Do you know if your Process is Stable?

Dofasco's Advanced Monitoring Applications

R. Rumpler, A. Smyth

OSISOFT Users Conference

Monterey, California

March, 2002

DOFASCO

Outline

- Background on Dofasco

- Why is Dofasco using PI?

- Gaining value from data - Advanced Monitoring Applications

  - Caster SOS ™ (Stable Operation Supervisor)

  - C-MAP™ (Controller Monitoring and Assessment of Performance) at the NG Mixing Station

- Questions

Dofasco Hamilton Works

- One of Canada's largest fully integrated steel producers

- $\approx$ 4.4 million tons of steel Shipped in 2001 with sales $\approx$ 3 billion $(Can)

- $\approx$ 7500 employees
  - $\approx$ 1000 in technology areas

- A North American leader in profitability

DOFASCO

Advanced Monitoring Applications using PI

Why is Dofasco using PI?

- Blast Furnace Hearth Breakout 1994
  - Requirement to monitor lining of the furnace for possible breakouts and important safety functions
  - Level 1 hardware upgraded
  - Many new thermocouples added to hearth
  - There were not many products on the market that could store vast quantities of historical data without taking up a lot of disk space
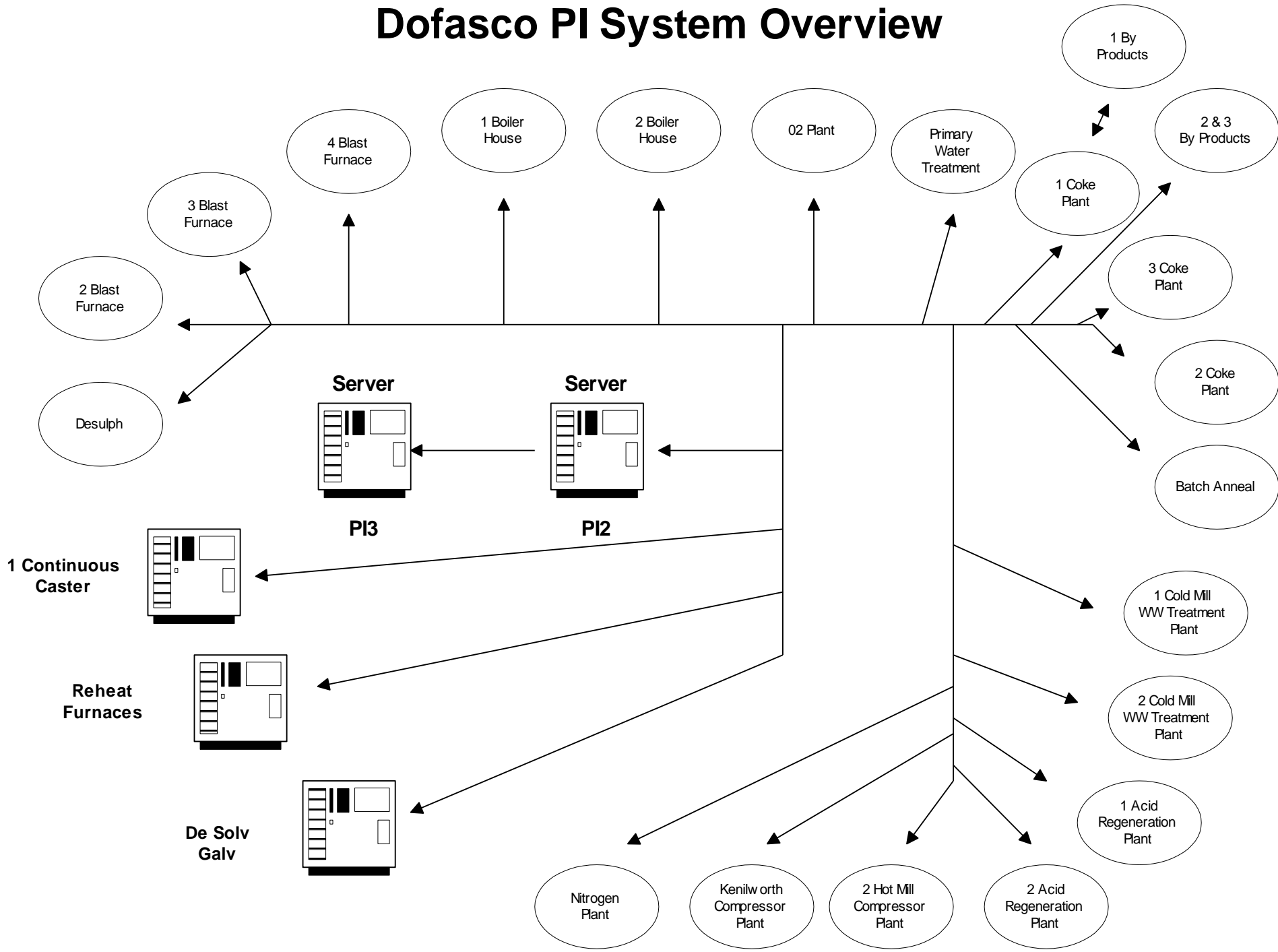
DOFASCO

Why is Dofasco using PI?

- Benefits of Using PI
    - Link to various PLC & DCS systems
    - Common user interface regardless of the type of PLC & DCS
    - Ease of use (anyone can build their own screens in a matter of minutes)
    - Proprietary compression algorithm minimizes use of disk space

