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# PSE&G Condition-Based Maintenance with OSI Technologies

*OSI 2002 Users Conference*

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# Introduction

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- Provide overview of PSE&G's condition-based maintenance project
- Discuss project, system architecture, implementation details
- Review some lessons learned

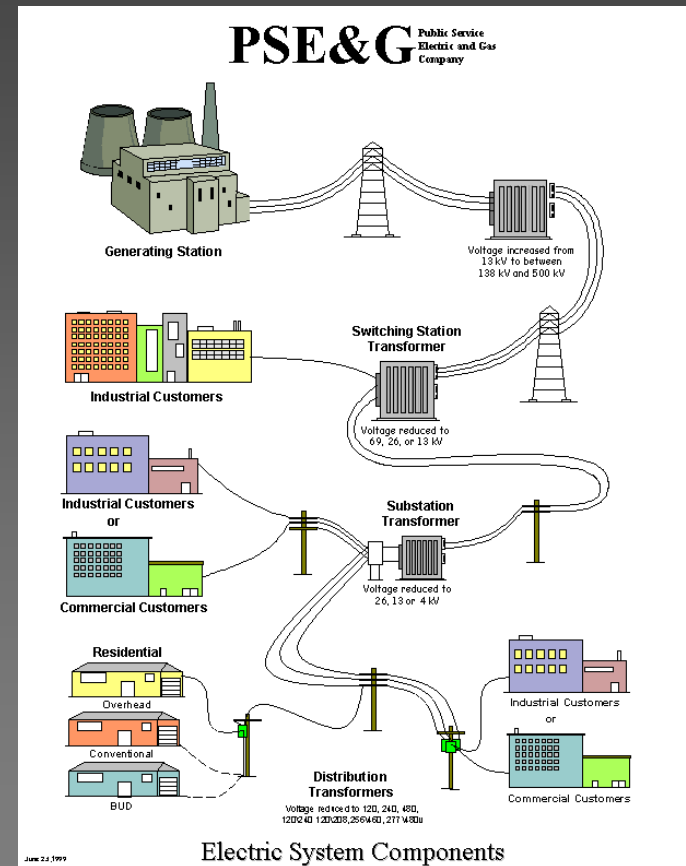
# Background

- PSE&G is one of the largest combined electric and gas companies in the nation
- PSE&G currently serves about  $\frac{3}{4}$  of the population of New Jersey across a 2,600 square mile service area
- Recent implementation of SAP PM (last 2 years)
- Computer Aided Dispatch via RF project

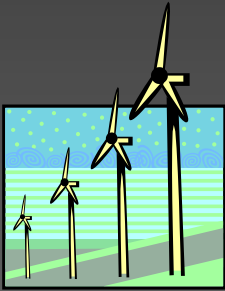


# Background

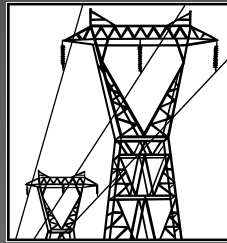
- This project focused on the electrical transmission and distribution (T&D) arm of the Delivery organization
- Primary assets are large transformers and breakers
- Market deregulation
- PSE&G experience with OSI technologies in other business areas



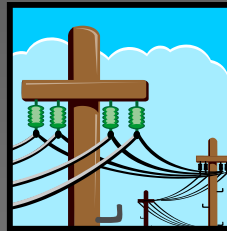
# Where Electricity Comes From



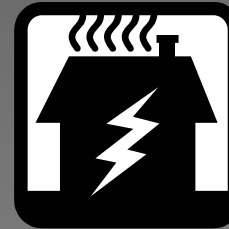
Generation



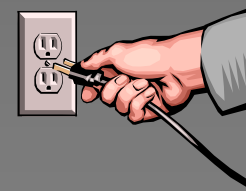
Transmission



Distribution



Household



Outlet

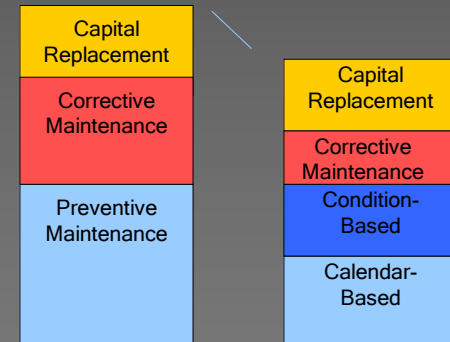
# Project Overview

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## ➤ Business Drivers

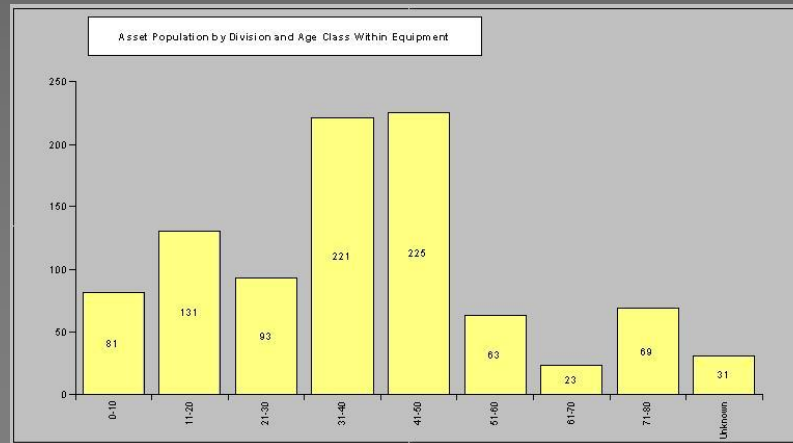
- Determination of asset health to focus maintenance activities
- Provide an analysis platform for engineering activities
- Perform condition-based maintenance
- ROI in < 3 years



# Project Overview

## ➤ Motivational Factors

- Increased reliance on aging assets
- Information on asset health in a variety of systems
- Expensive replacement projects
- Retention of expertise



# Project Scope

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- Asset Scope - T&D Substation
  - Transformers
  - Breakers
  - Related Equipment (Relays, LTC, etc)
- Work Process Scope
  - Substation Inspections
  - Diagnostic Data Collection
  - Preventive Maintenance Prioritization



# Project Scope

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## ➤ System Interfaces

- SAP PM historical data
- SAP PM measurement documents (RLINK)
- Transmission SCADA (PI-to-PI)
- Distribution SCADA (ETL & PI Batch)
- MV-90 Load Monitoring (ETL & PI Batch)
- Lab Systems – DeltaX & Doble (ETL & PI Batch)

## ➤ Condition Assessment

- Equation Builder
- Diagnostic Displays

# Project Scope

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- Condition-Based Maintenance Analysis
  - Counter-based Conditions
  - Volume Additions
  - Condition Indicator
- Maintenance Program Effectiveness
  - Asset Cost Profile
  - Asset Maintenance Profile (performance)
  - Failure Code Analysis
  - Key Performance Indicators

