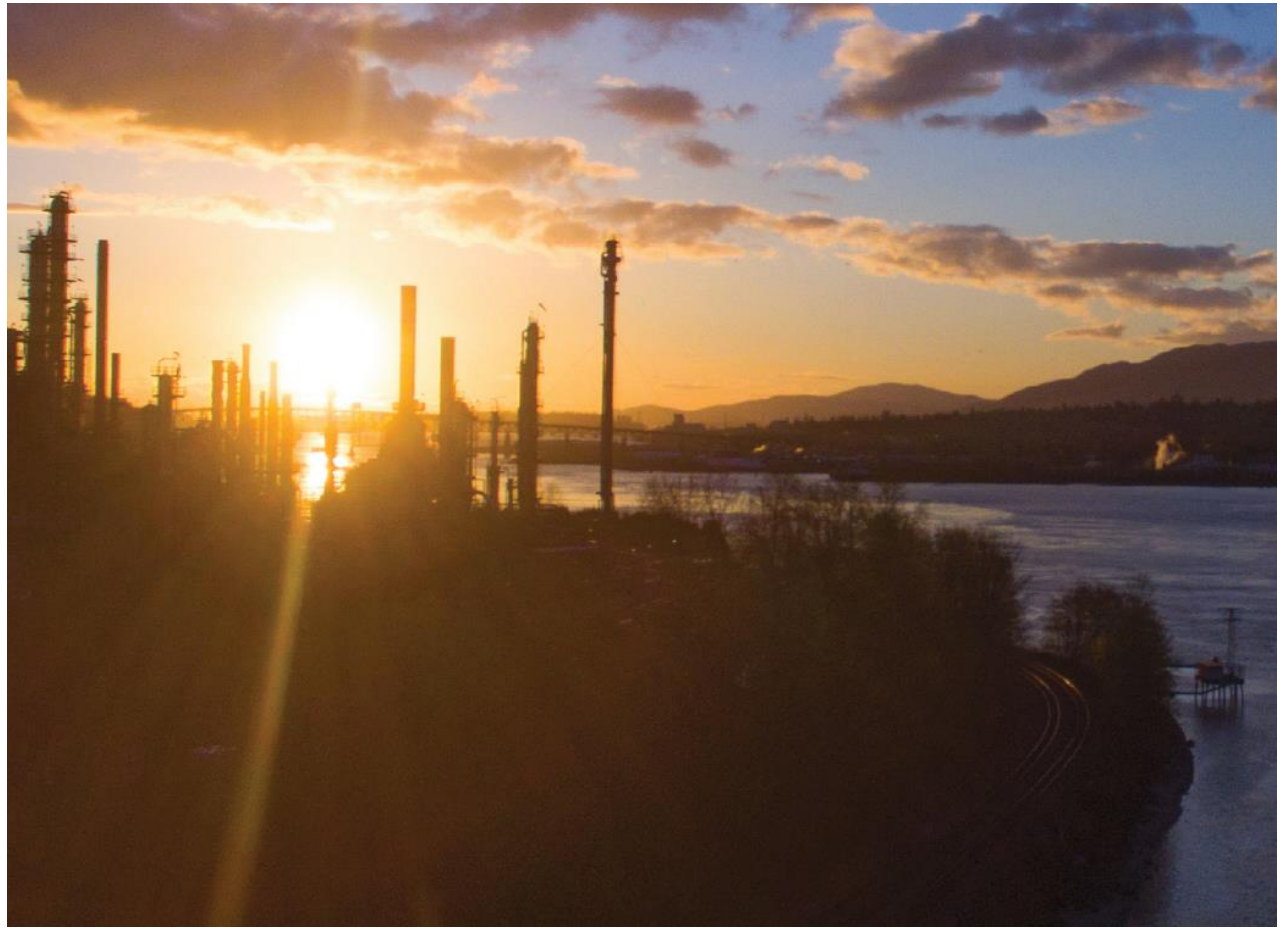
Self Service Analytics for Processing of Hydrocarbons

Siang Lim (Process Control)
Sarah Mahmoud (Process Engineering)

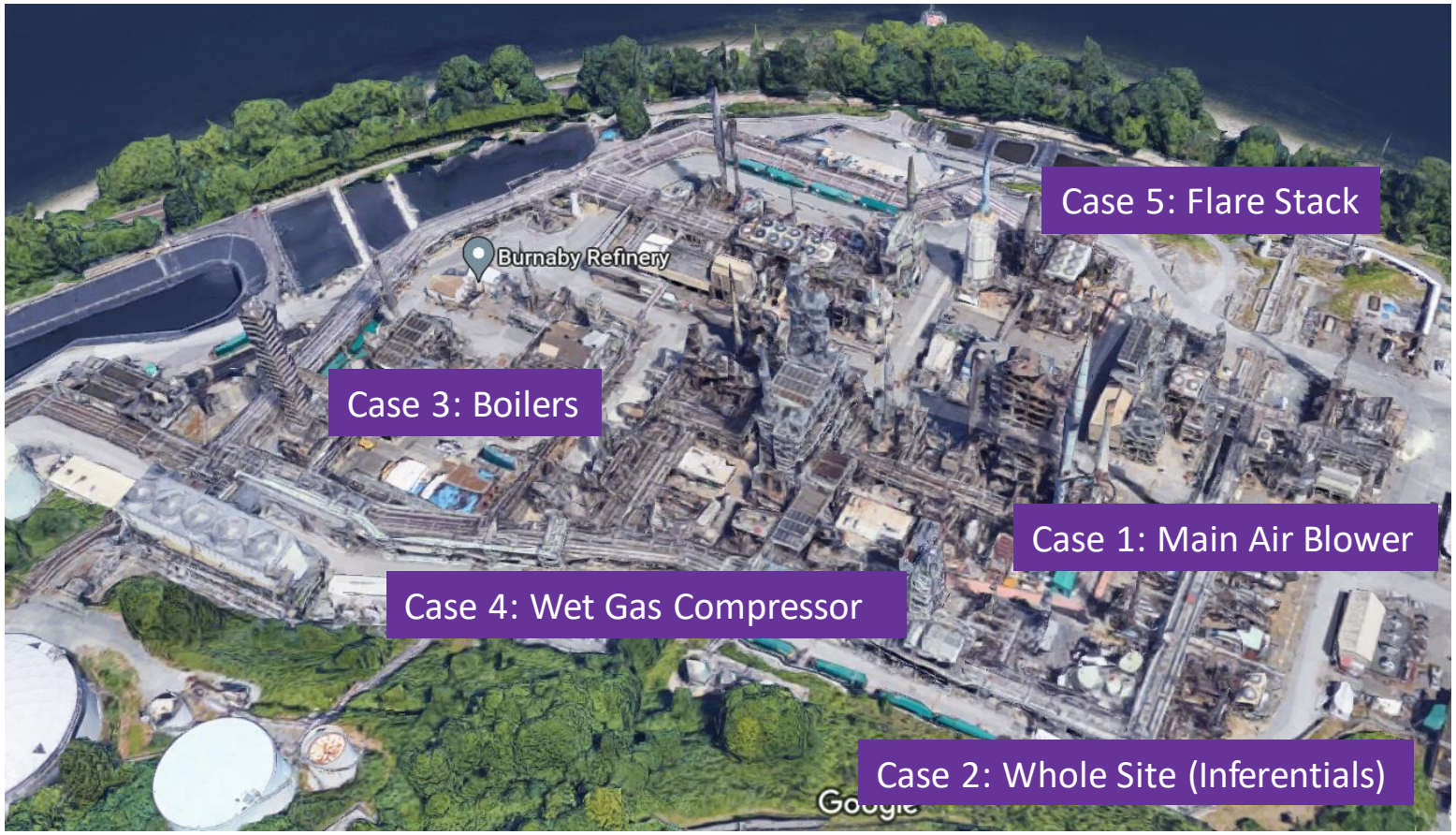
Burnaby Refinery - who are we?

