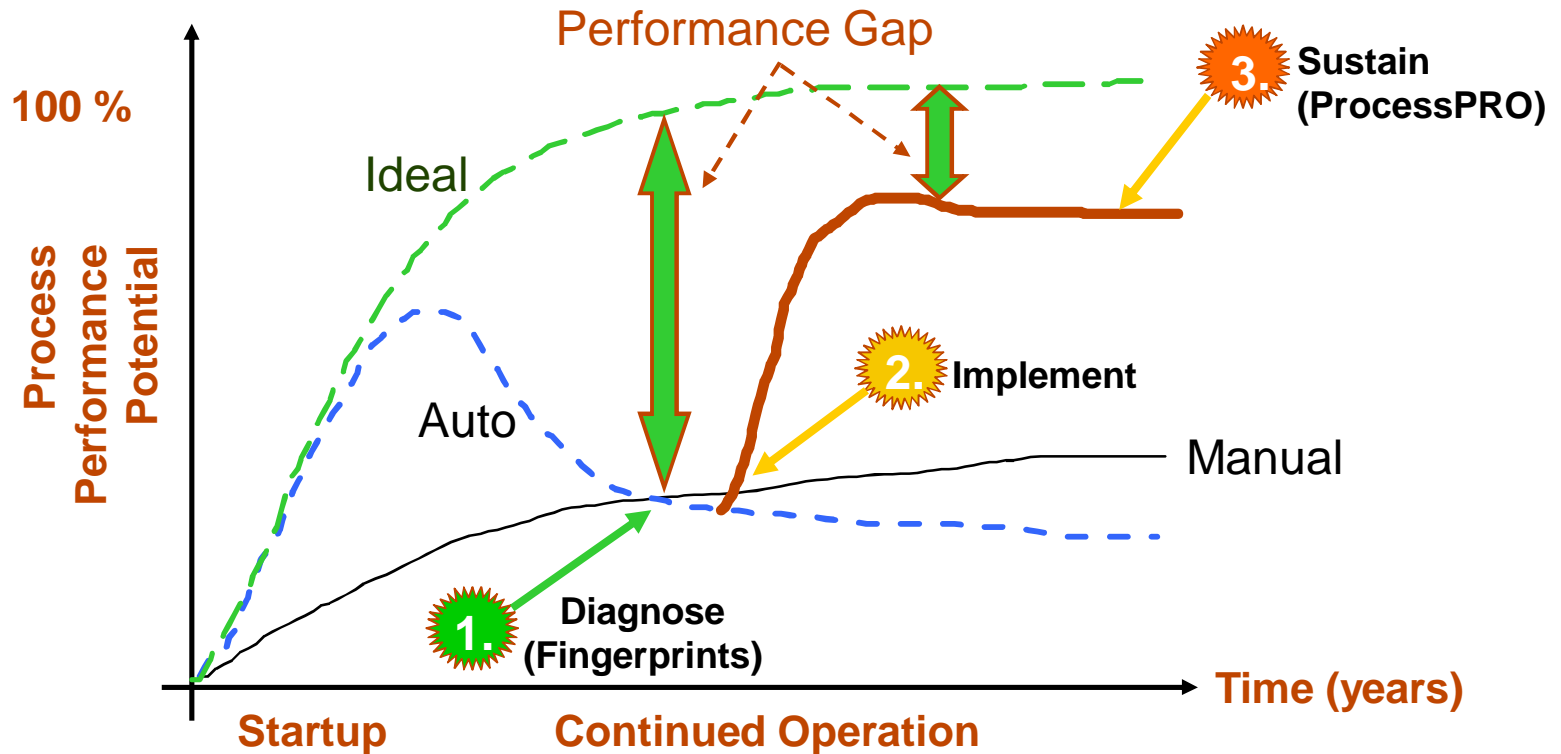


Optimization Services, Tools and Advanced Process Control

Outline

- Assuring Optimal Performance
 - Loop Performance – Dupont
 - Batch Optimization – BASF
 - Boiler Fuel Savings – Arkema
- Sustaining Performance
 - ServicePort
- Advanced Process Control
 - ABB Predict & Control
 - Steam and Power Generation Applications

Optimization Service Methodology



Goal: Measure and Reduce Performance Gap, Extend system life, Operate at the mechanical system constraints

ABB Fingerprint finds gaps, develops customer ROI



Report

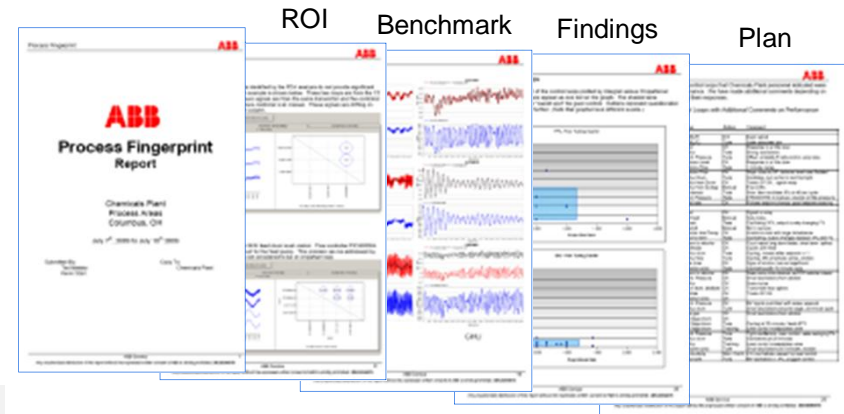
- Gap Analysis
- ROI Forecast
- Action Plan

Performance Evaluation

- Standard Methodology
- Analysis Expertise
- Performance Visualization

Data Collection/Testing

- 12 to 24 hours at 5-second data
- Controller parameters
- Customer interview: process area and loop criticality definitions.



ABB

People
Process
Tools

OPC Server Data Logger DL200

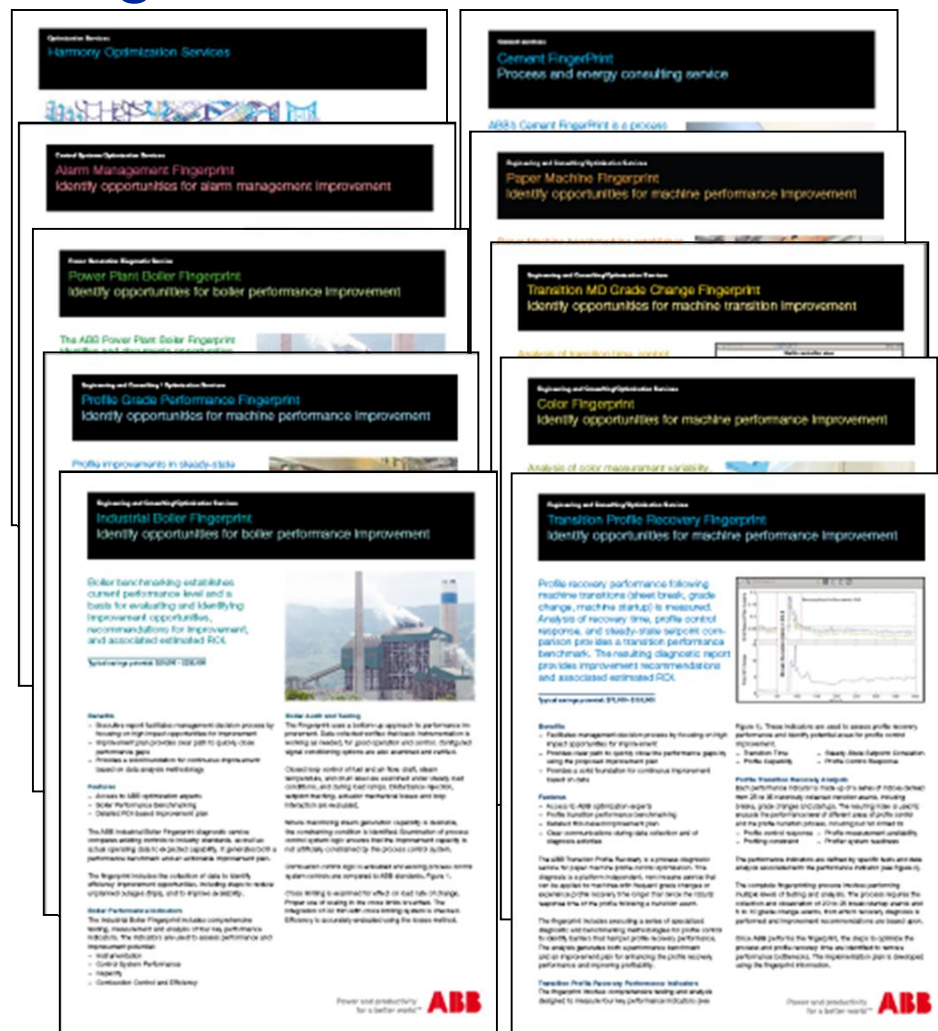
An open connectivity application for improved data access

The ABB OPC Server Data Logger (DL200) is a Microsoft .NET application that provides data logging from OPC servers.

ABB Services

OPC
Collection
Tools

ABB Advanced Services: Fingerprints are packaged diagnostic services



- Common Industrial Services :
- Boiler
- Alarm
- Loop Performance
- Control System
- Transition Analysis
- Batch Analysis
- Tuning

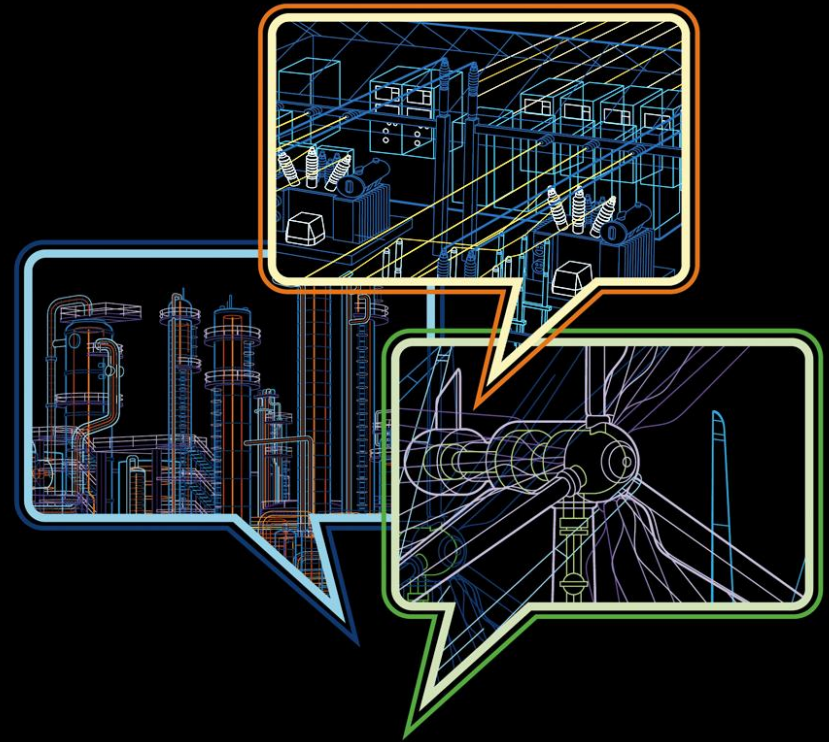


ABB Automation & Power World - May 18-20, 2010

CCH-101-1 11:00 Tuesday, room 351C

Doug Reeder, Ted Matsko

Loop Performance Fingerprint for a DuPont Monomers Plant

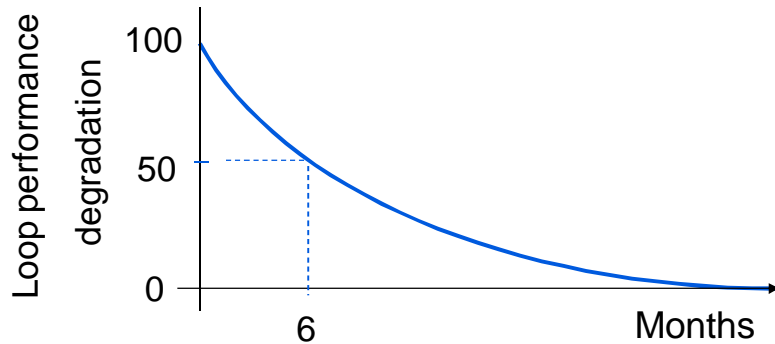
1

Control Performance Issues

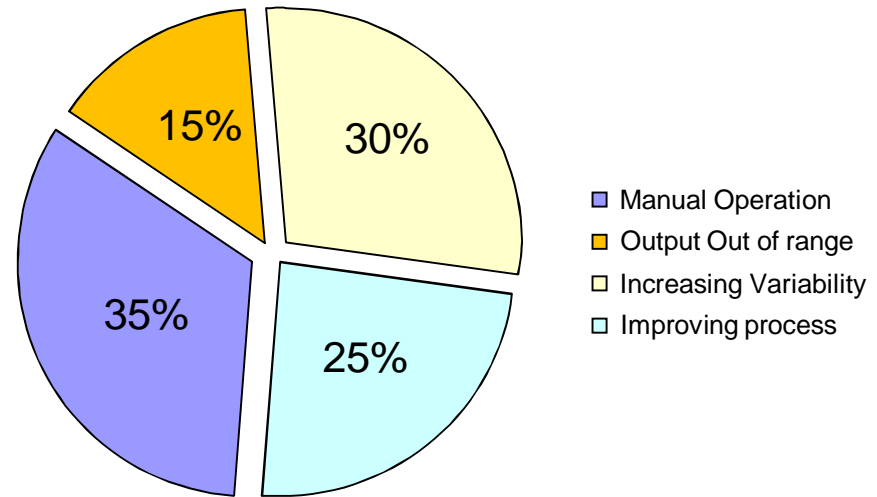
Half life of Process Controllers

Given: a 100 PID loops all tuned at once.

Then: it is estimated that with in 6 months, 50 of these loops will have a degradation in performance.



Simple PID Utilization



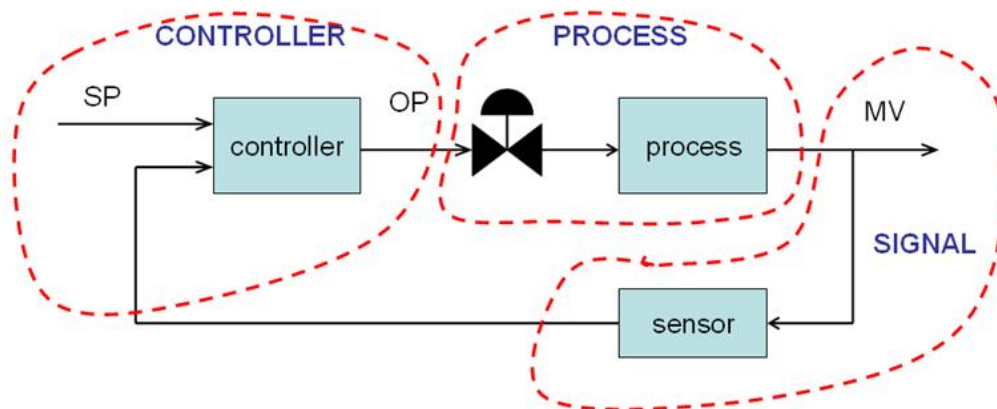
PID Controllers are designed to:

- Regulate the process
- Reduce product instability
- Improve operations

However, ABB is finding that PID Automation:

- PID loops are not being maintained
- PID loops have degraded
- PID loops are standing in the way of production and performance.

