CITY OF TAMPA

HOWARD F. CURREN AWTP PHASE 2 MASTER PLAN REPORT

FINAL DRAFT—VOLUME 3 | RFQ 15-D-00013

JUNE 2018

McKIM&CREED

Hazen

Appendix B

Howard F. Curren AWTP Master Plan

Process Model Sampling and Calibration Report

July 2017

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CITY OF TAMPA

HOWARD F. CURREN AWTP MASTER PLAN

Contract 15-D-00013

Process Model Sampling and Calibration

July 2017
Final

McKIM&CREED

Hazen

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List of Acronyms

Abbreviation	Definition
AADF	Annual Average Daily Flow
AWTP	Advanced Wastewater Treatment Plant
BOD5	biochemical oxygen demand
CaCO3	Calcium Carbonate
CAR	CARB Train 2, Stage 4 Sample Location
CARB	Carbonaceous Reactor (High Purity Oxygen Activated Sludge)
CBOD	carbonaceous biochemical oxygen demand
CE	CARD Clarifier Effluent Sample Location
City	City of Tampa
COD	chemical oxygen demand
DAR	diffused air reactors
DFE	Denit. Filter Effluent Sample Location
DO	dissolved oxygen
EPA	Environmental Protection Agency
GTO	gravity thickener overflow
Hazen	Hazen and Sawyer
HFC AWTP	Howard F. Curren Advanced Wastewater Treatment Plant
HPOAS	High-rate high purity oxygen activated sludge
lbs	pounds (mass)
McKim	McKim & Creed
MG	million gallons
mg/L	milligrams per liter
mgd	million gallons per day
MLSS	mixed liquor suspended solids
MPS	Main Pump Station
NCE	NIT Clarifier Effluent Sample Location

Abbreviation	Definition
NI	NIT Influent Sample Location
NIC	NIT Combined MLSS Sample Location
NIT	Nitrification Tanks (Dissolved Air Reactor)
NPDES	National Pollutant Discharge Elimination System
nm	nanometer
NO_3-N	nitrate nitrogen
NO_2-N	nitrite nitrogen
NH_4-N	ammonium nitrogen
NS1	NIT Train 2, Stage 1 Sample Location
NS2	NIT Train 2, Stage 2 Sample Location
NS4	NIT Train 2, Stage 4 Sample Location
NS6	NIT Train 2, Stage 6 Sample Location
PO_4-P	ortho-phosphate
ppd	pounds per day
QA/QC	quality assurance and quality control
RAS	return activated sludge
sBOD5	soluble biochemical oxygen demand
sCOD	soluble chemical oxygen demand
scfm	cubic feet per minute at standard conditions
SM	Standard Methods
SOP	Standard Operating Procedure
SRT	solids retention time
SRS	Septage Receiving Station
SVI	sludge volume index
TKN	Total Kjeldahl Nitrogen
TP	total phosphorus
TPS	Thickened Primary Sludge

Abbreviation	Definition
TSS	total suspended solids
TS	total solids
TWAS	thickened waste activated sludge
VFA	Volatile Fatty Acids
VSS	volatile suspended solids
VS	volatile solids
WAS	waste activated sludge
WERF	Water Environment and Reuse Foundation
XX	unfiltered
XG	glass fiber filtered
XM	membrane filtered
XF	floc filtered

1. Introduction and Background

This report describes the process model development for the City of Tampa's (City) Howard F. Curren Advanced Wastewater Treatment Plant (HFC AWTP). The City contracted with McKim & Creed (McKim) to develop a calibrated process model for HFC AWTP as a part of the Phase 2 Master Plan contract. Hazen and Sawyer (Hazen) was subcontracted through McKim to perform special sampling and process model QC.

1.1 Background

The HFC AWTP is owned and operated by the City. The plant is currently rated for 96 mgd on an annual average flow basis and the effluent is discharged to Hillsborough Bay or used for reclaimed water. The liquid stream treatment process include screening, grit removal, primary clarification, high-rate high purity oxygen activated sludge (HPOAS) for carbon removal, conventional activated sludge for nitrification, denitrification filters with methanol addition and chlorine disinfection. Solids stream processes include gravity thickening of waste activated sludge (WAS), digestion, belt filter press dewatering. Residuals generated by this facility can be heat dried to meet Class AA standards for distribution or can be dewatered for land application as a Class B residual. An aerial photograph of the plant is shown in **Figure 1-1.**

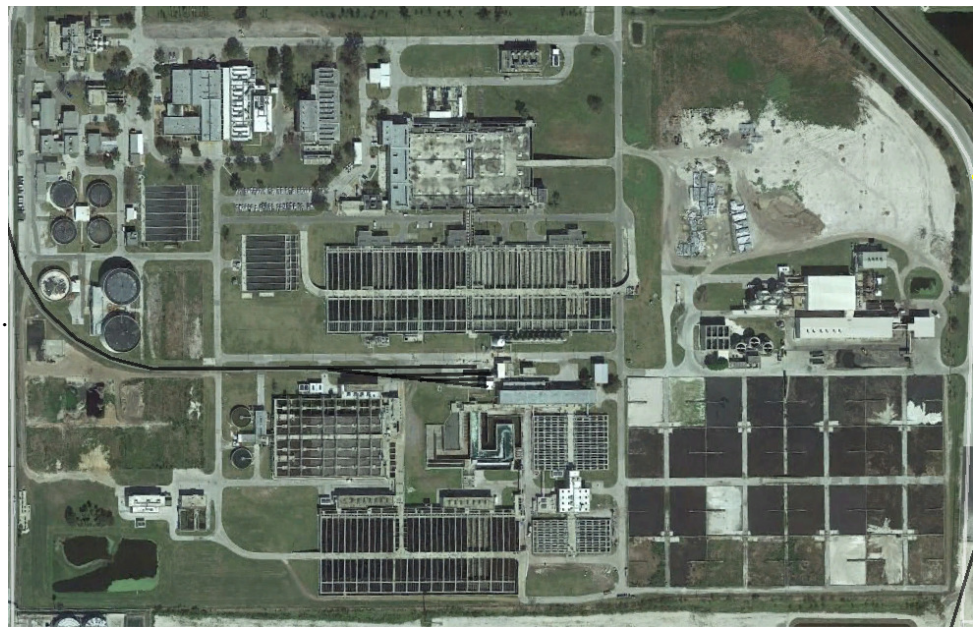

Figure 1-1: Aerial Photograph of HFC AWTP

The HFC AWTP is permitted to discharge of 96 mgd annual average daily flow (AADF) of treated municipal and industrial wastewater to Tampa Bay and 12.6 MDG AADF to reuse water systems under the current National Pollutant Discharge Elimination System (NPDES) permit. Select parameters from HFC AWTP's current permit limits are summarized in presented in **Table 1-1**.

Table 1-1: HFCAWTP NPDES Permit Limits

Water Quality Parameter	Surface Water Discharge Limit (Annual Average)	Surface Water Discharge Limit (5 year Average)	Reclaimed Water Limit (Annual Average)
Carbonaceous 5 day BOD, mg/L	5.0 mg/L	--	20 mg/L
Total Suspended Solids (TSS), mg/L	5.0 mg/L	--	5.0 mg/L
Total Nitrogen, mg/L	3.0 mg/L	213.2 tons/yr	--

During Phase 1 of the Master Plan a detailed review of the existing processes at HFC AWTP was performed. A summary of the findings and an in depth analysis of the most recent historical data is presented in the August 2016 *Existing Systems Technical Memorandum of Findings*. The Phase 1 evaluation identified limitations with the existing GPS-X process model that need to be improved to proceed with the treatment alternative analysis. The original model was developed during the diffused air reactors (DAR) Aeration Improvements Project and was a partial plant model that does not include primary, tertiary or biosolids handling processes.

The update to the process model calibration completed under the Phase 2 Master Plan involved the following major activities:

- Update and expansion of the existing process model layout
- Detailed special sampling completed over one week in February 2017
- Calibration of process model to steady-state and dynamic conditions

1.2 Report Contents

Sections and associated content of this report include the following:

1. **Introduction/Background** – Project background and overall objectives.
2. **Special Sampling Procedures**– Summary of the special detailed sampling at the plant and procedures used during the sampling and analysis.
3. **Special Sampling Results**– Review/analysis of special sampling data.
4. **Model Setup and Calibration** – Setup of the model in GPS-X® and the calibration of the model to the historical and special sampling data.

2. Special Sampling Procedures

Wastewater process models use a detailed fractionation of the influent wastewater to predict process performance. Influent loadings are typically broken into multiple components, most of which are most commonly related to chemical oxygen demand (COD). Fractions of particulate, soluble, colloidal constituents are needed to partition organic and refractory components. In addition, biodegradable, readily biodegradable, slowly biodegradable, and non-biodegradable fractions are also defined.

Special sampling is typically performed prior to process model calibration to gather the necessary detailed influent wastewater characterization data, as well detailed process performance data throughout the plant. Sampling is focused on characterizing the properties of samples throughout the plant, consistent with Water Environment and Reuse Foundation (WERF) Level 3 calibration. It is important that good quality and representative data be collected at this stage to ensure an accurate model calibration.

A full week of process sampling was completed to gather information necessary for process model calibration on February 19-26, 2017. A follow up week of sampling was performed April 4-6, 2017. During the sampling periods, the plant was operated in dry weather mode. Prior to obtaining samples, a special sampling plan was submitted to the City for review and subsequently approved. This section summarizes the sampling plan, sampling and analysis procedures, and quality assurance/quality control practices. This data is presented in Section 3.1.1.

2.1 Special Sampling Plan

The sampling plan was prepared to capture details of significant processes at HFC AWTP. This included composites, process grabs, diurnals, and sidestream samples. Constituents measured included the following:

- TSS
- VSS
- CBOD
- BOD
- TKN
- NH_3-N
- NO_3-N
- NO_2-N
- TP
- PO_4-P
- COD
- TS
- VS
- pH
- Alkalinity
- Calcium
- VFA
- Magnesium
- DO

Four different sample preparation and filtering steps were used in the analysis. These are presented below along with the symbols used in the sampling plan.

- XX – Unfiltered/raw sample
- XG – Glass fiber filter using a 1.5 µm porous size filter
- XM – Membrane filter using a 0.45 µm porous size filter
- XF – Floc filtered; zinc sulfate is used to precipitate solids before filtering using a 0.45 µm porous size filter

The complete sampling plan is located in **Appendix A**. A visual representation of the sampling plan is shown in **Figure 2-1**. Hazen/McKim analyzed a portion of samples onsite, the City analyzed a portion of samples onsite and the remaining samples were sent to a third party laboratory, Test America, for analysis. Approximately 1,800 analyses were performed during the special sampling week; about 900 of those analyses were performed by Hazen/McKim, about 800 by the City lab, with the remaining 74 by Test America.

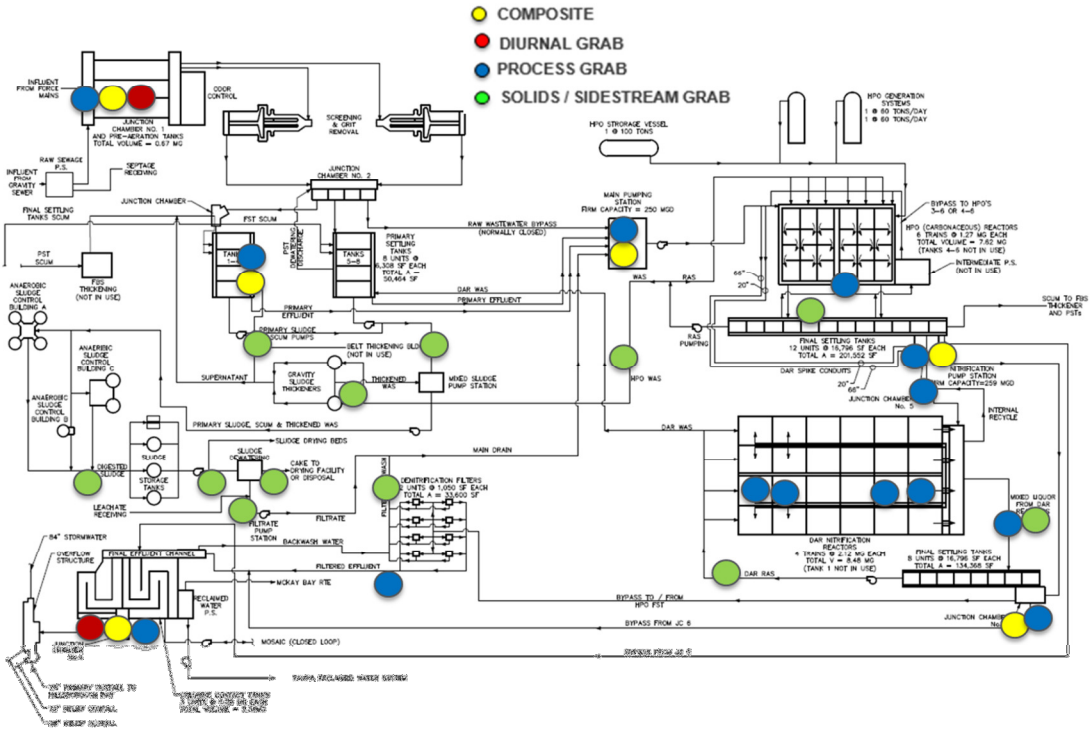

Figure 2-1: Sample Collection Locations

2.1.1 Composite Samples

Samples were collected at midnight every day, corresponding to the time of normal plant collection. The composite samples were collected from six process locations.

Plant Influent Composite Sample – The plant influent composite sample was split from the plant influent composite sampler by the plant operators. Plant influent is collected by hand from a location just upstream of grit removal to a jug, inside a cooler full of ice. It is a flow weighted composite.

Primary Effluent Composite Sample – The primary effluent composite sample was collected by a portable composite sampler by the plant operators. The sample is pumped to a time-based composite sampler from the Primary Clarifier Nos. 1-4 effluent channel. During the sampling week, the recycle streams that are typically directed to this channel were routed to Primary Clarifiers 5-8. The primary effluent composite sampler is shown in **Figure 2-2.**

Figure 2-2: Primary Effluent Composite Sampler

Main Pump Station Composite Sample – The Main Pump Station composite sample was split from the plant composite sample by the plant operators. This time-based sample is collected and composited by hand by the plant operators.

Carbonaceous Clarifier Effluent Composite Sample – The Carbonaceous Clarifier effluent composite samples were split by the operators. The operators collect a sample by hand and place in a beaker on ice in a cooler.

Nitrification Clarifier Effluent Composite Sample – The Nitrification Clarifier effluent composite samples were split by the operators. The operators collect a sample by hand and place in a beaker on ice in a cooler.

Final Effluent Composite Sample- The final effluent composite samples were split from the plant composite sampler by the operators.

2.1.2 Process Grab Samples

During the special sampling event, process grabs were collected on two days. On each process grab day, grab samples were collected twice a day from fourteen (14) locations.

- Plant Influent
- Primary Effluent
- Main Pump Station
- Carbonaceous Combined Effluent
- Carbonaceous Clarifier Effluent
- Nitrification Influent
- Nitrification Train 2, Stage 1
- Nitrification Train 2, Stage 2

- Nitrification Train 2, Stage 4
- Nitrification Train 2, Stage 6
- Nitrification Combined MLSS
- Nitrification Clarifier Effluent
- Denitrification Filter Effluent
- Final Effluent

Plant influent grab samples were collected from the same location as the composite sample. The plant influent sample was collected from the hatch in the aluminum plate on top of the Junction Chamber No. 1 (**Figure 2-3**).

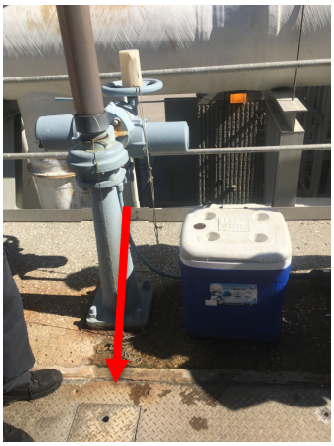

Figure 2-3: Plant Influent Grab Sample Location

The primary effluent grab samples were collected from the same location as the composite sample. The sample was collected from the location shown in **Figure 2-4**.

Figure 2-4: Primary Effluent Grab Sample Location

Main Pump Station grab samples were collected at the same location as the composite sample. The sample location is shown in **Figure 2-5.**

Figure 2-5: Main Pump Station Grab Sample Location

The Carbonaceous Effluent sample location is shown in **Figure 2-6.**

Figure 2-6: Carbonaceous Effluent Grab Sample Location

The Carbonaceous Clarifier Effluent sample location is shown in **Figure 2-7**.

Figure 2-7: Carbonaceous Clarifier Effluent Grab Sample Location

The nitrification influent grab samples were collected from JC5. To profile biological treatment through the nitrification reactors, process grabs were collected from Nitrification Train 2 (**Figure 2-8**). Samples were collected from the first stage, the beginning of the second stage, the beginning of the third stage and the end of the fourth stage.

Figure 2-8: Nitrification Train 2, Stage 1 Grab Sample Location

Process grabs were collected from the Nitrification Combined MLSS shown in **Figure 2-9**.

Figure 2-9: Nitrification Combined MLSS Grab Sample Location

Process grabs were collected from the Nitrification Clarifier Effluent from the sample sink shown in **Figure 2-10**.

Figure 2-10: Nitrification Clarifier Effluent Grab Sample Location

Grab samples of the denitrifcation filter effluent were collected from the sample sink shown in **Figure 2-11**.

Figure 2-11: Denitrification Filter Effluent Grab Sample Location

Grab samples of the final effluent were collected from the sample spigot shown in **Figure 2-12**.

Figure 2-12: Final Effluent Grab Sample Location

2.1.3 Diurnals

Diurnal samples were collected two days during the special sampling event – Monday and Wednesday.

Two locations were selected for diurnal sample locations, plant influent and final effluent. Plant operators collected samples from Junction Chamber No. 1 location by hand every two hours. This location is shown in **Figure 2-3.** A discrete sampler was set up at the final effluent and programmed to collect approximately 2 liters of sample every 2 hours. This sample location is shown in **Figure 2-13**.

Figure 2-13: Final Effluent Discrete Sampler

2.1.4 Sidestream Samples

Sidestream samples for Carbonaceous MLSS, Carbonaceous RAS/WAS, NIT MLSS, NIT RAS/WAS, primary sludge, digested sludge (**Figure 2-15** and **Figure 2-16**), cake (not pictured), dewatering filtrate (**Figure 2-17**) and thickened WAS were collected three times a day every day and analyzed by City staff. The primary sludge was sent to Test America for analysis (**Figure 2-14**).

The pH of the individual digested sludge was taken by Hazen. GTO and filter backwash (**Figure 2-18**) were collected three times a day every day by Hazen/McKim and City staff and analyzed by Hazen. The dewatering feed (**Figure 2-19**) was collected by Hazen/McKim and analyzed by the City lab.

Figure 2-14: Primary Sludge Sample Location

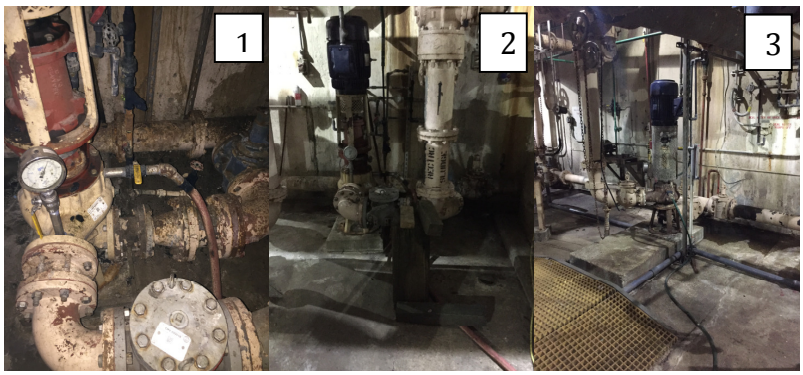

Figure 2-15: Digested Sludge Sample Location (1-3)

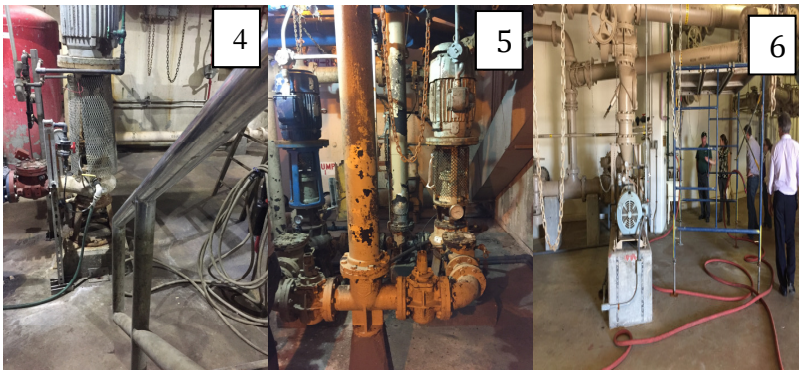

Figure 2-16: Digested Sludge Sample Location (4-6)

Figure 2-17: Dewatering Filtrate Sample Location

Figure 2-18: GTO Sample Location

Figure 2-19: Dewatering Feed Sample Location

2.2 Sampling Procedures

Samples were collected in polypropylene containers or similar, according to the sampling plan (see Appendix A) for each location and sample type (i.e., composite or grab). After sample collection, samples were split between the on-site and off-site laboratories, and prepared in accordance with Standard Methods and EPA Methods for the type of analysis being performed. As required, samples were filtered through glass fiber filters (pore size of 1.5 µm) using a vacuum pump, Buchner funnel, and Erlynmeyer flask, or through a 0.45-µm membrane filter with a 60-mL disposable luer lock syringe. Chemical precipitation by zinc sulfate and sodium hydroxide was also used on certain influent samples to remove the hydrophobic fraction, which is presumably not biodegradable. This step, when applicable, occurred prior to membrane filtration.

All samples sent for off-site analysis were preserved in accordance with Standard Methods and EPA Methods for the various analyses conducted, in containers provided by Test America. All samples were kept refrigerated at 4°C (**Figure 2-20**) until analysis and/or pickup by Test America for offsite analysis. Samples that were ready for pick up were packed in coolers with ice to maintain preservation methods.

Figure 2-20: Sample Storage

2.3 Analysis Procedures and QA/QC

Samples were analyzed onsite by Hazen/McKim personnel for COD, NH_4-N, NO_3-N, NO_2-N, PO_4-P, and TP, using HACH colorimetric test kits with a spectrophotometer. In addition, pH, temperature and DO measurements were taken as described in the sampling plan. All other sample analyses (CBOD, BOD5, TS, TSS, VSS, TKN, alkalinity, calcium, and magnesium) were conducted by the City lab or offsite by Test America in accordance with the applicable Standard Methods and EPA methods. Select samples were also split between Hazen and the City lab for duplicate analysis for COD XX, COD XG, COD XM, and COD XF as a form of QA/QC. In addition, Test America also has an internal Quality Control Program in place to estimate and control precision and bias of their analyses, including duplicate samples, multiple dilutions, method blanks and matrix spikes. Statistically-derived quality control limits are used to determine when corrective action is necessary.

2.3.1 On-Site Testing Procedures (Hazen/McKim)

All on-site analyses were performed within the appropriate hold times required by Standard Methods. All HACH TNT kits were used in conjunction with a HACH DR 2800 spectrophotometer. A DRB200 Reactor was used when digestion was required prior to colorimetric analysis. After each TNT sample vial was read in the spectrophotometer, it was removed, cleaned, and reread.

Chemical Oxygen Demand (COD) was measured using a HACH TNT 820/821/822 kit. This test involves digesting the sample for two hours at 150°C with a strong oxidizing agent (potassium dichromate). During the digestion, the oxidizable organic compounds in the sample react with dichromate, reducing it to its trivalent form (Cr3+). This produces a green color proportional to the concentration of ions, which can be detected with a spectrophotometer at 420 nm or 620 nm, depending on concentration range.

Ammonium (NH_4-N) was measured using HACH TNT 830/831/832 kit. This kit uses the salicylate method, whereby ammonium ions react with hypochlorite and salicylate ions to form indophenols, in the presence of nitroprusside. The amount of color formed is proportional to the NH_4-N concentration present in the sample, and can be read by a spectrophotometer at 690 nm.

Nitrate (NO_3-N) was measured using HACH TNT 835/836 kit. This kit uses the dimethylphenol method in which nitrate ions, in solution with sulfuric acid and phosphoric acid, react with 2,6-dimethyphenol to form 4-nitro-2,6-dimethyphenol. A spectrophotometer detects concentration at 345 nm.

Nitrite (NO_2-N) was measured using the HACH TNT 839/840 kit. In this method, nitrites react with aromatic amines to form a diazonium salt, which forms a colored complex with another aromatic compound. Test results can be measured by a spectrophotometer at 525 nm.

Ortho-Phosphate (PO_4-P) was measured using the HACH Reactive and Total Phosphorous TNT 843/844 kit. This test kit uses the Ascorbic Acid method, whereby orthophosphate reacts with molybdate and antimony ions in an acid, to produce a mixed complex. Ascorbic acid then reduces this complex, producing an intense blue color that can be read on a spectrophotometer at 890 nm. Total Phosphorus (TP) is measured by this same method; however, the method requires that all particulates and polyphosphates first be converted to orthophosphates. This can be accomplished by first digesting the sample at 100° C for one hour with acid and persulfate, prior to using the ascorbic acid method.

The pH was measured using an IntelliCAL PHC Rugged Gel Filled pH Electrode and HQ40d Portable Multiparameter Meter. DO was measured using an IntelliCAL LDO101 Rugged Luminescent Dissolved Oxygen probe and HQ40d Portable pH, conductivity, DO, ORP and ISE Multiparameter Meter. Temperature and flow rates were recorded using the plant's influent temperature gauge and flow meter.

2.3.2 On-Site Testing Procedures (City Lab)

The City lab performed on-site analyses within the appropriate hold times as required by Standard Methods and EPA regulations. Quality Control procedures varied for each test and are detailed in the Standard Operating Procedures (SOPs).

Total alkalinity was measured according to Standard Method 2320B. This test involves titration of a strong acid into a known volume of sample. The pH is monitored during the analysis, and a color indicator is added to indicate when a pH of 4.5 is reached. The recorded volume and normality of titrant is correlated to the sample alkalinity, measured as mg/L as CaCO3.

Calcium and magnesium concentrations were determined using EPA Method 200.7. This test uses inductively-coupled plasma-atomic emission spectrometry (ICP-AES) to detect element-specific atomic emission through the use of grating spectrometer and photosensitive devices. Samples must first be either digested or filtered and acid preserved prior to analysis on the instrument.

Biochemical oxygen demand (BOD) tests were used to determine the oxygen required during the biological oxidation of organic matter in wastewater. A five-day BOD test (BOD5) is performed according to Standard Methods 5210B. A volume of sample is placed in a bottle, with a standard amount of seed organisms, as well as a buffered solution of nutrients. The bottle is capped and incubated five days at 20°C. Dissolved oxygen is measured before and after the test, and the difference is reported as mg/L O_2.

Carbonaceous biochemical oxygen demand (CBOD) was also determined according to Standard Methods 5210B. This test requires the addition a nitrification inhibitor to the BOD bottles prior to incubation to ensure that only the oxygen used during the test is as a result of the oxidation of carbon.

Chemical oxygen demand (COD) was measured using EPA Method 410.4. This test utilizes a digestion in the presence of dichromate for 2 hours at 150°C followed by colorimetric determination of the sample concentration.

Total and volatile solids are measured according to Standard Methods 2540. A representative known mass of sample is dried in an oven at 103°-105° C overnight. The dried residue is then weighed and recorded as % total solids. Volatile solids are determined by subsequently igniting the dried residue in a muddle furnace at 500 +/- 50°C for one hour. The volatilized portion of the dried residue is recorded as % volatile solids.

Total suspended solids (TSS) and volatile suspended solids (VSS) are measured according to Standard Methods 2540Dand Standard Methods 2540E, respectively. A representative sample is filtered through a glass fiber filter (pore size 1.2 µm). TSS is determined by drying the filter in the oven at 103°-105° C and weighing the residue. VSS is determined by subsequently igniting the dried residue in a muffle furnace at

550°C for 20 minutes. The inert fraction remaining is weighed and then subtracted from the TSS, to yield VSS.

Total kjeldahl nitrogen (TKN) is determined according to Standard Methods 4500-NorgB and Standard methods 4500-NH3C. During this test, a sample is digested using heat, sulfuric acid, potassium sulfate and copper sulfate for 2.5 hours. During this time, any organic nitrogen is converted to ammonium sulfate. The ammonium (present as free ammonium or ammonium sulfate) in the digestate is then buffered to a pH above 11.0 and distilled into a boric acid solution. The boric acid solution is titrated with a standardized sulfuric acid solution to determine the TKN result.

2.3.3 Off-site Testing Procedures (Test America)

Test America performed offsite analyses within the appropriate hold times as required by Standard Methods. Quality Control procedures varied for each test and are detailed in the Standard Operating Procedures (SOPs).

Calcium and magnesium concentrations were determined using EPA Method 200.7. This test uses inductively-coupled plasma-atomic emission spectrometry (ICP-AES) to detect element-specific atomic emission through the use of grating spectrometer and photosensitive devices. Samples must first be either digested or filtered and acid preserved prior to analysis on the instrument.

Biochemical oxygen demand (BOD) tests were used to determine the oxygen required during the biological oxidation of organic matter in wastewater. A five-day BOD test (BOD5) is performed according to Standard Methods 5210B/EPA 405.1. A volume of sample is placed in a bottle, with a standard amount of seed organisms, as well as a buffered solution of nutrients. The bottle is capped and incubated five days at 20°C. Dissolved oxygen is measured before and after the test, and the difference is reported as mg/L O_2.

Volatile fatty acids (VFA) concentrations were measured by Test America on filtered samples. The test uses ion chromatography to measure individual short chain fatty acids including acetate, formic, lactic, n-butyric, propionic, and pyruvic.

3. Special Sampling Results

Approximately 1,800 analyses were completed during the seven day sampling period (February 19-26, 2017). The data collected is provided in electronic format in Appendix B. The data was compiled and reviewed, during which it was screened for obvious outliers, based on the following criteria:

- Filtered values greater than non-filtered values for BOD and other constituents with soluble components.
- Values significantly out of range with other parameters remaining within normal ranges (based on data on days before and after that specific sampling day).
- Ratios developed based on the data that were significantly different from typical range (e.g., BOD/TSS ratio significantly less than 0.80 or greater than 1.2).
- Values significantly different from QA/QC samples that were analyzed for the same parameter, assuming the QA/QC samples are within normal range.

For the purposes of this report, only the data set containing adjustments is presented. The reader is directed to Appendix B for a record of data that was filtered/eliminated as part of this review.

3.1 Composite Samples

Composite samples were taken daily over the seven day sampling period. Once the results were collected, the data was scrutinized based on obvious outliers and data that resulted in wastewater fractions that were out of an acceptable range (as previously presented).

The average data collected from the influent composite sample location is summarized in **Table 3-1**.

Table 3-1: Plant Influent Composite Results- Special Sampling

Parameter	Special Sampling Results
Flow, mgd	52.0
BOD XX, mg/L	263
BOD XG, mg/L	112
COD XX, mg/L	587
COD XG, mg/L	233
COD XM, mg/L	182
COD XF, mg/L	158
VFA XG, mg/L	41.4
TSS, mg/L	230
VSS, mg/L	204
TKN XX, mg/L	42.6
TKN XG, mg/L	35.4
NH3-N, mg/L	35.5
NO3-N, mg/L	0.42
NO2-N, mg/L	0.05
TP XX, mg/L	6.14
PO4-P, mg/L	3.61
Alkalinity, mg/L as CaCO3	356
Calcium, mg/L	92.5
Magnesium, mg/L	16.2

Influent soluble TKN was reported to be very close and in some cases lower the influent NH_3-N concentrations. For the purposes of model calibration influent NH_3-N values are considered to be accurate and a relationship between NH_3-N and soluble TKN was used as described in Section 4.

Aside from the two data quality issues noted above, the relative relationships between the influent parameters were consistent with expected and/or historical values. A summary of key parameter relationships is presented in **Table 3-2.**

Table 3-2: Influent Ratios Calculated from Special Sampling Composites Data

Parameter	Ratio
COD/BOD	2.25
BOD/TSS	1.16
VSS/TSS	0.89
COD/TKN	13.8
COD/NH_3	18.4
COD/TP	95.1
BOD/TKN	6.18
BOD/NH_3	7.70
BOD/TP	42.9
CODp/VSS	1.70
NH_3/TKN	0.82
PO_4/TP	0.57

A summary of the Primary Effluent composite results are summarized in **Table 3-3.**

Table 3-3: Primary Effluent Composite Sampling Results

Parameter	Special Sampling Results (mg/L)
BOD XX	163
COD XX	405
COD XG	262
COD XM	219
COD XF	199
TSS	57.4
VSS	50.0
TKN XX	39.8
NH_3-N	35.1
TP XX	5.20
PO_4-P	3.65

Primary Effluent data collected during the sampling week was consistent with a primary clarifier solids removal of about 70%. Soluble parameters, such as COD XG, NH_3-N and PO_4-P were very close to the averages measured on the influent composite samples, as expected.

Primary Effluent data is not collected on a regular basis so data for calibration was limited to what was collected during the sampling week. There were some issues throughout the sampling week with the portable sampler used to collect this data which may have impacted data quality. An additional 3 days of sample collection were performed in early April on the Influent, Primary Effluent and Main Pump Station to verify the primary clarifier removal assumptions. This data is presented in Section 3.1.1.

A summary of the main pump station (MPS) composite data is presented in **Table 3-4**.

Table 3-4: Main Pump Station Composite Sampling Results

Parameter	Special Sampling Results (mg/L)
COD XX	473
COD XG	229
TSS	127
VSS	111
TKN XX	44.3
NH_3-N	32.6
NO_3-N	0.56
NO_2-N	0.26
TP XX	6.24
PO_4-P	3.96
Alkalinity, mg/L as $CaCO_3$	363

Several recycle streams come back into the process in or upstream of the MPS, including Nitrification Reactor WAS, GTO, Filtrate, Filter Backwash and Leachate. Data was collected on effluent from the MPS, along with individual samples on each of the streams (presented in Section 3.3) to verify the total load to the Carbonaceous reactors. There is no flow meter located at the MPS, so for model inputs, flow was estimated based on the sum of the influent flow and approximate recycle stream flows, many of which were determined by mass balance.

A summary of the Carbonaceous Clarifier effluent composite data is presented in **Table 3-5**.

Table 3-5: Carbonaceous Clarifier Effluent Composite Sampling Results

Parameter	Special Sampling Results (mg/L)
BOD XX	31.9
COD XX	58.2
COD XG	40.4
TSS	8.46
TP	3.29
PO_4-P	3.02

The measured Carbonaceous effluent concentrations reflect the typical expected treatment for this reactor (BOD removal with no nitrification). There is some BOD carryover (approximately 30 mg/L) into the Nitrification Reactor, consistent with historical averages. NH_3-N and NO_3-N measured in the Carbonaceous Clarifier effluent are not presented due to issues with nitrification of the composite sample occurred during the collection period.

A summary of the Nitrification Clarifier effluent composite data is presented in **Table 3-6**.

Table 3-6: Nitrification Clarifier Effluent Composite Sampling Results

Parameter	Special Sampling Results (mg/L)
BOD XX	10.6
COD XX	27.9
COD XG	22.0
TSS	3.96
TKN XX	1.26
NH_3-N	0.03
NO_3-N	21.72
NO_2-N	0.03
TP	3.53
PO4-P	3.48

The Nitrification Clarifier effluent composite sample show complete nitrification and a small amount of denitrification occurring in these tanks. Effluent concentrations are consistent with historical averages. A summary of the Final Effluent data is presented in **Table 3-7**.

Table 3-7: Final Effluent Composite Sampling Results

Parameter	Special Sampling Results (mg/L)
BOD XX	1.30
COD XX	22.6
COD XG	20.7
COD XM	20.1
COD XF	16.6
TSS	0.34
TN	2.28
TKN XX	1.09
TKN XG	1.02
NH_3-N	0.02
NO_3-N	1.18
NO_2-N	0.01

Parameter	Special Sampling Results (mg/L)
TP	3.47
PO4-P	3.24

The Final Effluent composite data measured during the sampling week was similar to historical averages, reflecting good nitrogen removal performance.

3.1.1 Follow Up Sampling

Due to limited primary effluent data collection during the original sampling week, limited follow up data was collected over 3 days in early April to confirm primary clarifier removals. This data is presented in **Table 3-8**.

Table 3-8: Follow Up Sampling Event Results

Parameter	Plant Influent	Primary Effluent	Main Pump Station
TSS (mg/L)	226	61.0	120
BOD (mg/L)	246	155	177
COD (mg/L)	523	306	400

The data collected April 4-6 on the primary effluent was consistent with the removals observed during the original sampling week (70-75%), providing confidence in model input development.

3.2 Process Grabs

Process grab samples were collected in the morning and afternoon on two weekdays to capture the variation that occurs in plant performance at low and high loading. Process grabs can be used to collect information that cannot be easily captured through a composite sample, such as nutrient profiles on biological tanks. Grabs can also provide confirmation of composite data, such as influent characterization. **Table 3-9** summarizes the average grab sample results throughout the entire process.

The Influent, Primary Effluent, MPS and Final Effluent average grab data were similar to the composite data presented in Section 3-1. The data presented in Table 3-9 are averages of two individual data points rather than a flow-weighted composite. Individual grab sample results are presented in **Appendix B** and were used for comparison of dynamic modeling results in Section 4.

Process grab profiles of the Nitrification Reactor were collected to gather additional information on the nitrification occurring in these tanks. CODXG, NH_3-N, NO_3-N and NO_2-N concentrations were measured on grab samples collected here (presented in **Figure 3-1**). This concentration data along with DO data measured with a handheld probe (**Figure 3-2**) were used for comparison during model calibration. PO_4-P profiles confirm no biological phosphorus removal is occurring in these tanks. Profiles could not be taken on the Carbonaceous Reactor due to lack of access to the individual stages.2

Table 3-9: Process Grab Sample Results

Parameter	Plant Influent (mg/L)	Primary Effluent (mg/L)	Main Pump Station (mg/L)	CARB Train 2, Stage 4 (mg/L)	CARB Clarifier Effluent (mg/L)	NIT Influent (mg/L)	NIT Train 2, Stage 1 (mg/L)	NIT Train 2, Stage 2 (mg/L)	NIT Train 2, Stage 4 (mg/L)	NIT Train 2, Stage 6 (mg/L)	NIT Combined MLSS (mg/L)	NIT Clarifier Effluent (mg/L)	Denit. Filter Effluent (mg/L)	Final Effluent (mg/L)
BOD XX	270	228	283	--	20.5	50.5	7.70	--	--	--	--	6.33	2.70	2.67
BOD XG	168	--	139	--	--	--	--	--	--	--	--	--	--	--
COD XX	521	411	401	--	--	115	--	--	--	--	--	--	--	25.3
COD XG	277	286	248	44.6	32.5	76.4	28.0	34.0	20.7	16.0	12.4	10.7	15.3	20.4
COD XM	238	230	--	--	--	--	--	--	--	--	--	--	--	16.5
COD XF	251	204	--	--	--	--	--	--	--	--	--	--	--	11.2
TSS	158	58.3	89.5	--	4.30	36.5	--	12.16	--	--	--	2.5	--	0.15
VSS	141	49.0	80.0	--	4.20	16.1	--	--	--	--	--	--	--	--
TKN XX	40.9	35.8	46.1	--	--	--	--	--	--	--	--	--	--	--
TKN XG	33.6	--	36.8	--	--	--	--	--	--	--	--	--	--	--
NH_3-N	34.4	32.3	37.4	28.2	29.1	28.65	13.3	12.2	5.63	0.03	0.02	0.03	0.15	0.00
NO3-N	0.40	--	0.50	1.50	0.90	--	3.89	7.57	14.7	19.7	21.7	20.7	0.49	1.35
NO2-N	0.06	--	0.21	1.02	0.59	--	0.99	0.65	0.53	0.14	0.01	0.03	0.78	0.01
TP XX	5.35	4.79	5.54	--	--	4.09	--	--	--	--	--	--	--	3.35
PO_4-P	3.21	3.19	3.85	2.74	--	--	3.31	3.71	3.79	3.88	--	--	--	3.22

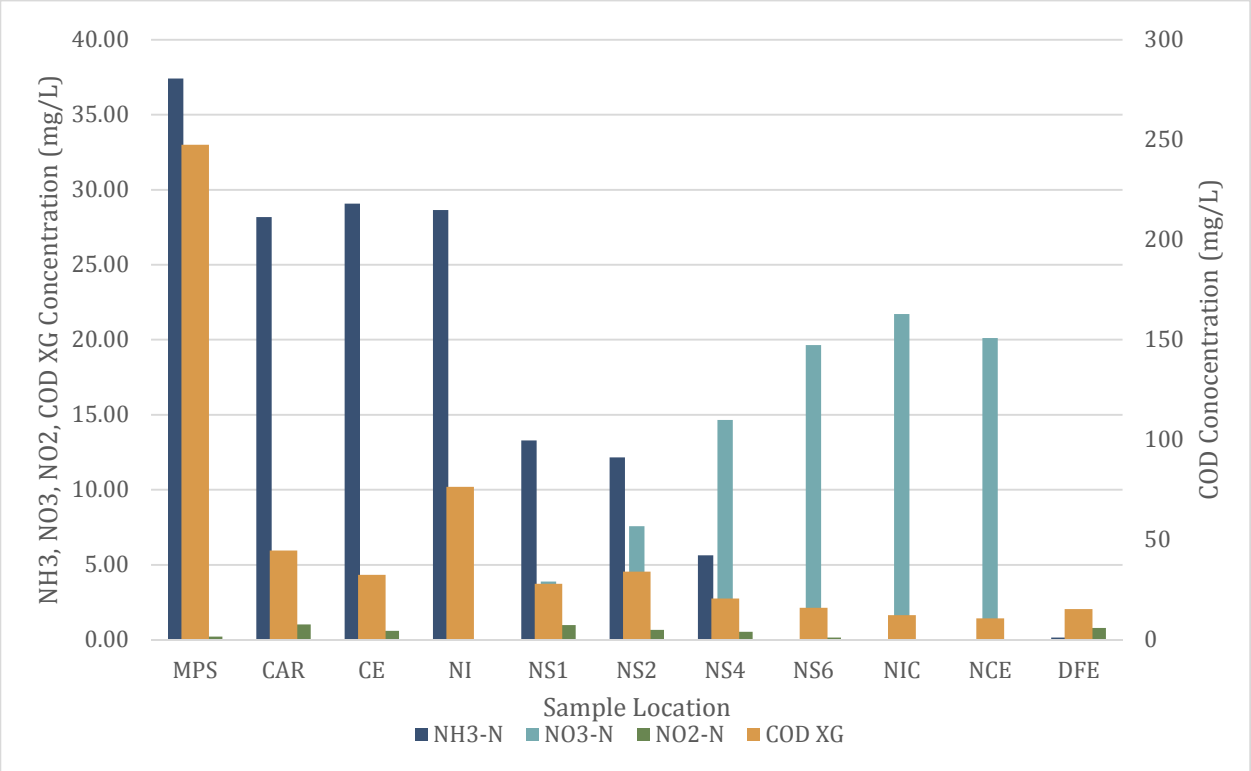

Figure 3-1: Nitrogen Profile

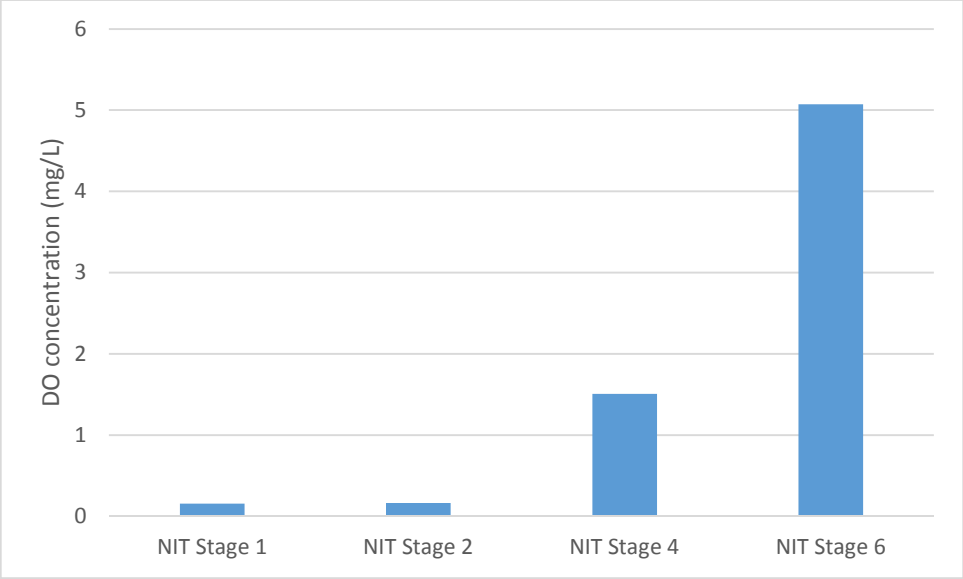

Figure 3-2: DO Profile Results for Nitrification Reactor

3.3 Solids and Sidestream Samples

Solids and sidestream samples were collected each day during the sampling period. A summary of the concentrations of the major sidestreams is presented in **Table 3-10.**

Table 3-10: Sidestream Sample Results

Parameter	GTO	Filter Backwash	Dewatering Filtrate
Flow, mgd	--	14.2	--
COD XX, mg/L	109	113	1,169
TSS, mg/L	15.7	121	650
TKN XX, mg/L	28.6	12.0	635
NH_3-N, mg/L	25.3	0.29	569
TP XX, mg/L	5.96	4.60	57.8

Filter backwash flows back to the Main Pump Station are calculated. No flow measurement is in place for the GTO and Dewatering Filtrate. The Dewatering Filtrate sample results presented includes the influence of wash water.

Mixed Liquor TSS and VSS were measured each day during the sampling week for both the Carbonaceous Reactor and Nitrification Reactor (**Table 3-11**). The Carbonaceous Reactor MLSS is typical for historical values, and the Nitrification Reactor MLSS reflects typical concentrations during dry weather mode operation.

Table 3-11: MLSS Sampling Results

Parameter	CARB MLSS	NIT MLSS
TSS	1,387	4,213
% VSS	86.8	88.1

Sludge sampling was performed throughout the solids train. The average results are presented in **Table 3-12**. The sludge concentrations are similar to historical averages.

Table 3-12: Sludge Sampling Results

Parameter	Primary Sludge	CARB WAS	NIT WAS	Thickened CARB WAS	Digested Sludge	Dewatering Feed	Cake
TS (%)	4.05	0.37	1.3	4.6	2.1	2.1	15.3
%VS	86.5	88.2	88.0	88.6	--	76.2	79.1

3.4 Diurnal Grabs

Discrete samples were collected on the influent at JC-1 and final effluent every 2 hours on two weekdays to gain a better understanding of dynamic loading and performance. Influent load peaking factors were calculated based on the results. There was an issue with discrete sample collection on the influent on the

second day, therefore the diurnal samples collected on day one are considered most accurate and are presented in **Figure 3-3**. The load peaking factors reflect a pattern consistent for a typical plant of this size. Flows and loads begin increasing around 7 am and peak mid-day.

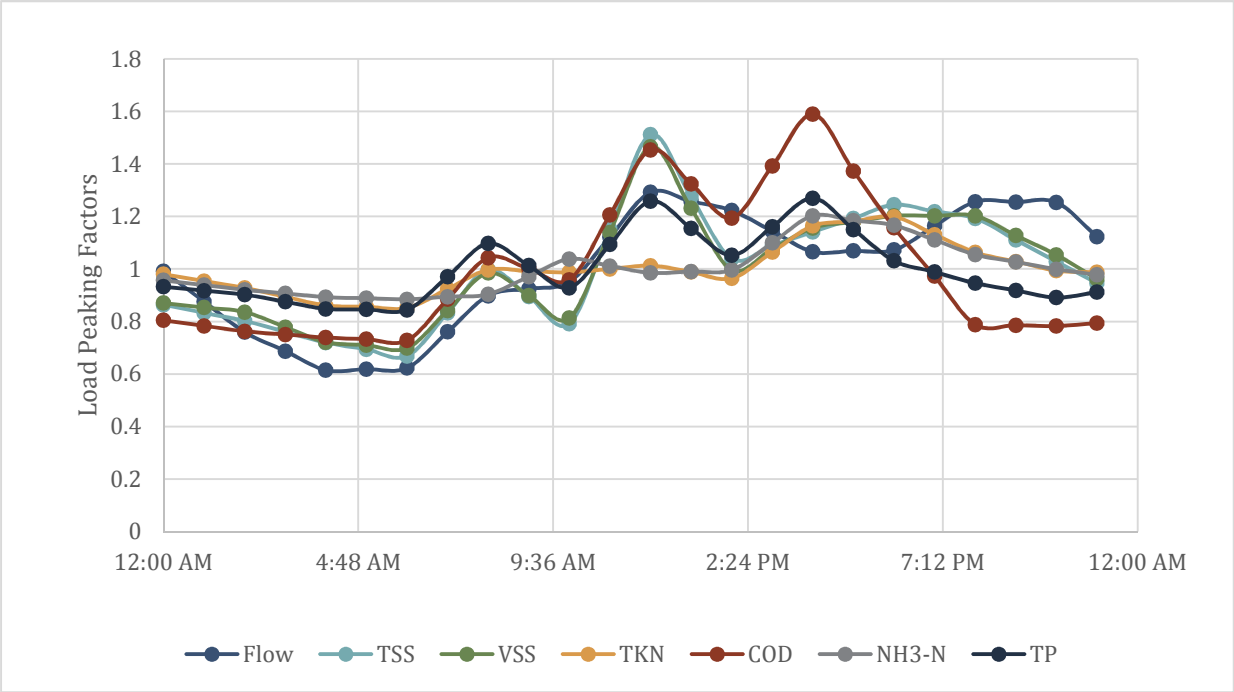

Figure 3-3: Selected Influent Load Peaking Factors

The discrete measurements of the final effluent were used to evaluate the model calibration on a dynamic basis. Plots of the measured diurnal concentrations of the final effluent are presented in **Figure 3-4** and **Figure 3-5**. In both cases, effluent TSS and NO_3-N increase around the daily flow peak. NH_3-N and NO_2-N are consistently non-detectable.

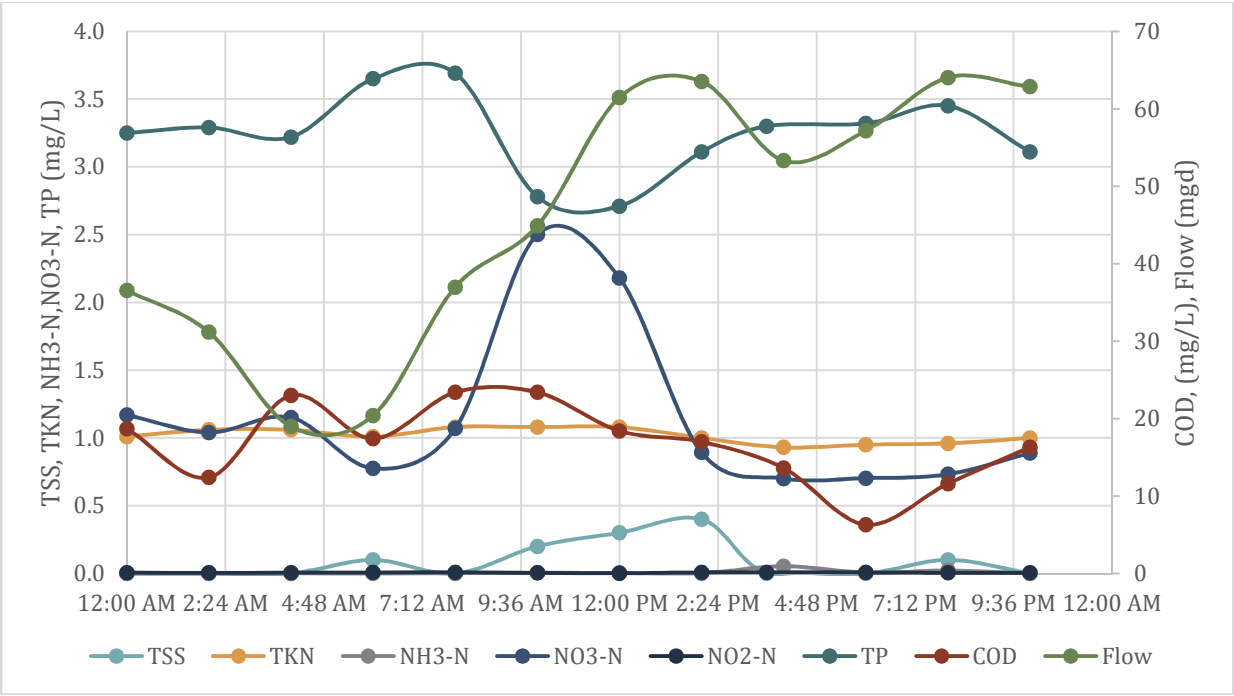

Figure 3-4: Monday Discrete Final Effluent Concentrations

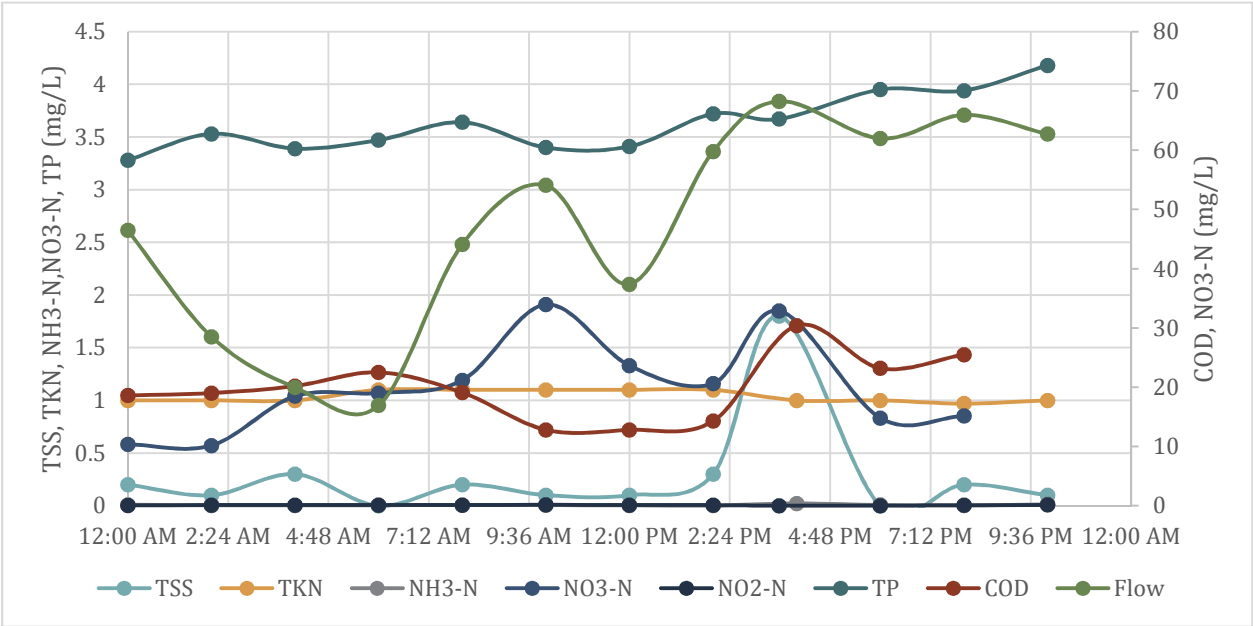

Figure 3-5: Wednesday Discrete Final Effluent Concentrations

3.5 Mass Balances for Special Sampling Period

Mass balances were calculated around different unit processes using the special sampling data. The primary clarifier mass balance is presented in **Table 3-13**.

Table 3-13: Primary Clarifier Mass Balance – Special Sampling

Primary Clarifier Influent	
Influent Flow, mgd	51.8
Influent TSS, mg/L	223
Influent TSS, ppd	99,200
Primary Effluent	
Primary Effluent Flow, mgd	51.6
Primary Effluent TSS, mg/L	53.8
Primary Effluent TSS, ppd	26,400
Primary Sludge	
Primary Sludge flow, mgd	0.2
Primary Sludge TS, %	4.1
Primary Sludge TSS, ppd	62,500
Mass Balance In	
Primary Influent TSS, ppd	99,200
Mass Balance Out	
Total Out TSS, ppd	88,900
% Difference TSS	**10%**

The primary clarifier mass balance is reasonable for the sampling week, providing confidence in the measured influent and primary effluent concentrations and estimated primary sludge loading. The difference between the clarifier influent and effluent solids may be due to low primary effluent TSS concentrations measured in the field or underestimated primary sludge flows. The primary sludge flow is not measured directly, but is the difference between the measured digested sludge feed and TWAS flow. Overall, these solids loads are close. Minor adjustments were made to model inputs as described in Section 4 to reflect the overall plant mass balance.

The mass balances for the Carbonaceous Clarifiers are presented in **Table 3-14**.

Table 3-14: Carbonaceous Clarifier Mass Balance - Special Sampling

Carbonaceous Reactor MLSS	
Clarifier Influent Flow, mgd	55.8
CARB Reactor MLSS TSS, mg/L	1,390
Clarifier Influent TSS, ppd	648,000
Carbonaceous Clarifier Effluent	
CARB Clarifier Effluent Flow, mgd	40.4
CARB Clarifier Effluent TSS, mg/L	9.0
CARB Clarifier Effluent TSS, ppd	2,951

RAS	
RAS Flow, mgd	18.0
RAS TSS Concentration, mg/L	3,720
RAS TSS, ppd	576,000
Mass Balance In	
Clarifier Influent TSS, ppd	648,000
Mass Balance Out	
Total TSS, ppd	576,000
% Difference TSS	**11%**

The mass balance around the Carbonaceous Clarifiers is reasonable, but indicates that there are 14% more solids entering the clarifiers than leaving. This is likely due to uncertainty regarding the influent flows to the Carbonaceous Reactor. This flow was calculated (Influent flow + recycle flows – Spike to NIT + CARB RAS Flow).

The mass balance around the Nitrification Clarifiers is presented in **Table 3-15**.

Table 3-15: Nitrification Clarifier Mass Balance - Special Sampling

Nitrification MLSS	
Clarifier Influent Flow, mgd	82.1
MLSS TSS, mg/L	4,256
Clarifier Influent TSS, ppd	2,810,000
Nitrification Effluent	
Clarifier Effluent Flow, mgd	62.1
Nitrification Clarifier Effluent TSS, mg/L	4.2
Nitrification Clarifier Effluent TSS, ppd	2,061.3
Nitrification RAS + WAS	
RAS +WAS Flow, mgd	23.3
RAS/WAS TSS Concentration, mg/L	13,500
RAS+WAS TSS, ppd	2,610,000
Mass Balance In	
Clarifier Influent TSS, ppd	2,810,000
Mass Balance Out	
Total TSS, ppd	2,610,000
% Difference TSS	**7%**

The mass balance around the Nitrification Clarifiers is reasonable, but indicates that there are 10% more solids entering the clarifiers than leaving. Similar to the Carbonaceous Clarifier Mass Balance, this is likely due to uncertainty regarding the influent flows to the Nitrification Reactor. This flow was calculated (Influent flow + recycle flows –NIT RAS Flow).

A mass balance was calculated based on sampling data around the gravity thickener (**Table 3-16**).

Table 3-16: Gravity Thickener Mass Balance

Parameter	All Data
CARB WAS	
CARB WAS Flow, mgd	1.7
CARB WAS TS, mg/L	3,720
CARB WAS TS, ppd	52,7000
GTO	
GTO Flow, mgd	1.5
GTO TSS, mg/L	15.7
GTO TSS, ppd	196
TWAS Sludge	
TWAS Flow, mgd	0.1
TWAS TS %	4.6
TWAS TS, ppd	56,780
Mass Balance In	
CARB WAS TSS, ppd	52,700
Mass Balance Out	
Total TS, ppd	57,000
% Difference TSS	**-12%**

The mass balance around the gravity thickener is reasonable, confirming WAS and TWAS loads are relatively accurate. The measured TWAS TSS load is slightly higher than the measured WAS TSS loads which is not possible, but GTO measurements confirm that solids capture in the process is very high, so the measured WAS and TWAS TSS loads should be very close.

A mass balance was also calculated around the centrifuge (**Table 3-17**).

Table 3-17: Centrifuge Mass Balance

Parameter	All Data
Dewatering Feed	
Dewatering Feed, mgd	0.36
Dewatering Feed % TSS	2.1%
Dewatering Feed TSS, ppd	61,800
Dewatering Filtrate	
Dewatering Filtrate Flow + wash water, mgd	0.54
Dewatering Filtrate TSS, mg/L	650
Dewatering Filtrate TSS, ppd	2,970

Cake	
Cake TS %	15.3
Cake TS, ppd	64,700
Mass Balance In	
Dewatering Feed TSS, ppd	61,800
Mass Balance Out	
Total TS, ppd	67,700
% Difference TSS	**-10%**

The mass balance around the dewatering belt filter presses is good, providing confidence in overall solids production values.

3.6 Observed Yields for Special Sampling Period

Total yields were calculated based on the special sampling week data on a pounds of TS generated per MG treated basis (**Table 3-18**) and on a pounds TS generated / pounds of BOD removed (**Table 3-19**). Secondary yields were also calculated for the sampling week and presented in **Table 3-20.** These results are consistent with expected values.

Table 3-18: Observed Yield (lb TS Generated/ MG Treated)

Parameter	All Data
Influent Flow, mgd	51.8
CARB WAS Load, ppd	52,700
Primary Sludge TSS, ppd	62,500
Yield (lb TS/Mgal)	**2,230**

Table 3-19: Observed Yield (lb TS generated/ lb BOD removed)

Parameter	All Data
Influent BOD, ppd	114,000
Effluent BOD, ppd	566
CARB WAS TSS, ppd	52,700
Primary Sludge TSS, ppd	62,500
Yield (lb TS/lb BOD Removed)	**1.0**

Table 3-20: Observed Carbonaceous Yield (lb TS Generated/ lb CBOD Removed)

Parameter	All Data
MPS BOD, ppd	102,700
CARB Effluent BOD, ppd	15,000
CARB WAS TSS, ppd	52,700
Yield (lb TS/lb BOD)	**0.60**

4. Model Set Up and Calibration

4.1 Model Setup

Influent

- Influent wastewater flow rates recorded during the special sampling week from the COT's permitted influent monitoring site in Junction Chamber 2 were used in the model for influent flow.
- The average influent flow rate measured during the sampling week was 51.8 MGD

Leachate Receiving

- Pasco County leachate flow was estimated from transported waste disposal records from the special sampling week provided by the COT that documented the total volume per day. The average volume per day of leachate hauled to the plant was estimated at 14,600 gpd.
- Desalination plant wash water from the Tampa Bay Water Desalination plant also enters the HFC AWTP along with Pasco County leachate via the main drain. This flow was included in the leachate receiving flow.
- Desalination plant filter washwater flow rates were estimated at approximately 2,000 gpd based on the historical data provided by the COT during the first phase of the Master Plan.

Primary Clarifiers

- The surface area was adjusted based on the number of primary clarifiers in service.
- The primary clarifiers were modeled with the empiric rectangular primary clarifier. The specified percent solids removal was adjusted to match observed primary effluent TSS concentrations from the special sampling week. Adjustments were made to the percent solids removal in the model to match Main Pump Station TSS, sBOD5, and sCOD concentrations.
- Primary sludge flows were estimated from reported flows for mixed sludge and thickened WAS. Primary sludge flow was determined by subtracting the thickened WAS flow from the mixed sludge flow.

The model setup used for the Primary Clarifiers is summarized in **Table 4-1**.

Table 4-1: Primary Clarifier Model Setup

Parameter	Calibration Value
Number	8
Surface Area, each, ft^2	6,308
Number in Service	6
Side Wall Depth, ft.	12.5
Settling Model	Empiric
% TSS Removal	70%

Main Pump Station

- Flows from the primary clarifiers, raw wastewater bypass, gravity thickener overflow, and nitrification reactor waste activated sludge all entered the MPS in the model based on record drawings and confirmation from the COT.
- Leachate receiving, belt filter press filtrate, and denitrification filter backwash all enter the MPS via the main drain combiner in the model.

Spike Splitter

- MPS effluent bypassing the carbonaceous reactors via the "spike" and "primary clarifier effluent to DAR (NIT)" streams that were recorded in the COT's operational data was sent to the nitrification reactors via the spike splitter in the model.
- A pumped flow splitter was used in the model to set the flow that bypassed the carbonaceous reactors to the nitrification reactors as a combination of both the "spike" and "primary clarifier effluent to DAR (NIT)" recorded values. The pumped flow was adjusted to match the flow rates reported.

Carbonaceous Reactors

- The carbonaceous reactors were modeled with the closed high purity oxygen reactor.
- Four equal volume stages were specified in the model to match the actual reactor layout.
- The carbonaceous reactors liquid volume and headspace volume were adjusted based on the number of trains in service. The carbonaceous reactors were modeled as one combined reactor with the total volume of two reactors. Carbonaceous reactor Nos. 1 and 2 were in service during the special sampling week.
- The liquid depth and headspace volume were calculated for each train based on the record drawings of the reactors and the hydraulic profile developed in Phase 1 of the Master Plan.
- Oxygen purity of the carbonaceous reactor feed gas was set at 95% based on the reported values in previous engineering studies and the oxygen purity from the cryogenic oxygen plant as reported by the COT.

- The aerator power for each stage of the carbonaceous reactors was entered based on shaft horsepower estimated from the April 2007 Aerator Witness Testing Report written by Greeley and Hansen, provided by COT. The typical impeller emergence in the carbonaceous reactors was estimated by COT at 6-inches and the corresponding shaft horsepower was entered into the model. Shaft horsepower in each stage was multiplied by the number of reactors in service.
- The COT indicated that the aerator in stage 4 of carbonaceous reactor No. 1 (URMA-19) was out of service during the special sampling week. The aerator power applied to stage 4 of the model carbonaceous reactors was adjusted to reflect this for the special sampling week simulations. Simulations of the historical operation assumed all aerators were in service for each reactor in service.

The model setup for the carbonaceous reactors is summarized in **Table 4-2**.

Table 4-2: Carbonaceous Reactor Model Setup

Parameter	Calibration Value
Number of Reactors	6
Liquid Volume, each, MG	1.27
Number of Reactors in Service	2
Liquid Depth, ft.	14.3
Headspace Volume, per reactor, MG	0.6
Number of Stages in Series	4
Oxygen Purity of Feed Gas	95%
HPO Gas Flow, scfm	910
Headspace Pressure Constant, each, m^3/(atm)*d	200,000
Vent Pressure Loss Constant, m^3/(atm)*d	200,000
Aerator Power, per reactor, Stage 1, hp	80[a]
Aerator Power, per reactor, Stage 2, hp	60[a]
Aerator Power, per reactor, Stage 3, hp	45[a]
Aerator Power, per reactor, Stage 4, hp	45[a]
Aerator OTR, each, lbO_2/(hp*h)	3.4
Low pH for Max Activity of AOBs and NOBs	7.2
High pH for Max Activity of AOBs and NOBs	7.2
Low pH for 50% Activity of AOBs and NOBs	6.7
High pH for 50% Activity of AOBs and NOBs	8.1
AOB and NOB Max Growth Rate, d^{-1}	0.75
Relaxation Factor for Gas States	0.0001
Specific Adsorption Rate of Colloidal COD, 1/(gCOD/m^3)/d	0.07

([a]) Aerator powers listed are shaft horsepower, estimated from the Aerator Witness Test Report (Contract 5-C-5, April 2007) written by Greeley and Hansen, provided by COT.

Carbonaceous Clarifiers 1 – 12

- The surface area was adjusted based on the number of carbonaceous clarifiers in service.
- Carbonaceous Clarifiers 1 – 12 were modeled with the empiric rectangular secondary clarifier. Initial modeling was done using the Simple1D rectangular clarifier model, but it was later converted to the empiric model for ease of calibration and to be consistent with the empiric model used for Nitrification Clarifiers 13 – 20. Adjustments were made to the percent solids removal in the model to match the effluent TSS and underflow TSS concentrations.
- Tank depth was based on the record drawings provided by the COT.
- RAS flows and WAS flows reported during the special sampling week were used to set the underflow rate and WAS split in the model.

The model setup used for Carbonaceous Clarifiers 1 – 12 is summarized in **Table 4-3**.

Table 4-3: Carbonaceous Clarifiers 1 – 12 Model Setup

Parameter	Calibration Value
Number	12
Surface Area, each, ft^2	16,796
Number in Service	5
Side Wall Depth, ft.	11.17
Settling Model	Empiric
% Removal	99.5%

Nitrification Reactors

- A plug flow aeration tank model with six equal volume stages was used to model the nitrification reactors. The total volume of the nitrification reactors was adjusted in the model based on the number of reactors in service during the special sampling week.
- Tank depth and volume was based on the record drawings provided by the COT and the hydraulic profile developed by McKim & Creed during Phase 1 of the Master Plan.
- Aeration in the nitrification reactors was setup using a DO controller in the model to match the average DO concentrations measured during the special sampling week. Air flow rate was also entered directly in some cases and air flow split to each stage of the nitrification reactors was calibrated to match DO concentrations reported.
- An internal MLSS recycle was set up in the model to recycle flow from the last stage of the nitrification reactors to the head of the first stage. The average internal recycle flow measured during the special sampling week was used to set the internal recycle rate in the model. The plant

uses internal recycle when the first two to three stages of the nitrification reactors are operated without aeration to provide nitrified mixed liquor to the head of the reactors for denitrification.

The model setup used for the nitrification reactors is summarized in **Table 4-4**.

Table 4-4: Nitrification Reactor Model Setup

Parameter	Calibration Value
Number of Reactors	4
Volume, each, MG	2.12
Number of Reactors in Service	3
Depth, ft.	16.6
Number of Stages in Series	6
Aeration Method	Diffused Air
Aeration Specification Method	DO Controller
DO Setpoint, Stage 1, mg/L	0.15
DO Setpoint, Stage 2, mg/L	0.15
DO Setpoint, Stage 3, mg/L	1.15
DO Setpoint, Stage 4, mg/L	1.50
DO Setpoint, Stage 5, mg/L	3.80
DO Setpoint, Stage 6, mg/L	5.00
Alpha Factor, each stage	0.67
Specific Adsorption Rate of Colloidal COD, 1/(gCOD/m^3)/d	0.07

Nitrification Clarifiers 13 – 20

- The surface area of Nitrification Clarifiers 13-20 was adjusted based on the number of nitrification clarifiers in service.
- Nitrification Clarifiers 13 – 20 were modeled with the empiric rectangular secondary clarifier. Initial modeling was done using the Simple1D rectangular secondary clarifier model, however the model experienced difficulty converging on simulation results due to a high sludge blanket depth. The empiric model did not suffer from convergence issues and adjustments were made to the percent solids removal in the model to match the effluent TSS and underflow TSS concentrations.
- Tank depth was based on the record drawings provided by the COT.
- The underflow rate was set in the model based on the RAS and WAS flow rates measured during the special sampling week.
- WAS from Nitrification Clarifiers 13-20 was separated from the underflow using a flow splitter. The flow split ratio was adjusted to match the measured RAS and WAS flow rates.

- The model set up allowed excess DO present in the RAS to be recycled to the head of the nitrification reactors. The empiric settling model default is to set the underflow stream DO to zero.

The model setup used for Nitrification Clarifiers 13 – 20 is summarized in **Table 4-5**.

Table 4-5: Nitrification Clarifiers 13 – 20 Model Setup

Parameter	Calibration Value
Number	8
Surface Area, each, ft^2	16,796
Number in Service	7
Side Wall Depth, ft.	11.2
Settling Model	Empiric
% TSS Removal	99.9%
Set Dissolved Oxygen to Zero in Underflow	OFF

Methanol Dosing

- The methanol dosage to the denitrification filters was set in the model based on the average flow rate measured during the special sampling week.
- Methanol dosing was combined with the nitrification clarifier effluent in the model.

Denitrification Filters

- The surface area of the denitrification filters was adjusted based on the expected number of filters in operation during the special sampling week. The filter media depth was based on the record drawings and operation & maintenance manual provided by the COT.
- Filter backwash flow was set based on the sum of the average measured backwash flows from each bank of filters during the special sampling week. The total backwash flow per day included normal backwashes and nitrogen release cycle (NRC) backwashes. The NRC backwash flows were estimated at 75% of the total backwash flow based on the operation schedule. NRC backwashes are normally operated with the effluent valves open, allowing all flow to pass through the filters and continue to the chlorine contact chambers. The NRC backwash operation was simulated in the model by using a splitter to recycle 75% of the backwash flow back to the denitrification filter influent. The remaining 25% of the total backwash flow was returned to the main drain combiner to then continue to the main pump station combiner and flow through the rest of the treatment process.
- Denitrification filter solids removal efficiency was adjusted to match the effluent TSS, NH3, NO3, and NO2 concentrations.
- The detachment rate in the mass transport parameters for the Denitrification Filters was also adjusted to match the effluent TSS, NH_3, NO_3, and NO_2 as closely as possible.

The model setup used for the Denitrification Filters is summarized in **Table 4-6**.

Table 4-6: Denitrification Filters Model Setup

Parameter	Calibration Value
Number	32
Surface Area, each, ft^2	1,050
Number in Service	30
Media Depth, ft.	4.5
Specific Surface of Media, 1/m	1,500
Maximum Biofilm Thickness, mm	1.5
Density of Biofilm, mg/L	750,000
Backwash Duration, hrs	24
% TSS Removal	98.6%
Attachment Rate of Biofilm, ft/d	1.76
Detachment Rate of Biofilm, $lb/(ft^2*d)$	0.011

Many kinetic parameters were also adjusted for the Denitrification Filters. These adjustments are shown in **Table 4-7**.

Table 4-7: Comparison of Calibrated and Default Kinetic Parameters for Denitrification Filters

Parameter	Calibrated Value	GPS-X Default
Heterotrophs		
Saturation Coefficient for Oxygen	0.05	0.2
Saturation Coefficient for Nitrogen as Nutrient, mgN/L	0.005	0.05
Reduction Factor for Denitrification on Nitrate-N	0.5	0.32
Reduction Factor for Denitrification on Nitrite-N	0.8	0.48
Saturation Coefficient for Nitrite, mgN/L	0.01	0.1
Saturation Coefficient for Nitrate, mgN/L	0.1	0.5
Oxygen Inhibition Coefficient for Denitrification, mgO_2/L	0.05	0.2
Anoxic Reduction Factor for Decay Rate	0.3758	0.9
Anaerobic Reduction Factor for Decay Rate	0.2113	0.6
Methylotrophs		
Oxygen Saturation Coefficient for Methylotrophs, mgO_2/L	0.05	0.2
Oxygen Inhibition Coefficient for Denitrification, mgO_2/L	0.05	0.2
Aerobic Methylotrophic Decay Rate, d^{-1}	0.04	0.2
Anoxic Reduction Factor for Decay Rate	0.75	0.9
Fermentative Biomass		
Maximum Fermentation Rate, d^{-1}	1.6	3.0

Parameter	Calibrated Value	GPS-X Default
Hydrolysis		
Hydrolysis Rate Constant for xs, d^{-1}	2.1	3.0
Saturation Coefficient for Particulate COD	0.06	0.1
Anoxic Hydrolysis Reduction Factor	0.28	0.8
Anaerobic Hydrolysis Reduction Factor	0.04	0.4
Ammonification		
Ammonification Rate, m^3/gCOD/d	0.04	0.08

Chlorine Contact Chambers

- The Chlorine Contact Chambers were modeled with the GPS-X "Chlorination" model to simulate the oxidation of NH3 by chlorination and the resultant disinfection by-products.
- The volume of the Chlorine Contact Chambers was adjusted based on the number of chambers in operation during the special sampling week, and the actual volume of each chamber from record drawings provided by the COT.
- The pH in the Chlorine Contact Chambers was set based on the average value recorded during the special sampling week.
- The t10 to detention time ratio was adjusted in the model to simulate some hydraulic deficiencies of the Chlorine Contact Chambers identified during Phase 1 of the Master Plan.
- Chlorine dosage was set in the model based on the average value reported during the special sampling week.

The model setup used for the Chlorine Contact Chambers is summarized in **Table 4-8**.

Table 4-8: Chlorine Contact Chambers Model Setup

Parameter	Calibration Value
Number	3
Volume, each, MG	0.79
Number in Service	1
t10 to Detention Time Ratio	0.5
t50 to Detention Time Ratio	0.9
Minimum NH_3 Limit for DBP Model, mgN/L	0.01

Gravity Sludge Thickeners

- The surface area of the Gravity Sludge Thickeners was adjusted based on the number of gravity thickeners in service during the special sampling week.

- The Gravity Sludge Thickeners were modeled with the empiric thickener. The underflow in the model was set based on the average measured flow rate of thickened WAS during the special sampling week. The removal efficiency of the Gravity Sludge Thickeners was adjusted to match the TWAS percent solids measured during the special sampling week.

The model setup used for the Gravity Sludge Thickeners is summarized in **Table 4-9**.

Table 4-9: Gravity Sludge Thickeners Model Setup

Parameter	Calibration Value
Number	2
Surface Area, each, ft^2	2,375
Number in Service	1
Side Wall Depth, ft.	10
Settling Model	Empiric
% Removal	99.6%

Anaerobic Digesters

- The anaerobic digester volume was set based on volumes determined from record drawings for the exact digesters that were in service.
- The digesters were modeled as one single digester, and the temperature was set assuming it was constantly maintained at 95 °F.
- The headspace volume entered was based on the headspace volume of the digesters in service with gasholder covers, assuming they were operated at a constant liquid level.
- Assumed that the digesters were well-mixed and there was no reduction in the effective volume.

The model setup used for the Anaerobic Digesters is summarized in **Table 4-10**.

Table 4-10: Anaerobic Digesters Model Setup

Parameter	Calibration Value
Number	7
Digesters 1-3 Volume, each, MG	0.838
Digester 4 Volume, MG	0.86
Digester 5 Volume, MG	1.6
Digsters 6-7 Volume, each, MG	2.45
Digesters 1-4 Headspace Volume, each, ft^3	22,500
Digesters 5-7 Headspace Volume, each, ft^3	0
Digesters in Service	1-6
Digester Temperature, °F	95

Belt Filter Press Dewatering

- The empiric dewatering model was used to simulate the belt filter press dewatering. The underflow solids concentration was set based on the average cake percent solids from the special sampling week. The measured filtrate concentrations from the sampling week reflect the impact of wash water.
- The dewatering unit removal efficiency in the model was adjusted to match the assumed mass rates of TSS, TKN, and NH3 after accounting for an estimated wash water flow.
- The dewatering removal efficiency used in the model is 94.3%.

The schematic layout of the HFC AWTP GPS-X® model is shown in **Figure 4-1.**

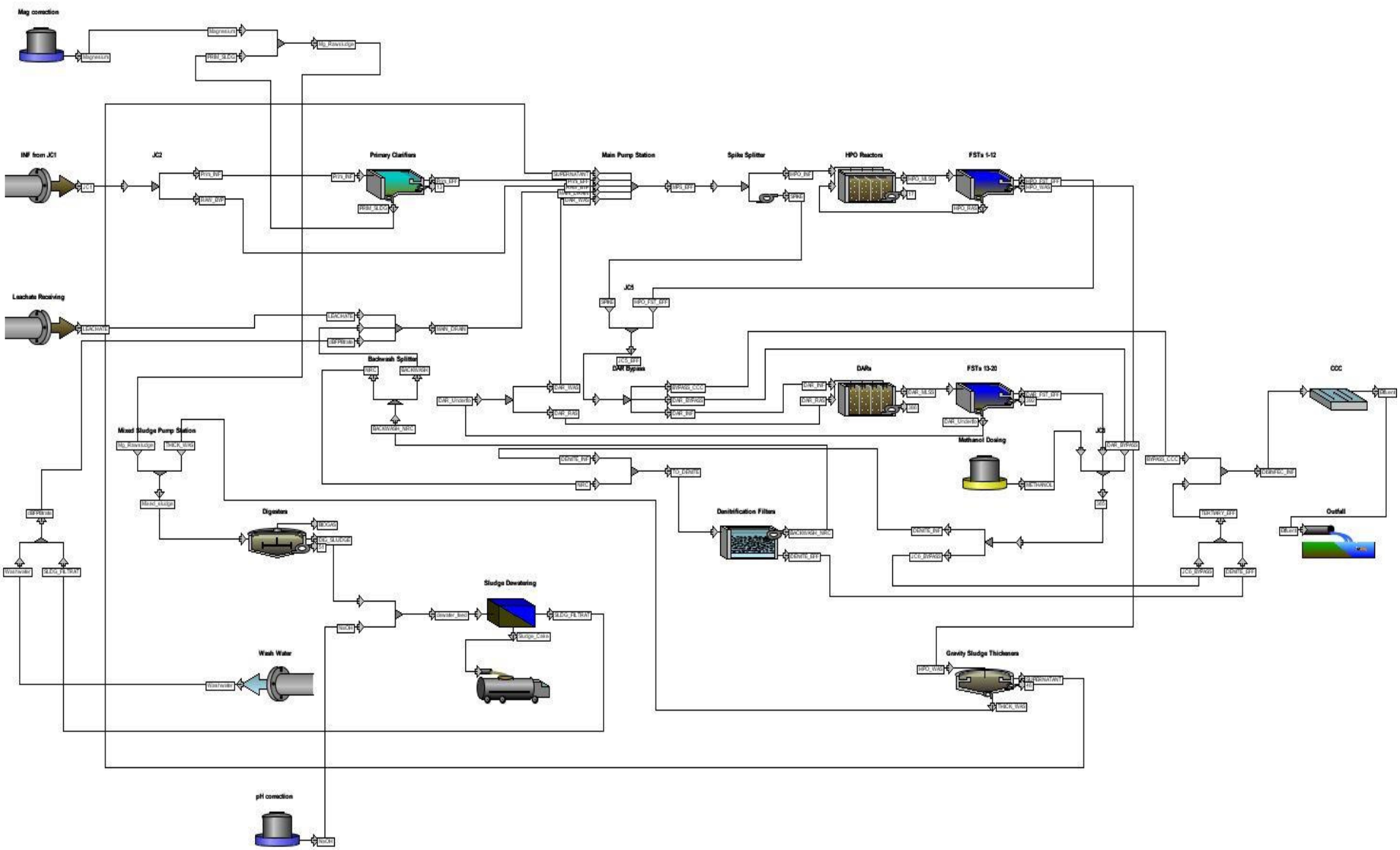

Figure 4-1: GPS-X® Model Set Up

4.2 Influent Fractions

Adjusted special sampling data was used to develop the detailed influent fractions used as inputs in the plant specific model. The criteria used for screening are presented in previous sections of this report. The influent fractions developed for the HFC AWTP, typical default fractions for GPS-X®, and source of data for values are shown in **Table 4-11**.

Table 4-11: Model Influent Fractions for HFC AWTP

Item for Comparison	Calibration Value	GPS-X® Default	GPS-X® Symbol	Units
Readily biodegradable COD fraction	0.174	0.2	frss	gCOD/g of total COD
Colloidal fraction of slowly biodegradable COD	0.265	0.15	frscol	gCOD/g of slowly biodegradable COD
Soluble inert fraction of total COD	0.036	0.05	frsi	gCOD/g of total COD
Particulate inert fraction of total COD	0.22	0.15	frxi	gCOD/g of total COD
Ammonia fraction of soluble TKN	0.97	0.9	frsnh	gNH_3-N/g soluble TKN
N content of soluble inert COD	0.028	0.05	insi	gN/g of Total COD
N content of particulate inert COD	0.01	0.05	inxi	gN/g of total COD
P content of soluble inert COD	0.03	0.01	ipsi	gP/g of total COD
P content of inert particulate COD	0.003	0.01	ipxi	gP/g of total COD
Ratio of soluble BOD to soluble COD	0.512	0.717	fssbodtoss cod	-
Ratio of particulate substrate BOD to particulate substrate COD	0.714	0.58	fpsbodtops cod	-
Particulate substrate COD:VSS ratio	1.74	1.8	icodtovssx s	g COD/g VSS
Particulate inert COD:VSS ratio	1.74	1.8	icodtovssxi	g COD/g VSS
COD/CBOD ratio	2.21	--	--	-
VSS/TSS ratio	0.889	0.75	ivsstotss	g VSS/g TSS

4.3 Model Calibration

The calibration of the HFC AWTP model meets the criteria for a Level 3 Calibrations based upon the criteria presented in the Water Environment Research Foundation Tiered Calibration Approach. Calibration of the model for the HFC AWTP generally followed the following steps, starting with periods of the most data and moving to those with the least amount of data.

1. Obtain agreement between the model and special sampling data.
2. Evaluate the model dynamically on an hourly basis with special sampling data.
3. Validate the model using steady state simulation to a time period outside the sampling week.
4. Validate the model dynamically using a time period outside the sampling week.

Each of these steps is described in greater detail in the following sections. Results presented in Steps 1-4 may slightly differ from current version of model. This is due to slight variations in model convergence.

4.3.1 Step 1 – Obtain agreement between the model and special sampling data.

The first step of the calibration process was to obtain relative agreement between the model and adjusted data collected during the sampling week. The adjusted data was averaged and input into the model. A majority of the operational parameters were monitored and recorded hourly at the HFC AWTP, such as RAS flows, oxygen flow, DO concentrations, filter backwash, and others. These operational parameters were averaged and input into the model.

After the data was input, the model was simulated under steady-state conditions. The effluent quality and sludge production predicted from the model was then compared to the average values measured during the sampling week. The data comparisons for the influent, effluent, sludge production, and other various unit processes/parameters are presented in **Tables 4-12** to **Table 4-21**.

Percent differences were calculated where the corresponding 24 hour composite data was collected for comparison. Results from grab sampling are presented where composite data is not available; however they are not considered representative of average conditions. Percent differences were also not calculated for sampling values that were less than 0.20 mg/L. When values of parameters are in low concentration ranges, relatively large differences in values on a percentage basis are often within the margin of error for the analysis. Discussion of the results is presented after each table.

A comparison of modeled and adjusted special sampling values for the plant influent is shown in **Table 4-12**. The modeled influent matches well with measured influent values, confirming selected influent fractions.

Table 4-12: Comparison of Model and Sampling Results– Influent

Parameter	Measured (Feb. 19-26, 2017)	Modeled	% Difference: Model to Measured
Flow, MGD	51.8	51.8	0%
TSS, mg/L	230	232	1%
VSS, mg/L	204	206	1%
COD, mg/L	587	587	0%
sCOD, mg/L	233	239	2%
BOD, mg/L	263	266	1%
sBOD, mg/L	112.0	111	0%
TKN, mg/L	42.6	42.6	0%
NH_3-N, mg/L	35.5	35.5	0%
TP, mg/L	6.14	6.14	0%
PO_4-P, mg/L	3.61	3.61	0%
Temperature, C	24.6	24.6	0%

Screening and grit removal was not included in the model due to its minimal impact on the soluble and particulate wastewater constituents of concern. Primary settling is the first process in the HFC AWTP model as shown in **Figure 4-1**. A comparison of modeled and adjusted special sampling values for the primary clarifier effluent is shown in **Table 4-13**. Percent removals measured during the special sampling week appeared to be high compared to industry standard ranges for removal from primary clarifiers. Typical removal percentages for primary clarifiers are 50% to 70% TSS removal and 25% to 40% BOD removal. The TSS removal efficiency in the model was set to 70%, as shown in **Table 4-1**, to better match the COD and BOD concentrations in the primary clarifier effluent which was found to provide a better match to the overall mass balance than matching TSS.

Table 4-13: Comparison of Model and Sampling Results – Primary Clarifier Effluent

Parameter	Measured (Feb. 19-26, 2017)	Modeled	% Difference: Model to Measured
TSS, mg/L	57.4	69.5	21%
VSS, mg/L	49.9	61.8	24%
COD, mg/L	405	343	-15%
sCOD, mg/L	275	239	-13%
BOD, mg/L	163	158	-3%
TKN, mg/L	39.8	38	-4%
NH_3-N, mg/L	35.1	35.5	1%
TP, mg/L	5.20	4.81	-7%
PO_4-P, mg/L	3.65	3.61	-1%

Primary effluent, GTO, nitrification reactor WAS, leachate influent, dewatering filtrate, and filter backwash are all combined in the MPS before the flow is pumped to the secondary treatment processes. A comparison of the modeled and special sampling values for the MPS effluent is shown in **Table 4-14**. Overall a good match was achieved between the modeled and special sampling values. Recycle flows from the dewatering process impacted the MPS COD and BOD values most, resulting in lower concentrations than reported. TP and PO_4 were predicted high in the MPS effluent due to high concentrations in the dewatering filtrate and denitrification filter backwash that are returned to the MPS via the main drain. A lack of struvite precipitation and removal in the belt filter press dewatering is suspected to be a cause of these high nutrient concentrations.

Table 4-14: Comparison of Model and Sampling Results – Main Pump Station Effluent

Parameter	Measured (Feb. 19-26, 2017)	Modeled	% Difference: Model to Measured
Flow, MGD	58.9	57.3	-3%
TSS, mg/L	127.1	123.1	-3%
VSS, mg/L	111.4	106.5	-4%
COD, mg/L	473	392	-17%
sCOD, mg/L	229	218	-5%
BOD, mg/L	218	167	-24%
TKN, mg/L	44.3	45.6	3%
NH_3-N, mg/L	32.6	39.5	21%
TP, mg/L	4.05	6.98	72%
PO_4-P, mg/L	3.96	4.79	21%

A comparison of the modeled and adjusted special sampling values for the carbonaceous reactors is shown in **Table 4-15**.

Table 4-15: Comparison of Model and Sampling Results – Carbonaceous Reactors

Parameter	Measured (Feb. 19-26, 2017)	Modeled	% Difference: Model to Measured
Carb MLSS, mg/L	1,390	1,530	11%
Carb MLVSS, %	87%	85%	-2%
Carb Stage #4 DO, mg/L	13.71	31.32	128%
Carb HPO gas flow, Ton/day	54	54	0%
Carb Vent Gas Purity, % O2	52%	78%	50%
Carb Oxygen Utilization, %	--	48%	--
Carb Total SRT, day	0.53	0.52	-3%
Carb MLSS Effluent NH3-N, mg/L	28.18	27.14	--
Carb MLSS Effluent NO3-N, mg/L	1.50	2.49	--
Carb MLSS Effluent NO2-N, mg/L	1.02	1.85	--

Table 4-15 shows that a good match was achieved for the mass of biomass in the reactors and the SRT, confirming the primary clarifier effluent and recycle loading to the carbonaceous reactors and the measured wasting loads.

The model is predicting a small amount of nitrification despite the low SRT. This is due to the seeding of nitrifiers from the nitrification reactor WAS that is recycled back to the primary clarifier effluent.

Adjustments were made to reflect expected pH inhibition of nitrifiers due to the build-up of carbonic acid in the closed HPO reactors, as shown in **Table 4-2**. This resulted in a better match on nitrification.

Oxygen transfer is not matching well in the model as demonstrated by high DO concentrations in all stages of the reactors, and high vent gas purity. The COT indicated that HPO gas feed was higher than typical during the sampling week to keep DO concentrations up while the stage 4 mechanical aerator was down in Reactor 1. The issues with oxygen transfer matching is thought to be the result of inaccurate vent purity and DO measurements at the reactors. The existing vent purity sampling lines are very long (greater than 100 feet), and may be subject to leaks and biofilm growth within the sample lines that would skew sample measurements. DO is currently measured from the open air sample drum on the reactor deck which is not representative of the reactor conditions due to off-gassing after the sample has been transferred. Further investigation may be required to determine the cause of the oxygen transfer discrepancies. Oxygen purity of the feed gas should be independently confirmed along with gas feed rate, reactor vent gas purity, impeller emergence in each stage, reactor DO concentrations, and reactor pH values. Overall loading to the plant appears to be confirmed through comparison of influent concentrations, primary effluent concentrations, main pump station concentrations, carbonaceous reactor BOD/COD, and biosolids production which all line-up within reason to the measured values. This supports the conclusion that oxygen transfer matching issues are related to data inaccuracy.

Very few adjustments were made to the nitrification reactors which achieved successful agreement with the special sampling data. A comparison of the modeled and adjusted special sampling values for the nitrification reactors is shown in **Table 4-16**. Adjustment was made to the fine bubble diffused aeration alpha factor to better match the air flow to the reactors.

Table 4-16: Comparison of Model and Sampling Results – Nitrification Reactors

Parameter	Measured (Feb. 19-26, 2017)	Modeled	% Difference: Model to Measured
Nit MLSS, mg/L	4,213	4,350	3%
Nit MLVSS, %	88%	82%	-6%
Nit Stage #1 DO, mg/L	0.15	0.08	-46%
Nit Stage #2 DO, mg/L	0.15	0.15	2%
Nit Stage #3 DO, mg/L	1.15	0.86	-25%
Nit Stage #4 DO, mg/L	1.50	1.26	-16%
Nit Stage #5 DO, mg/L	3.82	3.28	-14%
Nit Stage #6 DO, mg/L	5.00	4.74	-5%
Nit Airflow, acfm	20,882	20,882	0%
Nit Total SRT, day	12.64	11.96	-5%
Nit MLSS Effluent NH3-N, mg/L	0.02	0.04	--
Nit MLSS Effluent NO3-N, mg/L	21.73	20.63	--
Nit MLSS Effluent NO2-N, mg/L	0.01	0.02	--

The solids balance from the secondary processes achieved reasonable agreement with the special sampling values as shown in **Table 4-17** for the carbonaceous and nitrification clarifier solids parameters.

Table 4-17: Comparison of Model and Sampling Results – Carbonaceous and Nitrification Clarifiers

Parameter	Measured (Feb. 19-26, 2017)	Modeled	% Difference: Model to Measured
Carbonaceous Clarifiers 1 - 12			
FST 1-12 RAS Flow, mgd	18.0	18.0	0%
FST 1-12 RAS TSS, mg/L	3,720	4,401	18%
FST 1-12 WAS Flow, mgd	1.65	1.65	0%
FST 1-12 WAS TSS, mg/L	3,827	4,401	15%
FST 1-12 WAS Load, ppd	52,819	60,728	15%
Nitrification Clarifiers 13 - 20			
FST 13-20 RAS Flow, mgd	23.2	23.2	0%
FST 13-20 RAS TSS, mg/L	13,448	14,690	9%
FST 13-20 WAS Flow, mgd	0.14	0.14	0%
FST 13-20 WAS TSS, mg/L	13,448	14,690	9%
FST 13-20 WAS Load, ppd	15,811	17,238	9%

A good match was achieved for the total secondary effluent before the denitrification filters. A comparison of the modeled and special sampling values for the clarifier effluent is shown in **Table 4-18**. An excellent match was achieved for COD which indicated good fractionation of the influent COD between biodegradable and inert fractions. Secondary effluent BOD was significantly lower than the sampling results for both the carbonaceous and nitrification stage effluents; however the sampling results recorded were not inhibited for nitrification. The measured carbonaceous effluent BOD samples would likely nitrify without inhibiting the sample for nitrification due to the high NH_3 concentration in the carbonaceous stage effluent. The specific adsorption rate of colloidal COD was adjusted for both the carbonaceous and nitrification reactors to better match the model BOD concentrations with expected values. The modeled carbonaceous stage effluent BOD concentration was more realistic after the adjustment to the adsorption rate of colloidal COD. The modeled BOD concentration was compared to measured and modeled TSS concentrations as a gauge for this adjustment to ensure model BOD results were consistent with expected results for an inhibited cBOD sample.

Elevated NO_3-N and NO_2-N concentrations were seen in the modeled carbonaceous clarifier effluent as a result of the small amount of nitrification occurring in the carbonaceous reactors. The elevated NO_x concentrations did not have a significant impact on the nitrification clarifier effluent however. The carbonaceous clarifier effluent is mixed with the spike influent prior to the nitrification reactors which diluted the concentrations, and resulted in insignificant impact to the nitrification clarifier effluent NH_3-N and NO_x concentrations.

Table 4-18: Comparison of Model and Sampling Results – Clarifier Effluent

Parameter	Measured (Feb. 19-26, 2017)	Modeled	% Difference: Model to Measured
Carbonaceous Stage Effluent			
Flow, MGD	38.5	37.0	-4%
TSS, mg/L	8.46	7.67	-9%
COD, mg/L	58.0	51.3	-12%
BOD, mg/L	32.00	14.40	-55%
NH_3-N, mg/L	29.40	27.14	-8%
NO_3-N, mg/L	0.60	2.49	315%
NO_2-N, mg/L	0.59	1.85	--
TP, mg/L	3.29	3.27	-1%
PO_4-P, mg/L	3.02	2.49	-18%
Nitrification Stage Effluent			
Flow, MGD	57.1	55.5	-3%
TSS, mg/L	3.96	4.35	10%
COD, mg/L	28.0	28.2	1%
BOD, mg/L	11.00	2.05	-81%
TKN, mg/L	1.30	1.35	4%
NH_3-N, mg/L	0.03	0.04	--
NO_3-N, mg/L	21.72	20.63	-5%
NO_2-N, mg/L	0.03	0.02	--
TP, mg/L	3.53	3.84	9%
PO_4-P, mg/L	3.48	3.13	-10%

A comparison of the modeled and adjusted special sampling values for the denitrification filter effluent is shown in **Table 4-19**. All denitrification filter effluent values collected during the special sampling week were measured on grab samples. Percent differences are not presented below as stated previously since grab samples cannot be verified to be representative of overall averages.

Table 4-19: Comparison of Model and Sampling Results – Denitrification Filter Effluent

Parameter	Measured (Feb. 19-26, 2017)	Modeled	% Difference: Model to Measured
TSS, mg/L	0.45	1.09	--
sCOD, mg/L	15.0	22.0	--
BOD, mg/L	2.70	1.28	--
NH_3-N, mg/L	0.15	0.76	--
NO_3-N, mg/L	0.49	0.07	--
NO_2-N, mg/L	0.78	0.01	--

Many denitrification filter parameters were adjusted, as shown in **Table 4-7**, to match the denitrification performance. Adjustments were coordinated with Hydromantis and reflect other literature values. Model denitrification filter effluent NH_3-N and soluble organic nitrogen concentrations were much higher than expected as a result of over-prediction of methylotrophic decay in the model. NH_3-N and soluble organic nitrogen concentrations increased steadily in each layer of the model denitrification filters as soluble and particulate organic nitrogen was released through decay and ammonification of the decay products produced NH_3-N. Particulate organic nitrogen resulting from the over-prediction of methylotroph decay was captured in the filters and released in the backwash stream. The methylotrophic decay rate and the ammonification rate was reduced as much as practical to limit this over-prediction.

The final effluent from the model adequately represents the parameters least affected by the denitrification filters. Modeled COD, BOD, TP, PO_4-P, and pH values all reasonably match the adjusted special sampling values. This indicates that good fractionation of inert soluble COD in the model and reliable overall carbonaceous substrate removal. It also indicates reasonable predictions of phosphorus usage as a nutrient. Discrepancies between modeled and measured denitrification filter effluent did carryover into the final effluent values modeled as evidenced by the BOD, TKN, NO_3, and NO_2 values shown. Matching of the NH_3 effluent concentration was achieved through modeling of the disinfection process in which chlorine disinfection oxidizes remaining NH_3 to form disinfection byproducts, and eventual complete oxidation to form nitrogen gas. The depletion of the free chlorine residual as a result of this oxidation process occurs in the model, however it is likely overestimated in the model due to what appears to be excessive NH_3 in the denitrification filter effluent. Oxidation of NO_2-N to NO_3-N is expected to occur in the chlorination process; however this reaction is not modeled by the chlorination model in GPS-X. Effluent NO_3-N and NO_2-N concentrations are likely affected by this limitation of the model, resulting in lower model effluent NO_3-N and high model effluent NO_2-N.

A comparison of the modeled and adjusted special sampling values for the final effluent is shown in **Table 4-20**.

Table 4-20: Comparison of Model and Sampling Results – Final Effluent

Parameter	Measured (Feb. 19-26, 2017)	Modeled	% Difference: Model to Measured
Flow, MGD	52.2	52.0	0%
TSS, mg/L	0.34	1.09	221%
COD, mg/L	23.00	23.54	2%
sCOD, mg/L	21.00	21.98	5%
BOD, mg/L	1.30	1.28	-2%
sBOD, mg/L	0.00	0.00	--
TKN, mg/L	1.10	2.18	98%
NH_3-N, mg/L	0.02	0.76	--
NO_3-N, mg/L	1.18	0.07	-94%
NO_2-N, mg/L	0.01	0.01	--
TP, mg/L	3.47	3.56	3%
PO_4-P, mg/L	3.24	2.92	-10%
Alkalinity, mg/L	193.00	249.08	29%
pH	8.14	8.12	0%

The biosolids processes showed relatively good matches between the modeled and sampled values. WAS from the carbonaceous reactor is sent to the gravity thickening process prior to being combined with primary sludge before digestion. Gravity thickening in the model achieved a good match with the sampling data. A comparison of the modeled and adjusted special sampling values for the gravity sludge thickening is shown in **Table 4-21**.

Table 4-21: Comparison of Model and Sampling Results – Gravity Sludge Thickening

Parameter	Measured (Feb. 19-26, 2017)	Modeled	% Difference: Model to Measured
Carbonaceous WAS			
WAS Flow, mgd	1.65	1.65	0%
WAS TSS, mg/L	3,827	4,401	15%
WAS TSS, ppd	52,819	60,728	15%
Thickened WAS			
Thickened WAS Flow, mgd	0.16	0.16	0%
Thickened WAS TS, %	4.58%	4.60%	1%
Thickened WAS TSS, ppd	60,388	60,511	0%
Gravity Thickener Overflow			
GTO TSS Load, ppd	196	220	12%

A comparison of the modeled and adjusted special sampling values for the digested sludge and belt filter press dewatering is shown in **Table 4-22**. Digester volatile solids reduction matched extremely well with the special sampling value due to a very close match with the total sludge load to digestion. The modeled and measured digester pH are within a reasonable range for calibration, while the modeled dewatering feed pH is slightly lower than the measured value. This is suspected to be the result of chemical addition in sludge holding prior to dewatering. This is evident due to the difference between the digested sludge pH and the dewatering feed pH values reported in **Table 4-22**.

Table 4-22: Comparison of Model and Sampling Results – Digestion and Dewatering

Parameter	Measured (Feb. 19-26, 2017)	Modeled	% Difference: Model to Measured
Digestion/Dewatering Feed			
TWAS + PS Load, ppd	123,791	130,697	6%
Digested Sludge pH	7.3	7.1	-3%
Digester VSS Destruction, %	57%	57%	0%
Digester Biogas Production, cfm	435	882.1	103%
Dewatering Feed Flow, mgd	0.35	0.35	-3%
Dewatering Feed TS, %	20,664	21,964	6%
Dewatering Feed TS, ppd	61,079	63,258	4%
Dewatering Feed pH	7.8	7.1	-8%
Cake			
Cake TS, %	15%	15%	0%
Cake TS, ppd	64,725	60,144	-7%
Dewatering Filtrate Overflow			
Dewatering Filtrate TSS Load	2,929	3,114	6%
Dewatering Filtrate COD Load	5,268	4,084	-22%
Dewatering Filtrate TKN Load	2,861	3,357	17%

4.3.2 Step 2 – Evaluate the model dynamically on an hourly basis.

After steady-state calibration during the sampling week, the next step in the calibration process is to develop influent fractions dynamically and calibrate the model under dynamic conditions during the sampling week. The purpose of the dynamic simulation is to further calibrate the model, and confirm that the influent fractions developed represent the influent wastewater both statically and dynamically on a daily and/or hourly basis.

Dynamic hourly or diurnal simulations were conducted during the special sampling week to further calibrate the model to the diurnal variations observed at the treatment plant. Grab samples collected every two hours from the HFC AWTP influent were used to develop hourly concentration peaking factors. The peaking factors determined were then applied to the composite samples for each day during the sampling week to create the hourly diurnal influent characteristics. These data points were input into the model for the entire sampling week. All hourly and daily operating data that was measured and available for each unit process, such as return activated sludge flow rates, were used as controls in the sampling week diurnal simulation via hourly data files. Hourly grab samples and daily composite samples from each unit process and the final effluent were used to compare the model results from the sampling week diurnal simulation. Adjustments were made to the model while running the sampling week diurnal simulation to ensure consistent matching between the modeled and measured data.

Influent concentrations were entered into the model using user-specified data files to automatically adjust the influent parameters based on the time of day during the simulation. The results from the hourly simulations and sampling data from the week of February 19th, 2017 for influent constituents are shown in **Figures 4-2** through **4-6**.

Modeled and measured influent flow is presented in **Figure 4-2**. Flows were entered directly into the model based on the hourly flow measurement from the influent monitoring site.

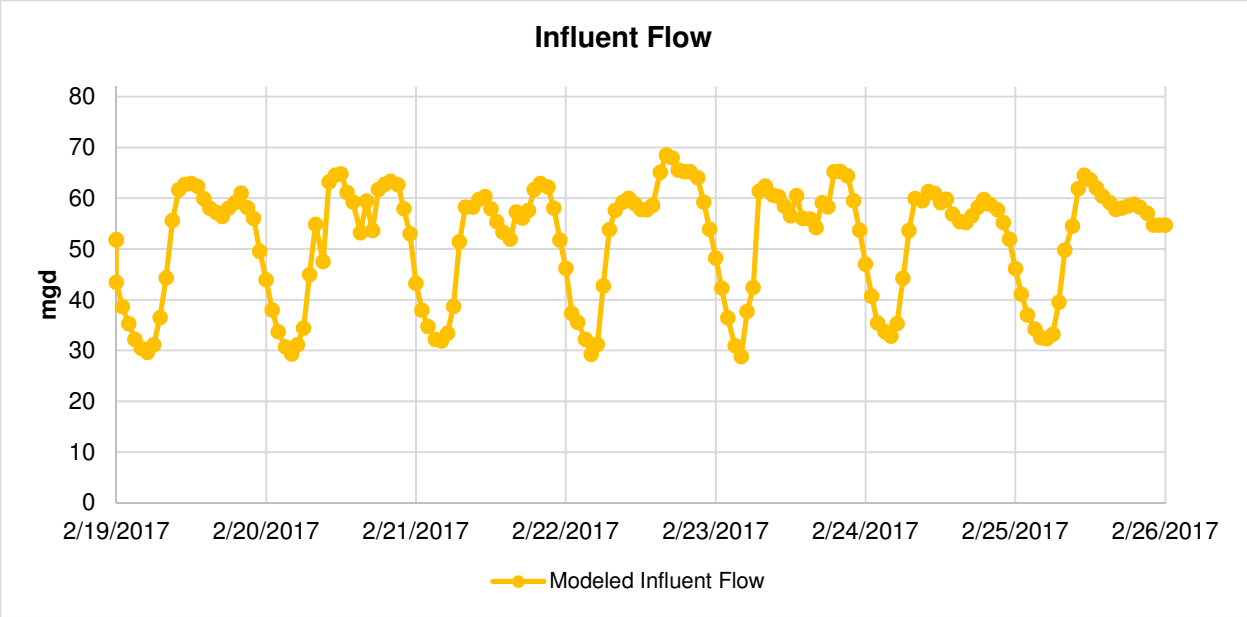

Figure 4-2: Dynamic Hourly Model Results – Influent Flow

Model predicted TSS and VSS are presented along with the sampling measurements in **Figure 4-3**. The model influent TSS and VSS concentrations were predicted by applying the influent fractions calculated from the influent characterization to the diurnal COD concentrations for the sampling week. The predicted TSS and VSS concentrations matched a majority of the sampling week data very well. Some TSS and VSS measurements appear to diverge from the estimated diurnal peaking factors. Most measured data points that exhibit this variation from the estimated diurnal trend are process grab samples not associated with the two diurnal sampling days.

Composite samples taken during the sampling week are depicted in the figure at the end of each day where data was available. The composite data also matches well with the predicted values, providing further confirmation of the applicability of the influent fractionation.

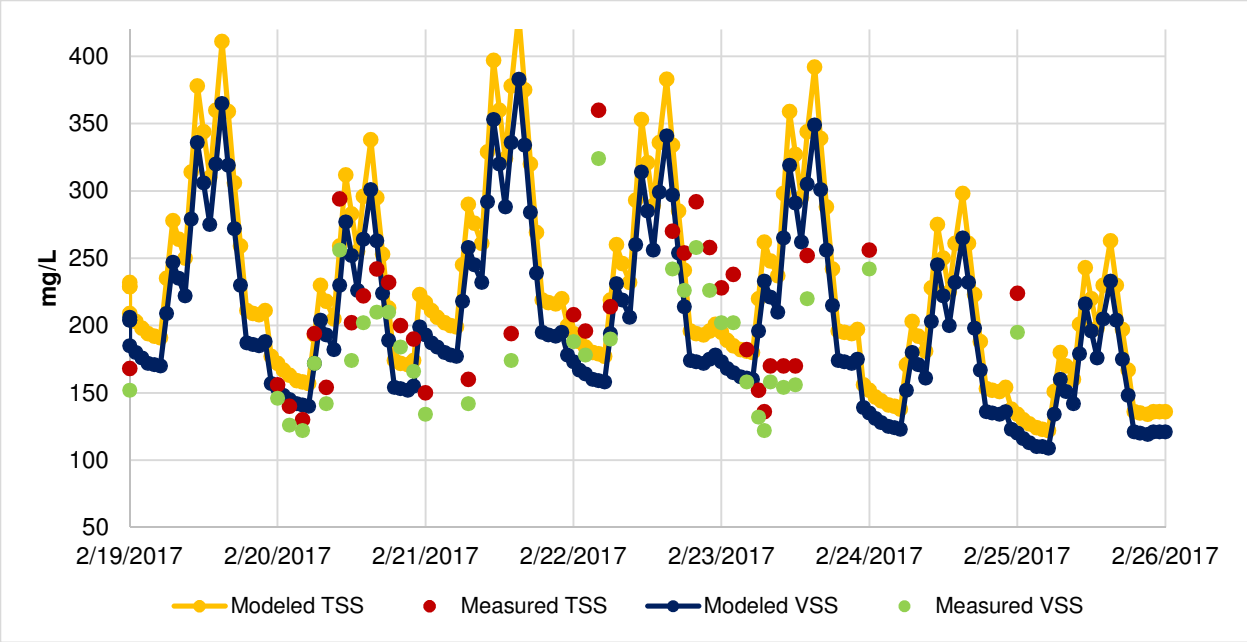

Figure 4-3: Dynamic Hourly Model Results – Influent TSS and VSS Concentrations

The model predicted COD concentrations were calculated directly from the diurnal peaking factors. As a result modeled COD concentrations were a direct match to measured data where the diurnal grab sample measurements are shown in **Figure 4-4**.

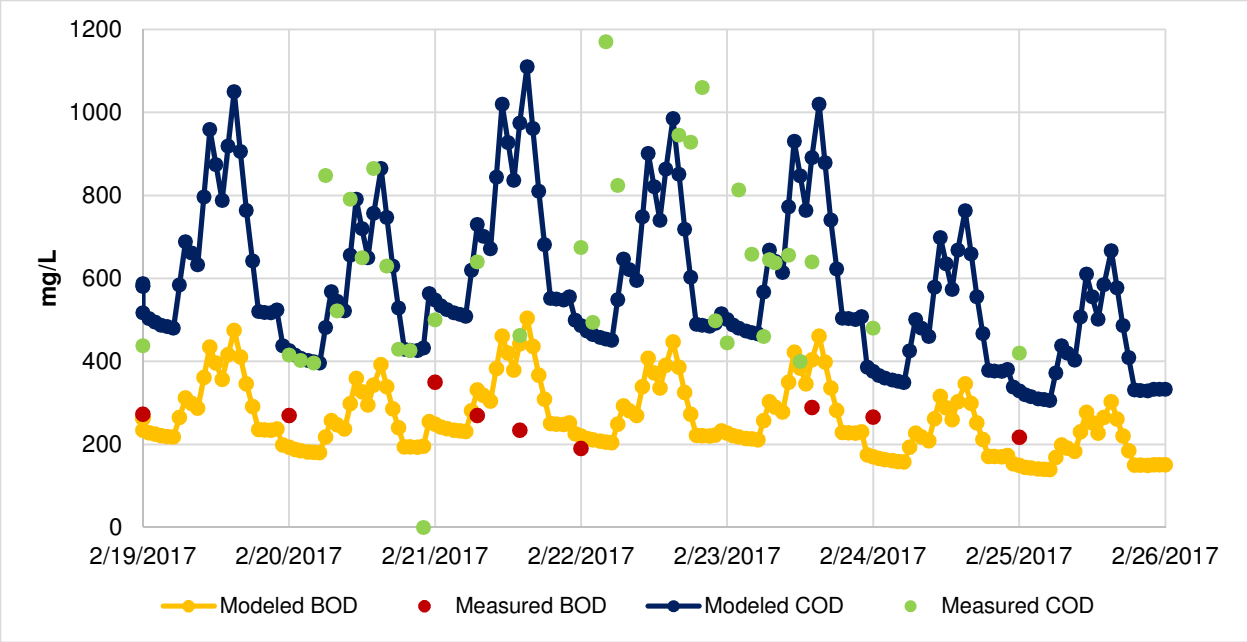

Figure 4-4: Dynamic Hourly Model Results – Influent BOD and COD Concentrations

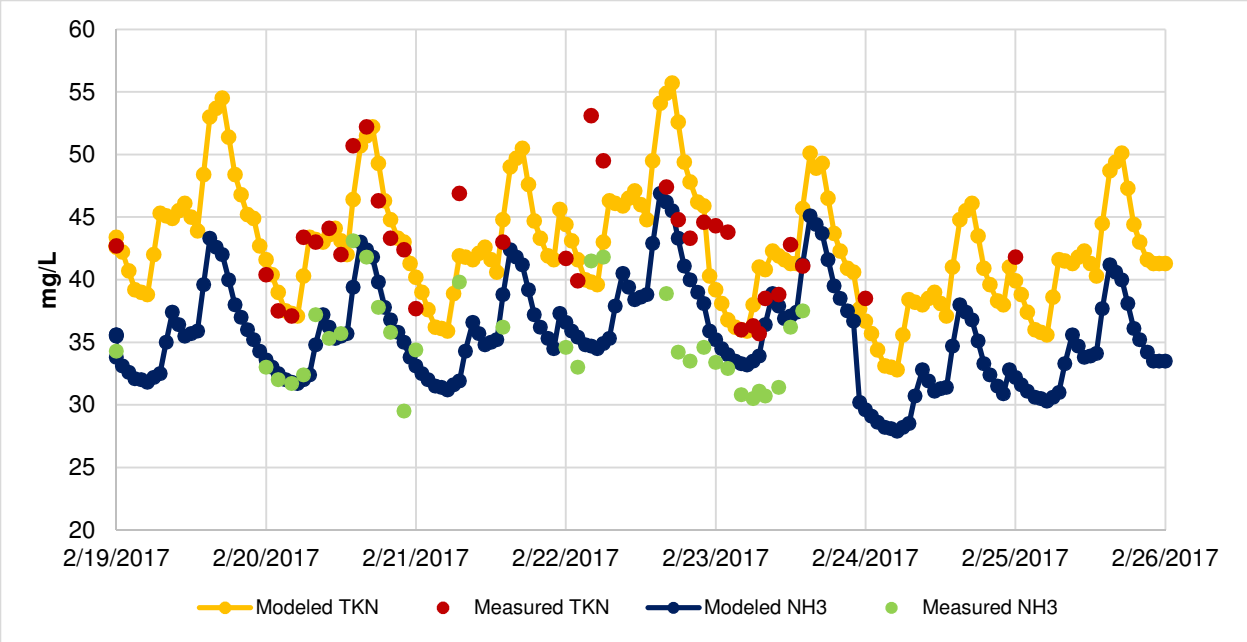

Figure 4-5: Dynamic Hourly Model Results – Influent TKN and NH_3-N Concentrations

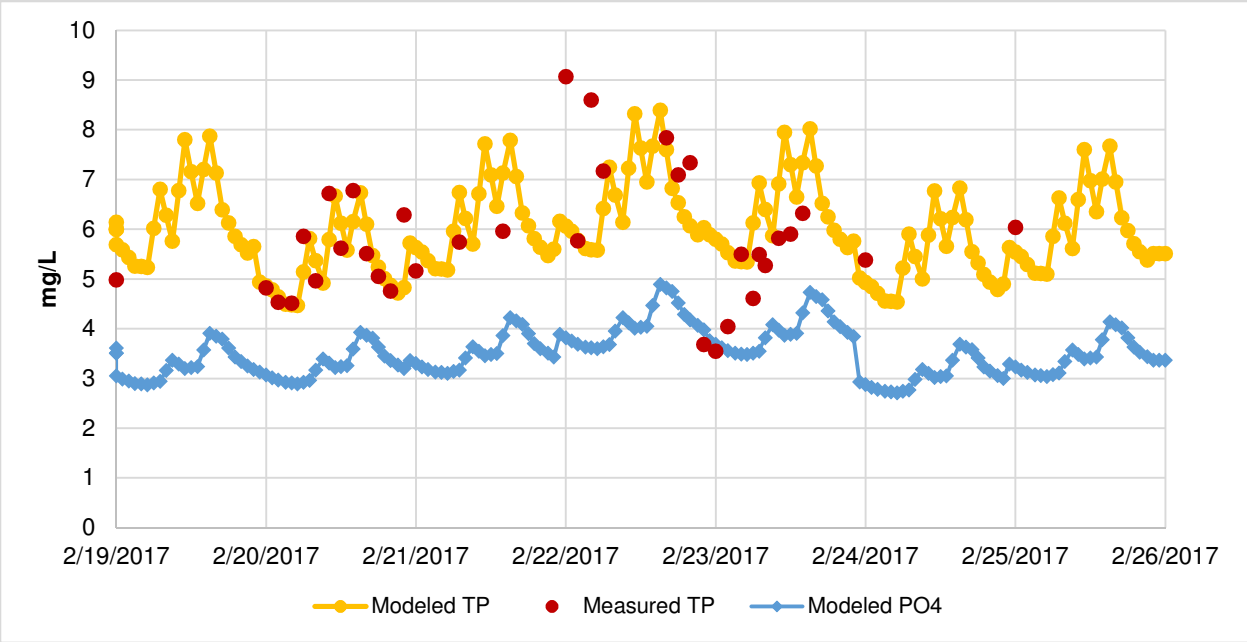

Figure 4-6: Dynamic Hourly Model Results – Influent TP Concentrations

TKN, NH_3-N, and TP values also directly matched diurnal grab sampling data where it was used to prepare the diurnal peaking factors as shown in **Figure 4-5** and **Figure 4-6**.

Results from the primary clarifier effluent provided additional confirmation of the influent fractionation used and increased confidence in the adjustments to the primary clarifier removal rates in the model. Primary clarifier effluent BOD and COD concentrations are shown in **Figure 4-7**, and show a good match to the composite sampling measurements taken during the sampling week. Primary clarifier effluent

TKN and NH_3-N concentrations also showed a good match to the measured composite samples and process grab samples as shown in **Figure 4-8**.

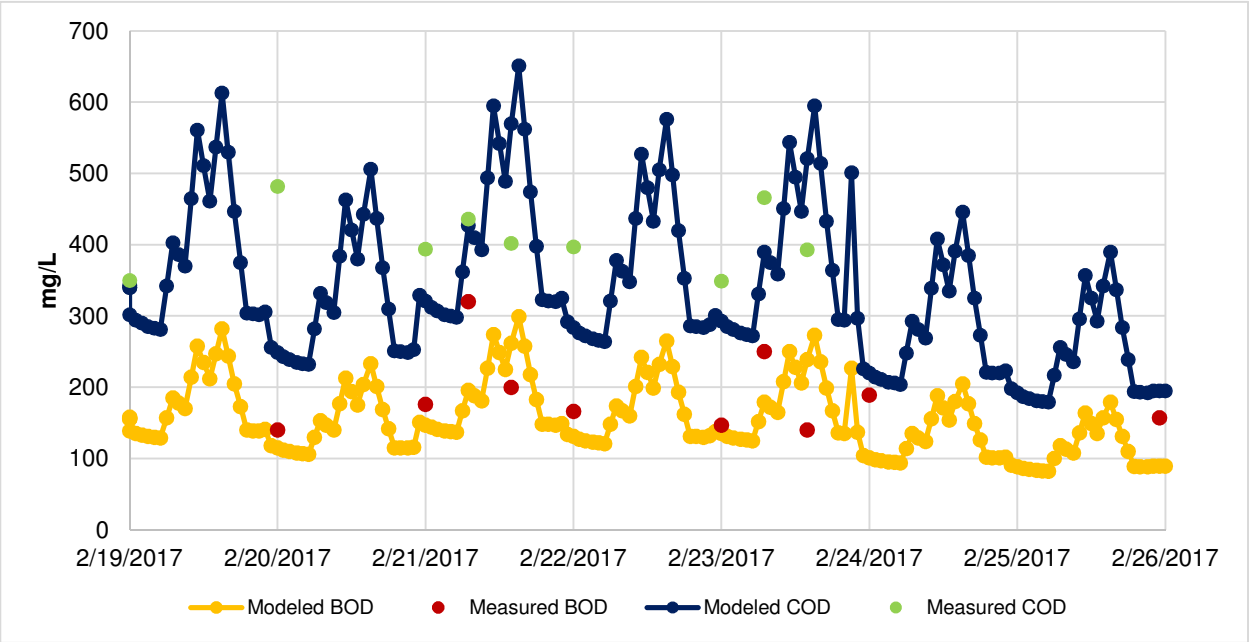

Figure 4-7: Dynamic Hourly Model Results – Primary Clarifier Effluent BOD and COD

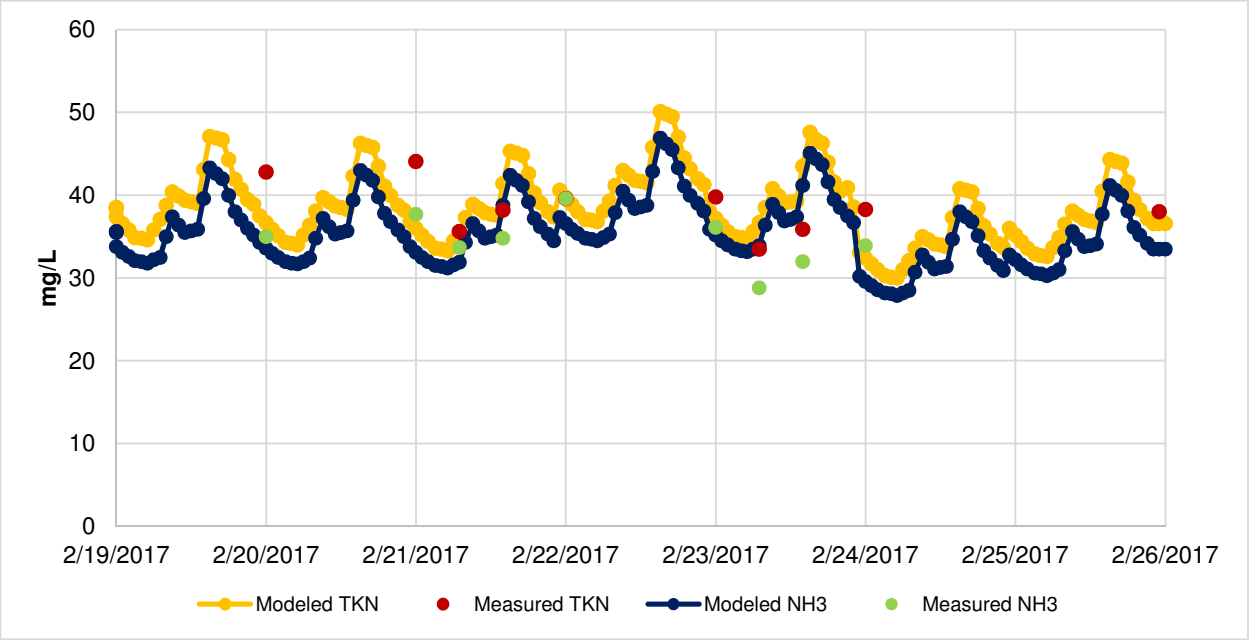

Figure 4-8: Dynamic Hourly Model Results – Primary Clarifier Effluent TKN and NH_3-N

Primary clarifier effluent TSS concentrations from the model showed some minor variation from the sampling week composite data as shown in **Figure 4-9**. This was expected due to the adjusted primary

clarifier removal efficiency in the model, and the results still provided a reasonable approximation of the primary clarifier effluent concentrations.

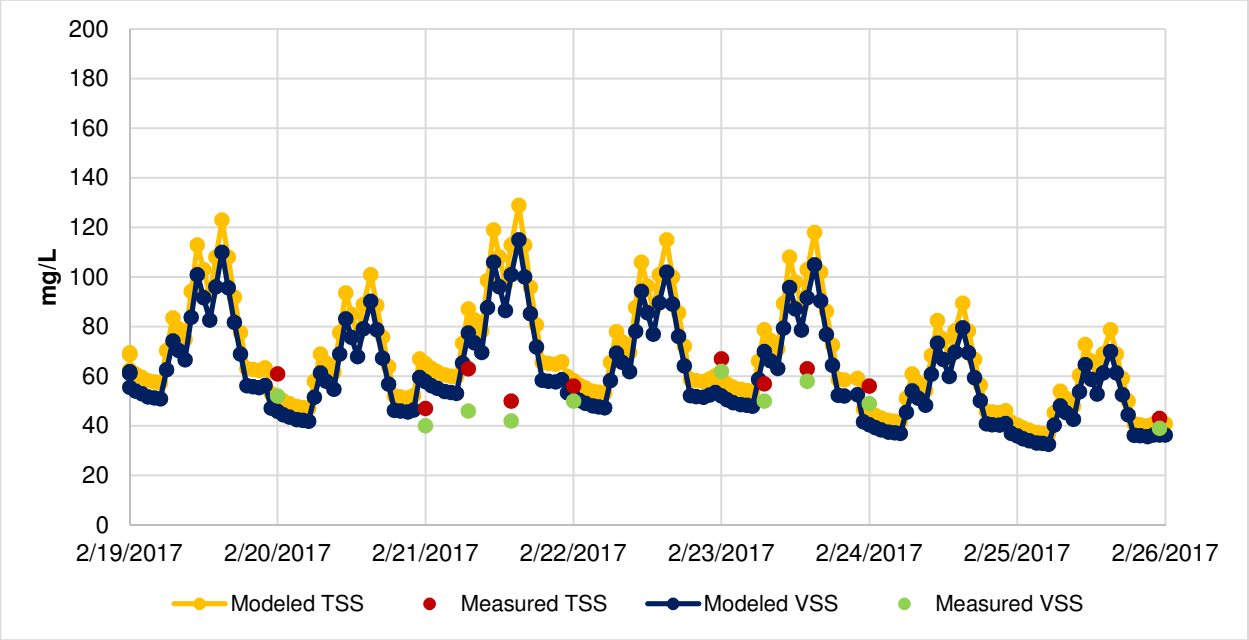

Figure 4-9: Dynamic Hourly Model Results – Primary Clarifier Effluent TSS and VSS

Applicability of the influent fractionation and confidence in the primary clarifier effluent concentrations was further confirmed based on the dynamic model results of the carbonaceous reactor MLSS concentrations and the carbonaceous clarifier effluent BOD, COD, TSS, and VSS concentrations. Carbonaceous reactor MLSS concentrations (shown in **Figure 4-10**), BOD, COD, TSS, and VSS (shown in **Figure 4-11**) matched well with the daily composite samples, while also exhibiting diurnal variation as would be expected from the high rate process.

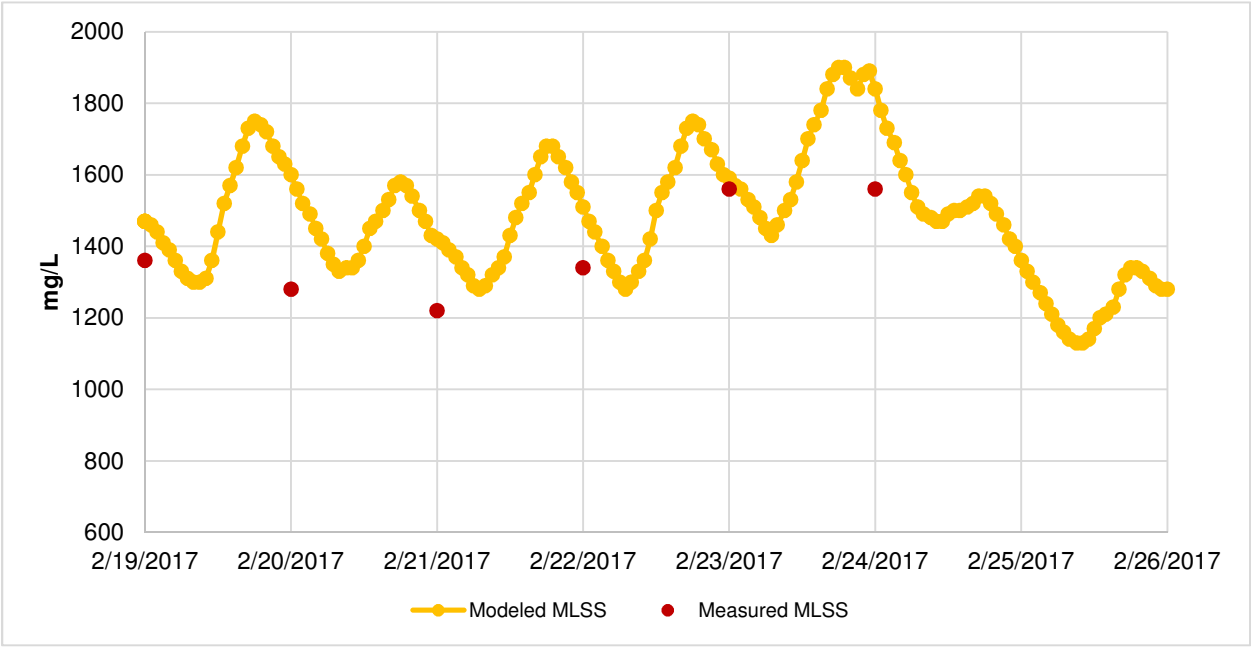

Figure 4-10: Dynamic Hourly Model Results – Carbonaceous Reactor MLSS

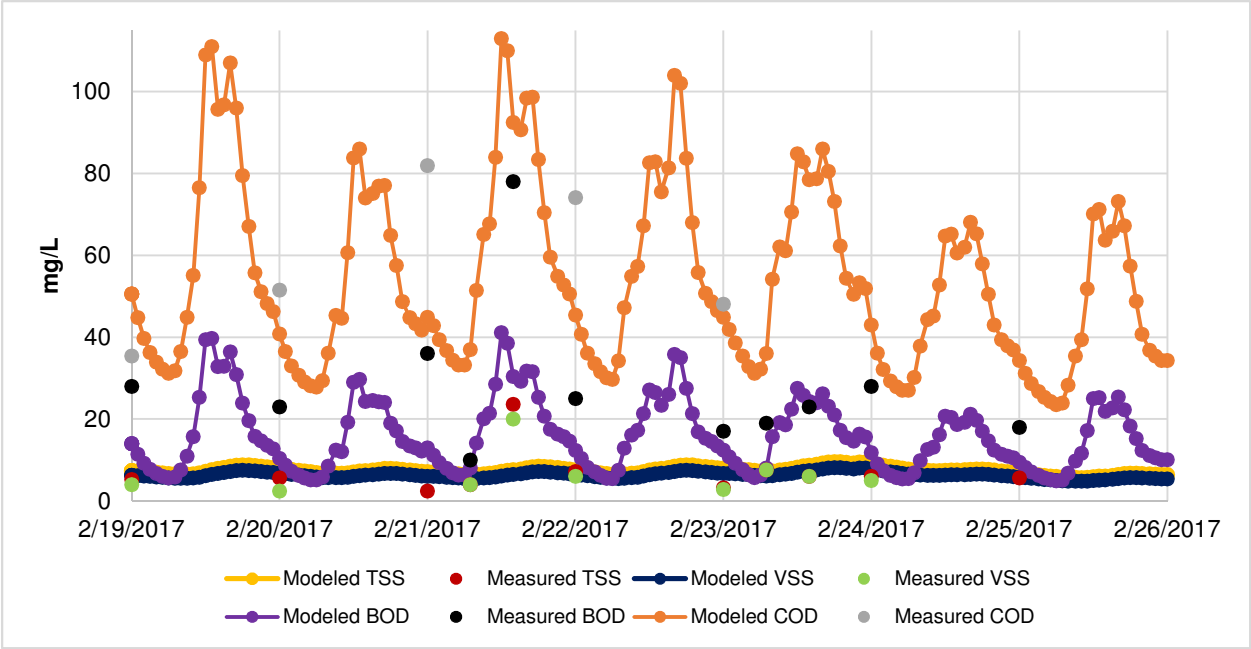

Figure 4-11: Dynamic Hourly Model Results – Carbonaceous Clarifier Effluent BOD, COD, TSS, and VSS

No measured data was available for comparison of nitrogen concentrations from the carbonaceous clarifier effluent. Instead, the modeled nitrification reactor influent nitrogen concentrations were compared to the measured hourly values from the nitrification reactor influent ChemScan analyzer. These measurements serve as a surrogate for the carbonaceous clarifier effluent nitrogen concentrations. Measured on-line ChemScan data for the nitrification reactor influent does include the "spike" line influent from the main pump station as well as nitrified recycle flow (NRCY) when the nitrification reactor recycle gate is open in anoxic operation. As a result, the ChemScan measured NH_3-N and NO_3-N concentrations are impacted by the "spike" and NRCY flows. The "spike" influent may increase the nitrification reactor influent NH_3-N concentration while also diluting the NO_3-N concentration some. On the other hand, the ChemScan measurement for NH_3-N is diluted by NRCY flow, while the NO_3-N concentration increases. Therefore, the ChemScan measurements for the nitrification reactor influent nitrogen concentrations will differ from the modeled values. However, the nitrification reactor influent measured data is valuable as general guidance to evaluate trends and order of magnitude concentrations.

The model did exhibit some difficulty in matching the nitrification reactor influent nitrogen concentrations as NH_3-N appeared to be out of phase with the hourly measurement data shown in **Figure 4-12**. Modeled NO_3-N concentrations shown below continue to show a small amount of nitrification occurring in the carbonaceous reactors as seen in the Step 1 steady state simulations.

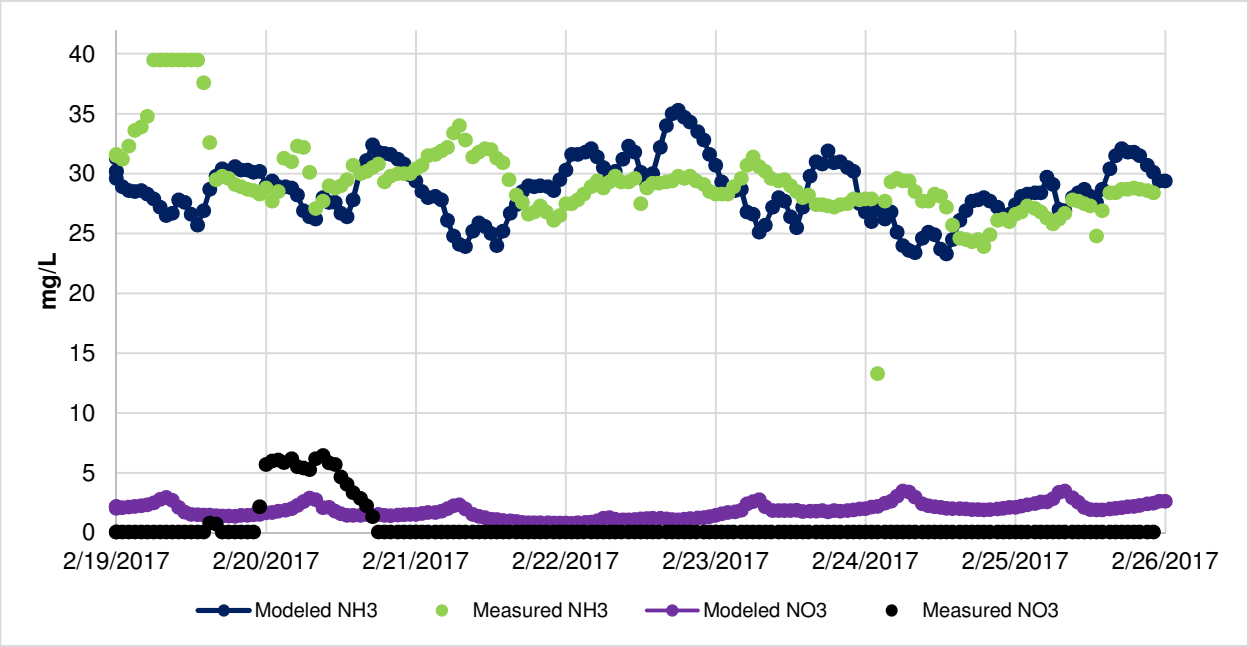

Figure 4-12: Dynamic Hourly Model Results – Nitrification Reactor Influent NH_3-N and NO_3-N

Nitrification reactor MLSS concentrations and nitrification clarifier effluent solids and substrate values matched well with the daily composite measurements from the sampling week as shown in **Figure 4-13** and **Figure 4-14**. Composite samples of the nitrification reactor MLSS concentration shown in **Figure 4-13** were unstable in the first three days of the sampling week. The high variability in the MLSS concentration is not believed to be accurate since it is unlikely to see this level of variation in an activated sludge process with an SRT greater than 10 days. Changes in MLSS concentration at an SRT of 10 days are expected to be gradual since a very small fraction of biomass in the reactors is wasted. An excellent

match to the remainder of the MLSS data was shown, confirming the nitrification reactor and clarifier calibration for oxidation of organics, sludge production, and settling.