- **Burnaby Refinery:**
  - Located near Vancouver, BC, Canada
  - We provide 25% of British Columbia's gasoline and diesel needs

- **80+ years of history:**
  - 1935: Refinery built and operated by Standard Oil of California (present-day Chevron)
    - 1950s -> 11,000 bpd
    - 1970s -> 35,000 bpd
  - 2017: Assets sold to **Parkland Corporation** - Canadian independent fuel retail company
    - Today -> 55,000 bpd
    - In Progress -> Expanding range of renewable bio-feedstocks (incl. tallow, canola) to lower GHG emissions and carbon footprint



5 cases studies on self-service analytics – empowering SMEs



How we use and benefit from Seeq:

- Used by Engineers (Technical Dept.) to support Operations with daily monitoring, incident investigation etc.
- Helps engineers save time, eliminate low-value work (e.g. data cleaning) and reduce analysis friction

Case Study 1: Conditional Filtering of Large Process Datasets

CHALLENGE

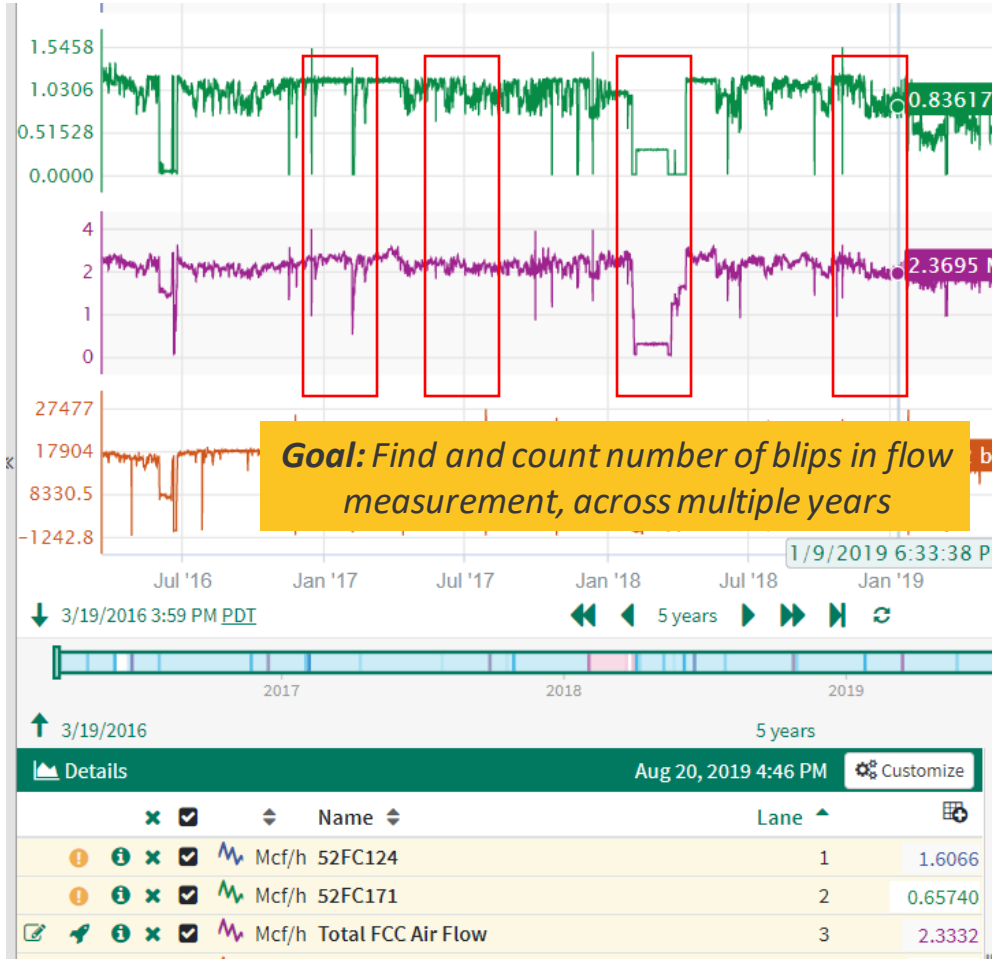
- Filtering large process datasets in spreadsheets is a very time-consuming and tedious process

SOLUTION

- Used Seeq's *Value Search* and *Chain View* to easily apply the right filters and hide irrelevant data

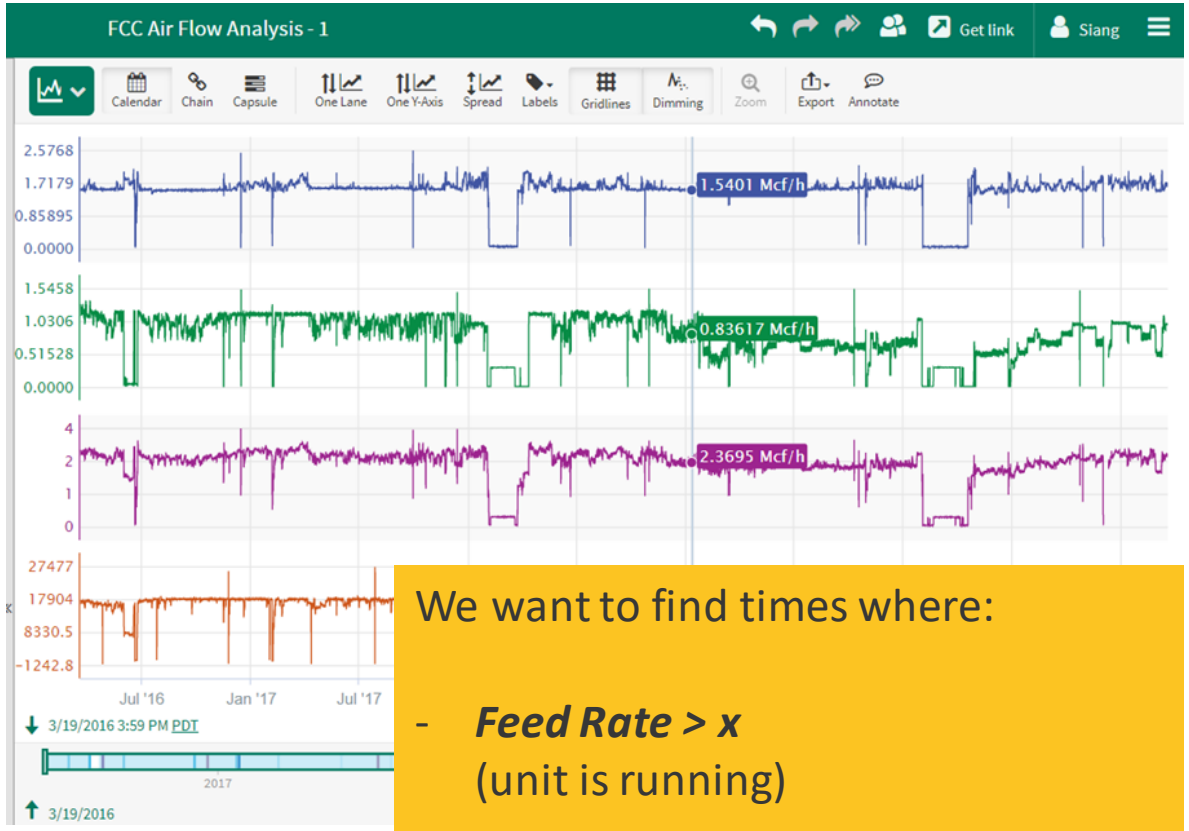
RESULTS

- Completed analysis in Seeq within an hour, compared to >40 hours in previous failed attempts using spreadsheets
- Time saved used for performing higher-value work (instead of data cleaning) and improving quality of investigations



Process background: anomalies in flow measurements

- **During HAZOP, found trip SP set too low:**
  - Engineering team identified risks with the Main Air Blower (MAB) low flow trip setpoint being set too low and recommended a higher setpoint
- **Tried to raise setpoint, but…**
  - Received pushback from Operations:
    - Observed random dips in the flow measurements
    - Concerned that a higher setpoint may cause spurious trips in the unit
- **Would we trip the unit? Need data:**
  - Due diligence: Find out how often these flow anomalies happen, and why before making further changes

