



Real Time Operational Intelligence with the PI System and Envoy Development Process Monitor

Presented by **Troy Foede**
John Antanies

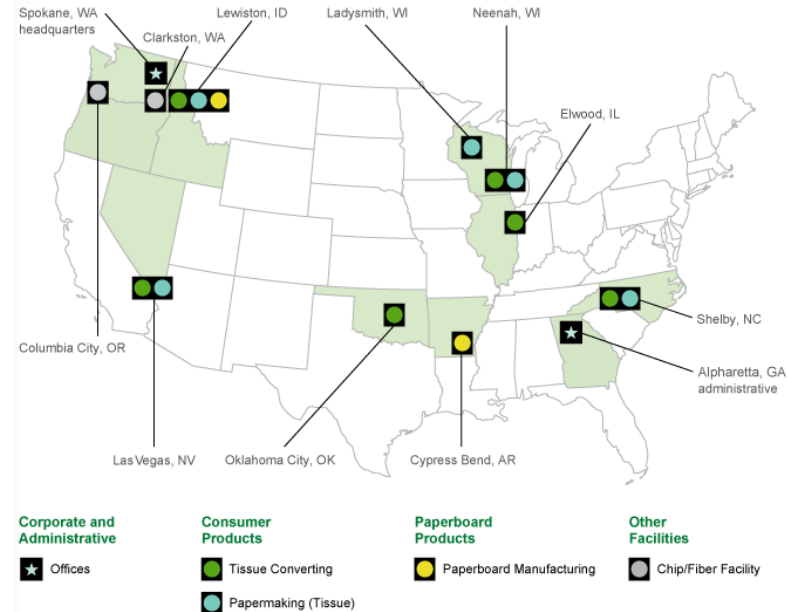


Clearwater Paper Overview



We are the country's largest provider of private label tissue to retail grocery chains and a world-class manufacturer of high-quality bleached paperboard.

- 7 manufacturing sites
- 10+ paper machines
- 50+ tissue converting lines
- Multiple extruders, pulp mills, recovery and power boilers
- Oldest PI system: 20+ years



Real Time Operational Intelligence with the PI System and Envoy Development Process Monitor

COMPANY and GOAL

Our mill PI Systems have thousand of tags that are impossible to constantly monitor in real time. DCS alarms are not effective at identifying exceptions before they become issues.



CHALLENGE

Paper mills have many processes, each of which can run dozens of grades. Targets and limits for KPIs are manageable, but the task becomes Herculean if we want to monitor all tags by grade. Different production rates add more complexity.

SOLUTION

Used the PI System and AF SDK to feed data into Envoy Process Monitor (EPM)

- EPM calculates historical operating envelopes for every tag in a process, by grade and production rate. Targets and limits not specified manually are calculated automatically and flagged using analytics.

RESULTS

Early identification of process deviations and reliability issues reduces time to solve issues, minimizing negative impacts to productivity.

- Reliability issues now identified and fed to operations daily
- Grade & rate specific limits created and remain updated without tying up resources to develop, enter, & maintain
- More time for problem solvers to attack the most critical issues

Business Challenge

- Clearwater Paper has tens of thousand of tags in PI
 - Some of these are KPIs, whose targets and limits are well understood
 - The vast majority are not watched, nor do they have defined targets or limits
 - The problem of targets and limits is further compounded by two huge issues:
 - Paper machines run dozens of grades, often several per day
 - The speed of each process can also impact the target
- Mill employees are stretched thin
 - We can outsource data analytics, but not taking action on the results

The Solution

- Clearwater Paper contracted with Envoy Development
 - Envoy Process Monitor collects and aggregates data from the PI System using AF SDK
 - Each mill is broken into processes
 - All tags with numerical values are collected
 - Much like internet search engines index the web, EPM indexes data from the PI System to identify what drives KPIs, tags that have moved outside of their normal operating envelope, and tags that correlate with a statistical change in either a tag or date
 - Analysis is done by both grade/product and speed/production rate
- Envoy engineers send us daily and monthly reports for each process and Envoy Process Monitor is available for real time exception identification

Envoy Process Monitor

Server Side

Envoy.DC
Data Collection Service



dbEnvoy
Microsoft SQL
Database

Targets and Limits
CUSUM Inflections
Coefficient of Variation



AF SDK

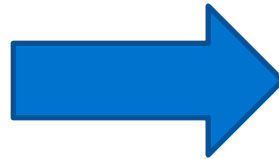


PI
System

Client Side



Envoy.exe



Envoy Process Monitor Home Dashboard Operator Comments Sigma All

Envoy - 2 Sigma - Watch All Variables for a Product

1) Select an Area: PAT 2) Select a Product: PRODUCT D - PRODUCT D

3) Select the Limits: Past 3 Months 4) Hide Previous Runs? 5) Use speed buckets?

