OSIsoft® UC2010

Real Time Information — Currency of the New Decade

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Mining PI Data to Improve Profit

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AGENDA

- Boise Inc. background
- Overview of the PI System
- Business challenges faced by our industry
- Overview of our data mining application
- Data mining considerations
- Case Studies
  - Chemical cost savings
  - Production debottlenecking
  - Paper machine maintenance/runnability
  - Vendor analysis

Boise Inc.

- We manufacture packaging products and papers including corrugated containers, containerboard, label and release and flexible packaging papers, imaging papers for the office and home, printing and converting papers, newsprint, and market pulp
- We operate five paper mills, five corrugated products plants, a corrugated sheet feeder, a corrugated sheet plant, two distribution facilities, and a transportation business
- We are the third-largest manufacturer of office paper; you may have seen our distinctive Boise® X9 ® papers in your workplace

International Falls has a 100-year history of making paper

Boise Inc. International Falls mill

- Located on the Canadian border in Minnesota, town of 6500 people

Overview of the PI System

- Boise Inc. is a long-time PI user, dating back to the mid 1990s
- All of our mills have PI systems and use ProcessBook extensively
- PI DataLink is used principally by engineers for analysis as well as for daily reports
- Boise International Falls employs 850 people, and produces 1500 tons/day of predominately cut-size paper
- Windows Active Directory network, 60 servers, 500 client workstations
- Our PI server currently has 55K tags and is fed from 12 interfaces
- Like many of you, our tag naming convention is based on control loop tags

Business challenges faced by our industry

- Producing paper is capital intensive
- Constant pressure to reduce variable costs
  - Vendor-supplied chemicals
  - Process optimization
  - Undetected maintenance upsets
- Reducing fixed costs is also a focus
  - Do more with less
  - Increase asset utilization

Data Mining application overview

- PI contains millions of data points; it is easy to analyze a particular tag, but difficult to analyze all tags
- We use Envoy Development's Cluster Analysis Tool to analyze PI data
  - Envoy has a patented application that identifies when a Key Performance Indicator (KPI) changed and the PI tags that changed at the same time
  - Data collection is divided along process units
  - Runs on a scheduled basis, typically once per day. It takes about 10 minutes to collect data from 2000 tags
  - Can calculate the correlation between a KPI and 2000 tags in about two minutes
  - Analysis is done on a server and presented on a web page
  - We use ProcessBook to display our KPI web pages

Real-time cost data in PI

- To many senior executives, the only real repository of cost data is the ERP system. But there are tremendous advantages to storing them in PI.

- Calculating real-time costs in PI has advantages

    - Single number that characterizes cost allows us to determine holistically the “health” of a process
    - In our industry, hydrogen peroxide can substitute for chlorine dioxide; the amount of sodium hydroxide (caustic) used is to a large extent based on chemical load in the front end of our bleach plant. A number that sums all of these costs allows us to optimize cost more efficiently

There are also caveats

- Constantly updating raw material costs to reflect reality is counterproductive; operators and engineers don't know if changes in cost are due to process improvement or raw material cost improvement
- Some real-time costs are impacted by recycled fiber, chemicals, and additives. When this recycled product is added, virgin materials are automatically reduced, creating a lower real time cost. Obviously, recycled materials are recycled because of a quality issue.
- Optimizing costs on one shift can cause the next shift to have to make up for it.
- The point here is that chasing real time costs is often counterproductive; the value lies in identifying systemic change that impact those costs.

Case study: Reducing bleaching costs

- Bleaching costs increased substantially after our 2009 annual outage
- We weren't sure what caused the problem

Bleaching overview

Wash

Apply Chemical

Retain in Tower

DC Stage
Chorine dioxide reacts with lignin to form chloro-lignin compounds

Wash

Apply Chemical

Retain in Tower

EO Stage
Caustic added to increase pH so chloro-lignin compounds become soluble; hyrdrogen peroxide added to increase brightness

