



# **PSE&G CMMS – Extending Condition Based Maintenance Program to Underground Networks**

Presented by

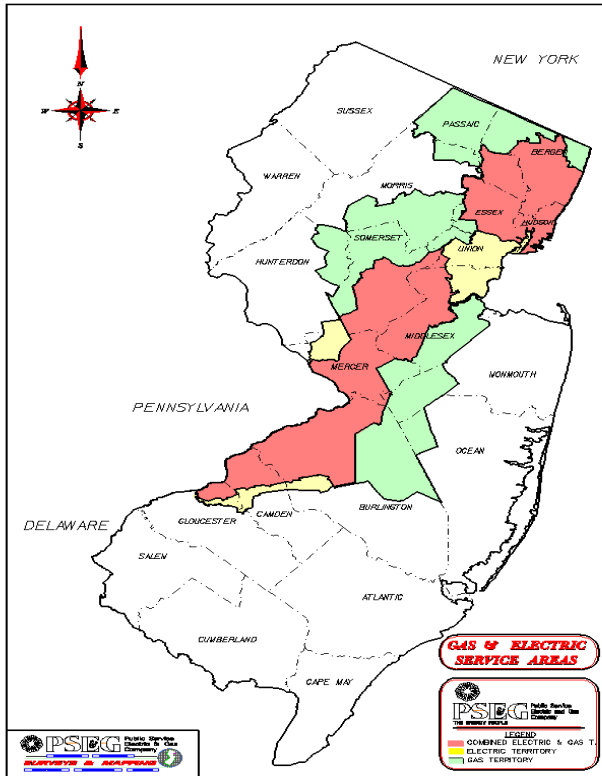
Angela Rothweiler  
Public Service Electric & Gas



# Agenda

- **About PSE&G**
- **Problem**
- **Functional Areas**
- **Data Collection**
- **Inside Plant Conditioned Based Maintenance (CBM)**
- **Benefits of CBM**
- **Engineering Desktop**
- **Expanding CBM to Underground Network**

# Background



## Utility Overview

- New Jersey Based
- Total Assets ~ \$14 Billion
- Total Revenue ~ \$7 Billion

## Service Territory

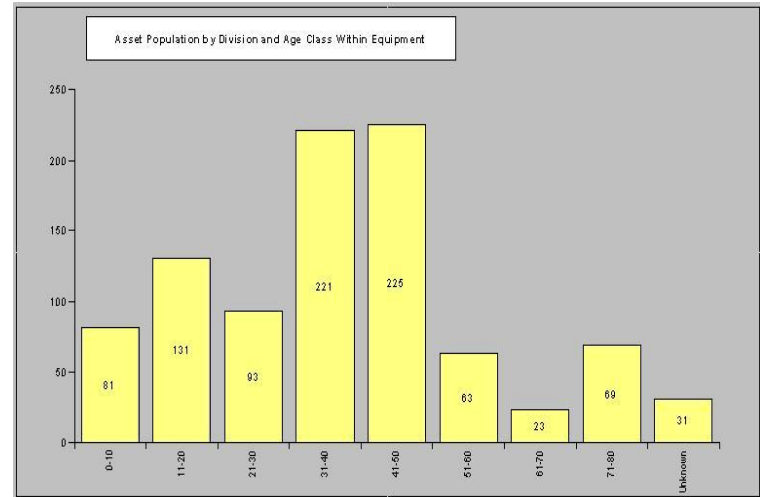
- 323 Municipalities
- 70% of New Jersey's population
- 2.1 million Electric customers
- 1.7 million Gas customers
- 2,600 Square Miles

## Delivery Implementation

- 1999 – SAP
- 2000 - OMS, GIS & CAD
- 2002 - CMMS

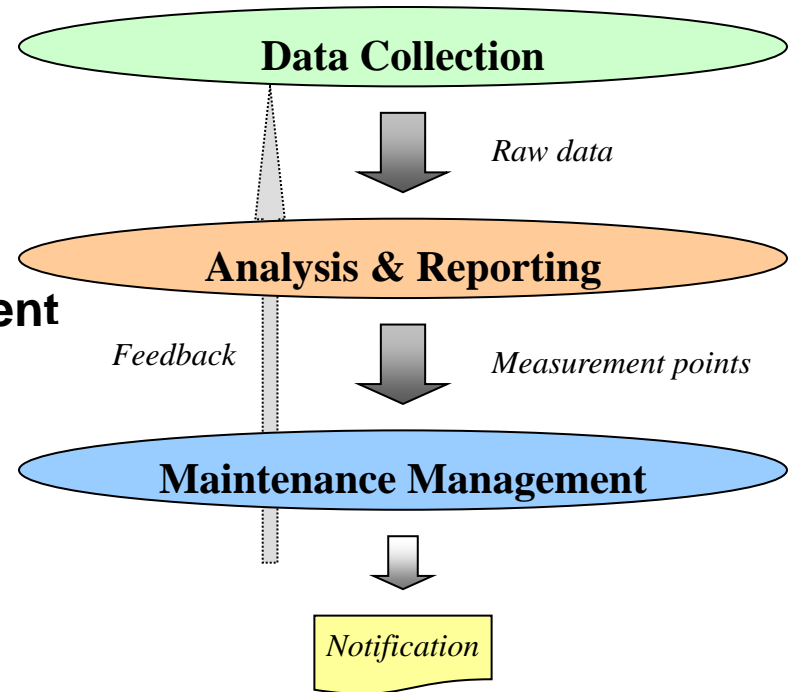
# Problem

- No predictive maintenance program or strategy
- Significant liability risk and system outage potential from old equipment vulnerable to failure
- Limited assessment tools for determining asset condition
- Decreasing expertise in both field maintenance and engineering
- No formalized capital spending program
- Asset Information in a variety of disparate systems

