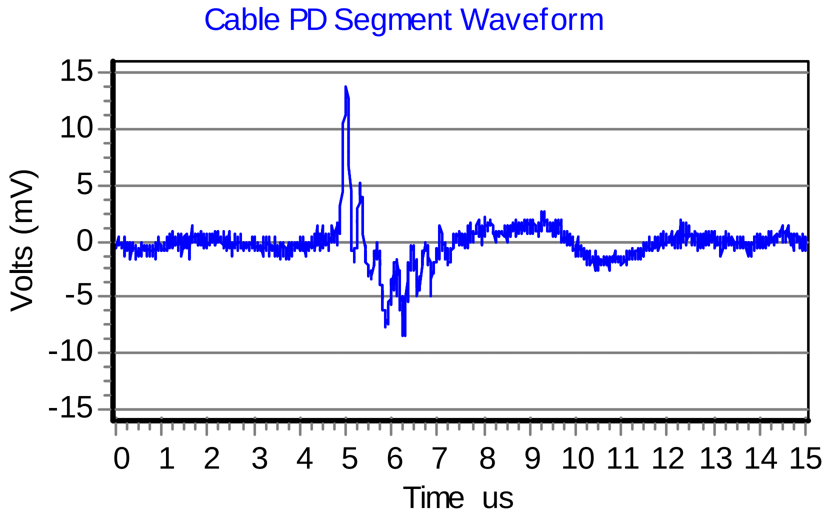
"Cable" PD (e.g. PD occurring within the cable somewhere along the circuit between terminations) Signal Magnitude	**"Local PD"** (e.g. PD occurring at switchgear, MCCs, transformers and terminations) Signal Magnitude	**Category of PD Severity**
>500 pC	>30 dB	Red
350 – 500 pC	15 dB – 30 dB	Orange
250 – 350 pC	10 dB – 15 dB	Yellow
0 – 250 pC	0 dB – 10 dB	Green

Note: These values are based on the testing and experience of the OLPD test equipment manufacturer.

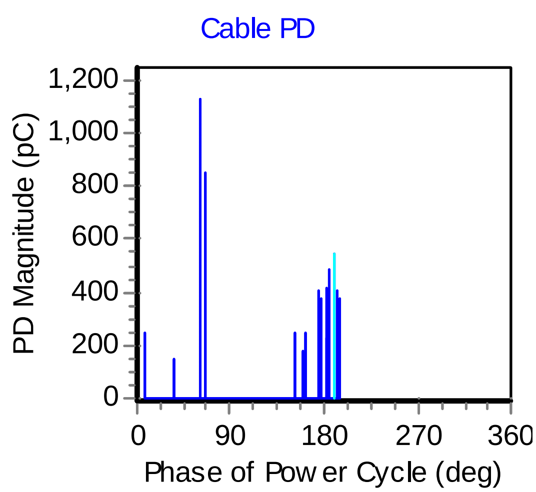
5 RESULTS AND RECOMMENDATIONS

5.1 POAs WITH SIGNIFICANT PD OF LEVELS – CATEGORY "RED"

PD levels at only 1 POA were of a magnitude that resulted in severity category "RED." POA 18 is located at the line side of the Chiller Bus Disconnect of Cramer Hall. The Channel 3 HFCT detected a PD magnitude of 544pC of cable PD. Since the TEV sensor detected no PD, and since on a graph of the 60Hz power frequency current, the PD detected by the HFCT was greatest near 0 degrees (PD that occurs around 0 and/or 180 degrees is generally indicative of a void in the insulation), it is most probable that the source of this PD is located within the termination of this cable. See graphs shown below.



POA 18 Line side Chiller Bus Disconnect - Cramer Hall. 14mV at 189°, 1.06MHZ, segment 3489



POA 18 Line side Chiller Bus Disconnect - Cramer Hall. Channel 3 HFCT, 544pC at 189°

ERS recommends that PSU consider replacing this cable, and improving the termination method on the line side in the process. See Appendix A for additional information.