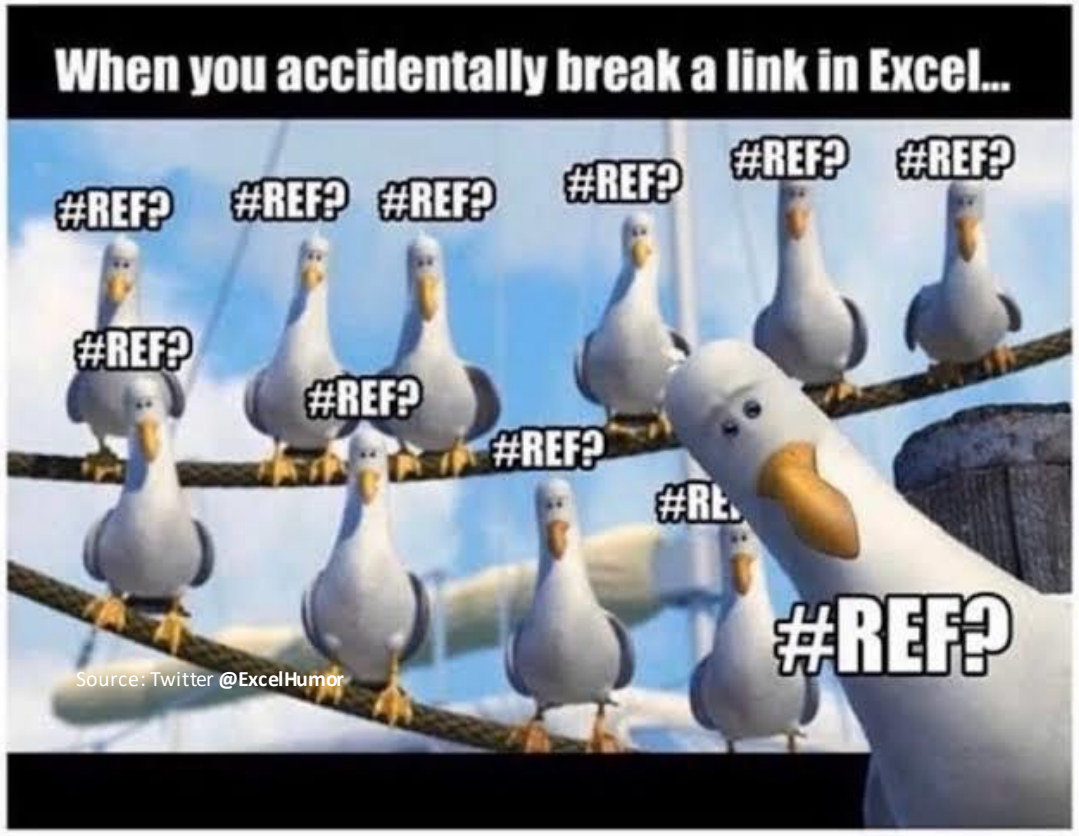


We want to find times where:

- ***Feed Rate > x***
  (unit is running)
- ***Air Flow < y***
  (anomalies in flow measurements)

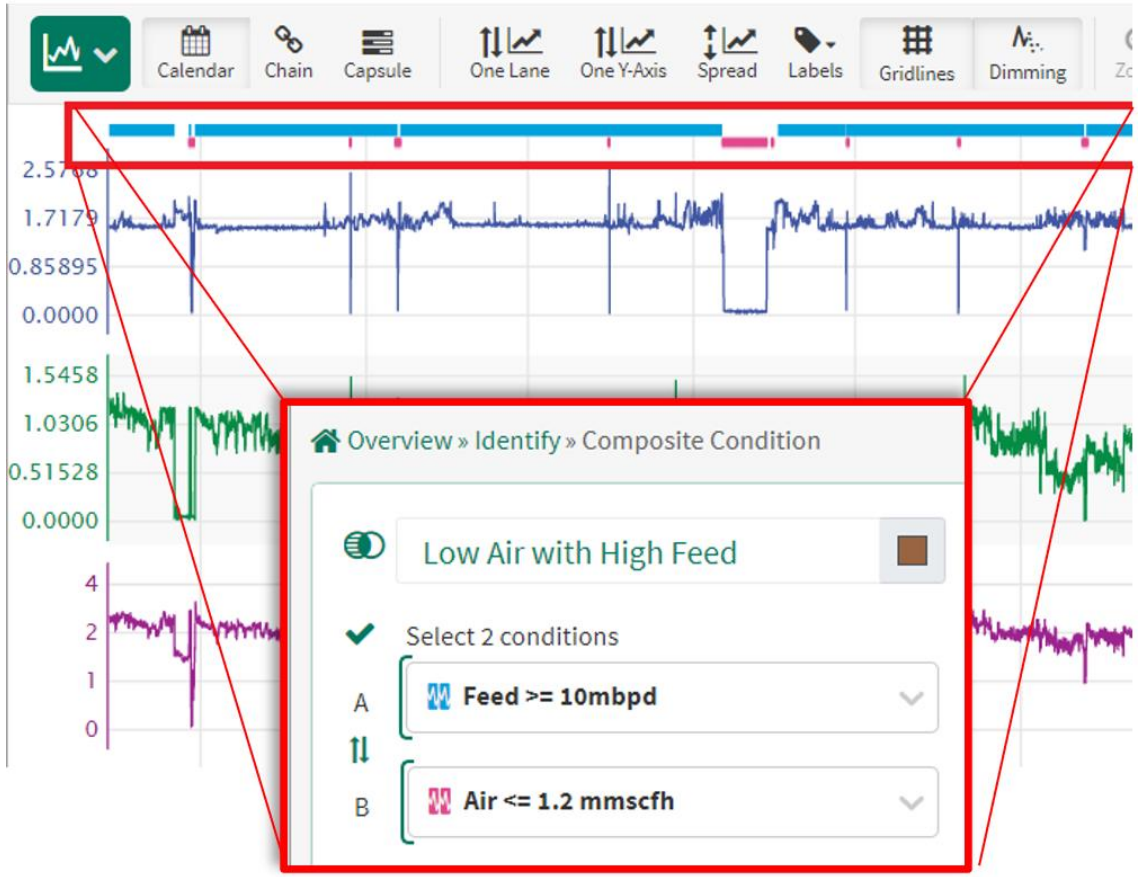
Challenges with filtering in spreadsheets

- **How much data do we need?**
  - Dips seem to happen sporadically (every few months)…
  - Dips may only last a few seconds…
  - Want to review 5-10 years of high-resolution data
- **What are the challenges in spreadsheets?**
  - **SLOW, HUGE FILES.**
    - Formulas and filters on millions of rows
  - **PI SYSTEM EXPERTISE. Can we just write queries?**
    - No. Investigation team was only familiar with Excel, not comfortable with PI queries, SQL or Python scripts.
- **Initial spreadsheet attempt took >40 hours:**
  - Played with historian settings, but didn't trust the data
    - *Is PI averaging the values? Do I need higher resolution?*
    - Hit Excel row limit, had to split into multiple files



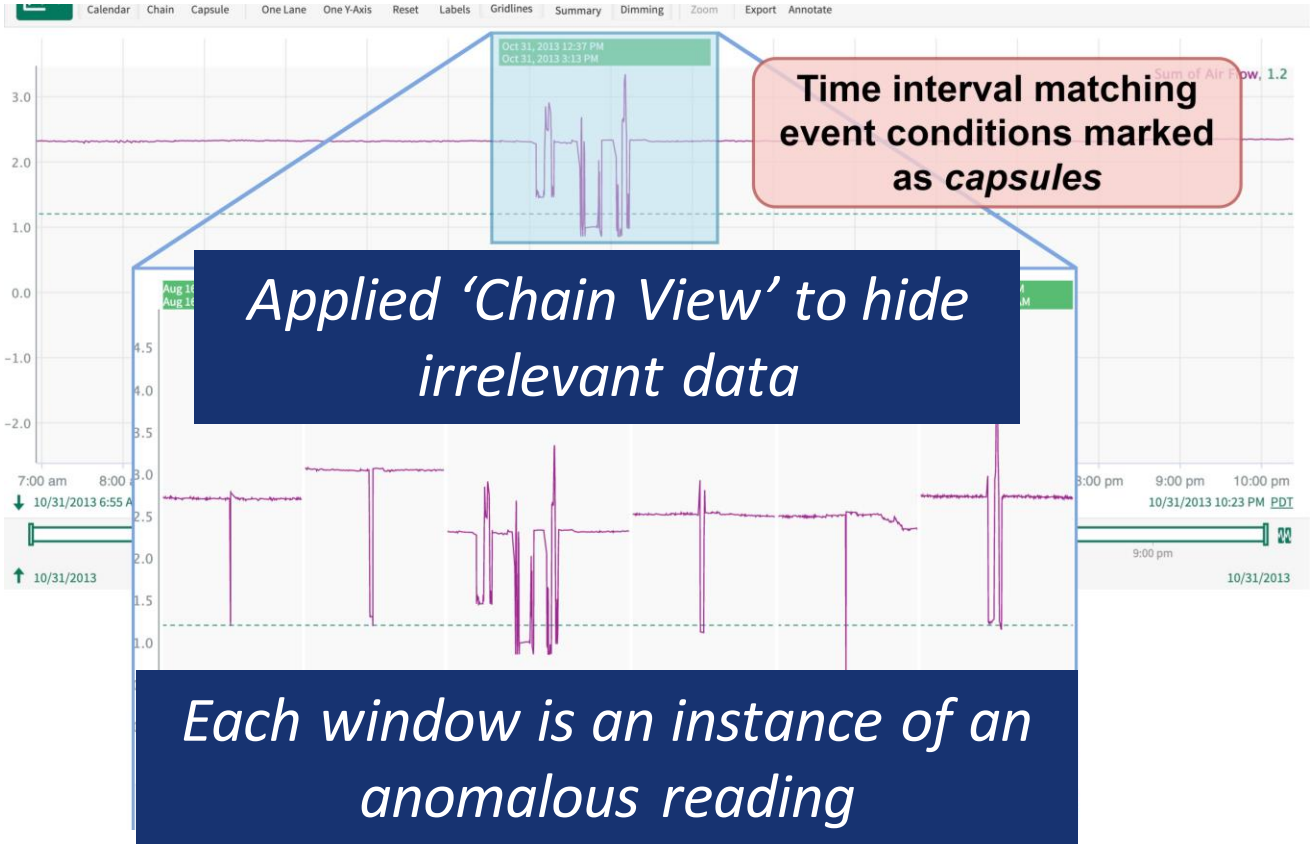
Solution: conditional filtering in Seeq

- **Successful attempt in Seeq took just 1 hour**
  - Easily defined **Composite Condition** and adjusted **Investigation Range** as needed.
  - Avoided the need to tweak historian retrieval settings and run IF-ELSE formulas in Excel and filters over millions of rows and multiple files
- **Technically, could've been faster!**
  - Team just started our Seeq trial and was still learning how to use the tool



Business results for conditional filtering in Seeq

- **Conclusions**
  - Rapidly and correctly identified all time periods with anomalies in Seeq
  - Seeq analysis provided confidence to proceed with setpoint changes.
- **Business Results & Implications**
  - Spurious trip would cost ~$1mil per day of downtime.
  - Not proceeding with change would've resulted in unacceptable safety risks.