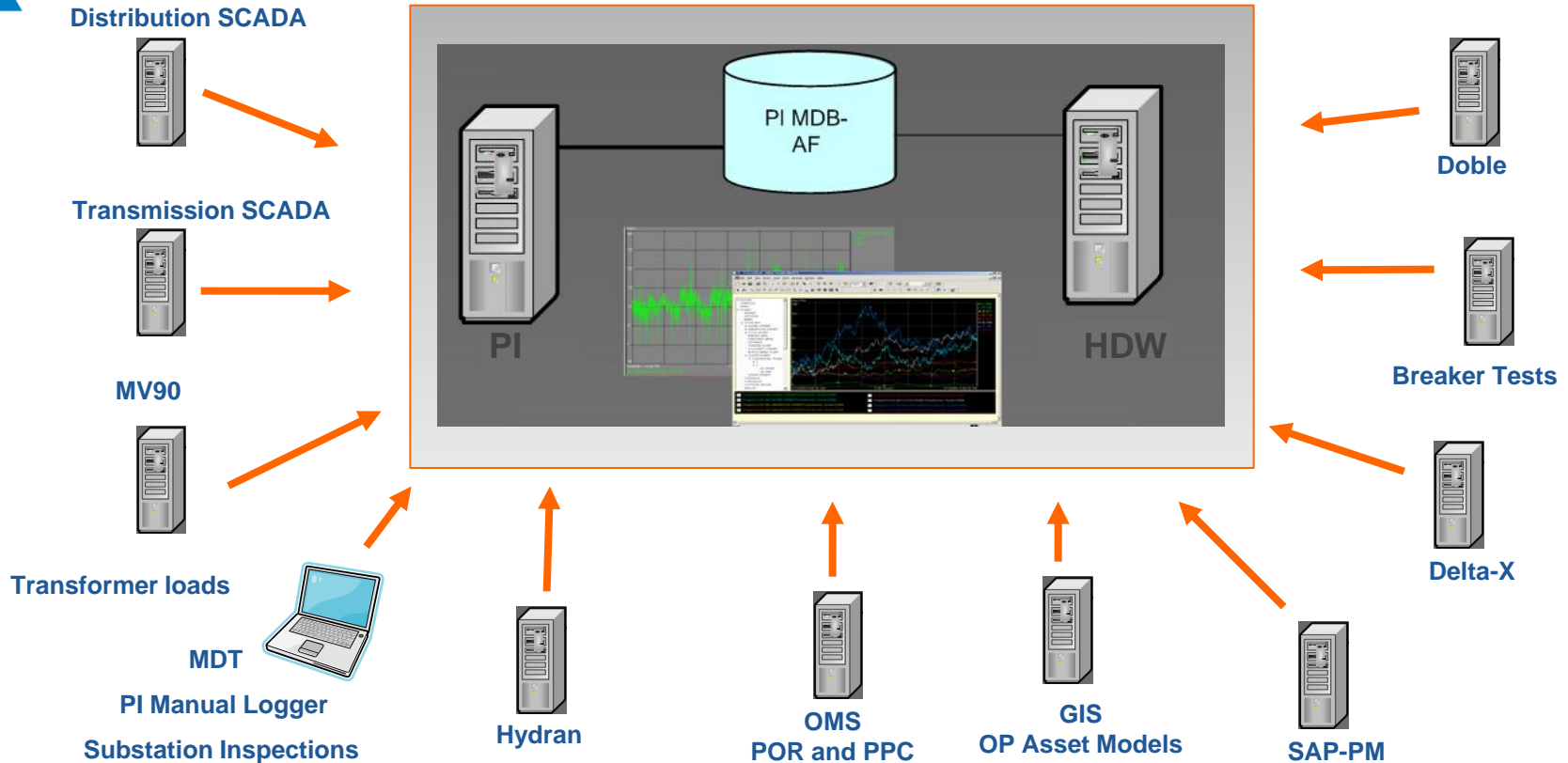


# Functional Areas of CMMS

- Data Collection and Consolidation
  - **Diagnostic and Inspection Data**
  - **Time-series Data**
  - **Relational Data**
  - **Maintenance Data**
- Asset Analysis and Reporting
  - **Condition & Criticality Assessment**
  - **Equipment Ranking**
  - **Work Priorization**
- Maintenance Management
  - **Measurement Points**
  - **Work Order Generations**
  - **Maintenance Planning**



# Consolidate Data



# Build Asset Model and Correlate Data in PI AF

**PI System Explorer - PISVRN\NWKAP565**

File Edit View Go Tools Help

Database Query Date Back Check In New Element New Attribute Search

**Elements**

- IPE
  - CE
    - ADA
      - 10H
      - 11G
      - 121G
      - 122G
      - 123G
      - 124G
      - 125G
      - 126G
      - 12G
      - 138D1
      - 138D2
      - 13G
      - 14G
      - 15G
      - 16G
      - 20H
      - 21G
      - 22G
      - 23G
      - 24G
      - 25G
      - 26G
      - 30H
      - 40H
      - COM-MEC
      - COM-RLY
      - T1
        - 00000000010503779 Circuit Switcher
        - 00000000010503783 Power Transformer
          - IPE-CE-ADA-T1 -7259B 2 Sets Trans Diff Relays - Pri and BU
          - IPE-CE-ADA-T1 -7259P Trans Diff Rly - Primary (T1)
          - IPE-CE-ADA-T1 -7261 CKT SWR Trip Checks
          - IPE-CE-ADA-T1 -7261M Main DC 1 CT CKTS

**00000000010503783 Power Transformer**

General Child Elements Attributes Ports Version

Group by: Category

Filter

Name	Value
FLOC NUMBER	IPE-CE-ADA-T1
GAL-X-1000	12.40
INST-COST	0.30
INSTALL DATE	1967/01/01
INSTR-BOOK	114
INSUL-SYSTEM	15.00
LOAD-LOSS-Kw	107.70
MANUFACTURER	WESTINGHOUSE
MAX WINDING #1 TEMP...	60
MODEL NUMBER	URT
MV90 KVAR (IN)	0
MV90 KVAR (OUT)	0
MV90 Kw	5040
MV90 VOLTS	70.184
MVA	-0.390624
MVAR	-0.52059
Mw	22.93186
NITROGEN CYLINDER P...	500
NITROGEN PRESSURE	2
NL-LOSS-KW	33.50
OIL-GALLONS	12000.00
OPER-KV	230-13
P1-NCP	Active
P1-NP	Pt Created
P1-OL	Pt Created

PI-OL

# Build Algorithms in PI AF

**PISVRNJNWKAPS65 - PI System Explorer**

File Edit View Go Tools Help

Database Query Date Back Check In New Element New Attribute Search

**Elements**

- Elements
  - NJNWKAPS65 ModuleDB
    - AF-Element-Test
      - CMMS
        - ALGORITHMS
          - CA BREAKER
            - CIRCUIT SWITCHERS - ACTION
              - GCB 138-765KV - ACTION
                - Age
                  - Operations - 12m
                  - Operations - 6m
                - GCB 26-69KV - ACTION
                - OCB 138-765KV - ACTION
                - OCB 26-69KV - ACTION
                - OTHER 26-765KV - ACTION
              - CA BREAKER - REPLACEMENT
              - CA BREAKER - REPLACEMENT - 09
              - CA LTC
              - CA LTC - REPLACEMENT
              - CA LTC1
              - CA RELAY
              - CA TRANSFORMER
              - CA TRANSFORMER - REPLACEMENT
              - CA TRANSFORMER - REPLACEMENT-OLD
              - COUNTERS
              - CRITICALITY - TRANSFORMERS
              - LTC THRU NEUTRAL
              - OH SAIFI
              - OLD
            - DEV AND TEST
            - IPE
            - CE

**Age**

General Child Elements Attributes Ports Version

Group by: Category

Filter

| Name       | Value                             |
|------------|-----------------------------------|
| Case       |                                   |
| Database   | cmms                              |
| From       | equipment                         |
| Multiplier | 0.3                               |
| select     | year(getdate())-construction_year |
| Server     | njnwksql12                        |
| Type       | DB SQL Query                      |
| Where      | equip_num=(&EQ Number)            |

Elements

Event Frames

Library

Server



# Calculation Structure

- Calculation Structure
  - $CA = F1(M1) + F2(M2) + F3(M3) + \dots$
  - Factors driven by data available
  - Example Factors
    - CM Cost & Count for Past 6 Months
    - Count of Operations for Past 6/12 Months
    - Gas Analysis Change over time
    - Average Load over Time
- Peer Groups
  - Apply calculations by peer group; Voltage, Class, Type
  - Example Groups:
    - 26KV – 69KV GCB
    - 138KV+ Power Transformer
    - LTC Vacuum Tanks

# Run Algorithms

**Equipment Condition Assessment Module**

File View Records Help

! [Save] [Print] [Find] [Help]

**Peer Group** Model 9  **Algorithm** CA LTC MODEL 1

| Score | FLOC              | EO Name                     | Description             | Serial Num |
|-------|-------------------|-----------------------------|-------------------------|------------|
| 8.41  | IPE-PA-NEW-T30    | 000000000010542736 Load Tap | Model 9/000000000001054 | A0296T     |
| 8.41  | IPE-SO-CAS-UNIT 1 | 000000000010520986 Load Tap | Model 9/000000000001052 | A117IX     |
| 8.41  | IPE-SO-SNF-4TRX   | 000000000010523972 Load Tap | Model 9/000000000001052 | ALM22911   |
| 7.51  | IPE-PA-MAY-T2     | 000000000010542731 Load Tap | Model 9/000000000001054 | 6311166    |
| 7.21  | IPE-PA-MAY-T1     | 000000000010542730 Load Tap | Model 9/000000000001054 | 6311169    |
| 7     | IPE-SO-CAS-UNIT 2 | 000000000010520987 Load Tap | Model 9/000000000001052 | A1181X     |
| 6.7   | IPE-PA-WAD-T20    | 000000000010542776 Load Tap | Model 9/000000000001054 | 6311168    |
| 6.7   | IPE-SO-THO-T1     | 000000000010524357 Load Tap | Model 9/000000000001052 | 6311165    |
| 6.4   | IPE-SO-THO-T2     | 000000000010524358 Load Tap | Model 9/000000000001052 | 6311170    |
| 6.02  | IPE-PA-WAD-T10    | 000000000010542773 Load Tap | Model 9/000000000001054 | 6311167    |
| 4.7   | IPE-SO-SCA-T2     | 000000000010523481 Load Tap | Model 9/000000000001052 | M102315    |