LoopAnalyzer Tool: Control Loop Diagnoses



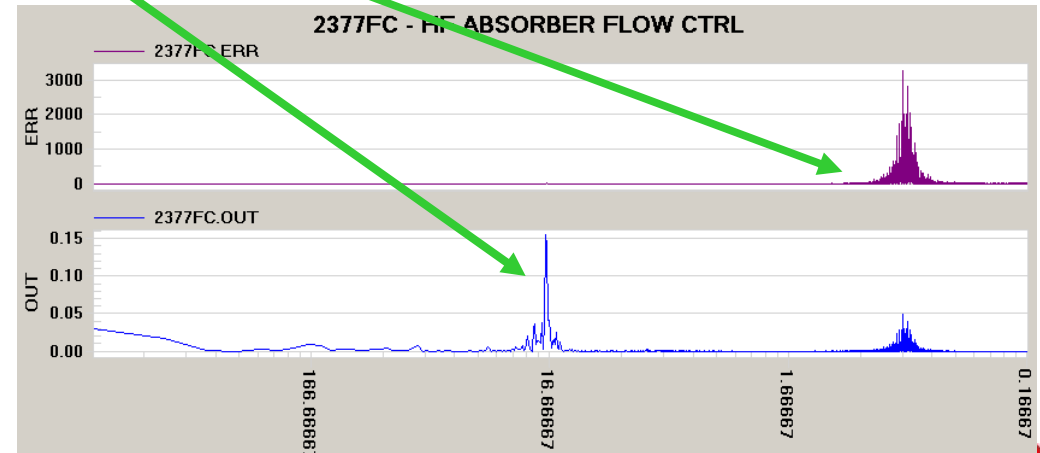
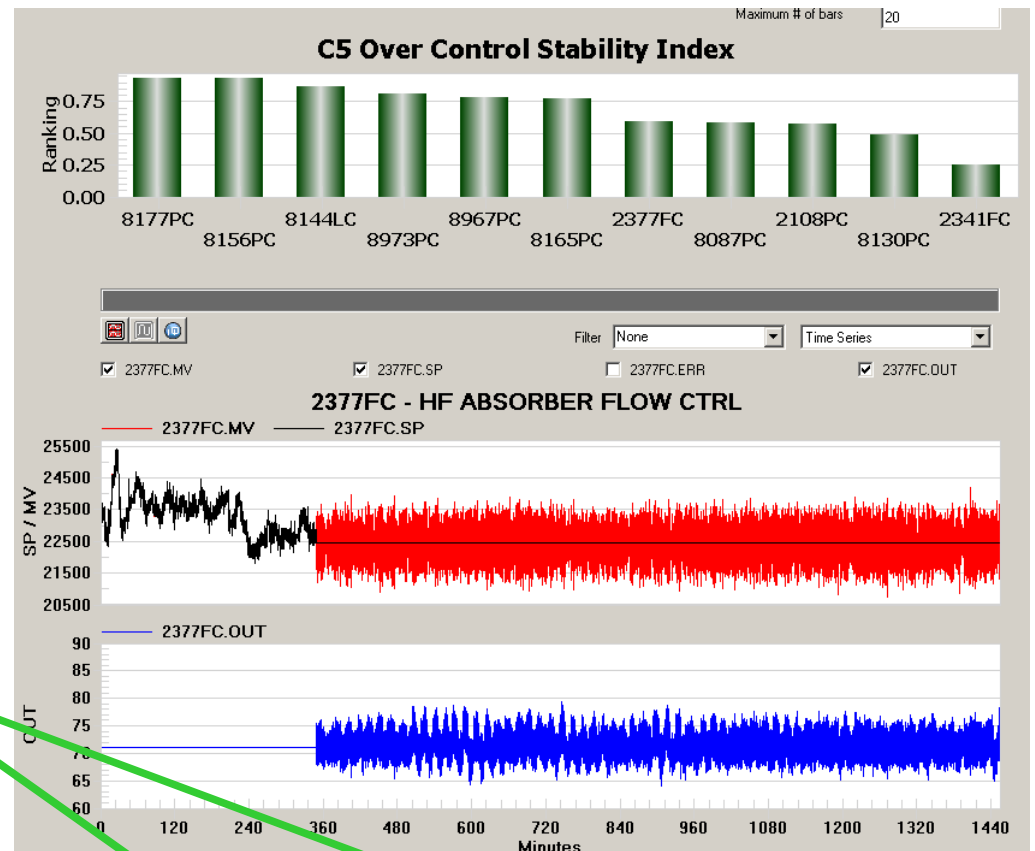
CONTROL	PROCESS	SIGNAL CONDITIONING
C1: Manual	P1: FCE Out of Range	S1: Quantized
C2: Oscillating Setpoint	P2: FCE Size	S2: Excessive Noise
C3: Error Deadband	P3: FCE Problem	S3: Spikes
C4: Offset	P4: FCE Leakage	S4: Step Out
C5: Over Control	P5: Intermittent Disturbance	S5: Data Compression
C6: Slow Control	P6: Persistent Disturbance	S6: Over Filtered
C7: FCE Travel	P7: Questionable	S7: Sampling Rate
C8: Slow Update Rate		S8: No Signal
C9: Questionable Control		S9: MV Out of Range
		S10: Questionable

FCE = Final Control Element

Loop Fingerprint Oscillating Loops

- When a loop oscillates in automatic mode and there is not evidence of an external disturbance, over tuning is a possible cause.
- Power spectrum shows two frequencies of interest
- This loop is in the TFE Synthesis area

Control	Severity
<input type="checkbox"/> C1 Manual	0
<input type="checkbox"/> C2 Oscillating Setpoint	0
<input type="checkbox"/> C3 Error Deadband	0
<input type="checkbox"/> C4 Offset	0
<input checked="" type="checkbox"/> C5 Over Control	0.59
<input type="checkbox"/> C6 Slow Control	0
<input type="checkbox"/> C7 FCE Travel	0
<input type="checkbox"/> C8 Slow Update Rate	0
<input type="checkbox"/> C9 Questionable Control	0

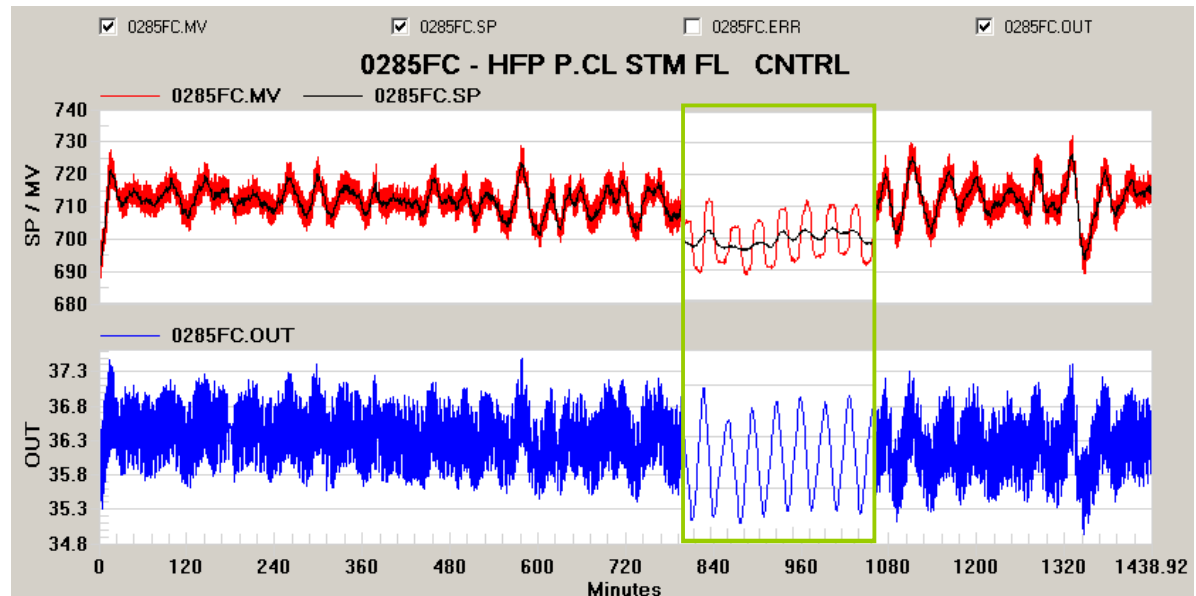


Loop Fingerprint

Final Control Element Problem

- This is a flow controller that is the inner loop of a cascade.
- Exhibits classic stiction
- Controller output ramps up and down in triangular pattern
- Process variable moves in square wave

Process	Severity
<input type="checkbox"/> P1 FCE Out Of Range	0
<input type="checkbox"/> P2 FCE Size	0
<input checked="" type="checkbox"/> P3 FCE Problem	53.4
<input type="checkbox"/> P4 FCE Leakage	0
<input checked="" type="checkbox"/> P5 Intermittent Disturbance	6.4
<input type="checkbox"/> P6 Persistent Disturbance	0
<input type="checkbox"/> P7 Questionable	0



Loop Fingerprint Report

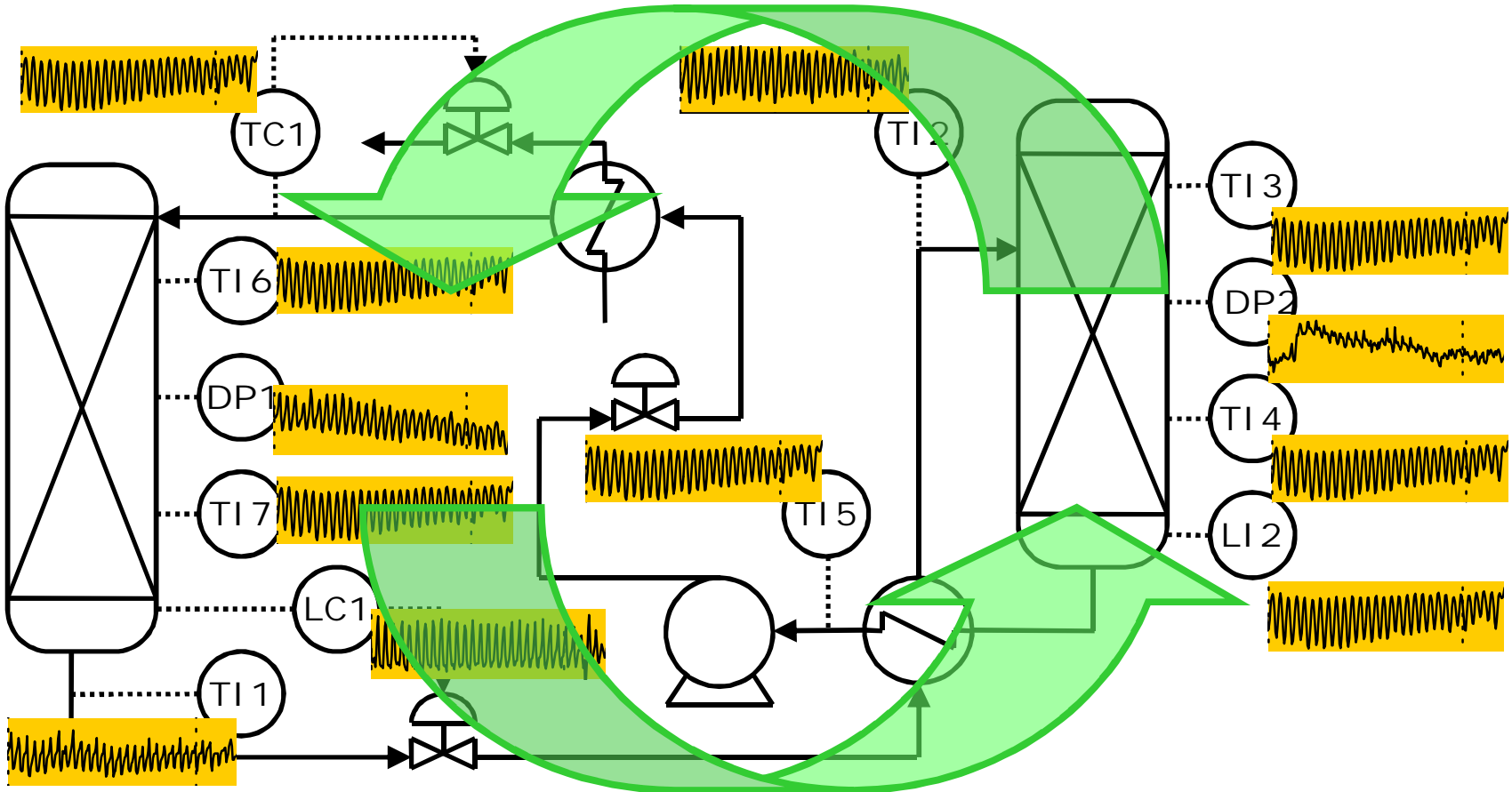
- The report highlights some loops, as shown in the previous slides and summarizes the results in tables. This table is for the TFE Synthesis section of the plant.