Source: **Siang, L. C., Elnawawi, S., & Steele, D. (2022). Self-Service Analytics and the Processing of Hydrocarbons. *Digital Chemical Engineering*, 100021.**

Case Study 2: Inferential Performance Assessment

CHALLENGE

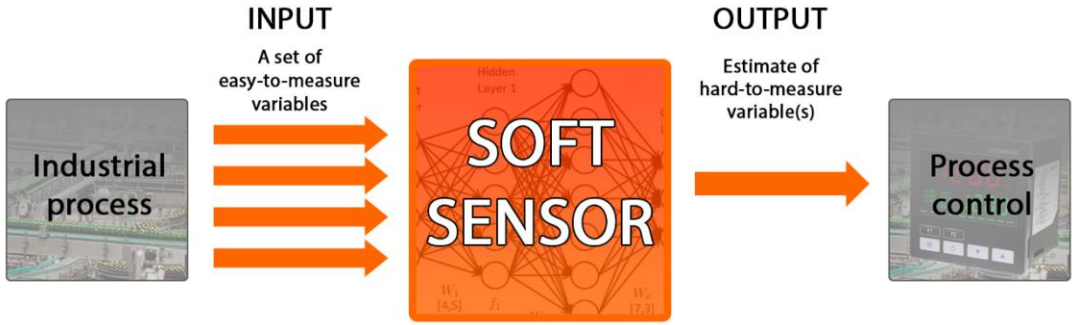
- Inferential models are used for estimating process variables in the absence of online measurements.
- Need to monitor model performance, but difficult to align timestamps for prediction vs. lab

SOLUTION

- Use Seeq *Capsules* to easily re-align timestamps for all samples and calculate prediction error.

RESULTS

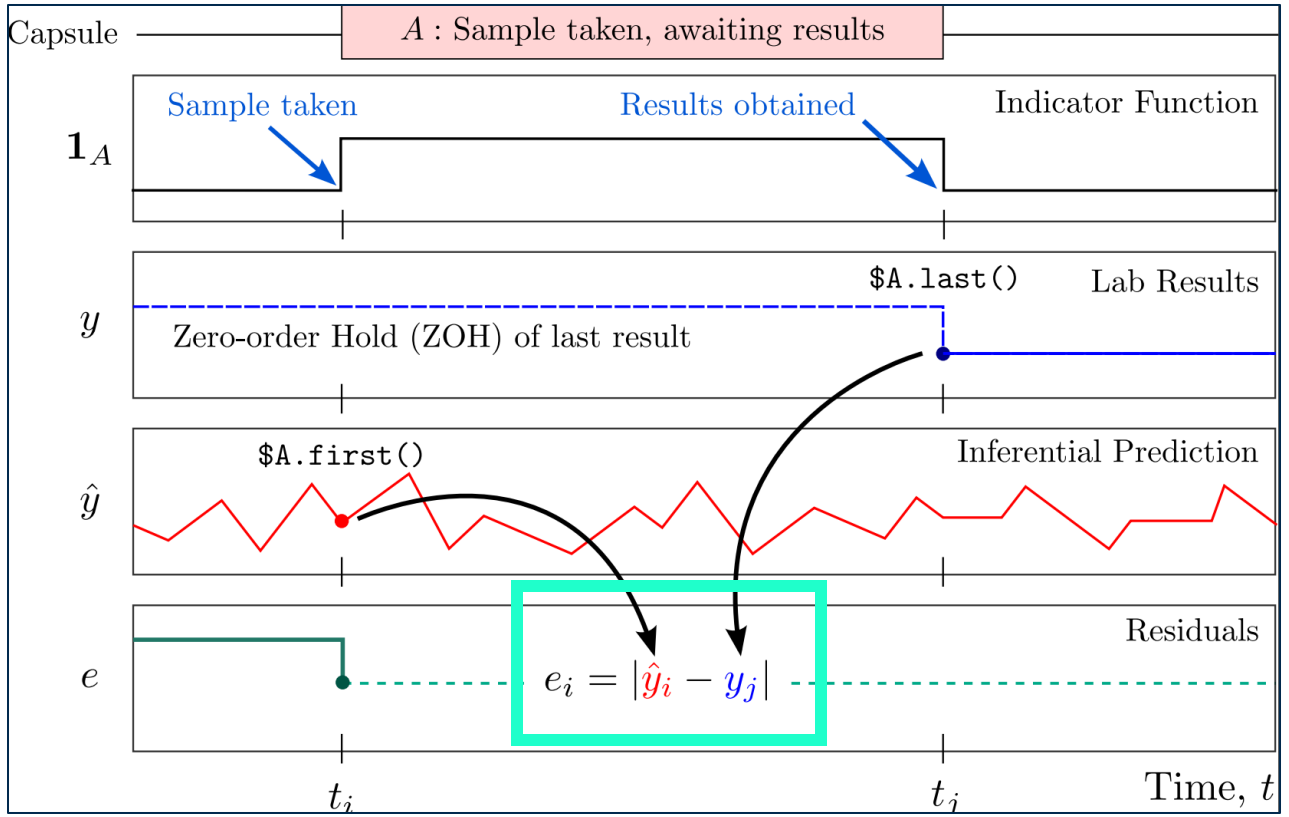
- Avoid the need to manually align sample timestamps.
- Scale calculations to multiple inferentials plant-wide using *Asset Trees.*



Source: **Curreri, F., Fiumara, G., & Xibilia, M. G. (2020). Input selection methods for soft sensor design: A survey.** ***Future Internet*****, 12(6), 97.**

Calculation background 1: residuals method

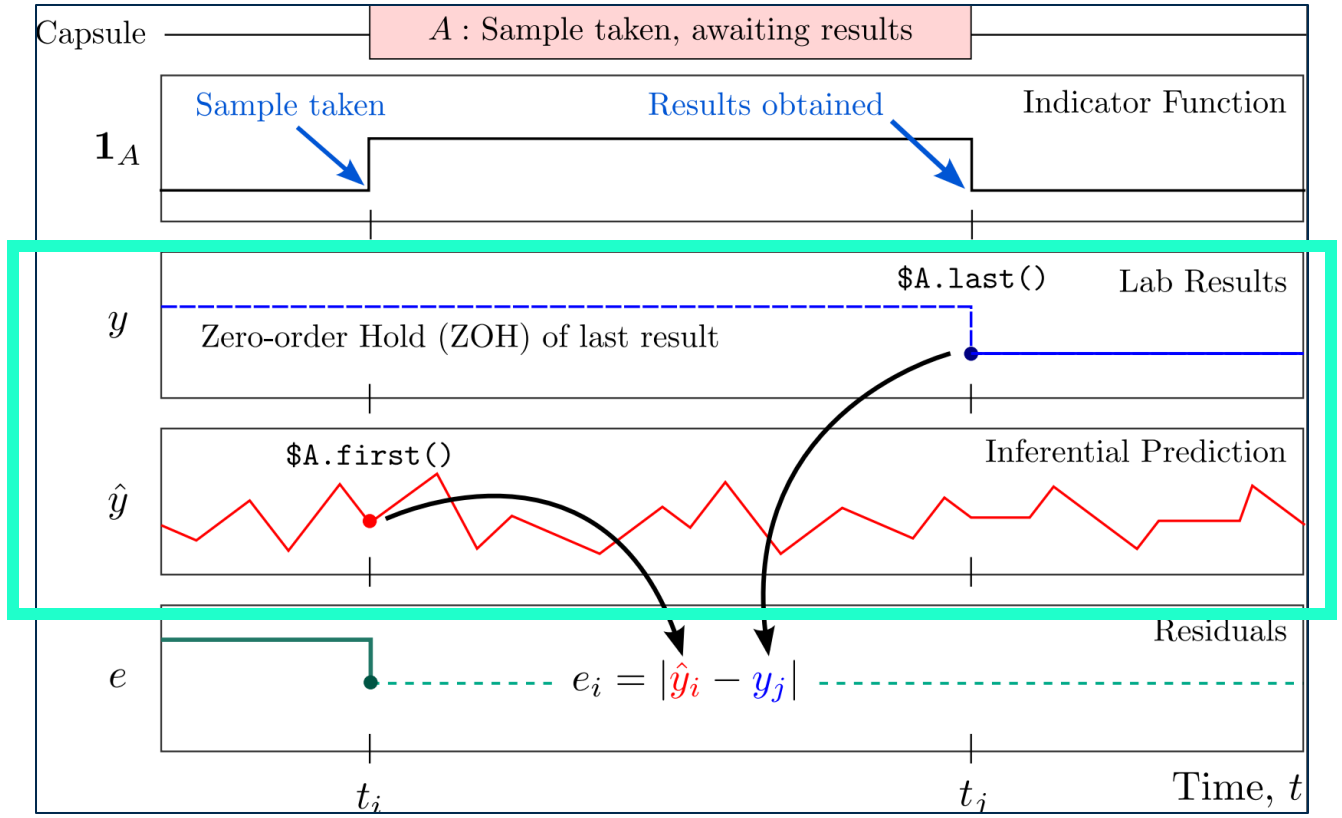
- **How do we measure model performance?**
  - Simplest method: take the **absolute difference between predictions and lab** (a.k.a. *error* or *residuals*).



