3° Workshop de Medición en Upstream y Downstream de Petróleo y Gas IAPG

22-23 AGO

IAPG INSTITUTO ARGENTINO DEL PETROLEO Y DEL GAS

Phase Analysis in Gas Pipelines: Detail for Operation and Safety

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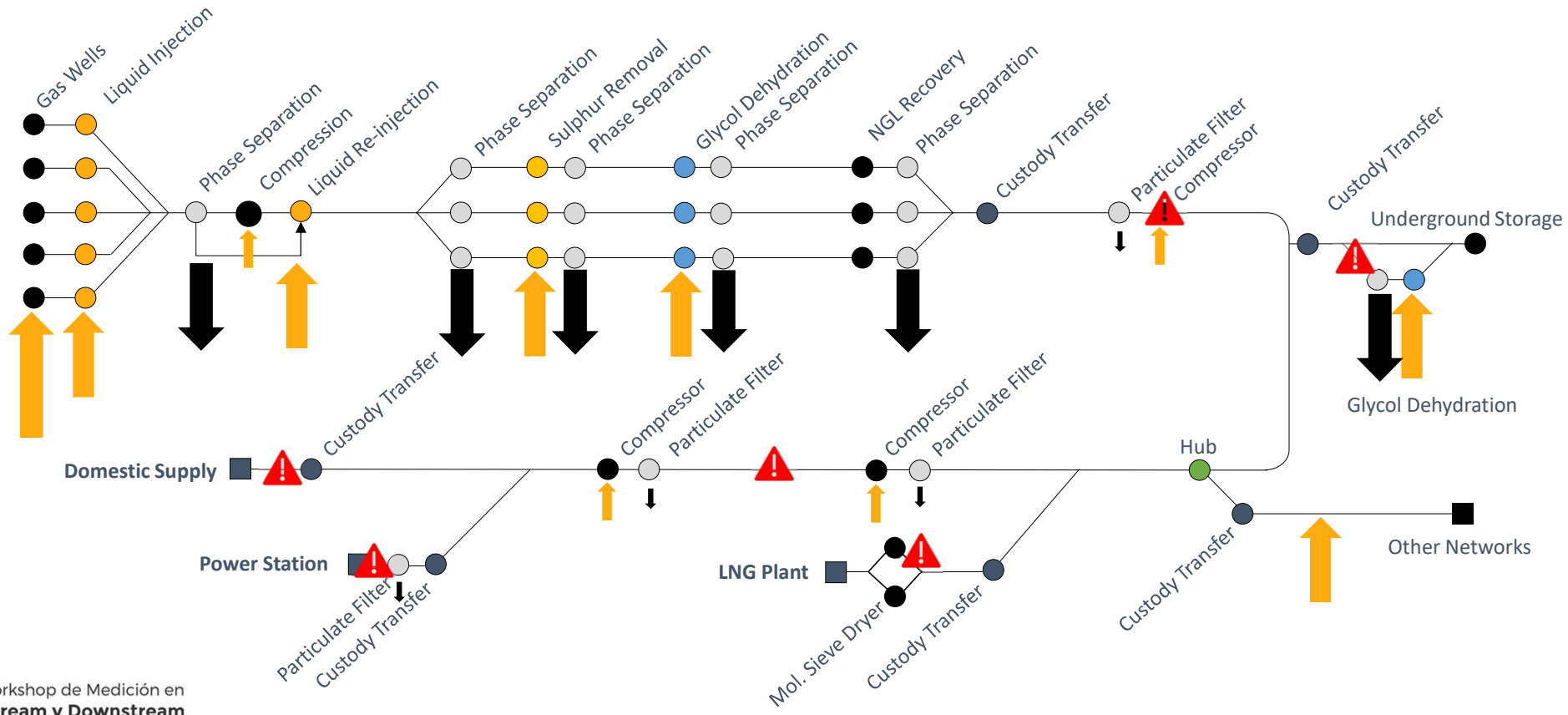
Process Cameras on a Pipeline

- Project started by a Transmission System Operator (TSO) wanting to know why contamination was getting into the network without tripping gas analyzer alarms
- Using process cameras reveals contamination
- Image processing is used to trip an alarm
- Benefits for both gas processors and TSOs
- Support for users during and after an event

The Gas Journey & Sources of Contamination

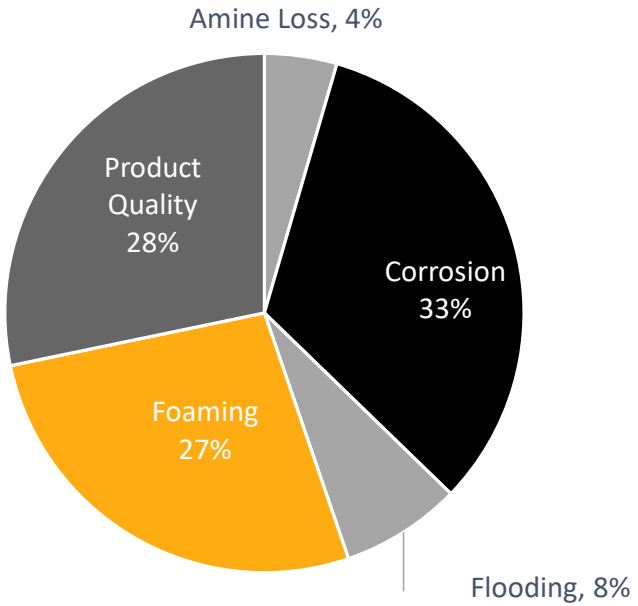


Liquid Carryover – Gas Processing

A survey of 400 cases of amine plant failures each with a cost of **$250k to $250m** per case.

The study concludes 3 main causes:

- **Corrosion** – Poor amine quality or insufficient regeneration
- **Foaming** – Contaminated gas at the inlet
- **Product Quality** – due to insufficient heat



Source: Trends in Tragedy – An in-depth study of Amine system failures, Amine Experts

Liquid Carryover – Gas Processing

- Foaming
- Loss of production – low flow rates to mitigate foaming risk
- Use of additional chemicals (defoamer)
- Loss of Amine
- Loss of Glycol

Liquid Carryover – Gas Transportation

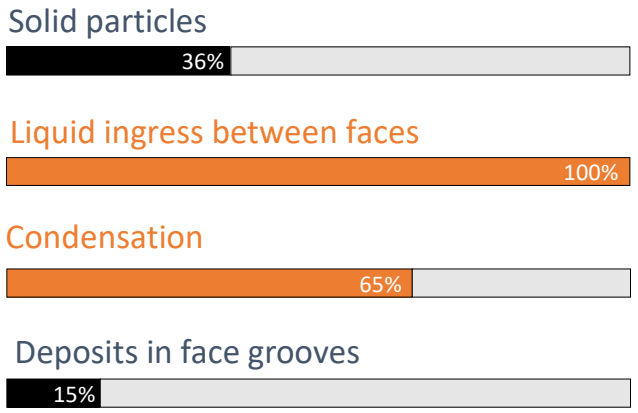
Dry gas seal failures on natural gas compressors

71 Failures of dry gas seals on 38 compressors

Cost: Loss of production + $60 - $120K servicing

5 Years
Design Life Requirements
(manufacturers & users)

1 Year
20 days
Survey Results
(Average)



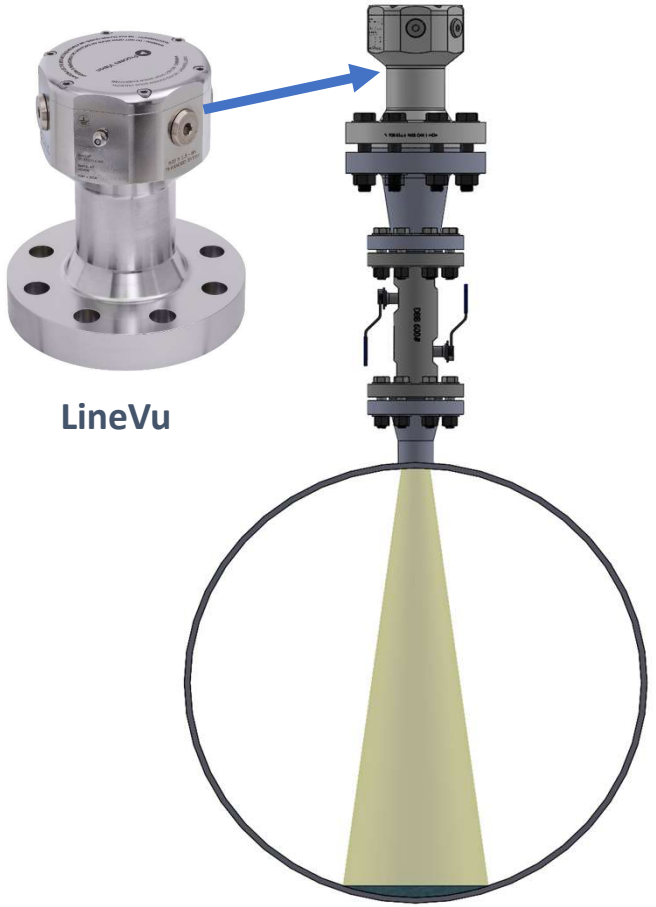
Source: HSE Survey Report 2000/070

Liquid Carryover – Gas Transportation

- High Servicing cost on compressors
- Errors in fiscal measurements of flow and calorific value
- High cost of pigging and disposal of contaminants
- Higher pressure drop across the gas network
- Pipeline corrosion
- Increase the risk to power station operators

A Camera on the Pipeline

- Helps configure gas processing for best performance
- Image processing used for alarms
- Secondary containment
- Recessed window means no contamination of the optics
- Live Stream to the control room
- Remote access and analytics via secure portal



Site Installation - Example

Normal Gas Flow – Time Lapse

Gas flow at entry to a gas network.