F22 and Pimary Columns

	Control									
	Loop Performance	Oscillating Error	Questionable Control	Manual	Offset	Slow Control	Oscillating Setpoint	Over Control	Output Out Of Range	Error Deadband
1	0378FC	2344PC	8093TC	2332TC	8964PC	8098TC	8175FC			
2	8098TC	8156PC	8098TC	2387PC	0378FC					
3	8964PC	8177PC	8116FC	2349TC	8146FC					
4	8089FC	8144LC	8173LC	2337FC	8089FC					
5	8146FC	0378FC	8085LC	2338FC						
6	2344PC	8175FC	8153TC							
7	8177PC	8973PC	2108PC							
8	8175FC	8967PC	8146FC							
9	8071FC	8165PC	8116FC1							
10	8093TC	8084FC								
11	2377FC	2377FC								
12	8085LC	8087PC								
13	8087PC	8130PC								
14	8116FC	8089FC								
15	8156PC	8052PC								
16	8173LC	2341FC								
17	8153TC	8179FC								
18	8084FC									
19	2108PC									
20	2341FC									
21	8973PC									
22	8052PC									
23	8130PC									
24	8967PC									
25	8116FC1									
26	8144LC									

Loop Fingerprint Plantwide Disturbance Analysis

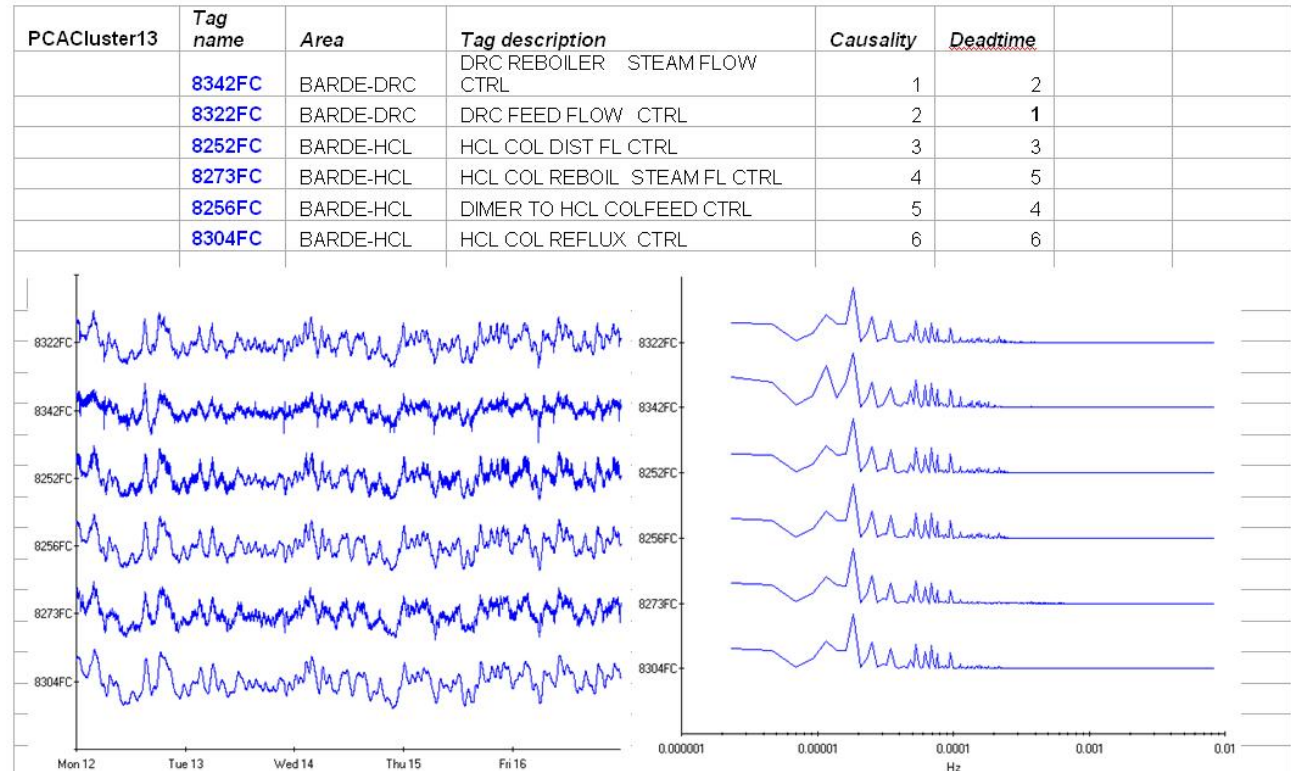
- Disturbances in chemical plants act on many process variables



- Disturbances can propagate counter flow because of recycle and thermal integration

Loop Fingerprint PCA Cluster Example

- Find signals with similar patterns, probably due to disturbances
- Not looking for oscillating signals
- Here all signals are in two columns that are adjacent

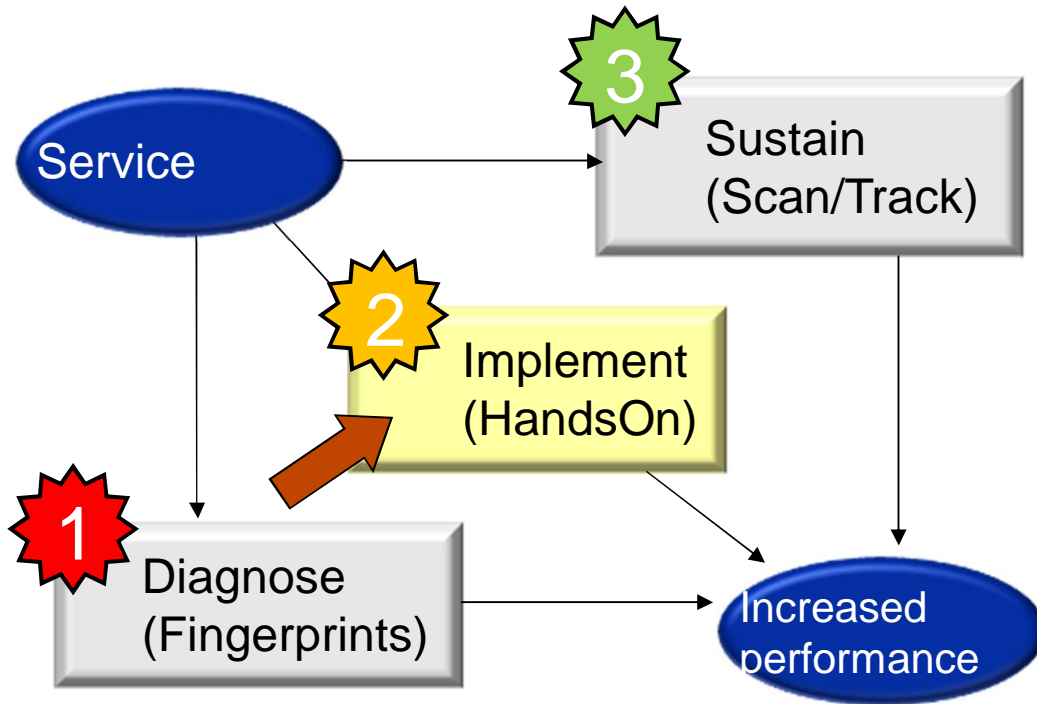


2 Loop Optimization implements improvements

Goal: Improve current performance level

- Scope based on Diagnose phase
- Focused, scheduled activities
- Proven practices
- ABB-managed improvement program

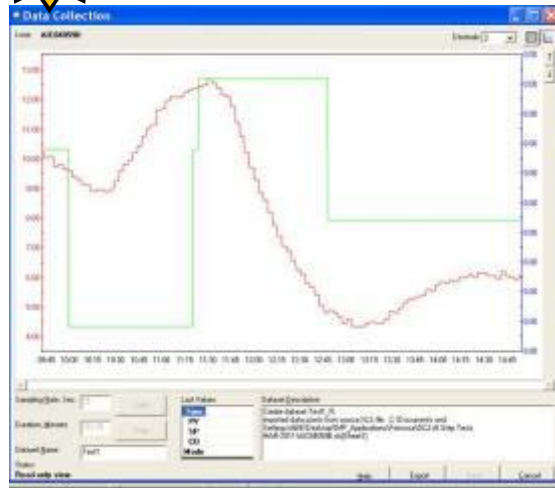
Proactive and collaborative



▪ **Solution categories:**

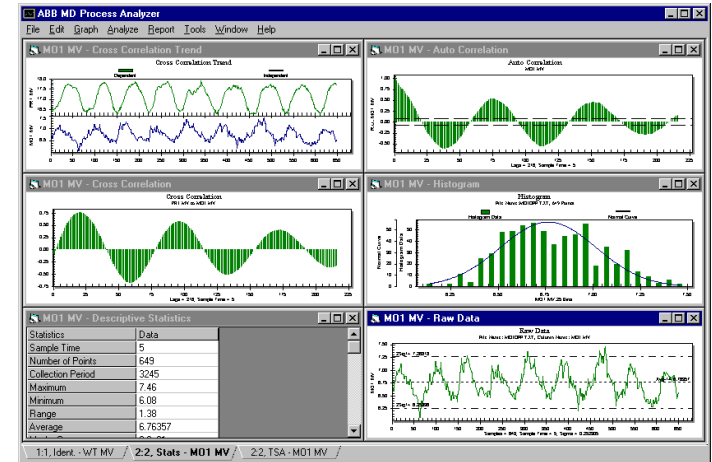
- Hardware
- Operations
- Tuning
- Application
- Process

2 Workbench: Implementation improvements



Visualization
and Setup

Analysis



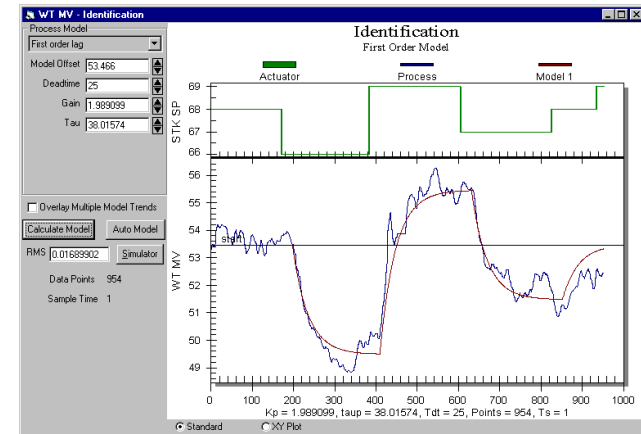
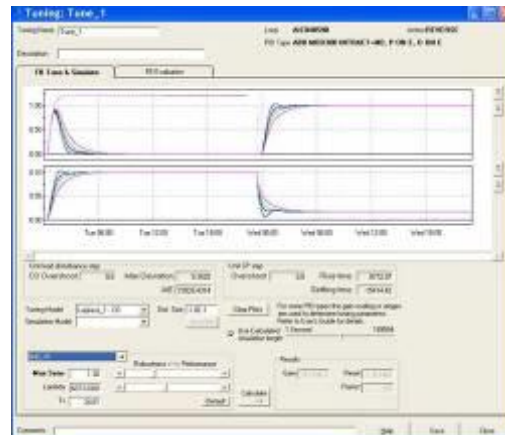
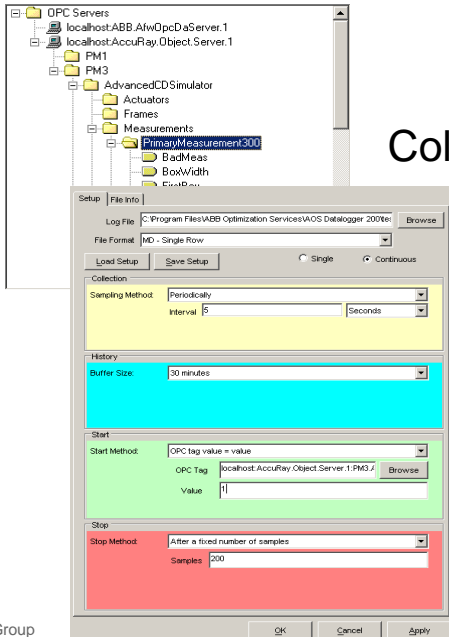
Standard Reporting

Tool Workbench

Identification

Collection

Tuning and Simulation



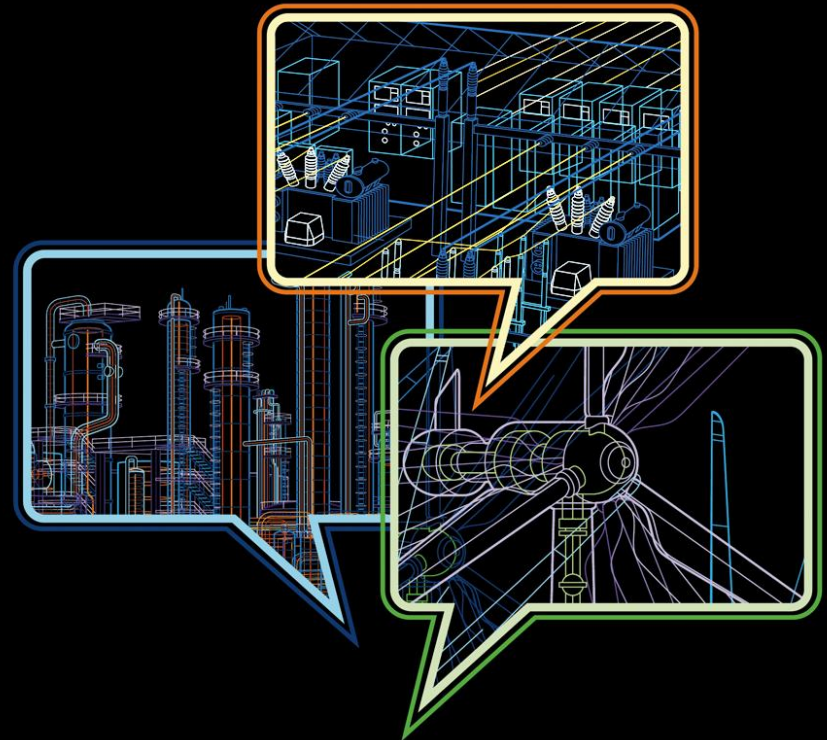


ABB Automation & Power World: April 23-26, 2012

C549I

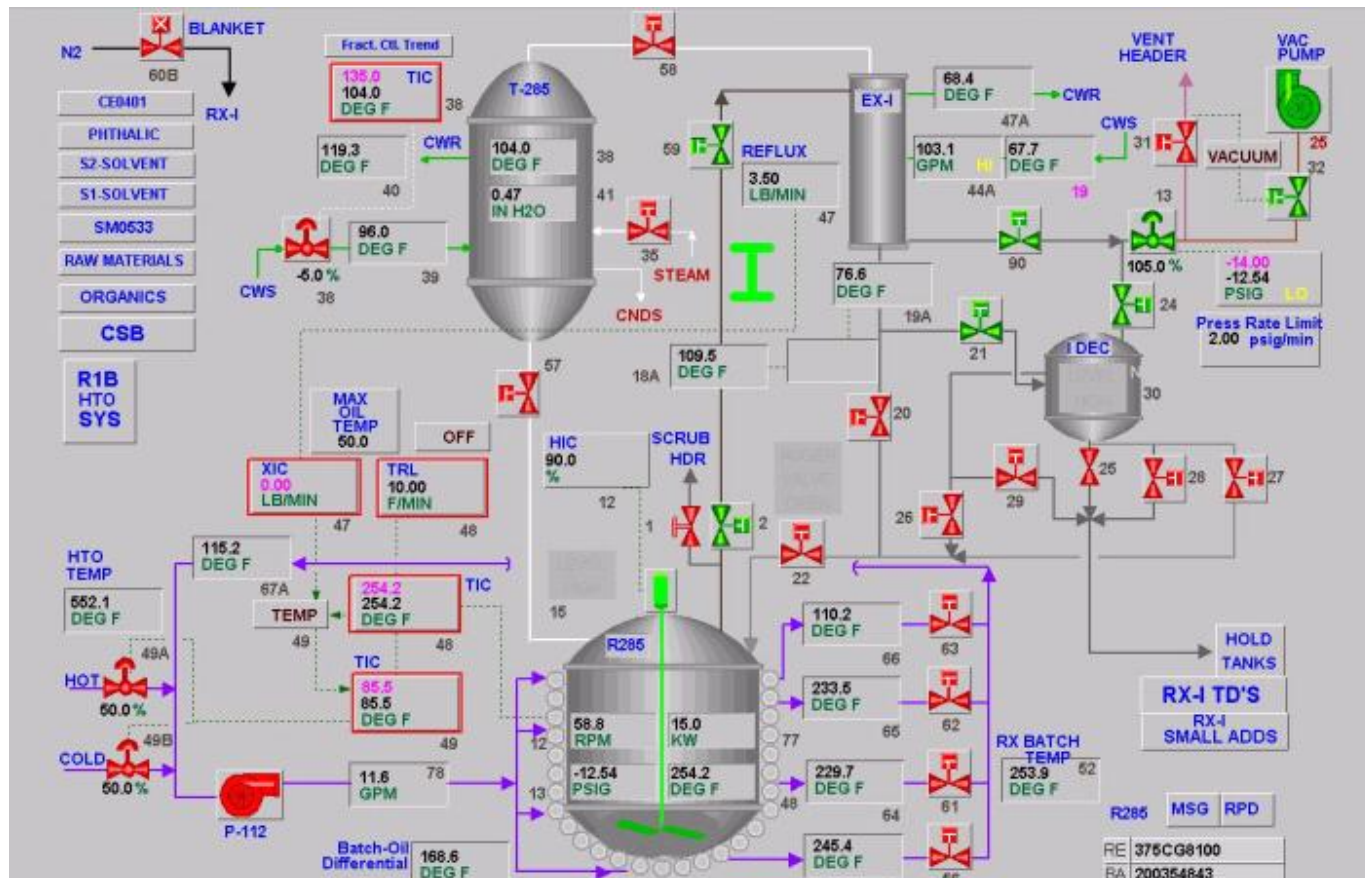
11:15 Wednesday, April 25, 2012 (room 371D)