◀ ▶






**Scores for Individual Factors**

| Factor           | Raw Value | Case | Multiplier | Score | Error | ▲ |
|------------------|-----------|------|------------|-------|-------|---|
| Water Content    | 44        | 10   | 0.15       | 1.5   |       |   |
| CM Costs         |           | 10   | 0.05       | 0.5   |       |   |
| Oil Physical     | 2         | 3    | 0.17       | 0.51  |       |   |
| CM Count         | 0         | 0    | 0.05       | 0     |       |   |
| LTC THRU NEUTRAL | 0         | 2    | 1          | 2     |       |   |
| LTC Operations   | 578       | 10   | 0.2        | 2     |       |   |
| PM Performance   | .33       | 2    | 0.1        | 0.2   |       |   |

Ready 07/17/2002 3:26 PM

# CMMS Save helped avert an in service failure

- Excessive gassing and over heating found on 3/1/2011

| DeltaX Total Combustible Gas  |          |             |     |       |           |        |          |         |                      |
|---|----------|-------------|-----|-------|-----------|--------|----------|---------|----------------------|
| Details   | ApprType | Sample Date | CO  | H2    | Acetylene | Ethane | Ethylene | Methane | Combustible Gas      |
|  | LTC      | 04/29/2011  | 66  | 148   | 243       | 2      | 36       | 30      | 525                  |
|  | LTC      | 02/18/2011  | 175 | 14078 | 19653     | 761    | 6789     | 3273    | 44729                |
|  | LTC      | 02/16/2011  | 151 | 9888  | 19334     | 803    | 6860     | 3022    | 40058                |
|  | LTC      | 04/21/2010  | 280 | 17598 | 23836     | 655    | 6580     | 3585    | 52534                |
|  | LTC      | 06/25/2009  | 53  | 16588 | 23339     | 505    | 5100     | 3489    | 49074                |
|   |          |             |     |       |           |        |          |         | Showing 1 to 5 of 23 |

# Action and Results

- T20 LTC excessive gassing and overheating problem identified by CMMS on 3/1/2011
- Inspection showed coking contacts
- Assembly cleaned and new contacts installed
- Great find because T20 contacts would have failed when additional load was added during replacement of T10 transformer
- Conservative Failure Avoidance Cost Saving = \$1.5M
  - **LTC = \$150k cost & labor**
  - **Transformer = \$1.5M cost & labor**

## Algorithm Factors

| Factor               | Raw Value | Case Value | Weight % | Score |
|----------------------|-----------|------------|----------|-------|
| Detectable Acetylene | -277      | 0          | 25       | 0     |
| Gas Rate of Change   | -631.486  | 0          | 15       | 0     |
| High Total Gas       | 525       | 0          | 20       | 0     |
| High Water           | 23        | 0          | 10       | 0     |
| Low Dielectric       | 54.8      | 0          | 10       | 0     |
| LTC Operations       | 140       | 0          | 10       | 0     |
| LTC THRU NEUTRAL     | 0         | 0          | 10       | 0     |



# CBM Benefits

- Extremely valuable system when you have
  - You have **\$1.6B of installed assets with a replacement value of \$5.7B**
  - **Average age of the assets exceeds 40 years**
  - **All equipment is expected to be **used and useful** all the time**
  - **Maintenance expenditures erode earnings and capital replacement provides for no new revenue?**
- Justify millions of dollars in saving over past 7 years in equipment failure avoidance

# Engineering Desktop Demo

CMMS Asset Information - Engineering Desktop  
Home

## Intellicast - Washington Park Weather Report in New Jersey (07102)

| fri        | sat        | sun        | mon        | tue        | wed        | thu          | fri          | sat        | sun        |
|------------|------------|------------|------------|------------|------------|--------------|--------------|------------|------------|
| sep 16     | sep 17     | sep 18     | sep 19     | sep 20     | sep 21     | sep 22       | sep 23       | sep 24     | sep 25     |
|            |            |            |            |            |            |              |              |            |            |
| M Sunny    | P Cloudy   | P Cloudy   | Sunny      | P Cloudy   | P Cloudy   | Sct T-Storms | Sct T-Storms | P Cloudy   | AM Clouds  |
| 68°<br>51° | 70°<br>55° | 70°<br>55° | 70°<br>60° | 72°<br>63° | 78°<br>67° | 79°<br>63°   | 77°<br>61°   | 77°<br>63° | 74°<br>59° |

Web Capture last updated at 9/16/2011 8:15 AM

## CMMS Asset Information

- ▢ IPE Equipment Search
- ▢ Mechanical Work Prioritization
- ▢ IPE Equipment Characteristics
- ▢ DeltaX Gas and Fluid Tests
- ▢ Relay Work Prioritization
- ▢ ESOC System Load
- ▢ Temperature Sensitive Ratings By Circuit & Section
- ▢ Temperature Sensitive Ratings Limiting Components

## Condition Assessment Summary Reports

- ▢ Transformer Action
- ▢ LTC Action
- ▢ Breaker Action
- ▢ Circuit Switcher Action
- ▢ Transformer & LTC Action Summary
- ▢ LTC Replacement
- ▢ GCB Breaker Replacement
- ▢ GCB Breaker Replacement By Voltage
- ▢ Transformer Replacement
- ▢ LTC NEW Action
- ▢ OCB Breaker Replacement
- ▢ OCB Breaker Replacement By Voltage
- ▢ LTC New Action By Peer Group
- ▢ Other Breaker Replacement
- ▢ Open Transformer/LTC CA Orders

## Equipment/Other Reports

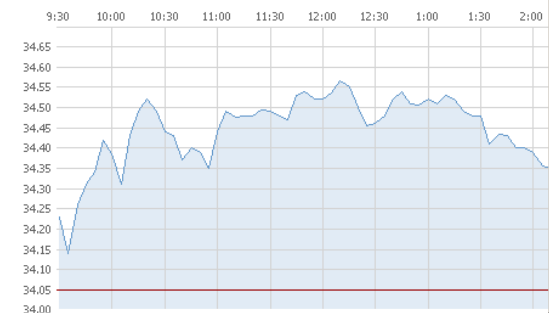
- ▢ DeltaX High Water Equipment
- ▢ DeltaX Overdue Gas Tests
- ▢ Transformer High Hydrogen
- ▢ Station Ground Tests By Division
- ▢ SAP Station List By Division
- ▢ SF6 Add Gas Total By Floc - Statewide
- ▢ LTCs Not Thru Neutral
- ▢ DeltaX LTC Gas Analysis
- ▢ CA Cooling Performance Summary

## Reports By Division

- ▢ Central Mechanical
- ▢ Central Operations
- ▢ Metro Mechanical
- ▢ Metro Operations
- ▢ Palisades Mechanical
- ▢ Palisades Operations
- ▢ Southern Mechanical
- ▢ Southern Operations



## Public Service Enterprise Group Inc (US:PEG) - Stock chart, Index



Web Capture last

## Databases

- ▢ IPE New Equipment Database (NED)
- ▢ JM Transformer Database
- ▢ CBM Orders
- ▢ IPE Breaker Codes
- ▢ CMMS Documentation & Measures