6) EXCLUDE items that have been outside of limits for specified days

Get Data Now! Total records returned: 60 Most recent time stamp: 17 August 2016 14:11

Current Value Aggregation: 10 min 60 min

PA1 is running Return to the Menu

Variable	Description	Current Value	Sigma Out	Percent Deviation from Target	Target	Upper Limit	Lower Limit	2016-08-17 09:29 AM	2016-08-14 12:00 PM	2016-08-13 07:47 AM
112-30-R-205 PV	Current-Disk Filter Drive	25.48	27.82	74.54	100.00	100.00	95.00	25.48	25.87	25.87
112-40-PC-611 BP	BP #1 Low Vac. Setpoint	8.98	2.28	15.60	9.55	10.25	8.85	9.68	9.45	9.45
112-40-PC-1004 OP	Flow Control Output - Post D.	1.00	1.48	65.28	2.88	3.98	1.80	3.16	2.81	2.89
112-30-FC-402 PV	Break to Machine Chest Feed	207.48	1.44	34.81	315.25	392.66	253.90	302.79	303.13	312.94
112-40-A-4060 PV	Power-Switchgear SS-H 3D-	598.89	1.43	10.83	689.38	711.80	627.12	679.71	688.59	688.82
112-30-PC-403 PV	Inlet Pressure Control Output	3.01	1.33	75.39	12.23	17.77	6.69	11.01	13.34	12.24
112-30-PS-558 PV	Outlet Pressure-T.P. Secm.	6.98	1.10	9.89	8.71	7.13	6.29	6.84	6.75	6.81
112-30-PC-403 BP	Inlet Pressure Setpoint Top	34.00	1.00	1.99	34.69	35.15	34.23	34.66	34.57	34.75
112-70-LC-202 PV	Level Effluent Chest	45.78	0.95	22.20	58.84	67.68	50.00	61.17	58.84	62.49
112-30-A-4010 PV	Power-DCS Cooler	-13.81	0.90	148.68	27.96	56.16	-9.86	33.30	29.28	29.84
112-40-FC-620 PV	TP #0 Low Vac Measurement	14.40	0.88	9.28	15.87	16.89	14.85	15.63	15.74	15.96
112-40-F1-677 PV	Generated Condensate Flow	55.89	0.76	8.25	60.82	64.46	57.18	61.12	61.17	60.98
112-40-LC-401 PV	Level Tank #1 Level	17.81	0.75	6.11	62.87	68.55	79.19	62.72	62.56	63.28
112-40-LV-510B PV	Make-up Valve Position In.	-1.95	0.75	50.00	-1.32	-0.84	-1.80	-1.24	-1.21	-1.27
112-30-FC-401 PV	Flow Primary Refiner to Mec.	1612.46	0.70	5.83	1776.09	1852.75	1699.31	1771.76	1794.43	1794.43
112-40-PS-203 PV	Pressure-PM High Pressure	439.38	0.63	1.53	446.38	451.93	441.23	445.07	446.43	446.43
112-30-PS-310 PV	Inlet Pressure-Secondary U-	28.00	0.64	2.30	28.66	29.16	28.16	28.78	28.71	28.69
112-40-FC-3010B PV	Automated Flow	1.08E-05	0.64	0.00	1.00E-06	1.40E-07	1.00E-05	1.00E-06	1.00E-06	1.00E-06

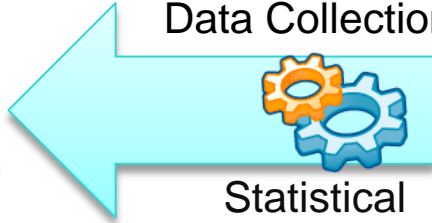
MS Office Automation with PI System Data

Server Side

Envoy.DC
Data Collection Service



dbEnvoy
Microsoft SQL
Database



Statistical
Indexing



PI
System

Client Side

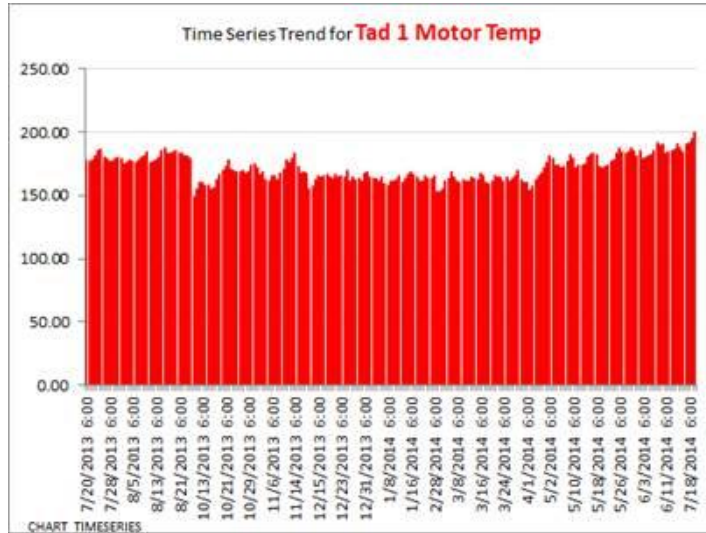


Excel files contain aggregated & filtered data for all tags in a process. If the process produces grades/products, then one file is generated for each product ran since the last report generation. Exception and shift reports can also be generated on a scheduled basis. Data can be evaluated further with the Envoy statistical add-in.

PowerPoint files contain a list of all tags (variables) that are outside of the normal operating footprint, categorized using an algorithm that prioritizes tags based on duration, severity, newness to the grade, etc.