Why is Dofasco using PI?
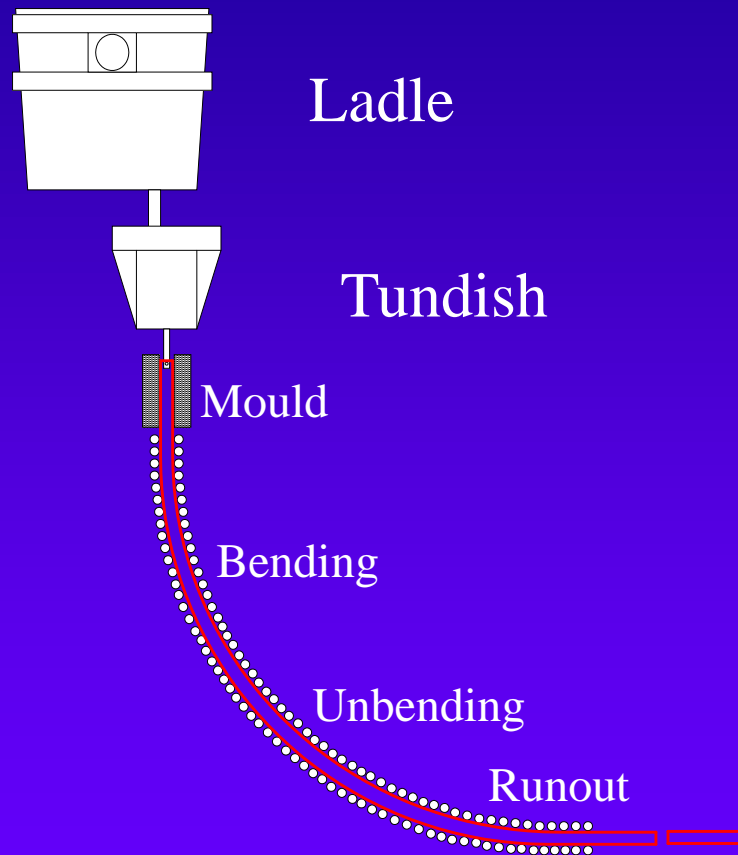
- Benefits of Using PI
  - Operators and technical personnel can use PI Processbook and PI Datalink to tune loops and quickly troubleshoot problems without going into the plant
  - Data can be manually stored in PI
  - Models that monitor the performance of the process and preemptively warn operations of deteriorating performance have been developed using PI Processbook as the HMI. (CMAP, SOS etc.)
  - PI data (daily totals) is loaded into Oracle for cost accounting purposes

DOFASCO

Dofasco PI System Overview

1 By Products

2 & 3 By Products

4 Blast Furnace

1 Boiler House

2 Boiler House

02 Plant

Primary Water Treatment

1 Coke Plant

3 Blast Furnace

3 Coke Plant

2 Blast Furnace

2 Coke Plant

Desulph

Server

Server

Batch Anneal

PI3

PI2

1 Continuous Caster

1 Cold Mill WW Treatment Plant

Reheat Furnaces

2 Cold Mill WW Treatment Plant

De Solv Galv

1 Acid Regeneration Plant

Nitrogen Plant

Kenilworth Compressor Plant

2 Hot Mill Compressor Plant

2 Acid Regeneration Plant

Caster
Stable Operation Supervisor (SOS)
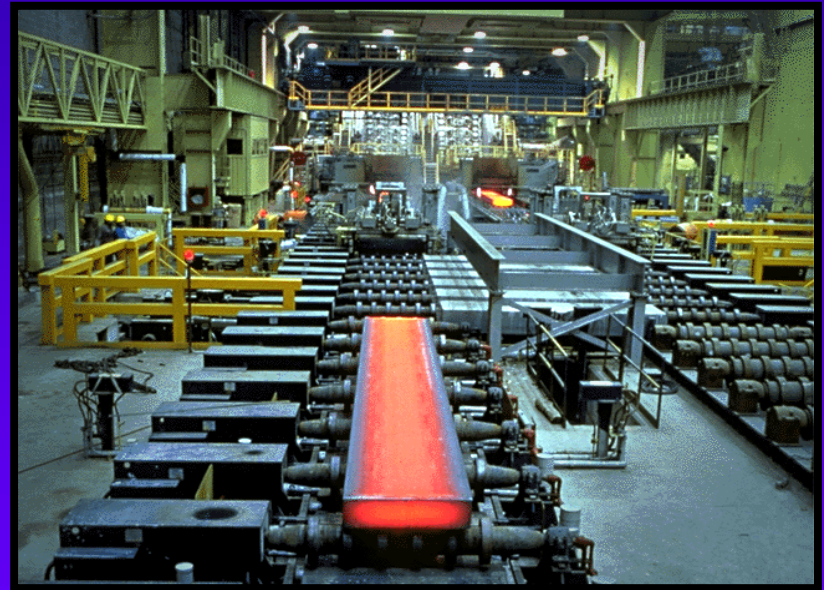
Continuous Casting

Ladle

Tundish

Mould

Bending

Unbending

Runout

What is the Caster SOS?

- The SOS is a software tool that ***monitors*** the state of the casting process at sub second intervals and ***alarms*** to the operator when an ***unusual*** event happens. (Multivariate Statistics)

- It also ***organizes*** the process data to help in ***troubleshooting*** during casting and after the fact.

Dofasco's #1 Continuous Caster

**Caster SOS commissioned on Dofasco's
1 Continuous Caster in 1997**

DOFASCO

Dofasco's #2 Continuous Caster
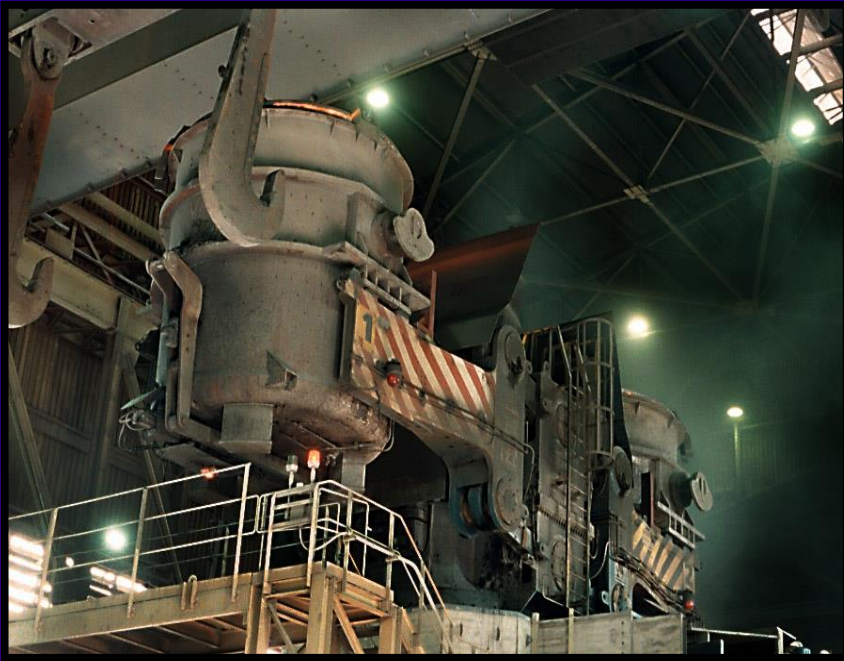
#2 Caster SOS commissioned on Dofasco's # 2 Continuous Caster in Feb 2002