5.2 POAs WITH INTERMEDIATE LEVELS OF PD – CATEGORY "ORANGE"

PD levels at 25 POAs were of a magnitude that resulted in severity category "ORANGE." See Appendix A. ERS recommends that these POAs be inspected, cleaned and repaired/replaced as appropriate during the next maintenance opportunity. OLPD re-testing should be performed following this maintenance work. If maintenance work is not practical, ERS recommends these POAs be re-tested within 6 months.

Many of these locations had signals that appeared to come from an outside source, mostly centered around 16MHz. Based on the condition of the equipment and lack of recent maintenance activity, the values obtained were taken at face value. Ideally maintenance should be performed followed by follow up PD testing, but if this is not possible within the next 12 months, PD testing should be repeated for trending purposes.

5.3 POAs WITH MODERATE LEVELS OF PD – CATEGORY "YELLOW"

PD levels at 4 POAs were of a magnitude that resulted in severity category "YELLOW." See Appendix A. ERS recommends that these POAs be re-tested within 12 to 18 months.

5.4 POAs WITH NON-SIGNIFICANT LEVELS OF PD – CATEGORY "GREEN"

For the 3 POA locations where no or non-significant levels of PD were detected (severity category "GREEN"), ERS recommends that a follow-up partial discharge measurement be performed within three years. Such testing will verify the effectiveness of preventive maintenance and establish a new data set to permit future trending and assessment of equipment/cable system health.

5.5 OTHER RECOMMENDATIONS

Please see the ERS report regarding permanent sensor installation for more discrepancies noted during the inspection.

Appendix A Trending Data

Client:	EC Company	Job Number:	3167064
Location:	Portland State University	Date:	1/2/2013 – 1/3/2013
Engineers:	Shane Smith	Test Equipment	LECROY,WR44XI-A LCRY0617N52765,6.2.1.2.1

POA Number	Equipment Designation (LN = line LD = load)	Test Date January 2-3, 2013		Test Date XX/XX/XX PD Magnitude	Test Date XX/XX/XX PD Magnitude	Test Date XX/XX/XX PD Magnitude	Test Date XX/XX/XX PD Magnitude	Notes
		Cable PD (pC)	Local PD (dB)					
POA 1	SB1 fdr B LD	80pC	22db					
POA 2	SB1 Fdr A LD	126pC	22db					
POA 3	Lincoln fdr LN	220pC	23db					
POA 4	SB1 fdr LN	0pC	23db					
POA 5	Heat Plant fdr A LN	147pC	18db					
POA 6	SRTC SWBD 1-4 LN	0pC	21db					
POA 7	SB1 fdr B LN	0 pC	20db					
POA 8	Heat Plant fdr B LN	193pC	22db					
POA 9	SRTC SWBD 5 LN	0pC	22db					
POA 10	SRTC SWBD 1-4 LD	28pC	14db					
POA 11	SRTC SWBD 5 LD	0pC	9db					

Online Partial Discharge Testing

POA Number	Equipment Designation (LN = line LD = load)	Test Date January 2-3, 2013		Test Date XX/XX/XX PD Magnitude	Test Date XX/XX/XX PD Magnitude	Test Date XX/XX/XX PD Magnitude	Test Date XX/XX/XX PD Magnitude	Notes
		Cable PD (pC)	Local PD (dB)					
POA 12	Cramer fdr B LN	0 pC	19dB					
POA 13	Cramer fdr A LN	0 pC	17db					
POA 14	Parking 2 fdr LD	225 pC	9db					
POA 15	Lincoln fdr LD	198pC	17dB					
POA 16	Parking 2 LN	76pC	27dB					
POA 17	Neuberger/ Smith fdrs LN	0pC	17dB					
POA 18	Chiller Bus Disconnect fdr LD	544pC	25dB					
POA 19	Chiller bus fdr LN	0pC	23dB					
POA 20	Cramer fdr B LD	19pC	23dB					
POA 21	Cramer ATS LD	23pC	22dB					
POA 22	Cramer fdr A LD	189pC	22dB					
POA 23	Chiller Bus fdr LD	92pC	20dB					
POA 24	Smith fdr LD / Library East fdr LN / Student Union fdr LN	0pC	19dB					
POA 25	Student Union fdr LD	0pC	14dB					
POA 26	Neuberger Jmpr LN	16pC	23dB					
POA 27	Neuberger Jmpr LD	0pC	14dB					