# Functional Areas

## ➤ Data Collection

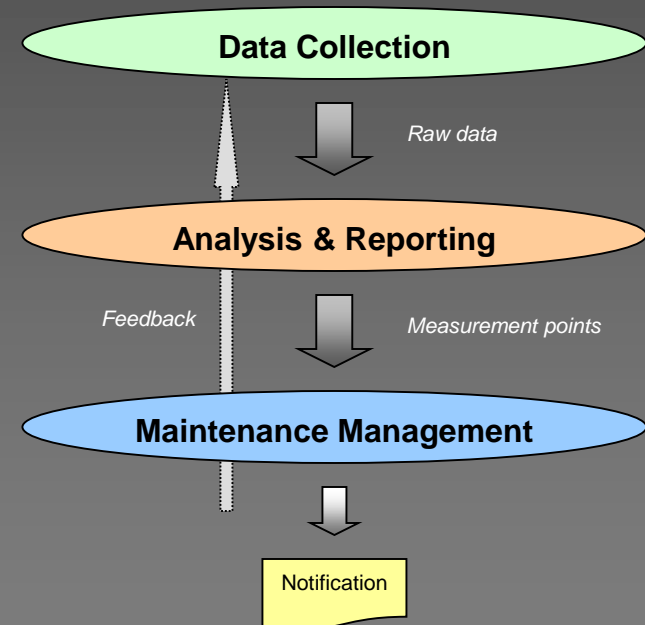
- Remote Time-Series Data Collection Application
- Diagnostic and Inspection Data
- Automated Interfaces
- SAP Data Collection

## ➤ Asset Analysis and Reporting

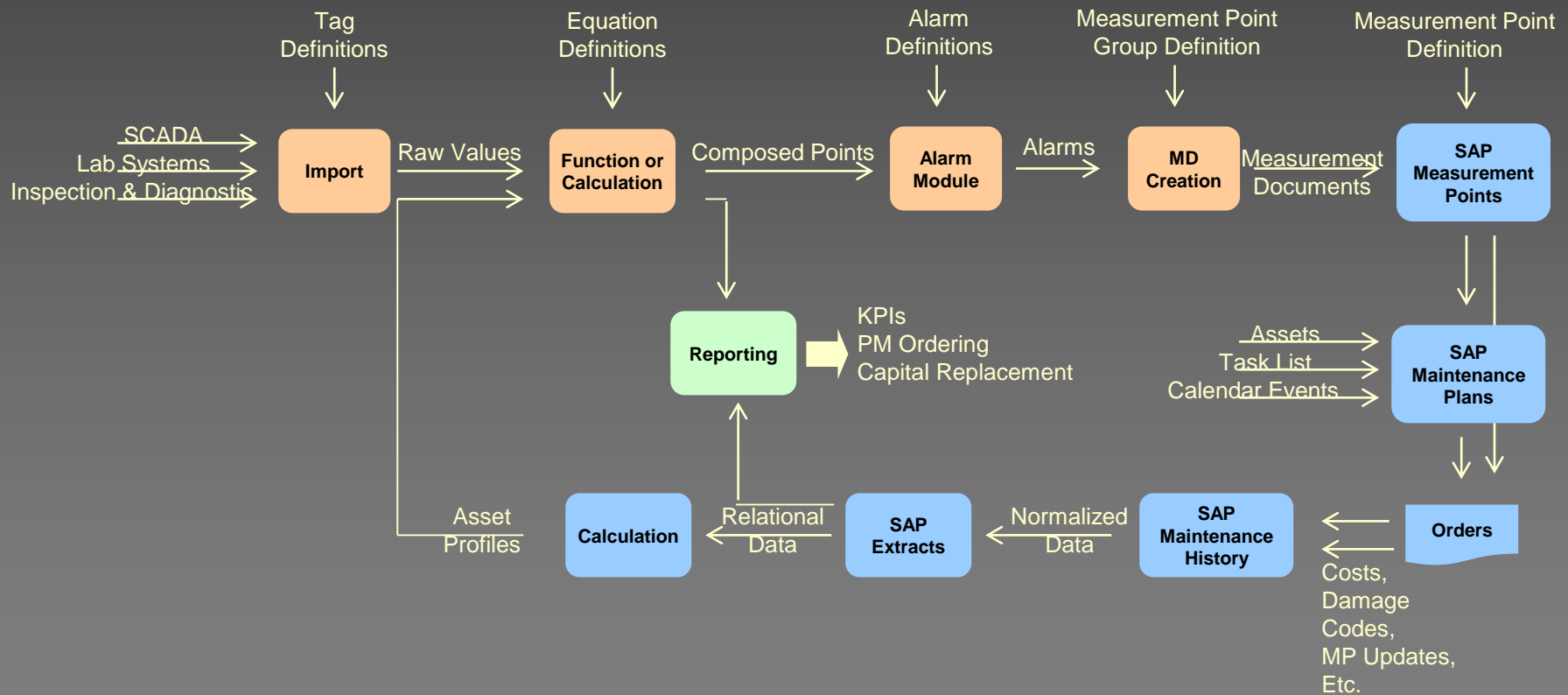
- Condition Assessment
- Preventive Maintenance Ranking
- Reports