## Other Links

- ▢ Information Central
- ▢ Consolidated Manager
- ▢ PSEG Online Applications

# Summary of Worst Performing LTCs

Home Documents and Lists Create Site Settings Help

 LTC CA-Action New Summary Report

Mo

CA Records

| Details   | Division | Floc              | Floc Descr                    | Equipment          | Equip Descr                     | Score | Person            | Status                  | Manufacturer     | Type   | ApprType | Serial Number | Tin |
|---|----------|-------------------|-------------------------------|--------------------|---------------------------------|-------|-------------------|-------------------------|------------------|--------|----------|---------------|-----|
|    | SO       | IPE-SO-MAD -T2    | # 2 Transformer               | 000000000010522665 | Load Tap Changer                | 6.7   | Mark Stoughton    | Awaiting Maint.         | WESTINGHOUSE     | UTTA   | LTC      | RBP39133      | Sei |
|    | ME       | IPE-ME-SNW -1TRH  | 132-1 Transformer             | 000000000010510407 | LTC/Selector and Transfer 13 Kv | 5     | Paul Morakinyo    | No Action               | WESTINGHOUSE     | URT2   | TS       | 7001829-13    | Sei |
|    | ME       | IPE-ME-SNW -1TRH  | 132-1 Transformer             | 000000000010510410 | LTC/Selector and Transfer 26 Kv | 5     | Paul Morakinyo    | Awaiting Maint.         | WESTINGHOUSE     | URT2   | TS       | 7001829-26    | Sei |
|    | ME       | IPE-ME-SNW -3TRH  | 132-3 Transformer             | 000000000010510415 | LTC/Selector and Transfer 13 Kv | 5     | Paul Morakinyo    | No Action               | WESTINGHOUSE     | URT2   | TS       | 6537551-13    | Sei |
|    | ME       | IPE-ME-SNW -3TRH  | 132-3 Transformer             | 000000000010510418 | LTC/Selector and Transfer 26 Kv | 5     | Paul Morakinyo    | Awaiting Maint.         | WESTINGHOUSE     | URT    | TS       | 6537551-26    | Sei |
|    | CE       | IPE-CE-ADA -T1    | # 1 Transformer               | 000000000010503781 | Load Tap Changer (URT)          | 4.75  | Shirish Patel     | Awaiting Maint. Results | WESTINGHOUSE     | URT    | SS       | RAR66902      | Sei |
|    | CE       | IPE-CE-SOS -T2    | # 2 Transformer               | 000000000010503189 | Load Tap Changer (URT)          | 4.6   | Mark Stoughton    | Awaiting Maint.         | WESTINGHOUSE     | URT    | SS       | 6994649       | Sei |
|    | CE       | IPE-CE-ADA -T1    | # 1 Transformer               | 000000000010503781 | Load Tap Changer (URT)          | 4.3   | Shirish Patel     | Awaiting Maint. Results | WESTINGHOUSE     | URT    | TS       | RAR66902      | Sei |
|    | ME       | IPE-ME-SNW -2TRH  | 132-2 Transformer             | 000000000010510413 | LTC/Selector and Transfer 26 Kv | 4.25  | George            | OK                      | WESTINGHOUSE     | URT2   | TS       | 6537553-26    | Sei |
|    | CE       | IPE-CE-SOS -T2    | # 2 Transformer               | 000000000010503189 | Load Tap Changer (URT)          | 4     | Mark Stoughton    | Awaiting Maint.         | WESTINGHOUSE     | URT    | TS       | 6994649       | Sei |
|    | CE       | IPE-CE-BEN -T2    | # 2 Transformer               | 000000000010503858 | Load Tap Changer (URT)          | 4     | Mark Stoughton    | Awaiting Maint.         | WESTINGHOUSE     | URT    | TS       | RAR66905      | Sei |
|    | CE       | IPE-CE-GBK -T2    | # 2 Transformer               | 000000000010504122 | Load Tap Changer (TC 546)       | 4     | NA                |                         | FEDERAL PACIFIC  | TC546  | LTC      | 502362        | Sei |
|    | ME       | IPE-ME-LAU -T1    | # 1 Transformer               | 000000000010507675 | Load Tap Changer-Main Tank      | 4     | George Arthur     | Awaiting Maint.         | WESTINGHOUSE     | UTT    | LTC      | UGP50682      | Sei |
|    | ME       | IPE-ME-SNW -2TRH  | 132-2 Transformer             | 000000000010510411 | LTC/Selector and Transfer 13 Kv | 4     | Don Fallon        | Pending Action          | WESTINGHOUSE     | URT2   | TS       | 6537553-13    | Sei |
|    | SO       | IPE-SO-BEA -T1    | # 1 Transformer               | 000000000010520910 | Load Tap Changer                | 4     | Geoge Arthur      | Awaiting Maint.         | FEDERAL PACIFIC  | TC546  | LTC      | 502222        | Sei |
|    | SO       | IPE-SO-LAW -T1    | # 1 Transformer               | 000000000010522331 | Load Tap Changer                | 4     | NA                |                         | WESTINGHOUSE     | UTTA   | LTC      | RBP39131      | Sei |
|    | SO       | IPE-SO-MAR -T4    | # 4 Transformer               | 000000000010522900 | Load Tap Changer                | 4     | NA                |                         | GENERAL ELECTRIC | LRT65  | LTC      | F9618548      | Sei |
|    | CE       | IPE-CE-SBR -1TRH  | 220-2 Transformer             | 000000000010505100 | Load Tap Changer 220-2 26Kv     | 3.5   | Mark              | Pending Action          | MOLONEY          | SRTMHD | TS       | P670632       | Sei |
|    | SO       | IPE-SO-SLA -T1LTC | 220-1 Transformer Tap Changer | 000000000010526193 | Load Tap Changer SEL 220-1      | 3.5   | Angela Rothweiler | Awaiting Maint.         | MOLONEY          | SRTMHD | SS       | P680443       | Sei |
|    | CE       | IPE-CE-GSE -1TRH  | 220-1 Transformer             | 000000000010501563 | Load Tap Changer                | 3.25  | Mark              | Pending Action          | WESTINGHOUSE     | UTH    | TS       | 7001753       | Sei |
|    | SO       | IPE-SO-LAW -T2    | # 2 Transformer               | 000000000010522332 | Load Tap Changer                | 3.25  |                   | No Action               | FEDERAL PACIFIC  | TC546  | LTC      | 501092        | Sei |
|    | SO       | IPE-SO-MAR -T1    | # 1 Transformer               | 000000000010522897 | Load Tap Changer                | 3.25  | NA                | Awaiting Maint. Results | GENERAL ELECTRIC | LRT65  | LTC      | D596044       | Sei |
|    | CE       | IPE-CE-SPF -T1    | # 1 Transformer               | 000000000010540523 | Load Tap Changer (UTT-A)        | 3.25  |                   |                         | WESTINGHOUSE     | UTTA   | LTC      | UGP50673      | Sei |
|    | CE       | IPE-CE-SAL -4TRH  | 220-4 Transformer             | 000000000010502666 | Load Tap Changer                | 3     |                   |                         | PENNSYLVANIA     | 394    | SS       | C0407351      | Sei |
|    | CE       | IPE-CE-SBY -20TR  | 220-1 Transformer             | 000000000010502885 | Load Tap Changer                | 3     |                   |                         | GENERAL ELECTRIC | LR500  | LTC      | D572025       | Sei |
|  | CE       | IPE-CE-POH -T2    | # 2 Transformer               | 000000000010504695 | Load Tap Changer (UVT)          | 3     | Don Fallon        | 2010 Replacment         | WESTINGHOUSE     | UVT    | LTC      | SLM54093      | Sei |
|  | CE       | IPE-CE-POH -T1    | # 1 Transformer               | 000000000010503780 | Load Tap Changer                | 3     | Paul Morakinyo    | Requested Maint.        | WESTINGHOUSE     | URT    | LTC      | RAR66902      | Sei |