Batch Process Optimization BASF Polymerization Reactor

BASF Batch Reactor Optimization

Polyester – Key Equipment in “I” Reactor System

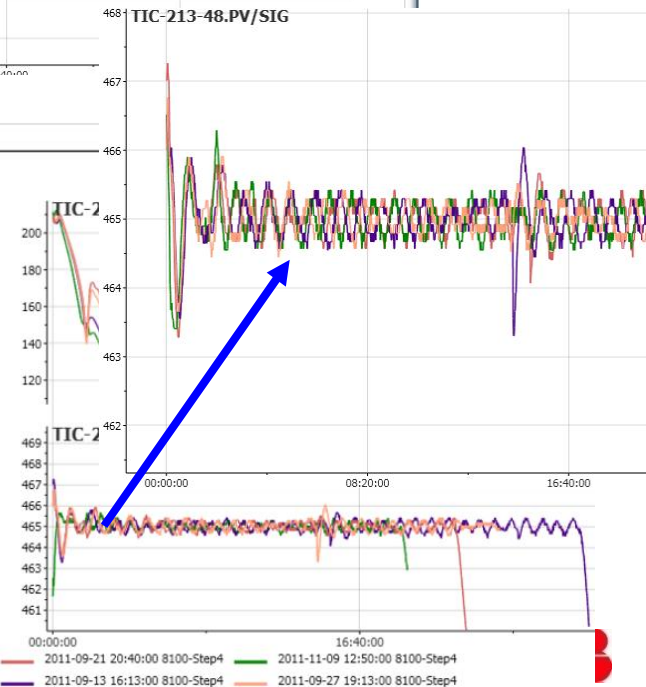
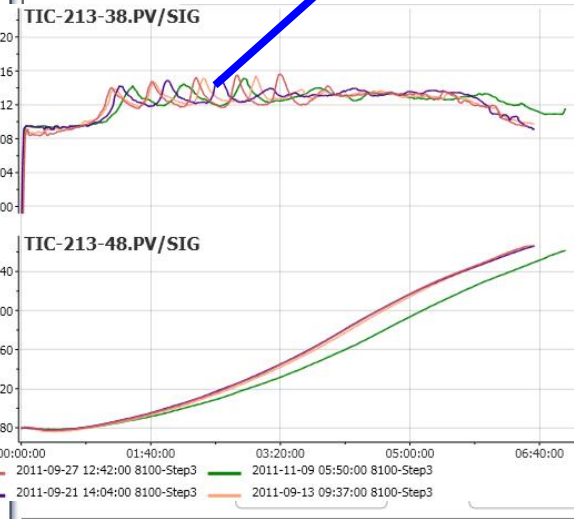
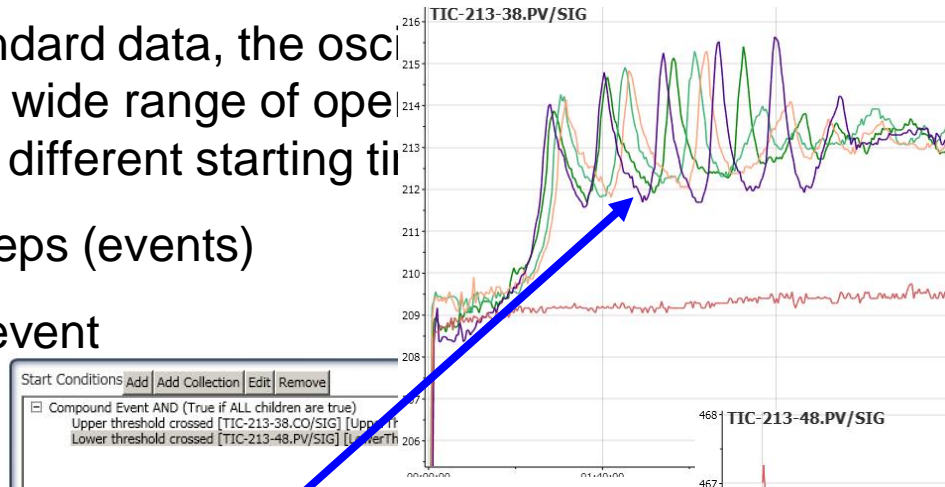
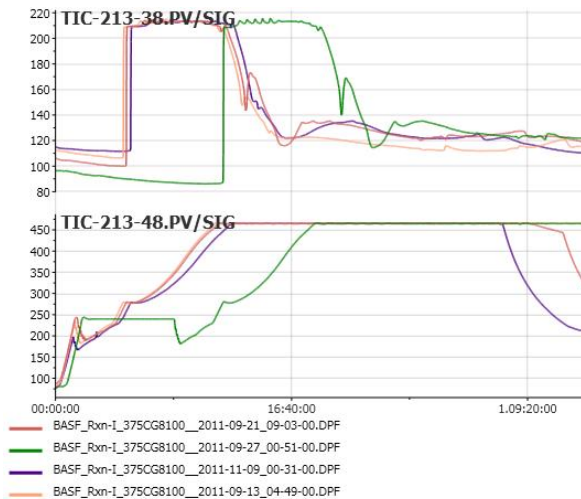
- 5,000 gallon reactor with Therminol-66 heating system
- Fractionator column
- Condenser and Decanter for water collection



BASF Batch Reactor Optimization

Temperature Control Loop Performance

- Looking at standard data, the oscillations are visible because of the wide range of operating processes and different starting times
- Define steps (events)
- View by event

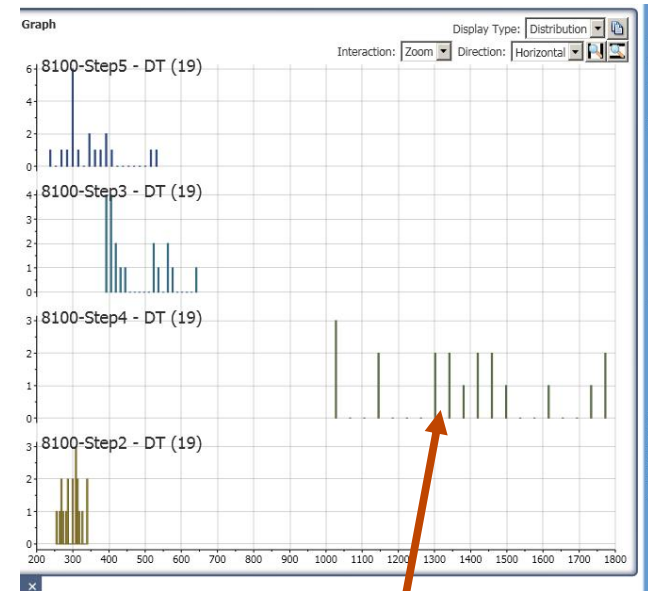


BASF Batch Reactor Optimization

Process Economics - Quality Control and Production Rate

Process Economics is tied to two things

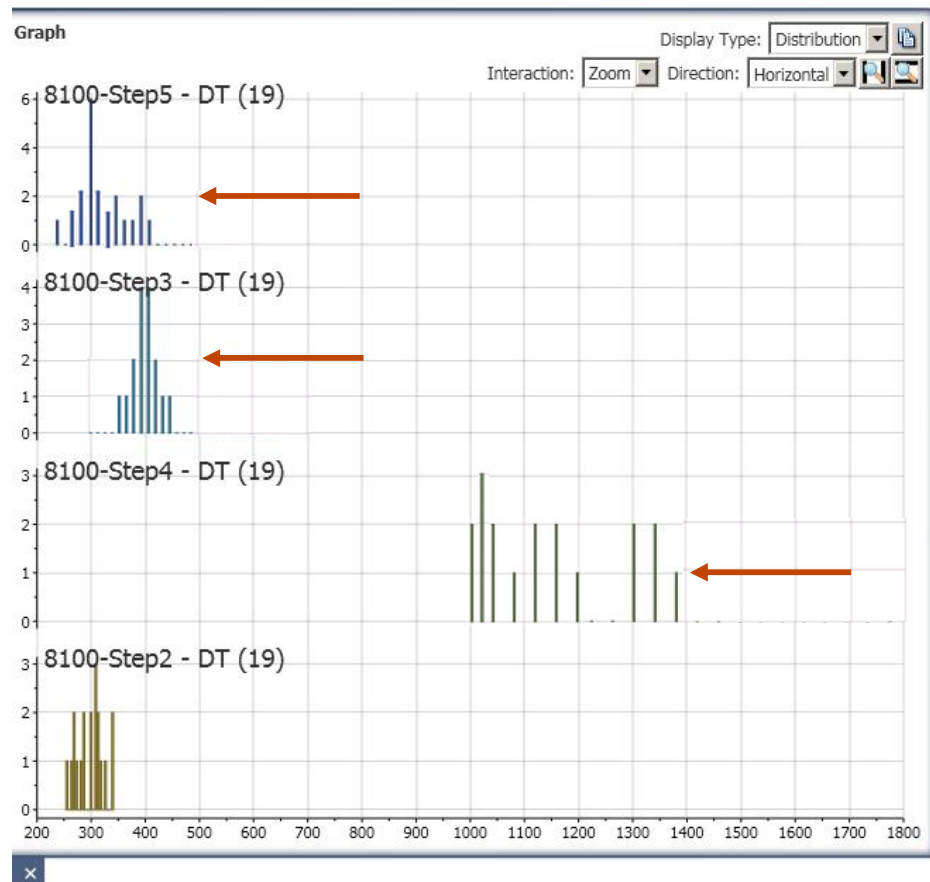
- Quality Control
 - Decrease cost, i.e. lower energy
 - Increase yield at same quality
 - Reduce offspec losses
 - Value increases with quality
- Production Rate
 - Hold fixed costs constant
 - Increase production rate, revenue
 - For a batch process, production rate means cycle time
- For this polyester product, Step 4 dominates



BASF Batch Reactor Optimization

Process Economics - Quality Control and Production Rate

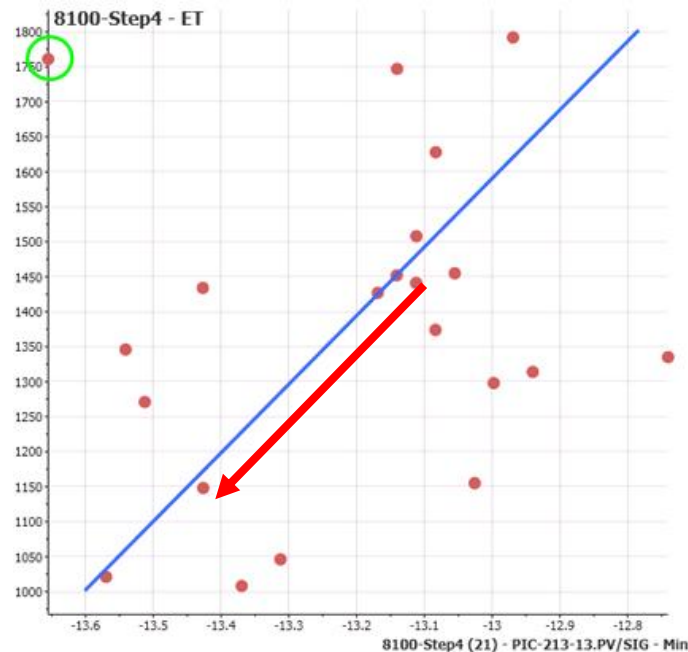
- Quality variance is very low for this product
 - Batch held until all specs met → increase time
 - Lab tests repeated, manual adjustments
- This plant is Production Rate limited on this product
 - Long cycle time
 - 5 day x 24 hr work week
 - 120 hrs working time
 - 60 hrs = 2; 40 hrs = 3 batches
- Opportunity
 - Reduce variance of step times



BASF Batch Reactor Optimization

Reducing Batch Cycle Times

- This plot confirms conclusion about vacuum and batch cycle time
- Real data is not always pretty (scatter)
 - Due to lab measurement, operator manual operations, unknown contaminants



Conclusion:

Investigate cost to improve vacuum

Achieved cycle time improvements.

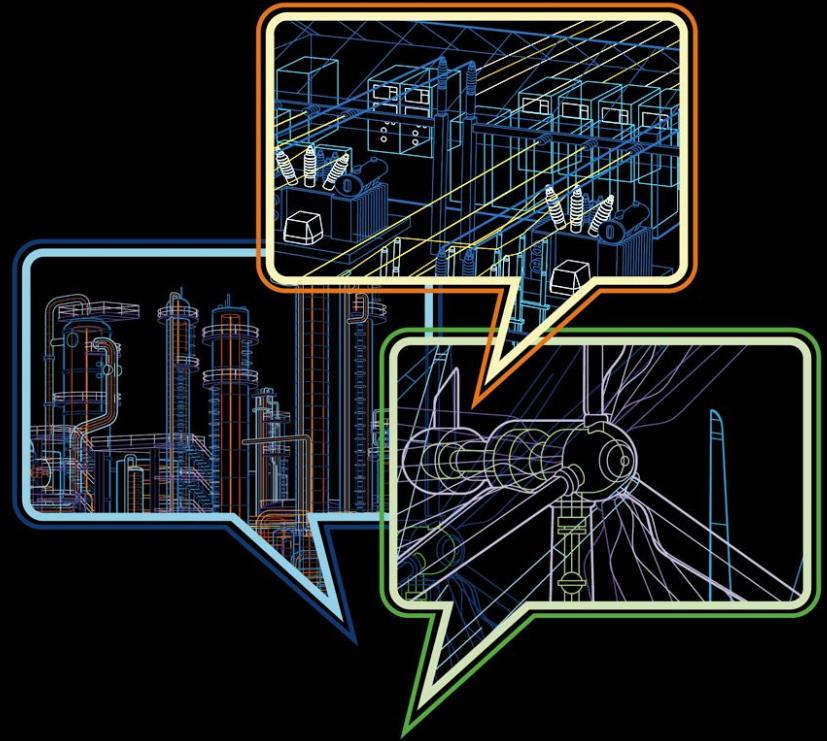
Step4 Elapsed Time(Vacuum)

Dwight Stoffel, Bob Horton
ABB Optimization Services

ABB Automation & Power World

CSE-102-1: Boiler Fingerprint

Success Story: How Arkema Saved \$300,000 per year on Energy



Boiler Fingerprint : Value

- Energy Savings
- More Responsive to Process Steam Demands
- Extended Operating Range
- More Reliable
- Improved Safety
- Reduced Carbon Footprint

Industrial Boiler Fingerprint

Process Industries
Diagnostic Service

Identify opportunities for boiler performance improvement

The ABB Industrial Boiler Fingerprint identifies and documents opportunities for boiler performance improvement. Boiler benchmarking establishes current performance level and provides a basis for evaluating and identifying improvement opportunities. The resulting diagnostic report provides improvement recommendations and associated estimated return on investment.