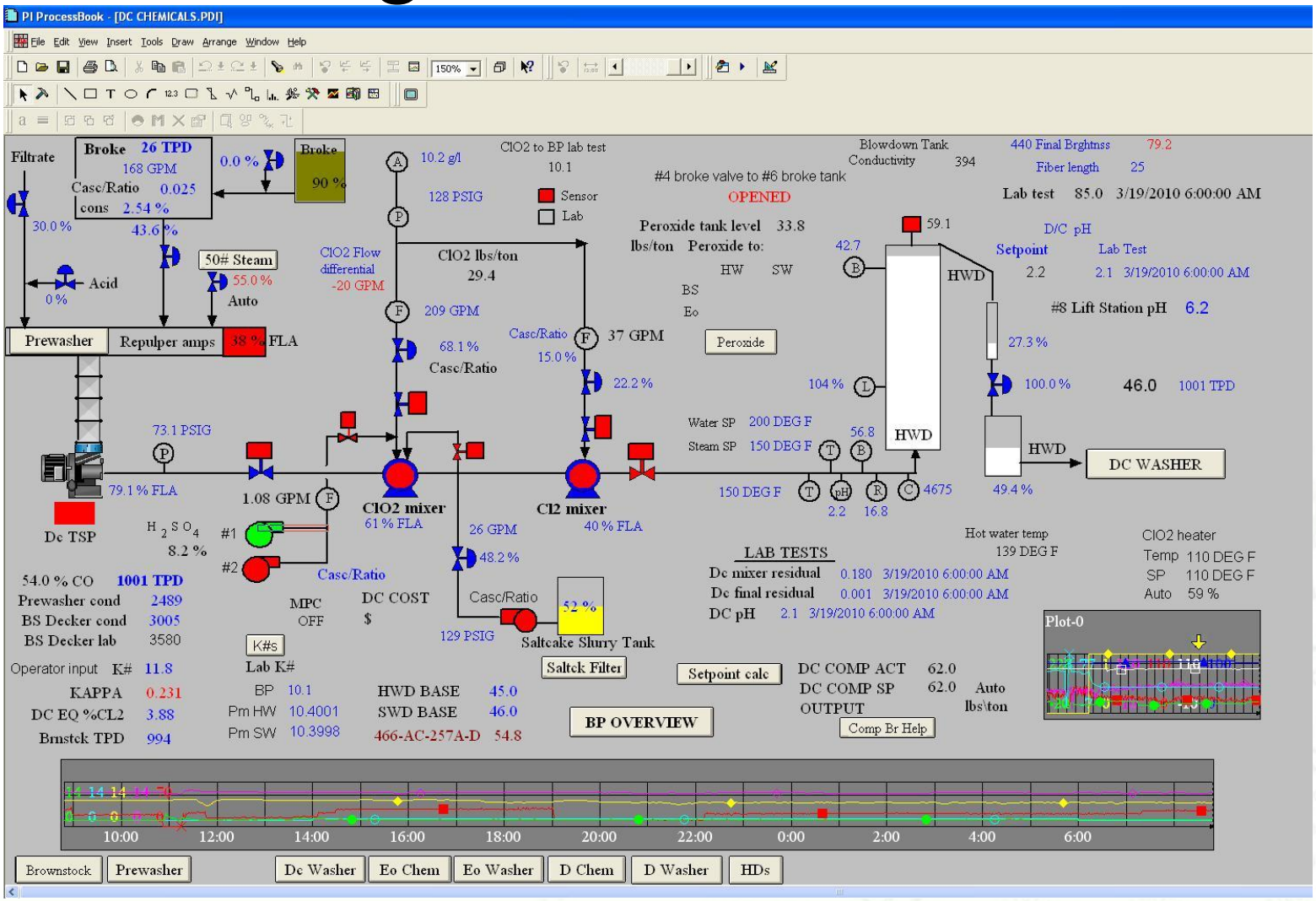
Wash

Apply Chemical

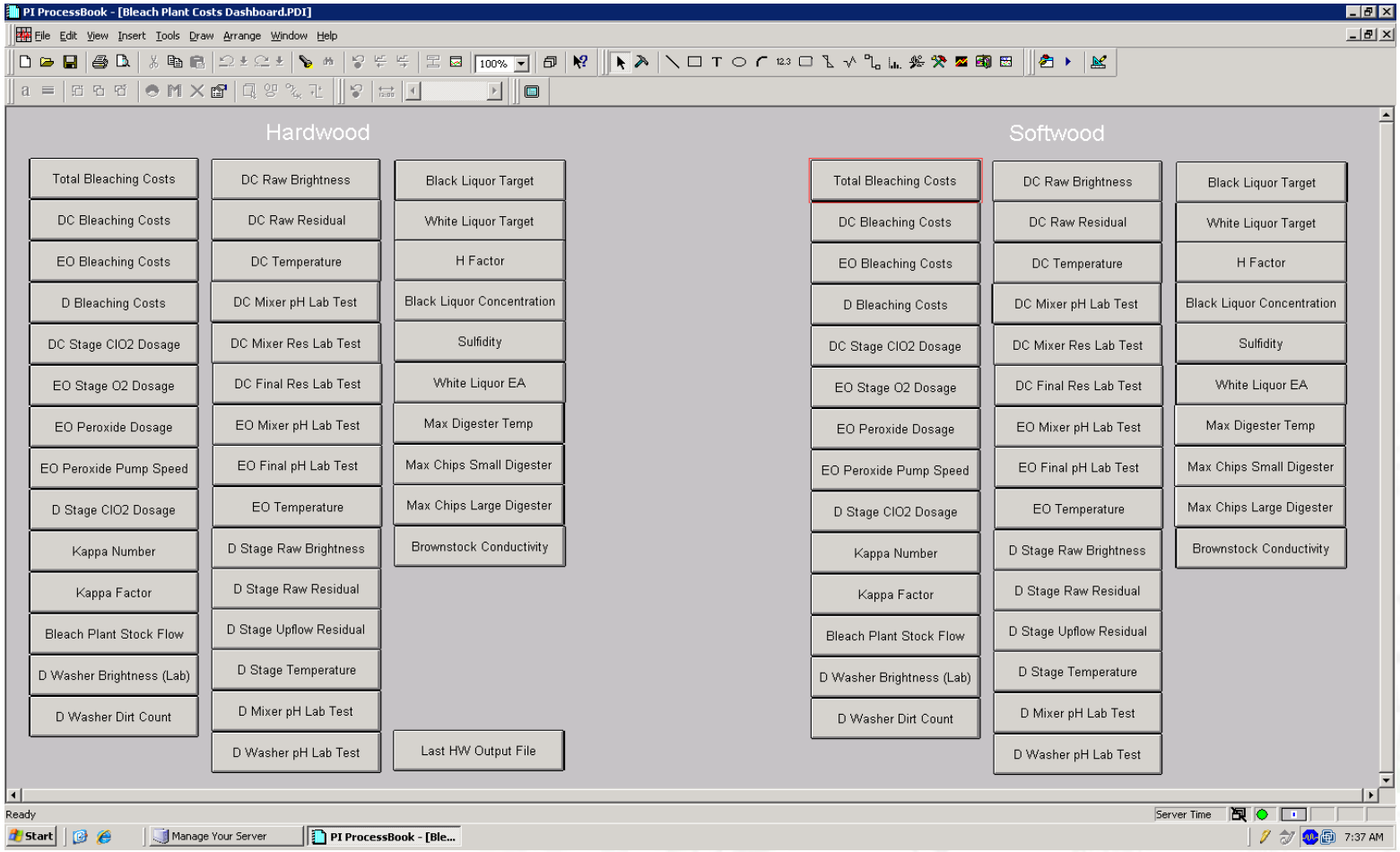
Retain in Tower

D Stage
Chlorine dioxide added to increase brightness

DC Stage from PI ProcessBook



Our KPI Dashboard in ProcessBook



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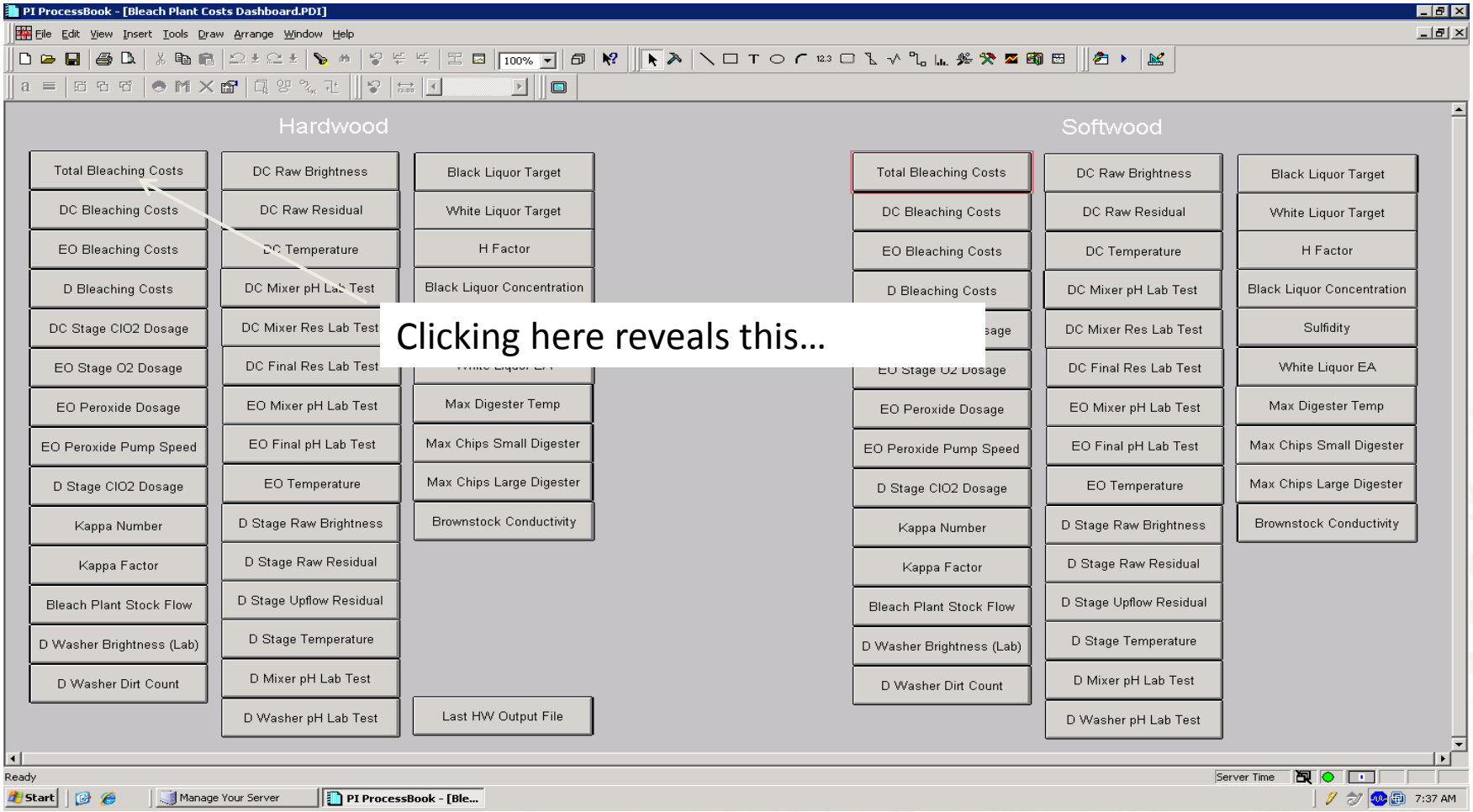
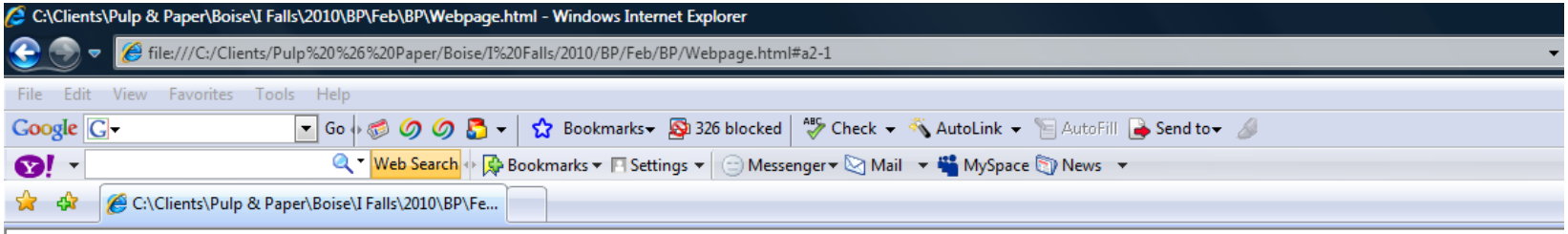
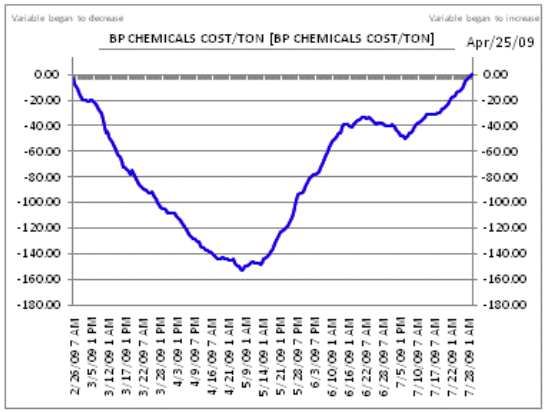
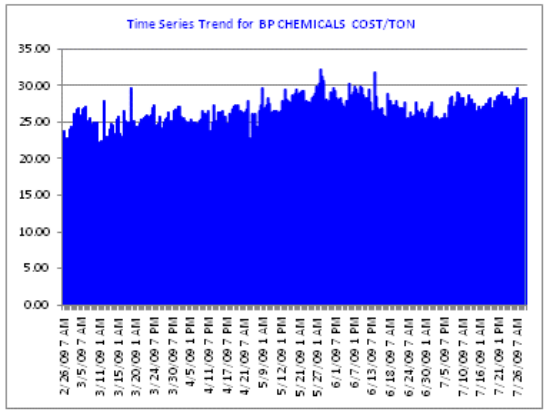