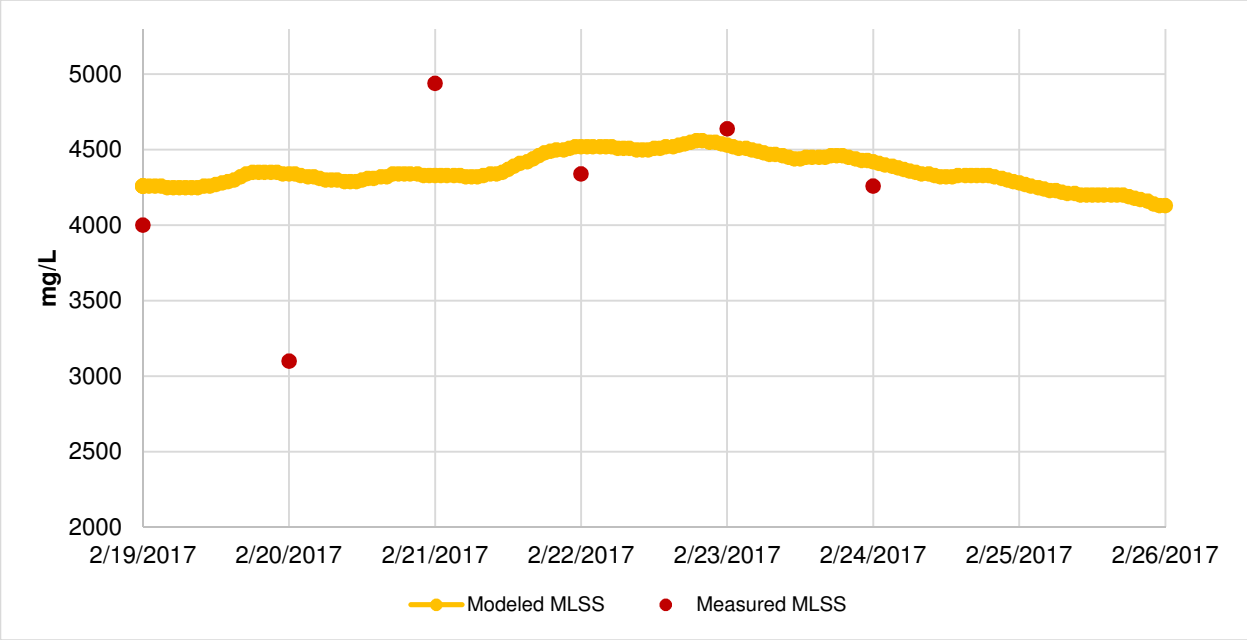

Figure 4-13: Dynamic Hourly Model Results – Nitrification Reactor MLSS

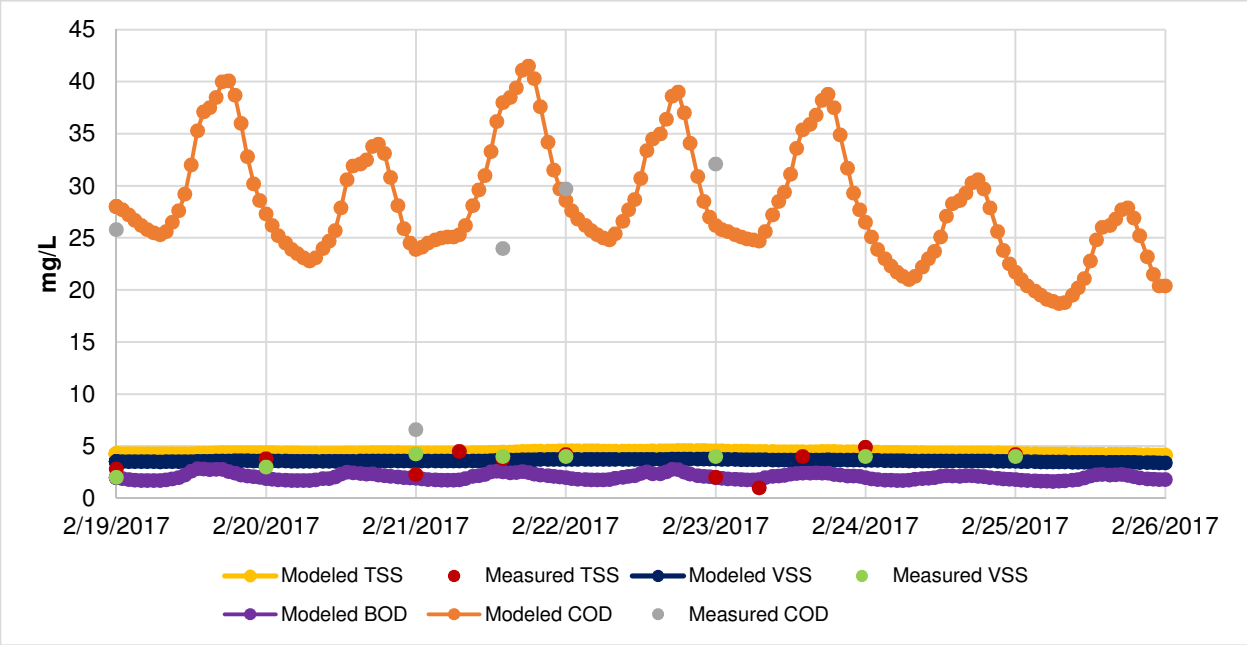

Figure 4-14: Dynamic Hourly Model Results – Nitrification Clarifier Effluent BOD, COD, TSS, and VSS

Modeled nitrification clarifier effluent nitrogen concentrations, shown in **Figure 4-15**, did not match the measured trends similar to the carbonaceous clarifier effluent nitrogen profiles. It should be noted that average values did match well throughout the week but diurnal flow trends showed an impact on the denitrification capacity of the nitrification reactors. Drops in NO_3-N in the model appeared to correspond to COD and BOD breakthrough from the carbonaceous reactors in the model. This difference appears to be caused by the influent COD peaking factors that were developed to characterize the diurnal influent. The COD peaking factors may be too variable, causing un-realistic peaks and subsequent COD breakthrough from the carbonaceous reactors that provides additional carbon to assist denitrification. No corresponding increase in nitrification clarifier effluent NH_3-N occurred in concert with these periods of high NO_3-N removal, indicating complete oxidation of NH_3-N at all times during the simulation.

Some spikes in NO_2-N are shown below, which also correspond to the periods of COD and BOD breakthrough from the carbonaceous reactors. These NO_2-N spikes indicate some incomplete denitrification due to the COD breakthrough from the carbonaceous reactors, which is confirmed by the major drop in NO_3-N predicted by the model. This does not appear to be a fault in the calibration of the model, rather it further confirms that COD peaking factors developed may be overly sensitive and resulting in unrealistic peaks. This may also be an indication of inaccurate timing of recycle returns in the model as some recycle flows are averaged throughout the day as a limitation of the model. Despite this, these diurnal variations are not expected to impact steady state simulations of improvement recommendations as average model results showed a good match to average measurements.

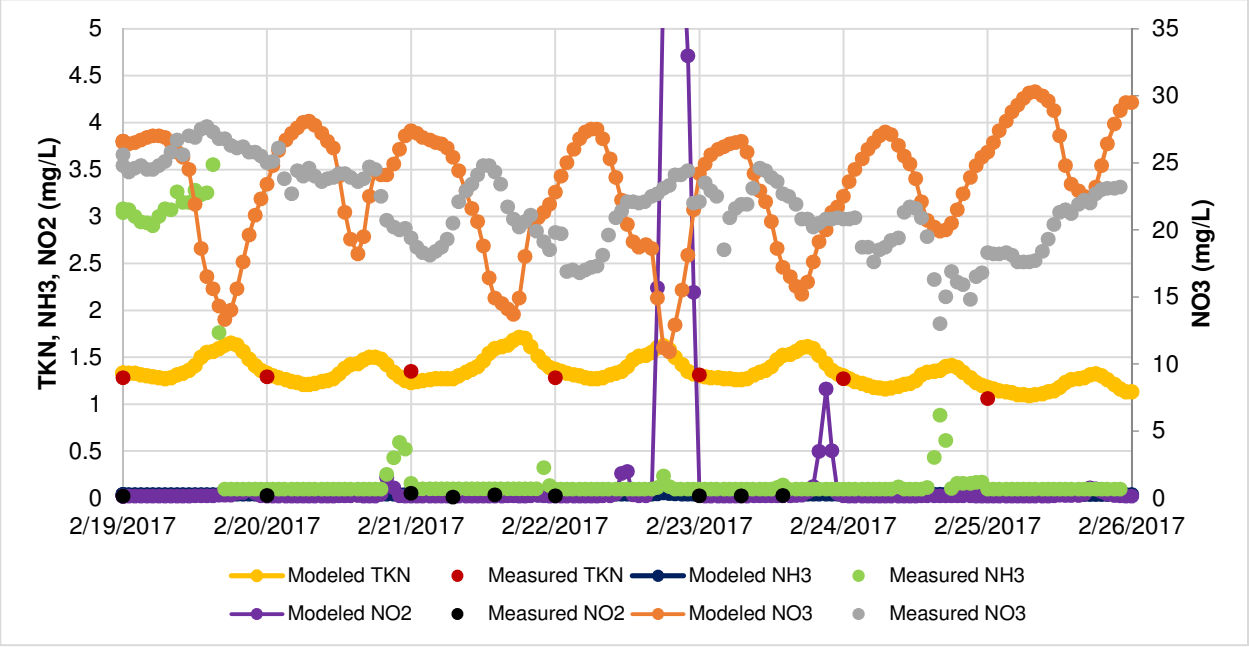

Figure 4-15: Dynamic Hourly Model Results – Nitrification Clarifier Effluent Nitrogen

The peaking behavior in the nitrification clarifier effluent did not have a major impact on the model results in the denitrification filters as shown in **Figure 4-16**. Original calibration of the denitrification filters was performed based on the hourly methanol flow rates reported from the methanol flow meters. These hourly flow rates were found to be inconsistent with the actual methanol volume used from rail cars. Discussions with plant operations staff indicated that the flow meter data reported in SCADA was not representative of the actual volume used. The methanol dose rate was therefore corrected in favor of

the actual daily methanol usage measurements, which increased the average dose rate from 2.4 to 2.9 gpm. Again, the average model results from the denitrification filters matched well with the measured data, however, timing of the NO_3-N loading from the nitrification clarifier effluent resulted in a few minor peaks of NO_3-N leaving the filters. Variability in the measured data increased significantly towards the end of the sampling week. As a result, the peaks resulting from this variability are not believed to be realistic.

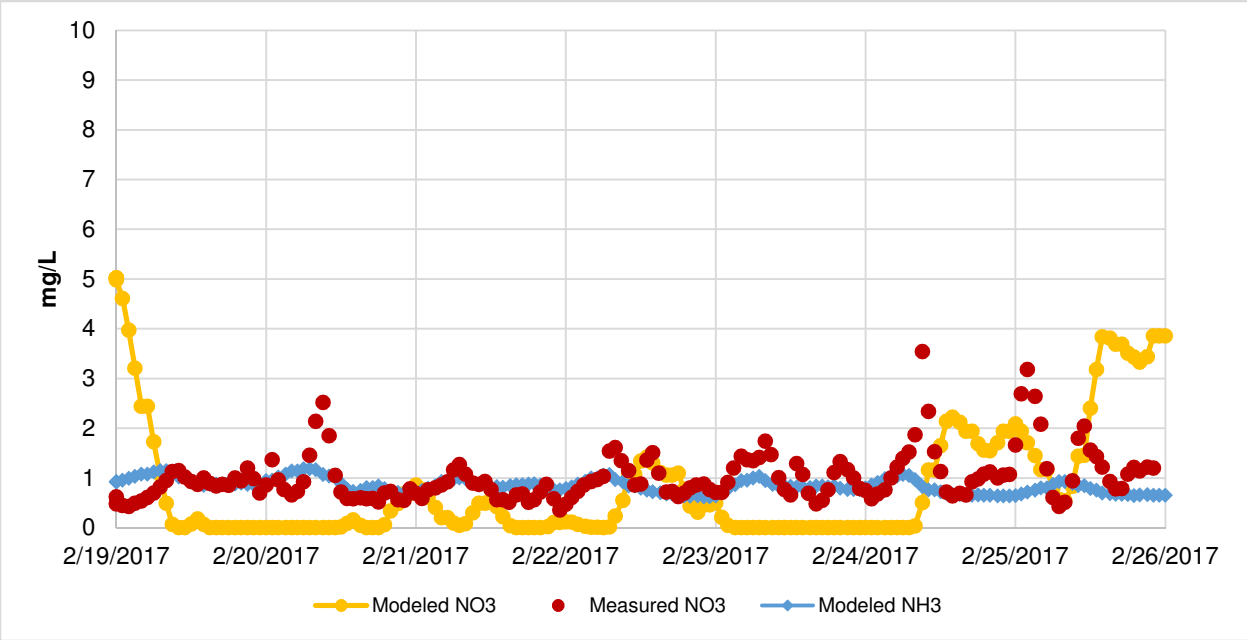

Figure 4-16: Dynamic Hourly Model Results – Denitrification Filter Nitrogen

Comparisons of the results from the hourly simulations and sampling data for the final effluent are shown in **Figures 4-17** through **4-20**.

Effluent TSS results from the model were relatively stable due to the empiric solids removal efficiency calibration of the denitrification filters. The empiric solids capture efficiency used in the model was calibrated to denitrification filter effluent TSS concentrations reported.

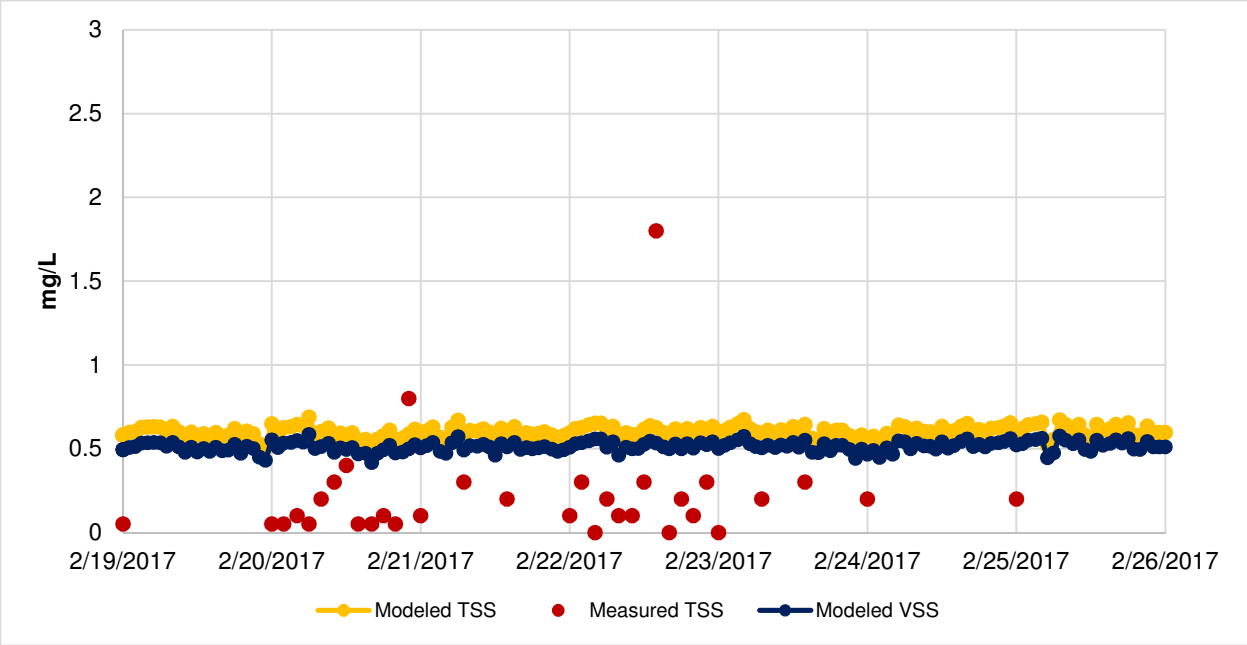

Figure 4-17: Dynamic Hourly Model Results – Final Effluent TSS Concentrations

Modeled effluent COD values were consistent with the upper range of sampled effluent COD values. It is important to note that some sampled effluent COD values presented in **Figure 4-17** were less than the minimum COD value possible in the model due to the set fraction of soluble inert COD. Modeled effluent COD values appeared to have reached the minimum value based on this fraction and therefore could not match the minimum sampled effluent COD values. The measured effluent COD values less than 15 mg/L are suspected to be inaccurate based on the final effluent composite sampling data that shows an average effluent COD of 23 mg/L.

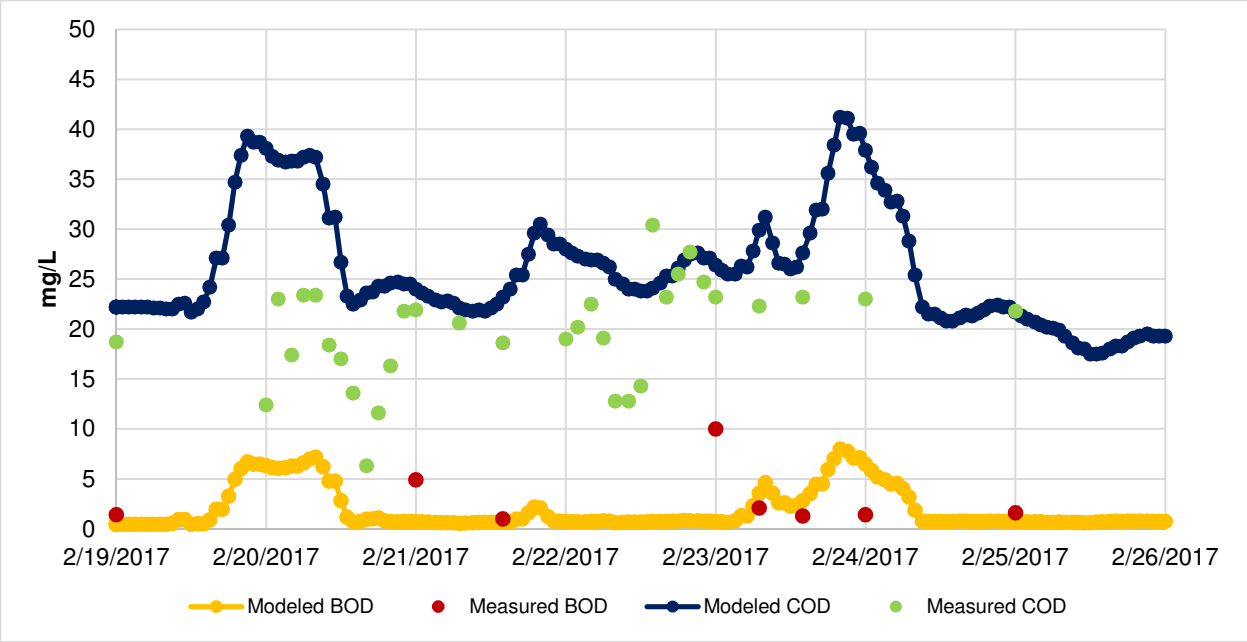

Figure 4-18: Dynamic Hourly Model Results – Final Effluent BOD and COD Concentrations

Modeled final effluent nitrogen species match well with the measured effluent values with the exception of effluent TKN and NH_3-N due to the model's over-prediction of methylotrophic decay as discussed previously.

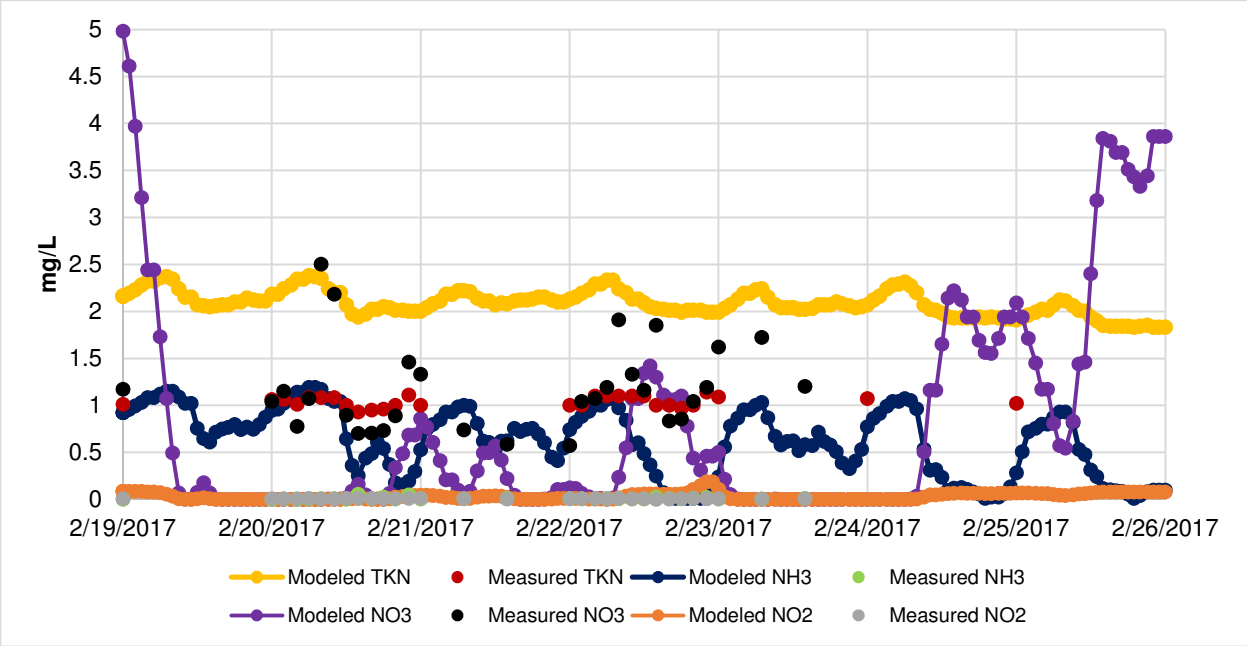

Figure 4-19: Dynamic Hourly Model Results – Final Effluent Nitrogen Concentrations

The model generally underestimates the effluent phosphorus concentration based on **Figure 4-20** below.

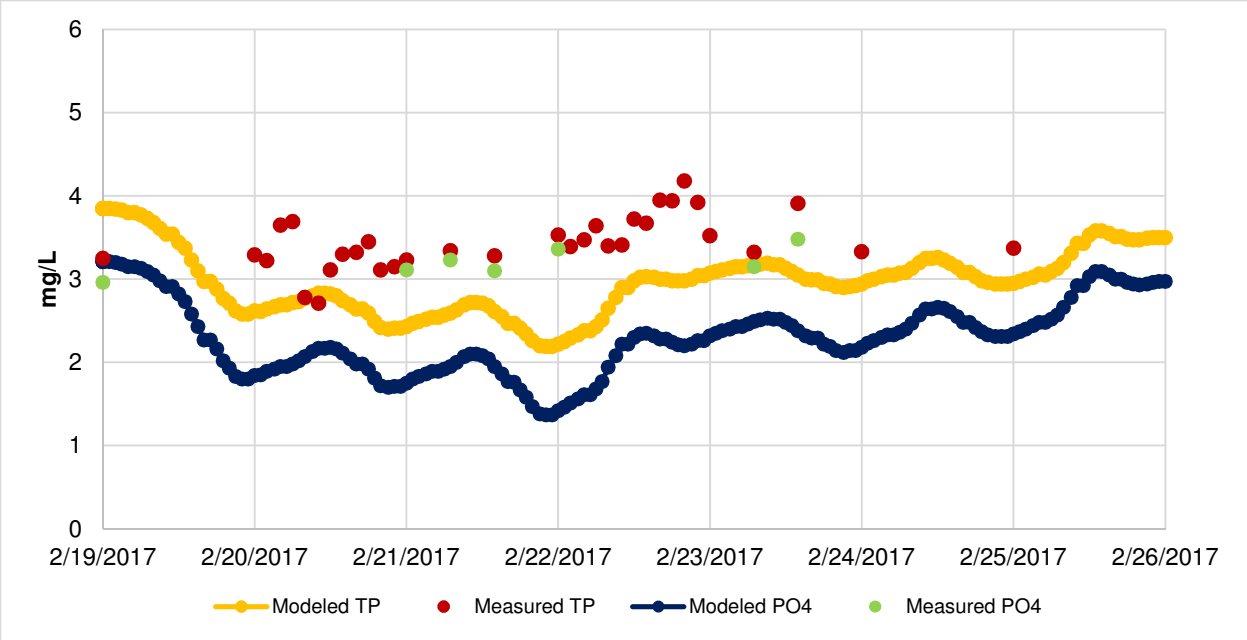

Figure 4-20: Dynamic Hourly Model Results – Final Effluent TP Concentrations

4.3.3 Step 3 – Validate the model using steady state simulation to a time period outside the sampling week.

After the steady state and dynamic calibration from the special sampling week data, historical steady state simulation was performed for a time period of steady influent flows and similar operation. Historical data was compiled from the month of March 2016, which experienced mildly varying flows and influent concentrations with operations very similar to the sampling week. Influent flow, TSS, BOD, cBOD, TKN, TP, alkalinity, and pH data was available from monthly operating reports and operational data provided by the COT. Influent fractions from the previous calibration steps were used to develop influent COD, NH_3-N, and PO_4-P concentrations from the historical data to input into the model.

Hourly historical plant operation data was averaged for the month and used to adjust the model operational inputs for each of the unit processes. A summary of the model operational inputs from the historical operating data is provided in **Table 4-23**.

Table 4-23: HFC AWTP Historical Operation Data – March 2016

Parameter	Historical March 2016 Average
Influent Flow, MGD	58.57
Carbonaceous RAS, MGD	18.32
Carbonaceous WAS, MGD	1.50
Oxygen Feed, Tons/day	34.40
Nitrification RAS, MGD	22.77
Nitrification WAS, MGD	0.154
Spike Flow to Nitrification Reactors, MGD	16.65
Diffused Air Flow, cfm	19,299
Total Denitrification Filter Backwash, MGD	14.238
Methanol Feed, gpm	3.02
Thickened WAS, gpm	113.47
Primary Sludge, gpm	127.44
Total Sludge to Digesters	240.91
Digested Sludge to Dewatering, gpm	242.61

A comparison of the modeled and historical average influent data for March 2016 is shown in **Table 4-24**.

Table 4-24: Comparison of Model Results and Historical Data – Influent

Parameter	Measured (March 2016)	Modeled	% Difference: Model to Measured
Flow, MGD	58.6	58.6	0%
TSS, mg/L	174	180	3%
COD, mg/L	453	453	0%
BOD, mg/L	209	206	-2%
TKN, mg/L	36.9	36.9	0%
NH_3-N, mg/L	30.7	30.7	0%
TP, mg/L	5.70	5.70	0%
PO_4-P, mg/L	3.40	3.40	0%
Temperature, C	24.6	24.6	0%

No historical data was available for comparison with the modeled primary clarifier effluent concentrations. The primary clarifier removal efficiency was reduced in several iterations until a removal efficiency set point of 50% achieved a good match with the carbonaceous reactors and nitrification reactors MLSS concentrations and the overall solids balance. Using a 50% primary clarifier removal efficiency in this historical simulation resulted in an overall process yield of 1.0 lb WAS/lb Primary

Effluent cBOD removed and is still within the typical range of removal efficiency for primary clarifiers. Furthermore, primary clarifier removal efficiencies are expected to vary significantly depending on a number of factors.

Historical data for the MPS effluent was compared to the model results, as shown in **Table 4-25**.

Table 4-25: Comparison of Model Results and Historical Data – Main Pump Station

Parameter	Measured (March 2016)	Modeled	% Difference: Model to Measured
Flow, MGD		64.0	
TSS, mg/L	90.0	131	45%
BOD, mg/L	155	153	-1%
TKN, mg/L	43.0	41	-5%
NH_3-N, mg/L	31.0	34.8	12%

While only a handful of historical values were available at the MPS, a good match was shown with the exception of TSS. Matching primary clarifier effluent BOD and MPS effluent BOD values is much more important to the overall mass balance of high rate activated sludge systems such as the carbonaceous reactors.

The comparison of model results and historical values for the carbonaceous reactors is shown in **Table 4-26**. Carbonaceous reactors MLSS and sludge production was well in line with the historical measurements. BOD and NO_3-N were lower than their historical measurements while NH_3-N was higher than its historical measurement. It should be noted that the measured NH_3-N and NO_3-N concentrations in **Table 4-26** are from the nitrification reactor influent ChemScan analyzer as a surrogate for the carbonaceous clarifier effluent. These nitrogen concentration measurements therefore provide only an order of magnitude estimate for the model results, as discussed previously in the Step 2 discussion of the nitrification reactor influent results.

Carbonaceous reactors DO concentrations remained high in this historical scenario as well despite matching the actual feed rate of high purity oxygen to the reactors, similar to the sampling week calibration.

Table 4-26: Comparison of Model Results and Historical Data – Carbonaceous Reactors

Parameter	Measured (March 2016)	Modeled	% Difference: Model to Measured
Carb MLSS, mg/L	1,530	1,650	8%
Carb HPO gas flow, Ton/day	34	33	-4%
Carb Total SRT, day	0.52	0.49	-5%
Carb Effluent TSS, mg/L	9	8.2	-8%
Carb Effluent BOD, mg/L	25	15.8	-37%
Carb Effluent NH3-N, mg/L	21.27	25.13	18%
Carb Effluent NO3-N, mg/L	4.99	1.9	-62%

The comparison of model results and historical values for the nitrification reactors is shown in **Table 4-27**. The MLSS concentration and aeration both match well, similar to the sampling week steady state simulation.

Table 4-27: Comparison of Model Results and Historical Data – Nitrification Reactors

Parameter	Measured (March 2016)	Modeled	% Difference: Model to Measured
Nit MLSS, mg/L	3,888	3,532	-9%
Nit Stage #4 DO, mg/L	2.10	1.50	-29%
Nit Stage #5 DO, mg/L	3.80	3.82	1%
Nit Stage #6 DO, mg/L	5.30	5.00	-6%
Nit Airflow, acfm	19,299	21,000	9%
Nit Total SRT, day	11.2	10.04	-10%
Nit Effluent TSS, mg/L	2.98	3.5	19%
Nit Effluent TKN, mg/L	1.61	1.2	-27%
Nit Effluent NH3-N, mg/L	0.10	0.03	--
Nit Effluent NO3-N, mg/L	19.2	19.4	1%

Sludge production from both the carbonaceous and nitrification reactors matched very well with the historical data as shown in **Table 4-28**. RAS and WAS flows were set in the model based on the historical flow data.

Table 4-28: Comparison of Model Results and Historical Data – Carbonaceous and Nitrification Clarifiers

Parameter	Measured (March 2016)	Modeled	% Difference: Model to Measured
Carbonaceous Clarifiers 1 - 12			
FST 1-12 RAS Flow, mgd	18.3	18.2	-1%
FST 1-12 RAS TSS, mg/L	5,008	5,474	9%
FST 1-12 WAS Flow, mgd	1.50	1.49	-1%
FST 1-12 WAS TSS, mg/L	5,008	5,474	9%
FST 1-12 WAS Load, ppd	62,688	68,035	9%
Nitrification Clarifiers 13 - 20			
FST 13-20 RAS Flow, mgd	22.8	22.8	0%
FST 13-20 RAS TSS, mg/L	12,872	13,128	2%
FST 13-20 WAS Flow, mgd	0.15	0.15	0%
FST 13-20 WAS TSS, mg/L	12,872	13,128	2%
FST 13-20 WAS Load, ppd	16,542	16,873	2%

No historical data was available for comparison to the model Denitrification Filter results, however final effluent data was available for comparison. Final effluent data can be safely used for this treatment plant to judge the Denitrification Filter performance. The comparison of model results and historical values for the final effluent is shown in **Table 4-29**. Model denitrification efficiency was initially very poor during the historical validation period and was suspected to be the result of inaccurate methanol dose reporting. Recalibration of the Denitrification Filters was attempted for the historical validation period by adjusting mass transfer parameters, heterotrophic and methylotrophic kinetics, and biofilm density. No improvement to the Denitrification Filter effluent was realized through this recalibration effort, therefore calibrated filter variables were returned to their values from the sampling week calibration. As a test, methanol dosing was increased to the dosing rate used during the sampling week, resulting in significantly better effluent concentrations that closely approximated the historical values. As discussed in the Step 2 discussion of the denitrification filter results, historical hourly methanol dose rates were found to be significantly inaccurate. Historical volume of methanol used daily from the rail cars was substituted for the hourly measurements. The updated methanol dosing adjusted the monthly average methanol dose rate from 1.72 gpm based on the hourly data, to 3.02 gpm using the actual volume removed from the rail cars. This adjustment significantly improved the model denitrification efficiency and brought the final effluent results much closer to the measured data.

Table 4-29: Comparison of Model Results and Historical Data – Final Effluent

Parameter	Measured (March 2016)	Modeled	% Difference: Model to Measured
Flow, MGD	57.7	58.8	2%
TSS, mg/L	1.02	2.19	115%
COD, mg/L	28	20.64	-26%
BOD, mg/L	1.45	2.19	51%
TKN, mg/L	1.48	2.03	37%
TN, mg/L	2.38	2.09	-12%
NH_3-N, mg/L	0.10	0.76	--
NO_X-N, mg/L	0.90	0.05	--
TP, mg/L	2.93	3.71	27%
Alkalinity, mg/L	181.39	204.18	13%
pH	6.90	7.94	15%

Model results for the biosolids processes are presented below in **Table 4-30** and **Table 4-31**. Carbonaceous WAS and thickened WAS values were similar to the measured values and indicated a relatively good match with sludge production. Sludge production predicted from the carbonaceous stage is moderately high, however it may have been impacted by influent COD values used in the model around 3/11/2016 and 3/16/2016 that are suspected to be erroneously high. If the influent COD values from those periods are in fact incorrect, predicted carbonaceous stage sludge production would be reduced.

There is also a significant difference in the total thickened WAS + primary sludge load shown in **Table 4-31**. The reported historical values for the thickened WAS + primary sludge load were calculated from the historical primary sludge flow rate and percent total solids. This historical calculated sludge load is suspected to be exaggerated because the primary sludge flow rate is not directly measured. Reported historical primary sludge flow rates are calculated from the flow of total sludge to the digesters, subtracted by the thickened WAS flow. There is considerable error in this calculation because there are multiple periods of negative primary sludge flows reported. It is expected that the actual primary sludge flow rates are less than reported.

Table 4-30: Comparison of Model Results and Historical Data – WAS Thickening

Parameter	Measured (March 2016)	Modeled	% Difference: Model to Measured
Carbonaceous Sludge			
WAS Flow, mgd	1.50	1.49	-1%
WAS TSS, mg/L	5,008	5,474	9%
WAS TSS, ppd	62,688	68,035	9%
Thickened Carbonaceous Sludge			
Thickened WAS Flow, mgd	0.16	0.16	0%
Thickened WAS TS, %	4.58%	4.97%	9%
Thickened WAS TSS, ppd	62,400	67,796	9%

Table 4-31: Comparison of Model Results and Historical Data – Digestion and Dewatering

Parameter	Measured (March 2016)	Modeled	% Difference: Model to Measured
Digestion/Dewatering Feed			
TWAS + PS Load, ppd	136,950	111,888	-18%
Dewatering Feed Flow, mgd	0.35	0.35	-1%
Dewatering Feed TS, ppd	60,310	54,306	-10%
Cake			
Cake TS, %	15.3%	16%	5%

4.3.4 Step 4 – Validate the model dynamically using a time period outside the sampling week.

After the successful steady state historical validation, dynamic simulations of the historical validation period were run. All available hourly and daily influent, operating, and monitoring data was compiled and input into the model via data files to automatically control changes to match the historical timing as best as possible. Some parameters and flow rates were unavailable and could not be included in the data files for inputs. Where only daily data was available, these values were utilized for the entire day. Data from the sampling week calibration step such as flow rates or removal rates were used when historical data was completely unavailable. Historical results from hourly or daily monitoring were compiled and are shown on the output figures that follow for comparison and validation of the modeled results. It should be noted that only daily composite values were available for the influent characteristics. This limits the model's ability to mimic short-term variations in the reported values. However, with daily influent data and some hourly operational data the model is capable of matching average trends that occur over a day or more.

Influent flow, substrate, solids, nitrogen, and phosphorus concentrations are shown in **Figures 4-21** through **4-25**. The influent fractionation for soluble to particulate COD showed a good match to the measured TSS concentrations for most of the dynamic simulation period, but several data points resulted in higher model influent TSS concentrations similar to the results of the sampling week dynamic simulation.

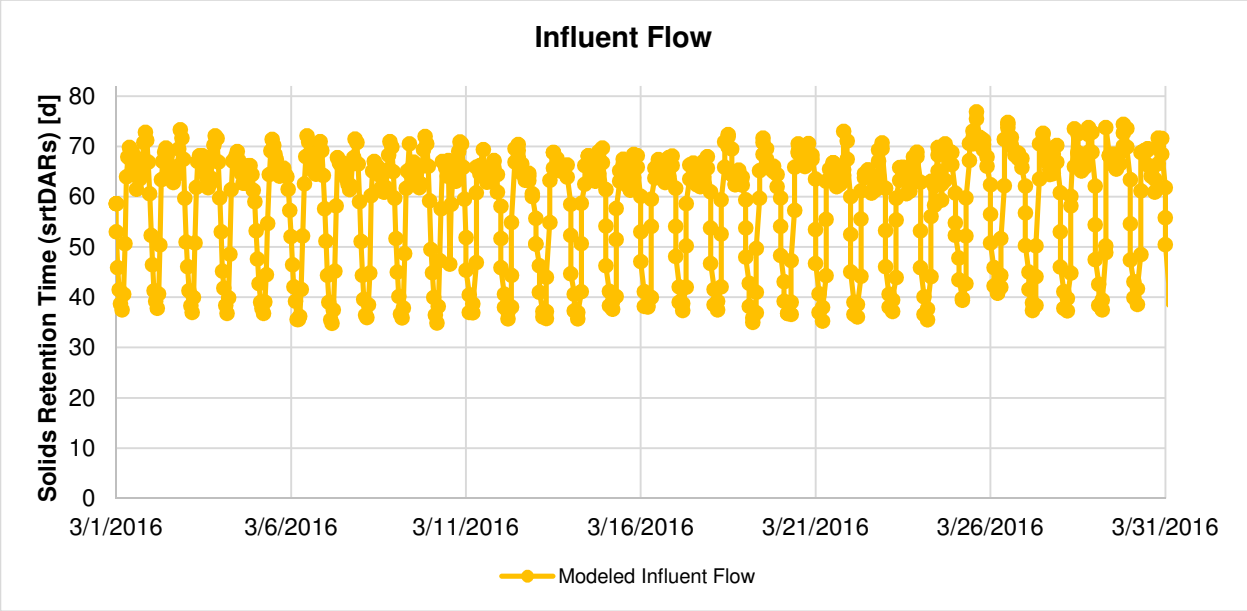

Figure 4-21: Dynamic Historical Model Results – Influent Flow

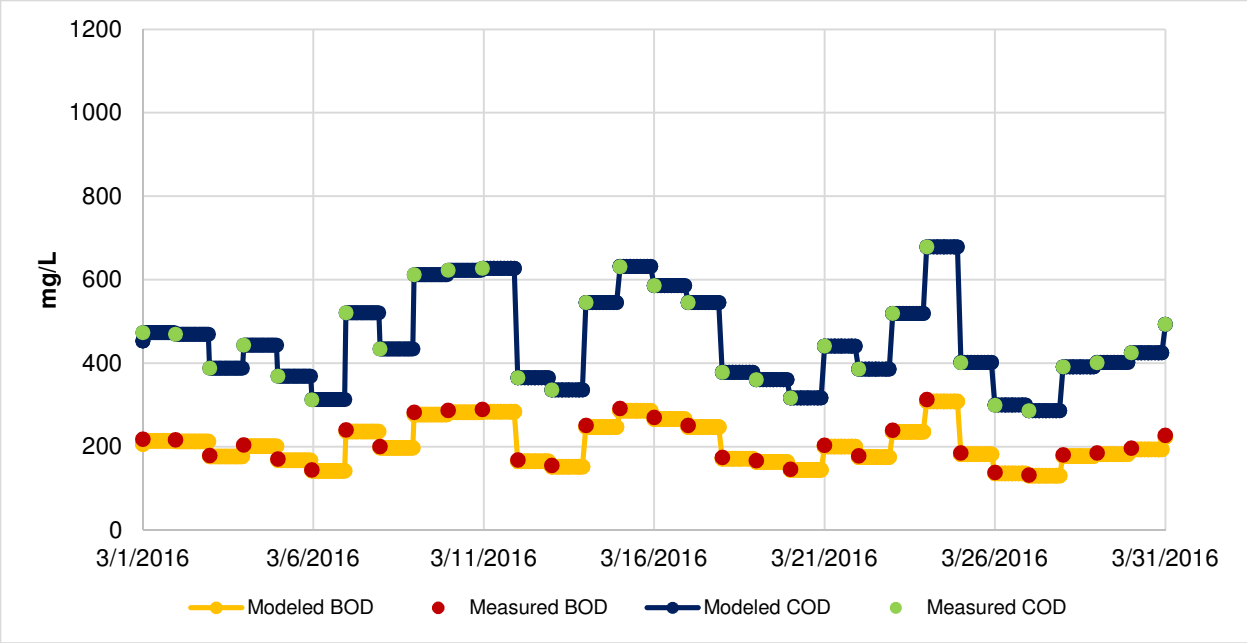

Figure 4-22: Dynamic Historical Model Results – Influent Substrate

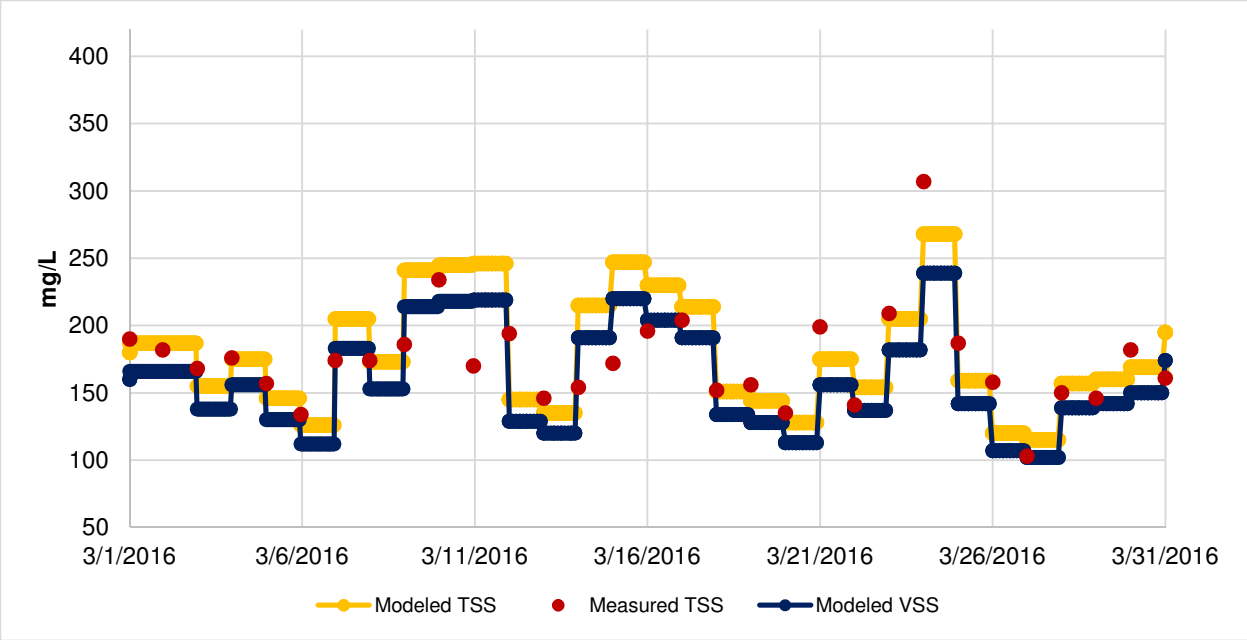

Figure 4-23: Dynamic Historical Model Results – Influent Solids

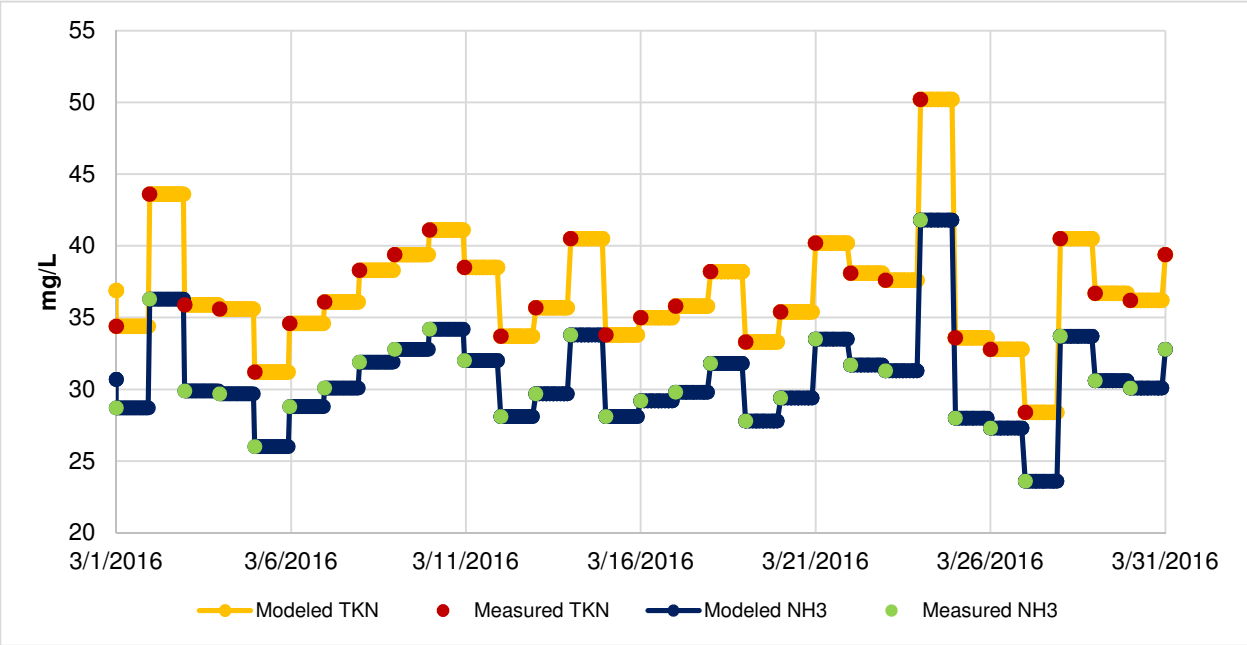

Figure 4-24: Dynamic Historical Model Results – Influent Nitrogen

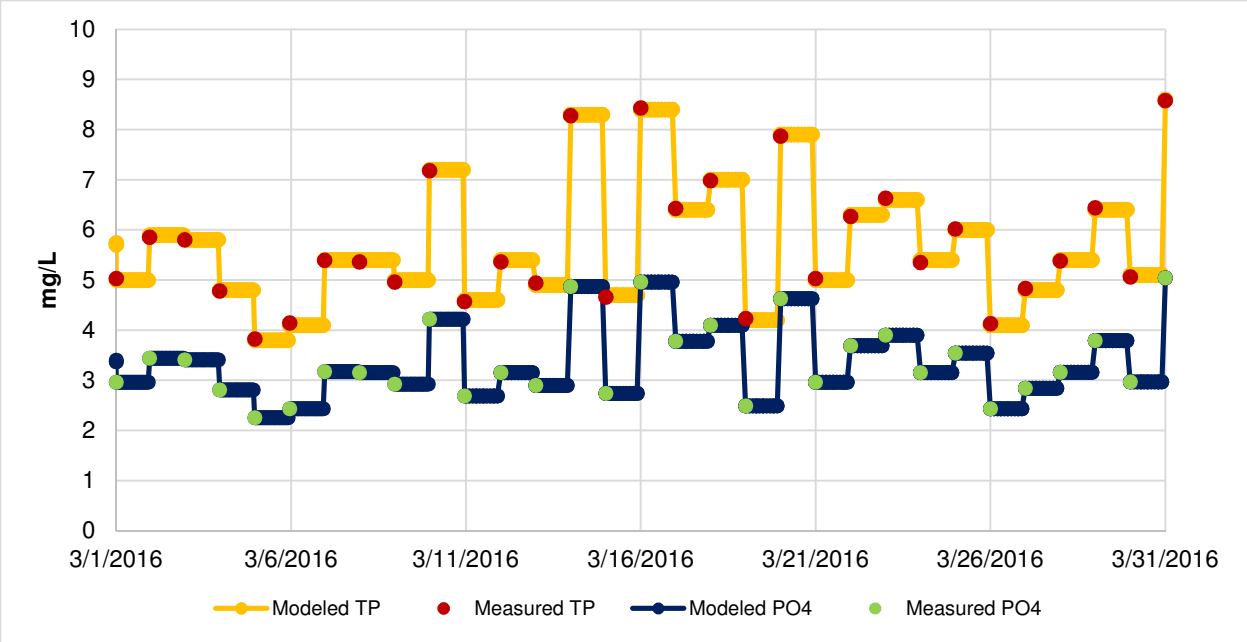

Figure 4-25: Dynamic Historical Model Results – Influent Phosphorus

The carbonaceous reactors exhibited relatively strong agreement with the average values and trends in MLSS concentration as well as effluent TSS, indicating a strong agreement with the overall solids balance. The model results for the carbonaceous reactors MLSS, effluent substrate, and effluent solids are shown in **Figure 4-26** and **Figure 4-27**. It should be noted that two periods of high model MLSS concentration were seen around 3/11/2016 and 3/16/2016. These two periods correspond to elevated influent COD concentrations as shown in **Figure 4-22** above. The model influent TSS concentrations, shown in **Figure 4-23** above, developed from the measured COD values during these two periods do not match as well to the measured TSS concentrations. The measured influent TSS concentration trend during these two periods does match well with the measured carbonaceous reactor MLSS concentration trend. This may indicate some data inaccuracy in the measured influent COD concentrations for the periods around 3/11/2016 and 3/16/2016.

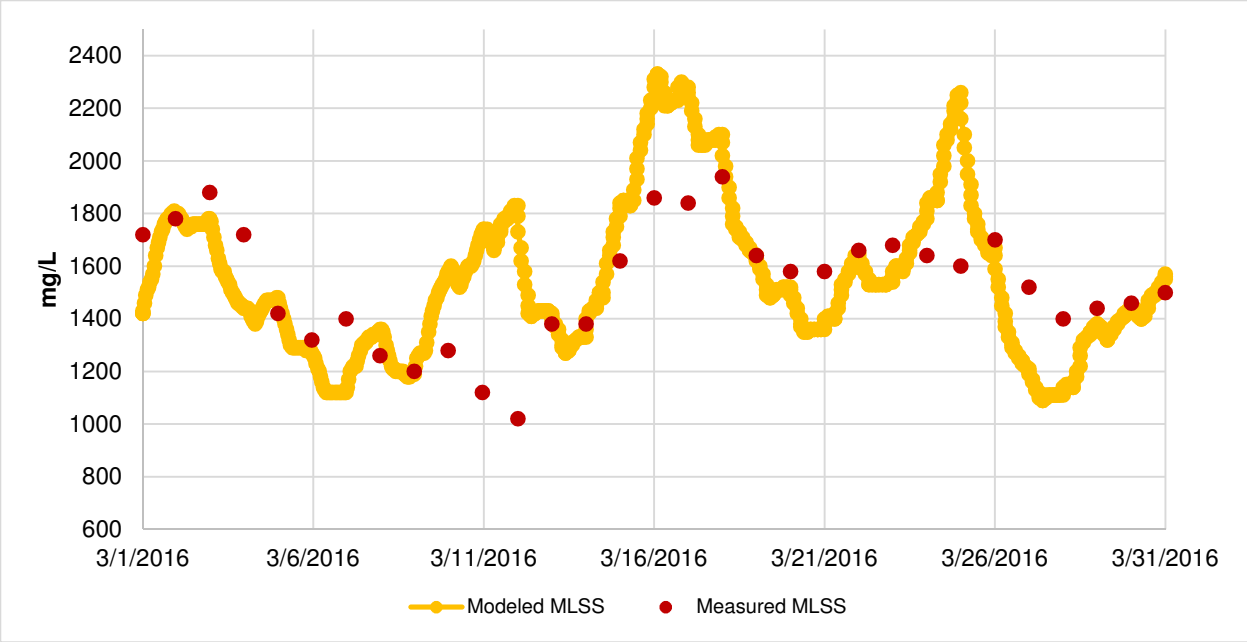

Figure 4-26: Dynamic Historical Model Results – Carbonaceous Clarifier MLSS

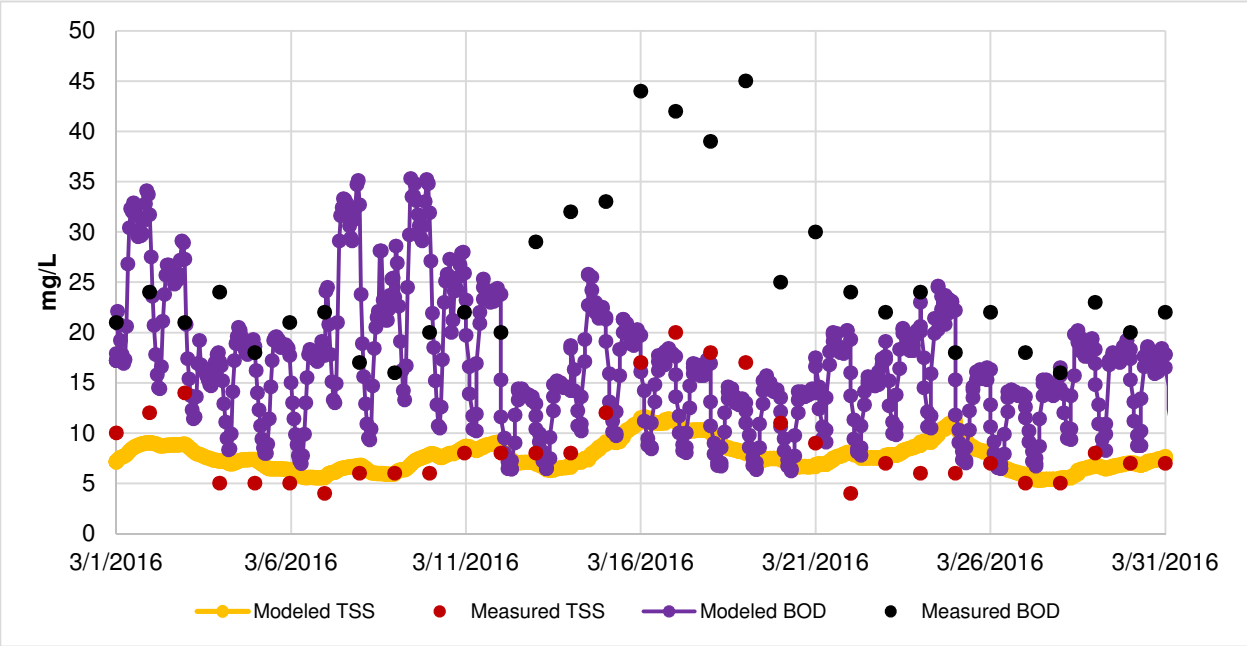

Figure 4-27: Dynamic Historical Model Results – Carbonaceous Clarifier TSS and BOD

No reliable historical data was available for carbonaceous reactor effluent nitrogen species since historical composite sample results reported in the Monthly Operating Reports were significantly influenced by sample nitrification. However, historical nitrification reactor influent NH_3-N and NO_3-N data was available for comparison to the model results. The historical values for the nitrification reactor influent NH_3-N and NO_3-N are again from the ChemScan analyzer as discussed in Steps 2 and 3. The comparison

of model results and historical values for the nitrification reactor influent NH_3-N and NO_3-N is shown in **Figure 4-28**. Influent NH_3-N to the nitrification reactors matched relatively well to the historical ChemScan hourly measurements. Model NH_3-N followed trends in the historical data for a large majority of the historical validation period. Model NO_3-N was also able to generally follow the trends in the historical data, but significantly less NO_3-N was predicted in the model compared to the historical data for several periods. The difference in modeled and measured NO_3-N for these periods is suspected to be the result of NO_3-N present in the nitrified recycle flow captured by the ChemScan measurements. The model results for the nitrification reactor influent NO_3-N is considered to be more representative of the order of magnitude of NO_3-N present without the influence of the "spike" and NRCY streams.

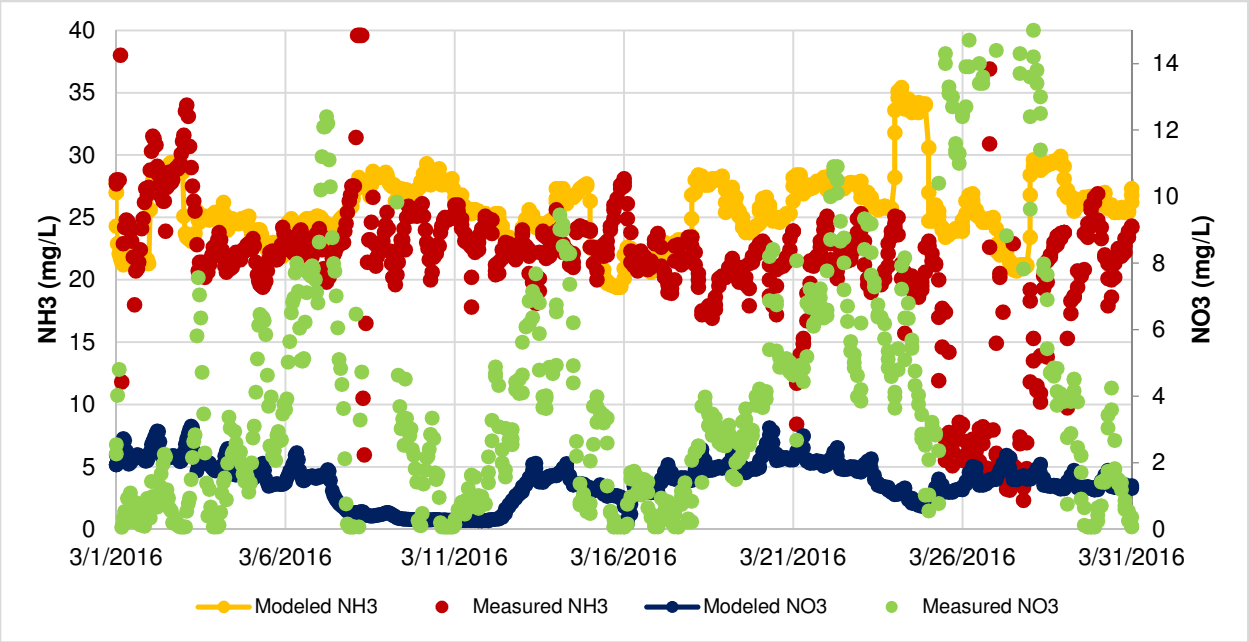

Figure 4-28: Dynamic Historical Model Results – Nitrification Reactor Influent NH_3-N and NO_3-N

Nitrification reactor MLSS concentrations varied significantly in the historical data and in the dynamic historical model results as shown in **Figure 4-29**. The model results followed the trends in the MLSS concentration relatively well, but some extremes could not be matched. The extreme variability of the measured MLSS concentration was impacted by high variability in sludge wasting flow rate from the nitrification clarifiers. The measured hourly WAS flow rates were entered in the model as control data as mentioned previously in the model set-up, therefore allowing the model to follow the general trend in MLSS concentration. However, several other factors appear to have impacted the MLSS concentration trend. First, some solids carryover from the carbonaceous stage clarifier appears to have occurred in the measured data around 3/16/2016. The increased TSS and BOD concentrations resulting during this period appears to have caused a spike in the nitrification reactor MLSS concentration. The modeled carbonaceous clarifiers are limited in their ability to simulate this apparent solids carryover event due to the clarifier model's empiric nature. Second, a number of the historical MLSS measurements are suspected to be unreliable since 1,500 to 2,000 mg/L changes in MLSS concentration is atypical of activated sludge systems with an SRT greater than 10 days.

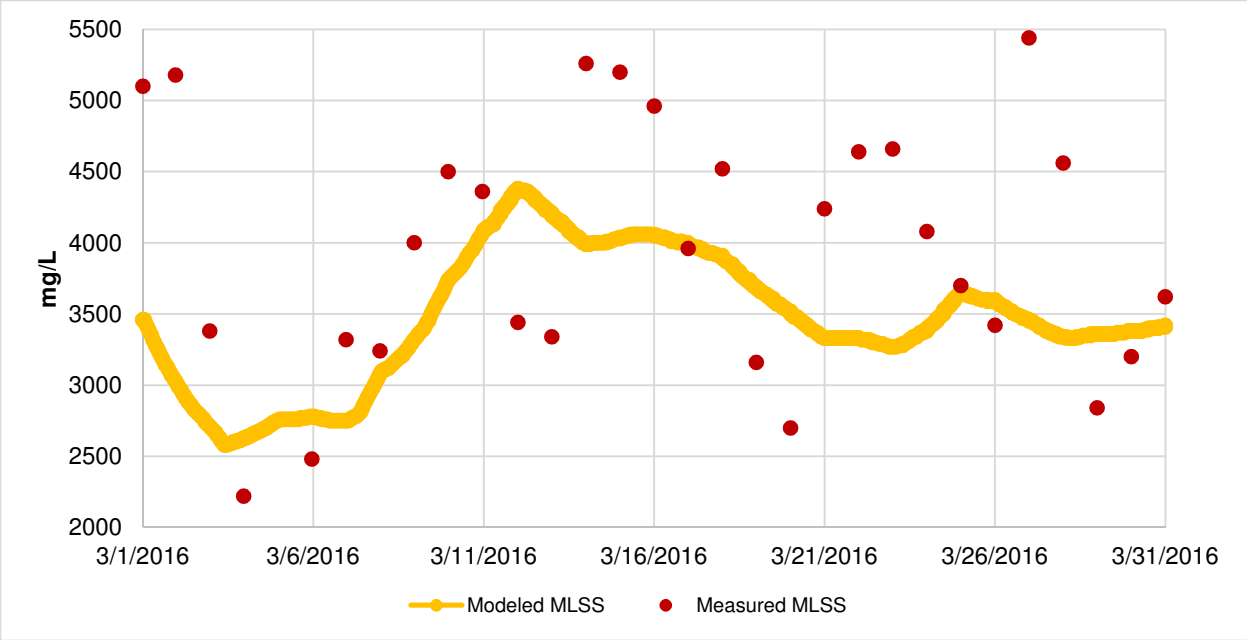

Figure 4-29: Dynamic Historical Model Results – Nitrification Reactor MLSS

The comparison of model results and historical values for the nitrification reactor effluent solids and substrate concentrations is shown in **Figure 4-30**. Historical data was only available for the effluent TSS concentration since BOD and COD concentrations were not reported in the Monthly Operating Reports. The modeled effluent TSS concentrations were very similar to the historical concentrations, validating the model solids removal efficiency for Nitrification Clarifiers 13-20. Modeled COD and BOD concentrations also appear to be generally in line with the results from the sampling week model simulations and expectations of the historical results.

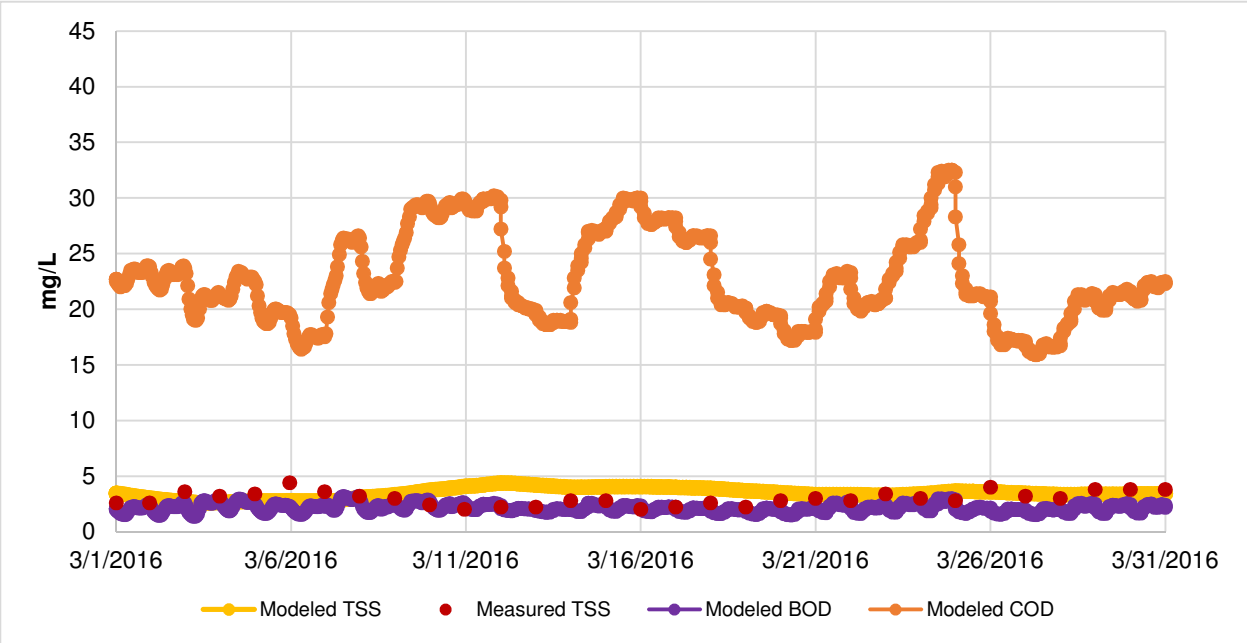

Figure 4-30: Dynamic Historical Model Results – Nitrification Reactor TSS, VSS, COD, and BOD

Modeled nitrification appeared to be a very close approximation of the measured results, while slightly overestimated in the model as effluent TKN values were lower than reported values shown in **Figure 4-31**. Overall the model was also able to follow the measured NO_3+NO_2 trend seen below, with a few periods of significant denitrification. The two most obvious periods of significant denitrification in the model seen below around 3/11/2016 and 3/16/2016 correspond to peaks in the modeled effluent COD concentration shown in **Figure 4-30** above. No corresponding peaks in effluent NH_3-N were seen. The consistent effluent NH_3-N concentration indicates that NO_3-N production via nitrification did not decrease. Similar results were seen in the sampling week diurnal simulations when COD breakthrough and a resulting increase in denitrification in the nitrification reactors occurred. These results do not appear to indicate any issues in the calibration of the model as the reactors are responding as expected to increased COD concentrations. However, this again highlights potential inaccuracy in the measured influent COD concentrations as these two periods of increased denitrification correspond to the periods of elevated influent COD concentrations.

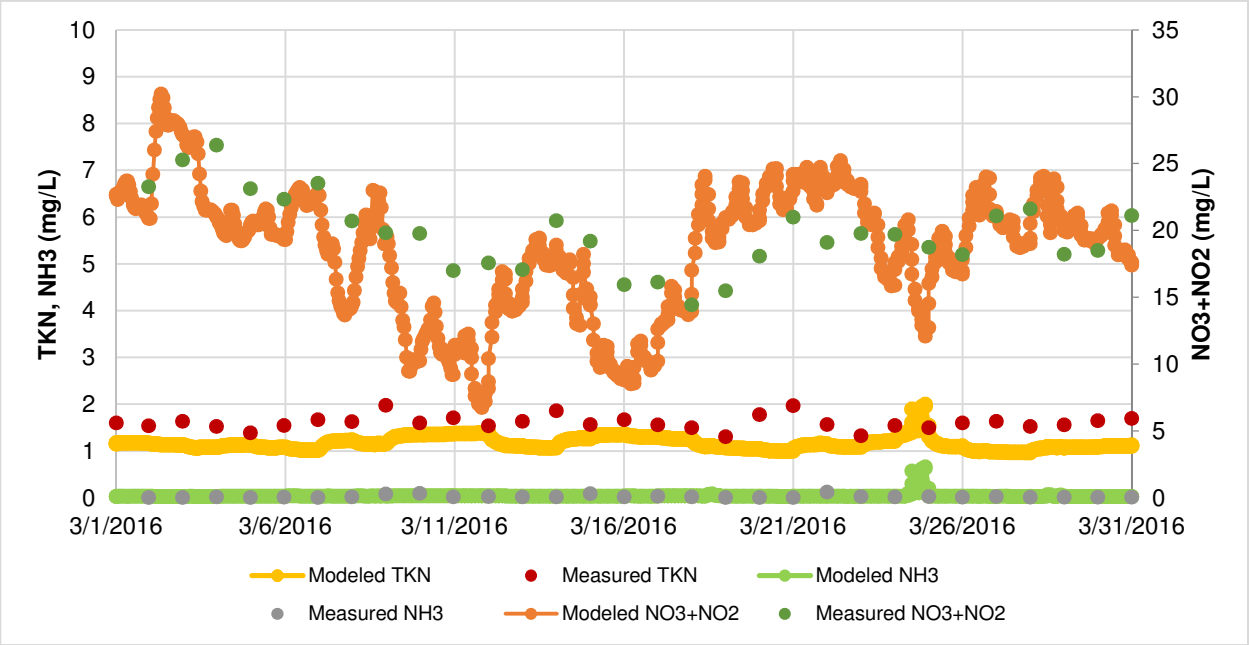

Figure 4-31: Dynamic Historical Model Results – Nitrification Reactor TKN, NH_3, and NO_3+NO_2

Initial simulations of the historical dynamic scenario suffered similar denitrification deficiencies as initially encountered in the historical steady state simulation in Step 3. After correction of the methanol dose rate, model results were much closer to measured NO_3-N concentrations as shown in **Figure 4-32**. The model results were sensitive to excess carbon conditions that were experienced around 3/11/2016, 3/16/2016, and 3/25/2016 most notably. These periods of complete denitrification associated with excess effluent BOD corresponds to the periods when plant influent COD concentrations were suspected to be artificially high. It should also be noted that the hourly methanol dose rates were corrected in favor of the daily measured volume of methanol usage. As a result, many sharp variations are seen in the denitrification filter effluent NO_3-N concentration since hourly changes in NO_3-N loading to the filters was not met with hourly variation in the methanol dose as it would in actual operation. The

denitrification filters do appear to realistically represent the range of variation in denitrification efficiency experienced in the measured data.

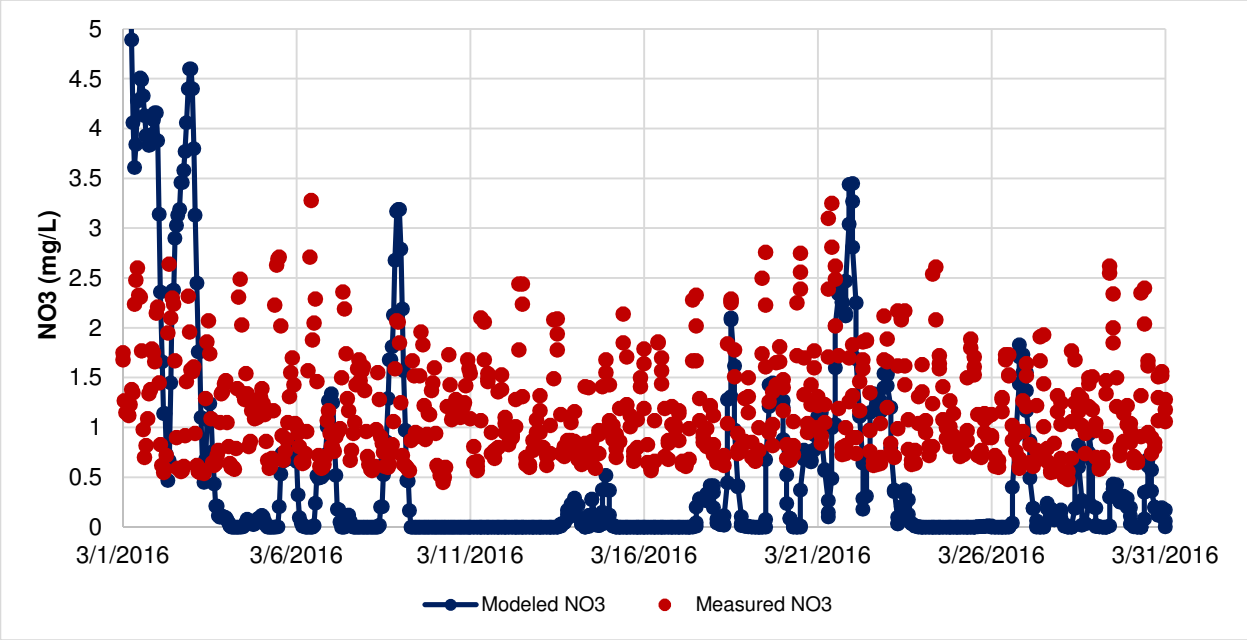

Figure 4-32: Dynamic Historical Model Results – Denitrification Filter Effluent NH_3 and NO_3

The comparison of model results to historical values for final effluent substrate, solids, nitrogen, and phosphorus species is shown below in **Figures 4-33** through **4-36**. The final effluent NH_3-N concentrations shown in **Figure 4-35** are reported prior to disinfection to prevent misinterpretation of the disinfection effluent results. NH_3-N carried through from the Denitrification Filters in the model was oxidized in the disinfection process as it models disinfection byproduct formation. As a result of this oxidation process, final effluent NH_3-N concentrations following the disinfection process were unrealistic and therefore omitted.

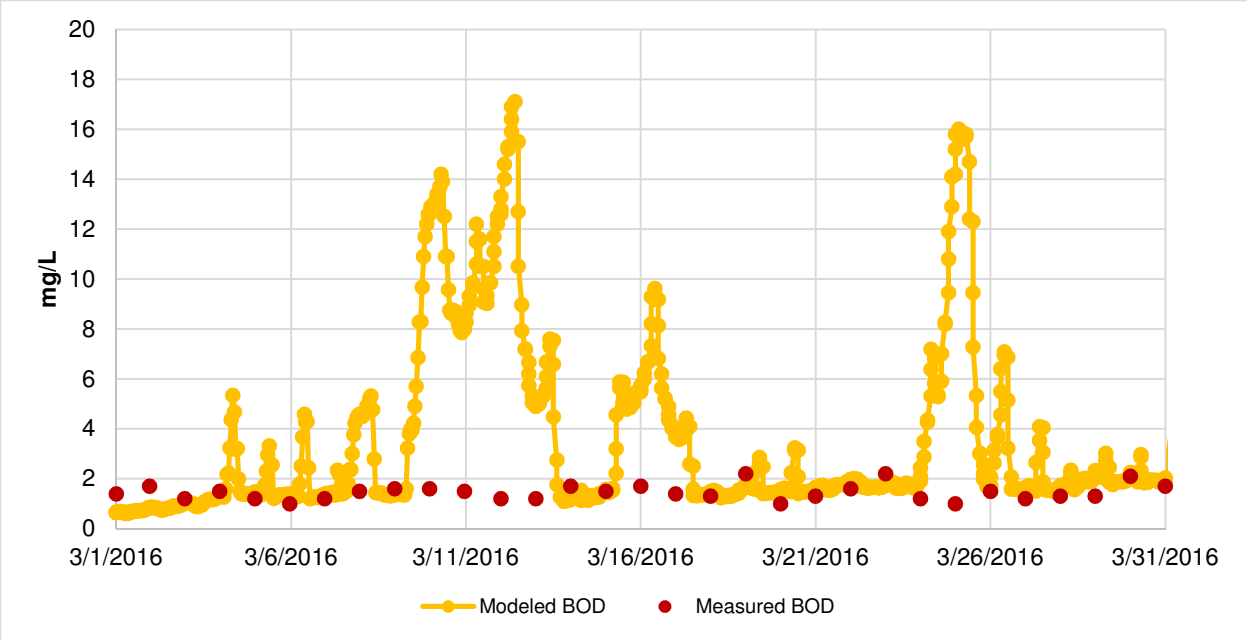

Figure 4-33: Dynamic Historical Model Results – Final Effluent COD and BOD

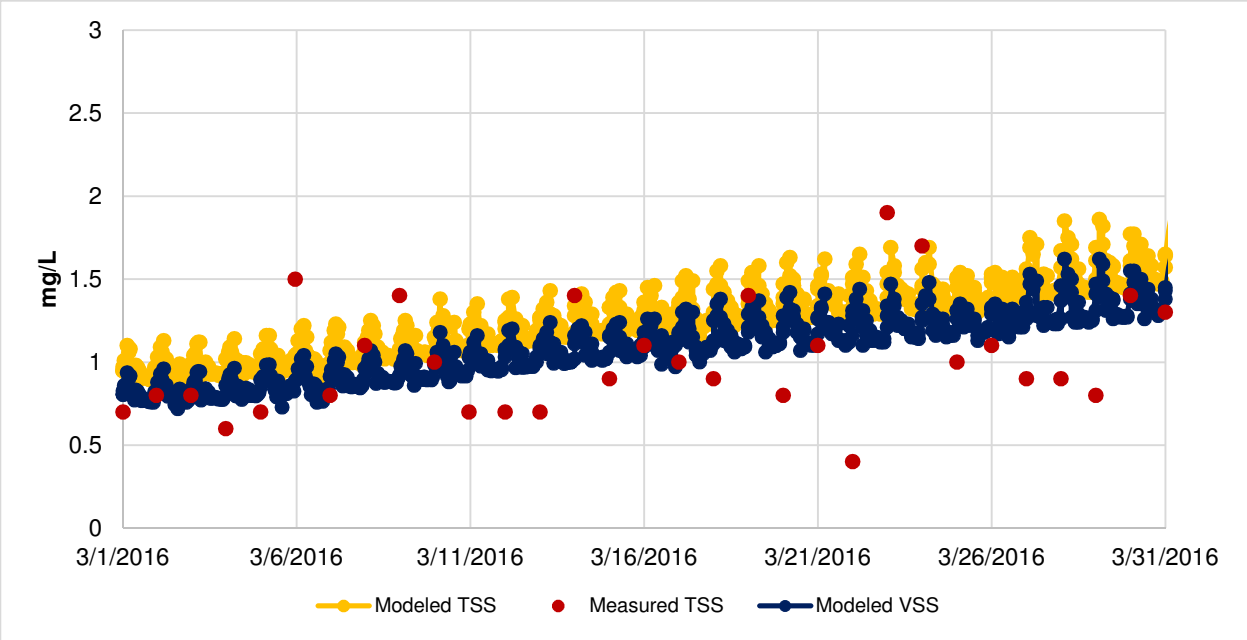

Figure 4-34: Dynamic Historical Model Results – Final Effluent TSS and VSS

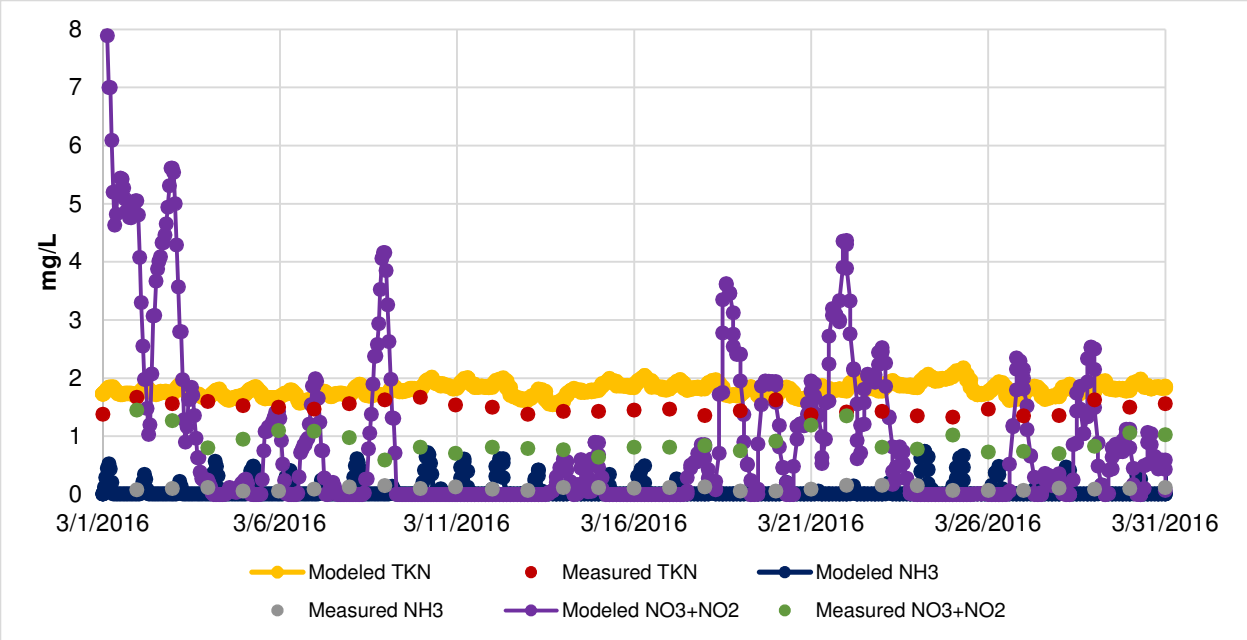

Figure 4-35: Dynamic Historical Model Results – Final Effluent TKN, NH_3, NO_3, and NO_2

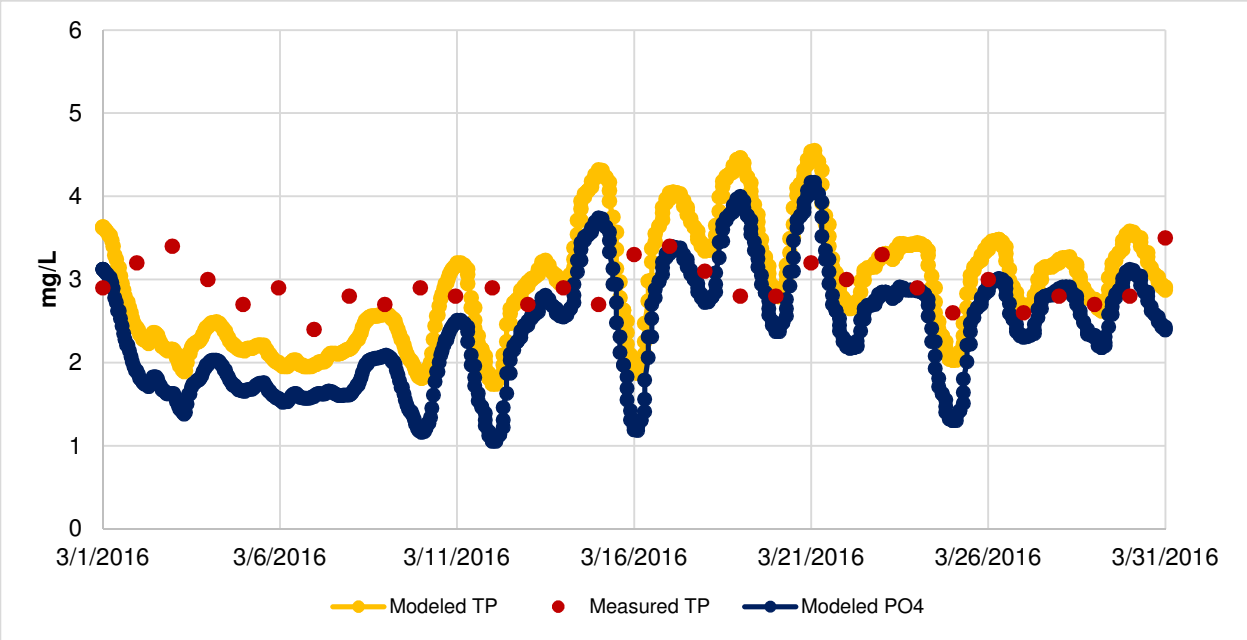

Figure 4-36: Dynamic Historical Model Results – Final Effluent TP and PO_4

Process Model Sampling and Calibration

Appendix A
Sampling Plan

TECHNICAL MEMORANDUM

City of Tampa Howard F. Curren AWTP

Process Model Sampling Plan

PREPARED FOR:	Karloren Guzman (COT); Charlie Lynch (COT)
COPY TO:	DOCUMENT CONTROLS
PREPARED BY:	Master Plan Team
DATE:	February 27, 2017
PROJECT NAME:	Howard F. Curren AWTP Master Plan
REVISION NUMBER:	2

Purpose

The first phase of the Master Plan identified limitations with the existing process model that need to be improved to proceed with analyzing various treatment alternatives. Some of these improvements include adding primary, tertiary, and biosolids treatment. The purpose of the process model additions and recalibration is to develop a fully calibrated whole plant model using Hydromantis GPS-X™ Version 6.5 for use in future planning for nutrient removal, evaluation of digestion and biogas recovery alternatives, operations assistance, and design.

A preliminary calibration (focused on sludge production) of the process model for the plant was completed based only on historical data. Detailed calibration of the process model requires a good understanding of the biological process and accurate characterization of the wastewater. Models such as these are based on a detailed fractionation or partitioning of influent organic material into particulate/soluble and biodegradable/inert portions, and influent nitrogen into ammonia and organic nitrogen, and so on. This fractionation of the influent wastewater significantly impacts model predictions. A detailed sampling campaign is proposed to obtain the requisite information for the development, calibration, and verification of a GPS-X™ model of the Howard F. Curren AWTP and confirmation of raw influent characteristics.

Process Model Sampling

The recommended sampling plan described herein has been developed from the WERF project "Methods for Wastewater Characterization in Activated Sludge Modeling". One full week of detailed sampling is proposed for this calibration effort, with provisions for a follow-up sampling event as necessary to collect any outstanding information or rectify any data quality issues. One full week of sampling is scheduled to begin February 20, 2017. The sampling will be completed during dry weather, and when the plant's operation is relatively steady state (typical and consistent operations with respect to wasting or solids handling). The labor required for this sampling effort is proposed to be shared between City of Tampa staff, McKim & Creed staff, Hazen and Sawyer staff, and a contract laboratory.

Four types of samples will be collected over the course of the sampling week. **Composite Samples** are representative daily average samples used to characterize loadings to the biological processes. **Solids and sidestream samples** are intended to capture solids handling process performance and recycle stream loading. **Diurnal Grab Samples** will be collected on two different days to characterize the variation in

influent load and process performance. **Process Grab Samples** will be collected on two different days throughout the plant to characterize process performance under low and high loadings.

McKim & Creed and Hazen and Sawyer (Consultant) staff will spend five (5) week days during the initial sampling week at the plant collecting and analyzing samples. A temporary on-site laboratory will be set up to allow the Consultant to analyze of some parameters in the field, and the remaining analyses will be split between the City's laboratory and a contract laboratory. The majority of the sample collection and analysis will take place during the week while the consultant is on-site, but if possible the composite samples should continue to be collected and analyzed by the City during the 2 weekend days following the sampling week as well to confirm any differences in influent loading.

The specific requirements of the initial full week of process model sampling program are summarized in more detail in the following sections. Any required follow up sampling, will be proposed following review of the initial sampling week data.

Composite Sampling

- **Performed by:** City of Tampa staff and Consultant
- **Frequency**: Samples collected each day during the sampling event (7 days during initial sampling week)
- **Samplers:** Flow-weighted, automatic, refrigerated composite samplers are recommended to be used to collect the 24-hour daily average samples. Reliable flow meters should be used to control these samplers. If flow-pacing is not available, time-based composite samplers or manually created composite samples may be used. Sample collection will be performed using existing samplers or method of hand sampling set up for routine sample collection where available. An additional portable sampler will be required for the Primary Clarifier 1-4 effluent location where composite samples are not currently collected. The consultant will coordinate to borrow a sampler from the City. Additional volume of sample must be collected at existing sampling locations for the analyses required.
- **Locations**: Composite samples will be collected for the raw influent, primary clarifier 1-4 effluent, MPS, HPO effluent, DAR effluent and final effluent. The Consultant will help coordinate specific locations to ensure representative sample collection during site visits.
- **Maintenance:** Each day during the sampling event, full sample containers will need to be collected, and replaced with a new clean sample container. Power will need to be provided for any portable samplers and ice will need to be replenished throughout the sampling event to preserve samples. The samplers should also be checked on a regular basis to ensure no clogging or other issues have occurred. The City will be responsible for maintaining the existing sample locations and the consultant will maintain the additional portable sampler at Primary Clarifier 1-4 Effluent.

Analyses will be split between the Contract lab, the City's lab and the consultant's field lab as shown in **Table 1**.

Table 1. Composite Sample Preparation and Analysis

Location	Contract Lab	City Lab										Consultant On-site Lab					
	VFA	BOD_5	$CBOD_5$	TSS	VSS	TKN	Alk	Ca	Mg	TP	COD	COD	NH_3	NO_3	NO_2	TP	PO_4-P
Plant Influent (Split COT Sample)																	
XX[1]		x	x	x	x	x	x	x	x	x	x	x					
XG[2]	x	x				x					x	x	x	x	x		x
XM[3]											x	x				x	
XF[4]											x	x					
Primary Effluent #1-4 (New Portable Sampler)[5]																	
XX[1]		x		x	x	x						x				x	
XG[2]												x	x				x
Main Pump Station (Split COT Sample)																	
XX[1]		x		x	x		x					x				x	
XG[2]		x										x	x	x	x		x
XM[3]												x				x	
XF[4]												x					
CARB Effluent (Split COT Sample)																	
XX[1]		x		x	x	x	x					x				x	
XG[2]												x					x
NIT Effluent (Split COT Sample)																	
XX[1]		x		x	x	x	x					x				x	
XG[2]												x	x	x	x		x
Final Effluent (Split COT Sample)																	
XX[1]		x		x	x	x	x		x	x	x	x					
XG[2]						x					x	x	x	x	x		x
XM[3]											x	x				x	
XF[4]											x	x					

[1]XX = not filtered unless specified in Standard Methods

[2]XG = filtered with glass fiber filter (1.5 µm)

[3]XM = filtered with 0.45 µm membrane filter

[4]XF = flocculated and filtered with 0.45 µm membrane filter

[5]The sampler batteries were not holding power and representative samples were not thought to be collected 2/20 through 2/22. Therefore, the sampler power source was converted to a direct power source on 2/23/17. To collect additional representative week day samples, sample collection continued for two additional week days (2/27 and 2/28) only including the City Lab analyses.

Solids and Sidestream Sampling

- **Performed by:** City of Tampa staff and Consultant Staff
- **Frequency**: Samples collected each week day during the sampling event (5 days during Initial sampling week)
- **Samplers:** Where feasible, an automatic sampler may be set up for flow-weighted or time-based composite sampling. Otherwise a multiple -grab composite may be used to collect a representative sample. In this case, roughly three grabs spaced out evenly throughout the day should be taken to create the daily composite sample. Specific consideration should be made for processes with intermittent operation or variable performance. Sample collection will be shared by the City of Tampa staff and the Consultant, as shown in Table 2 below.

- **Locations:** Sample locations have been selected to capture solids handling process performance and recycle stream loading, as shown in **Table 2**. The Consultant will help coordinate specific locations to ensure representative sample collection during site visits.
- **Maintenance:** Samples collected by hand using bottles or dippers, the sampler should be rinsed before collecting each new sample.

Analyses will be split between the Contract Lab, the City's lab and the consultant's field lab as shown in **Table 2**.

Table 2. Solids and Sidestream Sample Preparation and Analysis

	Contract Lab		City Lab							Consultant On-site Lab				
Location	**BOD_5**	**Mg**	**TS**	**VS**	**TSS**	**VSS**	**TKN**	**TP**	**Mg**	**COD**	**NH_3-N**	**NO_3-N**	**NO_2-N**	**PO_4-P**
	CARB MLSS (Split COT Sample)													
XX[1]					x	x								
	CARB RAS/WAS (Split COT Sample)													
XX[1]					x	x	x	x						
XG[2]														
	NIT MLSS (Split COT Sample)													
XX[1]					x	x								
	NIT RAS/WAS (Split COT Sample)													
XX[1]					x	x	x	x						
	Primary Sludge (Split COT Sample)													
XX[1]		x			x	x	x	x						
XG[2]		x												
	Thickened WAS (Split COT Sample)													
XX[1]					x	x	x	x						
	GTO (Consultant Collected Sample)													
XX[1]	x				x	x	x	x		x				
XG[2]											x			x
	Digested Sludge (Individual x6 -COT Sample)													
XX[1]			x											
	Dewatering Feed from Sludge storage (Consultant Collected Sample)													
XX[1]					x	x								
	Cake (Split COT Sample)													
XX[1]			x	x										
	Dewatering Filtrate (Split COT Sample)													
XX[1]	x				x	x	x	x	x	x				
XG[2]											x			x
	Filter Backwash (Consultant Collected Sample)													
XX[1]	x				x	x	x	x		x				
XG[2]											x	x	x	x

[1]XX = not filtered unless specified in Standard Methods

[2]XG = filtered with glass fiber filter (1.5 µm)

Diurnal Grab Sampling

- **Performed by:** City of Tampa staff and Consultant

- **Frequency**: Samples collected every two hours (12x/day) on Week 1 of the two days during the sampling event. The purpose of this effort is to define diurnal flow and loading patterns for model calibration.
- **Samplers:** At the Influent, samples should be collected by hand every 2 hours in line with the current influent sample collection routine. The Consultant will be responsible to set up and maintain a discrete sampler at the Final Effluent to collect samples every 2 hours.
- **Locations:** Plant Influent and effluent samples will be collected. The Consultant will help coordinate specific locations to ensure representative sample collection during site visits.

Diurnal grab samples will be prepared and analyzed as shown in **Table 3**.

Table 3. Diurnal Grab Sample Preparation and Analysis

	City Lab			Consultant On-site Lab				
Location	**TSS**	**VSS**	**TKN**	**COD**	**NH_3-N**	**NO_3-N**	**NO_2-N**	**TP**
Plant Influent								
XX[1]	x	x	x	x				x
XG[2]					x			
Final Effluent								
XX[1]	x	x	x	x				x
XG[2]					x	x	x	

[1]XX = not filtered unless specified in Standard Methods

[2]XG = filtered with glass fiber filter (1.5 µm)

Process Grab Sampling

- **Performed by:** The Consultant with assistance from City staff will access oxygenation tank sampling locations.
- **Frequency**: Samples collected as individual grabs samples at two different times during the day (morning and afternoon) on 2 days during each sample week.
- **Locations**: Selected to capture profiles of oxygenation tanks and performance of clarifiers. The Consultant will coordinate with City staff specific sampling locations to ensure access and representative sample collection during site visits.
- **Other Profiles** – The Consultant will also measure oxygen uptake rates, dissolved oxygen concentrations and pH throughout the oxygenation trains.

  Process grab samples will be prepared and analyzed as shown in **Table 4**.

Table 4. Process Grab Sample Preparation and Analysis

Locations	Contract	City Lab					Consultant On-site Lab							
	BOD	TSS	VSS	TKN	Alk	COD	COD	NH_3	NO_3	NO_2	TP	PO_4	pH	DO
Plant Influent (COT Sample Location)														
XX[1]	x	x	x	x	x	x	x				x			
XG[2]	x			x		x	x	x	x	x		x		
XM[3]						x	x							
XF[4]						x	x							
Primary Effluent #1-4 (upstream of recycles)														
XX[1]	x	x	x	x			x				x			
XG[2]								x				x		
MPS (COT Sample Location)														
XX[1]	x	x	x	x	x		x				x			
XG[2]	x			x			x	x	x	x		x		
XM[3]							x							
XF[4]							x							
CARB Train 2 Stage 4														
XX[1]													x	x
XG[2]							x	x	x	x		x		
CARB Clarifier Effluent														
XX[1]	x	x	x										x	x
XG[2]							x	x	x	x				
NIT Influent (after Spike) Location #1														
XX[1]	x	x	x				x				x			
XG[2]							x	x	x	x		x		
NIT Influent (after Spike) Location #2 [Pump Station][5]														
XX[1]	x	x	x				x				x			
XG[2]							x	x	x	x		x		
NIT Influent (after Spike) Location #3 [JC5][5]														
XX[1]	x	x	x				x				x			
XG[2]							x	x	x	x		x		
NIT Train 2 Stage 1														
XX[1]													x	x
XG[2]							x	x	x	x		x		
NIT Train 2 Stage 2														
XX[1]													x	x
XG[2]							x	x	x	x		x		
NIT Train 2 Stage 4														
XX[1]													x	x
XG[2]							x	x	x	x		x		
NIT Train 2 Stage 6														
XX[1]													x	x
XG[2]							x	x	x	x		x		
NIT Combined MLSS														
XX[1]		x	x											
XG[2]							x	x	x	x				

Locations	Contract	City Lab					Consultant On-site Lab							
	BOD	TSS	VSS	TKN	Alk	COD	COD	NH_3	NO_3	NO_2	TP	PO_4	pH	DO
NIT Clarifier Effluent														
XX[1]	x	x	x		x									
XG[2]							x	x	x	x				
Denitrification Filter Effluent														
XX[1]	x	x	x											
XG[2]							x	x	x	x				
Final Effluent														
XX[1]	x	x	x		x	x	x				x			
XG[2]						x	x	x	x	x		x		
XM[3]						x	x							
XF[4]						x	x							

[1]XX = not filtered unless specified in Standard Methods

[2]XG = filtered with glass fiber filter (1.5 µm)

[3]XM = filtered with 0.45 µm membrane filter

[4]XF = flocculated and filtered with 0.45 µm membrane filter

[5]The sample was collected only one day (Thursday 2/23)

Summary of Locations and Analyses

A summary of the recommended sampling locations for each sample type is shown in **Figure 1**.

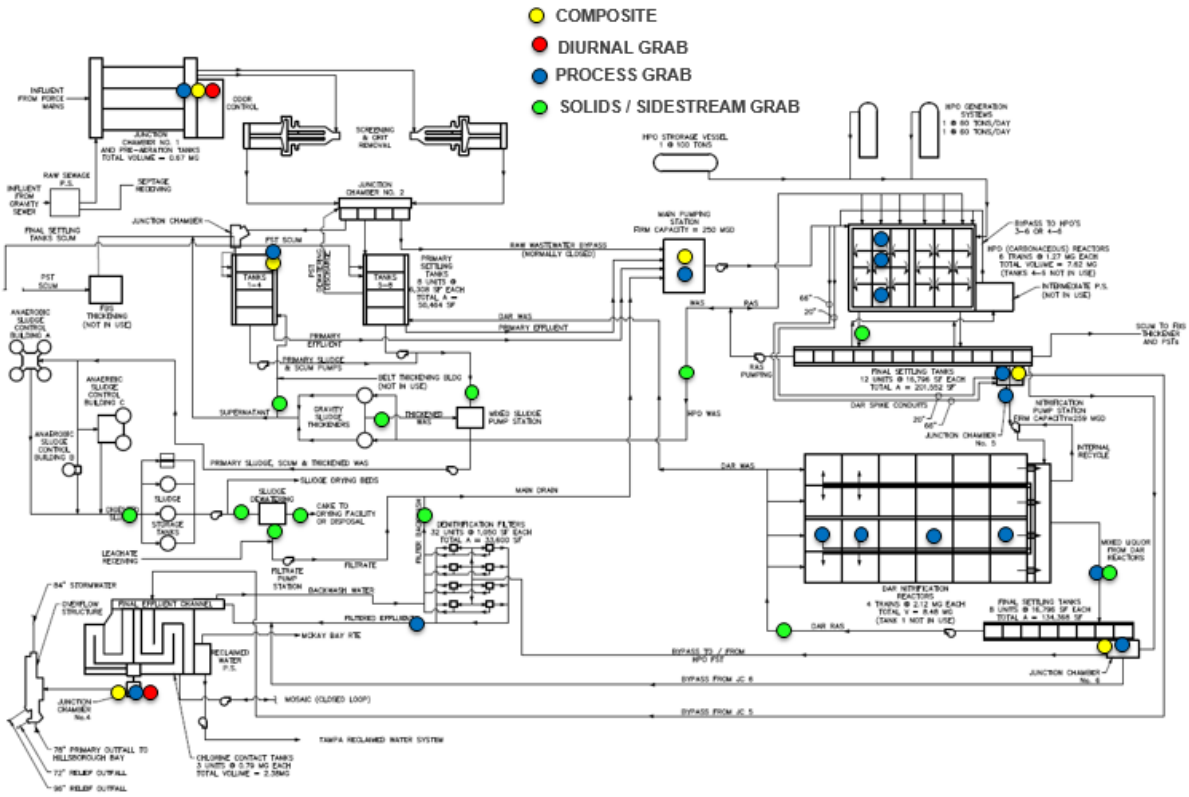

Figure 1. Process Sampling Locations

Based on the analyses proposed in Tables 1-4, the total number of analyses proposed during the first sampling week is about **1,700.** Data will be reviewed after the first sampling week is completed to determine the extent of sampling required during the second week. **Table 5** shows a breakdown of the number of analyses for each sample type. About 40% of these analyses will be performed by the City's lab, and 50% will be performed by the Consultant in the field and 10% will be performed by an outside Contract Laboratory.

Table 5. Summary of Analyses by Sample Type

	Analyses Required for Entire Sampling Period for each Parameter																
Sample Type	**TS**	**VS**	**TSS, VSS**	**BOD**	**CBOD**	**TKN**	**Alk**	**Ca**	**Mg**	**COD**	**NH_3**	**NO3 NO2**	**TP**	**PO 4**	**pH**	**VFA**	**Total**
Composite, per parameter	0	0	44	58	7	58	35	7	14	130	25	20	49	30	0	5	546
Process, per parameter	0	0	40	44	0	20	16	0	0	140	60	56	24	44	24	0	564
Solids, Sidestreams, per parameter	17	5	50	15	0	35	0	0	15	15	15	5	35	15	10	0	287
Diurnal Grabs, per parameter	0	0	48	0	0	48	-	-	0	48	48	24	48	0	-	0	336
Total	17	5	364	117	7	161	51	7	29	333	148	210	156	89	34	5	1,733

Table 6. Summary of Analyses by Lab

Sample Type	Analyses Required for Entire Sampling Period for each Parameter																
	TS	VS	TSS, VSS	BOD	CBOD	TKN	Alk	Ca	Mg	COD	NH_3	NO3 NO2	TP	PO4	pH	VFA	Total
City Lab, per parameter	17	5	182	58		161	51	7	19	72	0	0	49	0	0		810
Contract Lab, per parameter				59	7				10							5	74
Consultant, per parameter										261	148	105	107	89	34	0	849
Total	17	5	364	117	7	161	51	7	29	333	148	210	156	89	34	5	1,733

Sample Splitting and Preservation

Prior to the sampling event, the Consultant will coordinate with City staff regarding the appropriate sample volumes for each location and type of sample, and will help coordinate ordering the appropriate number and size bottles (with preservatives, as necessary) for the City's lab. City lab staff will be responsible for splitting representative Composite or Solids and Sidestream samples between the efforts required for routine permitting/process control samples and the model calibration sampling efforts. Labeled sample bottles will be provided by the City's lab. Only the sample collection date and time will need to be added as necessary to the labels. Samples should be refrigerated or kept on ice until picked up or dropped off to the City's lab.

Sample Transportation to Contract Laboratory

If a contract laboratory is needed, chain of custodies will be provided by the contract lab. Date and time of sample collection should be filled out for each set of bottles delivered or picked up by the contract lab from the plant. Transportation will be coordinated by Consultant (likely to occur each day or every-other day) based on sample hold times.

Verification/Documentation of Flows and Other On-line Instrumentation

Operational data should be collected during the sampling event. The frequency of data collection will vary with parameter (from daily average to minute). The Consultant will coordinate with City staff to ensure that this data will be collected either automatically, or recorded by hand at the necessary frequency during the sampling event.

Table 7. Operational Data Collection During Sampling Event

Process Area	Parameter	Frequency
Influent	Flow	hourly
Leachate	Flow	daily
Septage	Flow	daily
Primary	Influent Flow (MRC 1,2,4)	hourly
	# tanks in service	daily
	Sludge Pump Starts	daily
	Spike Flow to DAR	hourly
MPS	pump run times	hourly
HPO Reactors	# reactors in service	daily
	# clarifiers in service	daily

Process Area	Parameter	Frequency
	oxygen flow	hourly
	Stage 4 Vent Purity, each tank	hourly
	Stage 4 DO, each tank	hourly
	RAS Flow	hourly
	WAS Flow	hourly
	SVI	daily
Nitrification Reactors	# reactors in service	daily
	# clarifiers in service	daily
	Influent Flow	hourly
	Internal Recycle Flow	hourly
	DO probe measurements, all	hourly
	Airflow, all	hourly
	RAS Flow	hourly
	WAS Flow	hourly
	SVI	daily
	Chemscan NO3	hourly
	Chemscan NH3	hourly
Denitrification	Filter Flow	hourly
	Backwash Flow	hourly
	Methanol Feed Flow	hourly
	Turbidity	hourly
	Chemscan NO3	hourly
Chorine Contact Tank	total channel flow	hourly
Sludge Handling	TWAS Flow	hourly
	Digested Sludge to Storage	hourly
	Dewatering Feed	hourly
Digester	Gas Production/ Gas to CoGen	hourly
Hauled Cake	Weight	Daily

Process Model Sampling and Calibration

Appendix B
Sampling Results

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McKIM&CREED
Hazen

Appendix C

Howard F. Curren AWTP Master Plan

Tampa HFC WWTP Online Partial Discharge Report

December 2017

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2017

Tampa HFC WWTP Online Partial Discharge Report

C.E. Testing, Inc.

Nat Crews, Louis Nemec

CE Testing

12/18/2017

Online Partial Discharge

Test Report

PRESENTED TO:

City of Tampa, HFC WWTP

2700 Maritime Blvd.

Tampa, FL

PRESENTED BY:

C.E. Testing, Inc.

6148 Tim Crews Rd, MacClenny, FL 32063

(904) 653-1900

cetesting@aol.com

Data Collected: 02/07/17 – 02/10/17

Revised Report Date: 12/18/2017

Performed by: Nat Crews, Louis Nemec

Reviewed by: Dane McGreevy, Aubrey Haudricourt

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1.0 Introduction

Electrical distribution systems are susceptible to the destructive effects of electrical partial discharges. Partial Discharges (PD) cause deterioration and erosion of electrical insulation systems of medium voltage cables, switchgear, transformers and other electrical apparatus. If not detected and corrected, PD will result in complete insulation failure, unplanned power outage, and/or personnel injury.

2.0 Project Purpose

The purpose of the project is to detect and characterize PD activity occurring in the MV cable distribution circuits at City of Tampa HFC WWTP. Analysis of PD activity can assist the client with prioritizing maintenance and equipment replacements. Performing the testing online during normal operation provides additional cost savings compared to offline testing which requires a scheduled power outage.

3.0 PD Test Equipment and Procedure

High Frequency Current Transformer (HFCT) sensors were placed around the cable shield conductors. Other sensor locations may include the cable (but below the stress cone connection) or around a grouped shield conductor depending on the cable configuration and the safe placement of the sensor. The photos in the Points Of Attachment (POA)s datasheets in Appendix 1 show the actual placement of the sensors.

In addition to the current sensors, a Transient Earth Voltage (TEV) sensor was magnetically attached to an adjacent metal surface. The TEV captures acoustic signals measured in decibels (dB); unique to the cable environment and allows for discrimination of local partial discharges from cable partial discharges.

The online partial discharge (OLPD) measurement system incorporates a wideband (0-400MHz) high-speed Digital Storage Oscilloscope (DSO) to capture high-resolution measurements of PD signals measured in picocolumb (pC). After collection of the PD signals, a range of analysis software is used to evaluate and categorize the PD data collected. 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 as Cable PD, Local PD, or transient signal noise.

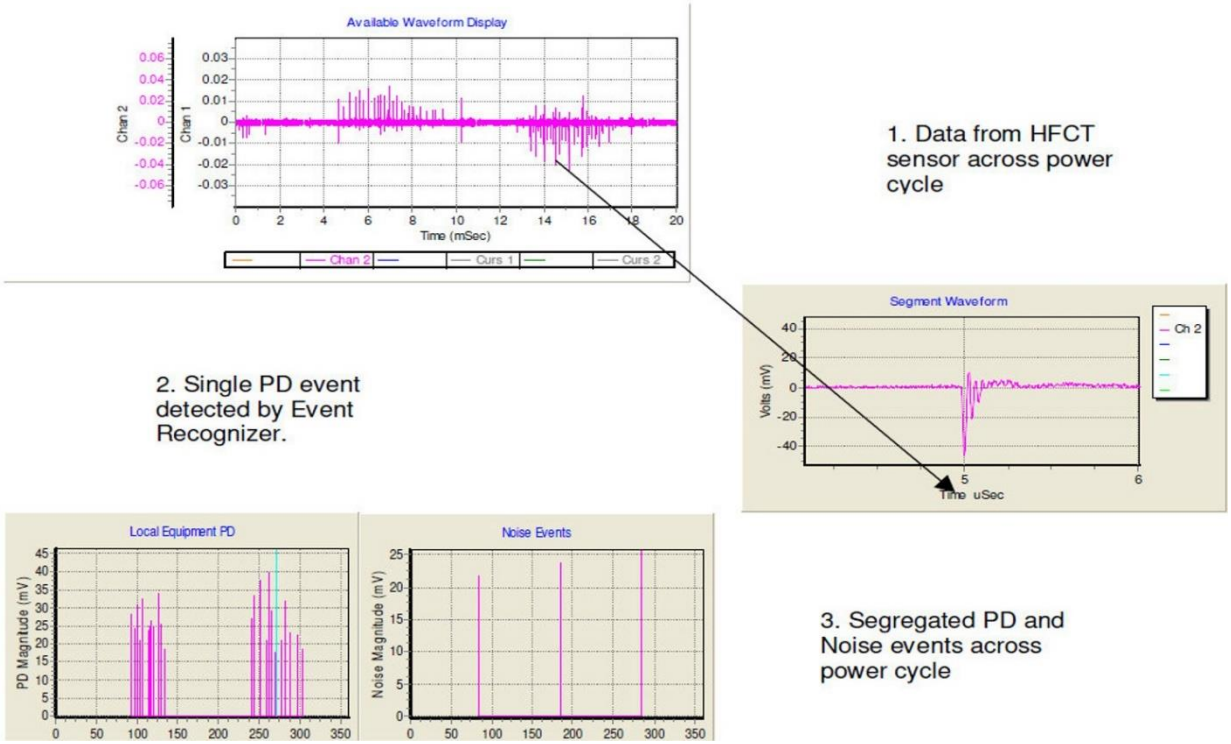


Photo 1: PD and Noise data segregation by Event Recognizer

The datasheets presented in Appendix 1 show extensive data on the individual POA's. Much of the data is for waveform identification and quantification. The data also presents comparisons images useful in future measurements where changes are anticipated due to maintenance or changes in PD activity. The data gives insight into possible location of the PD. An example is when significant local partial discharge activity is measured in both the HFCT and TEV channels of a POA. Channels 1-3 and the HFCT sensors are for phases A, B, and C respectively. Channel 4 is for the TEV sensor. The TEV is only for local PD. The HFCT are for cable PD and local PD. The photos provide identification of the test points where there is significant local PD activity.

Photo 1: Example of HFCT and TEV sensor placement in the cable cubicle.

Based on the magnitude of the detected PD pulse and the manner in which the pulses occurred, each POA was assigned a classification category, Red, Orange, Yellow or Green. Each classification represents a different criticality level. The table 2 and 3 below shows the classifications of partial discharge activity, and the needed response for partial discharge levels detected, in various electrical equipment.

Table 2:OLPD Levels vs. Recommendations

Medium Voltage Switchgear, Air Insulated		
0- dB – 10 dB	Discharge within acceptable limits	(Green) No action required, retest in 3 years.
10 dB – 15 dB	Some concern, monitoring recommended	(Yellow) No action required, retest in 12-18 months
15 Db – 30 dB	Some concern, regular monitoring recommended	(Orange) Action Recommended, retest within 6 months
>30 dB	Major concern, locate PD, repair or replace	(Red) Prioritize immediate corrective action. Retest to confirm and establish new baseline.

Note on Table 2: This table is applicable to values measured of local switchgear Partial discharge only as measured using a TEV sensor.

Table 3: OLPD Levels vs. Recommendations

Medium Voltage Cables: XLPE/EPR		
0 – 250 pC	Discharge within acceptable limits	(Green) No action required, retest in 3 years.
250 – 350 pC	Some concern, monitoring recommended	(Yellow) No action required, retest in 12-18 months
350 – 500 pC	Some concern, regular monitoring recommended	(Orange) Action Recommended, retest within 6 months
>500 pC	Major concern, locate PD, repair or replace	(Red) Prioritize immediate corrective action. Retest to confirm and establish new baseline.

Note on Table 3: This table is applicable to values measured from cables, splices, and terminations with HFCT sensors only. Typically cables and splices are not able to withstand higher PD levels.

The summary and findings below provides more details regarding each finding and in the comments section of each POA, which give specific recommendations. The recommendations are based on PD levels detected, and on baseline data developed by laboratory and on-site testing of MV distribution systems.

Current partial discharge information and the trending of that data over time provides powerful condition assessment information. Trended data can contribute to decisions regarding, replacement, and remaining life.

4.0 Summary

This project was initiated by Tampa WWTP Engineering. Data acquisition was performed by Nathaniel Crews and Louis Nemec on Feb 7 2017 – Feb. 10, 2017 at City of Tampa HFCT WWTP 2700 Maritime Blvd. Tampa, Florida. Previous testing was performed in December of 2010. Follow-up site visit and testing was performed in June 2011.

4.1 Locations Monitored

A total of 102 Points of Attachment (POA) were analyzed at the site during this project. The test data was gathered from temporary sensors affixed to each of the POA test locations. There were 14 POA, which were on the POA list, but were not tested. Of those:

1. POA 57C was not tested because the cables no longer exist.
2. POA 31B was not tested because the ground shields are not accessible.
3. POA 37, 45, 44, 46, 47, 40, 41, 86, and 86A – There was no local PD detected at these POA's. The cable shield grounds had accessibility issues and were not accessible to test. These POA's were tested with handheld UHF and TEV sensors and no abnormal PD signals were detected or recorded. They are considered Category Green. Use previous 2010 Emerson report TEV levels for comparative reference.
4. POA 6B, 7, 51A and 51B were found with no PD, but the test data files were corrupted due to extremely high noise. The PD software was unable to analyze the large number of noise pulses. The software returned a blank data file. If PD activity were nearby, then PD signals near 10MHz would have been seen bleeding over onto the grounds of adjacent POA's (6A, 50A and 50B). In addition, the noise signals in this plant were primarily 244 kHz and 488 kHz, which is much lower than the frequency of a PD pulse originating nearby.

Four (4) POA, were tested, but were not on the original POA's list. They are:

1. POA 22B, 29B, 24B, and 25B were tested as part of this project. The POA list provided did not include the "B" parts for these cubicles.

Individual datasheets were prepared to detail the findings at each POA. Table 1 displays the Partial Discharge Test Results for each POA. Appendix 1 contains the datasheets for each POA. The Table of Contents in Appendix 1 contains clickable links to each POA datasheet.

Summary of PD Classifications

RED

Cable PD

Four (4) POA's were found with significant Cable PD activities requiring immediate attention.

Cable PD greater than 500pC:

- POA 61 T-6B-1 978pC
- POA 54A T-4A-1 724pC
- POA 54B T-4A-1 724pC

Termination PD greater that 30dB:

- POA 63A T-5B-2 32dB Termination
- POA 57B T-4B-2 31dB Termination

Switchgear PD

Three (3) POA's were found with significant activity requiring immediate attention.

- POA 65 T-8B-3 TEV 31dB
- POA 36 3-52-G4 31dB HFCT, TEV 29dB
- POA 70 T-5B-7 TEV 32dB

ORANGE

Twenty-five (25) POA's were found with PD activities classified as "Orange" recommended for follow-up testing in 6 months.

GREEN

Seventy (70) POA's were found with PD activities classified as "Green".

4.2 Points of Attachment Organization

Switchgear Section A

1-52-1 MAIN BKR 1 (NO POA)

1-52-1A, POA 12

T-1A-1,

1-52-2A. POA 11A

T-2A-1A, POA 30A

T-2A-1A, POA 30B

T-2A-1, POA 29A

T-2A-2. POA 84T-2A-1, POA 29B

1-52-2A. POA 11B

T-2A-4, POA 50B

T-2A-4, POA 50A

T-2A-3, POA 53

1-52-3. POA 10

T-3A-1, POA 22A

T-3A-1, POA 22B

T-3A-2, POA 24A

T-3A-2, POA 24B

T-3A-3, POA 27

1-52-4A, POA 9

T-4A-1, POA 54 B

T-4A-1, POA 54 A

T-4A-2, POA 56B

T-4A-2, POA 56A

T-4A-3, POA 58

1-52-5A. POA 8

T-5A-2, POA 62B

T-5A-2, POA 62A

T-5A-1, POA 72 B

T-5A-1, POA 72 A

T-5A-3, POA 69 A

T-5A-3, POA 69 B

T-5A-7. POA 71

T-5A-5, POA 83A

T-5A-5, POA 83B

T-5A-6, POA 80

1-52-6A. POA 7

T-6A-1, POA 60

1-52-S1, POA 6A

BKR 3-52-S1. POA 38A (Indoor SWG 3, BUS 1)

1-52-S1, POA 6B

BKR 3-52-S1. POA 38B (Indoor SWG 3, BUS 1)

1-52-8A. POA 5

T-8A-1, POA 79

T-8A-2, POA 74

T-8A-5, POA 76

T-8A-4, POA 66A

T-8A-4, POA 66B

T-8A-3. POA 64

1-62-9A, POA 4

T-9A-1, POA 49

BKR 3A-52-1, POA 45 (Outdoor SWG 3A BUS 1)

** T-9A-2, POA 42 **(SHT. E0 of 15kV Cable Replacement drawings does not agree with hierarchy connection table in report, changed per cable replacement.)

Switchgear Section B

1-52-2, MAIN BKR 2 (NO POA)

1-52-1B, POA 21

T-1B-1,

1-52-2B, POA 20A

T-2B-4, POA 51B

T-2B-4, POA 51A

T-2B-3, POA 52

1-52-2B, POA 20B

T-2B·1A, POA 31A

T-2B·1A, POA 31B

T-2B-1 POA 28A

T-2B-1 POA 28B

T-2B-2, POA 85

1·52-3B, POA 19

T-3B·1, POA 23

T-3B-2. POA 25A

T-3B-2. POA 25B

T-3B-3 POA 87A

T-3B-3, POA 26

TS-3B-3 POA 87B

1-52-4B, POA 18

T-4B-1 POA 55A

T-4B-1 POA 55B

T-4B·2, POA 57A

T-4B·3, POA 59

T-4B·2, POA 57B (T-4B·2, POA 57C is a series tap off of 57B in transformer enclosure. See 57B data sheet picture.)

1-52-5B, POA 17

T·5B-2, POA 63A

T·5B-2, POA 63B

T·5B·1, POA 73A

T·5B·1, POA 73B

T-5B·3, POA 68A

T-5B·3, POA 68B

T-5B-7, POA 70

T-5B-5, POA 82 A

T-5B-5, POA 82 B

T-5B-6, POA 81

1-52-6B, POA 16

T-6B-1. POA 61

1·52-S2, POA 15 A

BKR 3-52-S2, POA 39A (Indoor SWG 3. BUS 2)

1·52-S2, POA 15 B

BKR 3-52-S2, POA 39B (Indoor SWG 3. BUS 2)

1·52-8B. POA 14

T-8B·1. POA 78

T-8B·5, POA 77

T-8B·2, POA 75

T-8B-4, POA 67B

T-8B-4, POA 67A

T-8B-3. POA 65

1·52-9B. POA 13

T-9B-1. POA 48

BKR 3A-52-3, POA 46 (Outdoor SWG 3A BUS 2)

T-9B-2, POA 43

Switchgear Section C

3-52-G1 POA 37-

4-52-G1 TECO

TS-3S-3 POA 87B Main pumping station

3·52-G2 POA 32

3-52-G3 POA 35

3-52-G4 POA 36

3-52-G5 POA 33

3-52-G6 POA 34

3A-52·2 POA 44

3-FU-S4 POA 40

3A-52·1 POA 45 (See POA 11)

3A-52·3 POA 46 (See POA 13)

3A-52-4 POA 47

3-FU-S3 POA 41

5.0 Findings and Recommendations

Observable Deficiencies and Partial Discharge Activity

This section contains additional observations and recommended actions for POA's with **observable deficiencies** and/or partial discharge activity needing expedited attention. The photographs associated with each deficiency are displayed in Appendix 1. **The comments shown here in Findings and Recommendations Section 5.0 are in addition to the comments in the appendix.**

1-52-2B POA 20A

PD: PD not detected.

Visual:

1. There is a ty-rap against C-phase. Recommend removing or cut the ty-rap from against the C-phase.

2. The ground straps are too close to conductors. Insufficient clearance. They should be re-routed so they do not come close to the conductors.

T-3B-2 POA 25A

Visual: Low voltage C phase conductor against A phase conductor.

Recommend spacing the conductors

T-2A-4 POA 50A

Visual: Residual Neutral CT is open circuited on the secondary circuit

Recommend short circuit the secondary if not in use.

T-2A-1 POA 29A

Visual: CT for the winding temperature gauge short-circuited

Recommend investigating reason for this.

T-6B-1 POA 61

PD Detected with HFCT and TEV. Common ground was used. Individual grounds not safely accessible. PD waveform detected at 1.39MHz. PD is corona/surface in one or more of the terminations. Recommendation is to re-terminate the conductors. Do not recommend replacing the cable. Category RED

Visual: POA 61
1. All phase conductors are terminated too close to the PT's.
Recommend removing the conductors and extending the buss outward approximately 6 inches and re-terminate conductors.

Recommend to separate each phase ground strap so an HFCT can go around each phase's ground strap separately. Position them so they can be access near the front door or the cubicle.

T-6A-1 POA 60

PD: PD not detected

Visual: All phase conductors are terminated too close to the PT's.

Recommend removing the conductors and extending the buss outward approximately 6 inches and re-terminate conductors.

T-8B-2 POA 75

Visual: A-phase lightning arrestor has faulted in the past.

Recommend replacing arrestor

T-8A-5 POA 76

Visual: Non-shielded B phase arrestor conductor against the ground shield-causing corona.

Recommend replacing or cleaning the conductor.

T-8B-5 POA 77

Visual: Oil lubricant leaking from the fuse non-shielded conductors to the insulator boards.

Recommend cleaning the lubricant from the boards and conductors. Sealing the conductors.

T-8A-4 POA 66A

Visual:

1. A phase lightning arrestor conductor on A side feeder shows corona.

   Recommend cleaning or replacing conductor.

2. All non-shielded fuse conductors show signs of corona at the top of each insulating board.

   Recommend cleaning or replacing each conductor.

3. Oil lubricant leaking from the fuse non-shielded conductors to the insulator boards.

   Recommend cleaning the lubricant from the boards and conductors. Sealing the conductors.

T-8B-4 POA 67A

Visual:

1. C phase of the A side feeder lighting arrestor conductor shows signs of corona.

   Recommend replacing the conductor.

2. All fuse conductors of all phases show signs of corona at the top of the insulating boards.

   Recommend cleaning or replacing each conductor.

3. Oil lubricant is leaking from the non-shielded fuse conductors to the insulator boards.

   Recommend cleaning the insulator boards and conductors. Sealing the conductors.

T-5A-2 POA 62A&B

Visual: Oil residue and water shown on the concrete pad of the transformer.

No signs of leaks from the bushings or devices. Recommend investigating and cleaning the concrete pad.

T-5B-2 POA 63A

PD: PD level 32dB A -Phase Termination/Local PD. Recommend follow-up PD testing in 3-6 months. Noise levels are also extremely high in the area.

T-4A-1 POA 54A & B

PD: PD level 724pC on A phase and local PD. Recommend offline test and inspect or follow-up PD testing periodically.

T-4A-2 POA 56A

Visual: B phase bushing drain wire is disconnected.

Recommend re-connecting the drain wire.

T-4B-2 POA 57A & B

PD: 57A PD Level: 22-29dB. PD indication on phase A,B,C

57B PD Level: 31 Phase A Local PD indicated by TEV and HFCT

Visual:

1. Transformer de-energized.
2. Low oil indication on gauge.
3. Signs of corrosion on lower enclosure.
4. C phase dead break drain wire disconnected.

Recommend re-connecting.

T-5A-5 POA 83 A&B

POA 83A Visual:

1. Several drain wires missing or disconnected.

Recommend replacing wires and re-connecting.

1. C phase dead break termination against the threaded rod.
Recommend placing insulation around threaded rod to insulate termination.

POA 83B PD:

1. Local PD A-phase and B-phase

T-5B-5 POA 82A & B

POA 82A
Visual: C phase dead break termination against the threaded rod.
Recommend placing insulation around threaded rod to insulate termination.
POA 82B
PD: POA 82 Local PD Detected on C Phase. Not sure is PD is on 82A or 82B.

T-8B-1 POA 78

Visual: Oil level gauge indicates low oil below 25 deg. C level. No signs of leaks.
Recommend investigating oil leak. Add oil to the required 25 deg. C. level.

T-9A-2 POA 42

PD: Local PD on 3 phases
Visual: Oil present on the concrete pad. No signs of leaks around bushings or devices.
Recommend investigating oil leak. Add oil to the required 25 deg. C. level.

3-52-G4 POA 36

PD: Machine PD levels are normal. Local PD 31dB. Local PD A –phase
Recommend investigate 3-52-G4

Additional Comments:

PD readings are a commonly influenced by electrical transient noise and causing erroneous readings. The plant electrical distribution system was found to have extremely high noise levels in many sections of the facility. This could be caused by discharges from certain types of equipment or electronic switching producing harmonics. The testing equipment provides some filtering; and it was used during the analysis to ascertain if the signals were either PD or noise.

If the number in PD column is marked green, then it is the noise. It is advantageous to keep a record of noise levels in the table for future reference. It is helpful to be aware of the noise levels during retesting. However, there were certain locations where excess noise made it impossible to get a measurement on all four channels. In those cases, the PD levels were reported as 0dB or PD waveform not detected. Many facilities have increased the number of VFD and switching transistors on the power systems. (Rectifiers, inverters, drives, tryristors) Additionally, wireless communication signals also induce noise. These factors cause RF noise that is very similar to radio frequency emission patterns of PD. When the noise signals combine with real PD signals from far away, the situation is difficult for the instrument's algorithms to distinguish. In addition, if there is a recent harmonic study such as THD calculation, that may be useful in accounting for some the extremely high noise levels encountered. Furthermore, the high levels of harmonics will also chip away at the insulation systems in a way similar to PD and thus shortening the life of power equipment. Harmonic mitigation should be considered or upgraded.

Table 1: Partial Discharge Test Results Table

POA's with visually **observable deficiencies** are marked with (*) and colored according to criticality. A RED POA number is a critical deficiency. A YELLOW POA number is a caution or less critical deficiency. GREEN is nominal but may have noise as indicated.

Many test points are category GREEN although the TEV and pC readings are shown. If no PD waveforms were detected, and the measurement was determined to be noise only, the test point was still marked green though it contains a noise measurement. The TEV and pC numbers reported indicate that TEV and HFCT noise is present as a reference point for future retesting of POA. For Cable and Switchgear sensors levels an additional level ORANGE corresponding to Tables 2 & 3 in Section 3 along with the other colors indicated.

Recommendations are based on combination of PD and observable deficiencies. Some POA's were not listed in this table as cables grounding shield wire were not accessible or the compartment was not accessible. For these POA, a handheld unit was used to scan for PD using TEV, and UHF sensors. No abnormal signals were found. These unlisted POA can be treated as category green. As stated above in Section 4.1.

Table 1: (Refer to Section 3.0 for explanation of easements.)

POA	Equipment #	Phase A Cable (pC) / Termination (dB)	Phase B Cable (pC) / Termination (dB)	Phase C Cable (pC) / Termination (dB)	Local PD TEV Enclosure (dB)
POA 12	1-52-1A	0 pC / 0dB	0pC / 17dB	0pC / 25dB	0pC / 27dB
POA 11A	1-52-2A	0pC / 0dB	0pC / 0dB	0pC / 20dB	0pC / 29dB
POA 11B	1-52-2B	0pC / 0dB	0pC / 0dB	0pC / 0dB	0pC / 30dB
POA 10	1-52-3A	0pC / 0dB	0pC / 0dB	0pC / 0dB	0pC / 24dB
POA 9	1-52-4A	0pC / 0dB	0pC / 0dB	0pC / 0dB	0pC / 26dB
POA 8	1-52-5A	0pC / 0dB	0pC / 0dB	0pC / 0dB	0pC / 26dB
POA 7	1-52-6A	0pC / 0dB	0pC / 0dB	0pC / 0dB	0pC / 26dB
POA 6A	1-52- S1	0pC / 0dB	0pC / 0dB	0pC / 0dB	0pC / 24dB
POA 6B	1-52- S1	0pC / 0dB	0pC / 0dB	0pC / 0dB	0pC / 24dB
POA 5	1-52-8A	0pC / 0dB	0pC / 0dB	0pC / 0dB	0pC / 20dB
POA 4	1-52-9A	0pC / 0dB	0pC / 0dB	0pC / 0dB	0pC / 22dB
POA 13	1-52-9B	0pC / 0dB	0pC / 0dB	0pC / 0dB	0pC / 18dB
POA 14	1-52-8B	0pC / 0dB	0pC / 0dB	0pC / 0dB	0pC / 0dB
POA 15A	1-52-S2	0pC / 0dB	0pC / 0dB	0pC / 0dB	0pC / 25dB
POA 15B	1-52-S2	0pC / 0dB	0pC / 0dB	0pC / 0dB	0pC / 22dB
POA 16	1-52-6B	0pC / 0dB	0pC / 0dB	0pC / 0dB	0pC / 0dB
POA 17	1-52-5B	0pC / 0dB	0pC / 0dB	0pC / 0dB	0pC / 0dB
POA 18	1-52-4B	0pC / 0dB	0pC / 0dB	0pC / 0dB	0pC / 10dB
POA 19	1-52-3B	0pC / 0dB	0pC / 0dB	0pC / 0dB	0pC / 0dB
POA 20A*	1-52-2B	0pC / 0dB	0pC / 0dB	0pC / 0dB	0pC / 9dB
POA 20B*	1-52-2B	0pC / 0dB	0pC / 0dB	0pC / 0dB	0pC / 0dB
POA 21	1-52-1B	0pC / 10dB	0pC / 0dB	0pC / 0dB	0pC / 8dB
POA 22A	T-3A-1	0pC / 0dB	0pC / 0dB	0pC / 0dB	0pC / 9dB
POA 22B	T-3A-1	0pC / 0dB	0pC / 0dB	0pC / 0dB	0pC / 10dB
POA 23	T-3B-1	0pC / 0dB	0pC / 0dB	0pC / 0dB	0pC / 9dB

Table 1: (Refer to Section 3.0 for explanation of easements.)

POA	Equipment #	Phase A Cable (pC) / Termination (dB)	Phase B Cable (pC) / Termination (dB)	Phase C Cable (pC) / Termination (dB)	Local PD TEV Enclosure (dB)
POA 24A	T-3A-2	0pC / 0dB	0pC / 0dB	0pC / 0dB	0pC / 8dB
POA 24B	T-3A-2	0pC / 0dB	0pC / 0dB	0pC / 0dB	0pC / 9dB
POA 25A*	T-3B-2	0pC / 0dB	0pC / 0dB	0pC / 0dB	0pC / 8dB
POA 25B	T-3B-2	0pC / 0dB	0pC / 0dB	0pC / 0dB	0pC / 9dB
POA 27	T-3A-3	0pC / 0dB	0pC / 0dB	0pC / 0dB	0pC / 8dB
POA 26	T-3B-3	332pC / 12dB	0pC / 0dB	0pC / 0dB	0pC / 9dB
POA 53	T-2A-3	0pC / 18dB	0pC / 20dB	0pC / 20dB	0pC / 9dB
POA 52	T-2B-3	0pC / 0dB	0pC / 0dB	0pC / 0dB	0pC / 9dB
POA 50A*	T-2A-4	0pC / 20dB	0pC / 0dB	0pC / 0dB	0pC / 9dB
POA 50B	T-2A-4	0pC / 0dB	0pC / 0dB	0pC / 0dB	0pC / 9dB
POA 31A	T-2B-1	0pC / 0dB	0pC / 0dB	1986pC / 0dB	0pC / 13dB
POA 30A	T-2A-1A	0pC / 0dB	0pC / 0dB	0pC / 0dB	0pC / 0dB
POA 30B	T-2A-1A	0pC / 10dB	0pC / 0dB	0pC / 0dB	0pC / 10dB
POA 28A	T-2B-1	2124pC / 0dB	2412pC / 0dB	1831pC / 0dB	0pC / 9dB
POA 28B	T-2B-1	0pC / 0dB	0pC / 0dB	0pC / 16dB	0pC / 9dB
POA 29A*	T-2A-1	0pC / 0dB	0pC / 0dB	0pC / 0dB	0pC / 9dB
POA 29B	T-2A-1	0pC / 0dB	0pC / 0dB	0pC / 0dB	0pC / 9dB
POA 84	T-2A-2	0pC / 0dB	0pC / 0dB	0pC / 0dB	0pC / 9dB
POA 85	T-2B-2	0pC / 8dB	0pC / 0dB	0pC / 7dB	0pC / 22dB
POA 61*	T-6B-1	0pC / 0dB	0pC / 0dB	978pC / 0dB	0pC / 24dB
POA 60*	T-6A-1	0pC / 0dB	0pC / 0dB	0pC / 0dB	0pC / 16dB

Table 1: (Refer to Section 3.0 for explanation of easements.)

POA	Equipment #	Phase A Cable (pC) / Termination (dB)	Phase B Cable (pC) / Termination (dB)	Phase C Cable (pC) / Termination (dB)	Local PD TEV Enclosure (dB)
POA 75*	T-8B-2	0pC / 0dB	0pC / 0dB	0pC / 0dB	0pC / 25dB
POA 74	T-8A-2	0pC / 0dB	0pC / 0dB	0pC / 0dB	0pC / 20dB
POA 76*	T-8A-5	0pC / 0dB	0pC / 0dB	0pC / 0dB	0pC / 9dB
POA 77*	T-8B-5	0pC / 0dB	0pC / 0dB	0pC / 0dB	0pC / 0dB
POA 73A	T-5B-1	0pC / 0dB	0pC / 0dB	0pC / 0dB	0pC / 20dB
POA 73B	T-5B-1	0pC / 0dB	0pC / 0dB	0pC / 0dB	0pC / 0dB
POA 72A	T-5A-1	0pC / 0dB	0pC / 0dB	0pC / 0dB	0pC / 0dB
POA 72B	T-5A-1	0pC / 0dB	0pC / 0dB	0pC / 0dB	0pC / 0dB
POA 66A*	T-8A-4	0pC / 0dB	0pC / 0dB	0pC / 0dB	0pC / 26dB
POA 66B	T-8A-4	0pC / 0dB	0pC / 0dB	0pC / 0dB	0pC / 22dB
POA 67A*	T-8B-4	3396pC / 0dB	0pC / 0dB	0pC / 0dB	0pC / 18dB
POA 67B	T-8B-4	0pC / 0dB	0pC / 0dB	0pC / 0dB	0pC / 17dB
POA 64	T-8A-3	0pC / 0dB	0pC / 0dB	0pC / 0dB	0pC / 25dB
POA 65	T-8B-3	0pC / 0dB	0pC / 0dB	0pC / 0dB	0pC / 31dB
POA 70	T-5B-7	0pC / 0dB	0pC / 0dB	0pC / 0dB	0pC / 32dB

Table 1: (Refer to Section 3.0 for explanation of easements.)

POA	Equipment #	Phase A Cable (pC) / Termination (dB)	Phase B Cable (pC) / Termination (dB)	Phase C Cable (pC) / Termination (dB)	Local PD TEV Enclosure (dB)
POA 71	T-5A-7	0pC / 21dB	0pC / 0dB	0pC / 23dB	0pC / 0dB
POA 68A	T-5B-3	6281pC / 0dB	0pC / 0dB	0pC / 0dB	0pC / 26dB
POA 68B	T-5B-3	9424pC / 0dB	0pC / 0dB	0pC / 0dB	0pC / 23dB
POA 69A	T-5A-3	0pC / 0dB	0pC / 0dB	0pC / 0dB	0pC / 0dB
POA 69B	T-5A-4	0pC / 0dB	0pC / 0dB	0pC / 0dB	0pC / 0dB
POA 62A*	T-5A-2	0pC / 0dB	0pC / 0dB	0pC / 0dB	0pC / 9dB
POA 62B*	T-5A-2	0pC / 0dB	0pC / 0dB	0pC / 0dB	0pC / 9dB
POA 63A	T-5B-2	0pC / 32dB	0pC / 0dB	0pC / 20dB	0pC / 32dB
POA 63B	T-5B-2	0pC / 22dB	0pC / 0dB	0pC / 0dB	0pC / 9dB
POA 54A	T-4A-1	134pC / 28dB	0pC / 0dB	0pC / 0dB	724pC / 11dB
POA 54 B	T-4A-1	134pC / 28dB	0pC / 0dB	0pC / 0dB	724pC / 11dB
POA 55A	T-4B-1	0pC / 14dB	0pC / 0dB	0pC / 0dB	0pC / 14dB
POA 55B	T-4B-1	0pC / 14dB	0pC /0dB	1731pC / 18dB	0pC / 0dB
POA 56B	T-4A-2	0pC / 0dB	0pC / 0dB	0pC / 0dB	0pC / 9dB
POA 56A*	T-4A-2	0pC / 0dB	0pC / 0dB	0pC / 25dB	0pC / 25dB

Table 1: (Refer to Section 3.0 for explanation of easements.)

POA	Equipment #	Phase A Cable (pC) / Termination (dB)	Phase B Cable (pC) / Termination (dB)	Phase C Cable (pC) / Termination (dB)	Local PD TEV Enclosure (dB)
POA 57B*	T-4B-2	0pC / 29dB	0pC / 23dB	0pC / 22dB	0pC / 24dB
POA 57A	T-4B-2	0pC / 31dB	0pC / 0dB	0pC / 18dB	0pC / 20dB
POA 80	T-5A-6	0pC / 22dB	0pC / 0dB	0pC / 0dB	0pC / 0dB
POA 81	T-5B-6	0pC / 0dB	0pC / 0dB	0pC / 18dB	0pC / 9dB
POA 83B*	T-5A-5	0pC / 0dB	0pC / 0dB	0pC / 0dB	32582pC / 0dB
POA 83A	T-5A-5	0pC / 20dB	0pC / 17dB	0pC / 0dB	0pC / 0dB
POA 82A*	T-5B-5	0pC / 0dB	0pC / 9dB	0pC / 0dB	0pC / 9dB
POA 82B	T-5B-5	0pC / 0dB	0pC / 0dB	0pC / 15dB	0pC / 15dB
POA 78*	T-8B-1	0pC / 0dB	0pC / 0dB	0pC / 0dB	0pC / 0dB
POA 79	T-8A-1	0pC / 0dB	0pC / 0dB	0pC / 0dB	0pC / 0dB
POA 48	T-9B-1	0pC / 0dB	0pC / 0dB	0pC / 0dB	0pC / 0dB
POA 49	T-9A-1	0pC / 0dB	0pC / 0dB	0pC / 0dB	0pC / 0dB
POA 42*	T-9A-2	0pC / 23dB	0pC / 25dB	0pC / 21dB	0pC / 25dB
POA 43	T-9B-2	0pC / 18dB	0pC / 21dB	0pC / 16dB	0pC / 25dB
POA 87A	TS-3B-3	0pC / 0dB	0pC / 0dB	0pC / 0dB	0pC / 9dB
POA 87B	TS-3B-3	0pC / 0dB	0pC / 0dB	0pC / 0dB	0pC / 23dB
POA 58	T-4A-3	0pC / 0dB	0pC / 0dB	0pC / 0dB	0pC / 23dB
POA 59	T-4B-3	0pC / 0dB	0pC / 0dB	0pC / 0dB	0pC / 27dB
POA 34	3-52-G6	350pC / 22dB	908pC / 15dB	968pC / 18dB	0pC / 25dB
POA 33	3-52-G5	1898pC / 29dB	1438pC / 31dB	1706pC / 26dB	0pC / 24dB

Table 1: (Refer to Section 3.0 for explanation of easements.)