Benefits

- Executive report facilitates management decision process by focusing on high impact opportunities for improvement
- Improvement plan provides clear path to quickly close performance gaps
- Provides a solid foundation for continuous improvement based on data analysis methodology

Features

- Access to ABB optimization experts
- Boiler Performance Benchmarking
- Detailed ROI-based Improvement plan

The ABB Industrial Boiler Fingerprint diagnostic service compares existing controls to industry standards, as well as actual operating data to expected capability. It generates both a performance benchmark and an actionable improvement plan.

ABB collects data to identify efficiency opportunities that can be improved during standard operation of the plant, including steps to reduce unplanned outages (trips) and improve availability.



Typical Industrial Boiler

Boiler Performance Indicators

The Industrial Boiler Fingerprint includes comprehensive testing, measurement and analysis of four key performance indicators. The indicators are used to assess performance and improvement potential:

- Instrumentation
- Control System Performance
- Capacity
- Combustion Control and Efficiency

Boiler Audit and Testing

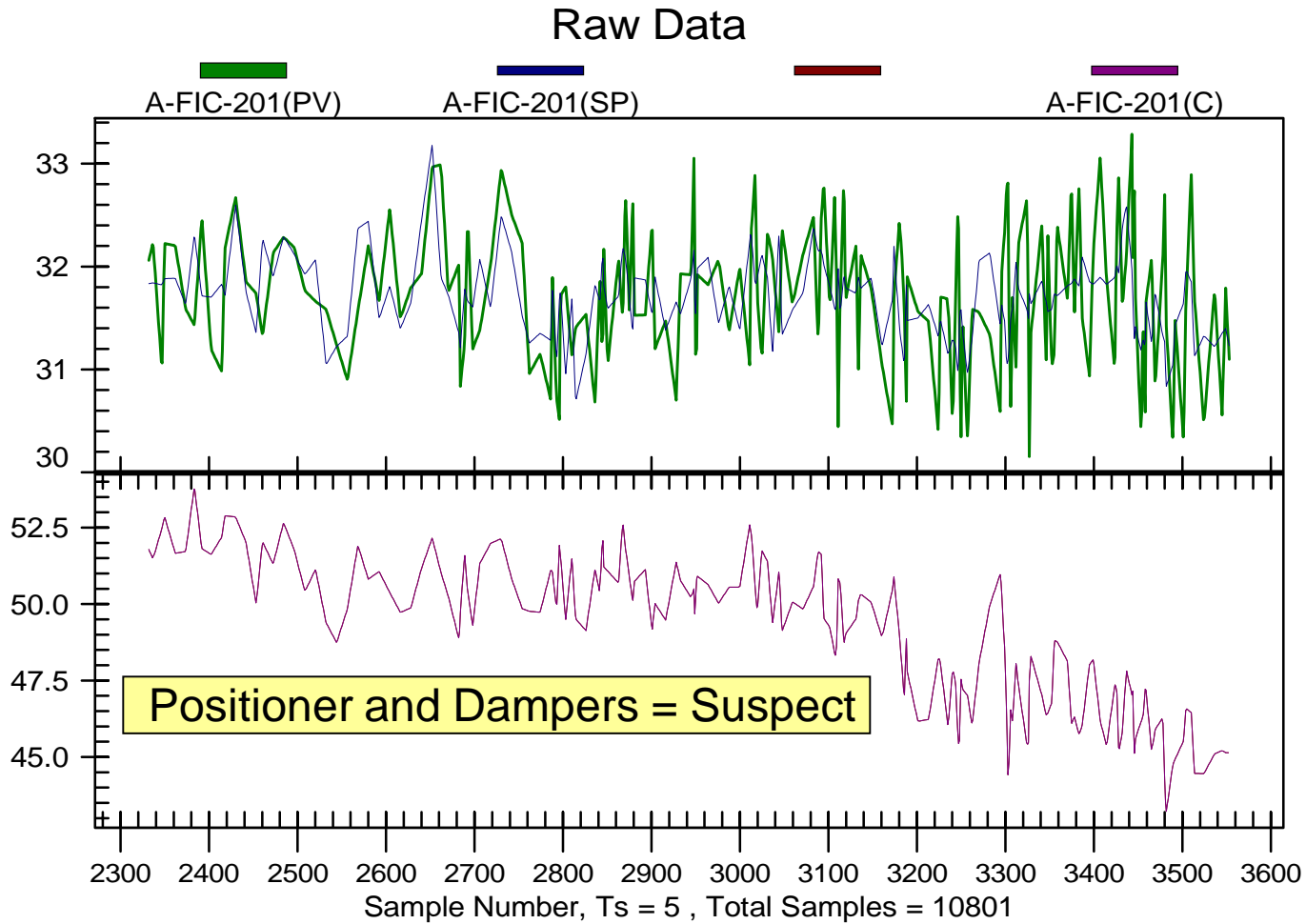
The Fingerprint uses a bottom-up approach to performance improvement. Data is collected to verify that basic instrumentation is working as needed, for good operation and control. Configured signal conditioning options are also examined and verified.

Closed loop control of fuel and air flow, draft, steam temperature, and drum level are examined under steady load conditions, and during load ramps. Disturbance rejection, setpoint tracking, actuator mechanical issues and loop interaction are evaluated.

ABB Services



FD Fan Control – Combustion Air



Boiler Hardware Issues



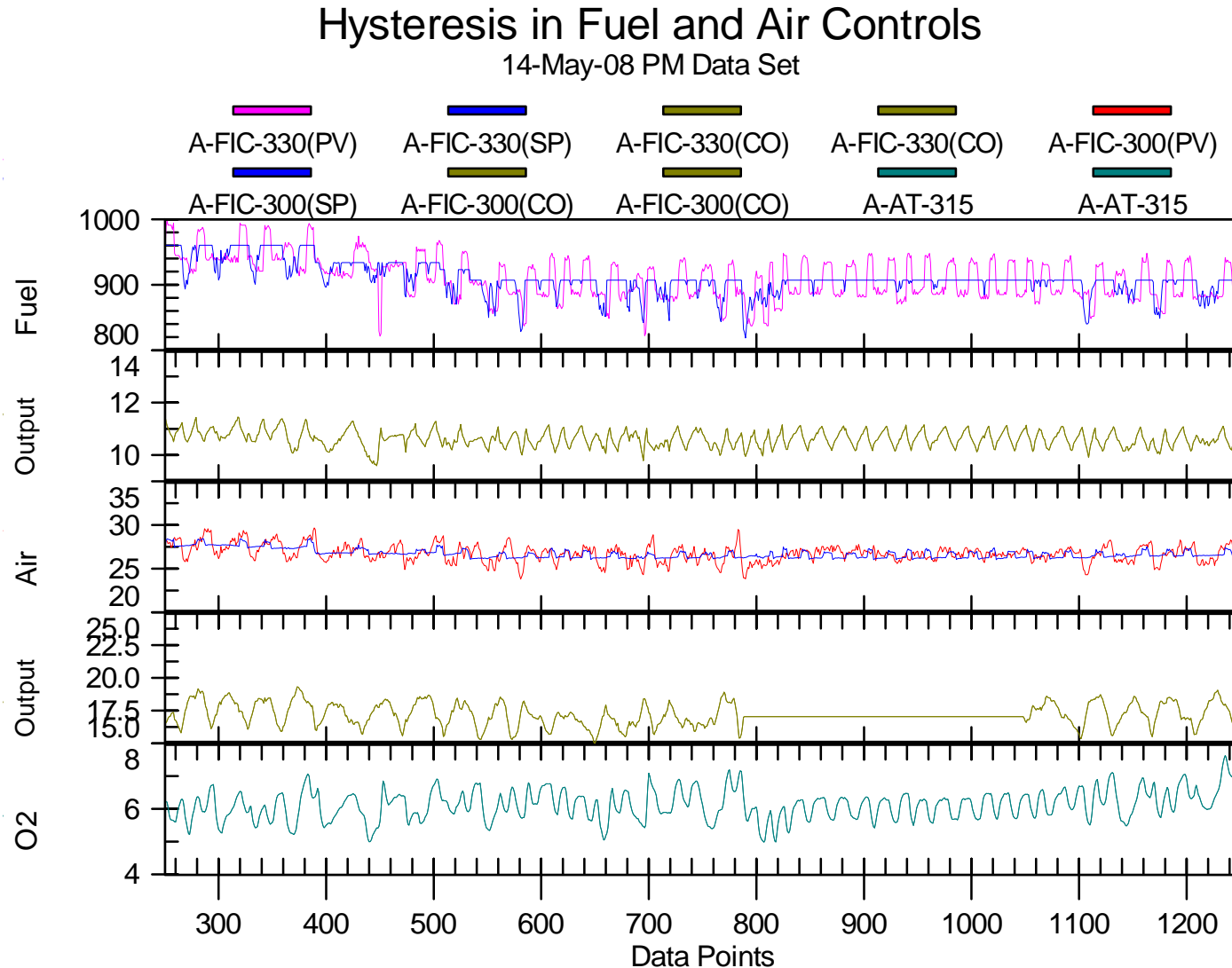
Forced Draft Control Drive and fan



Induced Draft Control Drive and fan

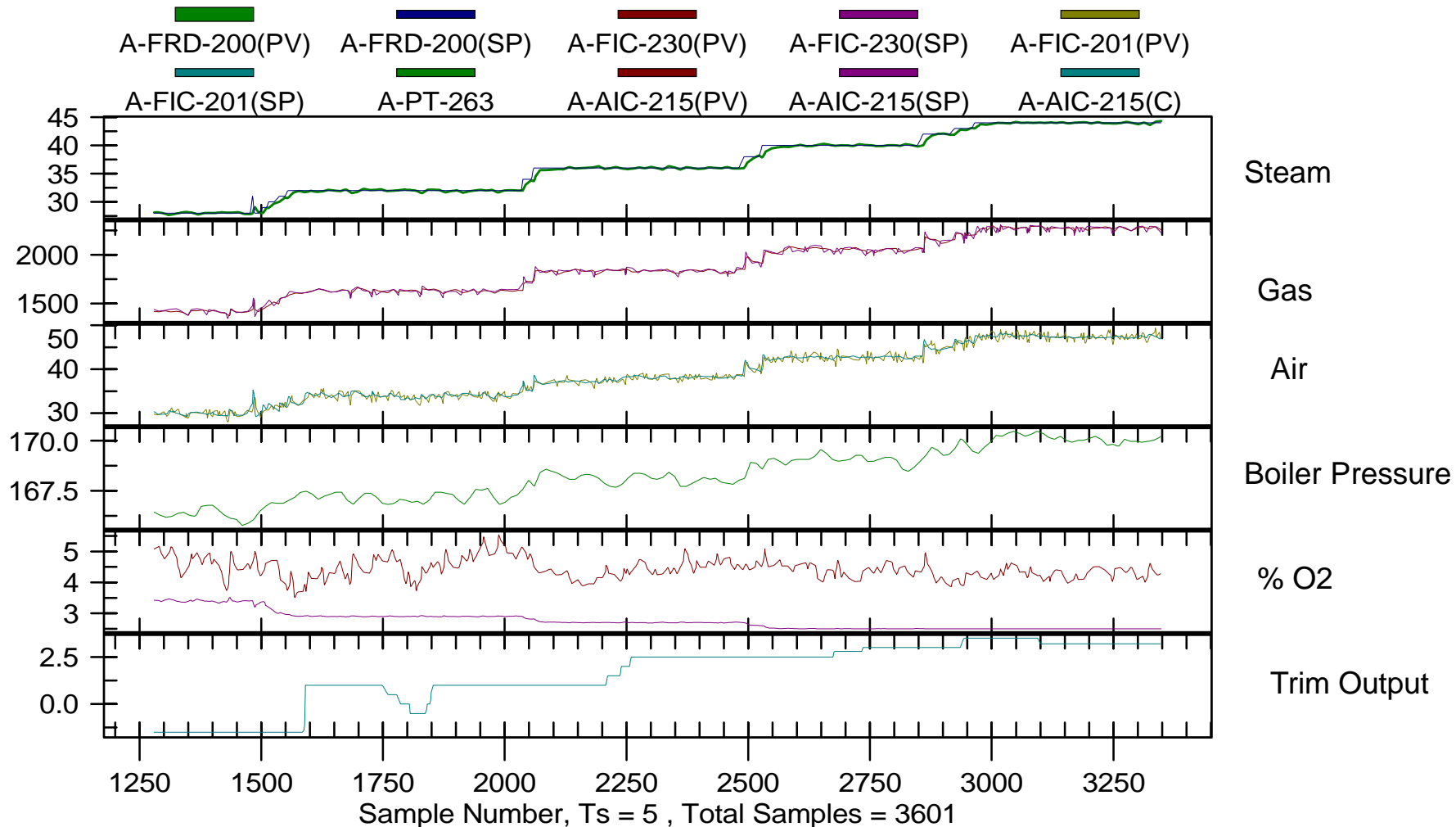
- Positioner drives not operating smoothly.
- Cylinder/Piston assemblies should be rebuilt or replaced.
- Motors are oversized.

