



10/21/2021

Flexim Flowmeters for Attenuator Block Valve Leak-by Detection

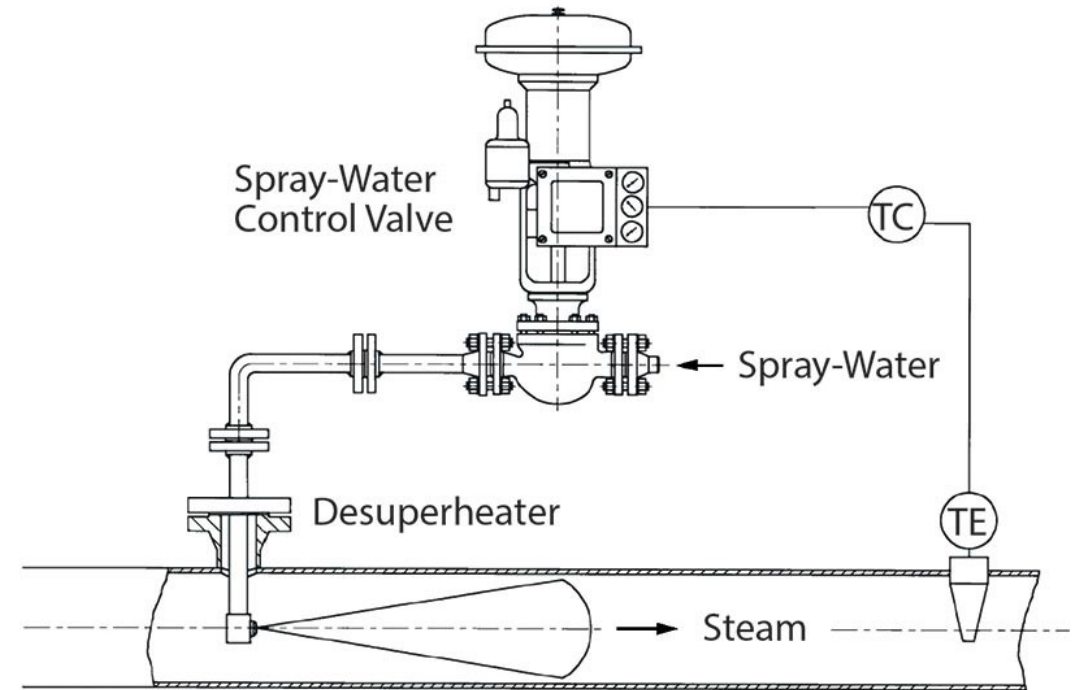
Eugene Eagle, PE

HRSG Engineer

Duke Energy—Carolina's Natural Gas

Introduction – Flexim Flow Meters for Attemperator Block Valve Leak-by Detection

- Attemperation is a critical process related to steam generation for steam turbines
- Attemperation is achieved by spraying liquid water into a steam flow which lowers the temperature of the steam by means of evaporation of the water
- Our fleet spray water lines typically operate with a block valve and temperature control valve combination
- It is critical that the attemperator work when needed, however it is equally as important that water is not sprayed into the attemperator piping when it is not required
- Wear on the block valve can lead to leak-by which has detrimental affects on the attemperator, internal liner, steam piping, and surrounding components
- Thermal quenching is likely once block valve leak-by occurs



Source: <https://www.process-heating.com/articles/92987-desuperheater-application-best-practices>