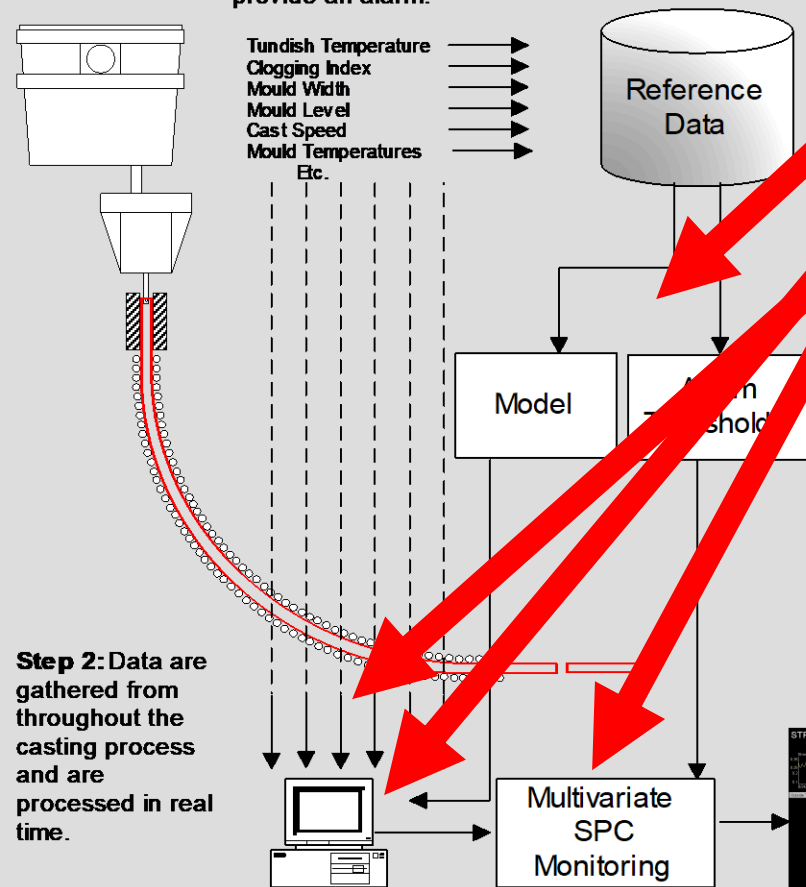Advanced Monitoring Applications using PI

Motivation

Motivation for the Caster SOS

Required a system that would help :

- Improve process stability
    - increase throughput
    - reduce faults
- Give operator's better process understanding, help them overcome "data overload"
    - currently they are expected to monitor hundreds of variables at once
- Commercial products were not providing the solution that was needed.

SYSTEM OVERVIEW

Caster SOS

Step 1: A model with associated alarming thresholds is developed off-line using data from periods of known good operation, deliberately excluding data for which the system should provide an alarm.

Tundish Temperature
Clogging Index
Mould Width
Mould Level
Cast Speed
Mould Temperatures
Etc.

Reference Data

Model

Alarm Thresholds

Step 7: Further investigation is performed by viewing the individual process trend charts.

Step 2: Data are gathered from throughout the casting process and are processed in real time.

Multivariate SPC Monitoring

Alarms

SUMMARY VIEW

CONTRIBUTION VIEW

TREND VIEW

Step 3: The model summarizes the input variables into performance indicators that are monitored in real time.

Step 4: The Caster SOS™ tests the performance indicators against predetermined thresholds to determine if the present casting conditions conform to known good casts, and issues an alarm if not.

Step 5: The information is presented graphically on the Summary Screen. When the system approaches abnormal operating conditions the graph(s) turns amber offering a warning to the operators. When an alarm situation occurs, the appropriate graph(s) turns red and an audible alarm sounds indicating that casting is abnormal.

Step 6: The alarm is diagnosed by the operator using the contribution information provided by the system. This contribution view highlights the variables that have a significant impact on the performance of the caster.

Step 7: Further investigation is performed by viewing the individual process trend charts.

Using PI for the Caster SOS

– Platform chosen because of ease of use

– Operator screens done with PI Process Book - utilized the available features

- *Trends Tool, Value Tool, Multi-States, Buttons*

– Screens have been modified several times based on operator feedback - key to successful implementation

Using PI for the Caster SOS

Flexibility

- *Developed a custom trend configuration screen using VBA to give the operators the ability to trend any of the system variables together*

Main

Go Ba

SPE A

1.2
1
0.8
0.6
0.4
0.2
0

3/5/02

HT Ala

1.2
1
0.8
0.6
0.4
0.2
0

Quick Trend Configuration

Statistics: [Add]

- CC2 HT Performance Index
- CC2 SPE Performance Index

Mold Information: [Add]

- CC2 Casting Speed
- CC2 Mold Osci Frequency
- CC2 Mold Level 1 Setpoint
- CC2 Mold Level
- CC2 Mold Level Change Speed
- CC2 Mold Breakout Alarm
- CC2 Mold Osci Stroke
- CC2 SEN Immersion Depth
- CC2 Stopper Rod Position
- CC2 Mold Level Controller Mode (1 at
- CC2 Strand Casting
- CC2 Mold Width
- CC2 Mold Narrow Taper East
- CC2 Mold Narrow Taper West
- CC2 Mold Width Change Speed East
- CC2 Mold Change Width Speed West
- CC2 Negative Strip Time

Tundish Information: [Add]

- CC2 Tundish Car Net Weight
- CC2 Tundish Car Sen Arg Flow
- CC2 Tundish Car Cont Temp
- CC2 Tundish Super-heat

Mold Water Information: [Add]

- CC2 Mold Water Flow East
- CC2 Mold Water Flow Fixed
- CC2 Mold Water Flow Loose
- CC2 Mold Water Flow West
- CC2 Mold Delta Temp East
- CC2 Mold Delta Temp Fixed
- CC2 Mold Delta Temp Loose
- CC2 Mold Delta Temp West
- CC2 Mold Water Inlet Temp
- CC2 MW Delta Delta T Narro
- CC2 MW Delta Delta T Broad