Time Lapse Video at 1500x speed.

24 hours in 57 seconds.

Gas flow from left to right.

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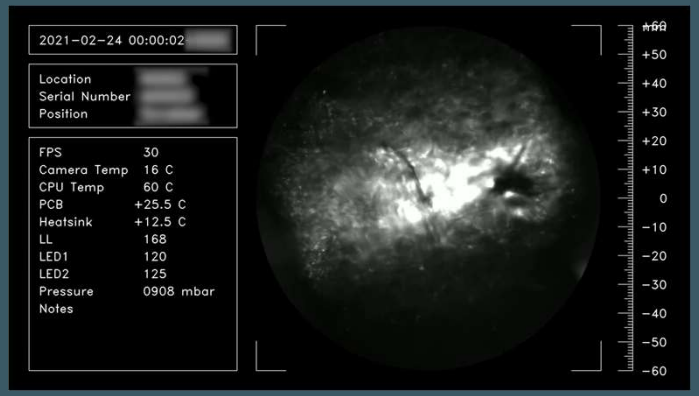

Liquid Flow Onset – Time Lapse

Gas flow at entry to a gas network.

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Gas flow from left to right.

Liquid Flow Onset – Time Lapse

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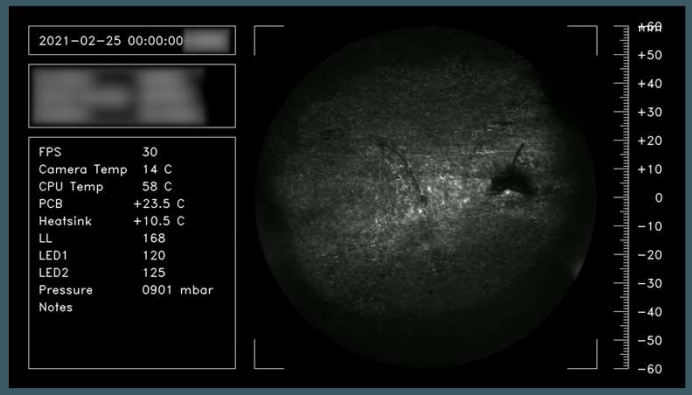

Liquid Flow Onset – Real time

A section of the same video in real-time.

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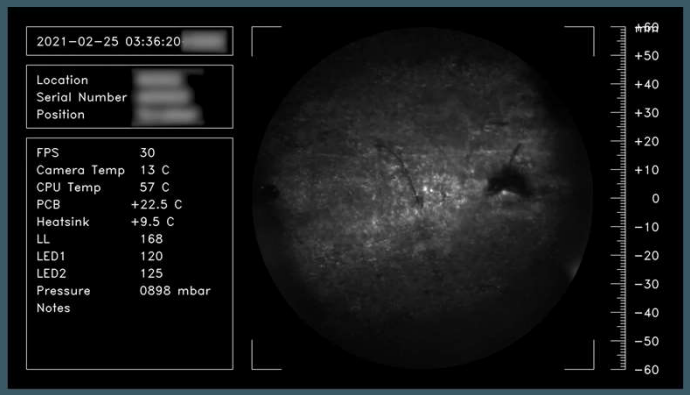

High Liquid Flow – Time Lapse

Gas flow at entry to a gas network.

Time Lapse Video at 1500x speed.

24 hours in 57 seconds.

Gas flow from left to right.

High Liquid Flow – Time Lapse

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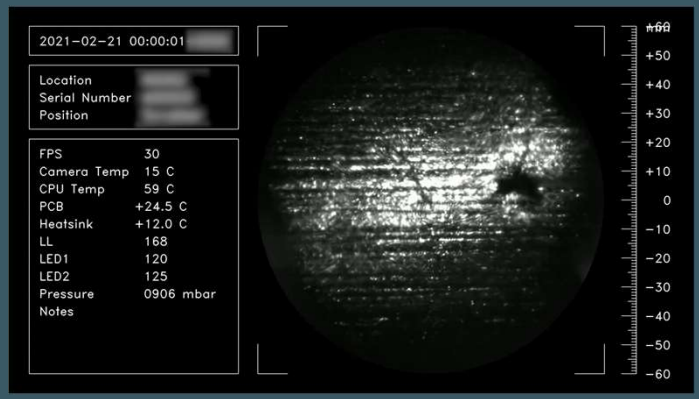

Reporting Process Failures

Process failure – revealed

15,000 gallons dumped in line due to hole in a heat exchanger

We were running on beta test and warnings were ignored, clean up costs exceeded $1mm

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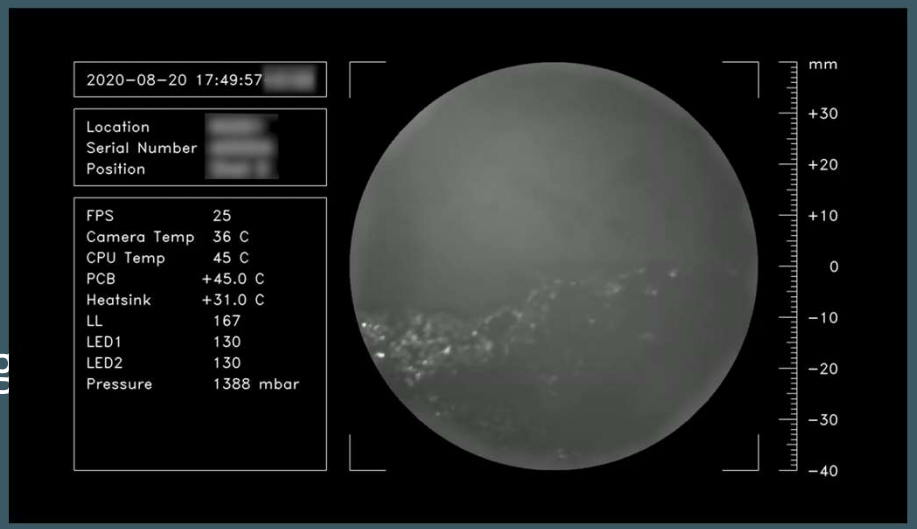
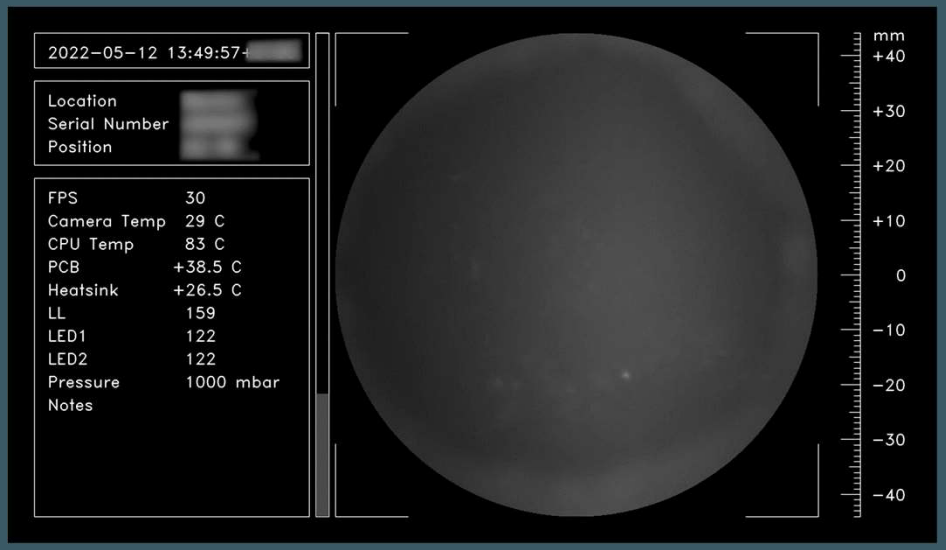


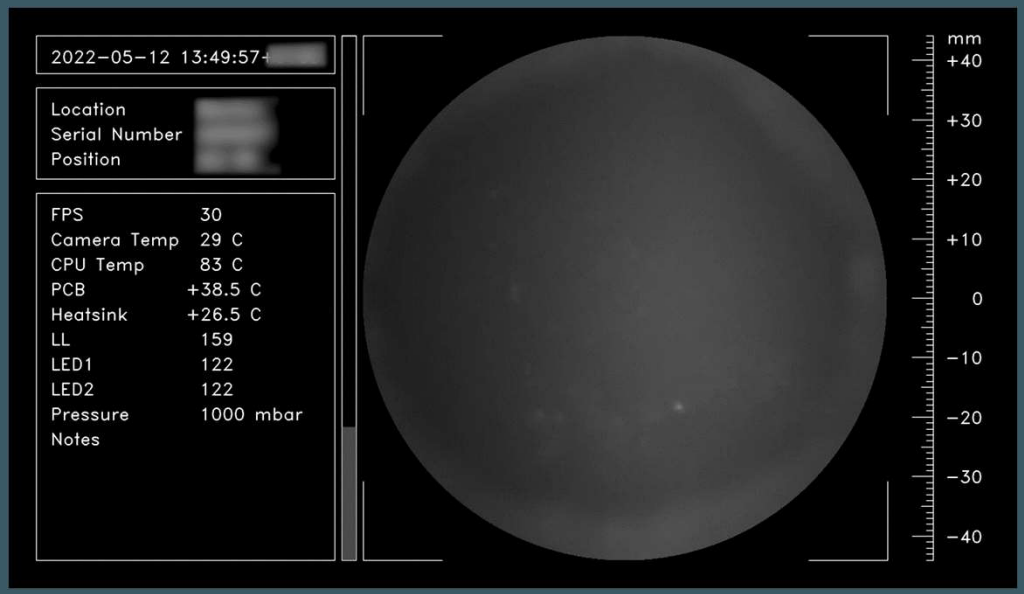
Are Gas Analyzers Telling us What We Need to Know?