Online Partial Discharge Testing

POA Number	Equipment Designation (LN = line LD = load)	Test Date January 2-3, 2013		Test Date XX/XX/XX PD Magnitude	Test Date XX/XX/XX PD Magnitude	Test Date XX/XX/XX PD Magnitude	Test Date XX/XX/XX PD Magnitude	Notes
		Cable PD (pC)	Local PD (dB)					
POA 28	Stott fdr LN	68pC	23dB					
POA 29	Heat Plant fdr A LD	48pC	23dB					
POA 30	Heat Plant fdr B LD	0pC	25dB					
POA 31	Millar fdr LD	100pC	27dB					
POA 32	Stott fdr LD	109pC	14dB					
POA 33	Millar fdr LN	23pC	9dB					

APPENDIX B: CABLE DATA

Client:	EC COMPANY	Job Number:	3167064
Location:	PORTLAND STATE UNIVERSITY	Date:	12/29/2012
Engineers:	SHANE T. SMITH	Test Equipment	LECROY,WR44XI-A LCRY0617N52765,6.2.1.2 .1
Source: COLLECTED DURING SENSOR INSTALLATION			

LOCATION	From	To:	Length in feet	Insulation	Wire Size	Manufacturer Date / Notes
SB1 FDR A	SRTC	SB1	350	EPR	4/0 AL	OKONITE 1C/PHASE
SB1 FDR B	SRTC	SB1	350	EPR	4/0 AL	OKONITE 1C/PHASE
LINCOLN HALL FDR	SB1	LINCOLN HALL	850	EPR	#2 CU	PIRELLI 1C/PHASE 2000
SWBD 1-4 FDR	SRTC	SWBD 1-4	140		4/0 CU	VULKENE, 1C/PHASE PROBABLY EP INSULATION
SWBD 5 FDR	SRTC	SWBD 5	190	EPR	#2 CU	SOUTHWIRE 1C/PHASE
HEAT PLANT FDR A	SRTC	HEAT PLANT	1000	EPR	4/0 CU	BICC 1C/PHASE
HEAT PLANT FDR B	SRTC	HEAT PLANT	1000	EPR	4/0 CU	BICC 1C/PHASE

Online Partial Discharge Testing

Client:	EC COMPANY	Job Number:	3167064
Location:	PORTLAND STATE UNIVERSITY	Date:	12/29/2012
Engineers:	SHANE T. SMITH	Test Equipment	LECROY,WR44XI-A LCRY0617N52765,6.2.1.2.1
Source: COLLECTED DURING SENSOR INSTALLATION			

LOCATION	From	To:	Length in feet	Insulation	Wire Size	Manufacturer Date / Notes
CRAMER HALL FDR A	SRTC	CRAMER HALL	1000		350 CU	APPEARED TO BE EPR SPLICE TO LEAD SHEATHED CABLE AT LOAD SIDE. LINE SIDE WAS 350 AL W/ EPR INSULATION
CRAMER HALL FDR B	SRTC	CRAMER HALL	1000		350 CU	APPEARED TO BE EPR SPLICE TO LEAD SHEATHED CABLE AT LOAD SIDE. LINE SIDE WAS 350 AL W/ EPR INSULATION
CRAMER HALL FDR	CRAMER HALL ATS	CRAMER HALL	8	EPR	350 CU	BICC 1C/PHASE
CRAMER HALL CHILLER BUS DISCONNECT FDR	CRAMER HALL	CHILLER BUS DISCONNECT	50	EPR	4/0 CU	BICC 1C/PHASE
CRAMER HALL CHILLER BUS FDR	CHILLER BUS DISCONNECT	CHILLER BUS	48	EPR	4/0 CU	INDUSTRIAL MARION 1C/PHASE

