



Enabling the Process Engineer with PI AF and Data Analytics -A Journey-

Aubyn Chavez





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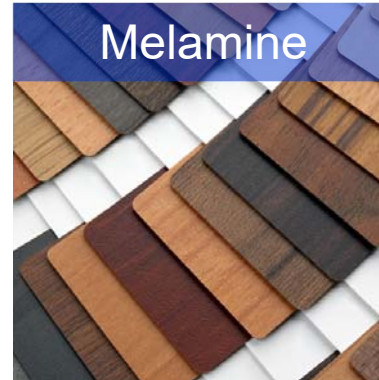
- Digitalization & Process Technology Engineer
- Cornerstone Chemical Co. 
- Aubyn.Chavez@cornerstonechemco.com



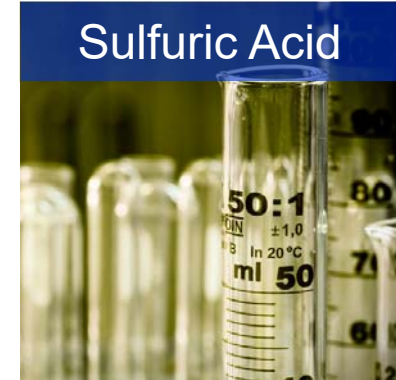
Acrylonitrile



Melamine



Sulfuric Acid



Leading Industry
Position

#2 North America
Producer

Sole North
American Producer

Leading Producer of
Non-Fuming & Regen
Acid in the USGC

End Market

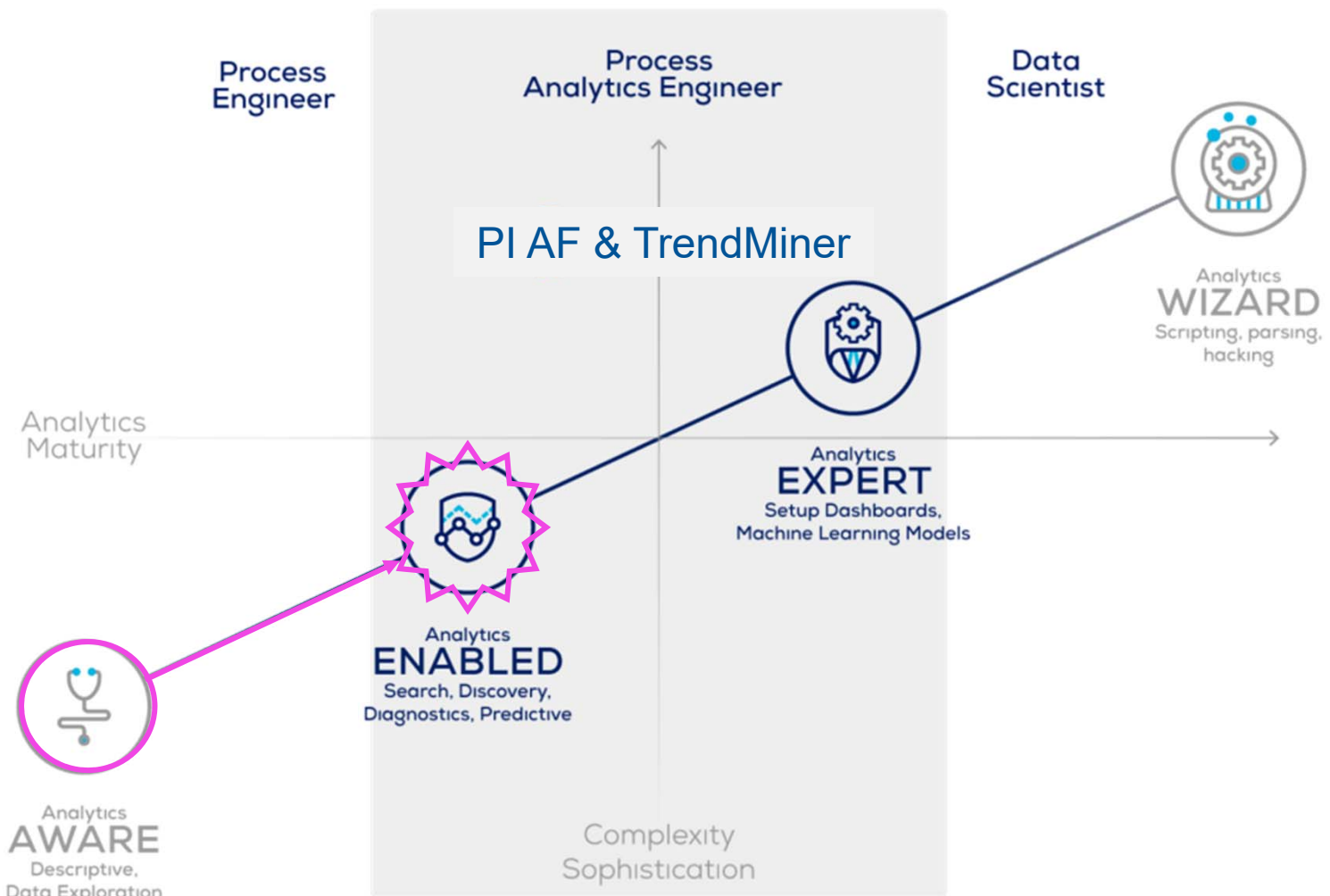
- Consumer Products
- Water Treatment
- Aerospace
- Energy
- Transport

- Building Products
- Consumer Products
- Transport
- Industrial Products

- Consumer Products
- Building Products
- Industrial Products
- Water Treatment
- Transport

Why process engineers?

They are the most intimate
with the chemical process.