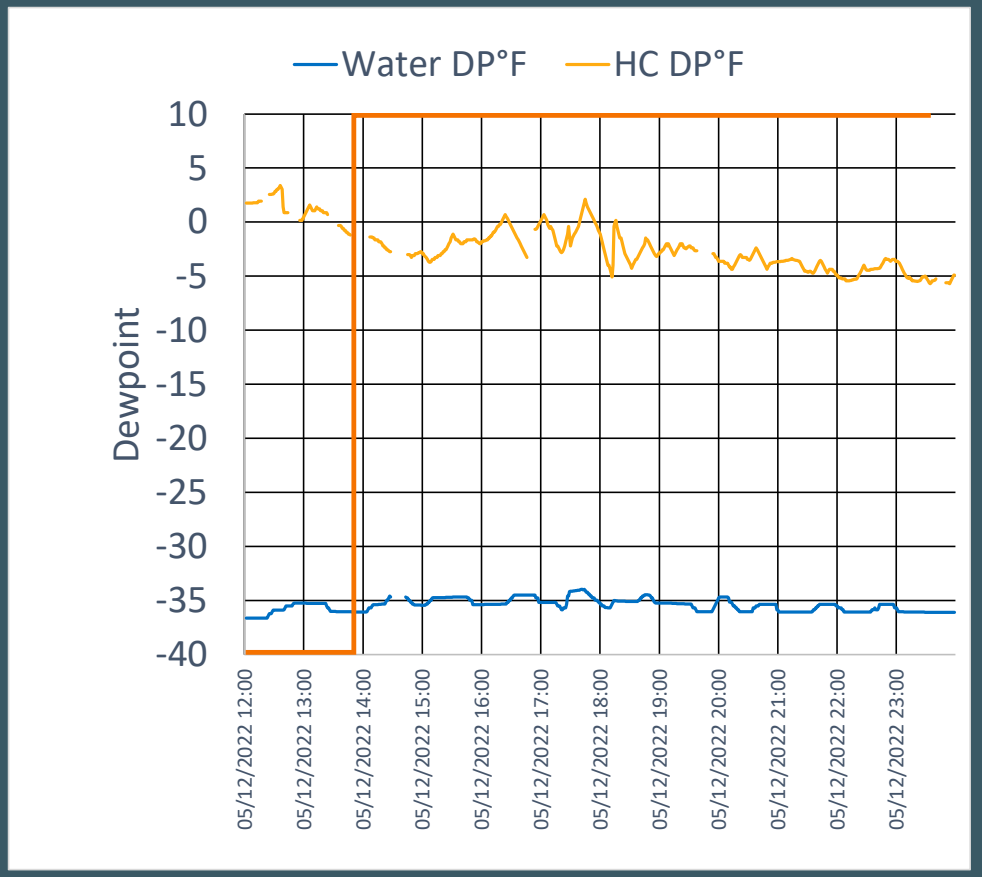
Let’s explore an example incident and our findings from a 2022 study

Are Gas Analyzers Telling us What We Need to Know?



Dewpoint Trace of the Event





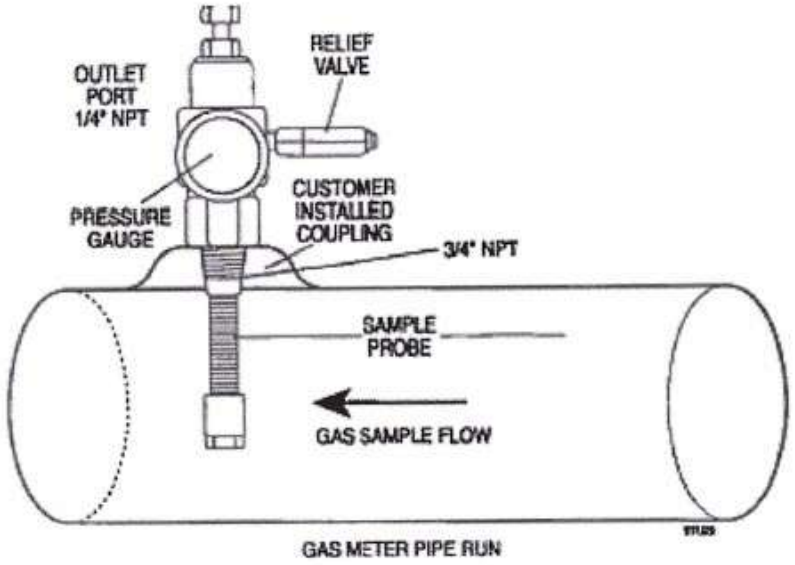
Gas Flow Stopped

Time Lapse – Liquid dries out

Solid Material Left on Pipe Floor

Gas Analyzer Sample Take-off API 14.1

- Sample take-off for gas analyzer is designed to avoid contamination on the pipe wall
- Membrane or coalescing filters remove liquids to protect the analyzer
- Gas analyzers measure gas phase only



TEG, MEG and liquid-phase HCs are not currently monitored

Two Phase Flow and API 14.1

API 14.1 is written around Single Phase Flow ONLY:

B.3 Multiphase Flow

Sampling of multiphase flow is outside the scope of this standard. Sampling of multiphase (gas and liquid) mixtures is not recommended and should be avoided if at all possible. In the multiphase flow, the ideal system would mix the gas and liquid flows uniformly and collect a sample of the true mixture flowing in the line by using a properly designed sample probe and an isokinetic sampling system. Current technology of natural gas sampling is not sufficiently advanced to accomplish this with reasonable accuracy. When sampling a multiphase liquid-gas flow, the recommended procedure is to eliminate the liquid from the sample. The liquid product that flows through the line should be determined by another method. The liquid fraction of the multiphase flow may contain water and hydrocarbons. The hydrocarbons can contribute significantly to the energy content (measured in British thermal units [Btu]) of the gas, and their presence in the gas line should not be overlooked.

When sampling we purposefully avoid liquids which, if present, can lead to **significant errors** in the energy content (Btu)!