POA	Equipment #	Phase A Cable (pC) / Termination (dB)	Phase B Cable (pC) / Termination (dB)	Phase C Cable (pC) / Termination (dB)	Local PD TEV Enclosure (dB)
POA 32	3-52-G2	0pC / 0dB	0pC / 0dB	2241pC / 0dB	0pC / 9dB
POA 39A	3-52-S2	0pC / 0dB	0pC / 20dB	1208pC / 0dB	0pC / 27dB
POA 39B	3-52-S2	2220pC / 20dB	0pC / 0dB	354pC / 19dB	0pC / 22dB
POA 35	3-52-G3	722pC / 24dB	1454pC / 0dB	1057pC / 23dB	0pC / 27dB
POA 36	3-52-G4	0pC / 31dB	1920pC / 26dB	0pC / 26dB	0pC / 29dB
POA 38A	3-52-S1	0pC / 0dB	0pC / 0dB	0pC / 0dB	0pC / 24dB
POA 38B	3-52-S2	28pC / 15dB	0pC / 0dB	0pC / 0dB	0pC / 27dB

APPENDIX

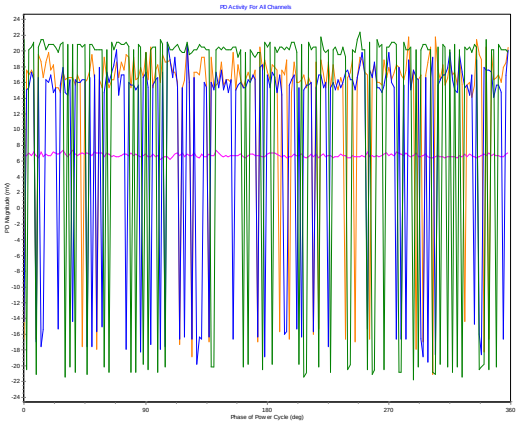
POA Datasheets

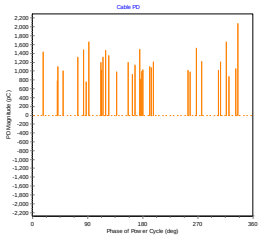
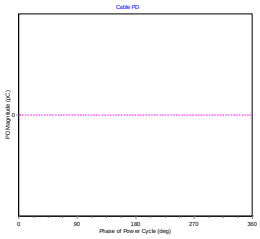
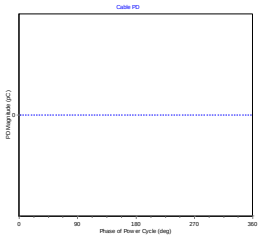
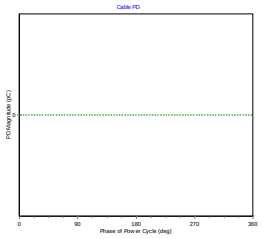
Substation/Site: 1-52-1A
Location: POA 12
Test No.:

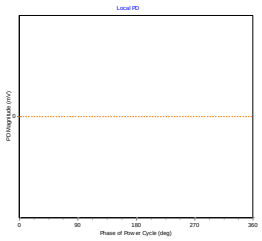
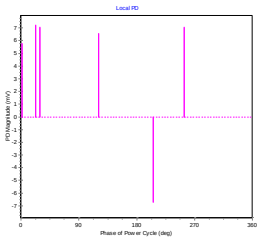
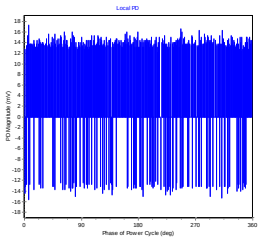
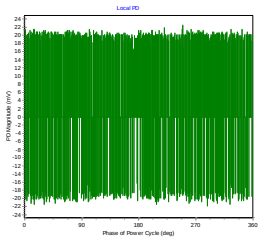
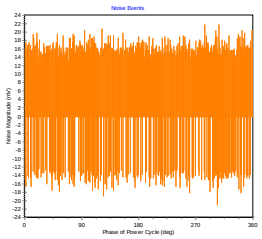
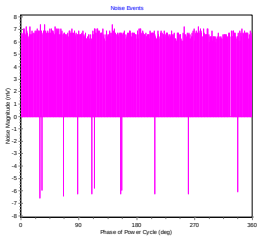
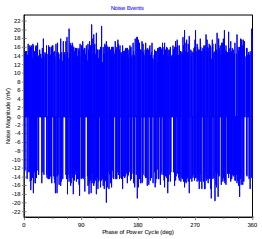
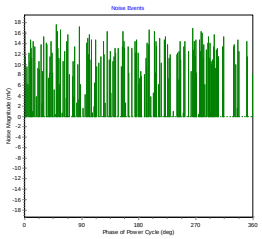
Customer: City of Tampa
Test Engineer: Nat Crews/ Louis Nemec
Test Date: 07/02/2017 10:34:25 AM

C.E. Testing, Inc.

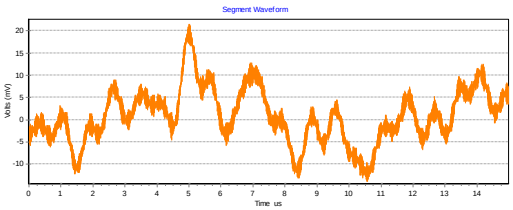
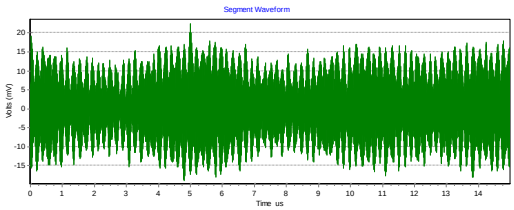
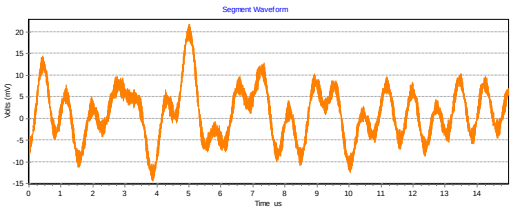
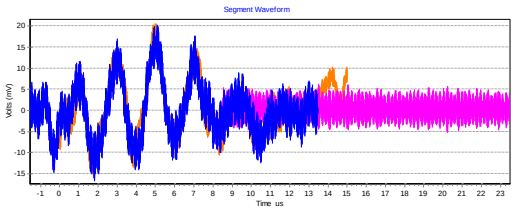
Sensor	Circuit/Description	V(kV)	Cable Type	Local Plant Type
HFCT	phA	13.2kV	Cable	EPR
HFCT	phB	13.2kV	Cable	EPR
HFCT	phC	13.2kV	Cable	EPR
TEV Probe	enclosure TEV	13.2kV	Switchgear	Solid Insulated

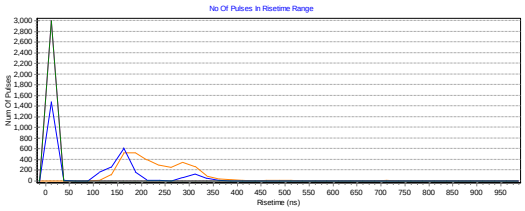
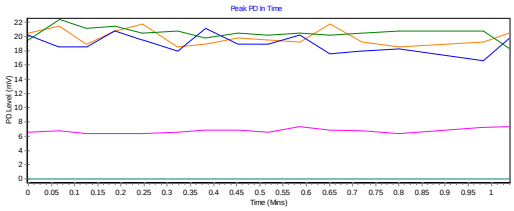
Phase-Resolved Graph (PD and Noise)	Photo of Sensor Attachment
	

	Channel 1		Channel 2		Channel 3		Channel 4	
	Cable PD	2070pC	Cable PD	0pC	Cable PD	0pC	Cable PD	0pC
	Local PD	0dB	Local PD	17dB	Local PD	25dB	Local PD	27dB
	Peak	21.76mV	Peak	7.36mV	Peak	21.12mV	Peak	22.40mV
	Std Dev	3.55mV	Std Dev	2.17mV	Std Dev	3.56mV	Std Dev	7.98mV
Cable PD								

Local PD				
Noise				

Sensor	Circuit/Description	V(kV)	Cable Type	Local Plant Type
HFCT	phA	13.2kV	Cable	EPR
HFCT	phB	13.2kV	Cable	EPR
HFCT	phC	13.2kV	Cable	EPR
TEV Probe	enclosure TEV	13.2kV	Switchgear	Solid Insulated

Cable PD Waveform				Local PD Waveform			
							
Peak	21.44 mV	**Frequency**	244.14 kHz	**Peak**	22.40 mV	**Frequency**	93.75 MHz
Rise Time	266.22 ns	**PD Level**	2.07 nC	**Rise Time**	1.12 ns	**PD Level**	
Noise Waveform				**Synchronous Waveform**			
							
Peak	21.76 mV	**Frequency**	488.28 kHz	**Peak**	-	**Frequency**	-
Rise Time	250.65 ns	**PD Level**	-	**Rise Time**	-	**PD Level**	-

No of Pulses vs. Pulse Rise-Time	Peak Level in Time
	

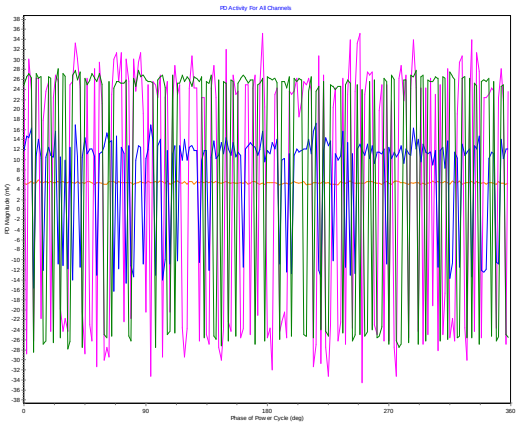
Comments
Noise Waveforms. No PD

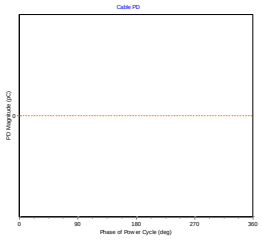
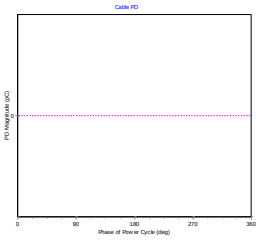
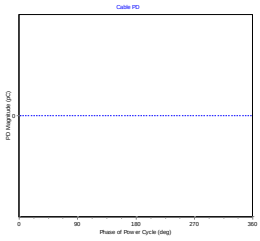
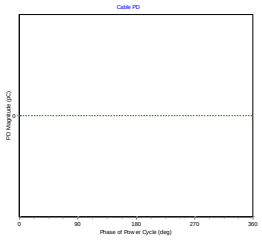
Substation/Site: 1-52-2A
Location: POA 11A
Test No.:

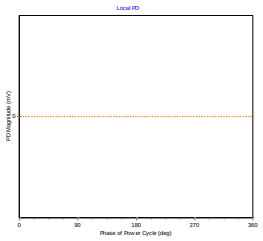
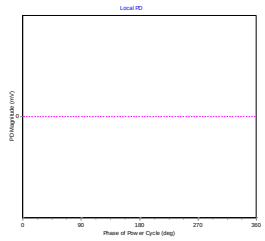
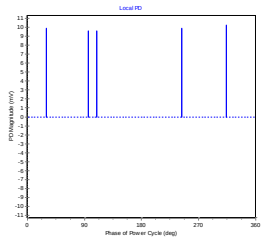
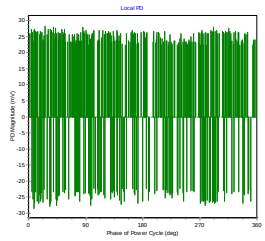
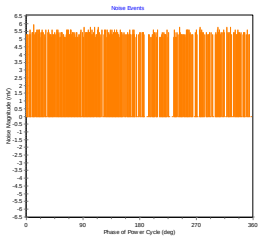
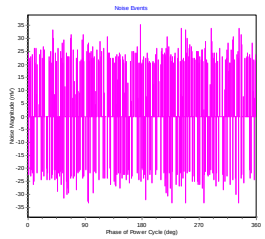
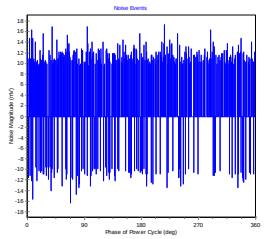
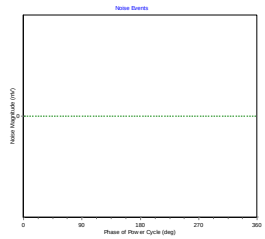
Customer: City of Tampa
Test Engineer: Nat Crews/ Louis Nemec
Test Date: 07/02/2017 11:00:56 AM

C.E. Testing, Inc.

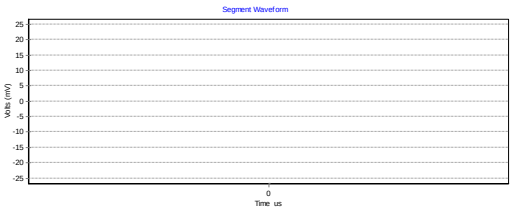
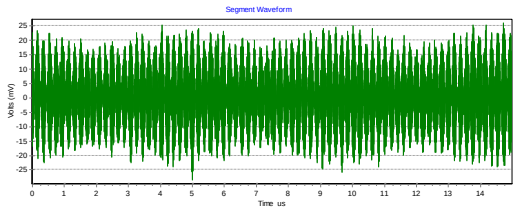
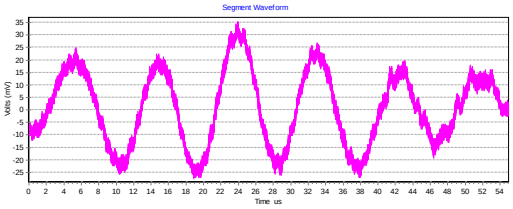
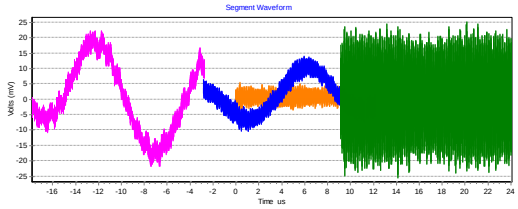
Sensor	Circuit/Description	V(kV)	Cable Type	Local Plant Type
HFCT	phA	13.2kV	Cable	EPR
HFCT	phB	13.2kV	Cable	EPR
HFCT	phC	13.2kV	Cable	EPR
TEV Probe	enclosure TEV	13.2kV	Switchgear	Air Insulated

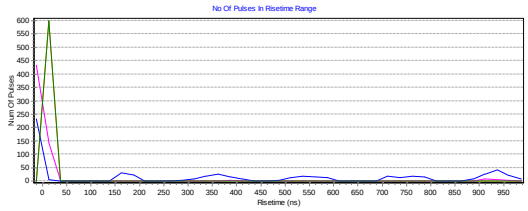
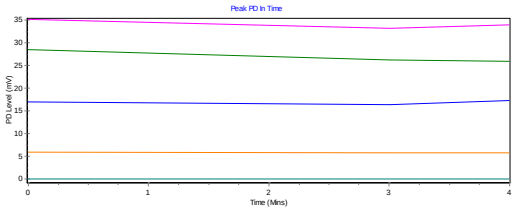
Phase-Resolved Graph (PD and Noise)	Photo of Sensor Attachment
	

	Channel 1		Channel 2		Channel 3		Channel 4	
	Cable PD	0pC	Cable PD	0pC	Cable PD	0pC	Cable PD	0pC
	Local PD	0dB	Local PD	0dB	Local PD	20dB	Local PD	29dB
	Peak	5.92mV	Peak	35.20mV	Peak	17.28mV	Peak	28.48mV
	Std Dev	1.56mV	Std Dev	7.04mV	Std Dev	3.15mV	Std Dev	9.14mV
Cable PD								

Local PD				
Noise				

Sensor	Circuit/Description	V(kV)	Cable Type	Local Plant Type
HFCT	phA	13.2kV	Cable	EPR
HFCT	phB	13.2kV	Cable	EPR
HFCT	phC	13.2kV	Cable	EPR
TEV Probe	enclosure TEV	13.2kV	Switchgear	Air Insulated

Cable PD Waveform				Local PD Waveform			
							
Peak		**Frequency**		**Peak**	-28.48 mV	**Frequency**	83.33 MHz
Rise Time		**PD Level**		**Rise Time**	1.23 ns	**PD Level**	
Noise Waveform				**Synchronous Waveform**			
							
Peak	35.20 mV	**Frequency**	106.81 kHz	**Peak**	-	**Frequency**	-
Rise Time	1.76 us	**PD Level**	-	**Rise Time**	-	**PD Level**	-

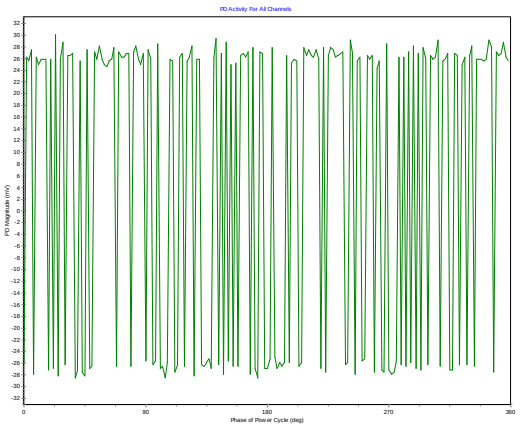
No of Pulses vs. Pulse Rise-Time	Peak Level in Time
	

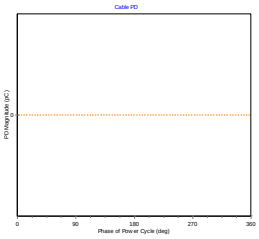
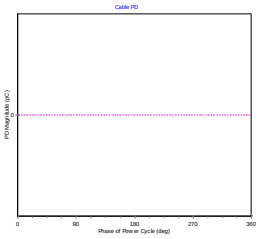
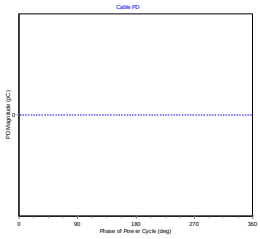
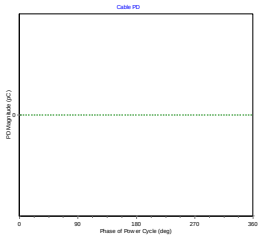
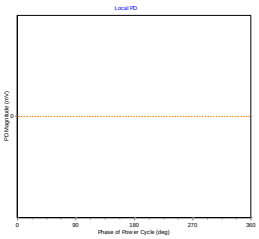
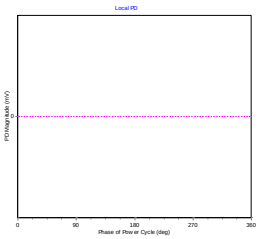
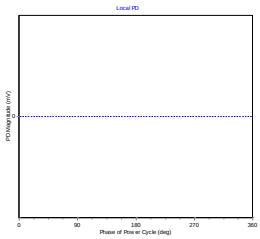
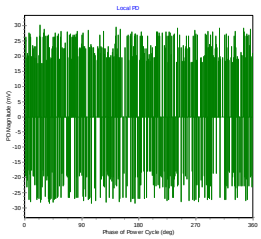
Comments
Noise Waveforms PD not indicated

Substation/Site:	1-52-2A	**Customer:**	City of Tampa
Location:	POA 11B	**Test Engineer:**	Nat Crews/ Louis Nemec
Test No.:		**Test Date:**	07/02/2017 11:17:03 AM

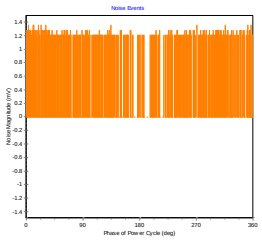
C.E. Testing, Inc.

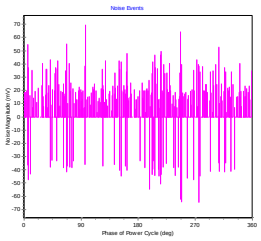
Sensor	Circuit/Description	V(kV)	Cable Type	Local Plant Type
HFCT	phA	13.2kV	Cable	EPR
HFCT	phB	13.2kV	Cable	EPR
HFCT	phC	13.2kV	Cable	EPR
TEV Probe	enclosure TEV	13.2kV	Switchgear	Air Insulated

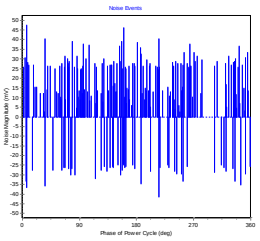
Phase-Resolved Graph (PD and Noise)	Photo of Sensor Attachment
	

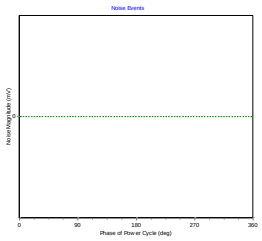
	Channel 1		Channel 2		Channel 3		Channel 4	
	Cable PD	0pC	Cable PD	0pC	Cable PD	0pC	Cable PD	0pC
	Local PD	0dB	Local PD	0dB	Local PD	0dB	Local PD	30dB
	Peak	1.35mV	Peak	69.12mV	Peak	47.36mV	Peak	30.08mV
	Std Dev	0.10mV	Std Dev	12.68mV	Std Dev	8.18mV	Std Dev	8.17mV
Cable PD								
Local PD								

Noise



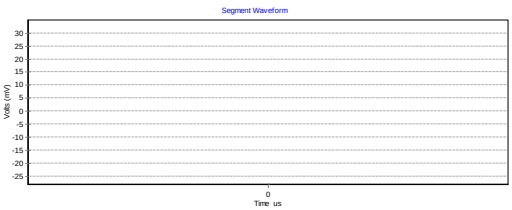






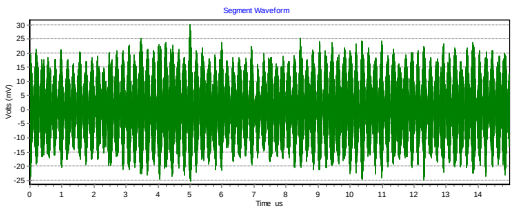
Sensor	Circuit/Description	V(kV)	Cable Type	Local Plant Type
HFCT	phA	13.2kV	Cable	EPR
HFCT	phB	13.2kV	Cable	EPR
HFCT	phC	13.2kV	Cable	EPR
TEV Probe	enclosure TEV	13.2kV	Switchgear	Air Insulated

Cable PD Waveform



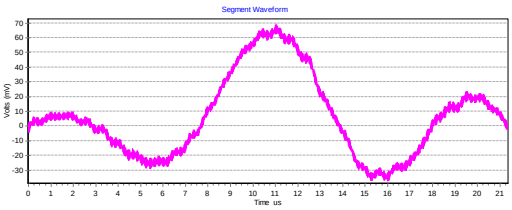
Peak		**Frequency**	
Rise Time		**PD Level**	

Local PD Waveform



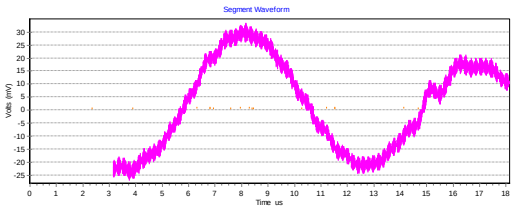
Peak	30.08 mV	**Frequency**	83.33 MHz
Rise Time	1.12 ns	**PD Level**	

Noise Waveform



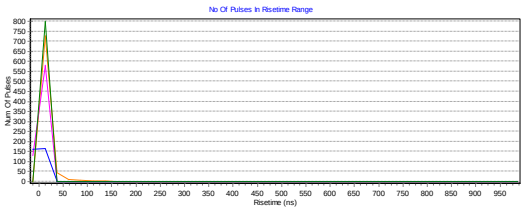
Peak	69.12 mV	**Frequency**	91.55 kHz
Rise Time	2.60 us	**PD Level**	-

Synchronous Waveform

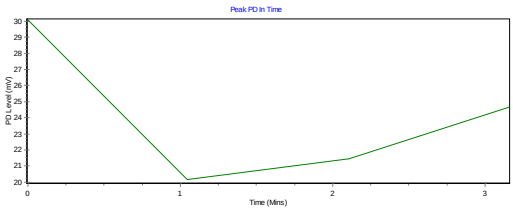


Peak	-	**Frequency**	-
Rise Time	-	**PD Level**	-

No of Pulses vs. Pulse Rise-Time



Peak Level in Time



Comments

Noise Waveforms
PD not indicated

Substation/Site: 1-52-3

Location: POA 10

Test No.:

Customer: City of Tampa

Test Engineer: Nat Crews/ Louis Nemec

Test Date: 07/02/2017 11:34:48 AM

C.E. Testing, Inc.

Sensor	Circuit/Description	V(kV)	Cable Type	Local Plant Type
HFCT	phA	13.2kV	Cable	EPR
HFCT	phB	13.2kV	Cable	EPR
HFCT	phC	13.2kV	Cable	EPR
TEV Probe	TEV	13.2kV	Switchgear	Air Insulated

Phase-Resolved Graph (PD and Noise)

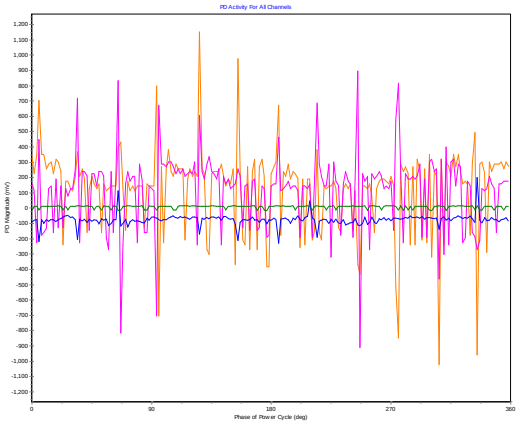
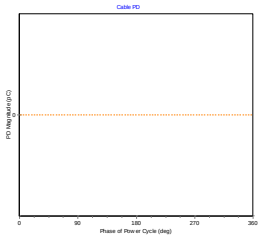
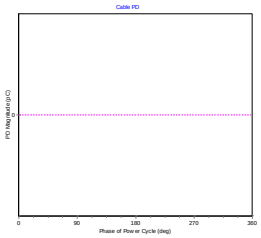
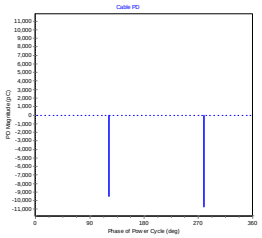
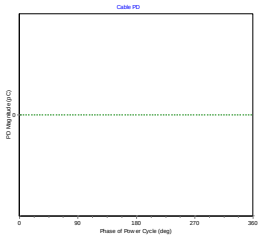
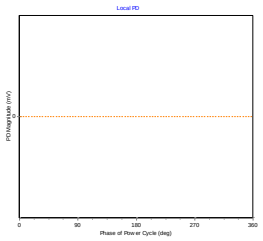
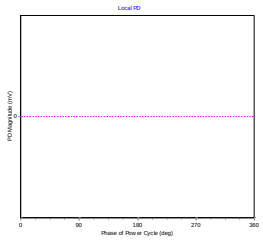
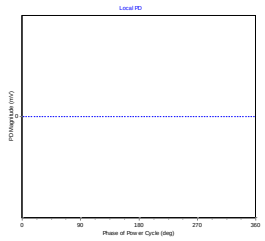
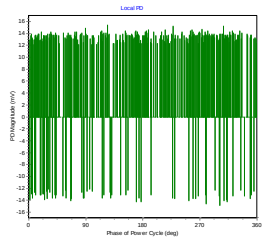
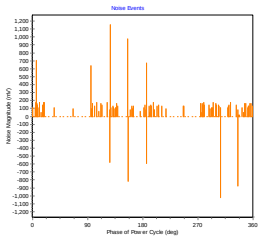
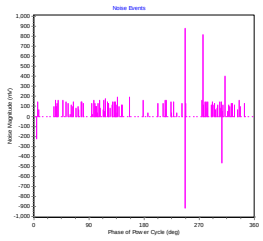
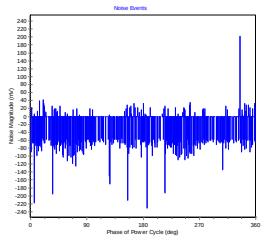
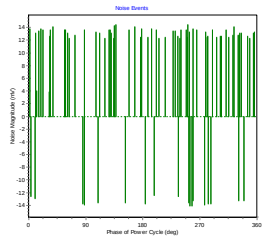
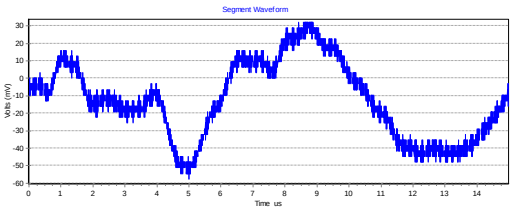
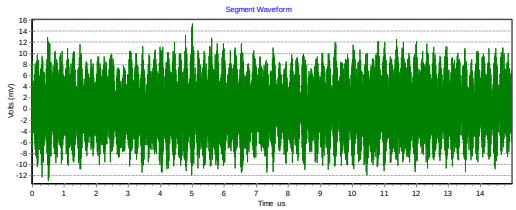
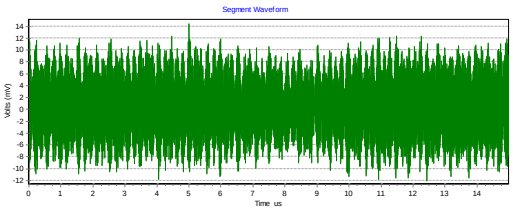
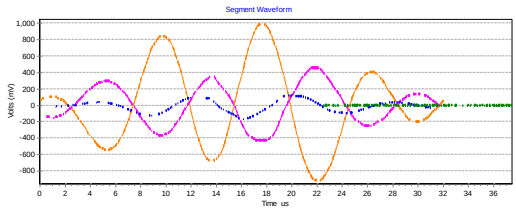


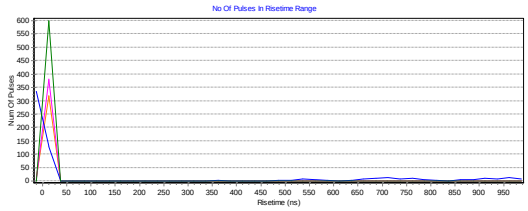
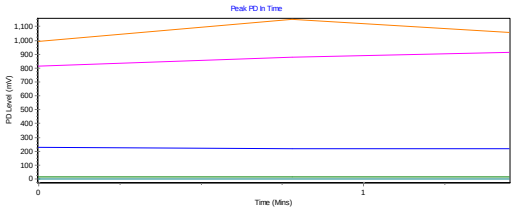
Photo of Sensor Attachment

	Channel 1		Channel 2		Channel 3		Channel 4	
	Cable PD	0pC	Cable PD	0pC	Cable PD	10710pC	Cable PD	0pC
	Local PD	0dB	Local PD	0dB	Local PD	0dB	Local PD	24dB
	Peak	1152.00mV	Peak	912.00mV	Peak	230.40mV	Peak	15.36mV
	Std Dev	87.90mV	Std Dev	77.35mV	Std Dev	20.77mV	Std Dev	5.57mV
Cable PD								

Local PD				
Noise				

Sensor	Circuit/Description	V(kV)	Cable Type	Local Plant Type
HFCT	a	13.2kV	Cable	EPR
HFCT	b	13.2kV	Cable	EPR
HFCT	c	13.2kV	Cable	EPR
TEV Probe	TEV	13.2kV	Switchgear	Air Insulated

Cable PD Waveform				Local PD Waveform			
							
Peak	-57.60 mV	**Frequency**	244.14 kHz	**Peak**	15.36 mV	**Frequency**	71.43 MHz
Rise Time	709.72 ns	**PD Level**	-10.71 nC	**Rise Time**	1.70 ns	**PD Level**	
Noise Waveform				**Synchronous Waveform**			
							
Peak	14.40 mV	**Frequency**	71.43 MHz	**Peak**	-	**Frequency**	-
Rise Time	2.39 ns	**PD Level**	-	**Rise Time**	-	**PD Level**	-

No of Pulses vs. Pulse Rise-Time	Peak Level in Time
	

Comments

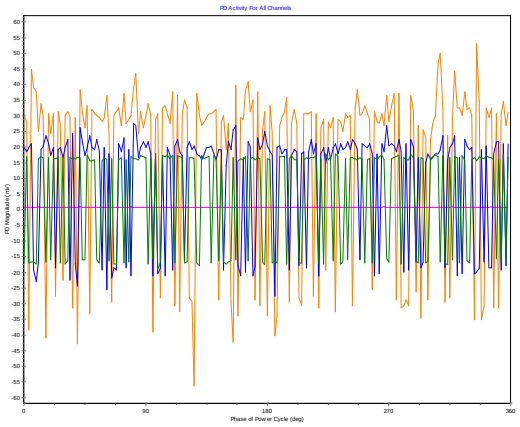
Noise waveforms. No PD measured.

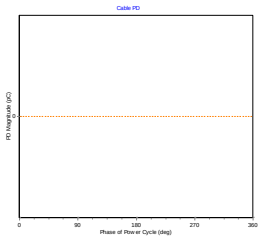
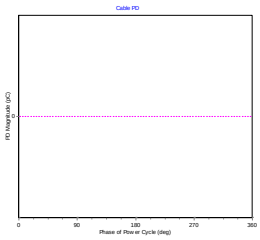
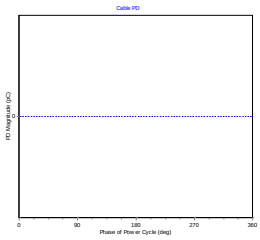
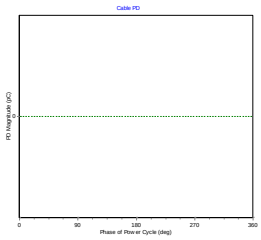
Substation/Site: 1-52-4A
Location: POA 9
Test No.:

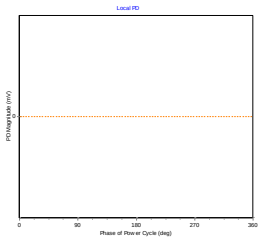
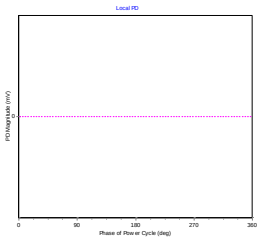
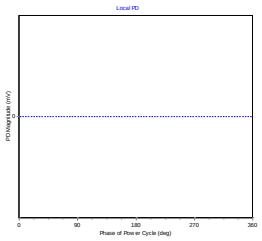
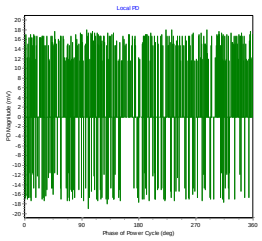
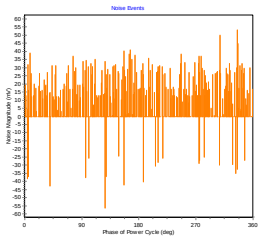
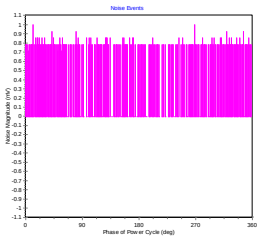
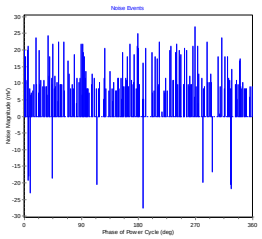
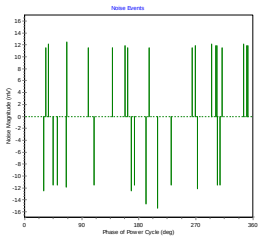
Customer: City of Tampa
Test Engineer: Nat Crews/ Louis Nemec
Test Date: 07/02/2017 11:43:46 AM

C.E. Testing, Inc.

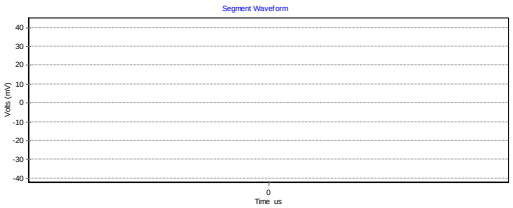
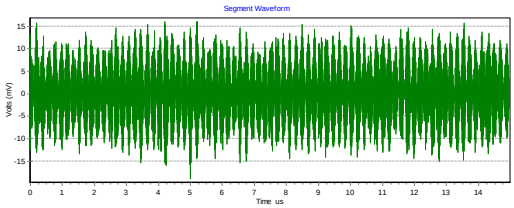
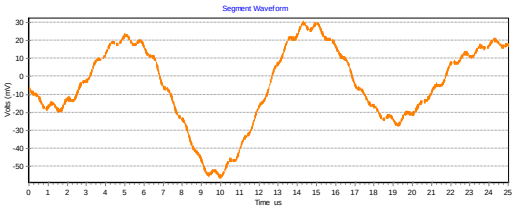
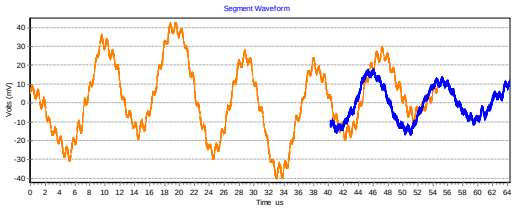
Sensor	Circuit/Description	V(kV)	Cable Type	Local Plant Type
HFCT	phA	15kV	Cable	EPR
HFCT	phB	15kV	Cable	EPR
HFCT	phC	15kV	Cable	EPR
TEV Probe	TEV	15kV	Cable	EPR

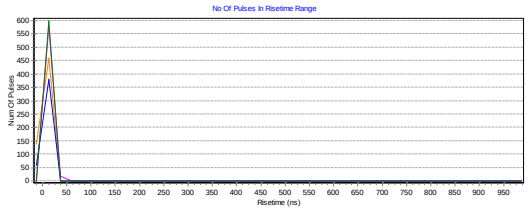
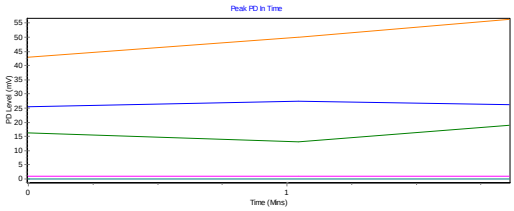
Phase-Resolved Graph (PD and Noise)	Photo of Sensor Attachment
	

	Channel 1		Channel 2		Channel 3		Channel 4	
	Cable PD	0pC	Cable PD	0pC	Cable PD	0pC	Cable PD	0pC
	Local PD	0dB	Local PD	0dB	Local PD	0dB	Local PD	26dB
	Peak	56.32mV	Peak	1.00mV	Peak	27.52mV	Peak	18.88mV
	Std Dev	9.64mV	Std Dev	0.10mV	Std Dev	5.95mV	Std Dev	5.19mV
Cable PD								

Local PD				
Noise				

Sensor	Circuit/Description	V(kV)	Cable Type	Local Plant Type
HFCT	phA	15kV	Cable	EPR
HFCT	phB	15kV	Cable	EPR
HFCT	phC	15kV	Cable	EPR
TEV Probe	TEV	15kV	Cable	EPR

Cable PD Waveform				Local PD Waveform			
							
Peak		**Frequency**		**Peak**	-18.88 mV	**Frequency**	83.33 MHz
Rise Time		**PD Level**		**Rise Time**	1.50 ns	**PD Level**	
Noise Waveform				**Synchronous Waveform**			
							
Peak	-56.32 mV	**Frequency**	91.55 kHz	**Peak**	-	**Frequency**	-
Rise Time	2.36 us	**PD Level**	-	**Rise Time**	-	**PD Level**	-

No of Pulses vs. Pulse Rise-Time	Peak Level in Time
	

Comments
Noise waveforms. No PD measured

Substation/Site: 1-52-5A
Location: POA 8
Test No.:

Customer: City of Tampa
Test Engineer: Nat Crews/ Louis Nemec
Test Date: 07/02/2017 11:53:21 AM

C.E. Testing, Inc.

Sensor	Circuit/Description	V(kV)	Cable Type	Local Plant Type
HFCT	phA	15kV	Cable	EPR
HFCT	phB	15kV	Cable	EPR
HFCT	phC	15kV	Cable	EPR
TEV Probe	TEV	15kV	Switchgear	Air Insulated

Phase-Resolved Graph (PD and Noise)

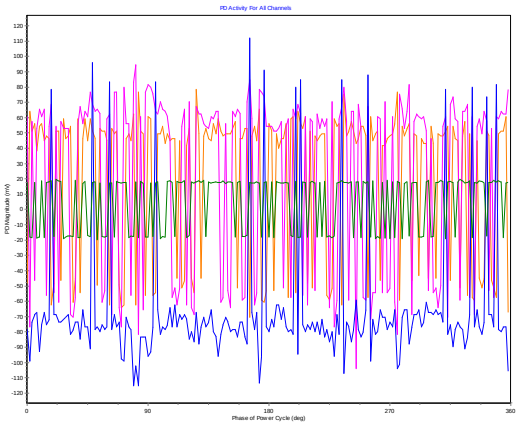
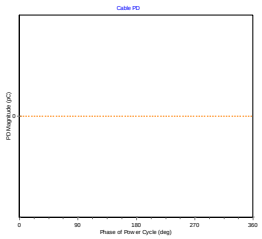
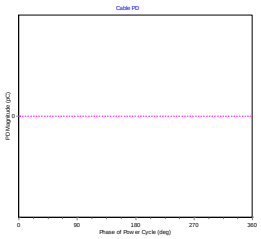
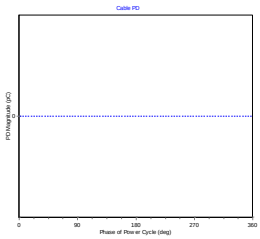
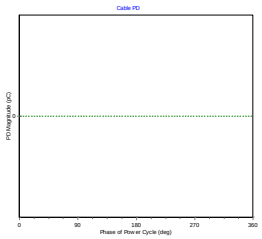
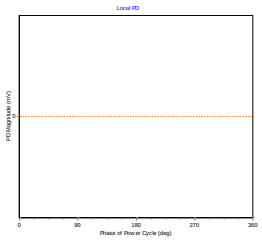
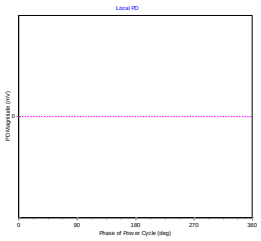
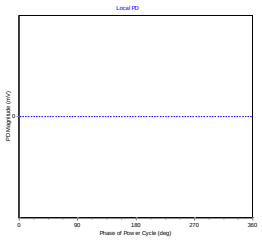
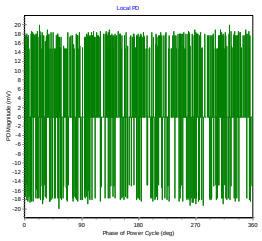
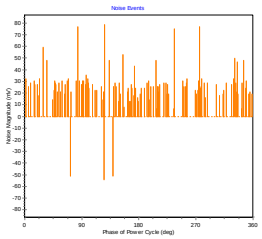
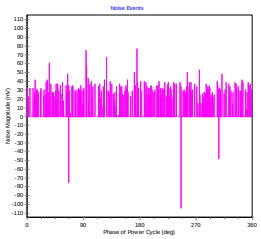
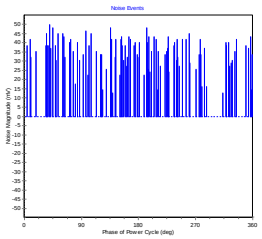
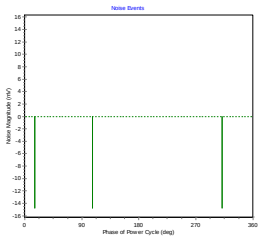
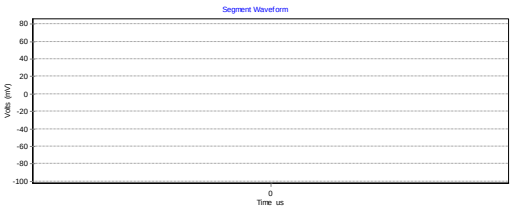
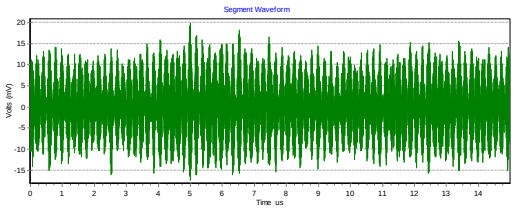
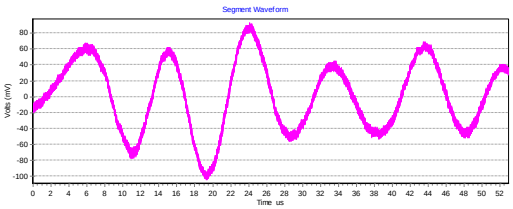
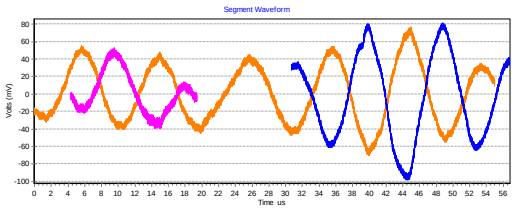


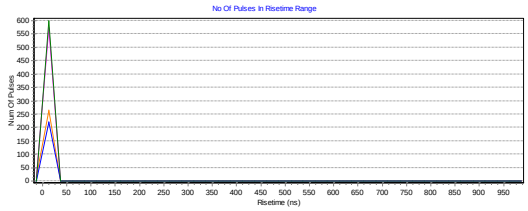
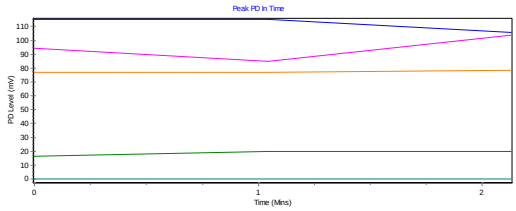
Photo of Sensor Attachment

	Channel 1		Channel 2		Channel 3		Channel 4	
	Cable PD	0pC	Cable PD	0pC	Cable PD	0pC	Cable PD	0pC
	Local PD	0dB	Local PD	0dB	Local PD	0dB	Local PD	26dB
	Peak	78.40mV	Peak	104.00mV	Peak	49.60mV	Peak	19.84mV
	Std Dev	15.81mV	Std Dev	19.39mV	Std Dev	24.73mV	Std Dev	6.45mV
Cable PD								

Local PD				
Noise				

Sensor	Circuit/Description	V(kV)	Cable Type	Local Plant Type
HFCT	phA	15kV	Cable	EPR
HFCT	phB	15kV	Cable	EPR
HFCT	phC	15kV	Cable	EPR
TEV Probe	TEV	15kV	Switchgear	Air Insulated

Cable PD Waveform				Local PD Waveform			
							
Peak		**Frequency**		**Peak**	19.84 mV	**Frequency**	93.75 MHz
Rise Time		**PD Level**		**Rise Time**	1.78 ns	**PD Level**	
Noise Waveform				**Synchronous Waveform**			
							
Peak	-104.00 mV	**Frequency**	106.81 kHz	**Peak**	-	**Frequency**	-
Rise Time	1.91 us	**PD Level**	-	**Rise Time**	-	**PD Level**	-

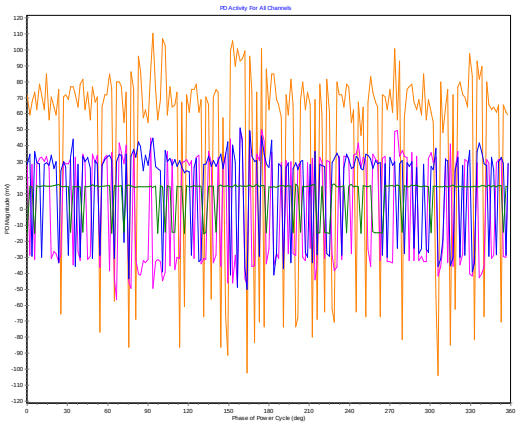
No of Pulses vs. Pulse Rise-Time	Peak Level in Time
	

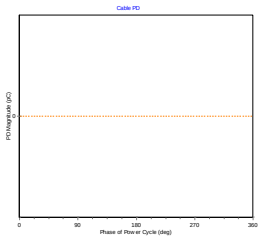
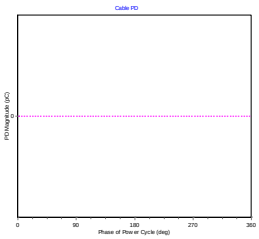
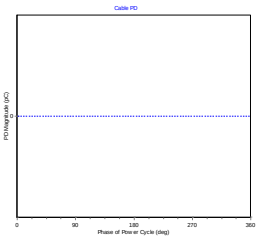
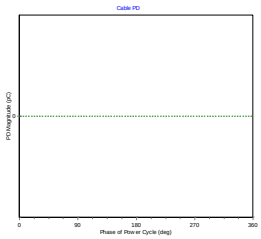
Comments
Noise waveforms. No PD measured.

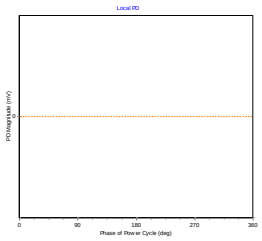
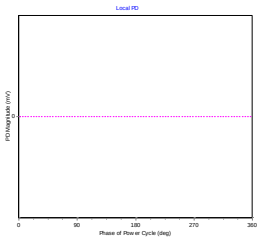
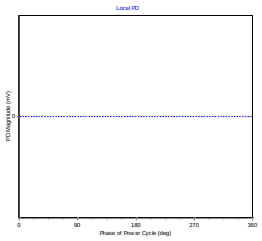
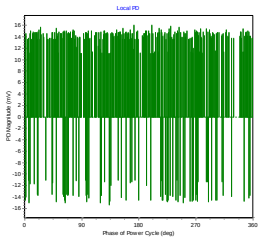
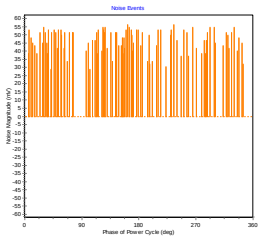
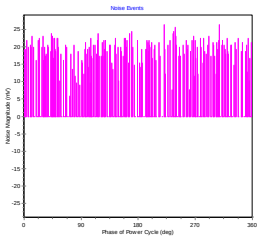
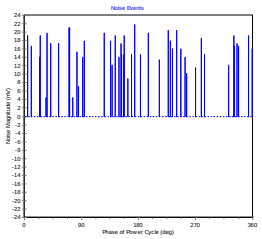
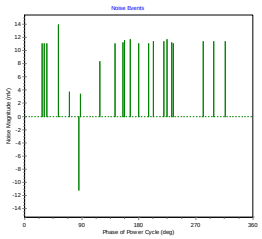
Substation/Site:	1-52-S1	**Customer:**	City of Tampa
Location:	main switchgear	**Test Engineer:**	Nat Crews/ Louis Nemec
Test No.:	POA 6A	**Test Date:**	07/02/2017 2:25:34 PM

C.E. Testing, Inc.

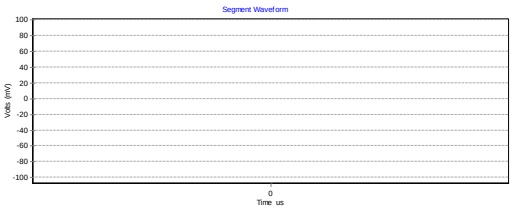
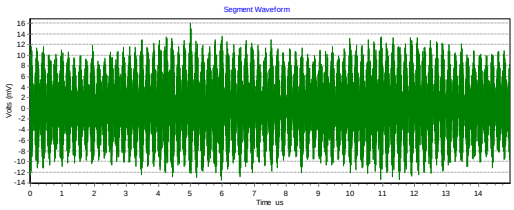
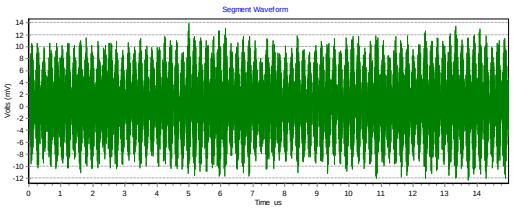
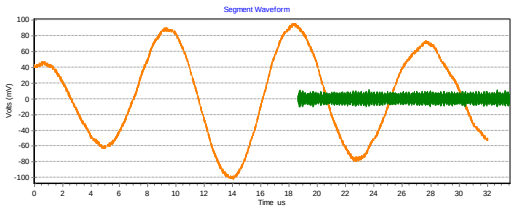
Sensor	Circuit/Description	V(kV)	Cable Type	Local Plant Type
HFCT	phA	15kV	Cable	EPR
HFCT	phB	15kV	Cable	EPR
HFCT	phC	15kV	Cable	EPR
TEV Probe	TEV	15kV	Cable	EPR

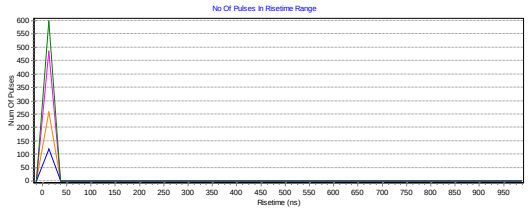
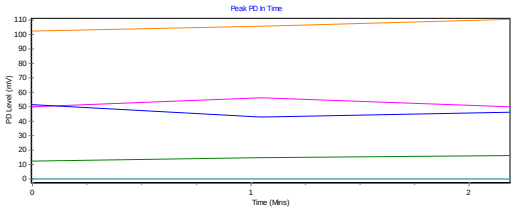
Phase-Resolved Graph (PD and Noise)	Photo of Sensor Attachment
	

	Channel 1		Channel 2		Channel 3		Channel 4	
	Cable PD	0pC	Cable PD	0pC	Cable PD	0pC	Cable PD	0pC
	Local PD	0dB	Local PD	0dB	Local PD	0dB	Local PD	24dB
	Peak	56.00mV	Peak	26.24mV	Peak	21.76mV	Peak	16.00mV
	Std Dev	25.80mV	Std Dev	11.32mV	Std Dev	10.26mV	Std Dev	5.44mV
Cable PD								

Local PD				
Noise				

Sensor	Circuit/Description	V(kV)	Cable Type	Local Plant Type
HFCT	phA	15kV	Cable	EPR
HFCT	phB	15kV	Cable	EPR
HFCT	phC	15kV	Cable	EPR
TEV Probe	TEV	15kV	Cable	EPR

Cable PD Waveform				Local PD Waveform			
							
Peak		**Frequency**		**Peak**	16.00 mV	**Frequency**	71.43 MHz
Rise Time		**PD Level**		**Rise Time**	1.45 ns	**PD Level**	
Noise Waveform				**Synchronous Waveform**			
							
Peak	13.92 mV	**Frequency**	71.43 MHz	**Peak**	-	**Frequency**	-
Rise Time	2.06 ns	**PD Level**	-	**Rise Time**	-	**PD Level**	-

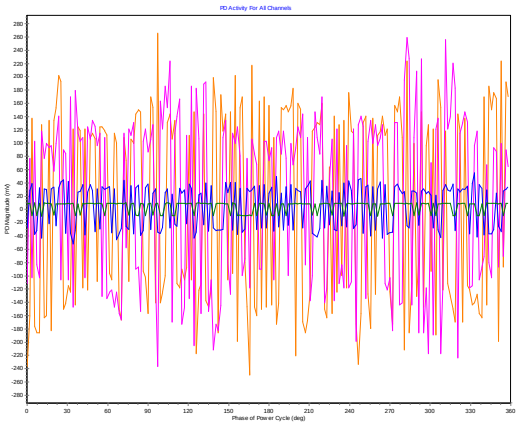
No of Pulses vs. Pulse Rise-Time	Peak Level in Time
	

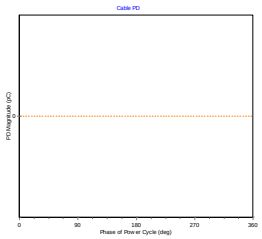
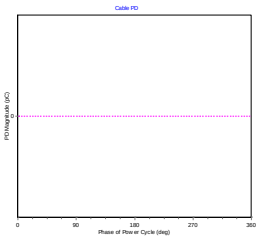
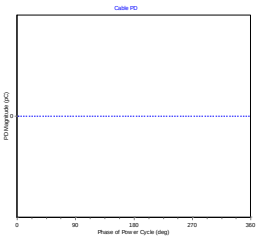
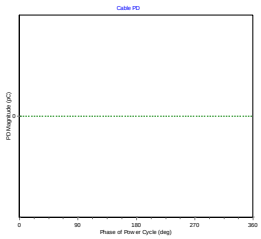
Comments
Noise waveforms. No PD measured

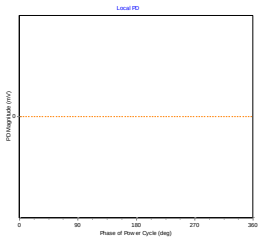
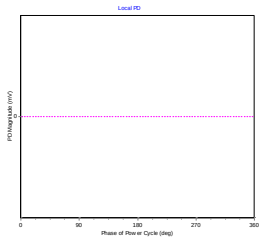
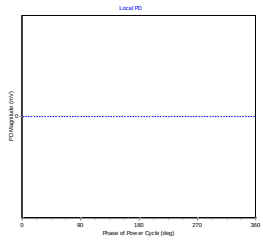
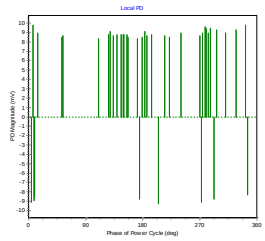
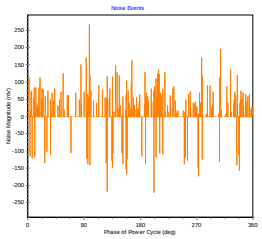
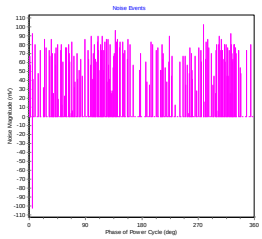
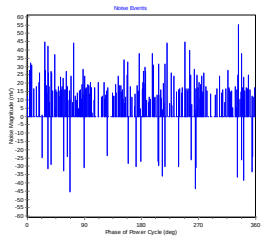
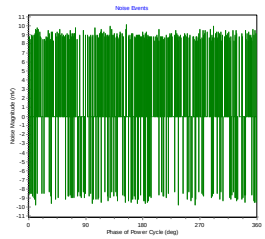
Substation/Site:	1-52-8A	**Customer:**	City of Tampa
Location:	Main Switchgear	**Test Engineer:**	Nat Crews/ Louis Nemec
Test No.:	POA 5	**Test Date:**	07/02/2017 2:38:00 PM

C.E. Testing, Inc.

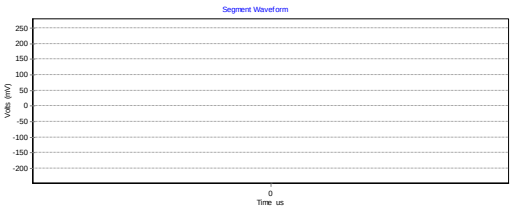
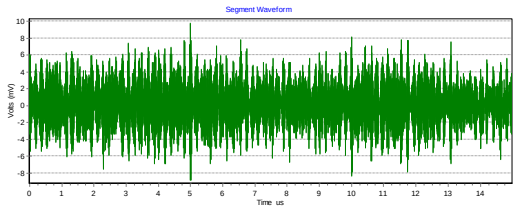
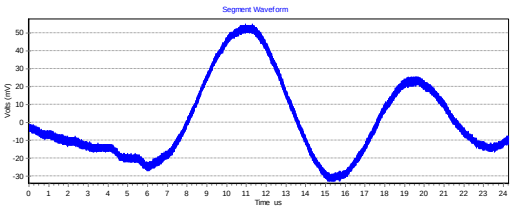
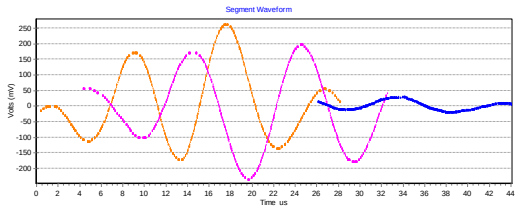
Sensor	Circuit/Description	V(kV)	Cable Type	Local Plant Type
HFCT	phA	15kV	Cable	EPR
HFCT	phB	15kV	Cable	EPR
HFCT	phC	15kV	Cable	EPR
TEV Probe	TEV	15kV	Switchgear	Air Insulated

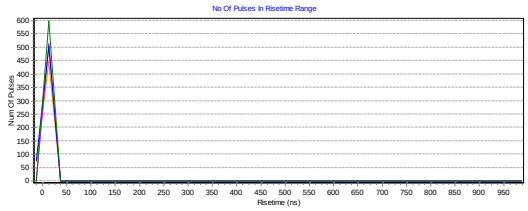
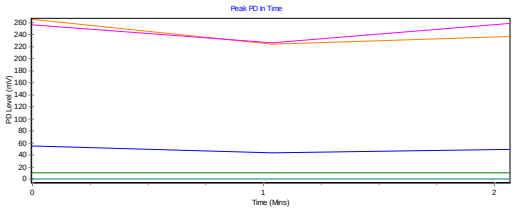
Phase-Resolved Graph (PD and Noise)	Photo of Sensor Attachment
	

	Channel 1		Channel 2		Channel 3		Channel 4	
	Cable PD	0pC	Cable PD	0pC	Cable PD	0pC	Cable PD	0pC
	Local PD	0dB	Local PD	0dB	Local PD	0dB	Local PD	20dB
	Peak	265.60mV	Peak	102.40mV	Peak	55.04mV	Peak	10.08mV
	Std Dev	44.68mV	Std Dev	41.31mV	Std Dev	9.86mV	Std Dev	3.09mV
Cable PD								

Local PD				
Noise				

Sensor	Circuit/Description	V(kV)	Cable Type	Local Plant Type
HFCT	phA	15kV	Cable	EPR
HFCT	phB	15kV	Cable	EPR
HFCT	phC	15kV	Cable	EPR
TEV Probe	TEV	15kV	Switchgear	Air Insulated

Cable PD Waveform				Local PD Waveform			
							
Peak		**Frequency**		**Peak**	9.76 mV	**Frequency**	93.75 MHz
Rise Time		**PD Level**		**Rise Time**	368.30 ps	**PD Level**	
Noise Waveform				**Synchronous Waveform**			
							
Peak	55.04 mV	**Frequency**	91.55 kHz	**Peak**	-	**Frequency**	-
Rise Time	2.30 us	**PD Level**	-	**Rise Time**	-	**PD Level**	-

No of Pulses vs. Pulse Rise-Time	Peak Level in Time
	

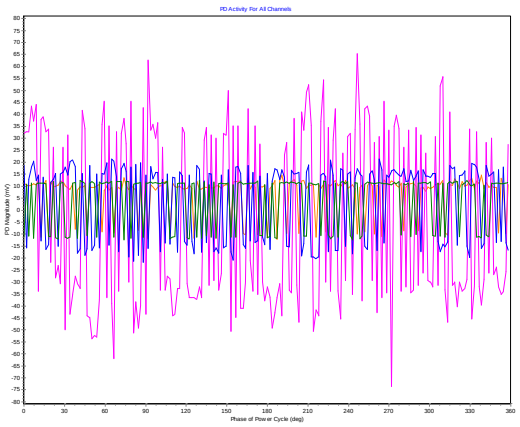
Comments
Noise Waveforms. No PD measured.

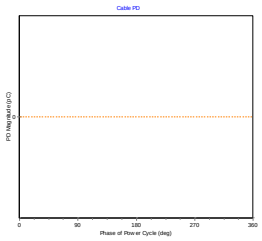
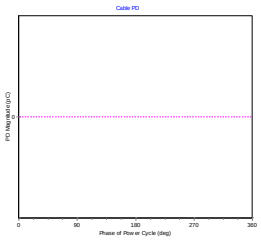
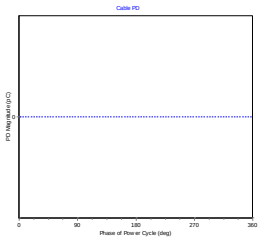
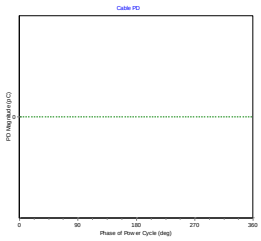
Substation/Site: 1-52-9A **Customer:** City of Tampa

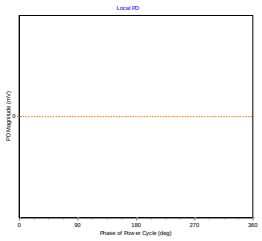
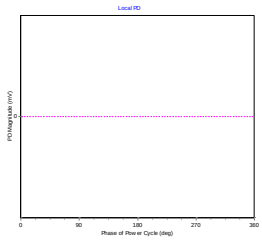
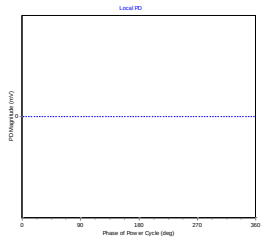
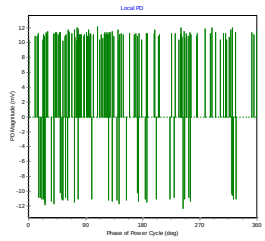
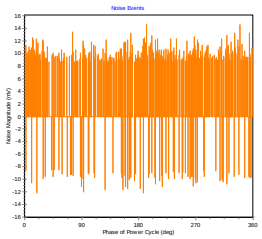
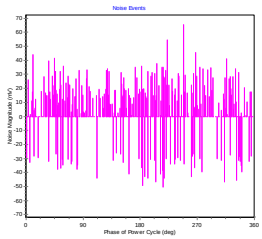
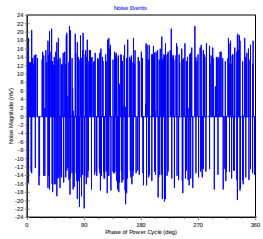
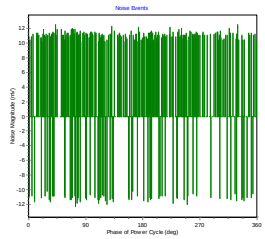
C.E. Testing, Inc.

Location: POA 4 **Test Engineer:** Nat Crews/ Louis Nemec
Test No.: **Test Date:** 07/02/2017 2:46:43 PM

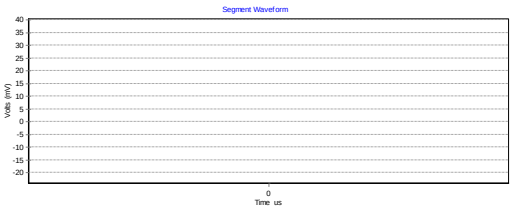
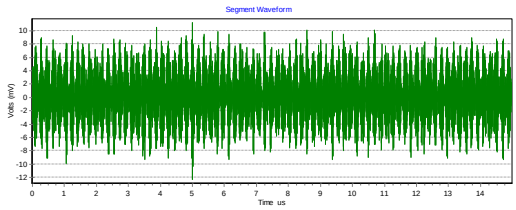
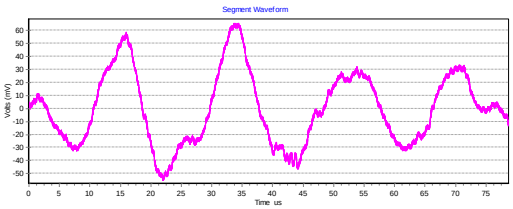
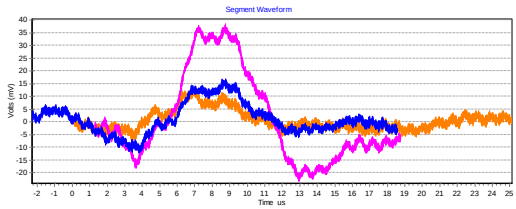
Sensor	Circuit/Description	V(kV)	Cable Type	Local Plant Type
HFCT	phA	15kV	Cable	EPR
HFCT	phB	15kV	Cable	EPR
HFCT	phC	15kV	Cable	EPR
TEV Probe	TEV	15kV	Switchgear	Air Insulated

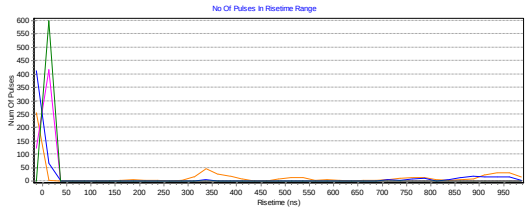
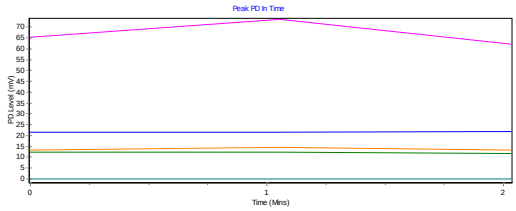
Phase-Resolved Graph (PD and Noise)	Photo of Sensor Attachment
	

	Channel 1		Channel 2		Channel 3		Channel 4	
	Cable PD	0pC	Cable PD	0pC	Cable PD	0pC	Cable PD	0pC
	Local PD	0dB	Local PD	0dB	Local PD	0dB	Local PD	22dB
	Peak	14.56mV	Peak	65.28mV	Peak	21.76mV	Peak	12.48mV
	Std Dev	2.62mV	Std Dev	11.66mV	Std Dev	4.35mV	Std Dev	3.72mV
Cable PD								

Local PD				
Noise				

Sensor	Circuit/Description	V(kV)	Cable Type	Local Plant Type
HFCT	phA	15kV	Cable	EPR
HFCT	phB	15kV	Cable	EPR
HFCT	phC	15kV	Cable	EPR
TEV Probe	TEV	15kV	Switchgear	Air Insulated

Cable PD Waveform				Local PD Waveform			
							
Peak		**Frequency**		**Peak**	-12.32 mV	**Frequency**	93.75 MHz
Rise Time		**PD Level**		**Rise Time**	2.05 ns	**PD Level**	
Noise Waveform				**Synchronous Waveform**			
							
Peak	65.28 mV	**Frequency**	53.41 kHz	**Peak**	-	**Frequency**	-
Rise Time	2.88 us	**PD Level**	-	**Rise Time**	-	**PD Level**	-

No of Pulses vs. Pulse Rise-Time	Peak Level in Time
	

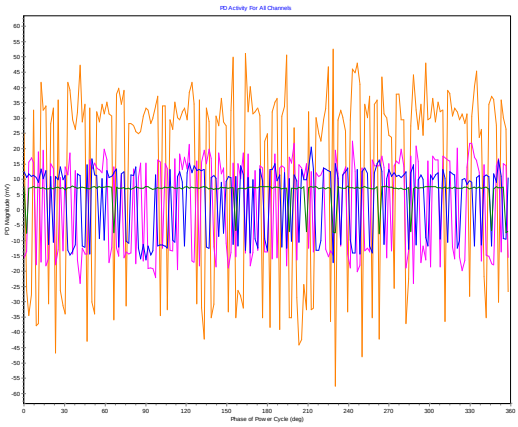
Comments
Noise waveforms. No PD measured

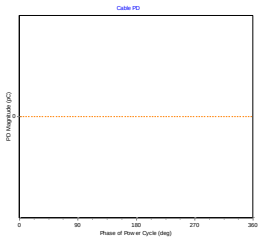
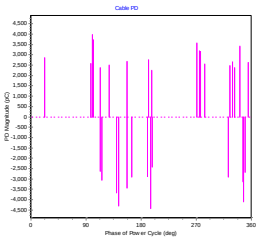
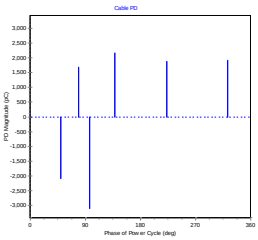
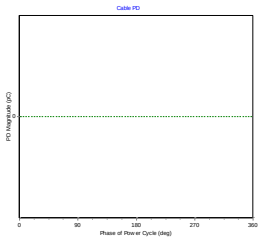
Substation/Site: 1-52-9B
Location: POA 13
Test No.:

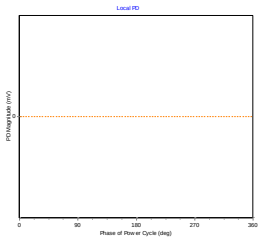
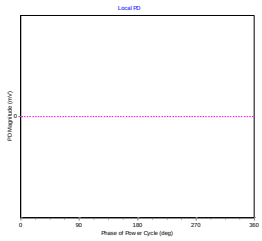
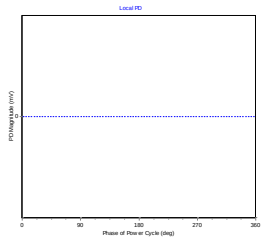
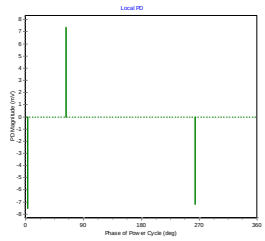
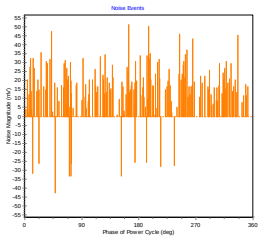
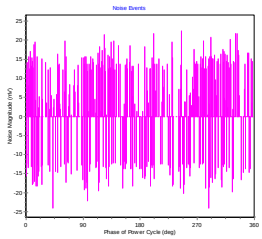
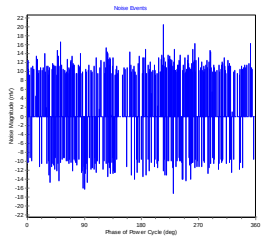
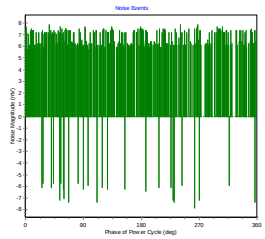
Customer: City of Tampa
Test Engineer: Nat Crews/ Louis Nemec
Test Date: 07/02/2017 3:03:34 PM

C.E. Testing, Inc.

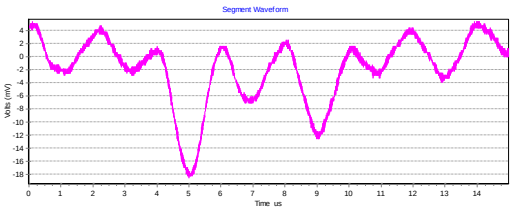
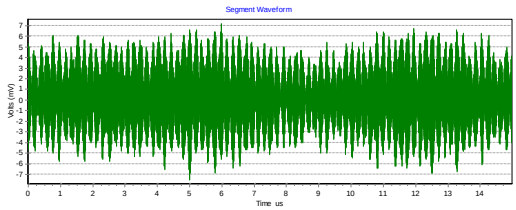
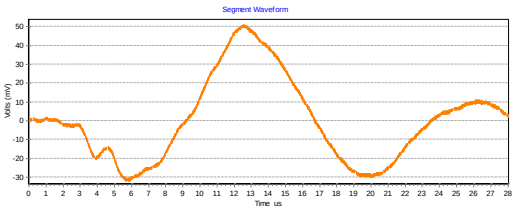
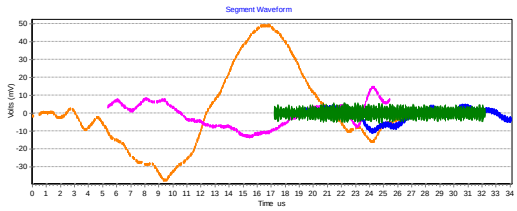
Sensor	Circuit/Description	V(kV)	Cable Type	Local Plant Type
HFCT	phA	13.2kV	Cable	EPR
HFCT	phB	13.2kV	Cable	EPR
HFCT	phC	13.2kV	Cable	EPR
TEV Probe	enclosure TEV	13.2kV	Switchgear	Air Insulated

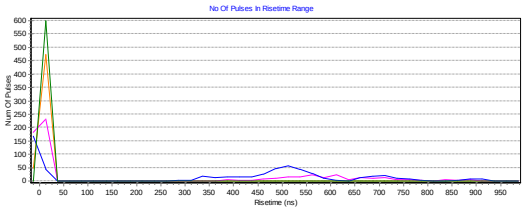
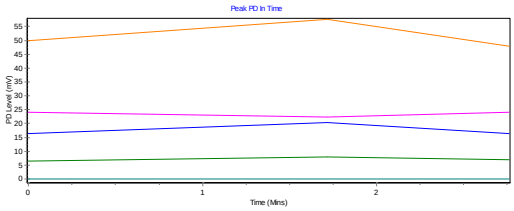
Phase-Resolved Graph (PD and Noise)	Photo of Sensor Attachment
	

	Channel 1		Channel 2		Channel 3		Channel 4	
	Cable PD	0pC	Cable PD	4417pC	Cable PD	3103pC	Cable PD	0pC
	Local PD	0dB	Local PD	0dB	Local PD	0dB	Local PD	18dB
	Peak	51.20mV	Peak	24.00mV	Peak	20.48mV	Peak	7.84mV
	Std Dev	11.44mV	Std Dev	4.62mV	Std Dev	3.05mV	Std Dev	2.34mV
Cable PD								

Local PD				
Noise				

Sensor	Circuit/Description	V(kV)	Cable Type	Local Plant Type
HFCT	phA	13.2kV	Cable	EPR
HFCT	phB	13.2kV	Cable	EPR
HFCT	phC	13.2kV	Cable	EPR
TEV Probe	enclosure TEV	13.2kV	Switchgear	Air Insulated

Cable PD Waveform				Local PD Waveform			
							
Peak	-18.56 mV	**Frequency**	244.14 kHz	**Peak**	-7.52 mV	**Frequency**	83.33 MHz
Rise Time	595.90 ns	**PD Level**	-4.29 nC	**Rise Time**	920.76 ps	**PD Level**	
Noise Waveform				**Synchronous Waveform**			
							
Peak	51.20 mV	**Frequency**	61.04 kHz	**Peak**	-	**Frequency**	-
Rise Time	2.33 us	**PD Level**	-	**Rise Time**	-	**PD Level**	-

No of Pulses vs. Pulse Rise-Time	Peak Level in Time
	

Comments
Noise waveforms. No PD measured.

Substation/Site: 1-52-8B
Location: POA 14
Test No.:

Customer: City of Tampa
Test Engineer: Nat Crews/ Louis Nemec
Test Date: 07/02/2017 3:10:39 PM

C.E. Testing, Inc.

Sensor	Circuit/Description	V(kV)	Cable Type	Local Plant Type
HFCT	phA	13.2kV	Cable	EPR
HFCT	phB	13.2kV	Cable	EPR
HFCT	phC	13.2kV	Cable	EPR
TEV Probe	TEV	13.2kV	Cable	EPR

Phase-Resolved Graph (PD and Noise)

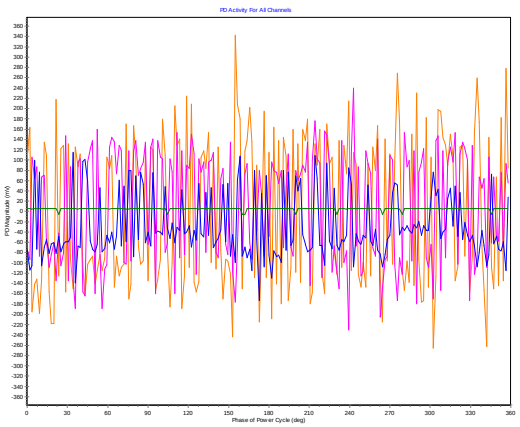
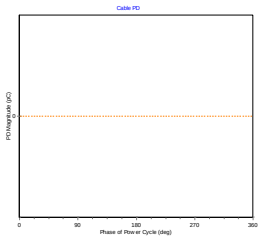
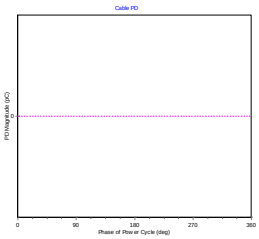
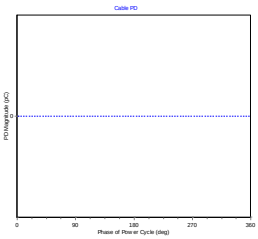
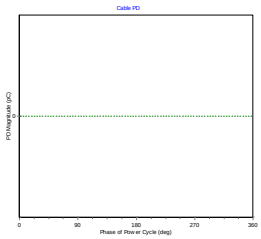
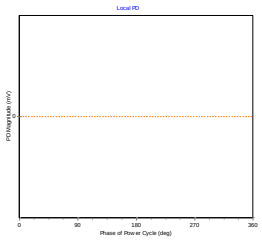
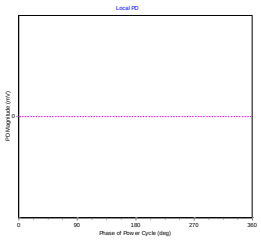
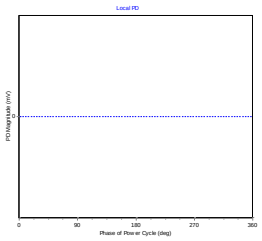
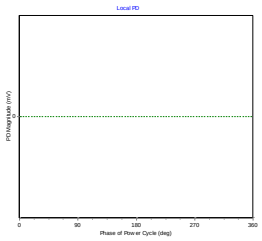
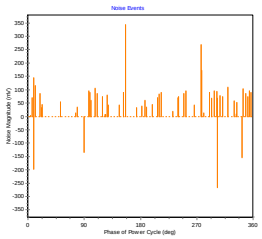
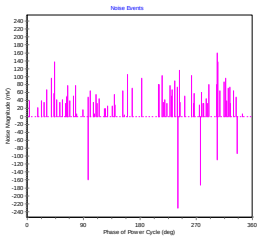
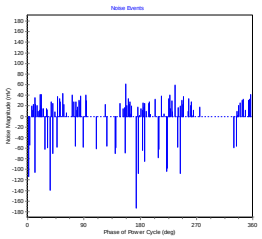
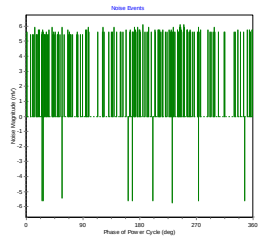
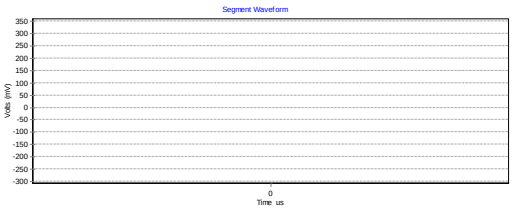
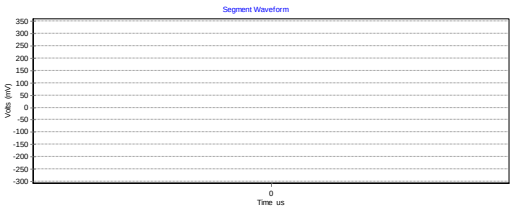
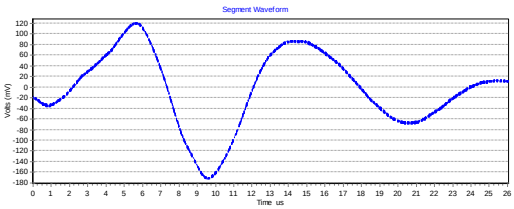
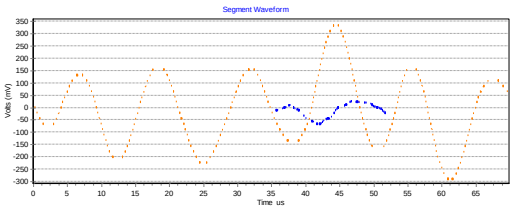


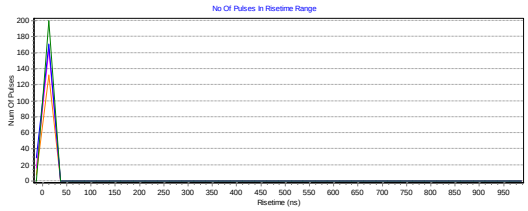
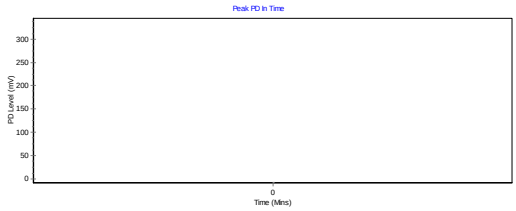
Photo of Sensor Attachment

	Channel 1		Channel 2		Channel 3		Channel 4	
	Cable PD	0pC	Cable PD	0pC	Cable PD	0pC	Cable PD	0pC
	Local PD	0dB	Local PD	0dB	Local PD	0dB	Local PD	0dB
	Peak	342.40mV	Peak	230.40mV	Peak	172.80mV	Peak	6.08mV
	Std Dev	54.10mV	Std Dev	41.47mV	Std Dev	22.18mV	Std Dev	2.15mV
Cable PD								

Local PD				
Noise				

Sensor	Circuit/Description	V(kV)	Cable Type	Local Plant Type
HFCT	phA	13.2kV	Cable	EPR
HFCT	phB	13.2kV	Cable	EPR
HFCT	phC	13.2kV	Cable	EPR
TEV Probe	TEV	13.2kV	Cable	EPR

Cable PD Waveform				Local PD Waveform			
							
Peak		**Frequency**		**Peak**		**Frequency**	
Rise Time		**PD Level**		**Rise Time**		**PD Level**	
Noise Waveform				**Synchronous Waveform**			
							
Peak	-172.80 mV	**Frequency**	91.55 kHz	**Peak**	-	**Frequency**	-
Rise Time	1.66 us	**PD Level**	-	**Rise Time**	-	**PD Level**	-

No of Pulses vs. Pulse Rise-Time	Peak Level in Time
	

Comments
Noise waveforms. No PD measured

Substation/Site: 1-52-S2

Location: POA 15A

Test No.:

Customer: City of Tampa

Test Engineer: Nat Crews/ Louis Nemec

Test Date: 07/02/2017 3:21:11 PM

C.E. Testing, Inc.

Sensor	Circuit/Description	V(kV)	Cable Type	Local Plant Type
HFCT	phA	13.2kV	Cable	EPR
HFCT	phB	13.2kV	Cable	EPR
HFCT	phC	13.2kV	Cable	EPR
TEV Probe	TEV	13.2kV	Switchgear	Air Insulated

Phase-Resolved Graph (PD and Noise)

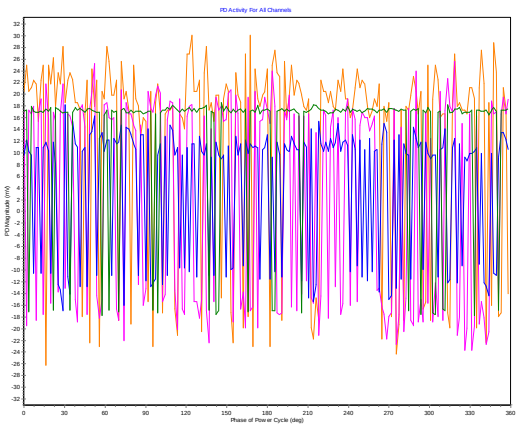
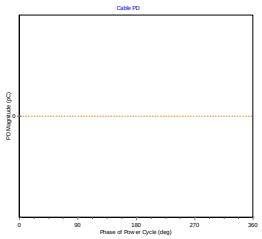
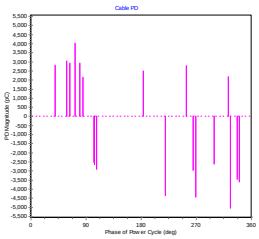
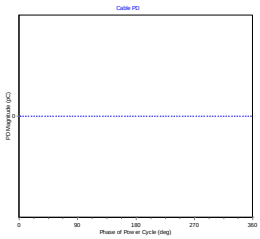
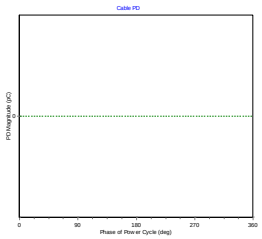
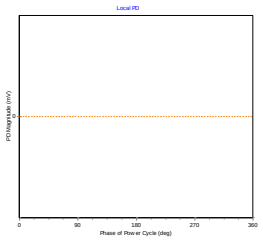
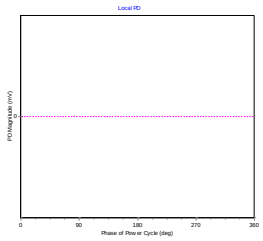
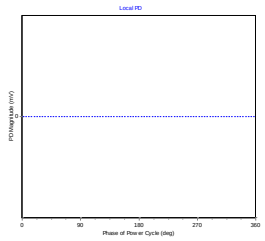
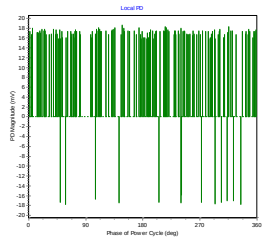
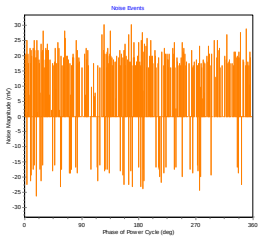
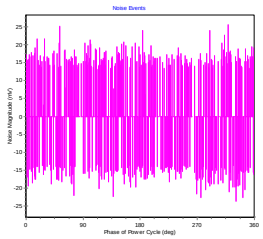
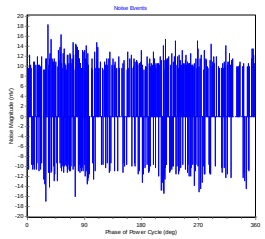
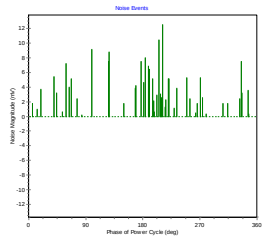
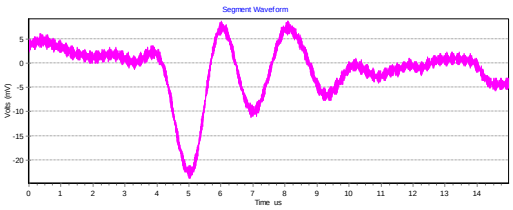
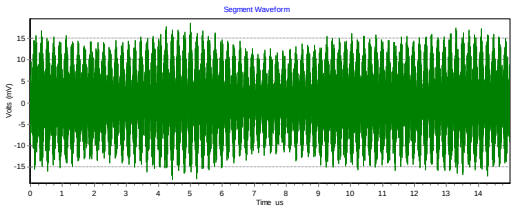
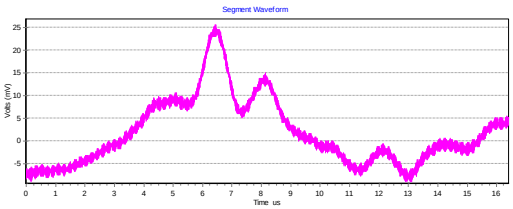
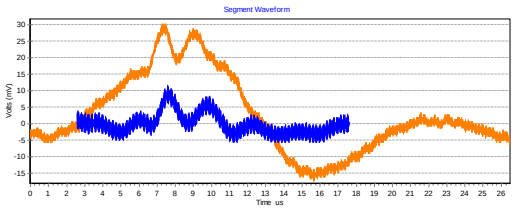


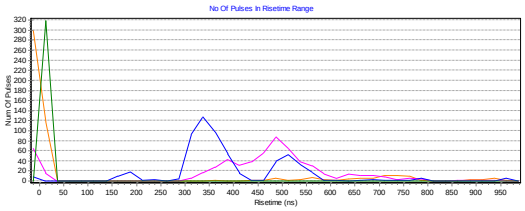
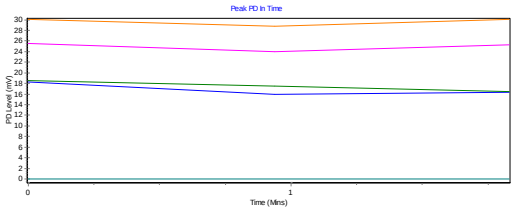
Photo of Sensor Attachment

	Channel 1		Channel 2		Channel 3		Channel 4	
	Cable PD	0pC	Cable PD	5024pC	Cable PD	0pC	Cable PD	0pC
	Local PD	0dB	Local PD	0dB	Local PD	0dB	Local PD	25dB
	Peak	30.08mV	Peak	25.60mV	Peak	18.24mV	Peak	18.56mV
	Std Dev	6.19mV	Std Dev	4.07mV	Std Dev	2.54mV	Std Dev	7.38mV
Cable PD								

Local PD				
Noise				

Sensor	Circuit/Description	V(kV)	Cable Type	Local Plant Type
HFCT	phA	13.2kV	Cable	EPR
HFCT	phB	13.2kV	Cable	EPR
HFCT	phC	13.2kV	Cable	EPR
TEV Probe	TEV	13.2kV	Switchgear	Air Insulated

Cable PD Waveform				Local PD Waveform			
							
Peak	-23.68 mV	**Frequency**	244.14 kHz	**Peak**	18.56 mV	**Frequency**	71.43 MHz
Rise Time	589.36 ns	**PD Level**	-5.02 nC	**Rise Time**	1.15 ns	**PD Level**	
Noise Waveform				**Synchronous Waveform**			
							
Peak	25.60 mV	**Frequency**	61.04 kHz	**Peak**	-	**Frequency**	-
Rise Time	1.34 us	**PD Level**	-	**Rise Time**	-	**PD Level**	-

No of Pulses vs. Pulse Rise-Time	Peak Level in Time
	

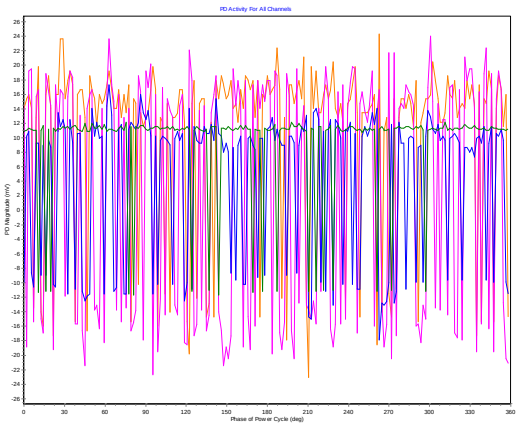
Comments
Noise waveforms. No PD detected.

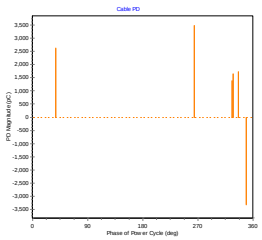
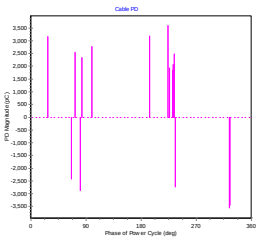
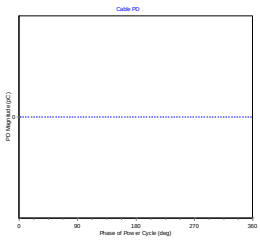
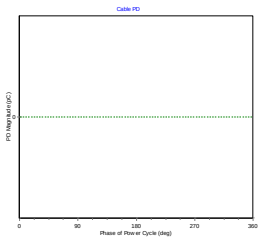
Substation/Site: 1-52-S2 **Customer:** City of Tampa

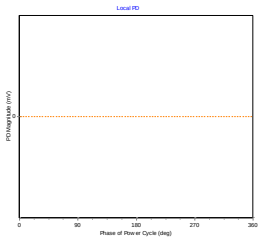
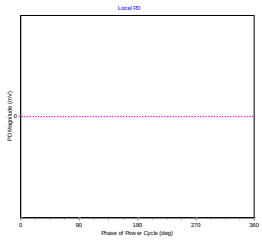
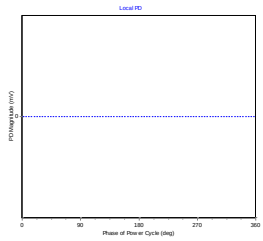
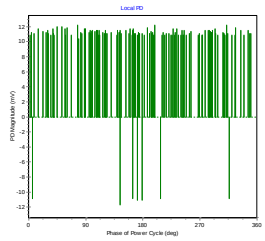
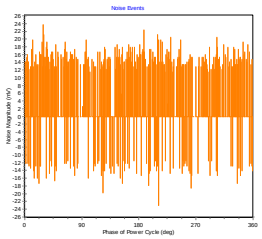
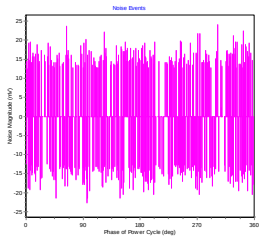
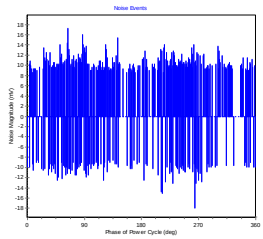
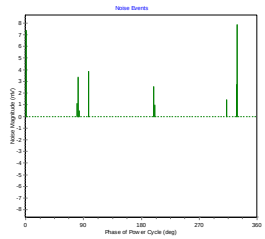
C.E. Testing, Inc.

Location: POA 15B **Test Engineer:** Nat Crews/ Louis Nemec
Test No.: **Test Date:** 07/02/2017 3:25:19 PM

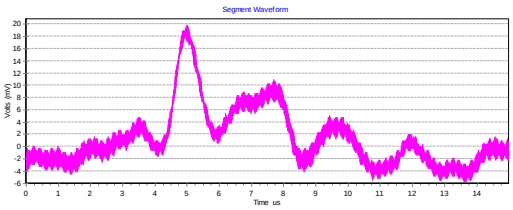
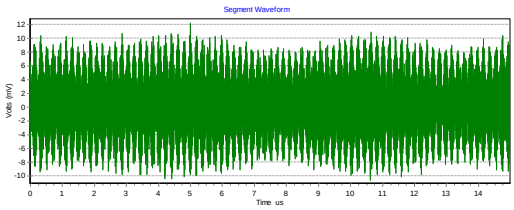
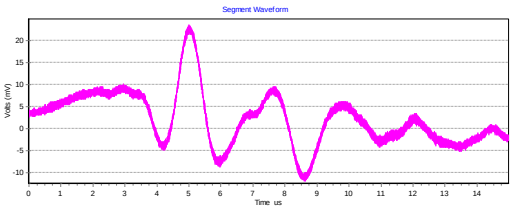
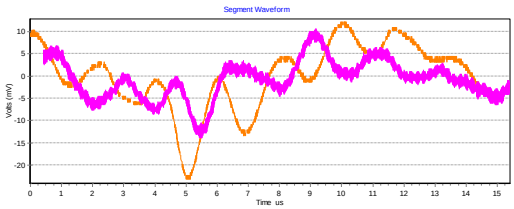
Sensor	Circuit/Description	V(kV)	Cable Type	Local Plant Type
HFCT	phA	13.2kV	Cable	EPR
HFCT	phB	13.2kV	Cable	EPR
HFCT	phC	13.2kV	Cable	EPR
TEV Probe	TEV	13.2kV	Cable	EPR

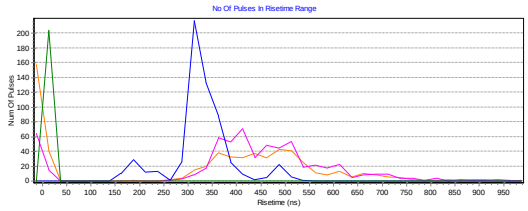
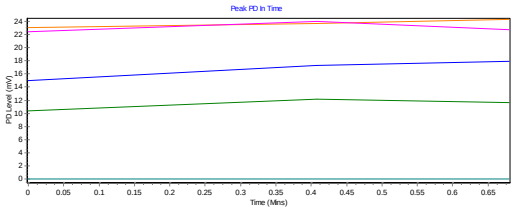
Phase-Resolved Graph (PD and Noise)	Photo of Sensor Attachment
	

	Channel 1		Channel 2		Channel 3		Channel 4	
	Cable PD	3463pC	Cable PD	3589pC	Cable PD	0pC	Cable PD	0pC
	Local PD	0dB	Local PD	0dB	Local PD	0dB	Local PD	22dB
	Peak	24.32mV	Peak	24.00mV	Peak	17.92mV	Peak	12.16mV
	Std Dev	3.96mV	Std Dev	3.94mV	Std Dev	2.04mV	Std Dev	4.87mV
Cable PD								

Local PD				
Noise				

Sensor	Circuit/Description	V(kV)	Cable Type	Local Plant Type
HFCT	phA	13.2kV	Cable	EPR
HFCT	phB	13.2kV	Cable	EPR
HFCT	phC	13.2kV	Cable	EPR
TEV Probe	TEV	13.2kV	Cable	EPR

Cable PD Waveform				Local PD Waveform			
							
Peak	19.84 mV	**Frequency**	244.14 kHz	**Peak**	12.16 mV	**Frequency**	71.43 MHz
Rise Time	480.09 ns	**PD Level**	3.59 nC	**Rise Time**	1.55 ns	**PD Level**	
Noise Waveform				**Synchronous Waveform**			
							
Peak	23.68 mV	**Frequency**	488.28 kHz	**Peak**	-	**Frequency**	-
Rise Time	397.69 ns	**PD Level**	-	**Rise Time**	-	**PD Level**	-

No of Pulses vs. Pulse Rise-Time	Peak Level in Time
	

Comments
PD not detected. Noise waveforms only.

Substation/Site: 1-52-6B
Location: POA 16
Test No.:

Customer: City of Tampa
Test Engineer: Nat Crews/ Louis Nemec
Test Date: 07/02/2017 3:47:05 PM

C.E. Testing, Inc.

Sensor	Circuit/Description	V(kV)	Cable Type	Local Plant Type
HFCT	phA	13.2kV	Cable	EPR
HFCT	phB	13.2kV	Cable	EPR
HFCT	phC	13.2kV	Cable	EPR
TEV Probe	TEV	13.2kV	Cable	EPR

Phase-Resolved Graph (PD and Noise)

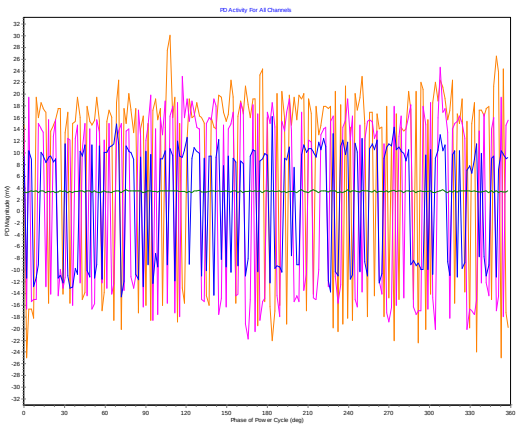
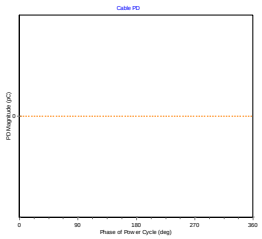
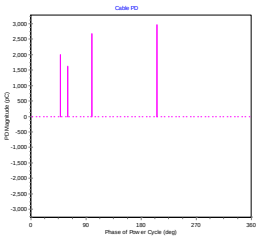
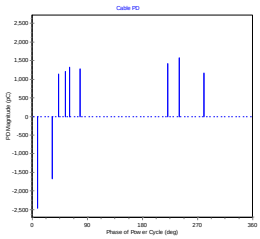
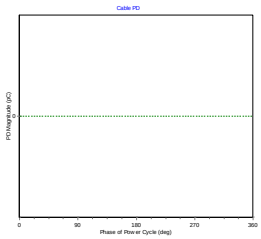
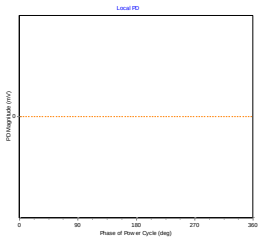
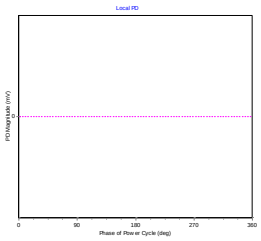
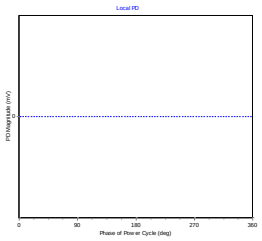
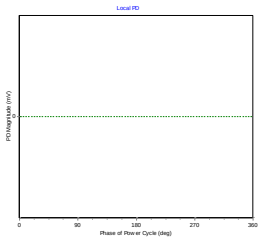
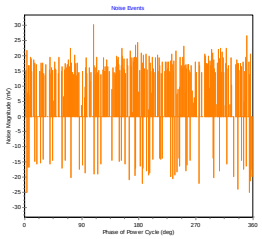
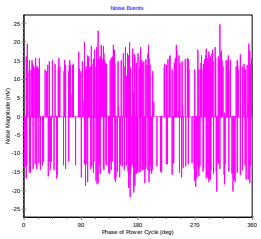
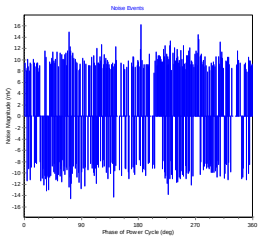
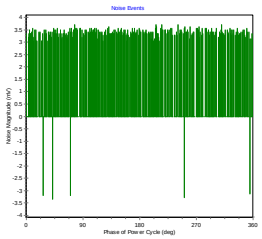
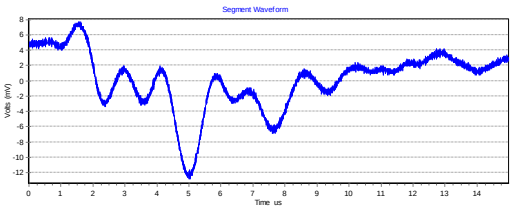
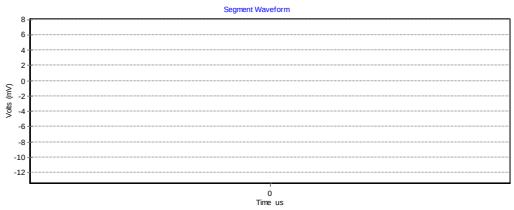
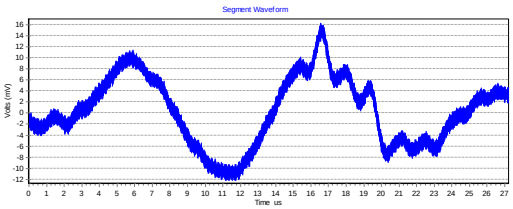
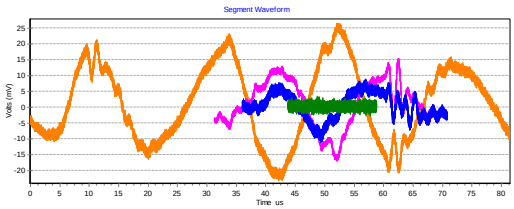


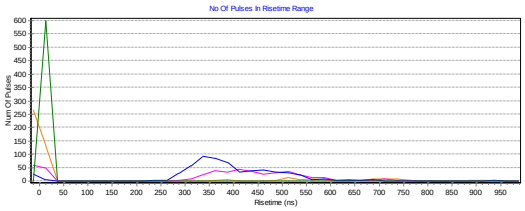
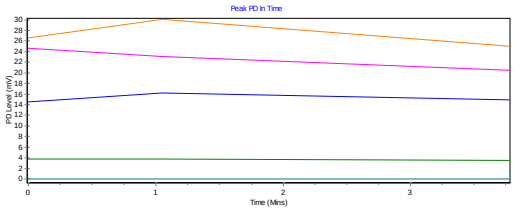
Photo of Sensor Attachment

	Channel 1		Channel 2		Channel 3		Channel 4	
	Cable PD	0pC	Cable PD	2960pC	Cable PD	2454pC	Cable PD	0pC
	Local PD	0dB	Local PD	0dB	Local PD	0dB	Local PD	0dB
	Peak	30.08mV	Peak	24.64mV	Peak	16.16mV	Peak	3.70mV
	Std Dev	5.31mV	Std Dev	3.98mV	Std Dev	2.28mV	Std Dev	1.10mV
Cable PD								

Local PD				
Noise				

Sensor	Circuit/Description	V(kV)	Cable Type	Local Plant Type
HFCT	phA	13.2kV	Cable	EPR
HFCT	phB	13.2kV	Cable	EPR
HFCT	phC	13.2kV	Cable	EPR
TEV Probe	TEV	13.2kV	Cable	EPR

Cable PD Waveform				Local PD Waveform			
							
Peak	-12.80 mV	**Frequency**	244.14 kHz	**Peak**		**Frequency**	
Rise Time	521.60 ns	**PD Level**	-2.45 nC	**Rise Time**		**PD Level**	
Noise Waveform				**Synchronous Waveform**			
							
Peak	16.16 mV	**Frequency**	91.55 kHz	**Peak**	-	**Frequency**	-
Rise Time	1.44 us	**PD Level**	-	**Rise Time**	-	**PD Level**	-

No of Pulses vs. Pulse Rise-Time	Peak Level in Time
	

Comments
No PD detected. Only noise waveforms.

Substation/Site: 1-52-5B
Location: POA 17
Test No.:

Customer: City of Tampa
Test Engineer: Nat Crews/ Louis Nemec
Test Date: 07/02/2017 4:00:25 PM

C.E. Testing, Inc.

Sensor	Circuit/Description	V(kV)	Cable Type	Local Plant Type
HFCT	phA	13.2kV	Cable	EPR
HFCT	phB	13.2kV	Cable	EPR
HFCT	phC	13.2kV	Cable	EPR
TEV Probe	TEV	13.2kV	Switchgear	Air Insulated

Phase-Resolved Graph (PD and Noise)

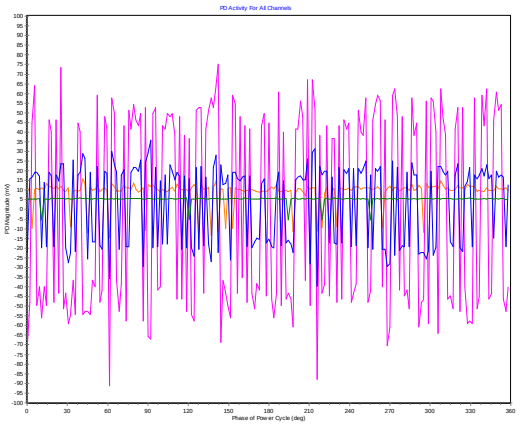
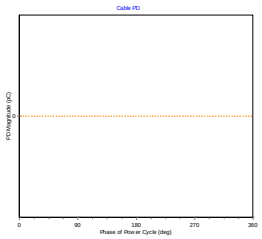
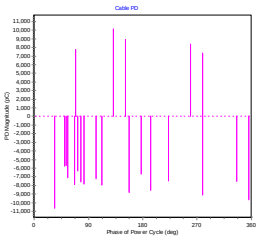
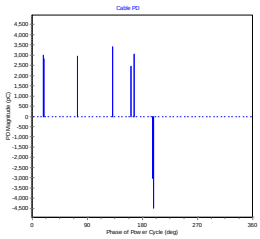
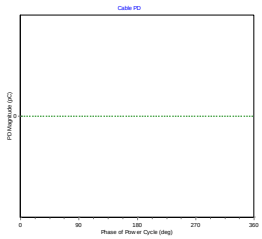
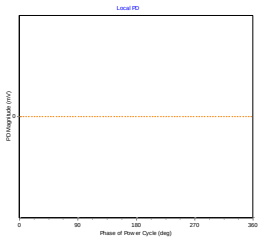
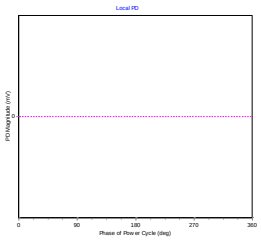
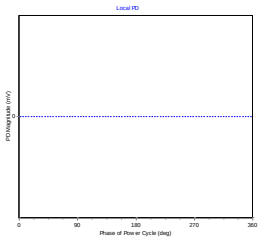
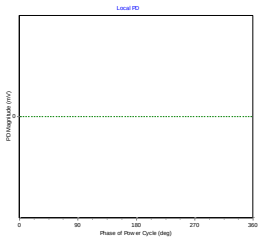
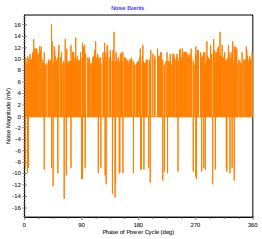
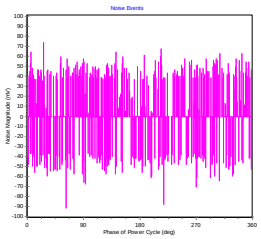
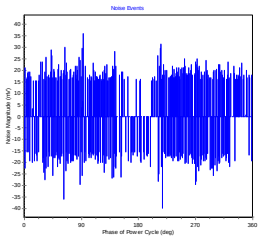
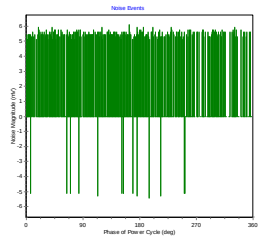
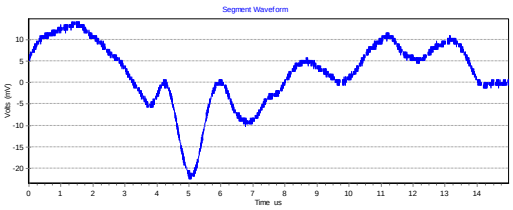
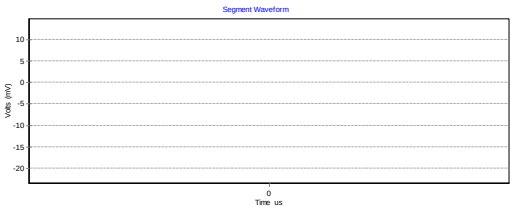
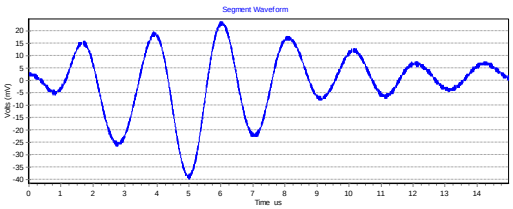
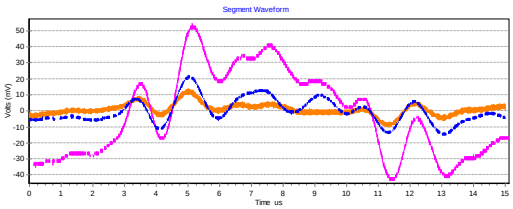


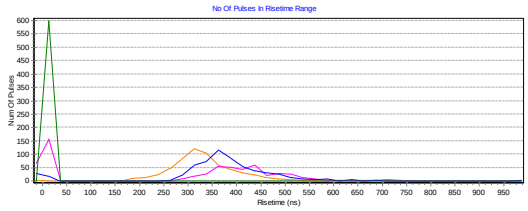
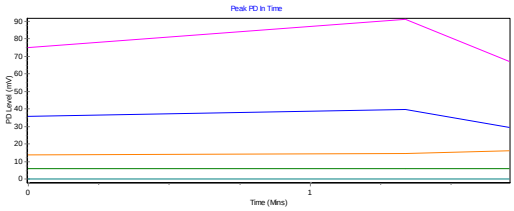
Photo of Sensor Attachment

	Channel 1		Channel 2		Channel 3		Channel 4	
	Cable PD	0pC	Cable PD	10608pC	Cable PD	4475pC	Cable PD	0pC
	Local PD	0dB	Local PD	0dB	Local PD	0dB	Local PD	0dB
	Peak	16.00mV	Peak	91.20mV	Peak	39.68mV	Peak	6.08mV
	Std Dev	2.00mV	Std Dev	13.15mV	Std Dev	4.42mV	Std Dev	2.02mV
Cable PD								

Local PD				
Noise				

Sensor	Circuit/Description	V(kV)	Cable Type	Local Plant Type
HFCT	phA	13.2kV	Cable	EPR
HFCT	phB	13.2kV	Cable	EPR
HFCT	phC	13.2kV	Cable	EPR
TEV Probe	TEV	13.2kV	Switchgear	Air Insulated

Cable PD Waveform				Local PD Waveform			
							
Peak	-22.40 mV	**Frequency**	122.07 kHz	**Peak**		**Frequency**	
Rise Time	459.92 ns	**PD Level**	-4.47 nC	**Rise Time**		**PD Level**	
Noise Waveform				**Synchronous Waveform**			
							
Peak	-39.68 mV	**Frequency**	488.28 kHz	**Peak**	-	**Frequency**	-
Rise Time	535.53 ns	**PD Level**	-	**Rise Time**	-	**PD Level**	-

No of Pulses vs. Pulse Rise-Time	Peak Level in Time
	

Comments
No PD detected. Noise waveforms.

Substation/Site:	1-52-4B	**Customer:**	City of Tampa
Location:	POA 18	**Test Engineer:**	Nat Crews/ Louis Nemec
Test No.:		**Test Date:**	07/02/2017 4:53:53 PM

C.E. Testing, Inc.

Sensor	Circuit/Description	V(kV)	Cable Type	Local Plant Type
HFCT	phA	13.2kV	Cable	EPR
HFCT	phB	13.2kV	Cable	EPR
HFCT	phC	13.2kV	Cable	EPR
TEV	TEV	13.2kV	Switchgear	Air Insulated

Phase-Resolved Graph (PD and Noise)

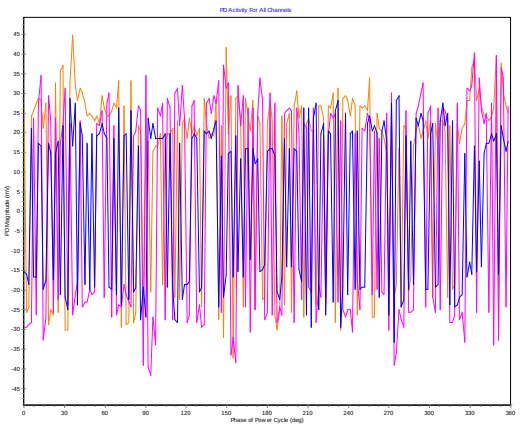
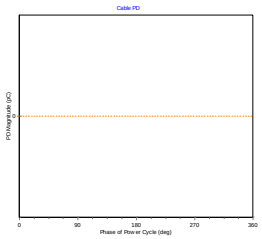
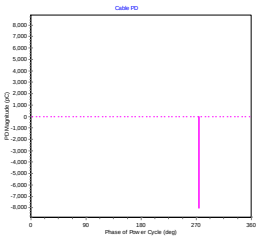
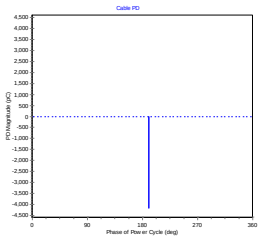
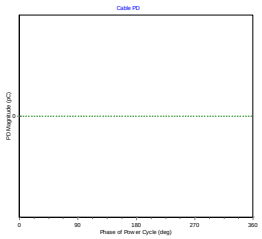
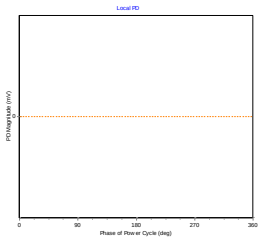
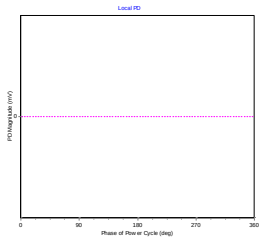
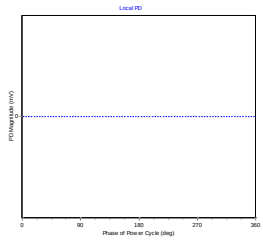
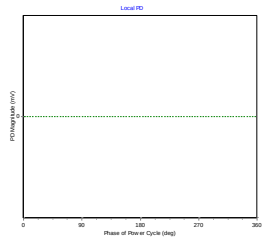
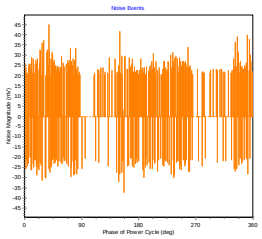
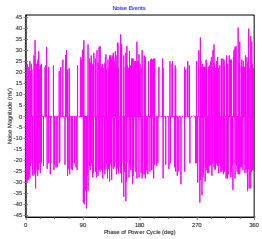
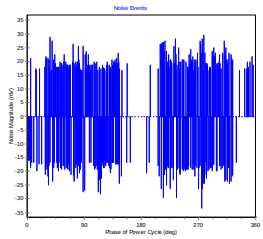
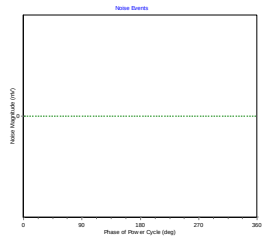
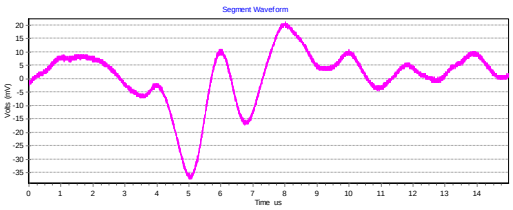
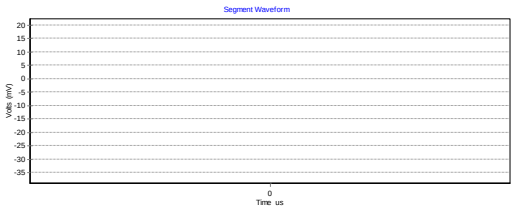
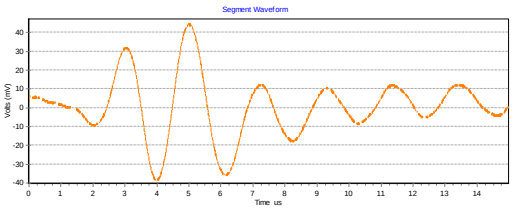
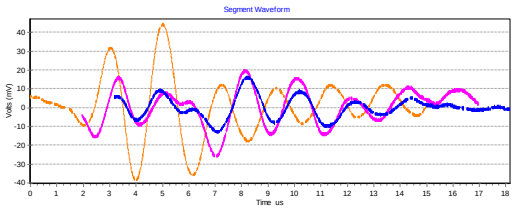


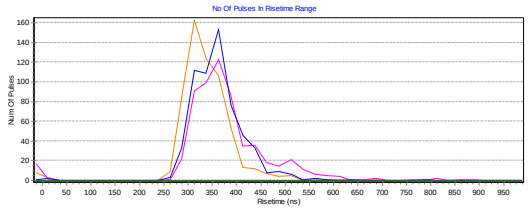
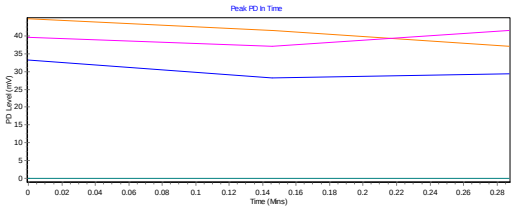
Photo of Sensor Attachment

	Channel 1		Channel 2		Channel 3		Channel 4	
	Cable PD	0pC	Cable PD	8009pC	Cable PD	4164pC	Cable PD	0pC
	Local PD	0dB	Local PD	0dB	Local PD	0dB	Local PD	0dB
	Peak	44.80mV	Peak	41.60mV	Peak	33.28mV	Peak	0.00mV
	Std Dev	5.30mV	Std Dev	5.82mV	Std Dev	4.00mV	Std Dev	0.00mV
Cable PD								

Local PD				
Noise				

Sensor	Circuit/Description	V(kV)	Cable Type	Local Plant Type
HFCT	phA	13.2kV	Cable	EPR
HFCT	phB	13.2kV	Cable	EPR
HFCT	phC	13.2kV	Cable	EPR
TEV	TEV	13.2kV	Switchgear	Air Insulated

Cable PD Waveform				Local PD Waveform			
							
Peak	-37.12 mV	**Frequency**	122.07 kHz	**Peak**		**Frequency**	
Rise Time	604.18 ns	**PD Level**	-8.01 nC	**Rise Time**		**PD Level**	
Noise Waveform				**Synchronous Waveform**			
							
Peak	44.80 mV	**Frequency**	488.28 kHz	**Peak**	-	**Frequency**	-
Rise Time	441.48 ns	**PD Level**	-	**Rise Time**	-	**PD Level**	-

No of Pulses vs. Pulse Rise-Time	**Peak Level in Time**
	

Comments
No PD detected. Noise waveforms.

Substation/Site:	1-52-3B	**Customer:**	City of Tampa
Location:	POA 19	**Test Engineer:**	Nat Crews/ Louis Nemec
Test No.:		**Test Date:**	07/02/2017 5:00:59 PM

C.E. Testing, Inc.

Sensor	Circuit/Description	V(kV)	Cable Type	Local Plant Type
HFCT	phA	13.2kV	Cable	EPR
HFCT	phB	13.2kV	Cable	EPR
HFCT	phC	13.2kV	Cable	EPR
TEV Probe	TEV	13.2kV	Switchgear	Air Insulated

Phase-Resolved Graph (PD and Noise)

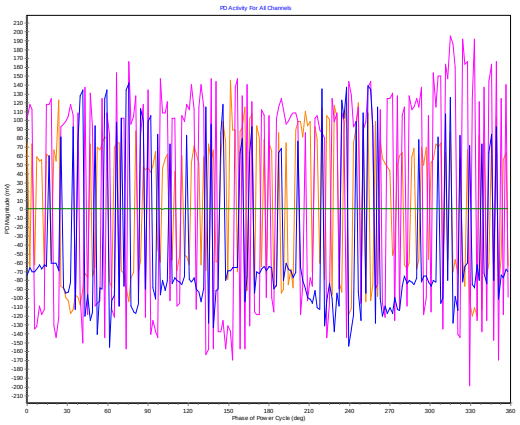
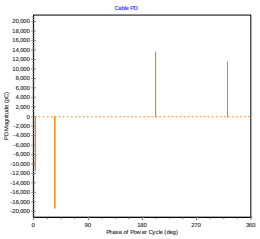
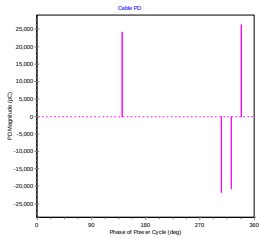
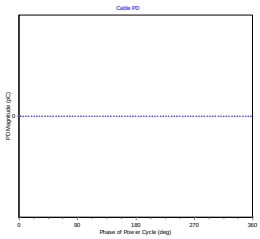
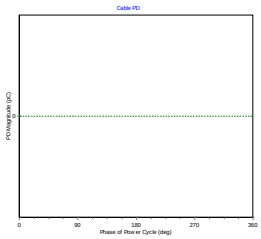
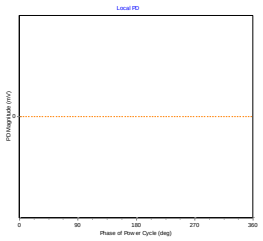
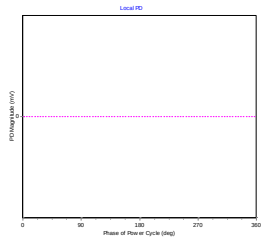
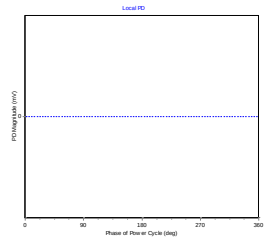
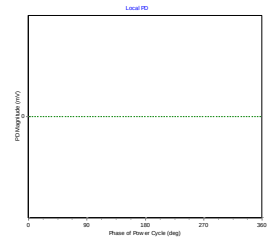
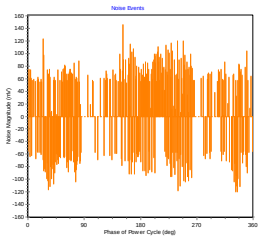
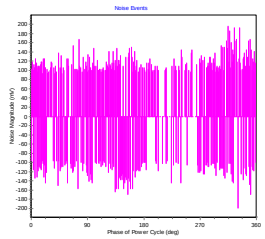
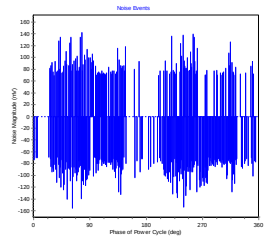
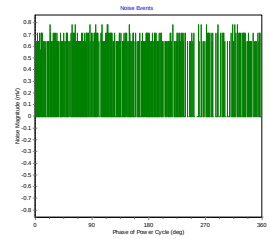
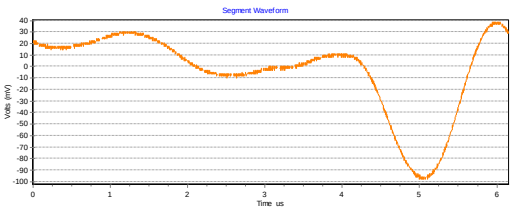
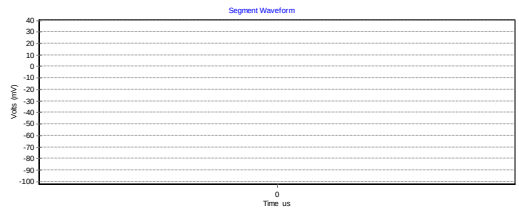
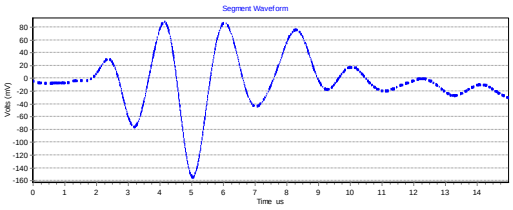
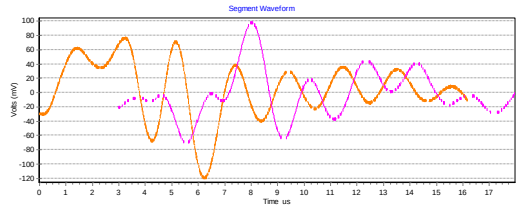


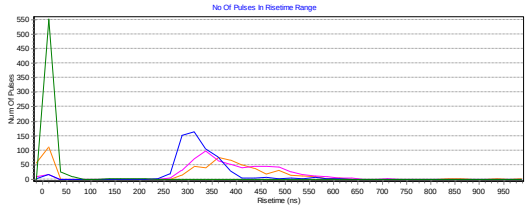
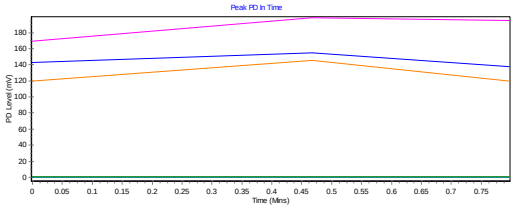
Photo of Sensor Attachment

	Channel 1		Channel 2		Channel 3		Channel 4	
	Cable PD	19280pC	Cable PD	26210pC	Cable PD	0pC	Cable PD	0pC
	Local PD	0dB	Local PD	0dB	Local PD	0dB	Local PD	0dB
	Peak	145.60mV	Peak	198.40mV	Peak	155.20mV	Peak	0.78mV
	Std Dev	18.06mV	Std Dev	25.29mV	Std Dev	16.74mV	Std Dev	0.11mV
Cable PD								

Local PD				
Noise				

Sensor	Circuit/Description	V(kV)	Cable Type	Local Plant Type
HFCT	phA	13.2kV	Cable	EPR
HFCT	phB	13.2kV	Cable	EPR
HFCT	phC	13.2kV	Cable	EPR
TEV Probe	TEV	13.2kV	Switchgear	Air Insulated

Cable PD Waveform				Local PD Waveform			
							
Peak	-97.60 mV	**Frequency**	244.14 kHz	**Peak**		**Frequency**	
Rise Time	521.09 ns	**PD Level**	-19.28 nC	**Rise Time**		**PD Level**	
Noise Waveform				**Synchronous Waveform**			
							
Peak	-155.20 mV	**Frequency**	488.28 kHz	**Peak**	-	**Frequency**	-
Rise Time	373.75 ns	**PD Level**	-	**Rise Time**	-	**PD Level**	-

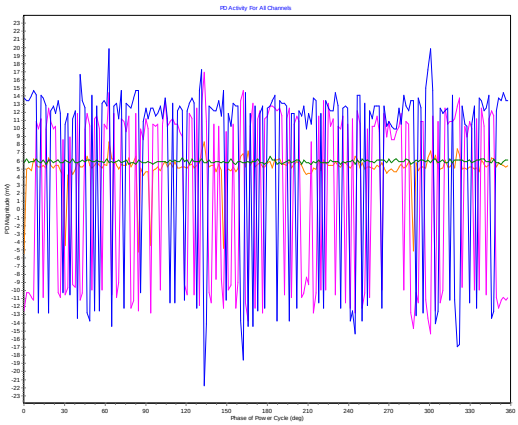
No of Pulses vs. Pulse Rise-Time	**Peak Level in Time**
	

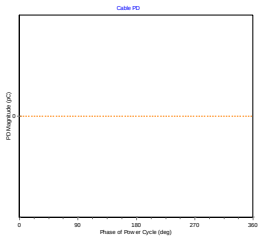
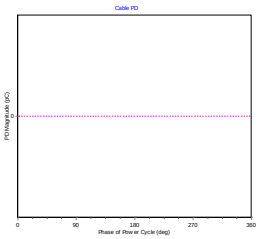
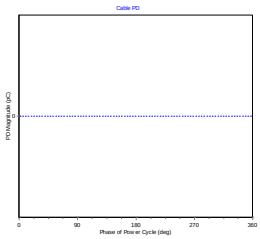
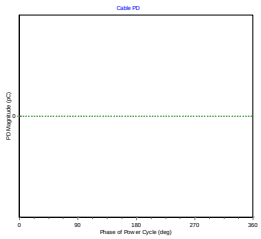
Comments
PD not detected. Noise waveforms

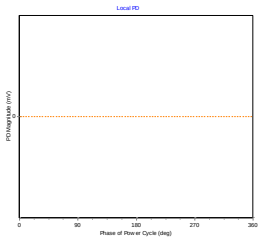
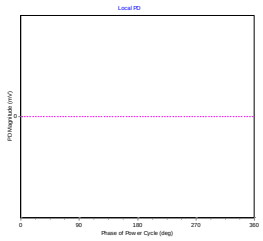
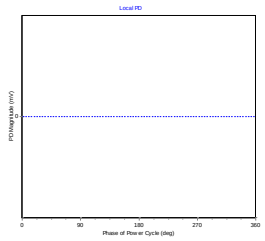
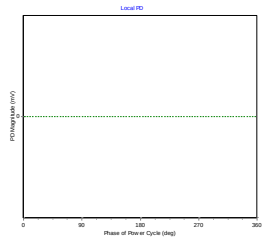
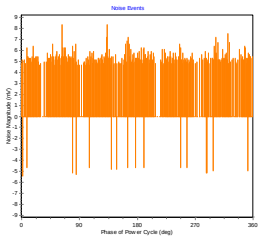
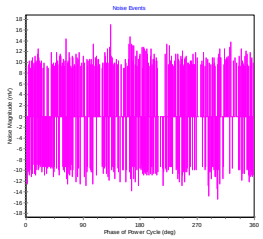
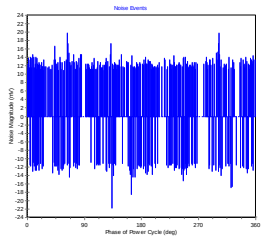
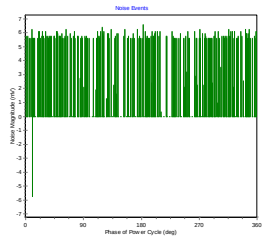
Substation/Site:	1-52-2B	**Customer:**	City of Tampa
Location:	POA 20A	**Test Engineer:**	Nat Crews/ Louis Nemec
Test No.:		**Test Date:**	07/02/2017 5:18:43 PM

C.E. Testing, Inc.

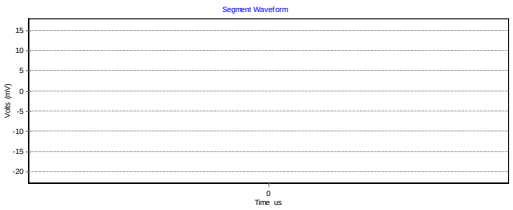
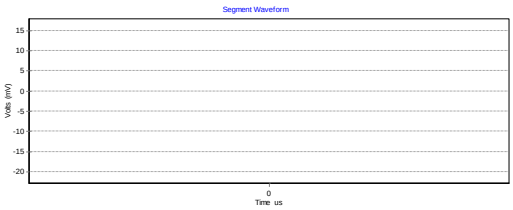
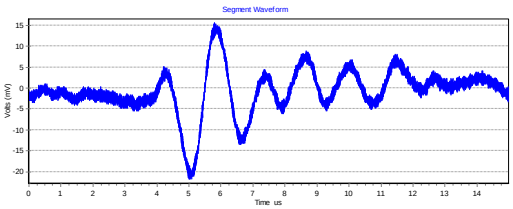
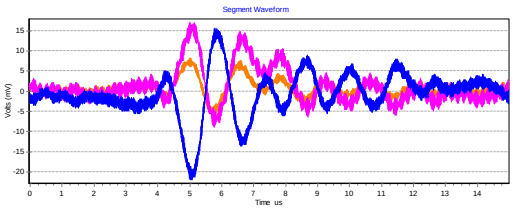
Sensor	Circuit/Description	V(kV)	Cable Type	Local Plant Type
HFCT	phA	13.2kV	Cable	EPR
HFCT	phB	13.2kV	Cable	EPR
HFCT	phC	13.2kV	Cable	EPR
TEV Probe	TEV	13.2kV	Switchgear	Air Insulated

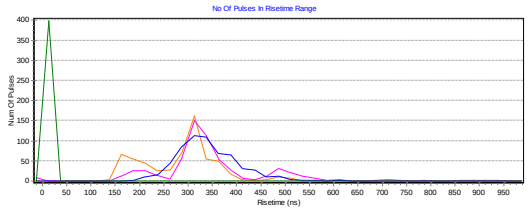
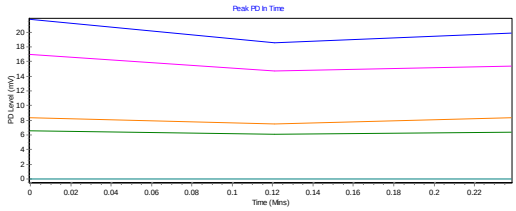
Phase-Resolved Graph (PD and Noise)	Photo of Sensor Attachment
	

	Channel 1		Channel 2		Channel 3		Channel 4	
	Cable PD	0pC	Cable PD	0pC	Cable PD	0pC	Cable PD	0pC
	Local PD	0dB	Local PD	0dB	Local PD	0dB	Local PD	0dB
	Peak	8.32mV	Peak	16.96mV	Peak	21.76mV	Peak	6.56mV
	Std Dev	0.89mV	Std Dev	2.33mV	Std Dev	2.26mV	Std Dev	2.55mV
Cable PD								

Local PD				
Noise				

Sensor	Circuit/Description	V(kV)	Cable Type	Local Plant Type
HFCT	phA	13.2kV	Cable	EPR
HFCT	phB	13.2kV	Cable	EPR
HFCT	phC	13.2kV	Cable	EPR
TEV Probe	TEV	13.2kV	Switchgear	Air Insulated

Cable PD Waveform				Local PD Waveform			
							
Peak		**Frequency**		**Peak**		**Frequency**	
Rise Time		**PD Level**		**Rise Time**		**PD Level**	
Noise Waveform				**Synchronous Waveform**			
							
Peak	-21.76 mV	**Frequency**	671.39 kHz	**Peak**	-	**Frequency**	-
Rise Time	335.50 ns	**PD Level**	-	**Rise Time**	-	**PD Level**	-

No of Pulses vs. Pulse Rise-Time	Peak Level in Time
	

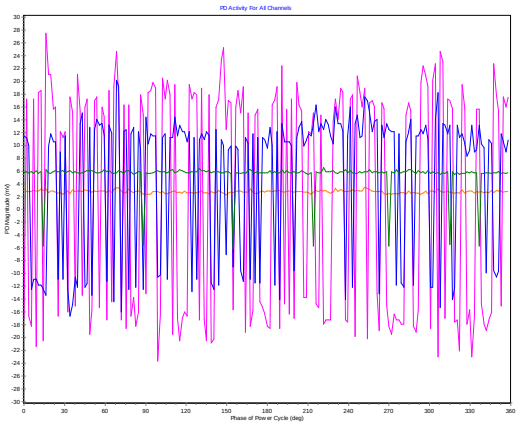
Comments
No PD waveforms detected. Only noise waveforms. POA 20A 1. Ty-rap against C phase Remove or cut the ty-rap. 2. Ground drain wires very close to the energized conductors Recommend re-routing drain wires

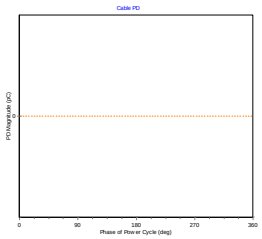
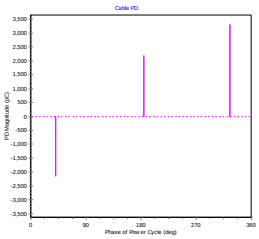
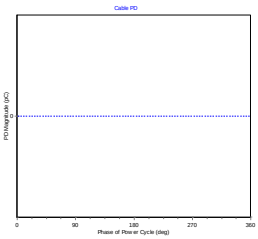
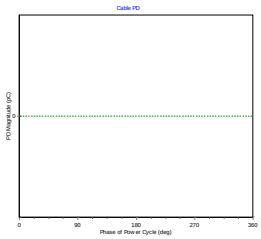
Substation/Site: 1-52-2B **Customer:** City of Tampa

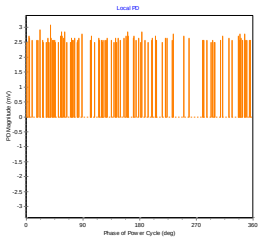
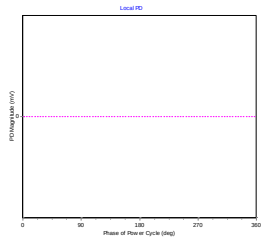
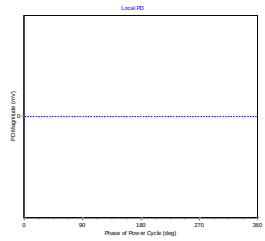
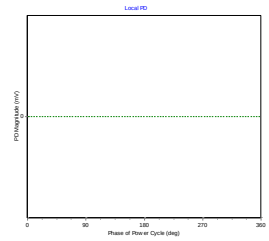
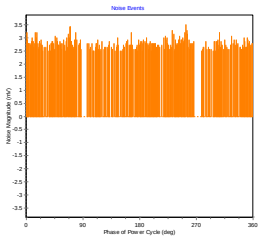
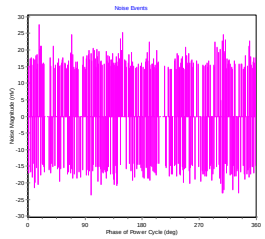
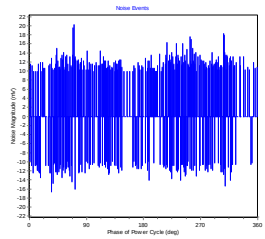
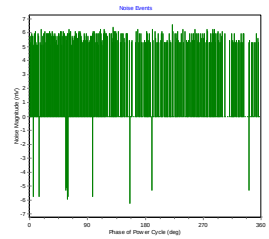
C.E. Testing, Inc.