## ➤ Maintenance Management

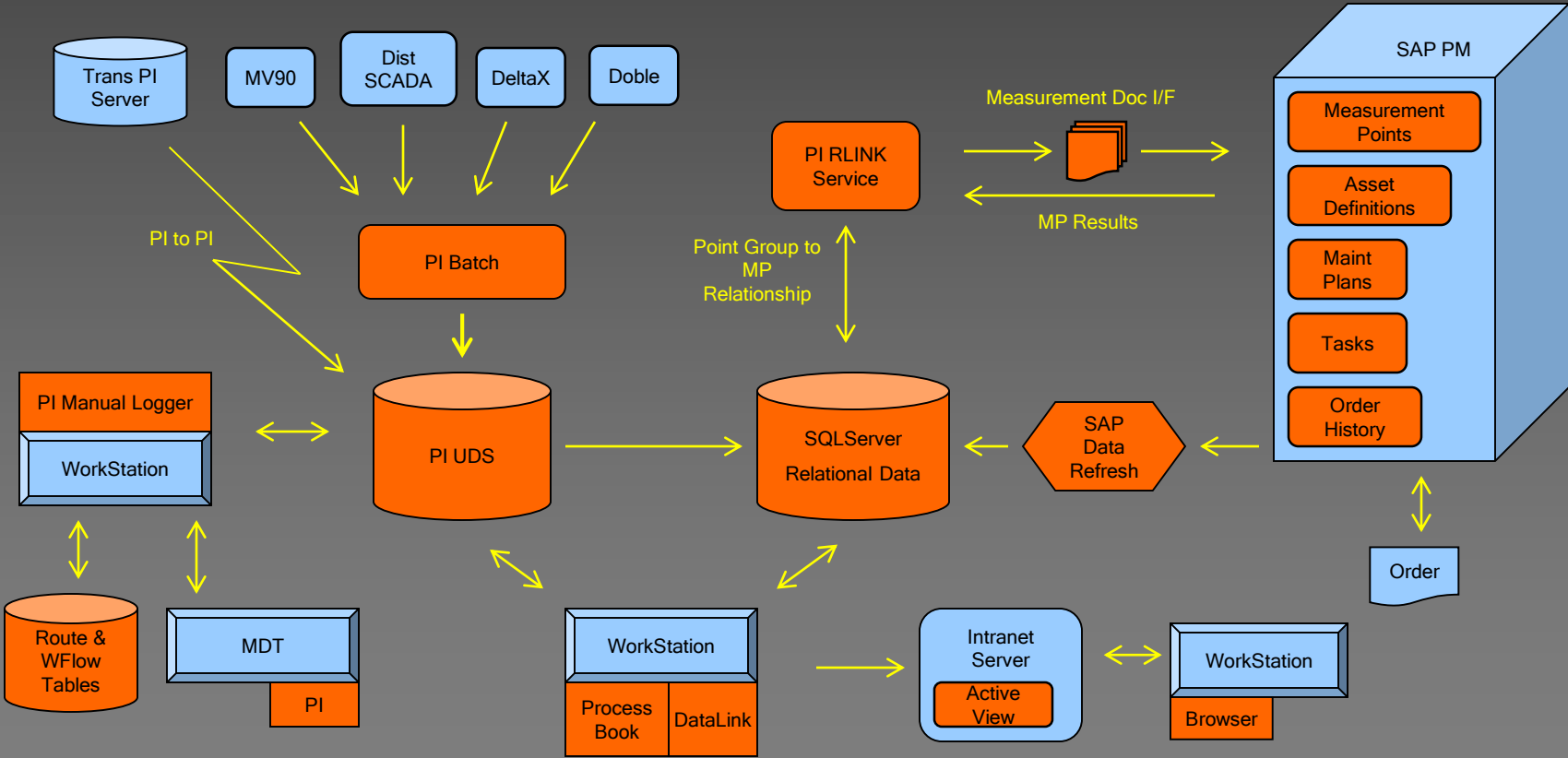
- Measurement Points
- Maintenance Plan Modifications



# System Model



# Conceptual Design



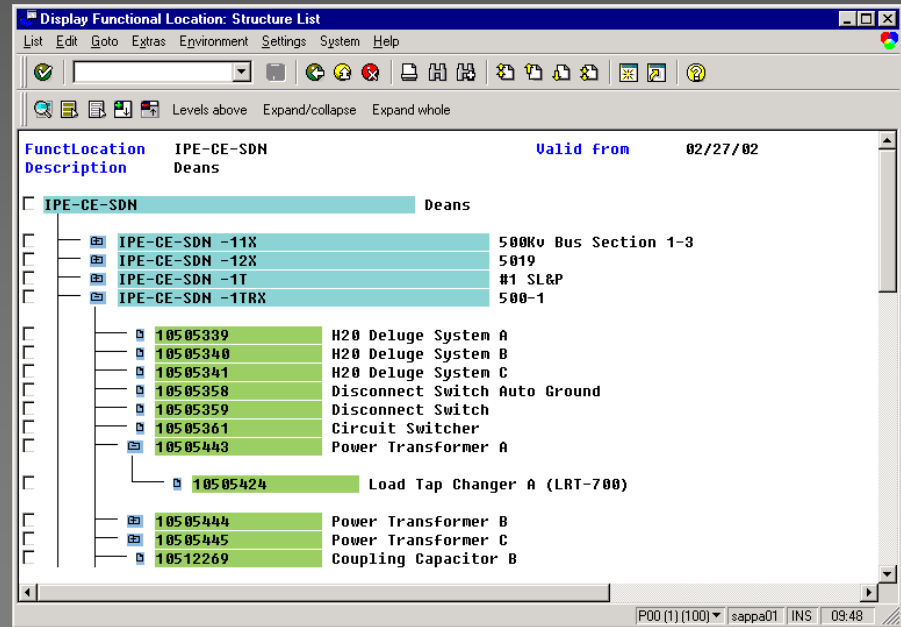
## PM Equipment Hierarchy

Functional Location Substation

└─ Functional Location Transformer Pad

└─ Equipment Transformer

└─ Equipment LTC



# SAP MP Overview

- Measurement Point Types
  - Qualitative (“Real Hot”)
  - Quantitative (> 220°F)
- Measurement Point Definition
  - Type
  - Association
  - Unit of Measure
- Measurement Document
  - Absolute vs. Differential
  - Notification Generation

The screenshot shows the 'Display Measuring Point: General Data' window in SAP. The window title is 'Display Measuring Point: General Data'. The menu bar includes 'Measuring points', 'Edit', 'Goto', 'Extras', 'Environment', 'System', and 'Help'. The main content area displays the following data:

Measuring point	9860	Cat.	IPE Quantitative
MeasPosition	LTC105336430PS		
Description	Load Tap Changer 1 (UTT-A)		
Equipment	10533643		
Description	Load Tap Changer 1 (UTT-A)		

**General data**

Characteristic	E-OPERATION-COUNTER	<input type="checkbox"/> Operation Counter	
CharactUnit	Ctrs	Operation Counter	
Decimal places	0	FloatPointExp	<input type="checkbox"/> MeasPoint is counter
Code group			
Assembly			
AuthorGroup			
MeasReadTransf.	<input type="checkbox"/> Desirable	Transfer of	

**Counter data**

CreOverReadg	1000	Ctrs	<input type="checkbox"/> Count backwards
AnnusEstimate	2000		
Text			

At the bottom right, the status bar shows 'P00 (1) (100) | sapapp01 | INS | 15:32'.