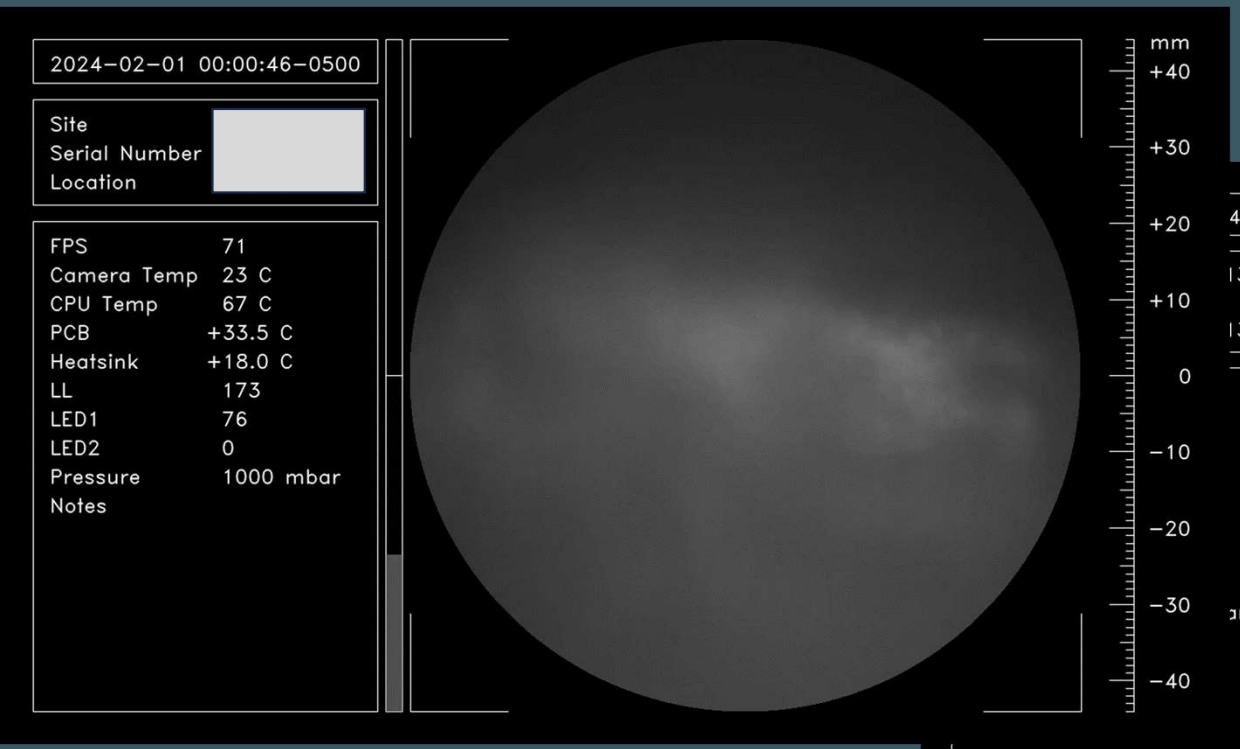
AND YOU WON'T KNOW

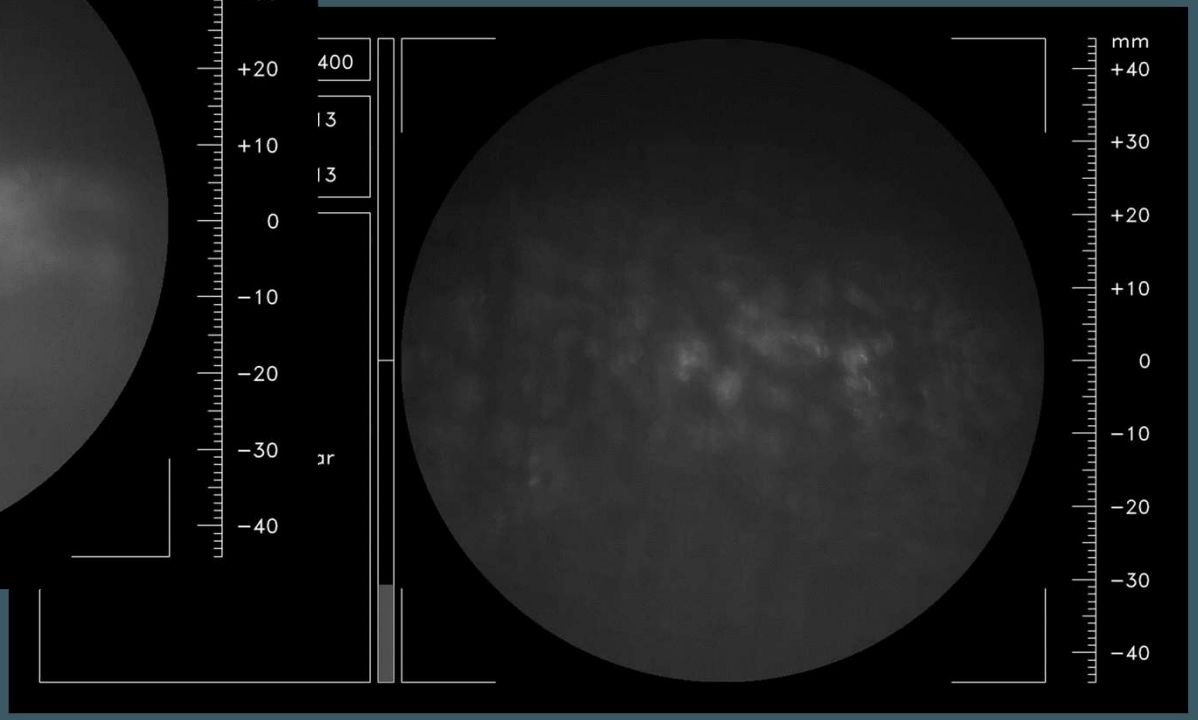
USA Pipeline Case Study – Spring 2024

Here we present a sample of a case study at a current US customer and how a camera system has helped them reduce liquid carryover.

Video Comparison

Feb 1st 2024





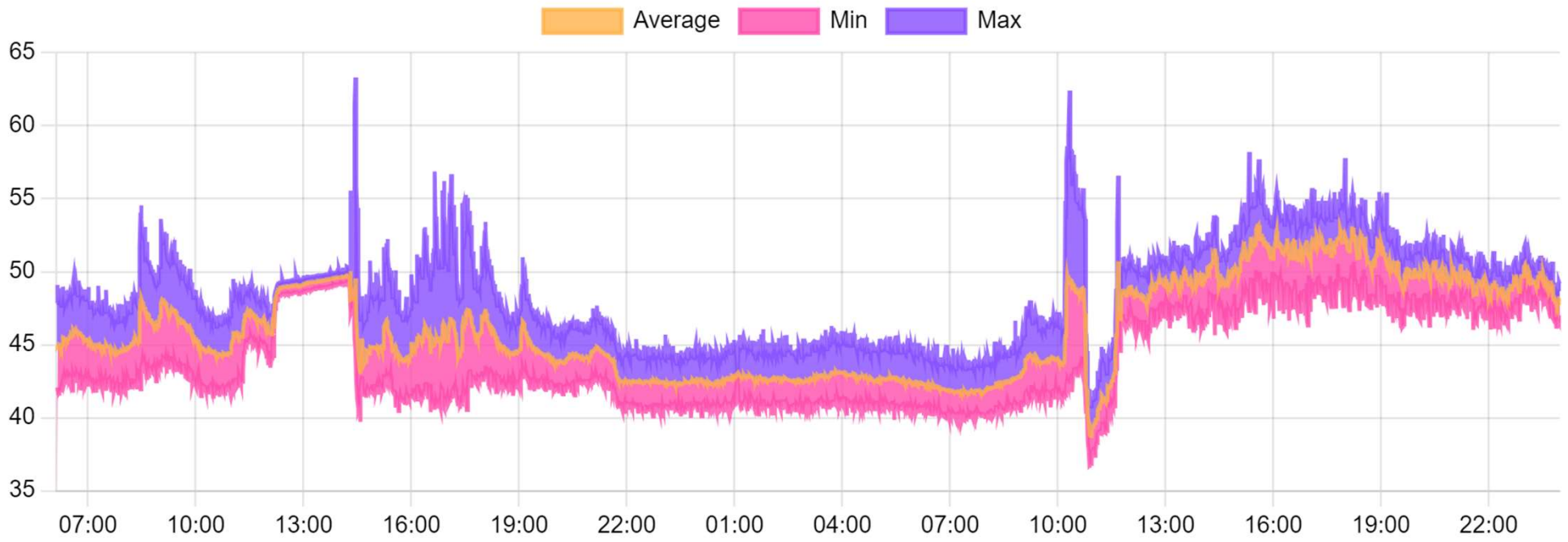
March 20th 2024

How we Score

Rating	Category	Description
7	Liquid Flows visible	Continuous Liquid flow observed
6	Liquids visible on the pipe wall	Liquid droplets observed on pipe wall
5	Very Heavy Mist Flow	Totally obscured pipe wall
4	Medium Mist Flow	Largely obscured pipe wall
3	Light to Medium Mist Flow	Heavy continuous shadows/lighter/obscuration
2	Light Mist Flow	Some shadows/lighter areas/obscuration observed
1	Very light Mist Flow	Clear views of pipe floor with occasional shadows/lighter areas/obscuration
0	Clear Gas	Very clear views of pipe floor

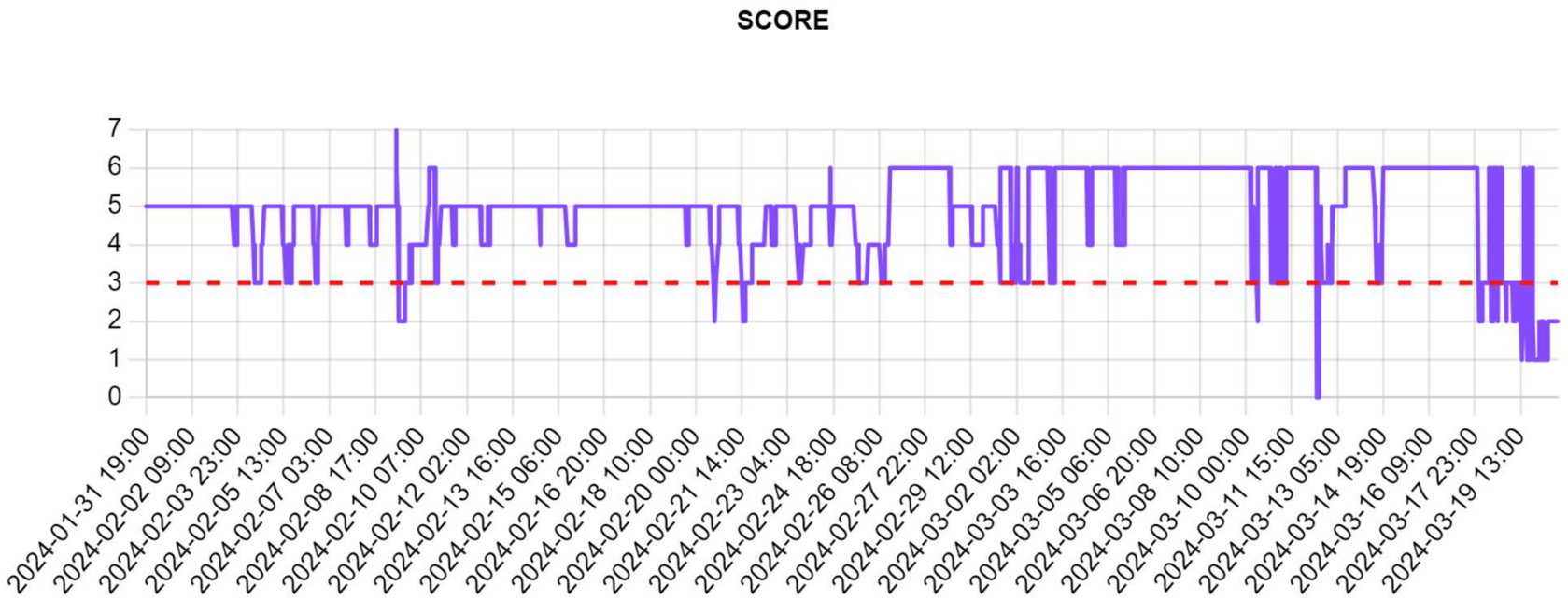
- Time-lapse videos are reviewed at very low speed to allow for frame counting when necessary.
- Also reviewed at a higher speeds to reveal distributed flows (droplets moving on the pipe wall)
- Once we have tuned in what normal looks like our machine learning (AI) model can be implemented for automated scoring…currently with 96% accuracy