Location: POA 20B **Test Engineer:** Nat Crews/ Louis Nemec
Test No.: **Test Date:** 07/02/2017 5:23:10 PM

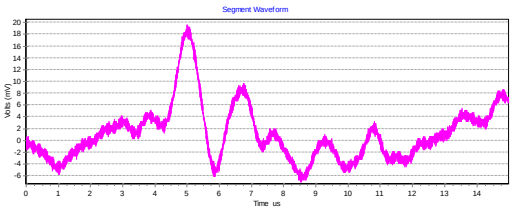
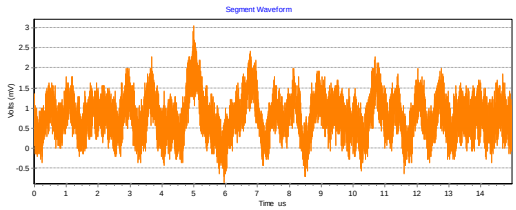
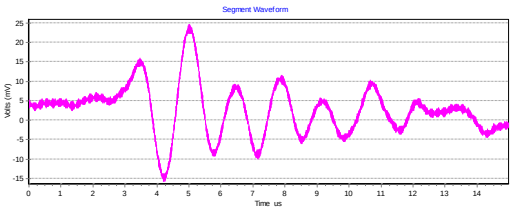
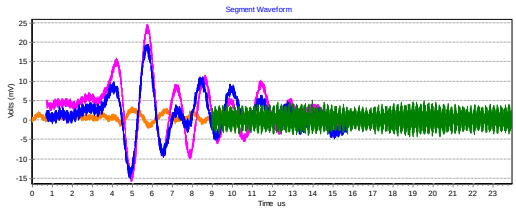
Sensor	Circuit/Description	V(kV)	Cable Type	Local Plant Type
HFCT	phA	13.2kV	Cable	EPR
HFCT	phB	13.2kV	Cable	EPR
HFCT	phC	13.2kV	Cable	EPR
TEV Probe	TEV	13.2kV	Switchgear	Air Insulated

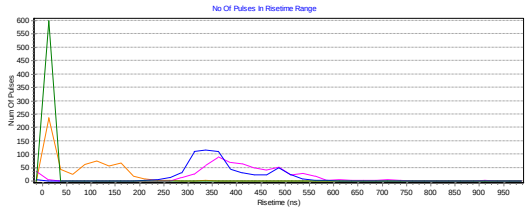
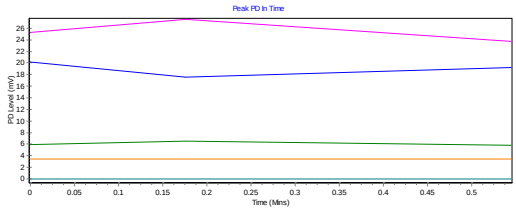
Phase-Resolved Graph (PD and Noise)	Photo of Sensor Attachment
	

	Channel 1		Channel 2		Channel 3		Channel 4	
	Cable PD	0pC	Cable PD	3289pC	Cable PD	0pC	Cable PD	0pC
	Local PD	10dB	Local PD	0dB	Local PD	0dB	Local PD	0dB
	Peak	3.48mV	Peak	27.52mV	Peak	20.16mV	Peak	6.56mV
	Std Dev	0.50mV	Std Dev	4.09mV	Std Dev	2.39mV	Std Dev	2.01mV
Cable PD								

Local PD				
Noise				

Sensor	Circuit/Description	V(kV)	Cable Type	Local Plant Type
HFCT	PHA	13.2kV	Cable	EPR
HFCT	PHB	13.2kV	Cable	EPR
HFCT	PHC	13.2kV	Cable	EPR
TEV Probe	TEV	13.2kV	Switchgear	Air Insulated

Cable PD Waveform				Local PD Waveform			
							
Peak	19.52 mV	**Frequency**	244.14 kHz	**Peak**	3.06 mV	**Frequency**	104.55 MHz
Rise Time	463.33 ns	**PD Level**	3.29 nC	**Rise Time**	6.56 ns	**PD Level**	
Noise Waveform				**Synchronous Waveform**			
							
Peak	24.64 mV	**Frequency**	610.35 kHz	**Peak**	-	**Frequency**	-
Rise Time	344.78 ns	**PD Level**	-	**Rise Time**	-	**PD Level**	-

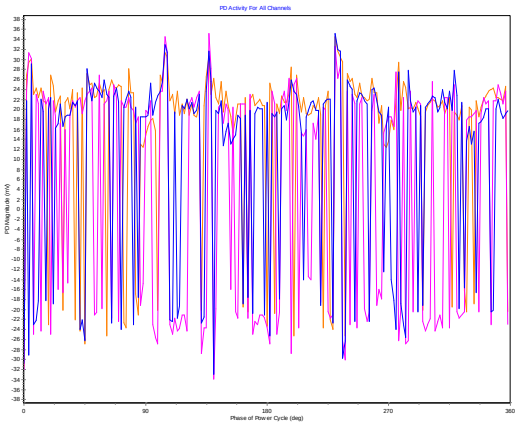
No of Pulses vs. Pulse Rise-Time	Peak Level in Time
	

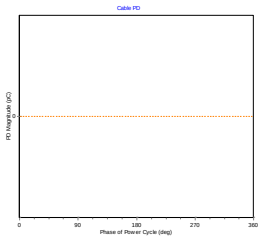
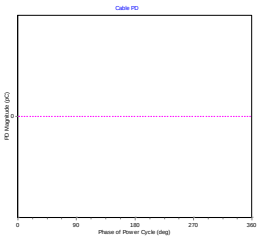
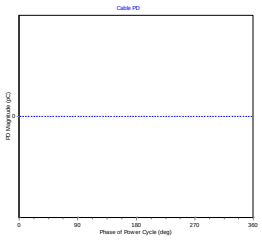
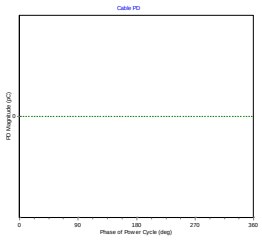
Comments
POA 20B 1. Ground drain wires very close to the energized conductors Recommend re-routing drain wires

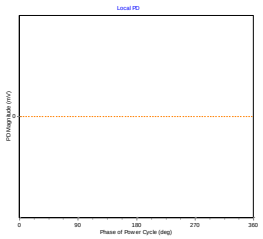
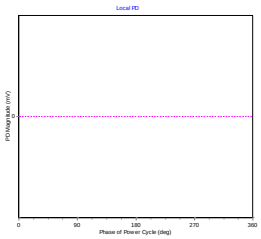
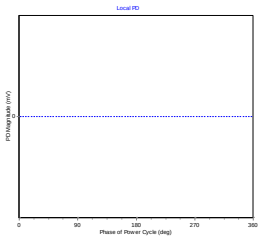
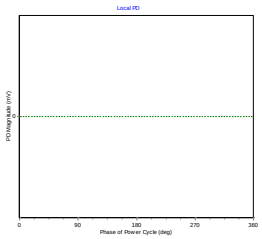
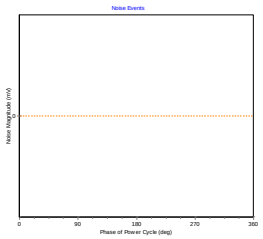
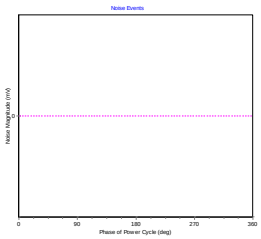
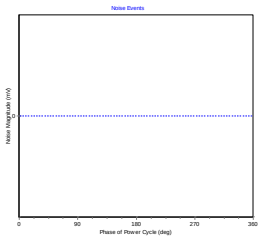
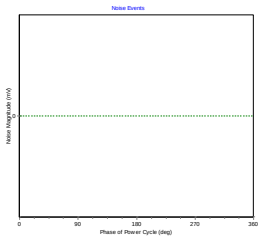
Substation/Site:	1-52-1B	**Customer:**	City of Tampa
Location:	POA 21	**Test Engineer:**	Nat Crews/ Louis Nemec
Test No.:		**Test Date:**	07/02/2017 5:23:10 PM

C.E. Testing, Inc.

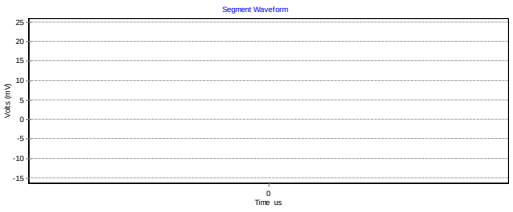
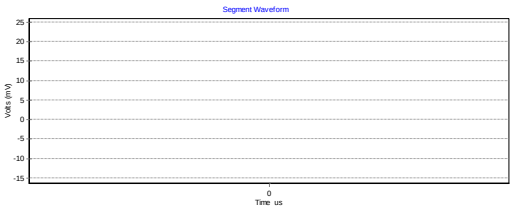
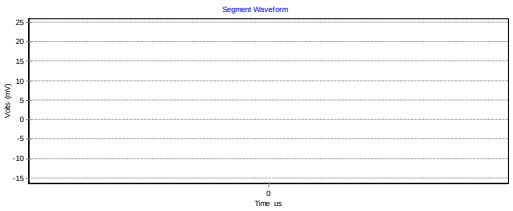
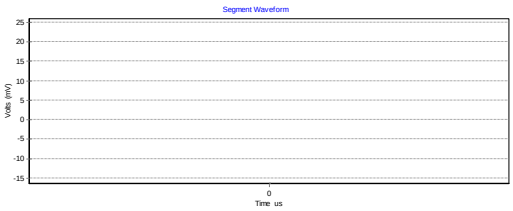
Sensor	Circuit/Description	V(kV)	Cable Type	Local Plant Type
HFCT	phA	13.2kV	Cable	EPR
HFCT	phB	13.2kV	Cable	EPR
HFCT	phC	13.2kV	Cable	EPR
N/A	TEV	13.2kV	Switchgear	Air Insulated

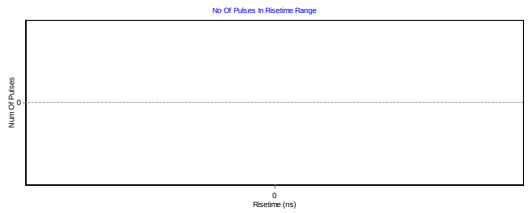
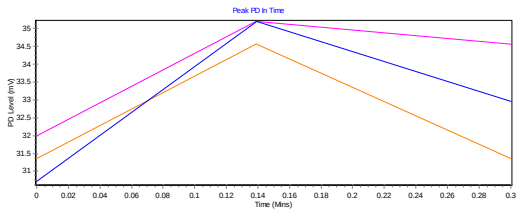
Phase-Resolved Graph (PD and Noise)	Photo of Sensor Attachment
	

	Channel 1		Channel 2		Channel 3		Channel 4	
	Cable PD	0pC	Cable PD	3289pC	Cable PD	0pC	Cable PD	0pC
	Local PD	10dB	Local PD	0dB	Local PD	0dB	Local PD	0dB
	Peak	3.48mV	Peak	27.52mV	Peak	20.16mV	Peak	6.56mV
	Std Dev	0.50mV	Std Dev	4.09mV	Std Dev	2.39mV	Std Dev	2.01mV
Cable PD								

Local PD				
Noise				

Sensor	Circuit/Description	V(kV)	Cable Type	Local Plant Type
HFCT	phA	13.2kV	Cable	EPR
HFCT	phB	13.2kV	Cable	EPR
HFCT	phC	13.2kV	Cable	EPR
N/A	TEV	13.2kV	Switchgear	Air Insulated

Cable PD Waveform				Local PD Waveform			
							
Peak		**Frequency**		**Peak**		**Frequency**	
Rise Time		**PD Level**		**Rise Time**		**PD Level**	
Noise Waveform				**Synchronous Waveform**			
							
Peak		**Frequency**		**Peak**	-	**Frequency**	-
Rise Time		**PD Level**	-	**Rise Time**	-	**PD Level**	-

No of Pulses vs. Pulse Rise-Time	Peak Level in Time
	

Comments
No PD Detected.

Substation/Site: T-3A-1
Location: POA 22A
Test No.:

Customer: City of Tampa
Test Engineer: Nat Crews/ Louis Nemec
Test Date: 08/02/2017 8:33:49 AM

C.E. Testing, Inc.

Sensor	Circuit/Description	V(kV)	Cable Type	Local Plant Type
HFCT	phA	13.2kV	Cable	EPR
HFCT	phB	13.2kV	Cable	EPR
HFCT	phC	13.2kV	Cable	EPR
TEV	TEV	13.2kV	Switchgear	Air Insulated

Phase-Resolved Graph (PD and Noise)

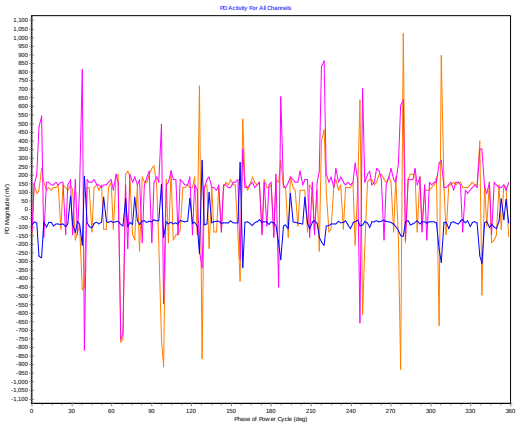
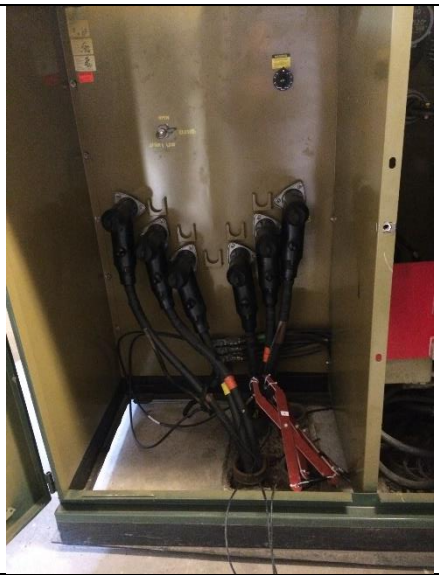
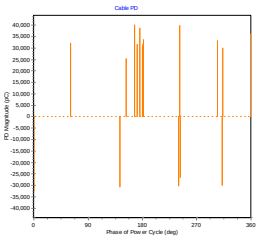
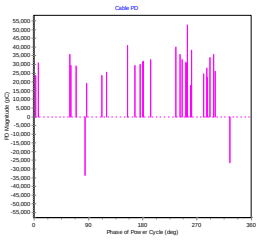
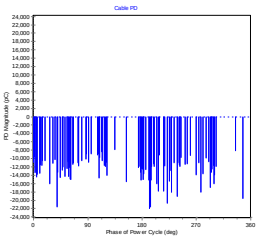
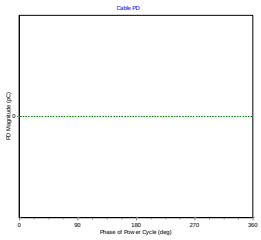
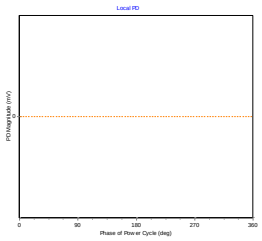
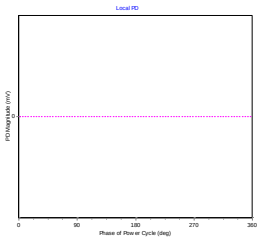
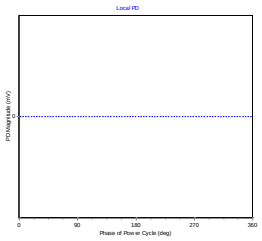
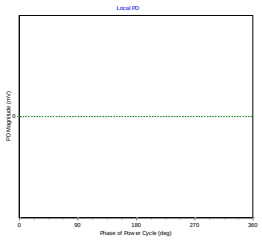
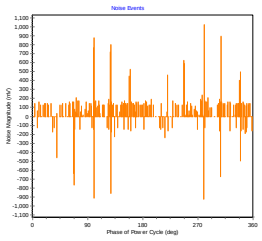
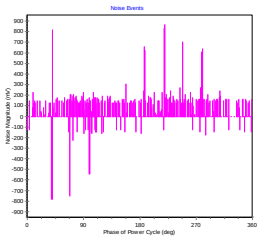
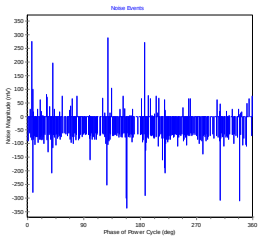
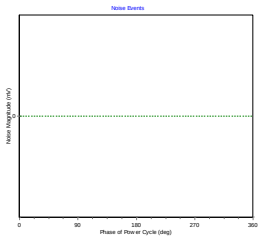


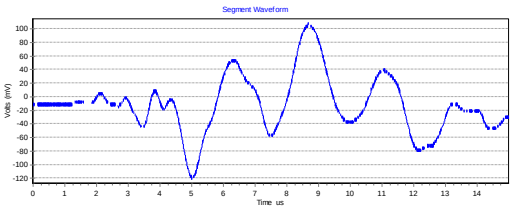
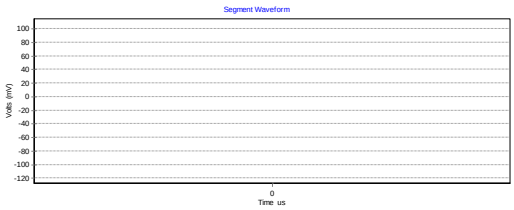
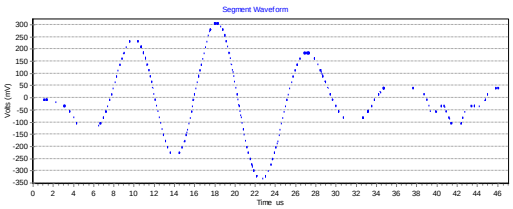
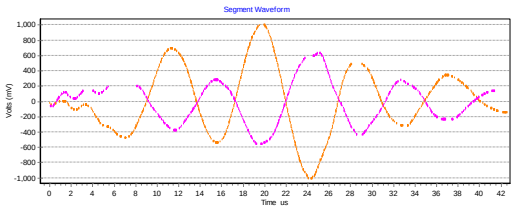
Photo of Sensor Attachment

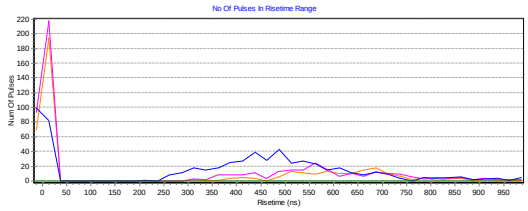
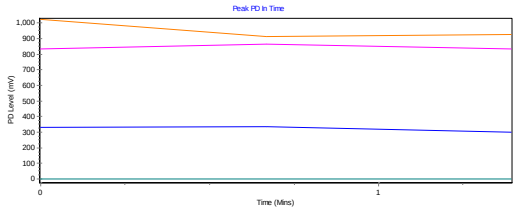


	Channel 1		Channel 2		Channel 3		Channel 4	
	Cable PD	39945pC	Cable PD	52447pC	Cable PD	21888pC	Cable PD	0pC
	Local PD	0dB	Local PD	0dB	Local PD	0dB	Local PD	8dB
	Peak	1024.00mV	Peak	864.00mV	Peak	336.00mV	Peak	0.00mV
	Std Dev	60.54mV	Std Dev	60.13mV	Std Dev	23.55mV	Std Dev	0.00mV
Cable PD								

Local PD				
Noise				

Sensor	Circuit/Description	V(kV)	Cable Type	Local Plant Type
HFCT	phA	13.2kV	Cable	EPR
HFCT	phB	13.2kV	Cable	EPR
HFCT	phC	13.2kV	Cable	EPR
TEV	TEV	13.2kV	Switchgear	Air Insulated

Cable PD Waveform				Local PD Waveform			
							
Peak	-121.60 mV	**Frequency**	488.28 kHz	**Peak**		**Frequency**	
Rise Time	380.72 ns	**PD Level**	-18.10 nC	**Rise Time**		**PD Level**	
Noise Waveform				**Synchronous Waveform**			
							
Peak	-336.00 mV	**Frequency**	106.81 kHz	**Peak**	-	**Frequency**	-
Rise Time	1.89 us	**PD Level**	-	**Rise Time**	-	**PD Level**	-

No of Pulses vs. Pulse Rise-Time	Peak Level in Time
	

Comments
Noise waveforms only. No PD detected.

Substation/Site:	T-3A-1	**Customer:**	City of Tampa
Location:	POA 22B	**Test Engineer:**	Nat Crews/ Louis Nemec
Test No.:		**Test Date:**	08/02/2017 8:38:01 AM

C.E. Testing, Inc.

Sensor	Circuit/Description	V(kV)	Cable Type	Local Plant Type
HFCT	PHA	13.2kV	Cable	EPR
HFCT	PHB	13.2kV	Cable	EPR
HFCT	PHC	13.2kV	Cable	EPR
TEV	TEV	13.2kV	Switchgear	Air Insulated

Phase-Resolved Graph (PD and Noise)

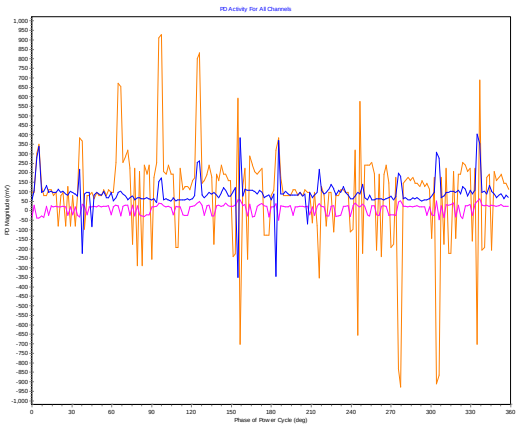
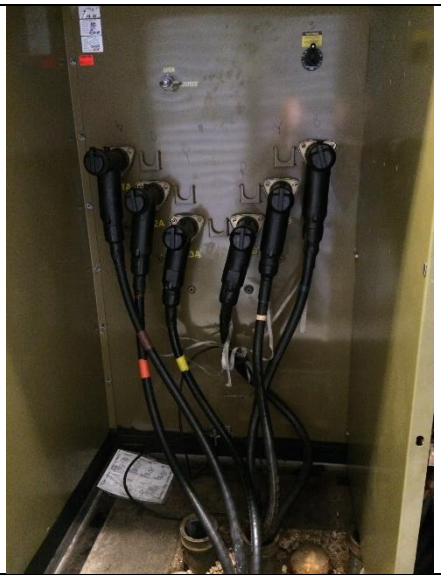
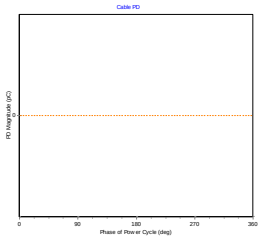
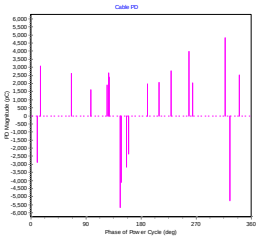
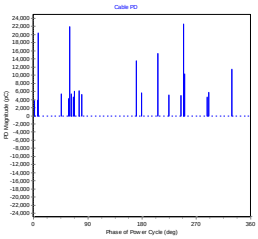
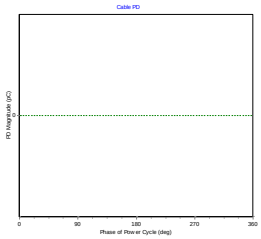
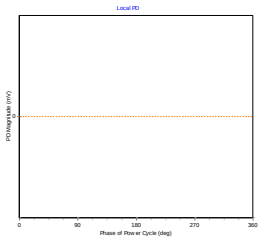
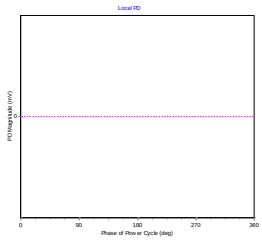
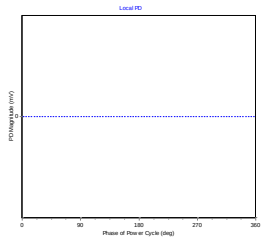
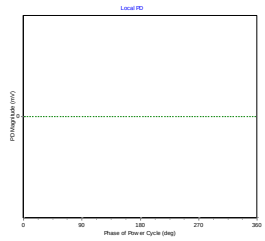
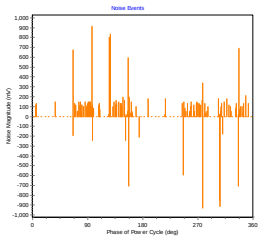
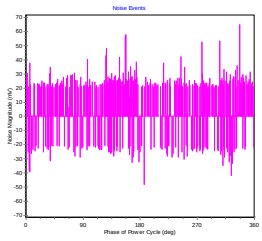
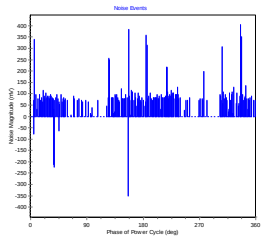
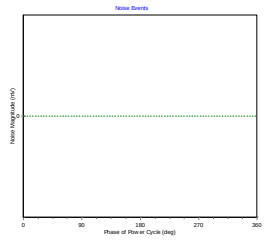


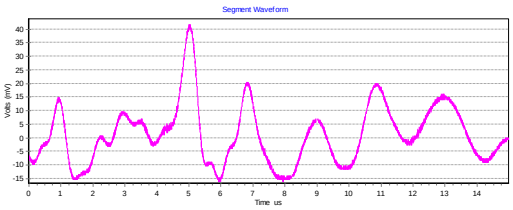
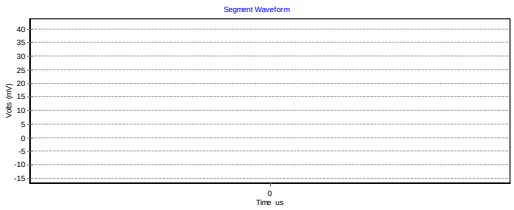
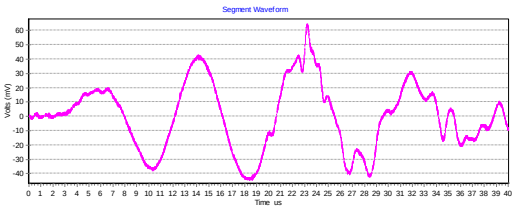
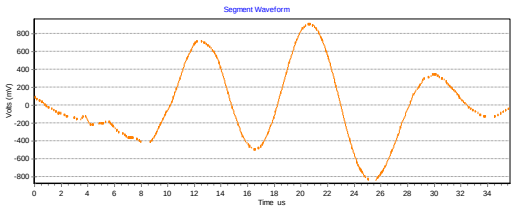
Photo of Sensor Attachment

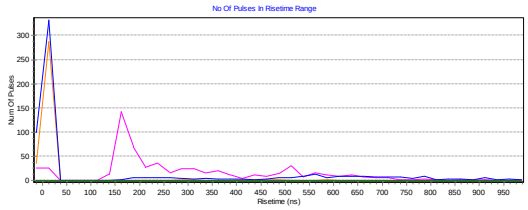
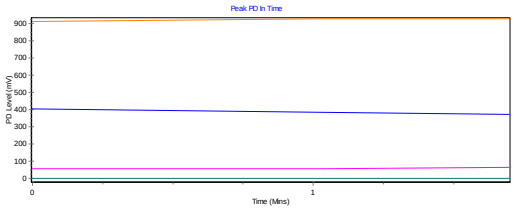


	Channel 1		Channel 2		Channel 3		Channel 4	
	Cable PD	0pC	Cable PD	5654pC	Cable PD	22509pC	Cable PD	0pC
	Local PD	0dB	Local PD	0dB	Local PD	0dB	Local PD	10dB
	Peak	928.00mV	Peak	64.64mV	Peak	403.20mV	Peak	0.00mV
	Std Dev	67.45mV	Std Dev	5.69mV	Std Dev	28.46mV	Std Dev	0.00mV
Cable PD								

Local PD				
Noise				

Sensor	Circuit/Description	V(kV)	Cable Type	Local Plant Type
HFCT	phA	13.2kV	Cable	EPR
HFCT	phB	13.2kV	Cable	EPR
HFCT	phC	13.2kV	Cable	EPR
TEV	TEV	13.2kV	Switchgear	Air Insulated

Cable PD Waveform				Local PD Waveform			
							
Peak	41.60 mV	**Frequency**	488.28 kHz	**Peak**		**Frequency**	
Rise Time	333.63 ns	**PD Level**	4.81 nC	**Rise Time**		**PD Level**	
Noise Waveform				**Synchronous Waveform**			
							
Peak	64.64 mV	**Frequency**	106.81 kHz	**Peak**	-	**Frequency**	-
Rise Time	1.66 us	**PD Level**	-	**Rise Time**	-	**PD Level**	-

No of Pulses vs. Pulse Rise-Time	**Peak Level in Time**
	

Comments
No PD detected. Noise waveforms.

Substation/Site: T-3B-1
Location: POA 23
Test No.:

Customer: City of Tampa
Test Engineer: Nat Crews/ Louis Nemec
Test Date: 08/02/2017 8:45:35 AM

C.E. Testing, Inc.

Sensor	Circuit/Description	V(kV)	Cable Type	Local Plant Type
HFCT	phA	13.2kV	Cable	EPR
HFCT	phB	13.2kV	Cable	EPR
HFCT	phC	13.2kV	Cable	EPR
TEV	TEV	13.2kV	Switchgear	Air Insulated

Phase-Resolved Graph (PD and Noise)

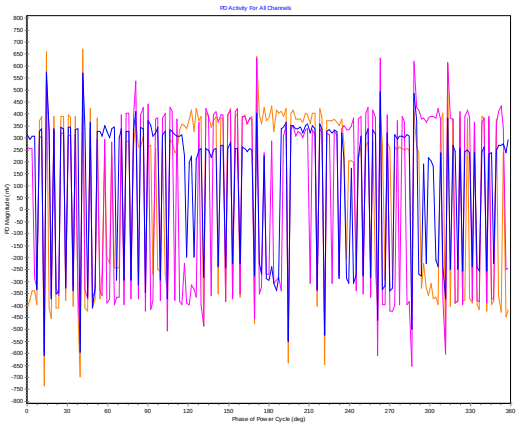
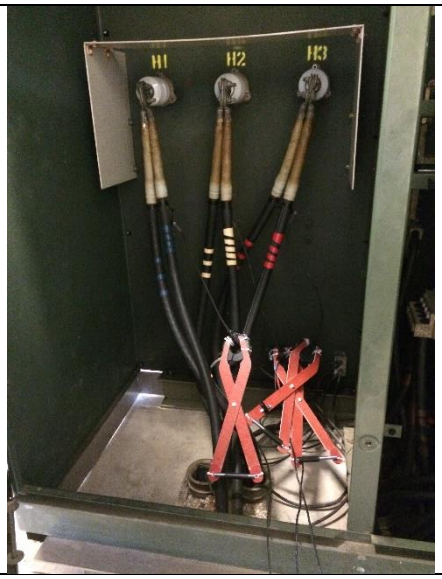
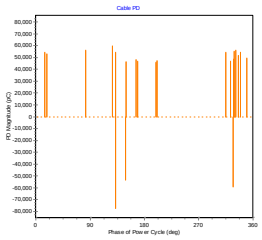
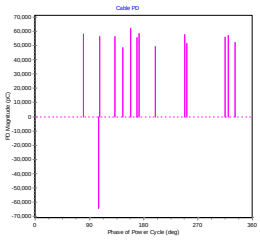
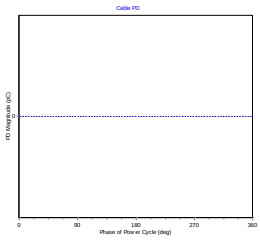
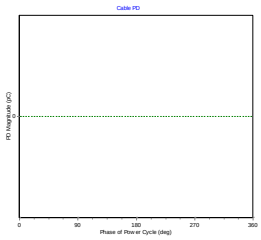
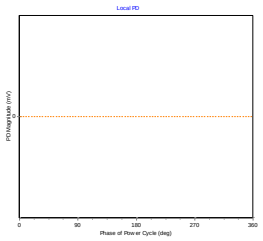
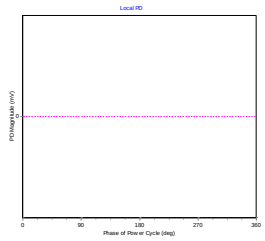
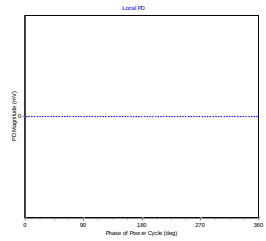
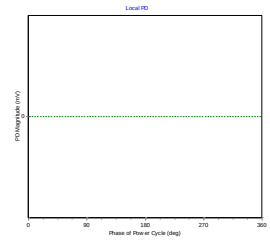
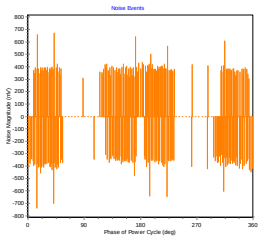
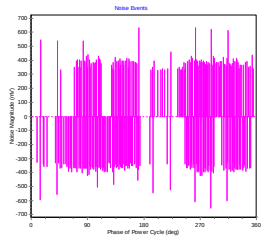
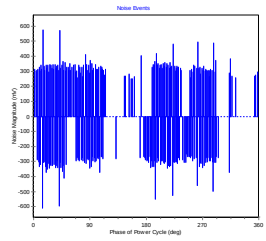
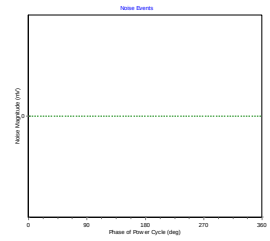


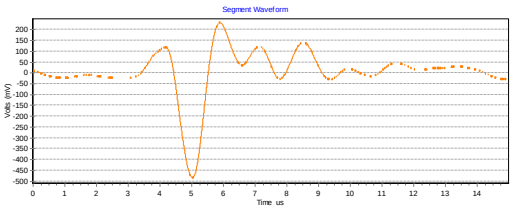
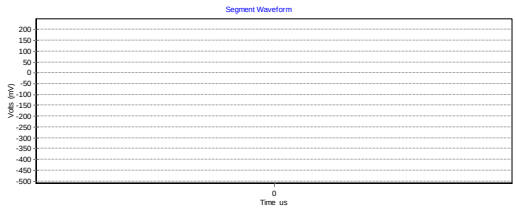
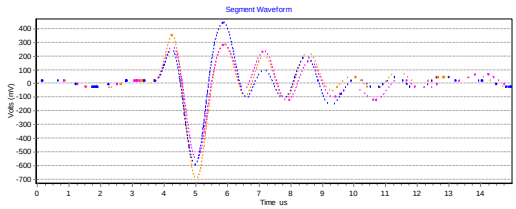
Photo of Sensor Attachment

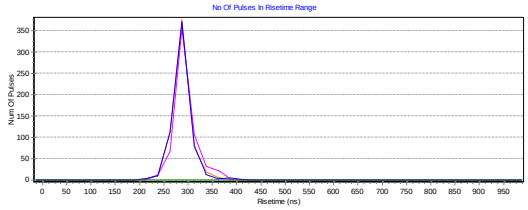


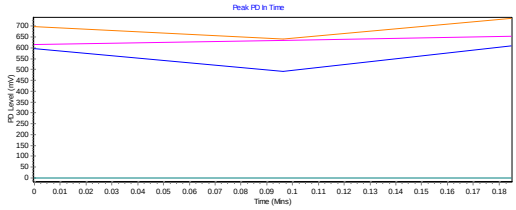
	Channel 1		Channel 2		Channel 3		Channel 4	
	Cable PD	77243pC	Cable PD	64361pC	Cable PD	0pC	Cable PD	0pC
	Local PD	0dB	Local PD	0dB	Local PD	0dB	Local PD	0dB
	Peak	736.00mV	Peak	652.80mV	Peak	608.00mV	Peak	0.00mV
	Std Dev	45.77mV	Std Dev	48.81mV	Std Dev	41.28mV	Std Dev	0.00mV
Cable PD								

Local PD				
Noise				

Sensor	Circuit/Description	V(kV)	Cable Type	Local Plant Type
HFCT	phA	13.2kV	Cable	EPR
HFCT	phB	13.2kV	Cable	EPR
HFCT	phC	13.2kV	Cable	EPR
TEV	TEV	13.2kV	Switchgear	Air Insulated

Cable PD Waveform				Local PD Waveform			
							
Peak	-486.40 mV	**Frequency**	366.21 kHz	**Peak**		**Frequency**	
Rise Time	451.29 ns	**PD Level**	-77.24 nC	**Rise Time**		**PD Level**	
Noise Waveform				**Synchronous Waveform**			
							
Peak	-736.00 mV	**Frequency**	488.28 kHz	**Peak**	-	**Frequency**	-
Rise Time	349.95 ns	**PD Level**	-	**Rise Time**	-	**PD Level**	-
No of Pulses vs. Pulse Rise-Time				**Peak Level in Time**			





Comments
PD not detected. Noise waveforms only.

Substation/Site: T-3A-2

Location: POA 24A

Test No.:

Customer: City of Tampa

Test Engineer: Nat Crews/ Louis Nemec

Test Date: 08/02/2017 8:56:31 AM

C.E. Testing, Inc.

Sensor	Circuit/Description	V(kV)	Cable Type	Local Plant Type
HFCT	phA	13.2kV	Cable	EPR
HFCT	phB	13.2kV	Cable	EPR
HFCT	phC	13.2kV	Cable	EPR
TEV	TEV	13.2kV	Switchgear	Air Insulated

Phase-Resolved Graph (PD and Noise)

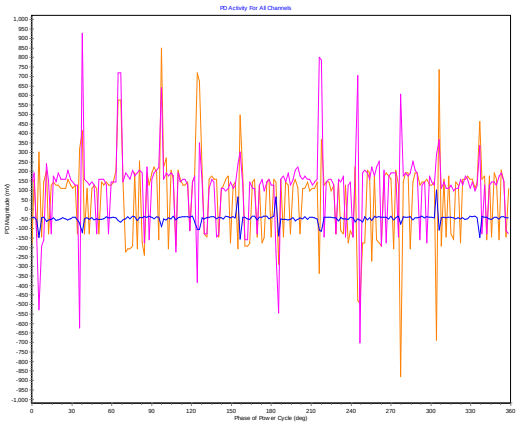
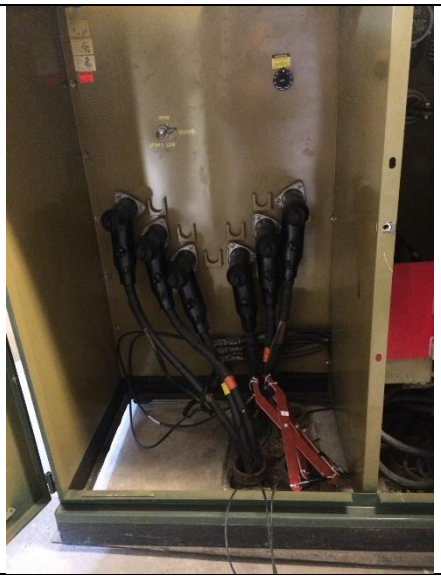
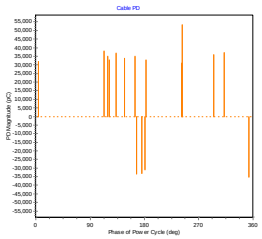
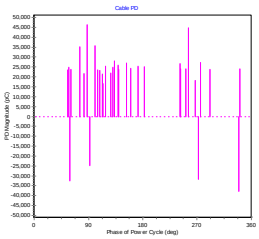
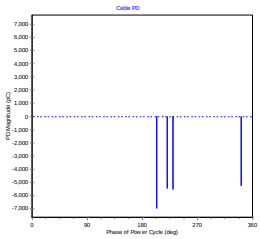
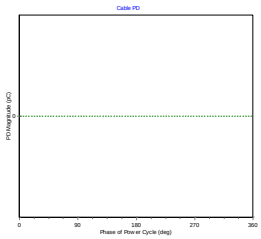
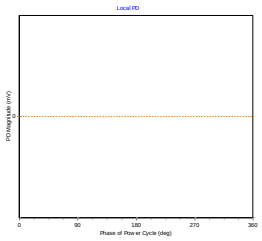
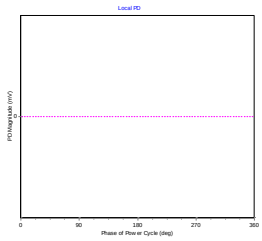
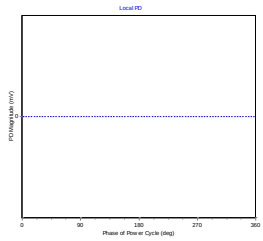
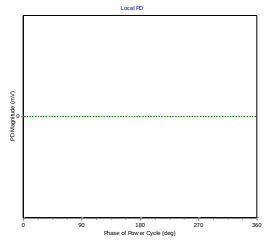
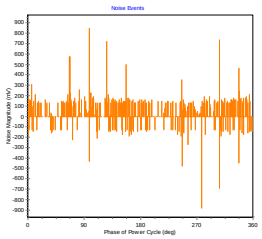
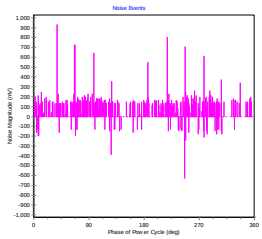
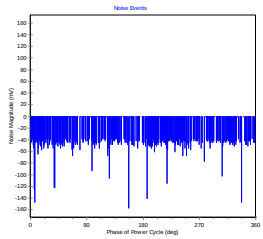
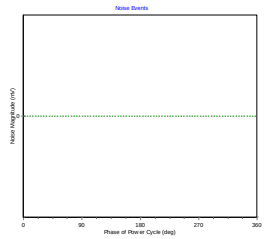


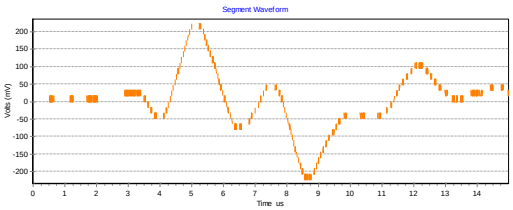
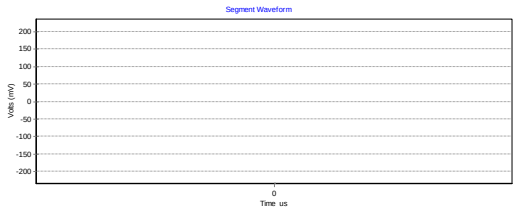
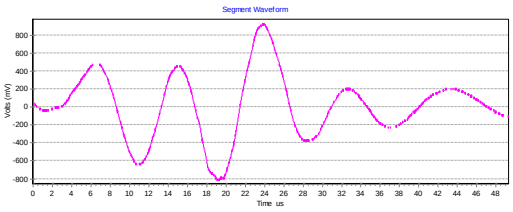
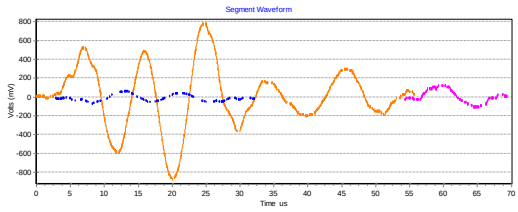
Photo of Sensor Attachment

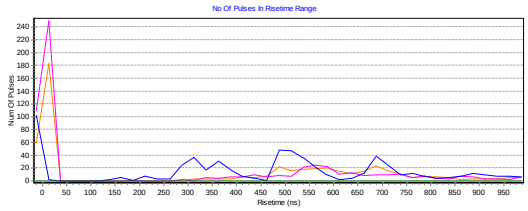
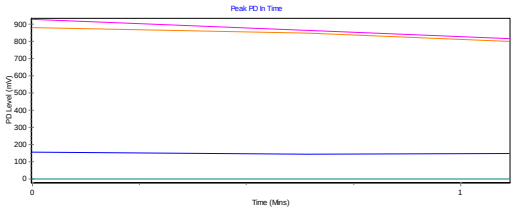


	Channel 1		Channel 2		Channel 3		Channel 4	
	Cable PD	53182pC	Cable PD	46178pC	Cable PD	6954pC	Cable PD	0pC
	Local PD	0dB	Local PD	0dB	Local PD	0dB	Local PD	0dB
	Peak	880.00mV	Peak	928.00mV	Peak	156.80mV	Peak	0.00mV
	Std Dev	57.45mV	Std Dev	60.05mV	Std Dev	11.16mV	Std Dev	0.00mV
Cable PD								

Local PD				
Noise				

Sensor	Circuit/Description	V(kV)	Cable Type	Local Plant Type
HFCT	phA	13.2kV	Cable	EPR
HFCT	phB	13.2kV	Cable	EPR
HFCT	phC	13.2kV	Cable	EPR
TEV	TEV	13.2kV	Switchgear	Air Insulated

Cable PD Waveform				Local PD Waveform			
							
Peak	224.00 mV	**Frequency**	244.14 kHz	**Peak**		**Frequency**	
Rise Time	454.99 ns	**PD Level**	53.18 nC	**Rise Time**		**PD Level**	
Noise Waveform				**Synchronous Waveform**			
							
Peak	928.00 mV	**Frequency**	106.81 kHz	**Peak**	-	**Frequency**	-
Rise Time	1.95 us	**PD Level**	-	**Rise Time**	-	**PD Level**	-

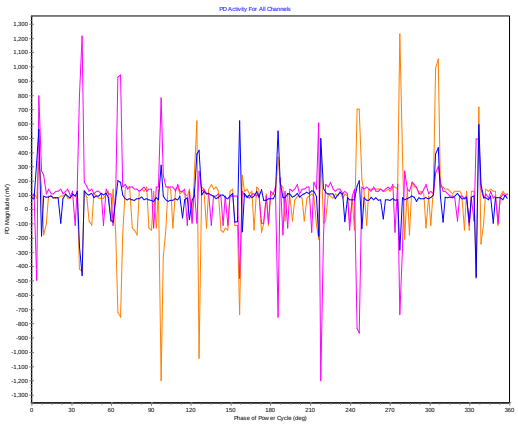
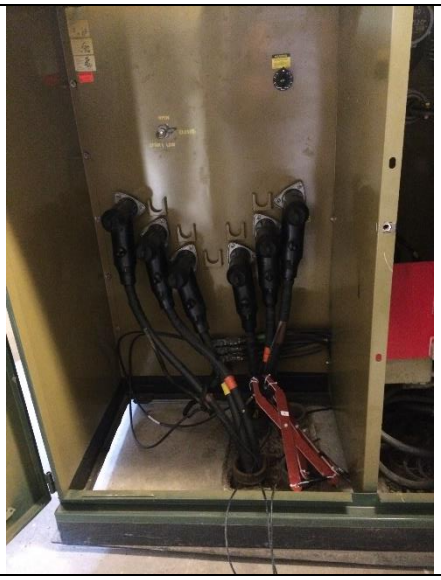
No of Pulses vs. Pulse Rise-Time	Peak Level in Time
	

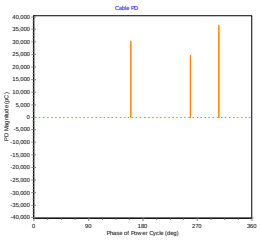
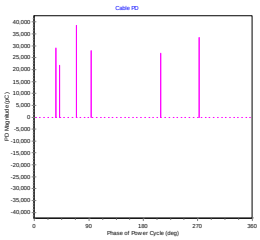
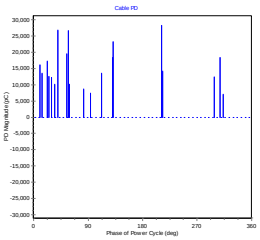
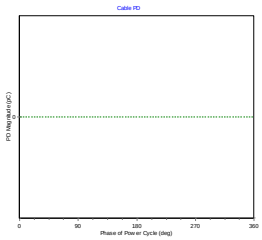
Comments
PD not detected. Only noise waveforms.

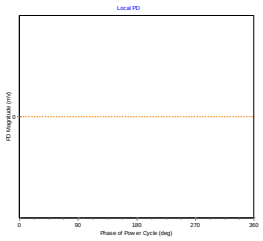
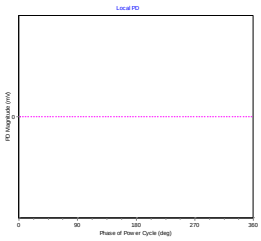
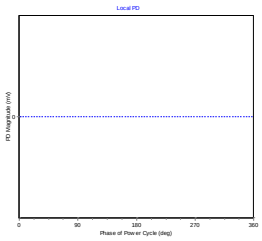
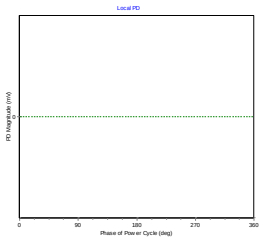
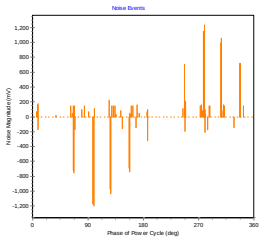
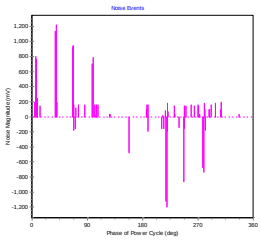
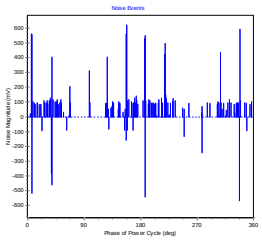
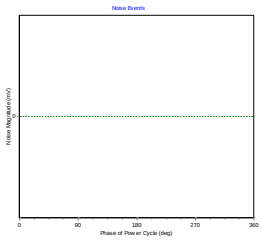
Substation/Site:	T-3A-2	**Customer:**	City of Tampa
Location:	POA 24B	**Test Engineer:**	Nat Crews/ Louis Nemec
Test No.:		**Test Date:**	08/02/2017 8:59:45 AM

C.E. Testing, Inc.

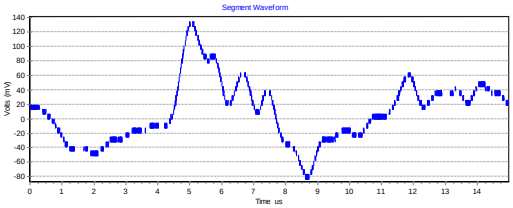
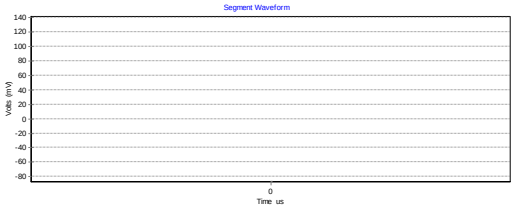
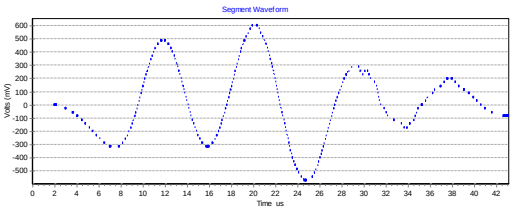
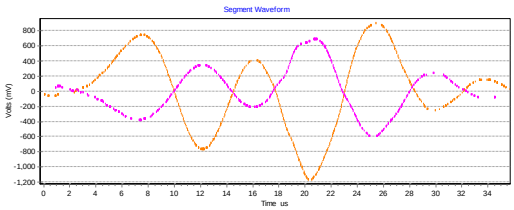
Sensor	Circuit/Description	V(kV)	Cable Type	Local Plant Type
HFCT	phA	13.2kV	Cable	EPR
HFCT	phB	13.2kV	Cable	EPR
HFCT	phC	13.2kV	Cable	EPR
TEV	TEV	13.2kV	Switchgear	Air Insulated

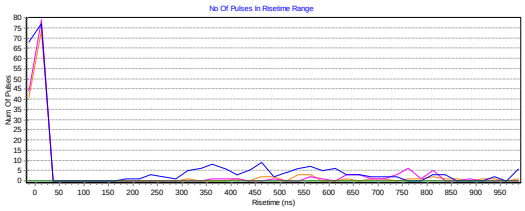
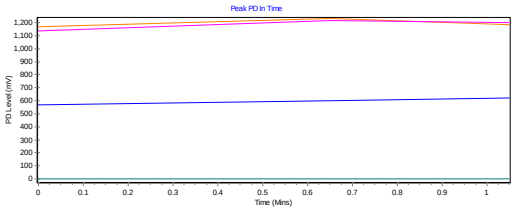
Phase-Resolved Graph (PD and Noise)	Photo of Sensor Attachment
	

	Channel 1		Channel 2		Channel 3		Channel 4	
	Cable PD	36480pC	Cable PD	38433pC	Cable PD	28147pC	Cable PD	0pC
	Local PD	0dB	Local PD	0dB	Local PD	0dB	Local PD	0dB
	Peak	1232.00mV	Peak	1216.00mV	Peak	620.80mV	Peak	0.00mV
	Std Dev	67.58mV	Std Dev	67.19mV	Std Dev	38.77mV	Std Dev	0.00mV
Cable PD								

Local PD				
Noise				

Sensor	Circuit/Description	V(kV)	Cable Type	Local Plant Type
HFCT	phA	13.2kV	Cable	EPR
HFCT	phB	13.2kV	Cable	EPR
HFCT	phC	13.2kV	Cable	EPR
TEV	TEV	13.2kV	Switchgear	Air Insulated

Cable PD Waveform				Local PD Waveform			
							
Peak	134.40 mV	**Frequency**	244.14 kHz	**Peak**		**Frequency**	
Rise Time	337.58 ns	**PD Level**	28.15 nC	**Rise Time**		**PD Level**	
Noise Waveform				**Synchronous Waveform**			
							
Peak	620.80 mV	**Frequency**	106.81 kHz	**Peak**	-	**Frequency**	-
Rise Time	1.98 us	**PD Level**	-	**Rise Time**	-	**PD Level**	-

No of Pulses vs. Pulse Rise-Time	**Peak Level in Time**
	

Comments
PD not detected. Noise waveforms only.

Substation/Site:	T-3B-2	**Customer:**	City of Tampa
Location:	POA 25A	**Test Engineer:**	Nat Crews/ Louis Nemec
Test No.:		**Test Date:**	08/02/2017 9:06:10 AM

C.E. Testing, Inc.

Sensor	Circuit/Description	V(kV)	Cable Type	Local Plant Type
HFCT	phA	13.2kV	Cable	EPR
HFCT	phB	13.2kV	Cable	EPR
HFCT	phC	13.2kV	Cable	EPR
TEV	TEV	13.2kV	Switchgear	Air Insulated

Phase-Resolved Graph (PD and Noise)

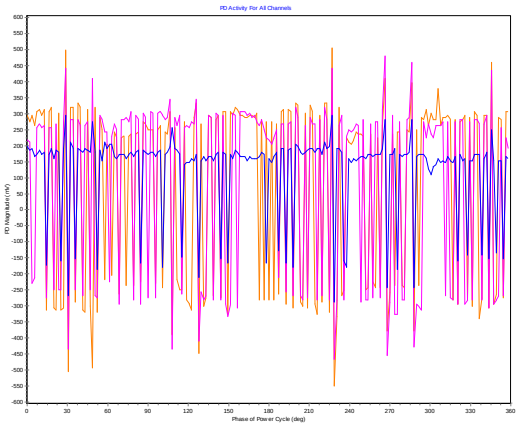
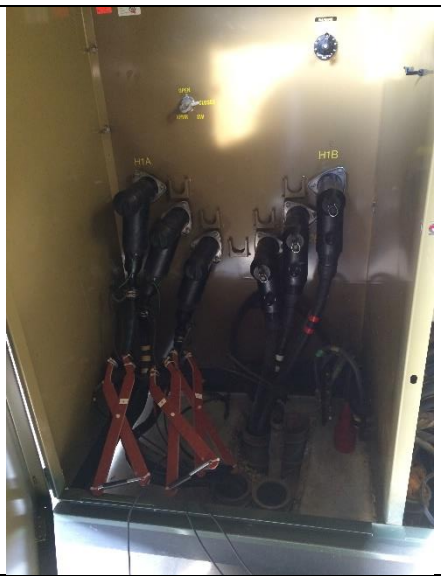
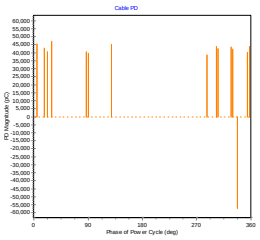
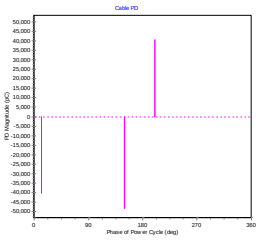
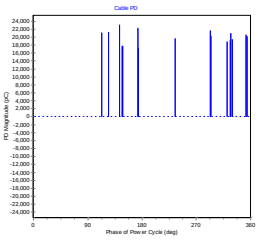
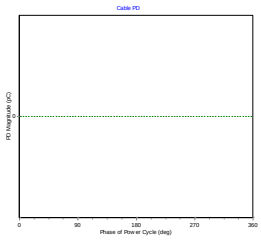
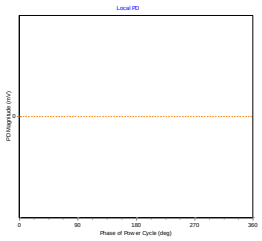
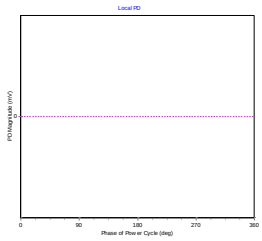
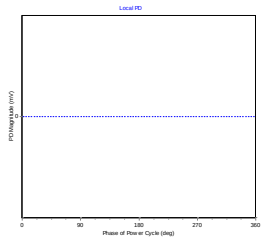
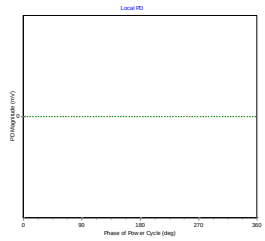
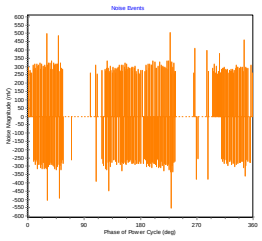
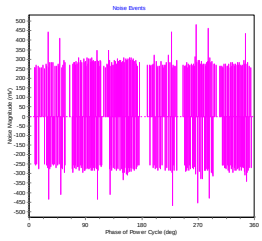
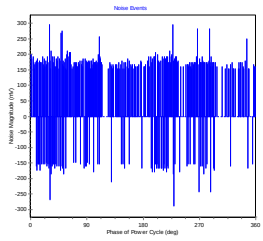
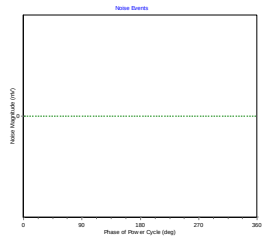


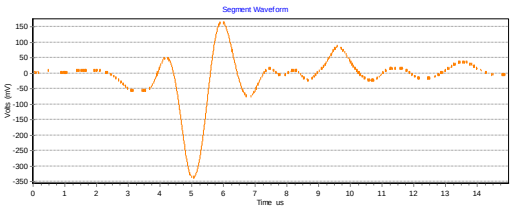
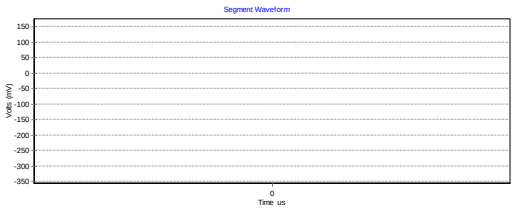
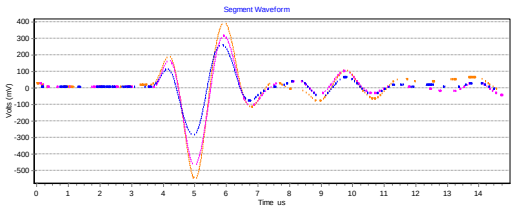
Photo of Sensor Attachment

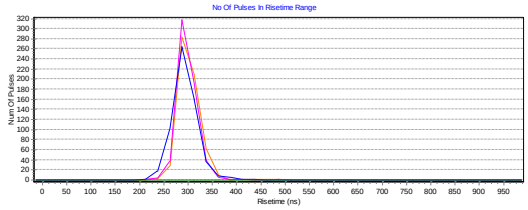


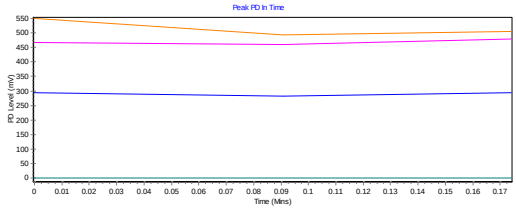
	Channel 1		Channel 2		Channel 3		Channel 4	
	Cable PD	57119pC	Cable PD	48338pC	Cable PD	22963pC	Cable PD	0pC
	Local PD	0dB	Local PD	0dB	Local PD	0dB	Local PD	0dB
	Peak	550.40mV	Peak	480.00mV	Peak	294.40mV	Peak	0.00mV
	Std Dev	39.95mV	Std Dev	40.24mV	Std Dev	25.17mV	Std Dev	0.00mV
Cable PD								

Local PD				
Noise				

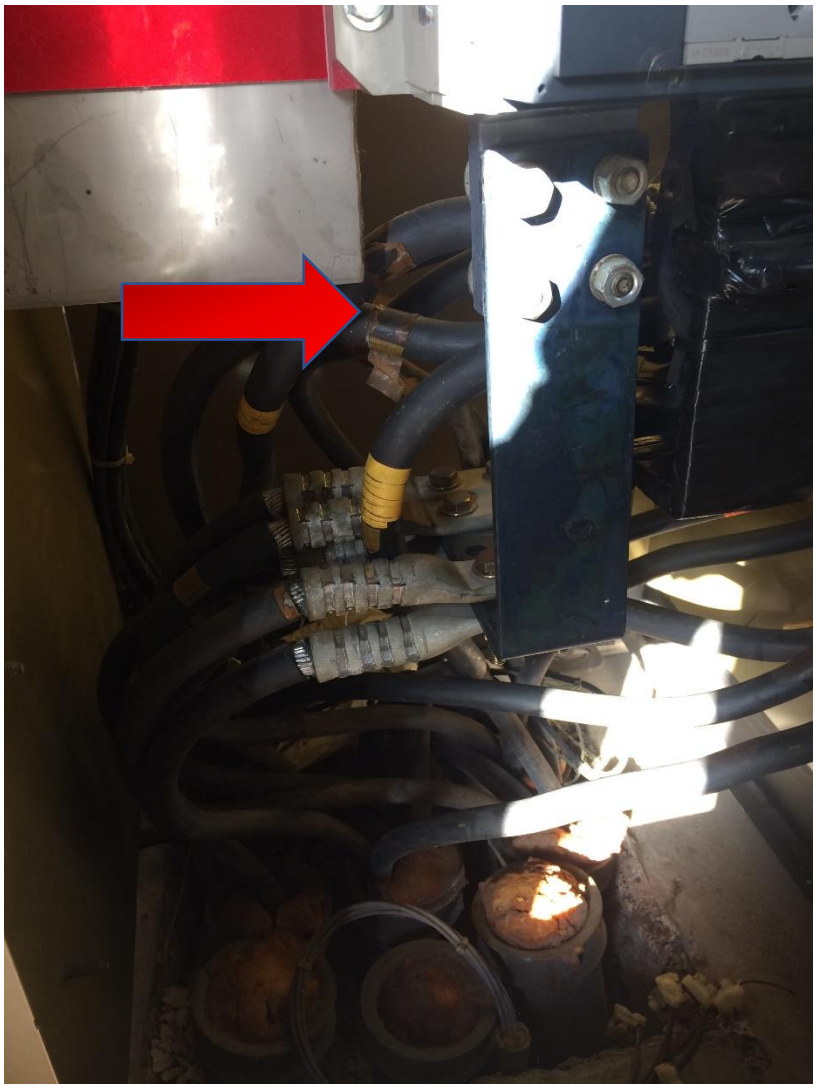
Sensor	Circuit/Description	V(kV)	Cable Type	Local Plant Type
HFCT	phA	13.2kV	Cable	EPR
HFCT	phB	13.2kV	Cable	EPR
HFCT	phC	13.2kV	Cable	EPR
TEV	TEV	13.2kV	Switchgear	Air Insulated

Cable PD Waveform				Local PD Waveform			
							
Peak	-339.20 mV	**Frequency**	488.28 kHz	**Peak**		**Frequency**	
Rise Time	419.25 ns	**PD Level**	-57.12 nC	**Rise Time**		**PD Level**	
Noise Waveform				**Synchronous Waveform**			
							
Peak	-550.40 mV	**Frequency**	488.28 kHz	**Peak**	-	**Frequency**	-
Rise Time	407.48 ns	**PD Level**	-	**Rise Time**	-	**PD Level**	-
No of Pulses vs. Pulse Rise-Time				**Peak Level in Time**			





Comments
PD not detected. Only noise waveforms.
POA 25A 1. On secondary side of transformers. Low voltage C phase conductor against A phase conductor on 480 secondary. Recommend spacing the conductors.



Substation/Site: T-3B-2 A
Location: POA 25 B
Test No.:

Customer: City of Tampa
Test Engineer: Nat Crews/ Louis Nemec
Test Date: 08/02/2017 9:09:15 AM

C.E. Testing, Inc.

Sensor	Circuit/Description	V(kV)	Cable Type	Local Plant Type
HFCT	phA	13.2kV	Cable	EPR
HFCT	phB	13.2kV	Cable	EPR
HFCT	phC	13.2kV	Cable	EPR
TEV	TEV	13.2kV	Switchgear	Air Insulated

Phase-Resolved Graph (PD and Noise)

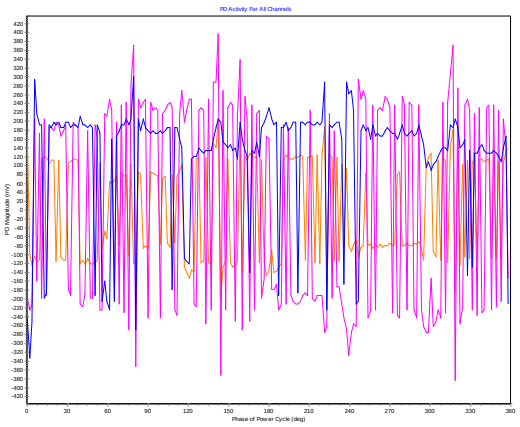
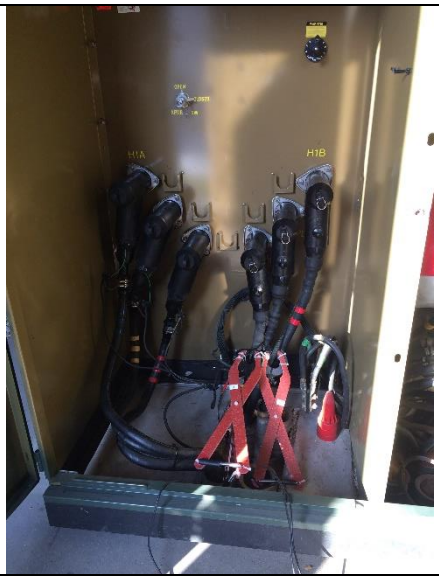
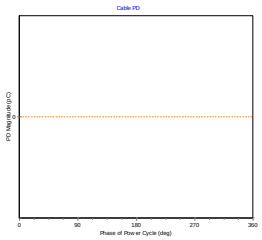
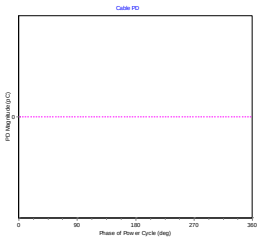
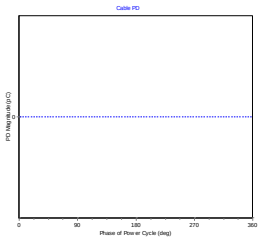
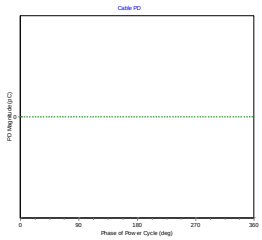
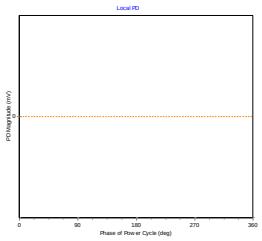
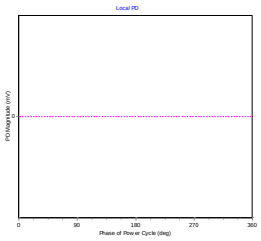
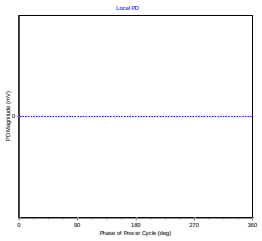
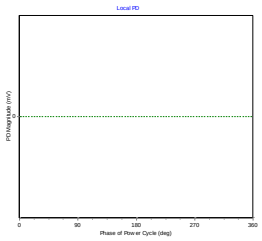
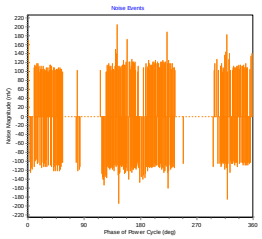
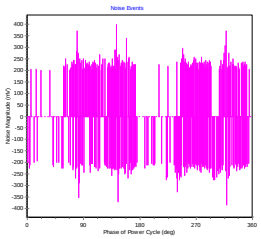
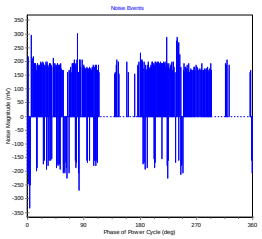
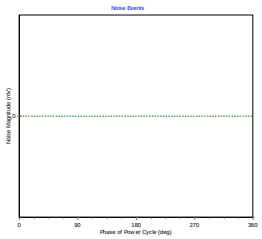


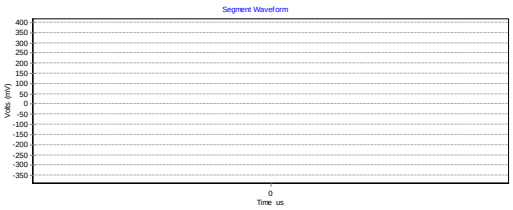
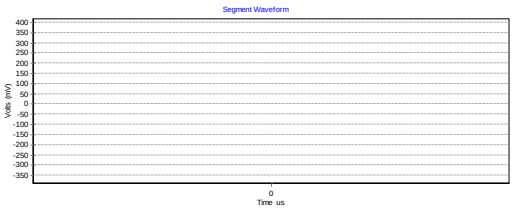
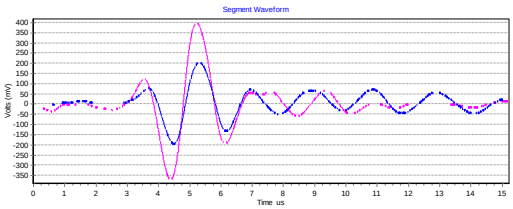
Photo of Sensor Attachment

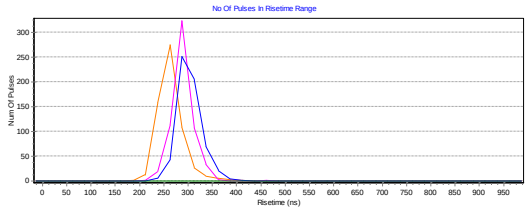
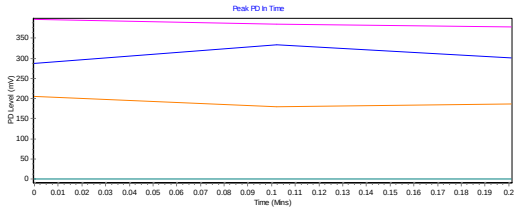


	Channel 1		Channel 2		Channel 3		Channel 4	
	Cable PD	0pC	Cable PD	0pC	Cable PD	0pC	Cable PD	0pC
	Local PD	0dB	Local PD	0dB	Local PD	0dB	Local PD	9dB
	Peak	204.80mV	Peak	396.80mV	Peak	332.80mV	Peak	0.00mV
	Std Dev	16.65mV	Std Dev	34.81mV	Std Dev	27.63mV	Std Dev	0.00mV
Cable PD								

Local PD				
Noise				

Sensor	Circuit/Description	V(kV)	Cable Type	Local Plant Type
HFCT	phA	13.2kV	Cable	EPR
HFCT	phB	13.2kV	Cable	EPR
HFCT	phC	13.2kV	Cable	EPR
TEV	TEV	13.2kV	Switchgear	Air Insulated

Cable PD Waveform				Local PD Waveform			
							
Peak		**Frequency**		**Peak**		**Frequency**	
Rise Time		**PD Level**		**Rise Time**		**PD Level**	
Noise Waveform				**Synchronous Waveform**			
							
Peak	204.80 mV	**Frequency**	488.28 kHz	**Peak**	-	**Frequency**	-
Rise Time	280.98 ns	**PD Level**	-	**Rise Time**	-	**PD Level**	-

No of Pulses vs. Pulse Rise-Time	Peak Level in Time
	

Comments
PD not detected. Noise waveforms only. See comment 25A on transformer secondary

Substation/Site: T-3A-3
Location: POA 27
Test No.:

Customer: City of Tampa
Test Engineer: Nat Crews/ Louis Nemec
Test Date: 08/02/2017 9:25:54 AM

C.E. Testing, Inc.

Sensor	Circuit/Description	V(kV)	Cable Type	Local Plant Type
HFCT	PHA	13.2kV	Cable	EPR
HFCT	PHB	13.2kV	Cable	EPR
HFCT	PHC	13.2kV	Cable	EPR
TEV	TEV	13.2kV	Switchgear	Air Insulated

Phase-Resolved Graph (PD and Noise)

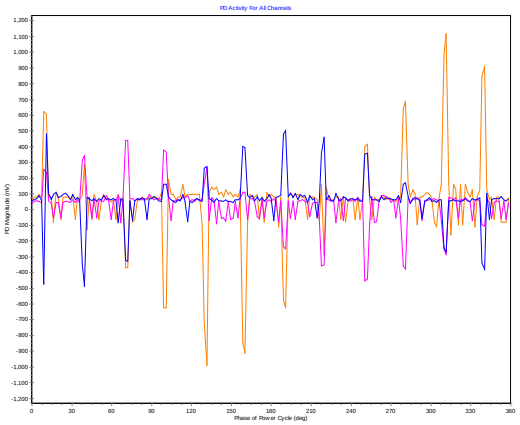
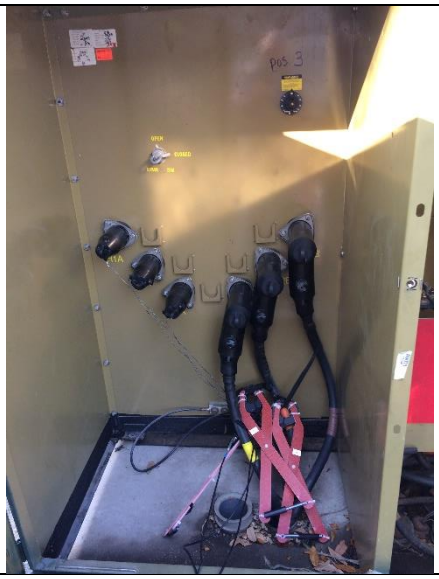
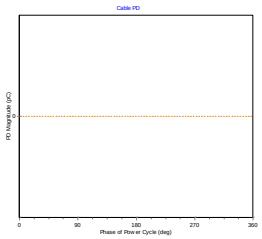
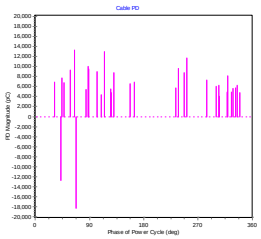
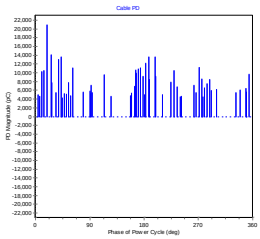
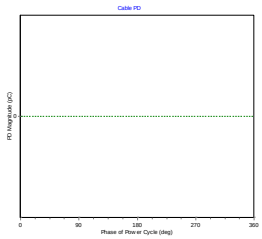
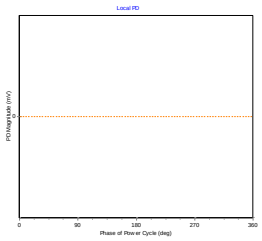
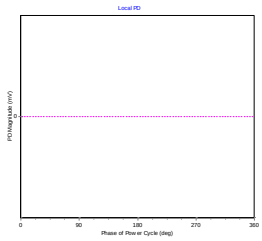
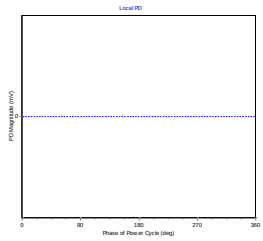
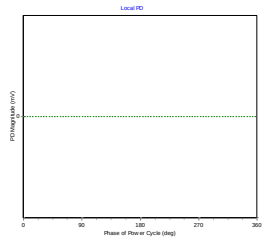
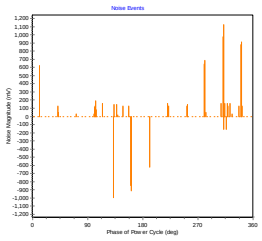
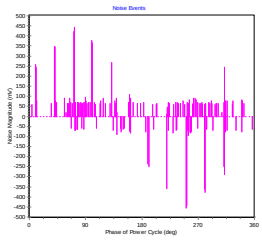
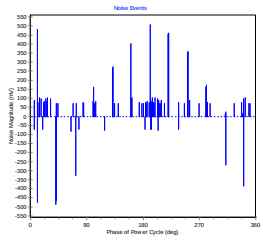
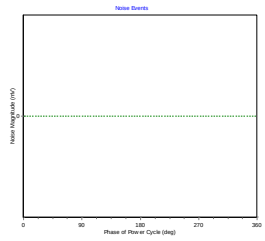


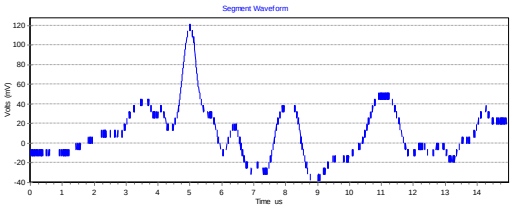
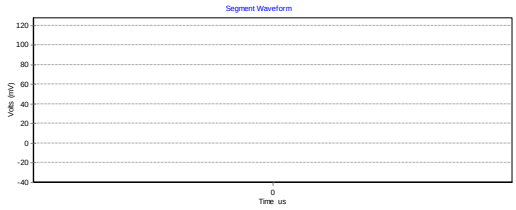
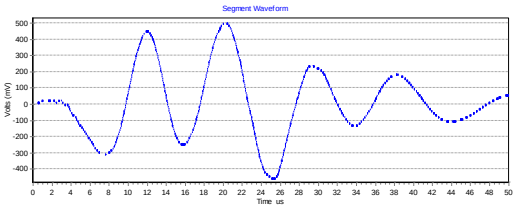
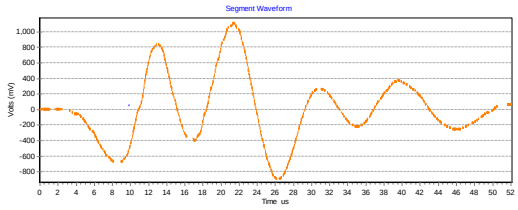
Photo of Sensor Attachment

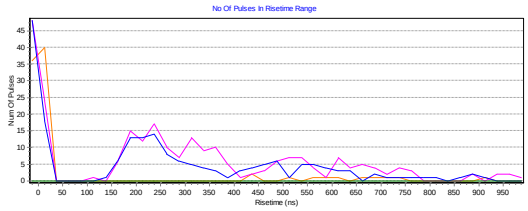
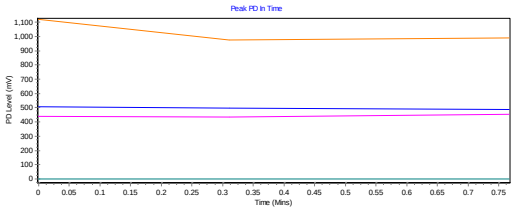


	Channel 1		Channel 2		Channel 3		Channel 4	
	Cable PD	0pC	Cable PD	18288pC	Cable PD	20877pC	Cable PD	0pC
	Local PD	0dB	Local PD	0dB	Local PD	0dB	Local PD	8dB
	Peak	1120.00mV	Peak	454.40mV	Peak	505.60mV	Peak	0.00mV
	Std Dev	56.05mV	Std Dev	26.90mV	Std Dev	31.36mV	Std Dev	0.00mV
Cable PD								

Local PD				
Noise				

Sensor	Circuit/Description	V(kV)	Cable Type	Local Plant Type
HFCT	phA	13.2kV	Cable	EPR
HFCT	phB	13.2kV	Cable	EPR
HFCT	phC	13.2kV	Cable	EPR
TEV	TEV	13.2kV	Switchgear	Air Insulated

Cable PD Waveform				Local PD Waveform			
							
Peak	121.60 mV	**Frequency**	488.28 kHz	**Peak**		**Frequency**	
Rise Time	323.03 ns	**PD Level**	13.00 nC	**Rise Time**		**PD Level**	
Noise Waveform				**Synchronous Waveform**			
							
Peak	505.60 mV	**Frequency**	106.81 kHz	**Peak**	-	**Frequency**	-
Rise Time	2.10 us	**PD Level**	-	**Rise Time**	-	**PD Level**	-

No of Pulses vs. Pulse Rise-Time	Peak Level in Time
	

Comments
PD not detected. Noise waveforms only.

Substation/Site: T-3B-3
Location: POA 26
Test No.:

Customer: City of Tampa
Test Engineer: Nat Crews/ Louis Nemec
Test Date: 08/02/2017 9:32:19 AM

C.E. Testing, Inc.

Sensor	Circuit/Description	V(kV)	Cable Type	Local Plant Type
HFCT	phA	13.2kV	Cable	EPR
HFCT	phB	13.2kV	Cable	EPR
HFCT	phC	13.2kV	Cable	EPR
TEV	TEV	13.2kV	Switchgear	Air Insulated

Phase-Resolved Graph (PD and Noise)

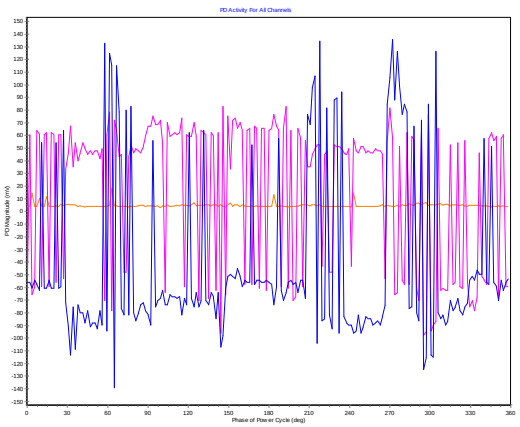
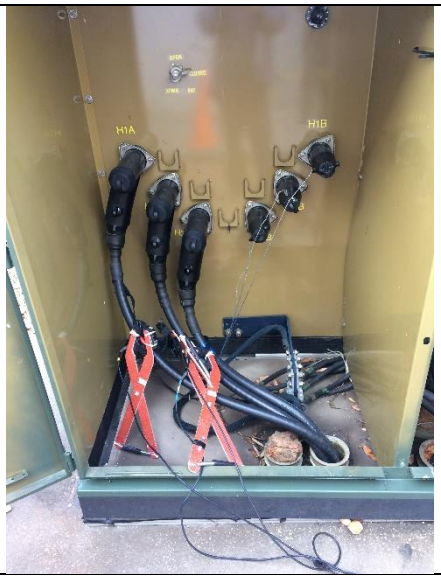
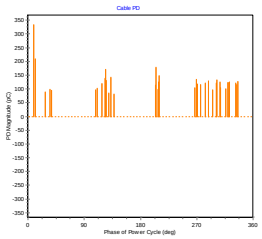
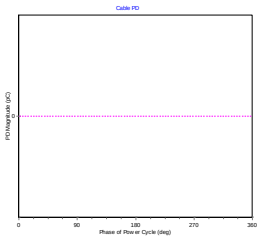
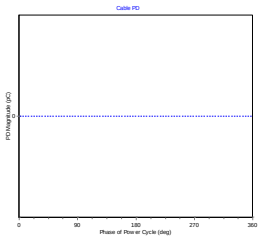
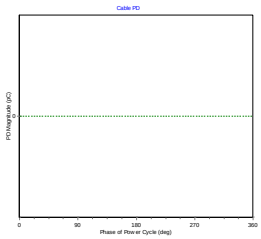
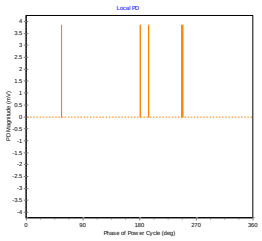
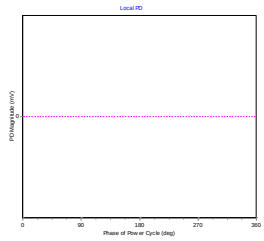
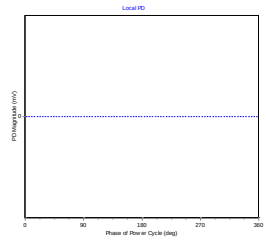
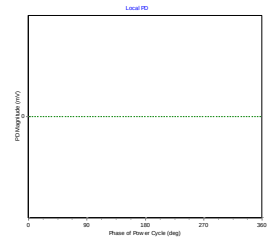
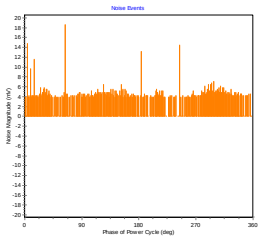
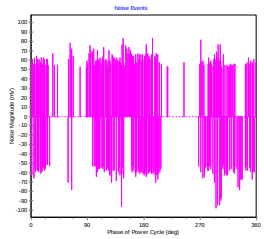
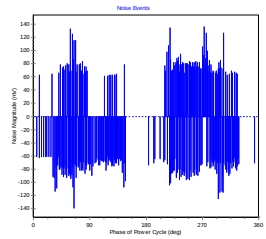
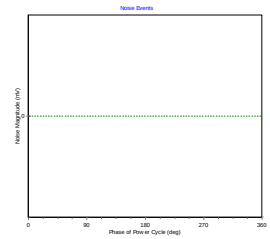


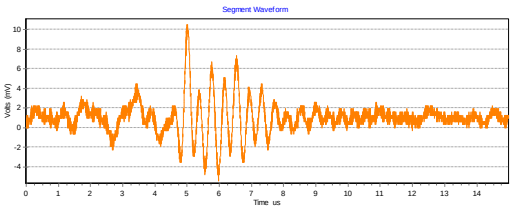
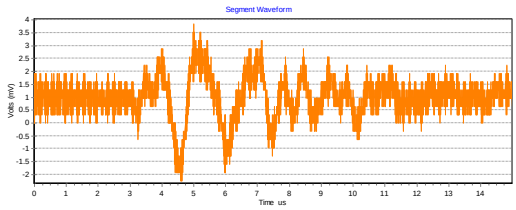
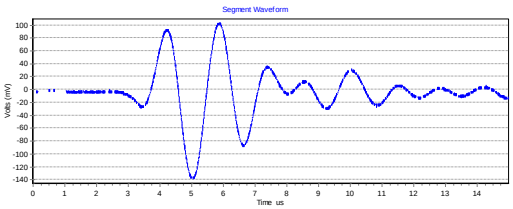
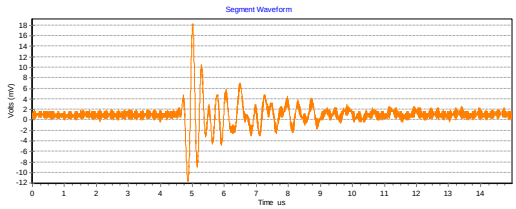
Photo of Sensor Attachment

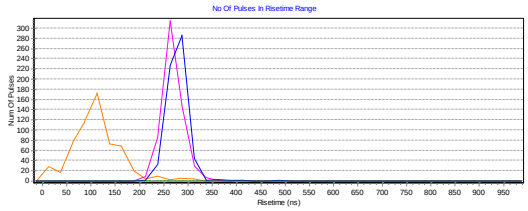
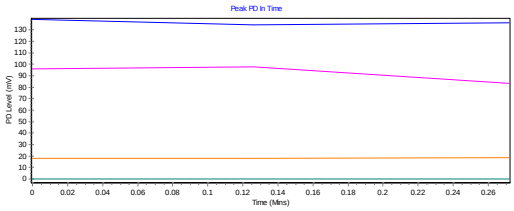


	Channel 1		Channel 2		Channel 3		Channel 4	
	Cable PD	332pC	Cable PD	0pC	Cable PD	0pC	Cable PD	0pC
	Local PD	12dB	Local PD	0dB	Local PD	0dB	Local PD	9dB
	Peak	18.56mV	Peak	97.60mV	Peak	139.20mV	Peak	0.00mV
	Std Dev	0.65mV	Std Dev	9.68mV	Std Dev	12.12mV	Std Dev	0.00mV
Cable PD								

Local PD				
Noise				

Sensor	Circuit/Description	V(kV)	Cable Type	Local Plant Type
HFCT	phA	13.2kV	Cable	EPR
HFCT	phB	13.2kV	Cable	EPR
HFCT	phC	13.2kV	Cable	EPR
TEV	TEV	13.2kV	Switchgear	Air Insulated

Cable PD Waveform				Local PD Waveform			
							
Peak	10.56 mV	**Frequency**	2.69 MHz	**Peak**	3.84 mV	**Frequency**	104.52 MHz
Rise Time	86.74 ns	**PD Level**	332.49 pC	**Rise Time**	15.96 ns	**PD Level**	
Noise Waveform				**Synchronous Waveform**			
							
Peak	-139.20 mV	**Frequency**	610.35 kHz	**Peak**	-	**Frequency**	-
Rise Time	345.58 ns	**PD Level**	-	**Rise Time**	-	**PD Level**	-

No of Pulses vs. Pulse Rise-Time	**Peak Level in Time**
	

Comments
Noise waveforms. No PD detected. Abnormal noise pulses are similar to PD pulses, but do not indicate PD.

Substation/Site: T-2A-3

Location: POA 53

Test No.:

Customer: City of Tampa

Test Engineer: Nat Crews/ Louis Nemec

Test Date: 08/02/2017 9:48:09 AM

C.E. Testing, Inc.

Sensor	Circuit/Description	V(kV)	Cable Type	Local Plant Type
HFCT	phA	13.2kV	Cable	EPR
HFCT	phB	13.2kV	Cable	EPR
HFCT	phC	13.2kV	Cable	EPR
TEV	TEV	13.2kV	Switchgear	Air Insulated

Phase-Resolved Graph (PD and Noise)

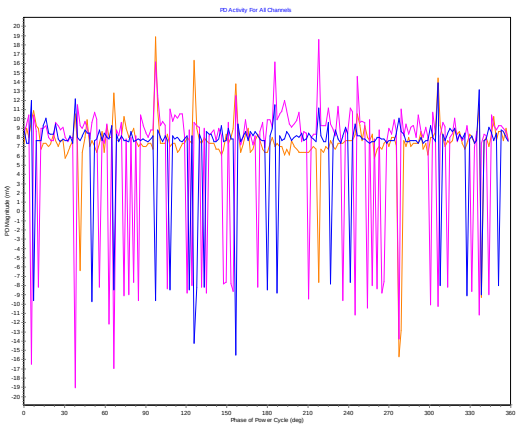
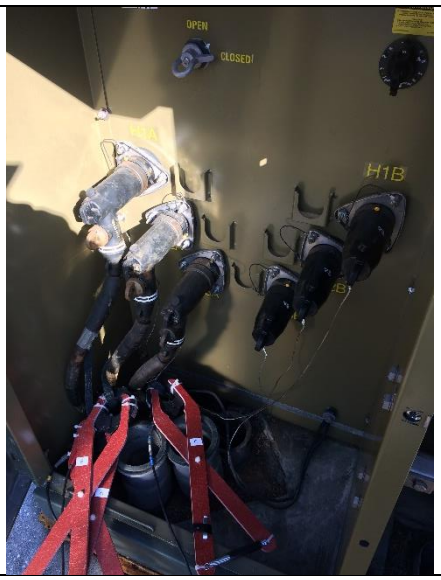
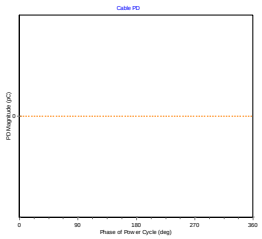
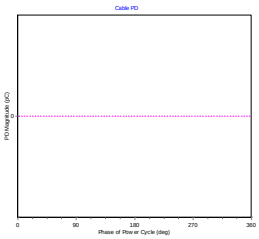
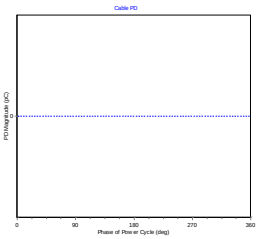
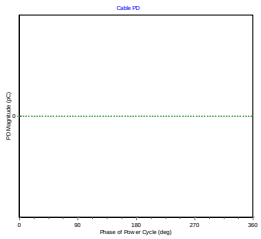
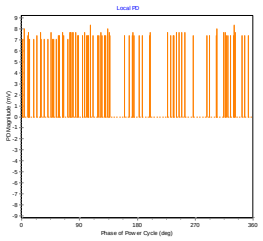
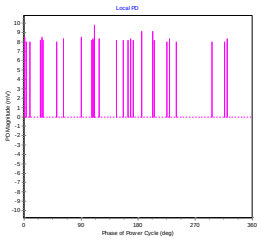
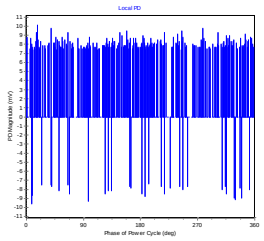
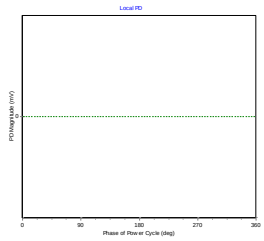
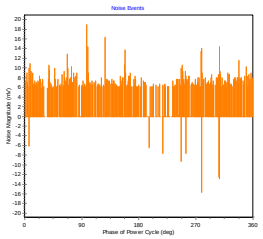
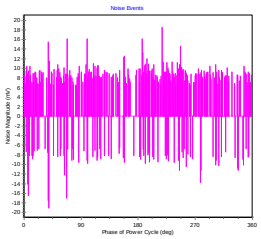
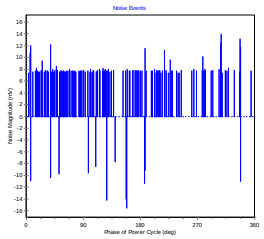
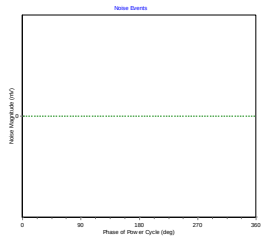


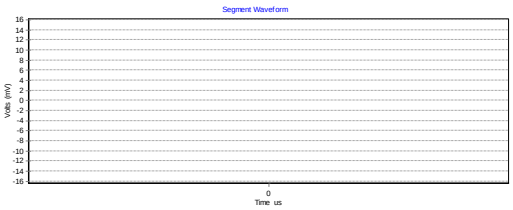
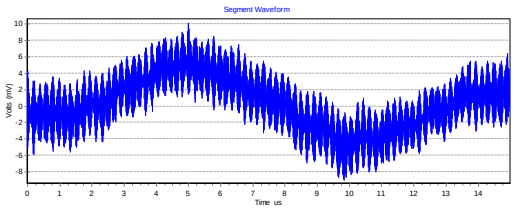
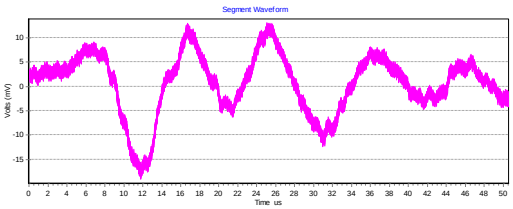
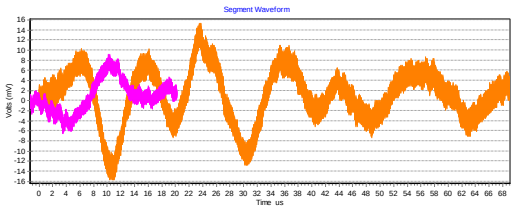
Photo of Sensor Attachment

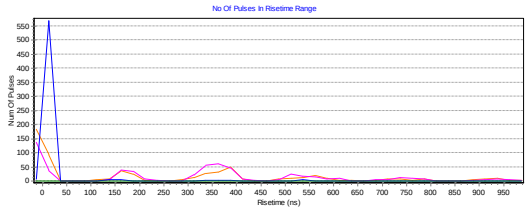
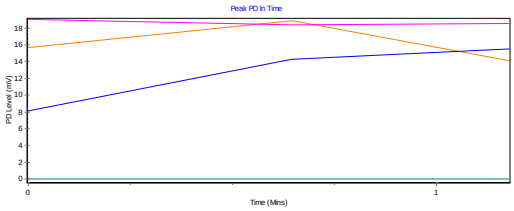


	Channel 1		Channel 2		Channel 3		Channel 4	
	Cable PD	0pC	Cable PD	0pC	Cable PD	0pC	Cable PD	0pC
	Local PD	18dB	Local PD	20dB	Local PD	20dB	Local PD	0dB
	Peak	18.88mV	Peak	19.04mV	Peak	15.52mV	Peak	0.00mV
	Std Dev	1.91mV	Std Dev	2.41mV	Std Dev	2.59mV	Std Dev	0.00mV
Cable PD								

Local PD				
Noise				

Sensor	Circuit/Description	V(kV)	Cable Type	Local Plant Type
HFCT	phA	13.2kV	Cable	EPR
HFCT	phB	13.2kV	Cable	EPR
HFCT	phC	13.2kV	Cable	EPR
TEV	TEV	13.2kV	Switchgear	Air Insulated

Cable PD Waveform				Local PD Waveform			
							
Peak		**Frequency**		**Peak**	10.08 mV	**Frequency**	104.65 MHz
Rise Time		**PD Level**		**Rise Time**	6.08 ns	**PD Level**	
Noise Waveform				**Synchronous Waveform**			
							
Peak	-19.04 mV	**Frequency**	106.81 kHz	**Peak**	-	**Frequency**	-
Rise Time	1.94 us	**PD Level**	-	**Rise Time**	-	**PD Level**	-

No of Pulses vs. Pulse Rise-Time	Peak Level in Time
	

Comments
PD not detected. Noise waveforms only.

Substation/Site: T-2B-3
Location: POA 52
Test No.:

Customer: City of Tampa
Test Engineer: Nat Crews/ Louis Nemec
Test Date: 08/02/2017 9:52:24 AM

C.E. Testing, Inc.

Sensor	Circuit/Description	V(kV)	Cable Type	Local Plant Type
HFCT	phA	13.2kV	Cable	EPR
HFCT	phB	13.2kV	Cable	EPR
HFCT	phC	13.2kV	Cable	EPR
TEV	TEV	13.2kV	Switchgear	Air Insulated

Phase-Resolved Graph (PD and Noise)

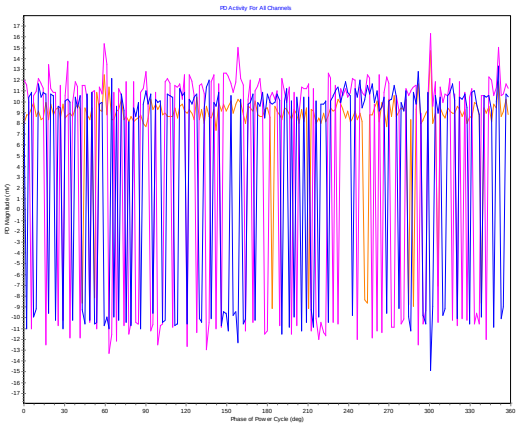
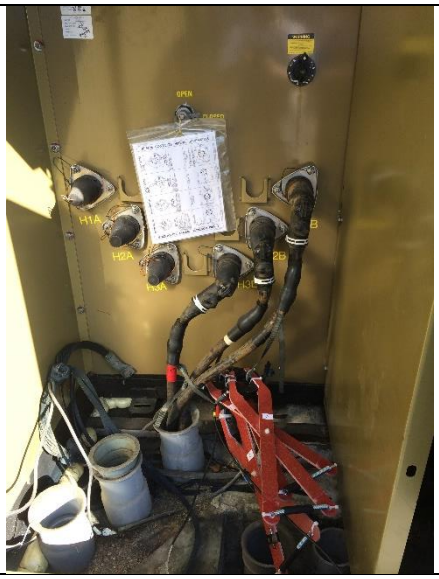
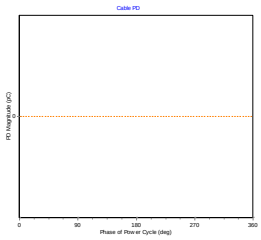
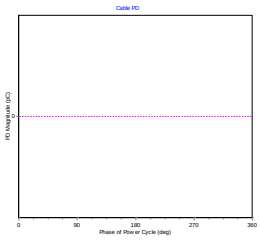
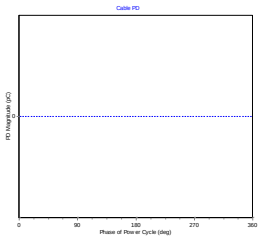
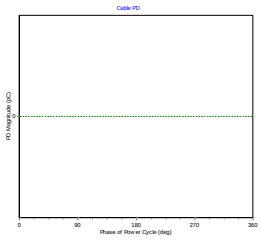
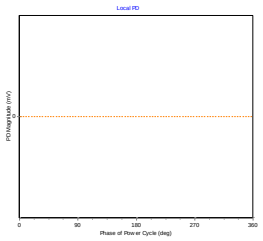
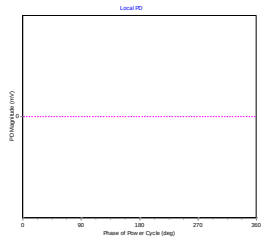
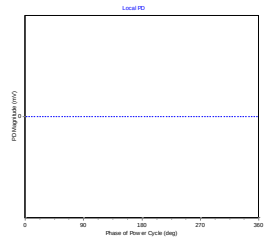
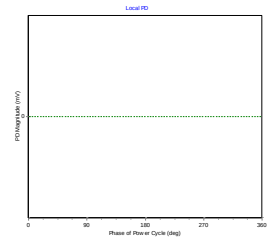
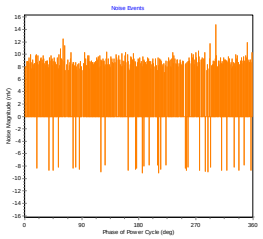
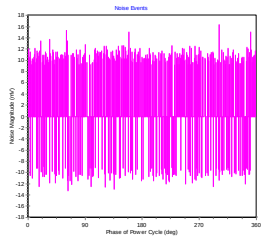
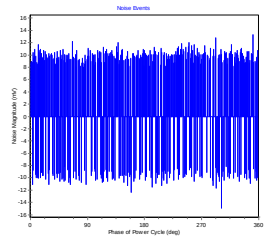
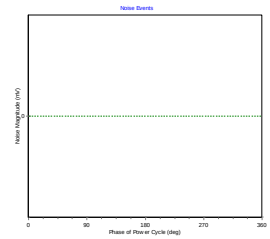


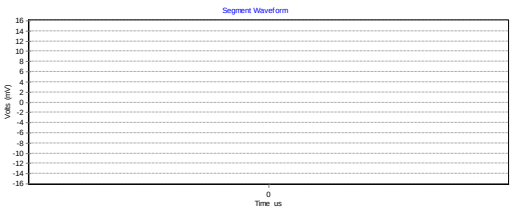
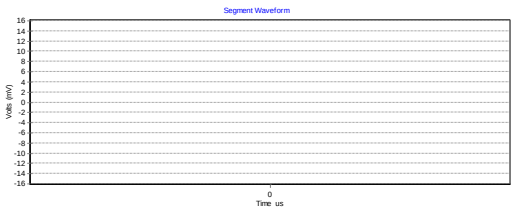
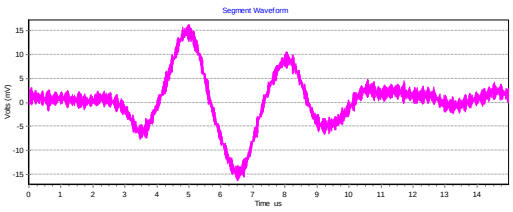
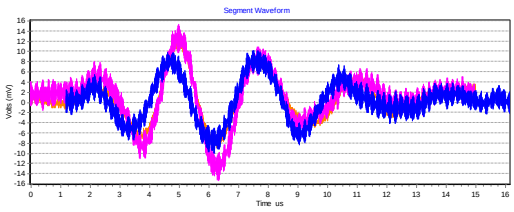
Photo of Sensor Attachment

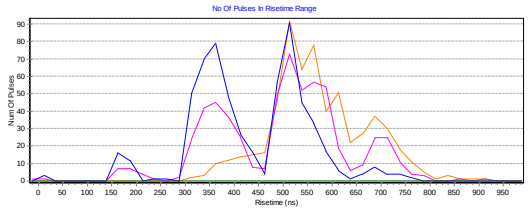
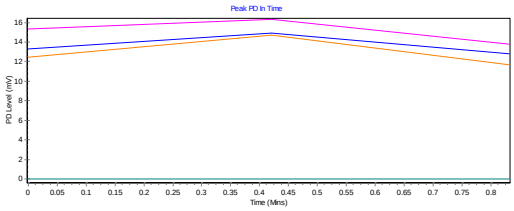


	Channel 1		Channel 2		Channel 3		Channel 4	
	Cable PD	0pC	Cable PD	0pC	Cable PD	0pC	Cable PD	0pC
	Local PD	0dB	Local PD	0dB	Local PD	0dB	Local PD	0dB
	Peak	14.72mV	Peak	16.32mV	Peak	14.88mV	Peak	0.00mV
	Std Dev	1.41mV	Std Dev	1.91mV	Std Dev	1.75mV	Std Dev	0.00mV
Cable PD								

Local PD				
Noise				

Sensor	Circuit/Description	V(kV)	Cable Type	Local Plant Type
HFCT	phA	13.2kV	Cable	EPR
HFCT	phB	13.2kV	Cable	EPR
HFCT	phC	13.2kV	Cable	EPR
TEV	TEV	13.2kV	Switchgear	Air Insulated

Cable PD Waveform				Local PD Waveform			
							
Peak		**Frequency**		**Peak**		**Frequency**	
Rise Time		**PD Level**		**Rise Time**		**PD Level**	
Noise Waveform				**Synchronous Waveform**			
							
Peak	16.32 mV	**Frequency**	305.18 kHz	**Peak**	-	**Frequency**	-
Rise Time	642.80 ns	**PD Level**	-	**Rise Time**	-	**PD Level**	-

No of Pulses vs. Pulse Rise-Time	Peak Level in Time
	

Comments
PD not detected. Noise waveforms only.

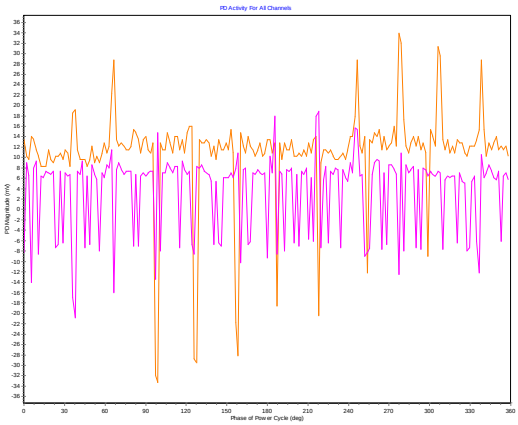
Substation/Site: T-2A-4 **Customer:** City of Tampa

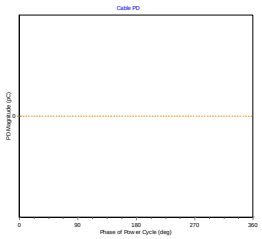
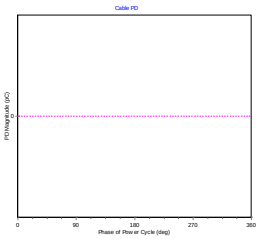
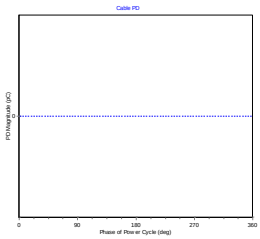
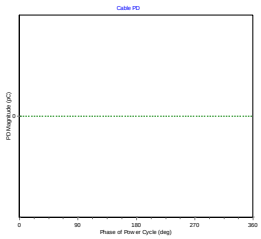
C.E. Testing, Inc.

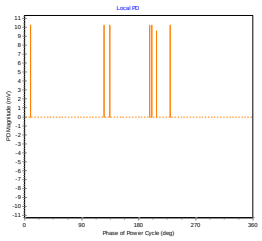
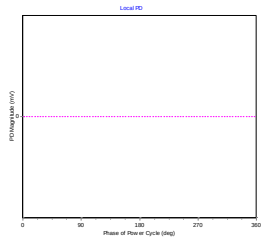
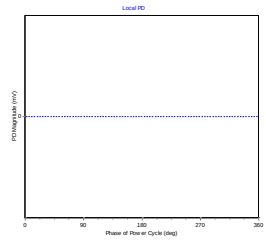
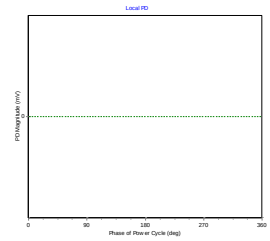
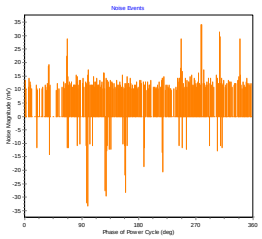
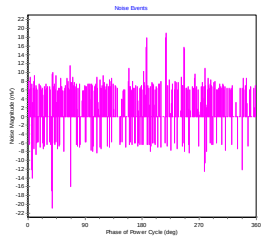
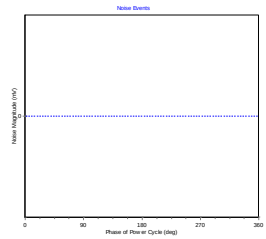
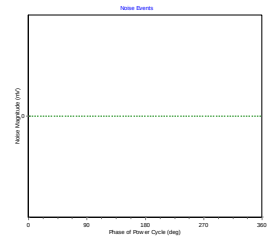
Location: POA 50A **Test Engineer:** Nat Crews/ Louis Nemec

Test No.: **Test Date:** 08/02/2017 10:20:05 AM

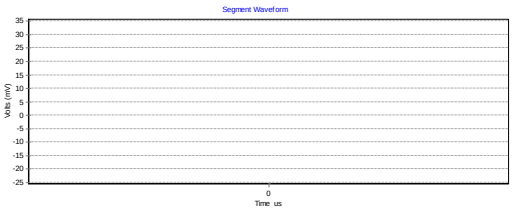
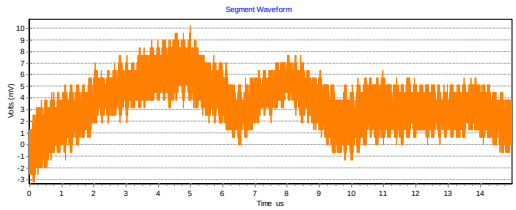
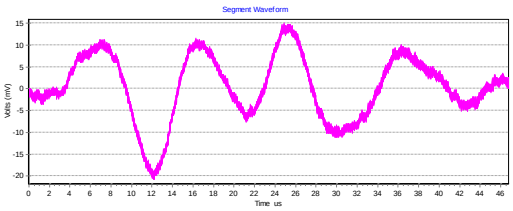
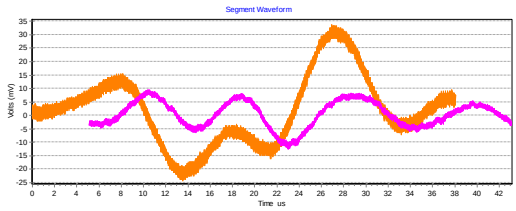
Sensor	Circuit/Description	V(kV)	Cable Type	Local Plant Type
HFCT	phA	13.2kV	Cable	EPR
HFCT	phB	13.2kV	Cable	EPR
HFCT	phC	13.2kV	Cable	EPR
TEV	TEV	13.2kV	Switchgear	Air Insulated

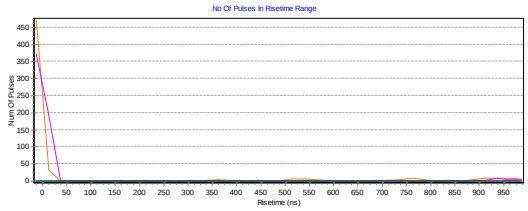
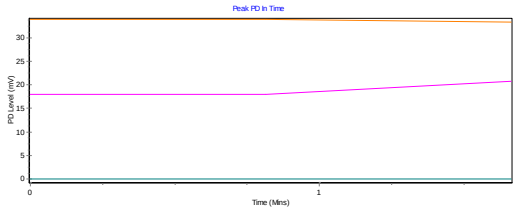
Phase-Resolved Graph (PD and Noise)	Photo of Sensor Attachment
	

	Channel 1		Channel 2		Channel 3		Channel 4	
	Cable PD	0pC	Cable PD	0pC	Cable PD	0pC	Cable PD	0pC
	Local PD	20dB	Local PD	0dB	Local PD	0dB	Local PD	10dB
	Peak	33.92mV	Peak	20.80mV	Peak	0.00mV	Peak	0.00mV
	Std Dev	3.68mV	Std Dev	2.21mV	Std Dev	0.00mV	Std Dev	0.00mV
Cable PD								

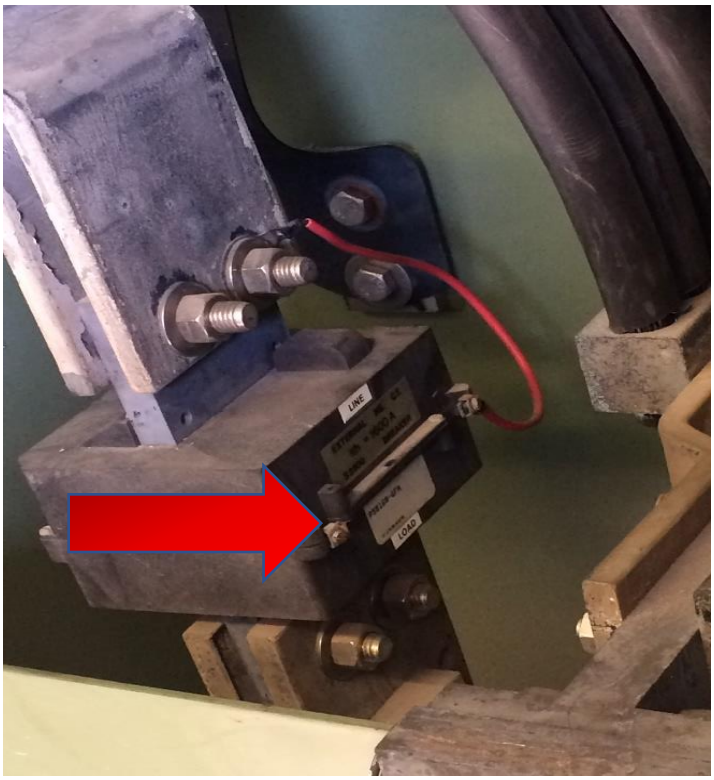
Local PD				
Noise				

Sensor	Circuit/Description	V(kV)	Cable Type	Local Plant Type
HFCT	phA	13.2kV	Cable	EPR
HFCT	phB	13.2kV	Cable	EPR
TEV	phC	13.2kV	Cable	EPR
TEV	TEV	13.2kV	Switchgear	Air Insulated

Cable PD Waveform				Local PD Waveform			
							
Peak		**Frequency**		**Peak**	10.24 mV	**Frequency**	99.61 MHz
Rise Time		**PD Level**		**Rise Time**	179.15 ns	**PD Level**	
Noise Waveform				**Synchronous Waveform**			
							
Peak	-20.80 mV	**Frequency**	106.81 kHz	**Peak**	-	**Frequency**	-
Rise Time	2.00 us	**PD Level**	-	**Rise Time**	-	**PD Level**	-

No of Pulses vs. Pulse Rise-Time	Peak Level in Time
	

Comments
PD not detected. Noise waveforms only.
1. Residual Neutral CT is open circuited on the secondary circuit Recommend short circuit the secondary if not in use.



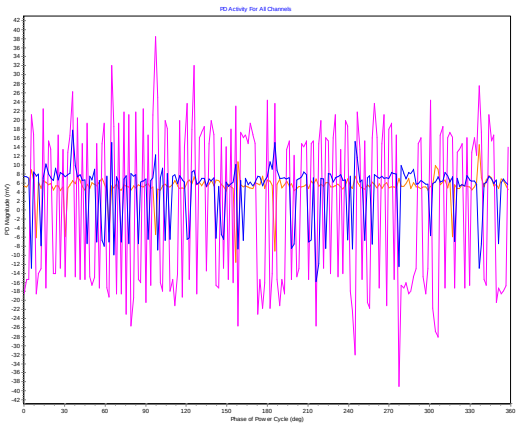
Comment Item 1

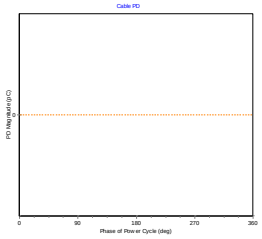
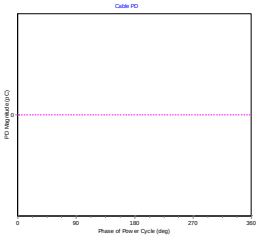
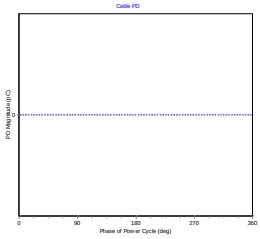
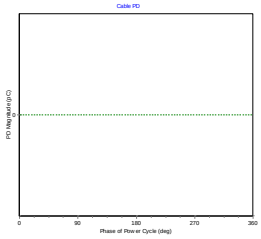
Substation/Site: T-2A-4 **Customer:** City of Tampa

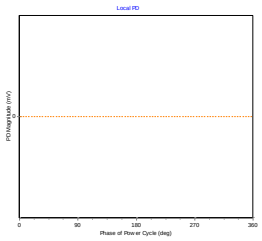
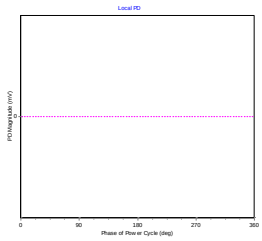
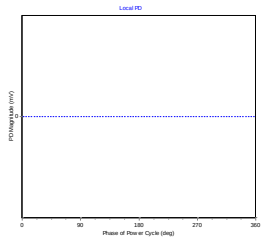
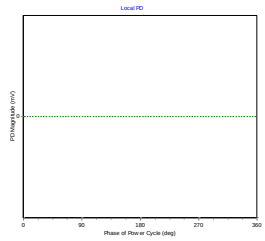
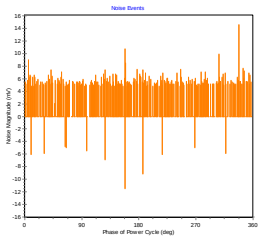
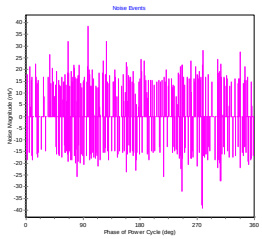
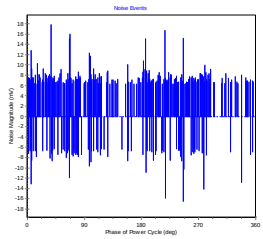
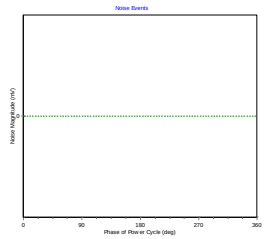
C.E. Testing, Inc.

Location: POA 50B **Test Engineer:** Nat Crews/ Louis Nemec
Test No.: **Test Date:** 08/02/2017 10:27:08 AM

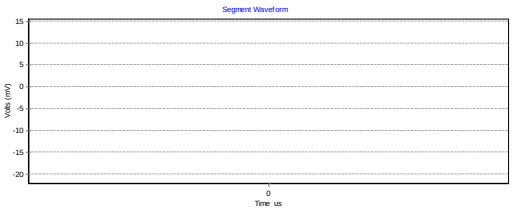
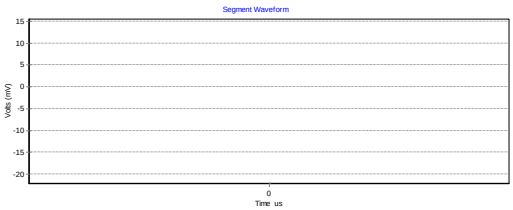
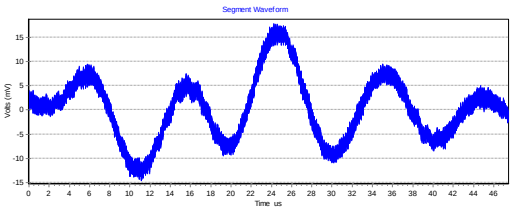
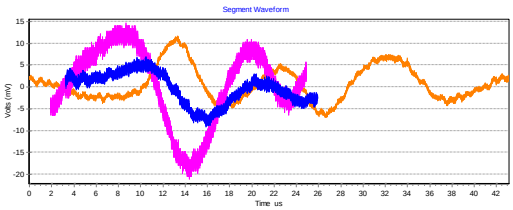
Sensor	Circuit/Description	V(kV)	Cable Type	Local Plant Type
HFCT	PHA	13.2kV	Cable	EPR
HFCT	PHB	13.2kV	Cable	EPR
HFCT	PHC	13.2kV	Cable	EPR
TEV	TEV	13.2kV	Switchgear	Air Insulated

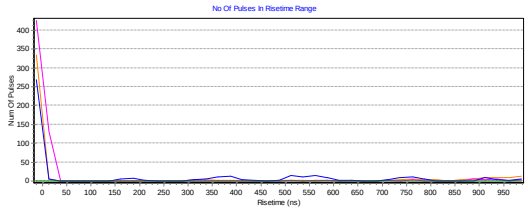
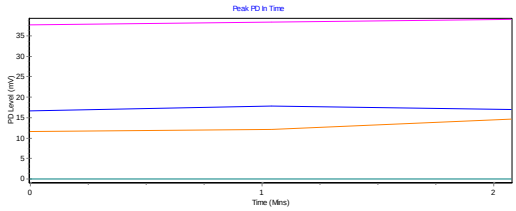
Phase-Resolved Graph (PD and Noise)	Photo of Sensor Attachment
	

	Channel 1		Channel 2		Channel 3		Channel 4	
	Cable PD	0pC	Cable PD	0pC	Cable PD	0pC	Cable PD	0pC
	Local PD	0dB	Local PD	0dB	Local PD	0dB	Local PD	0dB
	Peak	14.56mV	Peak	39.04mV	Peak	17.76mV	Peak	0.00mV
	Std Dev	1.43mV	Std Dev	5.18mV	Std Dev	2.12mV	Std Dev	0.00mV
Cable PD								

Local PD				
Noise				

Sensor	Circuit/Description	V(kV)	Cable Type	Local Plant Type
HFCT	phA	13.2kV	Cable	EPR
HFCT	phB	13.2kV	Cable	EPR
HFCT	phC	13.2kV	Cable	EPR
TEV	TEV	13.2kV	Switchgear	Air Insulated

Cable PD Waveform				Local PD Waveform			
							
Peak		**Frequency**		**Peak**		**Frequency**	
Rise Time		**PD Level**		**Rise Time**		**PD Level**	
Noise Waveform				**Synchronous Waveform**			
							
Peak	17.76 mV	**Frequency**	106.81 kHz	**Peak**	-	**Frequency**	-
Rise Time	1.69 us	**PD Level**	-	**Rise Time**	-	**PD Level**	-

No of Pulses vs. Pulse Rise-Time	Peak Level in Time
	

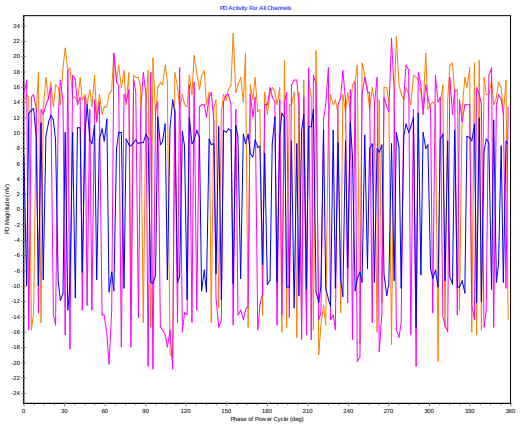
Comments
PD not detected. Noise waveforms only.

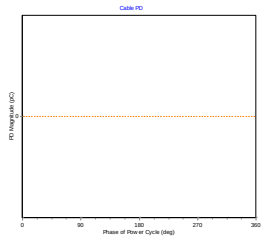
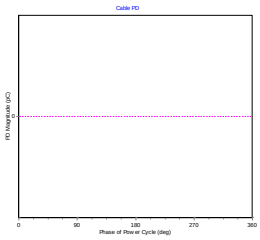
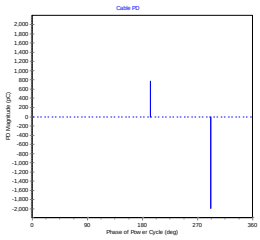
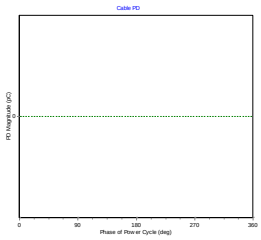
Substation/Site: T-2B-1A
Location: POA 31A
Test No.:

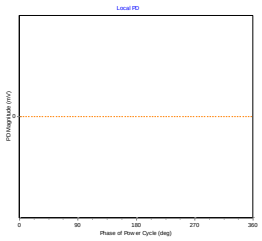
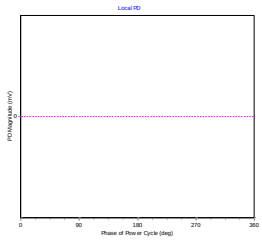
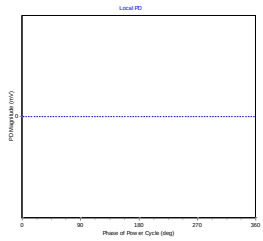
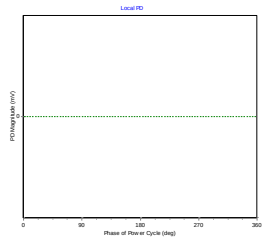
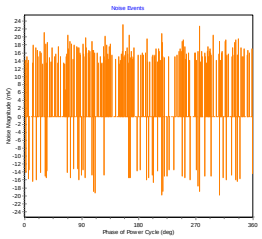
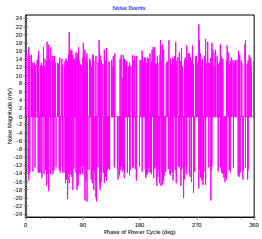
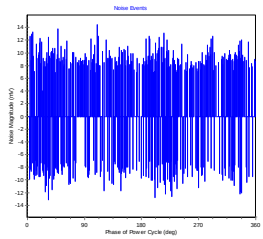
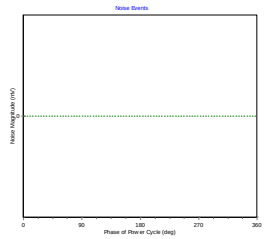
Customer: City of Tampa
Test Engineer: Nat Crews/ Louis Nemec
Test Date: 08/02/2017 11:09:04 AM

C.E. Testing, Inc.

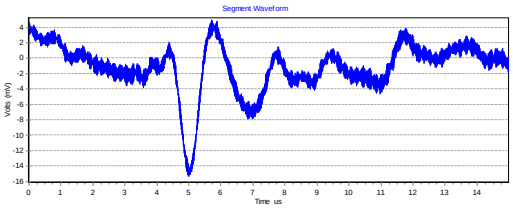
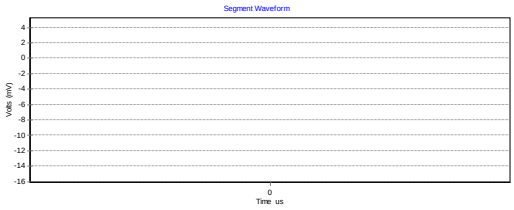
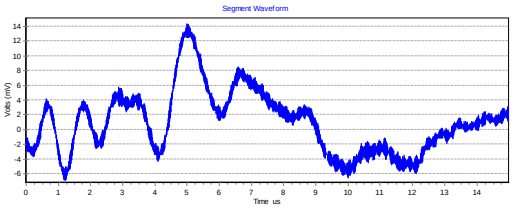
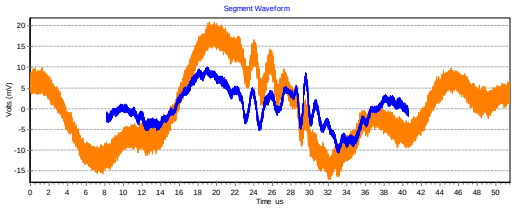
Sensor	Circuit/Description	V(kV)	Cable Type	Local Plant Type
HFCT	phA	13.2kV	Cable	EPR
HFCT	phB	13.2kV	Cable	EPR
HFCT	phC	13.2kV	Cable	EPR
TEV	TEV	13.2kV	Switchgear	Air Insulated

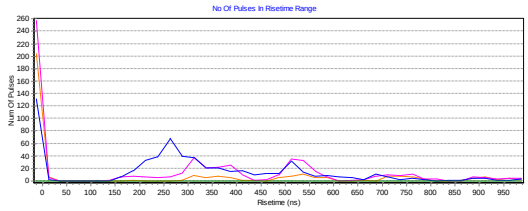
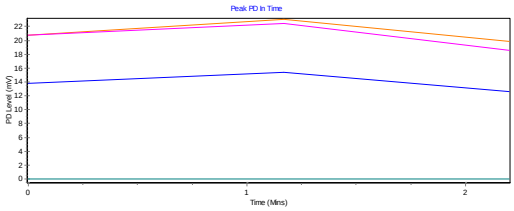
Phase-Resolved Graph (PD and Noise)	Photo of Sensor Attachment
	

	Channel 1		Channel 2		Channel 3		Channel 4	
	Cable PD	0pC	Cable PD	0pC	Cable PD	1986pC	Cable PD	0pC
	Local PD	0dB	Local PD	0dB	Local PD	0dB	Local PD	13dB
	Peak	23.04mV	Peak	22.40mV	Peak	15.36mV	Peak	0.00mV
	Std Dev	4.40mV	Std Dev	4.07mV	Std Dev	2.28mV	Std Dev	0.00mV
Cable PD								

Local PD				
Noise				

Sensor	Circuit/Description	V(kV)	Cable Type	Local Plant Type
HFCT	phA	13.2kV	Cable	EPR
HFCT	phB	13.2kV	Cable	EPR
HFCT	phC	13.2kV	Cable	EPR
TEV	TEV	13.2kV	Switchgear	Air Insulated

Cable PD Waveform				Local PD Waveform			
							
Peak	-15.36 mV	**Frequency**	488.28 kHz	**Peak**		**Frequency**	
Rise Time	340.95 ns	**PD Level**	-1.99 nC	**Rise Time**		**PD Level**	
Noise Waveform				**Synchronous Waveform**			
							
Peak	14.40 mV	**Frequency**	122.07 kHz	**Peak**	-	**Frequency**	-
Rise Time	467.45 ns	**PD Level**	-	**Rise Time**	-	**PD Level**	-

No of Pulses vs. Pulse Rise-Time	Peak Level in Time
	

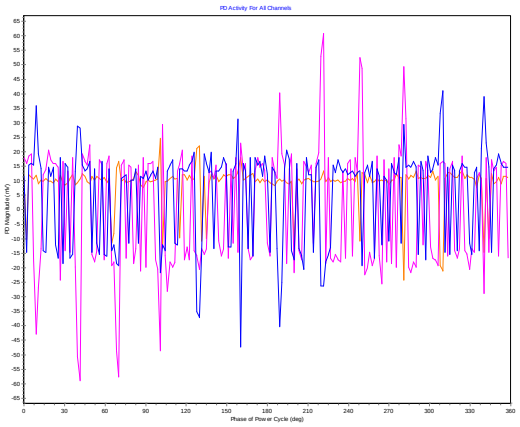
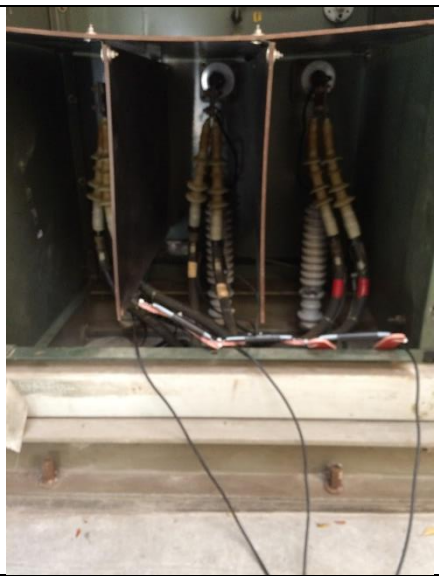
Comments
PD not detected. Noise waveforms only.

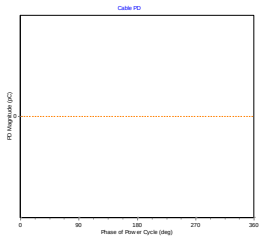
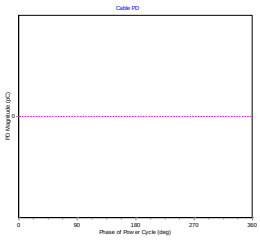
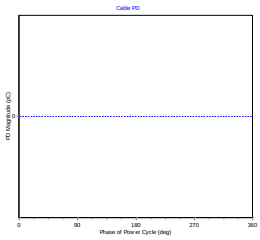
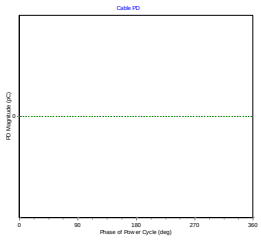
Substation/Site: T-2A-1A
Location: POA 30A
Test No.:

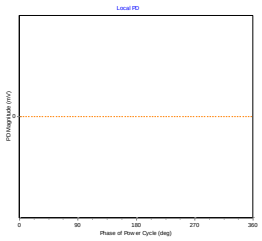
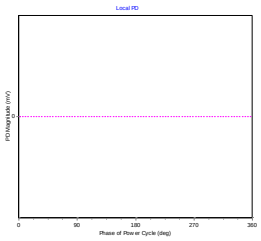
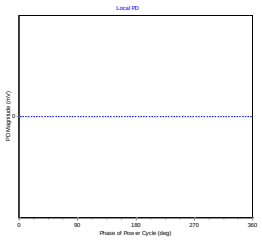
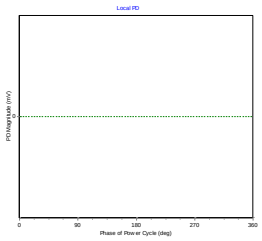
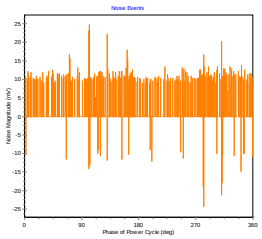
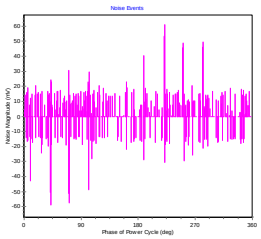
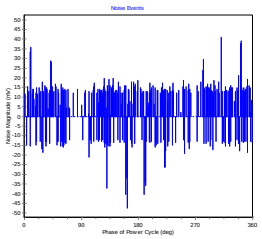
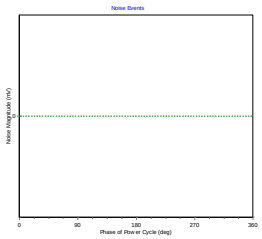
Customer: City of Tampa
Test Engineer: Nat Crews/ Louis Nemec
Test Date: 08/02/2017 11:30:25 AM

C.E. Testing, Inc.