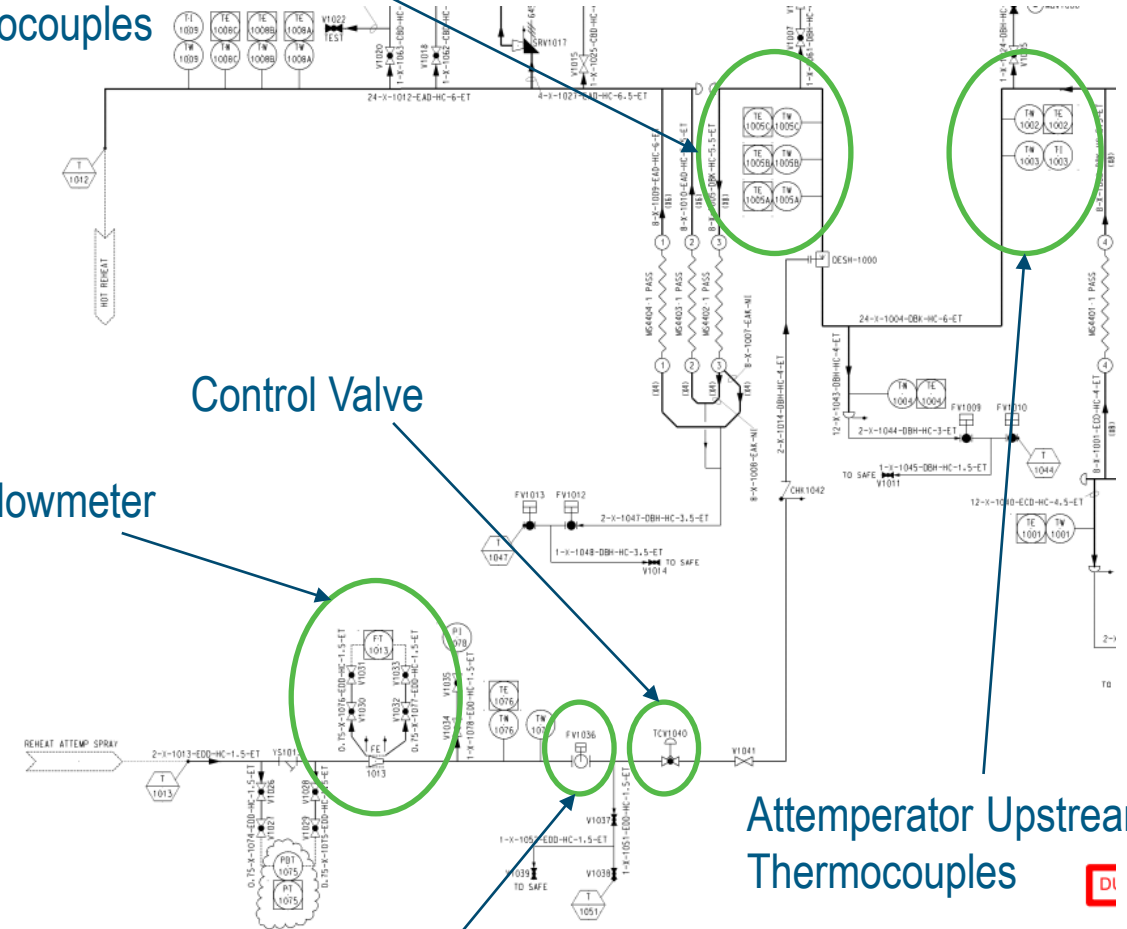
Background – Flexim Flow Meters for Attemperator Block Valve Leak-by Detection

- We want an indication of block valve leak-by, so we started with the existing instrumentation
- Existing flow transmitter – The existing flow transmitter is an orifice style DP flowmeter
 - Differential Pressure Flowmeters suffer from the non-linear relationship between flow and DP, which can have a detrimental affect on the accuracy and turndown of the flowmeter
- Thermocouple Comparison – In the past we have used a comparison of the thermocouples upstream and downstream of the attemperator (not accurate for low flows)
 - Acoustics – We considered acoustical monitoring, but current technology only give a noise signature, not an actual flow rate
- We found that both the TCV and block valve maintenance and replacements were being neglected at many of the CC Sites.