How we Alarm - Brightness



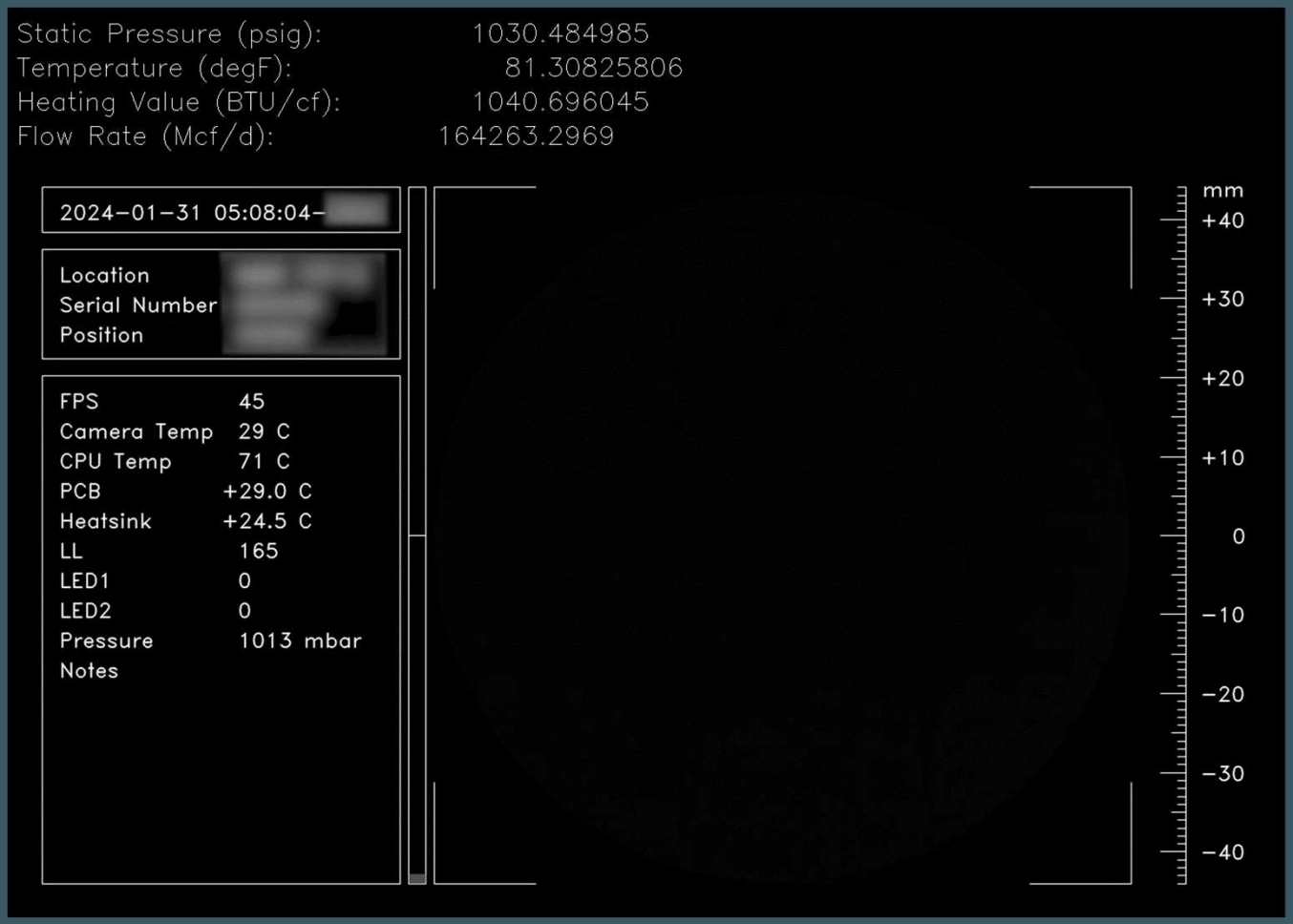
Scores – Entire Study Period to Date

Process Vision

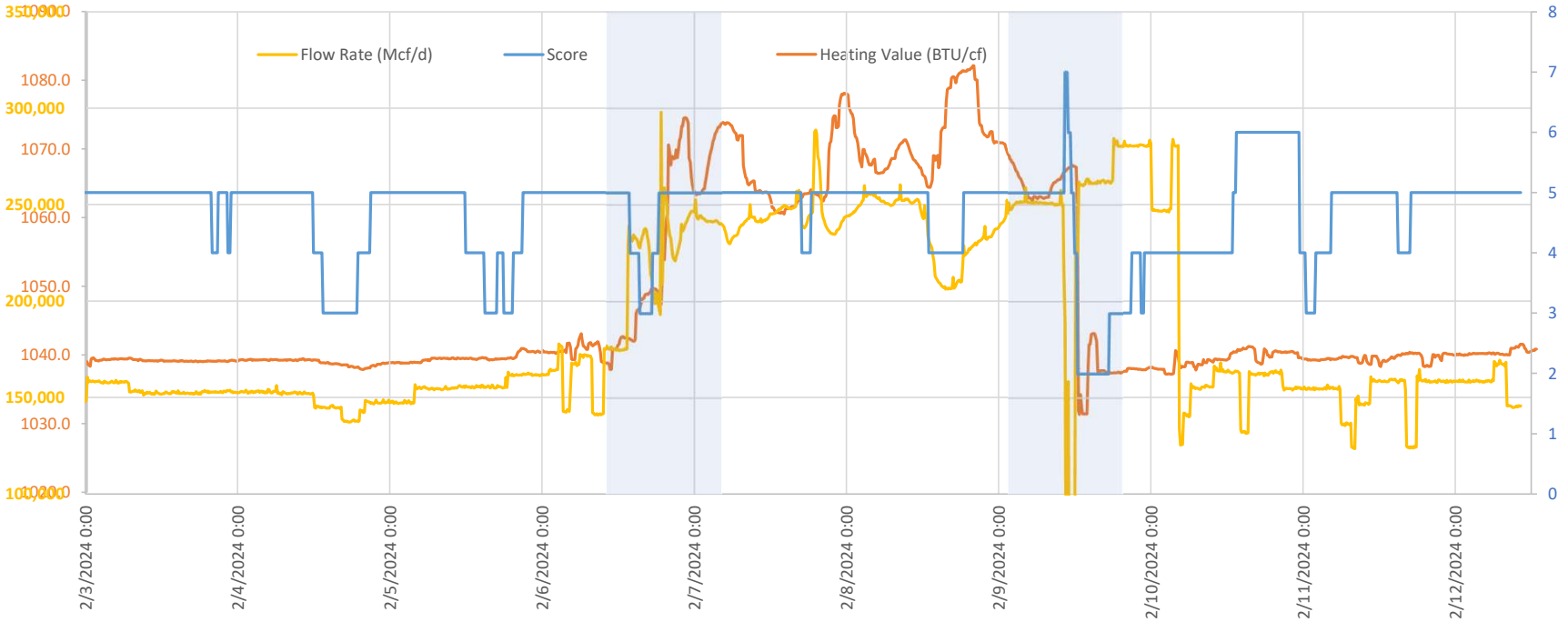


- Initial high mist flow changed to distributed flow (large droplets landing on the pipe floor)
- Over time, distributed flow has decreased
- April 2024 was mainly clear of liquids