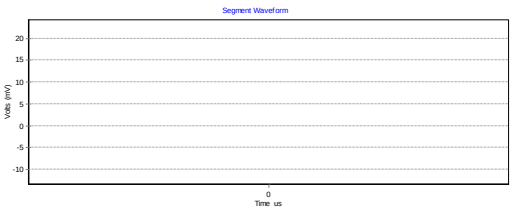
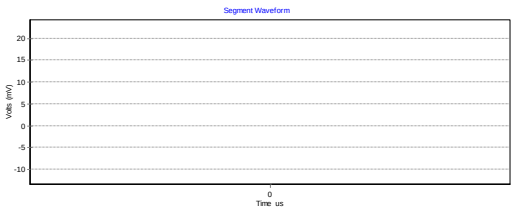
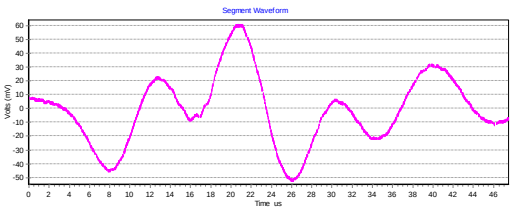
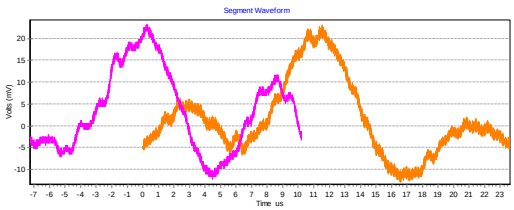
Sensor	Circuit/Description	V(kV)	Cable Type	Local Plant Type
HFCT	phA	13.2kV	Cable	EPR
HFCT	phB	13.2kV	Cable	EPR
HFCT	phC	13.2kV	Cable	EPR
N/A	TEV	13.2kV	Switchgear	Air Insulated

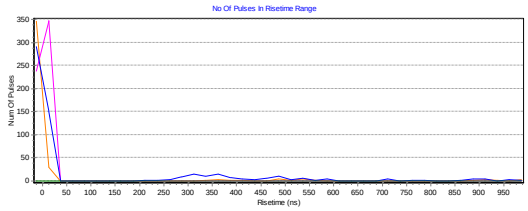
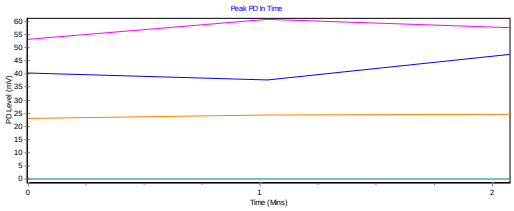
Phase-Resolved Graph (PD and Noise)	Photo of Sensor Attachment
	

	Channel 1		Channel 2		Channel 3		Channel 4	
	Cable PD	0pC	Cable PD	0pC	Cable PD	0pC	Cable PD	0pC
	Local PD	0dB	Local PD	0dB	Local PD	0dB	Local PD	0dB
	Peak	24.64mV	Peak	60.80mV	Peak	47.36mV	Peak	0.00mV
	Std Dev	2.90mV	Std Dev	6.13mV	Std Dev	4.59mV	Std Dev	0.00mV
Cable PD								

Local PD				
Noise				

Sensor	Circuit/Description	V(kV)	Cable Type	Local Plant Type
HFCT	phA	13.2kV	Cable	EPR
HFCT	phB	13.2kV	Cable	EPR
HFCT	phC	13.2kV	Cable	EPR
N/A	TEV	13.2kV	Switchgear	Air Insulated

Cable PD Waveform				Local PD Waveform			
							
Peak		**Frequency**		**Peak**		**Frequency**	
Rise Time		**PD Level**		**Rise Time**		**PD Level**	
Noise Waveform				**Synchronous Waveform**			
							
Peak	60.80 mV	**Frequency**	45.78 kHz	**Peak**	-	**Frequency**	-
Rise Time	2.48 us	**PD Level**	-	**Rise Time**	-	**PD Level**	-

No of Pulses vs. Pulse Rise-Time	Peak Level in Time
	

Comments
PD not detected. Noise waveforms only.

Substation/Site:	T-2A-1A	**Customer:**	City of Tampa
Location:	POA 30B	**Test Engineer:**	Nat Crews/ Louis Nemec
Test No.:		**Test Date:**	08/02/2017 11:35:15 AM

C.E. Testing, Inc.

Sensor	Circuit/Description	V(kV)	Cable Type	Local Plant Type
HFCT	PHA	13.2kV	Cable	EPR
HFCT	PHB	13.2kV	Cable	EPR
HFCT	PHC	13.2kV	Cable	EPR
TEV	TEV	13.2kV	Switchgear	Air Insulated

Phase-Resolved Graph (PD and Noise)

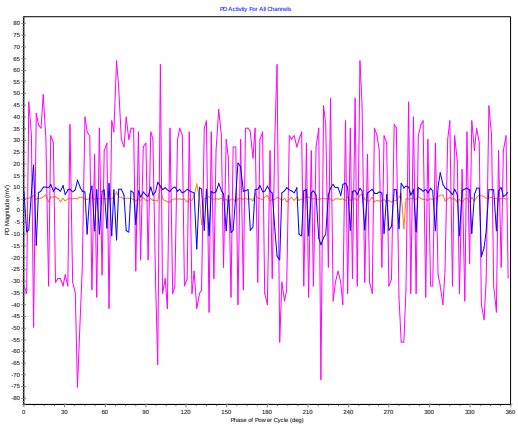
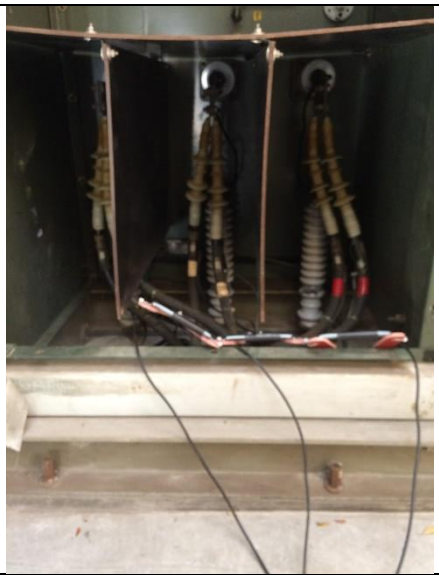
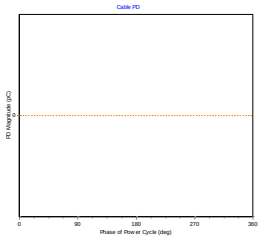
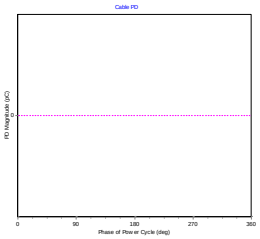
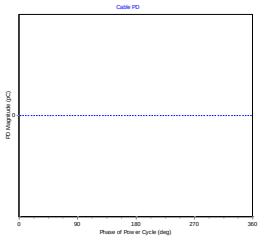
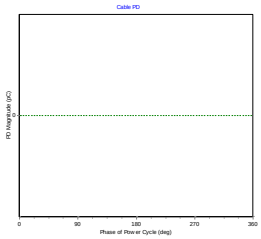
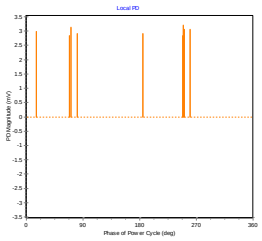
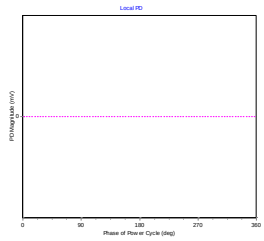
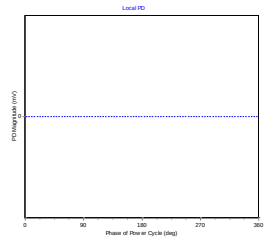
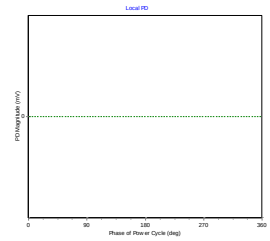
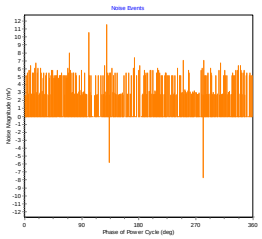
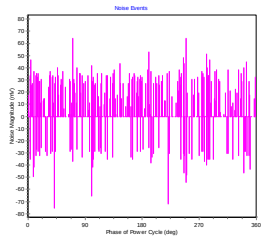
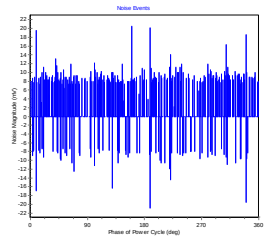
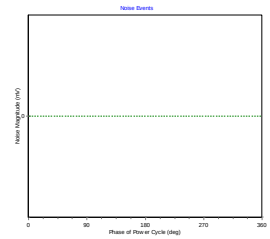


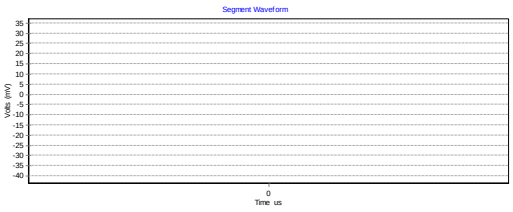
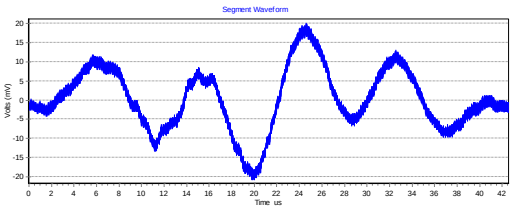
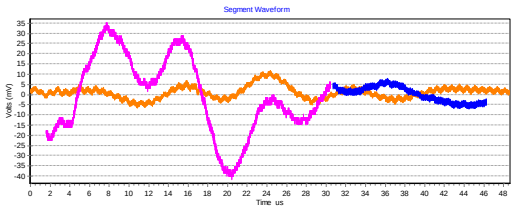
Photo of Sensor Attachment

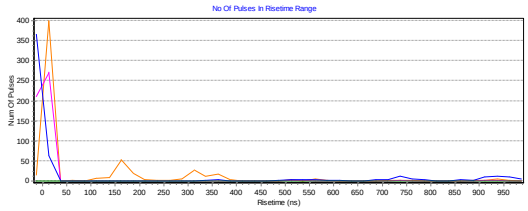
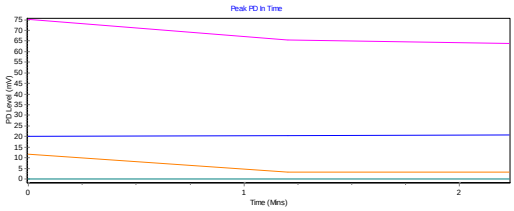


	Channel 1		Channel 2		Channel 3		Channel 4	
	Cable PD	0pC	Cable PD	0pC	Cable PD	0pC	Cable PD	0pC
	Local PD	10dB	Local PD	0dB	Local PD	0dB	Local PD	0dB
	Peak	11.52mV	Peak	75.20mV	Peak	20.80mV	Peak	0.00mV
	Std Dev	0.88mV	Std Dev	10.92mV	Std Dev	2.62mV	Std Dev	0.00mV
Cable PD								

Local PD				
Noise				

Sensor	Circuit/Description	V(kV)	Cable Type	Local Plant Type
HFCT	phA	13.2kV	Cable	EPR
HFCT	phB	13.2kV	Cable	EPR
HFCT	phC	13.2kV	Cable	EPR
TEV	TEV	13.2kV	Switchgear	Air Insulated

Cable PD Waveform				Local PD Waveform			
							
Peak		**Frequency**		**Peak**	3.20 mV	**Frequency**	100.00 MHz
Rise Time		**PD Level**		**Rise Time**	12.67 ns	**PD Level**	
Noise Waveform				**Synchronous Waveform**			
							
Peak	-20.80 mV	**Frequency**	106.81 kHz	**Peak**	-	**Frequency**	-
Rise Time	1.96 us	**PD Level**	-	**Rise Time**	-	**PD Level**	-

No of Pulses vs. Pulse Rise-Time	Peak Level in Time
	

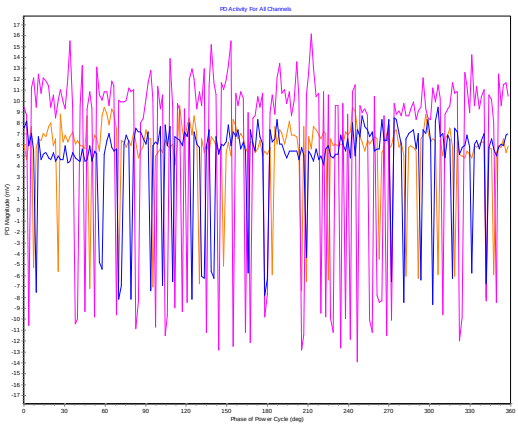
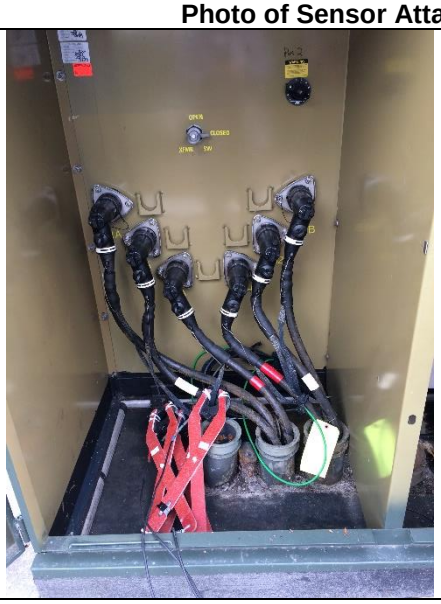
Comments
PD not detected. Noise waveforms only.

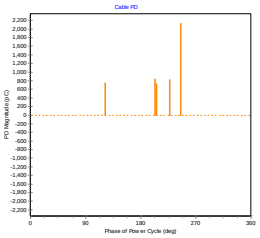
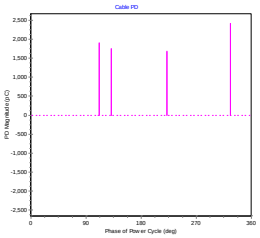
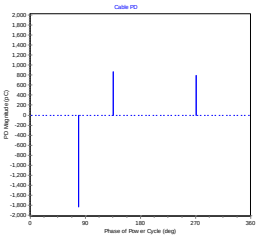
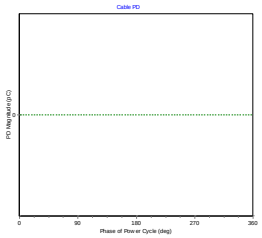
Substation/Site: T-2B-1
Location: POA 28A
Test No.:

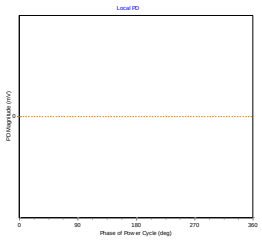
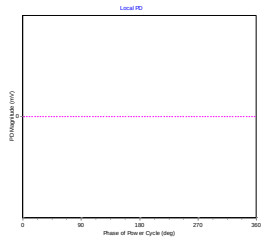
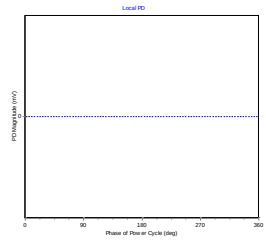
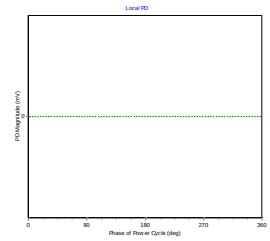
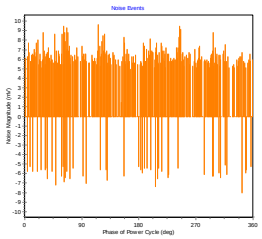
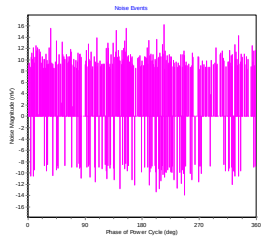
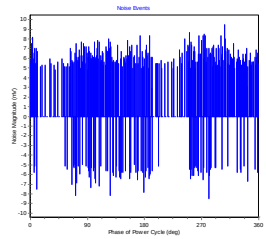
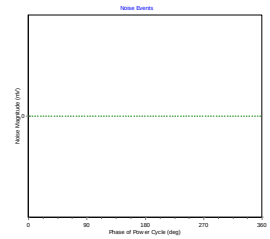
Customer: City of Tampa
Test Engineer: Nat Crews/ Louis Nemec
Test Date: 08/02/2017 1:36:47 PM

C.E. Testing, Inc.

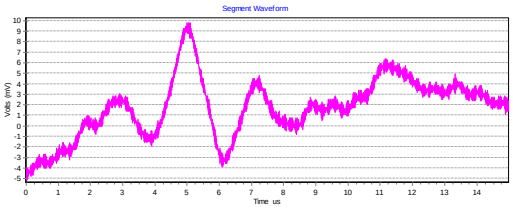
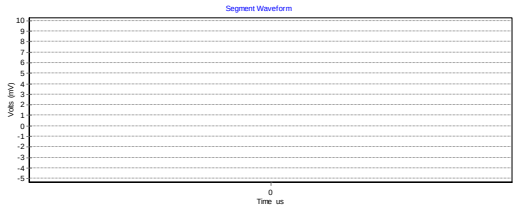
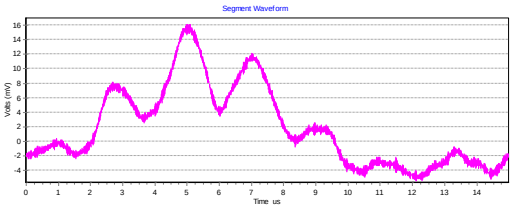
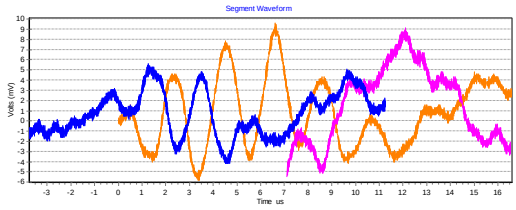
Sensor	Circuit/Description	V(kV)	Cable Type	Local Plant Type
HFCT	PHA	13.2kV	Cable	EPR
HFCT	PHB	13.2kV	Cable	EPR
HFCT	PHC	13.2kV	Cable	EPR
TEV	TEV	13.2kV	Switchgear	Air Insulated

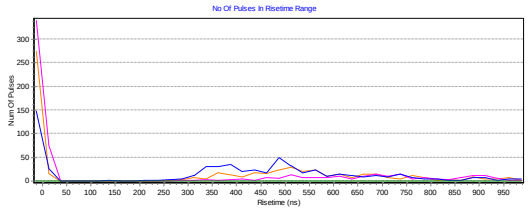
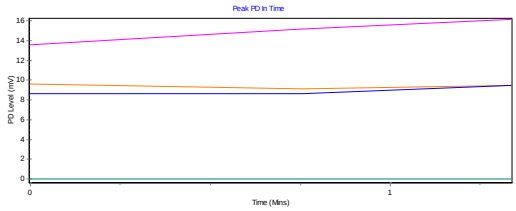
Phase-Resolved Graph (PD and Noise)	Photo of Sensor Attachment
	

	Channel 1		Channel 2		Channel 3		Channel 4	
	Cable PD	2124pC	Cable PD	2412pC	Cable PD	1831pC	Cable PD	0pC
	Local PD	0dB	Local PD	0dB	Local PD	0dB	Local PD	9dB
	Peak	9.60mV	Peak	16.16mV	Peak	9.44mV	Peak	0.00mV
	Std Dev	1.64mV	Std Dev	2.98mV	Std Dev	1.58mV	Std Dev	0.00mV
Cable PD								

Local PD				
Noise				

Sensor	Circuit/Description	V(kV)	Cable Type	Local Plant Type
HFCT	phA	13.2kV	Cable	EPR
HFCT	phB	13.2kV	Cable	EPR
HFCT	phC	13.2kV	Cable	EPR
TEV	TEV	13.2kV	Switchgear	Air Insulated

Cable PD Waveform				Local PD Waveform			
							
Peak	9.76 mV	**Frequency**	244.14 kHz	**Peak**		**Frequency**	
Rise Time	508.94 ns	**PD Level**	1.76 nC	**Rise Time**		**PD Level**	
Noise Waveform				**Synchronous Waveform**			
							
Peak	16.16 mV	**Frequency**	61.04 kHz	**Peak**	-	**Frequency**	-
Rise Time	827.28 ns	**PD Level**	-	**Rise Time**	-	**PD Level**	-

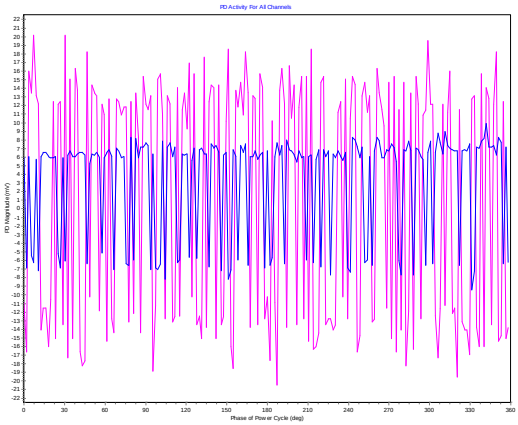
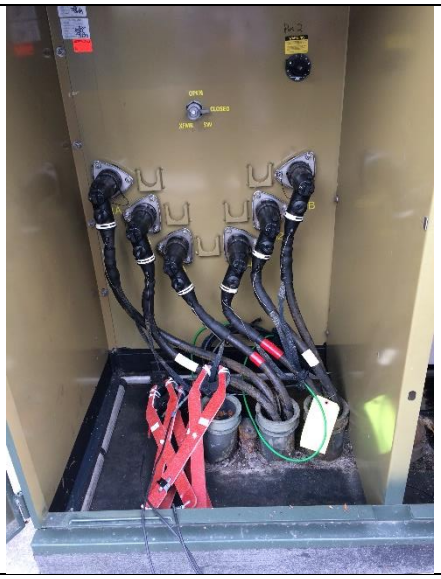
No of Pulses vs. Pulse Rise-Time	Peak Level in Time
	

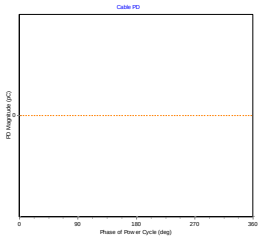
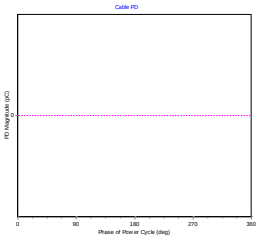
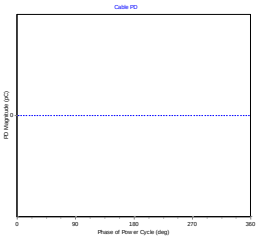
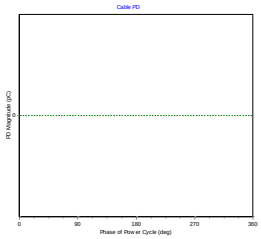
Comments
PD not detected. Noise waveforms only.

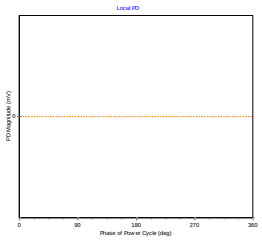
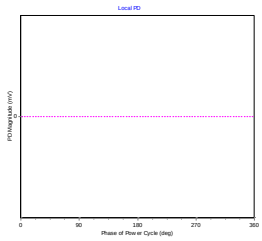
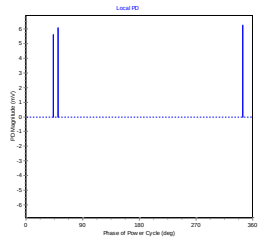
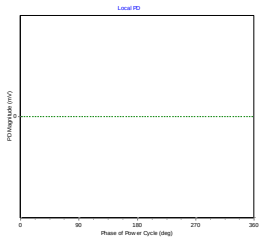
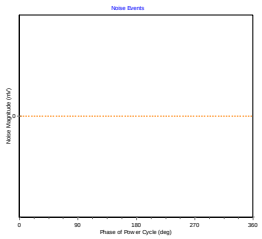
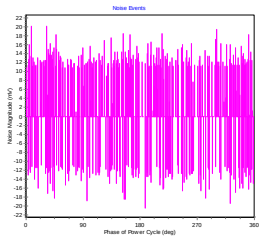
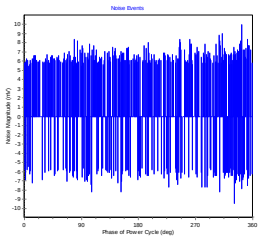
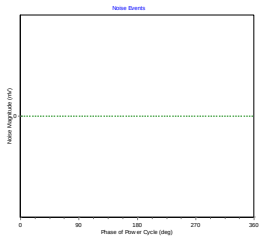
Substation/Site:	T-2B-1	**Customer:**	City of Tampa
Location:	POA 28B	**Test Engineer:**	Nat Crews/ Louis Nemec
Test No.:		**Test Date:**	08/02/2017 1:45:46 PM

C.E. Testing, Inc.

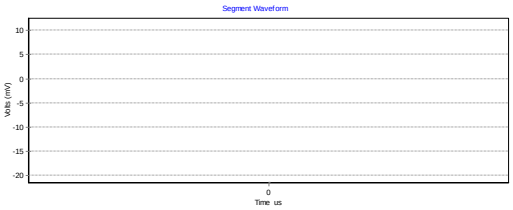
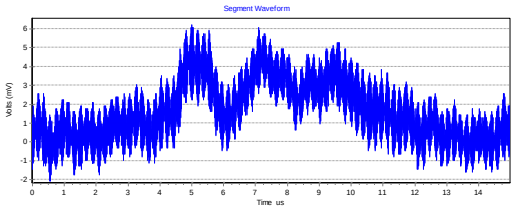
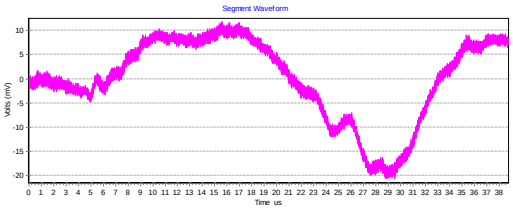
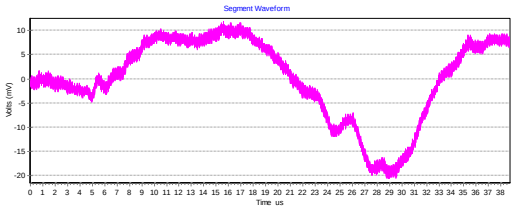
Sensor	Circuit/Description	V(kV)	Cable Type	Local Plant Type
N/A	N/A	13.2kV	Cable	EPR
HFCT	PHB	13.2kV	Cable	EPR
HFCT	PHC	13.2kV	Cable	EPR
TEV	TEV	13.2kV	Switchgear	Air Insulated

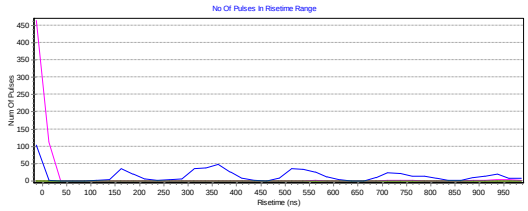
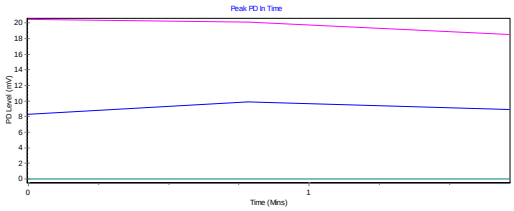
Phase-Resolved Graph (PD and Noise)	Photo of Sensor Attachment
	

	Channel 1		Channel 2		Channel 3		Channel 4	
	Cable PD	0pC	Cable PD	0pC	Cable PD	0pC	Cable PD	0pC
	Local PD	0dB	Local PD	0dB	Local PD	16dB	Local PD	9dB
	Peak	0.00mV	Peak	20.48mV	Peak	9.92mV	Peak	0.00mV
	Std Dev	0.00mV	Std Dev	4.32mV	Std Dev	1.70mV	Std Dev	0.00mV
Cable PD								

Local PD				
Noise				

Sensor	Circuit/Description	V(kV)	Cable Type	Local Plant Type
N/A	N/A	13.2kV	Cable	EPR
HFCT	phB	13.2kV	Cable	EPR
HFCT	phC	13.2kV	Cable	EPR
TEV	TEV	13.2kV	Switchgear	Air Insulated

Cable PD Waveform				Local PD Waveform			
							
Peak		**Frequency**		**Peak**	6.24 mV	**Frequency**	99.49 MHz
Rise Time		**PD Level**		**Rise Time**	298.33 ns	**PD Level**	
Noise Waveform				**Synchronous Waveform**			
							
Peak	-20.48 mV	**Frequency**	30.52 kHz	**Peak**	-	**Frequency**	-
Rise Time	4.49 us	**PD Level**	-	**Rise Time**	-	**PD Level**	-

No of Pulses vs. Pulse Rise-Time	Peak Level in Time
	

Comments
PD not detected. Noise waveforms only.

C.E. Testing, Inc.

Substation/Site:	T-2A-1	**Customer:**	**City of Tampa**
Location:	POA 29 A	**Test Engineer:**	**Nat Crews/ Louis Nemec**
Test No.:		**Test Date:**	**08/02/2017 1:51:54 PM**

Sensor	Circuit/Description	V(kV)	Cable Type	Local Plant Type
HFCT	PHA	13.2kV	Cable	EPR
HFCT	PHB	13.2kV	Cable	EPR
HFCT	PHC	13.2kV	Cable	EPR
TEV	TEV	13.2kV	Switchgear	Solid Insulated

Phase-Resolved Graph (PD and Noise)

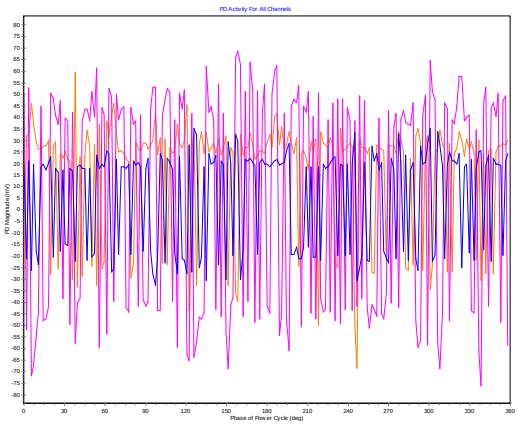
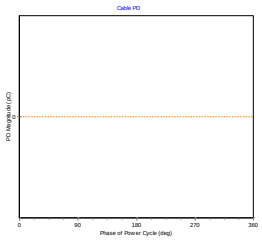
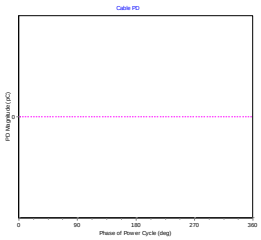
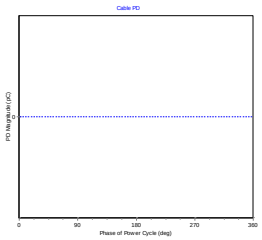
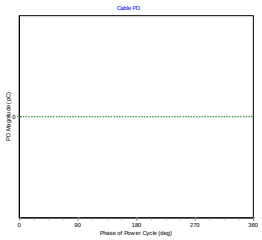
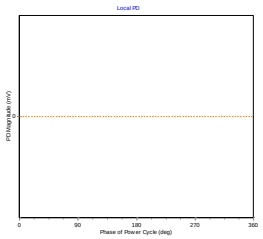
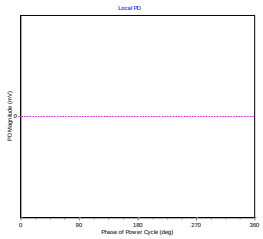
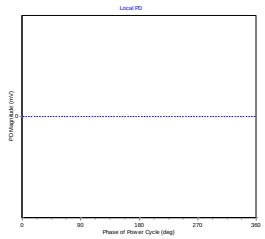
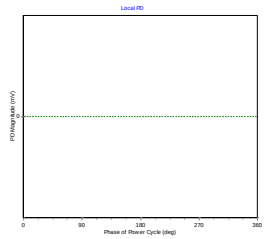
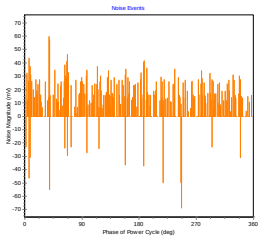
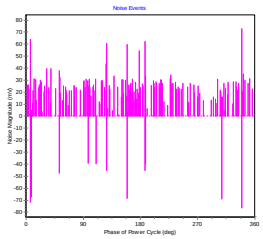
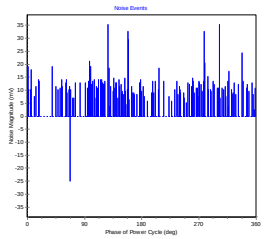
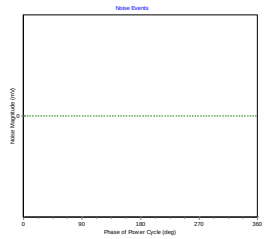
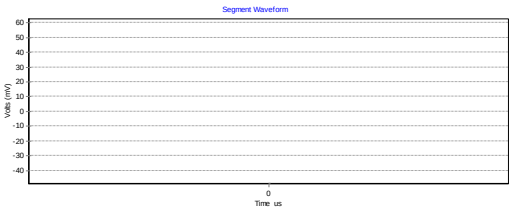
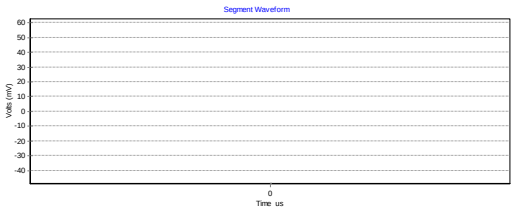
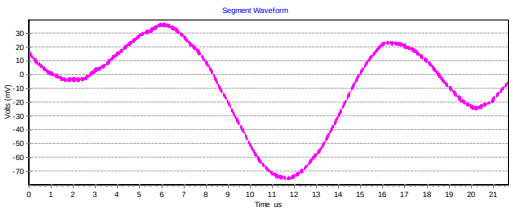
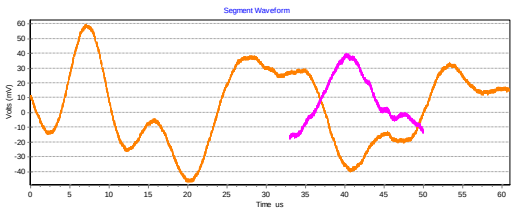


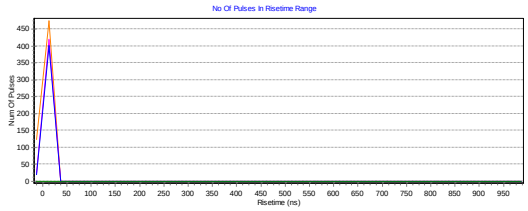
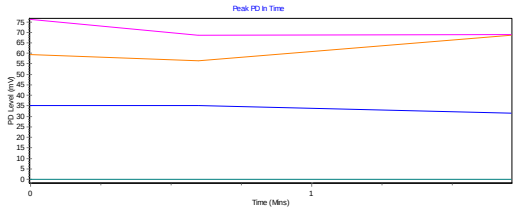
Photo of Sensor Attachment

	Channel 1		Channel 2		Channel 3		Channel 4	
	Cable PD	0pC	Cable PD	0pC	Cable PD	0pC	Cable PD	0pC
	Local PD	0dB	Local PD	0dB	Local PD	0dB	Local PD	0dB
	Peak	68.48mV	Peak	76.16mV	Peak	35.20mV	Peak	0.00mV
	Std Dev	9.30mV	Std Dev	15.99mV	Std Dev	7.00mV	Std Dev	0.00mV
Cable PD								

Local PD				
Noise				

Sensor	Circuit/Description	V(kV)	Cable Type	Local Plant Type
HFCT	phA	13.2kV	Cable	EPR
HFCT	phB	13.2kV	Cable	EPR
HFCT	phC	13.2kV	Cable	EPR
N/A	TEV	13.2kV	Switchgear	Air Insulated

Cable PD Waveform				Local PD Waveform			
							
Peak		**Frequency**		**Peak**		**Frequency**	
Rise Time		**PD Level**		**Rise Time**		**PD Level**	
Noise Waveform				**Synchronous Waveform**			
							
Peak	-76.16 mV	**Frequency**	91.55 kHz	**Peak**	-	**Frequency**	-
Rise Time	2.76 us	**PD Level**	-	**Rise Time**	-	**PD Level**	-

No of Pulses vs. Pulse Rise-Time	Peak Level in Time
	

Comments
PD not detected. Noise waveforms only. POA 29A: CT for the winding temperature gauge short-circuited. Recommend investigating reason for this.

C.E. Testing, Inc.

Substation/Site: T-2A-1 B
Location: POA 29 B
Test No.:

Customer: City of Tampa
Test Engineer: Nat Crews/ Louis Nemec
Test Date: 08/02/2017 1:56:31 PM

Sensor	Circuit/Description	V(kV)	Cable Type	Local Plant Type
HFCT	phA	13.2kV	Cable	EPR
HFCT	phB	13.2kV	Cable	EPR
HFCT	phC	13.2kV	Cable	EPR
TEV	TEV	13.2kV	Switchgear	Air Insulated

Phase-Resolved Graph (PD and Noise)

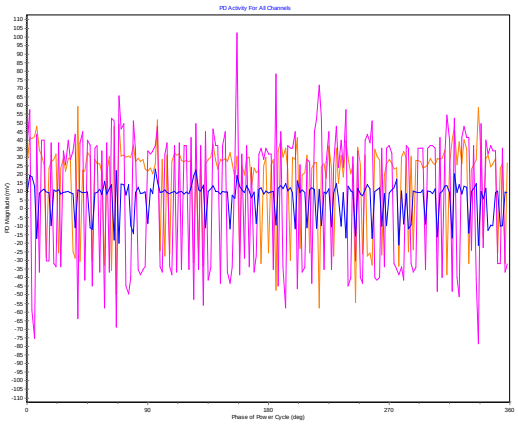
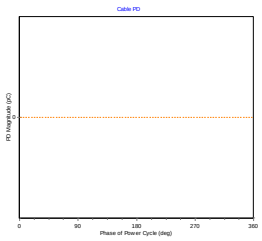
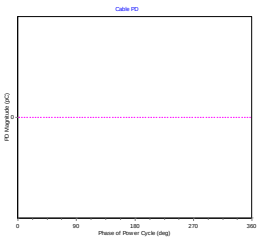
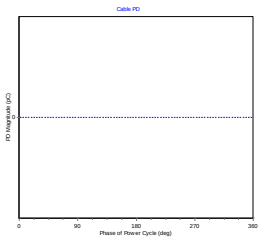
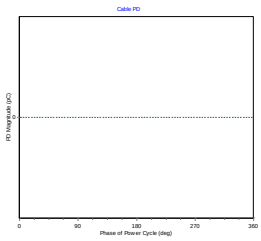
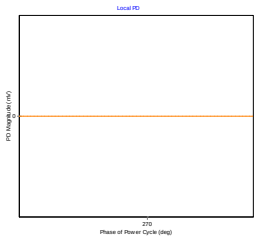
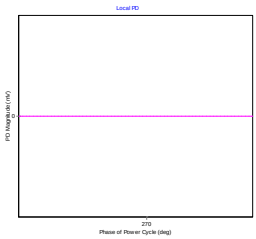
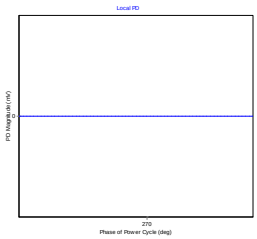
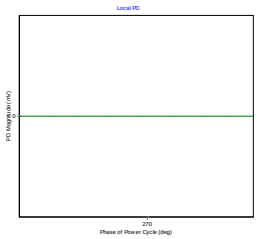
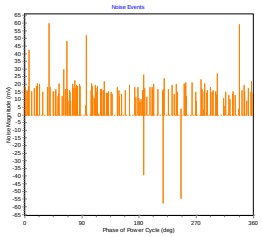
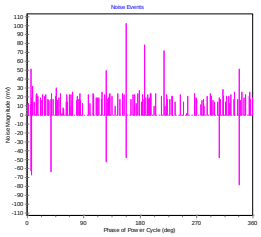
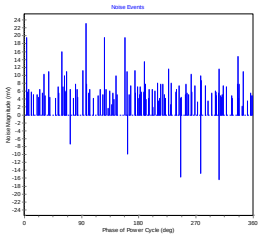
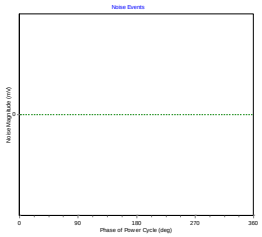
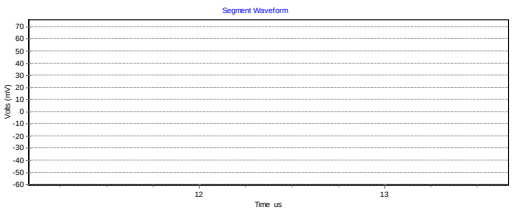
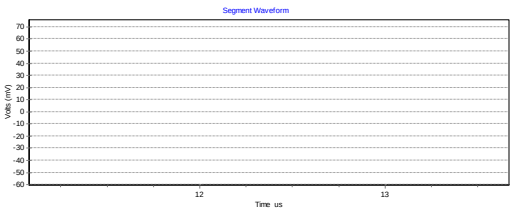
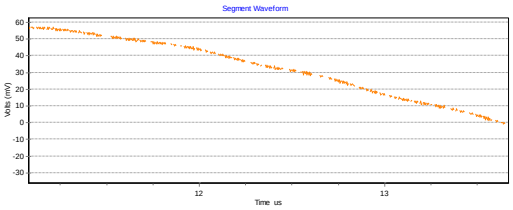
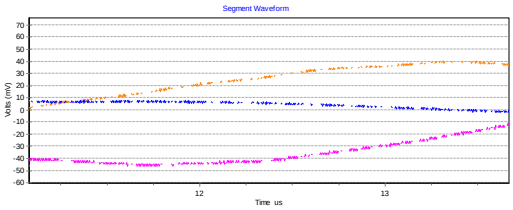


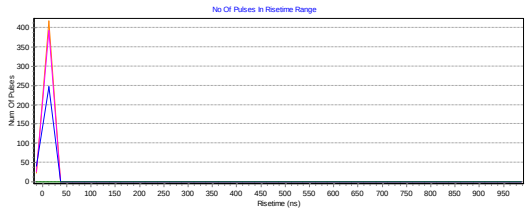
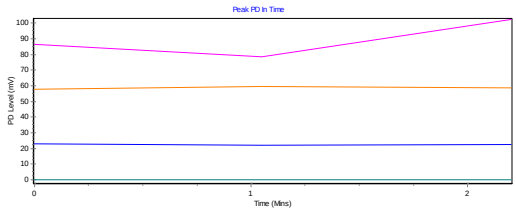
Photo of Sensor Attachment

	Channel 1		Channel 2		Channel 3		Channel 4	
	Cable PD	0pC	Cable PD	0pC	Cable PD	0pC	Cable PD	0pC
	Local PD	0dB	Local PD	0dB	Local PD	0dB	Local PD	0dB
	Peak	59.52mV	Peak	102.40mV	Peak	23.04mV	Peak	0.00mV
	Std Dev	9.14mV	Std Dev	12.28mV	Std Dev	3.42mV	Std Dev	0.00mV
Cable PD								

Local PD				
Noise				

Sensor	Circuit/Description	V(kV)	Cable Type	Local Plant Type
HFCT	phA	13.2kV	Cable	EPR
HFCT	phB	13.2kV	Cable	EPR
HFCT	phC	13.2kV	Cable	EPR
TEV	TEV	13.2kV	Switchgear	Air Insulated

Cable PD Waveform				Local PD Waveform			
							
Peak		**Frequency**		**Peak**		**Frequency**	
Rise Time		**PD Level**		**Rise Time**		**PD Level**	
Noise Waveform				**Synchronous Waveform**			
							
Peak	59.52 mV	**Frequency**	91.55 kHz	**Peak**	-	**Frequency**	-
Rise Time	1.96 us	**PD Level**	-	**Rise Time**	-	**PD Level**	-

No of Pulses vs. Pulse Rise-Time	Peak Level in Time
	

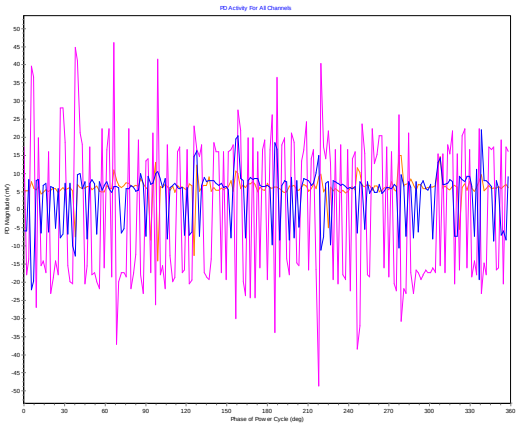
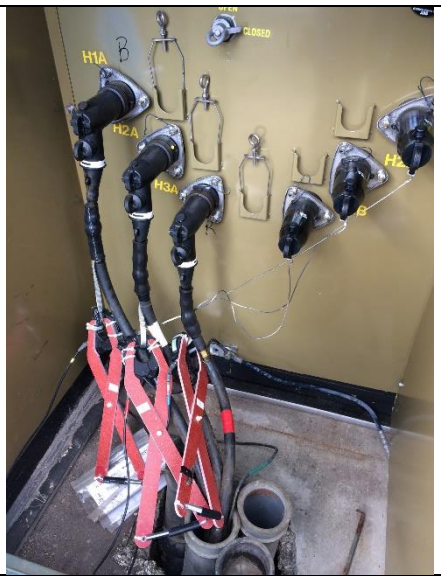
Comments
PD not detected. Noise waveforms.

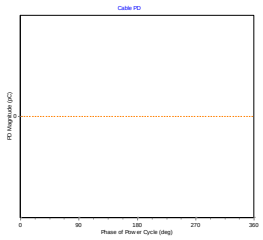
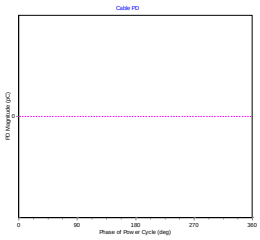
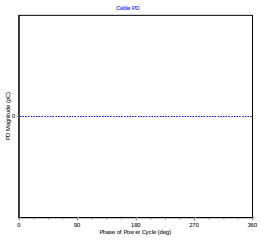
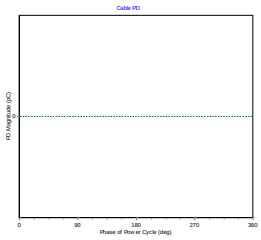
Substation/Site: T-2A-2
Location: POA 84
Test No.:

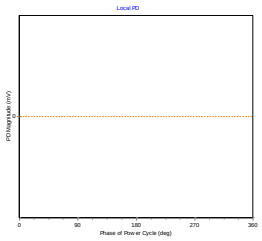
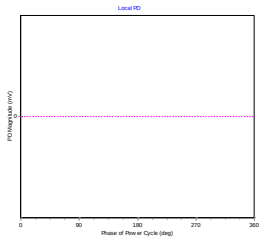
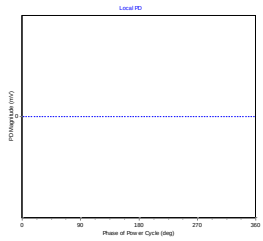
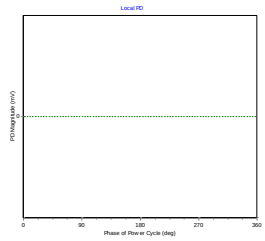
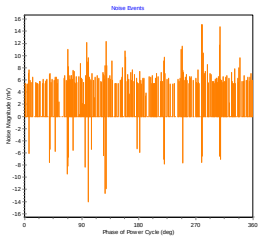
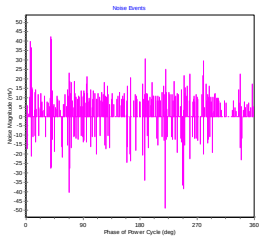
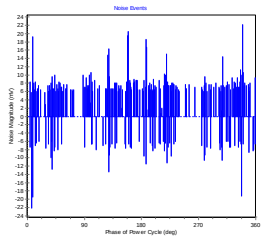
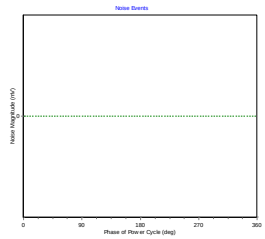
Customer: City of Tampa
Test Engineer: Nat Crews/ Louis Nemec
Test Date: 08/02/2017 2:13:28 PM

C.E. Testing, Inc.

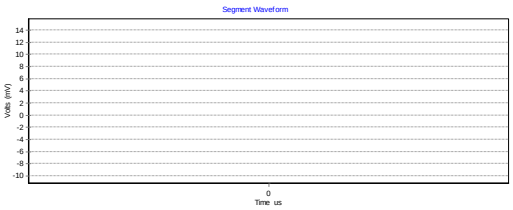
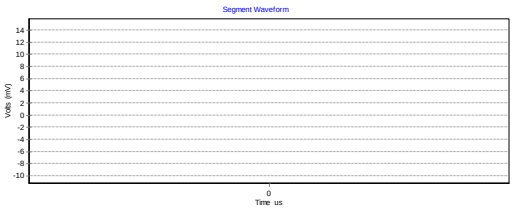
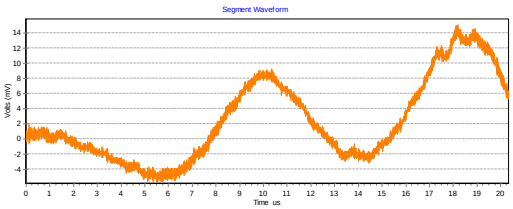
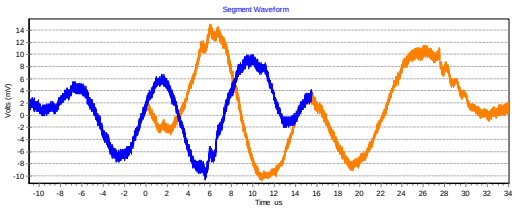
Sensor	Circuit/Description	V(kV)	Cable Type	Local Plant Type
HFCT	phA	13.2kV	Cable	EPR
HFCT	phB	13.2kV	Cable	EPR
HFCT	phC	13.2kV	Cable	EPR
TEV	TEV	13.2kV	Switchgear	Air Insulated

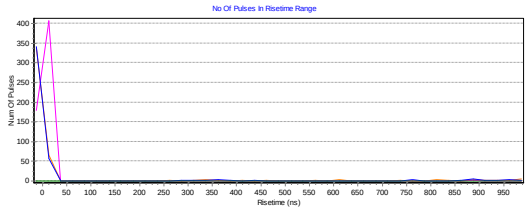
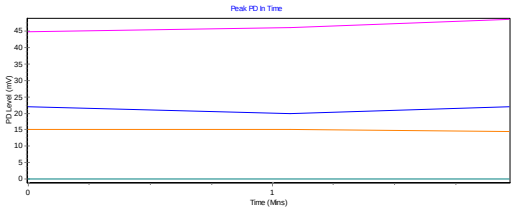
Phase-Resolved Graph (PD and Noise)	Photo of Sensor Attachment
	

	Channel 1		Channel 2		Channel 3		Channel 4	
	Cable PD	0pC	Cable PD	0pC	Cable PD	0pC	Cable PD	0pC
	Local PD	0dB	Local PD	0dB	Local PD	0dB	Local PD	9dB
	Peak	15.04mV	Peak	48.64mV	Peak	22.08mV	Peak	0.00mV
	Std Dev	1.70mV	Std Dev	5.90mV	Std Dev	2.26mV	Std Dev	0.00mV
Cable PD								

Local PD				
Noise				

Sensor	Circuit/Description	V(kV)	Cable Type	Local Plant Type
HFCT	phA	13.2kV	Cable	EPR
HFCT	phB	13.2kV	Cable	EPR
HFCT	phC	13.2kV	Cable	EPR
TEV	TEV	13.2kV	Switchgear	Air Insulated

Cable PD Waveform				Local PD Waveform			
							
Peak		**Frequency**		**Peak**		**Frequency**	
Rise Time		**PD Level**		**Rise Time**		**PD Level**	
Noise Waveform				**Synchronous Waveform**			
							
Peak	15.04 mV	**Frequency**	122.07 kHz	**Peak**	-	**Frequency**	-
Rise Time	0.00 ps	**PD Level**	-	**Rise Time**	-	**PD Level**	-

No of Pulses vs. Pulse Rise-Time	Peak Level in Time
	

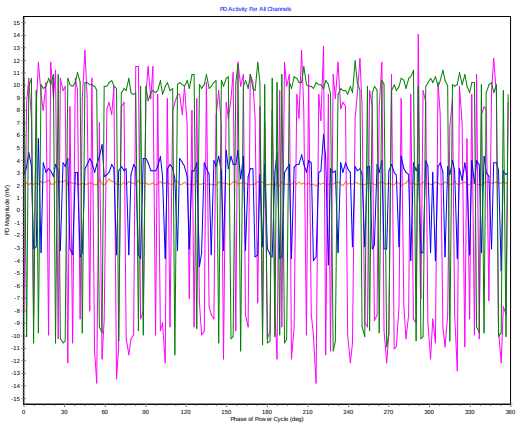
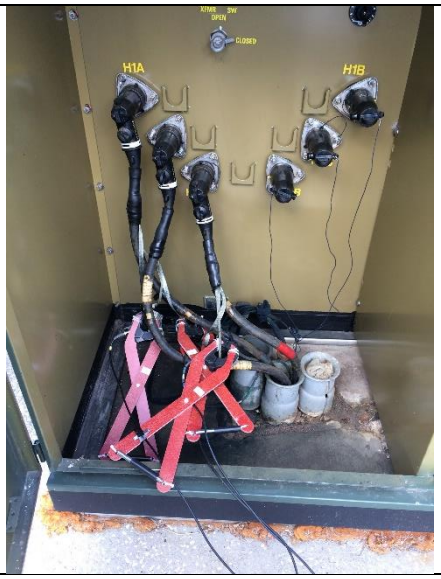
Comments
PD not detected. Noise waveforms only.

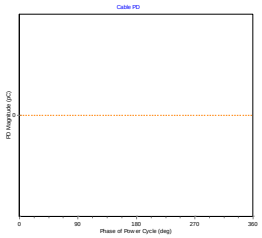
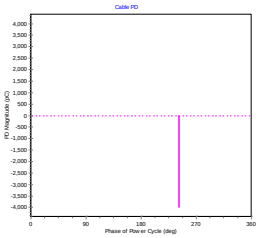
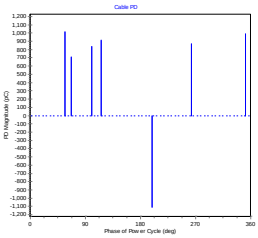
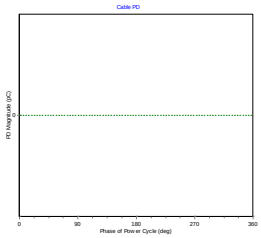
Substation/Site: T-2B-2
Location: POA 85
Test No.:

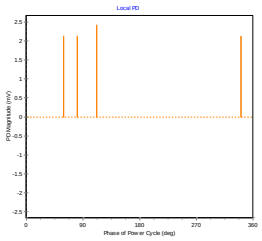
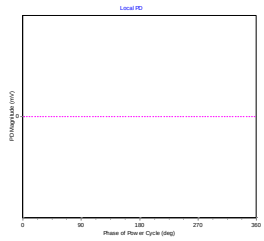
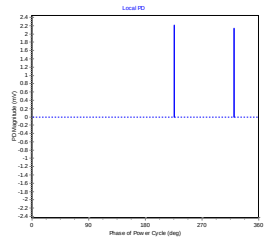
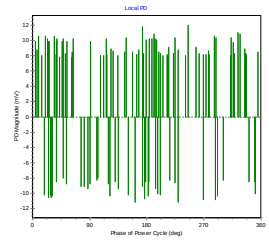
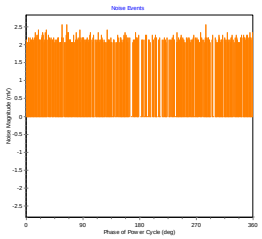
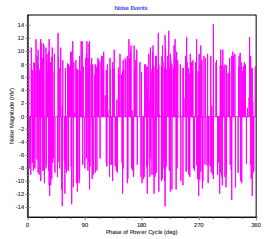
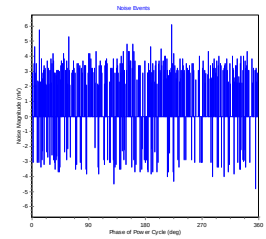
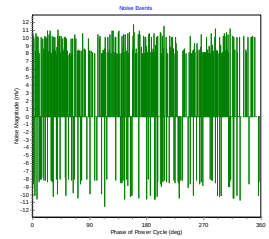
Customer: City of Tampa
Test Engineer: Nat Crews/ Louis Nemec
Test Date: 08/02/2017 2:20:55 PM

C.E. Testing, Inc.

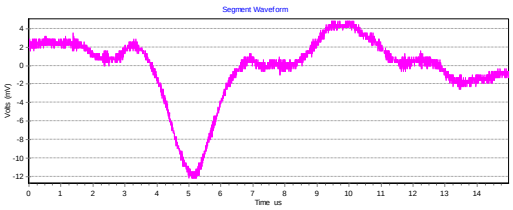
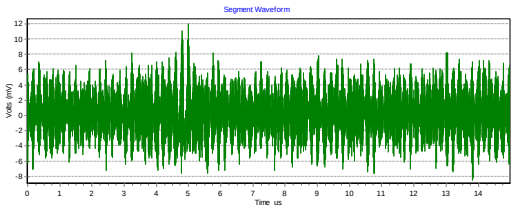
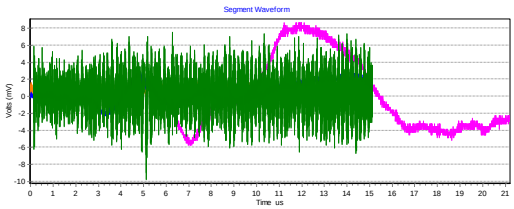
Sensor	Circuit/Description	V(kV)	Cable Type	Local Plant Type
HFCT	phA	13.2kV	Cable	EPR
HFCT	phB	13.2kV	Cable	EPR
HFCT	phC	13.2kV	Cable	EPR
TEV Probe	TEV	13.2kV	Switchgear	Solid Insulated

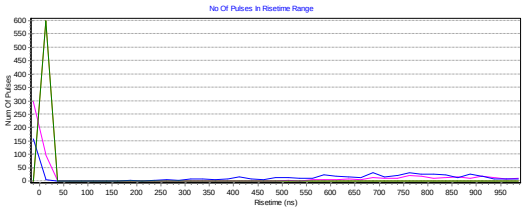
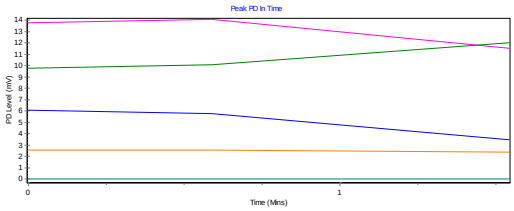
Phase-Resolved Graph (PD and Noise)	Photo of Sensor Attachment
	

	Channel 1		Channel 2		Channel 3		Channel 4	
	Cable PD	0pC	Cable PD	3980pC	Cable PD	1107pC	Cable PD	0pC
	Local PD	8dB	Local PD	0dB	Local PD	7dB	Local PD	22dB
	Peak	2.56mV	Peak	14.08mV	Peak	6.08mV	Peak	12.00mV
	Std Dev	0.37mV	Std Dev	2.51mV	Std Dev	0.72mV	Std Dev	2.71mV
Cable PD								

Local PD				
Noise				

Sensor	Circuit/Description	V(kV)	Cable Type	Local Plant Type
HFCT	phA	13.2kV	Cable	EPR
HFCT	phB	13.2kV	Cable	EPR
HFCT	phC	13.2kV	Cable	EPR
TEV	TEV	13.2kV	Switchgear	Solid Insulated

Cable PD Waveform				Local PD Waveform			
							
Peak	-12.16 mV	**Frequency**	122.07 kHz	**Peak**	12.00 mV	**Frequency**	71.43 MHz
Rise Time	719.50 ns	**PD Level**	-3.98 nC	**Rise Time**	4.18 ns	**PD Level**	
Noise Waveform				**Synchronous Waveform**			
							
Peak	11.68 mV	**Frequency**	107.14 MHz	**Peak**	-	**Frequency**	-
Rise Time	2.76 ns	**PD Level**	-	**Rise Time**	-	**PD Level**	-

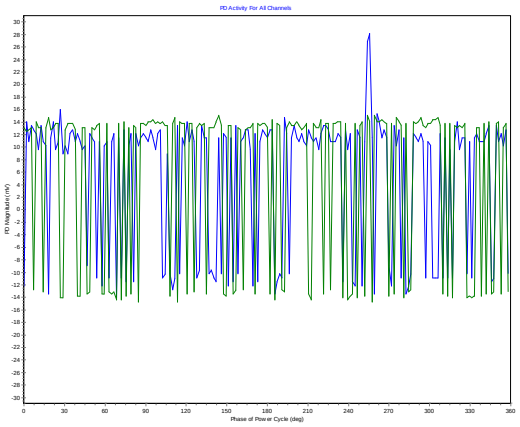
No of Pulses vs. Pulse Rise-Time	Peak Level in Time
	

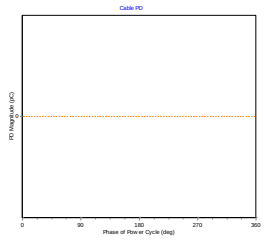
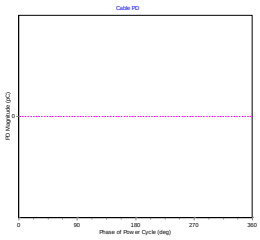
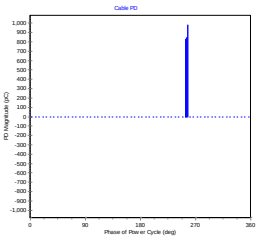
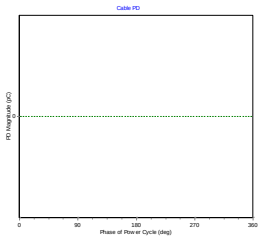
Comments
Noise waveforms. PD not indicated.

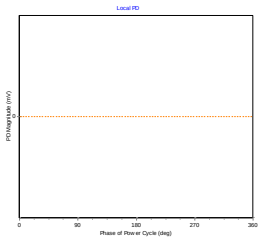
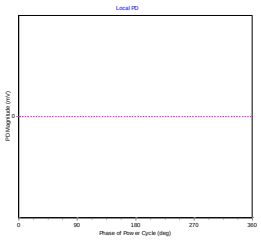
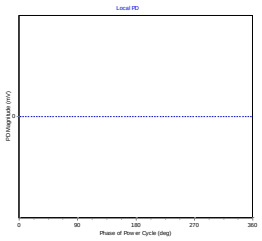
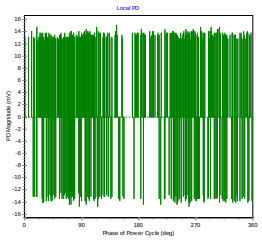
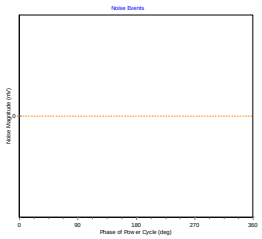
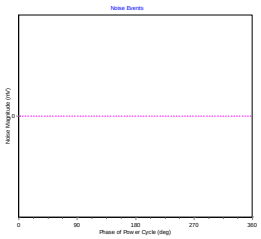
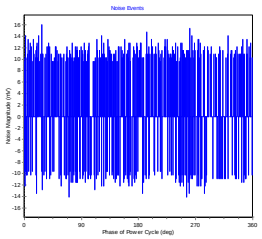
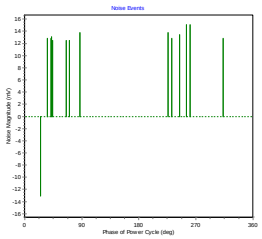
Substation/Site:	T-6B-1	**Customer:**	City of Tampa
Location:	POA 61	**Test Engineer:**	Nat Crews/ Louis Nemec
Test No.:		**Test Date:**	08/02/2017 2:41:59 PM

C.E. Testing, Inc.

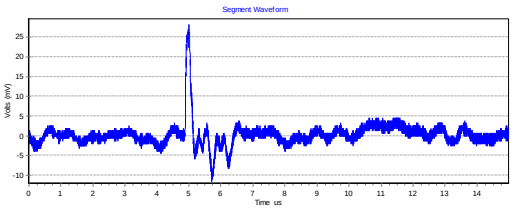
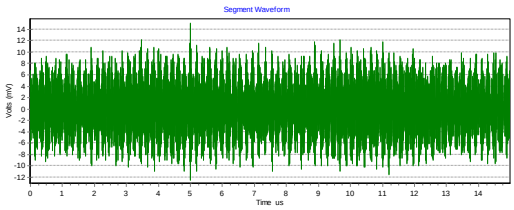
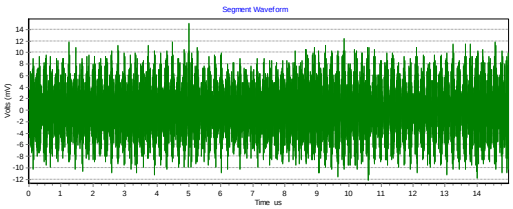
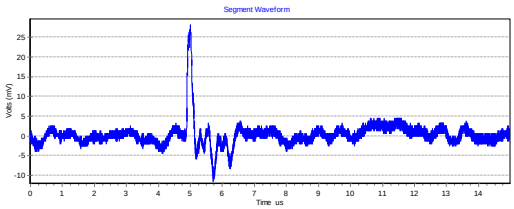
Sensor	Circuit/Description	V(kV)	Cable Type	Local Plant Type
HFCT	phA	13.2kV	Cable	EPR
HFCT	phB	13.2kV	Cable	EPR
HFCT	phC	13.2kV	Cable	EPR
TEV Probe	TEV	13.2kV	Switchgear	EPR

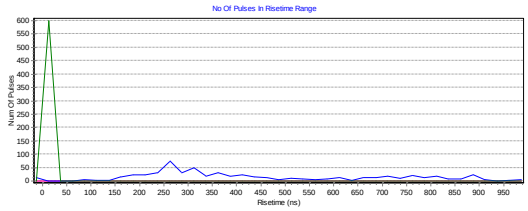
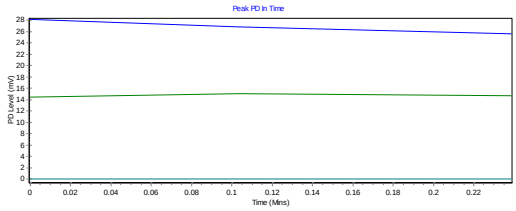
Phase-Resolved Graph (PD and Noise)	Photo of Sensor Attachment
	

	Channel 1		Channel 2		Channel 3		Channel 4	
	Cable PD	0pC	Cable PD	0pC	Cable PD	978pC	Cable PD	0pC
	Local PD	0dB	Local PD	0dB	Local PD	0dB	Local PD	24dB
	Peak	0.00mV	Peak	0.00mV	Peak	28.16mV	Peak	15.04mV
	Std Dev	0.00mV	Std Dev	0.00mV	Std Dev	2.71mV	Std Dev	4.91mV
Cable PD								

Local PD				
Noise				

Sensor	Circuit/Description	V(kV)	Cable Type	Local Plant Type
HFCT	phA	13.2kV	Cable	EPR
HFCT	phB	13.2kV	Cable	EPR
HFCT	phC	13.2kV	Cable	EPR
TEV Probe	TEV	13.2kV	Switchgear	EPR

Cable PD Waveform				Local PD Waveform			
							
Peak	28.16 mV	**Frequency**	1.39 MHz	**Peak**	15.04 mV	**Frequency**	93.75 MHz
Rise Time	122.95 ns	**PD Level**	977.92 pC	**Rise Time**	1.68 ns	**PD Level**	
Noise Waveform				**Synchronous Waveform**			
							
Peak	15.04 mV	**Frequency**	35.71 MHz	**Peak**	-	**Frequency**	-
Rise Time	2.40 ns	**PD Level**	-	**Rise Time**	-	**PD Level**	-

No of Pulses vs. Pulse Rise-Time	Peak Level in Time
	

Comments
Cable PD and Local PD Detected with HFCT and TEV. Common ground was used. PD waveform detected at 1.39MHz. POA 61 1. All phase conductors are terminated too close to the PT's. Recommend removing the conductors and extending the buss outward approximately 6 inches and re-terminate conductors.

Substation/Site:	T-6A-1	**Customer:**	City of Tampa
Location:	POA 60	**Test Engineer:**	Nat Crews/ Louis Nemec
Test No.:		**Test Date:**	08/02/2017 2:53:17 PM

C.E. Testing, Inc.

Sensor	Circuit/Description	V(kV)	Cable Type	Local Plant Type
HFCT	phA	13.2kV	Cable	EPR
HFCT	phB	13.2kV	Cable	EPR
HFCT	phC	13.2kV	Cable	EPR
TEV Probe	TEV	13.2kV	Switchgear	EPR

Phase-Resolved Graph (PD and Noise)

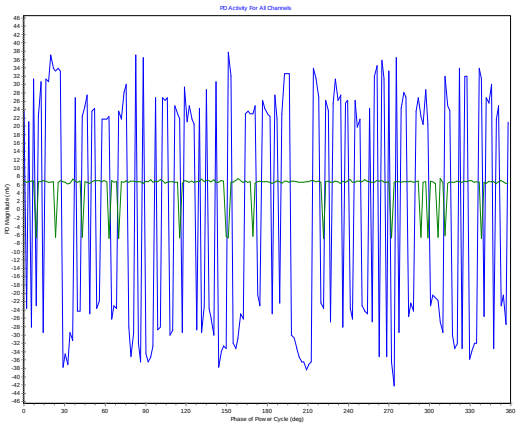
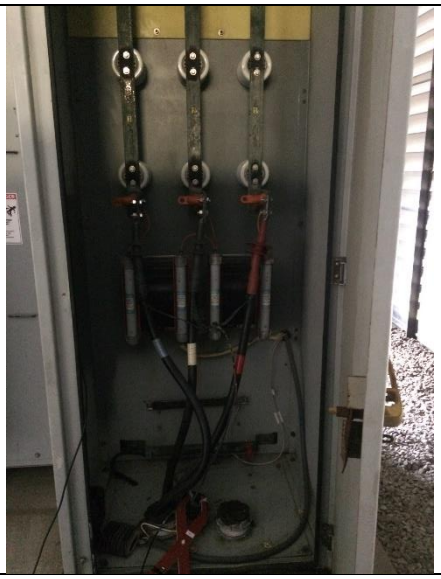
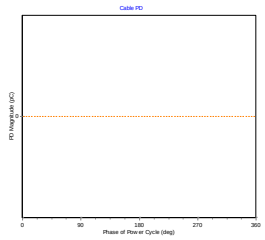
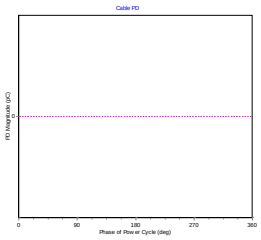
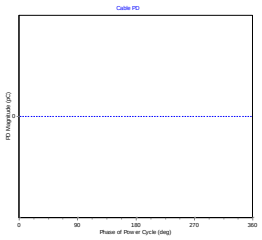
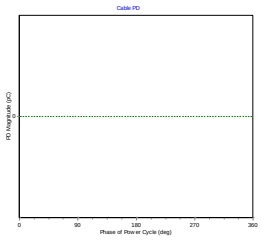
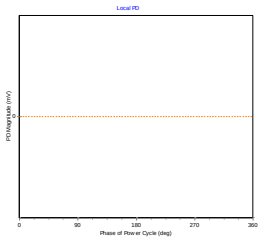
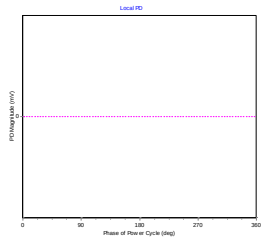
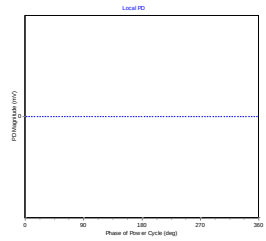
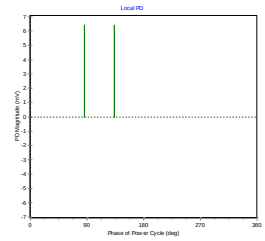
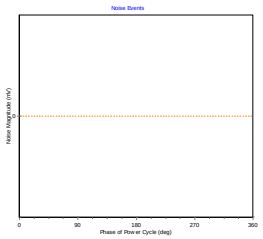
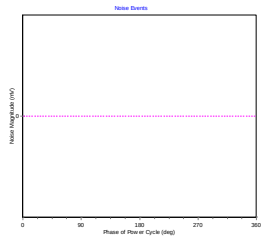
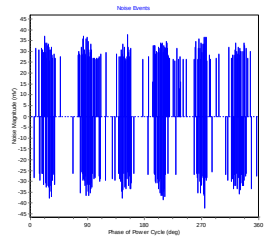
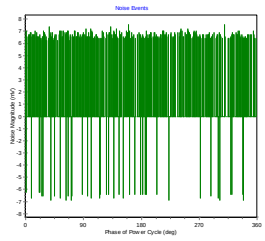


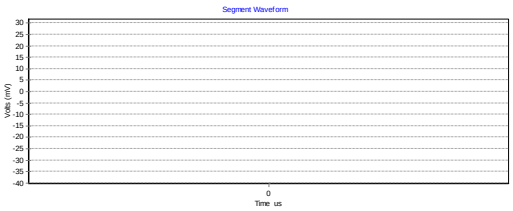
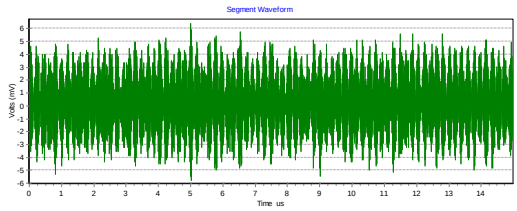
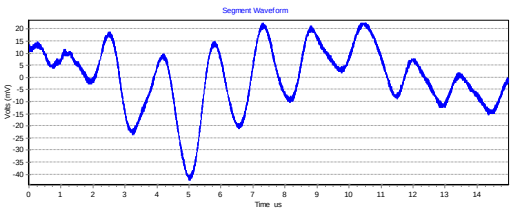
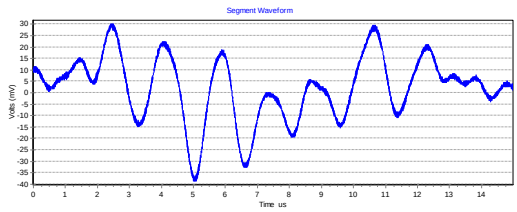
Photo of Sensor Attachment

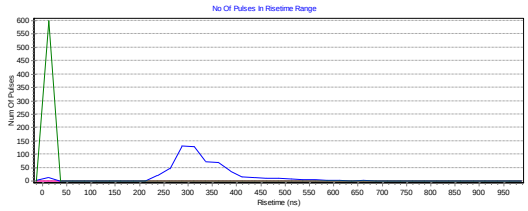
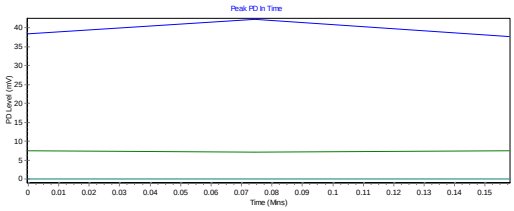


	Channel 1		Channel 2		Channel 3		Channel 4	
	Cable PD	0pC	Cable PD	0pC	Cable PD	0pC	Cable PD	0pC
	Local PD	0dB	Local PD	0dB	Local PD	0dB	Local PD	16dB
	Peak	0.00mV	Peak	0.00mV	Peak	42.24mV	Peak	7.52mV
	Std Dev	0.00mV	Std Dev	0.00mV	Std Dev	7.89mV	Std Dev	2.31mV
Cable PD								

Local PD				
Noise				

Sensor	Circuit/Description	V(kV)	Cable Type	Local Plant Type
HFCT	phA	13.2kV	Cable	EPR
HFCT	phB	13.2kV	Cable	EPR
HFCT	phC	13.2kV	Cable	EPR
TEV Probe	TEV	13.2kV	Switchgear	EPR

Cable PD Waveform				Local PD Waveform			
							
Peak		**Frequency**		**Peak**	6.40 mV	**Frequency**	83.33 MHz
Rise Time		**PD Level**		**Rise Time**	290.77 ps	**PD Level**	
Noise Waveform				**Synchronous Waveform**			
							
Peak	-42.24 mV	**Frequency**	488.28 kHz	**Peak**	-	**Frequency**	-
Rise Time	456.07 ns	**PD Level**	-	**Rise Time**	-	**PD Level**	-

No of Pulses vs. Pulse Rise-Time	Peak Level in Time
	

Comments
Only noise waveforms on cables. Local TEV signal is remnant from nearby POA 61 which was found to have Local PD.

Substation/Site: T-8B-2
Location: POA 75
Test No.:

Customer: City of Tampa
Test Engineer: Nat Crews/ Louis Nemec
Test Date: 08/02/2017 3:20:43 PM

C.E. Testing, Inc.

Sensor	Circuit/Description	V(kV)	Cable Type	Local Plant Type
HFCT	phA	13.2kV	Cable	EPR
HFCT	phB	13.2kV	Cable	EPR
HFCT	phC	13.2kV	Cable	EPR
TEV Probe	TEV	13.2kV	Switchgear	Solid Insulated

Phase-Resolved Graph (PD and Noise)

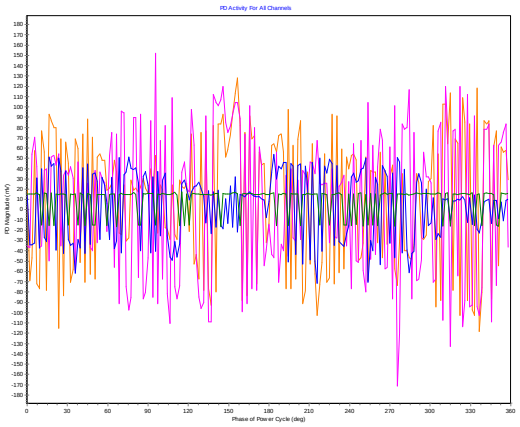
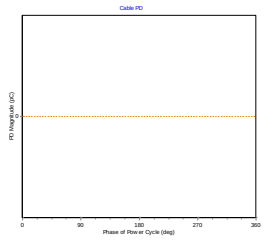
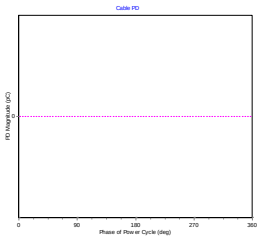
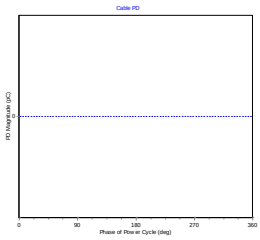
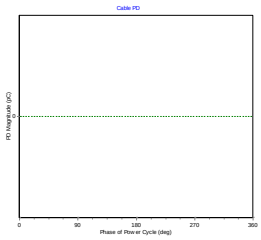
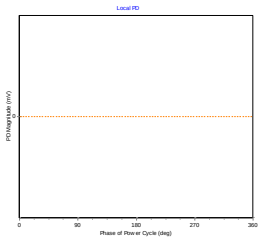
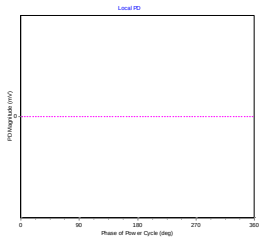
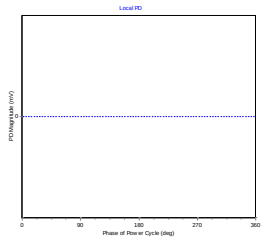
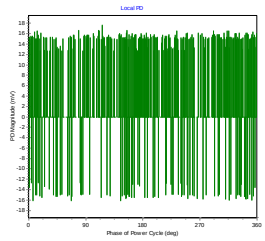
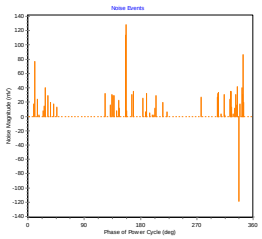
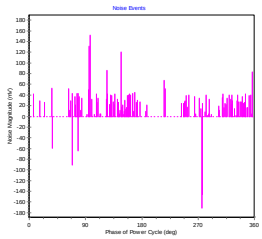
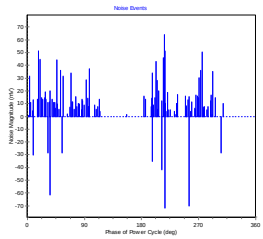
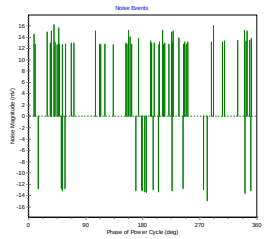
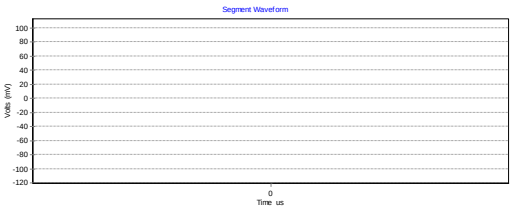
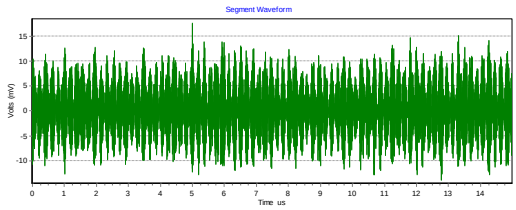
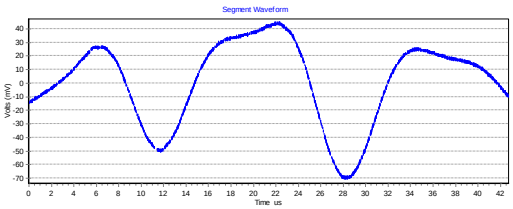
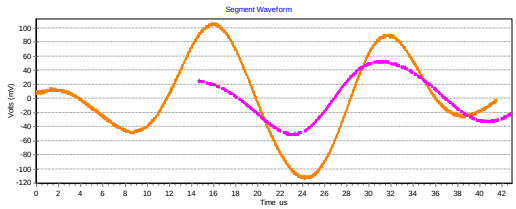


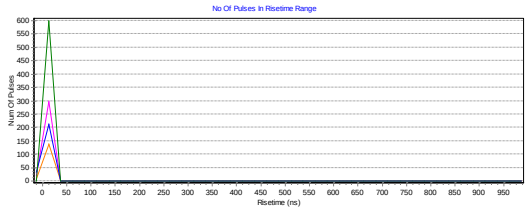
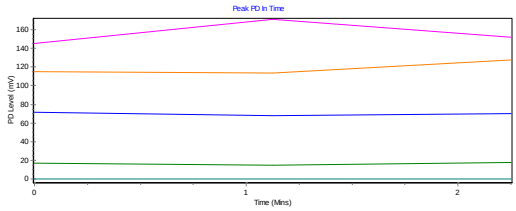
Photo of Sensor Attachment

	Channel 1		Channel 2		Channel 3		Channel 4	
	Cable PD	0pC	Cable PD	0pC	Cable PD	0pC	Cable PD	0pC
	Local PD	0dB	Local PD	0dB	Local PD	0dB	Local PD	25dB
	Peak	128.00mV	Peak	171.20mV	Peak	71.68mV	Peak	17.60mV
	Std Dev	19.31mV	Std Dev	21.47mV	Std Dev	9.11mV	Std Dev	4.75mV
Cable PD								

Local PD				
Noise				

Sensor	Circuit/Description	V(kV)	Cable Type	Local Plant Type
HFCT	phA	13.2kV	Cable	EPR
HFCT	phB	13.2kV	Cable	EPR
HFCT	phC	13.2kV	Cable	EPR
TEV Probe	TEV	13.2kV	Switchgear	Solid Insulated

Cable PD Waveform				Local PD Waveform			
							
Peak		**Frequency**		**Peak**	17.60 mV	**Frequency**	83.33 MHz
Rise Time		**PD Level**		**Rise Time**	1.74 ns	**PD Level**	
Noise Waveform				**Synchronous Waveform**			
							
Peak	-70.40 mV	**Frequency**	61.04 kHz	**Peak**	-	**Frequency**	-
Rise Time	2.45 us	**PD Level**	-	**Rise Time**	-	**PD Level**	-

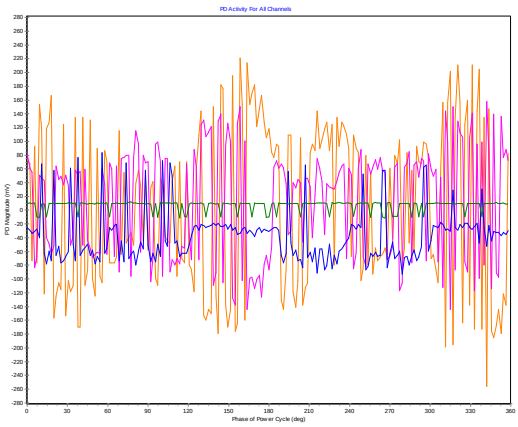
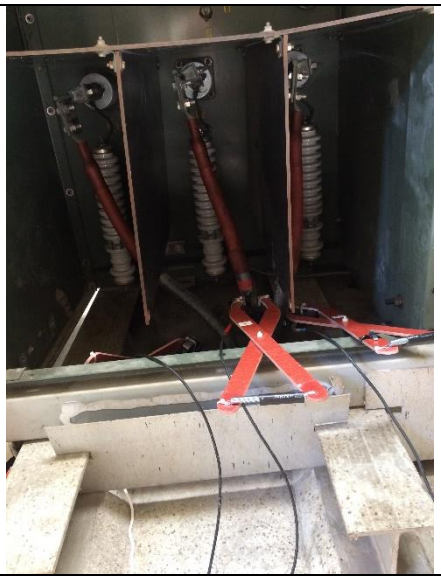
No of Pulses vs. Pulse Rise-Time	Peak Level in Time
	

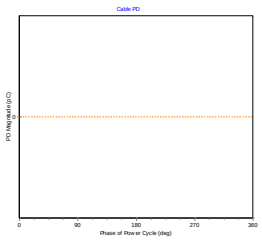
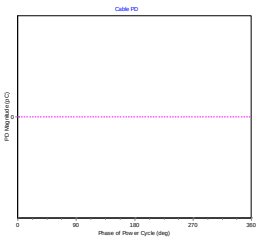
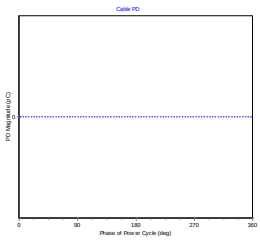
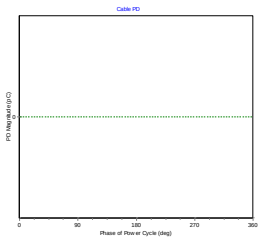
Comments
POA 75 1. A phase lightning arrestor has faulted in the past. Recommend replacing arrestor. Local PD TEV 25dB.

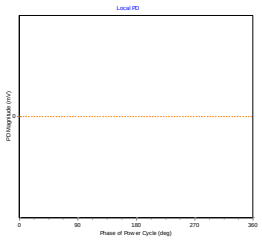
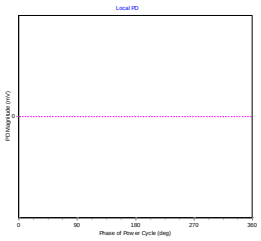
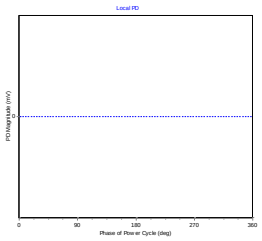
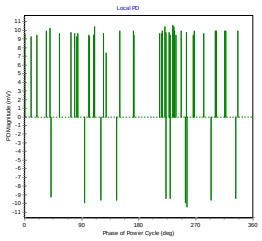
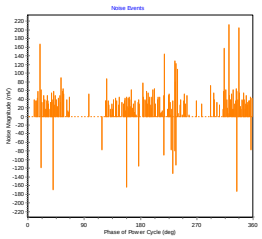
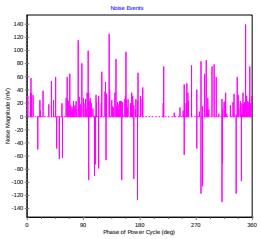
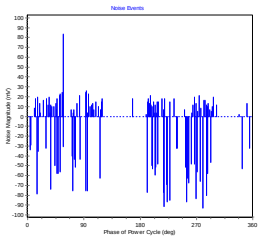
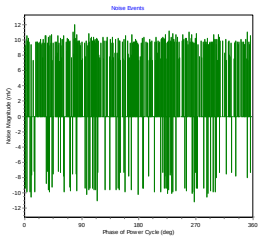
Substation/Site:	T-8A-2	**Customer:**	City of Tampa
Location:	POA 74	**Test Engineer:**	Nat Crews/ Louis Nemec
Test No.:		**Test Date:**	08/02/2017 3:30:07 PM

C.E. Testing, Inc.

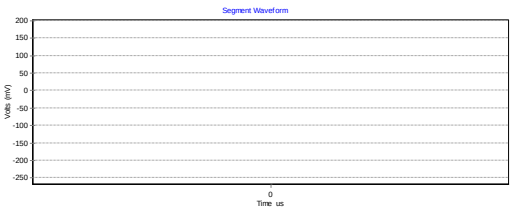
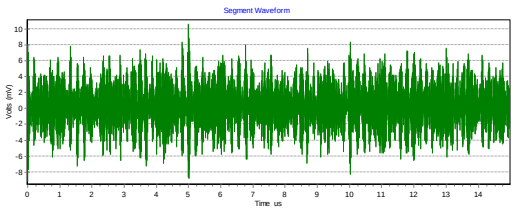
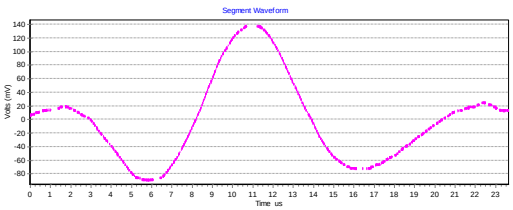
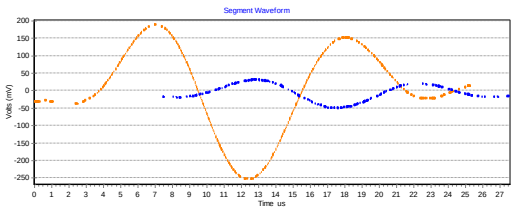
Sensor	Circuit/Description	V(kV)	Cable Type	Local Plant Type
HFCT	PHA	13.2kV	Cable	EPR
HFCT	PHB	13.2kV	Cable	EPR
HFCT	PHC	13.2kV	Cable	EPR
TEV Probe	TEV	13.2kV	Switchgear	Solid Insulated

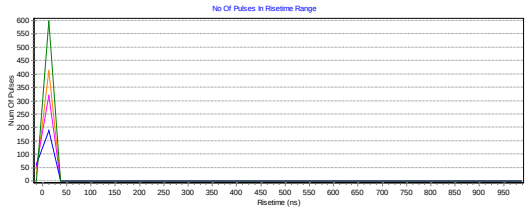
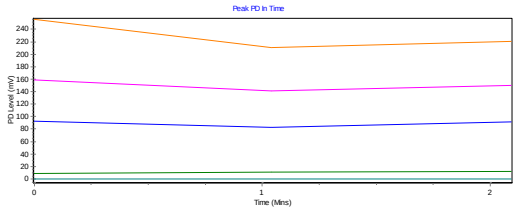
Phase-Resolved Graph (PD and Noise)	Photo of Sensor Attachment
	

	Channel 1		Channel 2		Channel 3		Channel 4	
	Cable PD	0pC	Cable PD	0pC	Cable PD	0pC	Cable PD	0pC
	Local PD	0dB	Local PD	0dB	Local PD	0dB	Local PD	20dB
	Peak	211.20mV	Peak	139.20mV	Peak	92.80mV	Peak	12.00mV
	Std Dev	32.24mV	Std Dev	21.08mV	Std Dev	13.18mV	Std Dev	2.49mV
Cable PD								

Local PD				
Noise				

Sensor	Circuit/Description	V(kV)	Cable Type	Local Plant Type
HFCT	phA	13.2kV	Cable	EPR
HFCT	phB	13.2kV	Cable	EPR
HFCT	phC	13.2kV	Cable	EPR
TEV	TEV	13.2kV	Switchgear	Solid Insulated

Cable PD Waveform				Local PD Waveform			
							
Peak		**Frequency**		**Peak**	10.56 mV	**Frequency**	102.94 MHz
Rise Time		**PD Level**		**Rise Time**	849.93 ps	**PD Level**	
Noise Waveform				**Synchronous Waveform**			
							
Peak	139.20 mV	**Frequency**	91.55 kHz	**Peak**	-	**Frequency**	-
Rise Time	1.98 us	**PD Level**	-	**Rise Time**	-	**PD Level**	-

No of Pulses vs. Pulse Rise-Time	Peak Level in Time
	

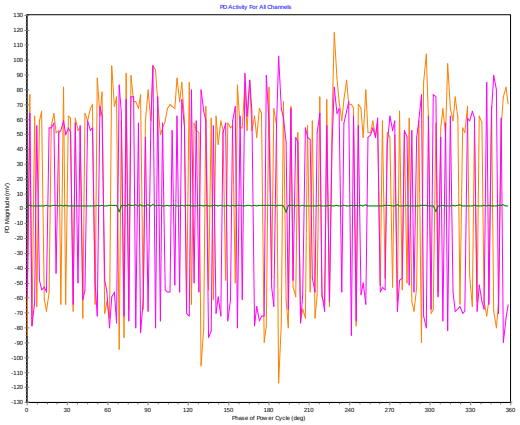
Comments
Local PD TEV 20dB. PD waveform detected. Bleed over from T-8B-2

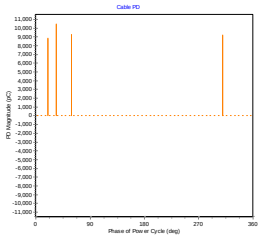
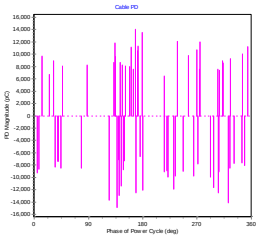
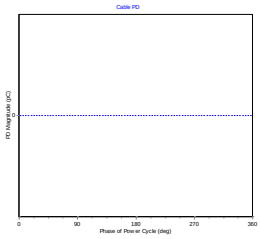
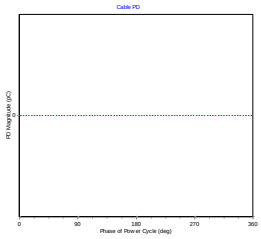
Substation/Site: T-8A-5 **Customer:** City of Tampa

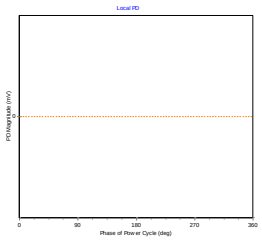
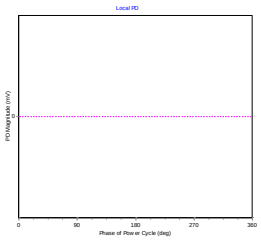
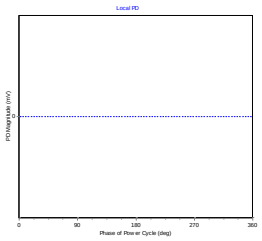
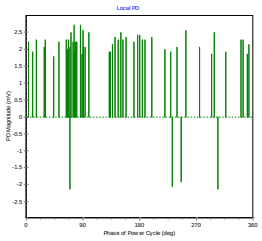
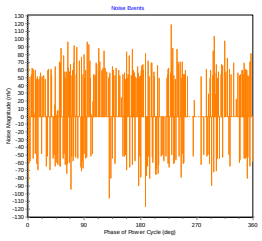
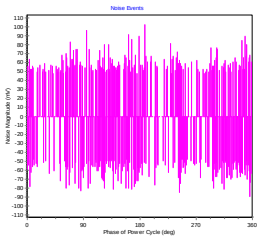
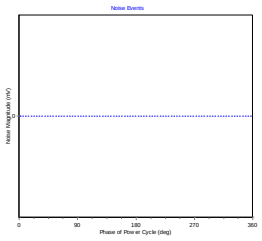
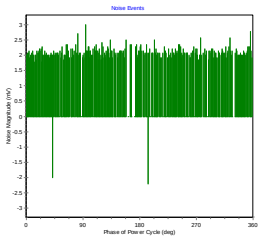
C.E. Testing, Inc.

Location: POA 76 **Test Engineer:** Nat Crews/ Louis Nemec
Test No.: **Test Date:** 08/02/2017 4:04:48 PM

Sensor	Circuit/Description	V(kV)	Cable Type	Local Plant Type
HFCT	PHA	13.2kV	Cable	EPR
HFCT	PHB	13.2kV	Cable	EPR
N/A	N/A	13.2kV	Cable	EPR
TEV	TEV	13.2kV	Switchgear	Solid Insulated

Phase-Resolved Graph (PD and Noise)	Photo of Sensor Attachment
	

	Channel 1		Channel 2		Channel 3		Channel 4	
	Cable PD	10429pC	Cable PD	14833pC	Cable PD	0pC	Cable PD	0pC
	Local PD	0dB	Local PD	0dB	Local PD	0dB	Local PD	9dB
	Peak	118.40mV	Peak	102.40mV	Peak	0.00mV	Peak	2.99mV
	Std Dev	15.00mV	Std Dev	13.76mV	Std Dev	0.00mV	Std Dev	0.50mV
Cable PD								

Local PD				
Noise				

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Substation/Site:	T-8A-5	**Customer:**	City of Tampa
Location:	POA 76	**Test Engineer:**	Nat Crews/ Louis Nemec
Test No.:		**Test Date:**	08/02/2017 4:04:48 PM

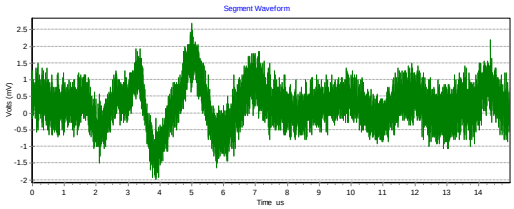
C.E. Testing, Inc.

Sensor	Circuit/Description	V(kV)	Cable Type	Local Plant Type
HFCT	phA	13.2kV	Cable	EPR
HFCT	phB	13.2kV	Cable	EPR
N/A	N/A	13.2kV	Cable	EPR
TEV	TEV	13.2kV	Switchgear	Solid Insulated

Cable PD Waveform

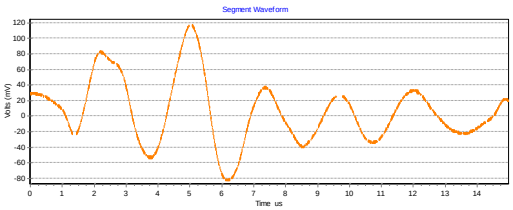
Peak	-86.40 mV	**Frequency**	244.14 kHz
Rise Time	359.61 ns	**PD Level**	-14.83 nC

Local PD Waveform



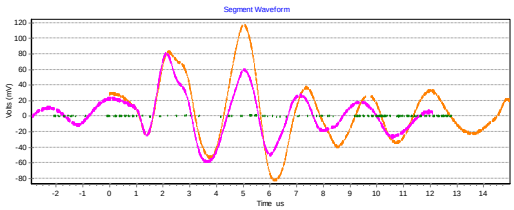
Peak	2.70 mV	**Frequency**	98.88 MHz
Rise Time	16.09 ns	**PD Level**	

Noise Waveform



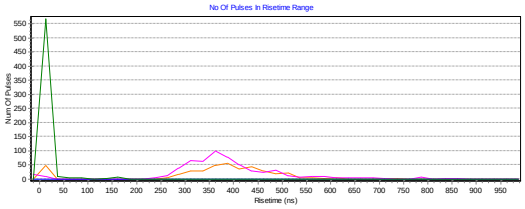
Peak	118.40 mV	**Frequency**	427.25 kHz
Rise Time	556.39 ns	**PD Level**	-

Synchronous Waveform

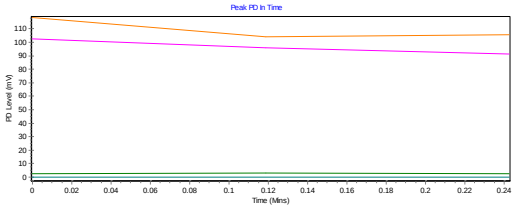


Peak	-	**Frequency**	-
Rise Time	-	**PD Level**	-

No of Pulses vs. Pulse Rise-Time



Peak Level in Time

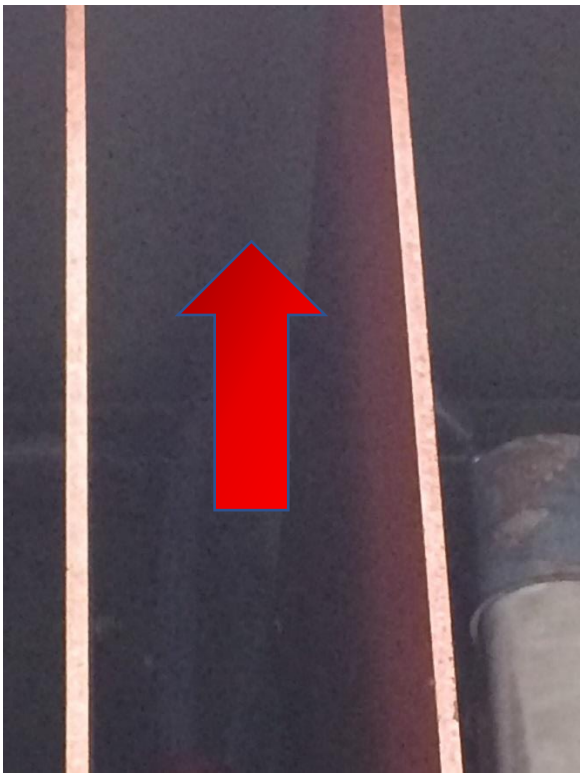


Comments

POA 76

1. Non-shielded B phase arrestor conductor against the ground shield, causing corona.
2. Recommend replacing or cleaning the conductor. See Photos

9dB corona PD pattern observed. Low level PD.

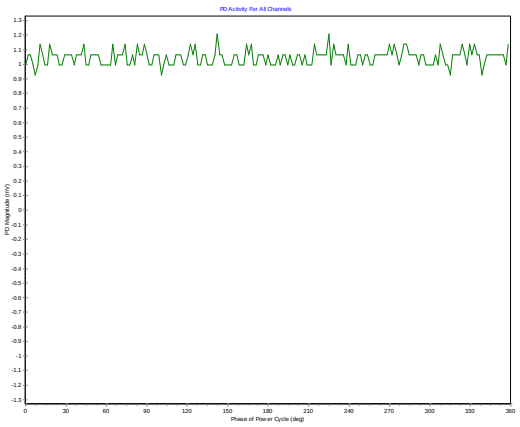
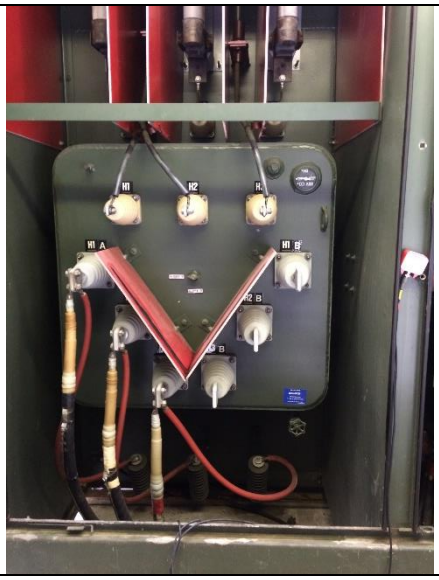


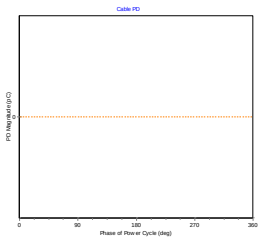
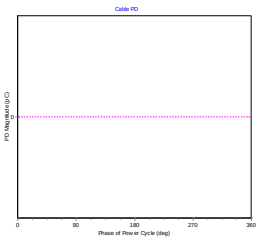
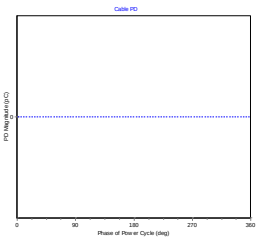
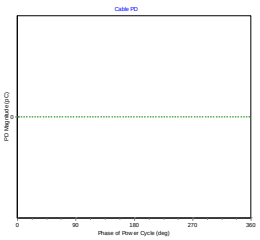
Substation/Site: T-8B-5
Location: POA 77
Test No.:

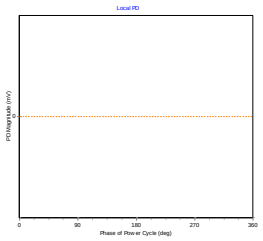
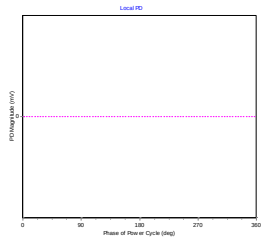
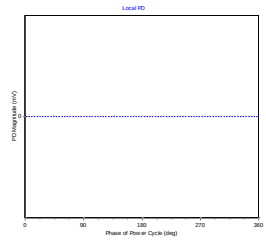
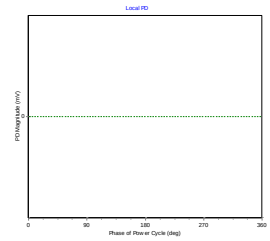
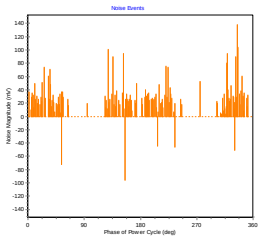
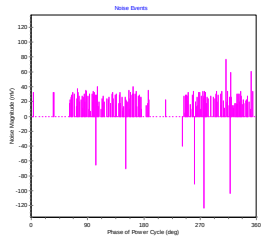
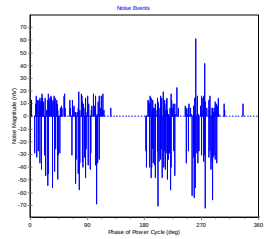
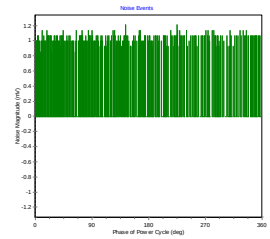
Customer: City of Tampa
Test Engineer: Nat Crews/ Louis Nemec
Test Date: 08/02/2017 4:13:51 PM

C.E. Testing, Inc.

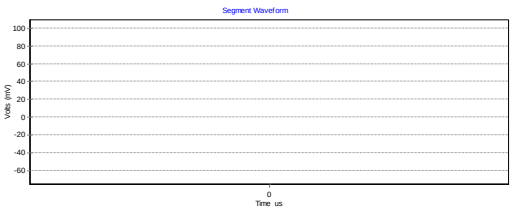
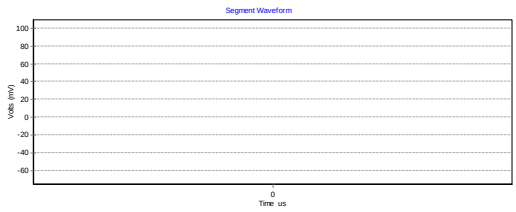
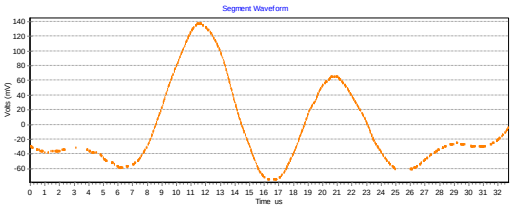
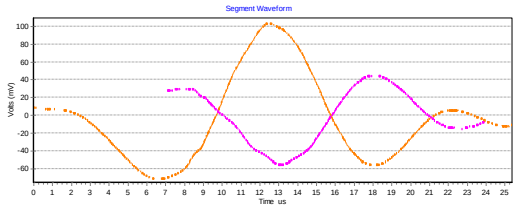
Sensor	Circuit/Description	V(kV)	Cable Type	Local Plant Type
HFCT	PHA	13.2kV	Cable	EPR
HFCT	PHB	13.2kV	Cable	EPR
HFCT	PHC	13.2kV	Cable	EPR
TEV Probe	TEV	13.2kV	Switchgear	Solid Insulated

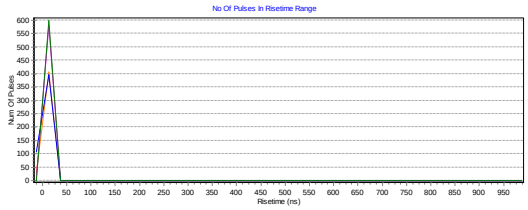
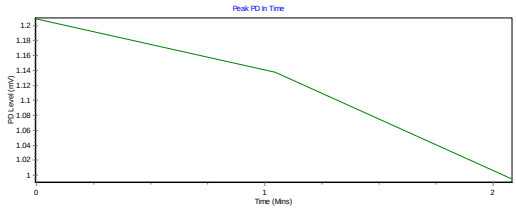
Phase-Resolved Graph (PD and Noise)	Photo of Sensor Attachment
	

	Channel 1		Channel 2		Channel 3		Channel 4	
	Cable PD	0pC	Cable PD	0pC	Cable PD	0pC	Cable PD	0pC
	Local PD	0dB	Local PD	0dB	Local PD	0dB	Local PD	0dB
	Peak	137.60mV	Peak	123.20mV	Peak	72.00mV	Peak	1.21mV
	Std Dev	17.50mV	Std Dev	17.16mV	Std Dev	10.12mV	Std Dev	0.22mV
Cable PD								

Local PD				
Noise				

Sensor	Circuit/Description	V(kV)	Cable Type	Local Plant Type
HFCT	phA	13.2kV	Cable	EPR
HFCT	phB	13.2kV	Cable	EPR
HFCT	phC	13.2kV	Cable	EPR
TEV Probe	TEV	13.2kV	Switchgear	Solid Insulated

Cable PD Waveform				Local PD Waveform			
							
Peak		**Frequency**		**Peak**		**Frequency**	
Rise Time		**PD Level**		**Rise Time**		**PD Level**	
Noise Waveform				**Synchronous Waveform**			
							
Peak	137.60 mV	**Frequency**	91.55 kHz	**Peak**	-	**Frequency**	-
Rise Time	2.08 us	**PD Level**	-	**Rise Time**	-	**PD Level**	-

No of Pulses vs. Pulse Rise-Time	**Peak Level in Time**
	

Comments
No PD Detected. Only noise waveforms. POA 77 1. Oil lubricant leaking from the fuse non-shielded conductors to the insulator boards. Recommend cleaning the lubricant from the boards and conductors. Sealing the conductors.

Substation/Site: T-5B-1
Location: POA 73A
Test No.:

Customer: City of Tampa
Test Engineer: Nat Crews/ Louis Nemec
Test Date: 08/02/2017 4:33:12 PM

C.E. Testing, Inc.

Sensor	Circuit/Description	V(kV)	Cable Type	Local Plant Type
HFCT	phA	13.2kV	Cable	EPR
HFCT	phB	13.2kV	Cable	EPR
HFCT	phC	13.2kV	Cable	EPR
TEV Probe	TEV	13.2kV	Cable	EPR

Phase-Resolved Graph (PD and Noise)

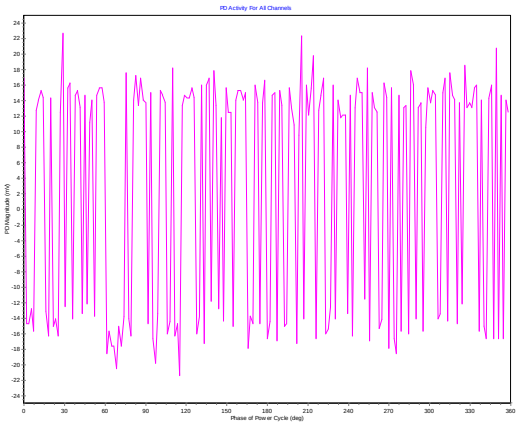
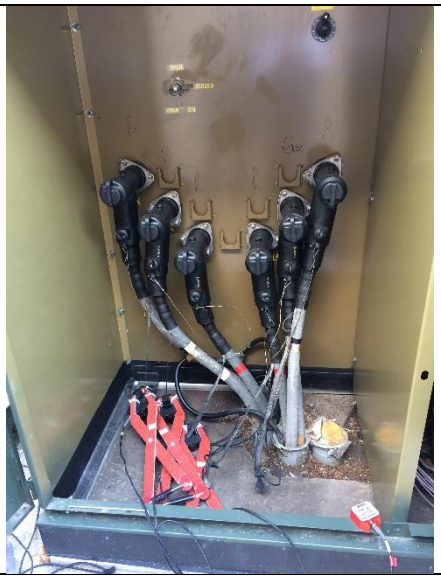
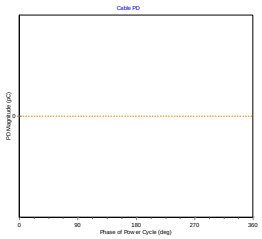
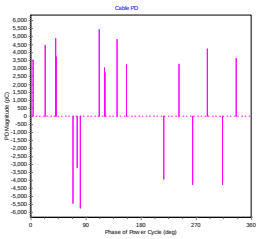
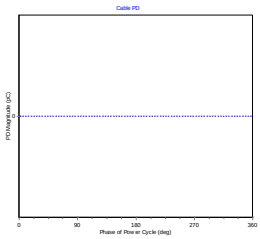
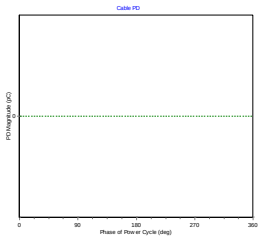
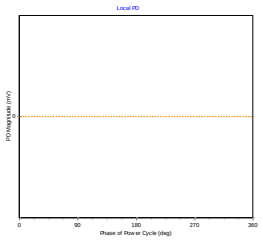
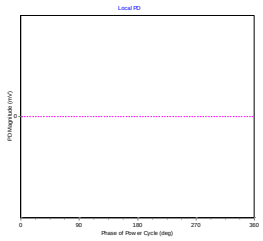
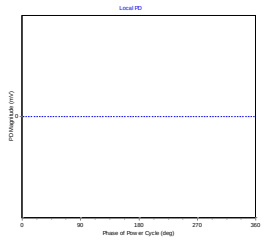
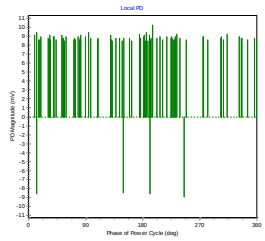
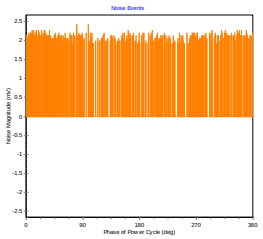
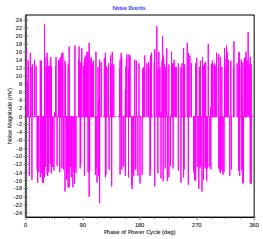
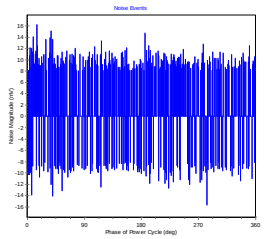
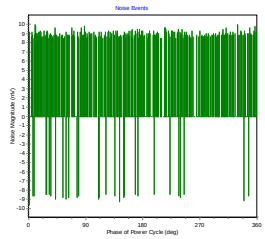


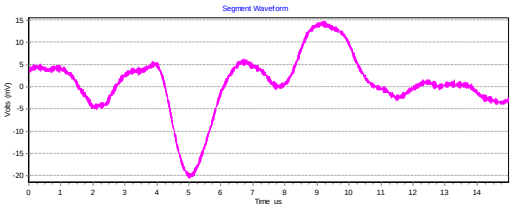
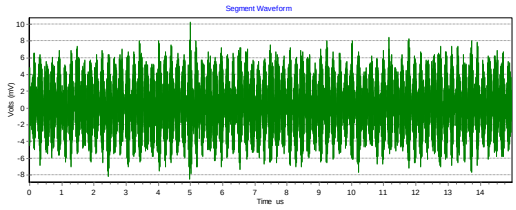
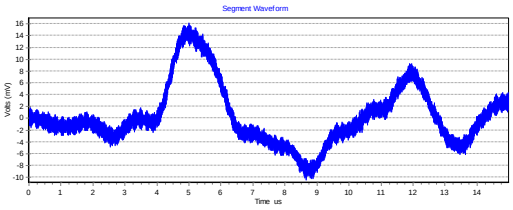
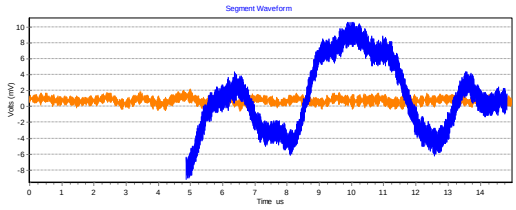
Photo of Sensor Attachment

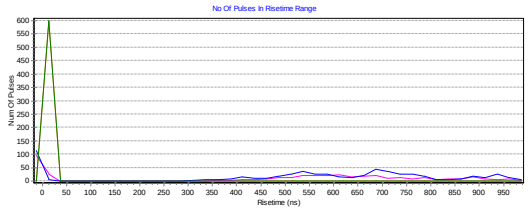
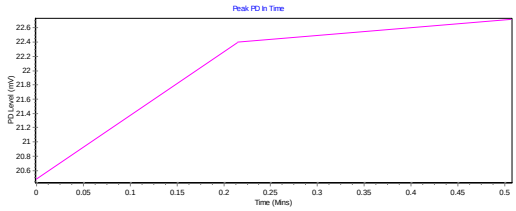


	Channel 1		Channel 2		Channel 3		Channel 4	
	Cable PD	0pC	Cable PD	5724pC	Cable PD	0pC	Cable PD	0pC
	Local PD	0dB	Local PD	0dB	Local PD	0dB	Local PD	20dB
	Peak	2.42mV	Peak	22.72mV	Peak	16.16mV	Peak	10.24mV
	Std Dev	0.41mV	Std Dev	4.08mV	Std Dev	2.53mV	Std Dev	3.10mV
Cable PD								

Local PD				
Noise				

Sensor	Circuit/Description	V(kV)	Cable Type	Local Plant Type
HFCT	phA	13.2kV	Cable	EPR
HFCT	phB	13.2kV	Cable	EPR
HFCT	phC	13.2kV	Cable	EPR
TEV Probe	TEV	13.2kV	Cable	EPR

Cable PD Waveform				Local PD Waveform			
							
Peak	-20.48 mV	**Frequency**	244.14 kHz	**Peak**	10.24 mV	**Frequency**	83.33 MHz
Rise Time	592.49 ns	**PD Level**	-5.43 nC	**Rise Time**	1.34 ns	**PD Level**	
Noise Waveform				**Synchronous Waveform**			
							
Peak	16.16 mV	**Frequency**	122.07 kHz	**Peak**	-	**Frequency**	-
Rise Time	649.14 ns	**PD Level**	-	**Rise Time**	-	**PD Level**	-

No of Pulses vs. Pulse Rise-Time	Peak Level in Time
	

Comments
No PD detected. Noise waveforms.

Substation/Site:	T-5B-1	**Customer:**	City of Tampa
Location:	POA 73B	**Test Engineer:**	Nat Crews/ Louis Nemec
Test No.:		**Test Date:**	08/02/2017 4:39:45 PM

C.E. Testing, Inc.

Sensor	Circuit/Description	V(kV)	Cable Type	Local Plant Type
HFCT	phA	13.2kV	Cable	EPR
HFCT	phB	13.2kV	Cable	EPR
HFCT	phC	13.2kV	Cable	EPR
TEV Probe	TEV	13.2kV	Cable	EPR

Phase-Resolved Graph (PD and Noise)

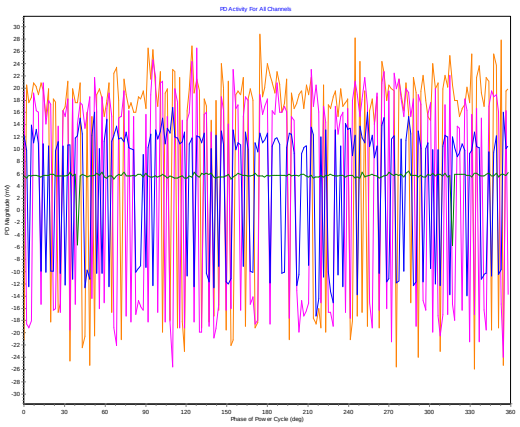
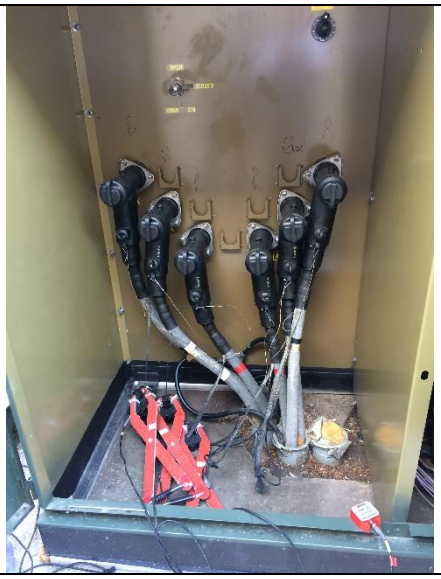
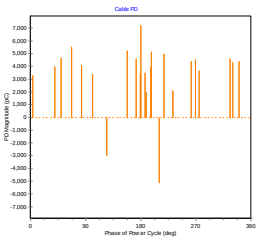
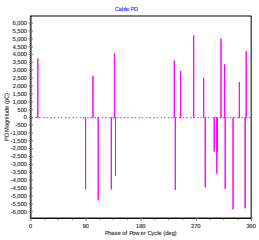
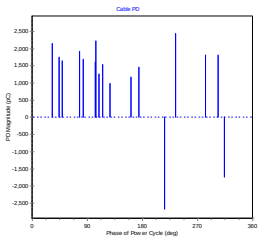
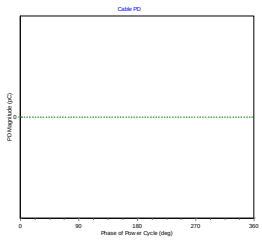
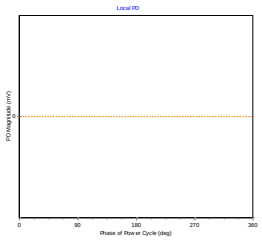
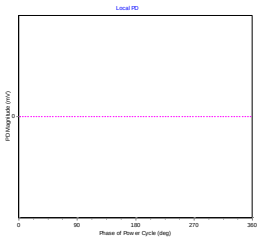
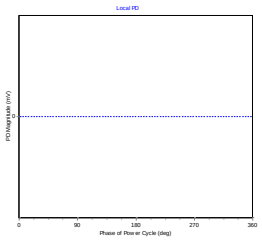
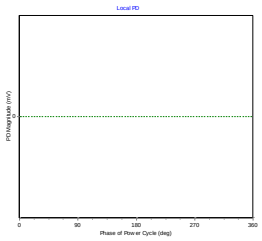
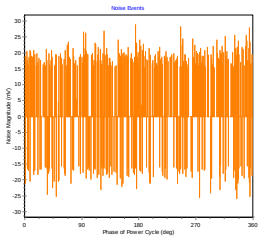
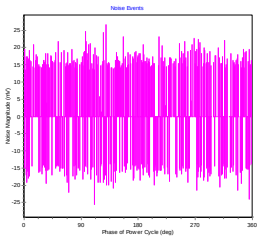
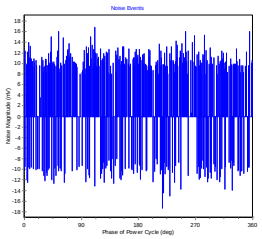
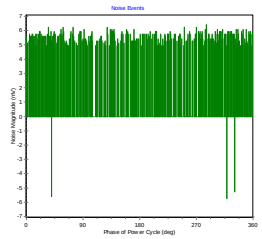


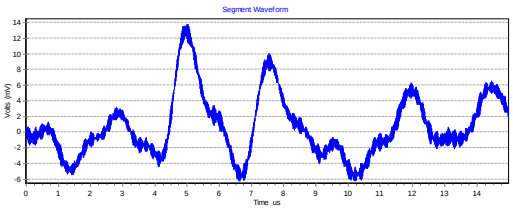
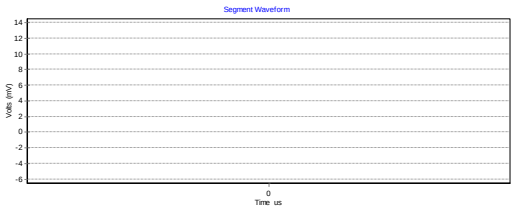
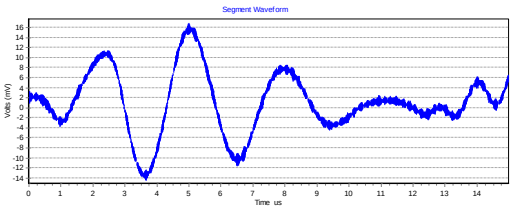
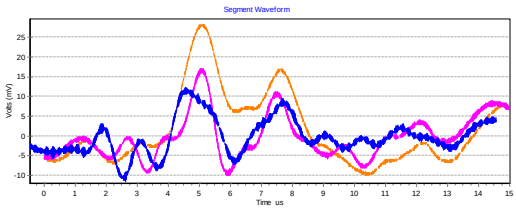
Photo of Sensor Attachment

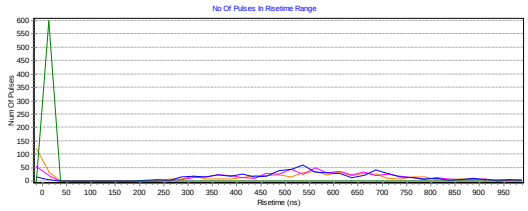
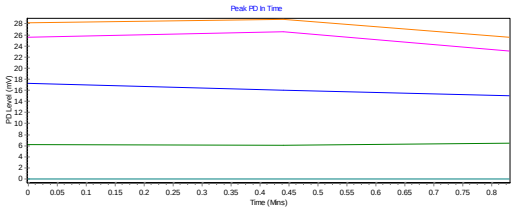


	Channel 1		Channel 2		Channel 3		Channel 4	
	Cable PD	7160pC	Cable PD	5808pC	Cable PD	2665pC	Cable PD	0pC
	Local PD	0dB	Local PD	0dB	Local PD	0dB	Local PD	0dB
	Peak	28.80mV	Peak	26.56mV	Peak	17.28mV	Peak	6.40mV
	Std Dev	5.30mV	Std Dev	4.39mV	Std Dev	2.54mV	Std Dev	1.94mV
Cable PD								

Local PD				
Noise				

Sensor	Circuit/Description	V(kV)	Cable Type	Local Plant Type
HFCT	phA	13.2kV	Cable	EPR
HFCT	phB	13.2kV	Cable	EPR
HFCT	phC	13.2kV	Cable	EPR
TEV	TEV	13.2kV	Cable	EPR

Cable PD Waveform				Local PD Waveform			
							
Peak	13.76 mV	**Frequency**	366.21 kHz	**Peak**		**Frequency**	
Rise Time	451.68 ns	**PD Level**	2.23 nC	**Rise Time**		**PD Level**	
Noise Waveform				**Synchronous Waveform**			
							
Peak	16.80 mV	**Frequency**	366.21 kHz	**Peak**	-	**Frequency**	-
Rise Time	543.14 ns	**PD Level**	-	**Rise Time**	-	**PD Level**	-

No of Pulses vs. Pulse Rise-Time	Peak Level in Time
	

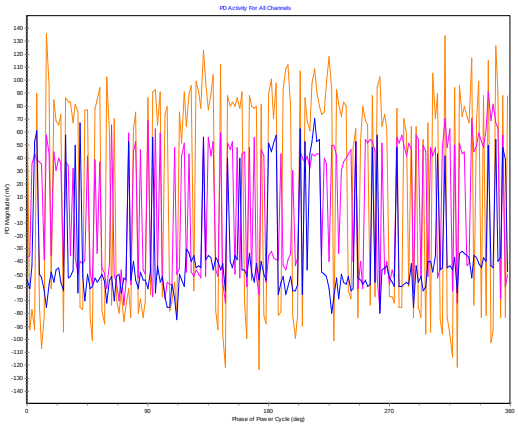
Comments
No PD detected. Noise waveforms.

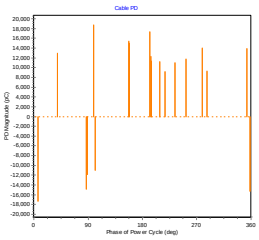
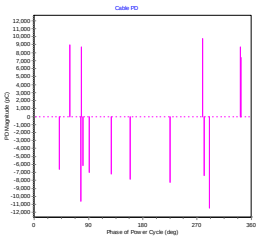
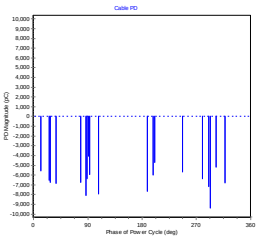
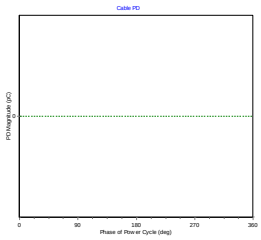
Substation/Site: T-5A-1
Location: POA 72A
Test No.:

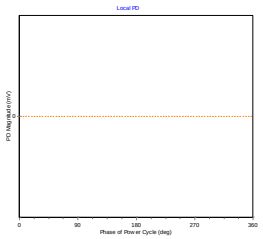
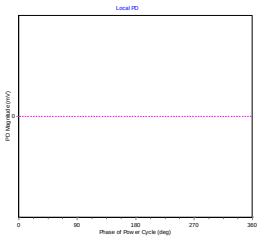
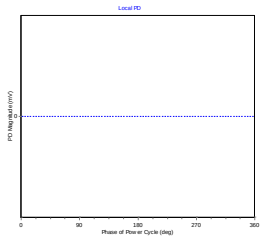
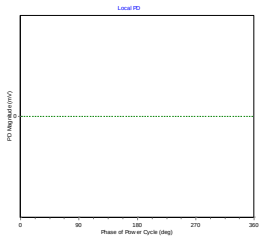
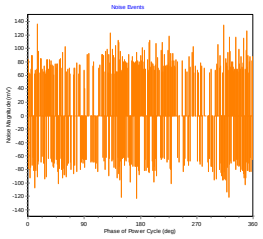
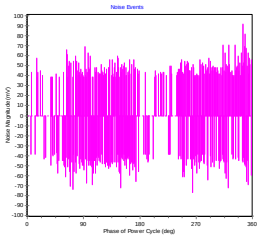
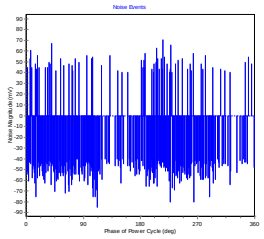
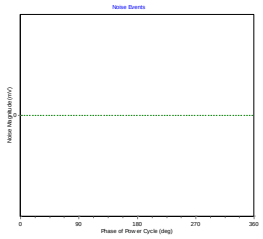
Customer: City of Tampa
Test Engineer: Nat Crews/ Louis Nemec
Test Date: 08/02/2017 4:54:34 PM

C.E. Testing, Inc.

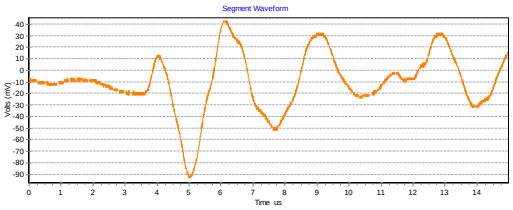
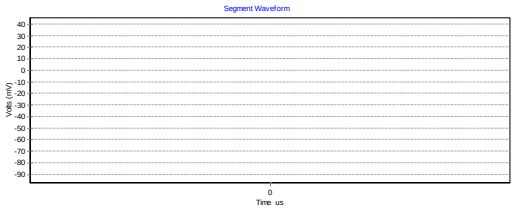
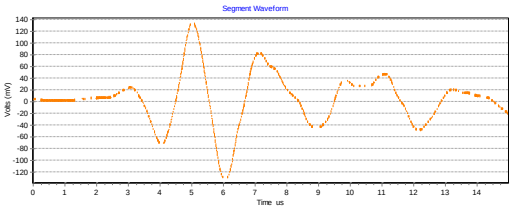
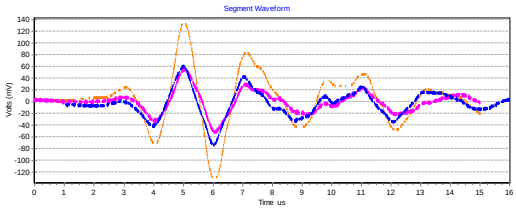
Sensor	Circuit/Description	V(kV)	Cable Type	Local Plant Type
HFCT	phA	13.2kV	Cable	FPR
HFCT	phB	13.2kV	Cable	FPR
HFCT	phC	13.2kV	Cable	FPR
N/A	TEV	15kV	Switchgear	Air Insulated

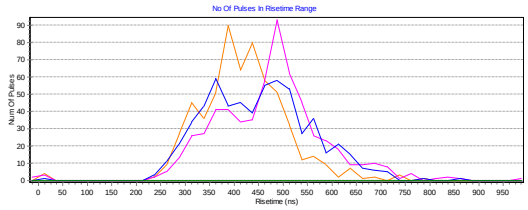
Phase-Resolved Graph (PD and Noise)	Photo of Sensor Attachment
	

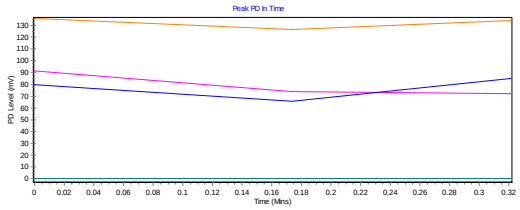
	Channel 1		Channel 2		Channel 3		Channel 4	
	Cable PD	18656pC	Cable PD	11433pC	Cable PD	9347pC	Cable PD	0pC
	Local PD	0dB	Local PD	0dB	Local PD	0dB	Local PD	0dB
	Peak	136.00mV	Peak	91.20mV	Peak	84.80mV	Peak	0.00mV
	Std Dev	16.63mV	Std Dev	9.76mV	Std Dev	9.35mV	Std Dev	0.00mV
Cable PD								

Local PD				
Noise				

Sensor	Circuit/Description	V(kV)	Cable Type	Local Plant Type
HFCT	phA	13.2kV	Cable	FPR
HFCT	phB	13.2kV	Cable	FPR
HFCT	phC	13.2kV	Cable	FPR
N/A	N/A	15kV	Switchgear	Air Insulated

Cable PD Waveform				Local PD Waveform			
							
Peak	-92.80 mV	**Frequency**	366.21 kHz	**Peak**		**Frequency**	
Rise Time	500.40 ns	**PD Level**	-17.33 nC	**Rise Time**		**PD Level**	
Noise Waveform				**Synchronous Waveform**			
							
Peak	136.00 mV	**Frequency**	366.21 kHz	**Peak**	-	**Frequency**	-
Rise Time	374.88 ns	**PD Level**	-	**Rise Time**	-	**PD Level**	-
No of Pulses vs. Pulse Rise-Time				**Peak Level in Time**			





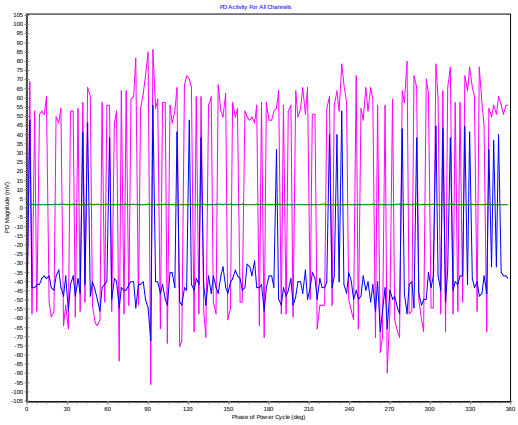
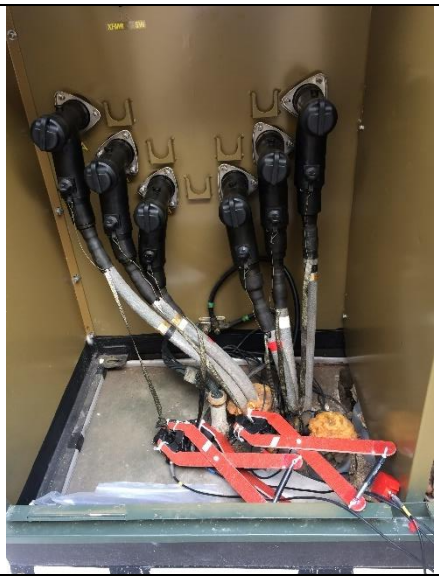
Comments
No PD detected. Noise waveforms only.