Source: **Siang, L. C., Elnawawi, S., & Steele, D. (2022). Self-Service Analytics and the Processing of Hydrocarbons. *Digital Chemical Engineering*, 100021.**

Calculation background 2: aligning prediction vs. lab

- **Sounds easy. Why is it difficult?**
  - **Data Cleaning!** Samples collected at the prediction time *(red dot)*, but lab results obtained hours later *(blue dot)*.
- **Must realign timestamps for inferential predictions vs. lab results**
  - Must shift blue dot to align with red dot
  - Shift varies for each sample, depending on how long the test takes, how busy the lab is, etc.
  - It is not just a simple constant time shift.
- **Easy to manually shift one sample, but what if you have many, many samples?**



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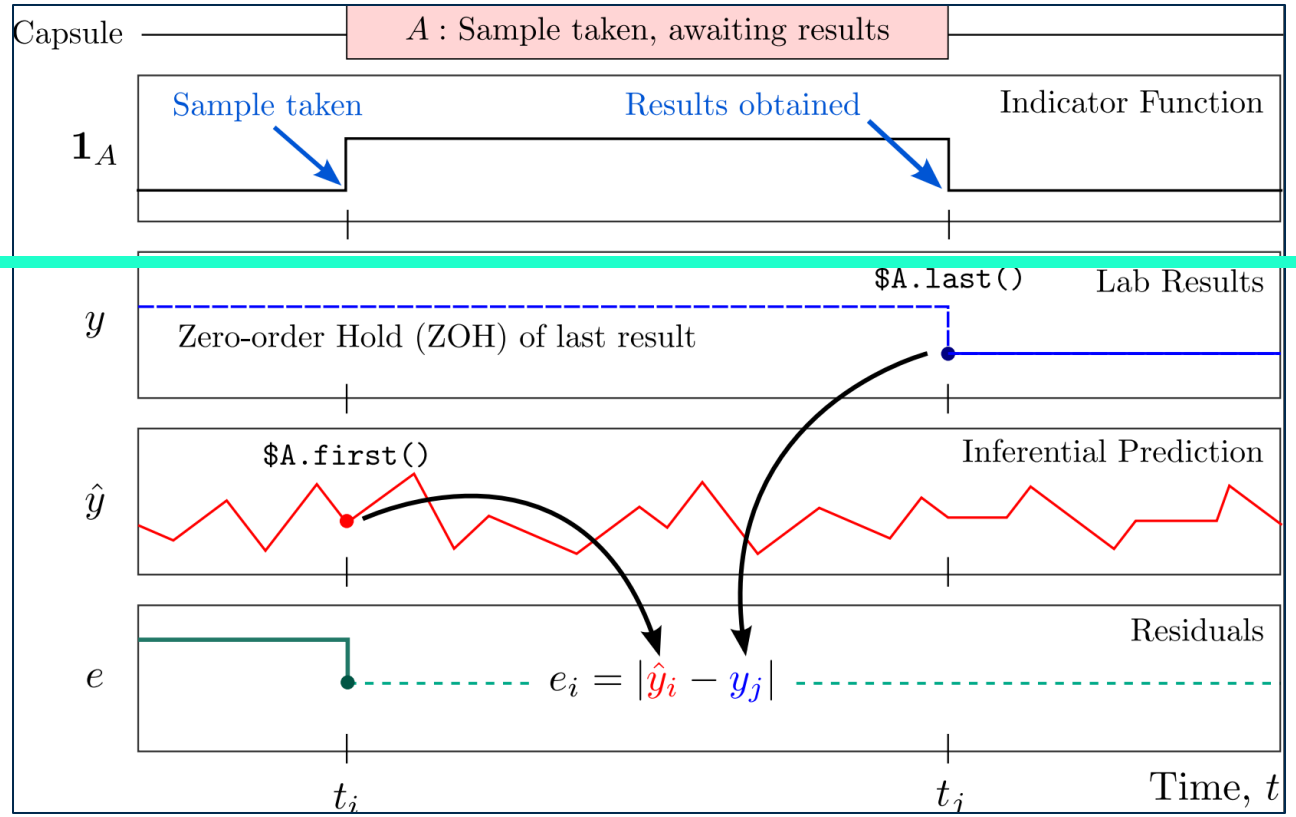
Calculation background 3: indicator function to capsules

- **How do we know the time shift?**
  - Use an **indicator function** configured in DCS: gives us the ΔT between the sampling time and lab results
  - Signal = 0 initially. Step change from 0 to 1 indicates sample taken
  - Signal = 1 while waiting for results. Step change from 1 to 0 when results are obtained
- **Solution:**
  - Step 1 – Convert indicator function signal to Seeq capsules
  - Step 2 – Use the capsules to align the prediction vs. lab values.



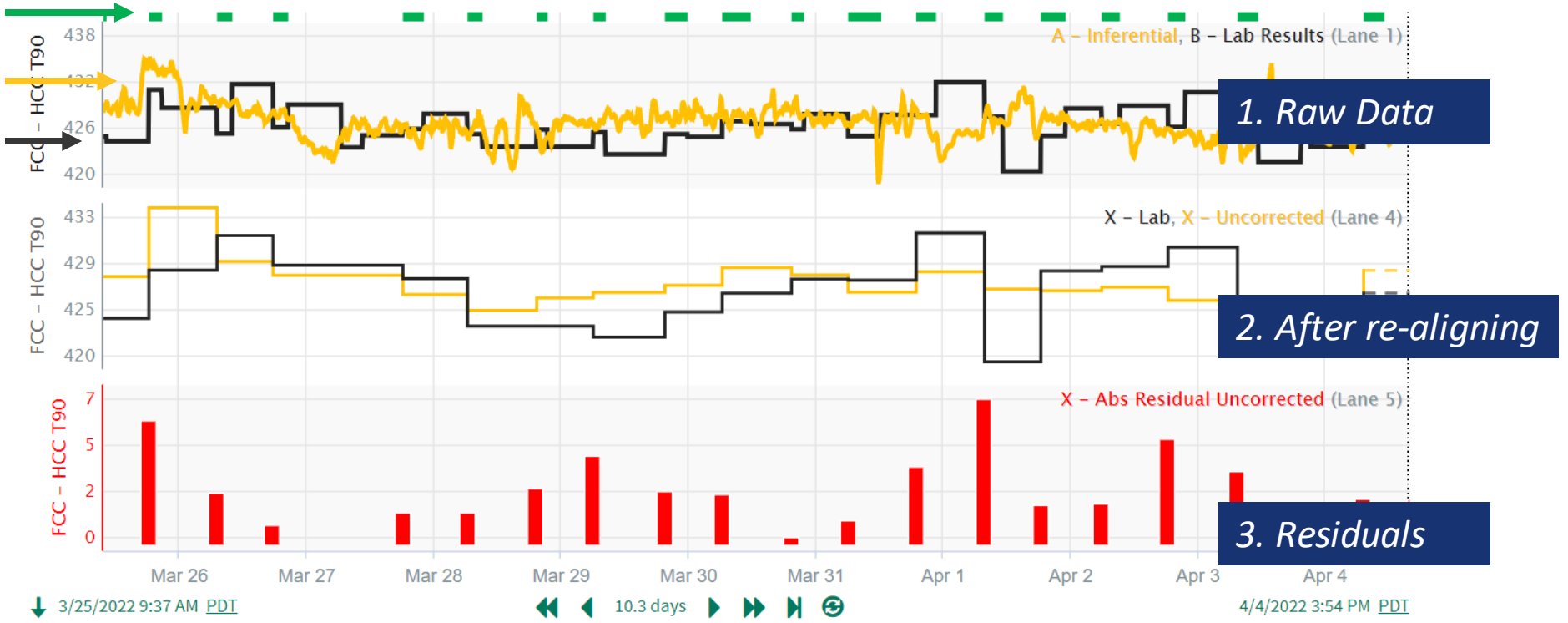
Source: **Siang, L. C., Elnawawi, S., & Steele, D. (2022). Self-Service Analytics and the Processing of Hydrocarbons. *Digital Chemical Engineering*, 100021.**