The screenshot shows the 'Display Measurement Document: General Data' window in SAP. The window title is 'Display Measurement Document: General Data'. The menu bar includes 'Measurement document', 'Edit', 'Goto', 'Extras', 'Environment', 'System', and 'Help'. The main content area displays the following data:

MeasDocument	153330		
Measuring point	9860	Cat.	IPE Quantitative
MeasPosition	LTC105336430PS		
Equipment	10533643		
Description	Load Tap Changer 1 (UTT-A)		

**Document data**

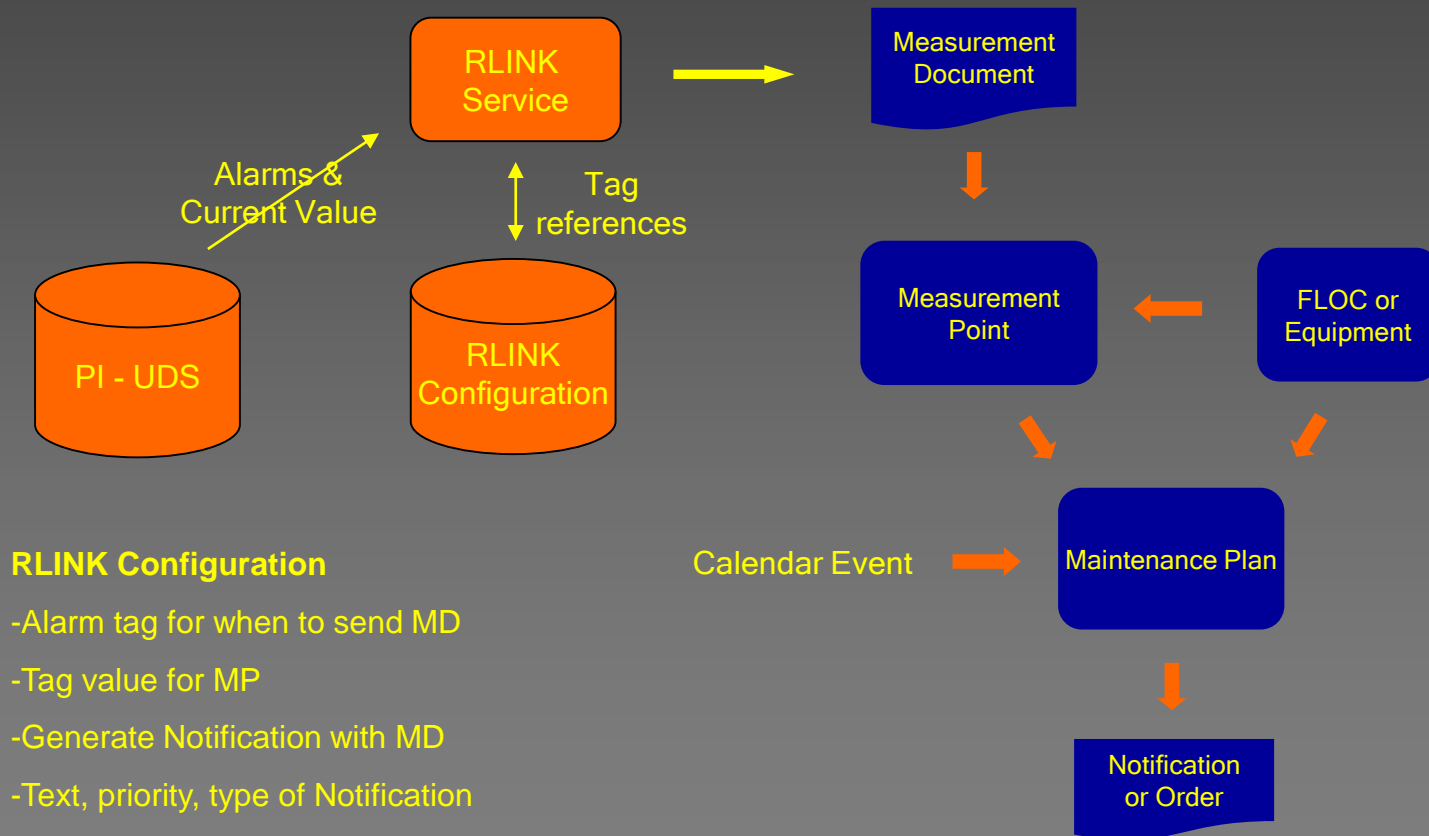
MeasurementTime	07/01/2001 / 12:00:00	<input type="checkbox"/> Documented after task
Characteristic	E-OPERATION-COUNTER	Operation Counter
CharactUnit	Ctrs	Operation Counter
Counter reading	376	
Difference	342376	<input type="checkbox"/> Difference entered
TotalCtReading	342376	
Valuation code		
Text		

**Detailed information**

Read by	PSEAR
ProcessStatus	<input type="checkbox"/>

At the bottom right, the status bar shows 'P00 (1) (100) | sapapp01 | INS | 09:17'.