Cost CUSUM and TimeSeries



View CUSUM and TimeSeries Charts



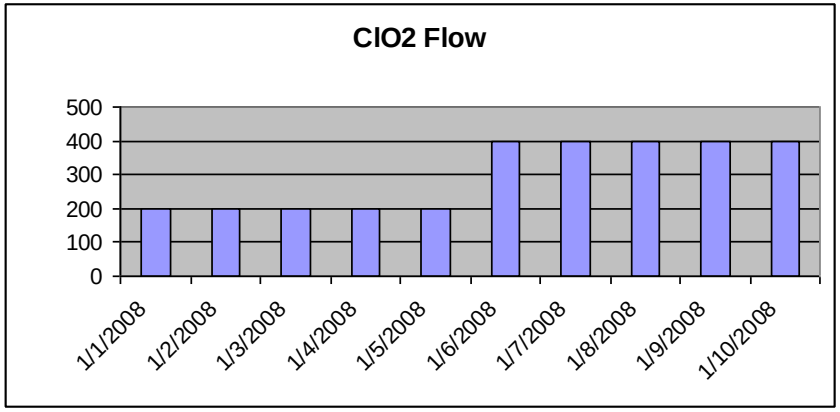


View Max/Min Correlations

View Significant Changes Since Last Run and Dead Tags

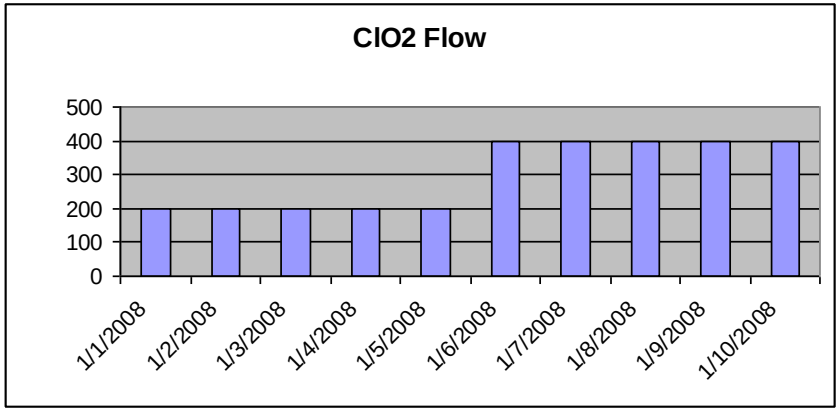
View top 25 R^2 Correlations

A Simple Time Series Chart…

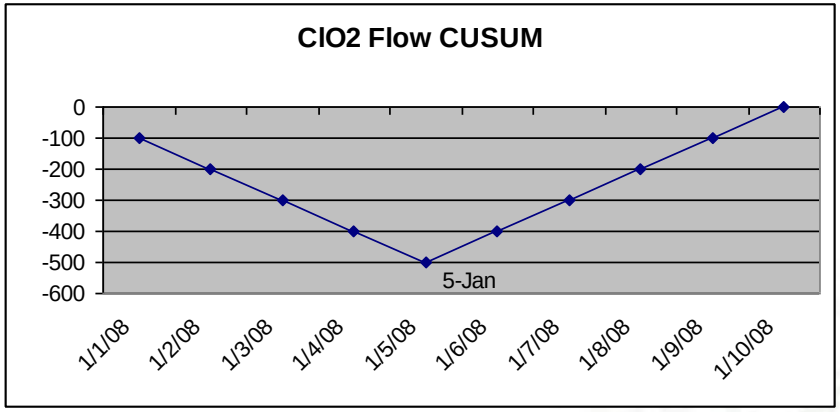


- Chart at left is a normal time series chart
- In this case, the date of change is obvious, but in reality, a time series chart is not the best way to identify changes