Attemperator Downstream
Thermocouples

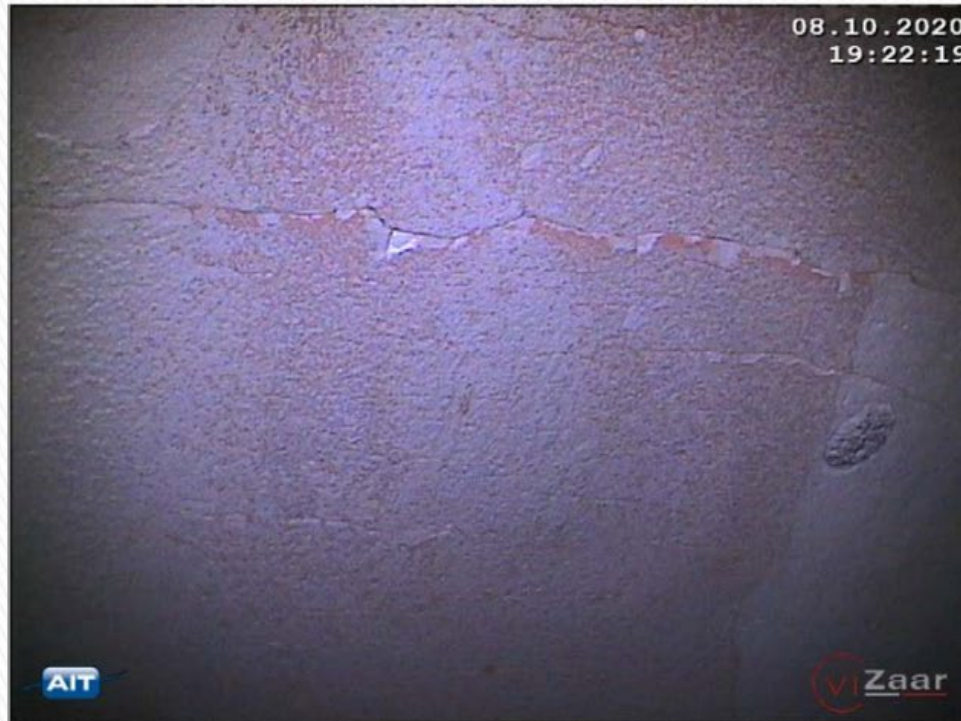
Control Valve
DP Flowmeter

Attemperator Upstream
Thermocouples



Why Do You Need Spray Valve Monitoring?

Borescope Photos



Unit 01A HP Attemperator Liner

Why Do You Need Spray Valve Monitoring?