# SAP PM - RLINK Interface





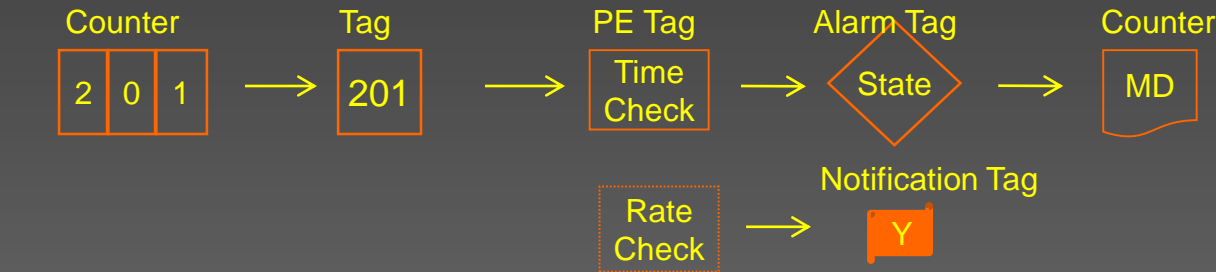
# PI RLINK Overview

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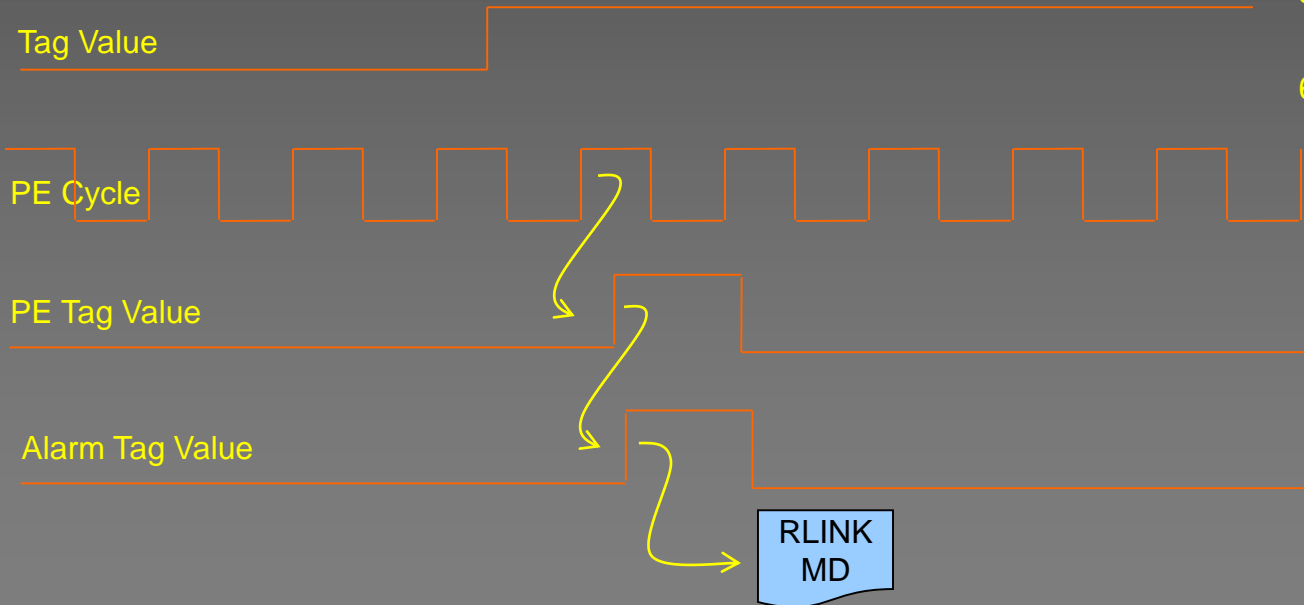
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- Approximately 1,000 measurement points
- 1 Equation tag for each MP driven by RLINK
- 1 Equation Tag for each rate change check
- 1 Equation Tag for each limit check
- Functional Uses
  - Counter Readings
  - LTC Movements
  - Runtime Hours
  - Breaker not operating
  - LTC not crossing neutral
  - Rate of Change

# MP Use at PSE&G



1. Tag changes state
2. PE Tag is evaluated on next cycle
3. PE tag changes state
4. Alarm changes state
5. PE Tag resets on next cycle
6. If rate check test positive, notification set



# PI RLINK Configuration Screen

The screenshot displays the RLINK-PM Configuration Application interface. On the left is a tree view showing the hierarchy: Base Plant, Plants (1101), BASE (BASE), CEDV (Central Division), Unit, Point Group, and ALARM. A list of point groups is shown under ALARM, with '626\*LTC1053364' selected. The main area shows the configuration for this selected point group. The form includes fields for Plant id (CEDV), Plant Description (Central Division), Group no (626), Group type (ALARM), Owner (dbo), Description (LTC105336430PS), Resource, Material id, Class (43 # 1 Transformer), Application id, and Process book. Below the form is a table of tags.

	Tag id	Tag alias	Order	Server	Applic
1	LAF:LTC.R001.M	VALUE	1	NJNwKAPS65	
2	LAF:LTC.R001.A1	ALARM	3	NJNwKAPS65	
3	RLK:GEN.Z002.INB	NOTIFY	10	NJNwKAPS65	
4	LAF:LTC.R001.D1	DOCUMENT	13	NJNwKAPS65	
5	RLK:TXT.Z001.TXT	SHORT_TEXT	21	NJNwKAPS65	
6					
7					

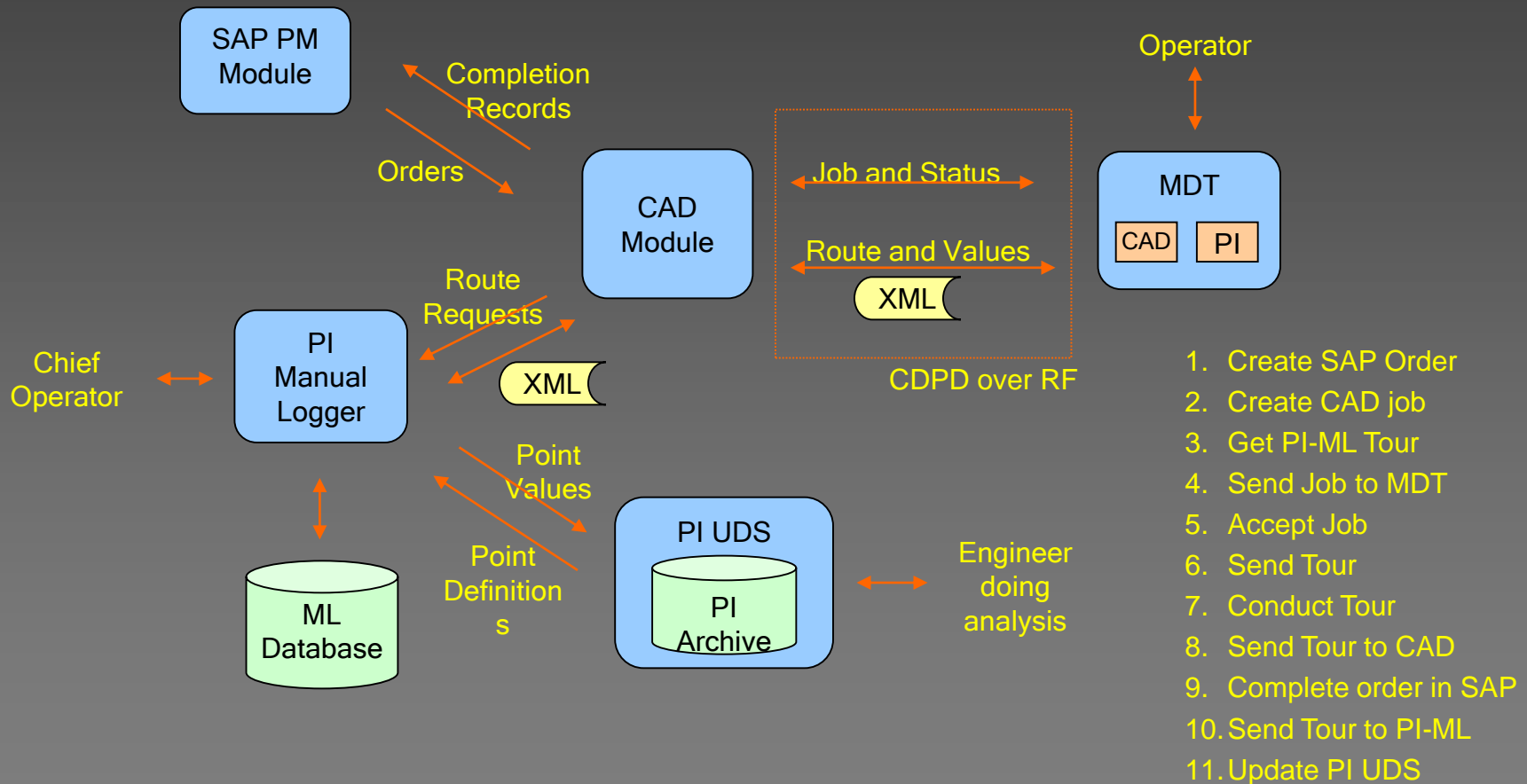
# PI Manual Logger

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- Substation Inspections
- 300 Substations – Weekly and Peak Inspections
- 20 – 500 points per station
- Scheduled in SAP PM
- Dispatched using CAD Dispatch over RF and CDPD
- XML file transfers of tour definition and data
- Equipment Oriented Point Collection

# Inspection Design Overview



# PI-ML Sample Screen

The screenshot shows the PI-Manual Logger application window. The title bar reads "PI-Manual Logger". The menu bar includes "File", "Edit", "Insert", "Records", "Window", and "Help". The toolbar contains icons for "LogOn/ piml", "PIML Client", "Tour", "Send", "Data Entry/Review", and "Receive". A status bar at the top right shows "Arial" and a help icon.