CUSUM Chart

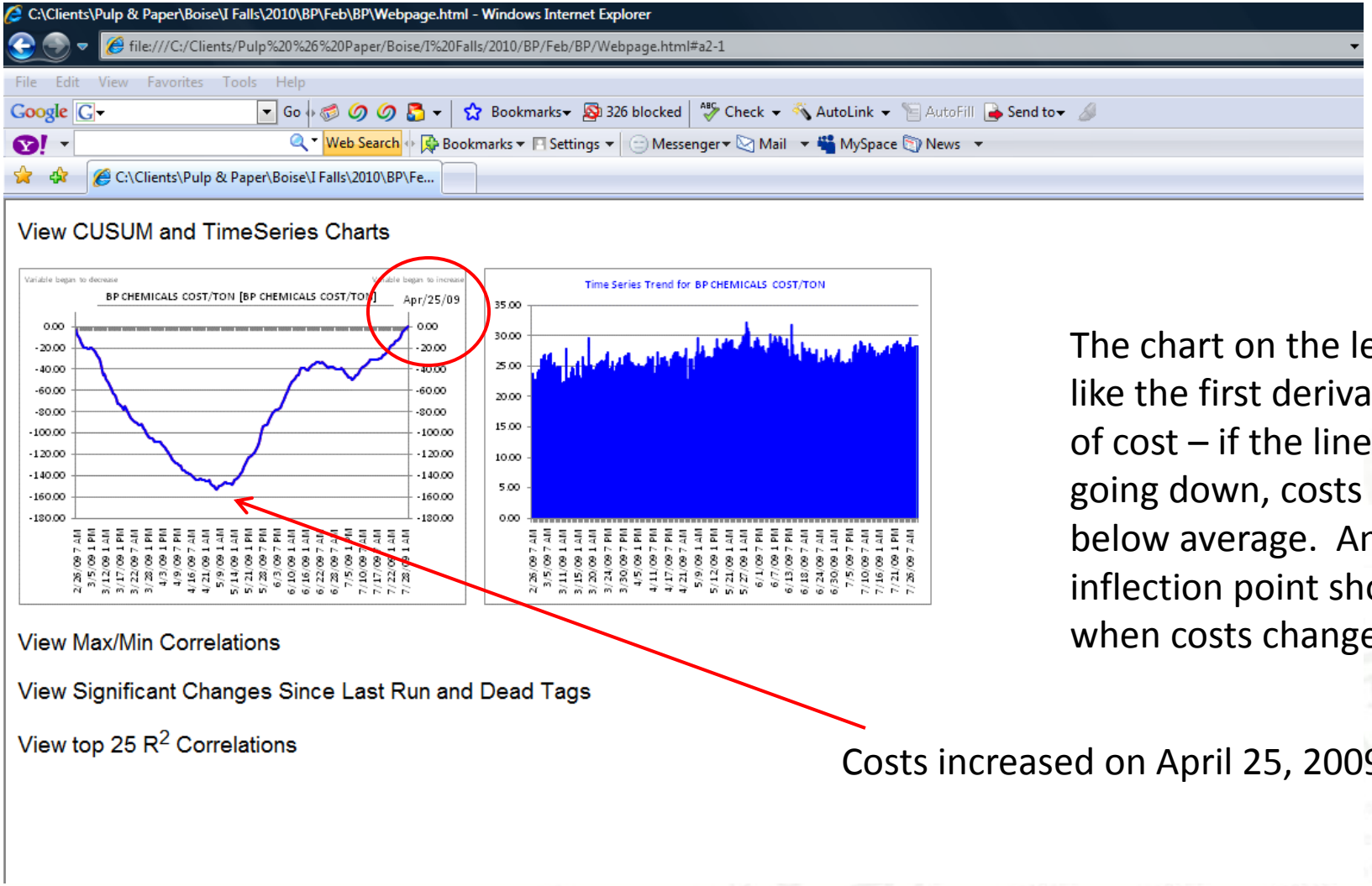


- Chart at left is the same normal time series chart



- The CUSUM chart shows us exactly when the change occurs, in this case, Jan 5

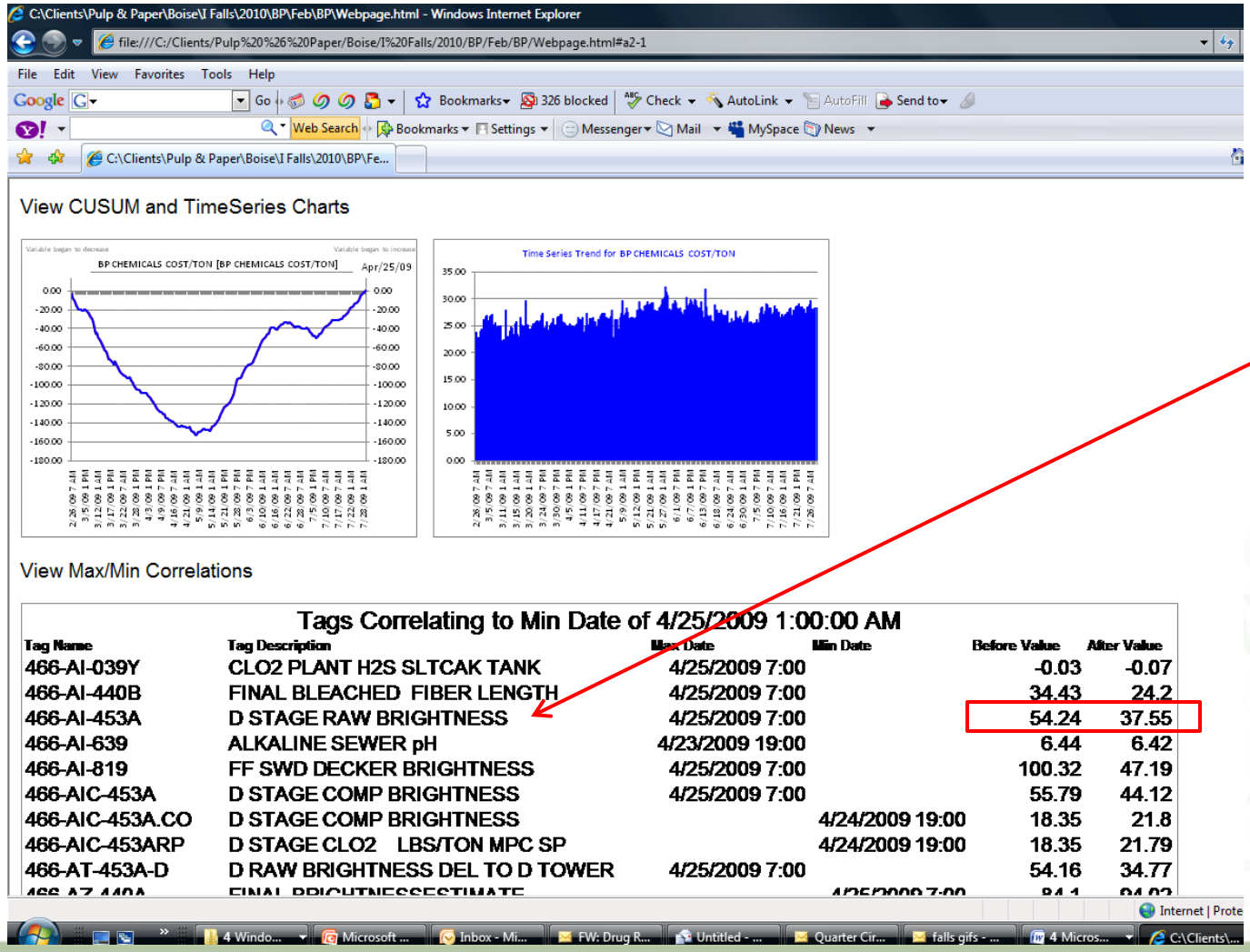
Cost CUSUM and TimeSeries



The chart on the left is like the first derivative of cost – if the line is going down, costs are below average. An inflection point shows when costs changed.

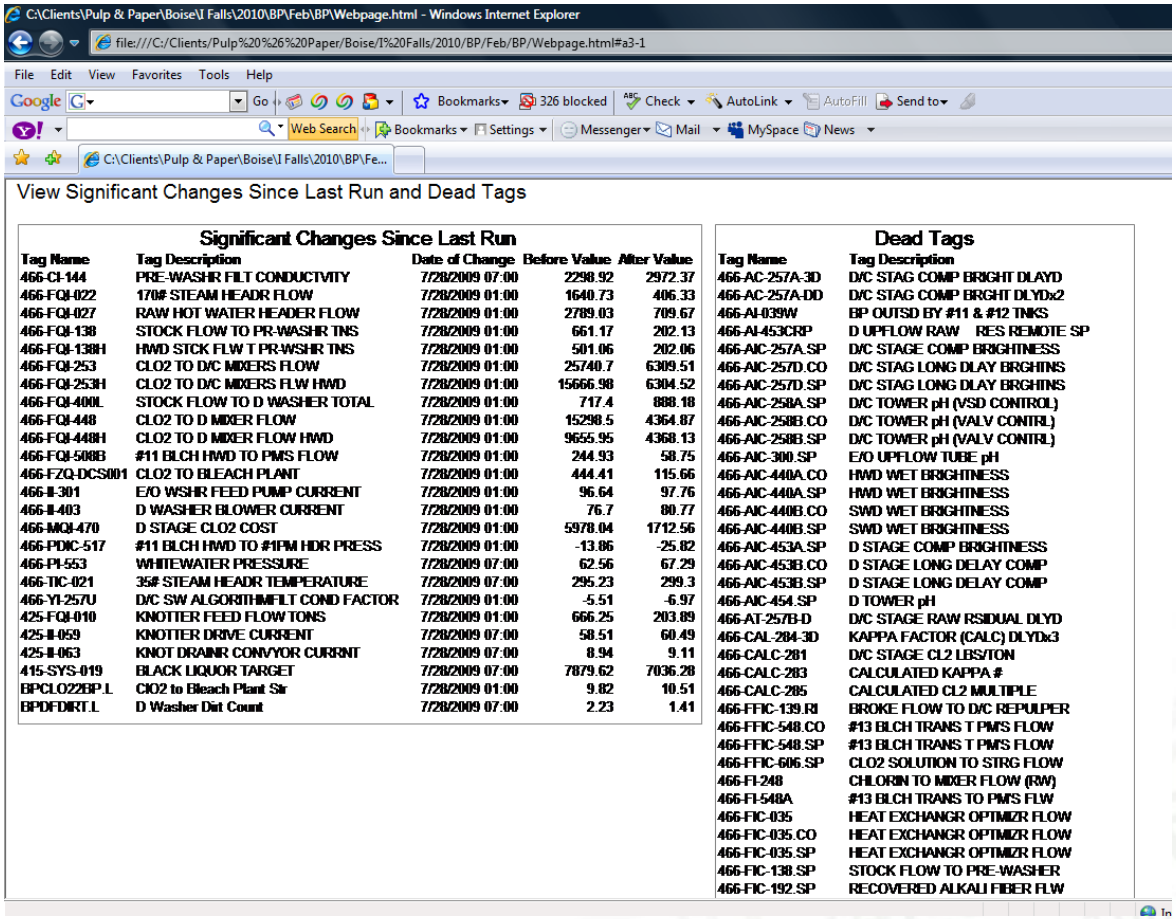
Costs increased on April 25, 2009

Tags that changed significantly are shown when a user clicks “View Max/Min Correlations”



This tag changed dramatically

Dead tags and changes since last run are identified



Significant Changes Since Last Run

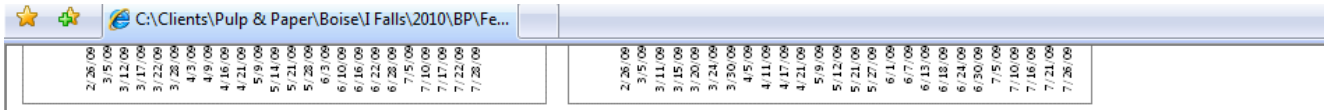
Tag Name	Tag Description	Date of Change	Before Value	After Value
466-CI-144	PRE-WASHR FILT CONDUCTVITY	7/28/2009 07:00	2298.92	2972.37
466-FQI-022	170# STEAM HEADR FLOW	7/28/2009 01:00	1640.73	406.33
466-FQI-027	RAW HOT WATER HEADER FLOW	7/28/2009 01:00	2789.03	709.67
466-FQI-138	STOCK FLOW TO PR-WASHR TNS	7/28/2009 01:00	661.17	202.13
466-FQI-138H	HWD STCK FLW T PR-WSHR TNS	7/28/2009 01:00	501.06	202.06
466-FQI-253	CLO2 TO D/C MIXERS FLOW	7/28/2009 01:00	25740.7	6309.51
466-FQI-253H	CLO2 TO D/C MIXERS FLW HWD	7/28/2009 01:00	15666.98	6304.52
466-FQI-400L	STOCK FLOW TO D WASHER TOTAL	7/28/2009 01:00	717.4	888.18
466-FQI-448	CLO2 TO D MIXER FLOW	7/28/2009 01:00	15298.5	4364.87
466-FQI-448H	CLO2 TO D MIXER FLOW HWD	7/28/2009 01:00	9655.95	4368.13
466-FQI-508B	#11 BLCH HWD TO PMS FLOW	7/28/2009 01:00	244.93	58.75
466-FZQ-DCS001	CLO2 TO BLEACH PLANT	7/28/2009 01:00	444.41	115.66
466-II-301	E/O WSHR FEED PUMP CURRENT	7/28/2009 01:00	96.64	97.76
466-II-403	D WASHER BLOWER CURRENT	7/28/2009 01:00	76.7	80.77
466-MQI-470	D STAGE CLO2 COST	7/28/2009 01:00	5978.04	1712.56
466-PDIC-517	#11 BLCH HWD TO #1PM HDR PRESS	7/28/2009 01:00	-13.86	-25.82
466-PI-553	WHITEWATER PRESSURE	7/28/2009 07:00	62.56	67.29
466-TIC-021	35# STEAM HEADR TEMPERATURE	7/28/2009 07:00	295.23	299.3
466-YI-257U	D/C SW ALGORITHMFILT COND FACTOR	7/28/2009 01:00	-5.51	-6.97
425-FQI-010	KNOTTER FEED FLOW TONS	7/28/2009 01:00	666.25	203.89
425-II-059	KNOTTER DRIVE CURRENT	7/28/2009 07:00	58.51	60.49
425-II-063	KNOT DRAINR CONVYOR CURRNT	7/28/2009 07:00	8.94	9.11
415-SYS-019	BLACK LIQUOR TARGET	7/28/2009 07:00	7879.62	7036.28
BPCLO2EBP.L	ClO2 to Bleach Plant Str	7/28/2009 01:00	9.82	10.51
BPDFDIRT.L	D Washer Dirt Count	7/28/2009 07:00	2.23	1.41