Online Partial Discharge Testing

Client:	EC COMPANY	Job Number:	3167064
Location:	PORTLAND STATE UNIVERSITY	Date:	12/29/2012
Engineers:	SHANE T. SMITH	Test Equipment	LECROY,WR44XI-A LCRY0617N52765,6.2.1.2.1
Source: COLLECTED DURING SENSOR INSTALLATION			

LOCATION	From	To:	Length in feet	Insulation	Wire Size	Manufacturer Date / Notes
PARKING #2 FDR	CRAMER HALL	PARKING #2	300	EP	1/0	ANACONDA
NEUBERGER HALL FDR	CRAMER HALL	NEUBERGER HALL	600	OIL	1/0	LEAD SHEATHED
SMITH MEMORIAL FDR	CRAMER HALL	SMITH MEMORIAL	300	OIL	1/0	LEAD SHEATHED
LIBRARY EAST FDR	SMITH MEMORIAL	LIBRARY EAST	100	OIL	1/0	LEAD SHEATHED
STUDENT UNION FDR	SMITH MEMORIAL	STUDENT UNION	200	OIL	1/0	LEAD SHEATHED
NEUBERGER HALL JUMPER	NEUBERGER HALL RM 003	NEUBERGER HALL RM 005	75			NO CABLE INFO VISIBLE
PETER STOTT FDR	HEAT PLANT	PETER STOTT	550	EP	1/0	OKONITE 1C/PHASE
MILLAR LIBRARY FDR	PETER STOTT	MILLAR LIBRARY	200			NO CABLE INFO VISIBLE