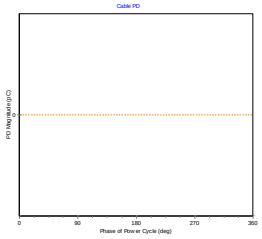
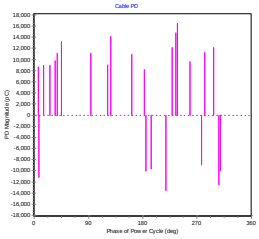
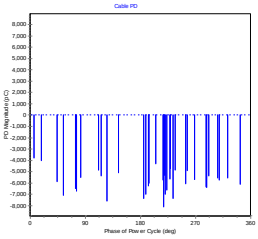
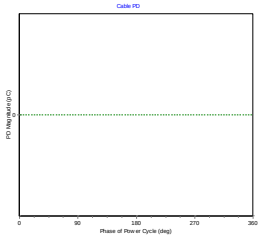
Substation/Site: T-5A-1 **Customer:** City of Tampa

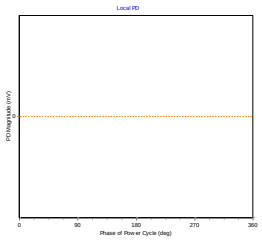
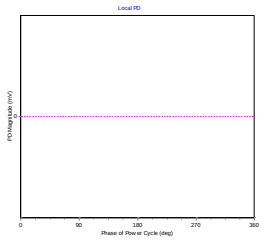
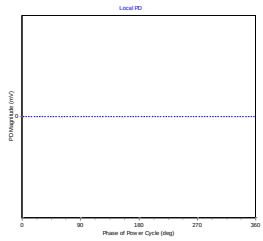
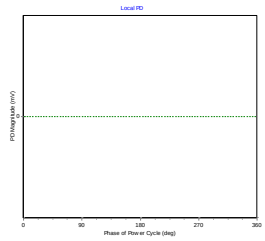
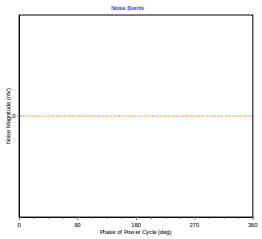
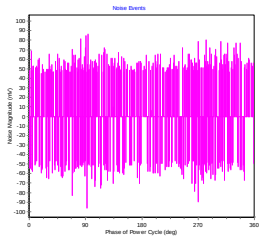
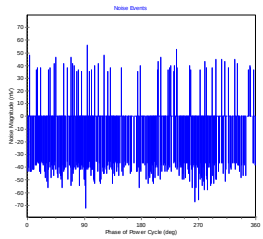
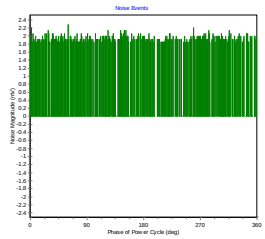
C.E. Testing, Inc.

Location: POA 72B **Test Engineer:** Nat Crews/ Louis Nemec
Test No.: **Test Date:** 08/02/2017 4:50:10 PM

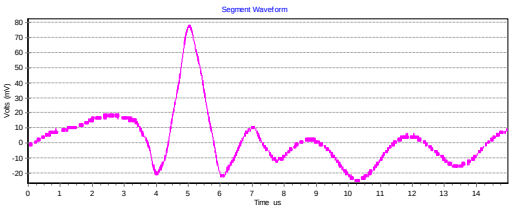
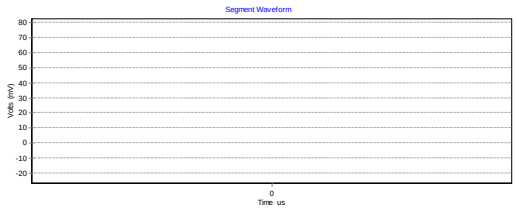
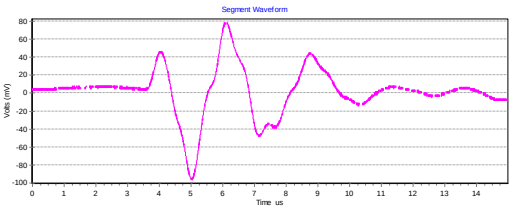
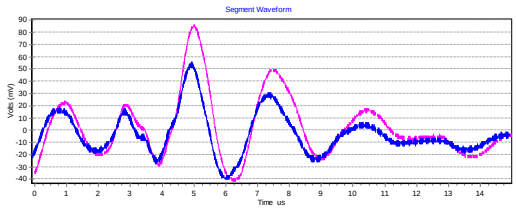
Sensor	Circuit/Description	V(kV)	Cable Type	Local Plant Type
HFCT	PHA	13.2kV	Cable	EPR
HFCT	PHB	13.2kV	Cable	EPR
HFCT	PHC	13.2kV	Cable	EPR
TEV	TEV	13.2kV	Switchgear	Solid Insulated

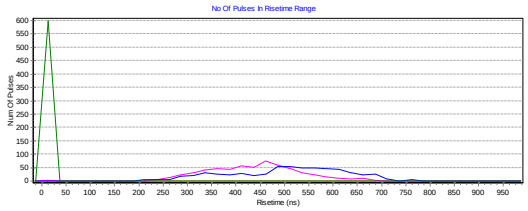
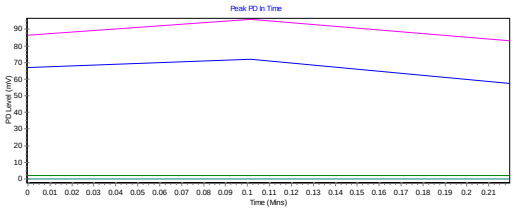
Phase-Resolved Graph (PD and Noise)	Photo of Sensor Attachment
	

	Channel 1		Channel 2		Channel 3		Channel 4	
	Cable PD	0pC	Cable PD	16428pC	Cable PD	8075pC	Cable PD	0pC
	Local PD	0dB	Local PD	0dB	Local PD	0dB	Local PD	0dB
	Peak	0.00mV	Peak	96.00mV	Peak	72.00mV	Peak	2.28mV
	Std Dev	0.00mV	Std Dev	11.96mV	Std Dev	7.90mV	Std Dev	0.56mV
Cable PD								

Local PD				
Noise				

Sensor	Circuit/Description	V(kV)	Cable Type	Local Plant Type
HFCT	phA	13.2kV	Cable	EPR
HFCT	phB	13.2kV	Cable	EPR
HFCT	phC	13.2kV	Cable	EPR
TEV Probe	TEV	13.2kV	Switchgear	Solid Insulated

Cable PD Waveform				Local PD Waveform			
							
Peak	78.40 mV	**Frequency**	488.28 kHz	**Peak**		**Frequency**	
Rise Time	429.56 ns	**PD Level**	14.81 nC	**Rise Time**		**PD Level**	
Noise Waveform				**Synchronous Waveform**			
							
Peak	-96.00 mV	**Frequency**	366.21 kHz	**Peak**	-	**Frequency**	-
Rise Time	421.32 ns	**PD Level**	-	**Rise Time**	-	**PD Level**	-

No of Pulses vs. Pulse Rise-Time	Peak Level in Time
	
Comments	
No PD detected. Noise waveforms only.	

T-8A-4

POA 66A

Substation/Site:
Location:
Test No.:

Customer: **City of Tampa**
Test Engineer: Nat Crews/ Louis Nemec
Test Date: 08/02/2017 5:17:30 PM

C.E. Testing, Inc.

Sensor	Circuit/Description	V(kV)	Cable Type	Local Plant Type
HFCT	PHA	13.2kV	Cable	EPR
HFCT	PHB	13.2kV	Cable	FPR
HFCT	PHC	13.2kV	Cable	FPR
TEV Probe	TEV	13.2kV	Switchgear	Solid Insulated

Phase-Resolved Graph (PD and Noise)

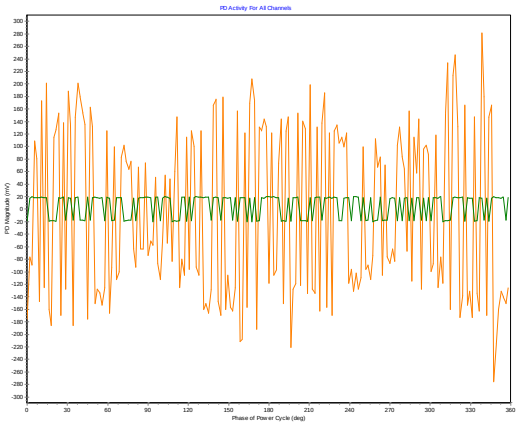
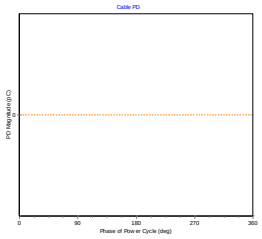
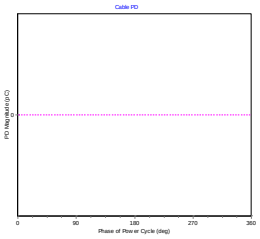
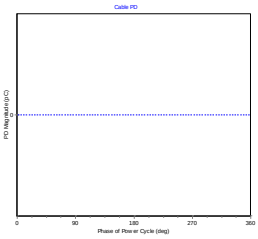
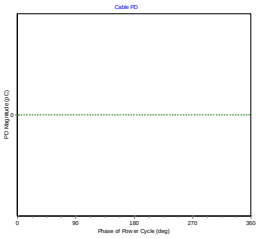
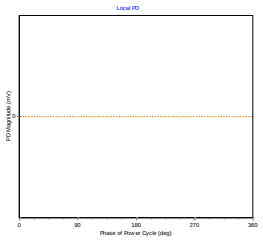
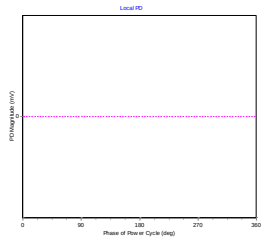
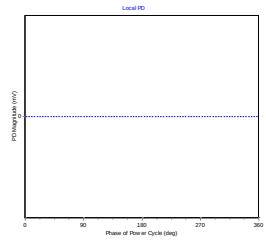
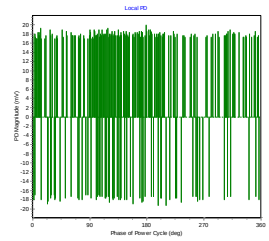
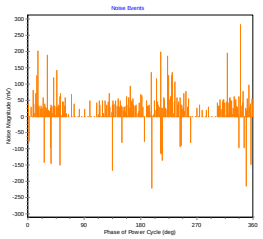
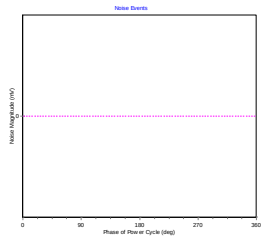
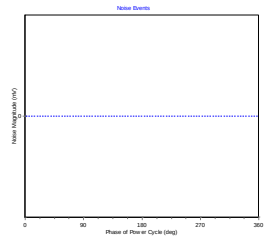
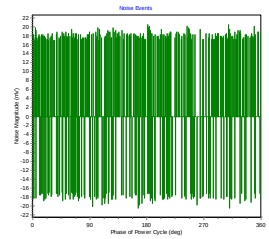
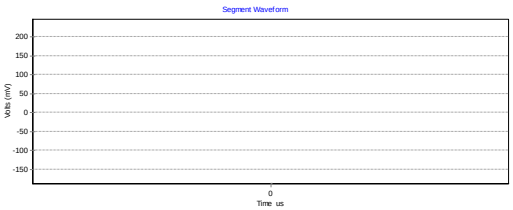
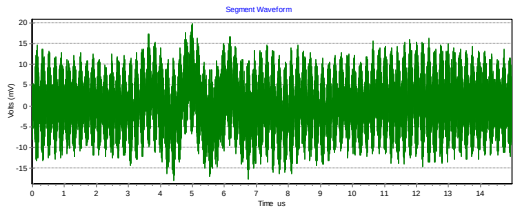
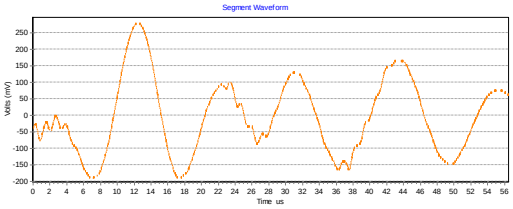
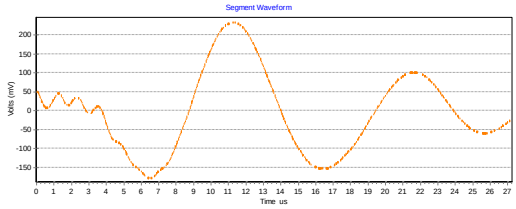


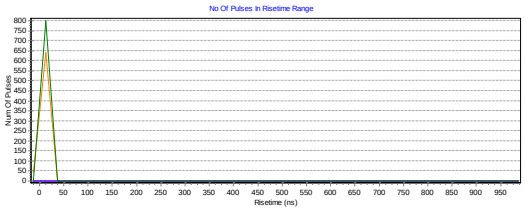
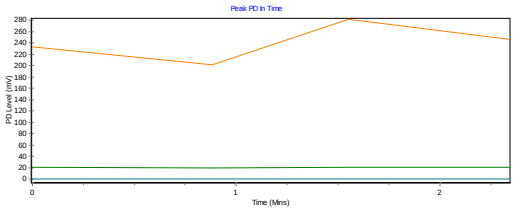
Photo of Sensor Attachment

	Channel 1		Channel 2		Channel 3		Channel 4	
	Cable PD	0pC	Cable PD	0pC	Cable PD	0pC	Cable PD	0pC
	Local PD	0dB	Local PD	0dB	Local PD	0dB	Local PD	26dB
	Peak	281.60mV	Peak	0.00mV	Peak	0.00mV	Peak	20.48mV
	Std Dev	33.47mV	Std Dev	0.00mV	Std Dev	0.00mV	Std Dev	7.09mV
Cable PD								

Local PD				
Noise				

Sensor	Circuit/Description	V(kV)	Cable Type	Local Plant Type
HFCT	PHA	13.2kV	Cable	EPR
N/A	N/A	13.2kV	Cable	FPR
N/A	N/A	13.2kV	Cable	FPR
TEV Probe	TEV	13.2kV	Switchgear	Solid Insulated

Cable PD Waveform				Local PD Waveform			
							
Peak		**Frequency**		**Peak**	19.84 mV	**Frequency**	71.43 MHz
Rise Time		**PD Level**		**Rise Time**	4.46 ns	**PD Level**	
Noise Waveform				**Synchronous Waveform**			
							
Peak	281.60 mV	**Frequency**	91.55 kHz	**Peak**	-	**Frequency**	-
Rise Time	2.16 us	**PD Level**	-	**Rise Time**	-	**PD Level**	-

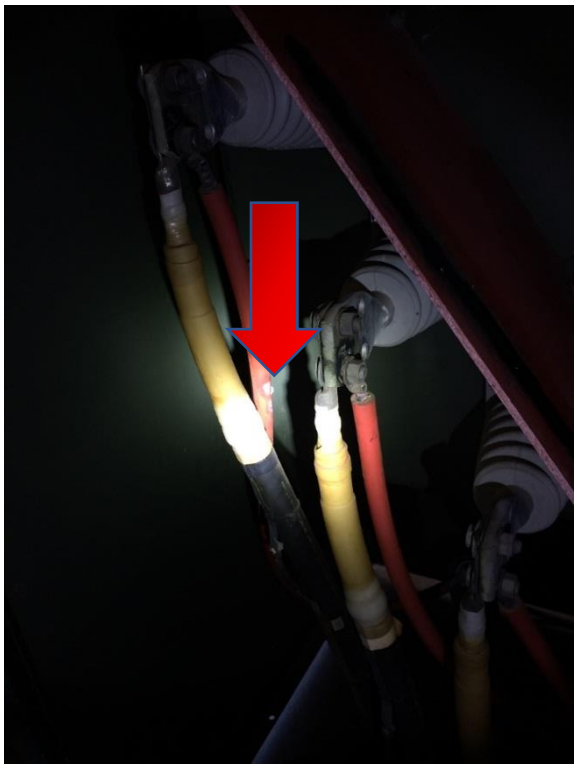
No of Pulses vs. Pulse Rise-Time	Peak Level in Time
	

Comments

POA 66A

1. A phase lightning arrestor conductor on A side feeder shows corona.
   Recommend cleaning or replacing conductor.
2. All non-shielded fuse conductors show signs of corona at the top of each insulating board.
   Recommend cleaning or replacing each conductor.
3, Oil lubricant leaking from the fuse non-shielded conductors to the insulator boards.
   Recommend cleaning the lubricant from the boards and conductors. Sealing the conductors.

Local PD: TEV 25dB Corona



Comment Item 2.

Comment Item 1.

Comment Item 1

Comment Item 3

Substation/Site:	T-8A-4	**Customer:**	City of Tampa
Location:	POA 66B	**Test Engineer:**	Nat Crews/ Louis Nemec
Test No.:		**Test Date:**	08/02/2017 5:26:10 PM

C.E. Testing, Inc.

Sensor	Circuit/Description	V(kV)	Cable Type	Local Plant Type
HFCT	phA	13.2kV	Cable	EPR
HFCT	phB	13.2kV	Cable	FPR
HFCT	phC	13.2kV	Cable	FPR
TEV Probe	TEV	13.2kV	Switchgear	Solid Insulated

Phase-Resolved Graph (PD and Noise)

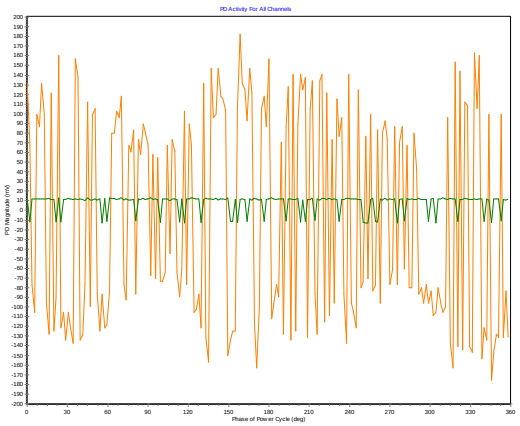
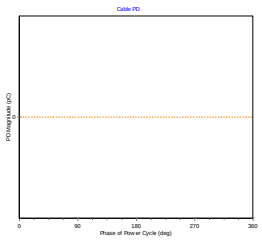
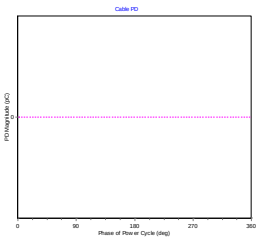
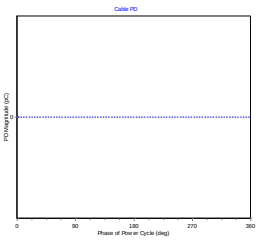
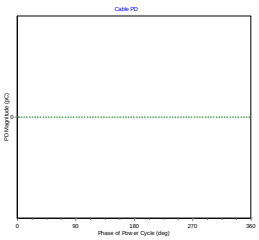
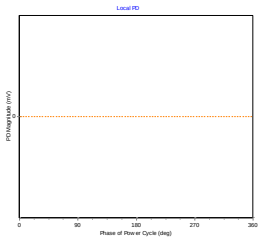
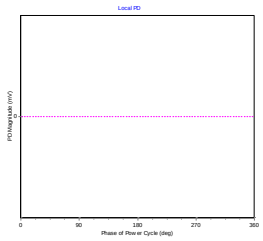
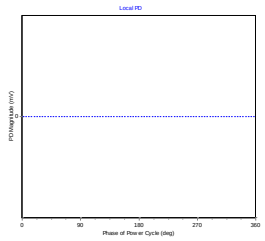
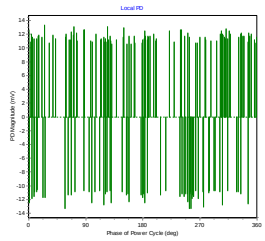
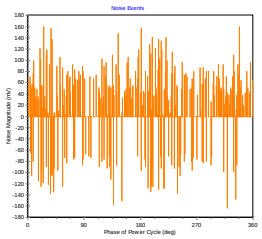
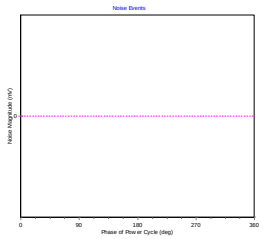
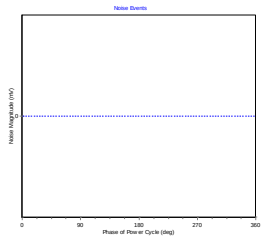
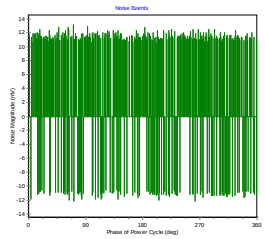
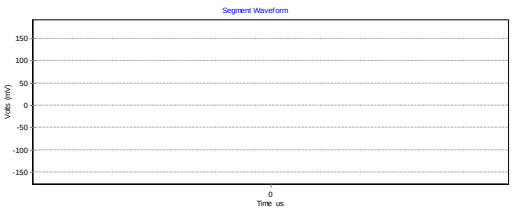
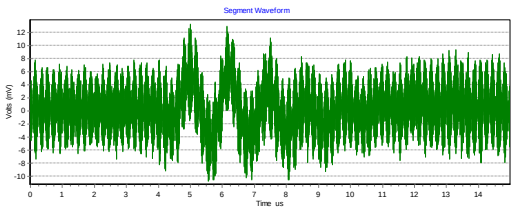
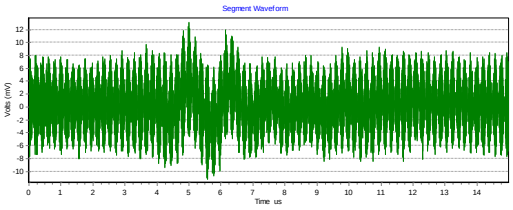
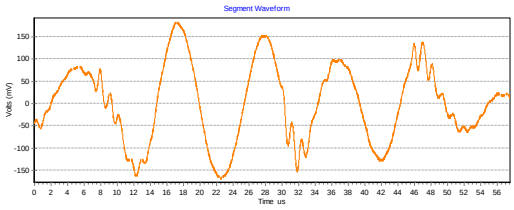


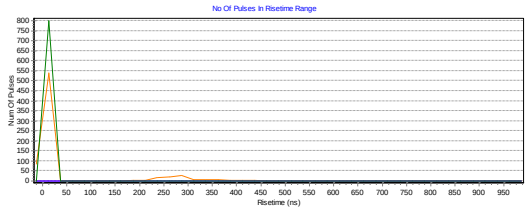
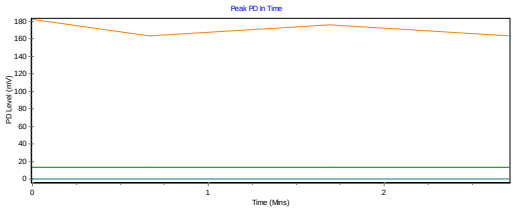
Photo of Sensor Attachment

	Channel 1		Channel 2		Channel 3		Channel 4	
	Cable PD	0pC	Cable PD	0pC	Cable PD	0pC	Cable PD	0pC
	Local PD	0dB	Local PD	0dB	Local PD	0dB	Local PD	22dB
	Peak	163.20mV	Peak	0.00mV	Peak	0.00mV	Peak	13.28mV
	Std Dev	27.67mV	Std Dev	0.00mV	Std Dev	0.00mV	Std Dev	3.97mV
Cable PD								

Local PD				
Noise				

Sensor	Circuit/Description	V(kV)	Cable Type	Local Plant Type
HFCT	phA	13.2kV	Cable	EPR
HFCT	phB	13.2kV	Cable	FPR
HFCT	phC	13.2kV	Cable	FPR
TEV Probe	TEV	13.2kV	Switchgear	Solid Insulated

Cable PD Waveform				Local PD Waveform			
							
Peak		**Frequency**		**Peak**	13.28 mV	**Frequency**	107.14 MHz
Rise Time		**PD Level**		**Rise Time**	4.91 ns	**PD Level**	
Noise Waveform				**Synchronous Waveform**			
							
Peak	13.12 mV	**Frequency**	71.43 MHz	**Peak**	-	**Frequency**	-
Rise Time	3.94 ns	**PD Level**	-	**Rise Time**	-	**PD Level**	-

No of Pulses vs. Pulse Rise-Time	Peak Level in Time
	

Comments
Multi-phase PD pattern observed. 22dB TEV

Substation/Site: T-8B-4
Location: POA 67A
Test No.:

Customer: City of Tampa
Test Engineer: Nat Crews/ Louis Nemec
Test Date: 08/02/2017 5:38:06 PM

C.E. Testing, Inc.

Sensor	Circuit/Description	V(kV)	Cable Type	Local Plant Type
HFCT	phA	15kV	Cable	EPR
HFCT	phB	13.2kV	Cable	FPR
HFCT	phC	13.2kV	Cable	FPR
TEV Probe	TEV	15kV	Switchgear	Solid Insulated

Phase-Resolved Graph (PD and Noise)

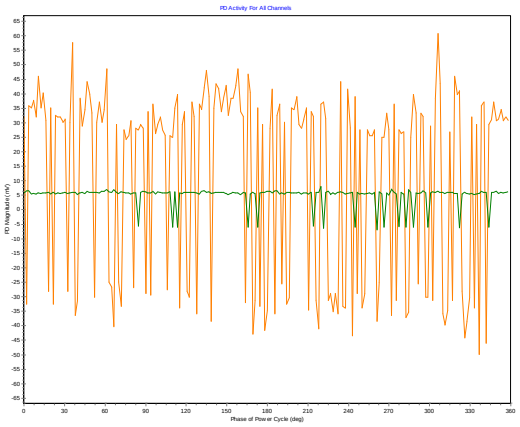
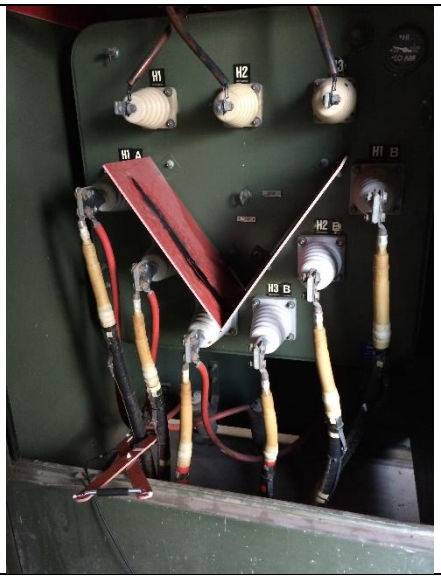
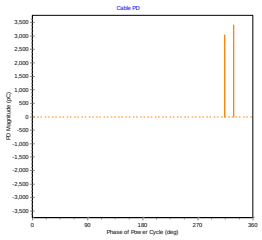
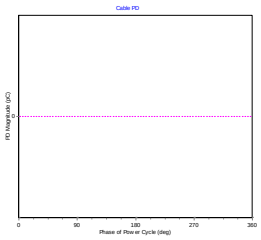
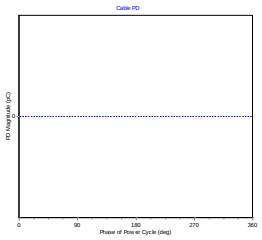
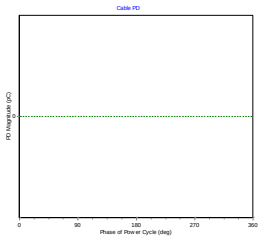
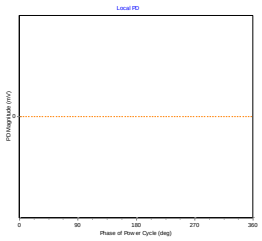
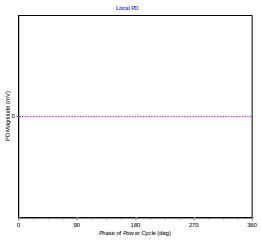
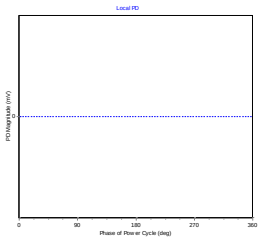
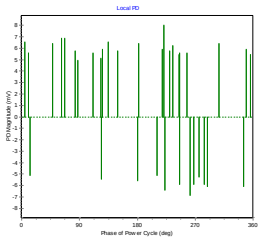
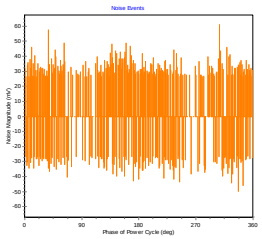
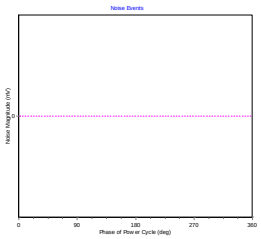
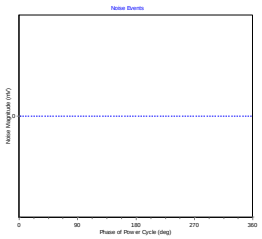
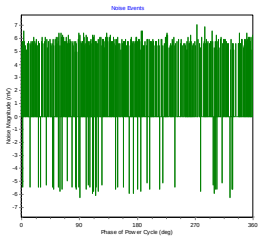


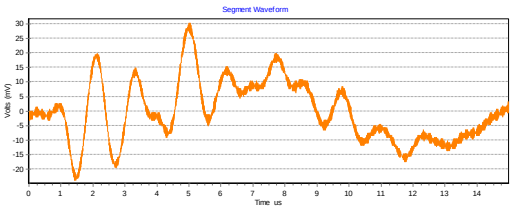
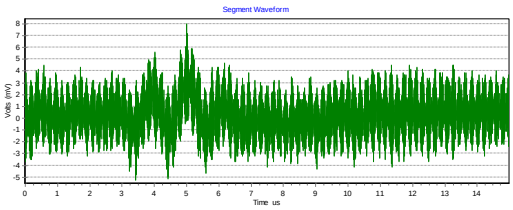
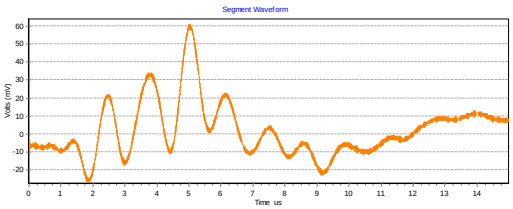
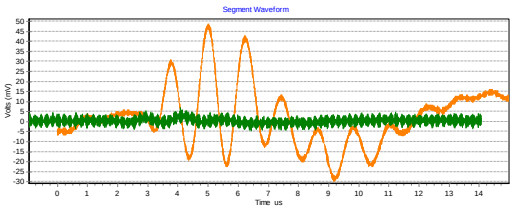
Photo of Sensor Attachment

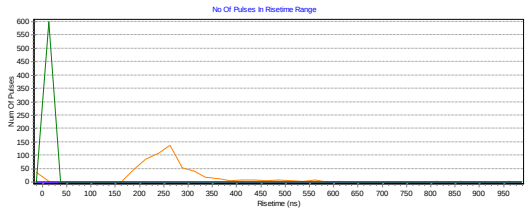


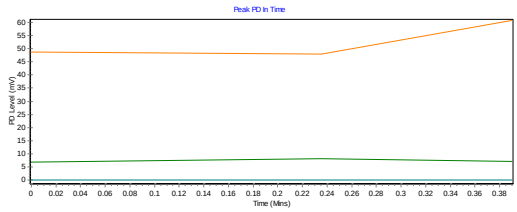
	Channel 1		Channel 2		Channel 3		Channel 4	
	Cable PD	3398pC	Cable PD	0pC	Cable PD	0pC	Cable PD	0pC
	Local PD	0dB	Local PD	0dB	Local PD	0dB	Local PD	18dB
	Peak	60.80mV	Peak	0.00mV	Peak	0.00mV	Peak	8.00mV
	Std Dev	6.52mV	Std Dev	0.00mV	Std Dev	0.00mV	Std Dev	1.74mV
Cable PD								

Local PD				
Noise				

Sensor	Circuit/Description	V(kV)	Cable Type	Local Plant Type
HFCT	phA	15kV	Cable	EPR
HFCT	phB	13.2kV	Cable	FPR
HFCT	phC	13.2kV	Cable	FPR
TEV Probe	TEV	15kV	Switchgear	Solid Insulated

Cable PD Waveform				Local PD Waveform			
							
Peak	30.08 mV	**Frequency**	488.28 kHz	**Peak**	8.00 mV	**Frequency**	105.26 MHz
Rise Time	334.79 ns	**PD Level**	3.40 nC	**Rise Time**	5.18 ns	**PD Level**	
Noise Waveform				**Synchronous Waveform**			
							
Peak	60.80 mV	**Frequency**	122.07 kHz	**Peak**	-	**Frequency**	-
Rise Time	314.43 ns	**PD Level**	-	**Rise Time**	-	**PD Level**	-
No of Pulses vs. Pulse Rise-Time				**Peak Level in Time**			



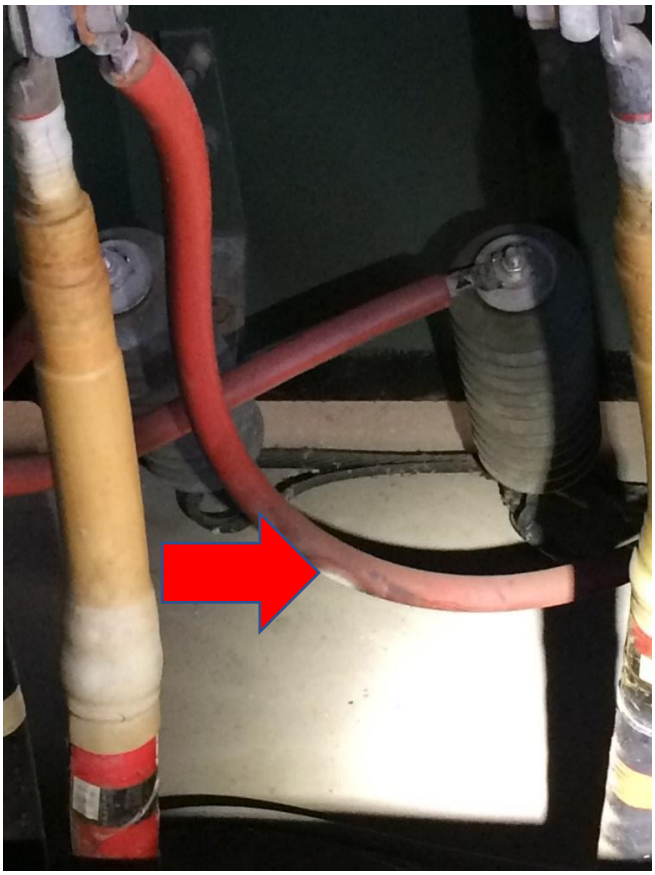


Comments

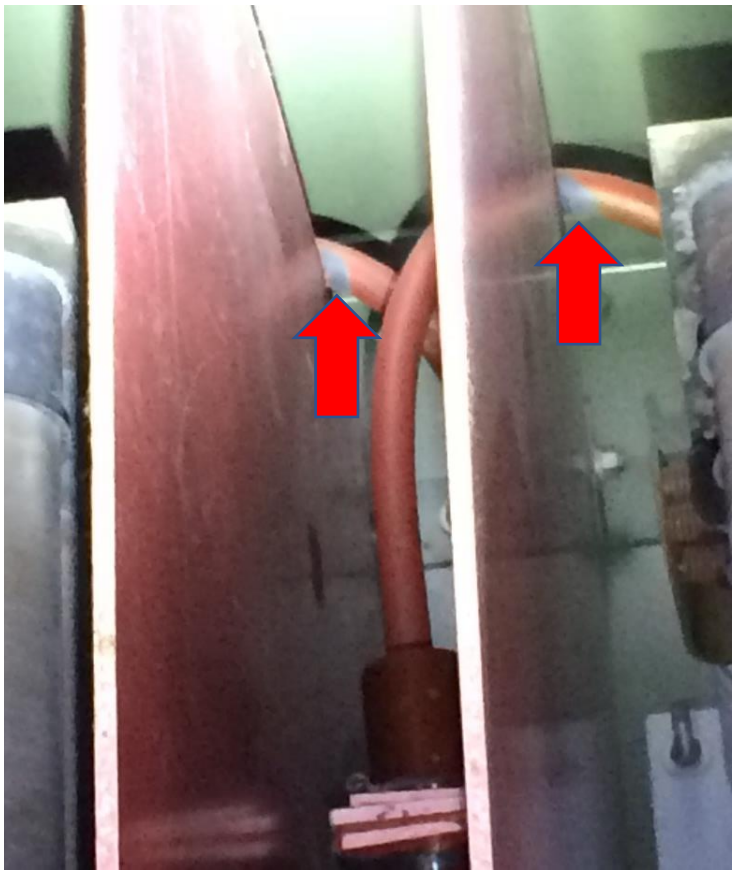
POA 67 A

1. C phase of the A side feeder lighting arrestor conductor shows signs of corona Recommend replacing the conductor
2. All fuse conductors of all phases show signs of corona at the top of the insulating boards Recommend cleaning or replacing each conductor.
3. Oil lubricant is leaking from the non-shielded fuse conductors to the insulator boards. Recommend cleaning the insulator boards and conductors. Sealing the conductors.

TEV 18dB, Corona PD

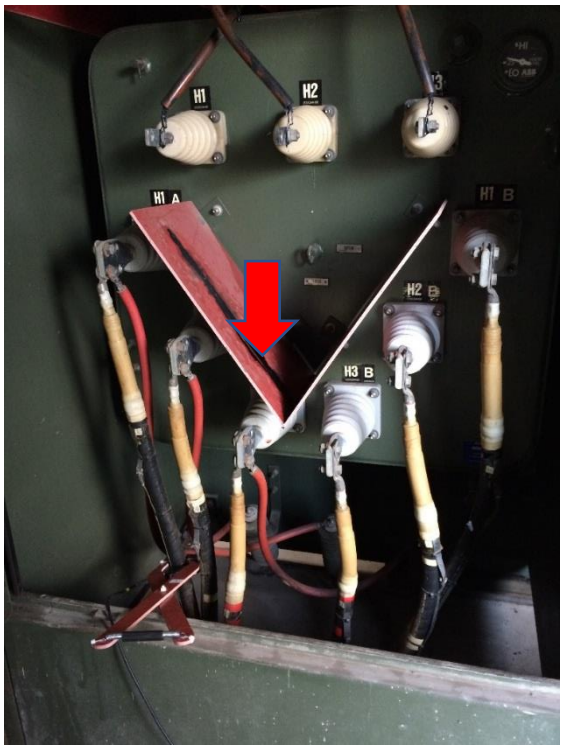


Comment Item 1



Comment Item 2

Comment Item 2

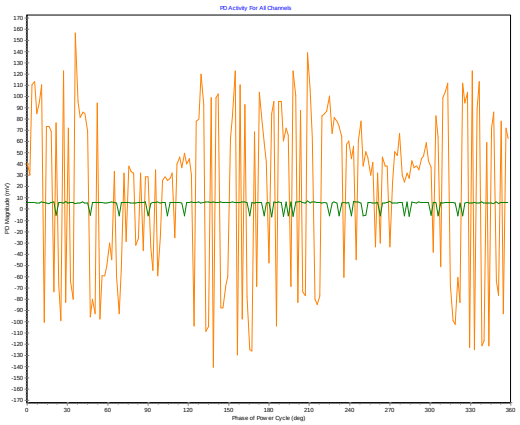
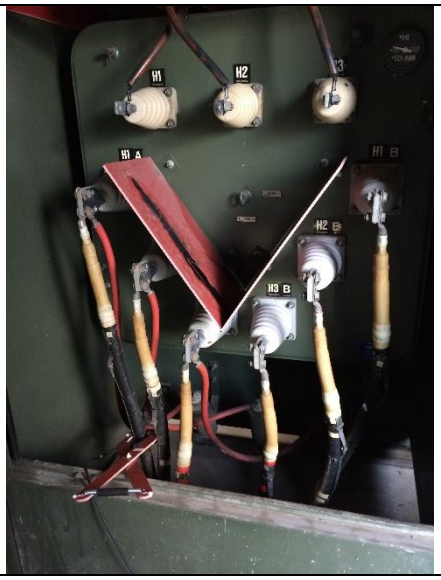


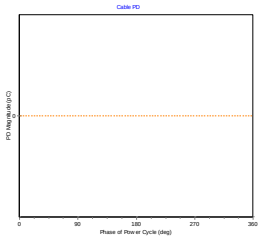
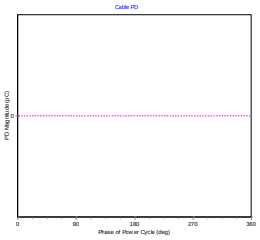
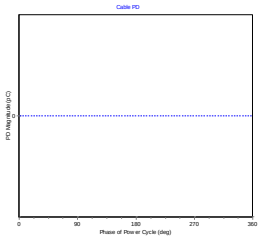
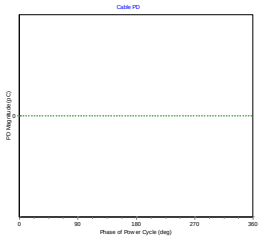
Comment Item 3

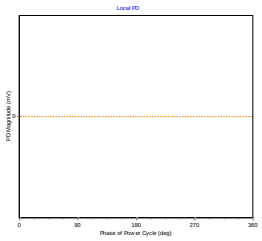
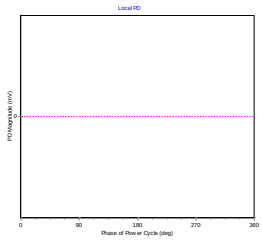
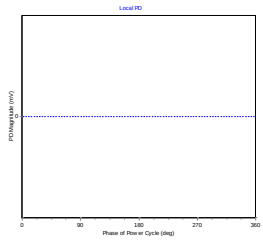
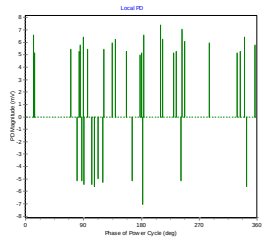
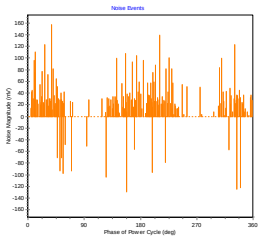
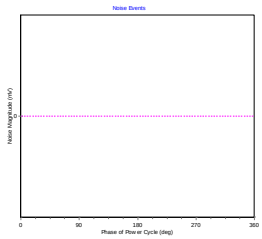
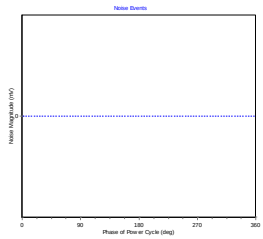
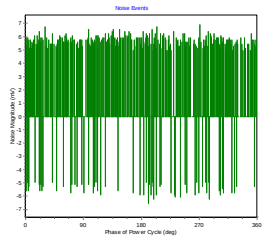
Substation/Site:	T-8B-4 B	**Customer:**	City of Tampa
Location:	POA 67B	**Test Engineer:**	Nat Crews/ Louis Nemec
Test No.:		**Test Date:**	08/02/2017 5:40:55 PM

C.E. Testing, Inc.

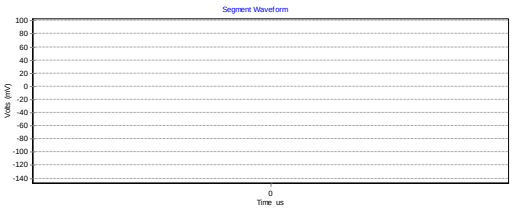
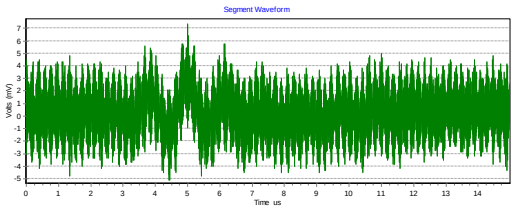
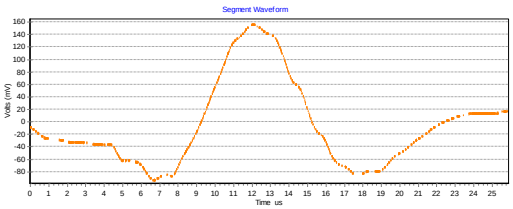
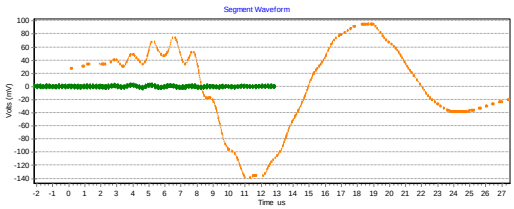
Sensor	Circuit/Description	V(kV)	Cable Type	Local Plant Type
HFCT	phA	15kV	Cable	EPR
HFCT	phB	13.2kV	Cable	FPR
HFCT	phC	13.2kV	Cable	FPR
TEV Probe	TEV	15kV	Cable	EPR

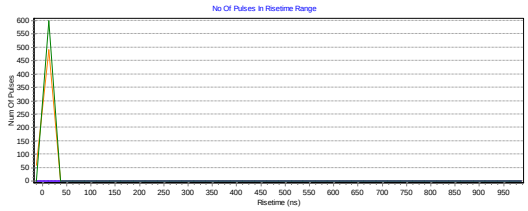
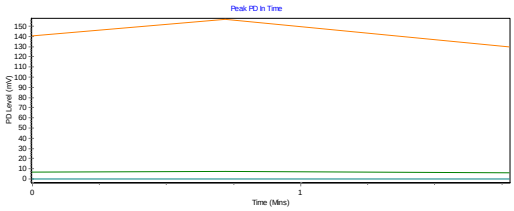
Phase-Resolved Graph (PD and Noise)	Photo of Sensor Attachment
	

	Channel 1		Channel 2		Channel 3		Channel 4	
	Cable PD	0pC	Cable PD	0pC	Cable PD	0pC	Cable PD	0pC
	Local PD	0dB	Local PD	0dB	Local PD	0dB	Local PD	17dB
	Peak	156.80mV	Peak	0.00mV	Peak	0.00mV	Peak	7.36mV
	Std Dev	20.53mV	Std Dev	0.00mV	Std Dev	0.00mV	Std Dev	1.73mV
Cable PD								

Local PD				
Noise				

Sensor	Circuit/Description	V(kV)	Cable Type	Local Plant Type
HFCT	phA	15kV	Cable	EPR
HFCT	phB	13.2kV	Cable	FPR
HFCT	phC	13.2kV	Cable	FPR
TEV Probe	TEV	15kV	Cable	EPR

Cable PD Waveform				Local PD Waveform			
							
Peak		**Frequency**		**Peak**	7.36 mV	**Frequency**	71.43 MHz
Rise Time		**PD Level**		**Rise Time**	5.52 ns	**PD Level**	
Noise Waveform				**Synchronous Waveform**			
							
Peak	156.80 mV	**Frequency**	61.04 kHz	**Peak**	-	**Frequency**	-
Rise Time	2.19 us	**PD Level**	-	**Rise Time**	-	**PD Level**	-

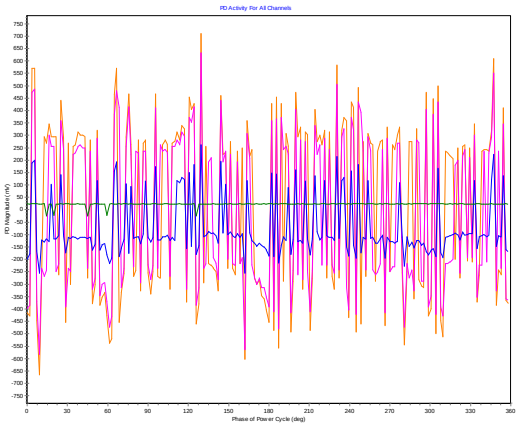
No of Pulses vs. Pulse Rise-Time	Peak Level in Time
	

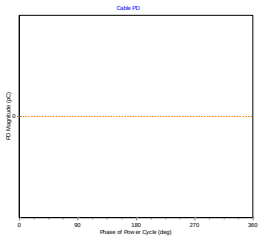
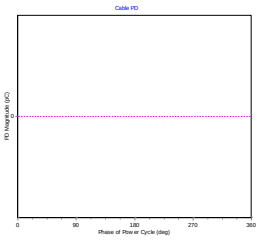
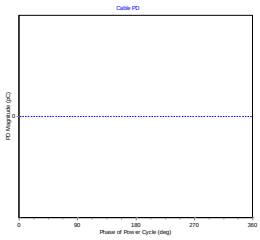
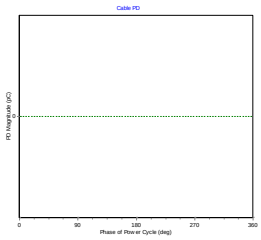
Comments
Refer to POA 67A for additional information Local PD Detected, 17dB @71MHz

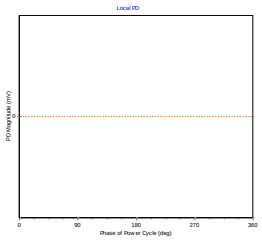
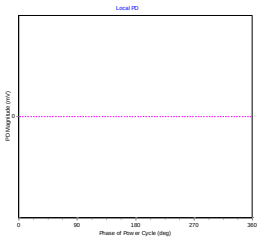
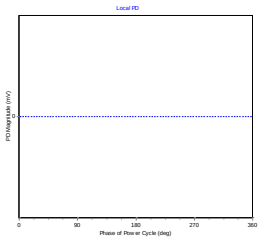
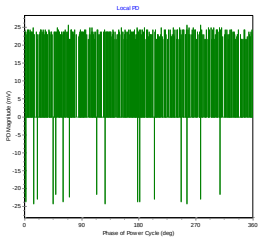
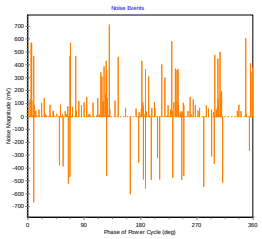
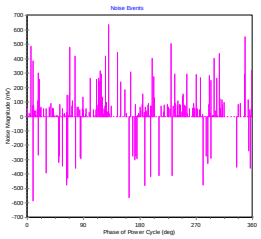
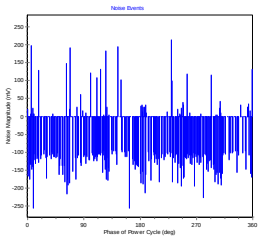
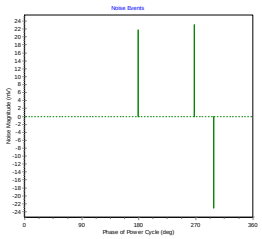
Substation/Site:	T-8A-3	**Customer:**	City of Tampa
Location:	POA 64	**Test Engineer:**	Nat Crews/ Louis Nemec
Test No.:		**Test Date:**	08/02/2017 5:57:44 PM

C.E. Testing, Inc.

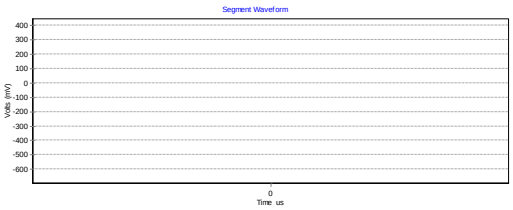
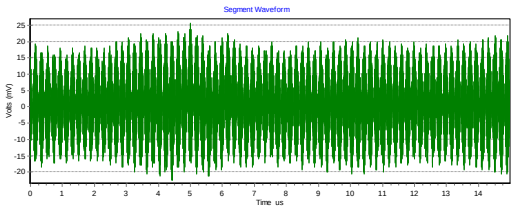
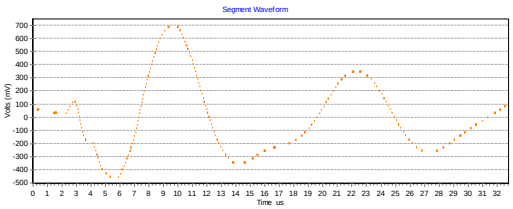
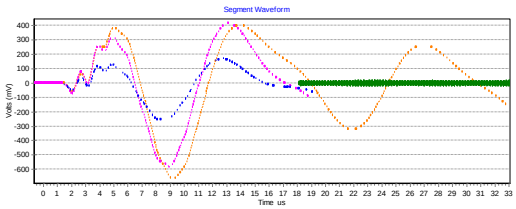
Sensor	Circuit/Description	V(kV)	Cable Type	Local Plant Type
HFCT	phA	13.2kV	Cable	EPR
HFCT	phB	13.2kV	Cable	EPR
HFCT	phC	13.2kV	Cable	EPR
TEV Probe	TEV	13.2kV	Cable	EPR

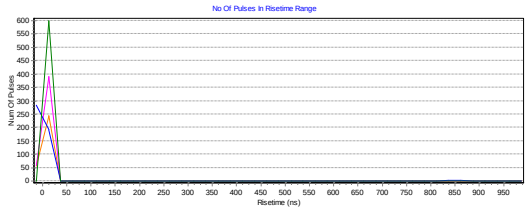
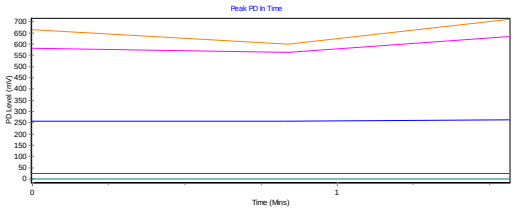
Phase-Resolved Graph (PD and Noise)	Photo of Sensor Attachment
	

	Channel 1		Channel 2		Channel 3		Channel 4	
	Cable PD	0pC	Cable PD	0pC	Cable PD	0pC	Cable PD	0pC
	Local PD	0dB	Local PD	0dB	Local PD	0dB	Local PD	28dB
	Peak	710.40mV	Peak	633.60mV	Peak	256.00mV	Peak	25.60mV
	Std Dev	86.02mV	Std Dev	72.54mV	Std Dev	30.85mV	Std Dev	9.69mV
Cable PD								

Local PD				
Noise				

Sensor	Circuit/Description	V(kV)	Cable Type	Local Plant Type
HFCT	phA	13.2kV	Cable	EPR
HFCT	phB	13.2kV	Cable	EPR
HFCT	phC	13.2kV	Cable	EPR
TEV Probe	TEV	13.2kV	Cable	EPR

Cable PD Waveform				Local PD Waveform			
							
Peak		**Frequency**		**Peak**	25.60 mV	**Frequency**	71.43 MHz
Rise Time		**PD Level**		**Rise Time**	1.84 ns	**PD Level**	
Noise Waveform				**Synchronous Waveform**			
							
Peak	710.40 mV	**Frequency**	91.55 kHz	**Peak**	-	**Frequency**	-
Rise Time	2.07 us	**PD Level**	-	**Rise Time**	-	**PD Level**	-

No of Pulses vs. Pulse Rise-Time	Peak Level in Time
	

Comments
Local PD detected. 28dB @ 71Mhz.

Substation/Site: T-8B-3
Location: POA 65
Test No.:

Customer: City of Tampa
Test Engineer: Nat Crews/ Louis Nemec
Test Date: 08/02/2017 6:09:10 PM

C.E. Testing, Inc.

Sensor	Circuit/Description	V(kV)	Cable Type	Local Plant Type
HFCT	PHA	13.2kV	Cable	EPR
HFCT	PHB	13.2kV	Cable	EPR
HFCT	PHC	13.2kV	Cable	EPR
TEV Probe	TEV	13.2kV	Switchgear	Solid Insulated

Phase-Resolved Graph (PD and Noise)

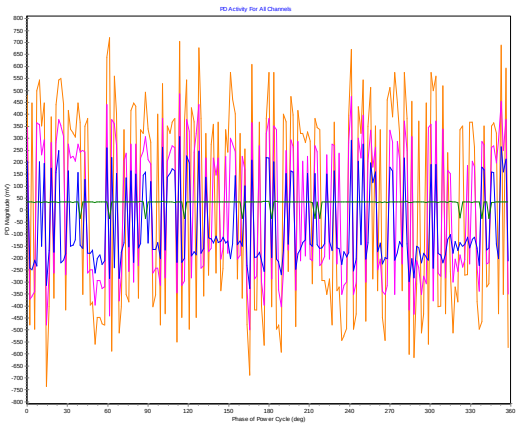
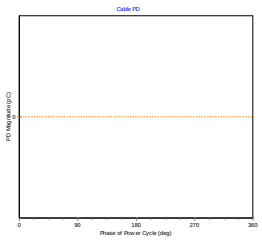
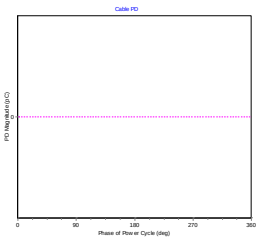
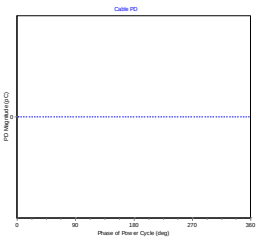
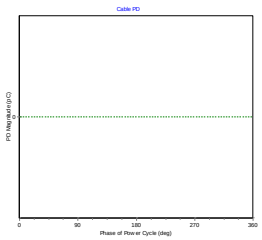
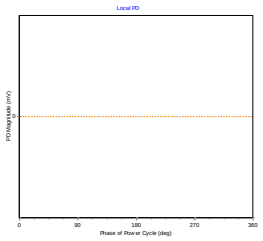
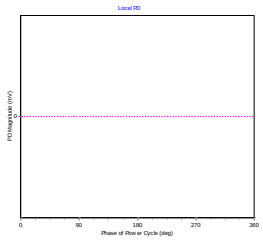
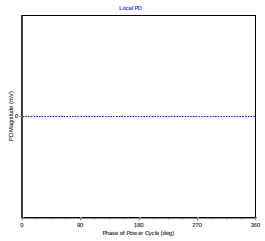
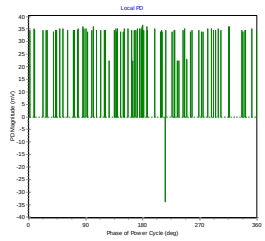
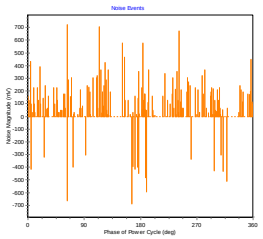
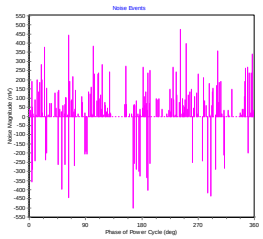
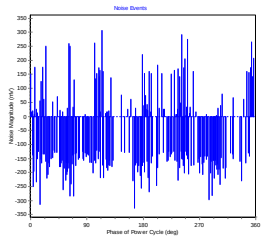
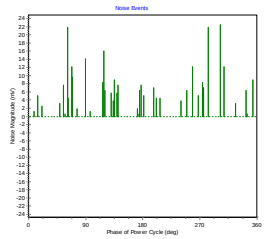
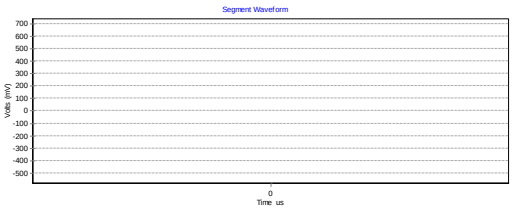
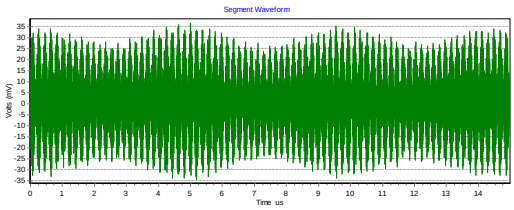
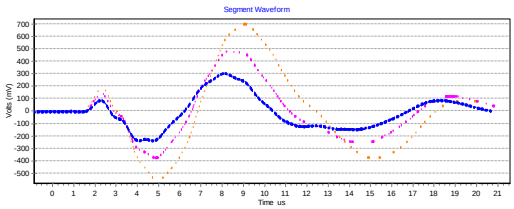


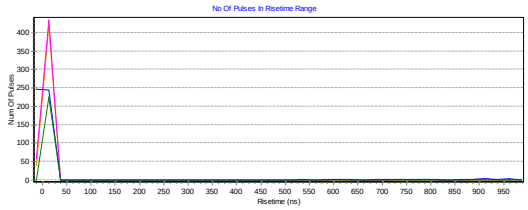
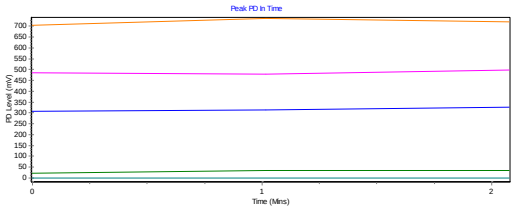
Photo of Sensor Attachment

	Channel 1		Channel 2		Channel 3		Channel 4	
	Cable PD	0pC	Cable PD	0pC	Cable PD	0pC	Cable PD	0pC
	Local PD	0dB	Local PD	0dB	Local PD	0dB	Local PD	31dB
	Peak	720.00mV	Peak	499.20mV	Peak	326.40mV	Peak	36.48mV
	Std Dev	117.66mV	Std Dev	75.45mV	Std Dev	43.64mV	Std Dev	13.45mV
Cable PD								

Local PD				
Noise				

Sensor	Circuit/Description	V(kV)	Cable Type	Local Plant Type
HFCT	phA	13.2kV	Cable	EPR
HFCT	phB	13.2kV	Cable	EPR
HFCT	phC	13.2kV	Cable	EPR
TEV	TEV	13.2kV	Switchgear	Solid Insulated

Cable PD Waveform				Local PD Waveform			
							
Peak		**Frequency**		**Peak**	36.48 mV	**Frequency**	71.43 MHz
Rise Time		**PD Level**		**Rise Time**	986.53 ps	**PD Level**	
Noise Waveform				**Synchronous Waveform**			
							
Peak	704.00 mV	**Frequency**	91.55 kHz	**Peak**	-	**Frequency**	-
Rise Time	1.82 us	**PD Level**	-	**Rise Time**	-	**PD Level**	-

No of Pulses vs. Pulse Rise-Time	**Peak Level in Time**
	

Comments
Local PD detected. 31dB @ 71Mhz.

Substation/Site: T-5B-7
Location: POA 70
Test No.:

Customer: City of Tampa
Test Engineer: Nat Crews/ Louis Nemec
Test Date: 08/02/2017 6:27:53 PM

C.E. Testing, Inc.

Sensor	Circuit/Description	V(kV)	Cable Type	Local Plant Type
HFCT	phA	13.2kV	Cable	EPR
HFCT	phB	13.2kV	Cable	EPR
HFCT	phC	13.2kV	Cable	EPR
TEV	TEV	13.2kV	Cable	EPR

Phase-Resolved Graph (PD and Noise)

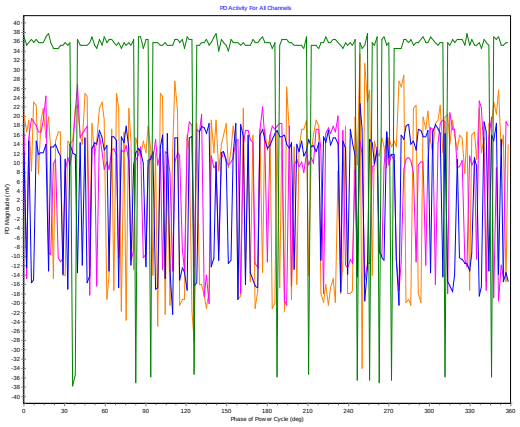
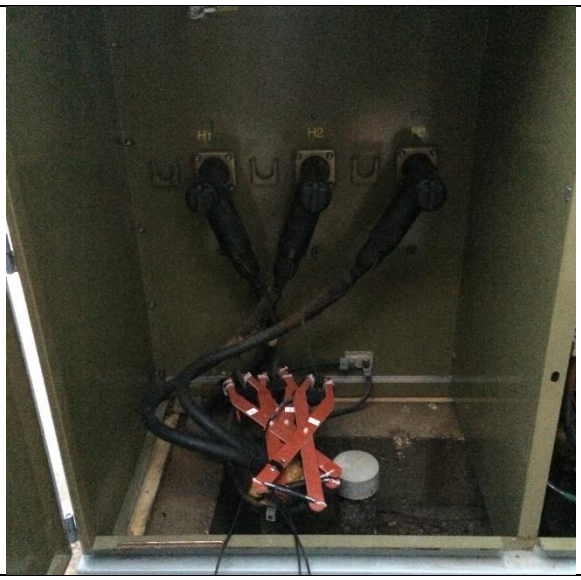
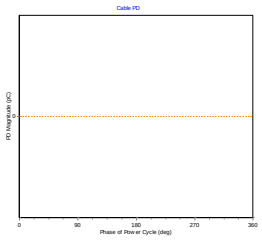
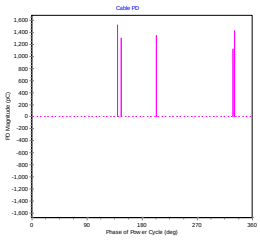
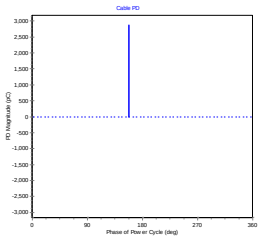
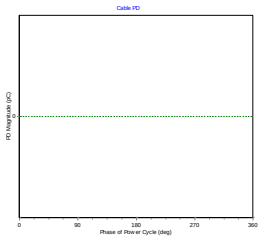
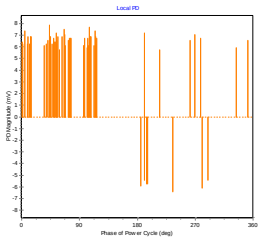
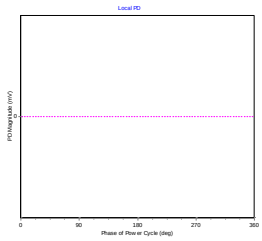
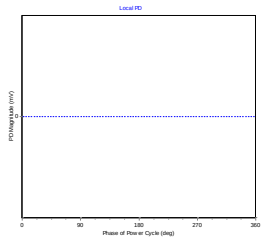
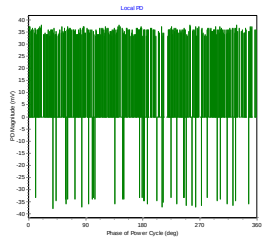
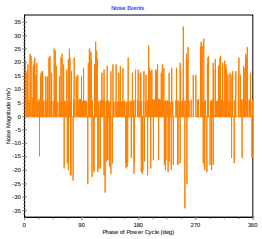
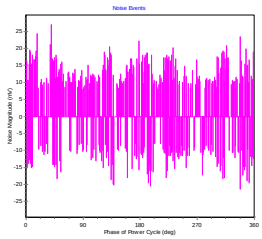
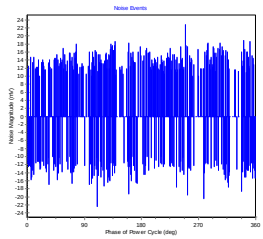
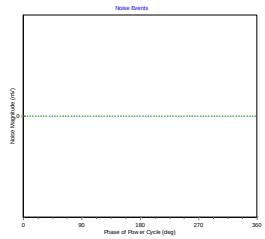


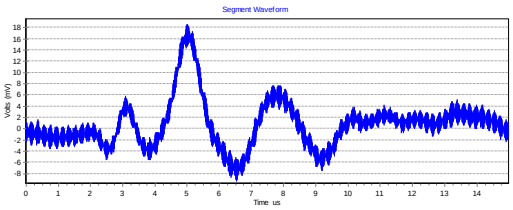
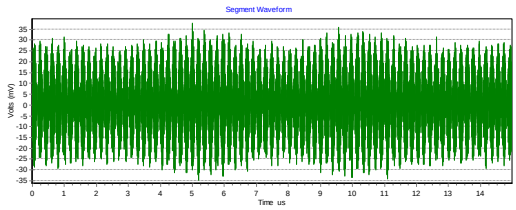
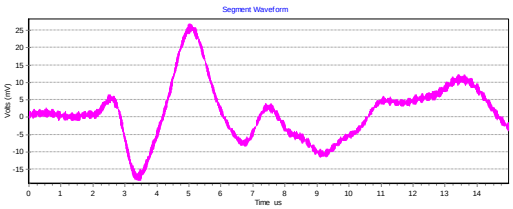
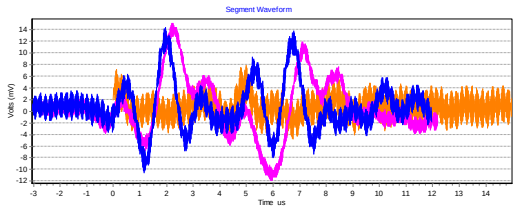
Photo of Sensor Attachment

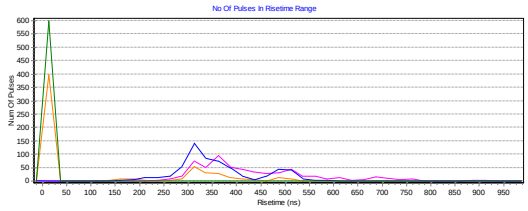
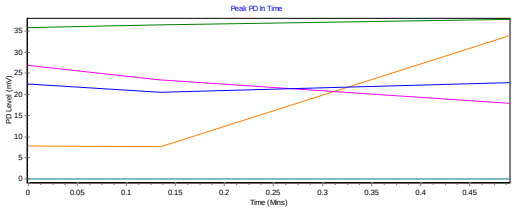


	Channel 1		Channel 2		Channel 3		Channel 4	
	Cable PD	0pC	Cable PD	1520pC	Cable PD	2867pC	Cable PD	0pC
	Local PD	18dB	Local PD	0dB	Local PD	0dB	Local PD	32dB
	Peak	33.92mV	Peak	26.88mV	Peak	22.72mV	Peak	37.76mV
	Std Dev	2.23mV	Std Dev	2.15mV	Std Dev	2.01mV	Std Dev	14.21mV
Cable PD								

Local PD				
Noise				

Sensor	Circuit/Description	V(kV)	Cable Type	Local Plant Type
HFCT	phA	13.2kV	Cable	EPR
HFCT	phB	13.2kV	Cable	EPR
HFCT	phC	13.2kV	Cable	EPR
TEV	TEV	13.2kV	Cable	EPR

Cable PD Waveform				Local PD Waveform			
							
Peak	18.56 mV	**Frequency**	366.21 kHz	**Peak**	37.76 mV	**Frequency**	71.43 MHz
Rise Time	425.69 ns	**PD Level**	2.87 nC	**Rise Time**	952.51 ps	**PD Level**	
Noise Waveform				**Synchronous Waveform**			
							
Peak	26.88 mV	**Frequency**	305.18 kHz	**Peak**	-	**Frequency**	-
Rise Time	557.17 ns	**PD Level**	-	**Rise Time**	-	**PD Level**	-

No of Pulses vs. Pulse Rise-Time	Peak Level in Time
	

Comments
Local PD detected. 32dB @ 71Mhz.

Substation/Site: T-5A-7
Location: POA 71
Test No.:

Customer: City of Tampa
Test Engineer: Nat Crews/ Louis Nemec
Test Date: 08/02/2017 6:33:49 PM

C.E. Testing, Inc.

Sensor	Circuit/Description	V(kV)	Cable Type	Local Plant Type
HFCT	phA	13.2kV	Cable	EPR
HFCT	phB	13.2kV	Cable	EPR
HFCT	phC	13.2kV	Cable	EPR
N/A	N/A	13.2kV	Cable	EPR

Phase-Resolved Graph (PD and Noise)

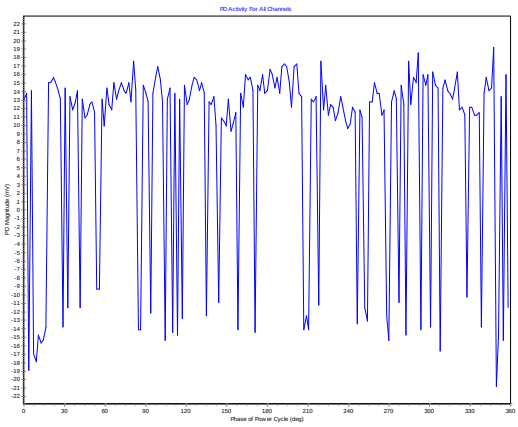
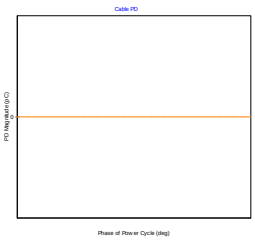
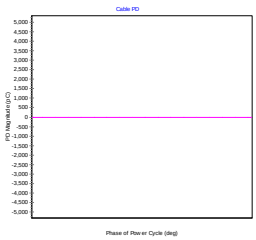
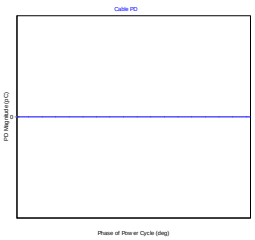
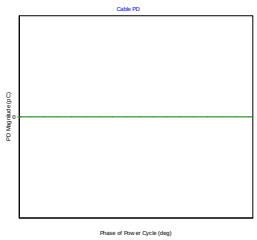
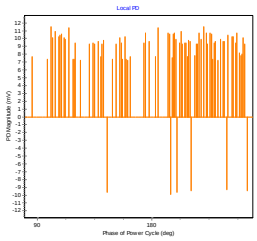
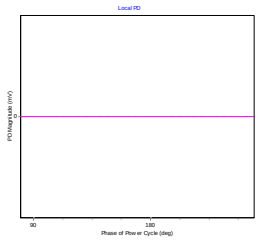
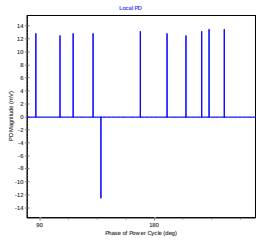
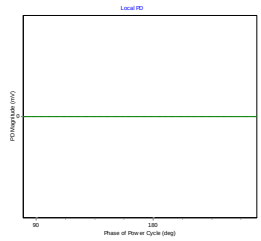
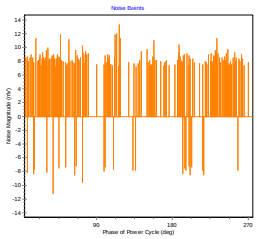
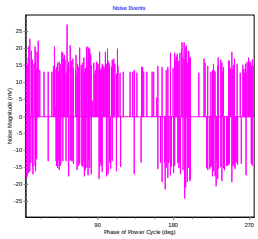
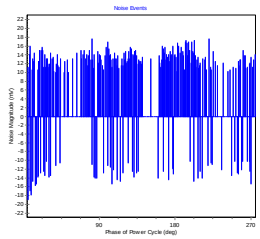
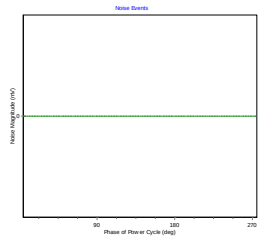
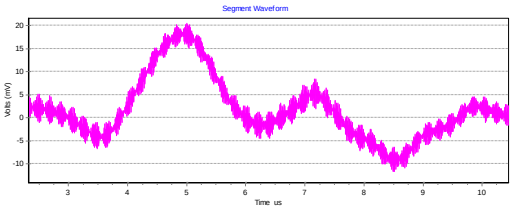
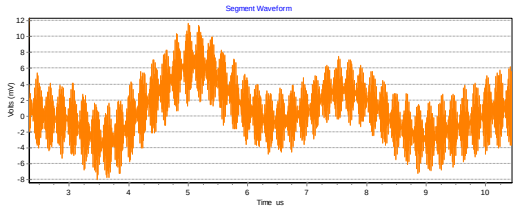
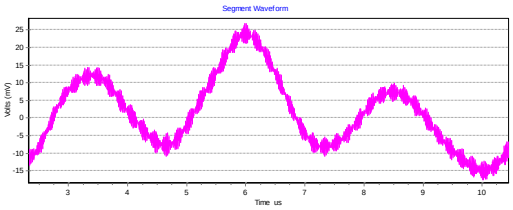
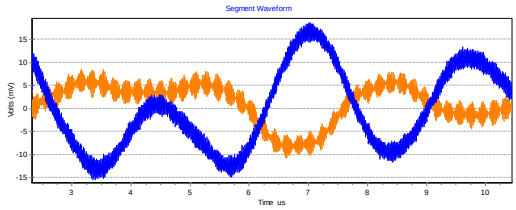


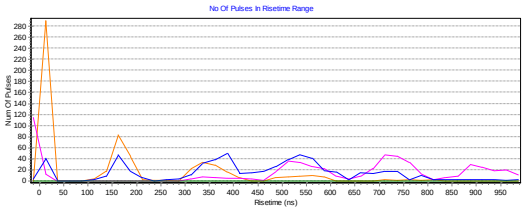
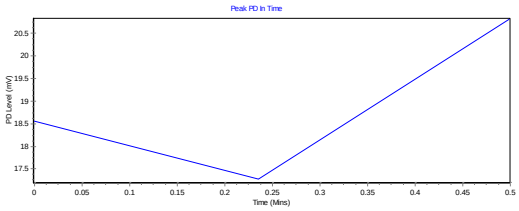
Photo of Sensor Attachment

	Channel 1		Channel 2		Channel 3		Channel 4	
	Cable PD	0pC	Cable PD	4828pC	Cable PD	0pC	Cable PD	0pC
	Local PD	21dB	Local PD	0dB	Local PD	23dB	Local PD	0dB
	Peak	13.28mV	Peak	26.88mV	Peak	20.80mV	Peak	0.00mV
	Std Dev	2.18mV	Std Dev	3.84mV	Std Dev	3.17mV	Std Dev	0.00mV
Cable PD								

Local PD				
Noise				

Sensor	Circuit/Description	V(kV)	Cable Type	Local Plant Type
HFCT	phA	13.2kV	Cable	EPR
HFCT	phB	13.2kV	Cable	EPR
HFCT	phC	13.2kV	Cable	EPR
N/A	N/A	13.2kV	Cable	EPR

Cable PD Waveform				Local PD Waveform			
							
Peak	20.48 mV	**Frequency**	122.07 kHz	**Peak**	11.68 mV	**Frequency**	100.00 MHz
Rise Time	795.54 ns	**PD Level**	4.83 nC	**Rise Time**	5.84 ns	**PD Level**	
Noise Waveform				**Synchronous Waveform**			
							
Peak	26.88 mV	**Frequency**	366.21 kHz	**Peak**	-	**Frequency**	-
Rise Time	583.38 ns	**PD Level**	-	**Rise Time**	-	**PD Level**	-

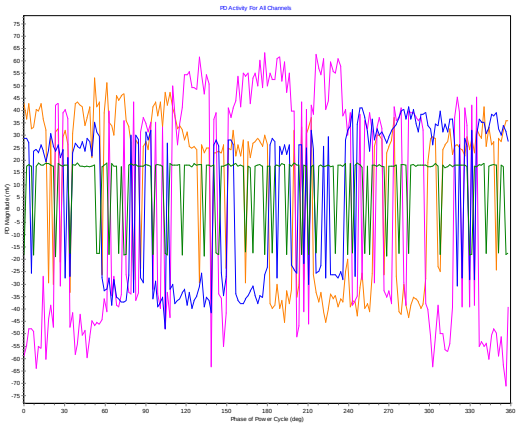
No of Pulses vs. Pulse Rise-Time	Peak Level in Time
	

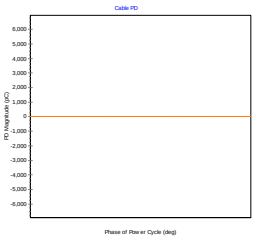
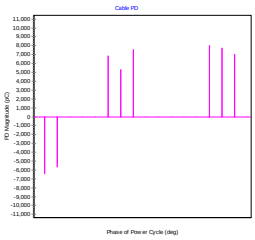
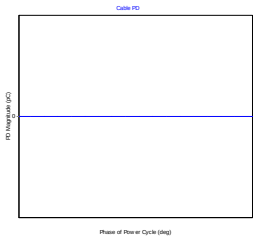
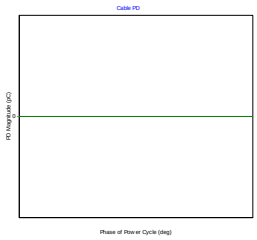
Comments
No PD detected. Noise waveforms.

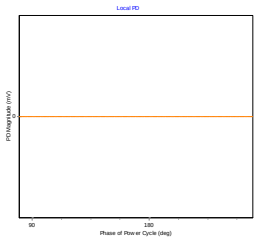
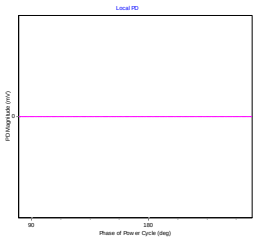
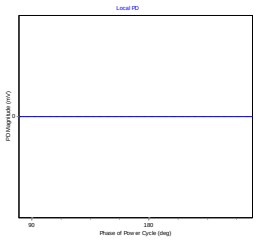
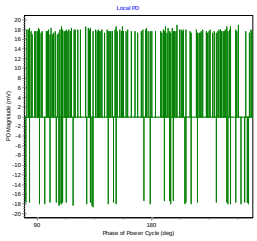
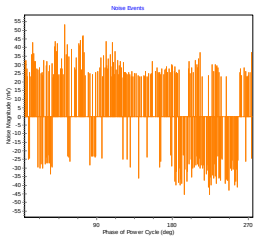
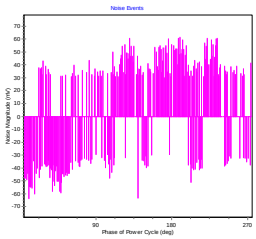
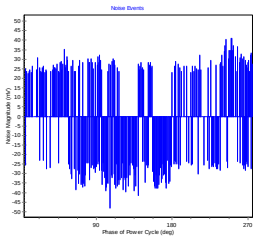
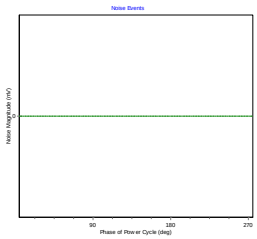
Substation/Site:	T-5B-3	**Customer:**	City of Tampa
Location:	POA 68A	**Test Engineer:**	Nat Crews/ Louis Nemec
Test No.:		**Test Date:**	08/02/2017 6:41:11 PM

C.E. Testing, Inc.

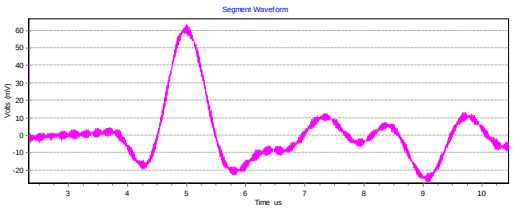
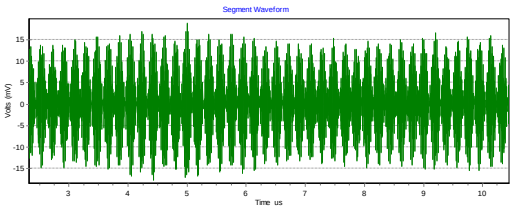
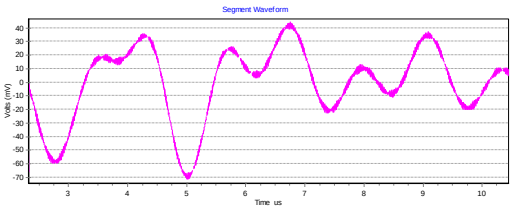
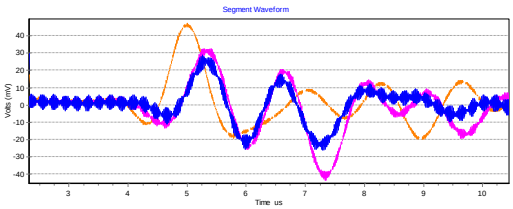
Sensor	Circuit/Description	V(kV)	Cable Type	Local Plant Type
HFCT	phA	13.2kV	Cable	EPR
HFCT	phB	13.2kV	Cable	EPR
HFCT	phC	13.2kV	Cable	EPR
TEV Probe	TEV	13.2kV	Switchgear	Solid Insulated

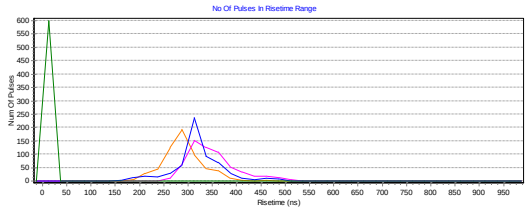
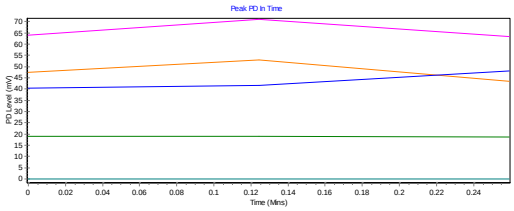
Phase-Resolved Graph (PD and Noise)	Photo of Sensor Attachment
	

	Channel 1		Channel 2		Channel 3		Channel 4	
	Cable PD	6281pC	Cable PD	10305pC	Cable PD	0pC	Cable PD	0pC
	Local PD	0dB	Local PD	0dB	Local PD	0dB	Local PD	26dB
	Peak	53.12mV	Peak	71.04mV	Peak	48.00mV	Peak	18.88mV
	Std Dev	3.98mV	Std Dev	5.51mV	Std Dev	4.12mV	Std Dev	7.24mV
Cable PD								

Local PD				
Noise				

Sensor	Circuit/Description	V(kV)	Cable Type	Local Plant Type
HFCT	phA	13.2kV	Cable	EPR
HFCT	phB	13.2kV	Cable	EPR
HFCT	phC	13.2kV	Cable	EPR
TEV Probe	TEV	13.2kV	Switchgear	Solid Insulated

Cable PD Waveform				Local PD Waveform			
							
Peak	63.36 mV	**Frequency**	488.28 kHz	**Peak**	18.88 mV	**Frequency**	93.75 MHz
Rise Time	380.41 ns	**PD Level**	8.68 nC	**Rise Time**	571.51 ps	**PD Level**	
Noise Waveform				**Synchronous Waveform**			
							
Peak	-71.04 mV	**Frequency**	366.21 kHz	**Peak**	-	**Frequency**	-
Rise Time	318.63 ns	**PD Level**	-	**Rise Time**	-	**PD Level**	-

No of Pulses vs. Pulse Rise-Time	Peak Level in Time
	

Comments
Local PD detected. 26dB @ 71Mhz.

Substation/Site:	T-5B-3 B	**Customer:**	City of Tampa	C.E. Testing, Inc.
Location:	POA 68 B	**Test Engineer:**	Nat Crews/ Louis Nemec	
Test No.:		**Test Date:**	08/02/2017 6:49:30 PM	

Sensor	Circuit/Description	V(kV)	Cable Type	Local Plant Type
HFCT	phA	13.2kV	Cable	EPR
HFCT	phB	13.2kV	Cable	EPR
N/A	N/A	13.2kV	Cable	EPR
TEV Probe	TEV	13.2kV	Switchgear	Solid Insulated

Phase-Resolved Graph (PD and Noise)

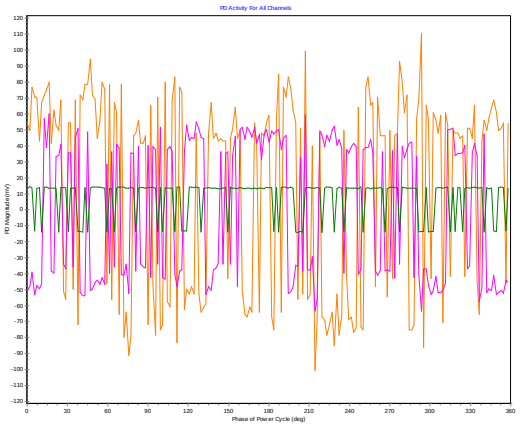
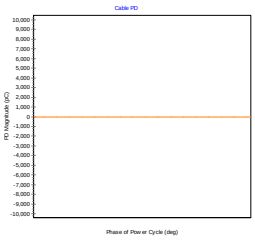
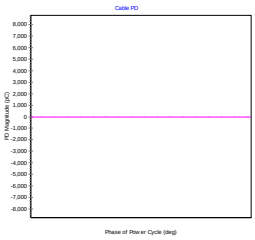
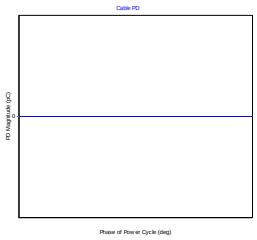
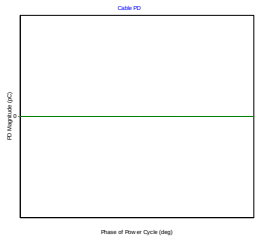
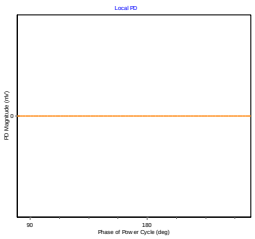
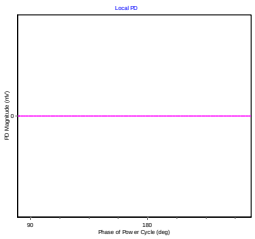
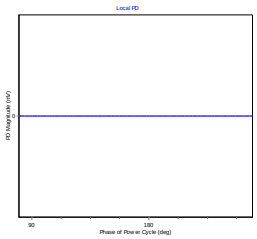
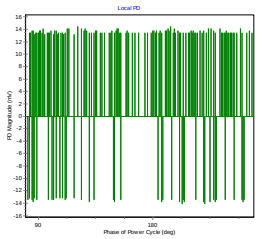
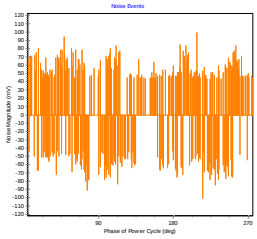
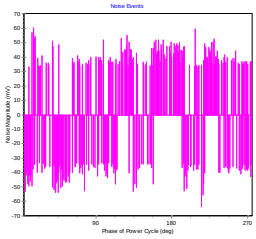
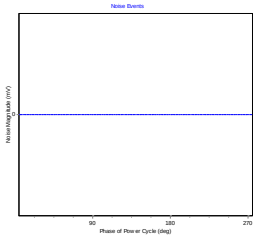
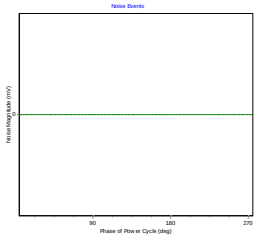
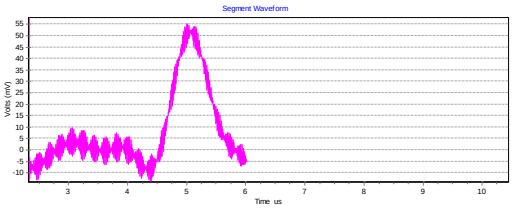
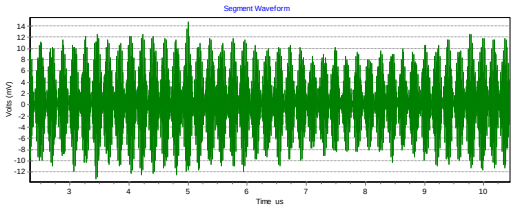
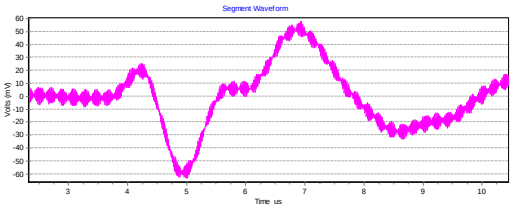
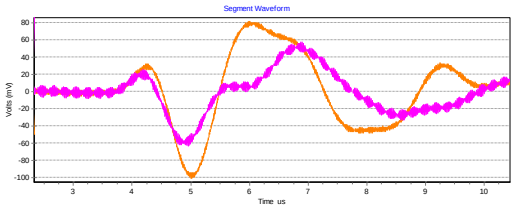
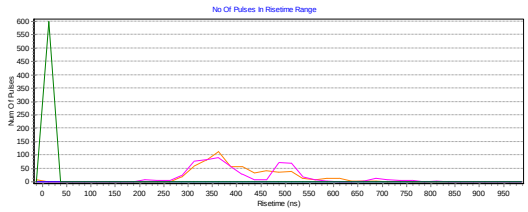
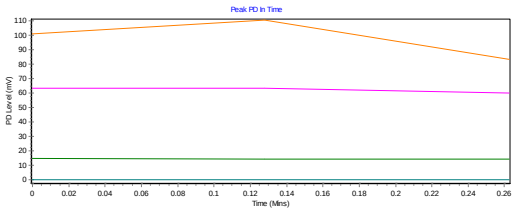


Photo of Sensor Attachment

	Channel 1		Channel 2		Channel 3		Channel 4	
	Cable PD	9424pC	Cable PD	7922pC	Cable PD	0pC	Cable PD	0pC
	Local PD	0dB	Local PD	0dB	Local PD	0dB	Local PD	23dB
	Peak	110.40mV	Peak	63.36mV	Peak	0.00mV	Peak	14.72mV
	Std Dev	9.01mV	Std Dev	6.50mV	Std Dev	0.00mV	Std Dev	5.47mV
Cable PD								
Local PD								

Noise			
			

Sensor	Circuit/Description	V(kV)	Cable Type	Local Plant Type
HFCT	phA	13.2kV	Cable	EPR
HFCT	phB	13.2kV	Cable	EPR
N/A	N/A	13.2kV	Cable	EPR
TEV	TEV	13.2kV	Switchgear	Solid Insulated

Cable PD Waveform				Local PD Waveform			
							
Peak	55.04 mV	**Frequency**	488.28 kHz	**Peak**	14.72 mV	**Frequency**	93.75 MHz
Rise Time	286.76 ns	**PD Level**	7.92 nC	**Rise Time**	1.44 ns	**PD Level**	
Noise Waveform				**Synchronous Waveform**			
							
Peak	-63.36 mV	**Frequency**	488.28 kHz	**Peak**	-	**Frequency**	-
Rise Time	437.33 ns	**PD Level**	-	**Rise Time**	-	**PD Level**	-
No of Pulses vs. Pulse Rise-Time				**Peak Level in Time**			
							

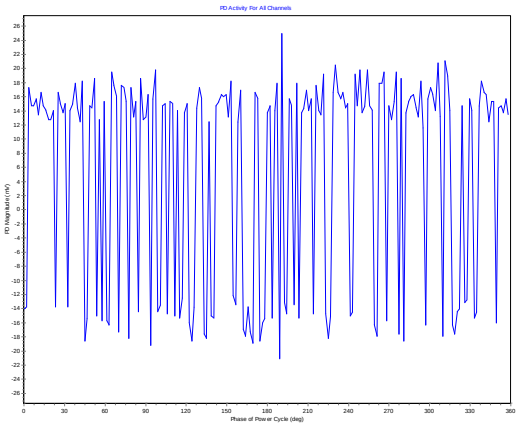
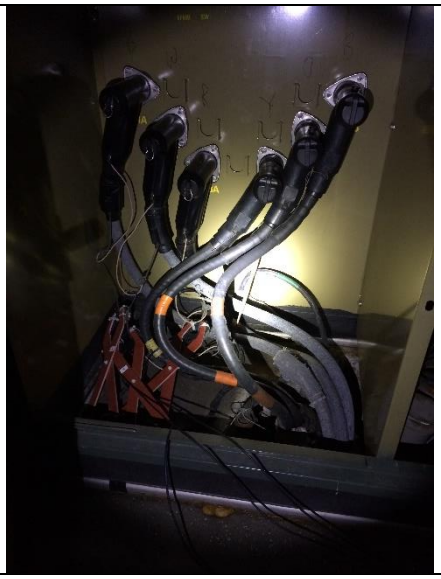
Comments
Local PD detected. 26dB @ 71Mhz.

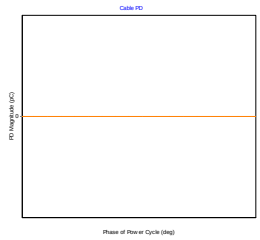
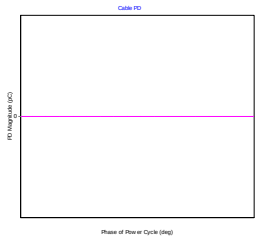
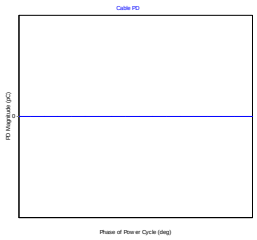
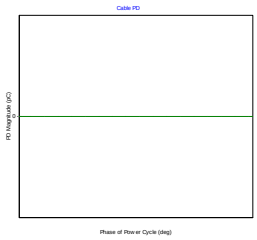
Substation/Site: T-5A-3
Location: POA 69A
Test No.:

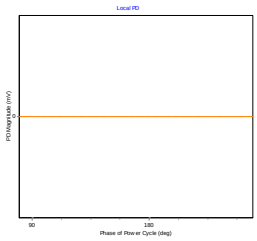
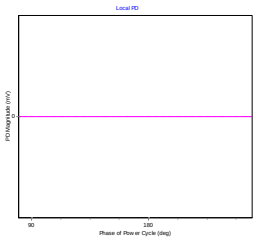
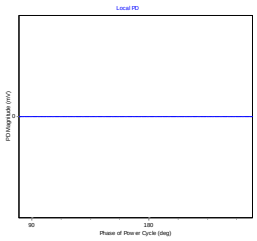
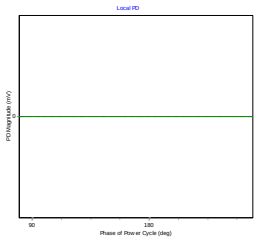
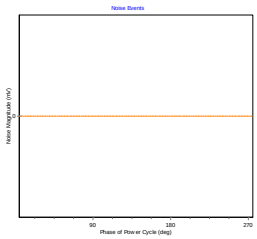
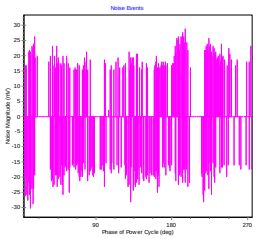
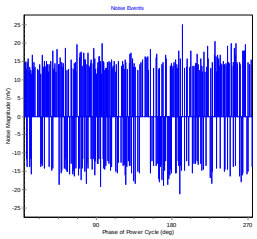
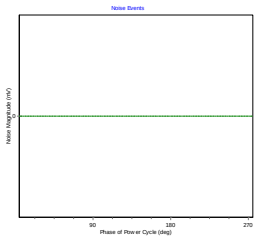
Customer: City of Tampa
Test Engineer: Nat Crews/ Louis Nemec
Test Date: 08/02/2017 6:58:36 PM

C.E. Testing, Inc.

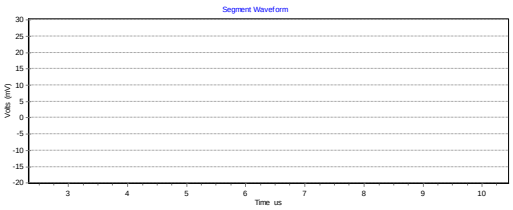
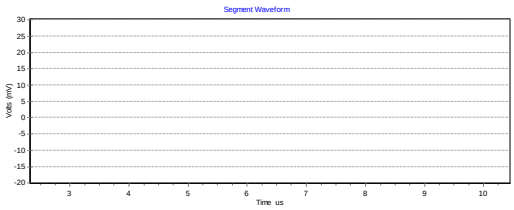
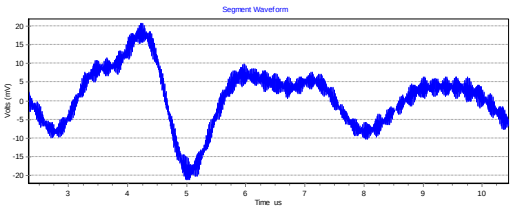
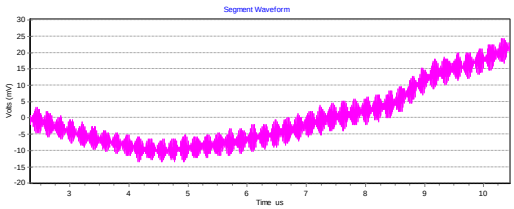
Sensor	Circuit/Description	V(kV)	Cable Type	Local Plant Type
HFCT	phA	13.2kV	Cable	EPR
HFCT	phB	13.2kV	Cable	EPR
HFCT	phC	13.2kV	Cable	EPR
TEV	TEV	13.2kV	Switchgear	Solid Insulated

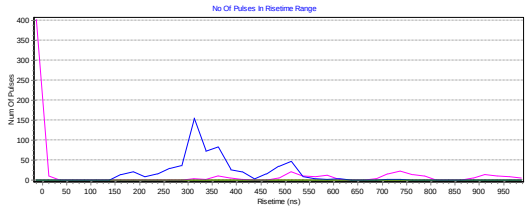
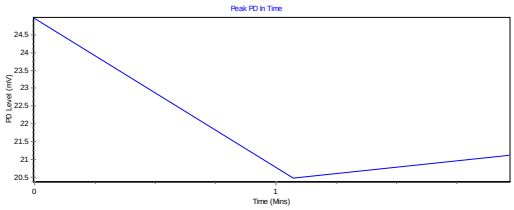
Phase-Resolved Graph (PD and Noise)	Photo of Sensor Attachment
	

	Channel 1		Channel 2		Channel 3		Channel 4	
	Cable PD	0pC	Cable PD	0pC	Cable PD	0pC	Cable PD	0pC
	Local PD	0dB	Local PD	0dB	Local PD	0dB	Local PD	0dB
	Peak	0.00mV	Peak	30.08mV	Peak	24.96mV	Peak	0.00mV
	Std Dev	0.00mV	Std Dev	5.30mV	Std Dev	3.14mV	Std Dev	0.00mV
Cable PD								

Local PD				
Noise				

Sensor	Circuit/Description	V(kV)	Cable Type	Local Plant Type
N/A	N/A	13.2kV	Cable	EPR
HFCT	phB	13.2kV	Cable	EPR
HFCT	phC	13.2kV	Cable	EPR
N/A	N/A	13.2kV	Switchgear	Solid Insulated

Cable PD Waveform				Local PD Waveform			
							
Peak		**Frequency**		**Peak**		**Frequency**	
Rise Time		**PD Level**		**Rise Time**		**PD Level**	
Noise Waveform				**Synchronous Waveform**			
							
Peak	-21.12 mV	**Frequency**	366.21 kHz	**Peak**	-	**Frequency**	-
Rise Time	240.03 ns	**PD Level**	-	**Rise Time**	-	**PD Level**	-

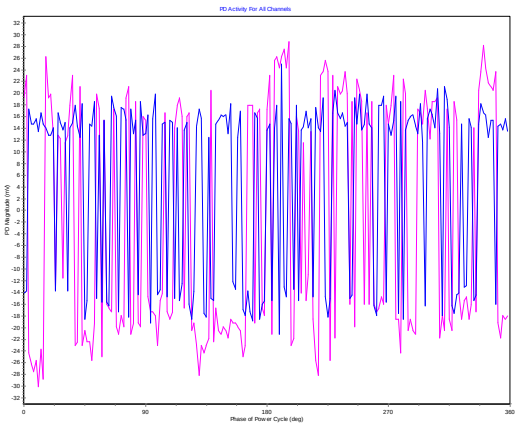
No of Pulses vs. Pulse Rise-Time	**Peak Level in Time**
	

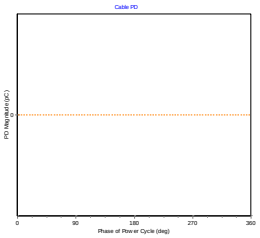
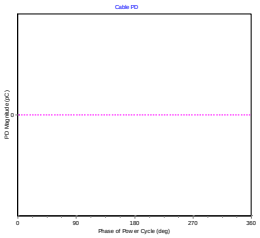
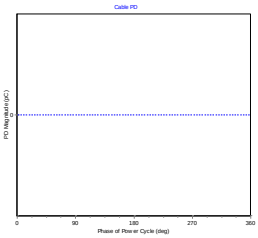
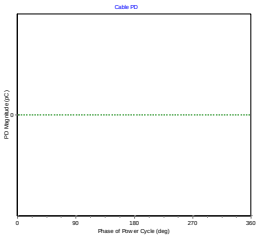
Comments
No PD detected.

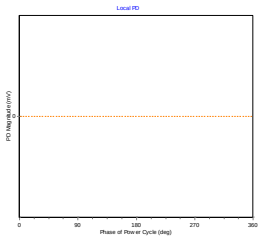
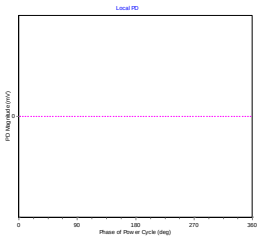
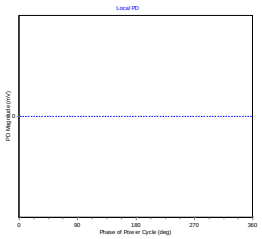
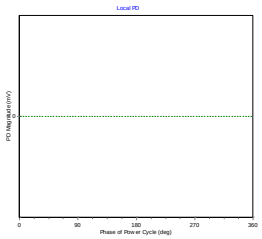
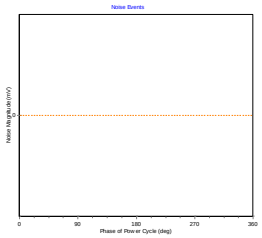
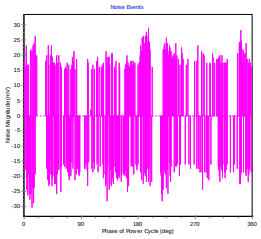
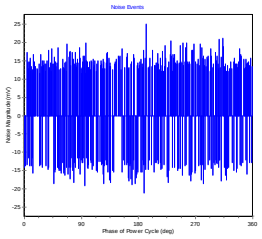
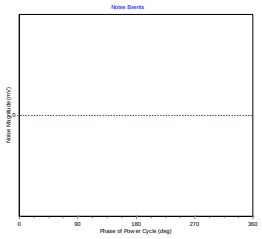
Substation/Site:	T-5A-3	**Customer:**	City of Tampa
Location:	POA 69B	**Test Engineer:**	Nat Crews/ Louis Nemec
Test No.:		**Test Date:**	08/02/2017 6:59:56 PM

C.E. Testing, Inc.

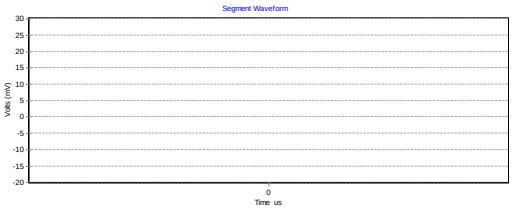
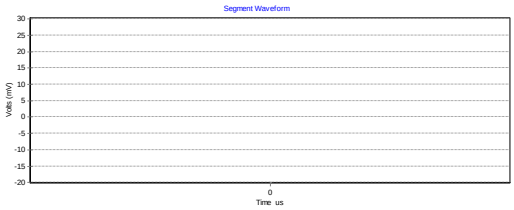
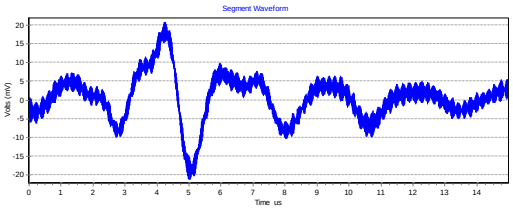
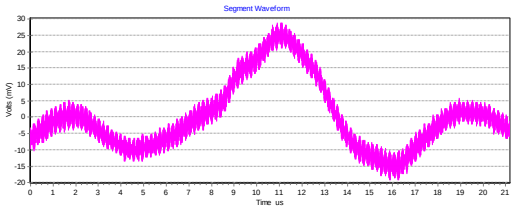
Sensor	Circuit/Description	V(kV)	Cable Type	Local Plant Type
HFCT	phA	13.2kV	Cable	FPR
HFCT	phB	13.2kV	Cable	EPR
HFCT	phC	13.2kV	Cable	EPR
TEV	TEV	15kV	Switchgear	Air Insulated

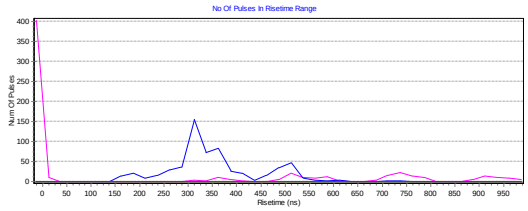
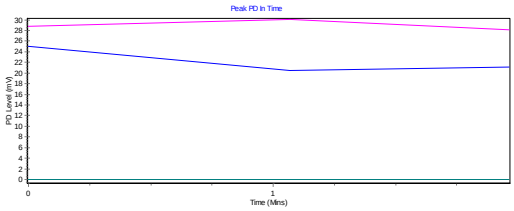
Phase-Resolved Graph (PD and Noise)	Photo of Sensor Attachment
	

	Channel 1		Channel 2		Channel 3		Channel 4	
	Cable PD	0pC	Cable PD	0pC	Cable PD	0pC	Cable PD	0pC
	Local PD	0dB	Local PD	0dB	Local PD	0dB	Local PD	0dB
	Peak	0.00mV	Peak	30.08mV	Peak	24.96mV	Peak	0.00mV
	Std Dev	0.00mV	Std Dev	5.30mV	Std Dev	3.14mV	Std Dev	0.00mV
Cable PD								

Local PD				
Noise				

Sensor	Circuit/Description	V(kV)	Cable Type	Local Plant Type
N/A	N/A	13.2kV	Cable	FPR
HFCT	phB	13.2kV	Cable	EPR
HFCT	phC	13.2kV	Cable	EPR
N/A	N/A	15kV	Switchgear	Air Insulated

Cable PD Waveform				Local PD Waveform			
							
Peak		**Frequency**		**Peak**		**Frequency**	
Rise Time		**PD Level**		**Rise Time**		**PD Level**	
Noise Waveform				**Synchronous Waveform**			
							
Peak	-21.12 mV	**Frequency**	366.21 kHz	**Peak**	-	**Frequency**	-
Rise Time	240.03 ns	**PD Level**	-	**Rise Time**	-	**PD Level**	-

No of Pulses vs. Pulse Rise-Time	Peak Level in Time
	

Comments
No PD detected. Noise waveforms.

Substation/Site: T-5A-2

Location: POA 62A

Test No.:

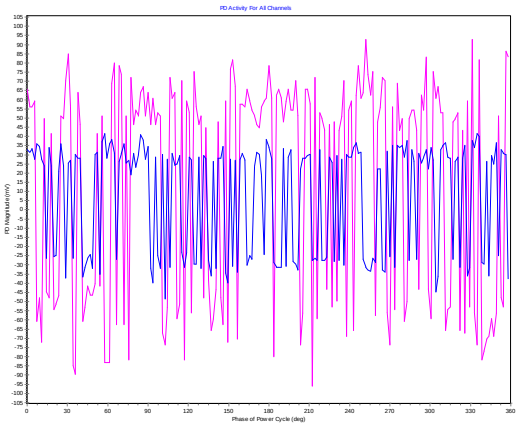
Customer: City of Tampa

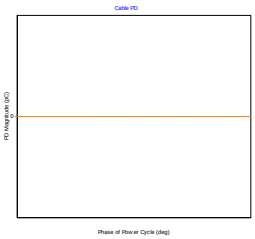
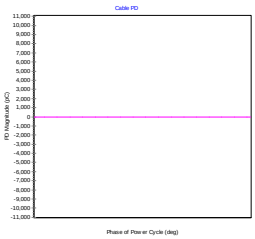
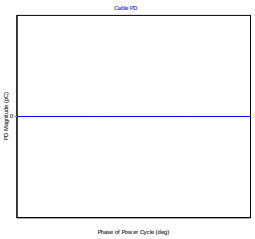
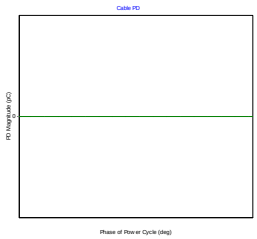
Test Engineer: Nat Crews/ Louis Nemec

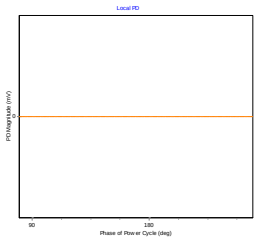
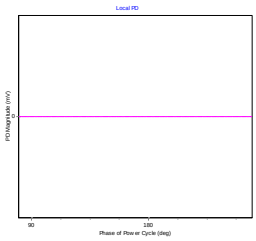
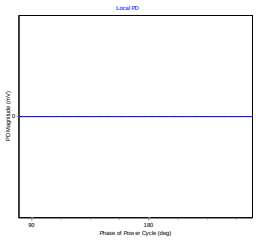
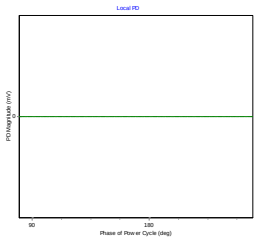
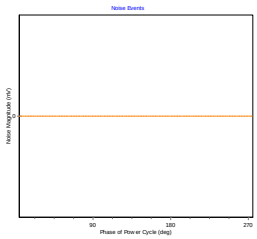
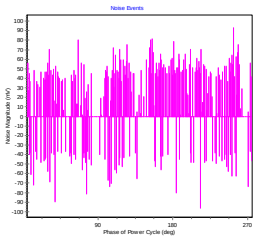
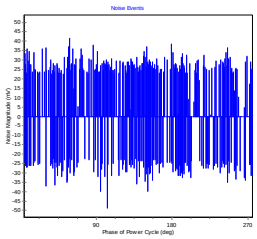
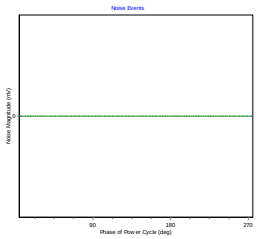
Test Date: 09/02/2017 7:49:37 AM

C.E. Testing, Inc.

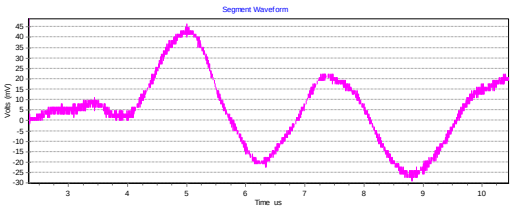
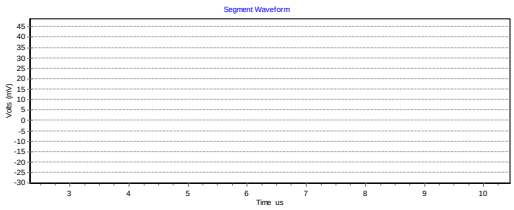
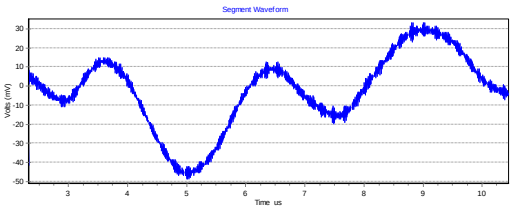
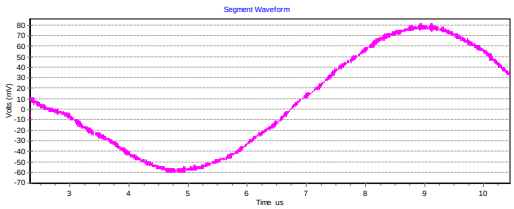
Sensor	Circuit/Description	V(kV)	Cable Type	Local Plant Type
HFCT	pha	13.2kV	Cable	EPR
HFCT	phb	13.2kV	Cable	EPR
HFCT	pha	13.2kV	Cable	EPR
TEV	TEV	13.2kV	Switchgear	Solid Insulated

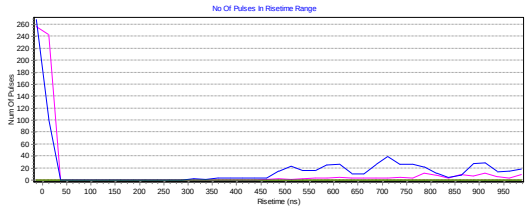
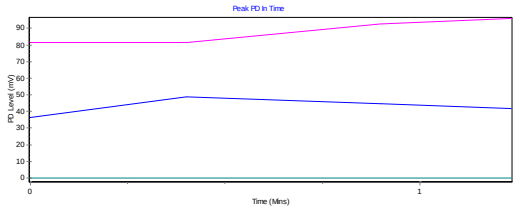
Phase-Resolved Graph (PD and Noise)	Photo of Sensor Attachment
	

	Channel 1		Channel 2		Channel 3		Channel 4	
	Cable PD	0pC	Cable PD	10009pC	Cable PD	0pC	Cable PD	0pC
	Local PD	0dB	Local PD	0dB	Local PD	0dB	Local PD	0dB
	Peak	0.00mV	Peak	96.00mV	Peak	48.64mV	Peak	0.00mV
	Std Dev	0.00mV	Std Dev	16.11mV	Std Dev	7.49mV	Std Dev	0.00mV
Cable PD								

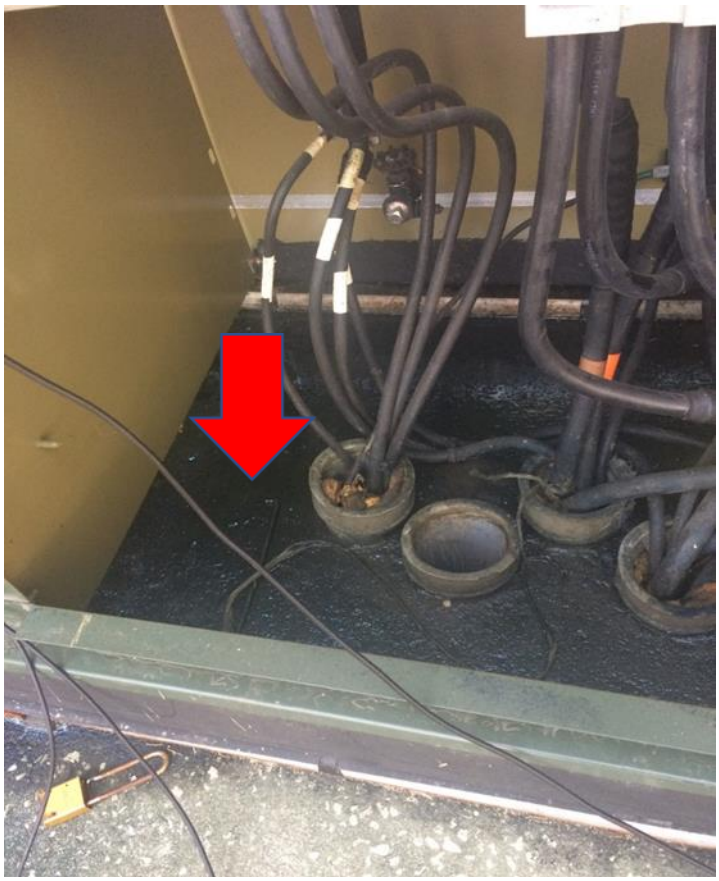
Local PD				
Noise				

Sensor	Circuit/Description	V(kV)	Cable Type	Local Plant Type
HFCT	phA	13.2kV	Cable	EPR
HFCT	phB	13.2kV	Cable	EPR
HFCT	phC	13.2kV	Cable	EPR
TEV	TEV	13.2kV	Switchgear	Solid Insulated

Cable PD Waveform				Local PD Waveform			
							
Peak	46.40 mV	**Frequency**	244.14 kHz	**Peak**		**Frequency**	
Rise Time	644.01 ns	**PD Level**	9.50 nC	**Rise Time**		**PD Level**	
Noise Waveform				**Synchronous Waveform**			
							
Peak	-48.64 mV	**Frequency**	122.07 kHz	**Peak**	-	**Frequency**	-
Rise Time	699.25 ns	**PD Level**	-	**Rise Time**	-	**PD Level**	-

No of Pulses vs. Pulse Rise-Time	**Peak Level in Time**
	

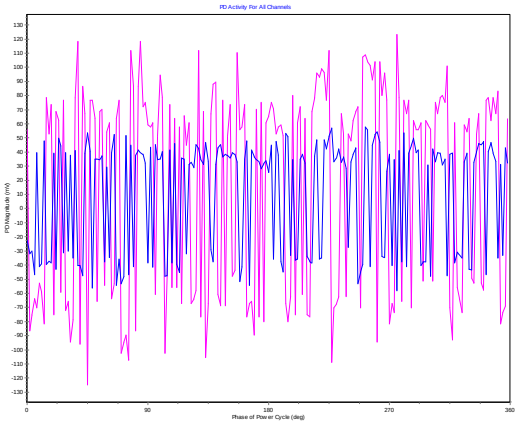
Comments
POA 62 A 1. Oil residue and water shown on the concrete pad of the transformer. No signs of leaks from the bushings or devices. Recommend investigating and cleaning the concrete pad. No PD detected. Only noise waveforms. Extremely high noise

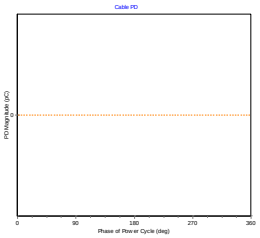
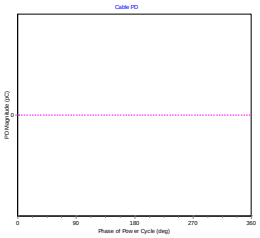
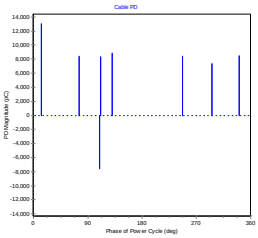
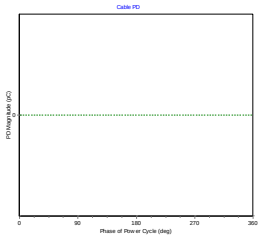


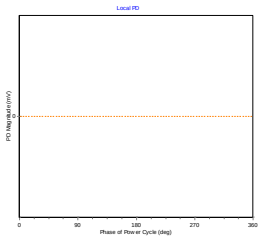
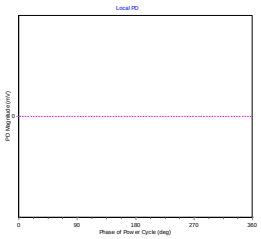
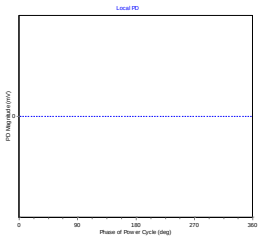
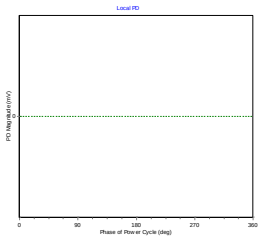
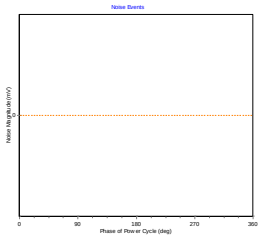
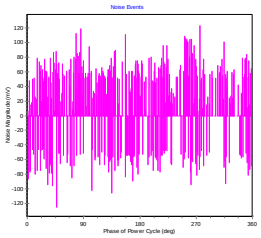
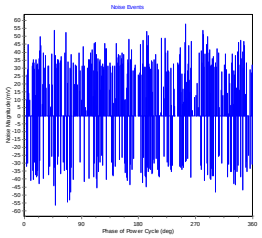
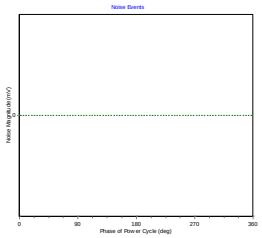
Comment Item 1

Substation/Site:	T-5A-2	**Customer:**	City of Tampa	C.E. Testing, Inc.
Location:	POA 62 B	**Test Engineer:**	Nat Crews/ Louis Nemec	
Test No.:		**Test Date:**	09/02/2017 7:55:08 AM	

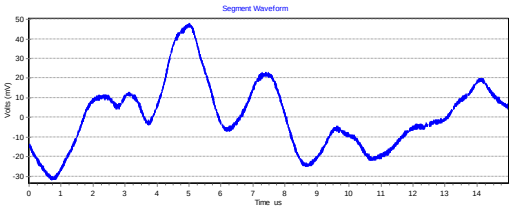
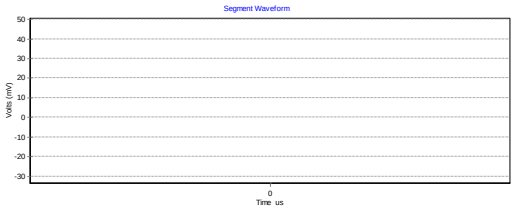
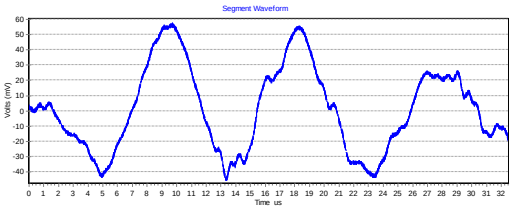
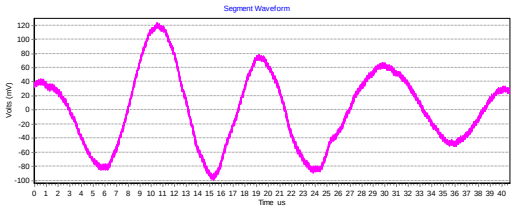
Sensor	Circuit/Description	V(kV)	Cable Type	Local Plant Type
N/A	PHA	13.2kV	Cable	FPR
HFCT	PHB	13.2kV	Cable	EPR
HFCT	PHB	13.2kV	Cable	EPR
TEV	TEV	15kV	Switchgear	Air Insulated

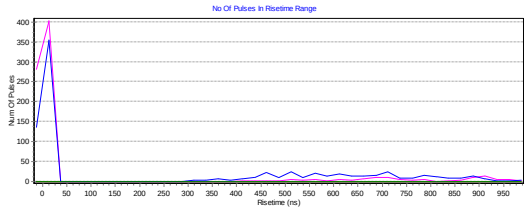
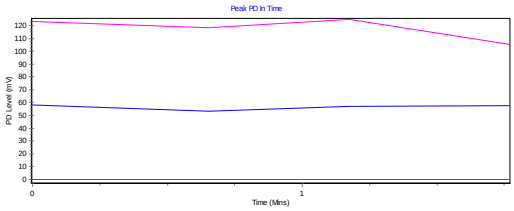
Phase-Resolved Graph (PD and Noise)	Photo of Sensor Attachment
	

	Channel 1		Channel 2		Channel 3		Channel 4	
	Cable PD	0pC	Cable PD	0pC	Cable PD	12988pC	Cable PD	0pC
	Local PD	0dB	Local PD	0dB	Local PD	0dB	Local PD	0dB
	Peak	0.00mV	Peak	124.80mV	Peak	57.60mV	Peak	0.00mV
	Std Dev	0.00mV	Std Dev	19.37mV	Std Dev	10.57mV	Std Dev	0.00mV
Cable PD								

Local PD				
Noise				

Sensor	Circuit/Description	V(kV)	Cable Type	Local Plant Type
N/A	PHA	13.2kV	Cable	FPR
HFCT	PHB	13.2kV	Cable	EPR
HFCT	PHC	13.2kV	Cable	EPR
TEV	TEV	15kV	Switchgear	Air Insulated

Cable PD Waveform				Local PD Waveform			
							
Peak	48.00 mV	**Frequency**	122.07 kHz	**Peak**		**Frequency**	
Rise Time	881.32 ns	**PD Level**	12.99 nC	**Rise Time**		**PD Level**	
Noise Waveform				**Synchronous Waveform**			
							
Peak	57.60 mV	**Frequency**	122.07 kHz	**Peak**	-	**Frequency**	-
Rise Time	2.30 us	**PD Level**	-	**Rise Time**	-	**PD Level**	-

No of Pulses vs. Pulse Rise-Time	Peak Level in Time
	

Comments
POA 62 B 1. Oil residue and water shown on the concrete pad of the transformer. No signs of leaks from the bushings or devices. Recommend investigating and cleaning the concrete pad.
No PD detected. Only noise waveforms. Extremely high noise

Substation/Site: T-5B-2
Location: POA 63 A
Test No.:

Customer: City of Tampa
Test Engineer: Nat Crews/ Louis Nemec
Test Date: 09/02/2017 8:02:03 AM

C.E. Testing, Inc.

Sensor	Circuit/Description	V(kV)	Cable Type	Local Plant Type
HFCT	pha	13.2kV	Cable	EPR
HFCT	phb	13.2kV	Cable	EPR
HFCT	pha	13.2kV	Cable	EPR
TEV	TEV	13.2kV	Switchgear	Solid Insulated

Phase-Resolved Graph (PD and Noise)

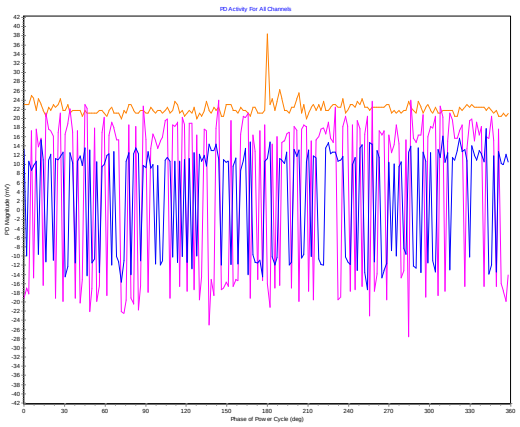
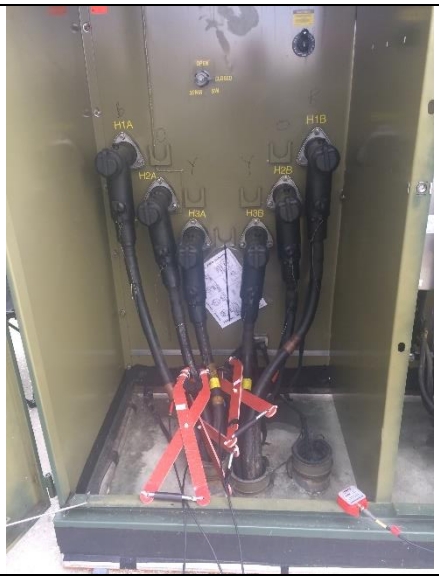
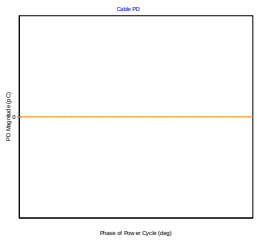
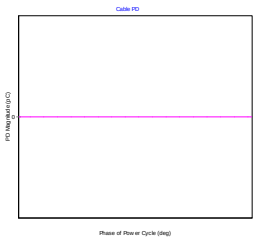
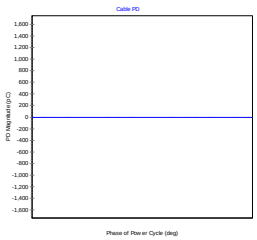
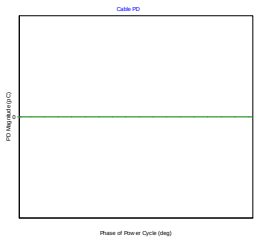
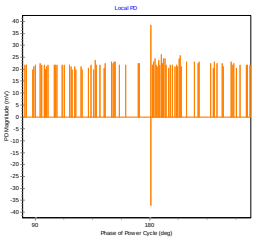
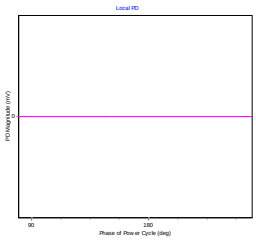
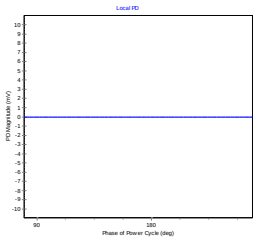
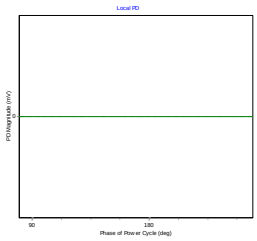
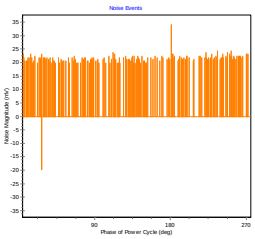
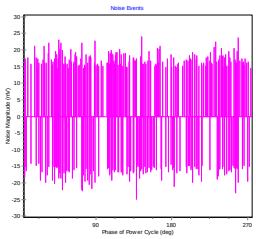
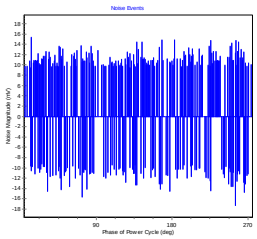
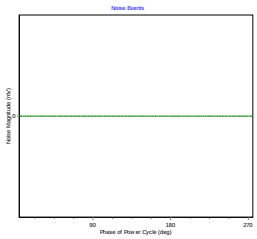


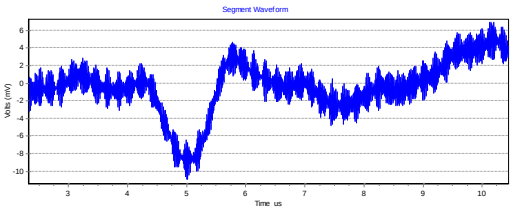
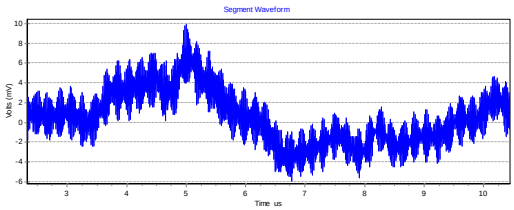
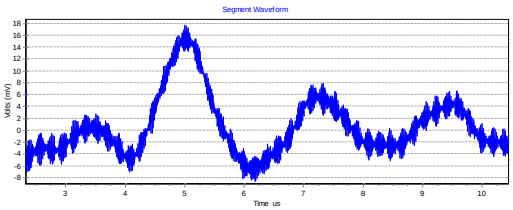
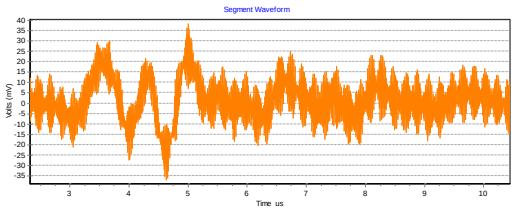
Photo of Sensor Attachment

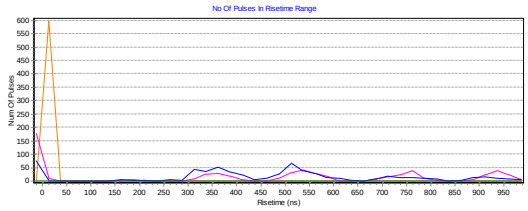
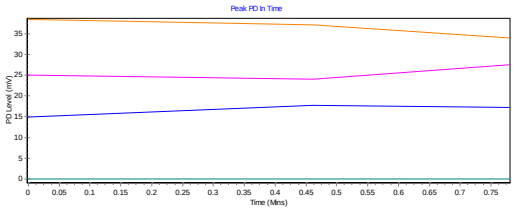


	Channel 1		Channel 2		Channel 3		Channel 4	
	Cable PD	0pC	Cable PD	0pC	Cable PD	1580pC	Cable PD	0pC
	Local PD	32dB	Local PD	0dB	Local PD	20dB	Local PD	0dB
	Peak	38.40mV	Peak	27.52mV	Peak	17.76mV	Peak	0.00mV
	Std Dev	7.28mV	Std Dev	4.60mV	Std Dev	2.73mV	Std Dev	0.00mV
Cable PD								

Local PD				
Noise				

Sensor	Circuit/Description	V(kV)	Cable Type	Local Plant Type
HFCT	PHA	13.2kV	Cable	EPR
HFCT	phb	13.2kV	Cable	EPR
HFCT	pha	13.2kV	Cable	EPR
TEV	TEV	13.2kV	Switchgear	Solid Insulated

Cable PD Waveform				Local PD Waveform			
							
Peak	-10.88 mV	**Frequency**	244.14 kHz	**Peak**	9.92 mV	**Frequency**	99.61 MHz
Rise Time	395.32 ns	**PD Level**	-1.58 nC	**Rise Time**	123.84 ns	**PD Level**	
Noise Waveform				**Synchronous Waveform**			
							
Peak	17.76 mV	**Frequency**	488.28 kHz	**Peak**	-	**Frequency**	-
Rise Time	399.44 ns	**PD Level**	-	**Rise Time**	-	**PD Level**	-

No of Pulses vs. Pulse Rise-Time	Peak Level in Time
	

Comments
Local PD detected A phase, cable PD is only noise waveform. Recommend perform PD testing in 3-6 months to see if PD signals increase or become clearer. Noise interference is very high at POA 62 and 63. PD may be present on the cable or nearby. Possibly in the transformer that is possibly leaking.

Substation/Site:	T-5B-2 B	**Customer:**	City of Tampa
Location:	POA 63 B	**Test Engineer:**	Nat Crews/ Louis Nemec
Test No.:		**Test Date:**	09/02/2017 8:06:35 AM

C.E. Testing, Inc.

