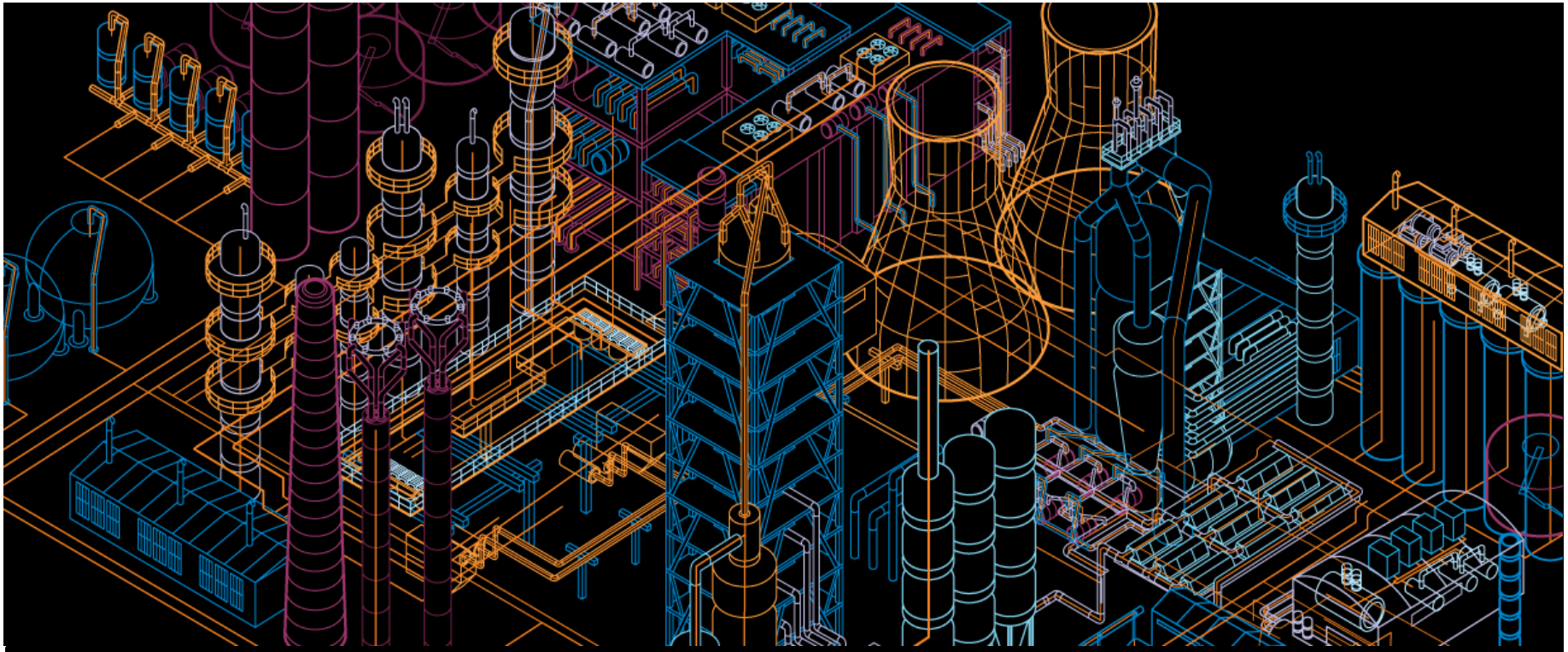
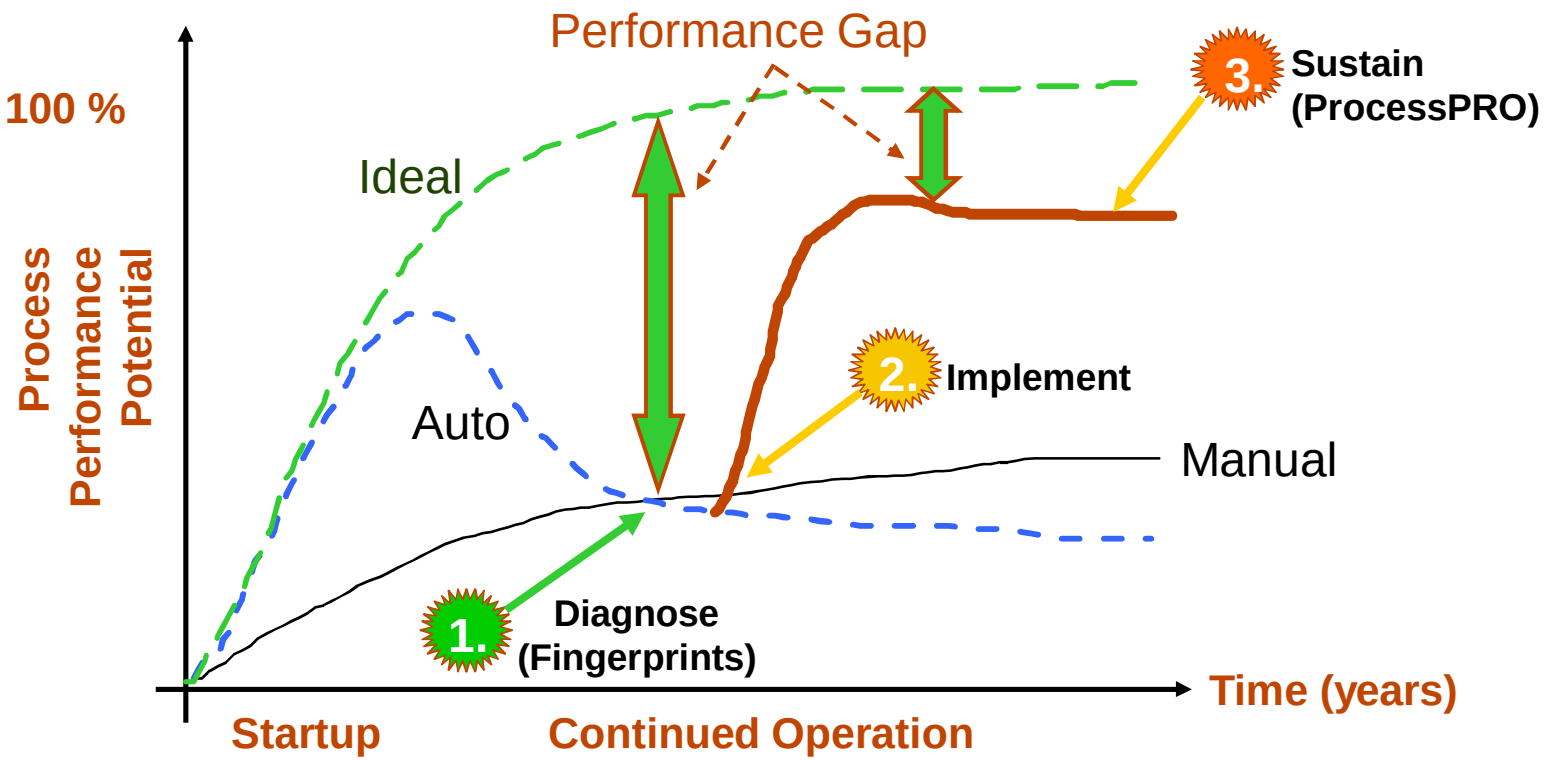


Optimization Services, Tools and Advanced Process Control

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

Action

Report

Interpret

Analyze

View

Get

Problem

Report

- Gap Analysis
- ROI Forecast
- Action Plan

Performance Evaluation

- Standard Methodology
- Analysis Expertise
- Performance Visualization

ABB

People

Process

Tools

Data Collection/Testing

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

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 Group
October 29, 2013 | Slide 5

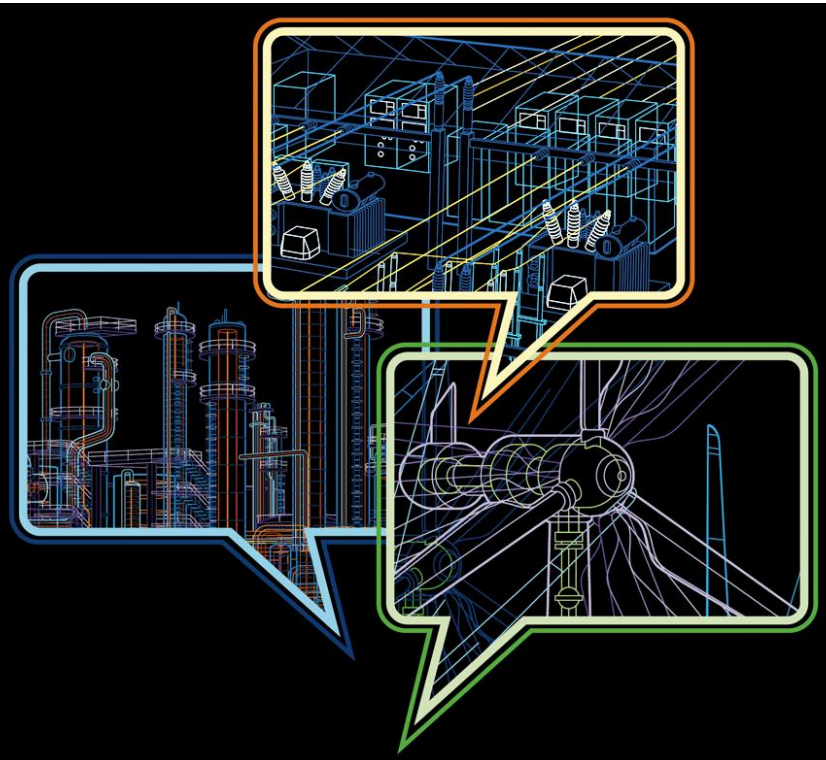


ABB Automation & Power World - May 18-20, 2010

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

Doug Reeder, Ted Matsko

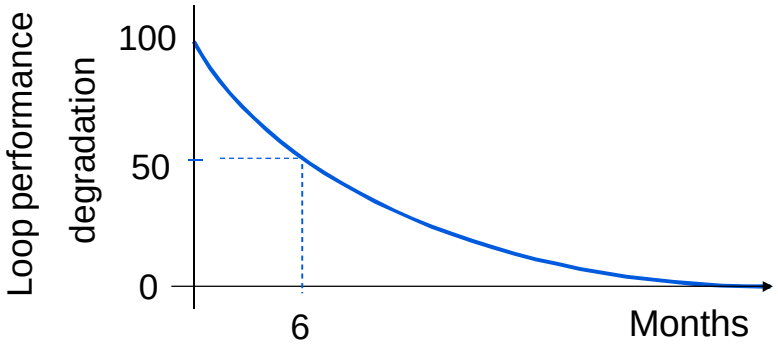
Loop Performance Fingerprint for a DuPont Monomers Plant

Control Performance Issues

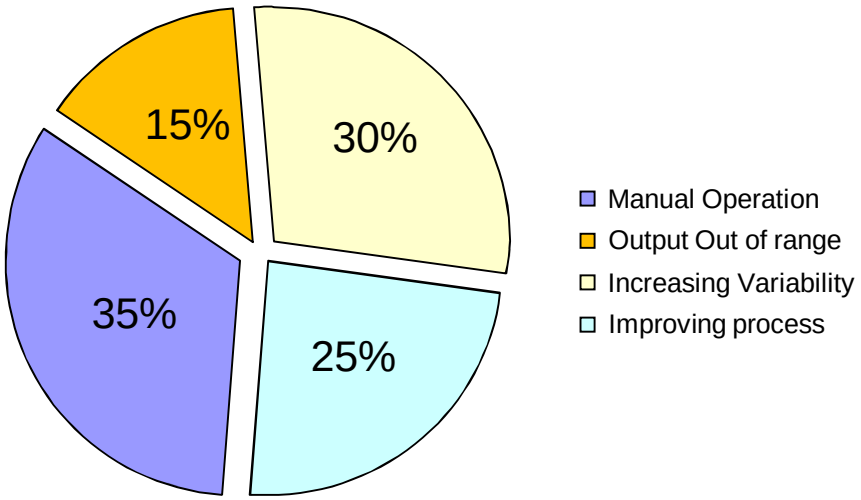
Half life of Process Controllers

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



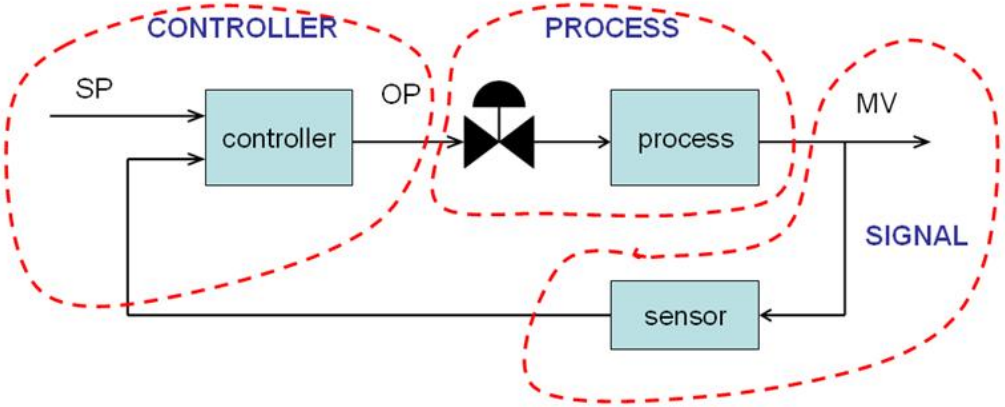
PID Controllers are designed to:

- 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

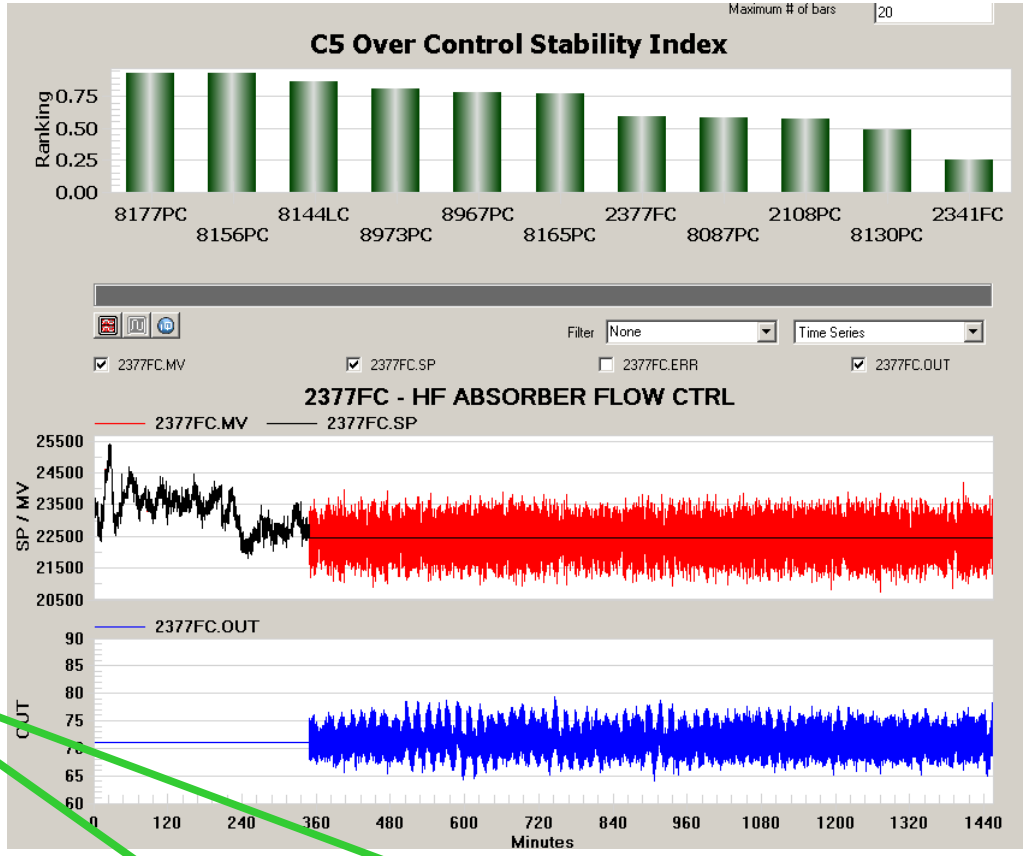


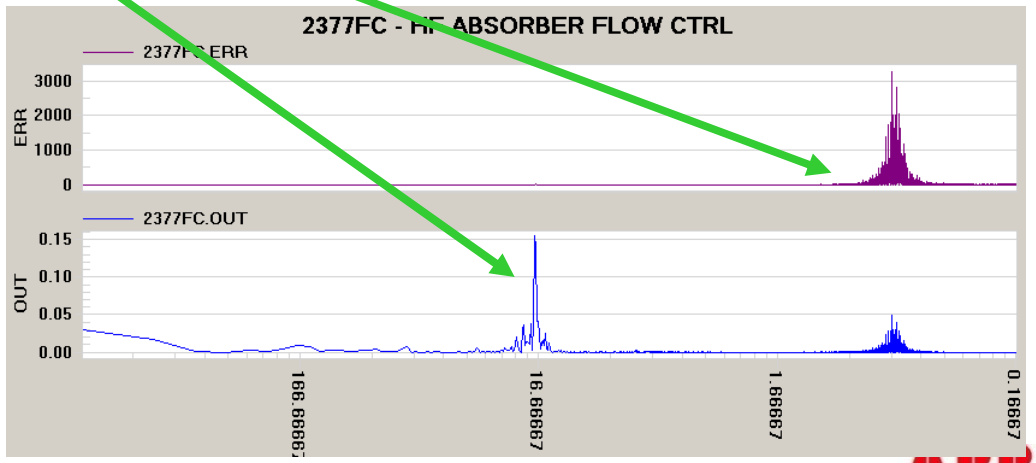
CONTROL	PROCESS	SIGNAL CONDITIONING
C1: Manual	P1: FCE Out of Range	S1: Quantized
C2: Oscillating Setpoint	P2: FCE Size	S2: Excessive Noise
C3: Error Deadband	P3: FCE Problem	S3: Spikes
C4: Offset	P4: FCE Leakage	S4: Step Out
C5: Over Control	P5: Intermittent Disturbance	S5: Data Compression
C6: Slow 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

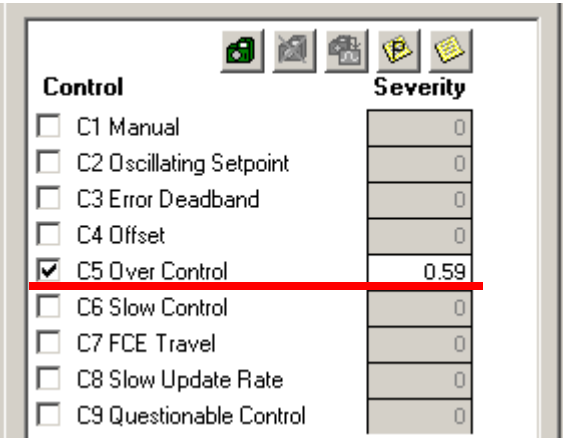
FCE = Final Control Element

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





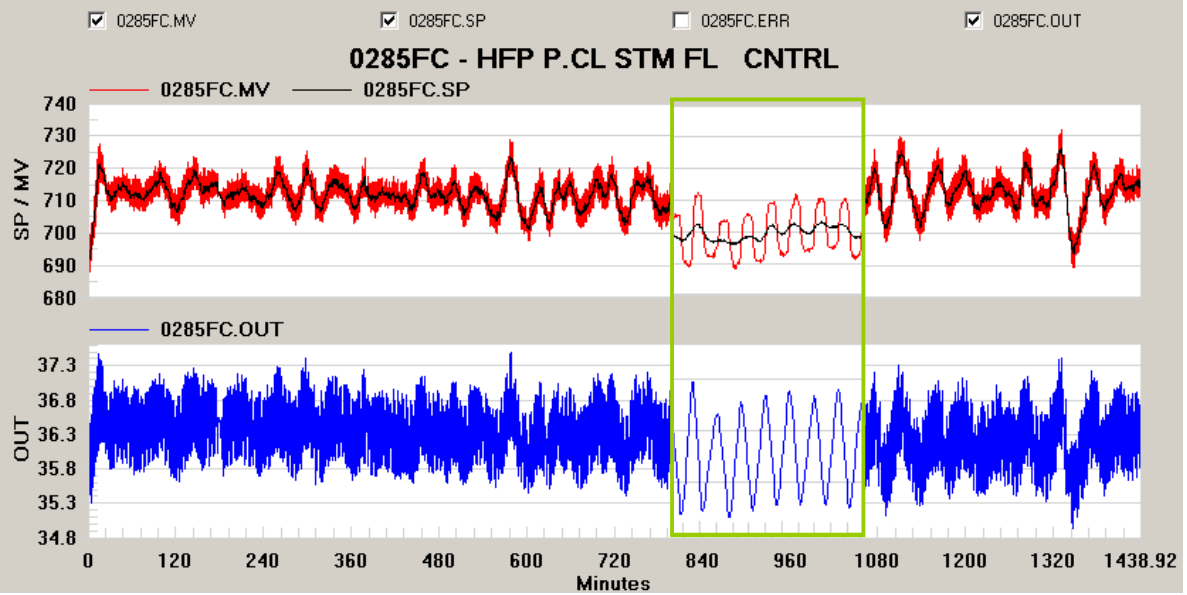


Control	Severity
C1 Manual	0
C2 Oscillating Setpoint	0
C3 Error Deadband	0
C4 Offset	0
C5 Over Control	0.59
C6 Slow Control	0
C7 FCE Travel	0
C8 Slow Update Rate	0
C9 Questionable Control	0

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
☐ P1 FCE Out Of Range	0
☐ P2 FCE Size	0
☑ P3 FCE Problem	53.4
☐ P4 FCE Leakage	0
☑ P5 Intermittent Disturbance	6.4
☐ P6 Persistent Disturbance	0
☐ P7 Questionable	0



Loop Fingerprint Report

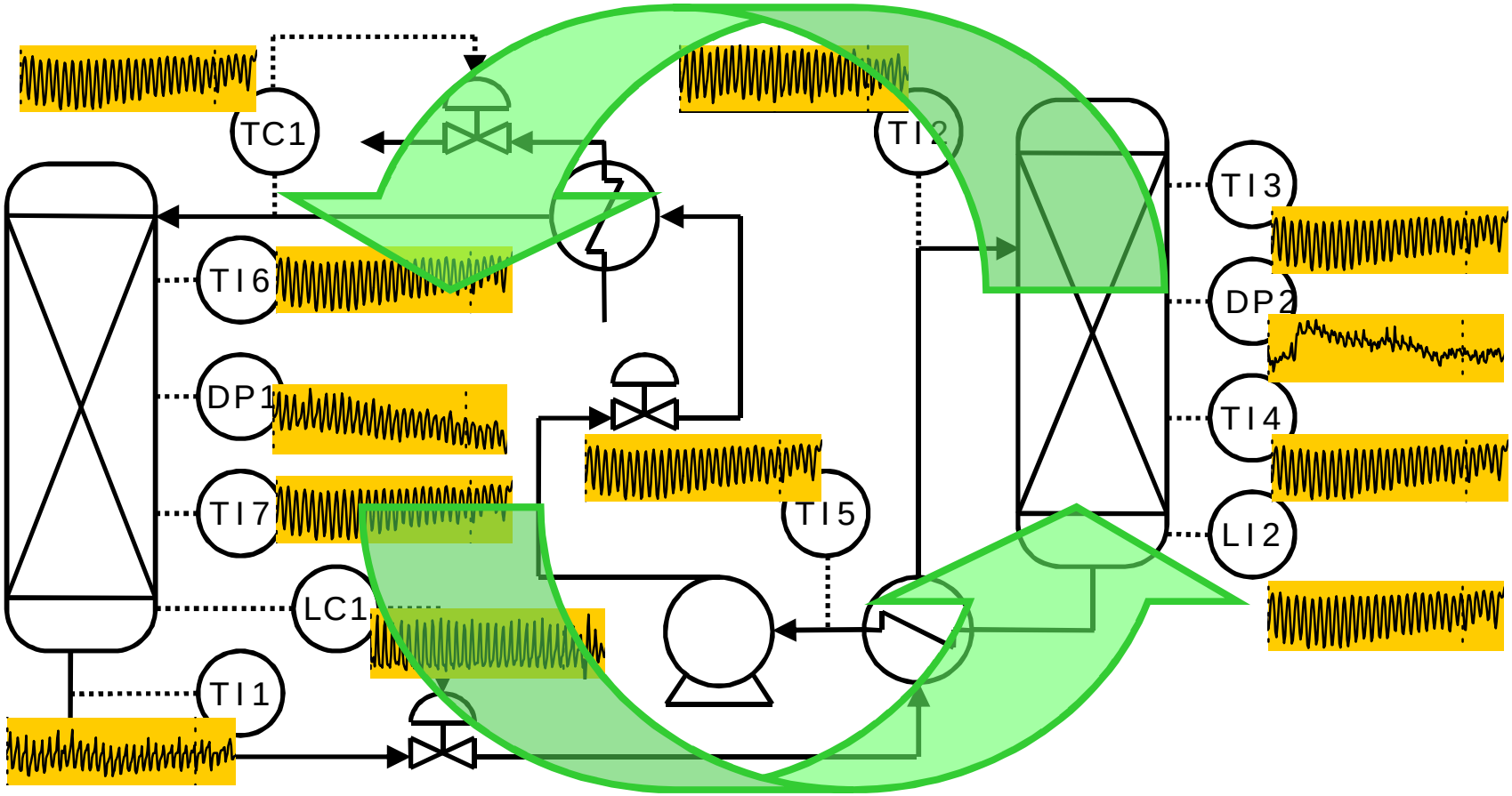
- The report highlights some loops, as shown in the previous slides and summarizes the results in tables. This table is for the TFE Synthesis section of the plant.