APPENDIX C: SYSTEM DRAWING

GENERAL NOTES

A. 12.47KV CABLE LENGTH IS AN ESTIMATE.

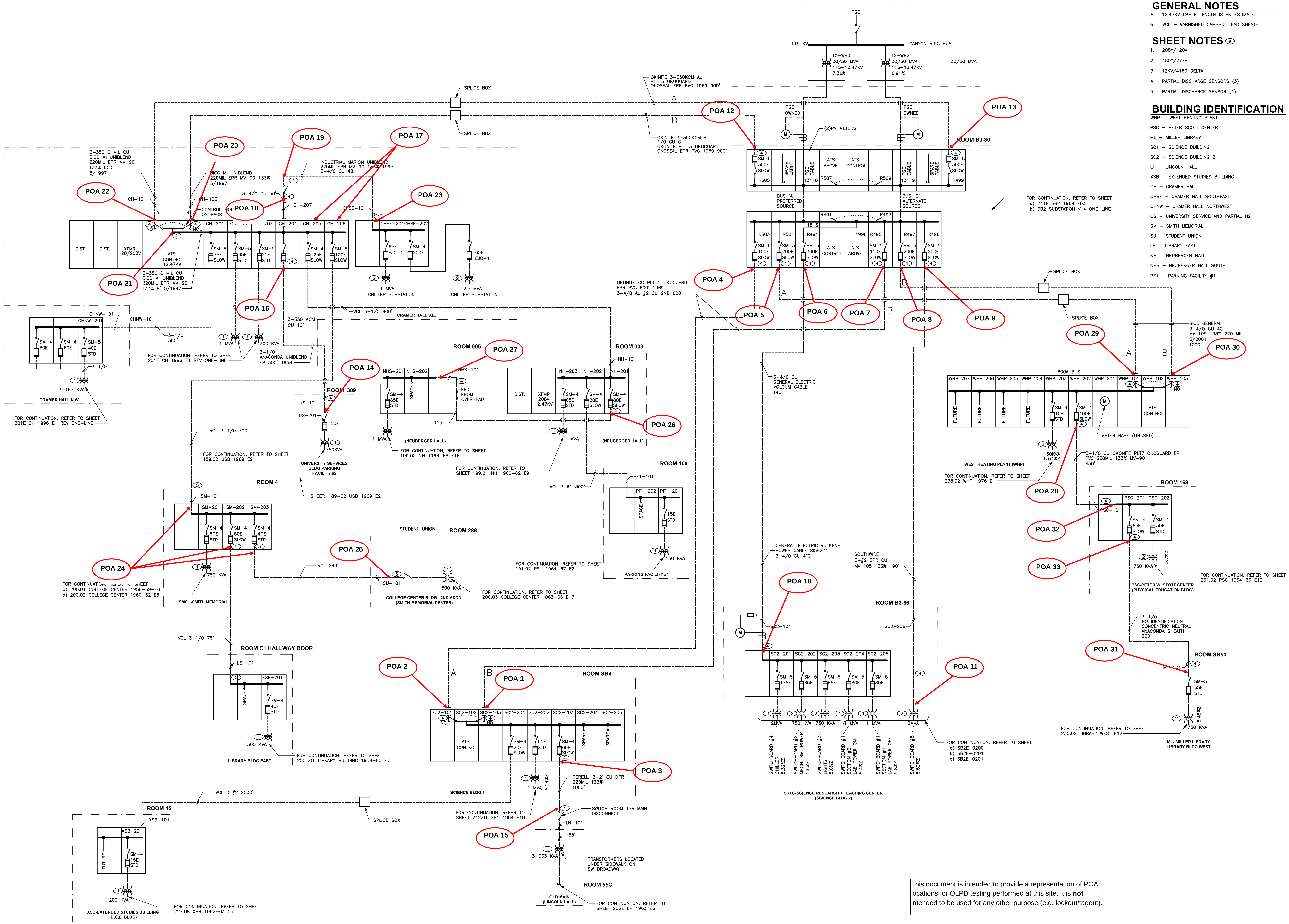
B. VCL – VARNISHED CAMBRIC LEAD SHEATH

SHEET NOTES

1. 208Y/120V
2. 480Y/277V
3. 12KV/4160 DELTA
4. PARTIAL DISCHARGE SENSORS (3)
5. PARTIAL DISCHARGE SENSOR (1)

BUILDING IDENTIFICATION

WHP – WEST HEATING PLANT
PSC – PETER SCOTT CENTER
ML – MILLER LIBRARY
SC1 – SCIENCE BUILDING 1
SC2 – SCIENCE BUILDING 2
LH – LINCOLN HALL
XSB – EXTENDED STUDIES BUILDING
CH – CRAMER HALL
CHSE – CRAMER HALL SOUTHEAST
CHNW – CRAMER HALL NORTHWEST
US – UNIVERSITY SERVICE AND PARTIAL H2
SM – SMITH MEMORIAL
SU – STUDENT UNION
LE – LIBRARY EAST
NH – NEUBERGER HALL
NHS – NEUBERGER HALL SOUTH
PF1 – PARKING FACILITY #1



This document is intended to provide a representation of POA locations for OLPD testing performed at this site. It is **not** intended to be used for any other purpose (e.g. lockout/tagout).

GLUMAC
engineers for a sustainable future

PORTLAND STATE UNIVERSITY
724 S.W. HARRISON ST. PORTLAND, OREGON

Title:

Project:

Revisions:
DRAFT 1/16/2013

Drawing No.:

Scale:

Date:

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Electrical Reliability Services, Inc.
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USA

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F (503) 659-9733
www.assetweb.com/ers

January 11, 2013

EC Company
PO Box 10286
Portland, OR 97296

Attention: Mr. Richard Grabill

Subject: OLPD Permanent Sensor Installation and MV System Inspection
Reference No.: 3167064

Dear Mr. Grabill:

Enclosed is one copy of the test report, as prepared by our lead field engineer. It was our pleasure to be of service to you on this project. If you have any questions, or if we can be of further assistance, please do not hesitate to call.

Sincerely,

Electrical Reliability Services, Inc

Larry Newby
Service Center Manager

Enclosures

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OLPD Permanent Sensor Installation, Test and MV System Inspection Report

At

Portland State University
Portland, OR

For

EC Company
PO Box 10286
Portland, OR 97296

Attention: Mr. Richard Grabill
Order No: MA S09010 JOB 74753

Reference No. 3167064

Submitted By: Shane Smith, Field Engineer

January 11, 2013

Reviewed By: Larry Newby, Service Center Manager

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1 PURPOSE

The purpose of the OLPD sensor installation is to allow for safe and easy connection for the OLPD test set during subsequent cable testing. The inspections will provide information about the overall condition of the medium voltage infrastructure throughout the Portland State campus, as well as supplementing information for arc flash evaluation. The information developed through the tests and inspections will enable decisions to be made for repairs or system modifications to ensure increased system reliability.