Solution for inferential calculations in Seeq

`$A - indicator function`

`$pred - predictions`

`$lab - lab samples`



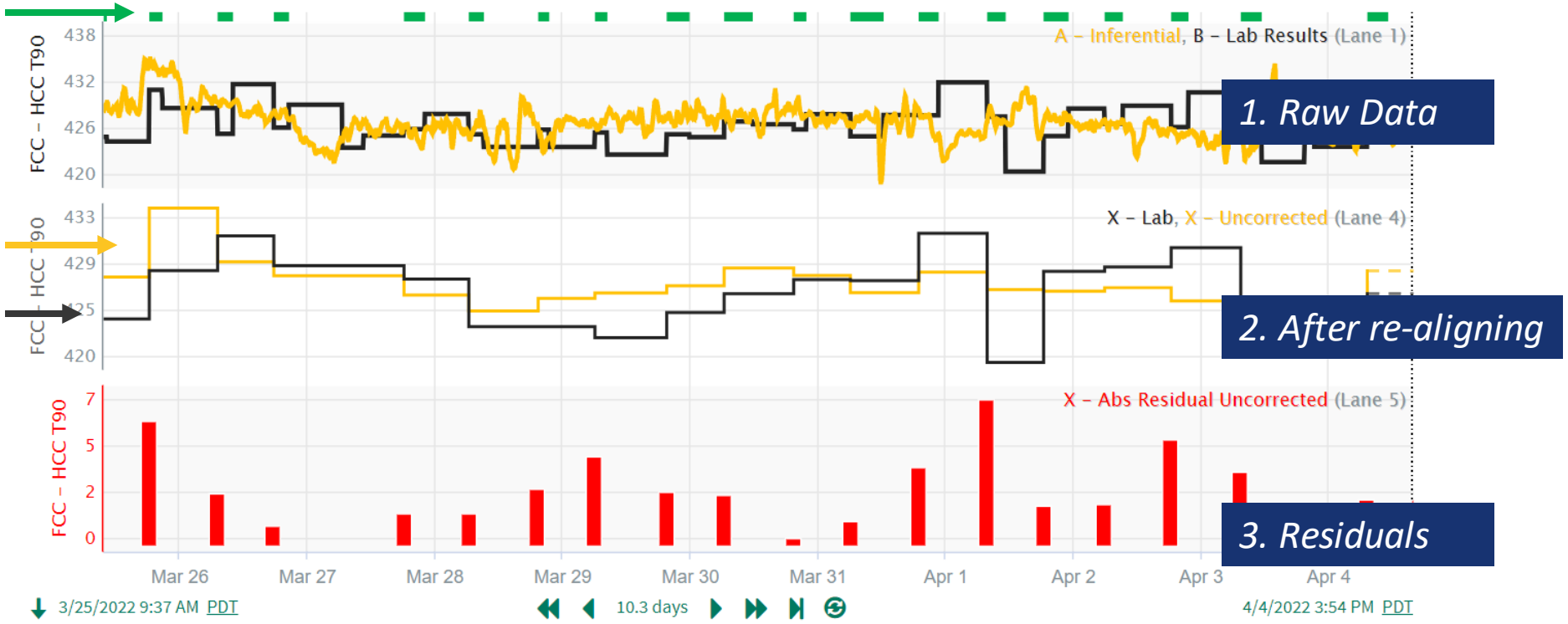
- **Step 1 – Convert lab and prediction signals to scalars bounded by indicator function capsules**
  - **First value of $pred in $A is when the sample is taken:** `$pred.toScalars($A).first()`
  - **Last value of $lab in $A is when lab results are returned:** `$lab.toScalars($A).last()`

Solution for inferential calculations in Seeq

$A – indicator function

$pred – predictions

$lab – lab samples

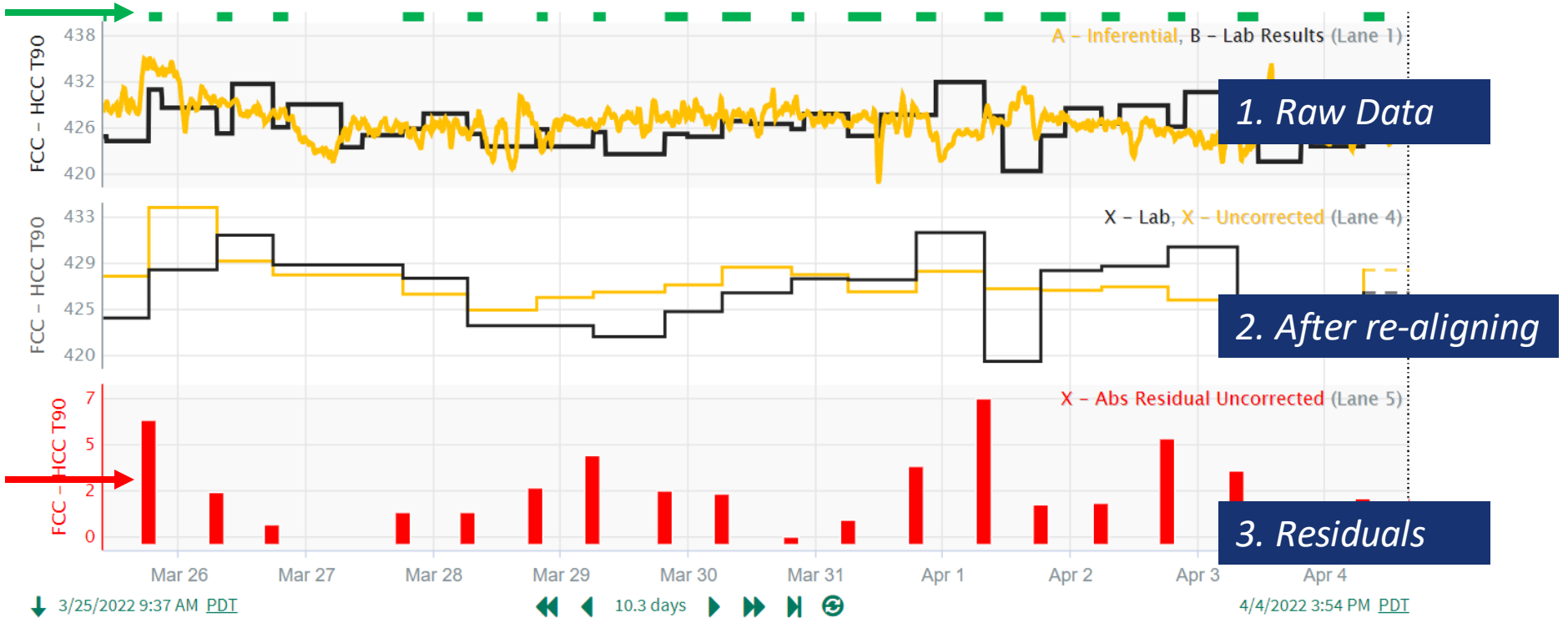


- **Step 2 - Difference in prediction vs. lab is easy to calculate as a Seeq formula**
  - Previous formulas created 2 new, cleaned signals. Predictions and lab results are now aligned.
  - Ready for residual calculation.