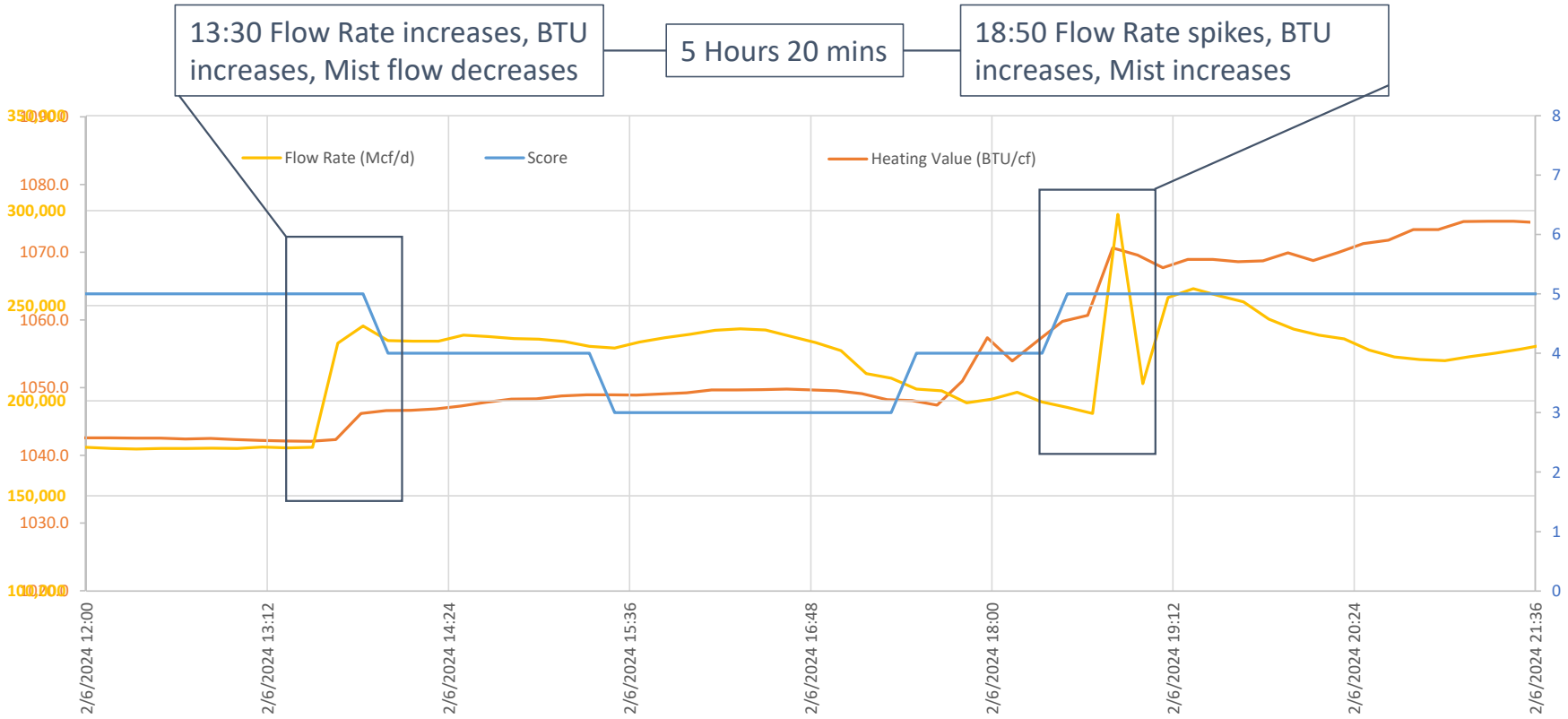
SCADA OVERLAY



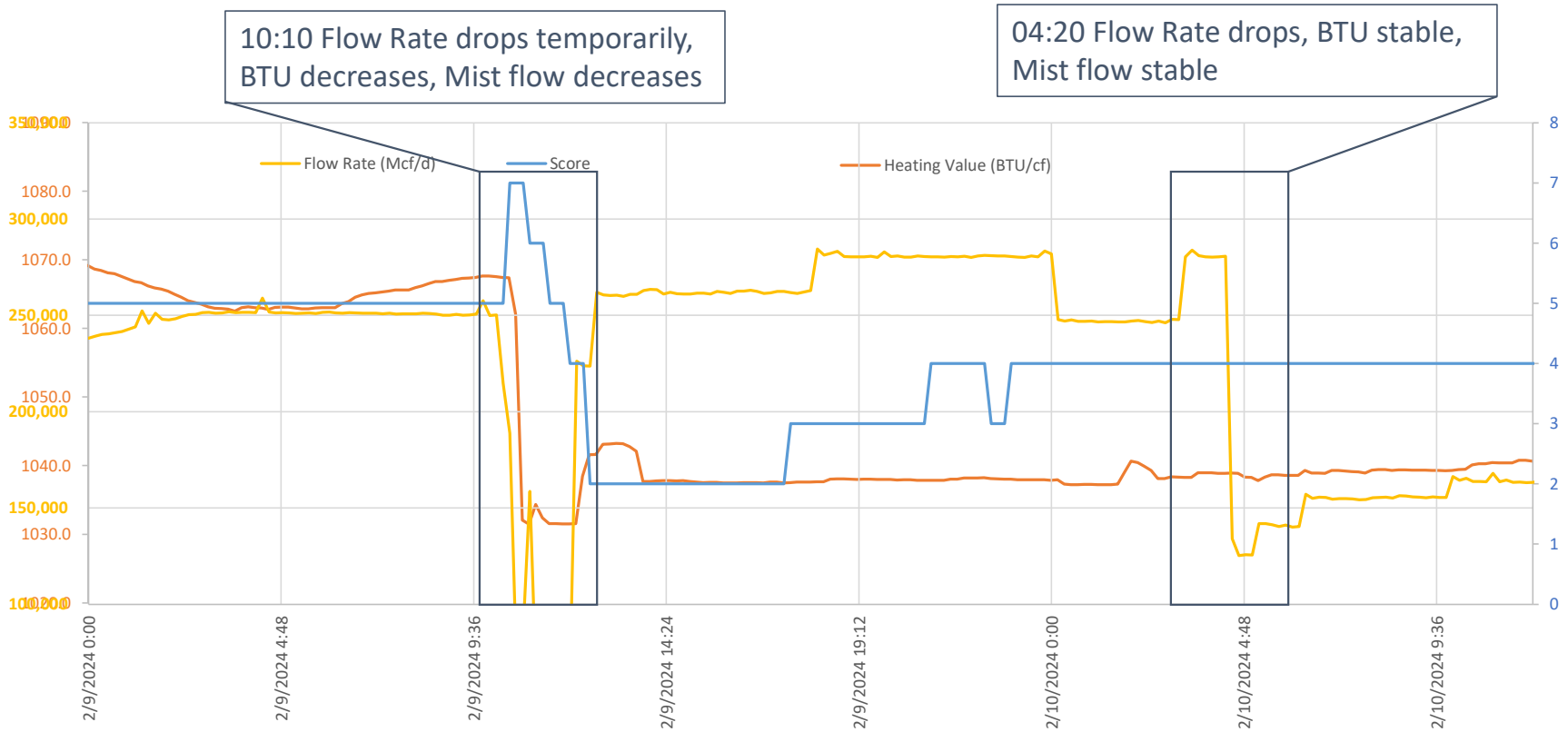
From March 3rd through March 12th



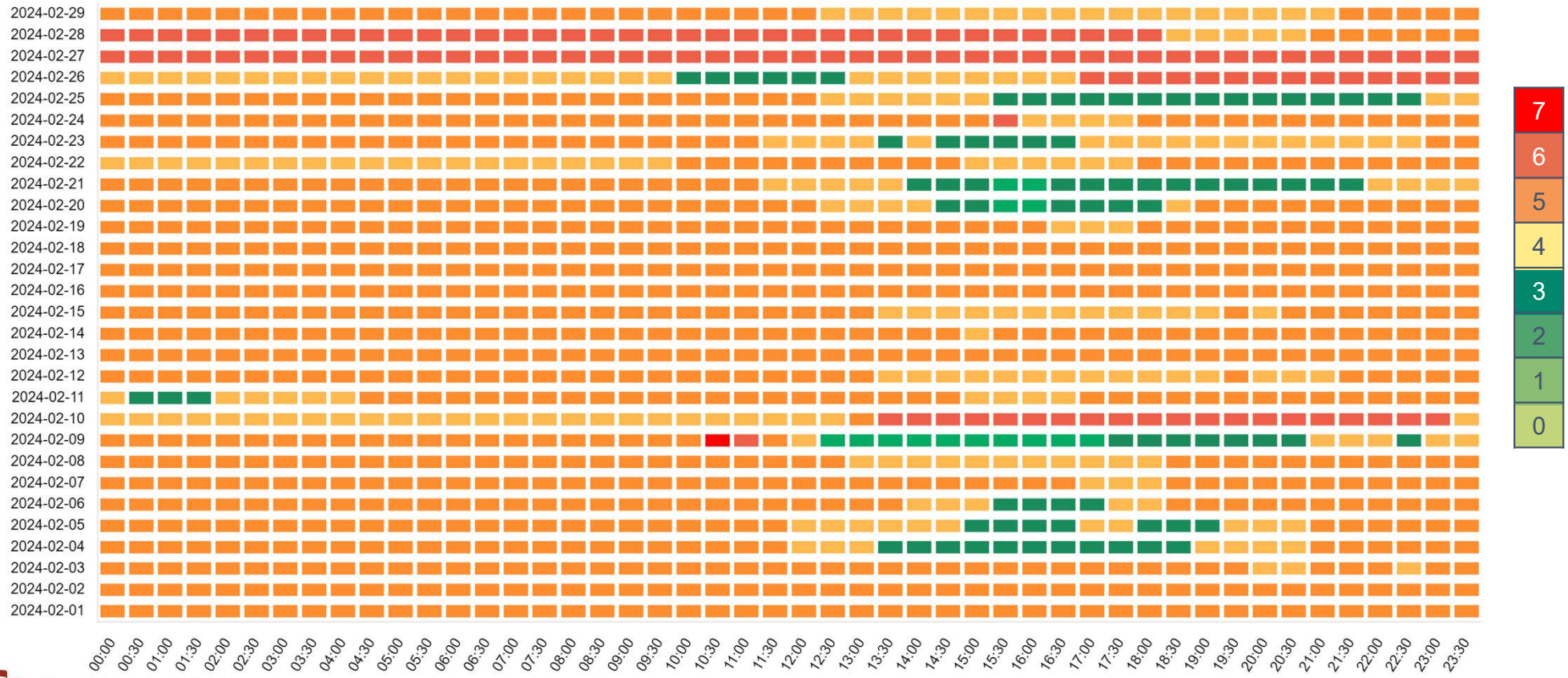
March 6th 12:00 Through 21:00



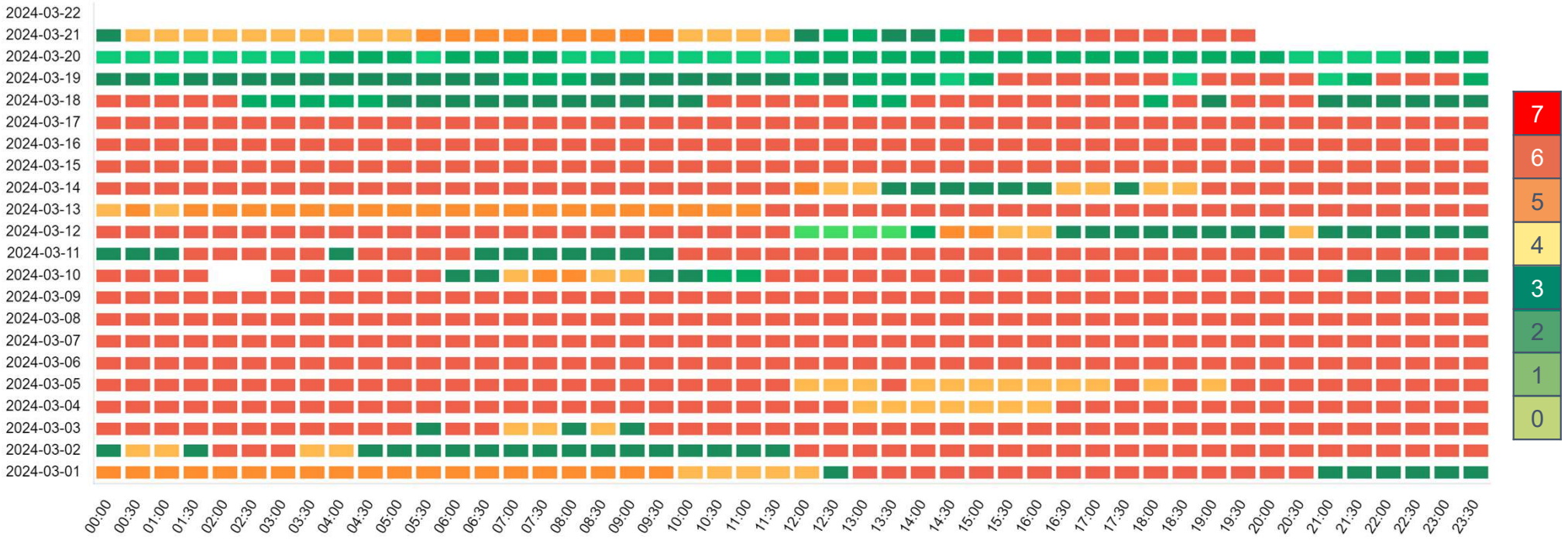
March 9th & 10th



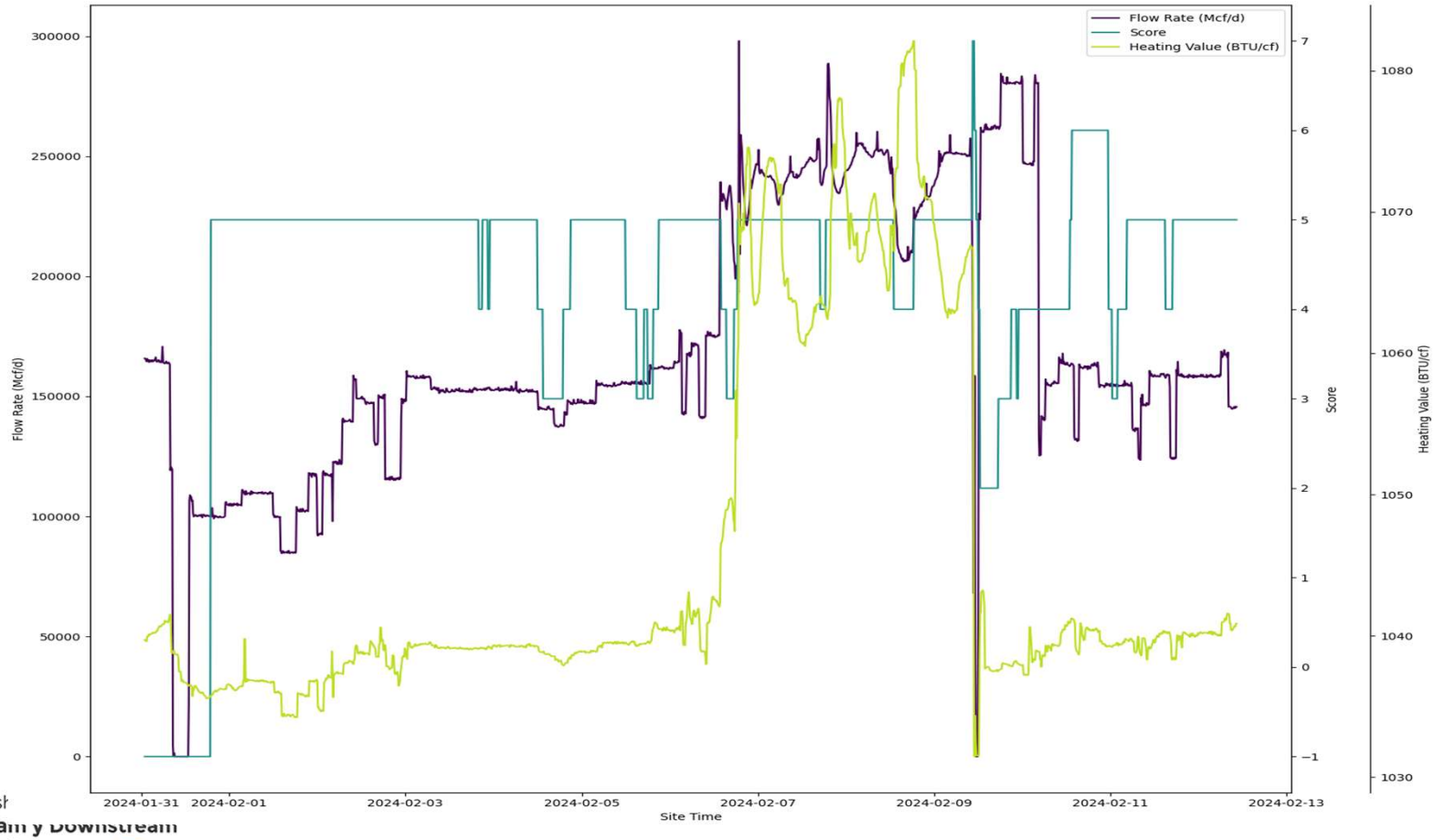
Heat Map - February



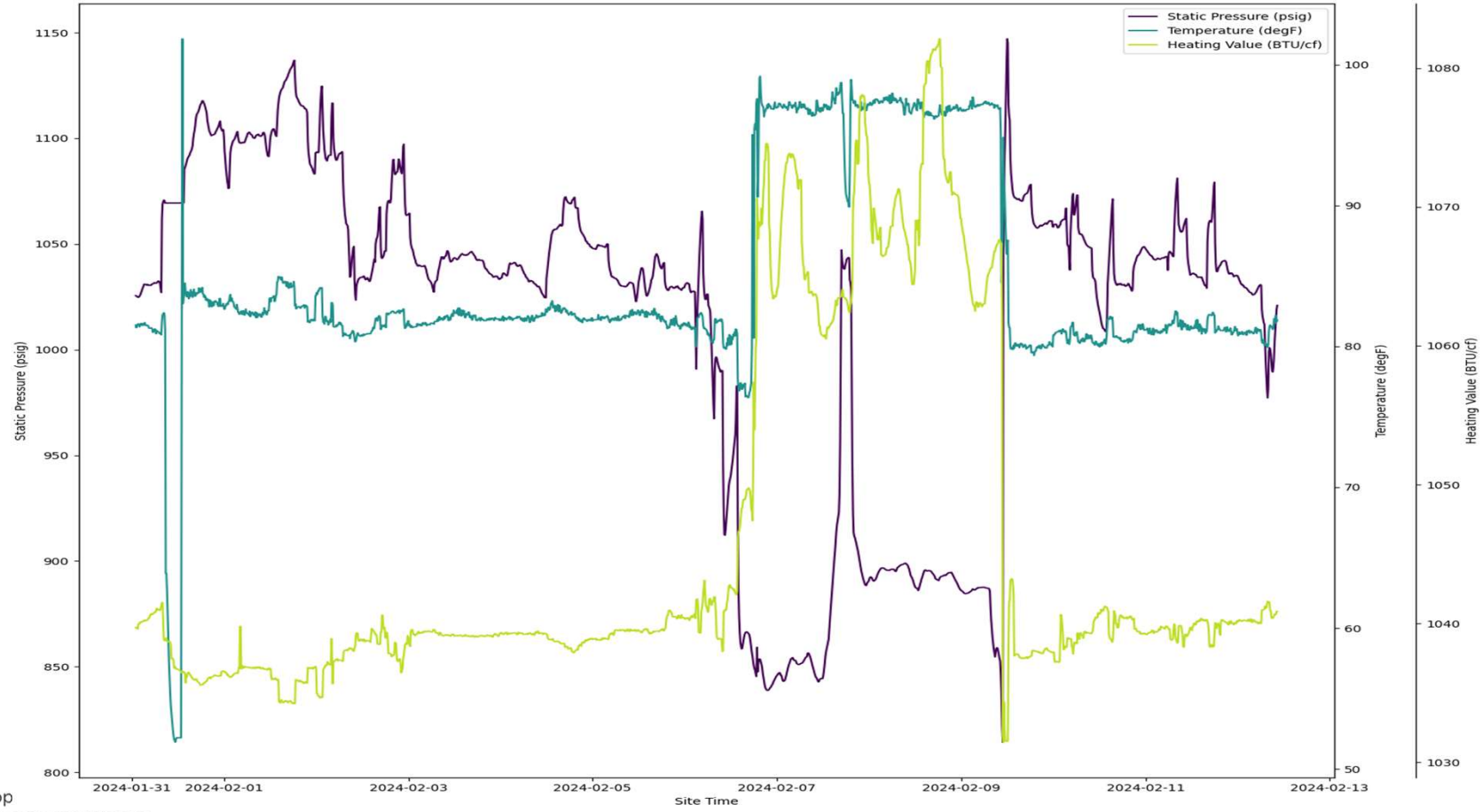
Heat Map - March



Flow – BTU – Mist Score



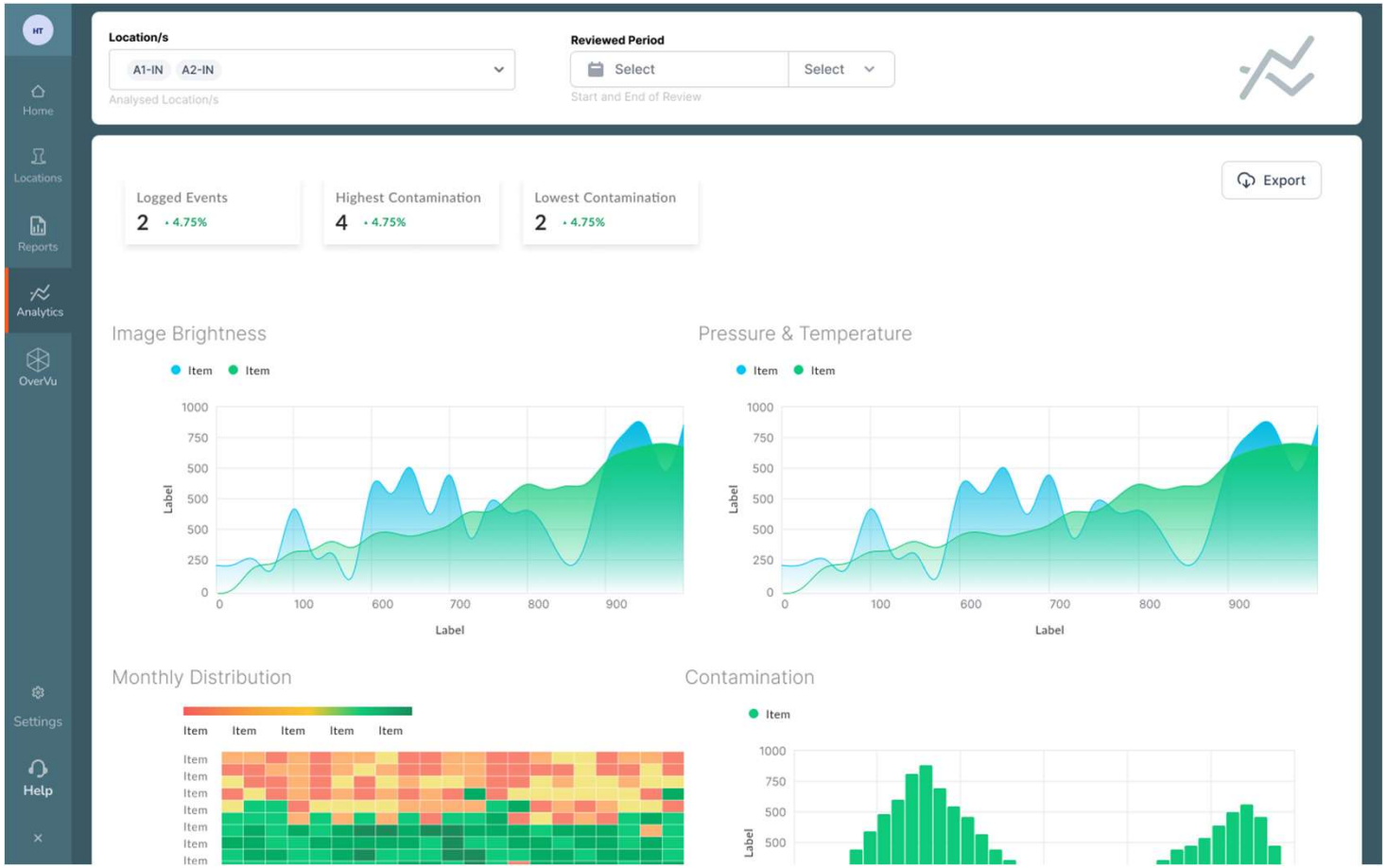
Flow, Temp & Pressure



USA Pipeline Case Study – Conclusion

- Customer initially had almost continuous heavy mist flow
- Working with processor were able to change filters and reduce liquids, but did take days to clear out
- During study found correlation between BTU fluctuation and flow rates (should only be measuring BTU of gas)
  - Determined with filter manufacturer that filters were overloaded at high flows and allowing liquid through
- Customer currently running studies at 5 additional sites

Online Portal – Automated Analytics



Study Report - Installation

6. [redacted] Installation

The system was installed on the 90cm diameter pipe to monitor incoming gas from [redacted]

Figure 3. OverView of site and location of LineVu installation

Figure 3 and Figure 4 show the tapping point location for the LineVu Canera Can at [redacted].

Figure 4. Details of tapping point used in trial

7. [redacted] Results