Example: Motor Temperature High

- Tad 1 Motor Temp: Tad 1 Motor Temp
 - Upper two sigma at 191.3
 - Current value at 199.4
 - Prior 24 hours at 199.8



- Comment from the mill:
- TAD Roll #1 Motor was completely plugged with debris. I cleaned the motor this morning and the temp dropped from 200+°F to 141°F.

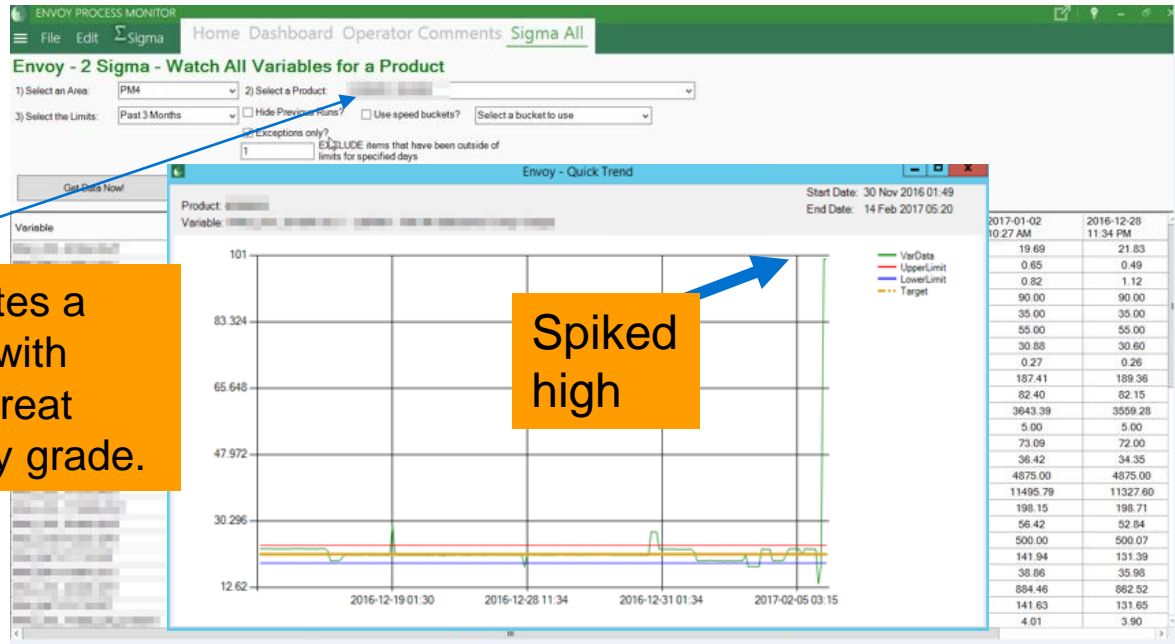
Grade Specific Exceptions

If the process produces grades or products, targets and limits are calculated for each grade

Current grade and

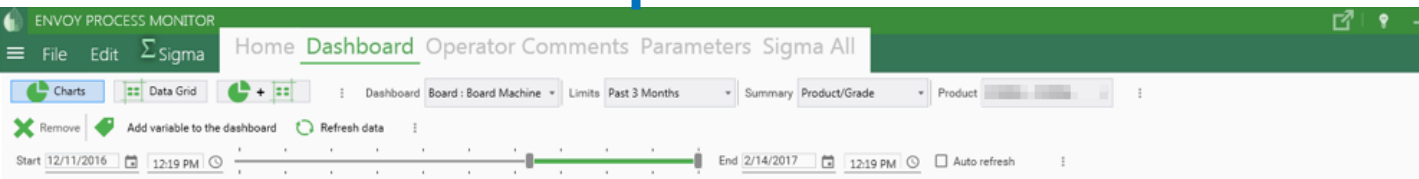
Double clicking on a tag generates a quick trend that is grade based with limits. PI Coresight is another great option for displaying the limits by grade.

Instead of configuring SPC type rules, Envoy identifies exceptions by filtering for duration and magnitude

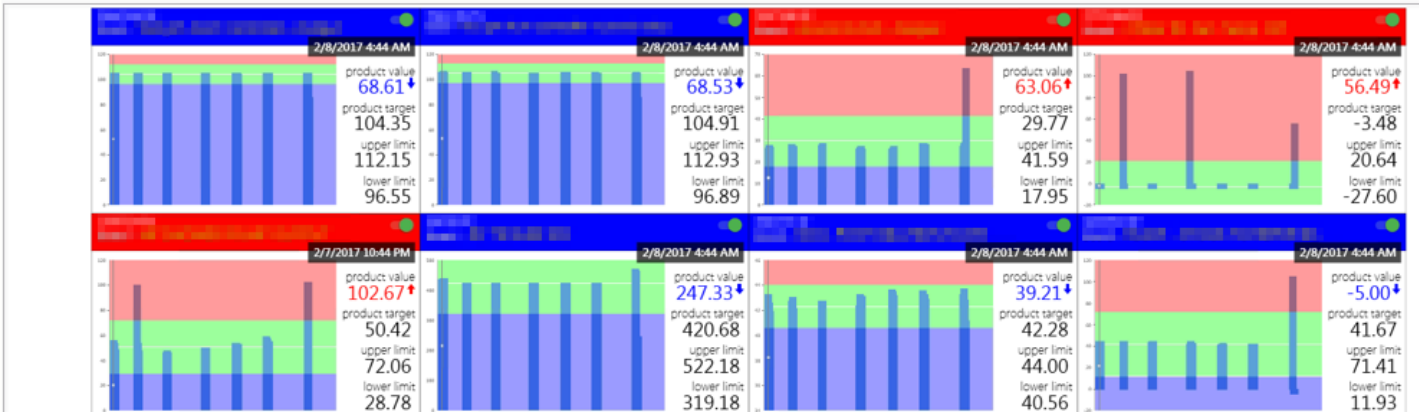


In this example, we are looking at exceptions lasting at least one hour but not over 24, sorted by standard deviation above target