Solution for inferential calculations in Seeq

`$A - indicator function`

`$X - Residuals`

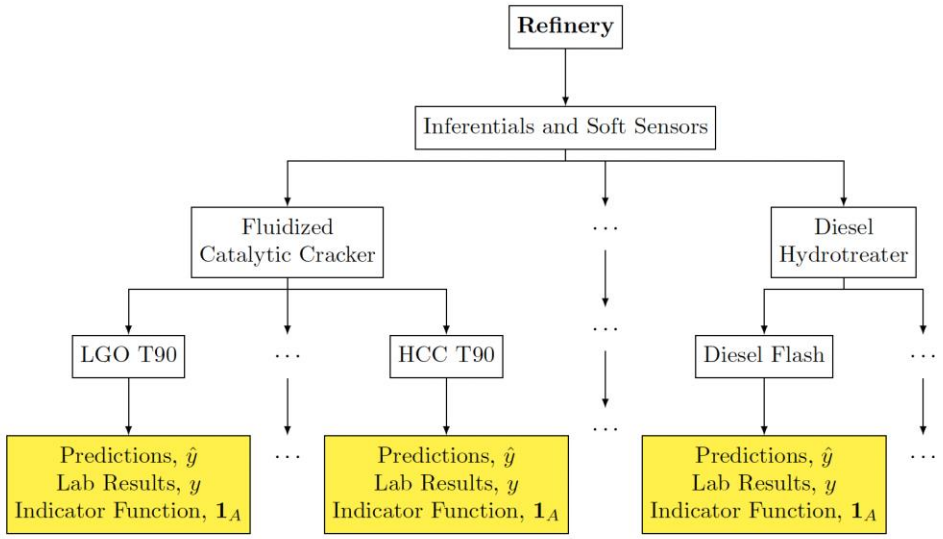


- **Step 3: Putting it all together - Residuals calculation is a simple one-liner in Seeq**

```
abs($lab.toScalars($A).last() - $pred.toScalars($A).first())
```

Lab ***Prediction***

Results for inferential calculations in Seeq



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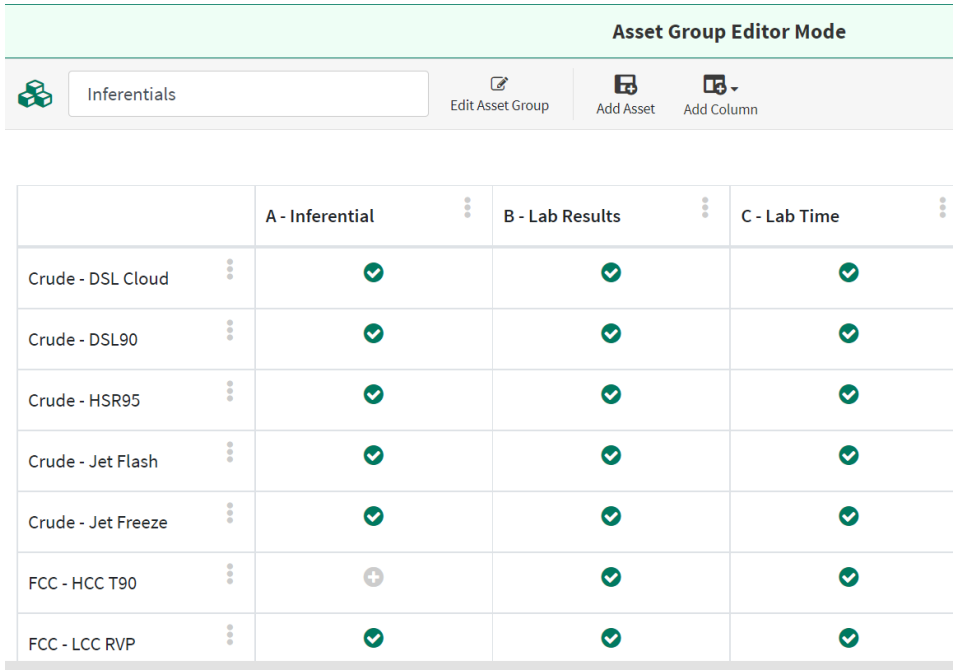


- **Results**
  - Avoid manually aligning timestamps in Excel by leveraging ***capsule properties***
  - Use the calculations as a template. Easily scale to other inferentials by defining ***Asset Trees (Groups)***
  - **Conclusion:** Simple tasks can be tedious without the right tools! Users often don't need/want machine learning/advanced algorithms (depending on the problem), but just the ability to quickly access, filter and clean our data. Seeq makes it easy to do all these -> empowering engineers to quickly get the results they need.

Case Study 3: Incident Investigation

CHALLENGE

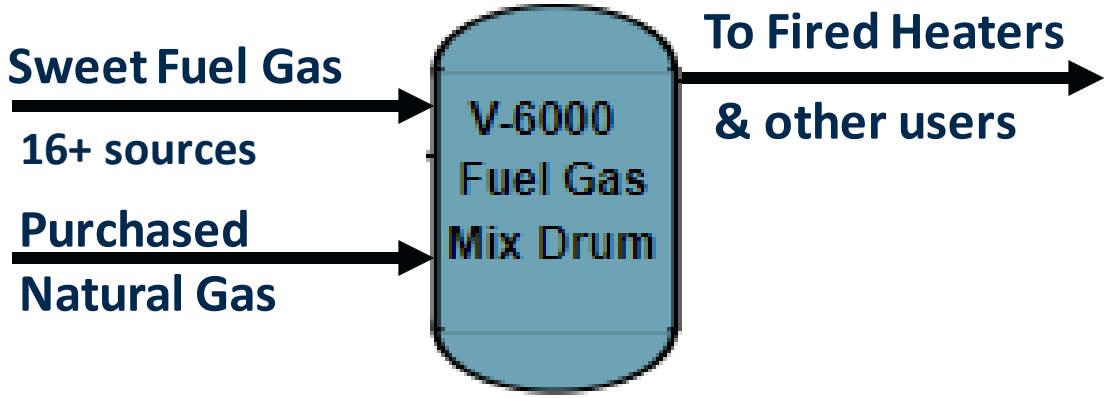
- Incident investigation for flooded boiler
- Fuel gas system has 16+ inputs – Excel and other data historians are time consuming to pull data for analysis.

SOLUTION

- Use Seeq to pull large amounts of data quickly and use *Value Search* to identify parameters outside of normal operating range.

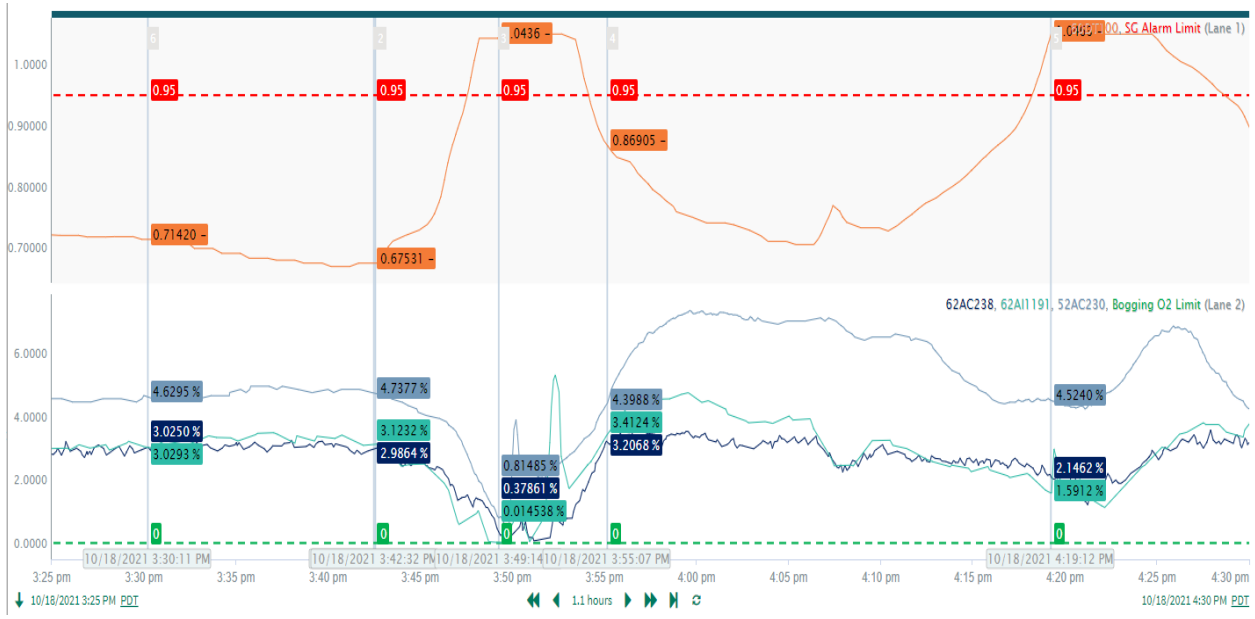
RESULTS

- Identified culprit fuel gas producer and improved start-up procedures based on results.
- Incident investigation took 1 day instead of 1 week of analysis due to Seeq.



Results of incident investigation

- **Use Seeq to pull data for 16+ inputs**
  - Easily trend everything rather than pulling data then trending in Excel
  - Quickly add limits and other visual cues for presentation to stakeholders
  - Identified the culprit stream and events leading up to incident using *Value Search*
- **Conclusion and Business Results**
  - Identified culprit fuel gas producer and improved start-up procedures based on results.
  - Incident investigation took 1 day instead of 1 week of analysis due to Seeq.