The main window is divided into two panes. The left pane, titled "Select Equipment", contains a list of equipment items with checkboxes. The right pane, titled "Data Entry ald1:aldene 1/3/02 5:00:00 PM", displays a table of data entries.

Description:	Tag Value:	Eng Unit:	Violations Display
# 20 Transformer-Power Transformer-Tank Oil Level	Idle		
# 20 Transformer-Power Transformer-Gas Detection Relay	Idle Out of Service Below 25C 25C Above 25C	cc	
# 20 Transformer-Power Transformer-Max Liquid Temperature		Deg C	
# 20 Transformer-Power Transformer-Max Winding #1 Temperature		Deg C	
# 20 Transformer-Power Transformer-Max Winding #2 Temperature		Deg C	

At the bottom of the right pane, there is a record navigation bar showing "Record: 1 of 5 (Filtered)". A "FLTR" button is located at the bottom right of the window.

# PI Module Database

## ➤ PI Module Overview

- Define Module
  - Descriptive Information
  - Properties
  - Tag Alias

PI Module (Power Transformer T1)

PI Module | PIAliases | PIProperties | PIHeading | Summary

Name: Power Transformer T1

Type of Object: PIModule

UniqueID: 0a839073-f40c-11d5-ad34-00508bb84a8f

Created: 12/19/2001 11:17:55 AM

Modified: 02/28/2002 9:38:58 AM

Effective Date: 12/31/1969 7:00:01 PM

PI Server: njnwkaps65

Current User: piadmin

Attribute:  Batch Processing Unit? [IsPIUnit]

Security:  Read-Only?

OK Cancel Apply

PI Module (Power Transformer T1)

PI Module | PIAliases | PIProperties | PIHeading | Summary

Description

Name: Power Transformer T1

Description: 10501328

PI Unit: FALSE

ParentList: T1

Origin

Creator: piadmin

Last Modified By: piadmin

Revision Number: 34

Comment:

Date of Creation: 12/19/2001 11:17:55 AM

Date Last Modified: 02/28/2002 9:38:58 AM

Effective Date: 12/31/1969 7:00:01 PM

Query Date: 02/28/2002 9:39:43 AM

OK Cancel Apply

PI Module (Power Transformer T1)

PI Module | PIAliases | PIProperties | PIHeading | Summary

PIProperties: A hierarchical collection of PIProperty objects.

PIProperty Name	Value	Datatype
MANUFACTURER	Pennsylvania	String
MODEL NUMBER		String
SERIAL NUMBER	C0406152	String
OPERATING VOLTAGE		String
NORMAL RATING		String
INSTALLED DATE	25934	String
EQUIPMENT CLASS	E-TRANSF-CL	String
EQUIPMENT TYPE	E-TRF-TRF	String
ABC INDICATOR		String
REPLACEMENT COST		String

Add PIProperty... Edit PIProperty... Remove PIProperty

OK Cancel Apply

PI Module (Power Transformer T1)

PI Module | PIAliases | PIProperties | PIHeading | Summary

PIAliases: A collection of PIAlias objects.

PIAlias Name	Tag Name	Server
15 MIN INTEGRATE...	FAW:TRF.E015.W	njnwkaps6
EQUIPMENT CONDI...	FAW:TRF.Q004.YX	njnwkaps6
FLUID CONDITION	FAW:TRF.Q002.YX	njnwkaps6
LOAD IN MVA	FAW:TRF.E001.Q	njnwkaps6
MEGAWATTS	FAW:TRF.E007.W	njnwkaps6
PEAK TOP OIL TEMP...	FAW:TRF.T001.M	njnwkaps6
PEAK WINDING #1 ...	FAW:TRF.T002.M	njnwkaps6
PEAK WINDING #2 ...	FAW:TRF.T003.M	njnwkaps6
REACTIVE LOAD	FAW:TRF.E002.Q	njnwkaps6
TANK OIL LEVEL	FAW:TRF.L001.M	njnwkaps6

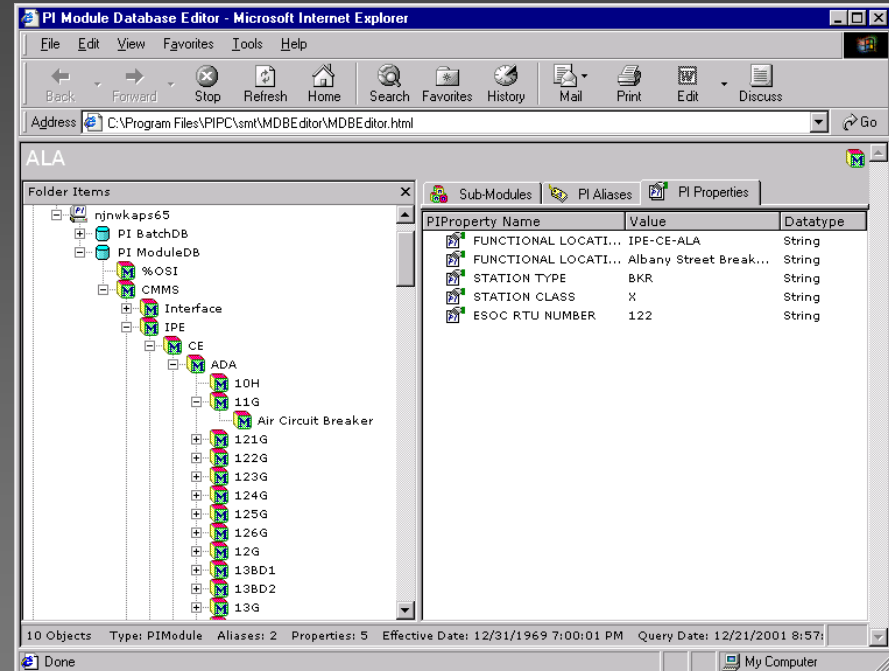
Add PIAlias... Edit PIAlias... Remove PIAlias