Hysteresis – Air and Fuel



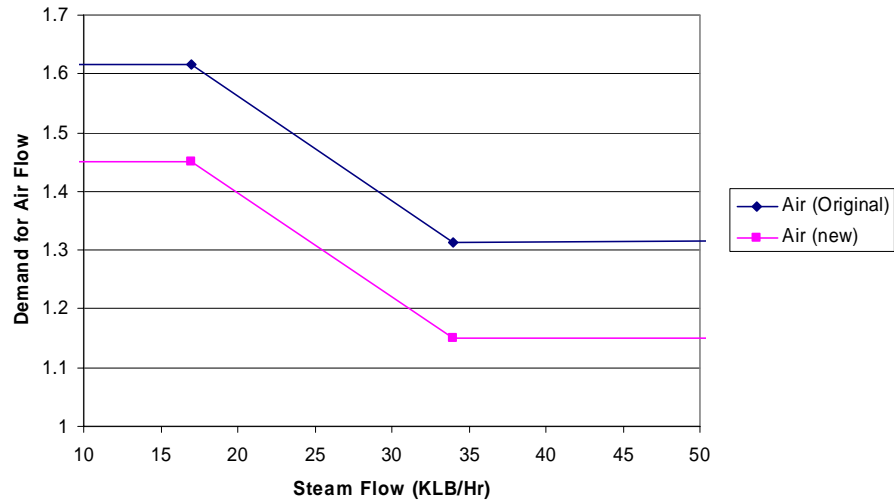
Load Test

Raw Data

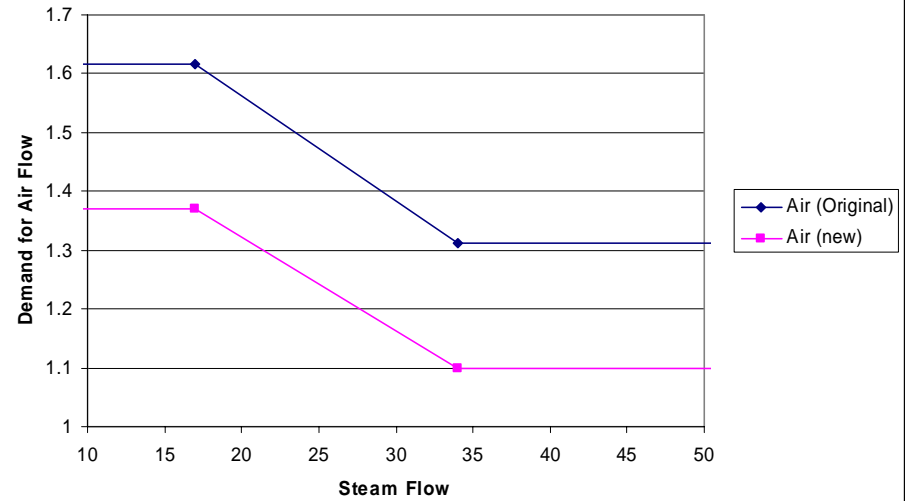


Updated Air Curves

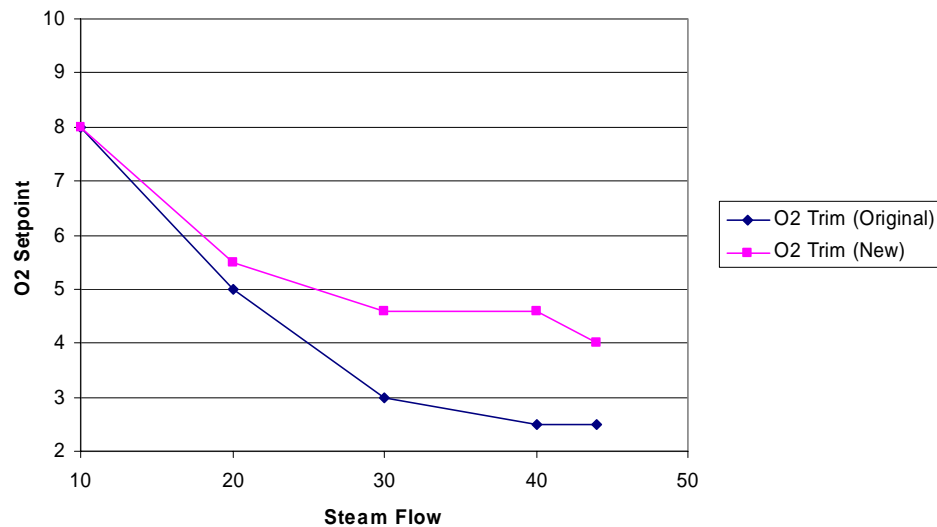
Gas Fuel for Air Curve



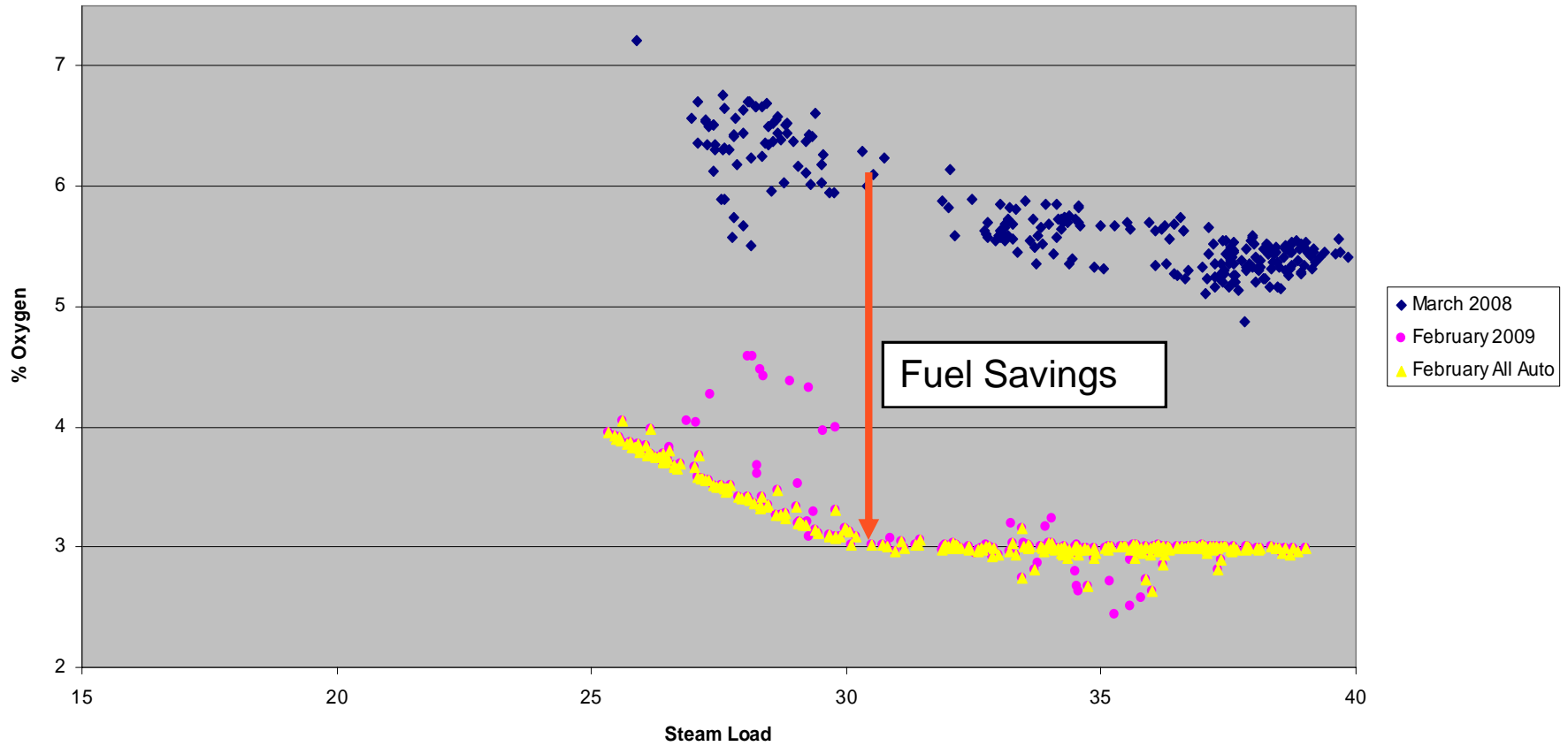
Oil Fuel for Oil Curve



Steam to Trim O2 Curve



Boiler #2: Customer results



Financial Impact – Boiler #2

Boiler #2 rated at 40 klb steam/hr

**Savings range of 2% to 3% achieved
without major capital**

**Approximate value = \$75K to \$100K for
Boiler No. 2 alone**

Savings for all four boilers = \$300,000

3 Loop Optimization helps sustain customer results

Goal: Maintain improved performance level

- Adjust maintenance operating procedures
- Adjust standard operating procedures
- Remote process monitoring

Proactive and collaborative

- Specifics are a function of the Implement phase
- Periodic monitoring of key process indices utilizing local or remote expertise

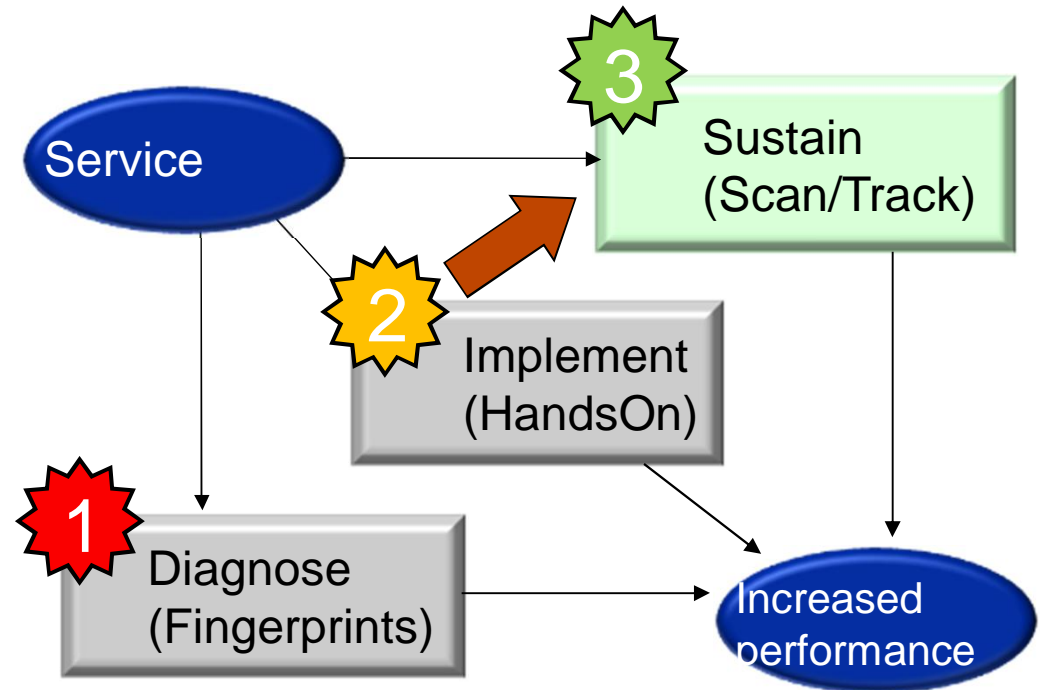
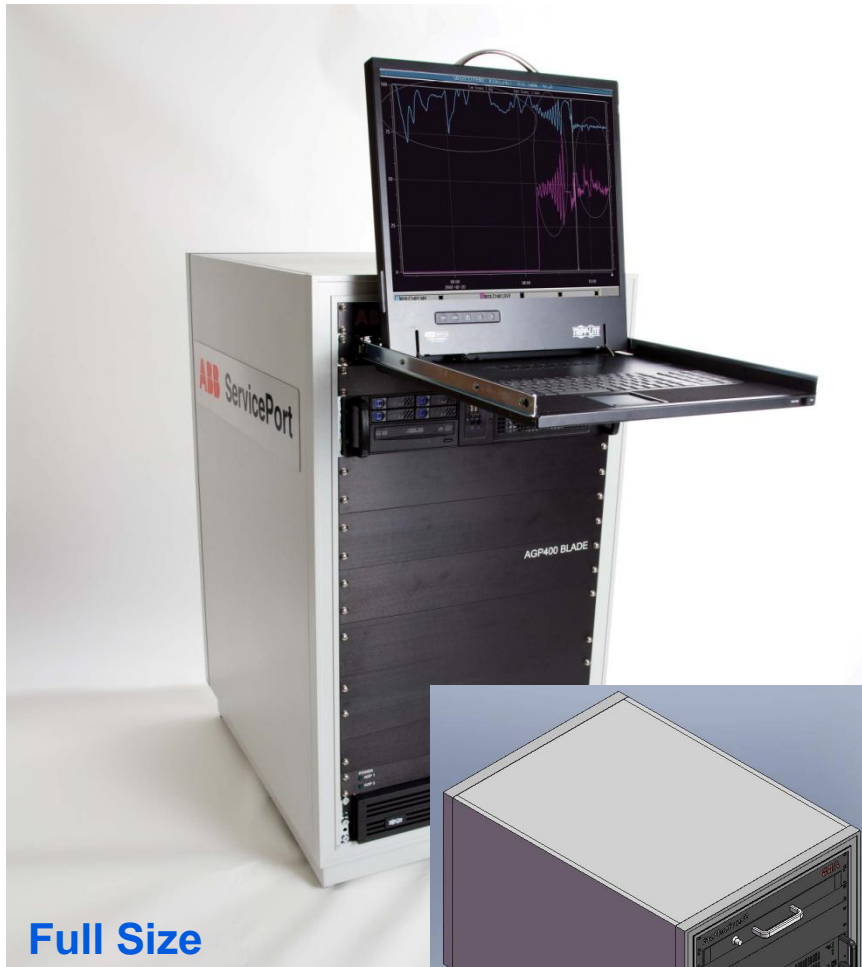
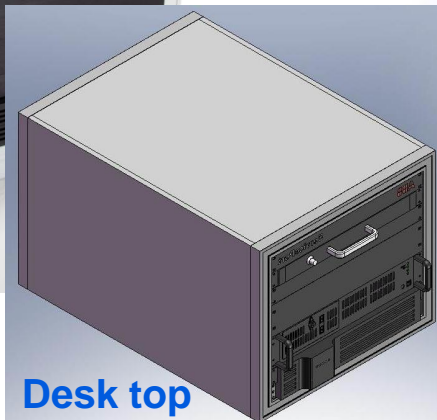


ABB ServicePort™

Secure, remote delivery for Scan and Track



Full Size



Desk top

- Secure portal residing at customer site through which plant personnel and ABB experts can access:
 - Configuration tools
 - Diagnostic applications
 - Improvement activities
 - Performance-sustaining troubleshooting
 - Scanning software that deploys agreed actions.
- ABB can connect to any system through ServicePort and implement fixes to diagnosed problems.