Case Study 4: Flowmeter Correlation

CHALLENGE

- Steam flowmeter for compressor turbine broken for 2+ years.
- Equipment is a large 400# steam consumer and required for steam balance / energy saving initiative.

SOLUTION

- Use Seeq *XY Plot* and *Model & Predict* to build a correlation between the turbine governor valve and steam flow using data from 2016-2018.

RESULTS

- Correlation used for steam reduction test run and daily monitoring of approximate steam consumption using the live governor position.

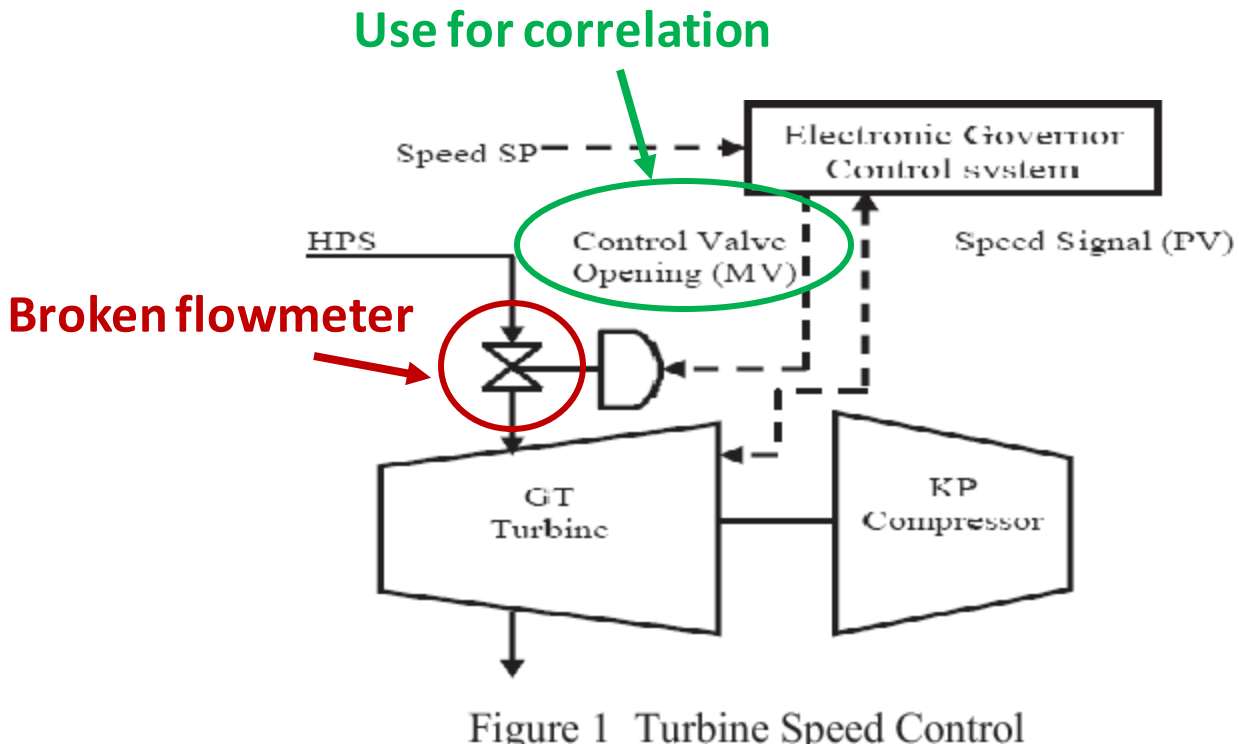
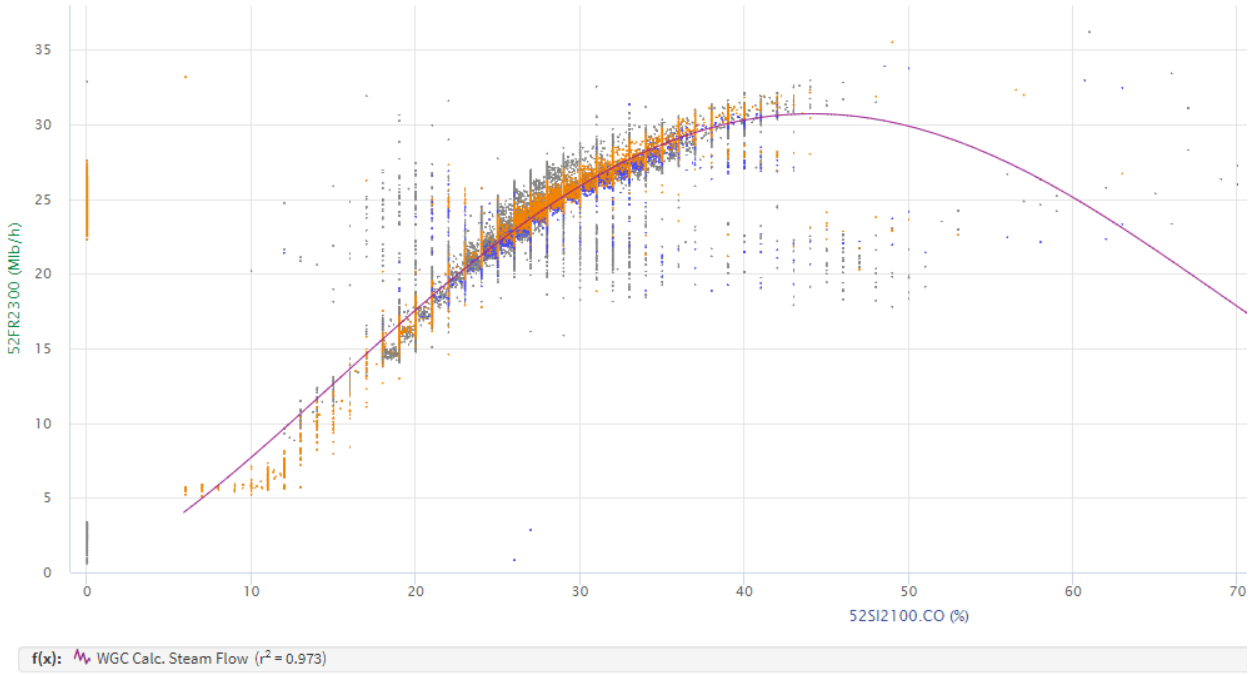


Figure 1 Turbine Speed Control

Source: **Ismail, M.M. (2012). Adaptation of PID controller using AI technique for speed control of isolated steam turbine.** ***Japan-Egypt Conference on Electronics, Communications and Computers***

Results of X Y correlation

- **Use Seeq to build correlation**
  - Quickly pull years of data to build a good correlation.
  - Seeq automatically color codes by year, ensuring any drift or step changes in correlation are captured.
- **Conclusion and Business Results**
  - Plot created in ~5 minutes.
  - Relationship had an r2 = 0.973.
  - Rather than generating coefficients in excel, submitting an IT ticket to PI for a calculation tag, and then monitoring on PI/XHQ, easily create a live calculation value in Seeq energy tracking dashboard.
  - Results in 1 day rather than weeks and save an IT resource and PI Tag slot.



Case Study 5: Flare Baseline Flow

CHALLENGE

- Flaring above design purge requirements wastes valuable energy and increases GHG emissions.
- Hard to tell what the target is without a proper baseline.

SOLUTION

- Use Seeq's *Value Search* to find times when all equipment is on and at high rates.
- Use Seeq's *Signal from Condition* to find the average baseline flow.

RESULTS

- Analyzed >10 years' worth of data in short amount of time
- Identified and mitigated $500,000 worth of excess flaring in 2022

Results of flare analysis

- **Establish Minimum Actual Rate**
  - Minimum theoretical rates set by purge requirements of 1 ft/s.
  - Minimum actual rates will be higher - always some extra flow from passing PSVs, etc. that cannot be fixed until the turnaround
  - Minimum actual may change depending on front-end rates and which units are online
  - *Value Search* and *Signal from Condition* easily identify these periods, rather than manually searching/conditioning in Excel
- **Conclusion and Business Results**
  - Determined baseline for flare flow – anything above this requires investigation and mitigation
  - Identified and mitigated $600,000 /year worth of excess flaring in 2022

Conclusion

- **Seeq is:**
  - Reducing the amount of time to analyze data
  - Increasing the quality of the conclusions drawn
  - Expanding opportunities to troubleshoot and optimize
- **Where are we going?**
  - Increase Seeq literacy in the Technical group
  - Build more tools for continuous improvement
  - Use as a link from PI System data to other interfaces (eg. Power BI) because of ease of calculation edits

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