OK Cancel Apply

# PI Module Database Screen

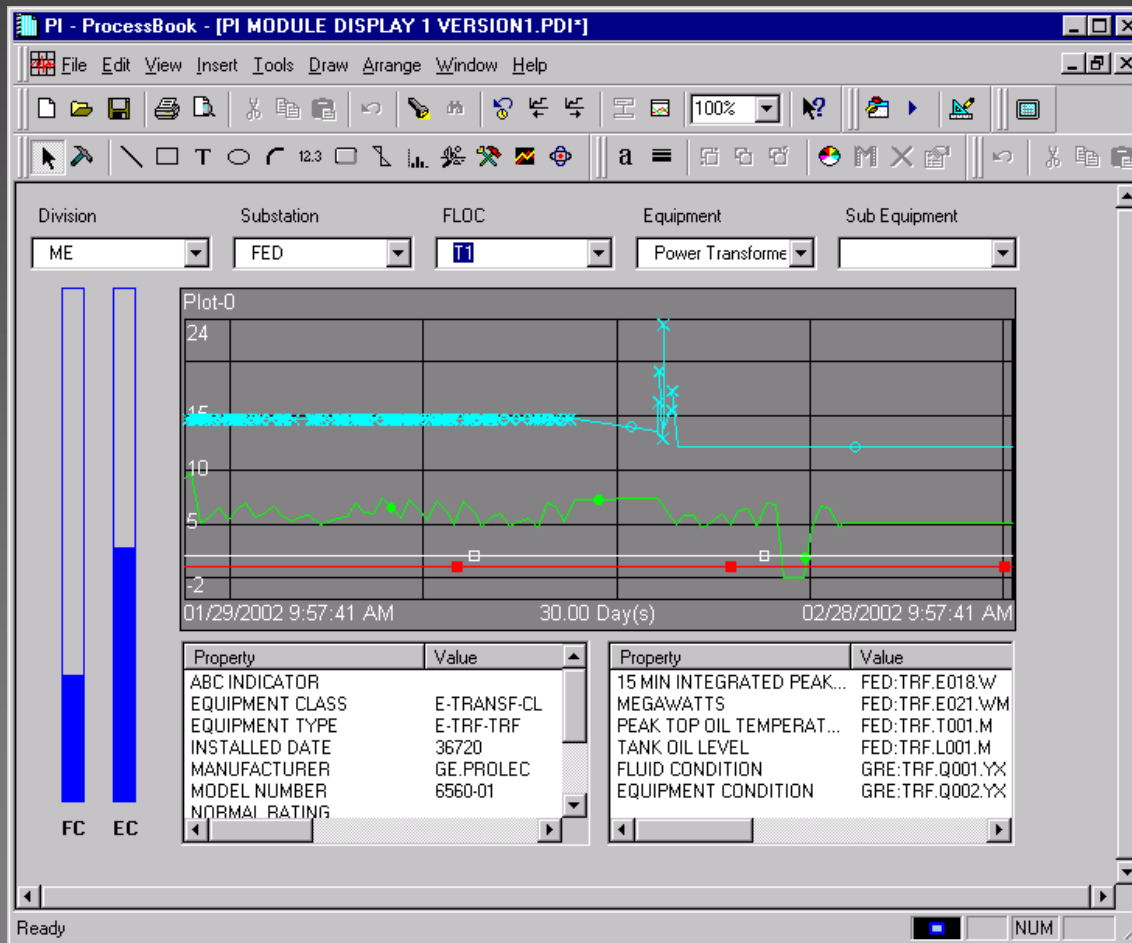
## ➤ Define Module Taxonomy

- Define Hierarchies
- Each level has a parent-child relationship
- Any module can appear many times in the hierarchy
- Load the hierarchies





# PI Module Database Display



# Condition Assessment Overview

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## ➤ Equations

- $CA = F_1(M_1) + F_2(M_2) + F_3(M_3) + \dots$

## ➤ Example factors include:

- Average Load over time period
- Last oil test results
- Maintenance cost data
- Number of operations

## ➤ Factor components dependent on peer group

## ➤ Multiplier used to weight the factor result

## ➤ Must be flexible in terms of definition and composition

# Condition Assessment

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## ➤ Our Use of PI Module

- Module for each level of the SAP PM hierarchy and installed functional locations and equipment
- Defined peer groups and installed equipment modules
- Defined factors and equations
- Created Module for each equation and for each equation factor
- Developed displays using PI Module

# PI Module Database Factor 1

## ➤ Average MVA (load) factor

- Type: PI Calc
- Alias: Load in MVA
- Start Time = \*
- End Time = \*-30d
- Mode: Average
- Case: Assign value to factor
- Multiplier = 0.2

The screenshot shows the 'PI Module Database Editor' interface. The left pane displays a tree view of the database structure, with 'Average MVA' selected under 'Condition Assessment'. The right pane shows the configuration for this property in a table format.

PIProperty Name	Value	Datatype
PI Alias	LOAD IN MVA	String
Start Time	*	String
End Time	*-30d	String
Mode	average	String
Type	PI Calc	String
Case	<10	String
	10,0	String
	<50	String
	50,2	String
	<200	String
	200,5	String
	<500	String
	500,7	String
	Else,10	String
Else	Else,10	String
Multiplier	0.2	String

At the bottom of the window, an error message is visible: 'Error: -2147220447 - frmPIPropertyEdit - btnApply\_Click:addNew pidcommon.dll : Cannot add duplicate name to the collection: Case'.

# PI Module Database Factor 2

## ➤ Last Oil Test Result Factor

- Type: DeltaX CV
- Select: equipcond
- From: equipment
- Where: serialnum = '&Serial Number'
- Case: Assign value to factor
- Multiplier = 0.25

The screenshot shows the 'PI Module Database Editor - Microsoft Internet Explorer' window. The address bar indicates the path: C:\Program Files\PIPC\sm\MDBEditor\MDBEditor.html. The main content area is titled 'Gas Physical' and contains a 'Folder Items' tree on the left and a 'PI Properties' table on the right.