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

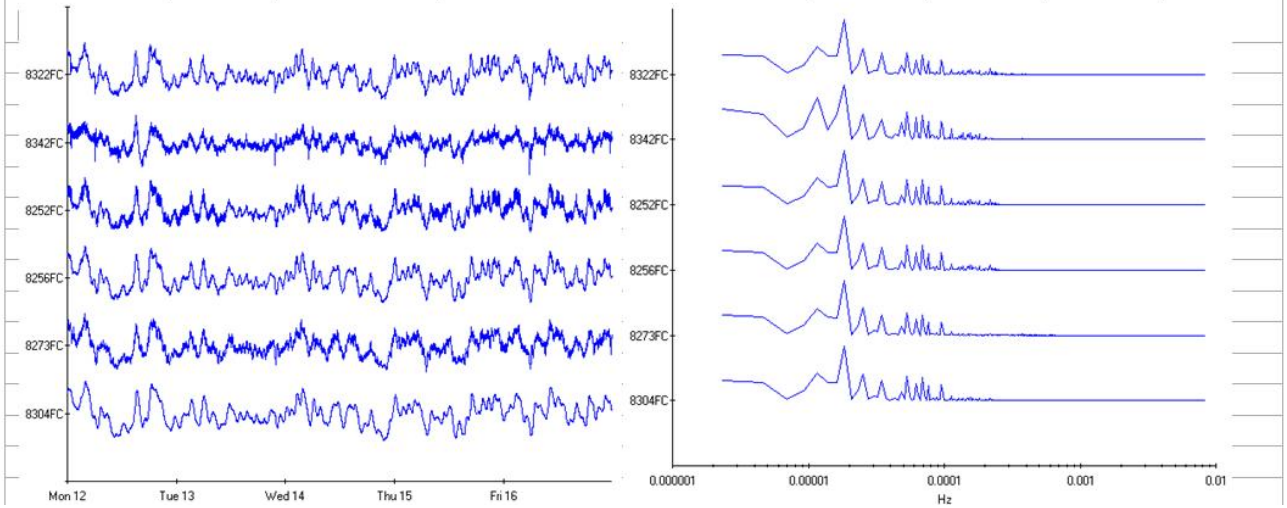


- Disturbances can propagate counter flow because of recycle and thermal integration

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

PCACluster13	Tag name	Area	Tag description	Causality	Deadtime		
	8342FC	BARDE-DRC	DRC REBOILER STEAM FLOW CTRL	1	2		
	8322FC	BARDE-DRC	DRC FEED FLOW CTRL	2	1		
	8252FC	BARDE-HCL	HCL COL DIST FL CTRL	3	3		
	8273FC	BARDE-HCL	HCL COL REBOIL STEAM FL CTRL	4	5		
	8256FC	BARDE-HCL	DIMER TO HCL COLFEED CTRL	5	4		
	8304FC	BARDE-HCL	HCL COL REFLUX CTRL	6	6		

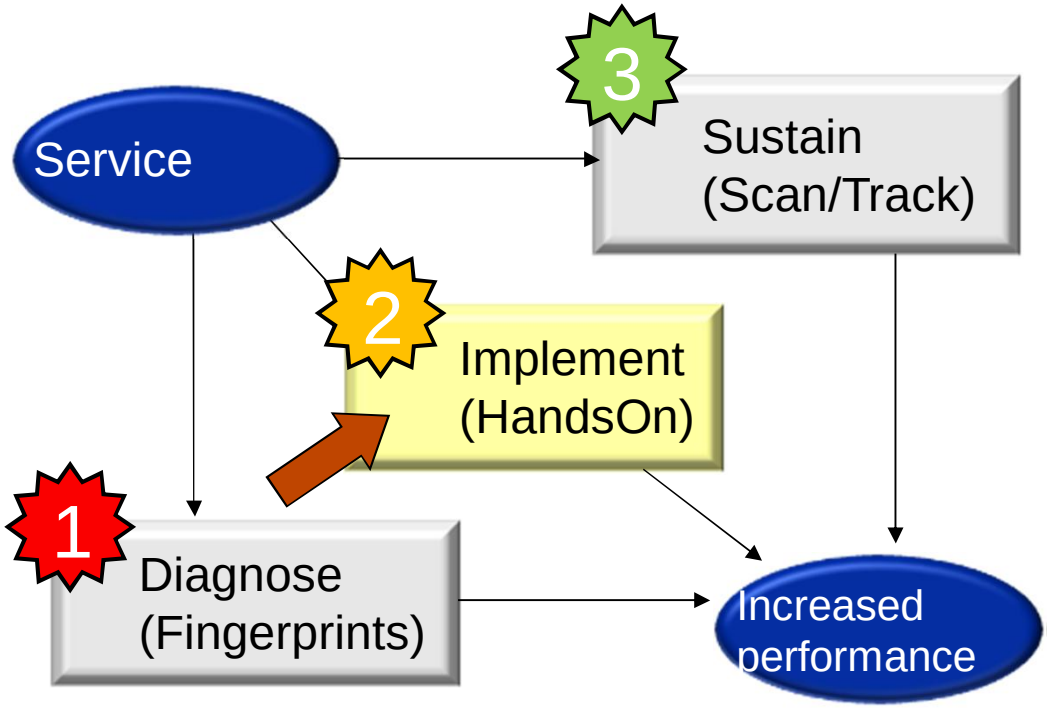


2 Loop Optimization implements improvements

Goal: Improve current performance level

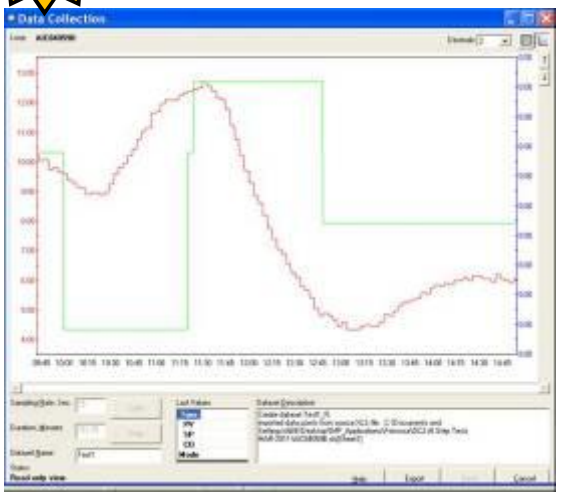
- Scope based on Diagnose phase
- Focused, scheduled activities
- Proven practices
- ABB-managed improvement program

Proactive and collaborative



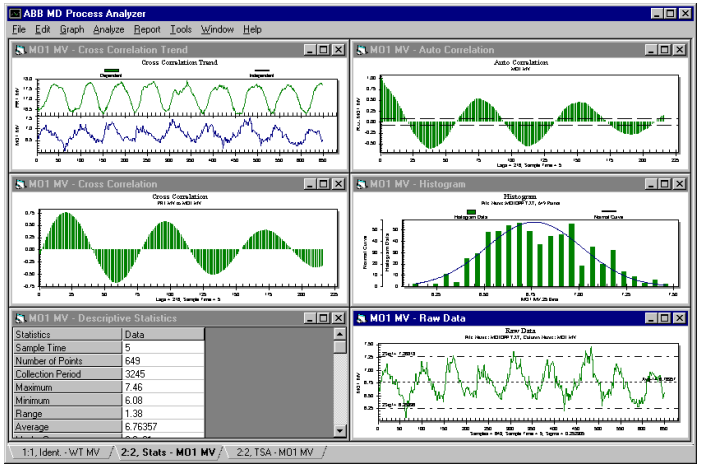
- **Solution categories:**
- Hardware
- Operations
- Tuning
- Application
- Process