Sensor	Circuit/Description	V(kV)	Cable Type	Local Plant Type
HFCT	phA	13.2kV	Cable	EPR
HFCT	phB	13.2kV	Cable	EPR
HFCT	phC	13.2kV	Cable	EPR
TEV	TEV	13.2kV	Switchgear	Solid Insulated

Phase-Resolved Graph (PD and Noise)

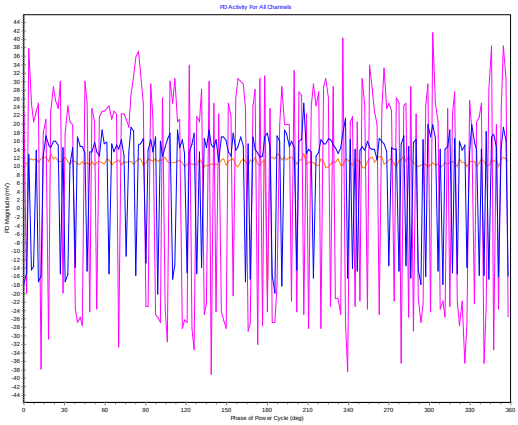
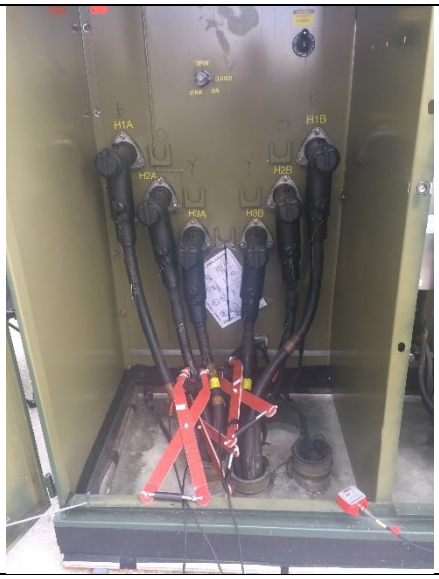
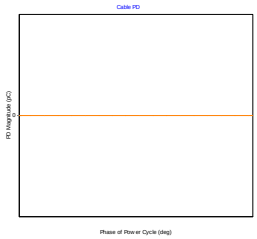
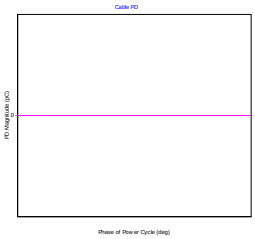
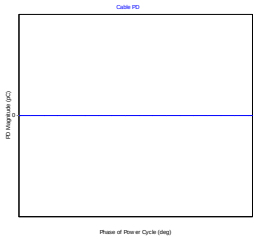
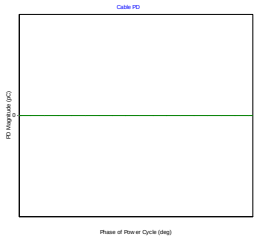
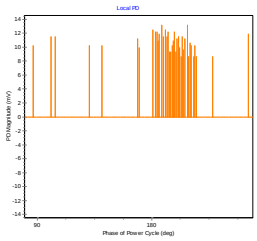
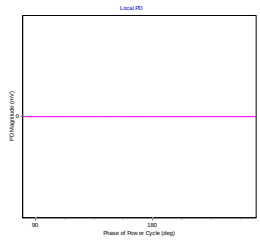
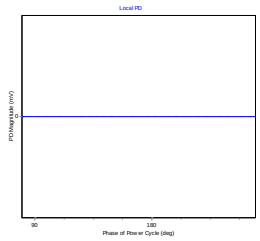
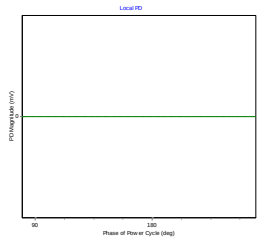
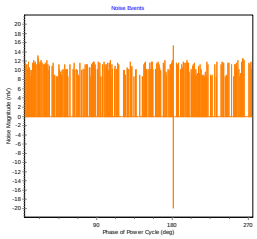
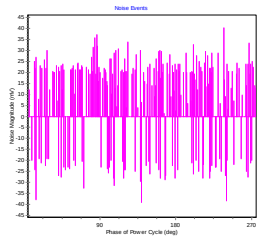
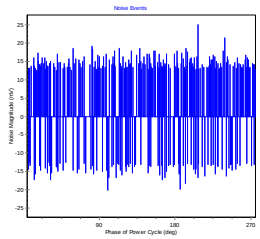
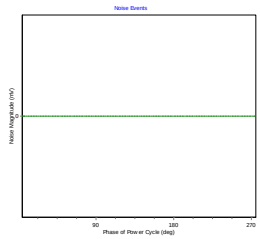


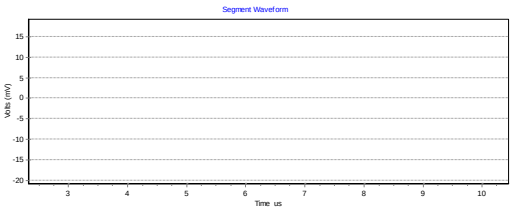
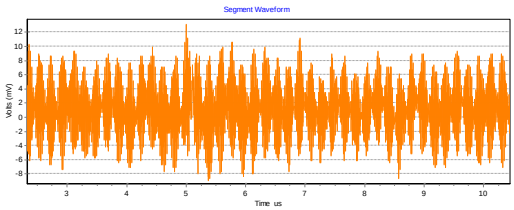
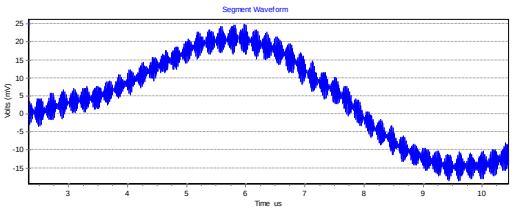
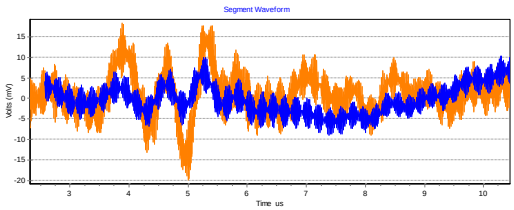
Photo of Sensor Attachment

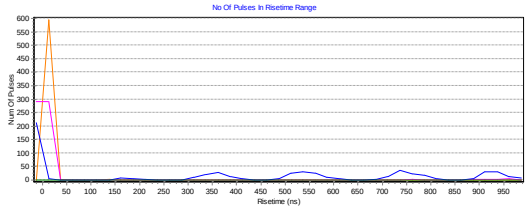


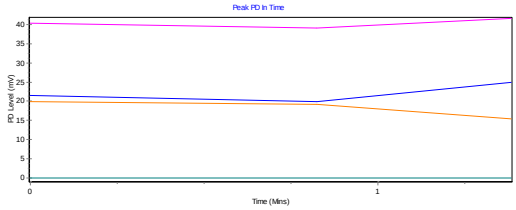
	Channel 1		Channel 2		Channel 3		Channel 4	
	Cable PD	0pC	Cable PD	0pC	Cable PD	0pC	Cable PD	0pC
	Local PD	22dB	Local PD	0dB	Local PD	0dB	Local PD	0dB
	Peak	19.84mV	Peak	41.60mV	Peak	24.96mV	Peak	0.00mV
	Std Dev	2.95mV	Std Dev	7.52mV	Std Dev	4.00mV	Std Dev	0.00mV
Cable PD								

Local PD				
Noise				

Sensor	Circuit/Description	V(kV)	Cable Type	Local Plant Type
HFCT	phA	13.2kV	Cable	EPR
HFCT	phB	13.2kV	Cable	EPR
HFCT	phC	13.2kV	Cable	EPR
TEV	TEV	13.2kV	Switchgear	Solid Insulated

Cable PD Waveform				**Local PD Waveform**			
							
Peak		**Frequency**		**Peak**	13.12 mV	**Frequency**	104.17 MHz
Rise Time		**PD Level**		**Rise Time**	4.22 ns	**PD Level**	
Noise Waveform				**Synchronous Waveform**			
							
Peak	24.96 mV	**Frequency**	91.55 kHz	**Peak**	-	**Frequency**	-
Rise Time	1.75 us	**PD Level**	-	**Rise Time**	-	**PD Level**	-
No of Pulses vs. Pulse Rise-Time				**Peak Level in Time**			



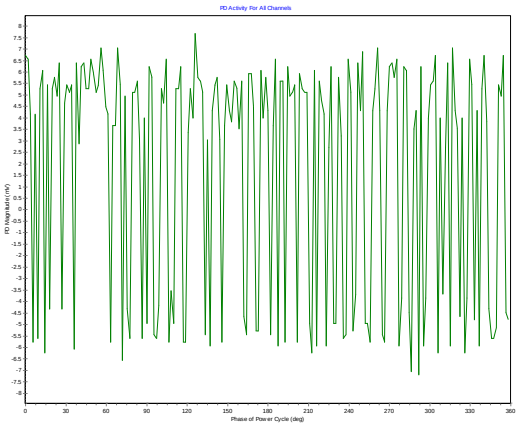
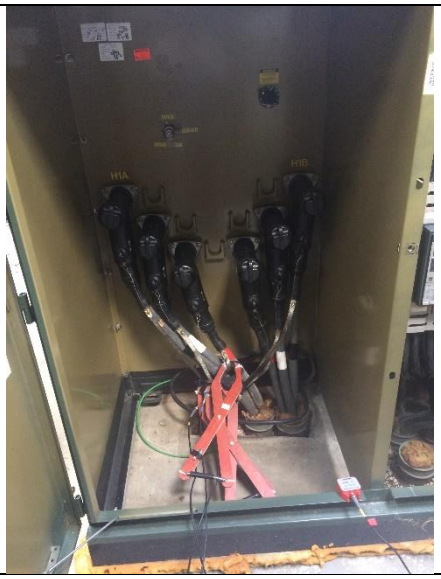


Comments
Local PD 22dB A phase

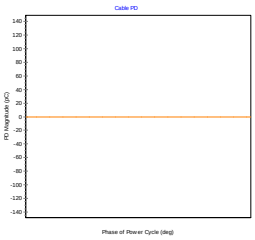
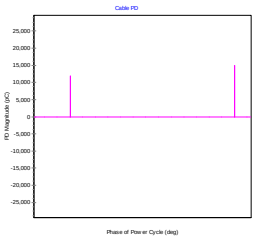
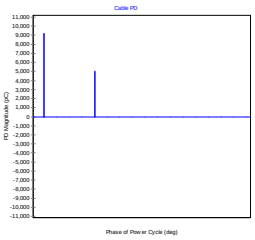
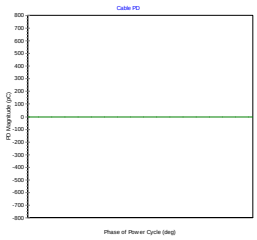
Substation/Site:	T-4A-1	**Customer:**	City of Tampa
Location:	POA 54 A	**Test Engineer:**	Nat Crews/ Louis Nemec
Test No.:		**Test Date:**	09/02/2017 8:39:17 AM

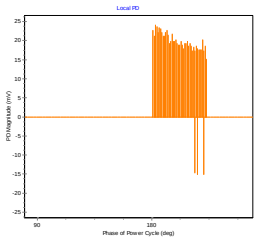
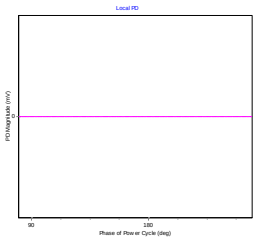
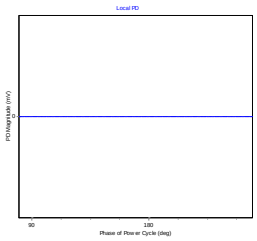
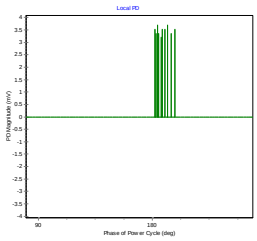
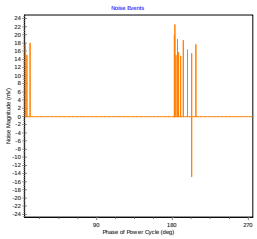
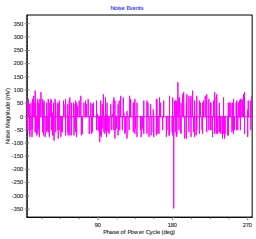
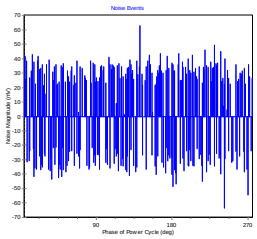
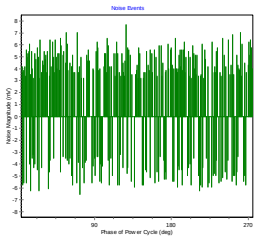
C.E. Testing, Inc.

Sensor	Circuit/Description	V(kV)	Cable Type	Local Plant Type
HFCT	phA	13.2kV	Cable	EPR
HFCT	phB	13.2kV	Cable	EPR
HFCT	phC	13.2kV	Cable	EPR
TEV Probe	TEV	13.2kV	Switchgear	Solid Insulated

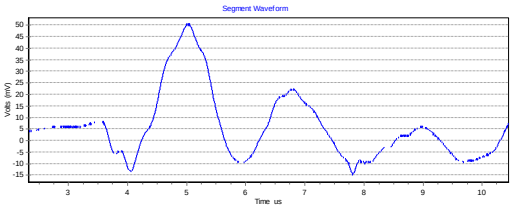
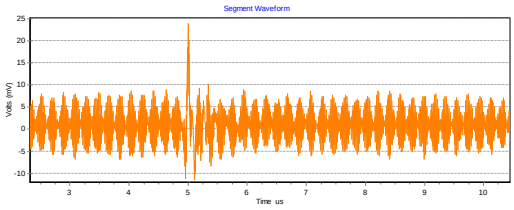
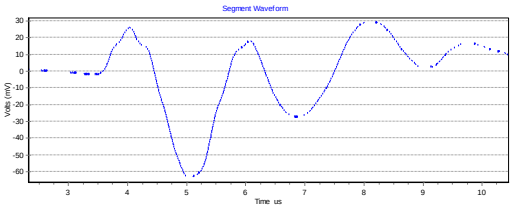
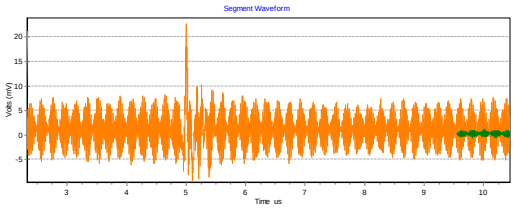
Phase-Resolved Graph (PD and Noise)	Photo of Sensor Attachment
	

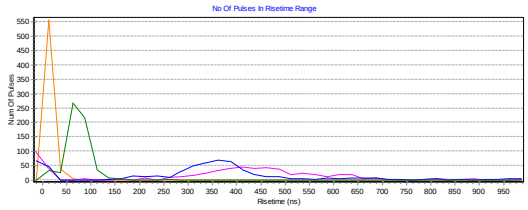
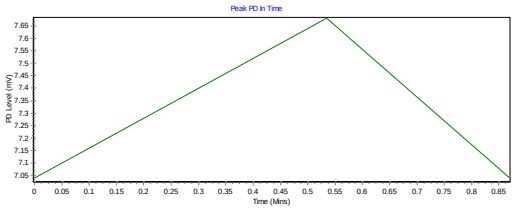
In Table

	Channel 1		Channel 2		Channel 3		Channel 4	
	Cable PD	134pC	Cable PD	26657pC	Cable PD	10098pC	Cable PD	724pC
	Local PD	28dB	Local PD	0dB	Local PD	0dB	Local PD	11dB
	Peak	24.00mV	Peak	345.60mV	Peak	63.36mV	Peak	7.68mV
	Std Dev	3.27mV	Std Dev	15.33mV	Std Dev	6.90mV	Std Dev	0.54mV
Cable PD								

Local PD				
Noise				

Sensor	Circuit/Description	V(kV)	Cable Type	Local Plant Type
HFCT	phA	13.2kV	Cable	EPR
HFCT	phB	13.2kV	Cable	EPR
HFCT	phC	13.2kV	Cable	EPR
TEV Probe	TEV	13.2kV	Switchgear	Solid Insulated

Cable PD Waveform				Local PD Waveform			
							
Peak	50.56 mV	**Frequency**	488.28 kHz	**Peak**	24.00 mV	**Frequency**	6.10 MHz
Rise Time	520.44 ns	**PD Level**	9.27 nC	**Rise Time**	14.12 ns	**PD Level**	
Noise Waveform				**Synchronous Waveform**			
							
Peak	-63.36 mV	**Frequency**	488.28 kHz	**Peak**	-	**Frequency**	-
Rise Time	416.61 ns	**PD Level**	-	**Rise Time**	-	**PD Level**	-

No of Pulses vs. Pulse Rise-Time	**Peak Level in Time**
	

Comments
Local PD Detected on A phase @ 6.1MHz. Recommend Investigate. Seen on A phase local and TEV, PD is most likely in or near termination. A Phase PD seen at T-5B-2 /POA63 may be a result of bleed over from this PD here at T-4A-1.

Substation/Site:	T-4A-1	**Customer:**	City of Tampa
Location:	POA 54 B	**Test Engineer:**	Nat Crews/ Louis Nemec
Test No.:		**Test Date:**	09/02/2017 8:39:17 AM

C.E. Testing, Inc.

Sensor	Circuit/Description	V(kV)	Cable Type	Local Plant Type
HFCT	phA	13.2kV	Cable	EPR
HFCT	phB	13.2kV	Cable	EPR
HFCT	phC	13.2kV	Cable	EPR
TEV Probe	TEV	13.2kV	Switchgear	Solid Insulated

Phase-Resolved Graph (PD and Noise)

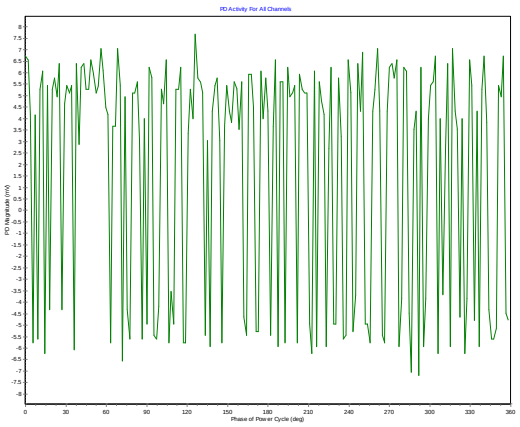
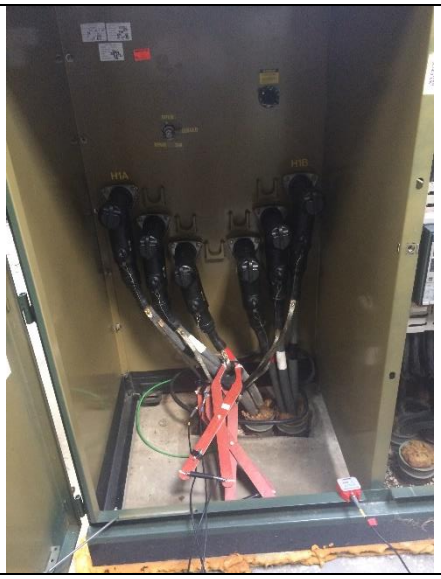
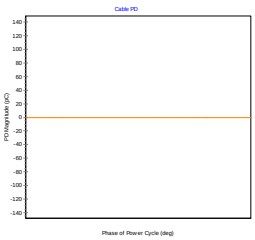
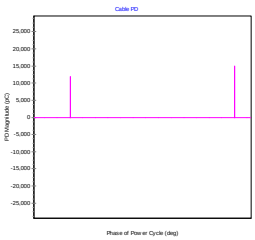
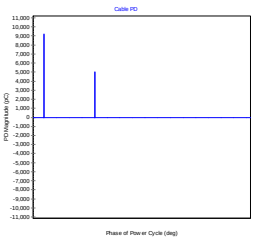
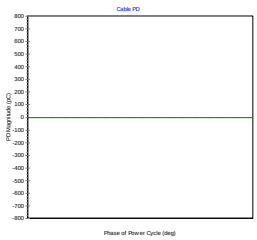
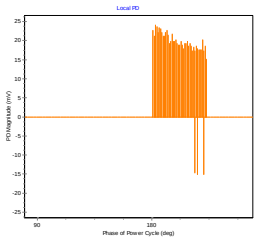
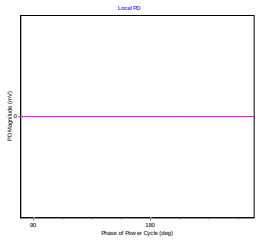
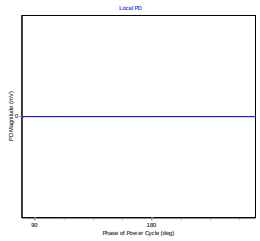
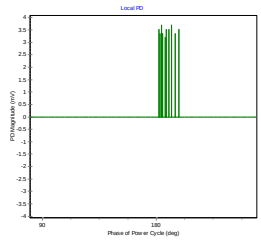
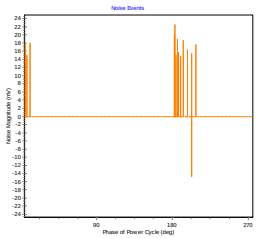
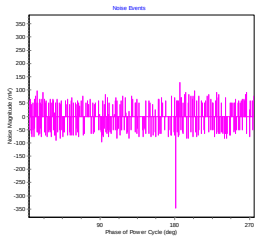
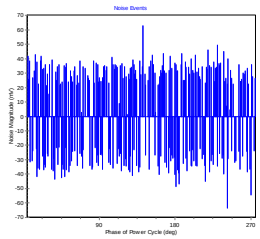
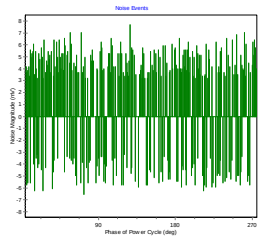


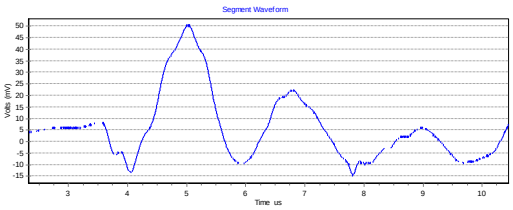
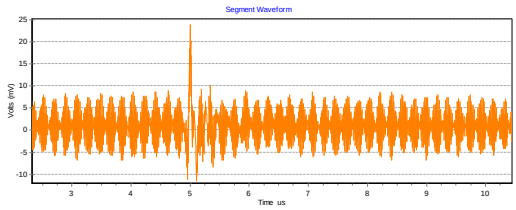
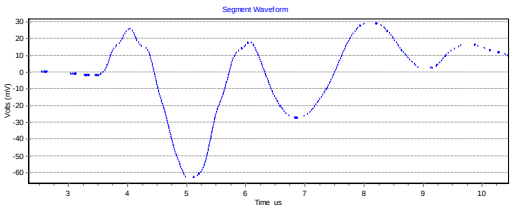
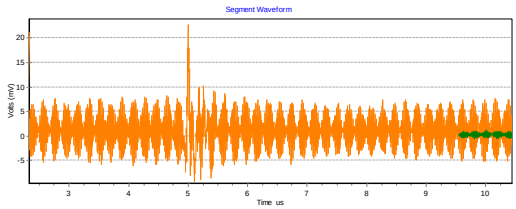
Photo of Sensor Attachment

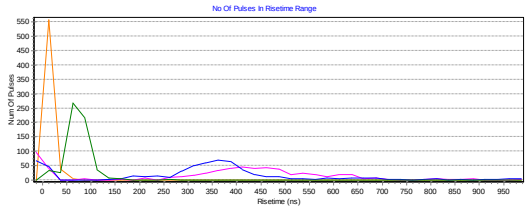
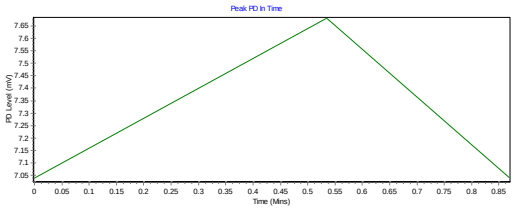


	Channel 1		Channel 2		Channel 3		Channel 4	
	Cable PD	134pC	Cable PD	26657pC	Cable PD	10098pC	Cable PD	724pC
	Local PD	28dB	Local PD	0dB	Local PD	0dB	Local PD	11dB
	Peak	24.00mV	Peak	345.60mV	Peak	63.36mV	Peak	7.68mV
	Std Dev	3.27mV	Std Dev	15.33mV	Std Dev	6.90mV	Std Dev	0.54mV
Cable PD								

Local PD				
Noise				

Sensor	Circuit/Description	V(kV)	Cable Type	Local Plant Type
HFCT	phA	13.2kV	Cable	EPR
HFCT	phB	13.2kV	Cable	EPR
HFCT	phC	13.2kV	Cable	EPR
TEV Probe	TEV	13.2kV	Switchgear	Solid Insulated

Cable PD Waveform				Local PD Waveform			
							
Peak	50.56 mV	**Frequency**	488.28 kHz	**Peak**	24.00 mV	**Frequency**	6.10 MHz
Rise Time	520.44 ns	**PD Level**	9.27 nC	**Rise Time**	14.12 ns	**PD Level**	
Noise Waveform				**Synchronous Waveform**			
							
Peak	-63.36 mV	**Frequency**	488.28 kHz	**Peak**	-	**Frequency**	-
Rise Time	416.61 ns	**PD Level**	-	**Rise Time**	-	**PD Level**	-

No of Pulses vs. Pulse Rise-Time	**Peak Level in Time**
	

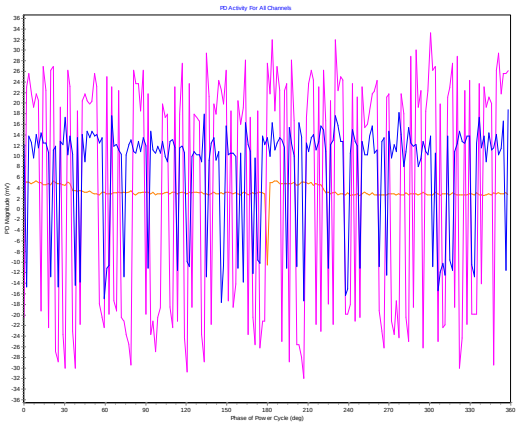
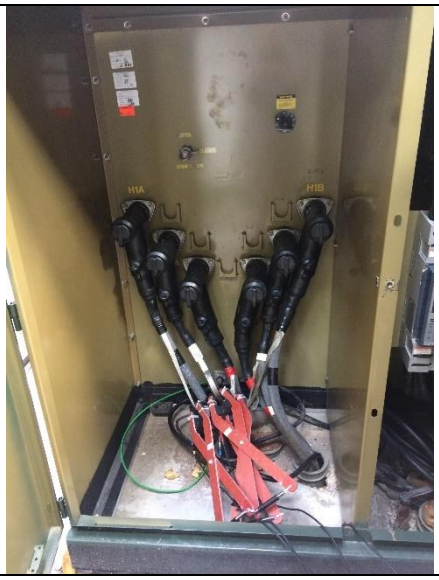
Comments
Local PD Detected on A phase @ 6.1MHz. Recommend investigation of T-4A-1, T-5B-2, and T-5A-2

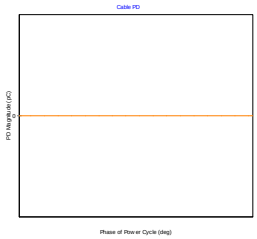
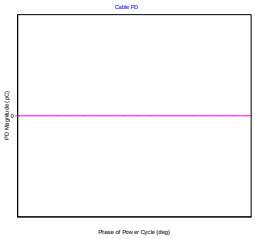
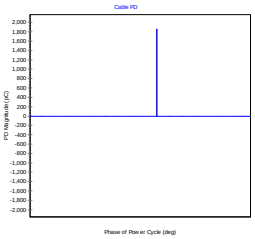
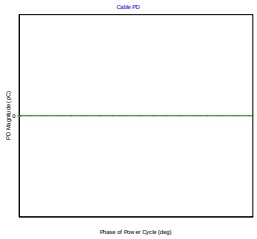
Substation/Site: T-4B-1
Location: POA 55A
Test No.:

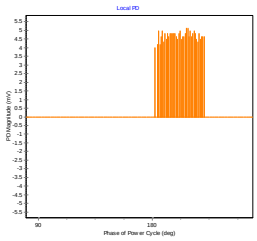
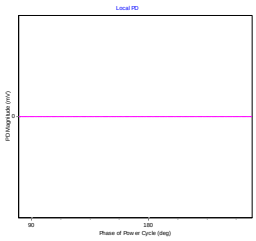
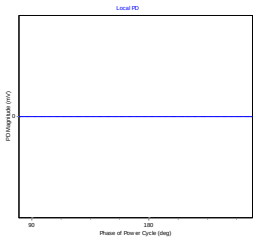
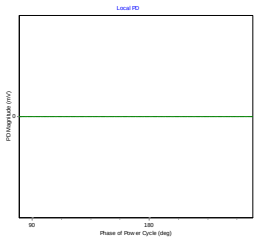
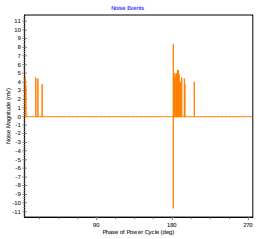
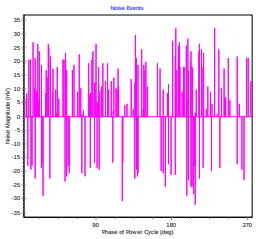
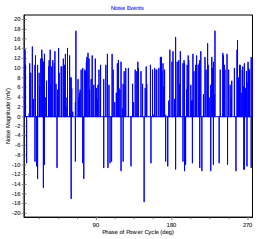
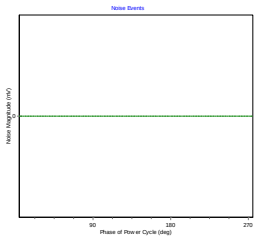
Customer: City of Tampa
Test Engineer: Nat Crews/ Louis Nemec
Test Date: 09/02/2017 8:56:48 AM

C.E. Testing, Inc.

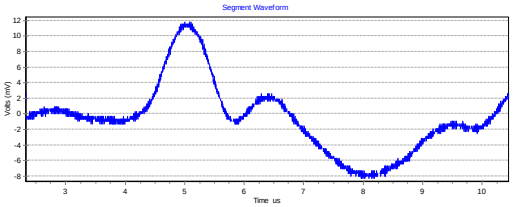
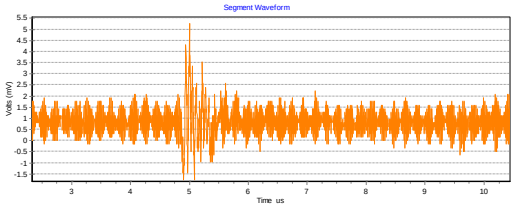
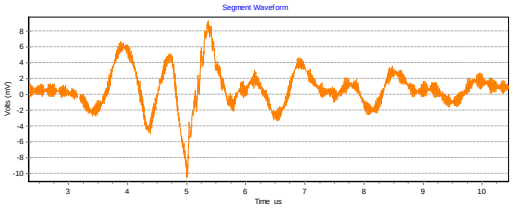
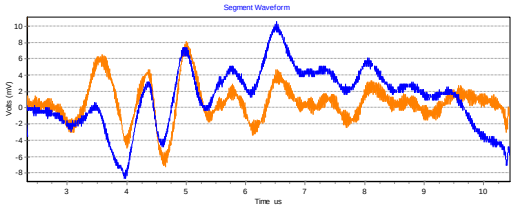
Sensor	Circuit/Description	V(kV)	Cable Type	Local Plant Type
HFCT	phA	13.2kV	Cable	EPR
HFCT	phB	13.2kV	Cable	EPR
HFCT	phC	13.2kV	Cable	EPR
TEV	TEV	13.2kV	Switchgear	Air Insulated

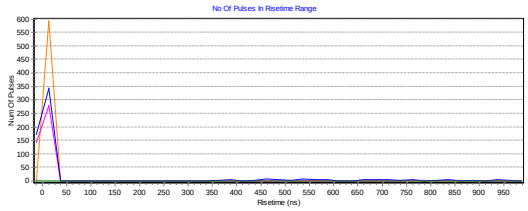
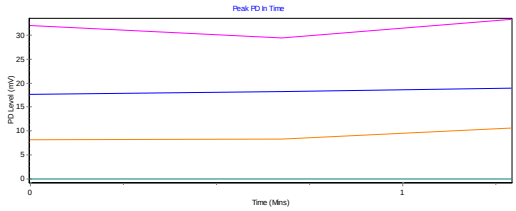
Phase-Resolved Graph (PD and Noise)	Photo of Sensor Attachment
	

	Channel 1		Channel 2		Channel 3		Channel 4	
	Cable PD	0pC	Cable PD	0pC	Cable PD	1956pC	Cable PD	0pC
	Local PD	14dB	Local PD	0dB	Local PD	0dB	Local PD	14dB
	Peak	10.56mV	Peak	33.28mV	Peak	18.88mV	Peak	0.00mV
	Std Dev	0.52mV	Std Dev	6.77mV	Std Dev	3.56mV	Std Dev	0.00mV
Cable PD								

Local PD				
Noise				

Sensor	Circuit/Description	V(kV)	Cable Type	Local Plant Type
HFCT	PHA	13.2kV	Cable	EPR
HFCT	phb	13.2kV	Cable	EPR
HFCT	pha	13.2kV	Cable	EPR
N/A	N/A	13.2kV	Switchgear	Air Insulated

Cable PD Waveform				Local PD Waveform			
							
Peak	11.84 mV	**Frequency**	244.14 kHz	**Peak**	5.28 mV	**Frequency**	17.05 MHz
Rise Time	434.70 ns	**PD Level**	1.96 nC	**Rise Time**	12.23 ns	**PD Level**	
Noise Waveform				**Synchronous Waveform**			
							
Peak	-10.56 mV	**Frequency**	1.22 MHz	**Peak**	-	**Frequency**	-
Rise Time	123.17 ns	**PD Level**	-	**Rise Time**	-	**PD Level**	-

No of Pulses vs. Pulse Rise-Time	Peak Level in Time
	

Comments
Local PD A Phase 14dB @17MHz. Likely bleed over from PD at T-4A-1/ POA 54

Substation/Site:	T-4B-1 B	**Customer:**	City of Tampa
Location:	POA 55B	**Test Engineer:**	Nat Crews/ Louis Nemec
Test No.:		**Test Date:**	09/02/2017 8:59:41 AM

C.E. Testing, Inc.

Sensor	Circuit/Description	V(kV)	Cable Type	Local Plant Type
HFCT	phA	13.2kV	Cable	EPR
HFCT	phB	13.2kV	Cable	EPR
HFCT	phC	13.2kV	Cable	EPR
N/A	N/A	13.2kV	Switchgear	Air Insulated

Phase-Resolved Graph (PD and Noise)

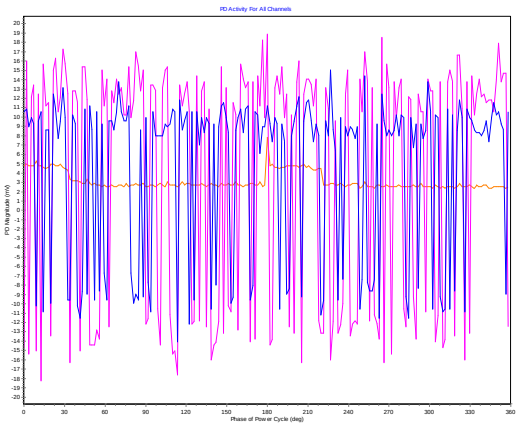
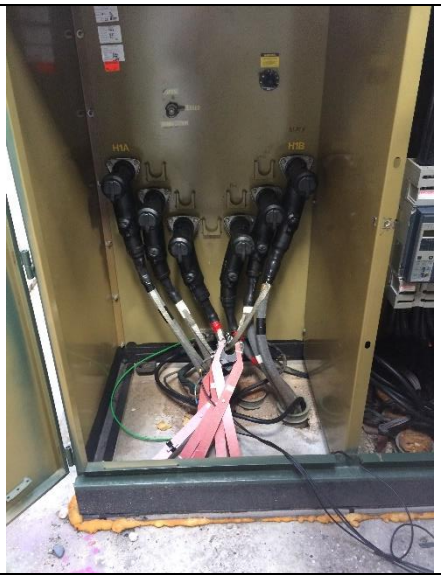
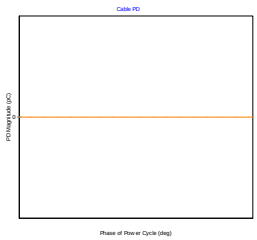
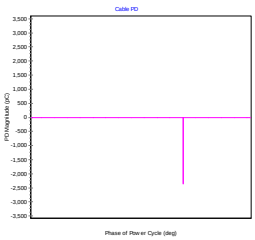
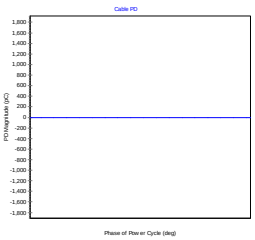
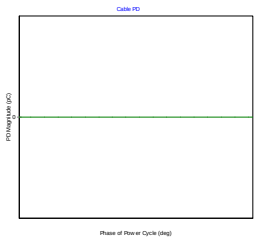
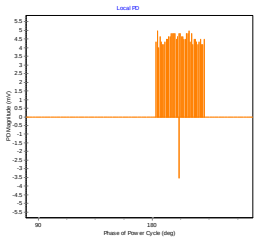
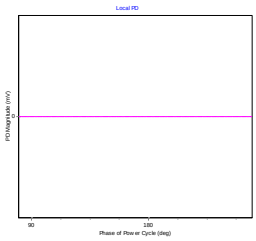
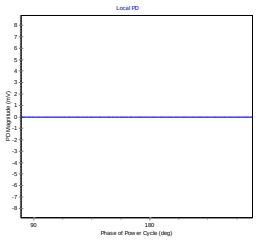
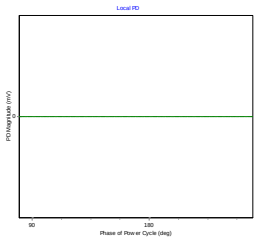
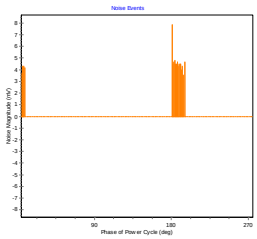
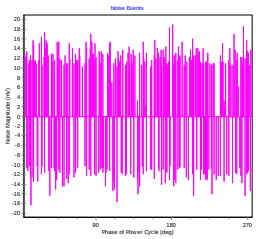
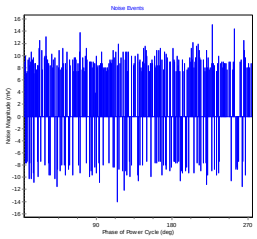
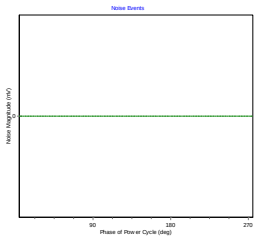


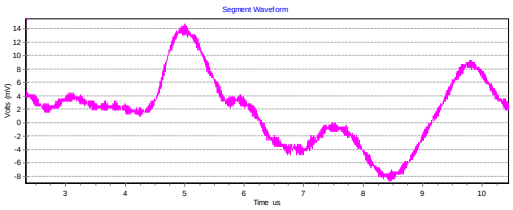
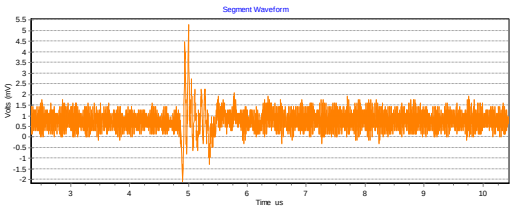
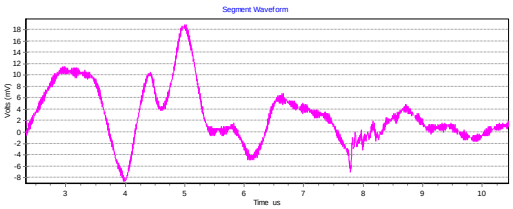
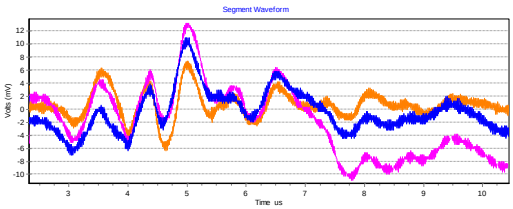
Photo of Sensor Attachment

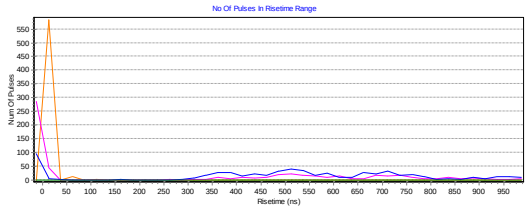
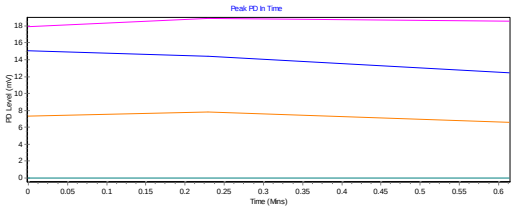


	Channel 1		Channel 2		Channel 3		Channel 4	
	Cable PD	0pC	Cable PD	3248pC	Cable PD	1731pC	Cable PD	0pC
	Local PD	14dB	Local PD	0dB	Local PD	18dB	Local PD	0dB
	Peak	7.84mV	Peak	18.88mV	Peak	15.04mV	Peak	0.00mV
	Std Dev	0.47mV	Std Dev	3.42mV	Std Dev	2.07mV	Std Dev	0.00mV
Cable PD								

Local PD				
Noise				

Sensor	Circuit/Description	V(kV)	Cable Type	Local Plant Type
HFCT	phA	13.2kV	Cable	EPR
HFCT	phB	13.2kV	Cable	EPR
HFCT	phC	13.2kV	Cable	EPR
N/A	N/A	13.2kV	Switchgear	Air Insulated

Cable PD Waveform				Local PD Waveform			
							
Peak	14.72 mV	**Frequency**	244.14 kHz	**Peak**	5.28 mV	**Frequency**	17.24 MHz
Rise Time	462.71 ns	**PD Level**	2.71 nC	**Rise Time**	13.14 ns	**PD Level**	
Noise Waveform				**Synchronous Waveform**			
							
Peak	18.88 mV	**Frequency**	488.28 kHz	**Peak**	-	**Frequency**	-
Rise Time	293.09 ns	**PD Level**	-	**Rise Time**	-	**PD Level**	-

No of Pulses vs. Pulse Rise-Time	**Peak Level in Time**
	

Comments
Local PD Detected on A & C Phase. 14dB & 18dB respectivily @ 17.24 MHz. Likely bleed over from PD at T-4A-1/ POA 54

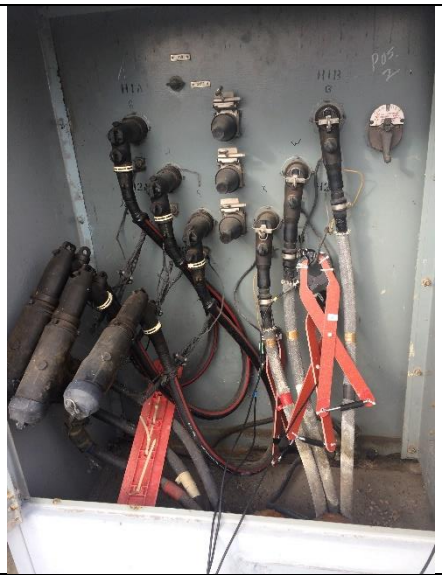
Substation/Site:	T-4A-2	**Customer:**	City of Tampa
Location:	POA 56 B	**Test Engineer:**	Nat Crews/ Louis Nemec
Test No.:		**Test Date:**	09/02/2017 9:30:15 AM

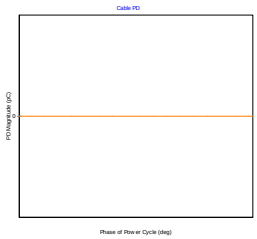
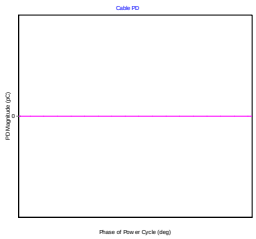
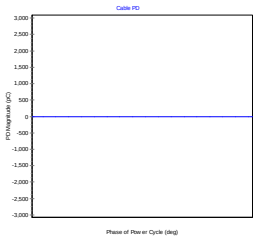
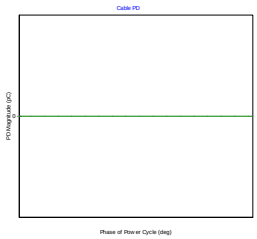
C.E. Testing, Inc.

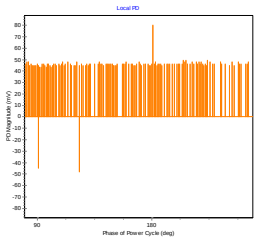
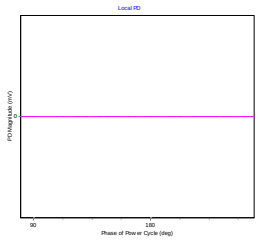
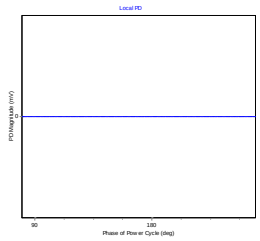
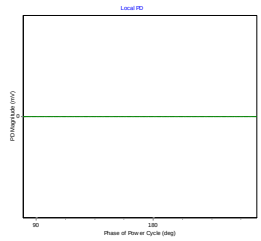
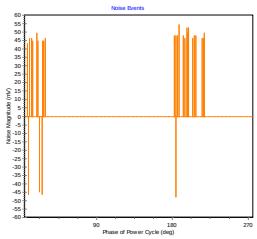
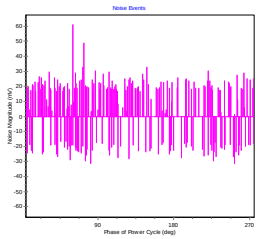
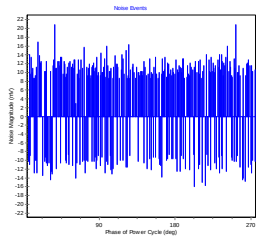
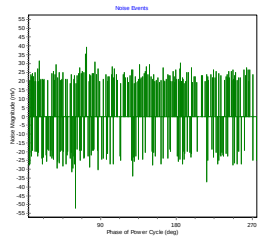
Sensor	Circuit/Description	V(kV)	Cable Type	Local Plant Type
HFCT	PHA	13.2kV	Cable	EPR
HFCT	PHB	13.2kV	Cable	EPR
HFCT	PHC	13.2kV	Cable	EPR
TEV Probe	TEV	13.2kV	Switchgear	Solid Insulated

Phase-Resolved Graph (PD and Noise)

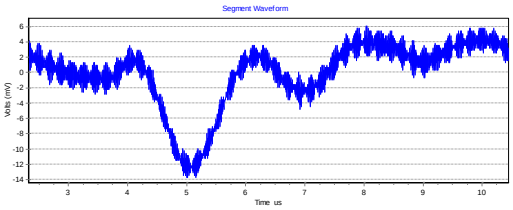
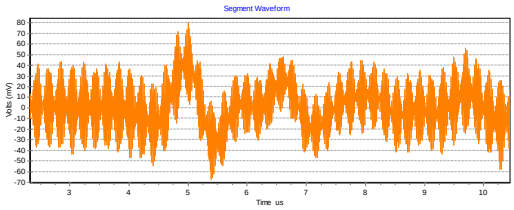
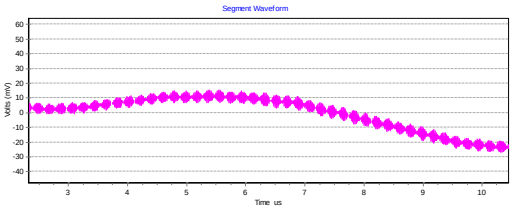
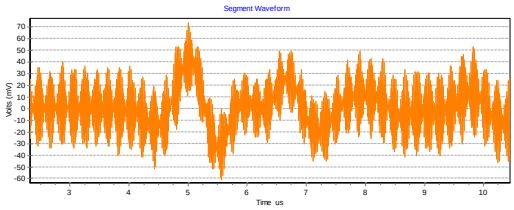
Photo of Sensor Attachment

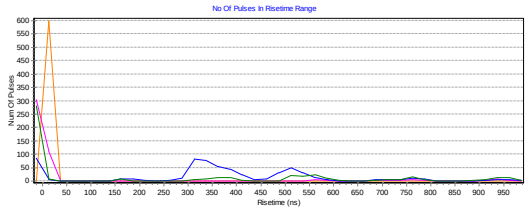
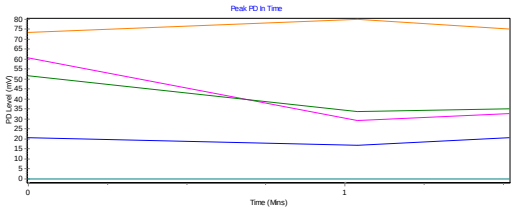


	Channel 1		Channel 2		Channel 3		Channel 4	
	Cable PD	0pC	Cable PD	0pC	Cable PD	2790pC	Cable PD	0pC
	Local PD	38dB	Local PD	0dB	Local PD	0dB	Local PD	0dB
	Peak	80.00mV	Peak	60.80mV	Peak	20.80mV	Peak	51.84mV
	Std Dev	17.86mV	Std Dev	6.40mV	Std Dev	2.47mV	Std Dev	6.36mV
Cable PD								

Local PD				
Noise				

Sensor	Circuit/Description	V(kV)	Cable Type	Local Plant Type
HFCT	PHA	13.2kV	Cable	EPR
HFCT	PHB	13.2kV	Cable	EPR
HFCT	PHC	13.2kV	Cable	EPR
TEV Probe	TEV	13.2kV	Switchgear	Solid Insulated

Cable PD Waveform				Local PD Waveform			
							
Peak	-13.76 mV	**Frequency**	122.07 kHz	**Peak**	80.00 mV	**Frequency**	100.57 MHz
Rise Time	438.77 ns	**PD Level**	-2.79 nC	**Rise Time**	6.54 ns	**PD Level**	
Noise Waveform				**Synchronous Waveform**			
							
Peak	60.80 mV	**Frequency**	53.41 kHz	**Peak**	-	**Frequency**	-
Rise Time	3.94 us	**PD Level**	-	**Rise Time**	-	**PD Level**	-

No of Pulses vs. Pulse Rise-Time	Peak Level in Time
	

Comments
No PD detected. Noise waveforms.

Substation/Site: T-4A-2

Location: POA 56 A

Test No.:

Customer: City of Tampa

Test Engineer: Nat Crews/ Louis Nemec

Test Date: 09/02/2017 9:35:41 AM

C.E. Testing, Inc.

Sensor	Circuit/Description	V(kV)	Cable Type	Local Plant Type
N/A	N/A	13.2kV	Cable	EPR
N/A	N/A	13.2kV	Cable	EPR
HFCT	phC	13.2kV	Cable	EPR
TEV	TEV	13.2kV	Switchgear	Air Insulated

Phase-Resolved Graph (PD and Noise)

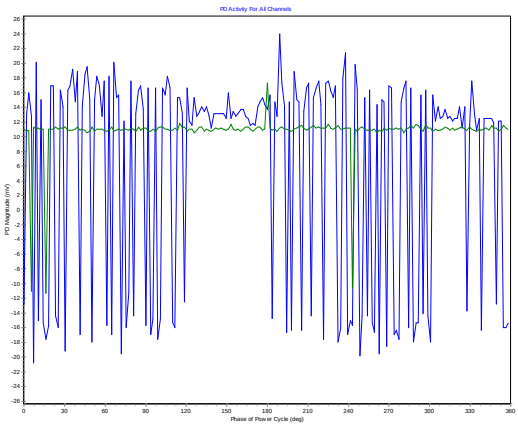
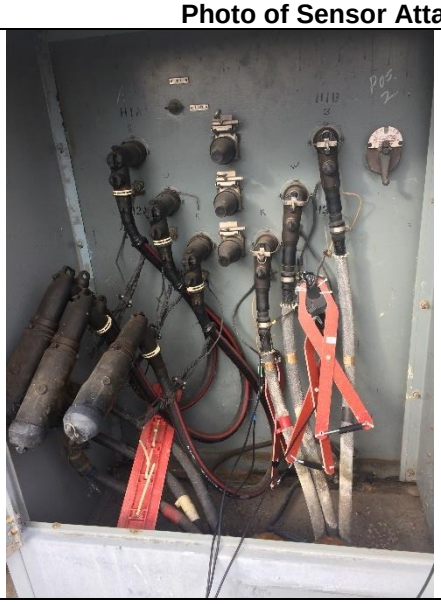
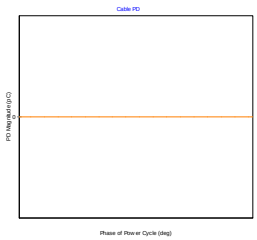
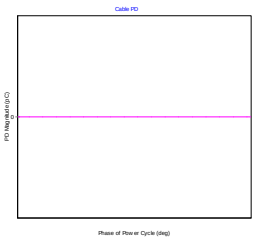
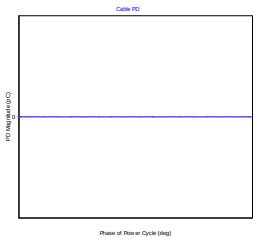
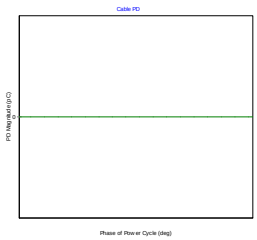
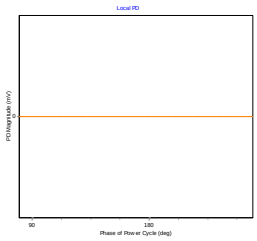
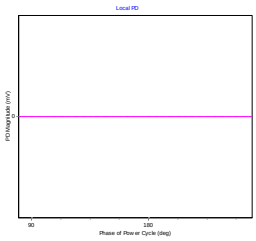
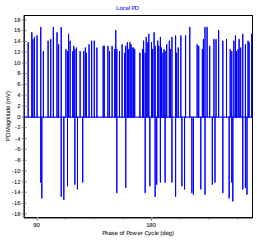
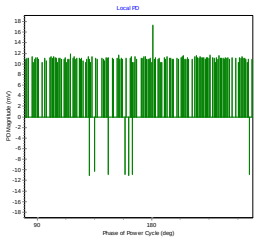
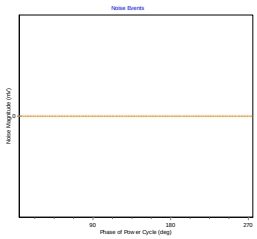
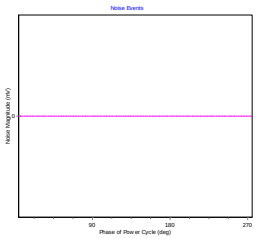
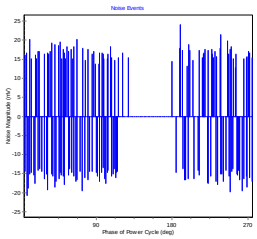
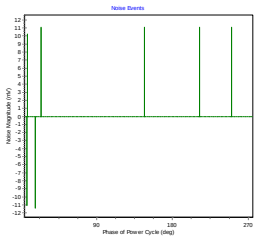


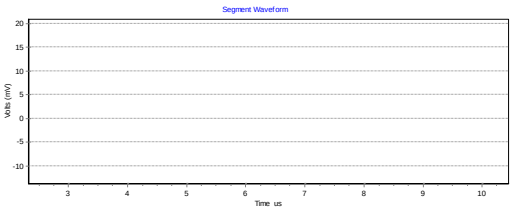
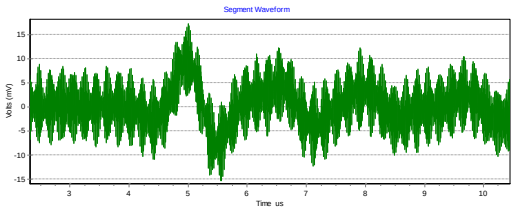
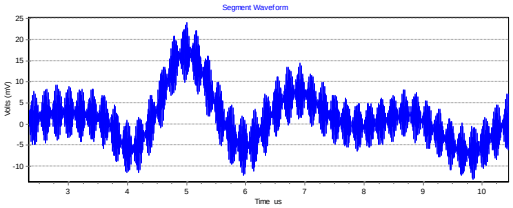
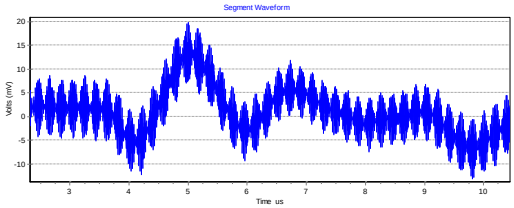
Photo of Sensor Attachment

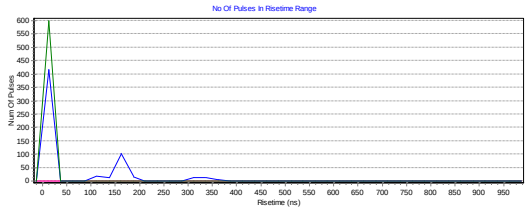
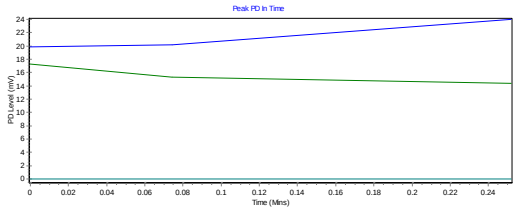


	Channel 1		Channel 2		Channel 3		Channel 4	
	Cable PD	0pC	Cable PD	0pC	Cable PD	0pC	Cable PD	0pC
	Local PD	0dB	Local PD	0dB	Local PD	25dB	Local PD	25dB
	Peak	0.00mV	Peak	0.00mV	Peak	24.00mV	Peak	17.28mV
	Std Dev	0.00mV	Std Dev	0.00mV	Std Dev	3.69mV	Std Dev	4.48mV
Cable PD								

Local PD				
Noise				

Sensor	Circuit/Description	V(kV)	Cable Type	Local Plant Type
N/A	N/A	13.2kV	Cable	EPR
N/A	N/A	13.2kV	Cable	EPR
HFCT	phC	13.2kV	Cable	EPR
TEV	TEV	13.2kV	Switchgear	Air Insulated

Cable PD Waveform				Local PD Waveform			
							
Peak		**Frequency**		**Peak**	17.28 mV	**Frequency**	99.40 MHz
Rise Time		**PD Level**		**Rise Time**	6.20 ns	**PD Level**	
Noise Waveform				**Synchronous Waveform**			
							
Peak	24.00 mV	**Frequency**	488.28 kHz	**Peak**	-	**Frequency**	-
Rise Time	293.41 ns	**PD Level**	-	**Rise Time**	-	**PD Level**	-

No of Pulses vs. Pulse Rise-Time	Peak Level in Time
	

Comments
1. B phase busing drain wire disconnected. Recommend re-connecting. Local PD 25dB

Substation/Site: T-4B-2
Location: POA 57B
Test No.:

Customer: City of Tampa
Test Engineer: Nat Crews/ Louis Nemec
Test Date: 09/02/2017 9:47:11 AM

C.E. Testing, Inc.

Sensor	Circuit/Description	V(kV)	Cable Type	Local Plant Type
HFCT	phA	13.2kV	Cable	EPR
HFCT	phB	13.2kV	Cable	EPR
HFCT	phC	13.2kV	Cable	EPR
TEV	TEV	13.2kV	Switchgear	Air Insulated

Phase-Resolved Graph (PD and Noise)

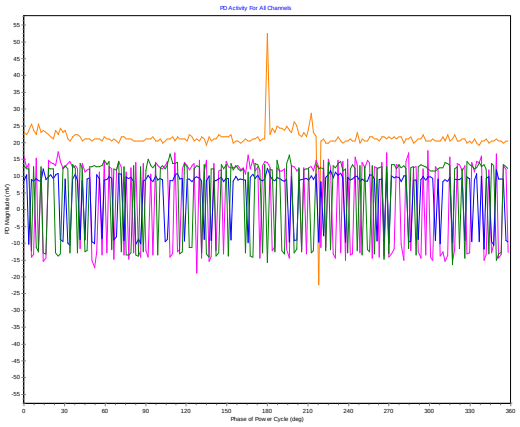
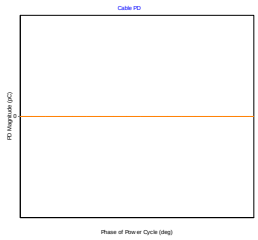
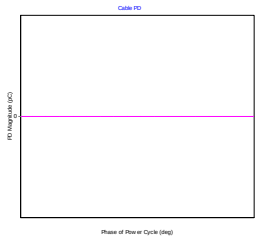
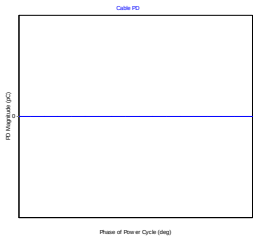
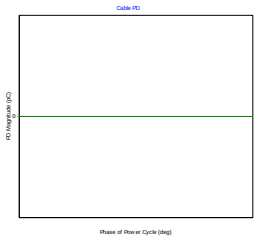
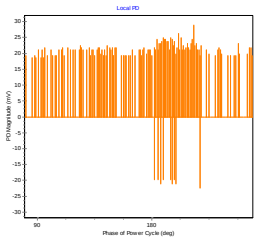
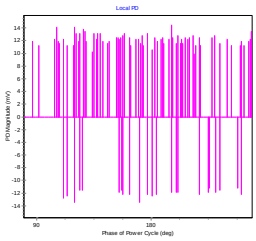
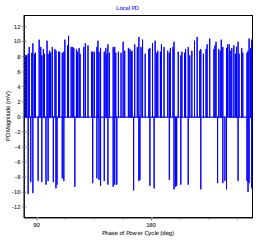
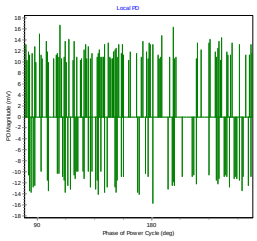
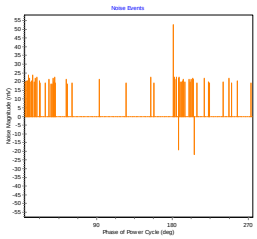
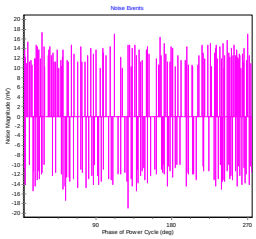
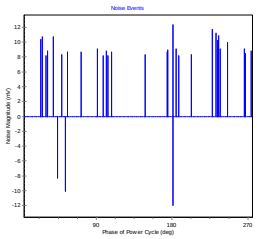
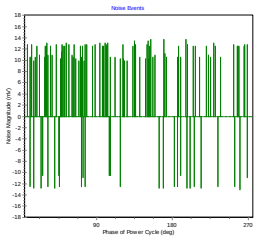
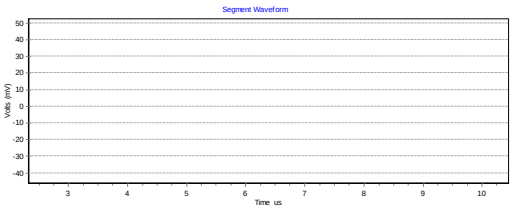
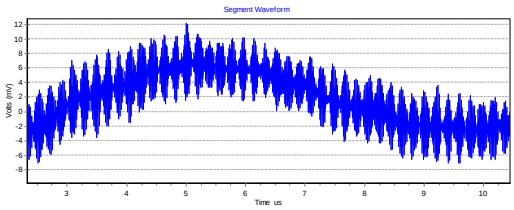
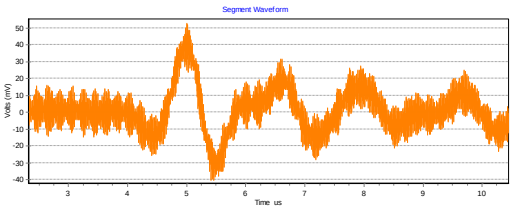
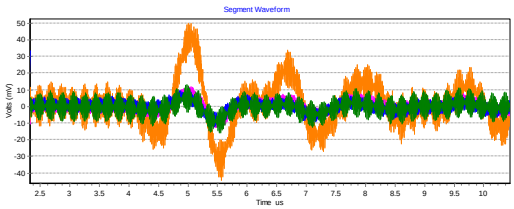


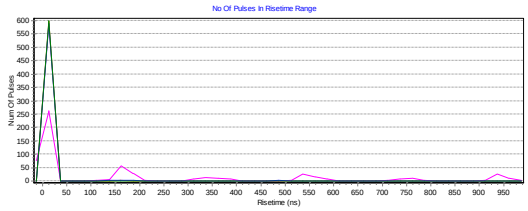
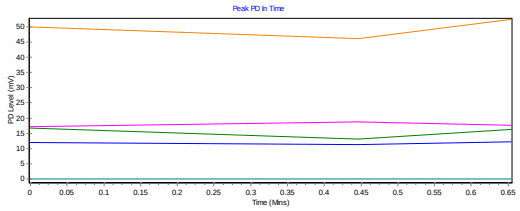
Photo of Sensor Attachment

	Channel 1		Channel 2		Channel 3		Channel 4	
	Cable PD	0pC	Cable PD	0pC	Cable PD	0pC	Cable PD	0pC
	Local PD	29dB	Local PD	23dB	Local PD	22dB	Local PD	24dB
	Peak	52.48mV	Peak	18.88mV	Peak	12.32mV	Peak	16.64mV
	Std Dev	7.33mV	Std Dev	3.50mV	Std Dev	2.58mV	Std Dev	3.84mV
Cable PD								

Local PD				
Noise				

Sensor	Circuit/Description	V(kV)	Cable Type	Local Plant Type
HFCT	phA	13.2kV	Cable	EPR
HFCT	phB	13.2kV	Cable	EPR
HFCT	phC	13.2kV	Cable	EPR
TEV	TEV	13.2kV	Switchgear	Air Insulated

Cable PD Waveform				Local PD Waveform			
							
Peak		**Frequency**		**Peak**	12.16 mV	**Frequency**	100.00 MHz
Rise Time		**PD Level**		**Rise Time**	6.12 ns	**PD Level**	
Noise Waveform				**Synchronous Waveform**			
							
Peak	52.48 mV	**Frequency**	610.35 kHz	**Peak**	-	**Frequency**	-
Rise Time	157.59 ns	**PD Level**	-	**Rise Time**	-	**PD Level**	-

No of Pulses vs. Pulse Rise-Time	Peak Level in Time
	

Comments
POA 57B: 1. Transformer de-energized. 2. Low oil indication on gauge. 3. Signs of corrosion on lower enclosure. 4. C phase dead break drain wire disconnected. Recommend re-connecting. Local PD indicated on all phases 22-29dB

Comment Item 2

Comment Item 3

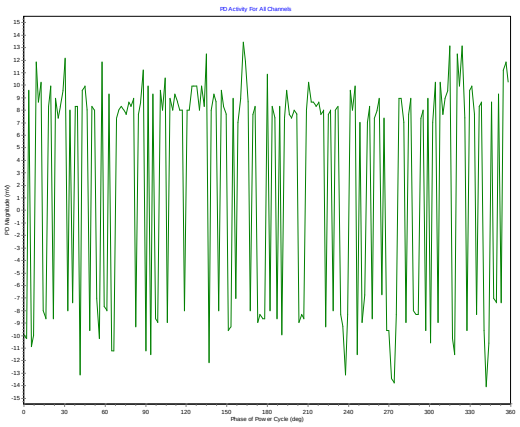
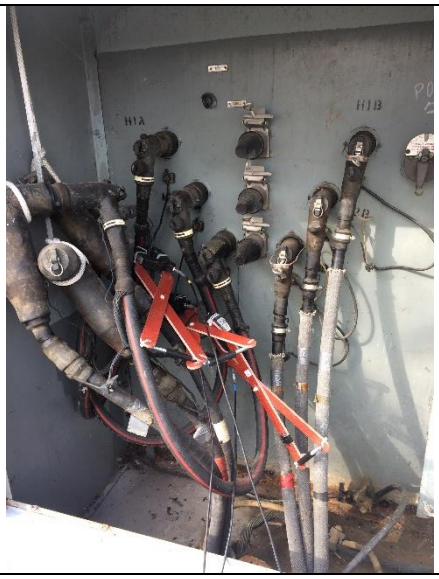
Comment Item 4

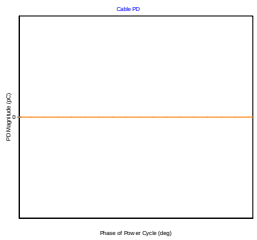
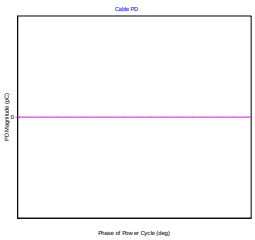
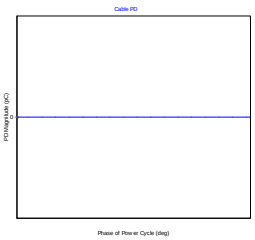
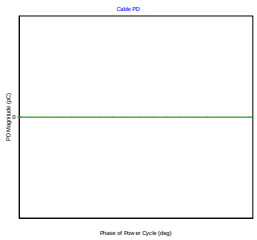
Substation/Site: T-4B-2 A
Location: POA 57A
Test No.:

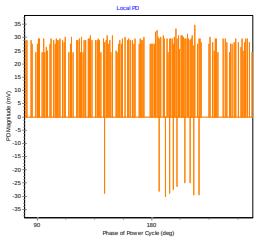
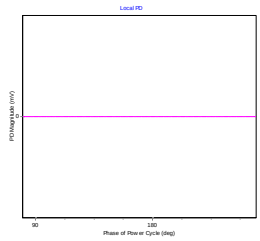
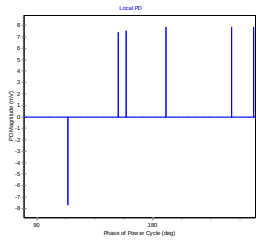
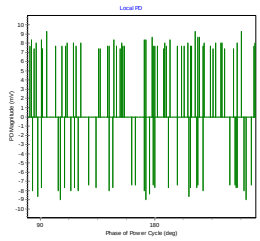
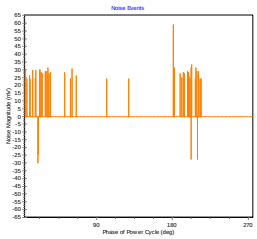
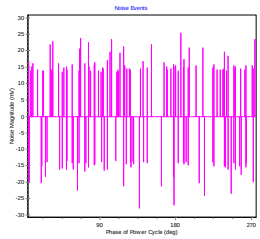
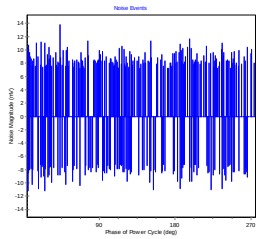
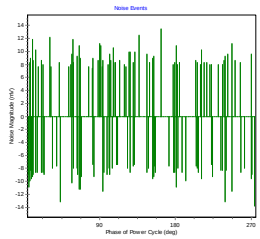
Customer: City of Tampa
Test Engineer: Nat Crews/ Louis Nemec
Test Date: 09/02/2017 9:51:48 AM

C.E. Testing, Inc.

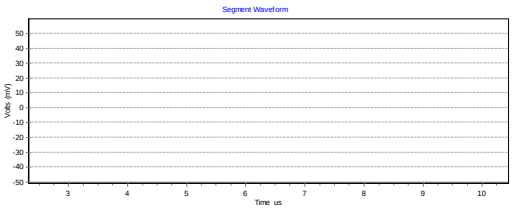
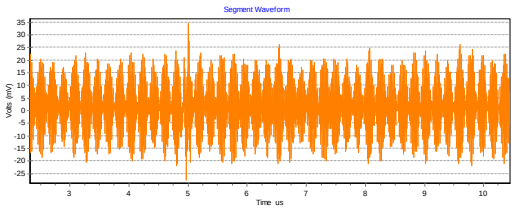
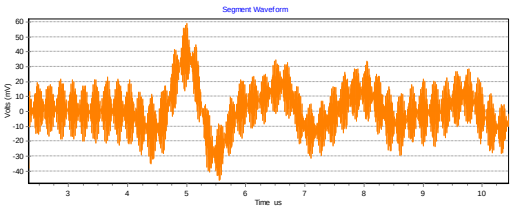
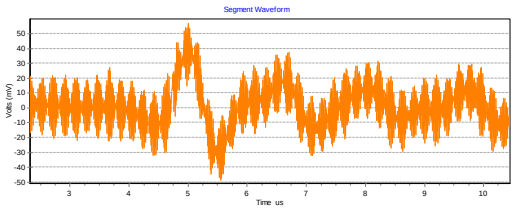
Sensor	Circuit/Description	V(kV)	Cable Type	Local Plant Type
HFCT	phA	13.2kV	Cable	EPR
HFCT	phB	13.2kV	Cable	EPR
HFCT	phC	13.2kV	Cable	EPR
TEV	TEV	13.2kV	Switchgear	Air Insulated

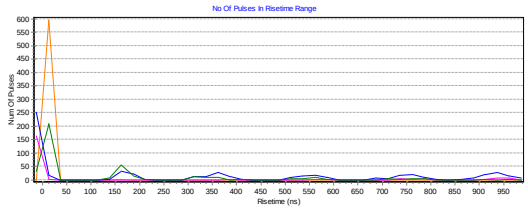
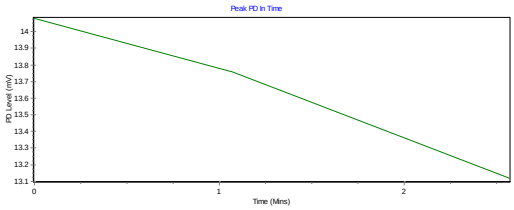
Phase-Resolved Graph (PD and Noise)	Photo of Sensor Attachment
	

	Channel 1		Channel 2		Channel 3		Channel 4	
	Cable PD	0pC	Cable PD	0pC	Cable PD	0pC	Cable PD	0pC
	Local PD	31dB	Local PD	0dB	Local PD	18dB	Local PD	20dB
	Peak	58.88mV	Peak	27.84mV	Peak	13.76mV	Peak	14.08mV
	Std Dev	10.19mV	Std Dev	4.73mV	Std Dev	2.42mV	Std Dev	2.47mV
Cable PD								

Local PD				
Noise				

Sensor	Circuit/Description	V(kV)	Cable Type	Local Plant Type
HFCT	phA	13.2kV	Cable	EPR
HFCT	phB	13.2kV	Cable	EPR
HFCT	phC	13.2kV	Cable	EPR
TEV	TEV	13.2kV	Switchgear	Air Insulated

Cable PD Waveform				Local PD Waveform			
							
Peak		**Frequency**		**Peak**	34.56 mV	**Frequency**	71.43 MHz
Rise Time		**PD Level**		**Rise Time**	2.76 ns	**PD Level**	
Noise Waveform				**Synchronous Waveform**			
							
Peak	58.88 mV	**Frequency**	732.42 kHz	**Peak**	-	**Frequency**	-
Rise Time	123.63 ns	**PD Level**	-	**Rise Time**	-	**PD Level**	-

No of Pulses vs. Pulse Rise-Time	**Peak Level in Time**
	

Comments
Local PD indicated by TEV and HFCT See comments for and pictures POA 57B

Substation/Site: T-5A-6
Location: POA 80
Test No.:

Customer: City of Tampa
Test Engineer: Nat Crews / Louis Nemec
Test Date: 09/02/2017 10:29:26 AM

C.E. Testing, Inc.

Sensor	Circuit/Description	V(kV)	Cable Type	Local Plant Type
HFCT	phA	13.2kV	Cable	EPR
HFCT	phB	13.2kV	Cable	EPR
HFCT	phC	13.2kV	Cable	EPR
N/A	N/A	13.2kV	Switchgear	Air Insulated

Phase-Resolved Graph (PD and Noise)

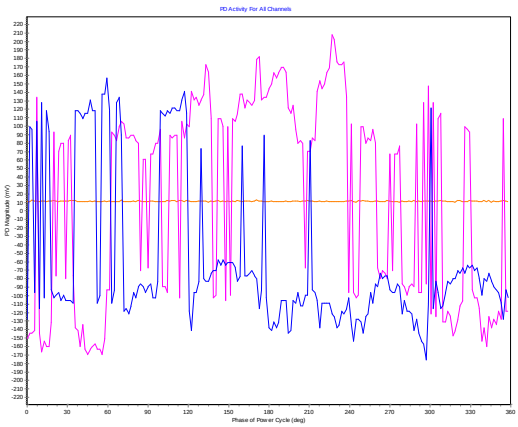
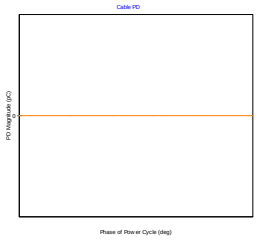
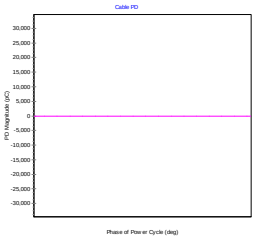
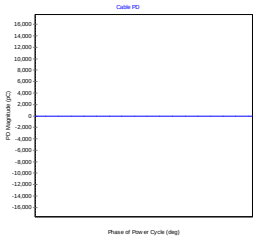
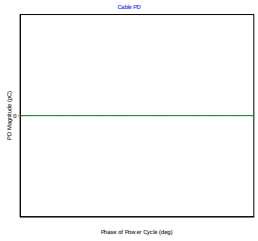
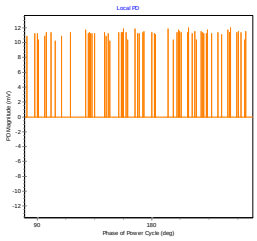
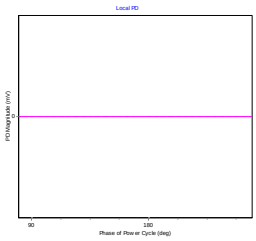
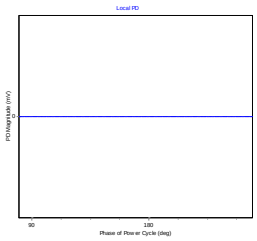
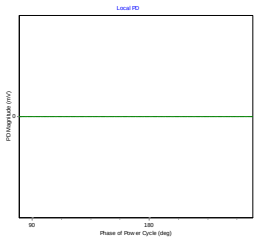
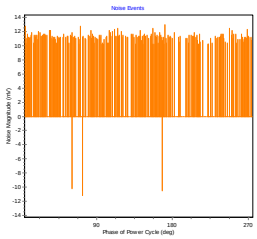
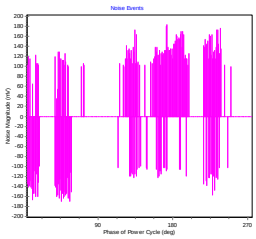
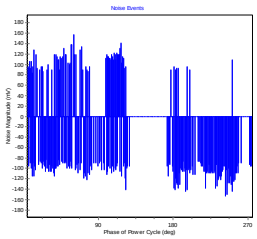
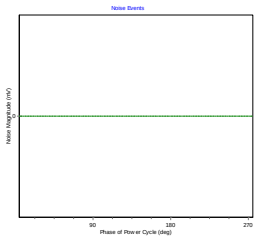
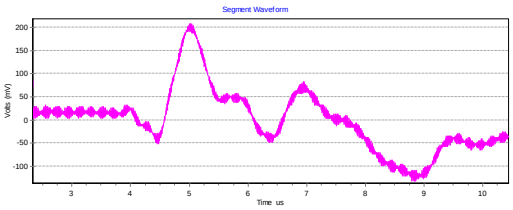
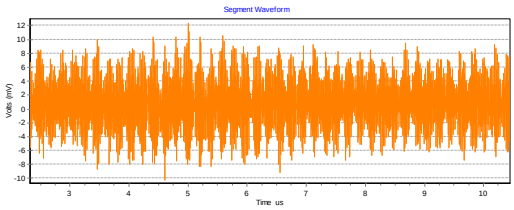
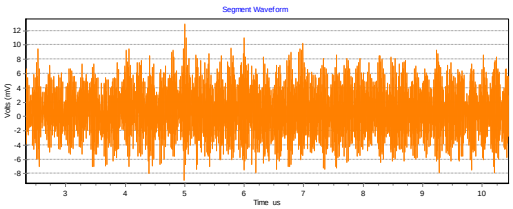
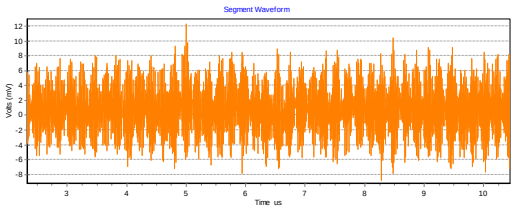


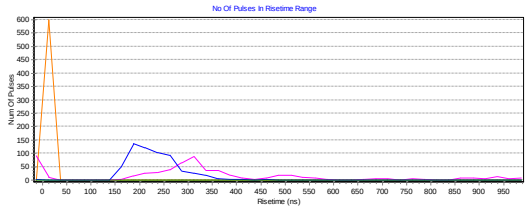
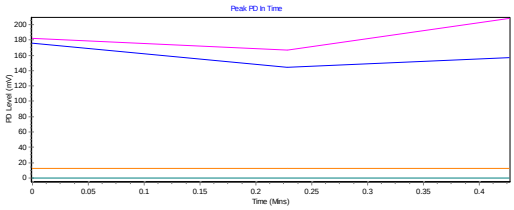
Photo of Sensor Attachment

	Channel 1		Channel 2		Channel 3		Channel 4	
	Cable PD	0pC	Cable PD	31357pC	Cable PD	15984pC	Cable PD	0pC
	Local PD	22dB	Local PD	0dB	Local PD	0dB	Local PD	0dB
	Peak	12.96mV	Peak	208.00mV	Peak	176.00mV	Peak	0.00mV
	Std Dev	3.80mV	Std Dev	28.81mV	Std Dev	20.42mV	Std Dev	0.00mV
Cable PD								

Local PD				
Noise				

Sensor	Circuit/Description	V(kV)	Cable Type	Local Plant Type
HFCT	phA	13.2kV	Cable	EPR
HFCT	phB	13.2kV	Cable	EPR
HFCT	phC	13.2kV	Cable	EPR
N/A	N/A	13.2kV	Switchgear	Air Insulated

Cable PD Waveform				Local PD Waveform			
							
Peak	208.00 mV	**Frequency**	244.14 kHz	**Peak**	12.32 mV	**Frequency**	93.75 MHz
Rise Time	313.09 ns	**PD Level**	27.01 nC	**Rise Time**	1.30 ns	**PD Level**	
Noise Waveform				**Synchronous Waveform**			
							
Peak	12.96 mV	**Frequency**	93.75 MHz	**Peak**	-	**Frequency**	-
Rise Time	1.09 ns	**PD Level**	-	**Rise Time**	-	**PD Level**	-

No of Pulses vs. Pulse Rise-Time	**Peak Level in Time**
	

Comments
No PD detected. Noise waveforms.

Substation/Site:	T-5B-6	**Customer:**	City of Tampa
Location:	POA 81	**Test Engineer:**	Nat Crews / Louis Nemec
Test No.:		**Test Date:**	09/02/2017 10:41:24 AM

C.E. Testing, Inc.

Sensor	Circuit/Description	V(kV)	Cable Type	Local Plant Type
HFCT	phA	13.2kV	Cable	EPR
HFCT	phB	13.2kV	Cable	EPR
HFCT	phC	13.2kV	Cable	EPR
N/A	N/A	13.2kV	Switchgear	Air Insulated

Phase-Resolved Graph (PD and Noise)

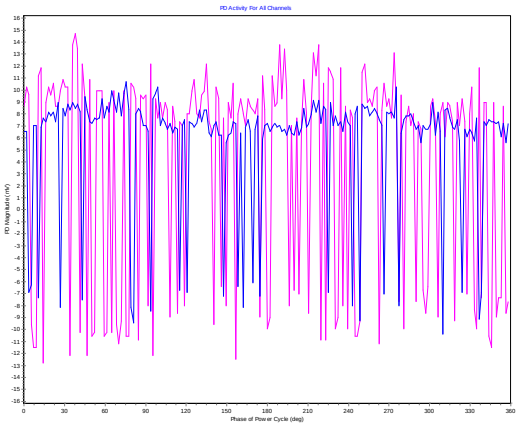
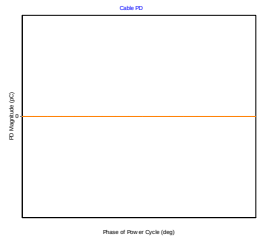
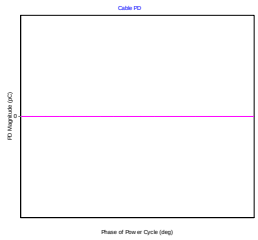
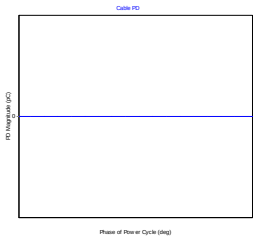
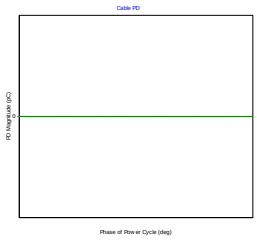
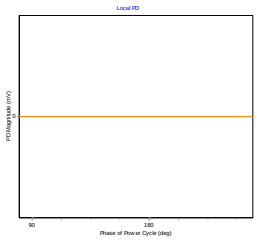
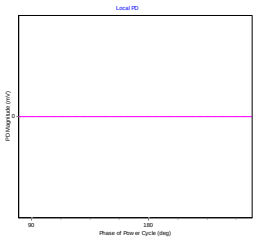
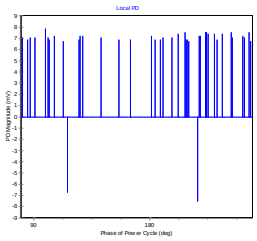
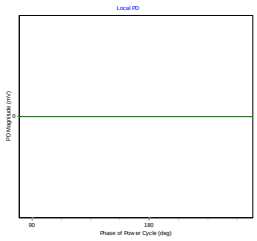
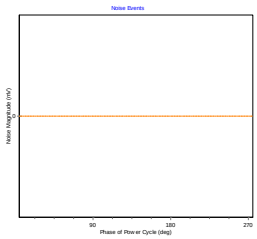
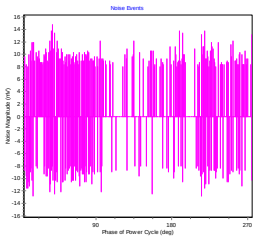
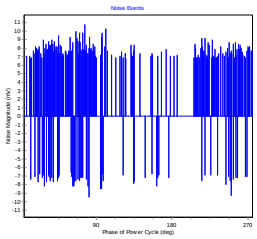
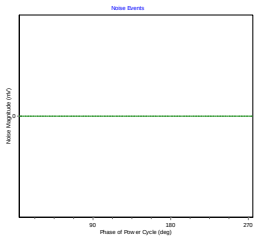
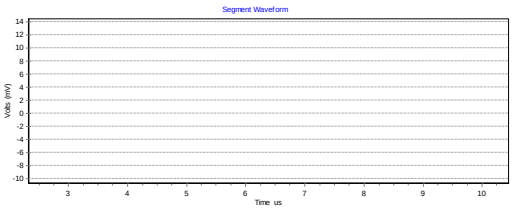
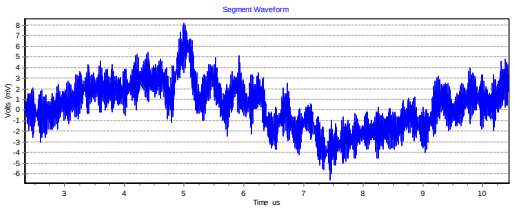
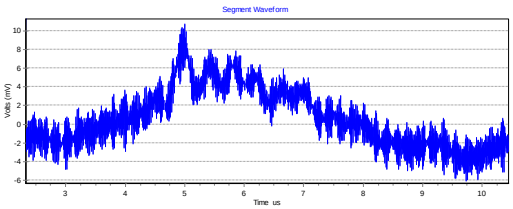
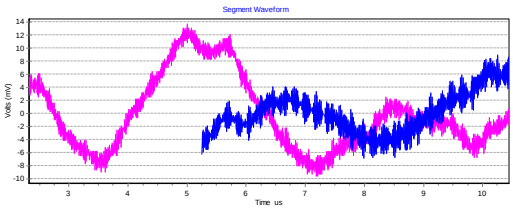


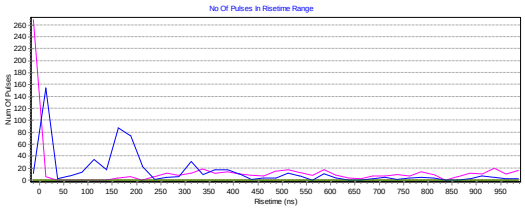
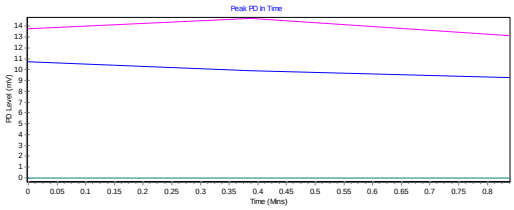
Photo of Sensor Attachment

	Channel 1		Channel 2		Channel 3		Channel 4	
	Cable PD	0pC	Cable PD	0pC	Cable PD	0pC	Cable PD	0pC
	Local PD	0dB	Local PD	0dB	Local PD	18dB	Local PD	0dB
	Peak	0.00mV	Peak	14.72mV	Peak	10.72mV	Peak	0.00mV
	Std Dev	0.00mV	Std Dev	2.44mV	Std Dev	1.86mV	Std Dev	0.00mV
Cable PD								

Local PD				
Noise				

Sensor	Circuit/Description	V(kV)	Cable Type	Local Plant Type
HFCT	phA	13.2kV	Cable	EPR
HFCT	phB	13.2kV	Cable	EPR
HFCT	phC	13.2kV	Cable	EPR
TEV	TEV	13.2kV	Switchgear	Air Insulated

Cable PD Waveform				Local PD Waveform			
							
Peak		**Frequency**		**Peak**	8.16 mV	**Frequency**	99.61 MHz
Rise Time		**PD Level**		**Rise Time**	127.74 ns	**PD Level**	
Noise Waveform				**Synchronous Waveform**			
							
Peak	10.72 mV	**Frequency**	244.14 kHz	**Peak**	-	**Frequency**	-
Rise Time	171.60 ns	**PD Level**	-	**Rise Time**	-	**PD Level**	-

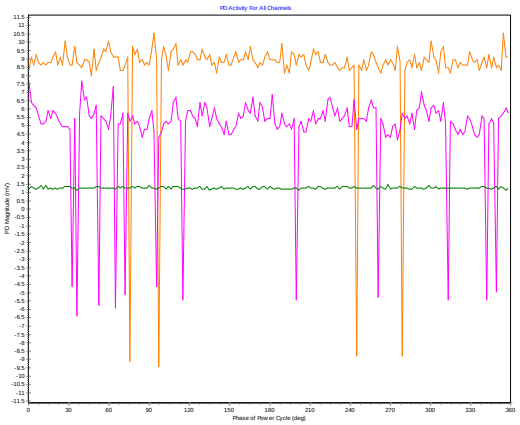
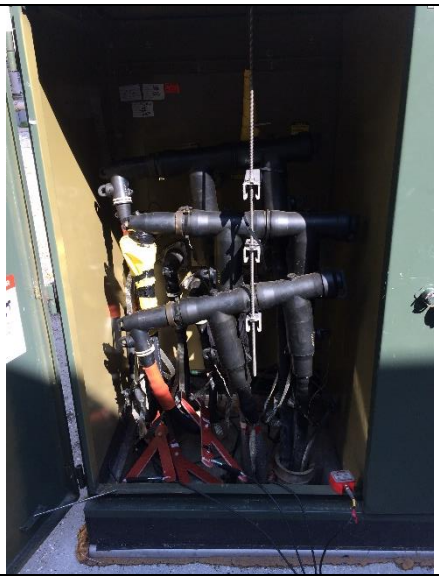
No of Pulses vs. Pulse Rise-Time	**Peak Level in Time**
	

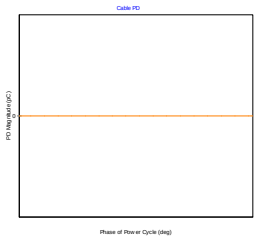
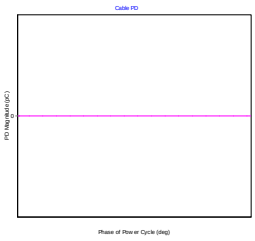
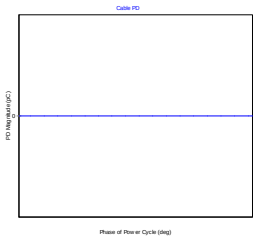
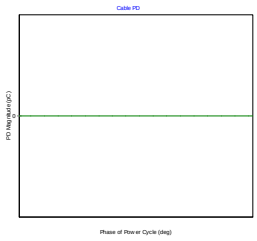
Comments
Local PD C-phase 18dB

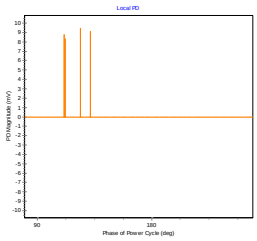
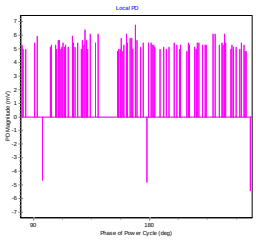
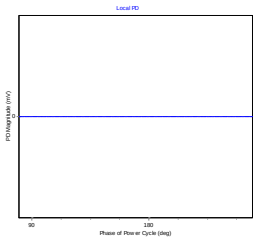
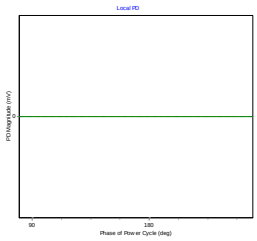
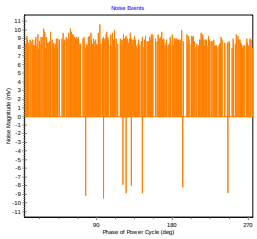
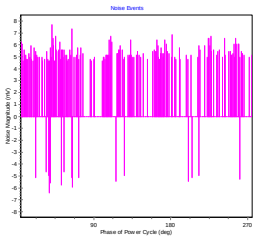
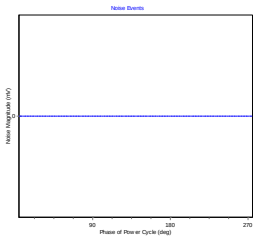
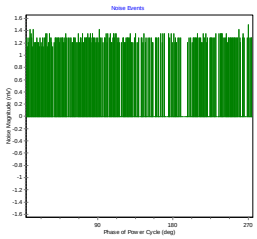
Substation/Site:	T-5A-5	**Customer:**	City of Tampa
Location:	POA 83A	**Test Engineer:**	Nat Crews / Louis Nemec
Test No.:		**Test Date:**	09/02/2017 11:09:36 AM

C.E. Testing, Inc.

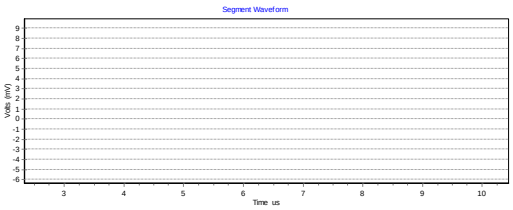
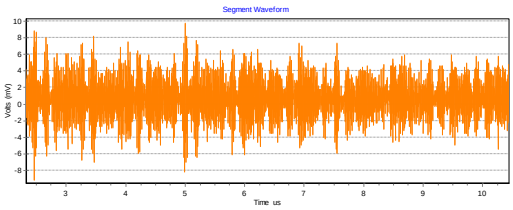
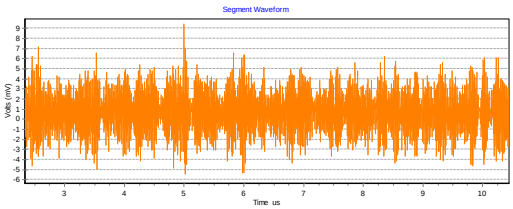
Sensor	Circuit/Description	V(kV)	Cable Type	Local Plant Type
HFCT	phA	13.2kV	Cable	EPR
HFCT	phB	13.2kV	Cable	EPR
N/A	phC	13.2kV	Cable	EPR
TEV	TEV	13.2kV	Transformer	Oil Filled

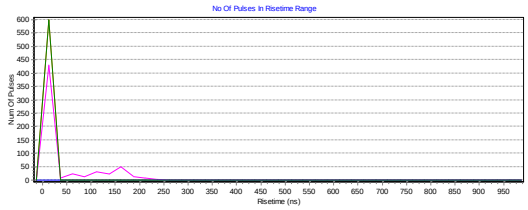
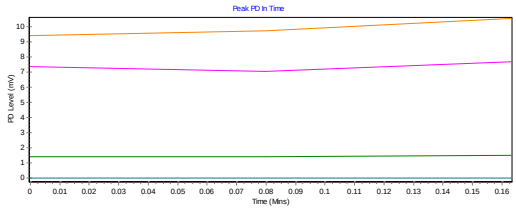
Phase-Resolved Graph (PD and Noise)	Photo of Sensor Attachment
	

	Channel 1		Channel 2		Channel 3		Channel 4	
	Cable PD	0pC	Cable PD	0pC	Cable PD	0pC	Cable PD	0pC
	Local PD	20dB	Local PD	17dB	Local PD	0dB	Local PD	0dB
	Peak	10.56mV	Peak	7.68mV	Peak	0.00mV	Peak	1.49mV
	Std Dev	2.40mV	Std Dev	1.14mV	Std Dev	0.00mV	Std Dev	0.26mV
Cable PD								

Local PD				
Noise				

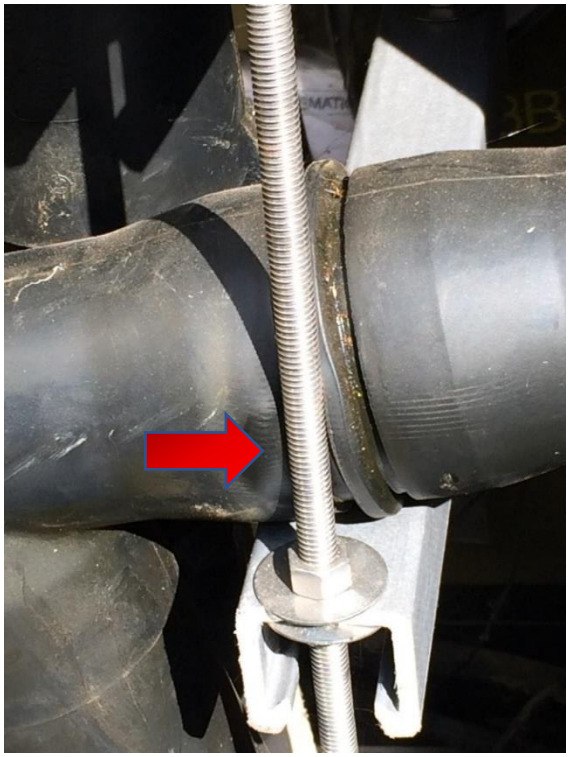
Sensor	Circuit/Description	V(kV)	Cable Type	Local Plant Type
HFCT	phA	13.2kV	Cable	EPR
HFCT	phB	13.2kV	Cable	EPR
HFCT	phC	13.2kV	Cable	EPR
TEV Probe	TEV	13.2kV	Transformer	Solid Insulated

Cable PD Waveform				Local PD Waveform			
							
Peak		**Frequency**		**Peak**	9.76 mV	**Frequency**	104.17 MHz
Rise Time		**PD Level**		**Rise Time**	193.84 ps	**PD Level**	
Noise Waveform				**Synchronous Waveform**			
							
Peak	10.56 mV	**Frequency**	71.43 MHz	**Peak**	-	**Frequency**	-
Rise Time	2.67 ns	**PD Level**	-	**Rise Time**	-	**PD Level**	-

No of Pulses vs. Pulse Rise-Time	**Peak Level in Time**
	

Comments
Local PD, A-phase and B-phase. PD Level Orange, retest in 6 months or after repairs. 1. Several drain wires missing or disconnected. Recommend replacing wires and re-connecting. 2. C phase dead break termination against the threaded rod. Recommend placing insulation around threaded rod to insulate termination.

Comment Item 1



Comment Item 2

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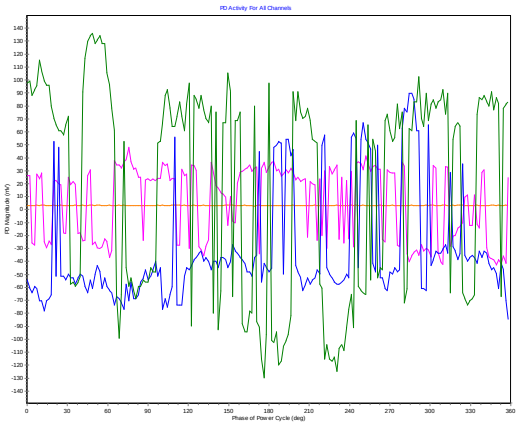
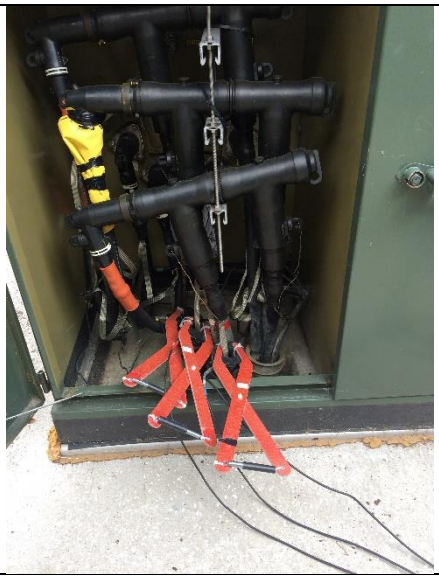
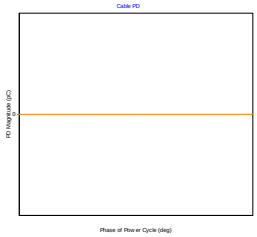
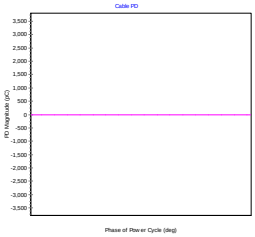
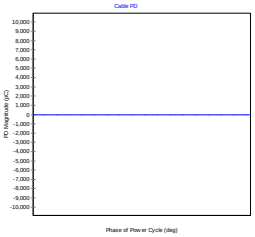
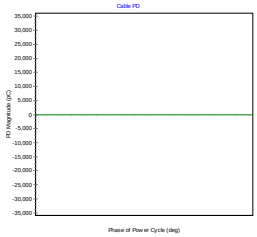
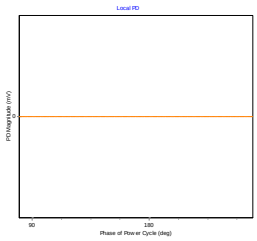
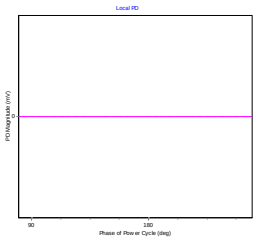
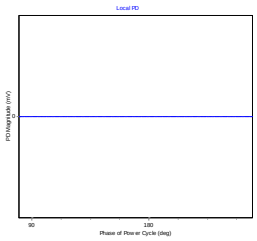
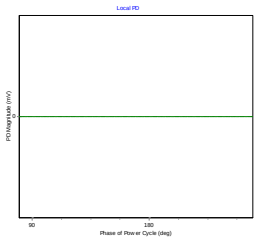
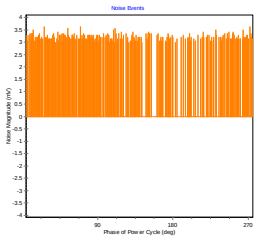
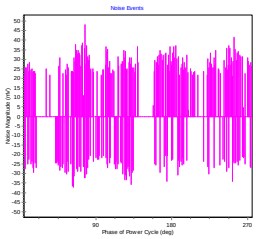
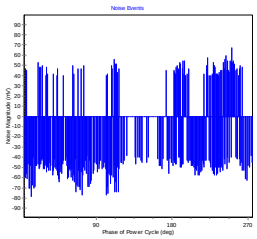
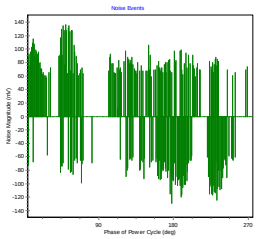
Substation/Site:	T-5A-5 B	**Customer:**	City of Tampa	C.E. Testing, Inc.
Location:	POA 83 B	**Test Engineer:**	Nat Crews / Louis Nemec	
Test No.:		**Test Date:**	09/02/2017 11:41:24 AM	

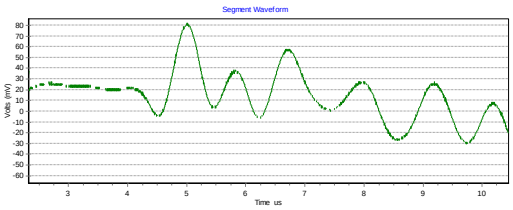
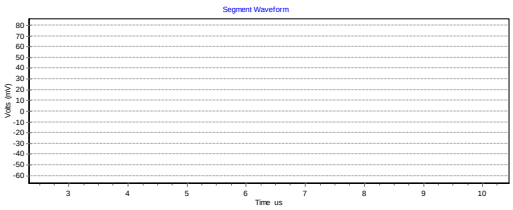
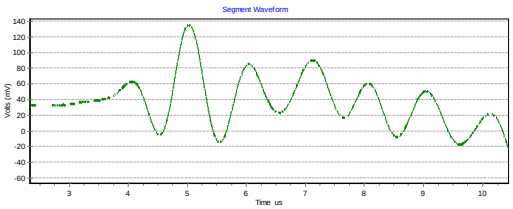
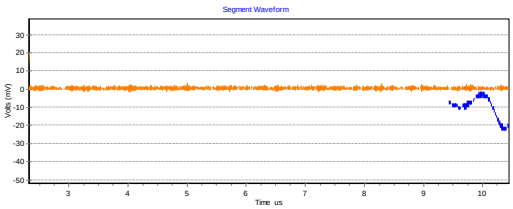
Sensor	Circuit/Description	V(kV)	Cable Type	Local Plant Type
HFCT	phA	13.2kV		
HFCT	phB	13.2kV	Cable	EPR
HFCT	phC	13.2kV		
TEV Probe	TEV	13.2kV	Transformer	Oil Filled

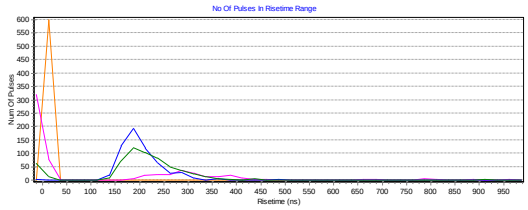
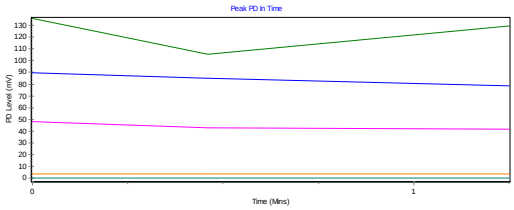
Phase-Resolved Graph (PD and Noise)	Photo of Sensor Attachment
	

	Channel 1		Channel 2		Channel 3		Channel 4	
	Cable PD	0pC	Cable PD	3433pC	Cable PD	9885pC	Cable PD	32582pC
	Local PD	0dB	Local PD	0dB	Local PD	0dB	Local PD	0dB
	Peak	3.70mV	Peak	48.00mV	Peak	89.60mV	Peak	136.00mV
	Std Dev	0.61mV	Std Dev	7.61mV	Std Dev	9.70mV	Std Dev	18.44mV
Cable PD								

Local PD				
Noise				

Sensor	Circuit/Description	V(kV)	Cable Type	Local Plant Type
HFCT	phA	13.2kV		
HFCT	phB	13.2kV	Cable	EPR
HFCT	phC	13.2kV		
TEV	TEV	13.2kV	Transformer	Oil Filled

Cable PD Waveform				Local PD Waveform			
							
Peak	81.60 mV	**Frequency**	488.28 kHz	**Peak**		**Frequency**	
Rise Time	278.48 ns	**PD Level**	32.58 nC	**Rise Time**		**PD Level**	
Noise Waveform				**Synchronous Waveform**			
							
Peak	136.00 mV	**Frequency**	122.07 kHz	**Peak**	-	**Frequency**	-
Rise Time	278.62 ns	**PD Level**	-	**Rise Time**	-	**PD Level**	-

No of Pulses vs. Pulse Rise-Time	**Peak Level in Time**
	

Comments
Local cable PD indicated by TEV and HFCT. Termination against threaded rod.

Substation/Site: T-5B-5
Location: POA 82 A
Test No.:

Customer: City of Tampa
Test Engineer: Nat Crews / Louis Nemec
Test Date: 09/02/2017 11:23:36 AM

Sensor	Circuit/Description	V(kV)	Cable Type	Local Plant Type
HFCT	phA	13.2kV	Cable	EPR
HFCT	phB	13.2kV	Cable	EPR
HFCT	phC	13.2kV	Cable	EPR
TEV	TEV	13.2kV	Transformer	Oil Filled

Phase-Resolved Graph (PD and Noise)

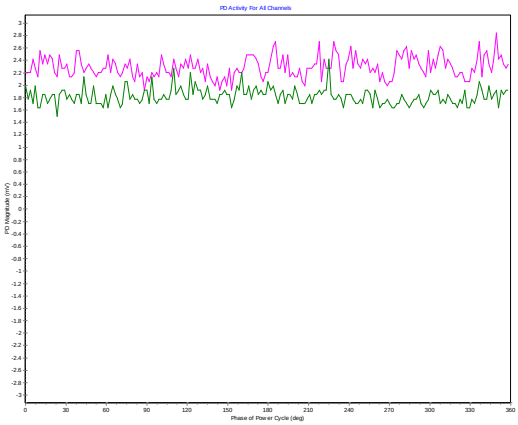
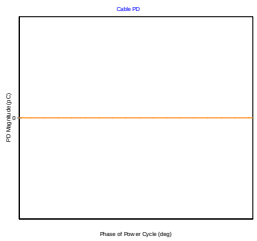
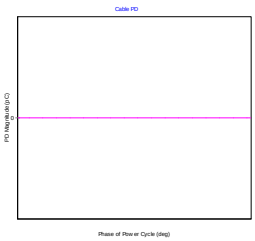
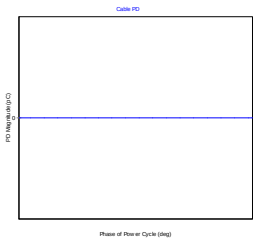
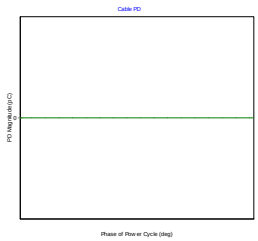
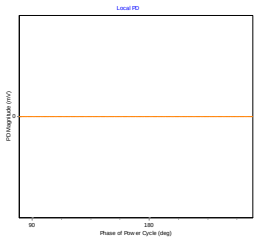
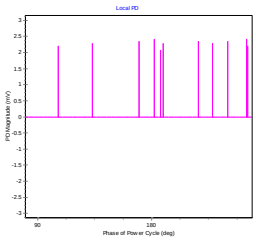
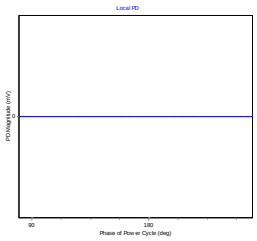
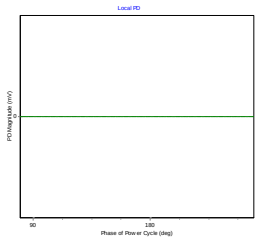
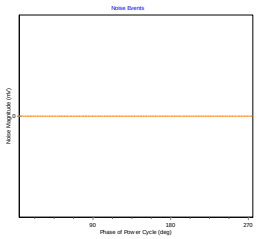
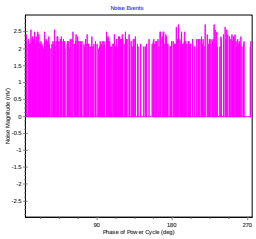
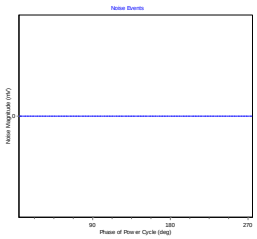
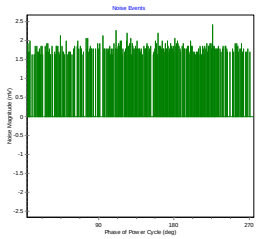
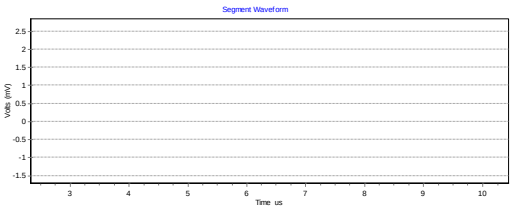
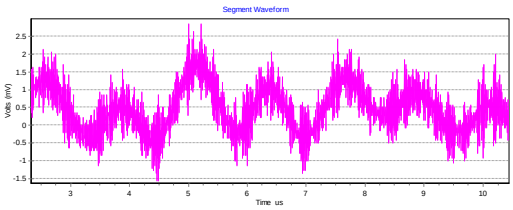
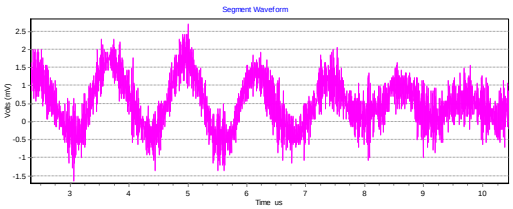
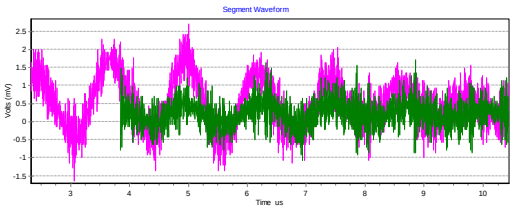


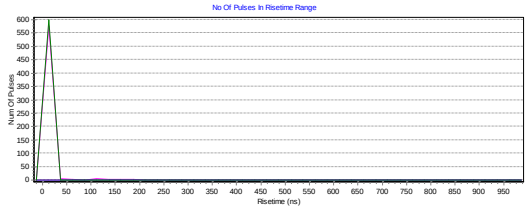
Photo of Sensor Attachment

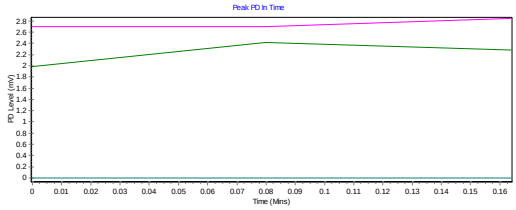
	Channel 1		Channel 2		Channel 3		Channel 4	
	Cable PD	0pC	Cable PD	0pC	Cable PD	0pC	Cable PD	0pC
	Local PD	0dB	Local PD	9dB	Local PD	0dB	Local PD	0dB
	Peak	0.00mV	Peak	2.84mV	Peak	0.00mV	Peak	2.42mV
	Std Dev	0.00mV	Std Dev	0.44mV	Std Dev	0.00mV	Std Dev	0.41mV
Cable PD								

Local PD				
Noise				

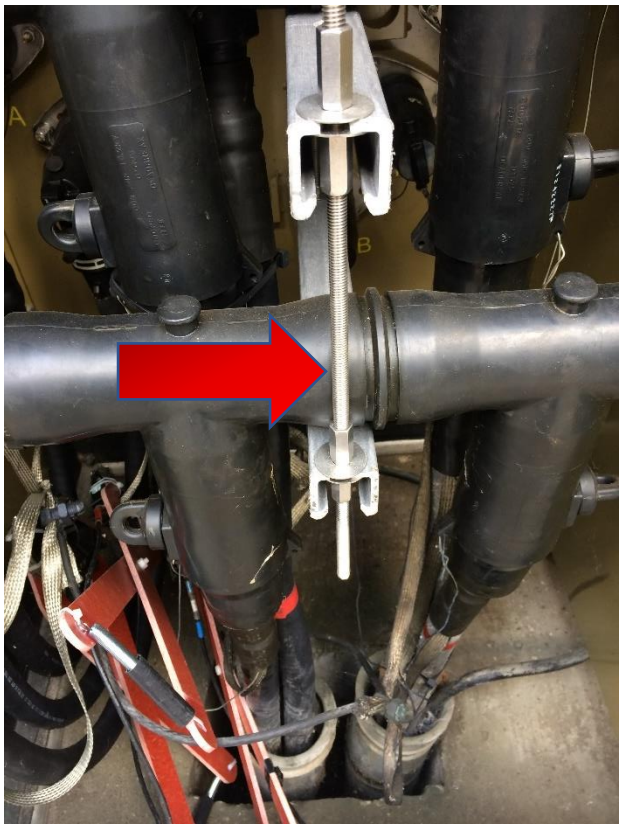
Sensor	Circuit/Description	V(kV)	Cable Type	Local Plant Type
HFCT	phA	13.2kV	Cable	EPR
HFCT	phB	13.2kV	Cable	EPR
HFCT	phC	13.2kV	Cable	EPR
TEV	TEV	13.2kV	Transformer	Oil Filled

Cable PD Waveform				Local PD Waveform			
							
Peak		**Frequency**		**Peak**	2.84 mV	**Frequency**	104.32 MHz
Rise Time		**PD Level**		**Rise Time**	5.20 ns	**PD Level**	
Noise Waveform				**Synchronous Waveform**			
							
Peak	2.70 mV	**Frequency**	732.42 kHz	**Peak**	-	**Frequency**	-
Rise Time	125.86 ns	**PD Level**	-	**Rise Time**	-	**PD Level**	-
No of Pulses vs. Pulse Rise-Time				**Peak Level in Time**			





Comments
1. C phase dead break termination against the threaded rod. Recommend placing insulation around threaded rod to insulate termination.

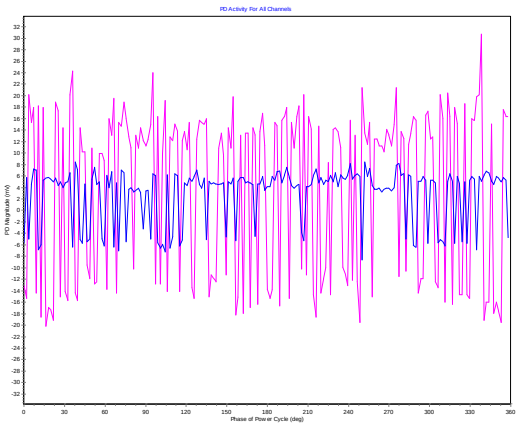
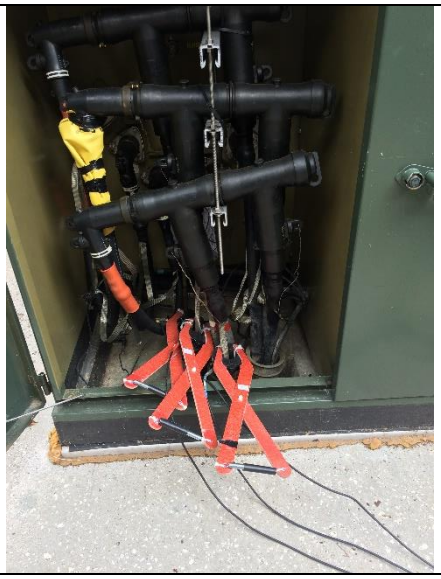


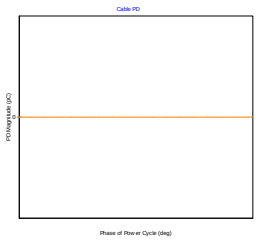
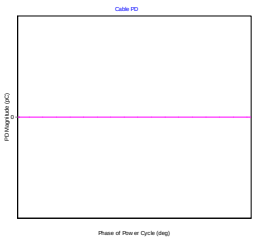
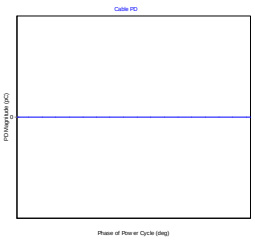
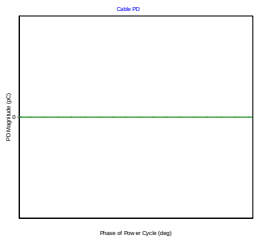
Comment Item 1

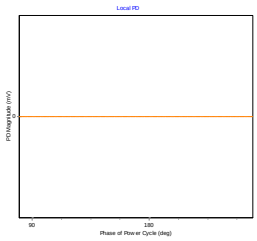
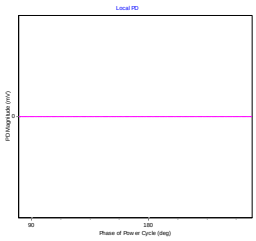
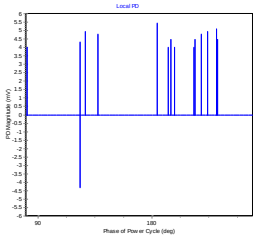
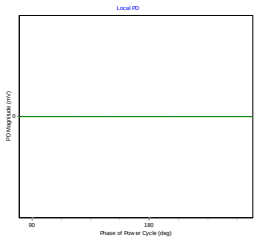
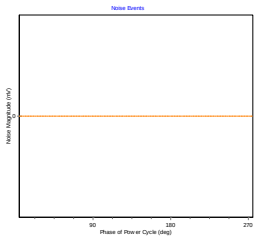
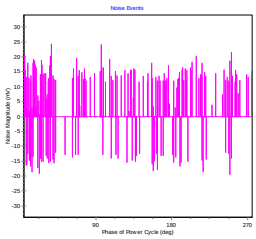
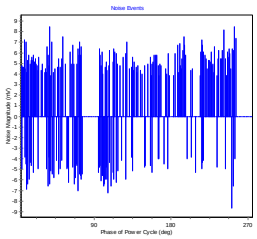
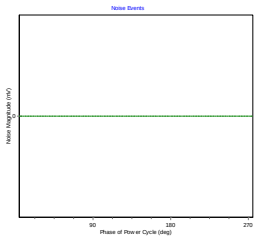
Substation/Site:	T-5B-5	**Customer:**	City of Tampa
Location:	POA 82 B	**Test Engineer:**	Nat Crews / Louis Nemec
Test No.:		**Test Date:**	09/02/2017 11:32:32 AM

C.E. Testing, Inc.

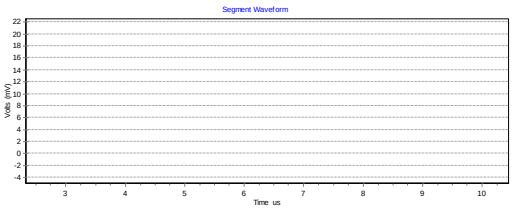
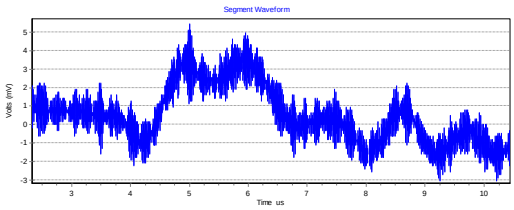
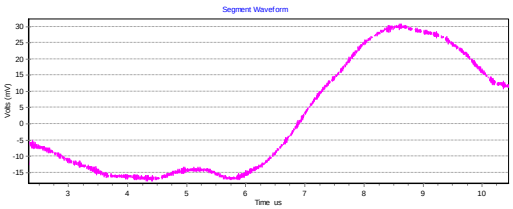
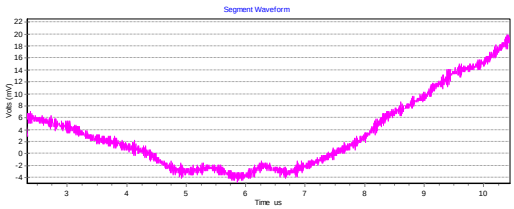
Sensor	Circuit/Description	V(kV)	Cable Type	Local Plant Type
HFCT	phA	13.2kV	Cable	EPR
HFCT	phB	13.2kV	Cable	EPR
HFCT	phC	13.2kV	Cable	EPR
TEV	TEV	13.2kV	Cable	EPR

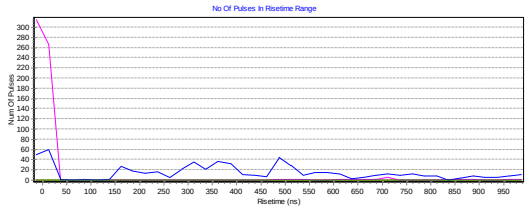
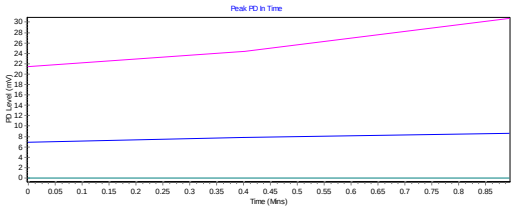
Phase-Resolved Graph (PD and Noise)	Photo of Sensor Attachment
	

	Channel 1		Channel 2		Channel 3		Channel 4	
	Cable PD	0pC	Cable PD	0pC	Cable PD	0pC	Cable PD	0pC
	Local PD	0dB	Local PD	0dB	Local PD	15dB	Local PD	15dB
	Peak	0.00mV	Peak	30.72mV	Peak	8.64mV	Peak	0.00mV
	Std Dev	0.00mV	Std Dev	4.48mV	Std Dev	1.19mV	Std Dev	0.00mV
Cable PD								

Local PD				
Noise				

Sensor	Circuit/Description	V(kV)	Cable Type	Local Plant Type
HFCT	phA	13.2kV	Cable	EPR
HFCT	phB	13.2kV	Cable	EPR
HFCT	phC	13.2kV	Cable	EPR
TEV	TEV	13.2kV	Cable	EPR

Cable PD Waveform				Local PD Waveform			
							
Peak		**Frequency**		**Peak**	5.44 mV	**Frequency**	103.33 MHz
Rise Time		**PD Level**		**Rise Time**	6.39 ns	**PD Level**	
Noise Waveform				**Synchronous Waveform**			
							
Peak	30.72 mV	**Frequency**	91.55 kHz	**Peak**	-	**Frequency**	-
Rise Time	1.37 us	**PD Level**	-	**Rise Time**	-	**PD Level**	-

No of Pulses vs. Pulse Rise-Time	**Peak Level in Time**
	

Comments
Local PD 15dB, C-phase Local PD indicated by TEV and HFCT. Retest in 6 months or after repairs.

Substation/Site: T-8B-1
Location: POA 78
Test No.:

Customer: City of Tampa
Test Engineer: Nat Crews/ Louis Nemec
Test Date: 09/02/2017 1:40:51 PM

C.E. Testing, Inc.

Sensor	Circuit/Description	V(kV)	Cable Type	Local Plant Type
HFCT	phA	13.2kV	Cable	EPR
HFCT	phB	13.2kV	Cable	EPR
HFCT	phC	13.2kV	Cable	EPR
TEV Probe	TEV	13.2kV	Cable	EPR

Phase-Resolved Graph (PD and Noise)

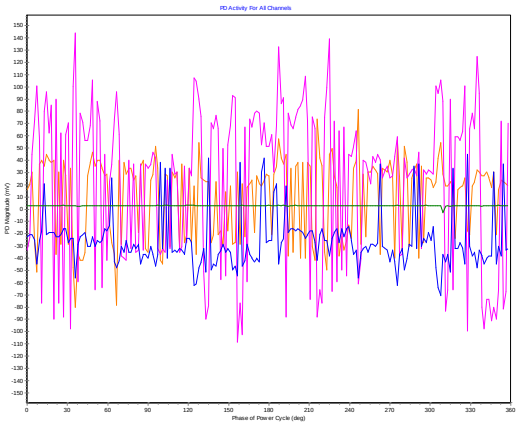
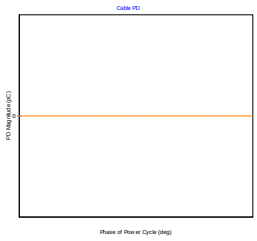
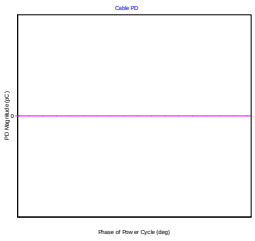
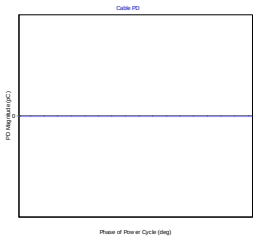
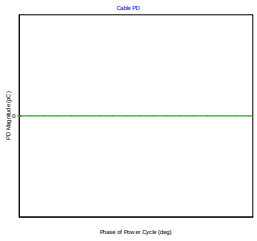
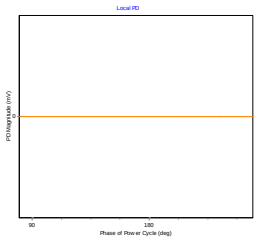
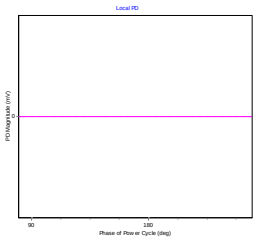
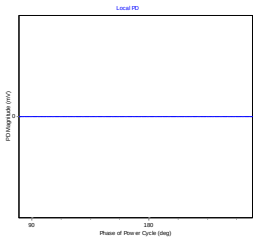
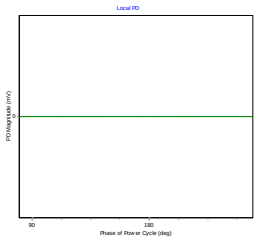
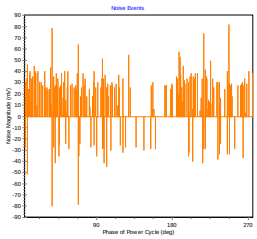
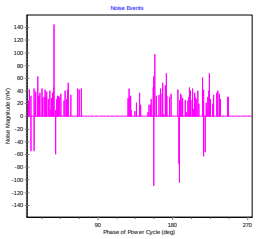
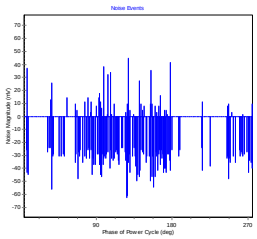
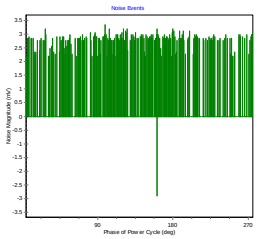
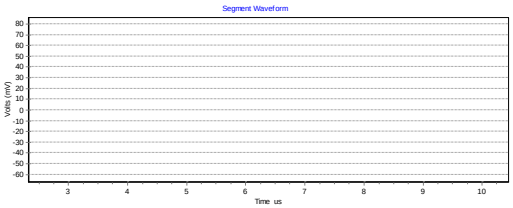
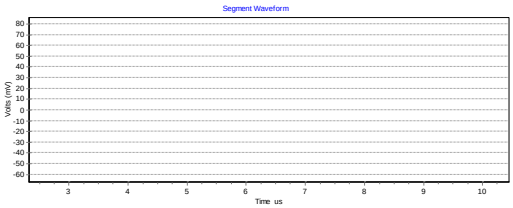
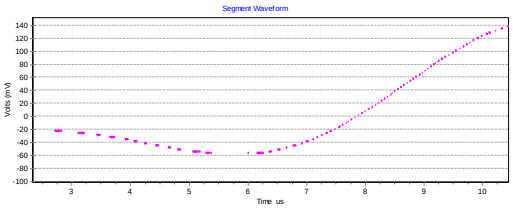
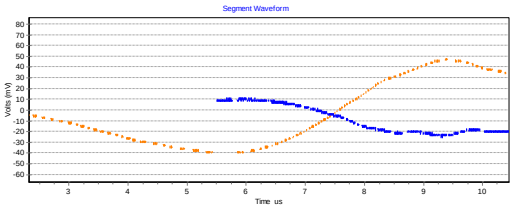


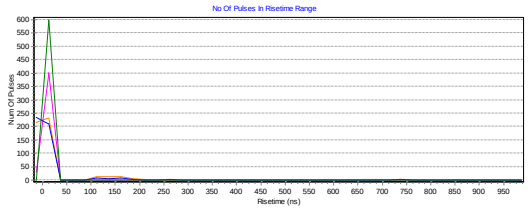
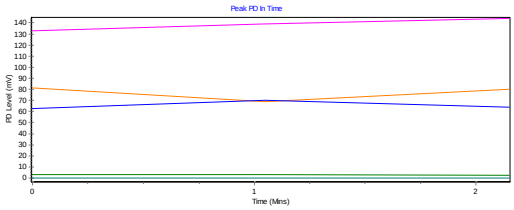
Photo of Sensor Attachment

	Channel 1		Channel 2		Channel 3		Channel 4	
	Cable PD	0pC	Cable PD	0pC	Cable PD	0pC	Cable PD	0pC
	Local PD	0dB	Local PD	0dB	Local PD	0dB	Local PD	0dB
	Peak	81.60mV	Peak	144.00mV	Peak	70.40mV	Peak	3.34mV
	Std Dev	9.65mV	Std Dev	20.52mV	Std Dev	9.22mV	Std Dev	0.70mV
Cable PD								

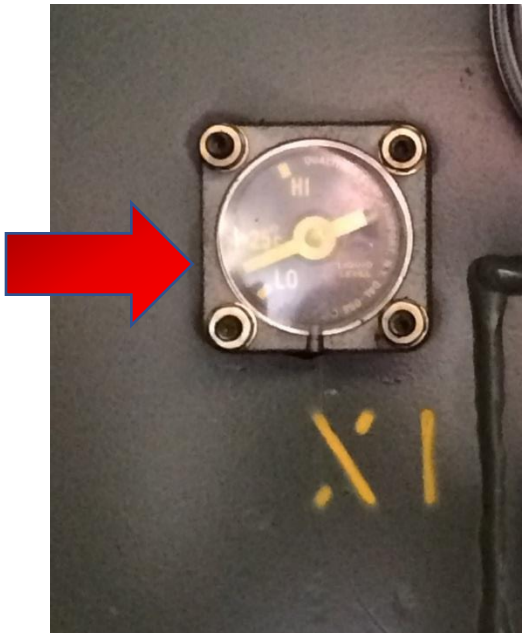
Local PD				
Noise				

Sensor	Circuit/Description	V(kV)	Cable Type	Local Plant Type
HFCT	phA	13.2kV	Cable	EPR
HFCT	phB	13.2kV	Cable	EPR
HFCT	phC	13.2kV	Cable	EPR
TEV Probe	TEV	13.2kV	Cable	EPR

Cable PD Waveform				Local PD Waveform			
							
Peak		**Frequency**		**Peak**		**Frequency**	
Rise Time		**PD Level**		**Rise Time**		**PD Level**	
Noise Waveform				**Synchronous Waveform**			
							
Peak	144.00 mV	**Frequency**	91.55 kHz	**Peak**	-	**Frequency**	-
Rise Time	2.07 us	**PD Level**	-	**Rise Time**	-	**PD Level**	-

No of Pulses vs. Pulse Rise-Time	**Peak Level in Time**
	

Comments
POA 78 1. Oil level gauge indicates low oil below 25 deg. C level. No signs of leaks. Recommend investigating oil leak. Add oil to the required 25 deg. C. level No PD Detected.



Comment Item 1

Substation/Site: T-8A-1
Location: POA 79
Test No.:

Customer: City of Tampa
Test Engineer: Nat Crews/ Louis Nemec
Test Date: 09/02/2017 1:50:05 PM

C.E. Testing, Inc.