# SME Knowledge of Asset

| <a href="#">Home</a> <a href="#">Documents and Lists</a> <a href="#">Create</a> <a href="#">Site Settings</a> <a href="#">Help</a> |  |                |                | Up to PSEG Delivery                |
|--|--|----------------|----------------|------------------------------------|
|  Condition Assessment Remarks/Comments             |  |                |                | <a href="#">Modify Shared Page</a> |
|    |  |                |                |                                    |
| CA Comments  |  |                |                |                                    |
| Date   | Comment  | Person         | Status         | Due Date                           |
| 07/23/2008   | Request new sample   | Paul           | Pending Action | 08/23/2008                         |
| 09/03/2008   | New Sample in Delta X on Aug 7, 2008 - Score on Sept 1 was 0 (New Algorithm)   | Paul           | OK             |                                    |
| 10/08/2008   | Request physical sample for the TS and SS  | George         | Pending Action | 11/08/2008                         |
| 12/13/2008   | Reviewed moisture and based on the last fluid sample it was determined that its moisture reading was ok. Reading was 34 for fluid sample.  | George         | OK             | 01/13/2009                         |
| 01/12/2009   | New Fluid Data in Delta X for TS on 10/15/2008   | George         | Needs Review   | 01/13/2009                         |
| 01/15/2009   | New Sample generated a score of 1.9 in January of 2009 which is acceptable.  | George         | OK             |                                    |
| 07/21/2010   | AR: Refurbishment scheduled for fall, we need George to review latest gas samples taken on 6/16/2010; all gases are up from previous sample taken on 5/20/2010 and recommend action.   | George Arthur  | Pending Action |                                    |
| 08/12/2010   | AR: Review all data prior to refurbishment and plan action   | Don Fallon     | Pending Action |                                    |
| 07/23/2011   | AR: Division (Mike Duffy) checked the Newark Sw 13 & 26KV CMV's on 7/23/11. Techs tell him they are functioning correctly.   | Paul Morakinyo | No Action      | 01/01/1900                         |
| 07/23/2011   | AR: I had them raise the 13 & 26 tap changers just above its high limit, the CMV brought the tap changer back within its limit then they lowered the voltage just below the low range and the CMV brought the voltage back in range. | Paul Morakinyo | No Action      | 01/01/1900                         |
| 07/23/2011   | AR: 13kv TS and SS are not a problem, on the top of the list becuase tanks where drained and cleaned last year and gases where close to 0; gas rate of change is high because of this. All 13kv LTCs look ok.                        | Paul Morakinyo | No Action      | 01/01/1900                         |

# Algorithm Details

[Home](#)
[Documents and Lists](#)
[Create](#)
[Site Settings](#)
[Help](#)
Up to PSE&G Delivery

**LTC CA New Action Algorithm Details**
Modify Shared Page

**Nameplate**

| Online | Division | Station Code | Station     | Station Type | Floc Descr      | Equipment          | Equipment Descr  | Equipment Type | Construction Year | Serial Number | Manufacturer | Model Number |
|--------|----------|--------------|-------------|--------------|-----------------|--------------------|------------------|----------------|-------------------|---------------|--------------|--------------|
|        | Southern | MAD          | MAPLE SHADE | H            | # 2 Transformer | 000000000010522665 | Load Tap Changer | E-LTC          | 1973              | RBP39133      | WESTINGHOUSE | UTTA         |

**Content Editor Web Part**

- Equipment Home Page
- SAP Order Details
- View and Trend Equipment PI Points
- CA LTC New Action Algorithm Rules
- CA Comment History

**Algorithm Factors**

| Factor               | Raw Value | Case Value | Weight % | Score |
|----------------------|-----------|------------|----------|-------|
| Detectable Acetylene | 18        | 10         | 25       | 2.5   |
| Gas Rate of Change   | 1085.28   | 10         | 15       | 1.5   |
| High Total Gas       | 107989    | 10         | 20       | 2     |
| High Water           | 72        | 7          | 10       | 0.7   |
| Low Dielectric       | 49.1      | 0          | 10       | 0     |
| LTC Operations       | 1829      | 0          | 10       | 0     |
| LTC THRU NEUTRAL     | 0         | 0          | 10       | 0     |

**CA Score**

| Score | maxScore | Ranking(%) | Peer Group |
|-------|----------|------------|------------|
| 6.7   | 6.7      | 100        | TS+LTC     |

**RTTrend**

**DeltaX Total Combustible Gas**

| Details | ApprType | Sample Date | CO  | H2   | Acetylene | Ethane | Ethylene | Methane | Combustible Gas |
|---------|----------|-------------|-----|------|-----------|--------|----------|---------|-----------------|
|         | LTC      | 09/14/2011  | 806 | 6271 | 7047      | 13655  | 63588    | 19469   | 1.1084E+05      |
|         | LTC      | 08/26/2011  | 909 | 1979 | 1927      | 13739  | 69662    | 20494   | 1.0871E+05      |
|         | LTC      | 08/10/2011  | 792 | 3514 | 2185      | 11892  | 66163    | 23443   | 1.0799E+05      |
|         | LTC      | 06/28/2011  | 972 | 2414 | 1391      | 7082   | 36359    | 13104   | 61322           |
|         | LTC      | 06/22/2011  | 887 | 2618 | 1223      | 6725   | 34789    | 12999   | 59241           |

Showing 1 to 5 of 25

**DeltaX Water**

| Details | ApprType | Sample Date | Fluid Temp (C) | Water |
|---------|----------|-------------|----------------|-------|
|         | LTC      | 09/14/2011  | 64             | 96    |
|         | LTC      | 08/26/2011  | 47             | 68    |
|         | LTC      | 08/10/2011  |                | 72    |
|         | LTC      | 06/28/2011  | 48             | 71    |
|         | LTC      | 06/22/2011  | 47             | 75    |


Showing 1 to 5 of 25

**DeltaX Fluid**

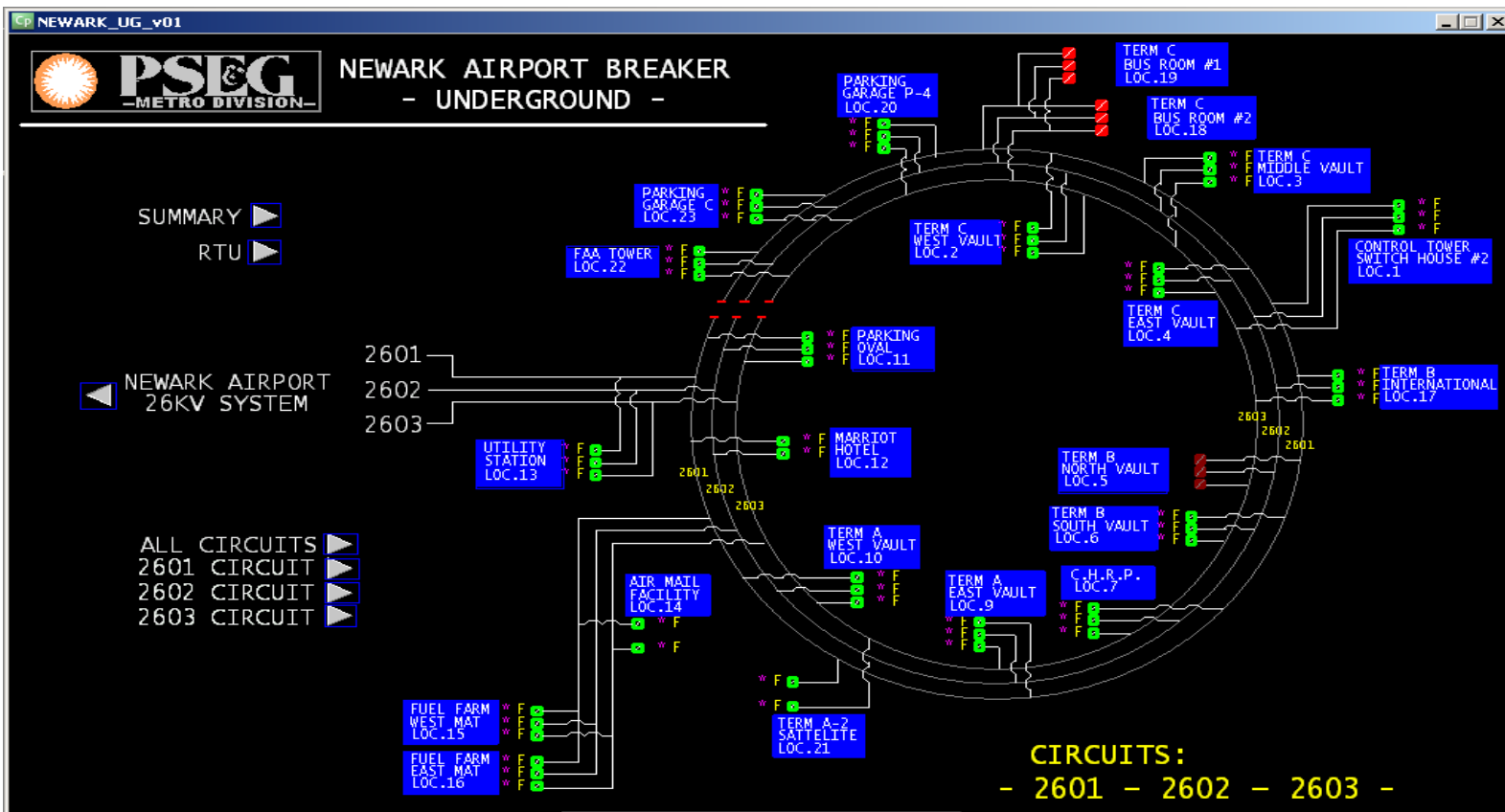
| Details | ApprType | Sample Date | Fluid Temp (C) | D877 | D1816 |
|---------|----------|-------------|----------------|------|-------|
|         | LTC      | 09/14/2011  | 64             | 31.4 |       |
|         | LTC      | 07/09/2007  |                | 49.1 |       |
|         | LTC      | 07/02/2007  |                | 48.1 |       |
|         | LTC      | 08/25/1999  |                | 49.3 |       |
|         | LTC      | 08/25/1999  |                | 50   |       |