2 Workbench: Implementation improvements



Visualization and Setup

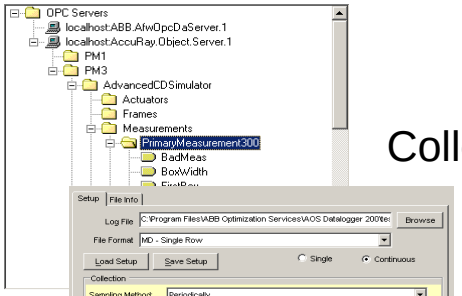
Analysis



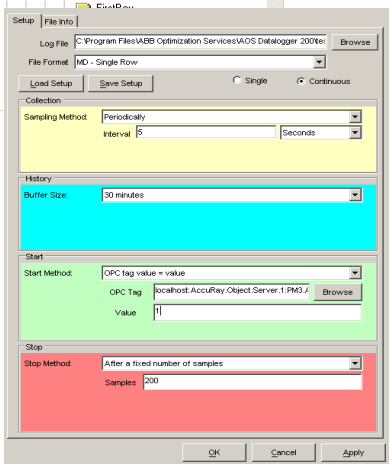
Standard Reporting

Tool Workbench

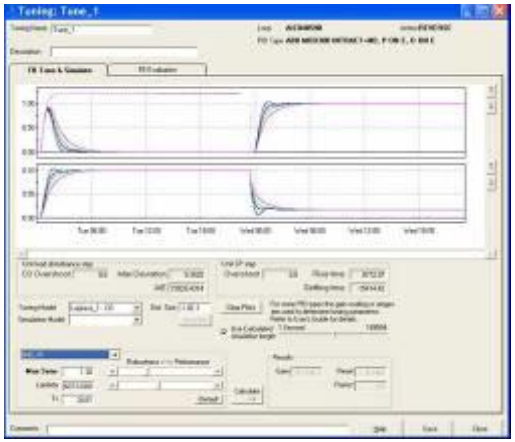
Identification

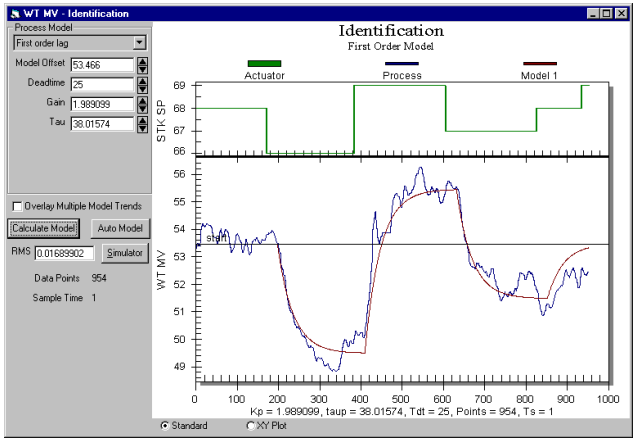


Collection



Tuning and Simulation





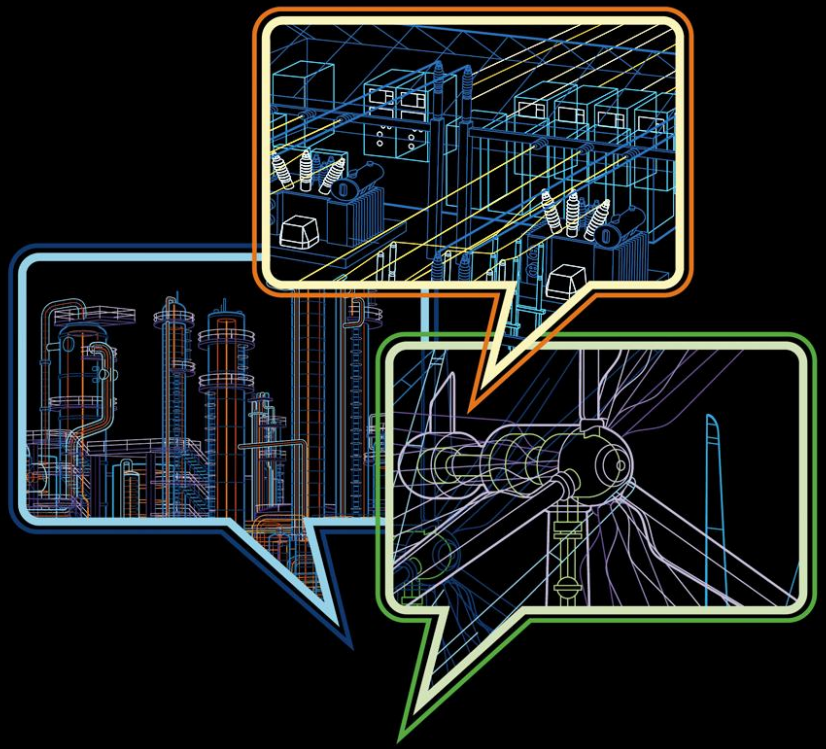


ABB Automation & Power World: April 23-26, 2012

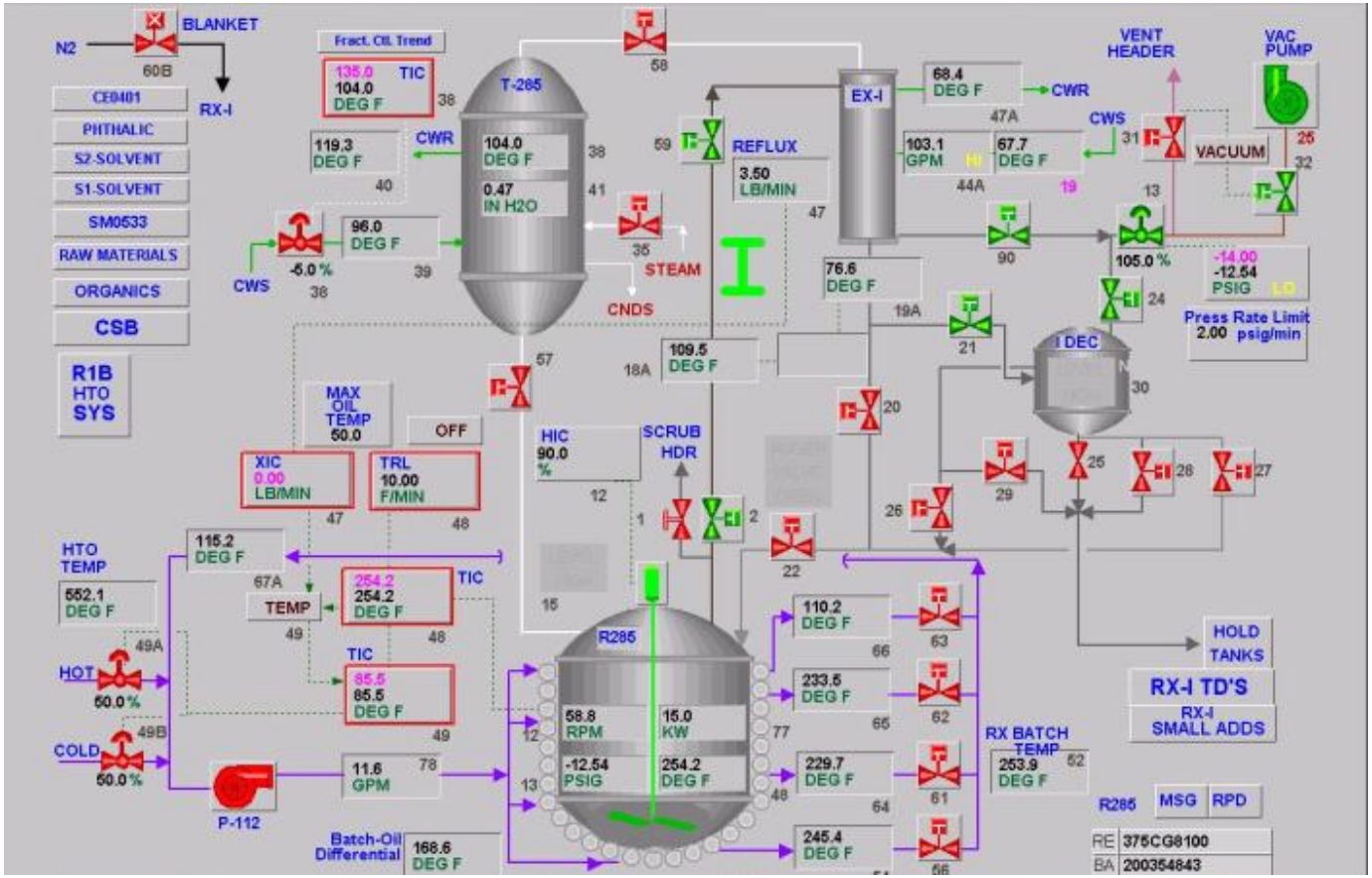
C549I

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

Batch Process Optimization
BASF Polymerization Reactor

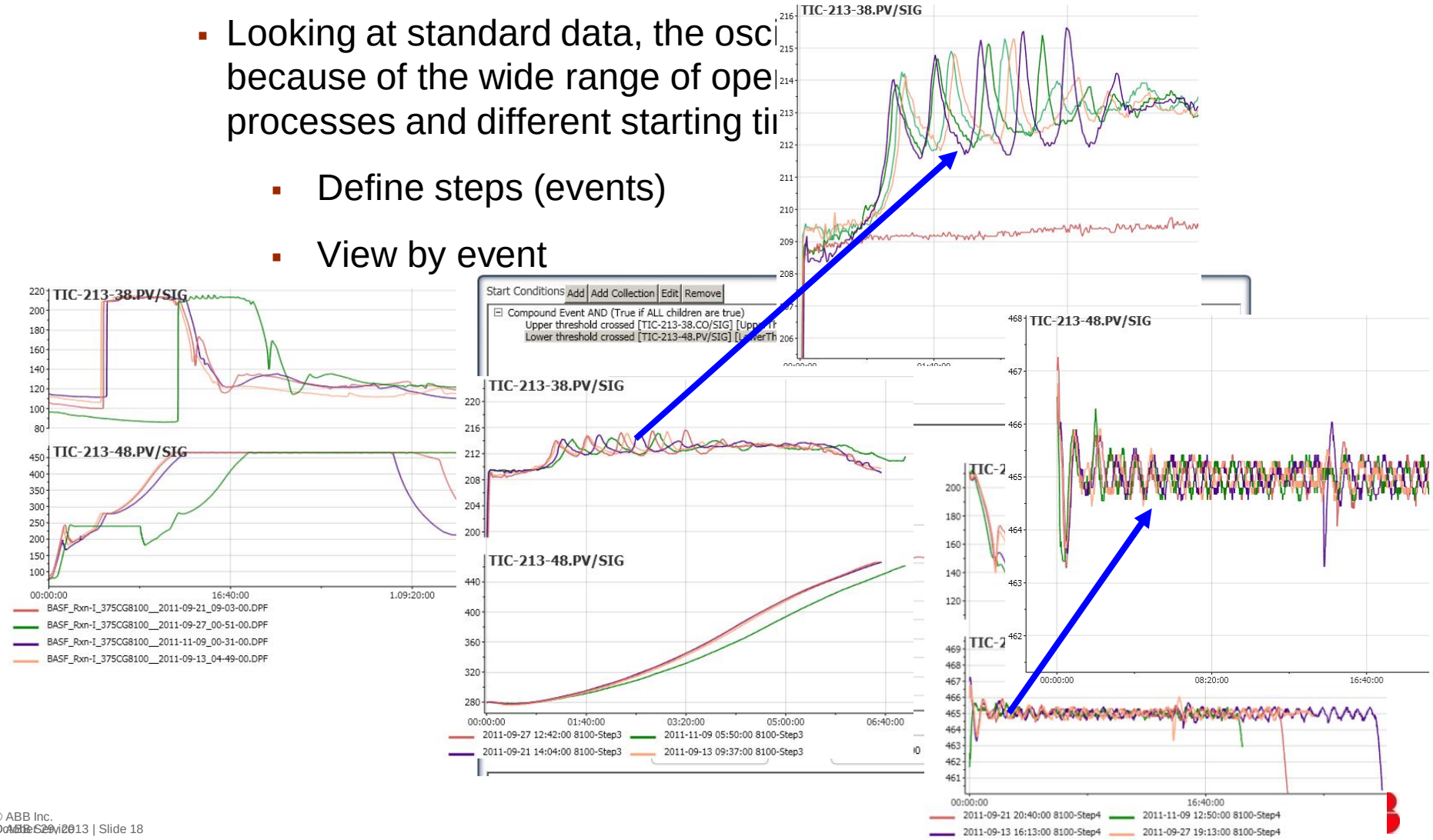
BASF Batch Reactor Optimization
Polyeseter – Key Equipment in “I” Reactor System

- 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 osc
  because of the wide range of ope
  processes and different starting ti
  - Define steps (events)
  - View by event



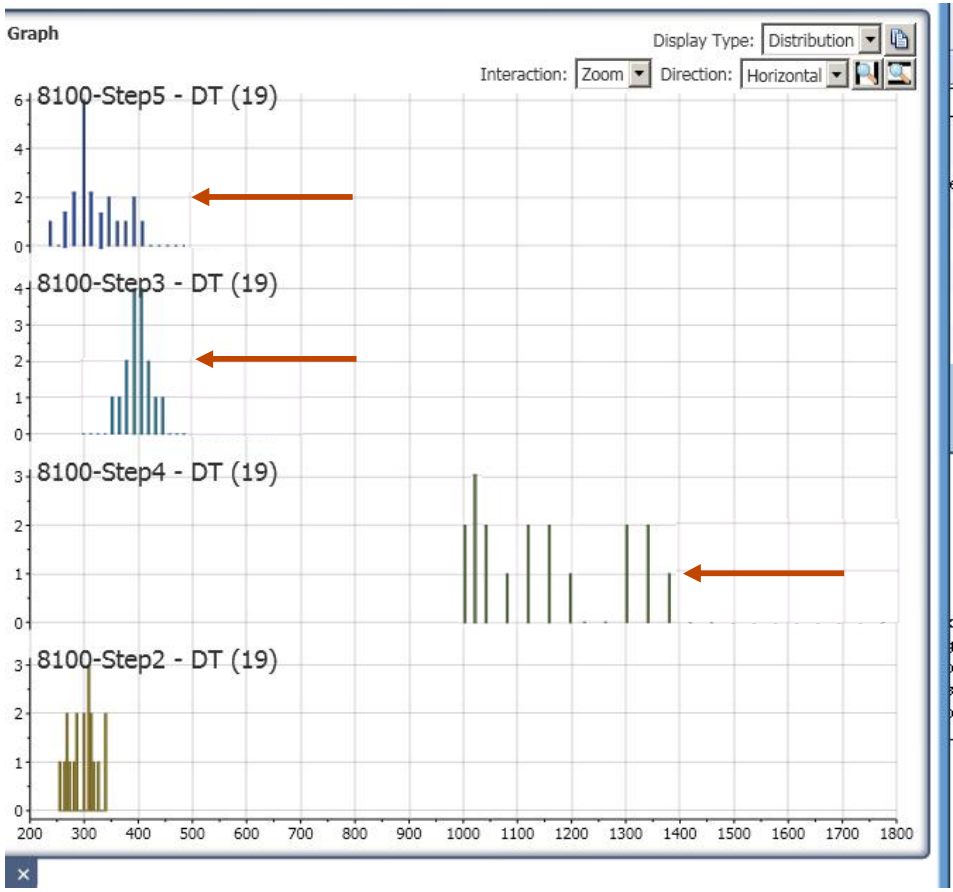
BASF Batch Reactor Optimization
Process Economics - Quality Control and Production Rate

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



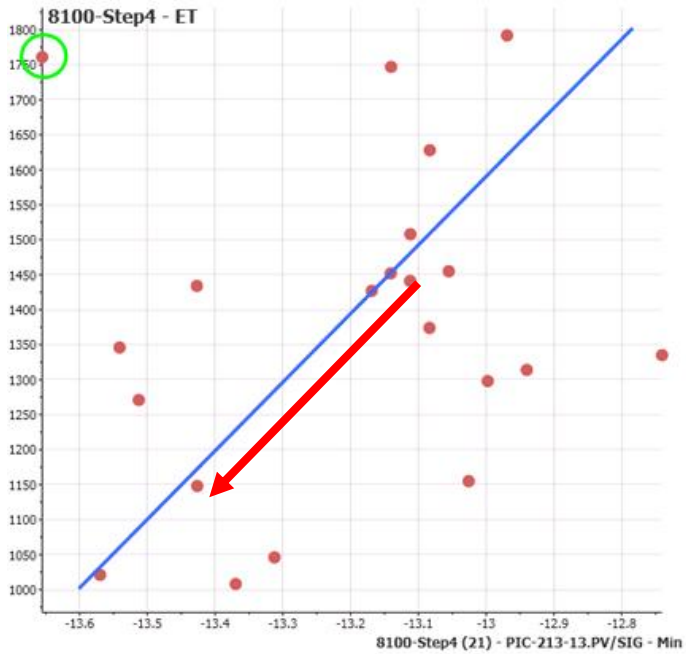
BASF Batch Reactor Optimization
Reducing Batch Cycle Times

- 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

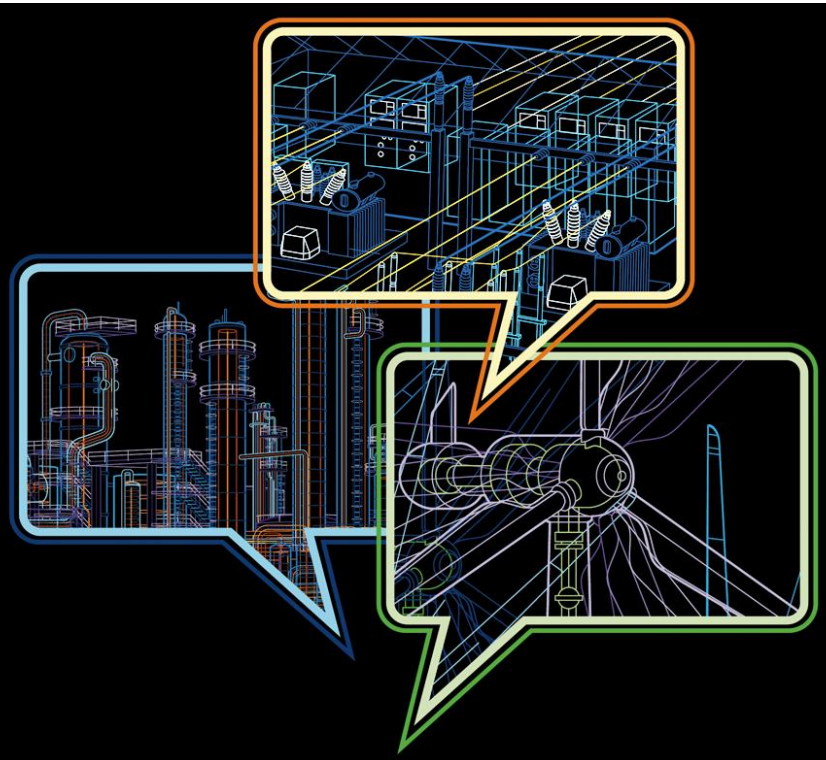
Conclusion:

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

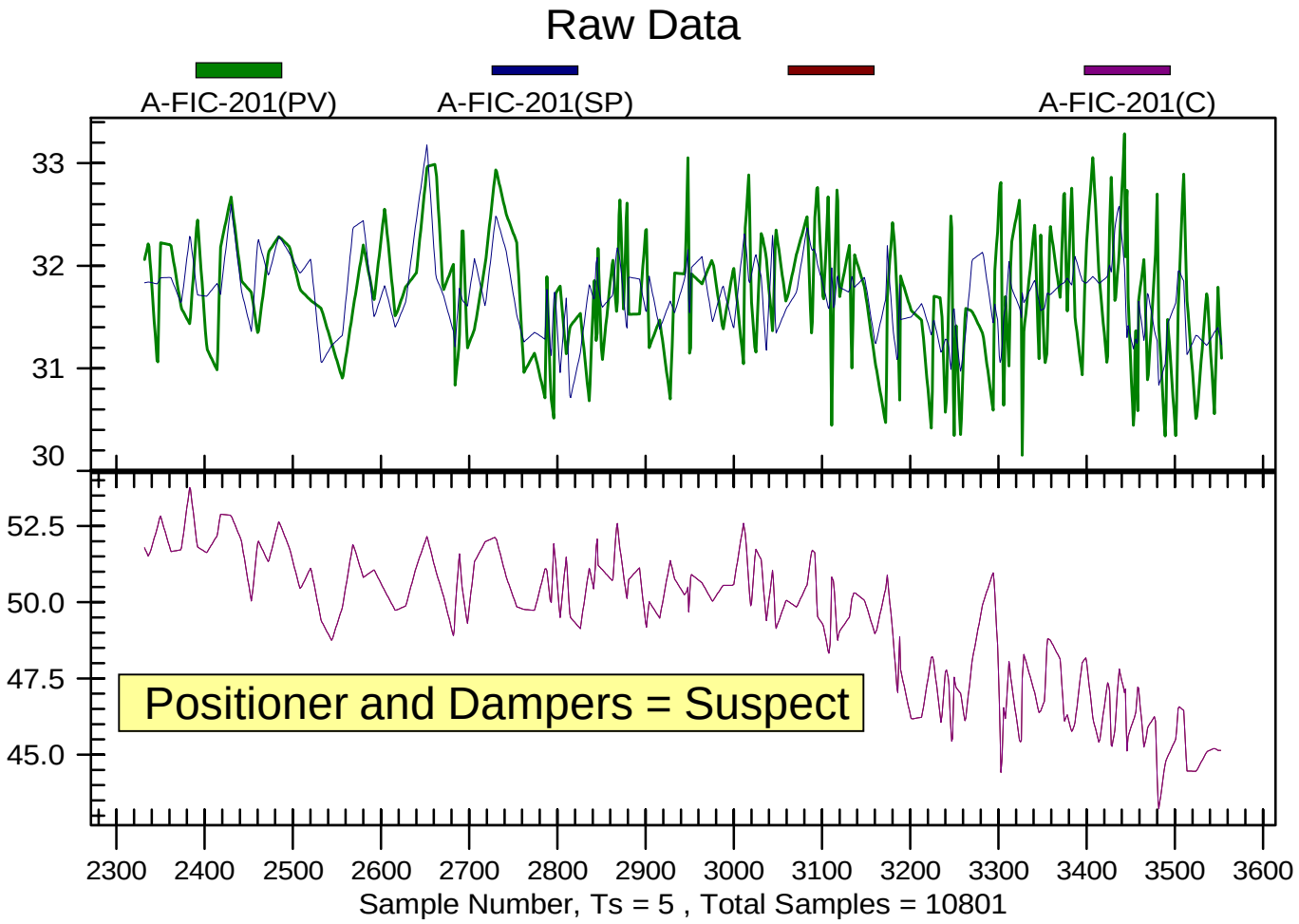
Boiler Audit and Testing
The Fingerprint uses a bottom-up approach to performance improvement. Data is collected to verify that basic instrumentation is working as needed, for good operation and control. Configured signal conditioning options are also examined and verified.
Closed loop control of fuel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