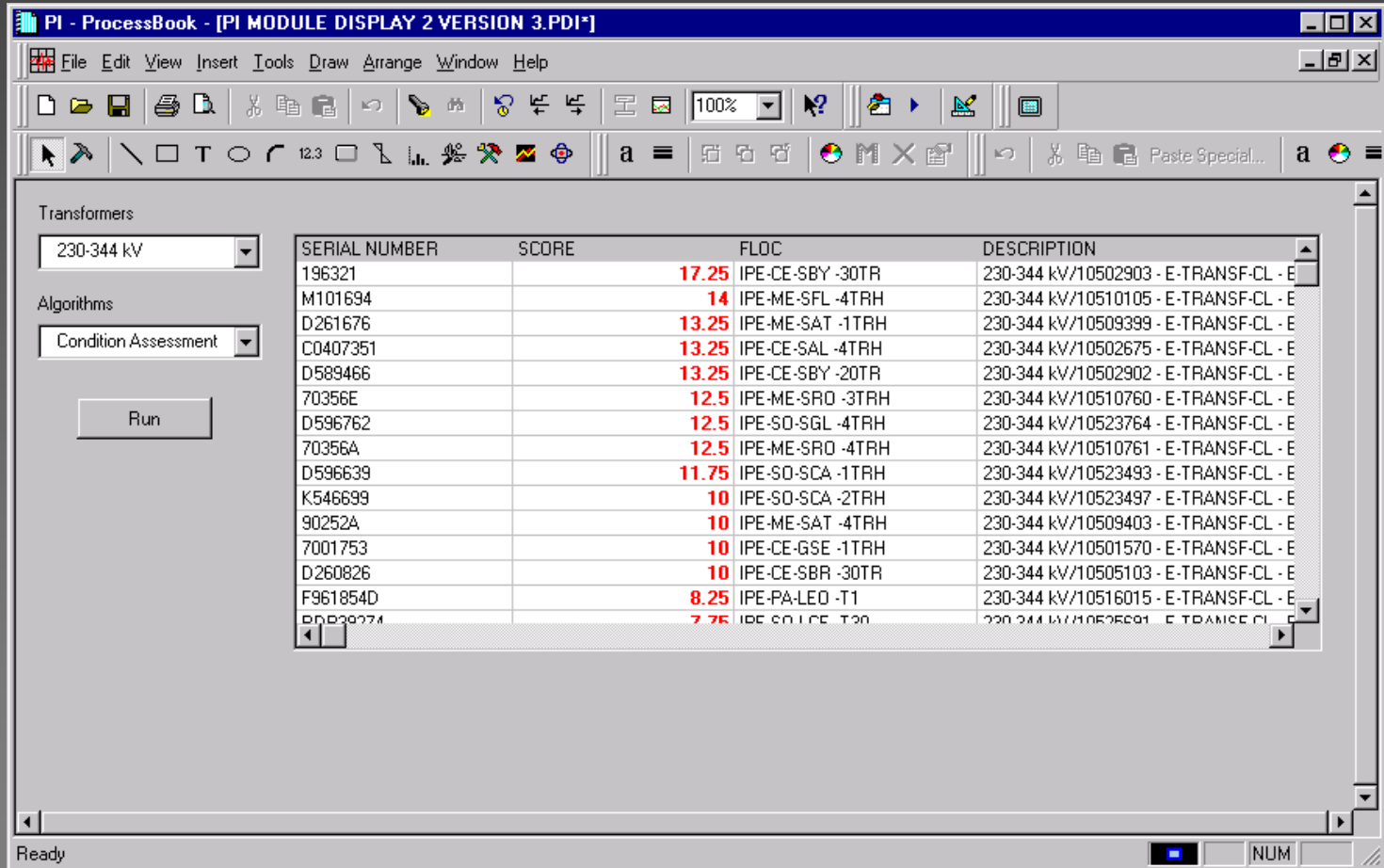
The 'Folder Items' tree shows a hierarchy of databases and modules. The 'Gas Physical' module is selected under the 'Oil Physical' folder.

The 'PI Properties' table is as follows:

PIProperty Name	Value	Datatype
Multiplier	0.25	Double
Select	EQUIPCOND	String
From	equipment	String
Where	serialnum = '&SERIAL NUMBER'	String
Case		String
0	0,0	String
0_1	1,0	String
3	2,3	String
7	3,7	String
10	4,10	String
Null	,5	String
Type	DeltaX CV	String
Database	DeltaX	String
Server	njnwksql12	String

The status bar at the bottom shows: 0 Objects Type: PIModule Aliases: 0 Properties: 0 Effective Date: 12/31/1969 7:00:01 PM Query Date: 01/10/2002 3:15:37 PM Creator: piadm

# Condition Assessment Sample



The screenshot shows the PI - ProcessBook software interface. The main window displays a table of transformer condition assessment results. The table has four columns: SERIAL NUMBER, SCORE, FLOC, and DESCRIPTION. The scores are color-coded: red for scores below 10, black for scores 10 and above. The 'Run' button is visible on the left side of the interface.

SERIAL NUMBER	SCORE	FLOC	DESCRIPTION
196321	17.25	IPE-CE-SBY -30TR	230-344 kV/10502903 - E-TRANSF-CL - E
M101694	14	IPE-ME-SFL -4TRH	230-344 kV/10510105 - E-TRANSF-CL - E
D261676	13.25	IPE-ME-SAT -1TRH	230-344 kV/10509399 - E-TRANSF-CL - E
C0407351	13.25	IPE-CE-SAL -4TRH	230-344 kV/10502675 - E-TRANSF-CL - E
D589466	13.25	IPE-CE-SBY -20TR	230-344 kV/10502902 - E-TRANSF-CL - E
70356E	12.5	IPE-ME-SRO -3TRH	230-344 kV/10510760 - E-TRANSF-CL - E
D596762	12.5	IPE-SD-SGL -4TRH	230-344 kV/10523764 - E-TRANSF-CL - E
70356A	12.5	IPE-ME-SRO -4TRH	230-344 kV/10510761 - E-TRANSF-CL - E
D596639	11.75	IPE-SD-SCA -1TRH	230-344 kV/10523493 - E-TRANSF-CL - E
K546699	10	IPE-SD-SCA -2TRH	230-344 kV/10523497 - E-TRANSF-CL - E
90252A	10	IPE-ME-SAT -4TRH	230-344 kV/10509403 - E-TRANSF-CL - E
7001753	10	IPE-CE-GSE -1TRH	230-344 kV/10501570 - E-TRANSF-CL - E
D260826	10	IPE-CE-SBR -30TR	230-344 kV/10505103 - E-TRANSF-CL - E
F961854D	8.25	IPE-PA-LEO -T1	230-344 kV/10516015 - E-TRANSF-CL - E
B0020774	7.75	IPE-SD-LCE -T30	230-344 kV/10525691 - E-TRANSF-CL - E

# Lessons Learned

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- Helps to have good vision
- Concepts are difficult for many users
- Data, data, data – start early with knowledgeable, dedicated resources
- Lots of data required for meaningful representations – consider backfile
- It's going to change, start with a flexible foundation – don't fixate on initial equations, displays or reports
- Train on Displays, not ProcessBook – Use ActiveView or ICE
- Many spin-offs from initial deployment, hard to manage scope creep
- The software is not the issue, culture and data are

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# Q&A