Dead Tags

Tag Name	Tag Description
466-AC-257A-3D	D/C STAG COMP BRIGHT DLAYD
466-AC-257A-DD	D/C STAG COMP BRGHT DLYDx2
466-AI-039W	BP OUTSD BY #11 & #12 TNKS
466-AI-453CRP	D UPFLOW RAW RES REMOTE SP
466-AIC-257A.SP	D/C STAGE COMP BRIGHTNESS
466-AIC-257D.CO	D/C STAG LONG DLAY BRGHTNS
466-AIC-257D.SP	D/C STAG LONG DLAY BRGHTNS
466-AIC-258A.SP	D/C TOWER pH (VSD CONTROL)
466-AIC-258B.CO	D/C TOWER pH (VALV CONTRL)
466-AIC-258B.SP	D/C TOWER pH (VALV CONTRL)
466-AIC-300.SP	E/O UPFLOW TUBE pH
466-AIC-440A.CO	HWD WET BRIGHTNESS
466-AIC-440A.SP	HWD WET BRIGHTNESS
466-AIC-440B.CO	SWD WET BRIGHTNESS
466-AIC-440B.SP	SWD WET BRIGHTNESS
466-AIC-453A.SP	D STAGE COMP BRIGHTNESS
466-AIC-453B.CO	D STAGE LONG DELAY COMP
466-AIC-453B.SP	D STAGE LONG DELAY COMP
466-AIC-454.SP	D TOWER pH
466-AT-257B-D	D/C STAGE RAW RSIDUAL DLYD
466-CAL-284-3D	KAPPA FACTOR (CALC) DLYDx3
466-CALC-281	D/C STAGE CL2 LBS/TON
466-CALC-283	CALCULATED KAPPA #
466-CALC-285	CALCULATED CL2 MULTIPLE
466-FFIC-139.RI	BROKE FLOW TO D/C REPULPER
466-FFIC-548.CO	#13 BLCH TRANS T PMS FLOW
466-FFIC-548.SP	#13 BLCH TRANS T PMS FLOW
466-FFIC-606.SP	CLO2 SOLUTION TO STRG FLOW
466-FI-248	CHLORIN TO MIXER FLOW (RW)
466-FI-548A	#13 BLCH TRANS TO PMS FLW
466-FIC-035	HEAT EXCHANGR OPTIMIZR FLOW
466-FIC-035.CO	HEAT EXCHANGR OPTIMIZR FLOW
466-FIC-035.SP	HEAT EXCHANGR OPTIMIZR FLOW
466-FIC-138.SP	STOCK FLOW TO PRE-WASHER
466-FIC-192.SP	RECOVERED ALKALI FIBER FLW

A controller that is maxed out or completely shut off will show up on the dead tags list

Tags that correlate to cost are automatically ranked in order of importance



View Max/Min Correlations

View Significant Changes Since Last Run and Dead Tags

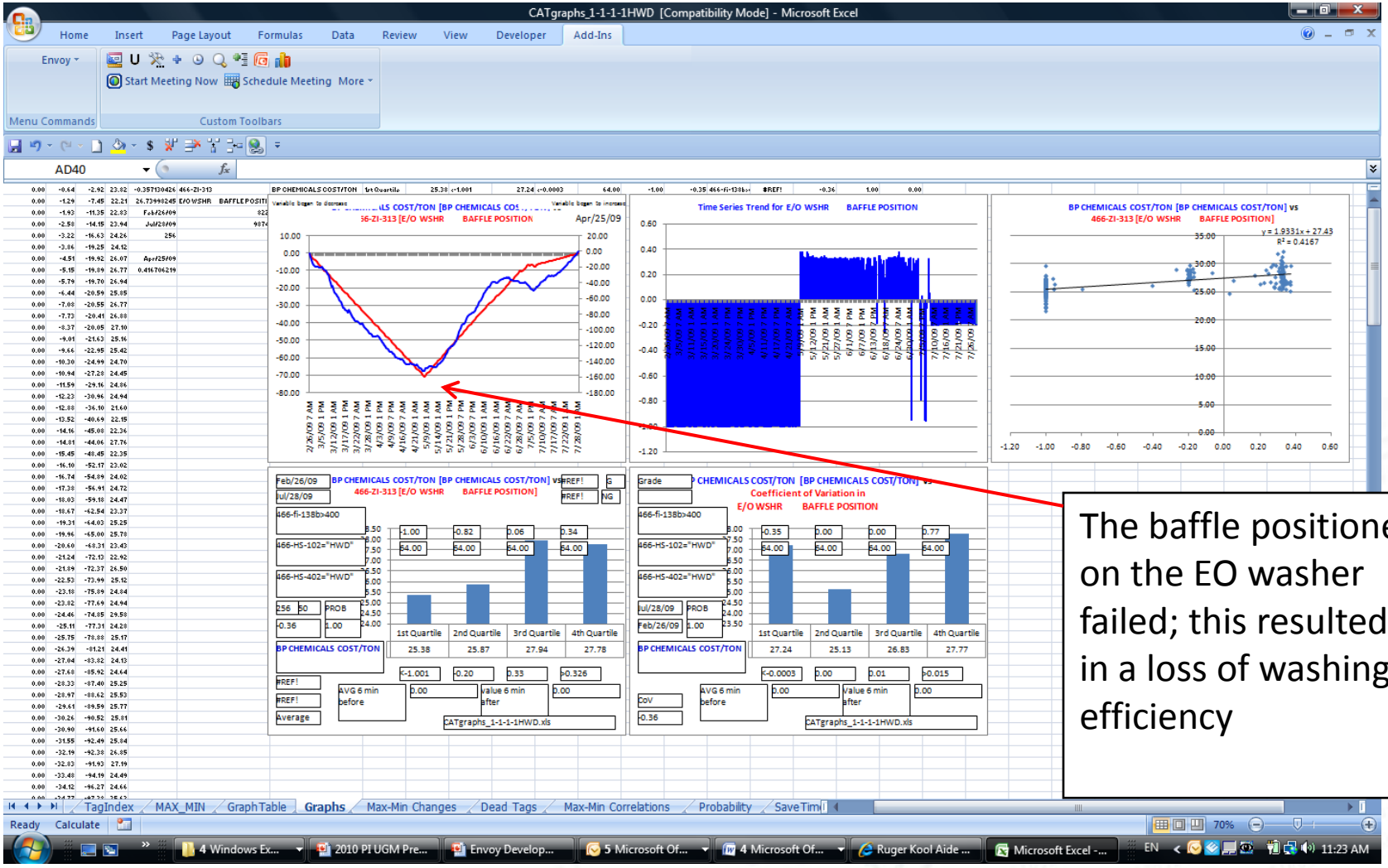
View top 25 R^2 Correlations

R2 Correlation Table for BP CHEMICALS COST/TON

Tag 1	Tag 1 Description	Tag 2	Tag 2 Description	r2
BP CHEMICALS COST/TON	BP CHEMICALS COST/TON	466-MONY-472	BP CHEMICALS COST/TON	1
BP CHEMICALS COST/TON	BP CHEMICALS COST/TON	466-YI-279C	TOTAL EQ %CL2	0.713695008
BP CHEMICALS COST/TON	BP CHEMICALS COST/TON	466-HIC-453C.SP	D LBS/TON SETPOINT	0.555514583
BP CHEMICALS COST/TON	BP CHEMICALS COST/TON	466-AIC-453A.CO	D STAGE COMP BRIGHTNESS	0.555412564
BP CHEMICALS COST/TON	BP CHEMICALS COST/TON	466-CALC-286	D STAGE CLO2 LBS/TON	0.555061712
BP CHEMICALS COST/TON	BP CHEMICALS COST/TON	466-MONY-468	D STAGE CLO2 COST/TON	0.554800685
BP CHEMICALS COST/TON	BP CHEMICALS COST/TON	466-MONY-470	D STAGE CHEMICAL COST/TON	0.554689841
BP CHEMICALS COST/TON	BP CHEMICALS COST/TON	466-YI-453G	D SWD ALGRTHM CL2 FLW FCTR	0.554429823
BP CHEMICALS COST/TON	BP CHEMICALS COST/TON	466-YI-453C	D HWD ALGRTHM CL2 FLW FCTR	0.554400312
BP CHEMICALS COST/TON	BP CHEMICALS COST/TON	466-HIC-453C	D LBS/TON SETPOINT	0.554296658
BP CHEMICALS COST/TON	BP CHEMICALS COST/TON	466-AIC-453ARP	D STAGE CLO2 LBS/TON MPC SP	0.546284454
BP CHEMICALS COST/TON	BP CHEMICALS COST/TON	466-MONY-368	E/O STAGE COST/TON	0.522898877
BP CHEMICALS COST/TON	BP CHEMICALS COST/TON	466-AT-453A-D	D RAW BRIGHTNESS DEL TO D TOWER	0.500857007
BP CHEMICALS COST/TON	BP CHEMICALS COST/TON	466-AI-453A	D STAGE RAW BRIGHTNESS	0.499582506
BP CHEMICALS COST/TON	BP CHEMICALS COST/TON	466-YI-453E	D SWD ALGORTHM RW BR FACTR	0.498924782
BP CHEMICALS COST/TON	BP CHEMICALS COST/TON	466-YI-453A	D HWD ALGORTHM RW BR FACTR	0.49789707
BP CHEMICALS COST/TON	BP CHEMICALS COST/TON	466-LIC-311.CO	E/O WSHR POND LEVEL	0.47278444
BP CHEMICALS COST/TON	BP CHEMICALS COST/TON	466-II-324	E/O WSHR H UNT PUMP CURRNT	0.461368512
BP CHEMICALS COST/TON	BP CHEMICALS COST/TON	466-YI-279B	D STAGE EQ %CL2	0.449817187
BP CHEMICALS COST/TON	BP CHEMICALS COST/TON	466-SI-312	E/O WSHR DRUM SPEED	0.449232928
BP CHEMICALS COST/TON	BP CHEMICALS COST/TON	466-AI-819	FF SWD DECKER BRIGHTNESS	0.442746987
BP CHEMICALS COST/TON	BP CHEMICALS COST/TON	466-TIC-375.SP	GLYCOL HEATER DSCH TEMP	0.442738084
BP CHEMICALS COST/TON	BP CHEMICALS COST/TON	466-PIC-207.CO	D/C WSHR HOOD PRESSURE	0.428718051
BP CHEMICALS COST/TON	BP CHEMICALS COST/TON	466-ZI-313	E/O WSHR BAFFLE POSITION	0.416706219
BP CHEMICALS COST/TON	BP CHEMICALS COST/TON	466-LI-380	GLYCOL EXPAN TANK LEVEL	0.415586459