ABB

ABB

FD Fan Control – Combustion Air



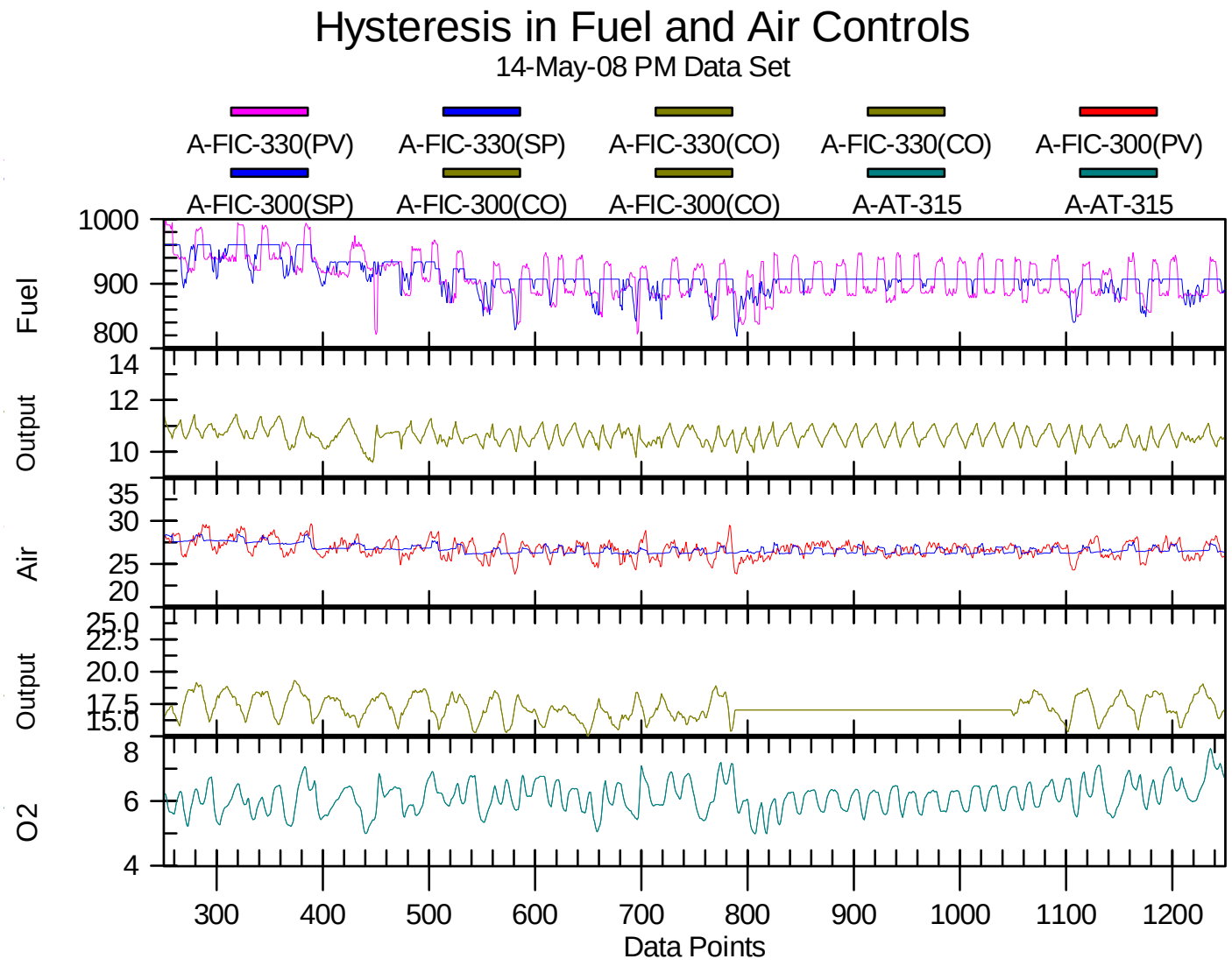
Boiler Hardware Issues

Forced Draft Control Drive and fan

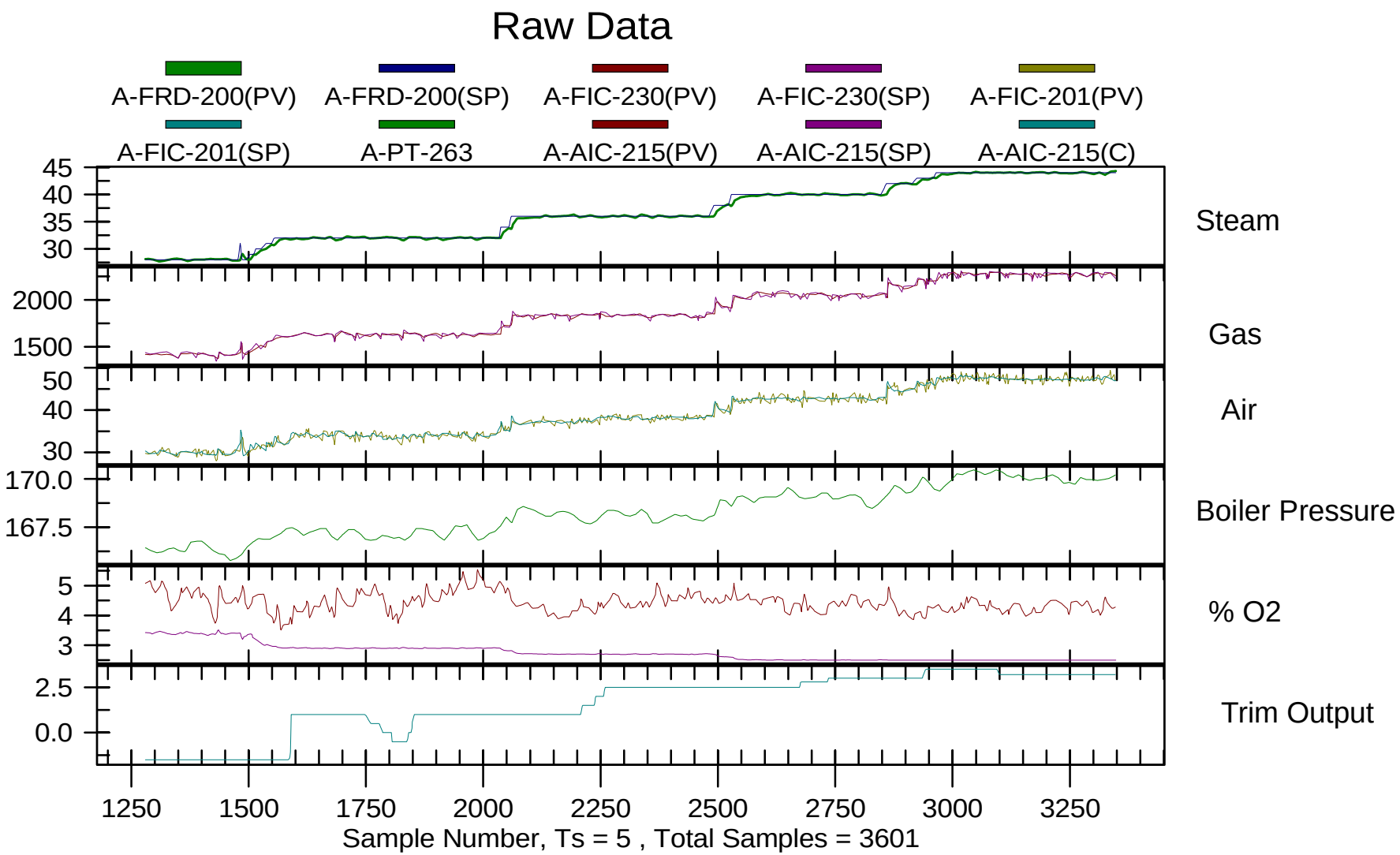
Induced Draft Control Drive and fan

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

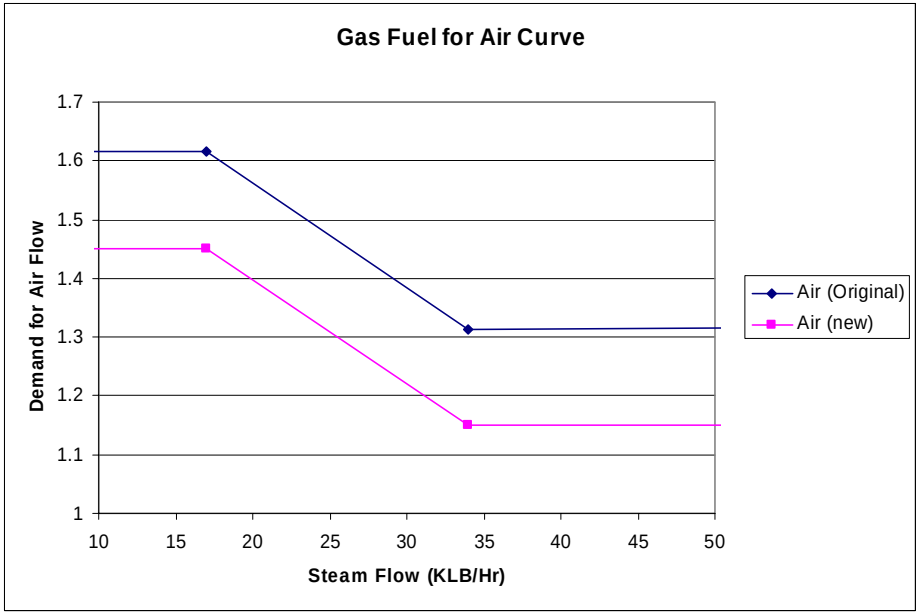
Hysteresis – Air and Fuel

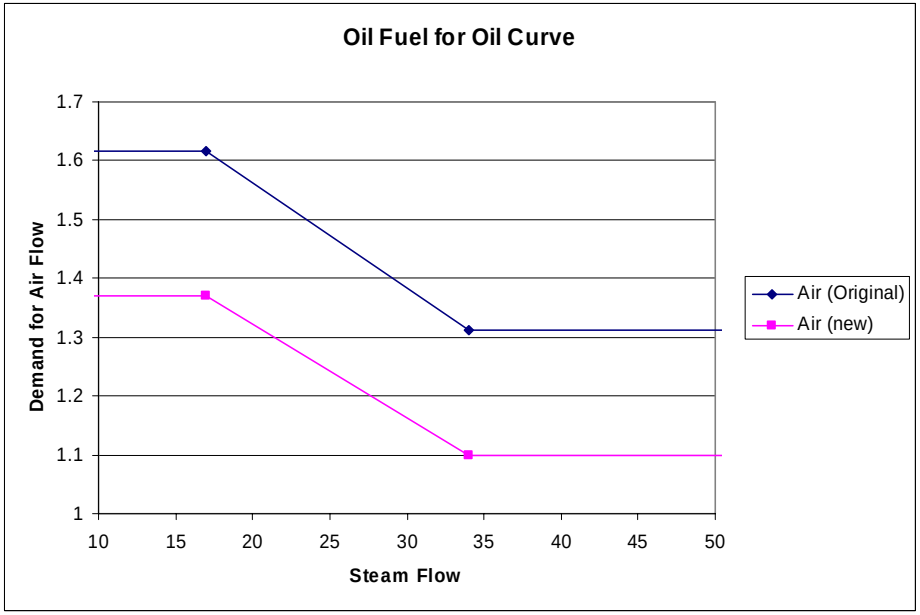


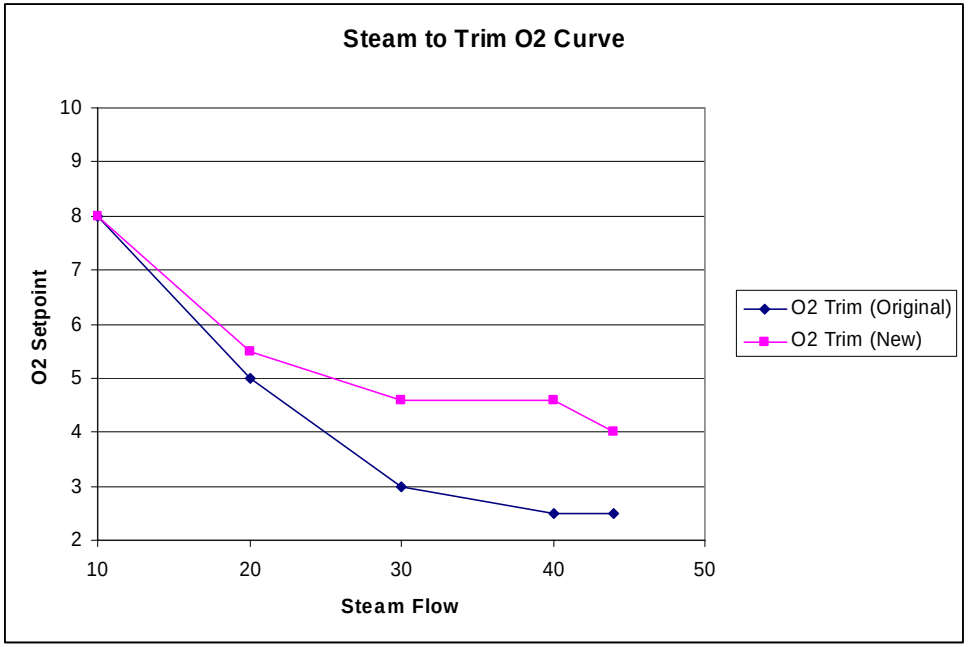
Load Test



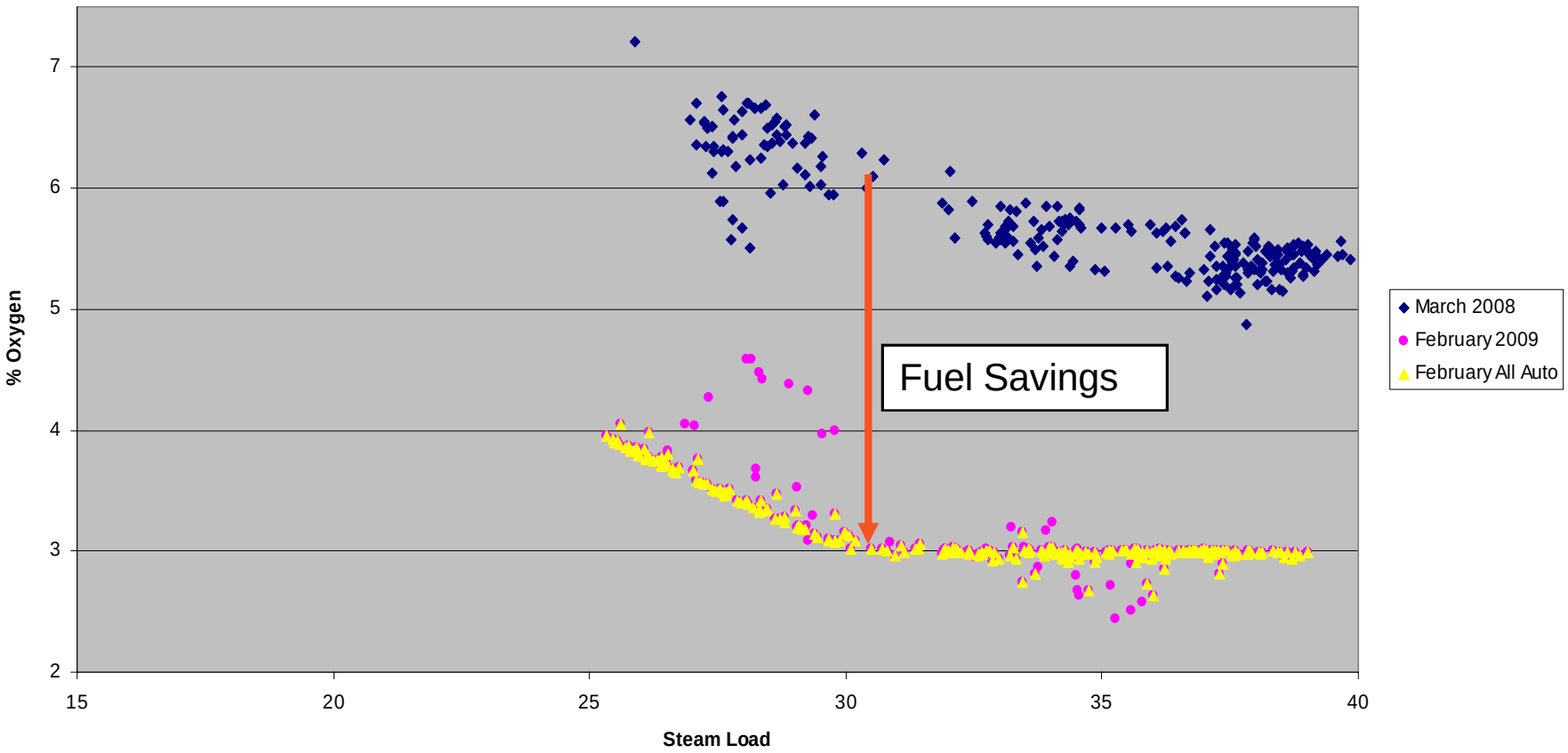
Updated Air Curves







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

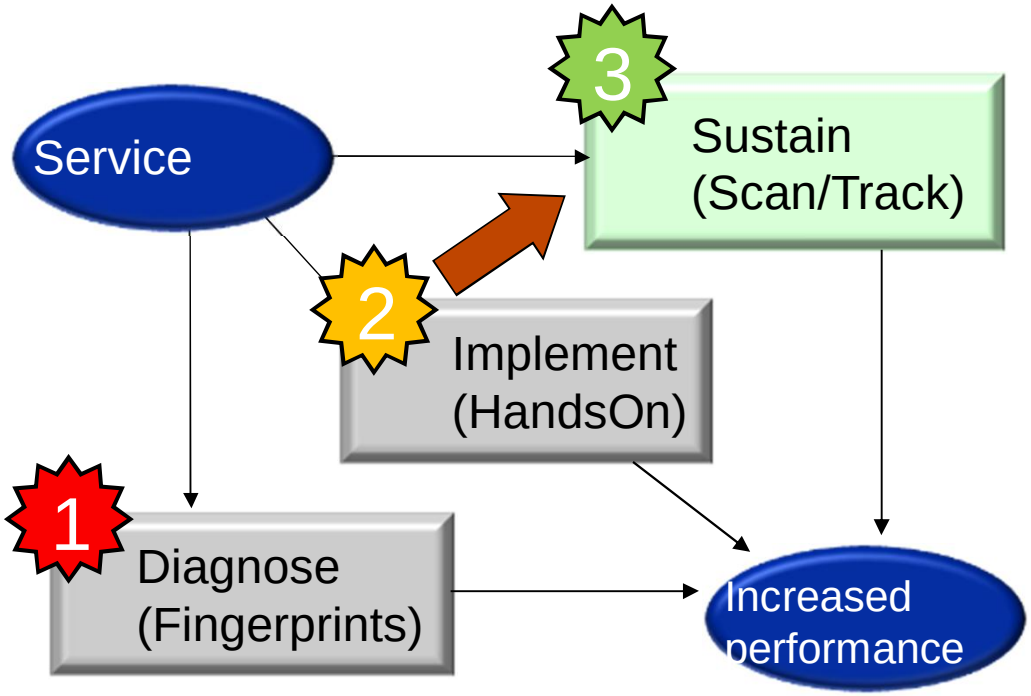
Savings for all four boilers = $300,000

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

- 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

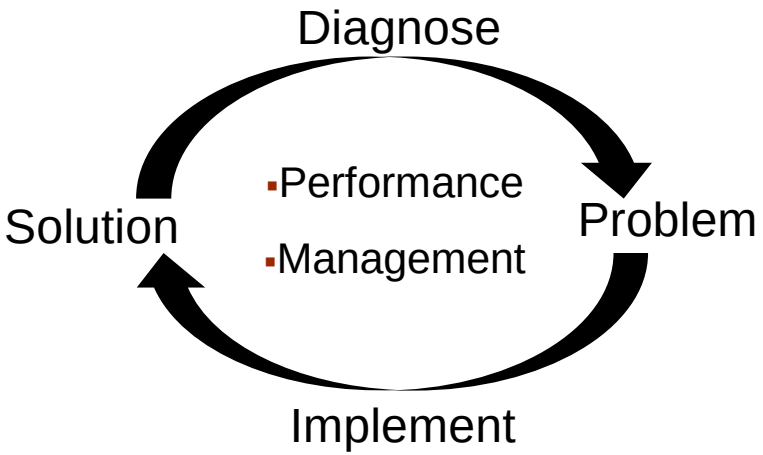
Loop Tuning

- LoopTune

Batch and Grade Change Analysis

- Sequence Analyzer

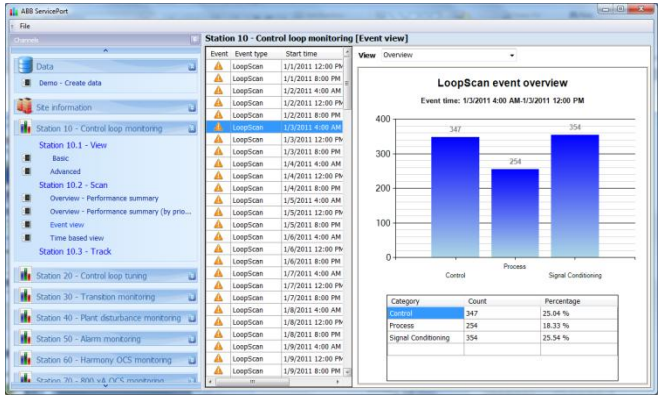
- Loop Performance Monitoring
  - ServicePort Loop Performance Channel



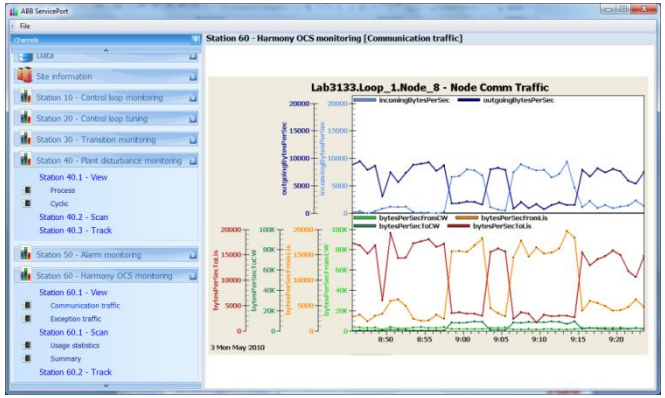
Continuous Improvement at Maximum efficiency

ServicePort + Channels

- **ServicePort Base Unit**
- **Process Channels**
  - **Control Loop**
  - **Quality Control System**
  - **Mine Hoist**