Grade Based Exceptions as Trends



Tags appear by percent out of limit and are automatically trended; this is a grade based trend



ENVOY PROCESS MONITOR

Home Dashboard Operator Comments Parameters Sigma All

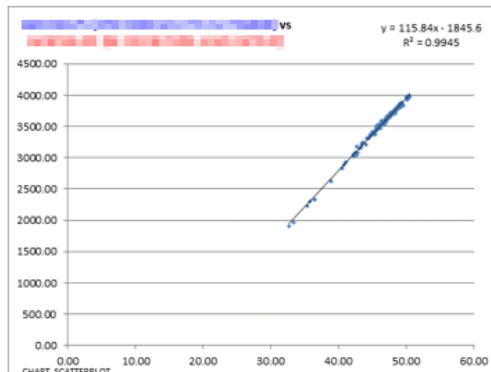
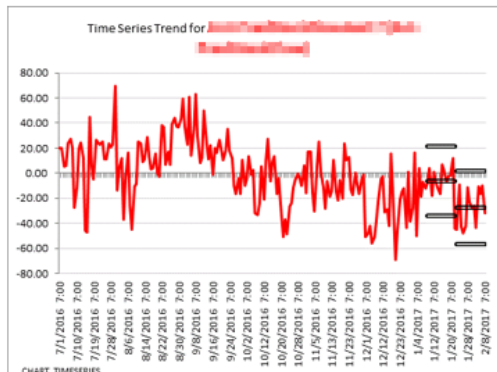
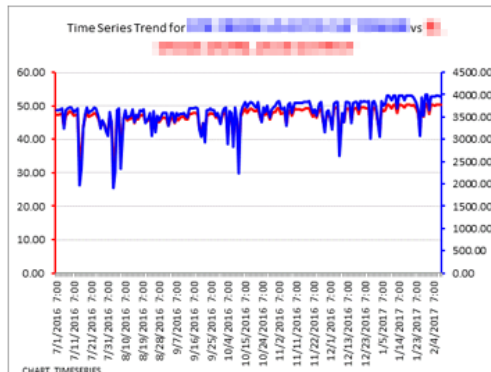
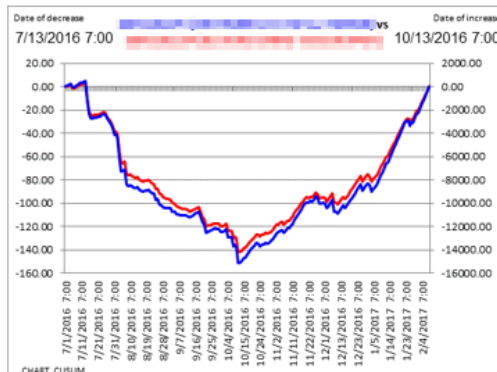
Charts Data Grid Dashboard Board: Board Machine Limits Past 3 Months Summary Product/Grade Product

Remove Add variable to the dashboard Refresh data

Start 12/11/2016 12:19 PM End 2/14/2017 12:19 PM Auto refresh

Add To Charts	Area	Variable	Description	Timestamp	Value	Target	Lower Limit	Upper Limit	<= 100% = IN CONTROL > 100% = OUT OF CONTROL
	Board			2/8/2017 4:44:00 AM	68.61	104.35	96.55	112.15	458.25%
	Board			2/8/2017 4:44:00 AM	68.53	104.91	96.89	112.93	453.65%
	Board			2/8/2017 4:44:00 AM	63.06	29.77	17.95	41.59	281.67%
	Board			2/8/2017 4:44:00 AM	56.49	-3.48	-27.6	20.64	248.62%
	Board			2/7/2017 10:44:00 PM	102.67	50.42	28.78	72.06	241.46%
	Board			2/8/2017 4:44:00 AM	39.21	42.28	40.56	44	178.74%
	Board			2/8/2017 4:44:00 AM	247.33	420.68	319.18	522.18	170.79%