Note how D and EO chemicals correlates to cost – more so than D/C, which doesn't even show up

What happened? We used the Envoy add-in to find out

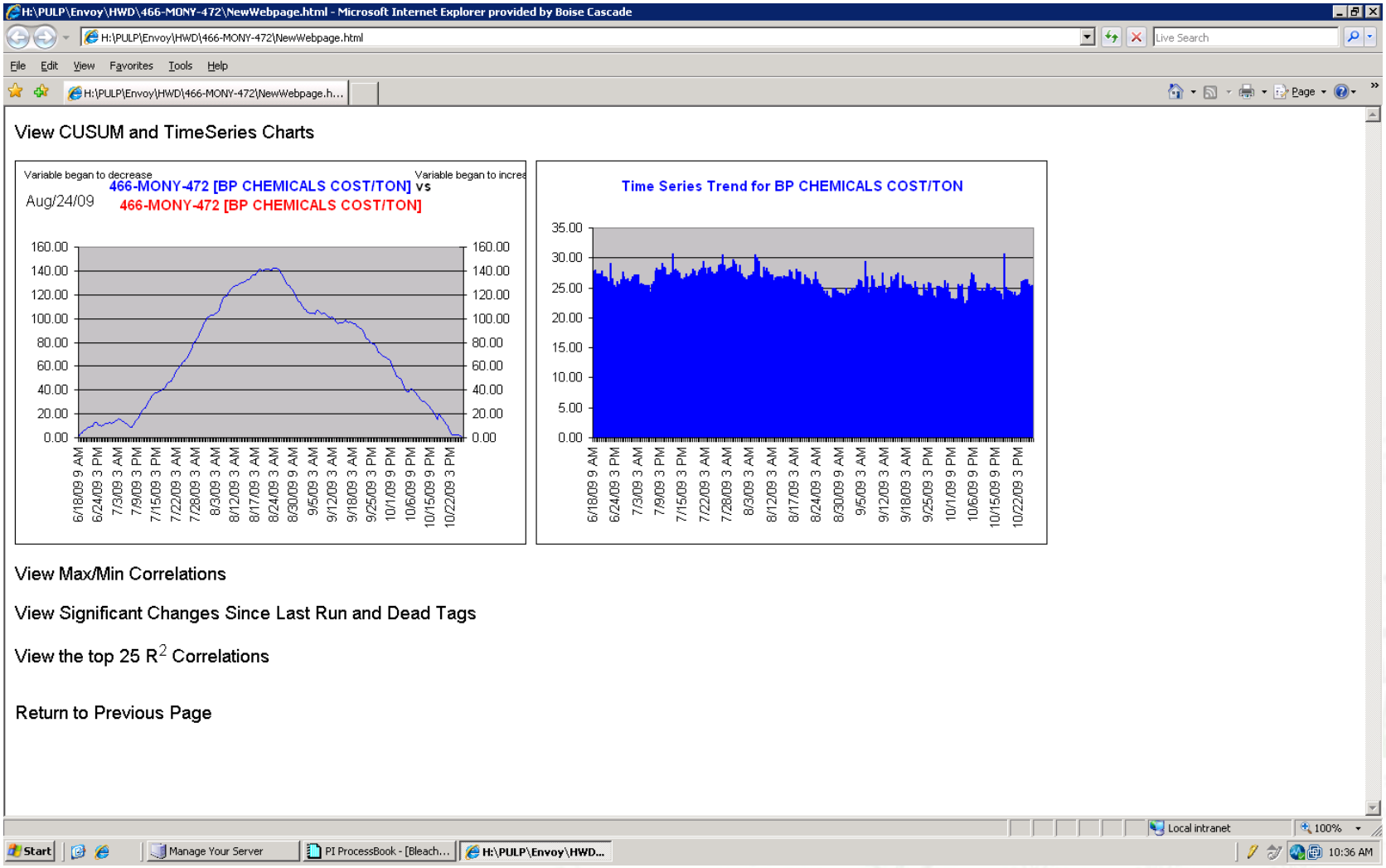


The baffle positioner on the EO washer failed; this resulted in a loss of washing efficiency

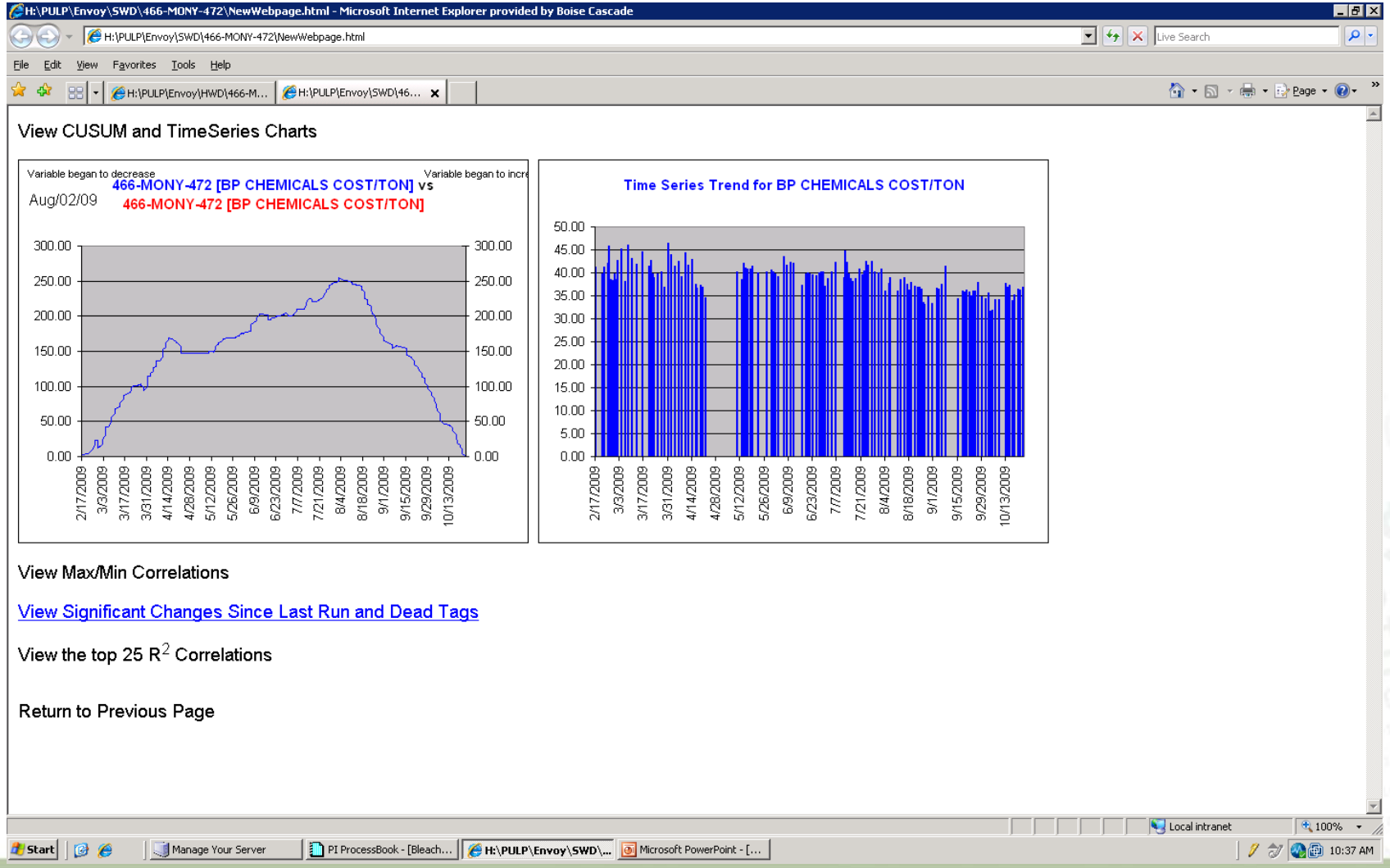
Summary

- When the EO washer baffle failed, washing efficiency dropped
- D raw brightness dropped dramatically
- Operators added peroxide in the EO stage
- Peroxide, when not washed out, acts as an anti-chlor, meaning even more D stage ClO2 was added
- The corrective measure was to cut peroxide and of course, repair the baffle actuator
- This move saved between $3,000 and $4,000 per day, depending on whether we bleach hardwood or softwood