Study Report - Analysis

Process Vision

mist flow. Glycol and compressor oil are a non-volatile liquids and therefore would tend to appear as liquid on the pipe floor. HC liquids can appear as either mist flow or stratified flow.

Figure 9.Chart of gas flow Vs mist flow score.

Gas flow data was made available for some of the trial period. Figure 9 shows the interaction gas flow with the appearance of liquid on the pipefloor. Stratified flow can occur after a drop in gas flow rate when mist flow convertes to stratified flow due to the lower kinetic energy. This may appear immediately or several daya later depending upon how far back in the network the conversion occurs. Liquid droplets or a flow of liquid appears just after a drop in flow rate, on a few occasions and a general increase in frequency of liquid on the pipe floor can be seen 3 days after the gas flow rate decreased.

	Events	%	Cumulative wet gas flow
Level 0	558	21.8%	Dry Gas
Level 1	875	34.3%	34.3%
Level 2	409	16.0%	50.3%
Level 3	237	9.3%	59.6%
Level 4	136	5.3%	64.9%
Level 5	19	0.7%	65.6%
Level 6	309	12.1%	77.7%
Level 7	11	0.4%	78.2%
Total	2554	100.0%	

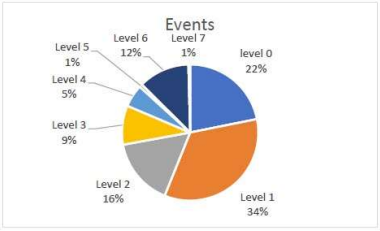


Figure 10. Mist flow catagories

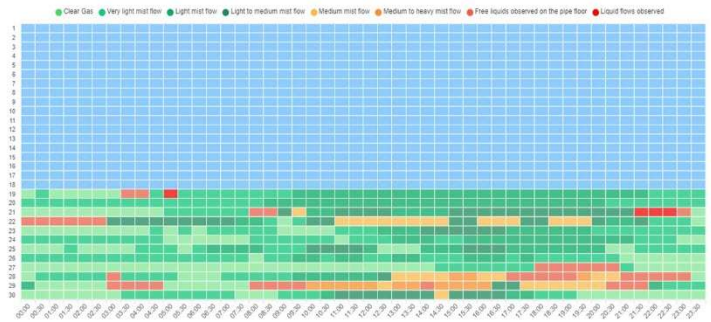
As seen in Figure 10, dry gas was observed for 22% of the trial time. The most frequest mist level (34% of time during the trial) was level 1. Wet gas was present for 78% of trial time.