Compositions: [Add]

- CC2 Carbon composition %
- CC2 Chromium composition %
- CC2 Mn composition %
- CC2 Molybenium composition %
- CC2 Nickel composition %
- CC2 Nitrogen composition %
- CC2 Phosphorus composition %
- CC2 Silicon composition %
- CC2 Sulphur composition %
- CC2 Titanium composition %
- CC2 Carbon Equivalence

Heat Transfer: [Add]

- CC2 Heat Transfer East
- CC2 Heat Transfer West
- CC2 Heat Transfer Fixed
- CC2 Heat Transfer Loose

Thermocouple Information

☐ 6FU ☐ 5FU ☐ 4FU ☐ 3FU ☐ 2FU ☐ 1FU
☐ 6FL ☐ 5FL ☐ 4FL ☐ 3FL ☐ 2FL ☐ 1FL
☐ 6FDif ☐ 5FDif ☐ 4FDif ☐ 3FDif ☐ 2FDif ☐ 1FDif
☐ 4FLL

☐ EU
☐ EL
☐ EDif

[Add Thermocouples] [Reset]

☐ WU
☐ WL
☐ WDif

☐ 1LU ☐ 2LU ☐ 3LU ☐ 4LU ☐ 5LU ☐ 6LU
☐ 1LL ☐ 2LL ☐ 3LL ☐ 4LL ☐ 5LL ☐ 6LL
☐ 1LDif ☐ 2LDif ☐ 3LDif ☐ 4LDif ☐ 5LDif ☐ 6LDif
☐ 4LLL

Trend Tags: [Remove]

[Trend Now] [Cancel]

3/5/02 7:56:15 AM 60.00 Min(s) 3/5/02 8:56:15 AM ▶

1L 2L 3L 4L 5L 6L

Loose Diff

WN
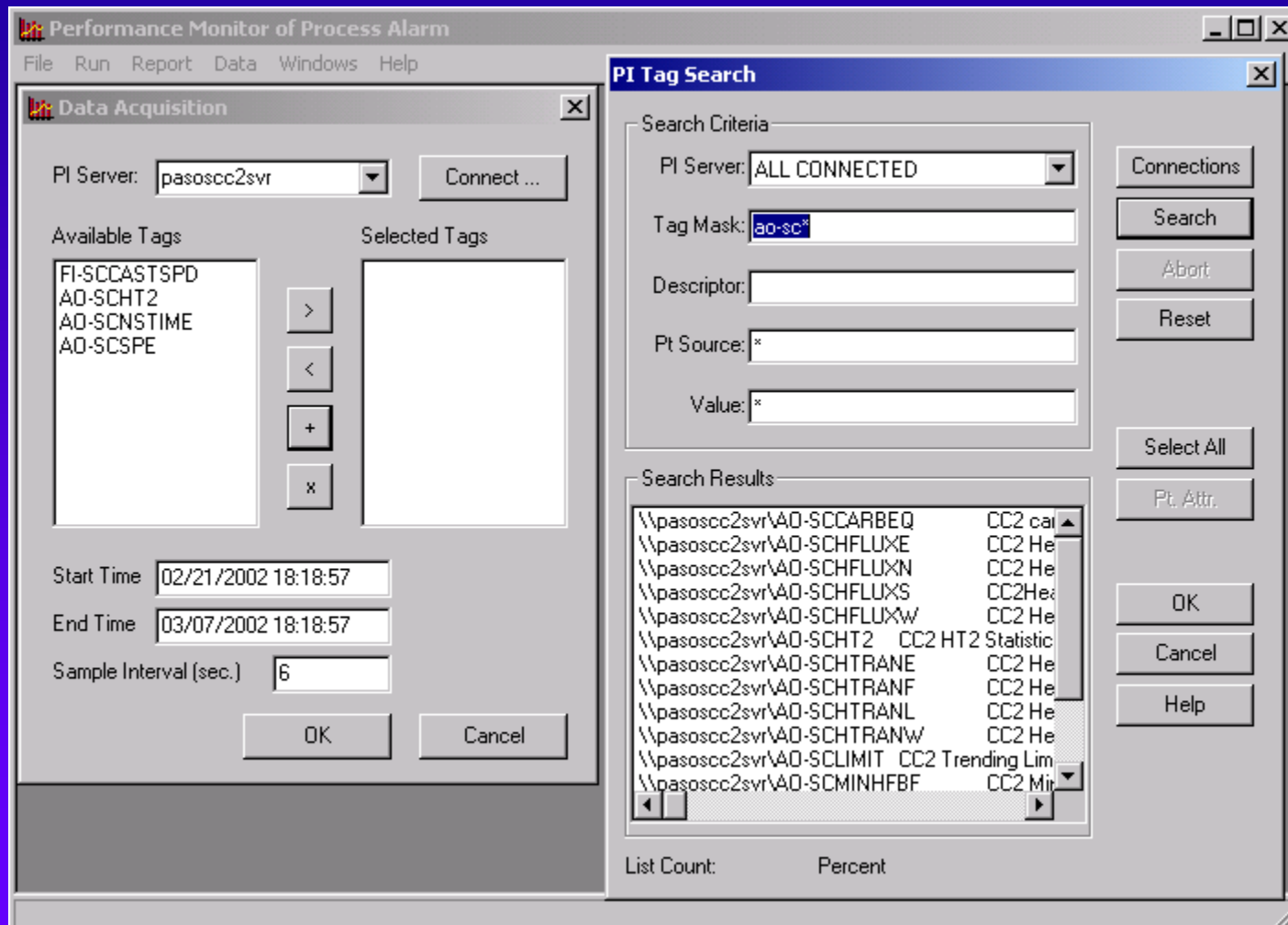
Using PI for the Caster SOS

Flexibility

- *Developed a VB program that can statistically analyze the performance of the system*