Dashboard view a few months later for hardwood



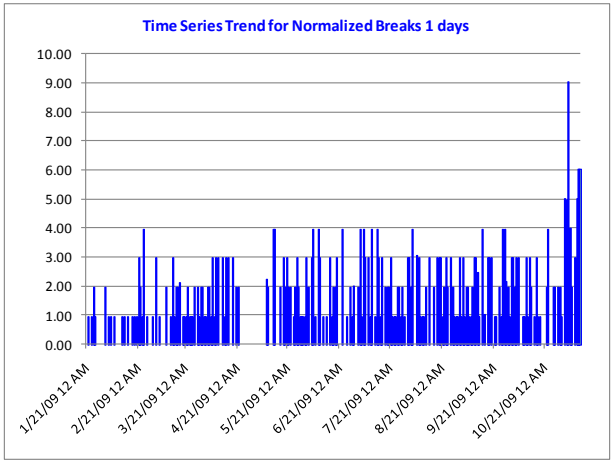
Same view for softwood, which is not produced as often as hardwood

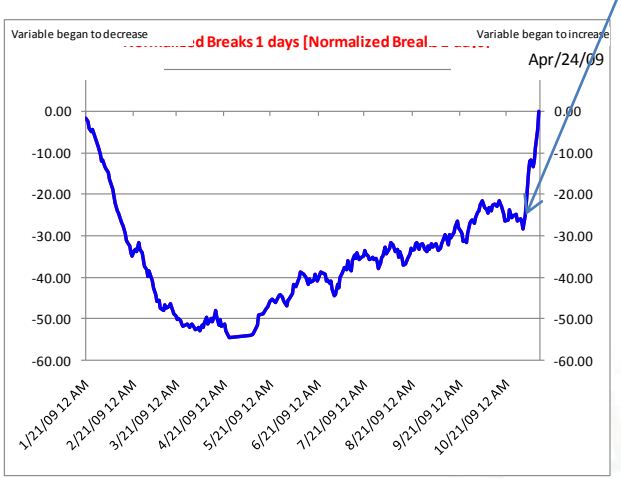


Another success story

- Our largest paper machine produces 335,000 tons of paper yearly
- Sheet breaks are a Key Performance Indicator. They require the entire machine to be rethreaded for production to resume, causing a loss of efficiency
- Nov. 2: Detected that sheet breaks increased dramatically

Normalized breaks 1 days

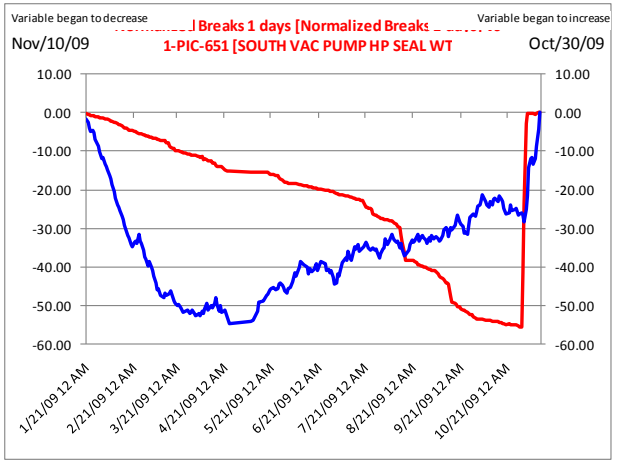


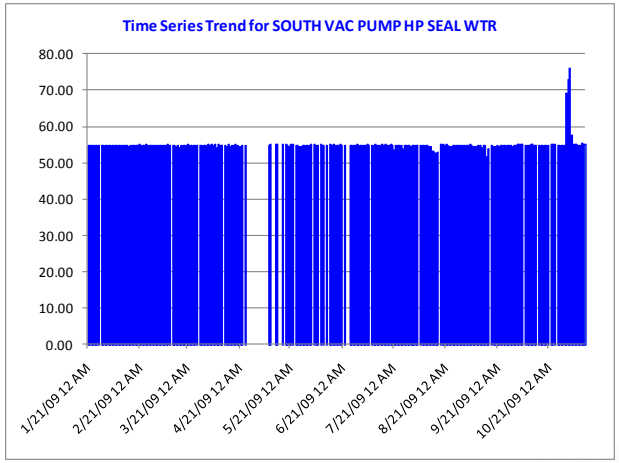


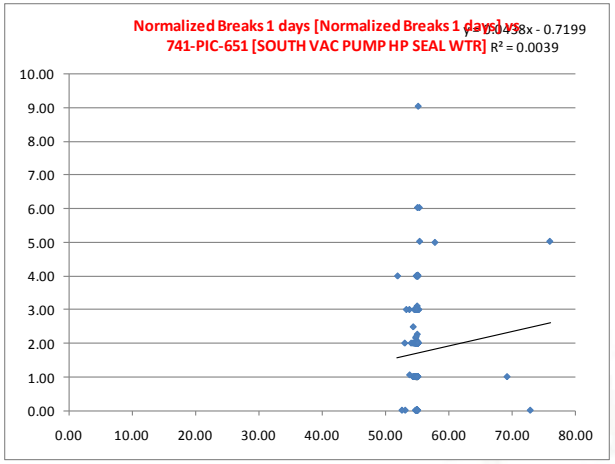
- Nov. 2: Breaks increase dramatically
- Absolutely a mechanical-E&I-Process Control issue, not a pulp change, etc.