Reliability Models

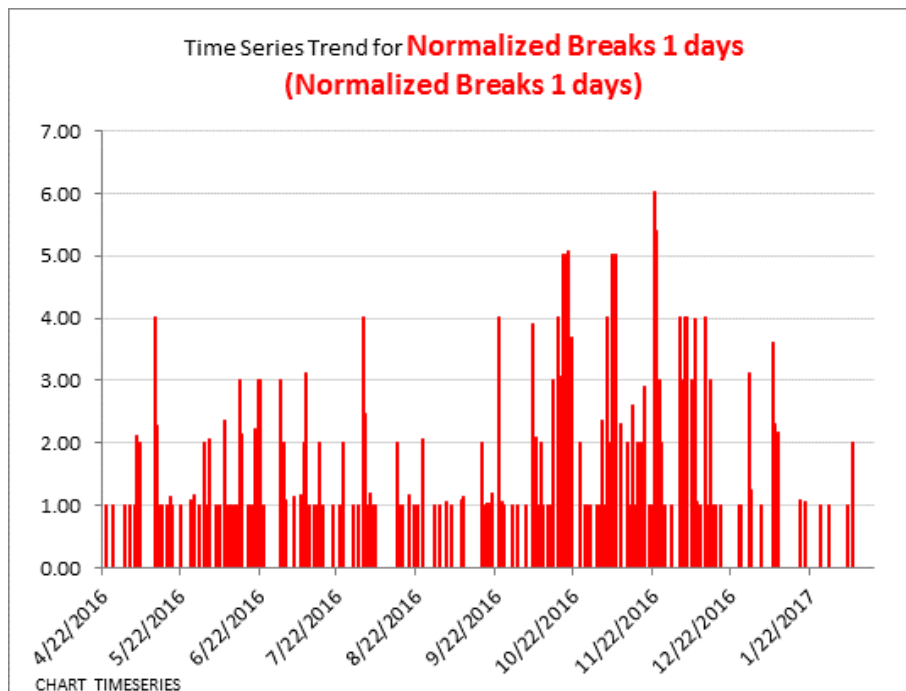
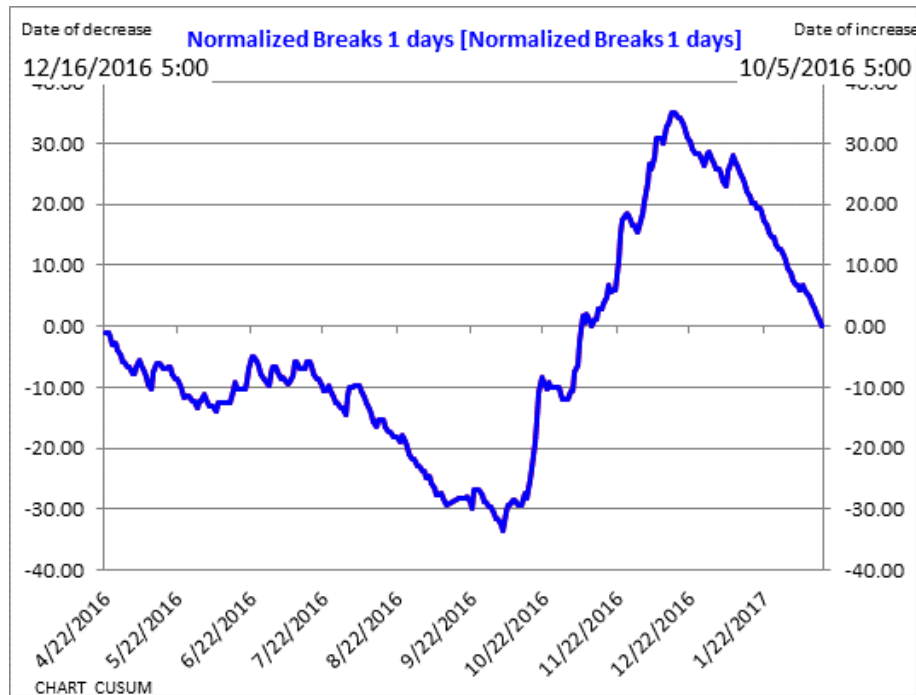


The Envoy Excel add-in allows users to create reliability models. This model indicates that we have a degree of confidence this flowmeter is working correctly (high R-sq). AF templates can be used to quickly replicate these models.

Other examples:

- BFW vs steam flow
- Amps vs speed on a VFD

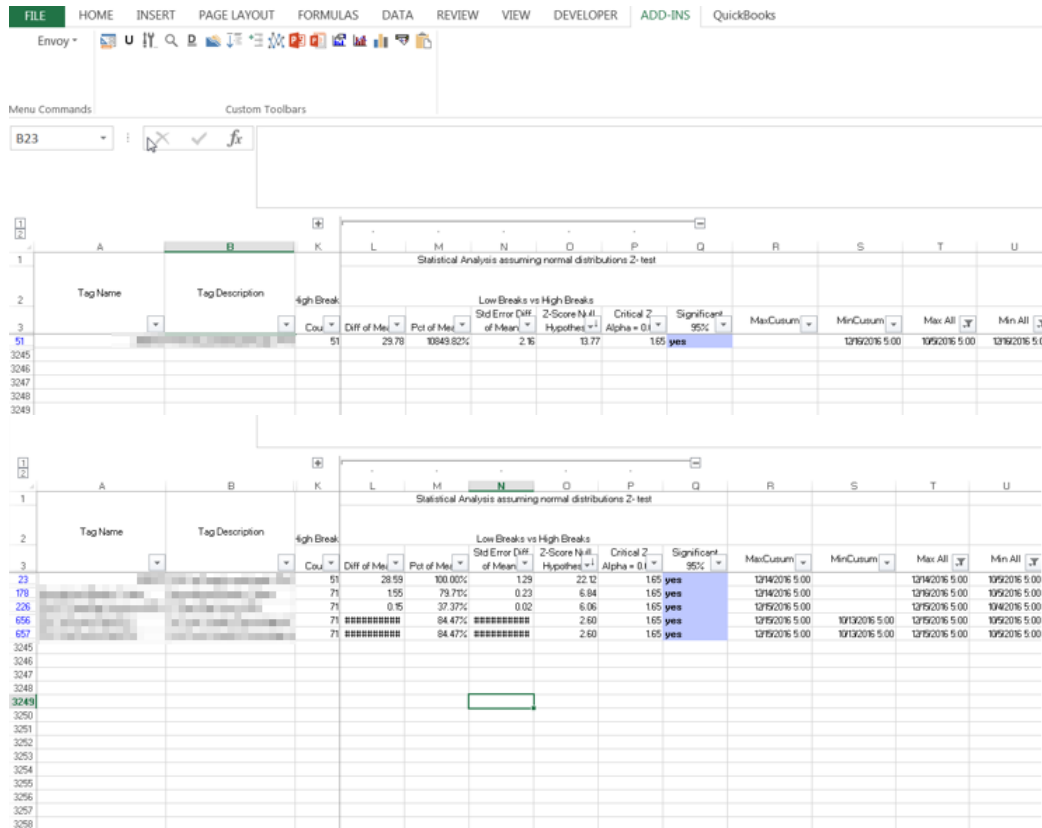
Example: From Oct 5 to Dec 16 breaks were high...what does the PI System tell us?



Tags are ranked by statistical significance in the Envoy Excel Add-in

	A	B	K	L	M	N	O	P	Q	R	S	T	U
1	Statistical Analysis assuming normal distributions Z- test												
2	Tag Name	Tag Description	High Break	Low Breaks vs High Breaks									
3			Count	Diff of Med	Pct of Med	Std Error Diff of Mean	Z-Score Null Hypothesis	Critical Z Alpha = 0.1	Significant 95%	MaxCusum	MinCusum	Max All	Min All
4	10/20/2016	10/20/2016	71	19.92	14.17%	0.38	52.48	1.65	yes		12/14/2016 5:00	7/5/2016 5:00	9/1/2016 5:00
5	10/20/2016	10/20/2016	71	3.88	2.99%	0.08	49.10	1.65	yes				9/1/2016 5:00
6	10/20/2016	10/20/2016	71	37.61	18.88%	0.81	46.66	1.65	yes	12/14/2016 5:00		7/5/2016 5:00	9/1/2016 5:00
7	10/20/2016	10/20/2016	71	1.19	27.08%	0.03	35.77	1.65	yes	12/13/2016 5:00		12/13/2016 5:00	
8	10/20/2016	10/20/2016	71	1.19	27.08%	0.03	35.76	1.65	yes				00
9	10/20/2016	10/20/2016	71	1.19	27.08%	0.03	35.76	1.65	yes				00
10	10/20/2016	10/20/2016	71	0.95	22.93%	0.03	31.23	1.65	yes				00
11	10/20/2016	10/20/2016	71	0.95	22.93%	0.03	31.23	1.65	yes				00
12	10/20/2016	10/20/2016	71	0.92	22.86%	0.03	29.77	1.65	yes				00
13	10/20/2016	10/20/2016	71	0.92	22.85%	0.03	29.75	1.65	yes				00
14	10/20/2016	10/20/2016	71	0.96	23.39%	0.03	28.98	1.65	yes				00
15	10/20/2016	10/20/2016	71	0.98					es				00
16	10/20/2016	10/20/2016	71	2.19					es				1/1/2016 5:00
17	10/20/2016	10/20/2016	71	0.68					es				00
18	10/20/2016	10/20/2016	53	4.62	30.79%	0.19	24.39	1.65	yes				12/2/2016 5:00
19	10/20/2016	10/20/2016	71	1.05	24.61%	0.04	24.30	1.65	yes				00
20	10/20/2016	10/20/2016	71	0.01	24.50%	0.00	24.15	1.65	yes				00
21	10/20/2016	10/20/2016	71	1.05	24.57%	0.04	24.06	1.65	yes				00
22	10/20/2016	10/20/2016	61	1.14	26.47%	0.05	22.81	1.65	yes				00
23	10/20/2016	10/20/2016	51	28.59	100.00%	1.29	22.12	1.65	yes				10/5/2016 5:00
24	10/20/2016	10/20/2016	71	0.17	11.06%	0.01	21.92	1.65	yes				9/3/2016 5:00
25	10/20/2016	10/20/2016	53	1.10	25.98%	0.05	21.55	1.65	yes	12/13/2016 5:00		12/13/2016 5:00	
26	10/20/2016	10/20/2016	71	2404.33	116.78%	119.92	20.05	1.65	yes		12/10/2016 5:00	9/1/2016 5:00	
27	10/20/2016	10/20/2016	53	26.96	188.01%	1.39	19.45	1.65	yes		12/22/2016 5:00	6/30/2016 5:00	12/2/2016 5:00