Borescope Photos

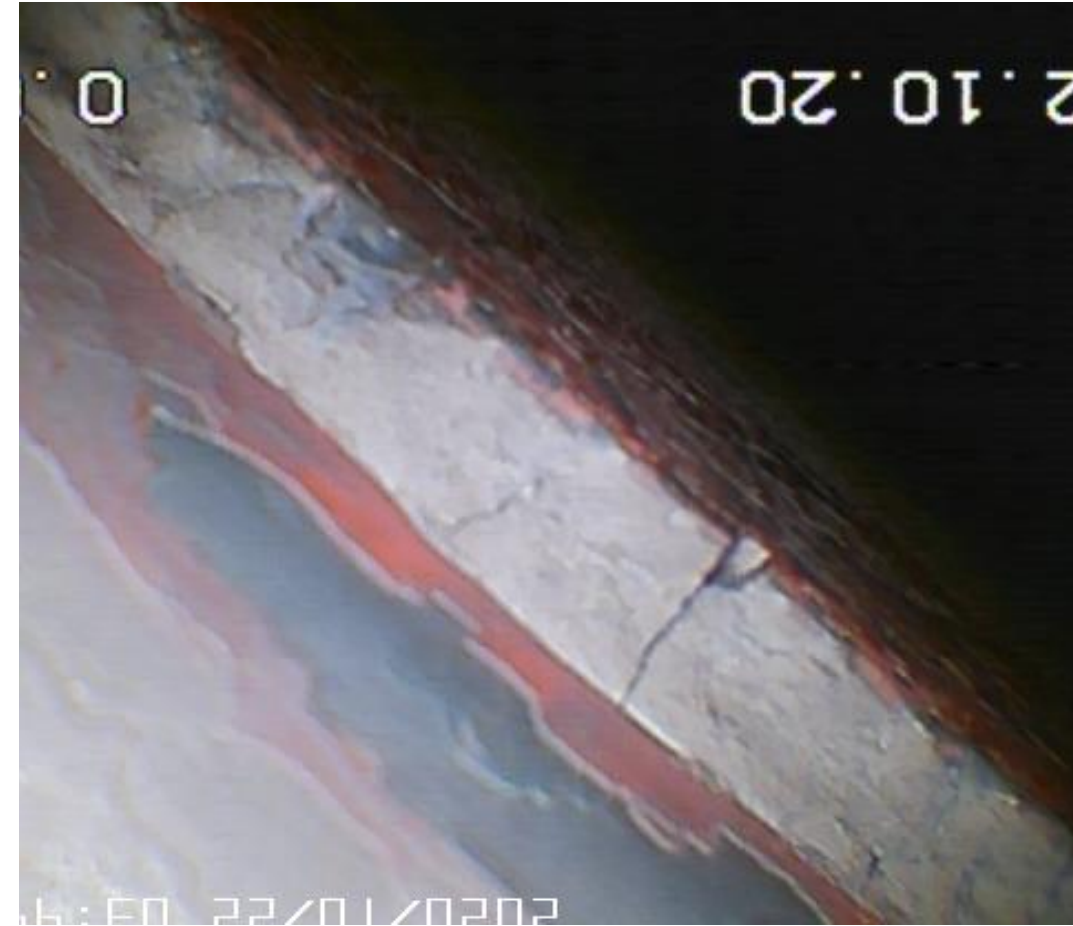


Unit 01C HP Attemperator Liner

Smith PB4 Unit 8 HRH Steam Piping Downstream of the Attenuator



Root of downstream steam pipe weld from the inside bottom



Steam Piping and Attemperator Internal Liner - Damage Examples



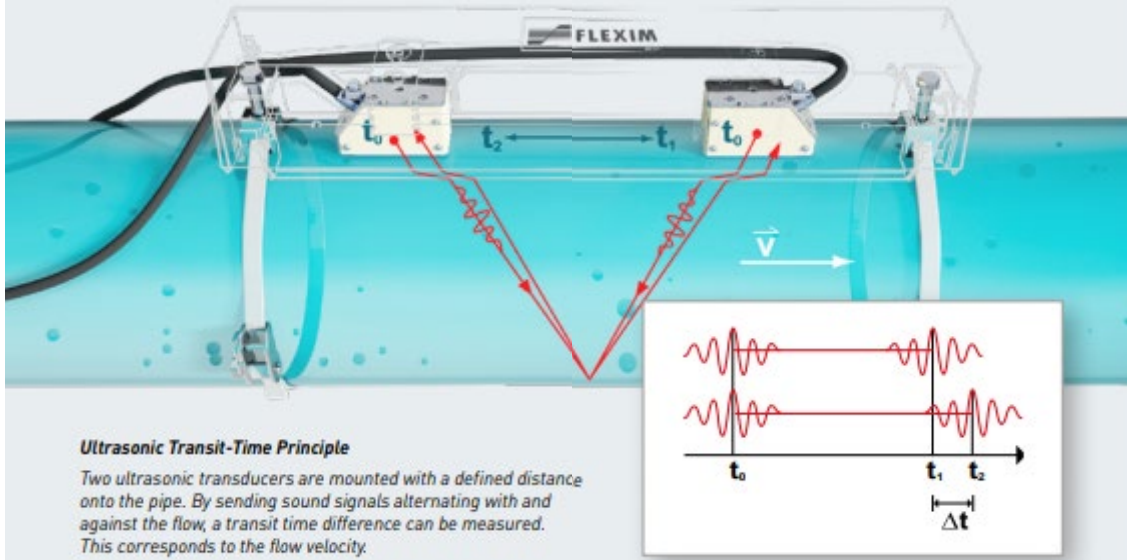
Steam Piping and Liner Damage

- Attemperator block valve leak-by was believed to be a primary or secondary root cause to many of these issues
- Expensive replacement projects are required to replace attemperators and steam piping