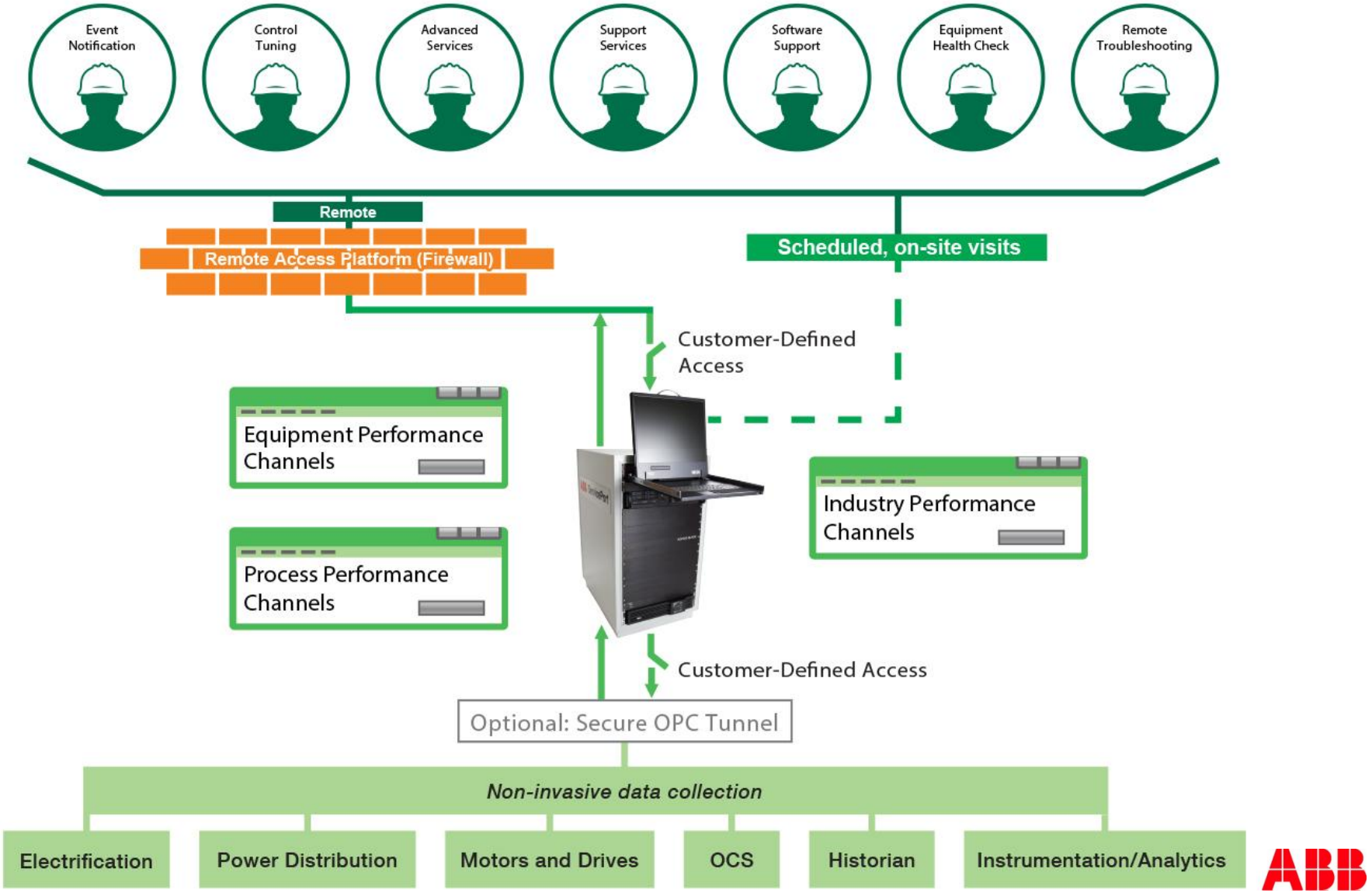


- **Equipment Channels**
  - **Harmony**
  - **800xA**
  - **Cyber Security**

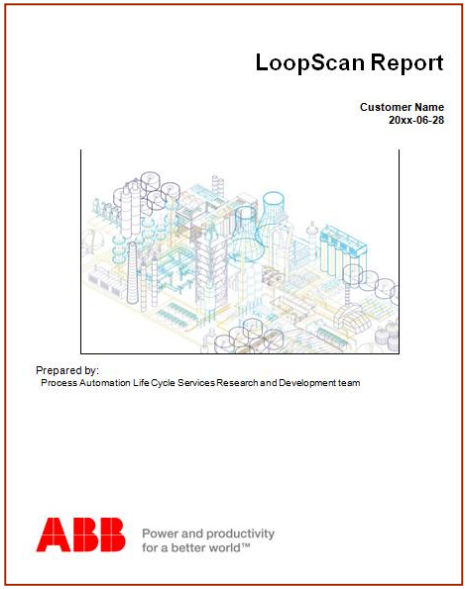


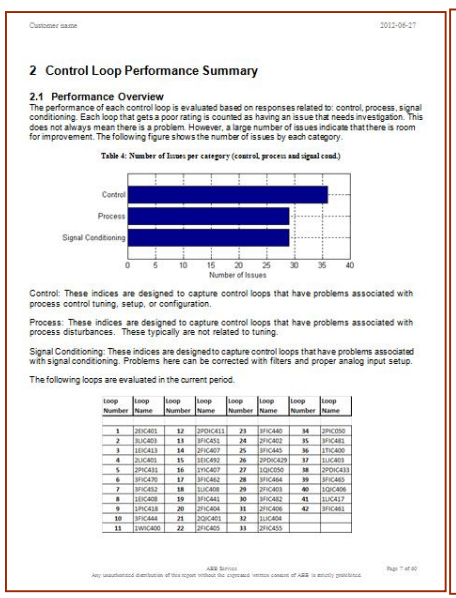
- **Remote Access Platform**

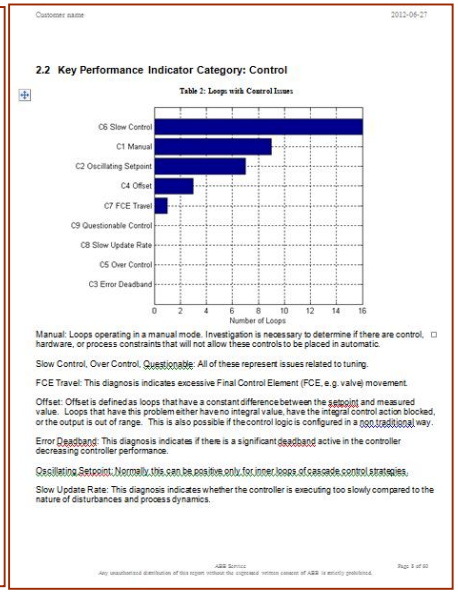
ABB ServicePort: Access to experts, reduces costs

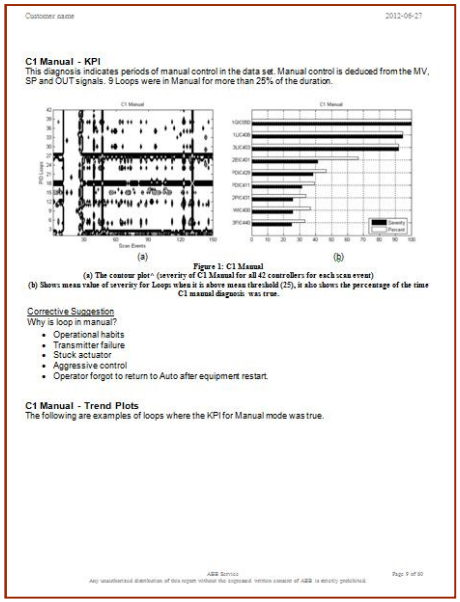


SCAN Performance Service Reports



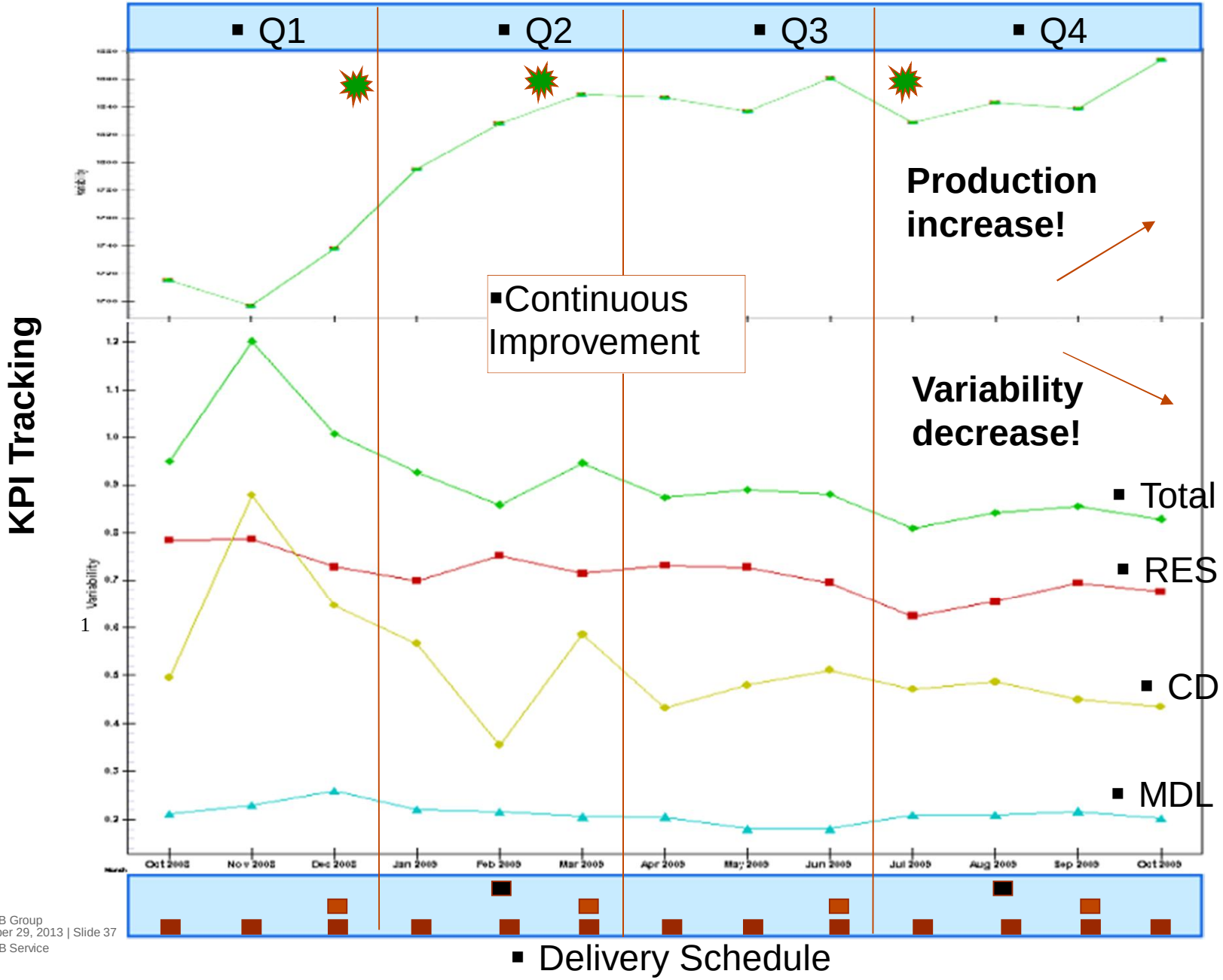






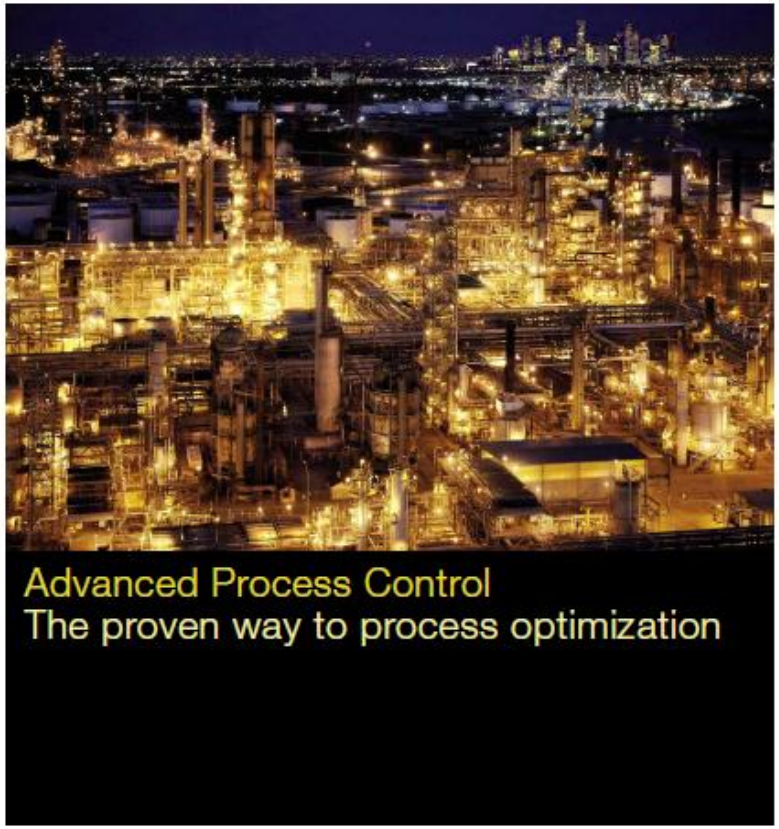
- Statistical Evaluation of Historical KPI’s performed twice a year
- Ensures stability of KPI’s
- Reduces the risk of false positives
- Keep up to date with process
- Crucial to ensure continuous improvement

Sustain: track KPIs to ensure improvement



1

What's APC?

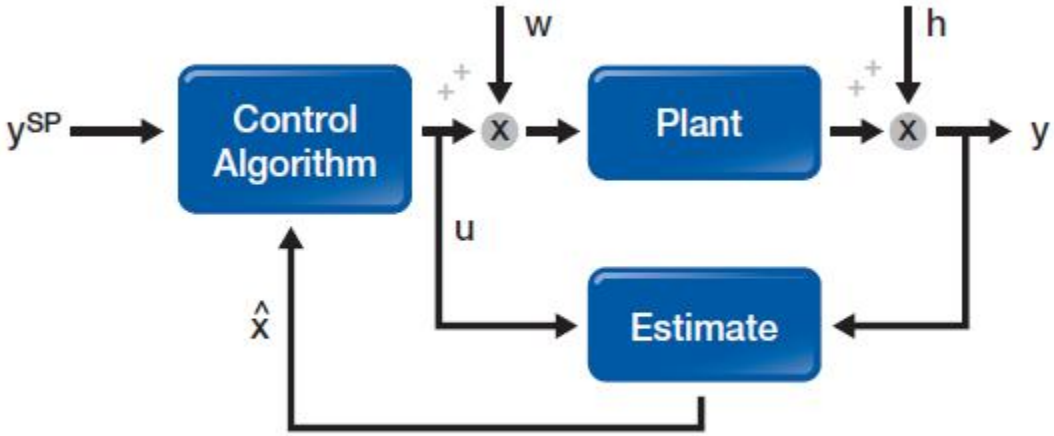


- APC – Advanced Process Control
- ARC - Advanced Regulatory Control
- MPC – Model Predictive Control
- MIMO – Multiple Inputs, Multiple Outputs
- Constraints – Process or Physical Limits
- Linear Programming – Cost Minimization
- IMP – Inferential Modeling Platform
- Scheduling and Batch optimization