We then filter by CUSUM inflection point



Tag Name	Tag Description	High Break	Low Breaks vs High Breaks	Std Error Diff	Z-Score	Hypothesis	Critical Z	Alpha	Significant	MaxCusum	MinCusum	Max All	Min All
51		51	29.78	10849.82%	2.16	13.77	1.65	yes		13162016 5.00	10952016 5.00	13162016 5.00	

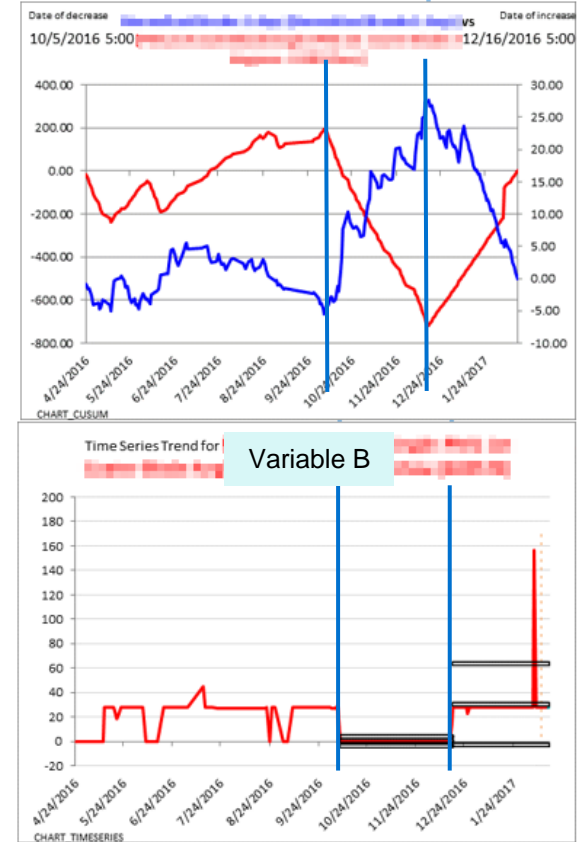
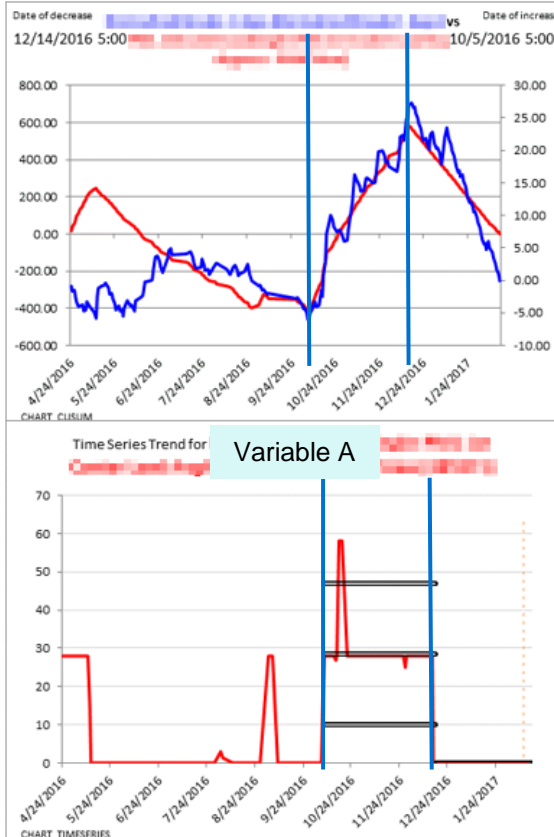
Tag Name	Tag Description	High Break	Low Breaks vs High Breaks	Std Error Diff	Z-Score	Hypothesis	Critical Z	Alpha	Significant	MaxCusum	MinCusum	Max All	Min All
23		51	28.59	100.00%	1.29	22.12	1.65	yes		13142016 5.00		13142016 5.00	10952016 5.00
178		71	1.55	79.71%	0.23	6.84	1.65	yes		13162016 5.00		13162016 5.00	10952016 5.00
226		71	0.15	37.37%	0.02	6.06	1.65	yes		13152016 5.00		13152016 5.00	10942016 5.00
656		71	84.47%	84.47%	2.60	1.65	yes			13152016 5.00	10932016 5.00	13152016 5.00	10952016 5.00
657		71	84.47%	84.47%	2.60	1.65	yes			13152016 5.00	10932016 5.00	13152016 5.00	10952016 5.00

By filtering by CUSUM inflection points, we can reduce the tag list to five tags, one of which is breaks itself. Now only two tags are more significant than breaks themselves: coater variable A and coater variable B

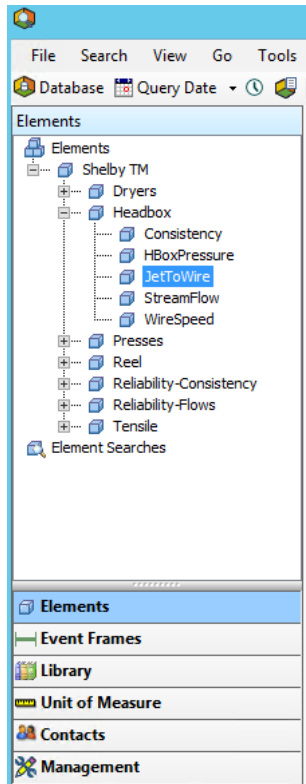
CUSUM date analysis leads to improved centerlines

- Variable A was increased from 0 to 28.6 while Variable B was reduced from 30.1 to 0.27.