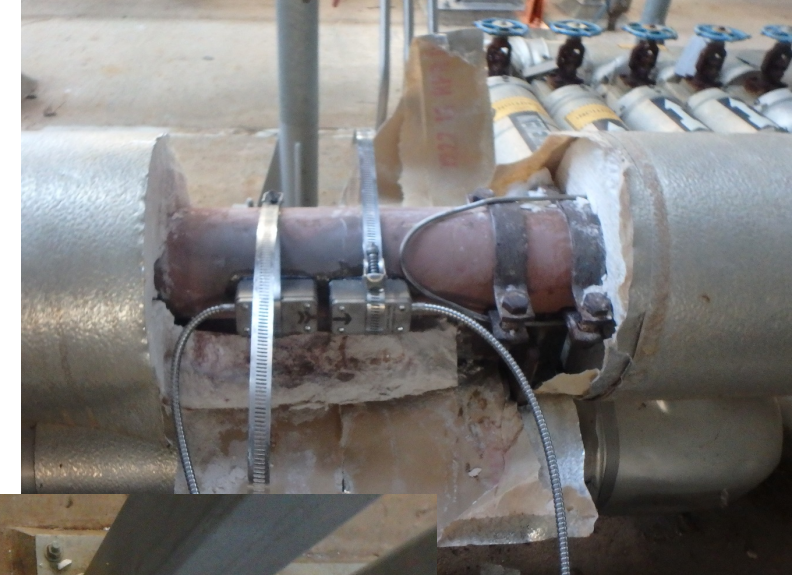


Flexim Technology – Flexim Flow Meters for Attemperator Block Valve Leak-by Detection

- Reached out to Bob Anderson and EPRI to see if they had recommendations for block valve leak-by detection – they offered up a portable Flexim Ultrasonic Flow Meter – F601 model for field trial
- An ultrasonic flow meter is a meter that is used to measure liquid velocity with ultrasound to analyze the volume of liquid flow