Power and productivity for a better world™ ABB

ABB

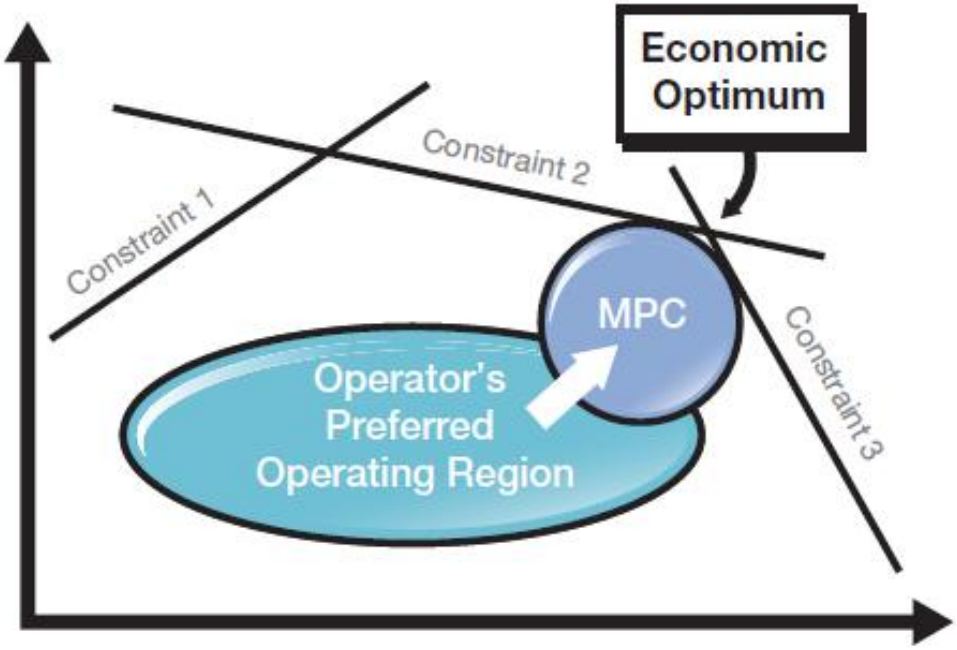
ABB's Predict and Control APC Solution



Features

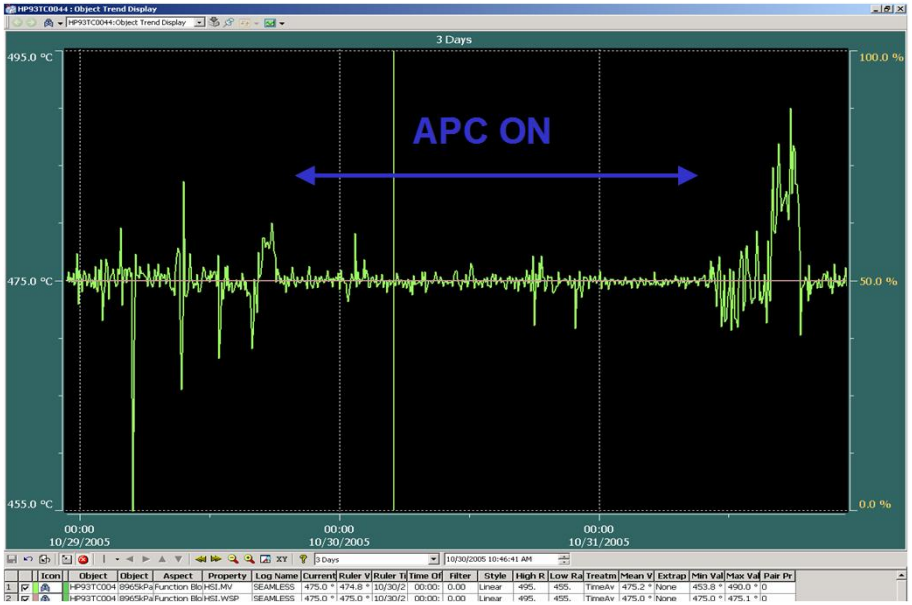
- True Multivariable Control
- State Space, Model Predictive Control (MPC) Structure
- Subspace and Prediction Error model identification methods
- Constraints (MVs and CVs): prioritize up to 30 classes
- OPC connectivity to process data
- Inferential Modeling Platform (IMP) to infer variables or properties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

APC - Predict and Control

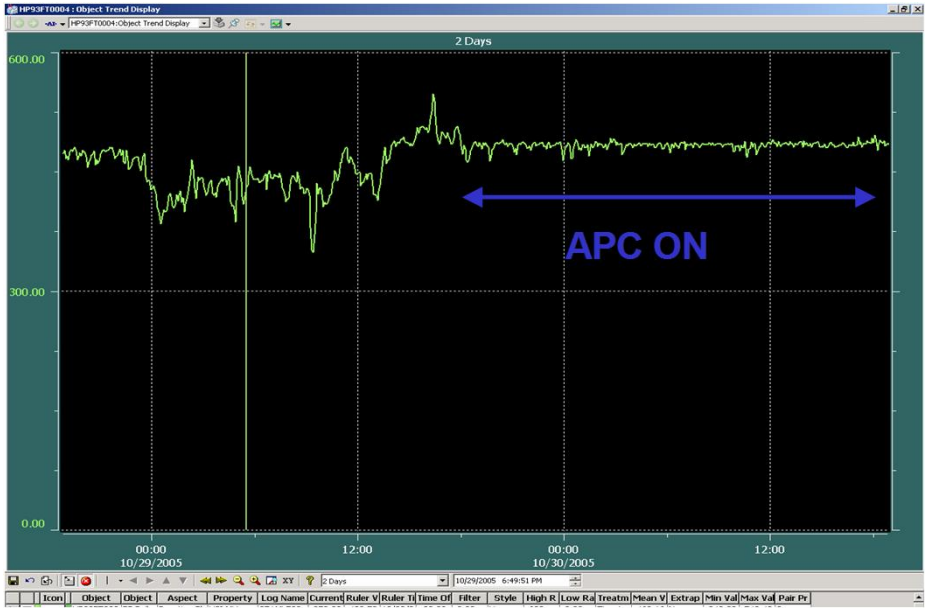


- Allows safe operation closer to constraints
- Smooths operation by predicting effects of control moves and compensating
- Works best when base level controls are optimized

Steam Temperature and Boiler Steam Flow Control



Temperature Control



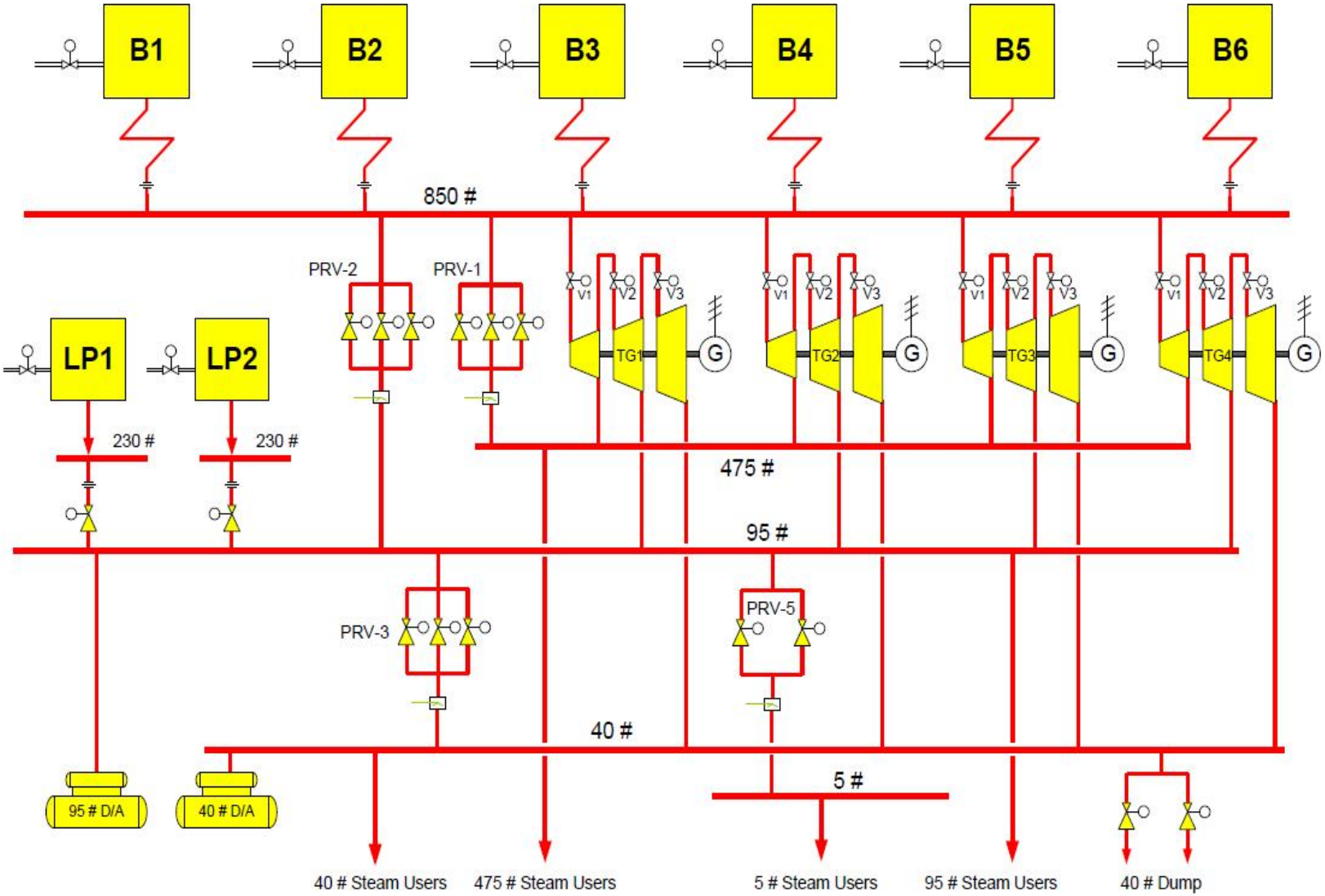
Steam Flow Control

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



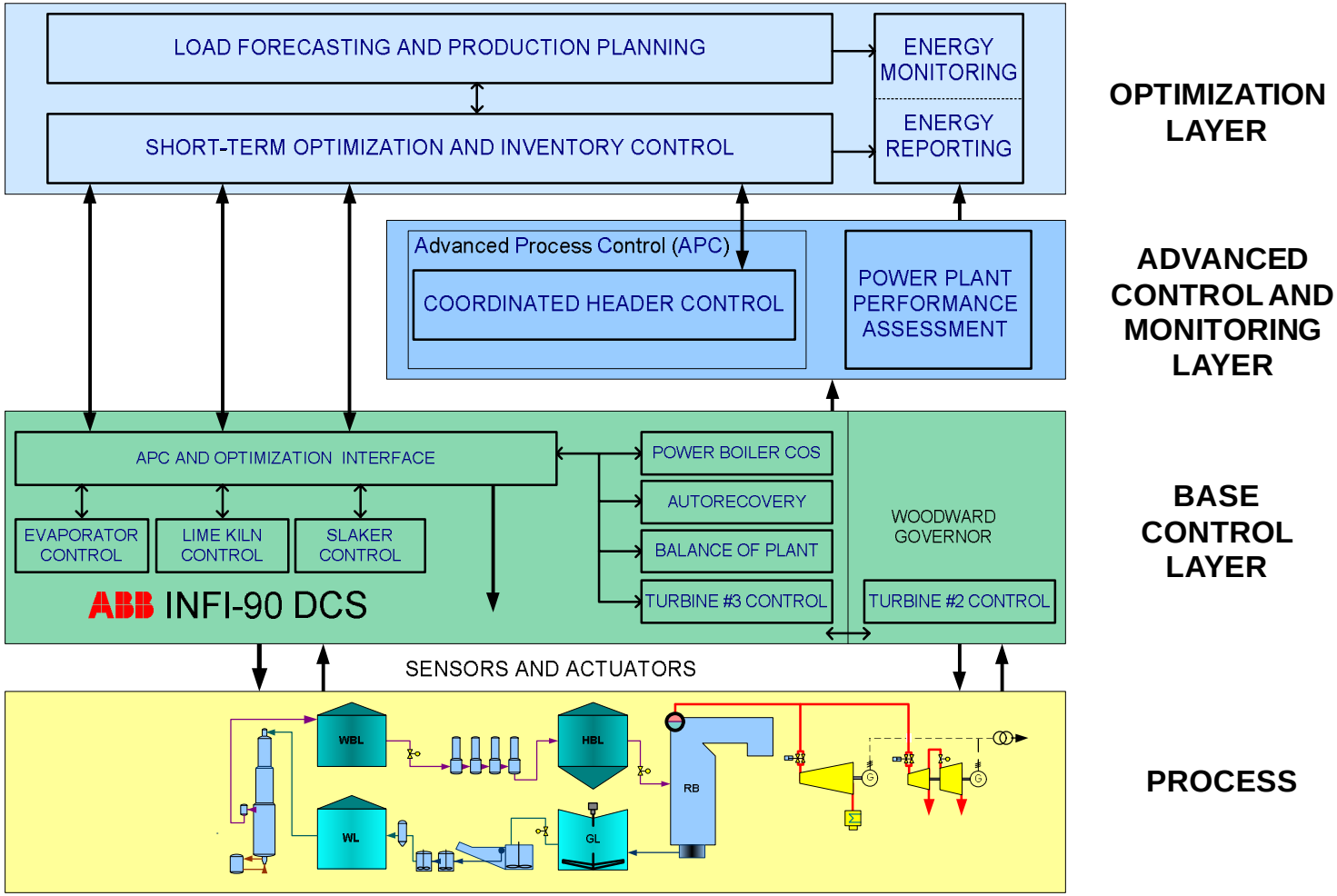
Alumina Refinery Powerhouse Optimization

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



Power and productivity
for a better world™

ABB