Using PI for the Caster SOS

Using PI for the Caster SOS

Performance Monitor of Process Alarm

File   Run   Report   Data   Windows   Help

Report Preview

Tag Name   `AO-SCSPE`   [<] [>]   [Save to file ...]   [Send to email ...]

```
Tag name:          AO-SCSPE        CC2 SPE Statistic
Time period:       02/21/2002 18:11:41   to   03/07/2002 18:11:41
Sample interval:   6          second(s)
Number of samples: 201601
Constraint:
        AND:   AO-SCHT2  >A  A=0.8  B=0
        AND:   AO-SCSPE  >A  A=0.8  B=0
Number of valid samples:       14803
Percentage of valid samples:   7.34%
Data statistics:
        mean     std      min      max       unit:
        102.58   151.20   0.80     479.35
        0~20%    20~40%   40~60%   60~80%   80~100%
        11365    2        407      1514     1515
Thresholds:
        TYPE = None   HI = 0   LO = 0
Critical Limits:
        LO Prob.% = NaN   HI Prob.% = NaN
        LCL = NaN   UCL = NaN
```

[OK]   [Cancel]

Using PI for the Caster SOS

Flexibility

- *Developed software based on downloaded "replay code" from the Devnet - able to see what the operators would have seen after the fact*

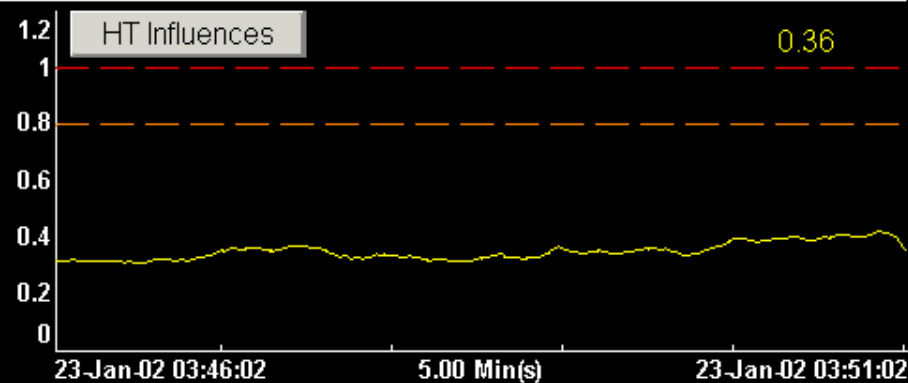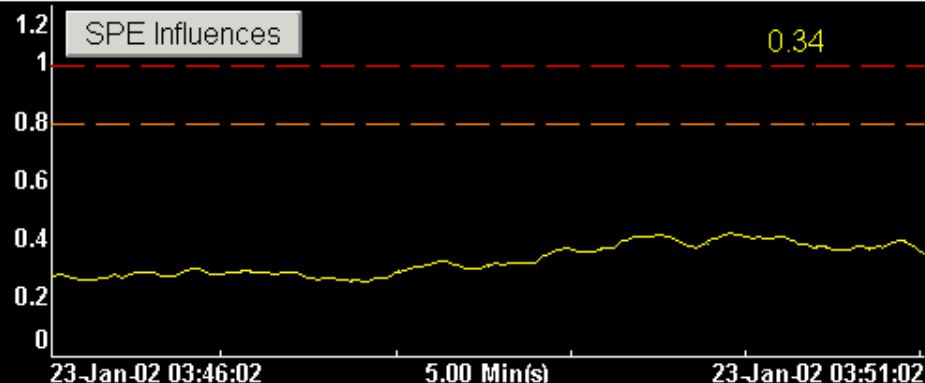| Audio Alarm	Feedback	Tag Selection	Tag Status	Quick View	Trend Menu

Grade **EA063**   SEN Depth   **-0.1628**   Speed   **1.34**   Stopper RP   **58.9**   E Narrow Taper   **7.23**   W Narrow Taper   **7.18**

SPE Influences	0.34

HT Influences	0.36

23-Jan-02 03:46:02   5.00 Min(s)   23-Jan-02 03:51:02

23-Jan-02 03:46:02   5.00 Min(s)   23-Jan-02 03:51:02

6FU	128	5FU	135	4FU	136	3FU	137	2FU	129	1FU	124
6FL	107	5FL	116	4FL	114	3FL	116	2FL	113	1FL	111

4FLL | 98

Mould Level   -100

EU | 123
EL | 103

WU | 119
WL | 104

Mould Width   1424.65

23-Jan-02 03:46:02   5.00 Min(s)   23-Jan-02 03:51:02

1LU	142	2LU	146	3LU	145	4LU	144	5LU	142	6LU	132
1LL	117	2LL	117	3LL	120	4LL	117	5LL	120	6LL	114

4LLL | 103

Legend

Selected   **Active**

123
123

Deselected
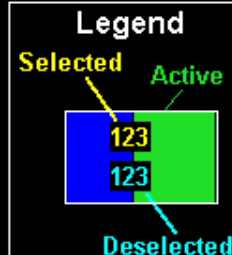
Narrowface	East Broadface	Center Broadface	West Broadface	Narrowface