Sensor	Circuit/Description	V(kV)	Cable Type	Local Plant Type
HFCT	phA	13.2kV	Cable	EPR
HFCT	phB	13.2kV	Cable	EPR
HFCT	phC	13.2kV	Cable	EPR
TEV Probe	TEV	13.2kV	Cable	EPR

Phase-Resolved Graph (PD and Noise)

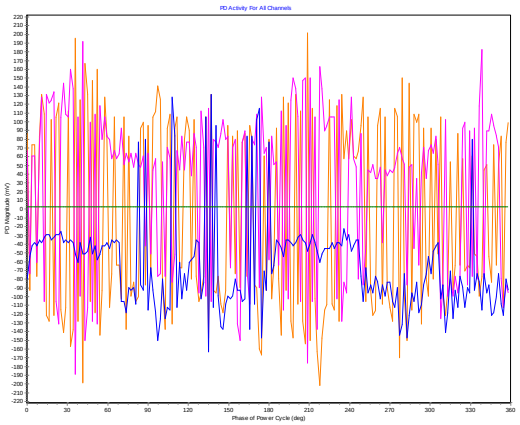
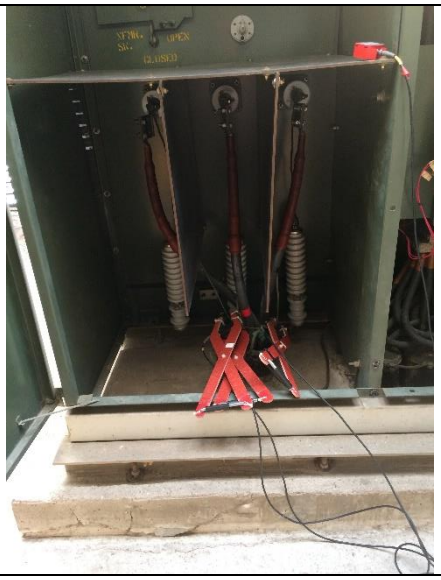
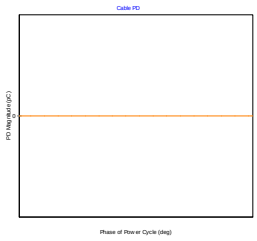
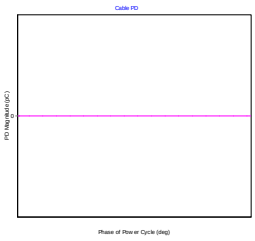
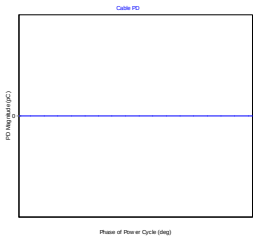
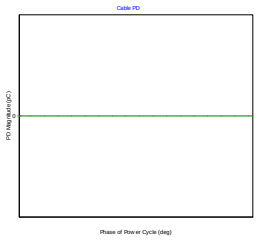
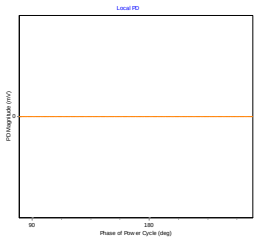
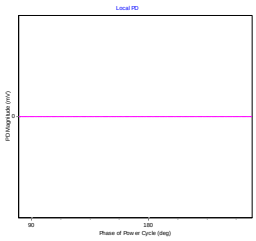
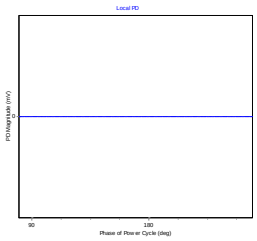
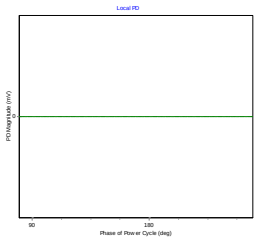
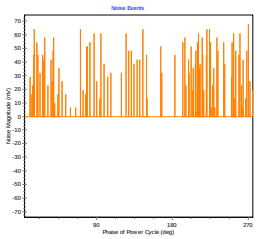
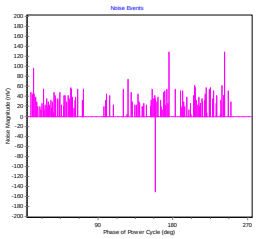
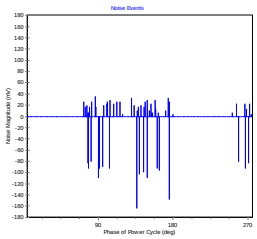
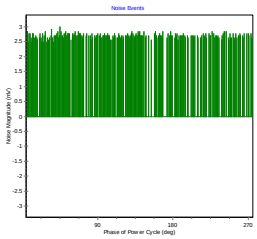


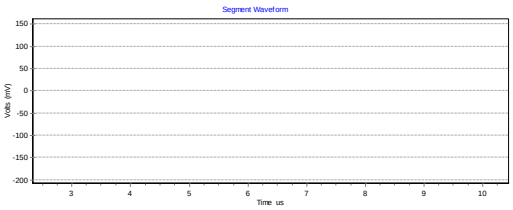
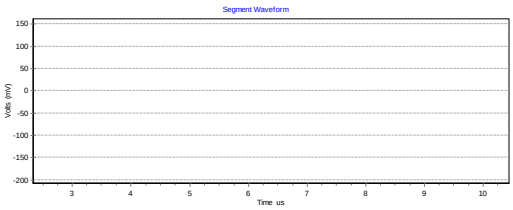
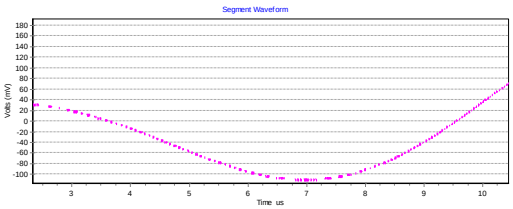
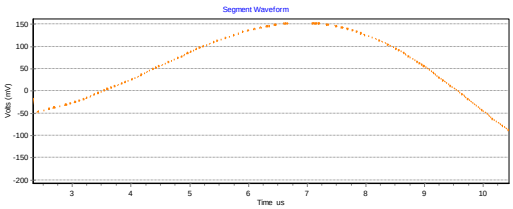
Photo of Sensor Attachment

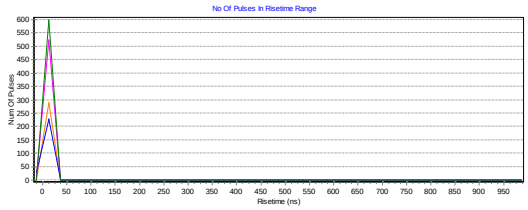
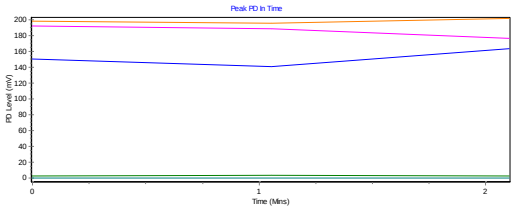


	Channel 1		Channel 2		Channel 3		Channel 4	
	Cable PD	0pC	Cable PD	0pC	Cable PD	0pC	Cable PD	0pC
	Local PD	0dB	Local PD	0dB	Local PD	0dB	Local PD	0dB
	Peak	67.20mV	Peak	182.40mV	Peak	163.20mV	Peak	3.06mV
	Std Dev	32.06mV	Std Dev	27.35mV	Std Dev	22.76mV	Std Dev	0.94mV
Cable PD								

Local PD				
Noise				

Sensor	Circuit/Description	V(kV)	Cable Type	Local Plant Type
HFCT	phA	13.2kV	Cable	EPR
HFCT	phB	13.2kV	Cable	EPR
HFCT	phC	13.2kV	Cable	EPR
TEV Probe	TEV	13.2kV	Cable	EPR

Cable PD Waveform				Local PD Waveform			
							
Peak		**Frequency**		**Peak**		**Frequency**	
Rise Time		**PD Level**		**Rise Time**		**PD Level**	
Noise Waveform				**Synchronous Waveform**			
							
Peak	182.40 mV	**Frequency**	91.55 kHz	**Peak**	-	**Frequency**	-
Rise Time	2.37 us	**PD Level**	-	**Rise Time**	-	**PD Level**	-

No of Pulses vs. Pulse Rise-Time	**Peak Level in Time**
	

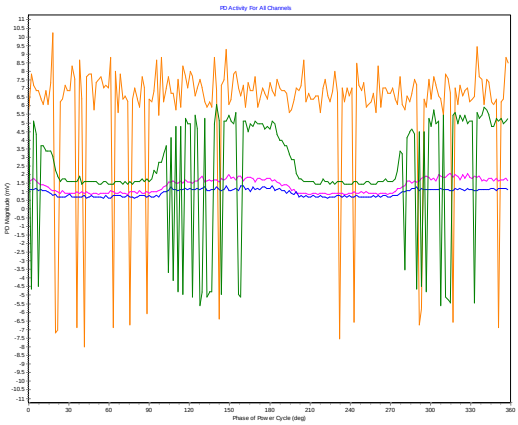
Comments
No PD detected

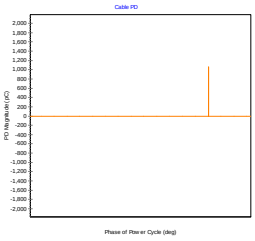
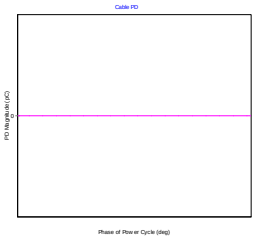
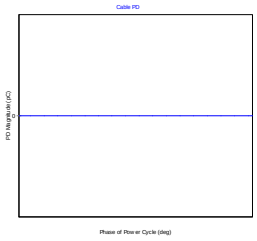
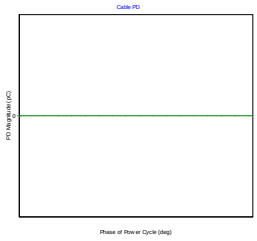
Substation/Site: T-9B-1 AB
Location: POA 48
Test No.:

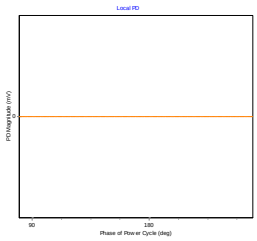
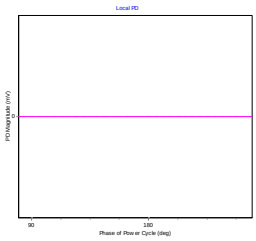
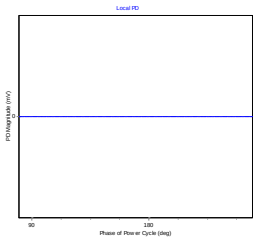
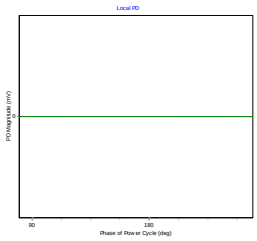
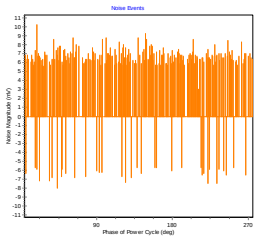
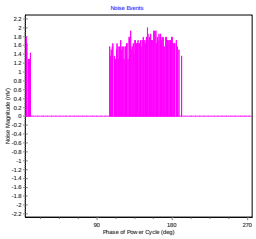
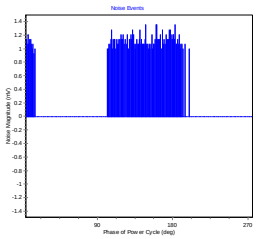
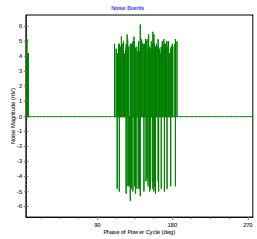
Customer: City of Tampa
Test Engineer: Nat Crews/ Louis Nemec
Test Date: 09/02/2017 2:13:03 PM

C.E. Testing, Inc.

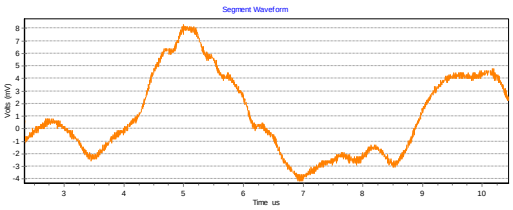
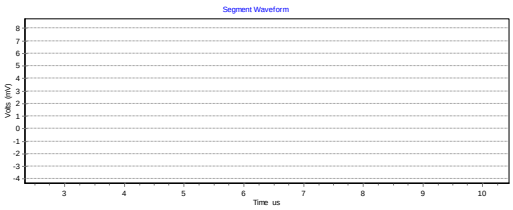
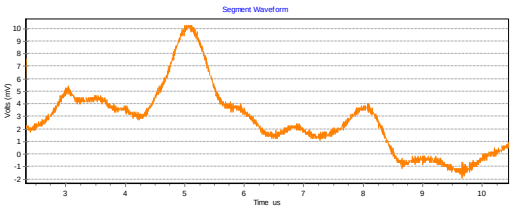
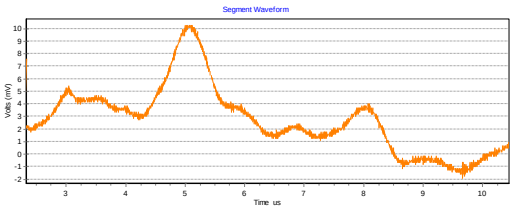
Sensor	Circuit/Description	V(kV)	Cable Type	Local Plant Type
HFCT	phA	13.2kV	Cable	EPR
HFCT	phB	13.2kV	Cable	EPR
HFCT	phC	13.2kV	Cable	EPR
TEV Probe	TEV	13.2kV	Switchgear	Air Insulated

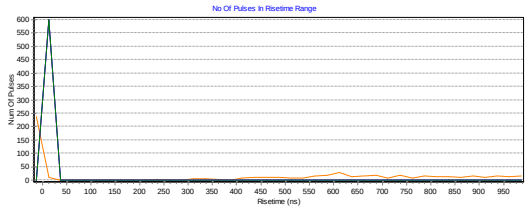
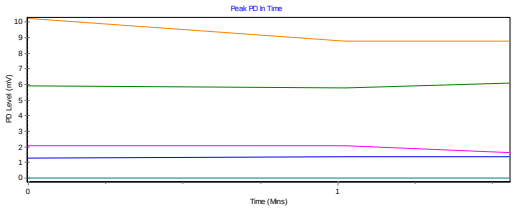
Phase-Resolved Graph (PD and Noise)	Photo of Sensor Attachment
	

	Channel 1		Channel 2		Channel 3		Channel 4	
	Cable PD	1975pC	Cable PD	0pC	Cable PD	0pC	Cable PD	0pC
	Local PD	0dB	Local PD	0dB	Local PD	0dB	Local PD	0dB
	Peak	10.24mV	Peak	2.06mV	Peak	1.35mV	Peak	6.08mV
	Std Dev	1.76mV	Std Dev	0.14mV	Std Dev	0.13mV	Std Dev	0.33mV
Cable PD								

Local PD				
Noise				

Sensor	Circuit/Description	V(kV)	Cable Type	Local Plant Type
HFCT	phA	13.2kV	Cable	EPR
HFCT	phB	13.2kV	Cable	EPR
HFCT	phC	13.2kV	Cable	EPR
TEV Probe	TEV	13.2kV	Switchgear	Air Insulated

Cable PD Waveform				Local PD Waveform			
							
Peak	8.32 mV	**Frequency**	244.14 kHz	**Peak**		**Frequency**	
Rise Time	590.21 ns	**PD Level**	1.98 nC	**Rise Time**		**PD Level**	
Noise Waveform				**Synchronous Waveform**			
							
Peak	10.24 mV	**Frequency**	122.07 kHz	**Peak**	-	**Frequency**	-
Rise Time	569.03 ns	**PD Level**	-	**Rise Time**	-	**PD Level**	-

No of Pulses vs. Pulse Rise-Time	**Peak Level in Time**
	

Comments
Common ground used. No PD detected.

Substation/Site: T-9A-1
Location: POA 49
Test No.:

Customer: City of Tampa
Test Engineer: Nat Crews/ Louis Nemec
Test Date: 09/02/2017 2:18:27 PM

C.E. Testing, Inc.

Sensor	Circuit/Description	V(kV)	Cable Type	Local Plant Type
HFCT	phA	13.2kV	Cable	EPR
N/A	N/A	13.2kV	Cable	EPR
N/A	N/A	13.2kV	Cable	EPR
TEV Probe	TEV	13.2kV	Switchgear	Air Insulated

Phase-Resolved Graph (PD and Noise)

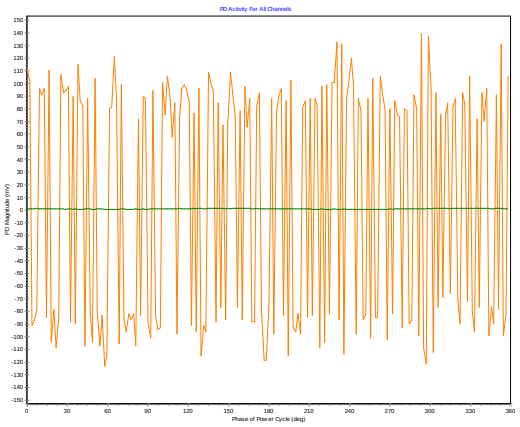
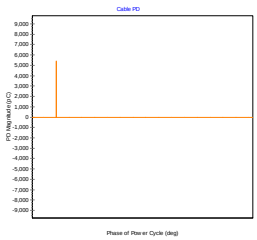
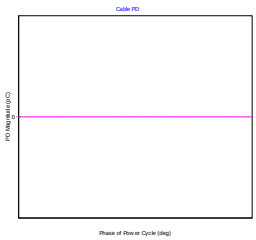
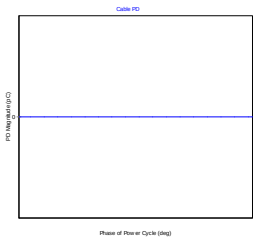
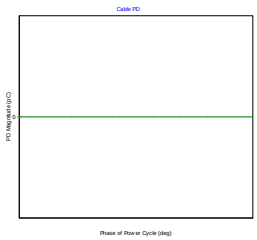
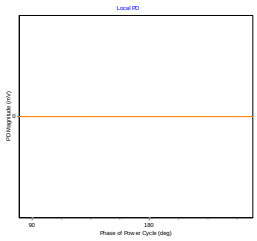
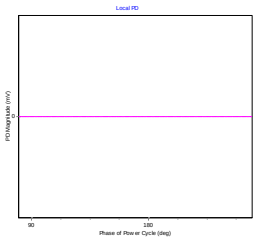
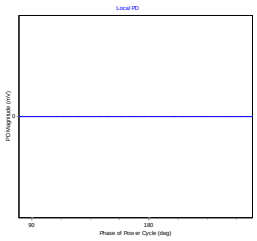
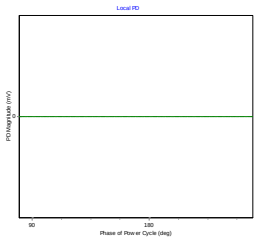
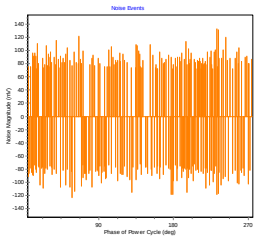
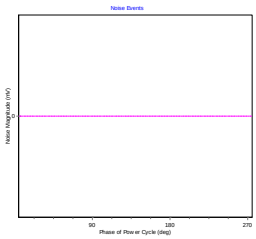
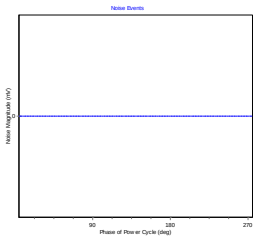
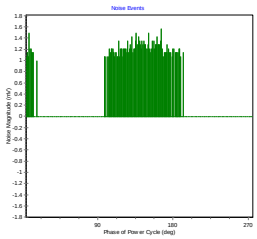
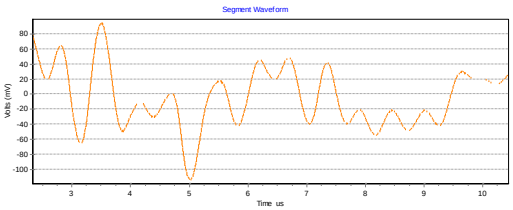
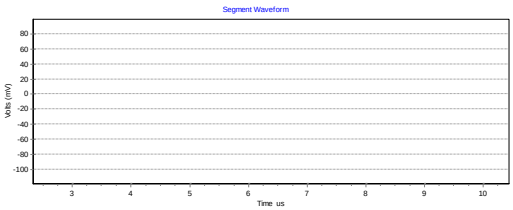
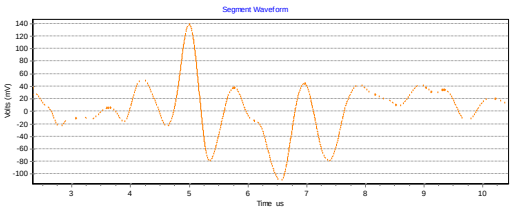
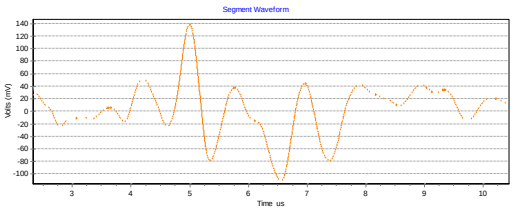


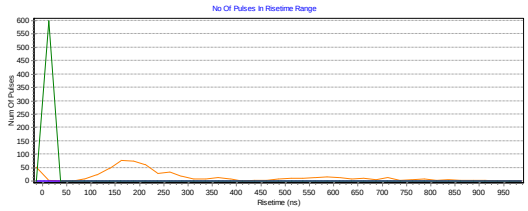
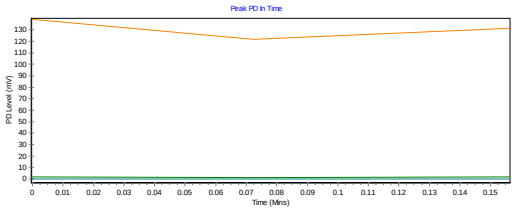
Photo of Sensor Attachment

	Channel 1		Channel 2		Channel 3		Channel 4	
	Cable PD	8821pC	Cable PD	0pC	Cable PD	0pC	Cable PD	0pC
	Local PD	0dB	Local PD	0dB	Local PD	0dB	Local PD	0dB
	Peak	139.20mV	Peak	0.00mV	Peak	0.00mV	Peak	1.64mV
	Std Dev	17.76mV	Std Dev	0.00mV	Std Dev	0.00mV	Std Dev	0.14mV
Cable PD								

Local PD				
Noise				

Sensor	Circuit/Description	V(kV)	Cable Type	Local Plant Type
HFCT	phA	13.2kV	Cable	EPR
N/A	N/A	13.2kV	Cable	EPR
N/A	N/A	13.2kV	Cable	EPR
TEV Probe	TEV	13.2kV	Switchgear	Air Insulated

Cable PD Waveform				Local PD Waveform			
							
Peak	-113.60 mV	**Frequency**	488.28 kHz	**Peak**		**Frequency**	
Rise Time	186.76 ns	**PD Level**	-8.82 nC	**Rise Time**		**PD Level**	
Noise Waveform				**Synchronous Waveform**			
							
Peak	139.20 mV	**Frequency**	1.46 MHz	**Peak**	-	**Frequency**	-
Rise Time	200.88 ns	**PD Level**	-	**Rise Time**	-	**PD Level**	-

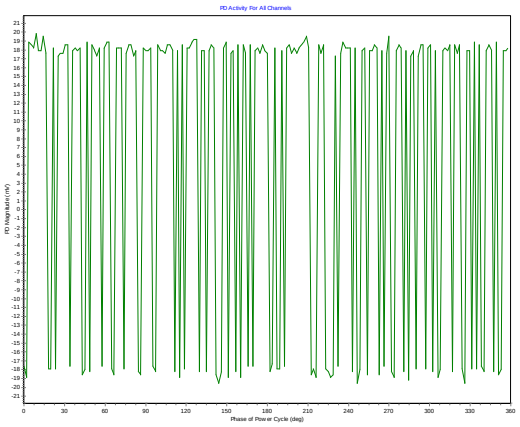
No of Pulses vs. Pulse Rise-Time	Peak Level in Time
	

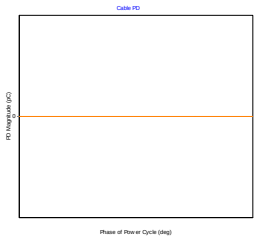
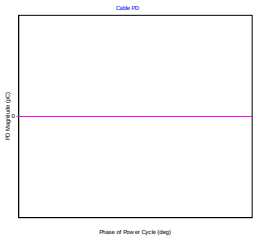
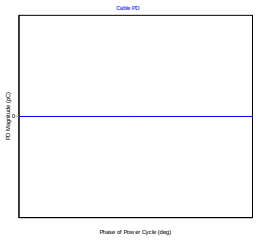
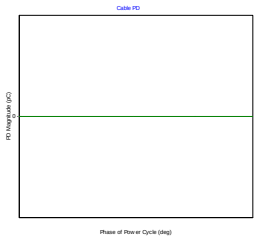
Comments
No PD detected. Noise waveforms.

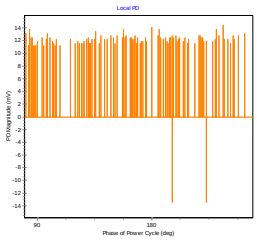
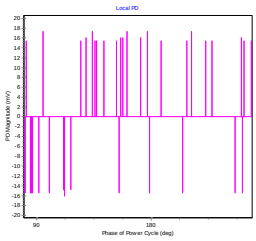
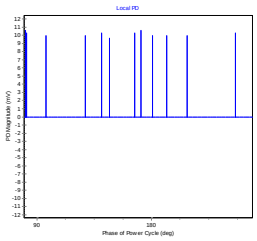
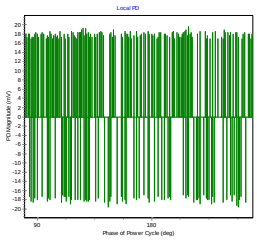
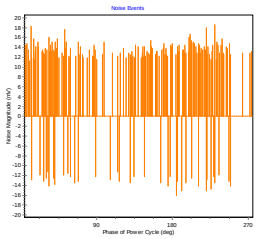
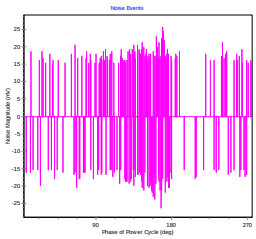
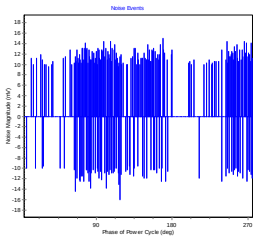
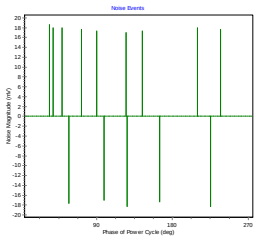
Substation/Site:	T-9A-2	**Customer:**	City of Tampa
Location:	POA 42	**Test Engineer:**	Nat Crews/ Louis Nemec
Test No.:		**Test Date:**	09/02/2017 2:35:03 PM

C.E. Testing, Inc.

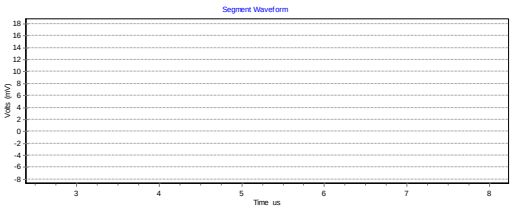
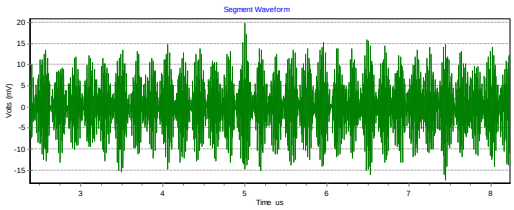
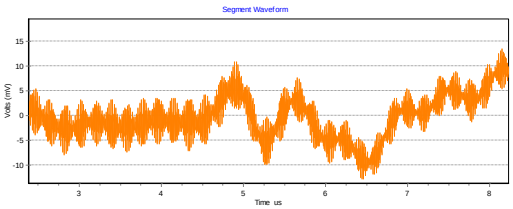
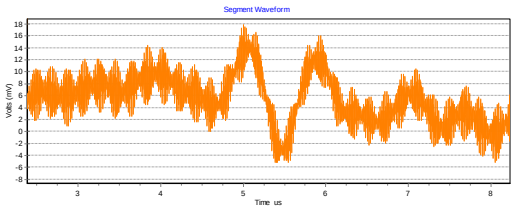
Sensor	Circuit/Description	V(kV)	Cable Type	Local Plant Type
HFCT	phA	13.2kV	Cable	EPR
HFCT	phB	13.2kV	Cable	EPR
HFCT	phC	13.2kV	Cable	EPR
TEV Probe	TEV	13.2kV	Switchgear	Air Insulated

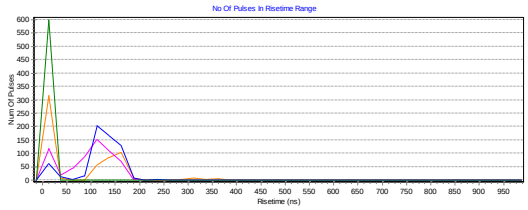
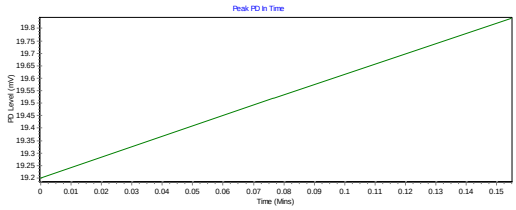
Phase-Resolved Graph (PD and Noise)	Photo of Sensor Attachment
	

	Channel 1		Channel 2		Channel 3		Channel 4	
	Cable PD	0pC	Cable PD	0pC	Cable PD	0pC	Cable PD	0pC
	Local PD	23dB	Local PD	25dB	Local PD	21dB	Local PD	26dB
	Peak	18.56mV	Peak	26.24mV	Peak	17.60mV	Peak	19.84mV
	Std Dev	3.20mV	Std Dev	4.33mV	Std Dev	2.47mV	Std Dev	6.60mV
Cable PD								

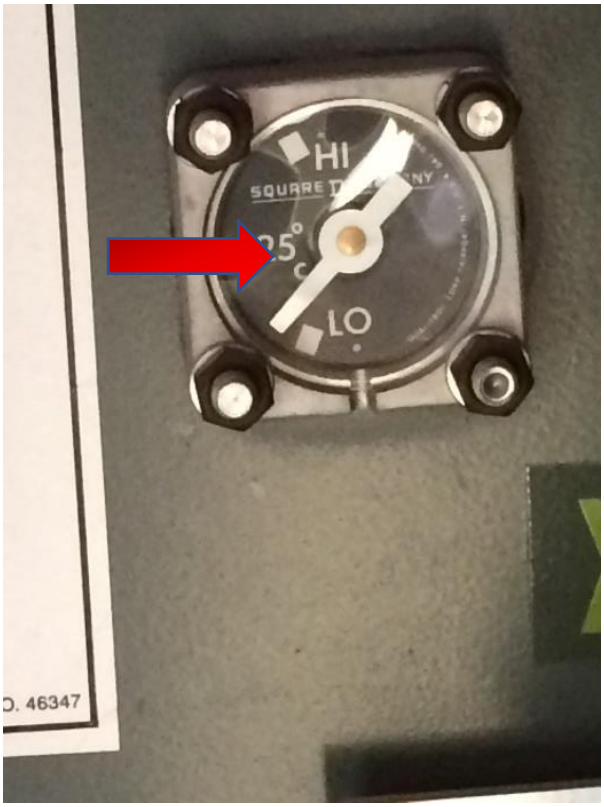
Local PD				
Noise				

Sensor	Circuit/Description	V(kV)	Cable Type	Local Plant Type
HFCT	phA	13.2kV	Cable	EPR
HFCT	phB	13.2kV	Cable	EPR
HFCT	phC	13.2kV	Cable	EPR
TEV Probe	TEV	13.2kV	Switchgear	Air Insulated

Cable PD Waveform				Local PD Waveform			
							
Peak		**Frequency**		**Peak**	19.84 mV	**Frequency**	93.75 MHz
Rise Time		**PD Level**		**Rise Time**	1.78 ns	**PD Level**	
Noise Waveform				**Synchronous Waveform**			
							
Peak	18.56 mV	**Frequency**	91.55 kHz	**Peak**	-	**Frequency**	-
Rise Time	504.24 ns	**PD Level**	-	**Rise Time**	-	**PD Level**	-

No of Pulses vs. Pulse Rise-Time	**Peak Level in Time**
	

Comments
POA 42 1. Oil present on the concrete pad. No signs of leaks around bushings or devices. Recommend investigating oil leak. Add oil to the required 25 deg. C. level. 2. Local PD on all phases Local PD Detected 25dB



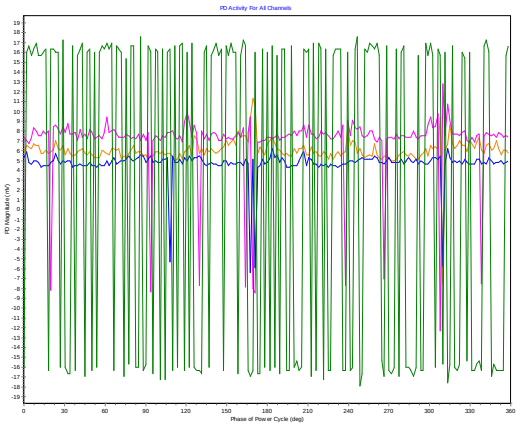
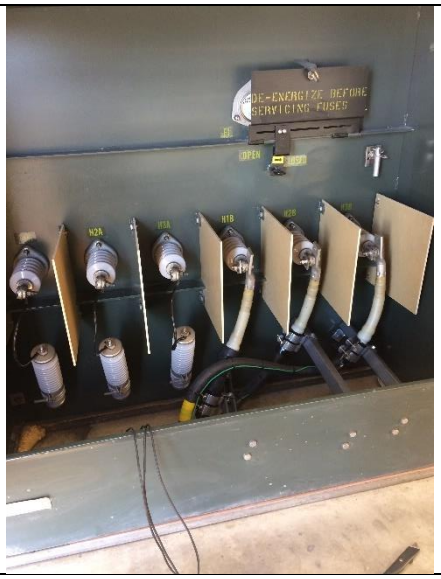
Comment Item 1

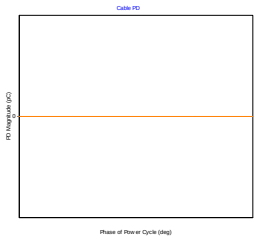
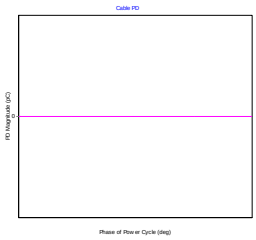
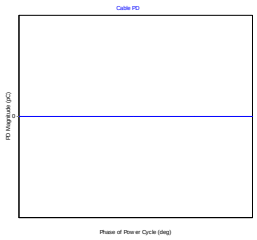
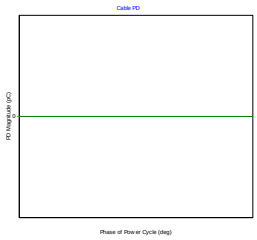
Substation/Site: T-9B-2
Location: POA 43
Test No.:

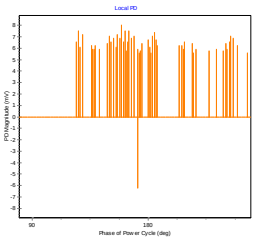
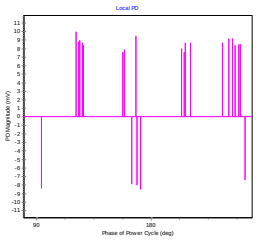
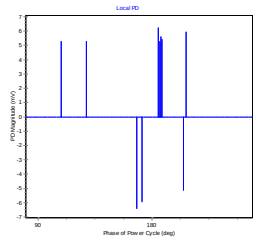
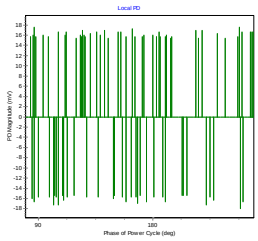
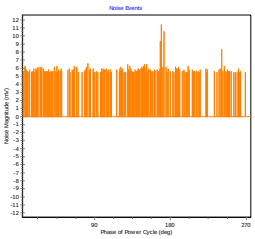
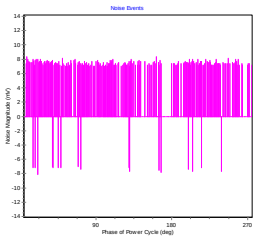
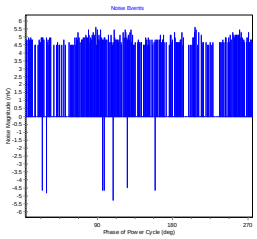
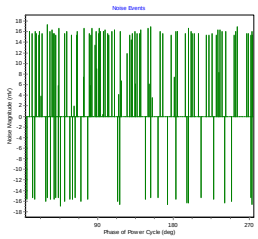
Customer: City of Tampa
Test Engineer: Nat Crews/ Louis Nemec
Test Date: 09/02/2017 2:53:58 PM

C.E. Testing, Inc.

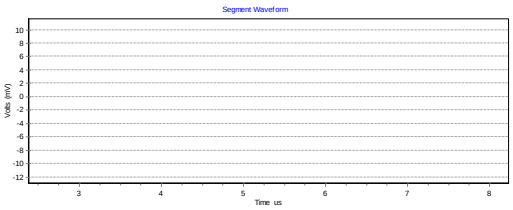
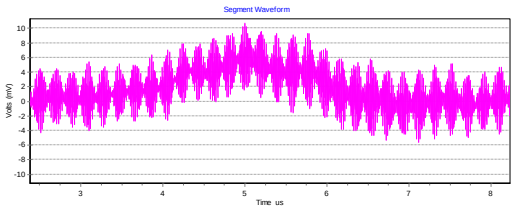
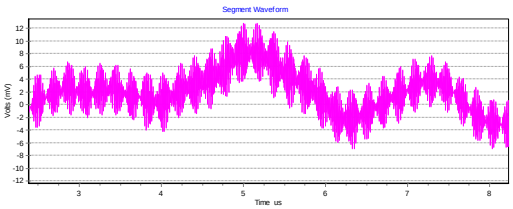
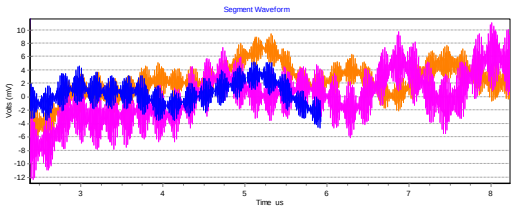
Sensor	Circuit/Description	V(kV)	Cable Type	Local Plant Type
HFCT	phA	13.2kV	Cable	EPR
HFCT	phB	13.2kV	Cable	EPR
HFCT	phC	13.2kV	Cable	EPR
TEV Probe	TEV	13.2kV	Transformer	Oil Filled

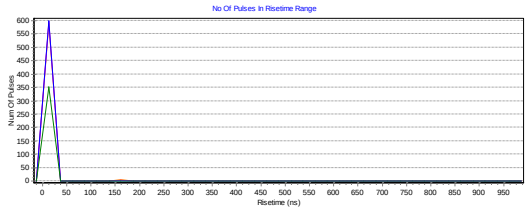
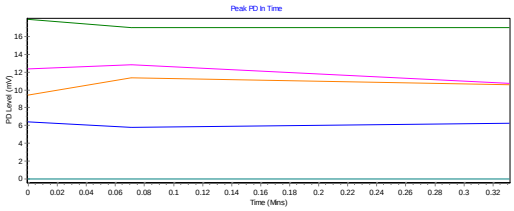
Phase-Resolved Graph (PD and Noise)	Photo of Sensor Attachment
	

	Channel 1		Channel 2		Channel 3		Channel 4	
	Cable PD	0pC	Cable PD	0pC	Cable PD	0pC	Cable PD	0pC
	Local PD	18dB	Local PD	21dB	Local PD	16dB	Local PD	25dB
	Peak	11.36mV	Peak	12.80mV	Peak	6.40mV	Peak	17.92mV
	Std Dev	1.61mV	Std Dev	2.49mV	Std Dev	1.50mV	Std Dev	7.04mV
Cable PD								

Local PD				
Noise				

Sensor	Circuit/Description	V(kV)	Cable Type	Local Plant Type
HFCT	phA	13.2kV	Cable	EPR
HFCT	phB	13.2kV	Cable	EPR
HFCT	phC	13.2kV	Cable	EPR
TEV Probe	TEV	13.2kV	Transformer	Oil Filled

Cable PD Waveform				Local PD Waveform			
							
Peak		**Frequency**		**Peak**	10.72 mV	**Frequency**	100.35 MHz
Rise Time		**PD Level**		**Rise Time**	6.20 ns	**PD Level**	
Noise Waveform				**Synchronous Waveform**			
							
Peak	12.80 mV	**Frequency**	488.28 kHz	**Peak**	-	**Frequency**	-
Rise Time	142.08 ns	**PD Level**	-	**Rise Time**	-	**PD Level**	-

No of Pulses vs. Pulse Rise-Time	Peak Level in Time
	

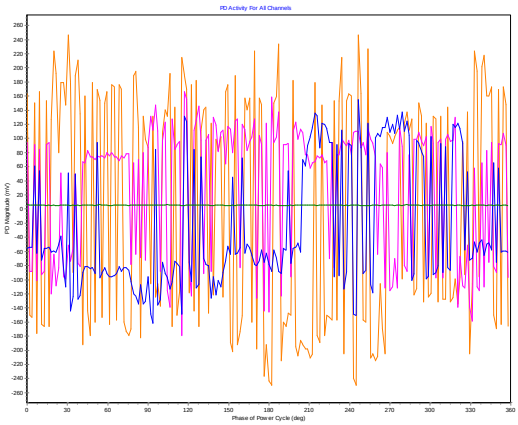
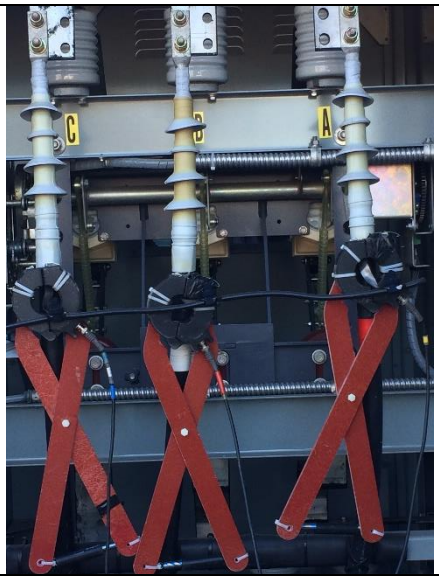
Comments
No PD detected. Noise waveforms.

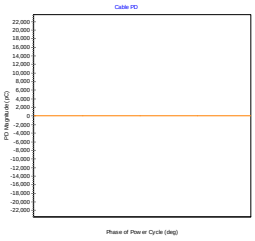
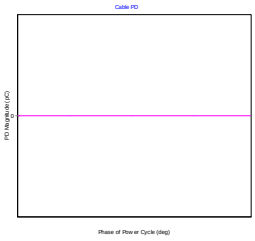
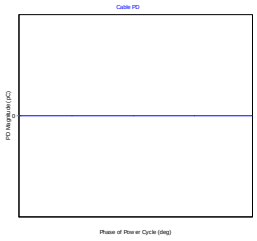
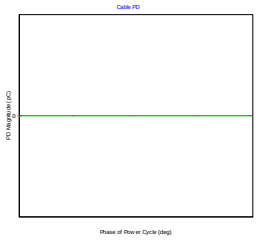
Substation/Site: TS-3B-3
Location: POA 87 A
Test No.:

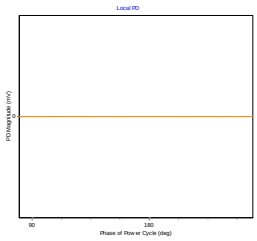
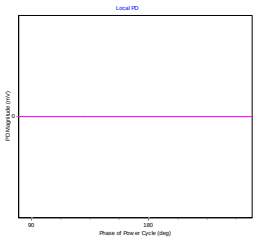
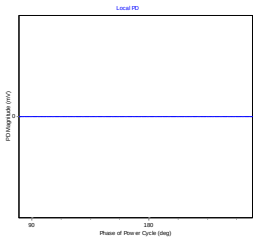
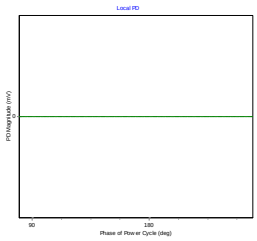
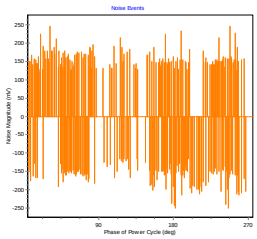
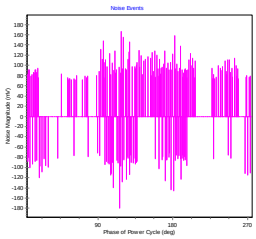
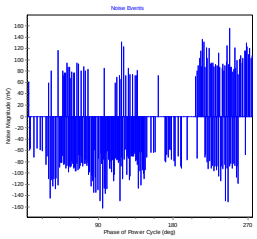
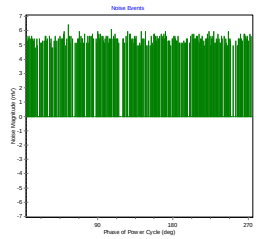
Customer: City of Tampa
Test Engineer: Nat Crews/ Louis Nemec
Test Date: 10/02/2017 8:17:46 AM

C.E. Testing, Inc.

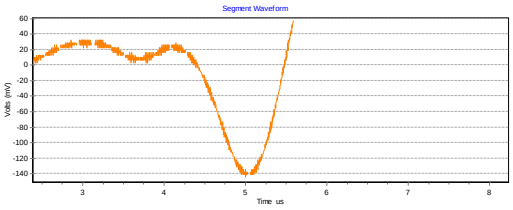
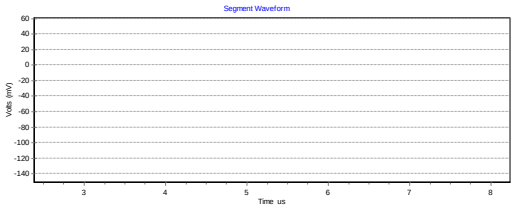
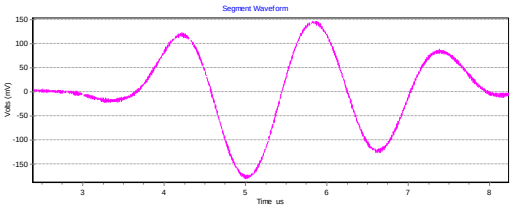
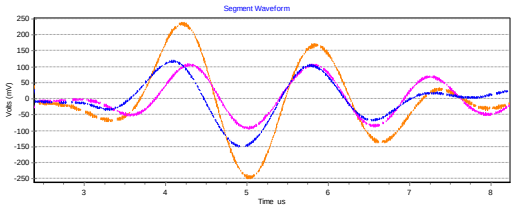
Sensor	Circuit/Description	V(kV)	Cable Type	Local Plant Type
HFCT	phA	13.2kV	Cable	EPR
HFCT	phB	13.2kV	Cable	EPR
HFCT	phC	13.2kV	Cable	EPR
TEV Probe	TEV	13.2kV	Switchgear	Air Insulated

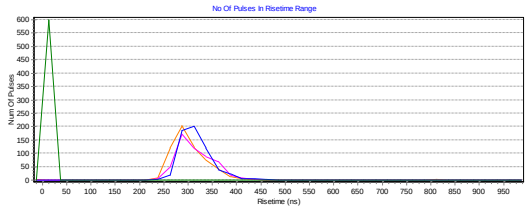
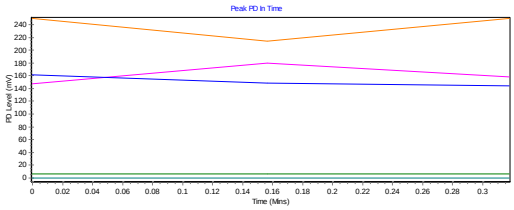
Phase-Resolved Graph (PD and Noise)	Photo of Sensor Attachment
	

	Channel 1		Channel 2		Channel 3		Channel 4	
	Cable PD	21310pC	Cable PD	0pC	Cable PD	0pC	Cable PD	0pC
	Local PD	0dB	Local PD	0dB	Local PD	0dB	Local PD	0dB
	Peak	249.60mV	Peak	179.20mV	Peak	161.60mV	Peak	6.40mV
	Std Dev	24.25mV	Std Dev	14.94mV	Std Dev	13.44mV	Std Dev	1.56mV
Cable PD								

Local PD				
Noise				

Sensor	Circuit/Description	V(kV)	Cable Type	Local Plant Type
HFCT	phA	13.2kV	Cable	EPR
HFCT	phB	13.2kV	Cable	EPR
HFCT	phC	13.2kV	Cable	EPR
TEV Probe	TEV	13.2kV	Switchgear	Air Insulated

Cable PD Waveform				Local PD Waveform			
							
Peak	-144.00 mV	**Frequency**	488.28 kHz	**Peak**		**Frequency**	
Rise Time	400.84 ns	**PD Level**	-20.80 nC	**Rise Time**		**PD Level**	
Noise Waveform				**Synchronous Waveform**			
							
Peak	-179.20 mV	**Frequency**	610.35 kHz	**Peak**	-	**Frequency**	-
Rise Time	351.10 ns	**PD Level**	-	**Rise Time**	-	**PD Level**	-

No of Pulses vs. Pulse Rise-Time	**Peak Level in Time**
	

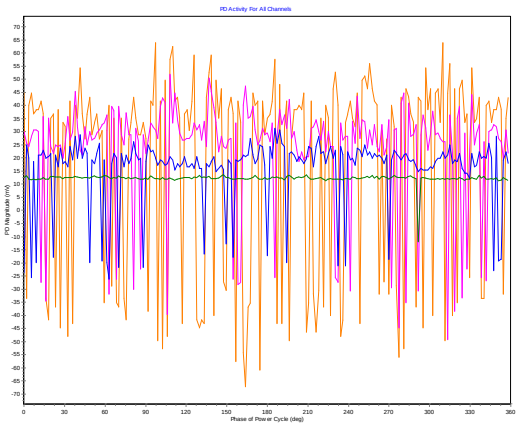
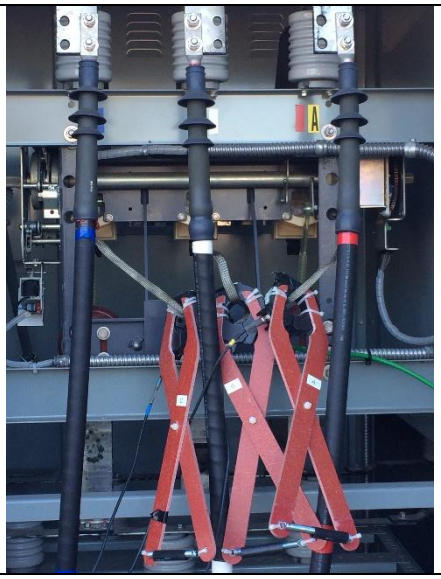
Comments
No PD detected. Noise waveforms.

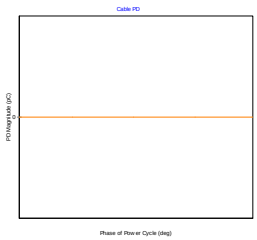
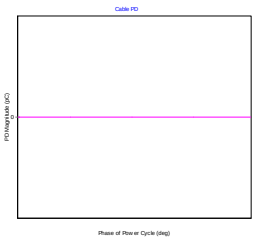
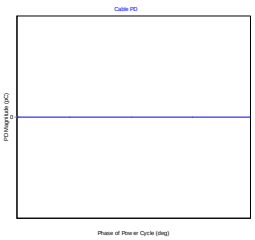
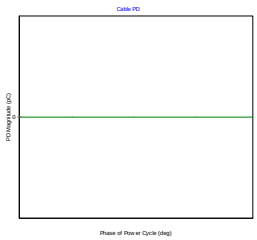
Substation/Site: TS-3B-3 B
Location: POA 87 B
Test No.:

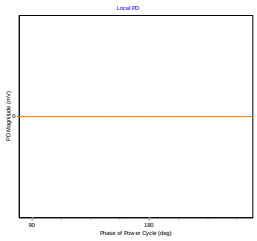
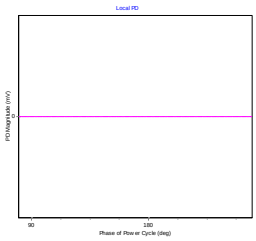
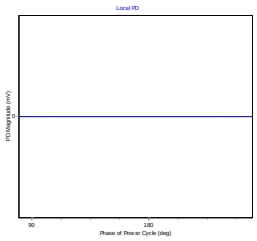
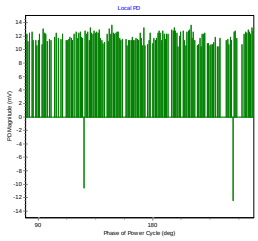
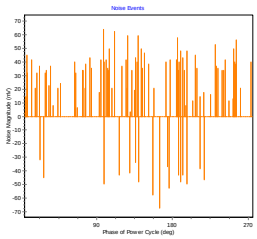
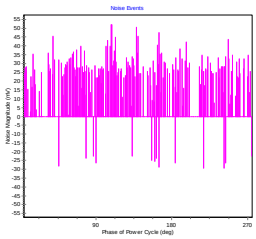
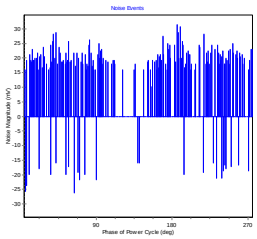
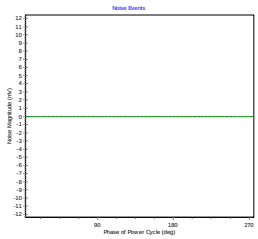
Customer: City of Tampa
Test Engineer: Nat Crews/ Louis Nemec
Test Date: 10/02/2017 8:20:44 AM

C.E. Testing, Inc.

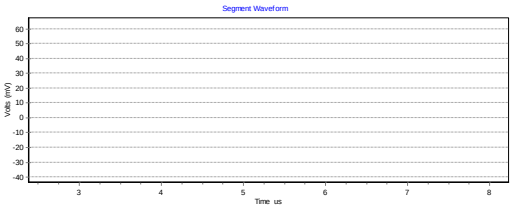
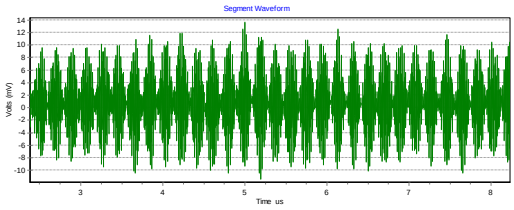
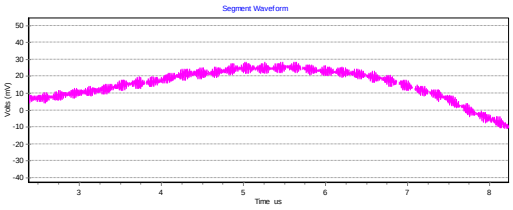
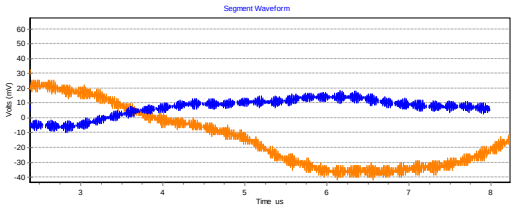
Sensor	Circuit/Description	V(kV)	Cable Type	Local Plant Type
HFCT	phA	13.2kV	Cable	EPR
HFCT	phB	13.2kV	Cable	EPR
HFCT	phC	13.2kV	Cable	EPR
TEV Probe	TEV	13.2kV	Cable	EPR

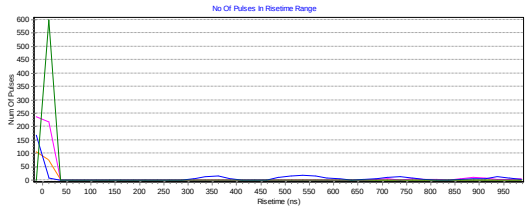
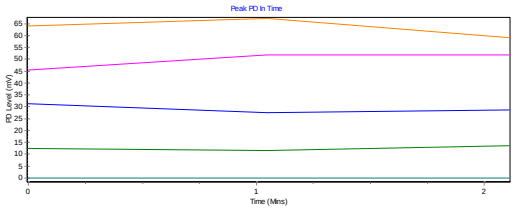
Phase-Resolved Graph (PD and Noise)	Photo of Sensor Attachment
	

	Channel 1		Channel 2		Channel 3		Channel 4	
	Cable PD	0pC	Cable PD	0pC	Cable PD	0pC	Cable PD	0pC
	Local PD	0dB	Local PD	0dB	Local PD	0dB	Local PD	23dB
	Peak	67.20mV	Peak	51.84mV	Peak	31.36mV	Peak	13.60mV
	Std Dev	11.82mV	Std Dev	8.81mV	Std Dev	4.96mV	Std Dev	4.37mV
Cable PD								

Local PD				
Noise				

Sensor	Circuit/Description	V(kV)	Cable Type	Local Plant Type
HFCT	phA	13.2kV	Cable	EPR
HFCT	phB	13.2kV	Cable	EPR
HFCT	phC	13.2kV	Cable	EPR
TEV Probe	TEV	13.2kV	Cable	EPR

Cable PD Waveform				Local PD Waveform			
							
Peak		**Frequency**		**Peak**	13.60 mV	**Frequency**	71.43 MHz
Rise Time		**PD Level**		**Rise Time**	1.57 ns	**PD Level**	
Noise Waveform				**Synchronous Waveform**			
							
Peak	51.84 mV	**Frequency**	83.92 kHz	**Peak**	-	**Frequency**	-
Rise Time	2.09 us	**PD Level**	-	**Rise Time**	-	**PD Level**	-

No of Pulses vs. Pulse Rise-Time	**Peak Level in Time**
	

Comments
No PD detected. Noise waveforms.

Substation/Site:	T-4A-3	**Customer:**	City of Tampa
Location:	POA 58	**Test Engineer:**	Nat Crews/ Louis Nemec
Test No.:		**Test Date:**	10/02/2017 9:08:47 AM

C.E. Testing, Inc.

Sensor	Circuit/Description	V(kV)	Cable Type	Local Plant Type
HFCT	phA	13.2kV	Cable	EPR
HFCT	phB	13.2kV	Cable	EPR
HFCT	phC	13.2kV	Cable	EPR
TEV Probe	TEV	13.2kV	Switchgear	Air Insulated

Phase-Resolved Graph (PD and Noise)

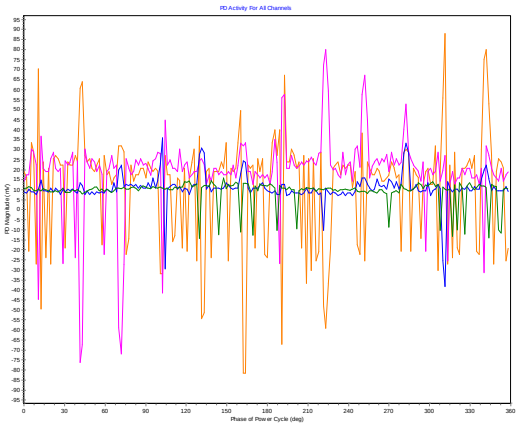
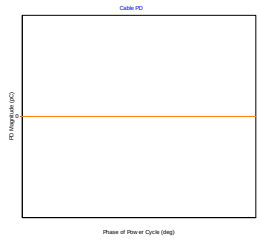
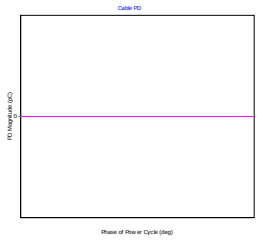
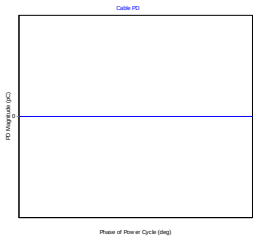
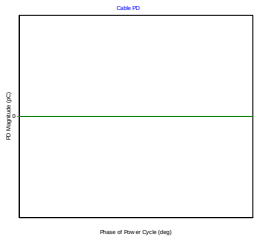
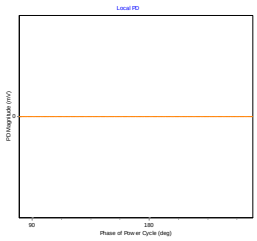
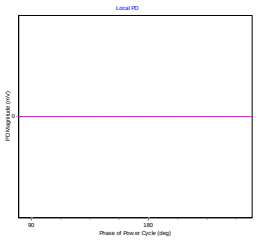
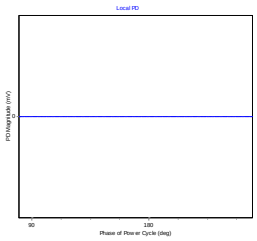
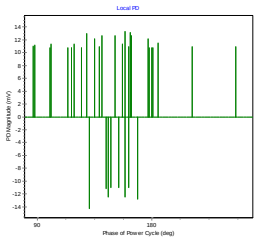
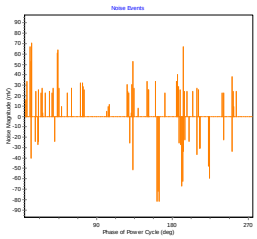
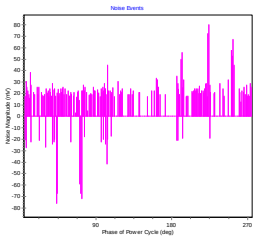
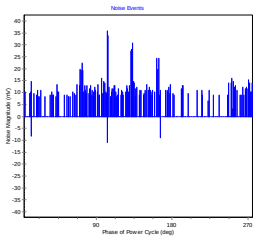
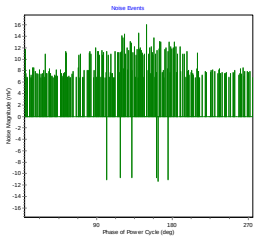
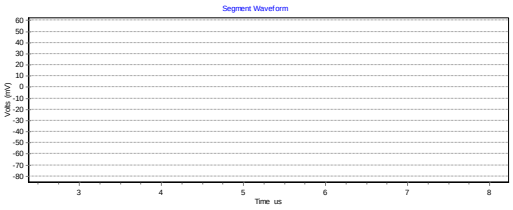
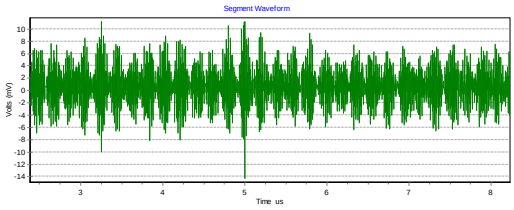
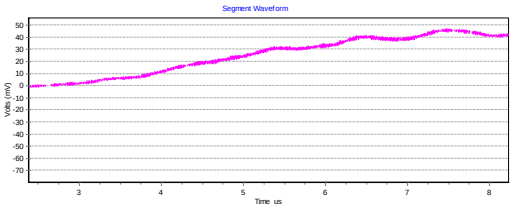
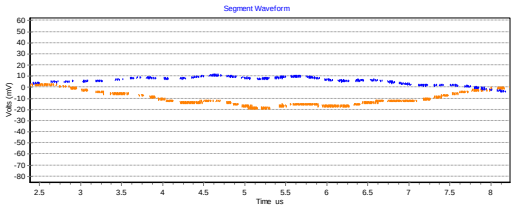


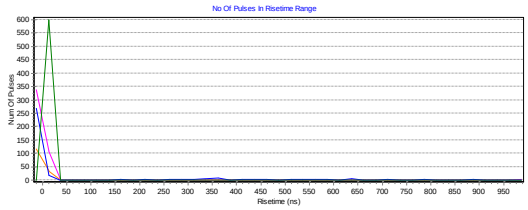
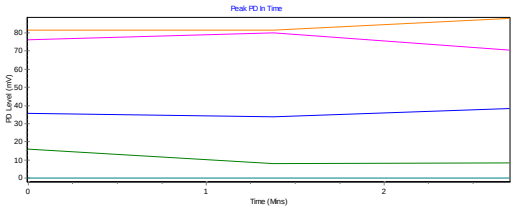
Photo of Sensor Attachment

	Channel 1		Channel 2		Channel 3		Channel 4	
	Cable PD	0pC	Cable PD	0pC	Cable PD	0pC	Cable PD	0pC
	Local PD	0dB	Local PD	0dB	Local PD	0dB	Local PD	23dB
	Peak	88.00mV	Peak	80.00mV	Peak	38.40mV	Peak	16.00mV
	Std Dev	8.57mV	Std Dev	7.46mV	Std Dev	3.26mV	Std Dev	2.36mV
Cable PD								

Local PD				
Noise				

Sensor	Circuit/Description	V(kV)	Cable Type	Local Plant Type
HFCT	phA	13.2kV	Cable	EPR
HFCT	phB	13.2kV	Cable	EPR
HFCT	phC	13.2kV	Cable	EPR
TEV Probe	TEV	13.2kV	Switchgear	Air Insulated

Cable PD Waveform				Local PD Waveform			
							
Peak		**Frequency**		**Peak**	-14.24 mV	**Frequency**	107.14 MHz
Rise Time		**PD Level**		**Rise Time**	1.66 ns	**PD Level**	
Noise Waveform				**Synchronous Waveform**			
							
Peak	-76.16 mV	**Frequency**	106.81 kHz	**Peak**	-	**Frequency**	-
Rise Time	2.10 us	**PD Level**	-	**Rise Time**	-	**PD Level**	-

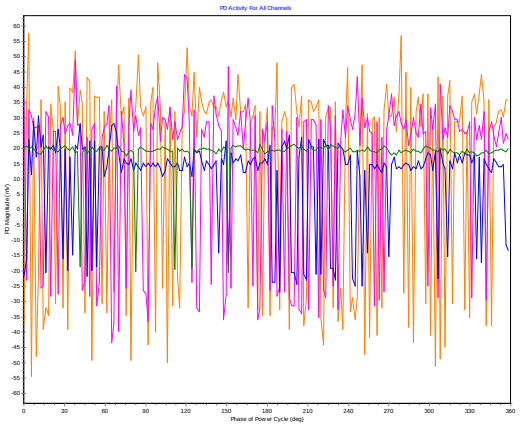
No of Pulses vs. Pulse Rise-Time	**Peak Level in Time**
	

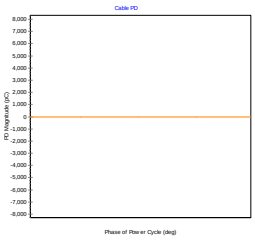
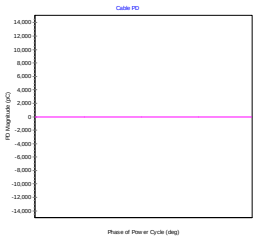
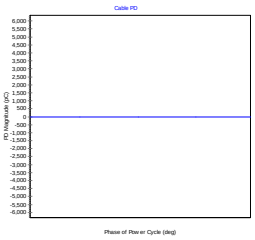
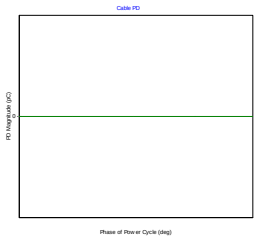
Comments
No PD detected. Noise waveforms.

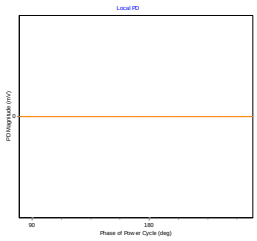
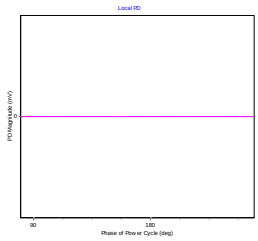
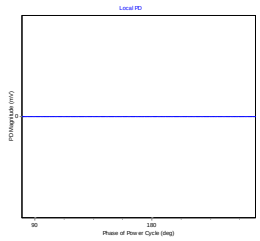
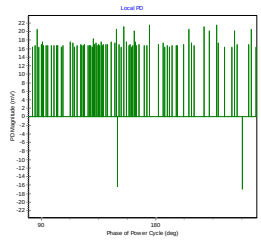
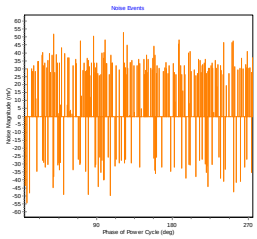
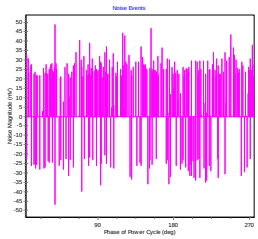
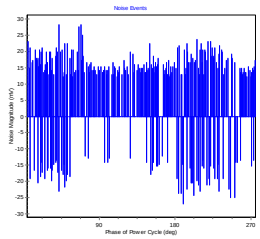
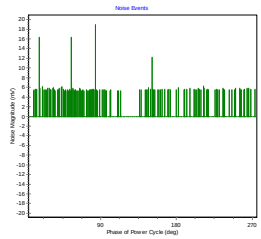
Substation/Site:	T-4B-3	**Customer:**	City of Tampa
Location:	POA 59	**Test Engineer:**	Nat Crews/ Louis Nemec
Test No.:		**Test Date:**	10/02/2017 9:17:08 AM

C.E. Testing, Inc.

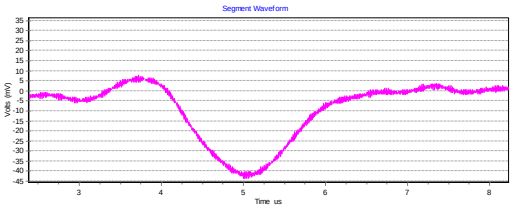
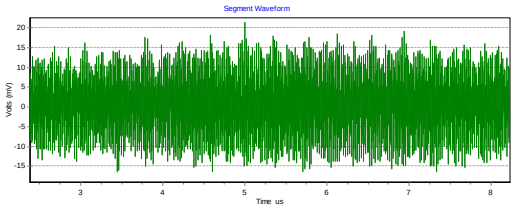
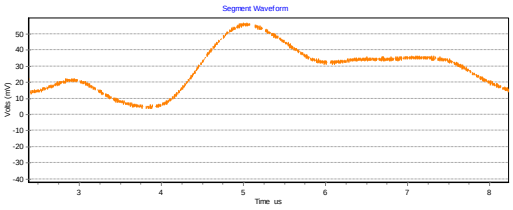
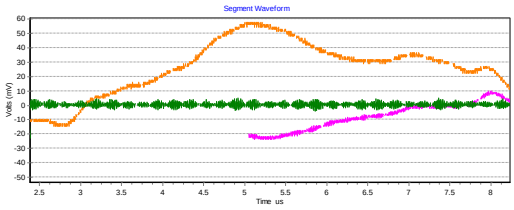
Sensor	Circuit/Description	V(kV)	Cable Type	Local Plant Type
HFCT	phA	13.2kV	Cable	EPR
HFCT	phB	13.2kV	Cable	EPR
HFCT	phC	13.2kV	Cable	FPR
TEV Probe	TEV	13.2kV	Switchgear	Air Insulated

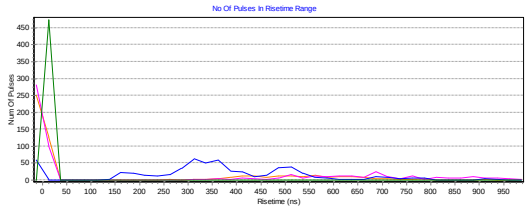
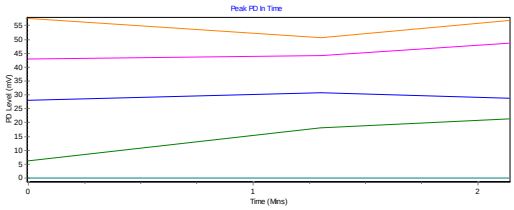
Phase-Resolved Graph (PD and Noise)	Photo of Sensor Attachment
	

	Channel 1		Channel 2		Channel 3		Channel 4	
	Cable PD	7513pC	Cable PD	13615pC	Cable PD	5729pC	Cable PD	0pC
	Local PD	0dB	Local PD	0dB	Local PD	0dB	Local PD	27dB
	Peak	57.60mV	Peak	48.64mV	Peak	30.72mV	Peak	21.44mV
	Std Dev	9.66mV	Std Dev	7.36mV	Std Dev	3.41mV	Std Dev	5.70mV
Cable PD								

Local PD				
Noise				

Sensor	Circuit/Description	V(kV)	Cable Type	Local Plant Type
HFCT	phA	13.2kV	Cable	EPR
HFCT	phB	13.2kV	Cable	EPR
HFCT	phC	13.2kV	Cable	FPR
TEV Probe	TEV	13.2kV	Switchgear	Air Insulated

Cable PD Waveform				Local PD Waveform			
							
Peak	-43.52 mV	**Frequency**	122.07 kHz	**Peak**	21.44 mV	**Frequency**	71.43 MHz
Rise Time	731.73 ns	**PD Level**	-13.61 nC	**Rise Time**	1.36 ns	**PD Level**	
Noise Waveform				**Synchronous Waveform**			
							
Peak	56.96 mV	**Frequency**	61.04 kHz	**Peak**	-	**Frequency**	-
Rise Time	729.31 ns	**PD Level**	-	**Rise Time**	-	**PD Level**	-

No of Pulses vs. Pulse Rise-Time	**Peak Level in Time**
	

Comments
No PD detected. Noise waveforms.

Substation/Site:	3-52-G6	**Customer:**	City of Tampa
Location:	POA 34	**Test Engineer:**	Nat Crews/ Louis Nemec
Test No.:		**Test Date:**	10/02/2017 9:53:40 AM

C.E. Testing, Inc.

Sensor	Circuit/Description	V(kV)	Machine Type	Local Plant Type
HFCT	phA	13.2kV	Rotating Machine	Generator
HFCT	phB	13.2kV	Rotating Machine	Generator
HFCT	phC	13.2kV	Rotating Machine	Generator
TEV Probe	TEV	13.2kV	Switchgear	Air Insulated

Phase-Resolved Graph (PD and Noise)

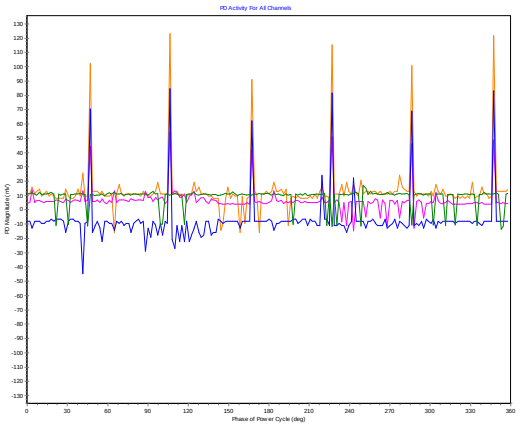
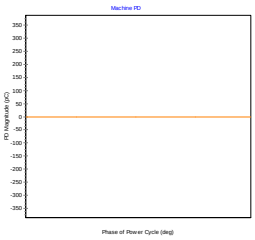
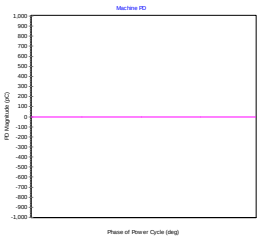
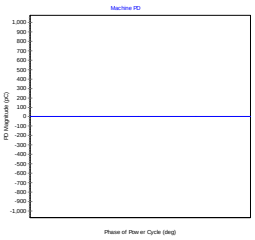
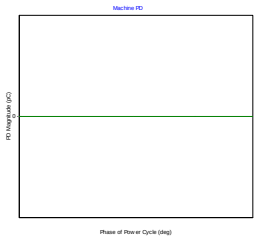
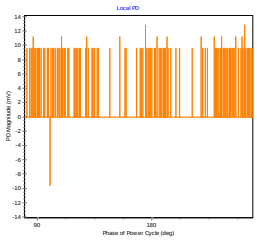
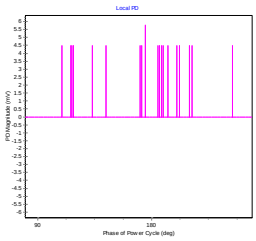
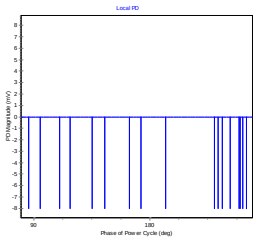
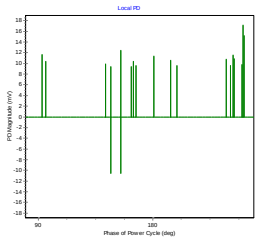
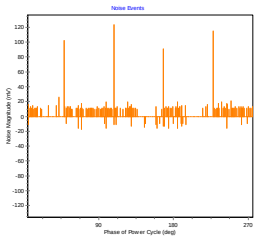
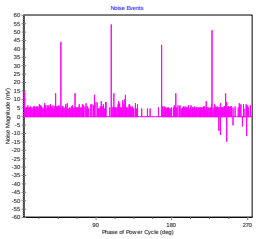
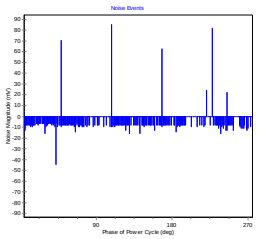
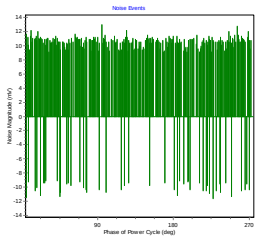
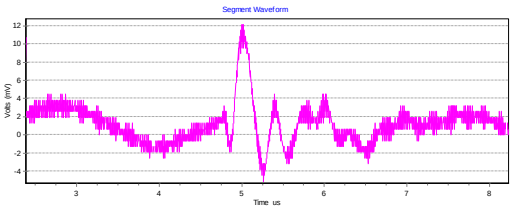
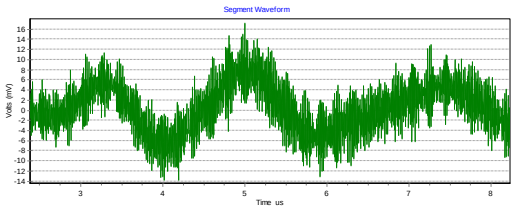
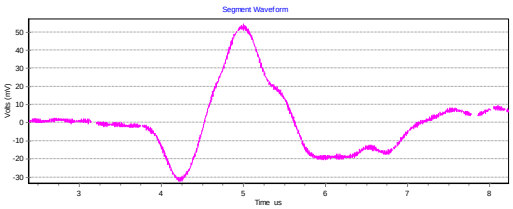
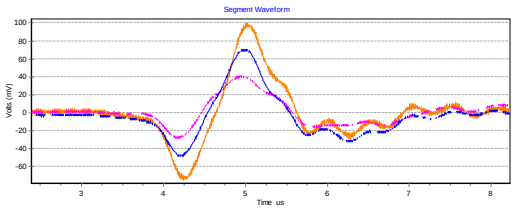


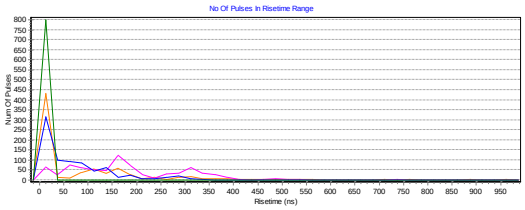
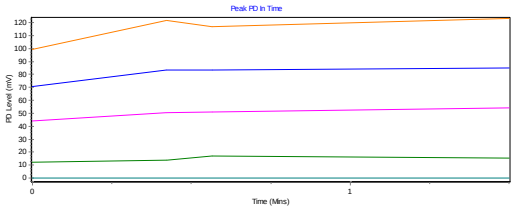
Photo of Sensor Attachment

	Channel 1		Channel 2		Channel 3		Channel 4	
	Machine PD	350pC	Machine PD	908pC	Machine PD	968pC	Machine PD	0pC
	Local PD	22dB	Local PD	15dB	Local PD	18dB	Local PD	25dB
	Peak	123.20mV	Peak	54.40mV	Peak	84.80mV	Peak	17.12mV
	Std Dev	2.81mV	Std Dev	1.16mV	Std Dev	1.53mV	Std Dev	3.50mV
Machine PD								

Local PD				
Noise				

Sensor	Circuit/Description	V(kV)	Machine Type	Local Plant Type
HFCT	phA	13.2kV	Rotating Machine	Generator
HFCT	phB	13.2kV	Rotating Machine	Generator
HFCT	phC	13.2kV	Rotating Machine	Generator
TEV Probe	TEV	13.2kV	Switchgear	Air Insulated

Machine PD Waveform				Local PD Waveform			
							
Peak	12.16 mV	**Frequency**	976.56 kHz	**Peak**	17.12 mV	**Frequency**	100.00 MHz
Rise Time	80.11 ns	**PD Level**	445.05 pC	**Rise Time**	6.05 ns	**PD Level**	
Noise Waveform				**Synchronous Waveform**			
							
Peak	54.40 mV	**Frequency**	366.21 kHz	**Peak**	-	**Frequency**	-
Rise Time	362.58 ns	**PD Level**	-	**Rise Time**	-	**PD Level**	-

No of Pulses vs. Pulse Rise-Time	**Peak Level in Time**
	

Comments
Machine PD levels normal. TEV signal is noise waveform. * Generators and motors are expected to have up to 2000pC when new. Up to 10000pC is acceptable for service-aged machines.

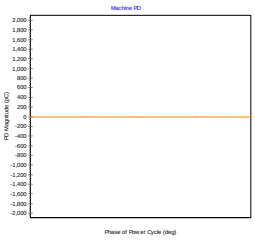
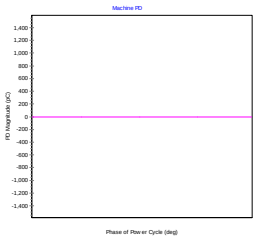
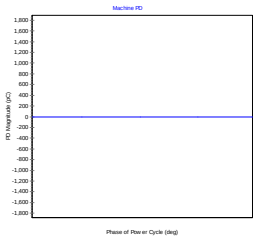
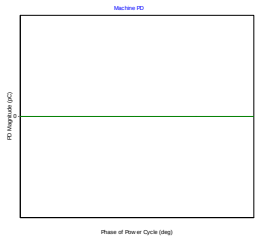
Substation/Site:	3-52-G5	**Customer:**	City of Tampa
Location:	POA 33	**Test Engineer:**	Nat Crews/ Louis Nemec
Test No.:		**Test Date:**	10/02/2017 9:57:43 AM

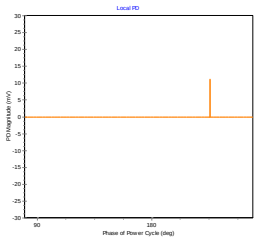
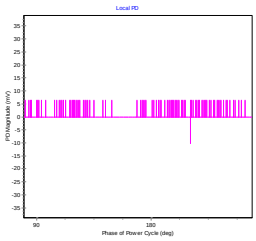
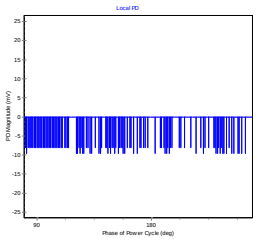
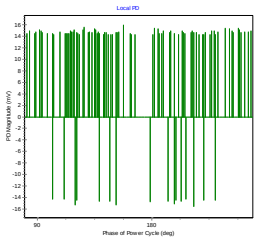
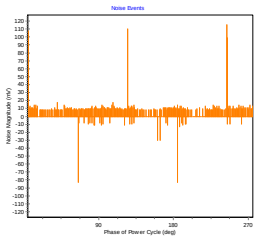
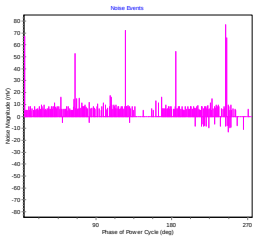
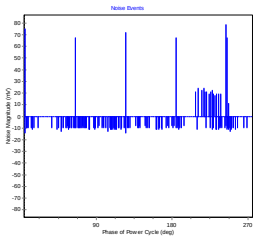
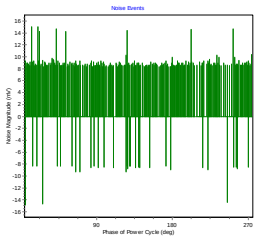
C.E. Testing, Inc.

Sensor	Circuit/Description	V(kV)	Machine Type	Local Plant Type
HFCT	phA	13.2kV	Rotating Machine	Generator
HFCT	phB	13.2kV	Rotating Machine	Generator
HFCT	phC	13.2kV	Rotating Machine	Generator
TEV Probe	TEV	13.2kV	Switchgear	Air Insulated

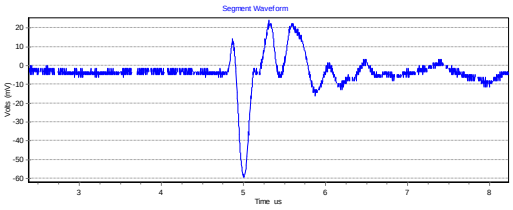
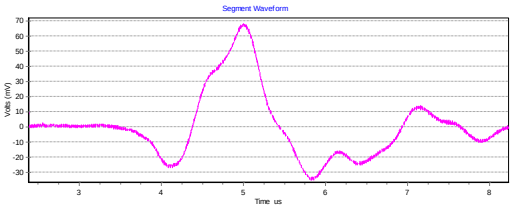
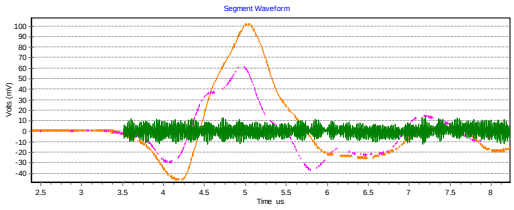
Phase-Resolved Graph (PD and Noise)

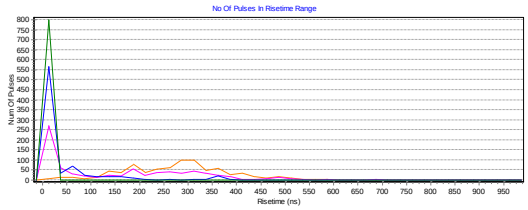
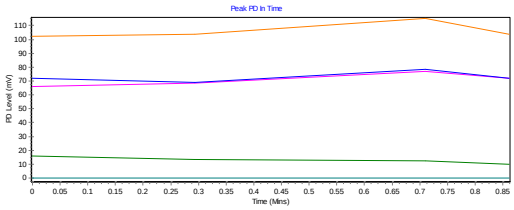
Photo of Sensor Attachment

	Channel 1		Channel 2		Channel 3		Channel 4	
	Machine PD	1898pC	Machine PD	1438pC	Machine PD	1706pC	Machine PD	0pC
	Local PD	29dB	Local PD	31dB	Local PD	28dB	Local PD	24dB
	Peak	115.20mV	Peak	76.80mV	Peak	78.40mV	Peak	15.84mV
	Std Dev	2.35mV	Std Dev	1.50mV	Std Dev	1.66mV	Std Dev	3.39mV
Machine PD								

Local PD				
Noise				

Sensor	Circuit/Description	V(kV)	Machine Type	Local Plant Type
HFCT	phA	13.2kV	Rotating Machine	Generator
HFCT	phB	13.2kV	Rotating Machine	Generator
HFCT	phC	13.2kV	Rotating Machine	Generator
TEV Probe	TEV	13.2kV	Switchgear	Air Insulated

Machine PD Waveform				Local PD Waveform			
							
Peak	-59.20 mV	**Frequency**	976.56 kHz	**Peak**	15.84 mV	**Frequency**	93.75 MHz
Rise Time	74.50 ns	**PD Level**	-1.71 nC	**Rise Time**	1.25 ns	**PD Level**	
Noise Waveform				**Synchronous Waveform**			
							
Peak	68.48 mV	**Frequency**	427.25 kHz	**Peak**	-	**Frequency**	-
Rise Time	476.31 ns	**PD Level**	-	**Rise Time**	-	**PD Level**	-

No of Pulses vs. Pulse Rise-Time	**Peak Level in Time**
	

Comments
Machine PD levels are normal. Local cable PD signal is noise. Local TEV signal is noise waveform.

Substation/Site: 3-52-G2
Location: POA 32
Test No.:

Customer: City of Tampa
Test Engineer: Nat Crews/ Louis Nemec
Test Date: 10/02/2017 10:01:52 AM

C.E. Testing, Inc.

Sensor	Circuit/Description	V(kV)	Machine Type	Local Plant Type
HFCT	phA	13.2kV	Rotating Machine	Generator
HFCT	phB	13.2kV	Rotating Machine	Generator
HFCT	phC	13.2kV	Rotating Machine	Generator
TEV Probe	TEV	13.2kV	Switchgear	Air Insulated

Phase-Resolved Graph (PD and Noise)

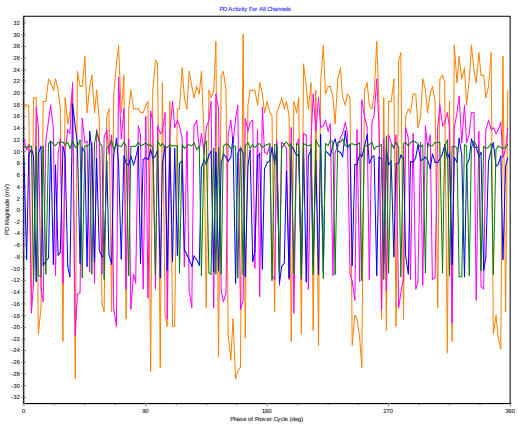
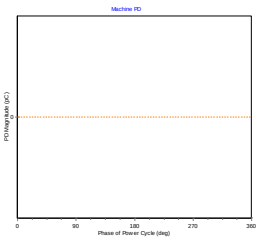
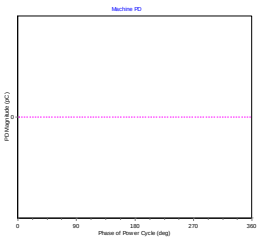
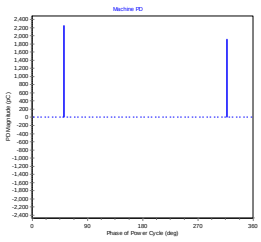
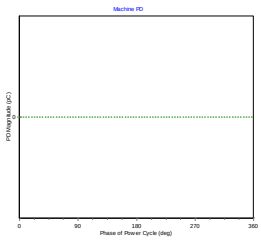
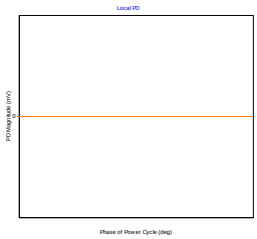
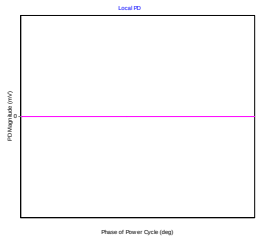
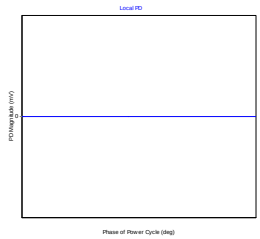
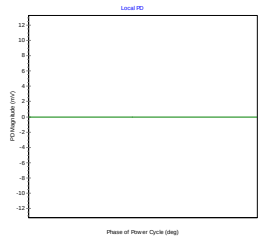
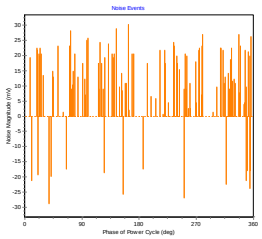
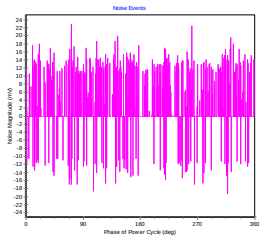
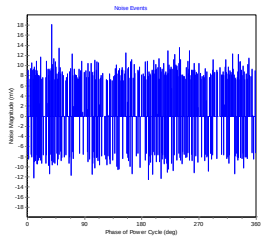
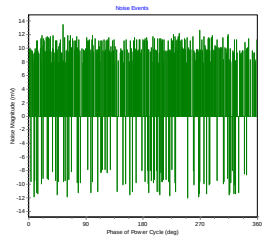
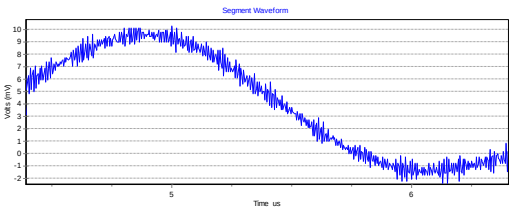
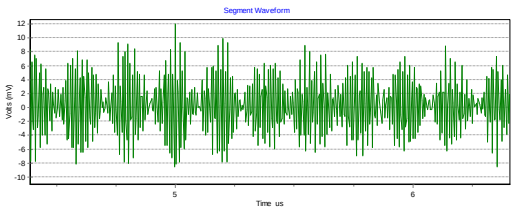
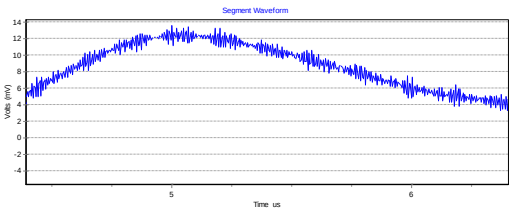
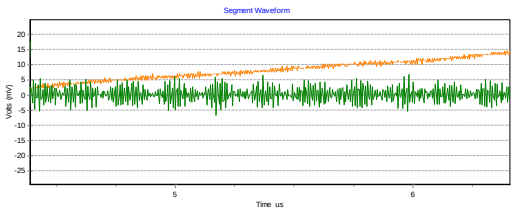


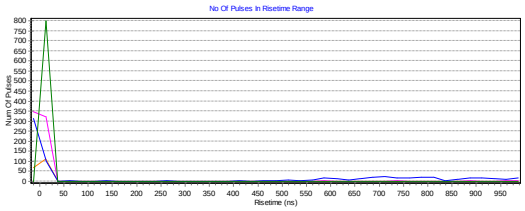
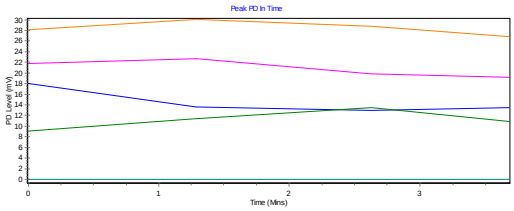
Photo of Sensor Attachment

	Channel 1		Channel 2		Channel 3		Channel 4	
	Machine PD	0pC	Machine PD	0pC	Machine PD	2241pC	Machine PD	0pC
	Local PD	0dB	Local PD	0dB	Local PD	0dB	Local PD	22dB
	Peak	30.08mV	Peak	22.72mV	Peak	18.08mV	Peak	13.44mV
	Std Dev	6.61mV	Std Dev	4.29mV	Std Dev	2.49mV	Std Dev	3.33mV
Machine PD								

Local PD				
Noise				

Sensor	Circuit/Description	V(kV)	Machine Type	Local Plant Type
HFCT	phA	13.2kV	Rotating Machine	Generator
HFCT	phB	13.2kV	Rotating Machine	Generator
HFCT	phC	13.2kV	Rotating Machine	Generator
TEV Probe	TEV	13.2kV	Switchgear	Air Insulated

Machine PD Waveform				Local PD Waveform			
							
Peak	10.24 mV	**Frequency**	244.14 kHz	**Peak**	12.00 mV	**Frequency**	83.33 MHz
Rise Time	818.18 ns	**PD Level**	2.24 nC	**Rise Time**	1.36 ns	**PD Level**	
Noise Waveform				**Synchronous Waveform**			
							
Peak	13.60 mV	**Frequency**	61.04 kHz	**Peak**	-	**Frequency**	-
Rise Time	633.04 ns	**PD Level**	-	**Rise Time**	-	**PD Level**	-

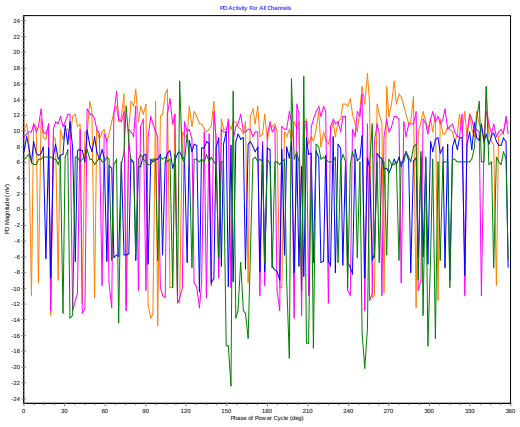
No of Pulses vs. Pulse Rise-Time	Peak Level in Time
	

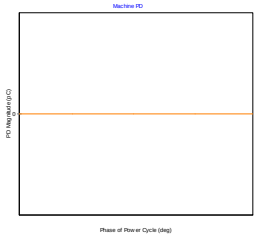
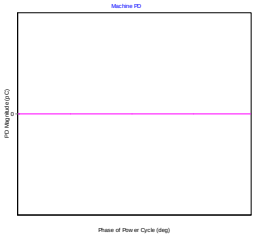
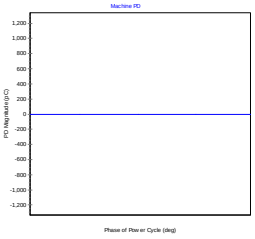
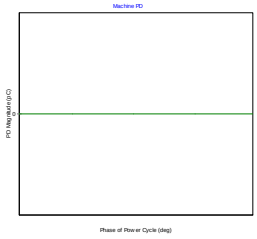
Comments
Machine PD levels normal. TEV signal is noise waveform.

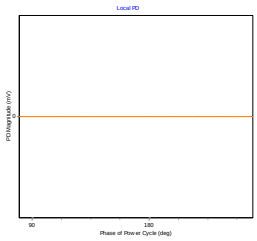
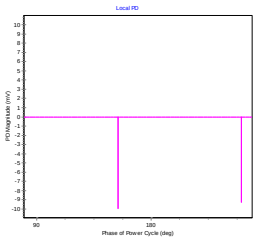
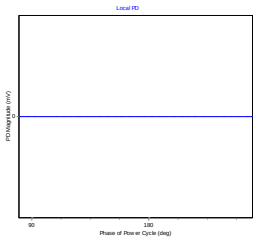
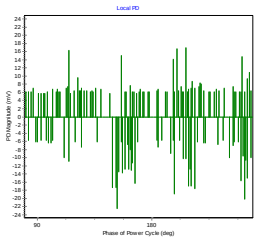
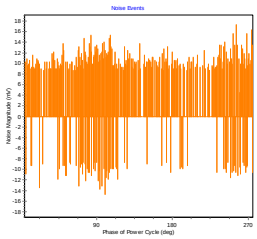
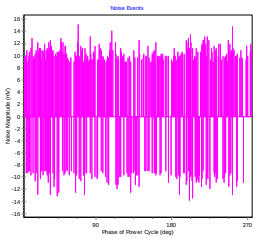
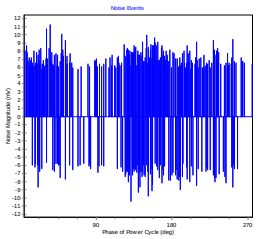
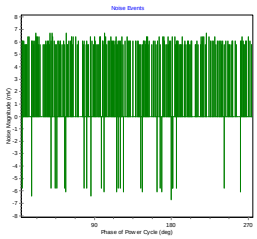
Substation/Site:	3-52-S2	**Customer:**	City of Tampa
Location:	POA 39A	**Test Engineer:**	Nat Crews/ Louis Nemec
Test No.:		**Test Date:**	10/02/2017 10:10:12 AM

C.E. Testing, Inc.

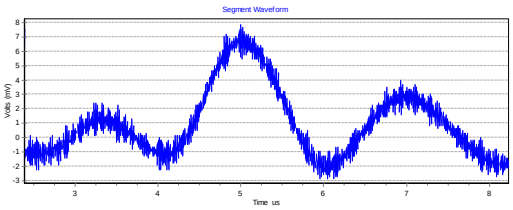
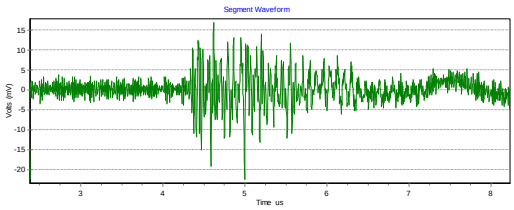
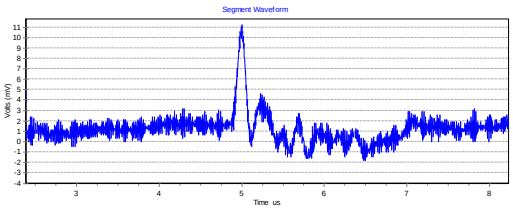
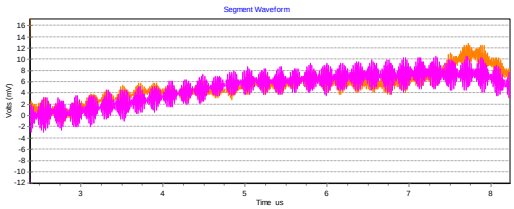
Sensor	Circuit/Description	V(kV)	Machine Type	Local Plant Type
HFCT	phA	13.2kV	Rotating Machine	Generator
HFCT	phB	13.2kV	Rotating Machine	Generator
HFCT	phC	13.2kV	Rotating Machine	Generator
TEV Probe	TEV	13.2kV	Switchgear	Air Insulated

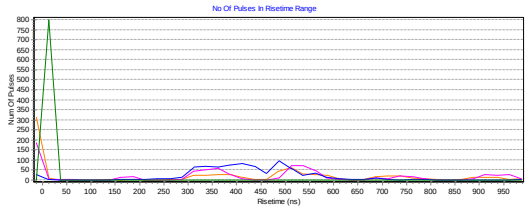
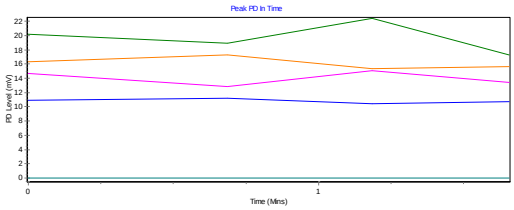
Phase-Resolved Graph (PD and Noise)	Photo of Sensor Attachment
	

	Channel 1		Channel 2		Channel 3		Channel 4	
	Machine PD	0pC	Machine PD	0pC	Machine PD	1208pC	Machine PD	0pC
	Local PD	0dB	Local PD	20dB	Local PD	0dB	Local PD	27dB
	Peak	17.28mV	Peak	15.04mV	Peak	11.20mV	Peak	22.40mV
	Std Dev	2.72mV	Std Dev	2.75mV	Std Dev	1.51mV	Std Dev	1.55mV
Machine PD								

Local PD				
Noise				

Sensor	Circuit/Description	V(kV)	Machine Type	Local Plant Type
HFCT	phA	13.2kV	Rotating Machine	Generator
HFCT	phB	13.2kV	Rotating Machine	Generator
HFCT	phC	13.2kV	Rotating Machine	Generator
TEV Probe	TEV	13.2kV	Switchgear	Air Insulated

Machine PD Waveform				Local PD Waveform			
							
Peak	7.84 mV	**Frequency**	244.14 kHz	**Peak**	-22.40 mV	**Frequency**	11.47 MHz
Rise Time	422.10 ns	**PD Level**	1.21 nC	**Rise Time**	14.71 ns	**PD Level**	
Noise Waveform				**Synchronous Waveform**			
							
Peak	11.20 mV	**Frequency**	2.08 MHz	**Peak**	-	**Frequency**	-
Rise Time	79.46 ns	**PD Level**	-	**Rise Time**	-	**PD Level**	-

No of Pulses vs. Pulse Rise-Time	**Peak Level in Time**
	

Comments
Local PD 27dB. Machine PD levels normal. Local PD waveform detected 27dB @ 11MHz. Recommend follow-up PD testing. *PD is more likely when there is no load yet the equipment is energized with voltage.

Substation/Site:	3-52-S2	**Customer:**	City of Tampa
Location:	POA 39B	**Test Engineer:**	Nat Crews/ Louis Nemec
Test No.:		**Test Date:**	10/02/2017 10:14:31 AM

C.E. Testing, Inc.

Sensor	Circuit/Description	V(kV)	Machine Type	Local Plant Type
HFCT	phA	13.2kV	Rotating Machine	Generator
HFCT	phB	13.2kV	Rotating Machine	Generator
HFCT	phC	13.2kV	Rotating Machine	Generator
TEV Probe	TEV	13.2kV	Switchgear	Air Insulated

Phase-Resolved Graph (PD and Noise)

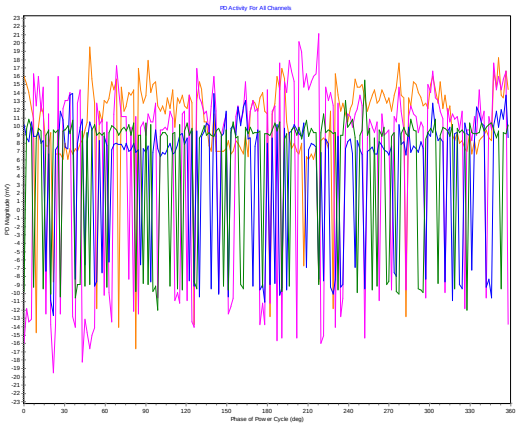
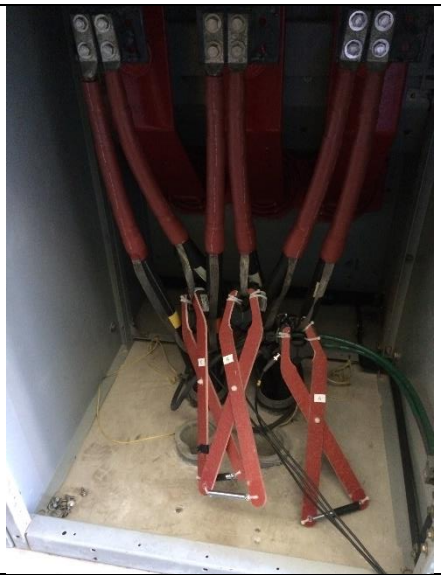
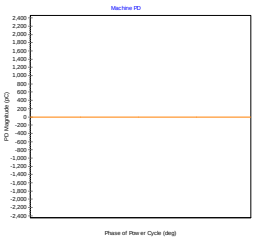
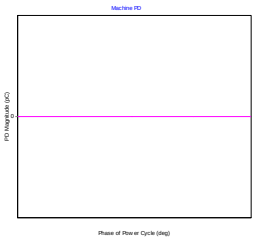
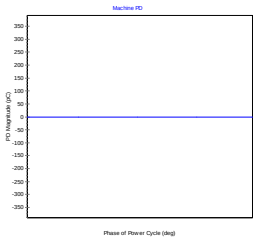
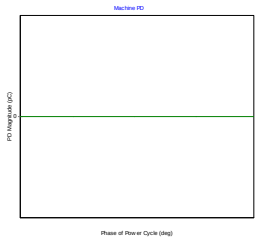
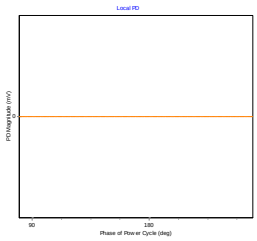
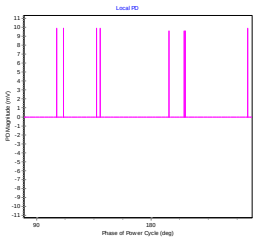
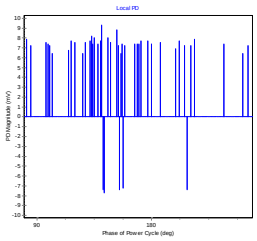
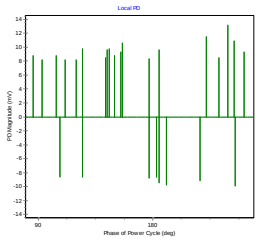
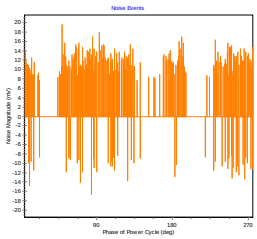
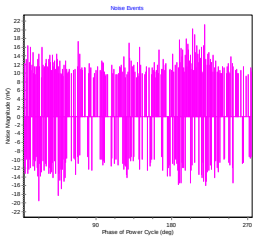
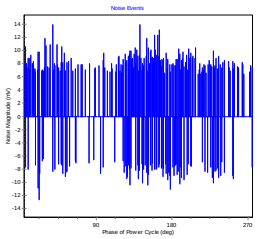
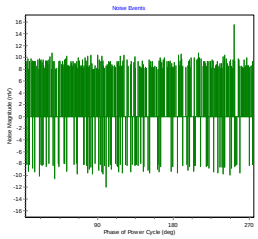


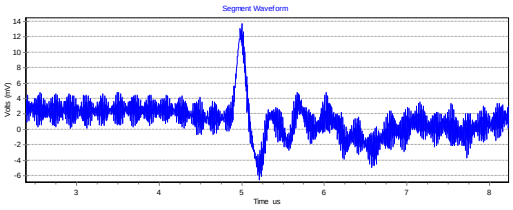
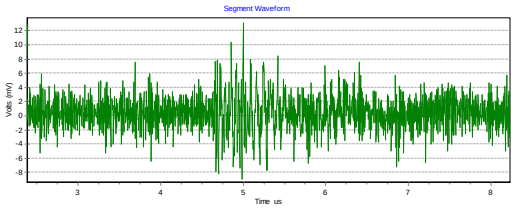
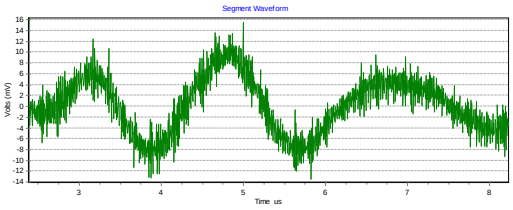
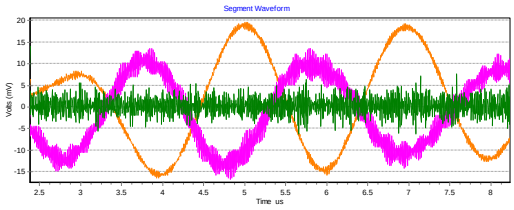
Photo of Sensor Attachment

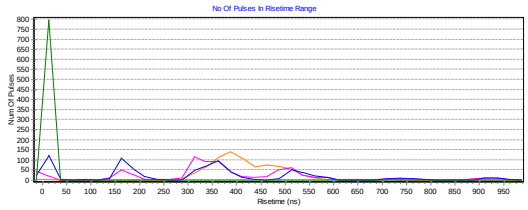
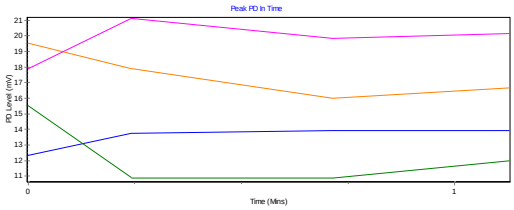


	Channel 1		Channel 2		Channel 3		Channel 4	
	Machine PD	2220pC	Machine PD	0pC	Machine PD	354pC	Machine PD	0pC
	Local PD	0dB	Local PD	20dB	Local PD	19dB	Local PD	22dB
	Peak	19.52mV	Peak	21.12mV	Peak	13.92mV	Peak	15.52mV
	Std Dev	2.09mV	Std Dev	2.79mV	Std Dev	2.02mV	Std Dev	2.20mV
Machine PD								

Local PD				
Noise				

Sensor	Circuit/Description	V(kV)	Machine Type	Local Plant Type
HFCT	phA	13.2kV	Rotating Machine	Generator
HFCT	phB	13.2kV	Rotating Machine	Generator
HFCT	phC	13.2kV	Rotating Machine	Generator
TEV Probe	TEV	13.2kV	Switchgear	Air Insulated

Machine PD Waveform				Local PD Waveform			
							
Peak	13.76 mV	**Frequency**	1.45 MHz	**Peak**	13.12 mV	**Frequency**	29.41 MHz
Rise Time	90.96 ns	**PD Level**	353.60 pC	**Rise Time**	8.49 ns	**PD Level**	
Noise Waveform				**Synchronous Waveform**			
							
Peak	15.52 mV	**Frequency**	488.28 kHz	**Peak**	-	**Frequency**	-
Rise Time	316.70 ns	**PD Level**	-	**Rise Time**	-	**PD Level**	-

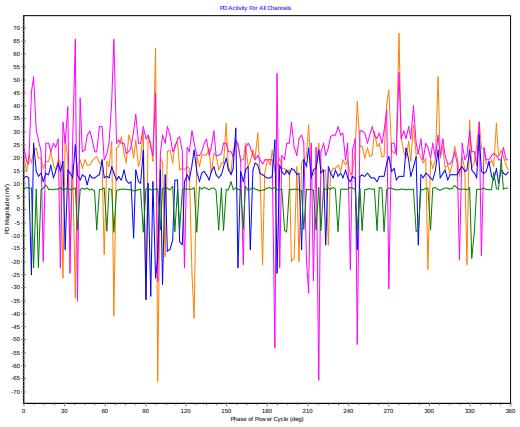
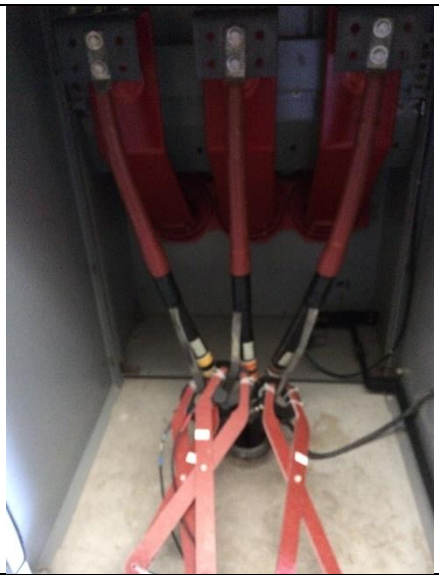
No of Pulses vs. Pulse Rise-Time	**Peak Level in Time**
	

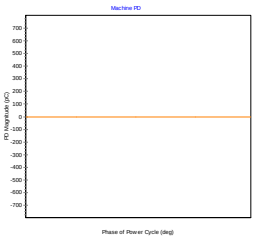
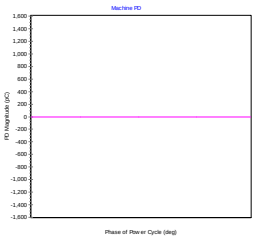
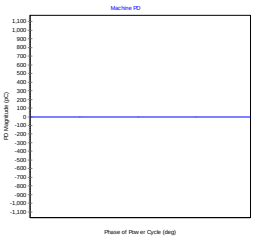
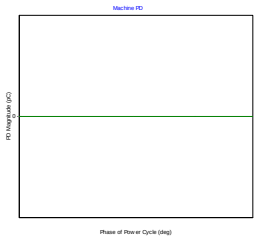
Comments
Local PD 22dB. Machine PD levels normal. Local PD waveform detected 22dB @ 11MHz. Recommend follow-up PD testing. *PD is more likely when there is no load yet the equipment is energized with voltage.

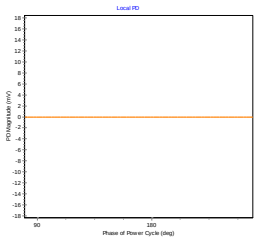
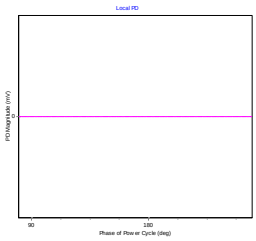
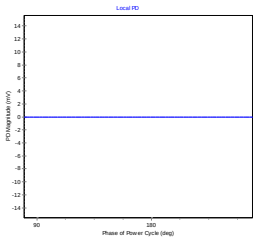
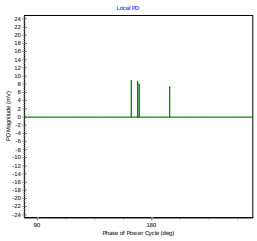
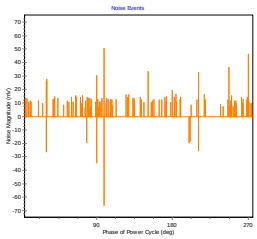
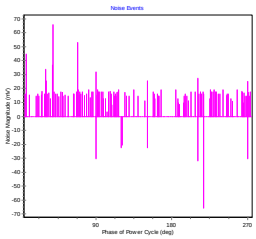
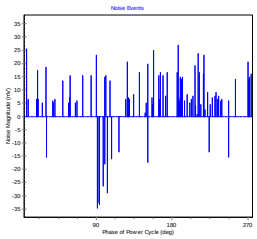
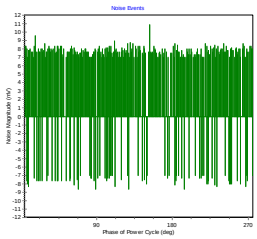
Substation/Site:	3-52-G3	**Customer:**	City of Tampa
Location:	POA 35	**Test Engineer:**	Nat Crews/ Louis Nemec
Test No.:		**Test Date:**	10/02/2017 10:24:43 AM

C.E. Testing, Inc.

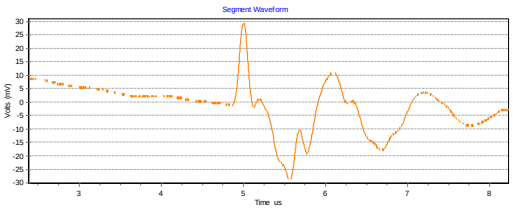
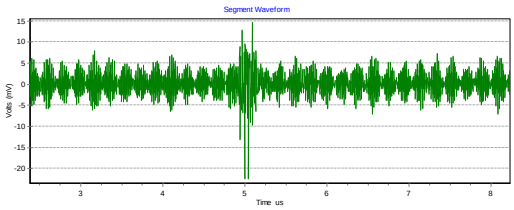
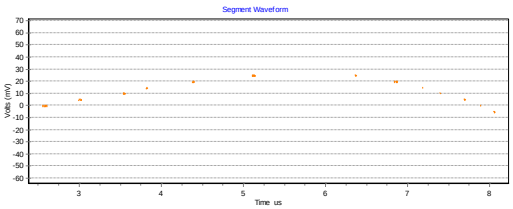
Sensor	Circuit/Description	V(kV)	Machine Type	Local Plant Type
HFCT	phA	13.2kV	Rotating Machine	Generator
HFCT	phB	13.2kV	Rotating Machine	Generator
HFCT	phC	13.2kV	Rotating Machine	Generator
TEV Probe	TEV	13.2kV	Switchgear	Air Insulated

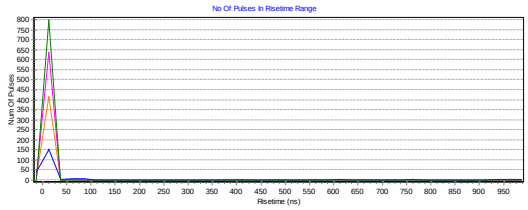
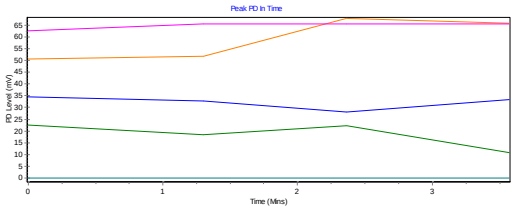
Phase-Resolved Graph (PD and Noise)	Photo of Sensor Attachment
	

	Channel 1		Channel 2		Channel 3		Channel 4	
	Machine PD	722pC	Machine PD	1454pC	Machine PD	1057pC	Machine PD	0pC
	Local PD	24dB	Local PD	0dB	Local PD	23dB	Local PD	27dB
	Peak	67.84mV	Peak	65.60mV	Peak	34.56mV	Peak	22.40mV
	Std Dev	6.75mV	Std Dev	8.82mV	Std Dev	4.12mV	Std Dev	2.39mV
Machine PD								

Local PD				
Noise				

Sensor	Circuit/Description	V(kV)	Machine Type	Local Plant Type
HFCT	phA	13.2kV	Rotating Machine	Generator
HFCT	phB	13.2kV	Rotating Machine	Generator
HFCT	phC	13.2kV	Rotating Machine	Generator
TEV Probe	TEV	13.2kV	Switchgear	Air Insulated

Machine PD Waveform				Local PD Waveform			
							
Peak	29.44 mV	**Frequency**	2.36 MHz	**Peak**	-22.40 mV	**Frequency**	83.33 MHz
Rise Time	71.07 ns	**PD Level**	721.80 pC	**Rise Time**	3.73 ns	**PD Level**	
Noise Waveform				**Synchronous Waveform**			
							
Peak	67.84 mV	**Frequency**	106.81 kHz	**Peak**	-	**Frequency**	-
Rise Time	2.14 us	**PD Level**	-	**Rise Time**	-	**PD Level**	-

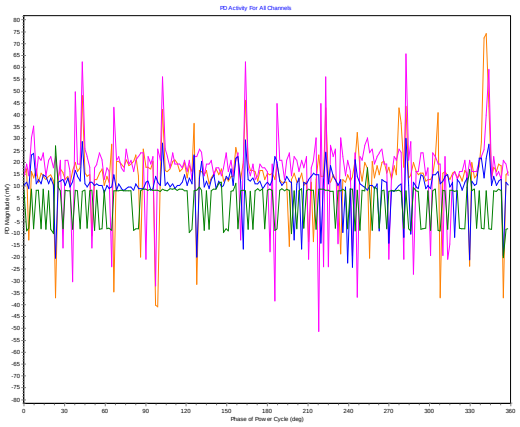
No of Pulses vs. Pulse Rise-Time	**Peak Level in Time**
	

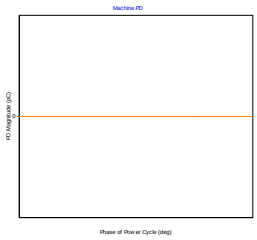
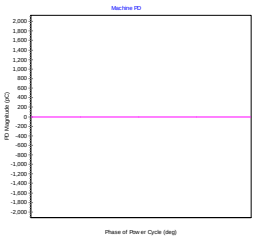
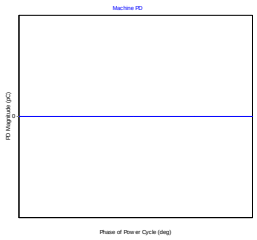
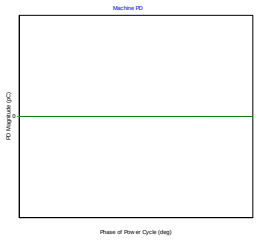
Comments
Local PD 27dB. Machine PD levels normal. Local PD waveform detected 27dB @ 11MHz. Recommend follow-up PD testing. *PD is more likely when there is no load yet the equipment is energized with voltage.

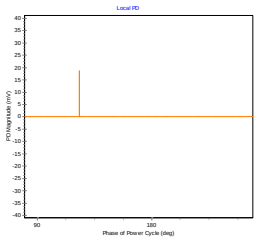
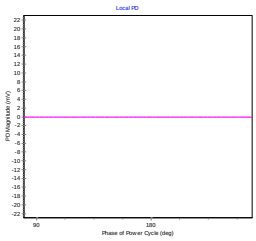
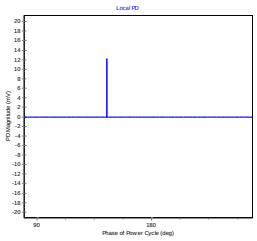
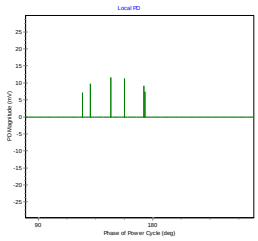
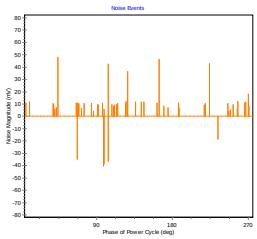
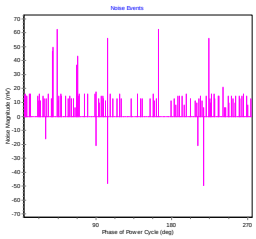
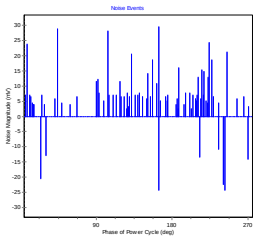
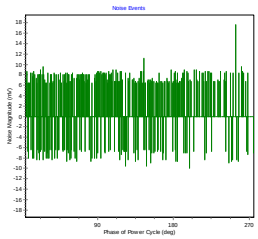
Substation/Site:	3-52-G4	**Customer:**	City of Tampa
Location:	POA 36	**Test Engineer:**	Nat Crews/ Louis Nemec
Test No.:		**Test Date:**	10/02/2017 10:37:01 AM

C.E. Testing, Inc.

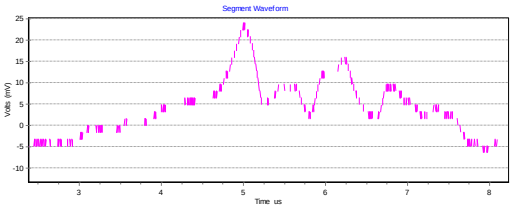
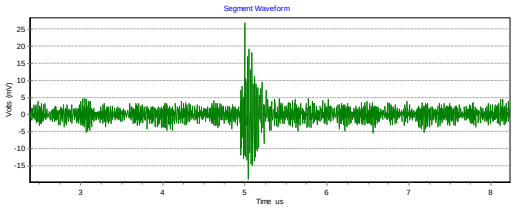
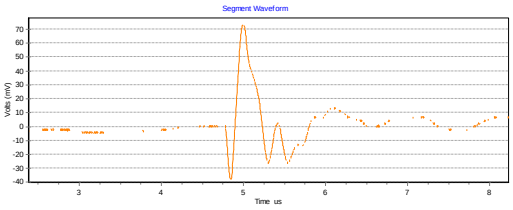
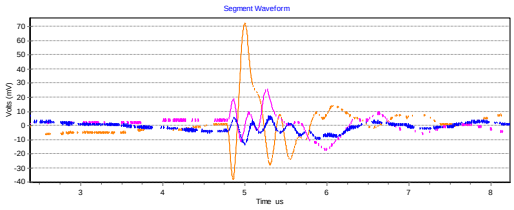
Sensor	Circuit/Description	V(kV)	Machine Type	Local Plant Type
HFCT	phA	13.2kV	Rotating Machine	Generator
HFCT	phB	13.2kV	Rotating Machine	Generator
HFCT	phC	13.2kV	Rotating Machine	Generator
TEV Probe	TEV	13.2kV	Switchgear	Air Insulated

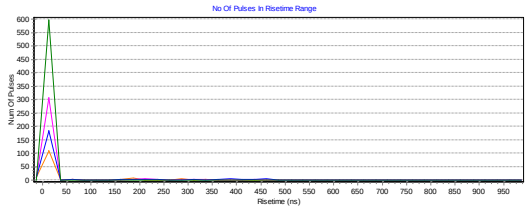
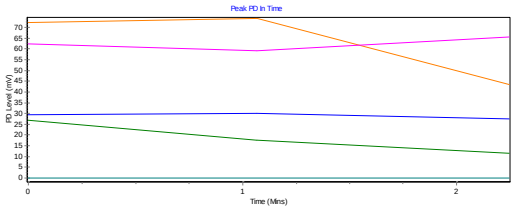
Phase-Resolved Graph (PD and Noise)	Photo of Sensor Attachment
	

	Channel 1		Channel 2		Channel 3		Channel 4	
	Machine PD	0pC	Machine PD	1920pC	Machine PD	0pC	Machine PD	0pC
	Local PD	31dB	Local PD	26dB	Local PD	26dB	Local PD	29dB
	Peak	74.24mV	Peak	65.60mV	Peak	30.08mV	Peak	26.88mV
	Std Dev	5.44mV	Std Dev	7.25mV	Std Dev	3.59mV	Std Dev	2.16mV
Machine PD								

Local PD				
Noise				

Sensor	Circuit/Description	V(kV)	Machine Type	Local Plant Type
HFCT	phA	13.2kV	Rotating Machine	Generator
HFCT	phB	13.2kV	Rotating Machine	Generator
HFCT	phC	13.2kV	Rotating Machine	Generator
TEV Probe	TEV	13.2kV	Switchgear	Air Insulated

Machine PD Waveform				Local PD Waveform			
							
Peak	24.00 mV	**Frequency**	488.28 kHz	**Peak**	26.88 mV	**Frequency**	55.56 MHz
Rise Time	258.47 ns	**PD Level**	1.92 nC	**Rise Time**	3.09 ns	**PD Level**	
Noise Waveform				**Synchronous Waveform**			
							
Peak	74.24 mV	**Frequency**	976.56 kHz	**Peak**	-	**Frequency**	-
Rise Time	85.87 ns	**PD Level**	-	**Rise Time**	-	**PD Level**	-

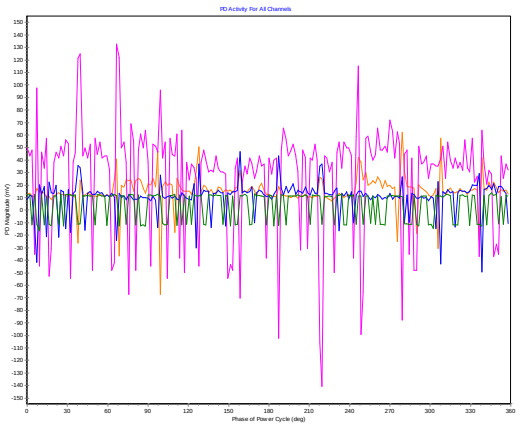
No of Pulses vs. Pulse Rise-Time	**Peak Level in Time**
	

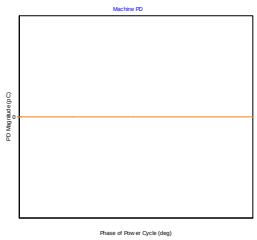
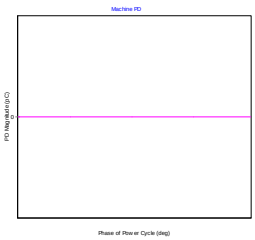
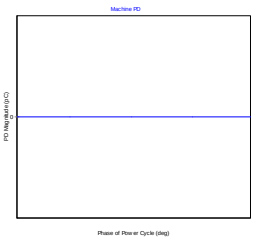
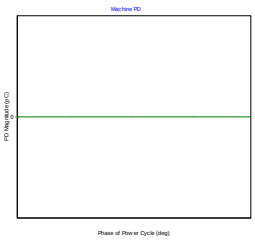
Comments
Machine PD levels are normal. Local PD 29dB. Local PD may be on A -phase.

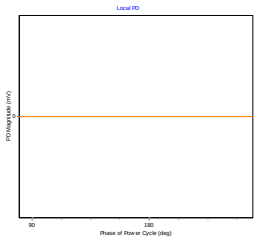
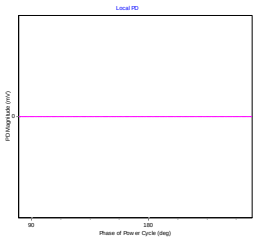
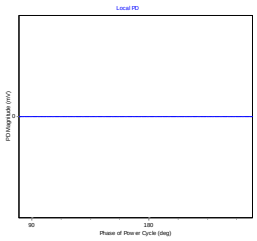
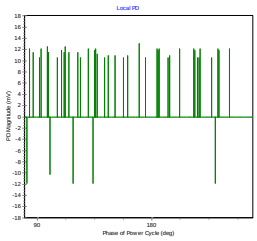
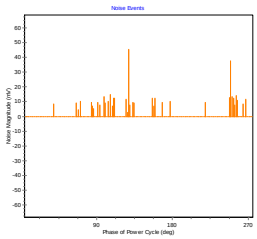
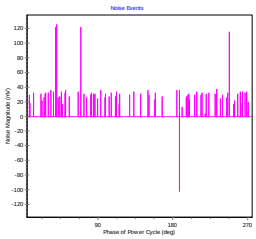
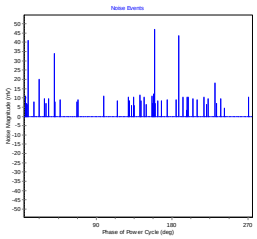
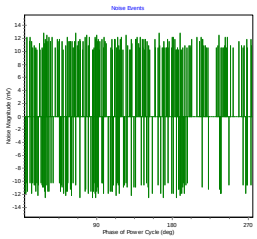
Substation/Site:	3-52-S1	**Customer:**	City of Tampa
Location:	POA 38 A	**Test Engineer:**	Nat Crews/ Louis Nemec
Test No.:		**Test Date:**	10/02/2017 10:42:49 AM

C.E. Testing, Inc.

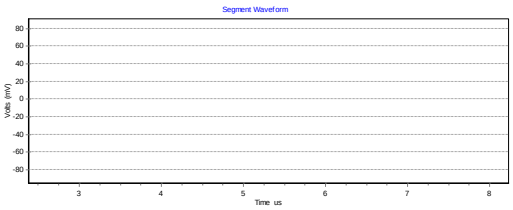
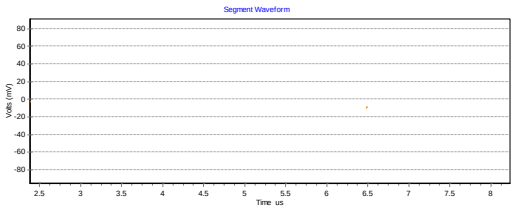
Sensor	Circuit/Description	V(kV)	Machine Type	Local Plant Type
HFCT	PHA	13.2kV	Rotating Machine	Generator
HFCT	PHB	13.2kV	Rotating Machine	Generator
HFCT	PHC	13.2kV	Rotating Machine	Generator
TEV Probe	TEV	13.2kV	Switchgear	Air Insulated

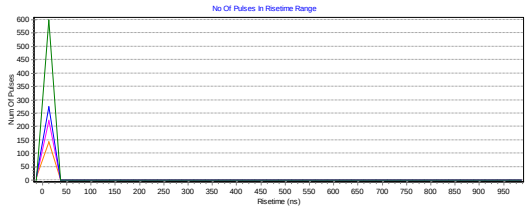
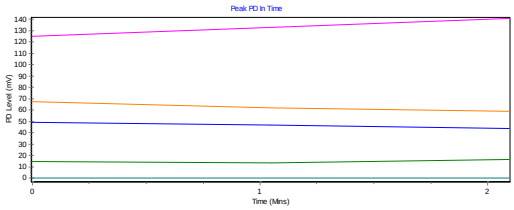
Phase-Resolved Graph (PD and Noise)	Photo of Sensor Attachment
	

	Channel 1		Channel 2		Channel 3		Channel 4	
	Machine PD	0pC	Machine PD	0pC	Machine PD	0pC	Machine PD	0pC
	Local PD	0dB	Local PD	0dB	Local PD	0dB	Local PD	24dB
	Peak	62.08mV	Peak	124.80mV	Peak	49.28mV	Peak	16.32mV
	Std Dev	6.10mV	Std Dev	16.78mV	Std Dev	5.16mV	Std Dev	3.77mV
Machine PD								

Local PD				
Noise				

Sensor	Circuit/Description	V(kV)	Machine Type	Local Plant Type
HFCT	phA	13.2kV	Rotating Machine	Generator
HFCT	phB	13.2kV	Rotating Machine	Generator
HFCT	phC	13.2kV	Rotating Machine	Generator
TEV Probe	TEV	13.2kV	Switchgear	Air Insulated

Machine PD Waveform				Local PD Waveform			
							
Peak		**Frequency**		**Peak**	-16.32 mV	**Frequency**	105.26 MHz
Rise Time		**PD Level**		**Rise Time**	1.59 ns	**PD Level**	
Noise Waveform				**Synchronous Waveform**			
							
Peak	62.08 mV	**Frequency**	106.81 kHz	**Peak**	-	**Frequency**	-
Rise Time	1.85 us	**PD Level**	-	**Rise Time**	-	**PD Level**	-

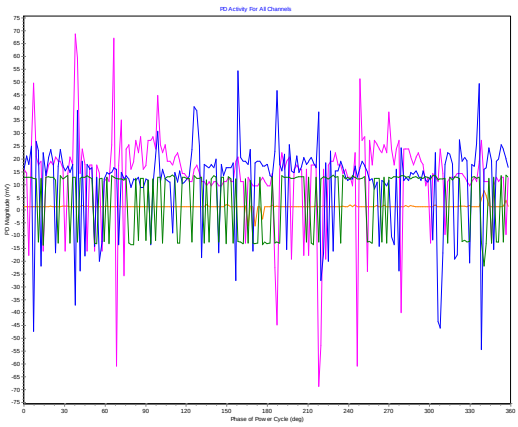
No of Pulses vs. Pulse Rise-Time	**Peak Level in Time**
	

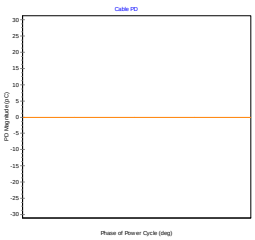
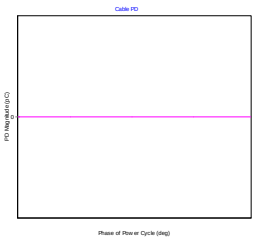
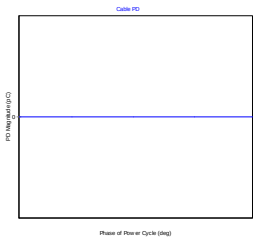
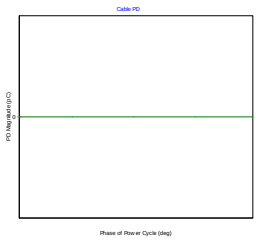
Comments
No PD detected. Signal is bleed-over from local PD at POA 36.

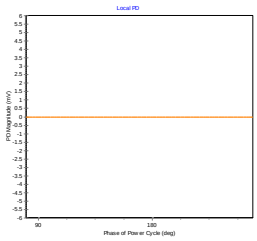
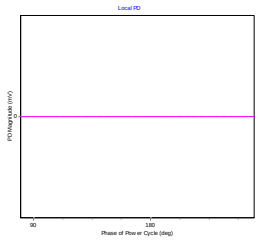
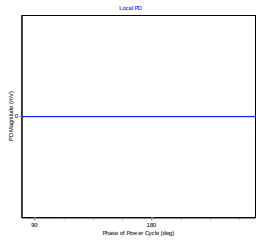
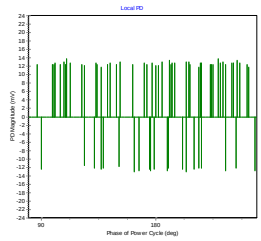
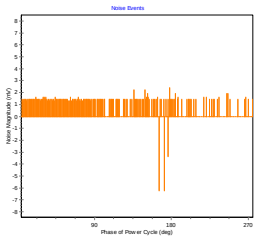
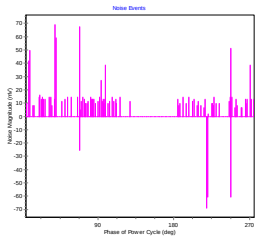
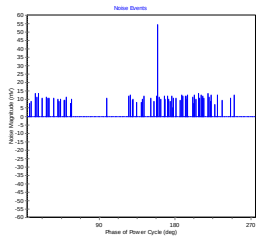
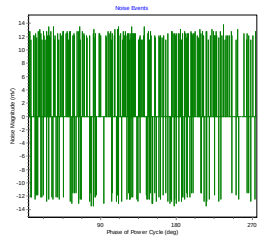
Substation/Site:	3-52-S2	**Customer:**	City of Tampa
Location:	POA 38 B	**Test Engineer:**	Nat Crews/ Louis Nemec
Test No.:		**Test Date:**	10/02/2017 10:47:48 AM

C.E. Testing, Inc.

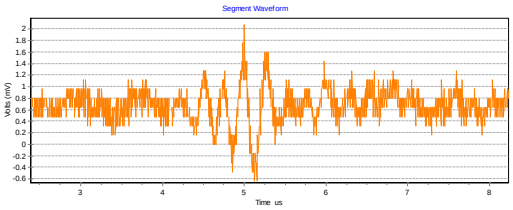
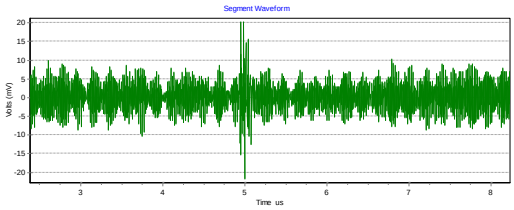
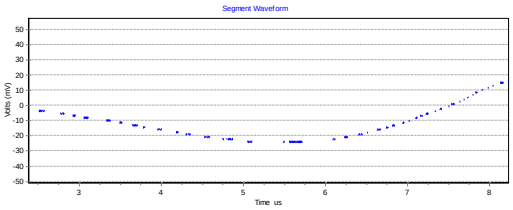
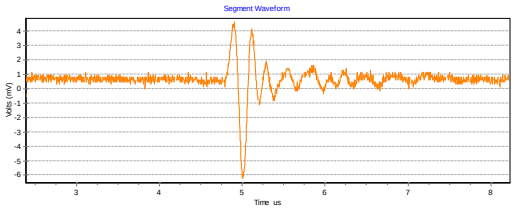
Sensor	Circuit/Description	V(kV)	Cable Type	Local Plant Type
HFCT	PHA	13.2kV	Cable	EPR
HFCT	PHB	13.2kV	Cable	EPR
HFCT	PHC	13.2kV	Cable	EPR
TEV Probe	TEV	13.2kV	Switchgear	Air Insulated

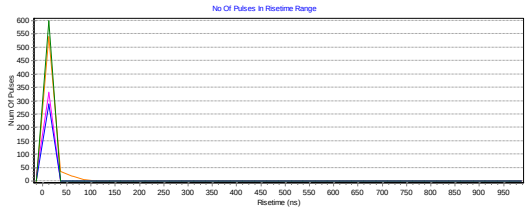
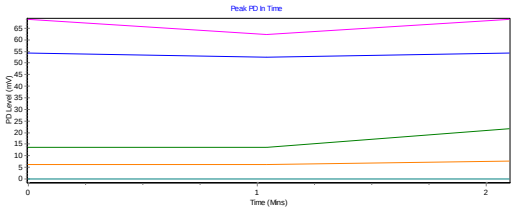
Phase-Resolved Graph (PD and Noise)	Photo of Sensor Attachment
	

	Channel 1		Channel 2		Channel 3		Channel 4	
	Cable PD	28pC	Cable PD	0pC	Cable PD	0pC	Cable PD	0pC
	Local PD	15dB	Local PD	0dB	Local PD	0dB	Local PD	27dB
	Peak	7.68mV	Peak	68.80mV	Peak	54.40mV	Peak	21.76mV
	Std Dev	0.17mV	Std Dev	6.68mV	Std Dev	6.48mV	Std Dev	4.35mV
Cable PD								

Local PD				
Noise				

Sensor	Circuit/Description	V(kV)	Cable Type	Local Plant Type
HFCT	PHA	13.2kV	Cable	EPR
HFCT	PHB	13.2kV	Cable	EPR
HFCT	PHC	13.2kV	Cable	EPR
TEV Probe	TEV	13.2kV	Switchgear	Air Insulated

Cable PD Waveform				Local PD Waveform			
							
Peak	2.08 mV	**Frequency**	122.07 kHz	**Peak**	-21.76 mV	**Frequency**	50.00 MHz
Rise Time	38.67 ns	**PD Level**	14.67 pC	**Rise Time**	2.84 ns	**PD Level**	
Noise Waveform				**Synchronous Waveform**			
							
Peak	54.40 mV	**Frequency**	106.81 kHz	**Peak**	-	**Frequency**	-
Rise Time	1.82 us	**PD Level**	-	**Rise Time**	-	**PD Level**	-

No of Pulses vs. Pulse Rise-Time	Peak Level in Time
	

Comments
Noise on A phase Cable. TEV is bleed over from 3-52-G4. 3-52-S2 noise on A phase is possibly the source of the 122 /244/688kHz noise observed throughout the plant.

Substation/Site:	T-4B-2	**Customer:**	City of Tampa
Location:	POA 51A & B	**Test Engineer:**	Nat Crews/ Louis Nemec
Test No.:		**Test Date:**	10/02/2017 10:47:48 AM

C.E. Testing, Inc.

T-4B-2 **POA 51 A & B Test data files were corrupted. The collected data was not useful.**

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