Within minutes, we can reduce 3000+ tags down to two.

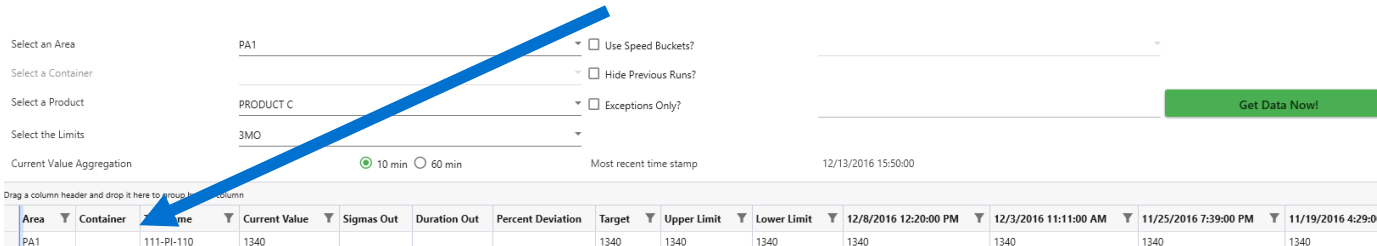


PI AF Allows Users to Link Data into Attributes and Adding Drill Down Capabilities



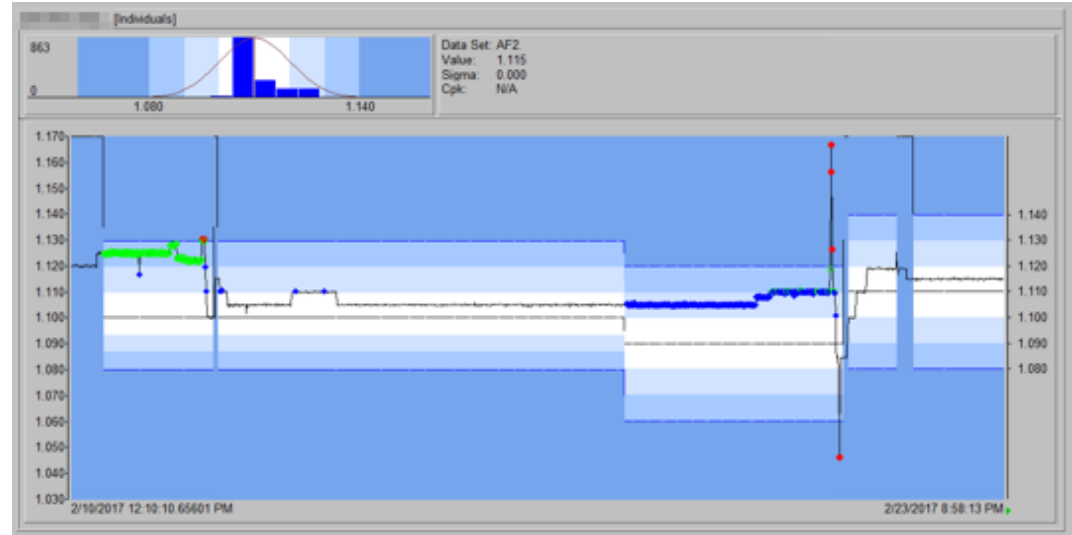
prodarea	ProductCode	VariableID	TimeSpan	Target	UpperLimit	LowerLimit	SpeedGroup
Shelby TM	9701	SBY:1S:FIC-...	6MO	16.38	20.52	12.25	0
Shelby TM	9701	SBY:1S:FIC-...	6MO	15.98	18.35	13.62	1
Shelby TM	9701	SBY:1S:FIC-...	6MO	17.40	22.11	12.69	2
Shelby TM	9701	SBY:1S:FIC-...	6MO	17.23	23.32	11.13	3
Shelby TM	9701	SBY:1S:FIC-...	6MO	15.00	15.01	14.99	4
Shelby TM	9701	SBY:1S:FIC-...	6MO	173.91	222.20	125.62	0
Shelby TM	9701	SBY:1S:FIC-...	6MO	179.33	241.35	117.30	1
Shelby TM	9701	SBY:1S:FIC-...	6MO	166.07	214.50	117.64	2
Shelby TM	9701	SBY:1S:FIC-...	6MO	164.20	191.09	137.31	3
Shelby TM	9701	SBY:1S:FIC-...	6MO	184.96	232.03	137.88	4

This table was imported into AF from dbEnvoy showing targets and limits. The speed group column delineates the speed quartile, with 0 being all data. AF allows tags to be filtered in Envoy Process Monitor by element



Using PI System tools to pull it all together

- With Envoy calculating & storing targets and limits for every PI system tag by grade, we can use PI AF to link dbEnvoy tables to tag attributes
- PI ProcessBook SQC Charts can be used to display alarm conditions based on high and low limits that automatically change with grade
- Targets and limits can also be retrieved using PI DataLink® or displayed in PI Coresight trends
- PI AF is the conduit that brings it all together



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谢谢

Danke

Merci

Gracias

Thank You

ありがとう

Спасибо

Obrigado