2 SUMMARY

This project was initiated by Mr. Richard Grabill with EC Company. All testing was performed by Electrical Reliability Services Field Engineers Mr. Scott Maynard and Mr. Shane Smith between Saturday, December 22, 2012 and Saturday, December 29, 2012.

The input and support for this project was greatly appreciated from the following people: Mr. Merv Lapp, Glumac; Mr. Charles Clayton, Mr. Mick Nelson and Mr. Quinn Soifer at PSU and especially Mr. Dave Kauss and his crew at EC Company, which resulted in a successful and incident free outcome to this project.

Please refer to Section 5, “Results and Recommendations,” for complete details of the inspection.

3 EQUIPMENT TESTED AND INSPECTED

	LOCATION	From	To:	Notes
3.1	SB1 FDR A	SRTC	SB1	3 sensors installed at both ends
3.2	SB1 FDR B	SRTC	SB1	3 sensors installed at both ends
3.3	LINCOLN HALL FDR	SB1	LINCOLN HALL	3 sensors installed at both ends
3.4	SWBD 1-4 FDR	SRTC	SWBD 1-4	3 sensors installed at both ends
3.5	SWBD 5 FDR	SRTC	SWBD 5	3 sensors installed at both ends
3.6	HEAT PLANT FDR A	SRTC	HEAT PLANT	3 sensors installed at both ends

	LOCATION	From	To:	Notes
3.7	HEAT PLANT FDR B	SRTC	HEAT PLANT	3 sensors installed at both ends
3.8	CRAMER HALL FDR A	SRTC	CRAMER HALL	3 sensors installed at both ends
3.9	CRAMER HALL FDR B	SRTC	CRAMER HALL	3 sensors installed at both ends
3.10	CRAMER HALL FDR	CRAMER HALL ATS	CRAMER HALL	3 sensors installed at both ends
3.11	CRAMER HALL CHILLER BUS DISCONNECT FDR	CRAMER HALL	CHILLER BUS DISCONNECT	3 sensors installed at load side only
3.12	CRAMER HALL CHILLER BUS FDR	CHILLER BUS DISCONNECT	CHILLER BUS	3 sensors installed at both ends
3.13	PARKING #2 FDR	CRAMER HALL	PARKING #2	3 sensors installed at both ends
3.14	NEUBERGER HALL FDR	CRAMER HALL	NEUBERGER HALL	No sensors installed
3.15	SMITH MEMORIAL FDR	CRAMER HALL	SMITH MEMORIAL	1 sensor installed at load side
3.16	LIBRARY EAST FDR	SMITH MEMORIAL	LIBRARY EAST	1 sensor installed at line side
3.17	STUDENT UNION FDR	SMITH MEMORIAL	STUDENT UNION	1 sensor installed at both ends
3.18	NEUBERGER HALL JUMPER	NEUBERGER HALL RM 003	NEUBERGER HALL RM 005	3 sensors installed at both ends
3.19	PETER STOTT FDR	HEAT PLANT	PETER STOTT	3 sensors installed at both ends
3.20	MILLAR LIBRARY FDR	PETER STOTT	MILLAR LIBRARY	3 sensors installed at both ends
3.21	XSB FDR	SB1	XSB	Inspection only

4 PROCEDURES

4.1 Equipment Inspection

4.1.1 Identify circuit for inspection at both ends

4.1.2 Open line side disconnect device

4.1.3 Verify zero energy state with contact meter

4.1.4 Barricade energized line side as necessary to mitigate arc flash hazard

4.1.5 Inspect the following areas for discrepancies

.1 Cable bend radius and support
.2 Contamination of insulated parts
.3 Fuse and switchblade contacts
.4 Evidence of overheating, corona discharge, or other damage electrical components
.5 General integrity of all switch components and accessories

4.1.6 Perform minor cleaning and/or maintenance as time and safe work practices allow

4.2 Sensor Installation

4.2.1 Remove drains from ground at one end of circuit and perform shield continuity test

4.2.2 Attach HFCT 100-50 with BNC coax connector around each accessible shielded conductor drain

4.2.3 Install pre-fabricated BNC panel mount plate

4.2.4 Route coax conductors from HFCTs to connection plate and secure to switchgear with tie wraps as necessary to ensure spacing from energized parts, and include strain relief where mounting plate is attached to moving parts.