Results

- Greater confidence in operation
  - Better process information
  - Continuous indication of process stability
  - Improved process understanding
- Increased Throughput
- Decreased Breakouts
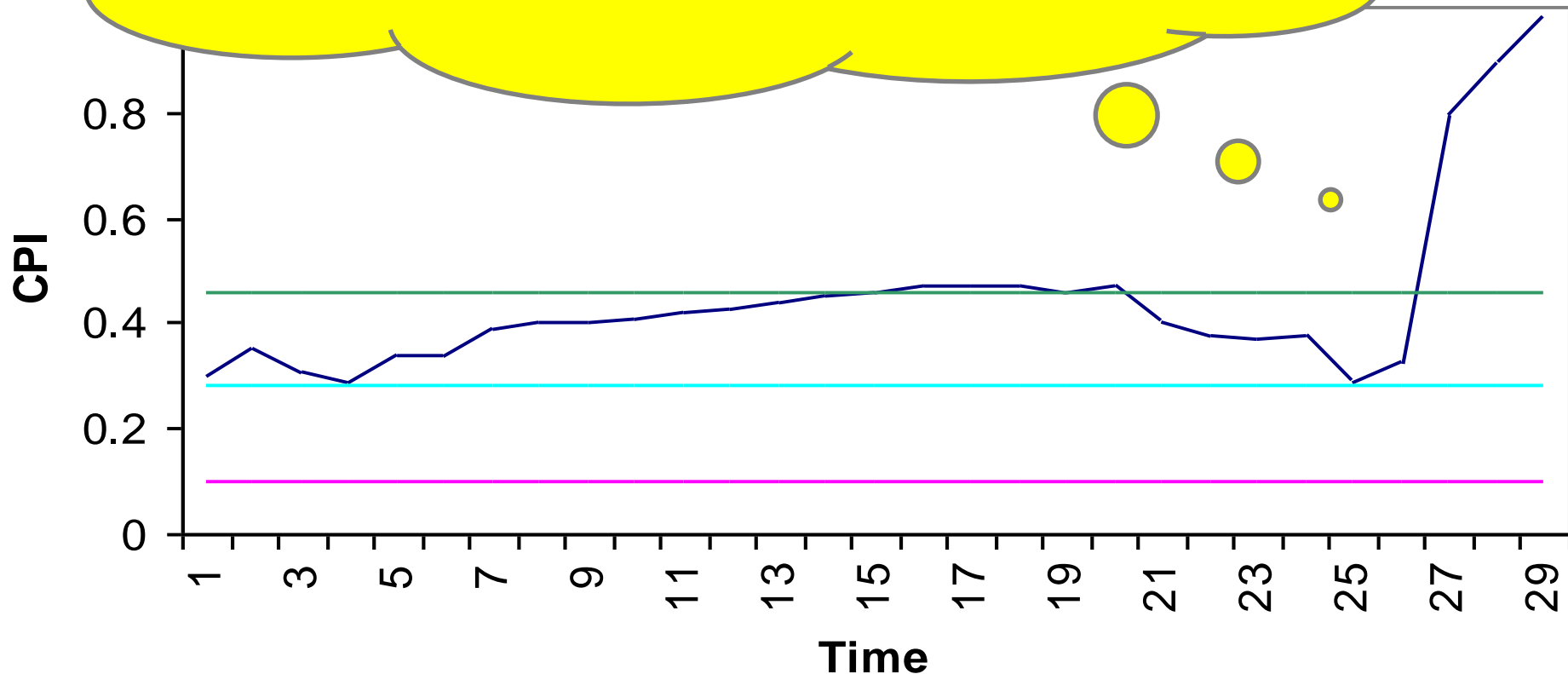- Real $ Benefit
- Unexpected Benefits
- Multiple Patents Pending

# #1CC Results
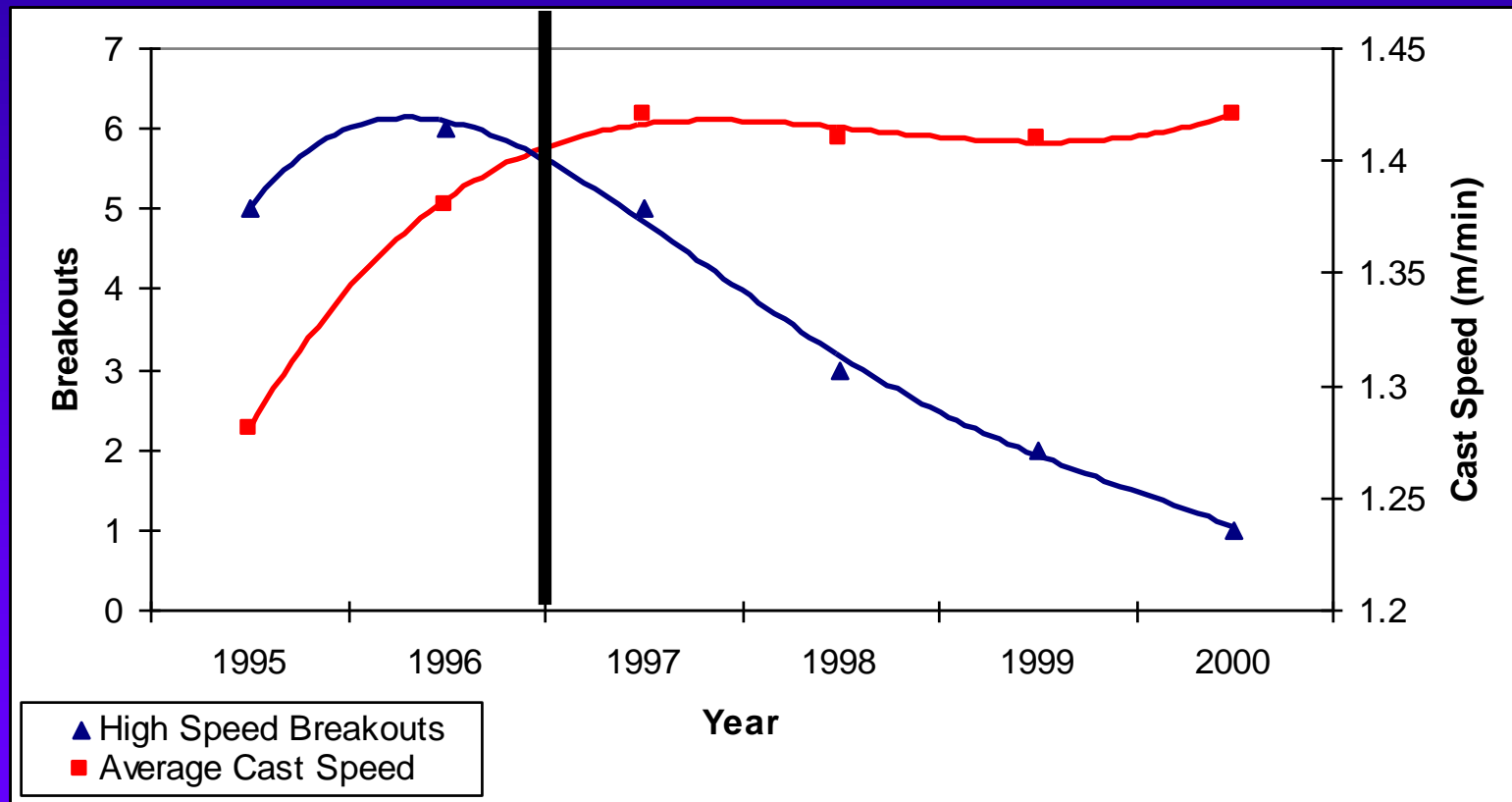
C-MAP at the Natural Gas Mixing Station

Troubleshooting with C-MAP

Suggests something has changed with respect to the controller. Automation personnel need to perform an off-line investigation

Natural Gas Mixing Station - Process Description

- Coke oven gas (COG) byproduct in the cokemaking process

- COG - valuable byproduct fuel high heating value (500 btu/ft^3)