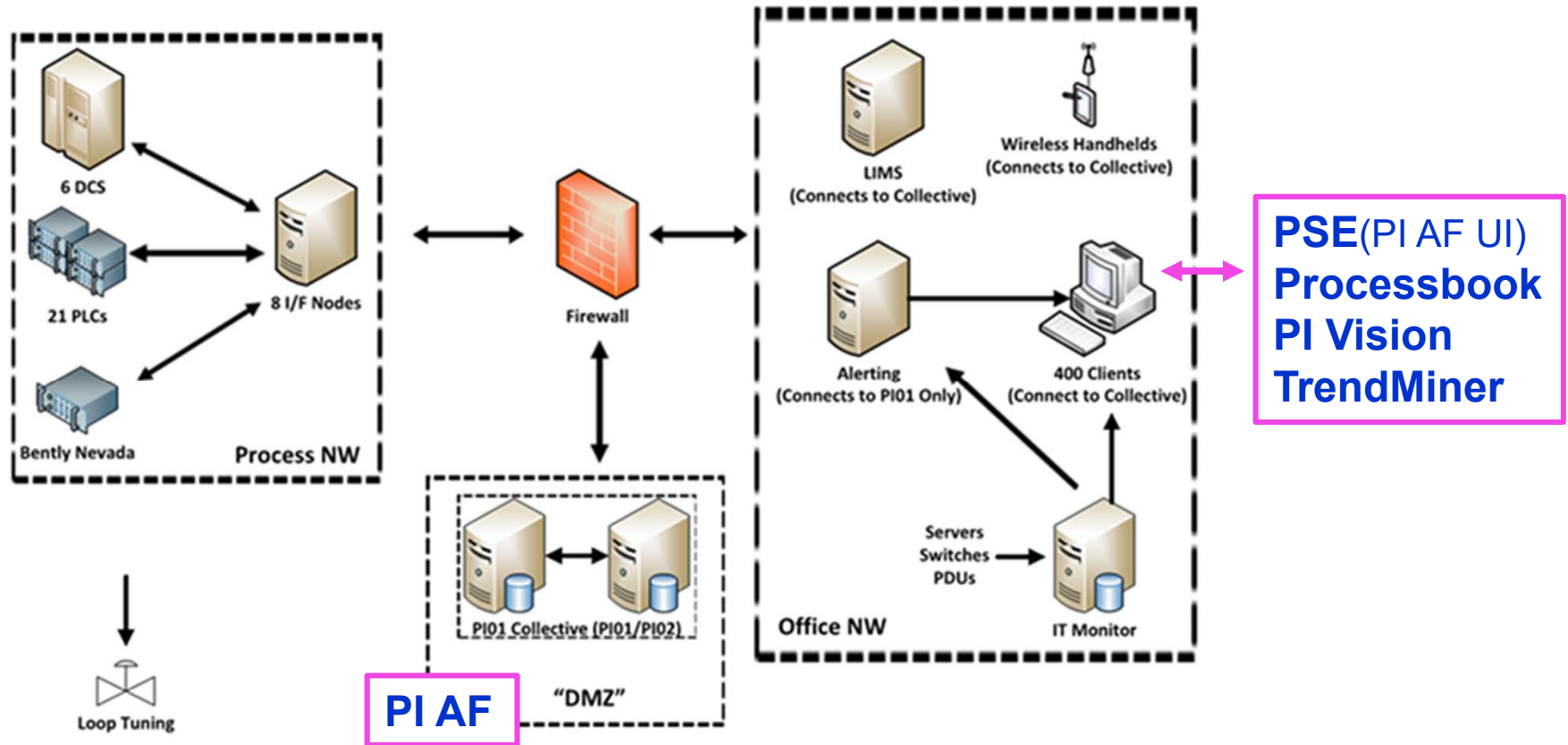
Analytical Tools★

Application · Approach · Obstacles · Synergy

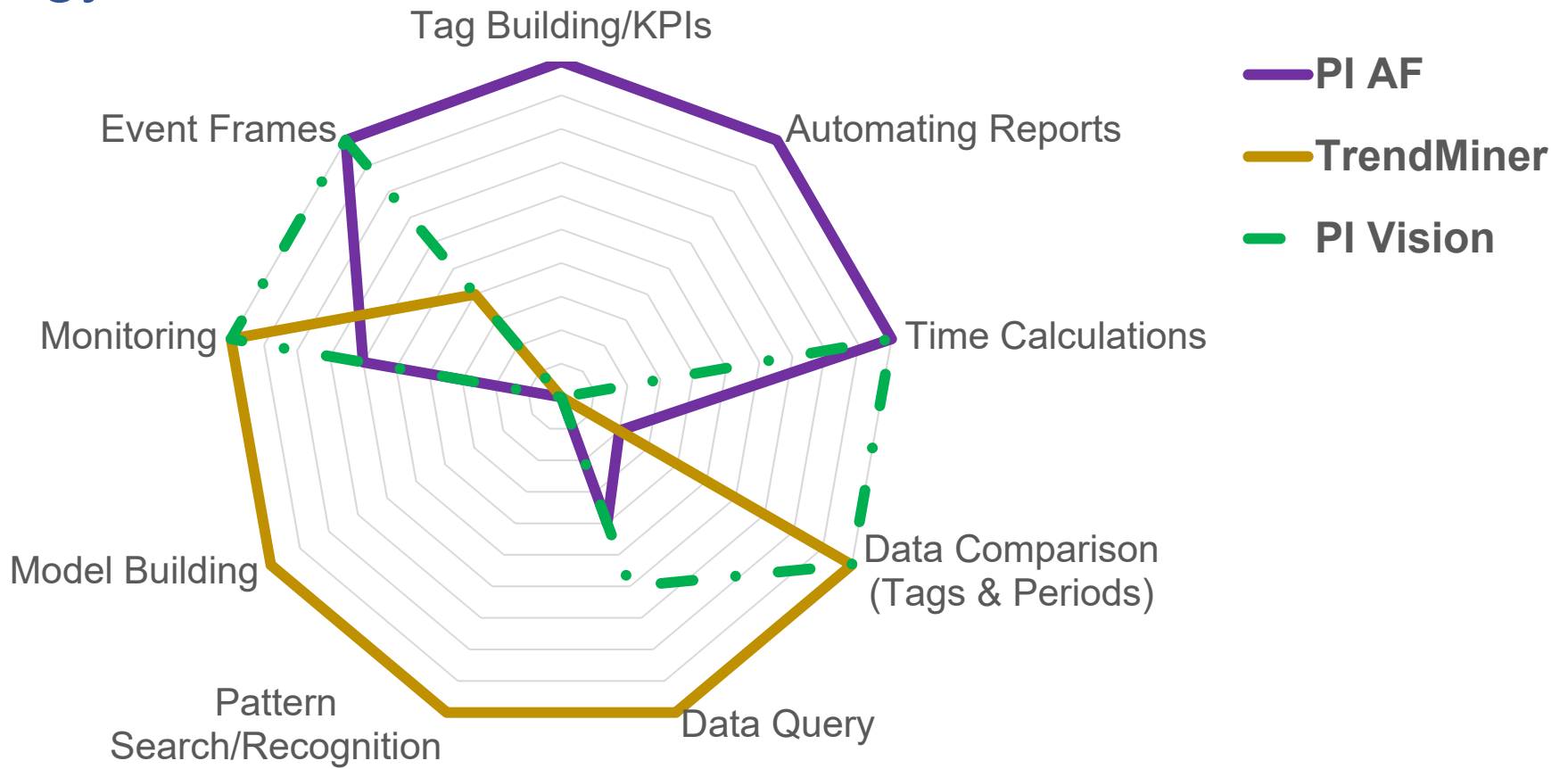
Examples

Report Automation · KPI Automation · Discovery · Diagnostics

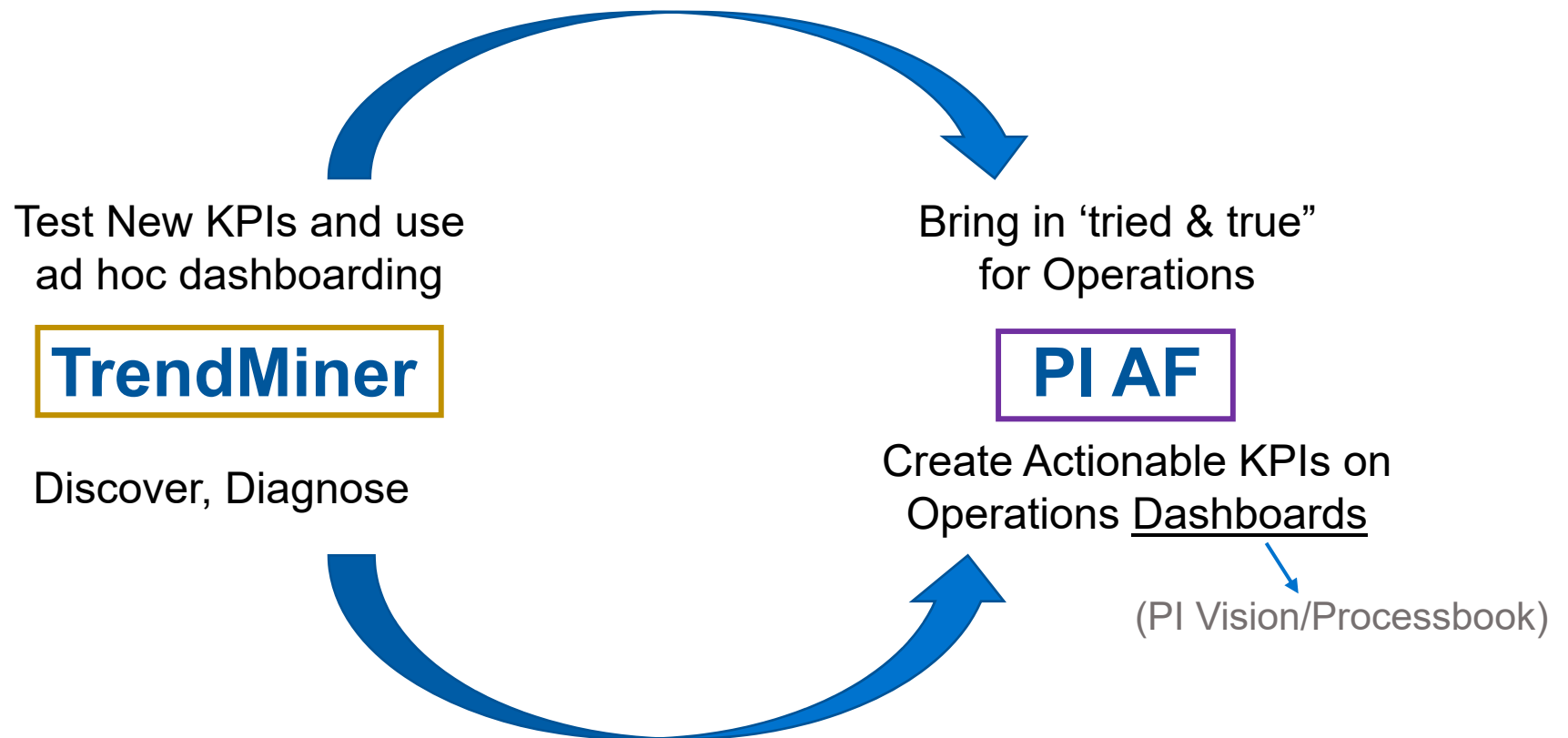
Cornerstone's OT Architecture



Synergy



PI AF & TrendMiner Synergy



DMAIC and how the tools apply:

Define the problem

Measure★ – aligned baseline metric

Analyze – find root cause, influences

Improve – implement solutions, verify improvement with metric

Control – sustaining improvement

PI AF

TrendMiner

PI AF,
PI Vision &
TrendMiner

PI AF,
PI Vision &
TrendMiner

★ 'Measure' Obstacles

The 'right' KPIs

How do we measure performance?