Workbench Tools – Improve efficiency and quality of service results

Data Collection

- DL400
- AGP400

Loop Performance Fingerprint

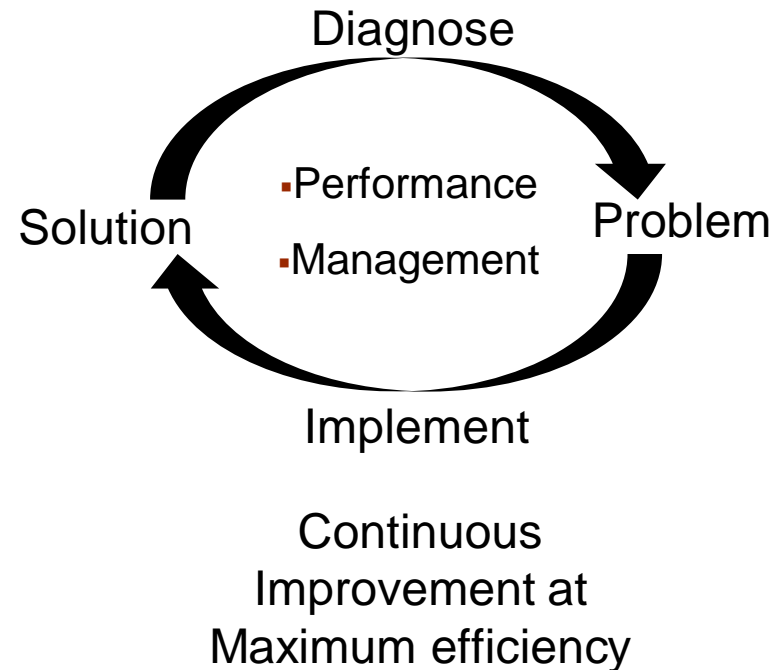
- Loop Analyzer
- Signal Analyzer

Loop Tuning

- LoopTune

Batch and Grade Change Analysis

- Sequence Analyzer
- Loop Performance Monitoring
 - ServicePort Loop Performance Channel



ServicePort + Channels

- ServicePort Base Unit
- Process Channels
 - Control Loop
 - Quality Control System
 - Mine Hoist
- Equipment Channels
 - Harmony
 - 800xA
 - Cyber Security
- Remote Access Platform

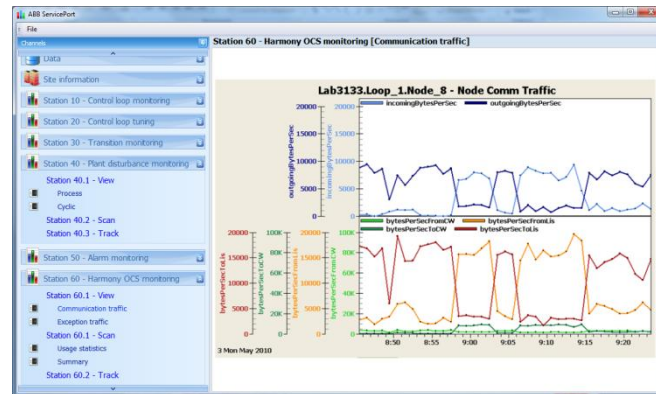
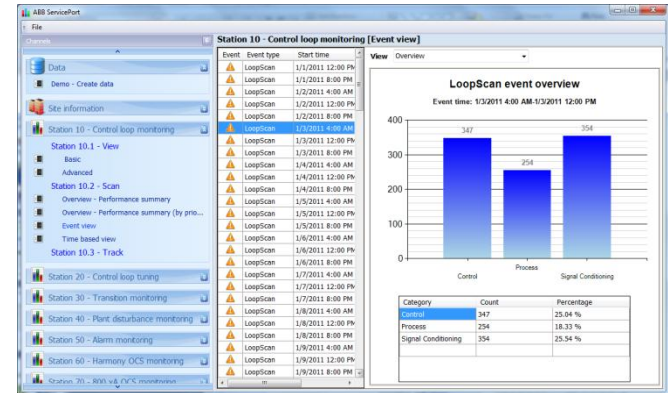
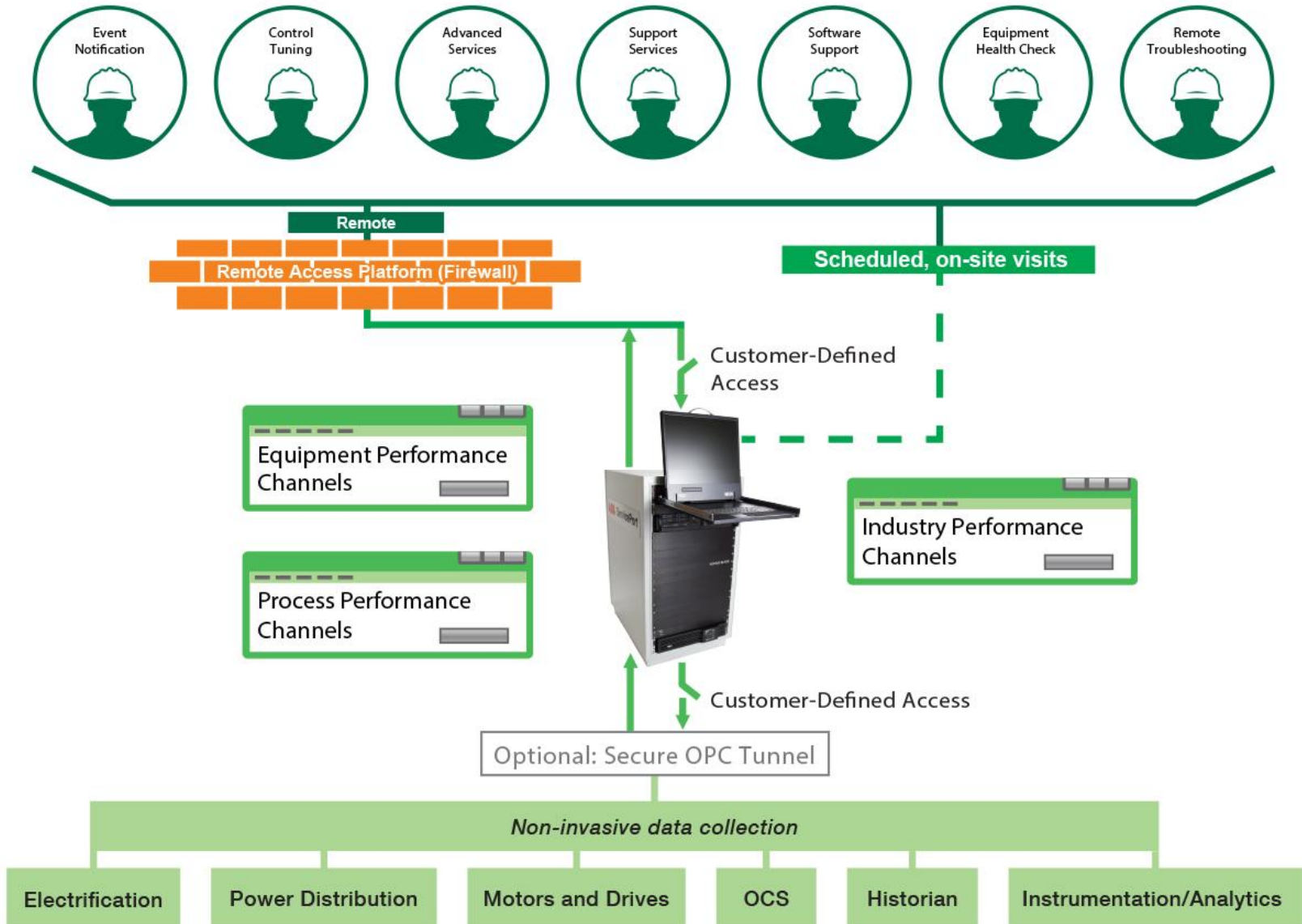


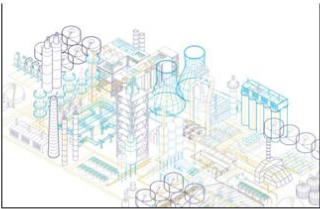
ABB ServicePort: Access to experts, reduces costs



SCAN Performance Service Reports

LoopScan Report

Customer Name
20xx-06-28



Prepared by:
Process Automation Life Cycle Services Research and Development team

ABB Power and productivity
for a better world™

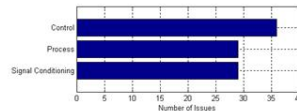
Customer name 2012-06-27

2 Control Loop Performance Summary

2.1 Performance Overview

The performance of each control loop is evaluated based on responses related to: control, process, signal conditioning. Each loop that gets a poor rating is counted as having an issue that needs investigation. This does not always mean there is a problem. However, a large number of issues indicate that there is room for improvement. The following figure shows the number of issues by each category.

Table 4: Number of Issues per category (control, process and signal cost)



Control: These indices are designed to capture control loops that have problems associated with process control tuning, setup, or configuration.

Process: These indices are designed to capture control loops that have problems associated with process disturbances. These typically are not related to tuning.

Signal Conditioning: These indices are designed to capture control loops that have problems associated with signal conditioning. Problems here can be corrected with filters and proper analog input setup.

The following loops are evaluated in the current period.

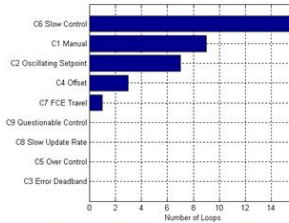
Loop Number	Loop Name	Loop Number	Loop Name	Loop Number	Loop Name	Loop Number	Loop Name
1	SPIC401	17	SPIC411	23	SPIC480	34	SPIC500
2	SPIC402	18	SPIC412	24	SPIC481	35	SPIC501
3	SPIC413	19	SPIC413	25	SPIC482	36	SPIC502
4	SPIC403	20	SPIC414	26	SPIC483	37	SPIC503
5	SPIC413	21	SPIC415	27	SPIC484	38	SPIC504
6	SPIC416	22	SPIC416	28	SPIC485	39	SPIC505
7	SPIC417	23	SPIC417	29	SPIC486	40	SPIC506
8	SPIC418	24	SPIC418	30	SPIC487	41	SPIC507
9	SPIC419	25	SPIC419	31	SPIC488	42	SPIC508
10	SPIC420	26	SPIC420	32	SPIC489		
11	SPIC421	27	SPIC421	33	SPIC490		

ABB Service
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Customer name 2012-06-27

2.2 Key Performance Indicator Category: Control

Table 2: Loop with Control Issues



Manual: Loops operating in a manual mode. Investigation is necessary to determine if there are control, hardware, or process constraints that will not allow these controls to be placed in automatic.

Slow Control, Over Control, Questionable: All of these represent issues related to tuning.

FCE Travel: This diagnosis indicates excessive Final Control Element (FCE, e.g. valve) movement.

Offset: Offset is defined as loops that have a constant difference between the setpoint and measured value. Loops that have this problem either have no integral value, have the integral control action blocked, or the output is out of range. This is also possible if the control logic is configured in a poor way.

Error Deadband: This diagnosis indicates if there is a significant deadband active in the controller decreasing controller performance.

Oscillating Setpoint: Normally this can be positive only for inner loops of cascade control strategies.

Slow Update Rate: This diagnosis indicates whether the controller is executing too slowly compared to the nature of disturbances and process dynamics.

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Customer name 2012-06-27

C1 Manual - KPI

This diagnosis indicates periods of manual control in the data set. Manual control is deduced from the MV, SP and OUT signals. 9 Loops were in Manual for more than 25% of the duration.

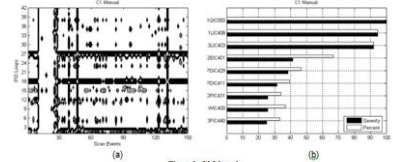


Figure 1: C1 Manual
(a) The contour plot (severity of C1 Manual for all 42 controllers for each scan event)
(b) Shows mean value of severity for Loops where it is above mean threshold (25), it also shows the percentage of the time C1 manual diagnosis was true.

Corrective Suggestion

Why is loop in manual?

- Operational habits
- Transmitter failure
- Stuck actuator
- Aggressive control
- Operator forgot to return to Auto after equipment restart.

C1 Manual - Trend Plots

The following are examples of loops where the KPI for Manual mode was true.

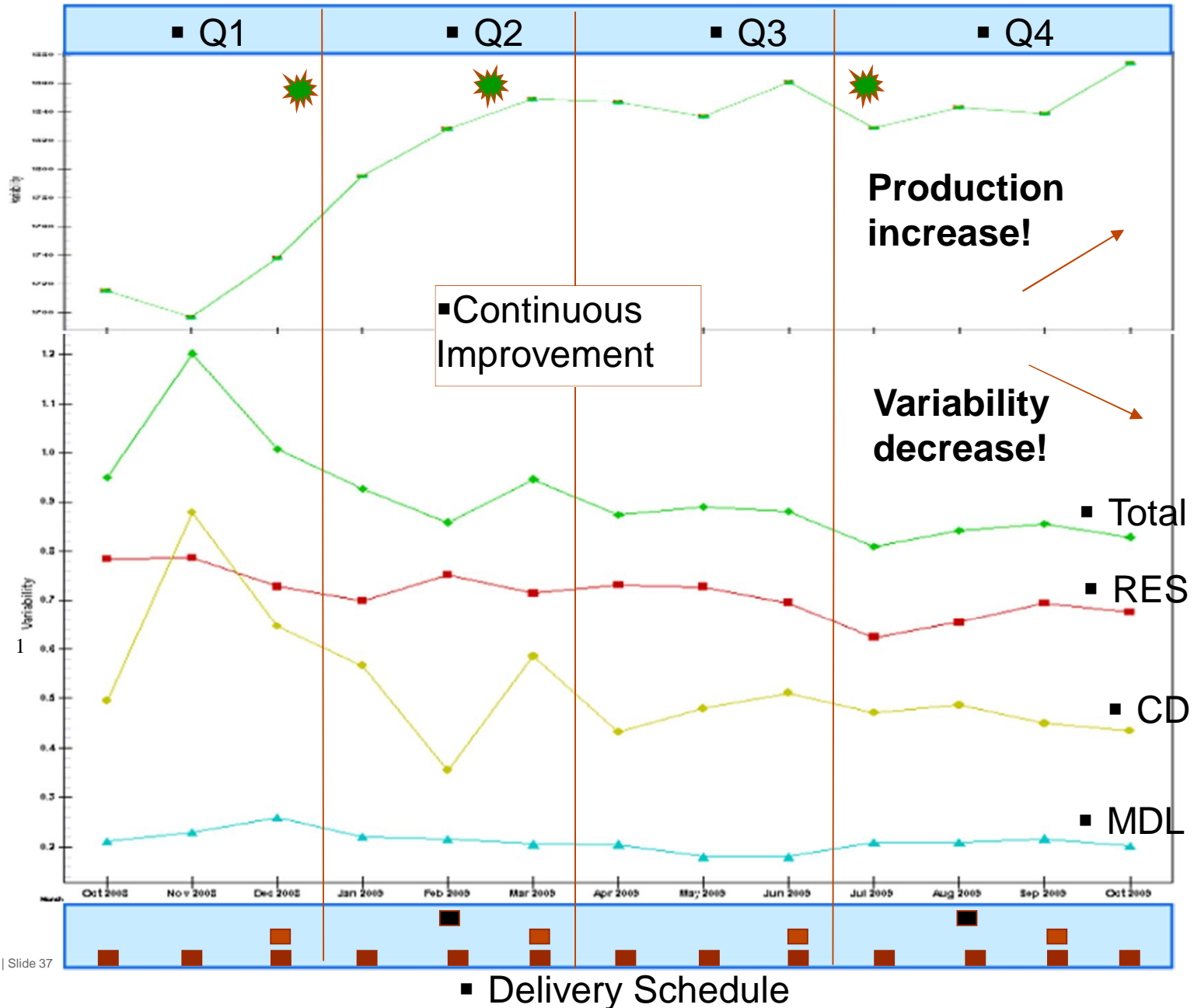
ABB Service
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- Statistical Evaluation of Historical KPI's performed twice a year
- Ensures stability of KPI's
- Reduces the risk of false positives
- Keep up to date with process
- Crucial to ensure continuous improvement

ABB

Sustain: track KPIs to ensure improvement

KPI Tracking



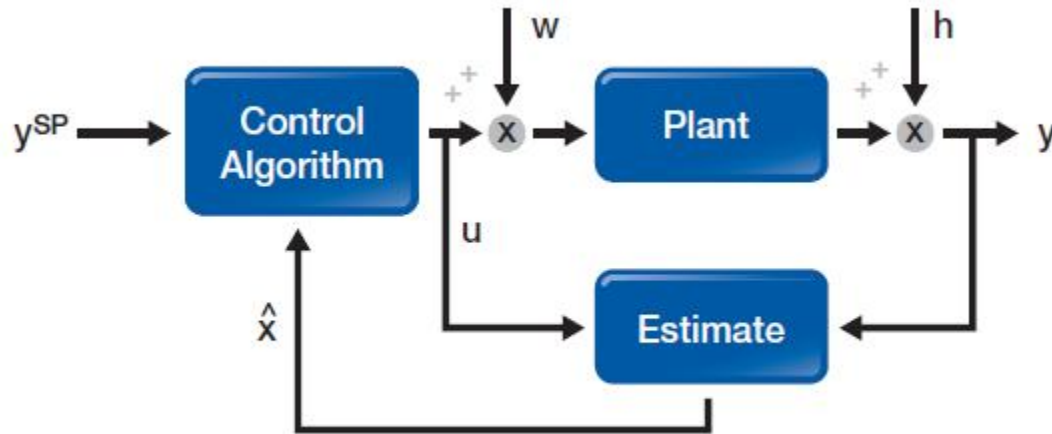
What's APC?