Presenting mist level on a "heat map" can often show repeating patterns of diurnal changes.

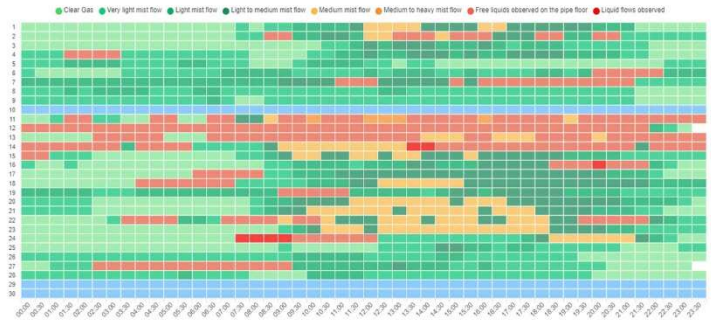
Study Report – Heat Map

Process Vision

[redacted]July 2023



[redacted]August 2023



The heat maps above show the mist level for each day of the trial starting at midnight running through to the following midnight. Durnal changes where a mist flow increases during the day and decreases or disappears during the night are an indication that the liquids seen are volatile and therefore HC liquids rather than glycol or compressor oil. These diurnal changes can be seen between the 18th to the 23rd August in the above heat maps.

45

Conclusions - Impact

Until now:

- Phase separator performance has not been monitored
- Glycol is not measured in gas quality measurements

The industry does not know when liquids are present

- Gas processors lose NGLs & glycol
- Increased operational expense for TSOs

Conclusions

With Live Camera Systems You:

- Improve confidence in gas quality.
- Sources of contamination better understood and controlled
- Increase production in gas plants
- Improve NGL recovery
- Lower fiscal measurement errors
- Lower pigging and disposal costs
- Lower compressor servicing costs

Thank You

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