Are all groups aligned on the calculation?

Data Wrangling

Does the data exist?

Is the data reliable?

Avoid:
GarbageIn → GarbageOut



Example

The 'right' KPIs

Raw Material Usage KPIs: NH3 in Melamine Unit

Finance:

$$\left(\frac{UreaTot}{MelTot} \right) * \left(\frac{NH3Tot}{UreaTot} + \frac{NH3Credit}{UreaTot} \right) * \frac{-NH3Credit}{MelTot}$$

Values come from
ERP System (not a PI
Tag)

Engineers:

$$\frac{NH3Tot - NH3Sold - UreaInv}{MelTot}$$

Not aligned

Unreliable Transmitter
for "NH3Sold" variable

Analytical Tools

Application · Approach · Obstacles · Synergy

Examples★

Report Automation · KPI Automation · Discovery · Diagnostics

Manual Reports

[illegible]

Manual Reports

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PI AF – automate excel reporting

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Boiler Feed Water Production			Condensate			Instrument Air		
January 2020			January 2020			January 2020		
STEAM PRODUCTION			EXPORT TO BFW					
9620	Boiler Plant	15880 US kgal	9660	Refrigeration	-1711.24 US kgal	8860	Shipping & Receiving*	2728.84 KCF
590	Acid Plant	8321.18 US kgal	522 M	Melamine	-4594.47 US kgal	9125	Pollution Control*	3129.45 KCF
			522 U	Urea	-4674.12 US kgal	9506	Maintenance*	8589.74 KCF
BOILER FEED WATER			555	AMD	-822.973 US kgal	9620	Steam*	23300.5 KCF
621	AOG	14684.2 US kgal	570 & 572	MMA	-2513.84 US kgal	9633	Coag*	6790.89 KCF
Total Produced			Total Produced			9661	Cooling Tower 2*	957.306 KCF
						9660	Refrigeration*	3461.13 KCF
Distribution of No. 2 CTW			NET TO BFW			522 M	Melamine*	7350 KCF
January 2020						522 U	Urea*	8684.34 KCF
9642	Instrument Air	264400 US kgal	9632	Condensate	14316.6 US kgal	555	AMD*	48448.7 KCF
9660	Refrigeration	969600 US kgal				570	MMA	2922.84 KCF
Total Produced						576	MMA (MAS)*	625.631 KCF
						590	Acid*	34282.2 KCF
						620	Acrylo*	45263.9 KCF
						621	AOG's*	1040.55 KCF
						630	Amino	1292.96 KCF
						Total Produced		
						NH3 Plant Waste Water to EOP		
						January 2020		
						NH3 Plant Waste Water to EOP		
						28680 US kgal		

Automate desired values and visualize in excel or a dashboard.

File Search View Go Tools Help

Database Query Date Back Check In Refresh New Element New Attribute Search Elements

Elements

CTBF

General Child Elements Attributes Ports Analyses Notification Rules Version

Filter

Name	Value	Time Stamp	Unit Of Measure
Category: BFW			
Acid Steam	75.437 kbs/hr	3/5/2020 1:58:25 PM	kilopounds per hour
Acid Steam Corr	75.437 kbs/hr	3/5/2020 1:58:25 PM	kilopounds per hour
AOG A Steam	26.828 kbs/hr	3/5/2020 1:59:46.024 PM	kilopounds per hour
AOG A Steam Corr	26.828 kbs/hr	3/5/2020 1:59:41.016 PM	kilopounds per hour
AOG B Steam	27.983 kbs/hr	3/5/2020 1:59:47.022 PM	kilopounds per hour
AOG B Steam Corr	28.021 kbs/hr	3/5/2020 1:59:42.014 PM	kilopounds per hour
AOG C Steam	106.78 kbs/hr	3/5/2020 1:59:46.024 PM	kilopounds per hour
AOG C Steam Corr	107.08 kbs/hr	3/5/2020 1:59:41.016 PM	kilopounds per hour
lbs/gal conv	8.33	1/1/1970 12:00:00 AM	<None>
UT Boiler 1	82.805 kbs/hr	3/5/2020 1:57:34.012 PM	kilopounds per hour
UT Boiler 1 Corr	82.805 kbs/hr	3/5/2020 1:57:39.009 PM	kilopounds per hour
UT Boiler 4	76.65 kbs/hr	3/5/2020 1:57:39.009 PM	kilopounds per hour
UT Boiler 4 Corr	76.65 kbs/hr	3/5/2020 1:57:39.009 PM	kilopounds per hour
Category: CTW			
Instrument Air	2.644E+05 US kgal	1/1/1970 12:00:00 AM	thousand US gallon
Refrigeration	9.696E+05 US kgal	1/1/1970 12:00:00 AM	thousand US gallon
Total CTW Monthly	1.234E+06 US kgal	1/1/1970 12:00:00 AM	thousand US gallon
Category: MonthEnd			
Acid Total NowMonth	1232.3 US kgal	3/5/2020 1:59:49.919 PM	thousand US gallon
Acid Total PrevMonth	8285.2 US kgal	3/5/2020 1:59:50.053 PM	thousand US gallon
AOG Total NowMonth	2092 US kgal	3/5/2020 1:59:50.719 PM	thousand US gallon
AOG Total PrevMonth	12951 US kgal	3/5/2020 1:59:50.468 PM	thousand US gallon
Total NowMonth	5444.3 US kgal	3/5/2020 1:59:50.743 PM	thousand US gallon
Total PrevMonth	32798 US kgal	3/5/2020 1:59:50.934 PM	thousand US gallon
UT BLR Total NowMo...	2120 US kgal	3/5/2020 1:59:50.743 PM	thousand US gallon
UT BLR Total PrevMo...	11562 US kgal	3/5/2020 1:59:50.934 PM	thousand US gallon
Category: NowMonth			
Acid Steam Totalizer	1232.3 US kgal	3/5/2020 1:58:25 PM	thousand US gallon
AOG A Steam Totalizer	358.79 US kgal	3/5/2020 1:59:41.016 PM	thousand US gallon
AOG B Steam Totalizer	350.54 US kgal	3/5/2020 1:59:42.014 PM	thousand US gallon
AOG C Steam Totalizer	1382.6 US kgal	3/5/2020 1:59:41.016 PM	thousand US gallon
UT Boiler 1 Totalizer	799.96 US kgal	3/5/2020 1:57:39.009 PM	thousand US gallon
UT Boiler 4 Totalizer	1320 US kgal	3/5/2020 1:57:39.009 PM	thousand US gallon

Group by: ☒ Category ☐ Template

Name: Acid Total PrevMonth

Description:

Properties: <None>

Categories: MonthEnd

Default UOM: thousand US gallon

Value Type: Double

Value: 8285.2 US kgal

Data Reference: Analysis

Display Digits: -5

Settings...

UT(Usages)CTBF[Acid Total PrevMonth] is mapped as an output for: Acid Totalizer

Limits Forecasts

Elements

AFF Test Element

AN

ML

OEE

OSIsoft Test Element

SF

UT

Boilers

CO2 Compressor Skid

Refrigeration

Usages

Condensate

CTBF

EOP NH3 Waste H2O

Inst Air

Natural Gas

Nitrogen

Refrigeration

Steam

Element Searches

How did we get from messy spreadsheet to simple & automated dashboard?