4.2.5 Label BNC ports as necessary following standard convention of left to right, top to bottom, and front to back.

5 RESULTS AND RECOMMENDATIONS

The following is a list of problems discovered during this testing project along with any corrective action that was made by Electrical Reliability Services. Those corrections beyond the scope of the project that require your additional corrective action are in bolded text.

If the equipment tested in Section 3 is not discussed in this section, the results of the tests indicate the equipment to be satisfactory.

5.1 The majority of the equipment inspected was noted to be contaminated by dirt and dust to varying degrees. All of the switches operated adequately with the exception of those noted below.

It is recommended that a regular maintenance cycle be developed to clean and test the medium voltage equipment at this location on an interval not to exceed five (5) years.

5.2 The following locations had inadequate cable and/or bus bracing, which could result in damage to cables and switchgear in the case of a fault condition downstream or seismic activity.

- SB1 Alternate feeder load side in building SB1
- SB1 Primary feeder in building SB1
- Peter Stott feeder in Peter Stott

Properly insulated bracing should be installed to prevent undue damage at these locations.

5.3 The protective jacket covering the stress cone on A phase at SWBD 1-4 in SRTC was found cut open along the top ten (10) inches. There also appeared to be nicks in the insulation underneath.

The existing stress cone should be removed, the insulation sanded and cleaned, and a new stress cone installed to prevent damage and contamination of this termination.

5.4 It was noted that the Chiller Bus in Cramer Hall was an addition to the existing system, and creates a failure point that could cause a loss of power to multiple buildings.

An electrical design engineer should be consulted to determine the best way to provide power to all of the existing systems while still maintaining coordination such that a fault will be isolated to the

smallest portion of the electrical system as possible (e.g. an existing switch in the Cramer Hall 15kV SWGR is used to feed a new switchgear that can feed the load previously fed from Cramer Hall and the Cramer Hall Chiller bus, and also provide room for future expansion).

5.5 The Cramer Hall Chiller Bus disconnect switch did not operate properly. It is a direct drive device and appears to be out of sync on the close cycle, resulting in a failure to close without outside mechanical influence.

This switch should not be operated under load until repairs can be made or the switch is replaced. A warning tag should be attached to the front of the switch indicating to "isolate all load from this switch before operating".

5.6 The following switches did not operate properly, but were temporarily corrected by exercising and in some cases lubricating:

- Neuberger Hall line side in Cramer Hall
- Neuberger Hall Jumper load side in Neuberger Hall
- Library East line and load side in Smith Memorial
- Millar Library load side in Millar Library

These switches should not be operated under load until maintenance has been performed, and their reliability is assured.

5.7 The Cramer Hall 15kV automatic transfer switch did not operate in auto mode. It would not transfer to either source unless operated manually. It appeared as if the voltage sensing modules may have been installed or setup improperly.

Until the automatic controller can be repaired or replaced, written instructions should be placed at the controller for manual transfer and appropriate personnel should be trained for the eventuality of a primary feeder outage.

5.8 The Millar Library line side disconnect in Peter Stott does not have proper interlocking installed. The energized fuse section is freely accessible with the switch in the closed section.

This presents a safety hazard to non-qualified personnel who may have access to the area and should be corrected as soon as possible. A warning sign should be attached to the compartment door indicating "Open switch and test for no Voltage prior to accessing internal parts".

5.9 The disconnect switch and jumpers at the XSB building transformer were inspected and the cabling was found to be installed incorrectly, which will eventually result in a failure at this point (please see pictures below).

The jumpers to the line side of the switch and from the load side to the transformer should be removed and replaced. When new cables are installed, care should be taken to maintain proper clearances phase-to-phase and phase-to-ground.