Showing 1 to 5 of 7

# History

|  |           |             |             |                 |                     |            |       |                |       |                   |  |         |          |          |                 |       |           |         |  |       |
|--|-----------|-------------|-------------|-----------------|---------------------|------------|-------|----------------|-------|-------------------|--|---------|----------|----------|-----------------|-------|-----------|---------|--|-------|
| <div><div></div><div>DeltaX Diagnostic Data</div></div> |           |             |             |                 |                     |            |       |                |       |                   |  |         |          |          |                 |       |           |         |  |       |
| Nameplate  |           |             |             |                 |                     |            |       |                |       |                   |  |         |          |          |                 |       |           |         |  |       |
| Location   |           | Designation |             | Equipment       |                     | Serial_Num |       | Equipment Type |       | Manufacturer Year |  | Model   |          | Rated Kv |                 |       |           |         |  |       |
| COXS CORNER  |           | No. 2 LTC   |             | 100200302       |                     | 100200302  |       | LTC            |       | 2002              |  | 3 PHASE |          | 230      |                 |       |           |         |  |       |
| COXS CORNER  |           | No. 2       |             | 100200302       |                     | 100200302  |       | TRN            |       | 2002              |  | 3 PHASE |          | 230      |                 |       |           |         |  |       |
| DeltaX Fluid Test Results  |           |             |             |                 |                     |            |       |                |       |                   |  |         |          |          |                 |       |           |         |  |       |
| ApprType   | Equipment | Designation | Sample Date | Fluid Condition | IFT                 | PF25       | D1816 | D877           | PF100 | Water             | Comment  |         |          |          |                 |       |           |         |  |       |
| LTC  | 100200302 | No. 2 LTC   | 05/13/2010  | 2               | 43.3                | 0.007      |       | 48.4           |       | 25                |  |         |          |          |                 |       |           |         |  |       |
| LTC  | 100200302 | No. 2 LTC   | 03/06/2009  | 1               | 35.6                | 0.026      |       | 48.9           |       | 14                |  |         |          |          |                 |       |           |         |  |       |
| TRN  | 100200302 | No. 2       | 03/06/2009  | 1               | 42.4                | 0.046      | 40.4  |                |       | 11                | LT 8   |         |          |          |                 |       |           |         |  |       |
| TRN  | 100200302 | No. 2       | 05/19/2008  | 1               | 35.2                | 0.064      | 43.6  |                |       | 19                |  |         |          |          |                 |       |           |         |  |       |
| TRN  | 100200302 | No. 2       | 05/12/2006  |                 | 39.2                | 0.069      | 31.1  |                |       | 24                | LT 30  |         |          |          |                 |       |           |         |  |       |
| LTC  | 100200302 | No. 2 LTC   | 12/07/2005  | 1               | 48.5                | 0.027      |       | 51.7           |       | 15                |  |         |          |          |                 |       |           |         |  |       |
| LTC  | 100200302 | No. 2 LTC   | 10/17/2005  | 2               | 48.5                | 0.027      |       | 50             |       | 21                | LT 20  |         |          |          |                 |       |           |         |  |       |
| LTC  | 100200302 | No. 2 LTC   | 10/03/2005  | 2               | 39.3                | 0.057      |       | 53.7           |       | 27                | LT 28  |         |          |          |                 |       |           |         |  |       |
| LTC  | 100200302 | No. 2 LTC   | 06/10/2004  | 1               | 37.9                | 0.058      |       | 53.4           |       | 12                | LT 32 > 16036 > 6050 > 1471 > 214 > 20 > 1   |         |          |          |                 |       |           |         |  |       |
| TRN  | 100200302 | No. 2       | 06/10/2004  | 1               | 38.2                | 0.048      | 37.5  |                |       | 9                 | LT 32 . > 3 16710 > 5 7512 > 10 1897 > 20 253 > 50 13 > 100 1  |         |          |          |                 |       |           |         |  |       |
| LTC  | 100200302 | No. 2 LTC   | 04/23/2004  | 2               | 31.5                | 0.034      |       | 53.7           |       | 30                |  |         |          |          |                 |       |           |         |  |       |
| TRN  | 100200302 | No. 2       | 04/23/2004  | 2               | 32.5                | 0.032      | 33.1  |                |       | 30                |  |         |          |          |                 |       |           |         |  |       |
| LTC  | 100200302 | No. 2 LTC   | 12/02/2002  | 1               | 39.2                | 0.038      |       | 53.6           |       | 3                 |  |         |          |          |                 |       |           |         |  |       |
| TRN  | 100200302 | No. 2       | 12/02/2002  | 1               | 39.3                | 0.035      | 37.1  |                |       | 2                 |  |         |          |          |                 |       |           |         |  |       |
| LTC  | 100200302 | No. 2 LTC   | 08/20/2002  | 1               | 38.3                | 0.042      |       | 49.7           |       | 18                |  |         |          |          |                 |       |           |         |  |       |
| TRN  | 100200302 | No. 2       | 08/20/2002  | 1               | 41.6                | 0.019      | 35    |                |       | 16                | >3 microns= 8956 >5 microns= 4291 >10 microns= 1429 >20 microns= 275 >50 microns= 12 >100 microns= 0 |         |          |          |                 |       |           |         |  |       |
| DeltaX Gas Test Results  |           |             |             |                 |                     |            |       |                |       |                   |  |         |          |          |                 |       |           |         |  |       |
| ApprType   | Equipment | Designation | Sample Date | Fluid Temp (C)  | Equipment Condition | CO         | CO2   | N2             | H2    | O2                | Acetylene  | Ethane  | Ethylene | Methane  | Combustible Gas | Water | Total Gas | Comment | Sam  |       |
| LTC  | 100200302 | No. 2 LTC   | 06/21/2011  | 32              | 1                   | 8          | 241   | 85411          |       | 25                | 13059  | 12      | 8        | 23       | 13              | 89    | 22        | 0.09    | LT=32 ; RS=24.5% Repaired LTC Mechanism MARK | ED FC |
| LTC  | 100200302 | No. 2 LTC   | 06/16/2011  | 45              | 4                   | 714        | 4041  | 68288          |       | 2527              | 8079   | 602     | 9835     | 37887    | 22427           | 73992 | 50        | 47.923  | LT=45 ; RS=34.4%                             | ED FC |
| LTC  | 100200302 | No. 2 LTC   | 05/02/2011  | 40              | 4                   | 783        | 3017  | 72063          |       | 1503              | 5775   | 554     | 2208     | 11909    | 6988            | 23945 | 34        | 22.849  | LT=40 ; RS=28.0%                             | CURT  |
| TRN  | 100200302 | No. 2       | 05/02/2011  | 40              | 1                   | 51         | 1269  | 93781          |       | 0                 | 1232   | 0       | 10       | 35       | 22              | 118   | 4         | 0.123   | LT=40 ; RS=3.3%                              | CURT  |
| LTC  | 100200302 | No. 2 LTC   | 09/29/2010  | 4               |                     | 24         | 711   | 76895          |       | 66                | 28256  | 325     | 10       | 80       | 33              | 538   | 20        | 0.506   | LT=N/A ; RS=N/A                              | ED FC |
| LTC  | 100200302 | No. 2 LTC   | 08/26/2010  | 4               |                     | 33         | 697   | 81607          |       | 101               | 27901  | 311     | 12       | 87       | 52              | 596   | 31        | 0.537   | LT=N/A ; RS=N/A                              | ED FC |
| LTC  | 100200302 | No. 2 LTC   | 07/29/2010  | 50              | 4                   | 35         | 706   | 1.0478E+05     |       | 217               | 39806  | 297     | 13       | 86       | 58              | 706   | 35        | 0.484   | LT=50 ; RS=20.2%                             | ED FC |
| LTC  | 100200302 | No. 2 LTC   | 07/13/2010  | 42              | 4                   | 21         | 599   | 73841          |       | 161               | 33114  | 155     | 10       | 59       | 40              | 446   | 37        | 0.413   | LT=42 ; RS=28.3%                             | ED FC |
| LTC  | 100200302 | No. 2 LTC   | 06/28/2010  | 53              | 2                   | 11         | 507   | 74683          |       | 19                | 32734  | 14      | 5        | 18       | 10              | 77    | 36        | 0.071   | LT=53 ; RS=18.7% ; Processed oil             | CURT  |