Elements

Elements

AFF Test Element

AN

ML

OEE

OSIsoft Test Element

SF

UT

Boilers

CO2 Compressor Skid

Refrigeration

Usages

Condensate

CTBF

EOP NH3 Waste H2O

Inst Air

Natural Gas

Nitrogen

Refrigeration

Steam

Element Searches

File Search View Go Tools Help
Database Query Date Back Check In Refresh New Element New Attribute

Elements
Elements
AFF Test Element
AN
ML
OEE
OSIsoft Test Element
SF
UT
Boilers
CO2 Compressor Sk
Refrigeration
Usages
Condensate
CTBF
EOP NH3 Wast
Inst Air
Natural Gas
Nitrogen
Refrigeration
Steam
Element Searches

CTBF
General Child Elements Attributes Ports Analyses Notification Rules Version
Filter

Name	Value	Time Stamp	Unit Of Measure
Category: BFW			
Add Steam	75.437 klbs/hr	3/5/2020 1:58:25 PM	kilopounds per hour
Acid Steam Corr	75.437 klbs/hr	3/5/2020 1:58:25 PM	kilopounds per hour
AOG A Steam	26.828 klbs/hr	3/5/2020 1:59:46.024 PM	kilopounds per hour
AOG A Steam Corr	26.828 klbs/hr	3/5/2020 1:59:41.016 PM	kilopounds per hour
AOG B Steam	27.983 klbs/hr	3/5/2020 1:59:47.022 PM	kilopounds per hour
AOG B Steam Corr	28.021 klbs/hr	3/5/2020 1:59:42.014 PM	kilopounds per hour
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AOG C Steam Corr	107.08 klbs/hr	3/5/2020 1:59:41.016 PM	kilopounds per hour
lbs/gal conv	8.33	1/1/1970 12:00:00 AM	<None>
UT Boiler 1	82.805 klbs/hr	3/5/2020 1:57:34.012 PM	kilopounds per hour
UT Boiler 1 Corr	82.805 klbs/hr	3/5/2020 1:57:39.009 PM	kilopounds per hour
UT Boiler 4	76.65 klbs/hr	3/5/2020 1:57:39.009 PM	kilopounds per hour
UT Boiler 4 Corr	76.65 klbs/hr	3/5/2020 1:57:39.009 PM	kilopounds per hour
Category: CTW			
Instrument Air	2.644E+05 US kgal	1/1/1970 12:00:00 AM	thousand US gallon
Refrigeration	9.696E+05 US kgal	1/1/1970 12:00:00 AM	thousand US gallon
Total CTW Monthly	1.234E+06 US kgal	1/1/1970 12:00:00 AM	thousand US gallon
Category: MonthEnd			
Add Total NowMonth	1232.3 US kgal	3/5/2020 1:59:49.919 PM	thousand US gallon
Add Total PrevMonth	8285.2 US kgal	3/5/2020 1:59:50.053 PM	thousand US gallon
AOG Total NowMonth	2092 US kgal	3/5/2020 1:59:50.19 PM	thousand US gallon
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Total NowMonth	5444.3 US kgal	3/5/2020 1:59:50.743 PM	thousand US gallon
Total PrevMonth	32798 US kgal	3/5/2020 1:59:50.934 PM	thousand US gallon
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Category: NowMonth			
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AOG A Steam Totalizer	358.79 US kgal	3/5/2020 1:59:41.016 PM	thousand US gallon
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UT Boiler 4 Totalizer	1320 US kgal	3/5/2020 1:57:39.009 PM	thousand US gallon

Name:
Description:
Properties:
Categories:
Default UOM:
Value Type:
Value:
Data Reference:
Display Digits:
UT\Usages\CTB as an output for

CTBF
General Child Elements Attributes Ports Analyses Notification Rules Version
Filter

Name	Value	Time Stamp	Unit Of Measure
Category: BFW			
Add Steam	75.437 klbs/hr	3/5/2020 1:58:25 PM	kilopounds per hour
Acid Steam Corr	75.437 klbs/hr	3/5/2020 1:58:25 PM	kilopounds per hour
AOG A Steam	26.828 klbs/hr	3/5/2020 1:59:46.024 PM	kilopounds per hour
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AOG C Steam	106.78 klbs/hr	3/5/2020 1:59:46.024 PM	kilopounds per hour
AOG C Steam Corr	107.08 klbs/hr	3/5/2020 1:59:41.016 PM	kilopounds per hour
lbs/gal conv	8.33	1/1/1970 12:00:00 AM	<None>
UT Boiler 1	82.805 klbs/hr	3/5/2020 1:57:34.012 PM	kilopounds per hour
UT Boiler 1 Corr	82.805 klbs/hr	3/5/2020 1:57:39.009 PM	kilopounds per hour
UT Boiler 4	76.65 klbs/hr	3/5/2020 1:57:39.009 PM	kilopounds per hour
UT Boiler 4 Corr	76.65 klbs/hr	3/5/2020 1:57:39.009 PM	kilopounds per hour

CTBF

General Child Elements Attributes Ports **Analyses** Notification Rules Version

Name	Backfilling
AOG A Corrected	✓
AOG A Totalizer	✓
AOG B Corrected	✓
AOG B Totalizer	✓
AOG C Corrected	✓
AOG C Totalizer	✓
AOG Totals	!
UT BLR Totals	!
UT Boilers Corr...	!
UT Boilers Total...	✓

Name: AOG B Totalizer

Description:

Categories:

Analysis Type: ☒ Expression ☐ Rollup ☐ Event Frame Generation ☐ SQC

Add a new variable

Name	Expression	Output Attribute
Variable1	(TagTot('AOG B Steam Corr', bom('*'), '*')*24)/'lbs/gal conv' //AOG B Steam Total KGals + 10% correction	AOG B Steam Totalizer
Variable2	PrevVal('AOG B Steam Totalizer', bom('*'))	Map
Variable3	TagVal('AOG B Steam Totalizer', '*')	Map

Evaluate

Functions

Insert functions into the expression [Reload](#)

All

- TagNum
- TagSource
- TagSpan
- TagTot
- TagType
- TagTypVal
- TagVal

1 of 4

TagTot(attribute attname, time startTime, time endTime)

Find the totalized value (time integral) of an attribute's values over a specified time range

Attributes

Scheduling: ☒ Event-Triggered ☐ Periodic

Trigger on: Any Input

Advanced...

Connected to the PI Analysis Service.

The screenshot shows the PI DataLink Excel application window titled "UT Current Monthend - Excel". The ribbon includes tabs for File, Home, Insert, Page Layout, Formulas, Data, Review, View, Developer, Aspen Properties, Aspen Simulation Workbook, Nitro Pro, PI DataLink, PI Builder, Power Pivot, Tell m, Chave..., and Share. The "Data" tab is active, showing options like Current Archive Value, Compressed Sampled Data, Timed Data, Calculated Data, Time Filtered, Explore Compare, Search Asset Filter, Properties, Update, Settings, and Feedback. A blue arrow points to the "Current Archive Value" button.

The formula bar displays the formula: `{=PICurrVal("\\FOSVMP\PIAF01\Test Database\UT\Usages\CTBF\UT BLR Total PrevMonth",0,"")}`. The active cell is F4.

The spreadsheet data is as follows:

	A	B	C	D	E	F	G	H
1								
2	Boiler Feed Water Production					February 2020		
3	STEAM PRODUCTION							
4		9620	Boiler Plant			11,561.8		
5								
6		590	Acid Plant			8,285.2	kgals	
7								
8	BOILER FEED WATER							
9		621	AOG			12,951.1	kgals	
10								
11			Total Produced			32,798.0	kgals	
12								
13	Distribution of No. 2 CTW							
14		9642	Instrument Air			264,400	kgals	
15								
16		9660	Refrigeration			969,600	kgals	
17								
18			Total Produced			1,234,000	kgals	

The "Current Value" dialog box is open on the right. It shows the "Data item(s)" field with the path `\\FOSVMP\PIAF01\Test Database\UT\Usages\CTBF\UT BLR Total PrevMonth`. The "Output cell" is set to `'CTBF'!F4`. The "No time stamp" option is selected. The "OK" and "Apply" buttons are at the bottom.