- COG sent to blast furnace stoves, coke ovens, various boilers and reheat furnaces

- Demand >Supply - Therefore - Installation Natural Gas Mixing Station - dilutes natural gas with air to produce a "synthetic COG"
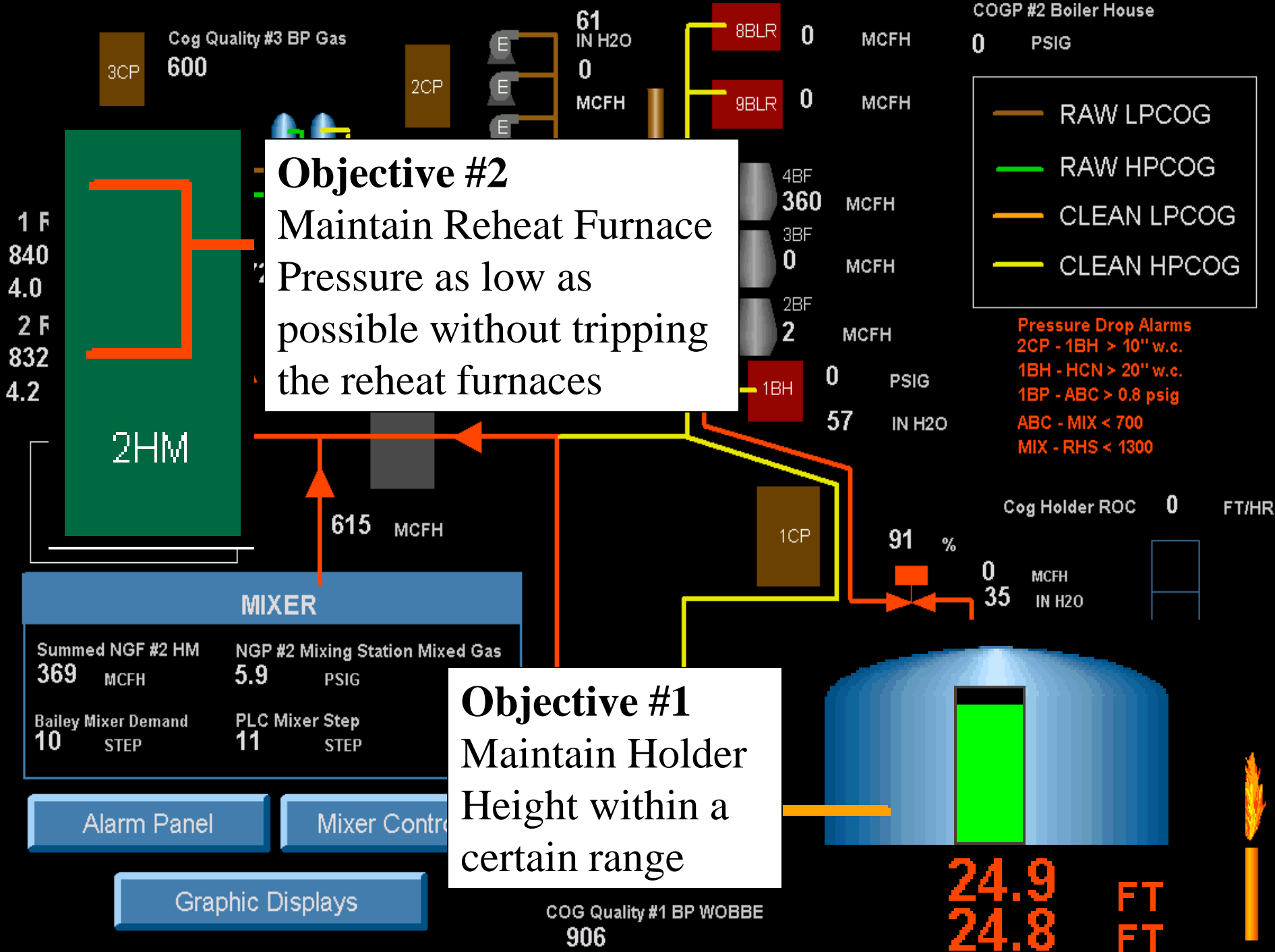
Objectives of C-MAP at the Mixing Station

- On-Line Monitoring of System
  - Timely Detection of System Faults
- Better Understanding of Faults
  - Compressor Problems
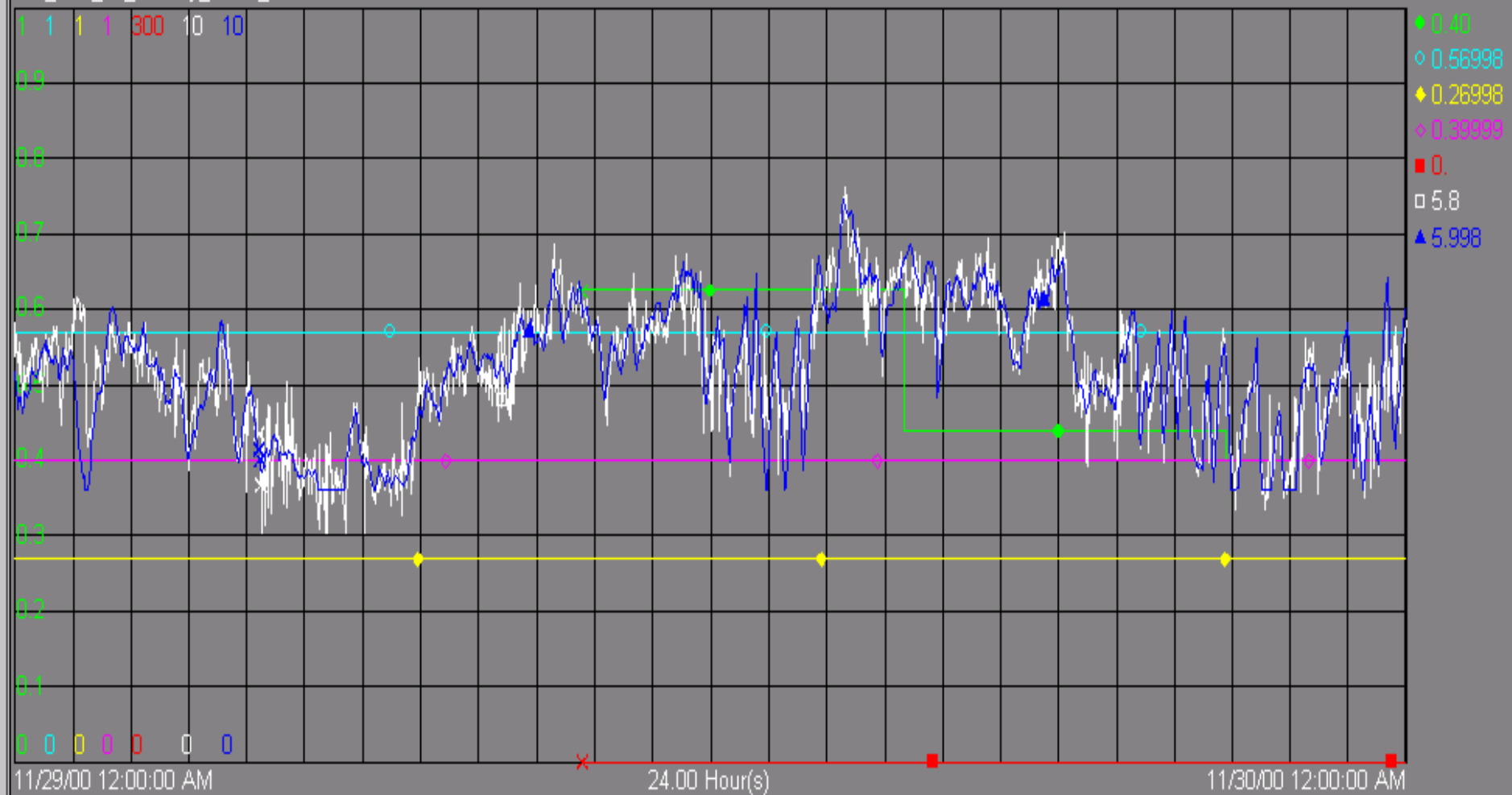 - Pipe Plugging
  - Need for Controller Re-tuning?