# Expanding CMMS to 26kv Underground Networks





# Benefits

- Provides system visibility
- Provides control and indication
- Identifies fault location
- Provide pattern recognition for fault types
- Provides Condition Assessment for transformers and network protector
- Remote access to network relays for settings and validation.



# Philosophy

- Install redundant fiber communications to all vaults
- Install sensors in all man-holes
  - Detecting water
  - Fault detection
- Design and replace all network relays
  - Microprocessor relays
  - Dual ported for remote setting changes.



# Installation

- Completed 5 Networks
  - Newark Airport
  - Newark Downtown
  - Paterson
  - Trenton
  - New Brunswick
- Length of Project was 2 years
- Installed 213 new Remote Terminal Units
- Integrated 441 pieces of equipment (transformers, protectors and relays)
- Installed 200,000' or 38 miles of fiber
- Created close to 40k new PI Points



# PI ACE Notifications/Alarms

- Understand data before building CBM algorithms
- Learn data through notifications and alarms
- Current PI ACE Notifications sent to Engineers
  - Protectors Excessive Operations > 50 ops/week
  - KVA 100% of nameplate ratings
  - Protector Temperatures > 120° C
  - Transformer Pressure Drop > 2 PSI
  - Protector Case Pressure Drop > 3 PSI
  - Failed to operate – new alarm created in relay to eliminate nuisance alarms; breaker is open and relay calling for a close gets no response in 5 seconds alarm is triggered
  - Fault Detector
- Notification and Alarm summaries are emailed to engineers



# PI ProcessBook Displays

- Summary & Calculation Displays
  - Protector Backfeed PI Calculations
  - Vault Summary
  - KVA Summary
- Displays reside in sharepoint
  - Accessible via the PI TreeView web part
  - Displayed in PI Graphic web part
- Eliminate need to have process book on installed on engineers desktop

# Vault Summary KVA, Amps and Status

## Newark Airport Vault Summary

Data as of: 9/6/2011 4:20:08 PM

|                                 | NWP status |      |      | XFMR kVA | I(FL) AMPS | 2601 Amps |      |      | 2602 Amps |      |      | 2603 Amps |      |      | kVA  |      |      |
|---------------------------------|------------|------|------|----------|------------|-----------|------|------|-----------|------|------|-----------|------|------|------|------|------|
|                                 | 2601       | 2602 | 2603 |          |            | A         | B    | C    | A         | B    | C    | A         | B    | C    | 2601 | 2602 | 2603 |
| Loc 01 Tower Switch House       | ■          | ■    | ■    | 1500     | 1804       | 60        | 66   | 78   | 0         | 0    | 0    | 54        | 60   | 72   | 57   | 0    | 52   |
| Loc 02 Terminal C West          | ■          | ■    | ■    | 2000     | 2406       | 1236      | 1212 | 1152 | 1206      | 1206 | 1146 | 1248      | 1194 | 1116 | 960  | 948  | 949  |
| Loc 03 Terminal C Middle        | ■          | ■    | ■    | 2000     | 2406       | 1236      | 1290 | 1158 | 1218      | 1122 | 1128 | 1320      | 1356 | 1272 | 1004 | 906  | 1033 |
| Loc 04 Terminal C East          | ■          | ■    | ■    | 2000     | 2406       | 906       | 930  | 846  | 888       | 882  | 774  | 720       | 822  | 750  | 715  | 679  | 614  |
| Loc 05 Terminal B North         | ■          | ■    | ■    | 2500     | 3007       | 854       | 854  | 805  | 868       | 861  | 805  | 791       | 819  | 763  | 694  | 692  | 653  |
| Loc 06 Terminal B South         | ■          | ■    | ■    | 2500     | 3007       | 588       | 588  | 574  | 539       | 581  | 560  | 539       | 588  | 595  | 470  | 510  | 465  |
| Loc 07 CHRP                     | ■          | ■    | ■    | 2000     | 2406       | 372       | 342  | 330  | 0         | 0    | 0    | 318       | 306  | 312  | 288  | 0    | 262  |
| No location #8                  |            |      |      |          |            |           |      |      |           |      |      |           |      |      |      |      |      |
| Loc 09 Terminal A East          | ■          | ■    | ■    | 2000     | 2406       | 492       | 516  | 510  | 498       | 510  | 474  | 594       | 570  | 540  | 403  | 400  | 456  |
| Loc 10 Terminal A West          | ■          | ■    | ■    | 2000     | 2406       | 714       | 684  | 642  | 612       | 600  | 594  | 720       | 678  | 630  | 548  | 679  | 546  |
| Loc 11 Parking Oval             | ■          | ■    | ■    | 750      | 902        | 41        | 38   | 36   | 31        | 31   | 31   | 41        | 41   | 38   | 28   | 22   | 29   |
| Loc 12 Marriott Hotel           | ■          | ■    | ■    | 1500     | 1804       | 465       | 455  | 455  | 500       | 480  | 490  |           |      |      | 380  | 403  |      |
| Loc 13 Utility Station 197      | ■          | ■    | ■    | 750      | 902        | 54        | 54   | 42   | 58        | 64   | 51   | 58        | 54   | 48   | 40   | 46   | 42   |
| Loc 14 Air Mail Facility        | ■          | ■    | ■    | 750      | 902        | 0         | 0    | 0    |           |      |      | 0         | 0    | 0    | 0    |      | 0    |
| Loc 15 Fuel Farm West 196       | ■          | ■    | ■    | 750      | 902        | 99        | 96   | 86   | 89        | 86   | 79   | 77        | 77   | 80   | 72   | 63   | 61   |
| Loc 16 Fuel Farm East 196       | ■          | ■    | ■    | 1500     | 1804       | 70        | 65   | 65   | 70        | 75   | 70   | 65        | 60   | 65   | 56   | 57   | 52   |
| Loc 17 Terminal B International | ■          | ■    | ■    | 2000     | 2406       | 816       | 834  | 792  | 840       | 846  | 792  | 834       | 870  | 804  | 705  | 681  | 679  |
| Loc 18 Terminal C-3 Bus Room 2  | ■          | ■    | ■    | 2000     | 2406       | 678       | 666  | 690  | 708       | 666  | 672  | 708       | 672  | 678  | 576  | 576  | 584  |
| Loc 19 Terminal C-3 Bus Room 1  | ■          | ■    | ■    | 2000     | 2406       | 696       | 606  | 648  | 702       | 732  | 606  | 666       | 612  | 624  | 553  | 574  | 539  |
| Loc 20 Parking Garage P-4       | ■          | ■    | ■    | 750      | 902        | 145       | 155  | 150  | 160       | 150  | 140  | 165       | 175  | 160  | 128  | 129  | 143  |
| Loc 21 Terminal A-2 Satellite   | ■          | ■    | ■    | 1000     | 1203       | 202       | 186  | 205  |           |      |      | 205       | 186  | 198  | 169  |      | 168  |
| Loc 22 FAA Tower                | ■          | ■    | ■    | 750      | 902        | 110       | 125  | 115  | 105       | 100  | 95   | 90        | 96   | 90   | 101  | 85   | 79   |
| Loc 23 Parking Garage C         | ■          | ■    | ■    | 750      | 902        | 180       | 180  | 140  | 185       | 185  | 145  | 185       | 170  | 135  | 144  | 147  | 139  |