Real-Time KPIs

- Raw Material Usage is a common KPI used in the industry to help drive optimization and lower costs.
- Our Melamine unit had a difficult year with Ammonia (NH₃) usage and so it was requested that we automate an [NH₃ consumed/Melamine produced] calculation to create more visibility and enable us to be more agile.

$$= \frac{NH_3 \text{ Consumed [lbs]}}{Melamine \text{ Produced [lbs]}}$$

Recall the example from earlier:

The 'right' KPIs

Data Wrangling

Raw Material Usage KPIs: NH3 in Melamine Unit

Finance:

$$\left(\frac{UreaTot}{MelTot} \right) * \left(\frac{NH3Tot}{UreaTot} + \frac{NH3Credit}{UreaTot} \right) * \frac{-NH3Credit}{MelTot}$$

Values come from ERP System (not a PI Tag)

Engineers:

$$\frac{NH3Tot - NH3Sold - UreaInv}{MelTot}$$

Not aligned

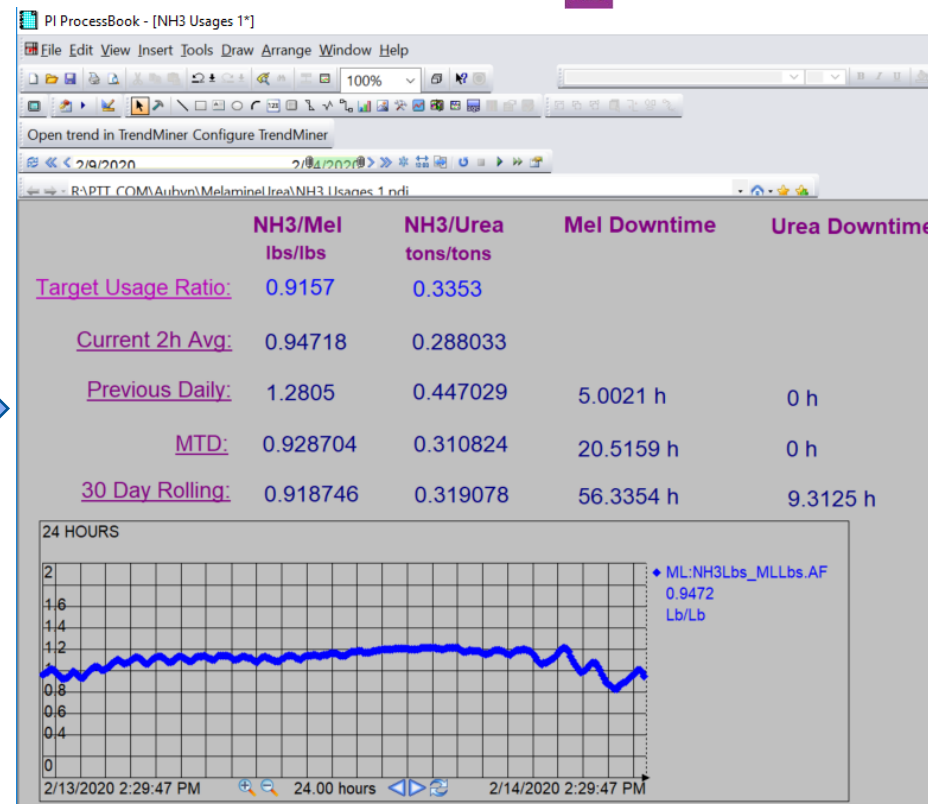
Unreliable Transmitter for "NH3Sold" variable