System Architecture

C-MAP
Computer

PI Server

DCS

DOFASCO

Advanced Monitoring Applications using PI

Faulty compressor - not mixing enough air with natural gas causing oscillation in the reheat furnace pressure
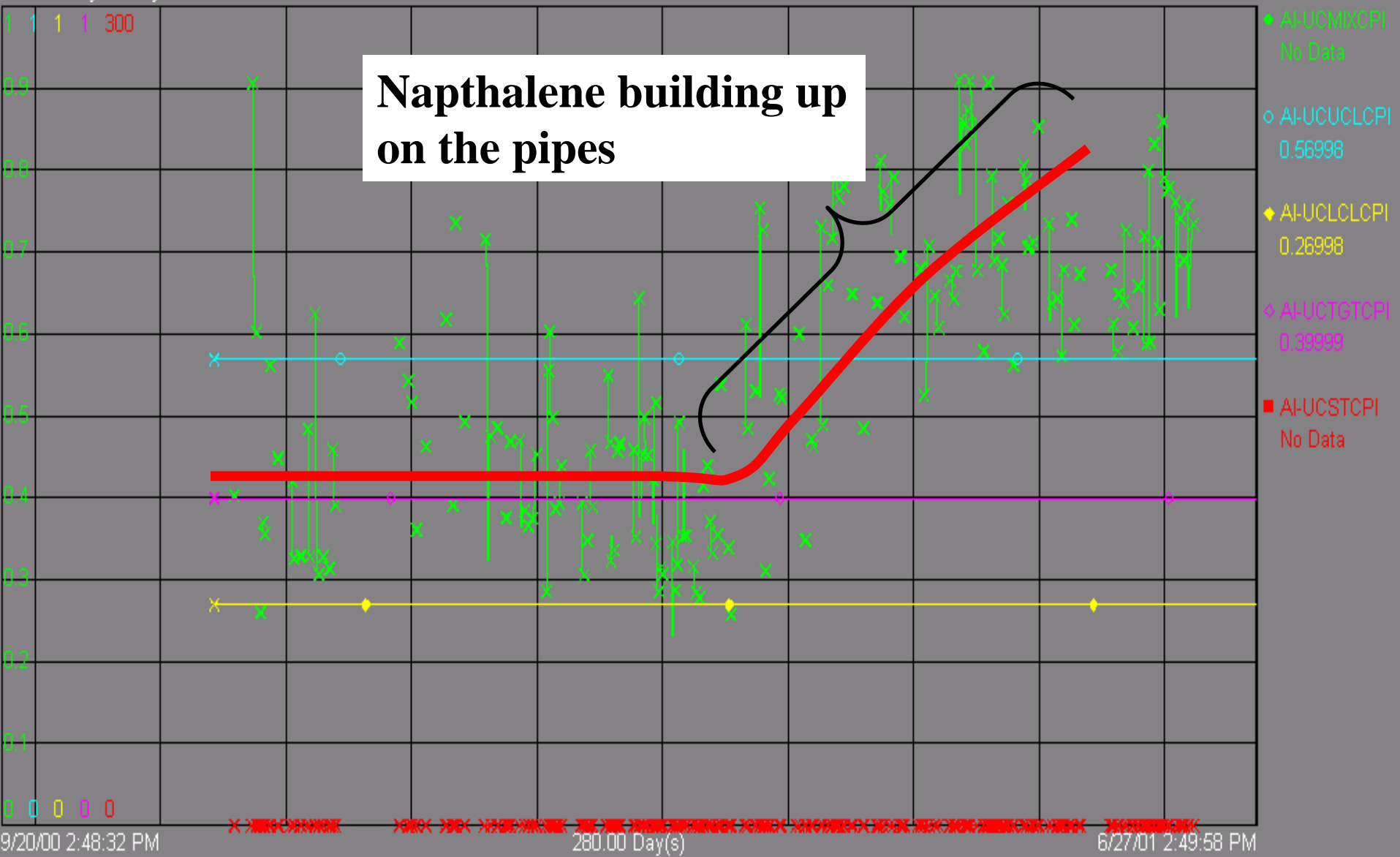
Main Menu

Variance CPI Control Chart for Steady State

Variance Error Squared Control Chart for Steady State

Minimum Variance Control Chart for Steady State

Questions

?

DOFASCO

Movie

WinZip File

DOFASCO