Advanced Process Control
The proven way to process optimization

- APC – Advanced Process Control
- ARC - Advanced Regulatory Control
- MPC – Model Predictive Control
- MIMO – Multiple Inputs, Multiple Outputs
- Constraints – Process or Physical Limits
- Linear Programming – Cost Minimization
- IMP – Inferential Modeling Platform
- Scheduling and Batch optimization

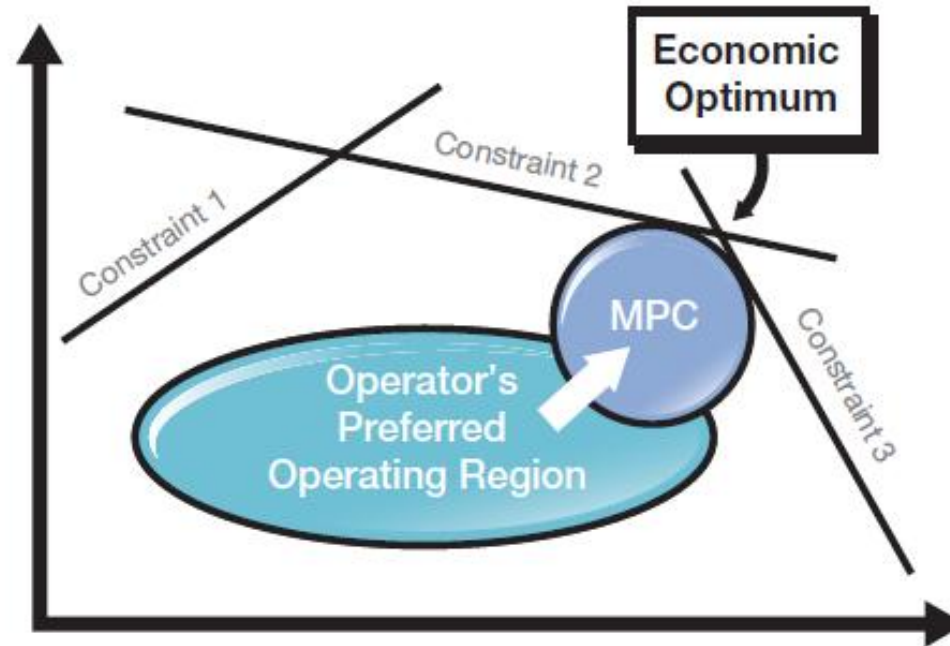
ABB's Predict and Control APC Solution



Features

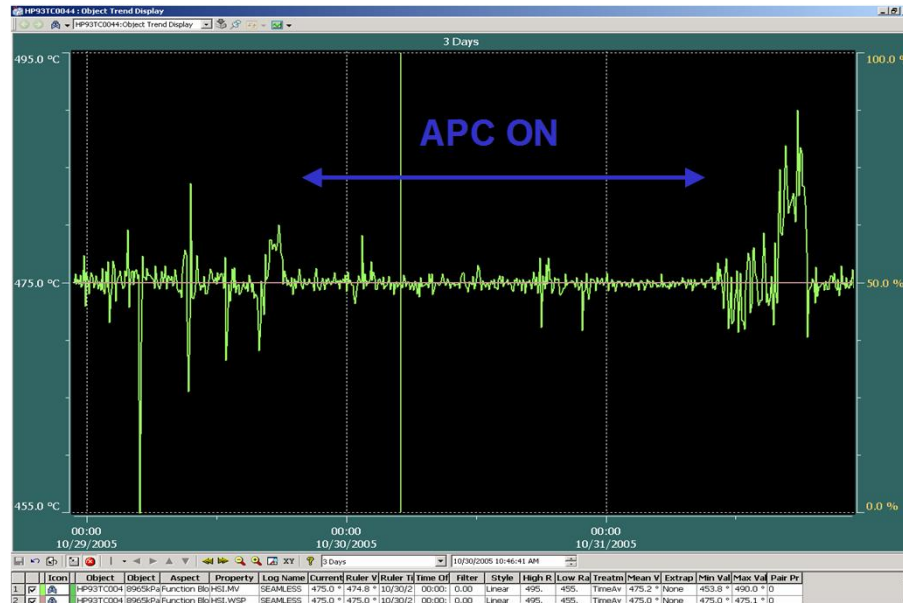
- True Multivariable Control
- State Space, Model Predictive Control (MPC) Structure
- Subspace and Prediction Error model identification methods
- Constraints (MVs and CVs): prioritize up to 30 classes
- OPC connectivity to process data
- Inferential Modeling Platform (IMP) to infer variables or properties that are difficult to measure

APC - Predict and Control

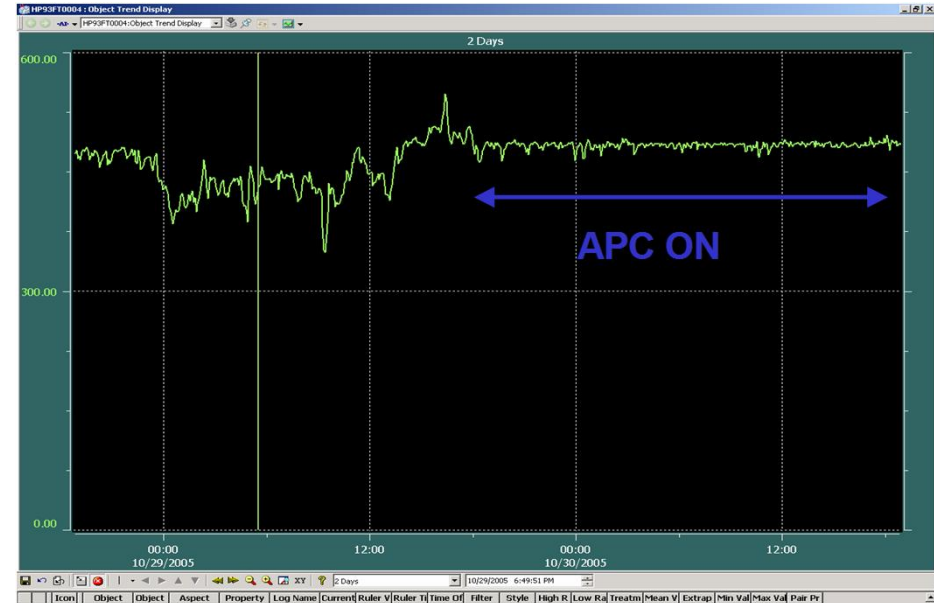


- Allows safe operation closer to constraints
- Smooths operation by predicting effects of control moves and compensating
- Works best when base level controls are optimized

Steam Temperature and Boiler Steam Flow Control



Temperature Control



Steam Flow Control

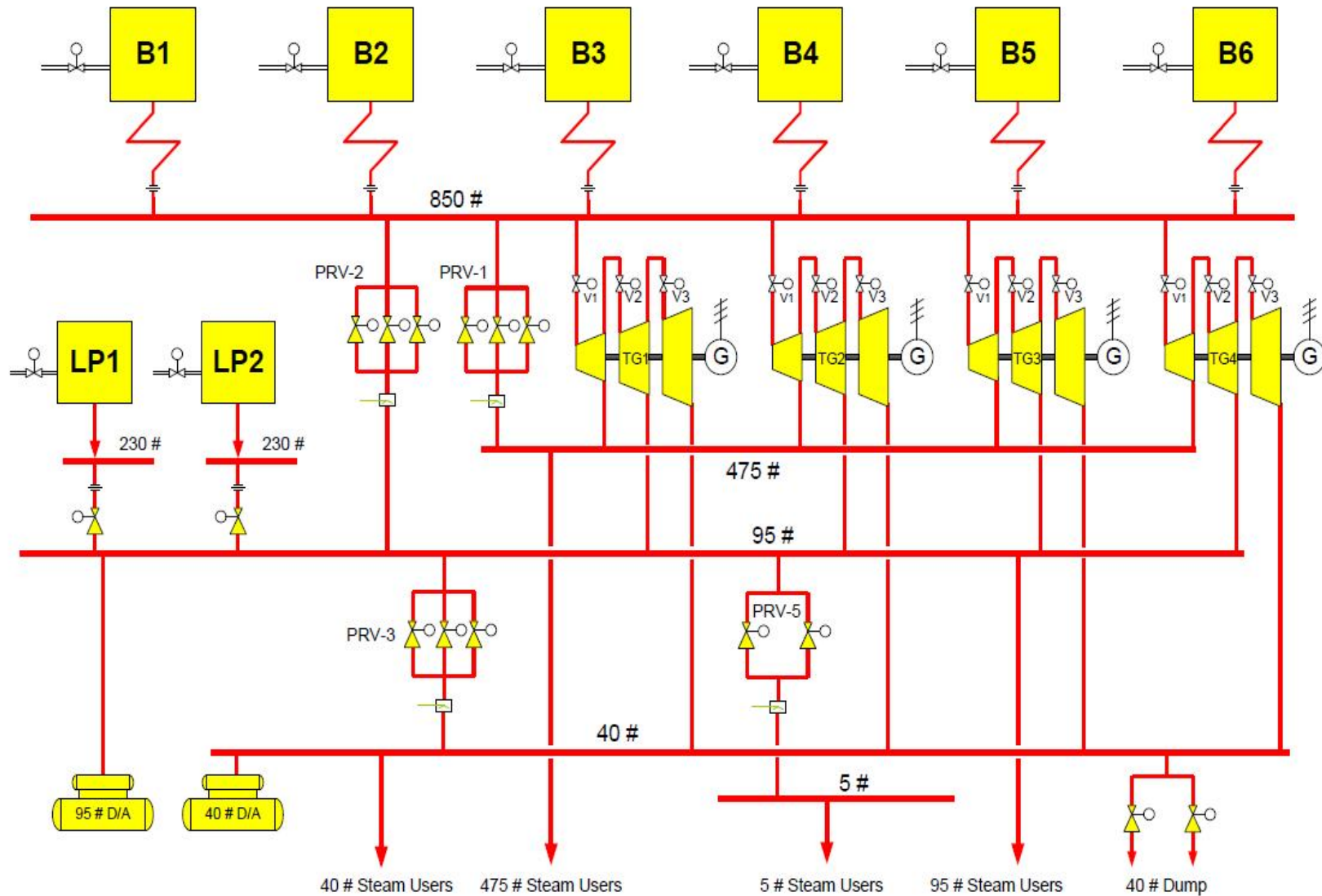
Benefits in Boiler Management

Steam Temperature and Boiler Steam Flow Control

- Better process stability: avoidance of boiler trips and loss of production
- 7 °C average steam temperature increase translates to 1.2 MW of power
- 29 tons/hr average steam flow rate increase translates to removal of steam-limited process conditions
- 5% savings in overall purchased energy costs

ROI: under 6 months

Alumina Refinery Powerhouse Optimization



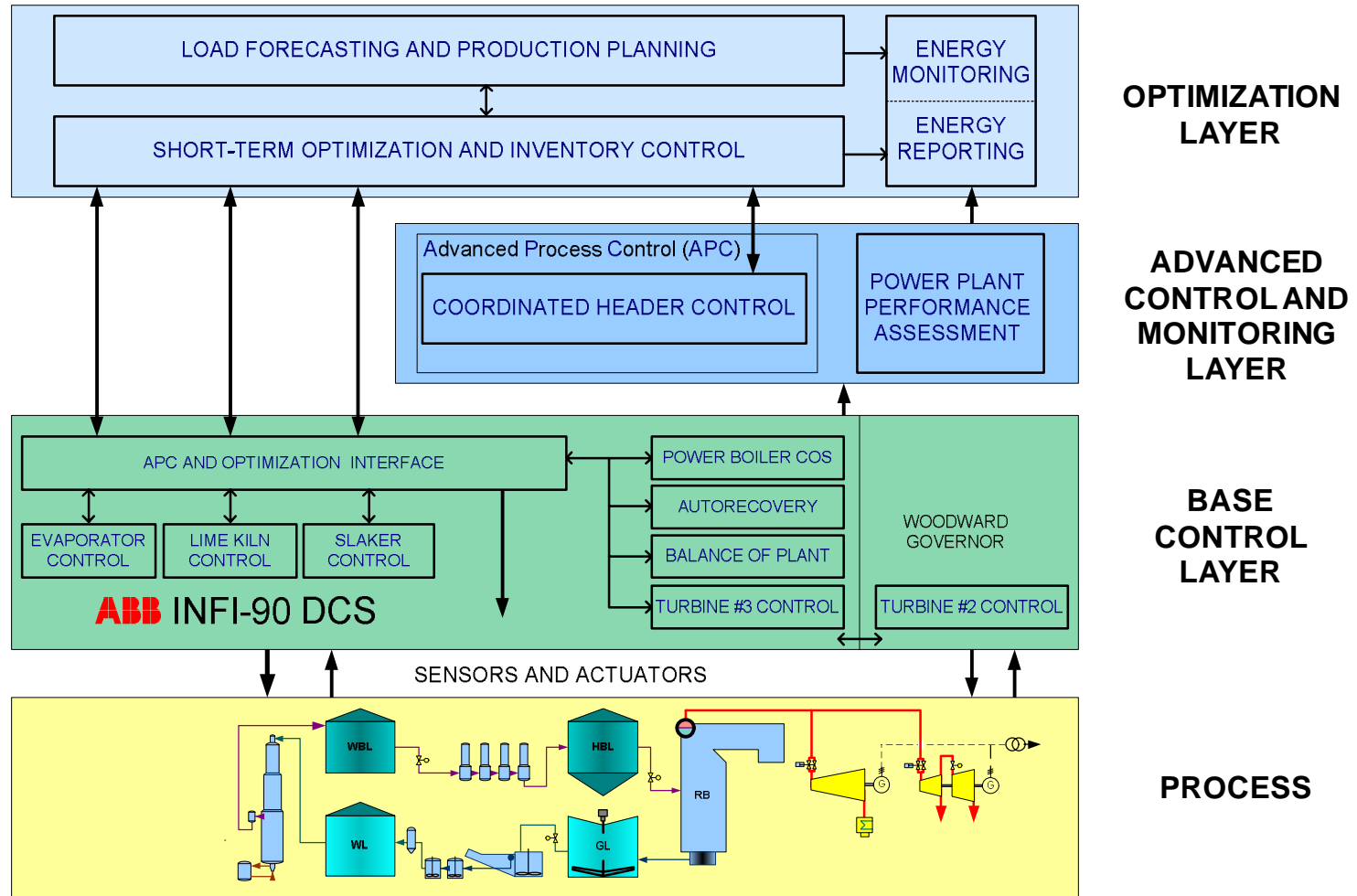
Alumina Refinery Powerhouse Optimization

Results

- 80% reduction in header pressure standard deviations
- Reduction in cascaded boiler trips, reducing outage time and production losses
- Savings in energy costs alone provided ROI within 6 months

APC Example: Zellstoff Celgar Supervisory Control Architecture

- Multi-Layered Solution



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