PI AF – Real-time KPIs

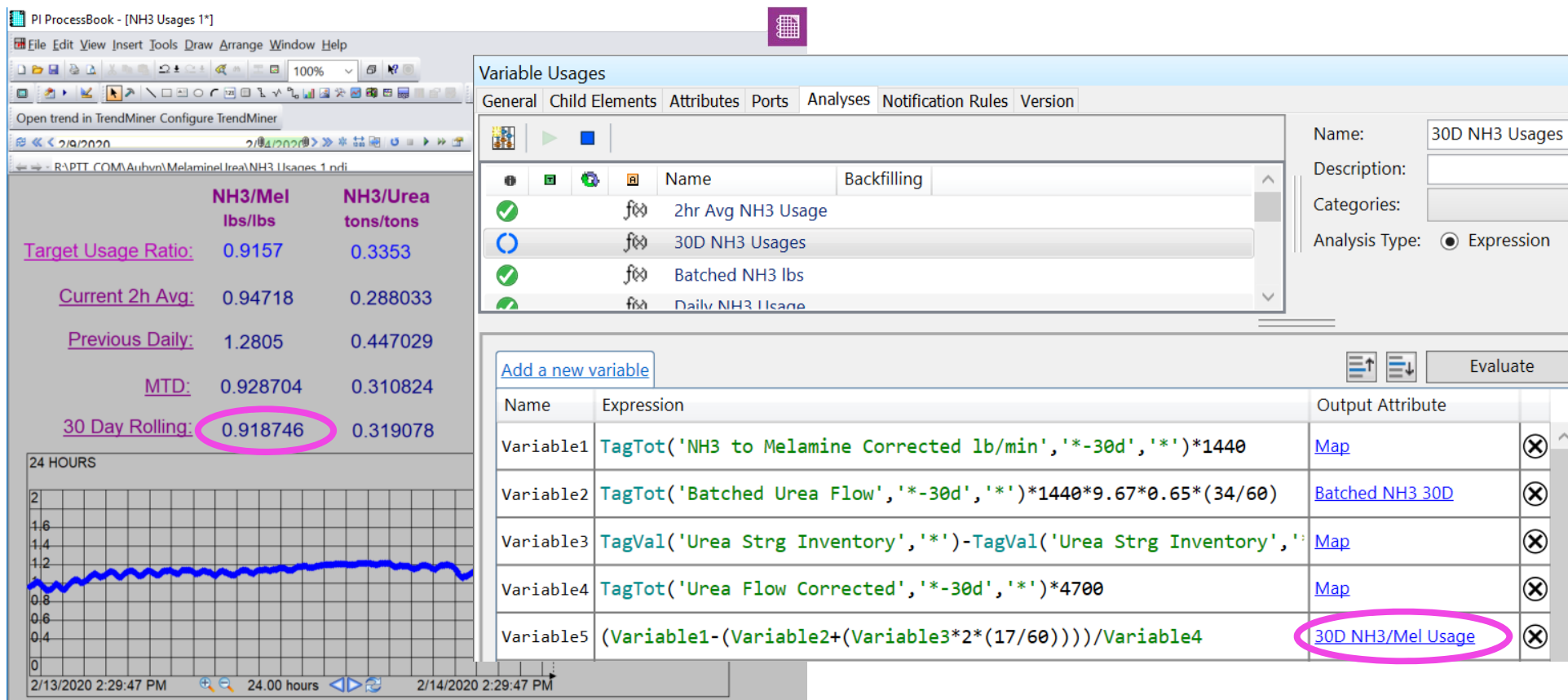
PI DataLink

Urea to Melamine									
Urea to Loading									
Urea Storage Tank									
	ML-FC2153.PV	lb real	ML-FQ1393.PV	lb real		ML-W11371.PV	Total: (lb real)		
1/1/2020	148150	150062138	274,336	178,319		47662.0	15610.6		
1/2/2020	130044	131722766	275,790	179,263		63272.7	5520.5		
1/3/2020	147655	149561603	465,943	302,863		68793.3	-36035.5		
1/4/2020	148239	150152318	398,876	259,269		32757.3	8962.2		
1/5/2020	139130	140926067	418,461	272,000		41719.6	11272.5		
1/6/2020	148302	150216599	296,702	192,856		52992.5	-8329.2		
1/7/2020	148307	150221795	402,862	261,860		44663.4	14438.5		
1/8/2020	82633	83699953	94,339	61,320		59102.3	-10151.5		
1/9/2020	112907	114364862	322,733	209,777		160618.8	-54942.2		
1/10/2020	148301	150215767	466,495	303,222		105676.0	-37797.5		
1/11/2020	46789	47392931	100,591	65,384		67878.0	124361.2		
1/12/2020	-60	-60332	0	0		192239.3	-30675.2		
1/13/2020	110854	112284860	81,921	53,249		166565.4	-63324.4		
1/14/2020	46322	46919602	33,251	21,613		57231.8	8127.7		
1/15/2020	126317	127947379	397,890	258,629		65359.0	-23279.5		
1/16/2020	94866	96091131	160,396	104,257		42079.8	-10148.8		
1/17/2020	85022	86119438	0	0		31931.2	36289.1		
1/18/2020	142398	144236144	475,492	309,069		68231.0	-361.4		
1/19/2020	137888	139668617	490,741	318,981		67859.6	9948.8		
1/20/2020	138066	139848424	488,743	317,683		57910.9	-5197.2		
1/21/2020	149657	151589497	405,600	263,640		52713.4	10048.1		
1/22/2020	149659	151591258	300,117	195,076		62761.4	142764.2		
1/23/2020	139860	141665843	0	0		205525.8	-121531.1		
1/24/2020	146313	148202044	390,927	254,102		83994.6	-33274.4		
1/25/2020	148989	150912772	364,110	236,671		50720.1	197287.0		
1/26/2020	138880	140673277	382,725	248,771		248007.2	-157035.5		
1/27/2020	146481	148371943	308,450	200,493		90971.8	-49306.5		
1/28/2020	50343	50891361	71	46		41665.7	15610.6		
1/29/2020	145925	147809085	194,746	126,585		No Data	#VALUE!		
1/30/2020	144959	146829998	213,983	139,089		No Data	#VALUE!		
1/31/2020	149653	151585082	4,146	2,695		No Data	#VALUE!		
2/1/2020	139835	141640166	643,022	417,964		No Data	#VALUE!		
2/2/2020	148024	149934821	82,890	53,878		No Data	#VALUE!		
2/3/2020	144051	145910445	No Data	#VALUE!		No Data	#VALUE!		
2/4/2020	[-11059] No Good Dc	#VALUE!	No Data	#VALUE!		No Data	#VALUE!		
2/5/2020	[-11059] No Good Dc	#VALUE!	No Data	#VALUE!		No Data	#VALUE!		
2/6/2020	[-11059] No Good Dc	#VALUE!	No Data	#VALUE!		No Data	#VALUE!		
2/7/2020	[-11059] No Good Dc	#VALUE!	No Data	#VALUE!		No Data	#VALUE!		
2/8/2020	[-11059] No Good Dc	#VALUE!	No Data	#VALUE!		No Data	#VALUE!		
2/9/2020	[-11059] No Good Dc	#VALUE!	No Data	#VALUE!		No Data	#VALUE!		
2/10/2020	[-11059] No Good Dc	#VALUE!	No Data	#VALUE!		No Data	#VALUE!		