# Protector Backfeed

## Newark Airport Backfeed Analysis

|                                 | NWP status |      |      | Backfeed Status |      |      | 2601 Amps |      |      | 2602 Amps |      |      | 2603 Amps |      |      | 2601 Phase Angle |     |     | 2602 Phase Angle |     |      | 2603 Phase Angle |     |     |
|---------------------------------|------------|------|------|-----------------|------|------|-----------|------|------|-----------|------|------|-----------|------|------|------------------|-----|-----|------------------|-----|------|------------------|-----|-----|
|                                 | 2601       | 2602 | 2603 | 2601            | 2602 | 2603 | A         | B    | C    | A         | B    | C    | A         | B    | C    | A                | B   | C   | A                | B   | C    | A                | B   | C   |
| Loc 01 Tower Switch House       | ■          | ■    | ■    | ●               | ●    | ●    | 60        | 66   | 78   | 0         | 0    | 0    | 54        | 60   | 72   | -24              | -9  | -19 | 61               | -27 | -113 | -19              | 3   | -10 |
| Loc 02 Terminal C West          | ■          | ■    | ■    | ●               | ●    | ●    | 1236      | 1212 | 1152 | 1206      | 1206 | 1146 | 1248      | 1194 | 1116 | -32              | -34 | -32 | -32              | -33 | -33  | -32              | -34 | -32 |
| Loc 03 Terminal C Middle        | ■          | ■    | ■    | ●               | ●    | ●    | 1236      | 1290 | 1158 | 1218      | 1122 | 1128 | 1320      | 1356 | 1272 | -33              | -34 | -33 | -35              | -41 | -35  | -33              | -35 | -35 |
| Loc 04 Terminal C East          | ■          | ■    | ■    | ●               | ●    | ●    | 906       | 930  | 846  | 888       | 882  | 774  | 720       | 822  | 750  | -30              | -34 | -34 | -30              | -33 | -35  | -38              | -40 | -46 |
| Loc 05 Terminal B North         | ■          | ■    | ■    | ●               | ●    | ●    | 854       | 854  | 805  | 868       | 861  | 805  | 791       | 819  | 763  | -34              | -35 | -36 | -33              | -34 | -35  | -33              | -35 | -37 |
| Loc 06 Terminal B South         | ■          | ■    | ■    | ●               | ●    | ●    | 588       | 588  | 574  | 539       | 581  | 560  | 539       | 588  | 595  | -27              | -28 | -30 | -32              | -34 | -38  | -33              | -34 | -37 |
| Loc 07 CHRP                     | ■          | ■    | ■    | ●               | ●    | ●    | 372       | 342  | 330  | 0         | 0    | 0    | 318       | 306  | 312  | -4               | -3  | 1   | 32               | 177 | 15   | -10              | -11 | -4  |
| No location #8                  |            |      |      |                 |      |      |           |      |      |           |      |      |           |      |      |                  |     |     |                  |     |      |                  |     |     |
| Loc 09 Terminal A East          | ■          | ■    | ■    | ●               | ●    | ●    | 492       | 516  | 510  | 498       | 510  | 474  | 594       | 570  | 540  | -40              | -42 | -40 | -37              | -37 | -35  | -34              | -36 | -30 |
| Loc 10 Terminal A West          | ■          | ■    | ■    | ●               | ●    | ●    | 714       | 684  | 642  | 612       | 600  | 594  | 720       | 678  | 630  | -33              | -35 | -34 | -30              | -33 | -35  | -36              | -35 | -33 |
| Loc 11 Parking Oval             | ■          | ■    | ■    | ●               | ●    | ●    | 41        | 38   | 36   | 31        | 31   | 31   | 41        | 41   | 38   | -37              | -44 | -34 | -19              | -30 | -20  | -39              | -44 | -36 |
| Loc 12 Marriott Hotel           | ■          | ■    | ■    | ●               | ●    | ●    | 465       | 455  | 455  | 500       | 480  | 490  |           |      |      | -32              | -33 | -26 | -48              | -42 | -41  |                  |     |     |
| Loc 13 Utility Station 197      | ■          | ■    | ■    | ●               | ●    | ●    | 54        | 54   | 42   | 58        | 64   | 51   | 58        | 54   | 48   | -23              | -30 | -30 | -14              | -30 | -24  | -30              | -32 | -33 |
| Loc 14 Air Mail Facility        | ■          | ■    | ■    | ●               | ●    | ●    | 0         | 0    | 0    |           |      |      | 0         | 0    | 0    | 176              | 168 | 165 |                  |     |      | -59              | -37 | -63 |
| Loc 15 Fuel Farm West 196       | ■          | ■    | ■    | ●               | ●    | ●    | 99        | 96   | 86   | 89        | 86   | 79   | 77        | 77   | 80   | -31              | -34 | -32 | -29              | -31 | -31  | -30              | -29 | -30 |
| Loc 16 Fuel Farm East 196       | ■          | ■    | ■    | ●               | ●    | ●    | 70        | 65   | 65   | 70        | 75   | 70   | 65        | 60   | 65   | -31              | -27 | -27 | -31              | -33 | -29  | -32              | -29 | -26 |
| Loc 17 Terminal B International | ■          | ■    | ■    | ●               | ●    | ●    | 816       | 834  | 792  | 840       | 846  | 792  | 834       | 870  | 804  | -39              | -39 | -36 | -41              | -39 | -36  | -21              | -19 | -15 |
| Loc 18 Terminal C-3 Bus Room 2  | ■          | ■    | ■    | ●               | ●    | ●    | 678       | 666  | 690  | 708       | 666  | 672  | 708       | 672  | 678  | -26              | -24 | -25 | -27              | -26 | -24  | -28              | -29 | -26 |
| Loc 19 Terminal C-3 Bus Room 1  | ■          | ■    | ■    | ●               | ●    | ●    | 696       | 606  | 648  | 702       | 732  | 606  | 666       | 612  | 624  | -23              | -28 | -18 | -16              | -21 | -16  | -23              | -30 | -24 |
| Loc 20 Parking Garage P-4       | ■          | ■    | ■    | ●               | ●    | ●    | 145       | 155  | 150  | 160       | 150  | 140  | 165       | 175  | 160  | -12              | -12 | -13 | -13              | -15 | -10  | -9               | -8  | -10 |
| Loc 21 Terminal A-2 Satellite   | ■          | ■    | ■    | ●               | ●    | ●    | 202       | 186  | 205  |           |      |      | 205       | 186  | 198  | -28              | -30 | -24 |                  |     |      | -28              | -31 | -24 |
| Loc 22 FAA Tower                | ■          | ■    | ■    | ●               | ●    | ●    | 110       | 125  | 115  | 105       | 100  | 95   | 90        | 96   | 90   | -39              | -38 | -40 | -40              | -46 | -42  | -33              | -42 | -44 |
| Loc 23 Parking Garage C         | ■          | ■    | ■    | ●               | ●    | ●    | 180       | 180  | 140  | 185       | 185  | 145  | 185       | 170  | 135  | -22              | -24 | -29 | -19              | -21 | -28  | -21              | -20 | -28 |

■ = Closed  
■ = Open

● = Normal Operation  
● = Open Breaker

Refreshes every minute  
Backfeed Calculation done every 10 minutes



# Questions

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- 973-303-8899



Thank you