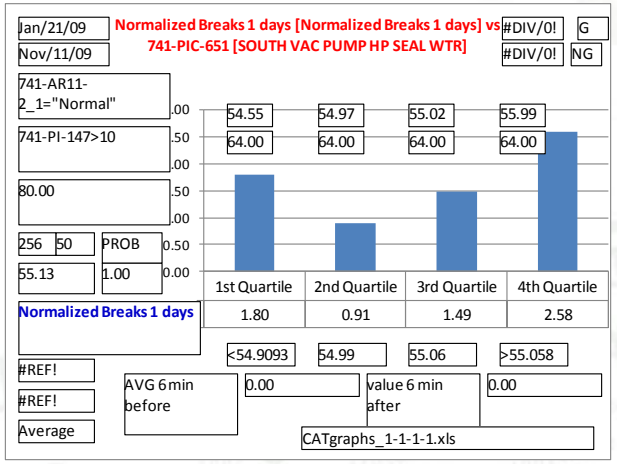
South Vac Pump HP Seal Wtr

This pressure spiked on Oct. 31



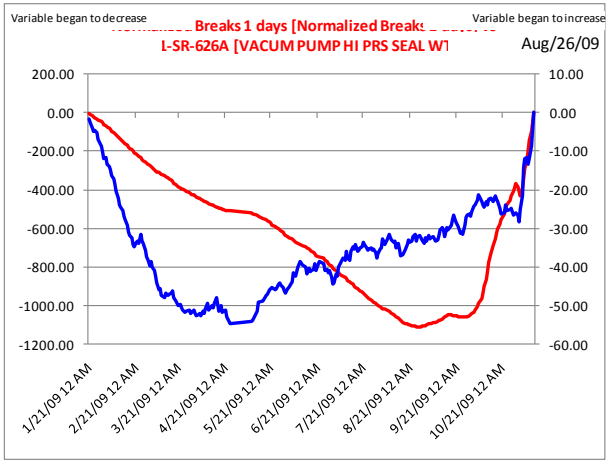


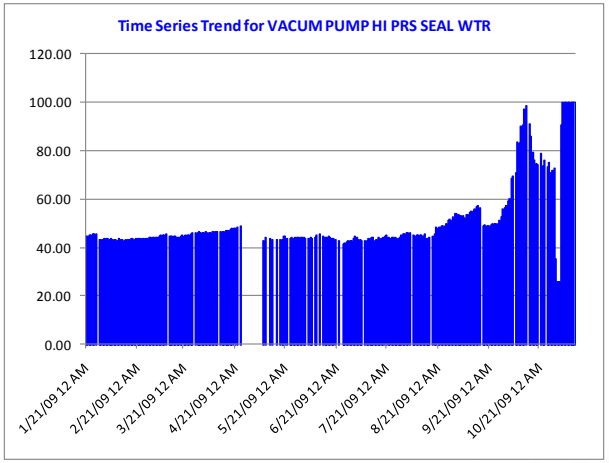


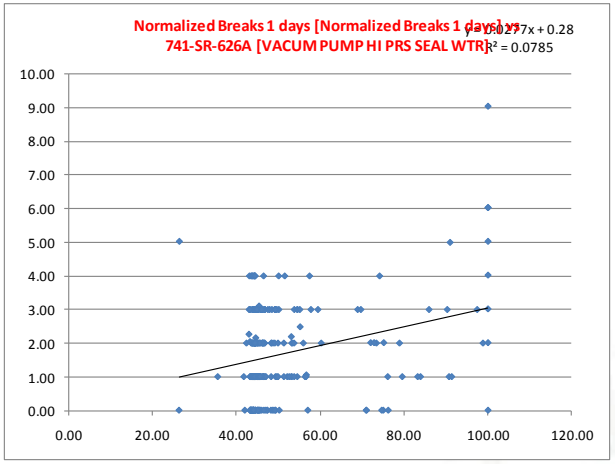


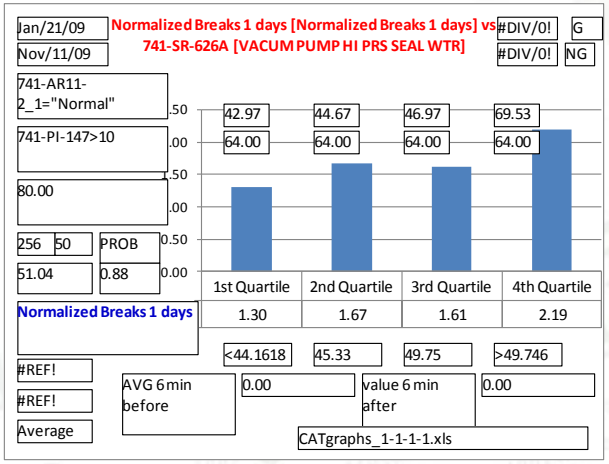
Vacum Pump HI PRS Seal Wtr

Significance unknown, but apparent not running normally



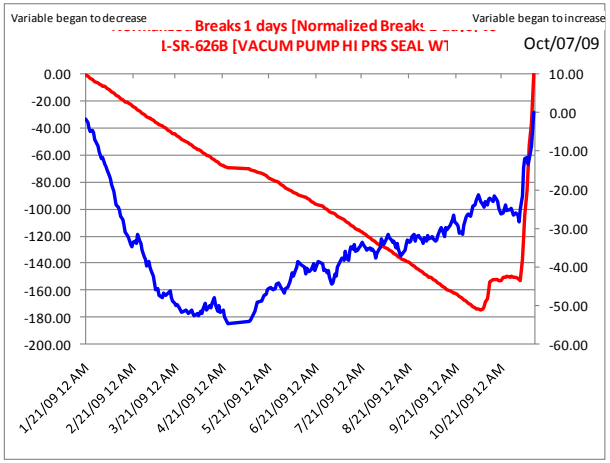


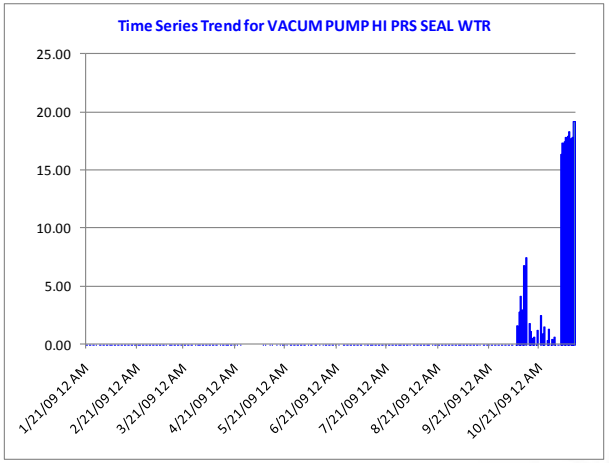


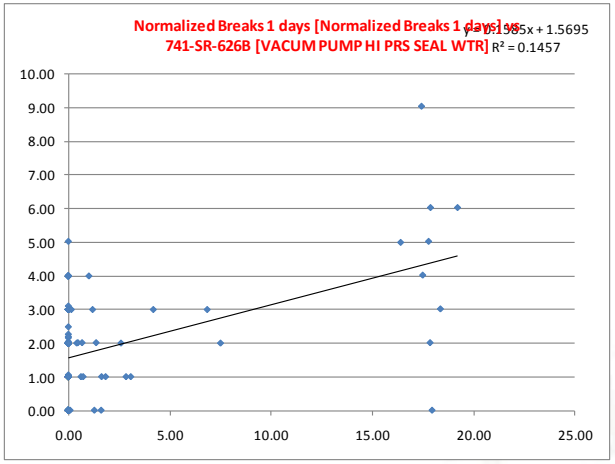


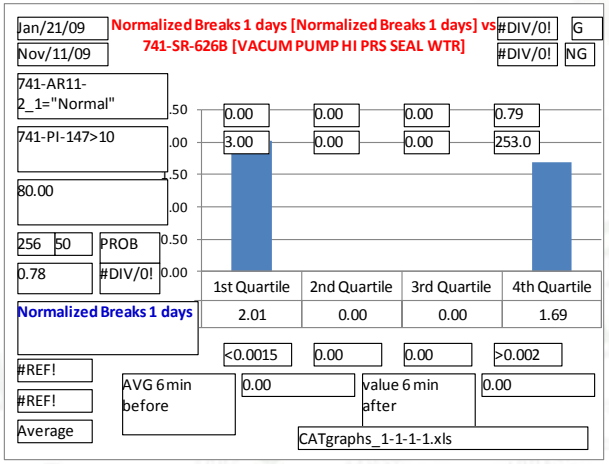
Vacum Pump HI PRS Seal Wtr

Controller shut off for months came on suddenly. Again, we didn't know what it meant, so we shut down the pump to inspect it









Results

- Pump full of scale
- Surmise it broke loose when we shut pump down a few days prior
- Seal water tags did not indicate what was wrong, only that things were operating way outside of normal specs

Evaluation of a trial

- Chemical vendors often promise to reduce costs, improve quality, or increase production
- Vendors today all use PI to “prove” their case
- We use PI as well, only we use automated data mining techniques from Envoy

Summary of data

Vendor insisted their trial reduced costs – but it wasn't even close

			BP CHEMICALS COST/TON	STOCK FLOW TO PRWASHR TPD	D/C STAGE 466-CALC-280	CLO2 LBS/TON	D STAGE CLO2 466-CALC-286	LBS/TON OXYGN 466-FFI-348	MEASURD VLUS	D/C STAGE 466-MONY-276 COST/TON	E/O STAGE 466-MONY-368 COST/TON	D STAGE CHEMICAL 466-MONY-470 COST/TON	BP CHEMICALS 466-MONY-472 COST/TON	CALCULATED 466-CALC-284	KAPPA FACTOR	CALCULATED 466-CALC-283	KAPPA #	SULPHIDITY 415-SYS-902	RECIPE EDITOR 415-SYS-909	MAX CK TEMP	H-FACTOR 415-SYS-100.SP	BLACK LIQUOR 415-SYS-019	TARGET
	All Trials	Average All Times	25.281	1086.066					9.766	11.473	6.019	7.788		0.245		15.722		29.318		338.194	802.412		7600.480
		Std Dev All	1.297	87.079	2.134	1.714			0.859	0.839	0.597	0.672	1.297	0.017		0.861		1.347		2.090	343.525		473.121
		Count	182.000	182.000	182.000	182.000			182.000	182.000	182.000	182.000	182.000	182.000		182.000		182.000		182.000	182.000		182.000
	Chelant trial	Average for Chelant trial	25.264	1059.864					9.737	11.750	5.975	7.538		0.248		15.938		30.102		338.265	836.356		7515.774
		Std Dev for Chelant trial	1.477	97.642	2.332	1.639			0.887	0.919	0.617	0.642	1.477	0.015		1.290		0.933		2.142	364.104		454.619
		Count for Chelant trial	68.000	68.000	68.000	68.000			68.000	68.000	68.000	68.000	68.000	68.000		68.000		68.000		68.000	68.000		68.000
	No Chelant	Average for No Chelant	25.215	1100.506					9.821	11.284	6.001	7.930		0.243		15.591		28.797		338.126	788.686		7671.822
		Std Dev for No Chelant	1.132	77.796	1.912	1.682			0.797	0.750	0.526	0.661	1.132	0.018		0.403		1.337		2.047	336.731		467.773
		Count for No Chelant	109.000	109.000	109.000	109.000			109.000	109.000	109.000	109.000	109.000	109.000		109.000		109.000		109.000	109.000		109.000
Statistical Analysis assuming normal distributions Z-test																							
		Difference of means	0.049	40.642	1.177	0.995			0.084	0.466	0.026	0.391	0.049	0.005		0.347		1.305		0.139	47.671		156.047
		Percentage of means	0.19%	3.69%	4.08%	4.92%			0.85%	4.13%	0.43%	4.94%	0.19%	1.95%		2.23%		4.53%		0.04%	6.04%		2.03%
		Standard error difference	0.209	13.990	0.337	0.256			0.132	0.133	0.090	0.100	0.209	0.003		0.161		0.171		0.325	54.679		71.041
		z score null hypothesis	0.232	2.905	3.493	3.890			0.635	3.512	0.287	3.903	0.232	1.892		2.154		7.639		0.426	0.872		2.197
		critical z, alpha = 0.05	1.645	1.645	1.645	1.645			1.645	1.645	1.645	1.645	1.645	1.645		1.645		1.645		1.645	1.645		1.645
For Chelant trial vs No Chelant		significant 95%	no	yes	yes	yes			no	yes	no	yes	no	yes		yes		yes		no	no		yes

Analysis done in a matter of minutes using Envoy software

One More Caveat…

- Historical data is corrupted by human and control policies
  - Correlation does not mean causation
  - Manipulated variable and controlled variable: a big difference
    - Data analysis on manipulated variables often shows relationships that are the opposite of what you would expect
    - This means the “lever” is overvalued

Example

- Most people expect chemical costs in a bleach plant to correlate with the brightness of the pulp, but in reality, the correlation is often negative: lower brightness pulp has a higher cost. The human or control policy is to cut chemical when brightness is above target. When brightness is below target, the operators add chemical. If something else such as pH is wrong, adding chemical will not fix the problem – it will only increase costs.

Key findings

- All historians are not created equally
  - PI allows us to collect data in an automated fashion with lightning speed
  - The ability to filter on the server is critical; not all historians can do this
- Every night we analyze thousands of tags to identify what drives our KPIs
  - PI never “hiccups”
  - The amount of historical on line allows us to look at long term statistical relationships

Questions?

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Thank you