PI ProcessBook



PI AF – Real-time KPIs



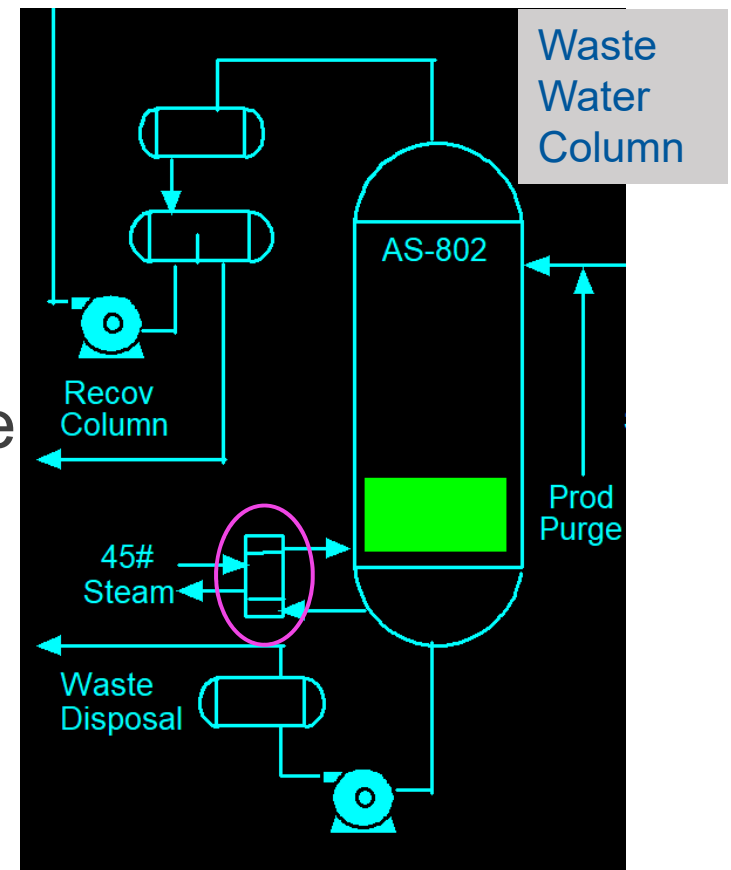
Discovery/Diagnostics - TrendMiner

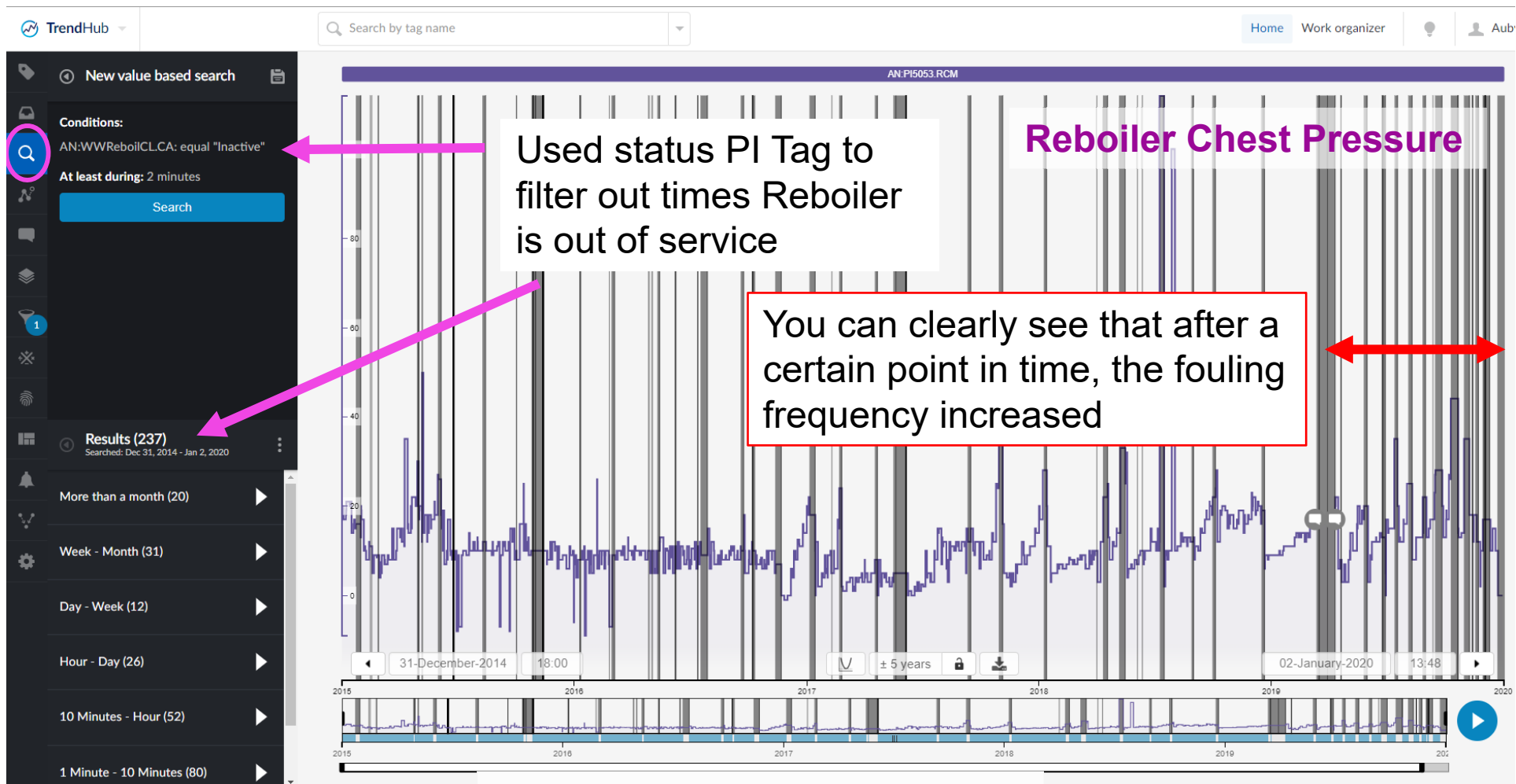
Unit: Acrylonitrile

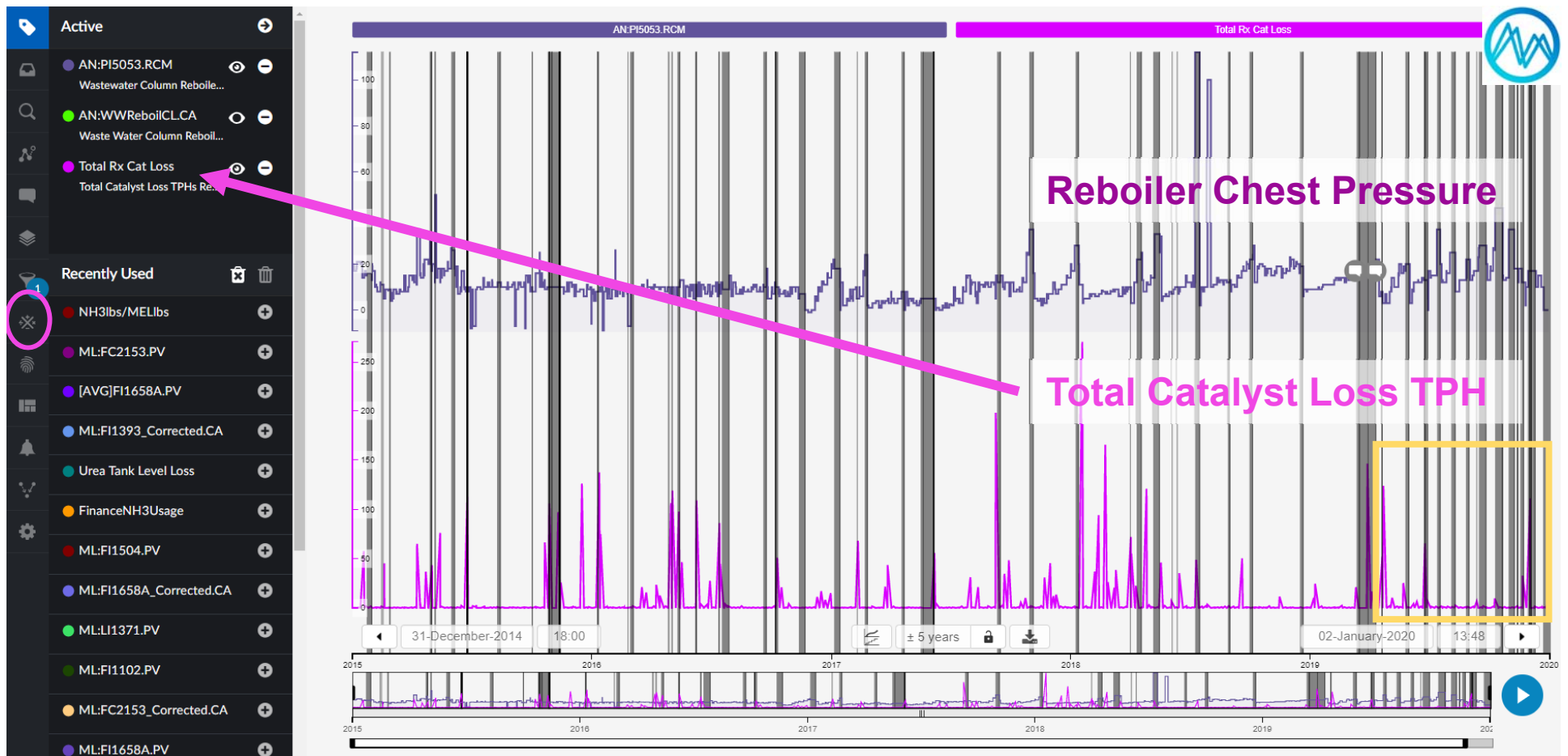
Equip: Reboiler on Waste Water Column

Problem: Reboiler is fouling more frequently as of late, causing it to have to be taken out of service for cleaning more often. This is very costly.

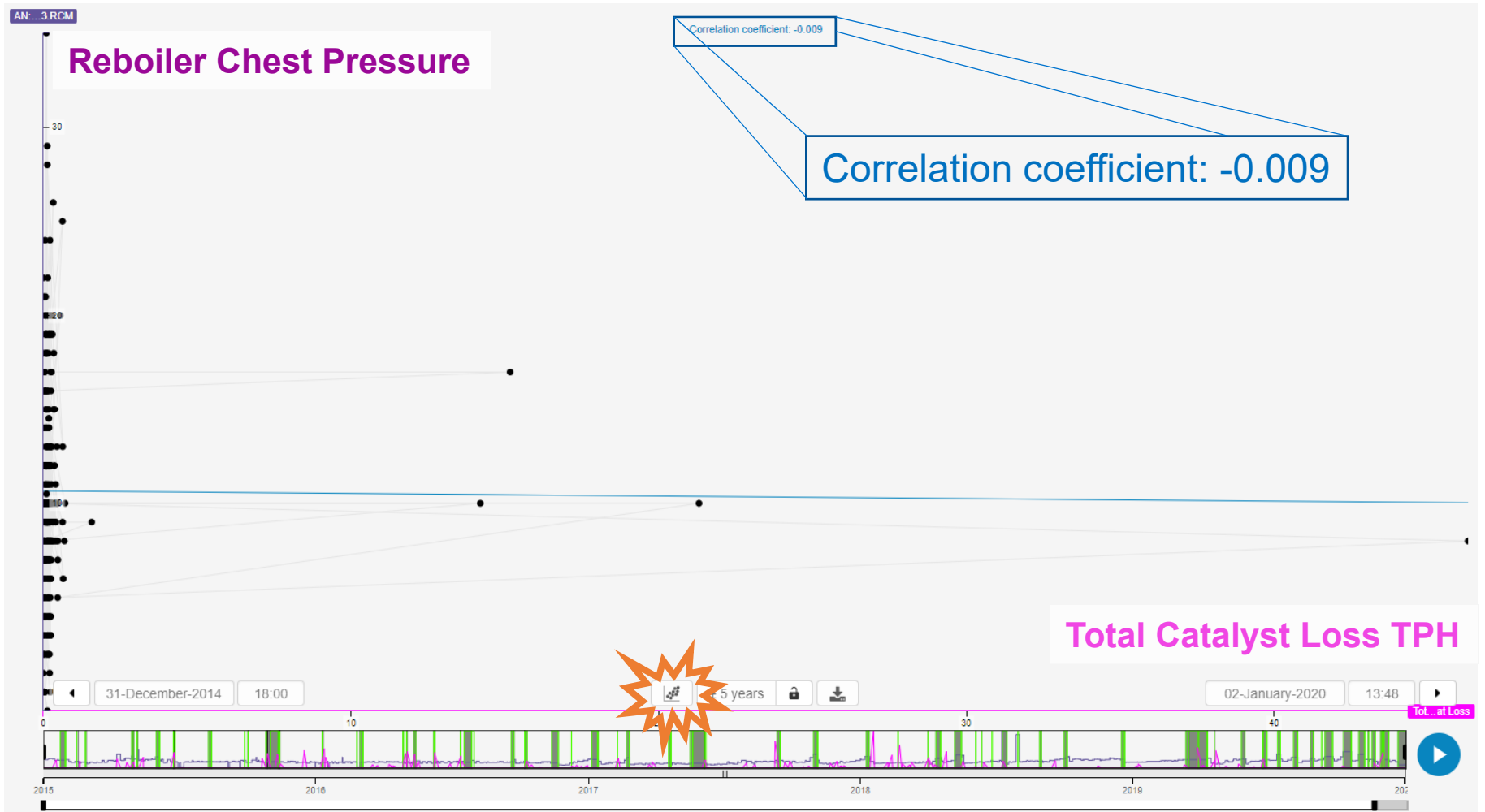
Hypothesis: Catalyst carry over from reactors is causing the fouling.

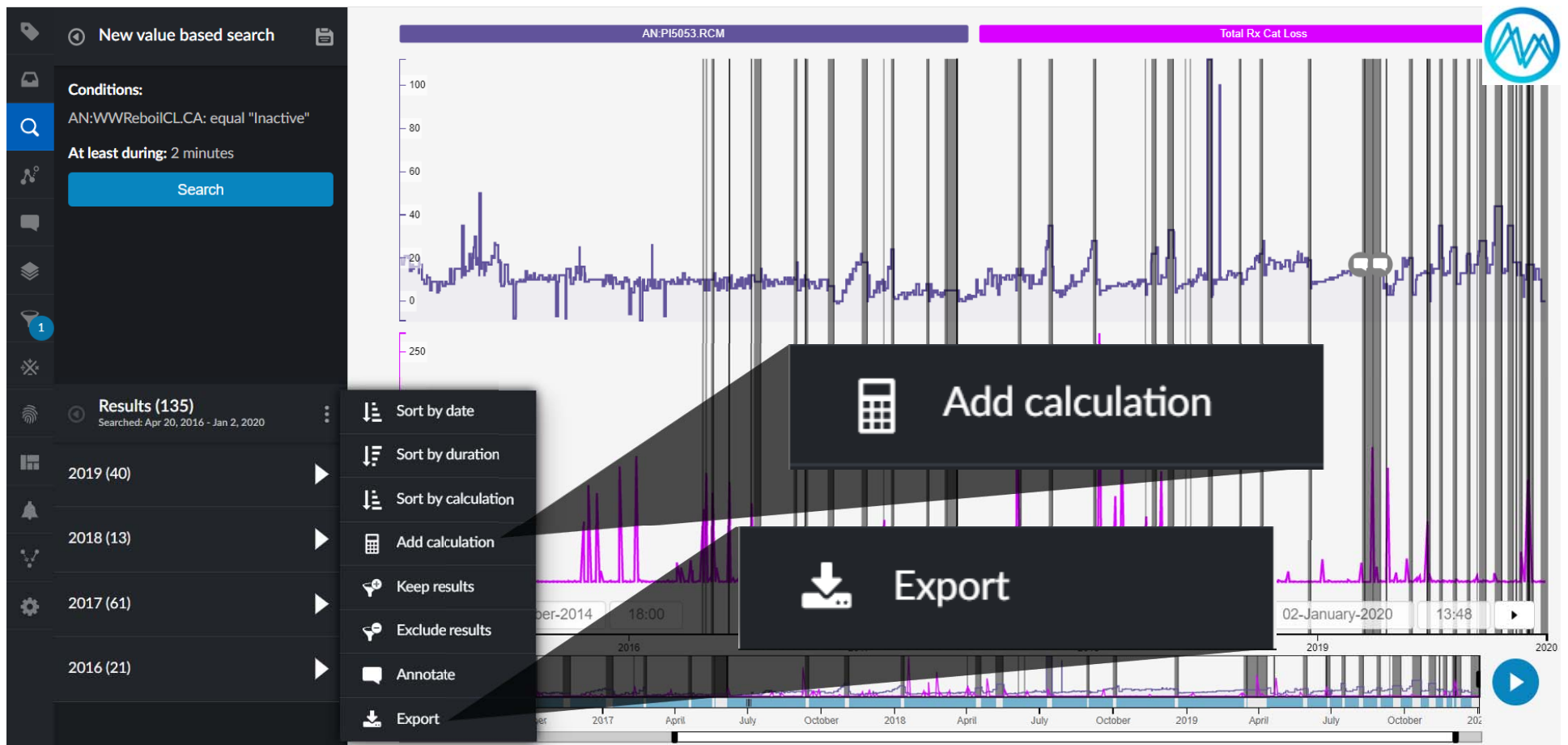


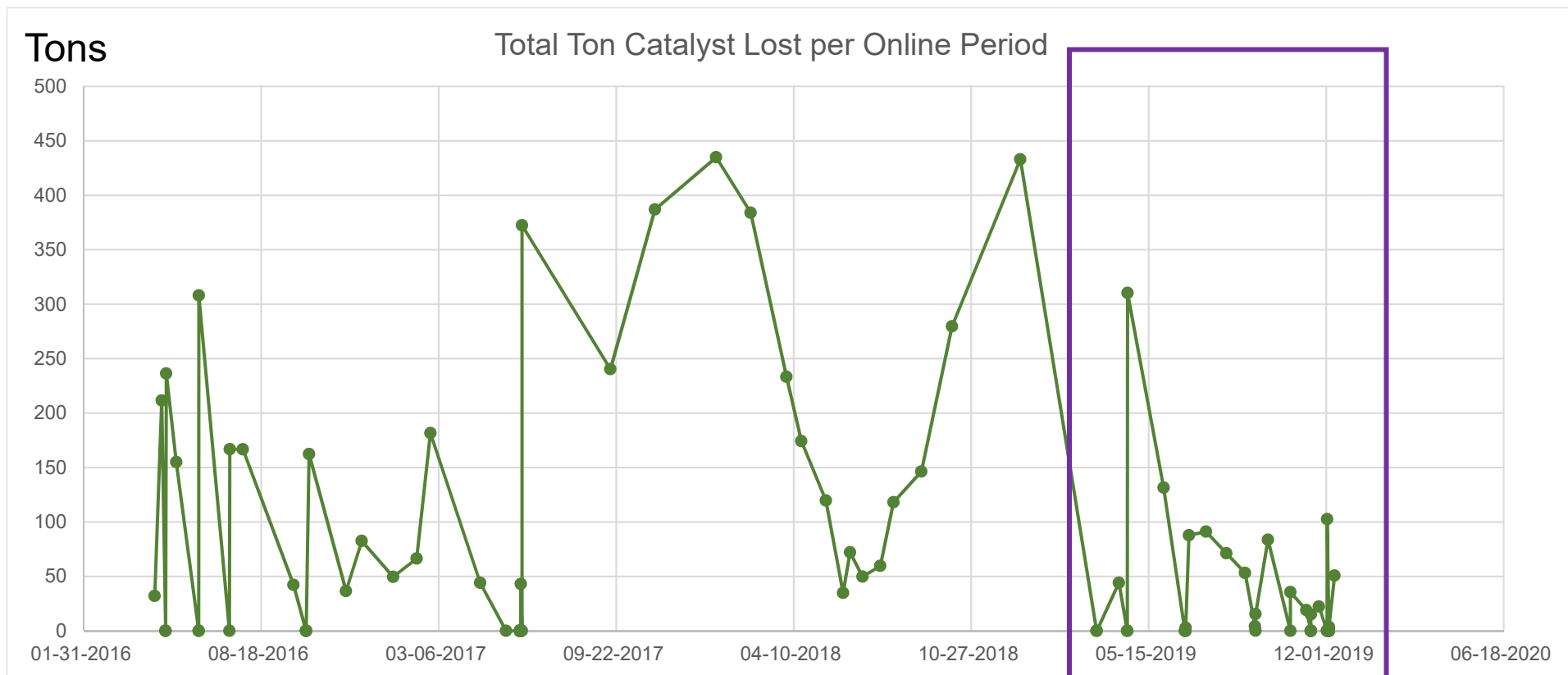




TrendMiner – Diagnostics – Catalyst Loss Hypothesis







By adding an integral calculation to TPH Catalyst Loss and exporting to Excel – we can disprove the catalyst hypothesis.

Next Steps! → Optimization

DMAIC

Recommendations

1) Establish relationship with
PI Admin & IT

based on

2) Align prioritized KPIs &
Use Cases with Management

my journey

3) Get reliability/equipment specialists involved
for a CBM & Predictive Maint initiative.

4) Become a champion. Push for training.
Schedule 1-on-1 time with engineers.

5) Don't wait for others to run with it & don't
get discouraged.

PI AF & Data Analytics

CHALLENGES

- Manual burdensome tasks
- KPIs
- Discovery, Diagnostics, Optimization
- Technical Obstacles
- Adaptation Obstacles

SOLUTION

- Using PI AF & TrendMiner, Cornerstone has progressively become more data driven.
- Aligning with management & becoming a champion helps to overcome obstacles along the way.

BENEFITS

- Process engineers utilizing their talents effectively and becoming more **collaborative** to start tackling problems that were previously too time-demanding or difficult.



Questions?

Please wait for
the **microphone**

State your
name & company



Save the Date...



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