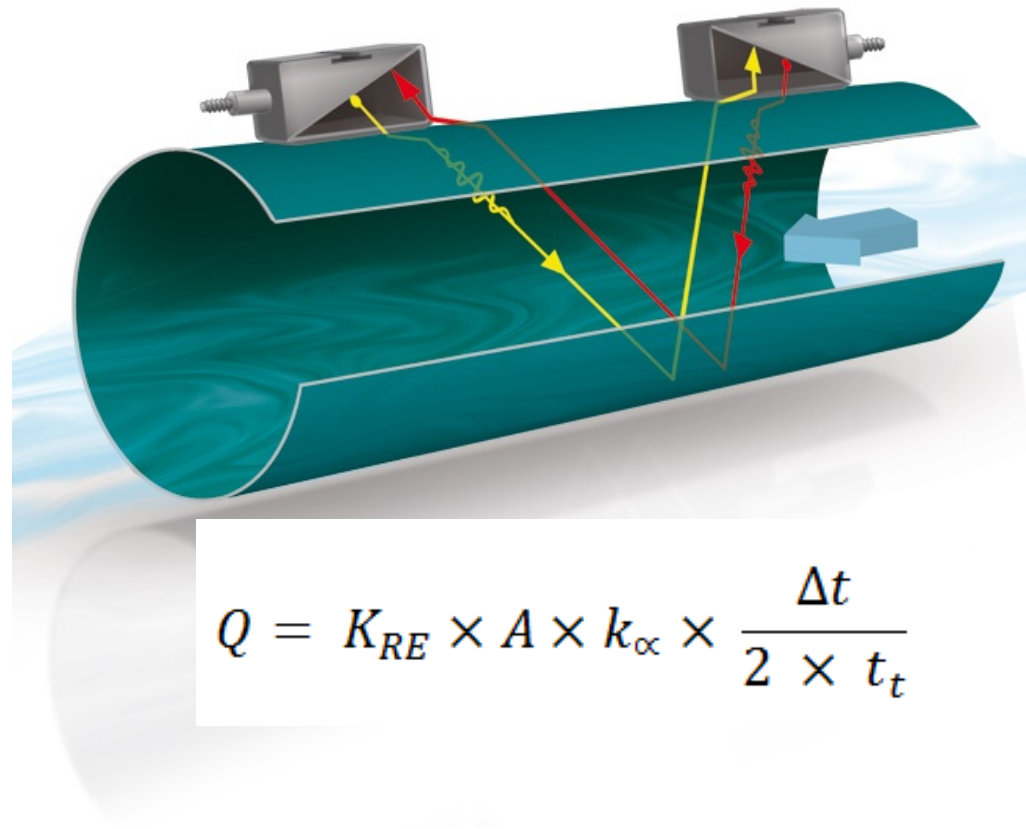
Source: Flexim Americas Corp



Basic Theory Ultrasonic Technology for Clamp On Metering

Transit Time Operating Principle Used for Liquid, Gas and Low-Pressure Steam

- Q - Volume Flow
- K_{RE} - Fluid Mechanical Correlation Factor
- A - Cross-Sectional Area of Pipe
- k_a - Transducer-Constant
- $D t$ - Transit Time Difference
- t_t - Transit Time in Medium



$$Q = K_{RE} \times A \times k_{\alpha} \times \frac{\Delta t}{2 \times t_t}$$

Advantages

General Non-Invasive

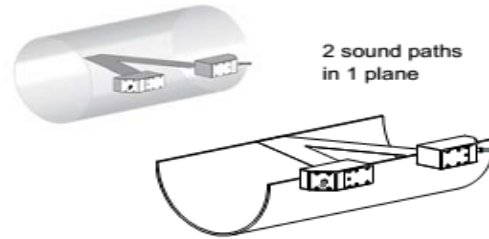
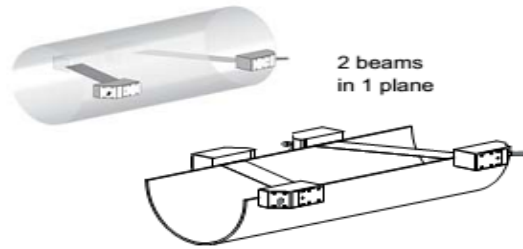
- **No Fouling**
 - **Scale – Abrasion – Corrosion**
- **Bi-Direction**
- **Extremely large measurement range**
 - **Catches back flow or leaky check valves**
 - **No pressure drop**
- **Nearly Indestructible**
- **Meters can be repurposed as needed**
- **Permanent Coupling pads = No maintenance**

FLEXIM

- **No Drift**
- **Completely Zeroed**
- **Industrial design**
- **Remote configuration and trouble shooting**
 - **24/7 Support**
 - **Technical Rep network**
- **Wide range of frequency and wave forms for best fit per application**
- **Complete focus on Flow and non-invasive technology**
- **Application Promise**

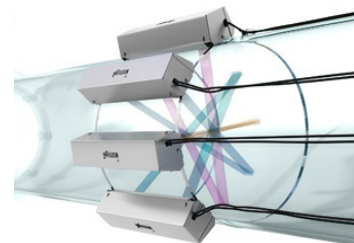
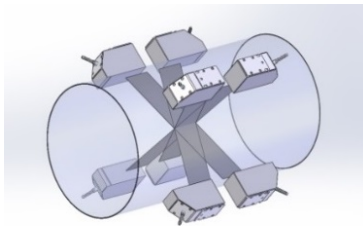
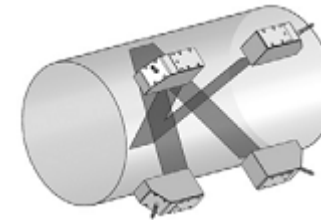
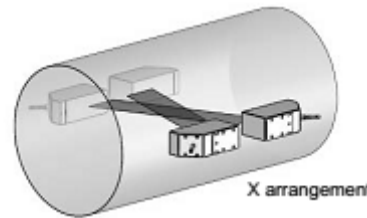
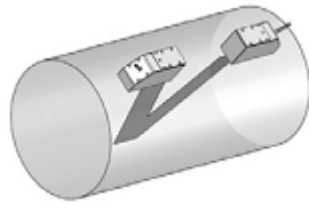
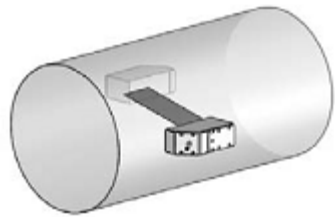
How are the sensors installed?

➤ Different ways of installing transducers on the pipe



➤ The compensation of flow profile deviation improves with increasing number of installed sound paths

➤ Following arrangements are common:

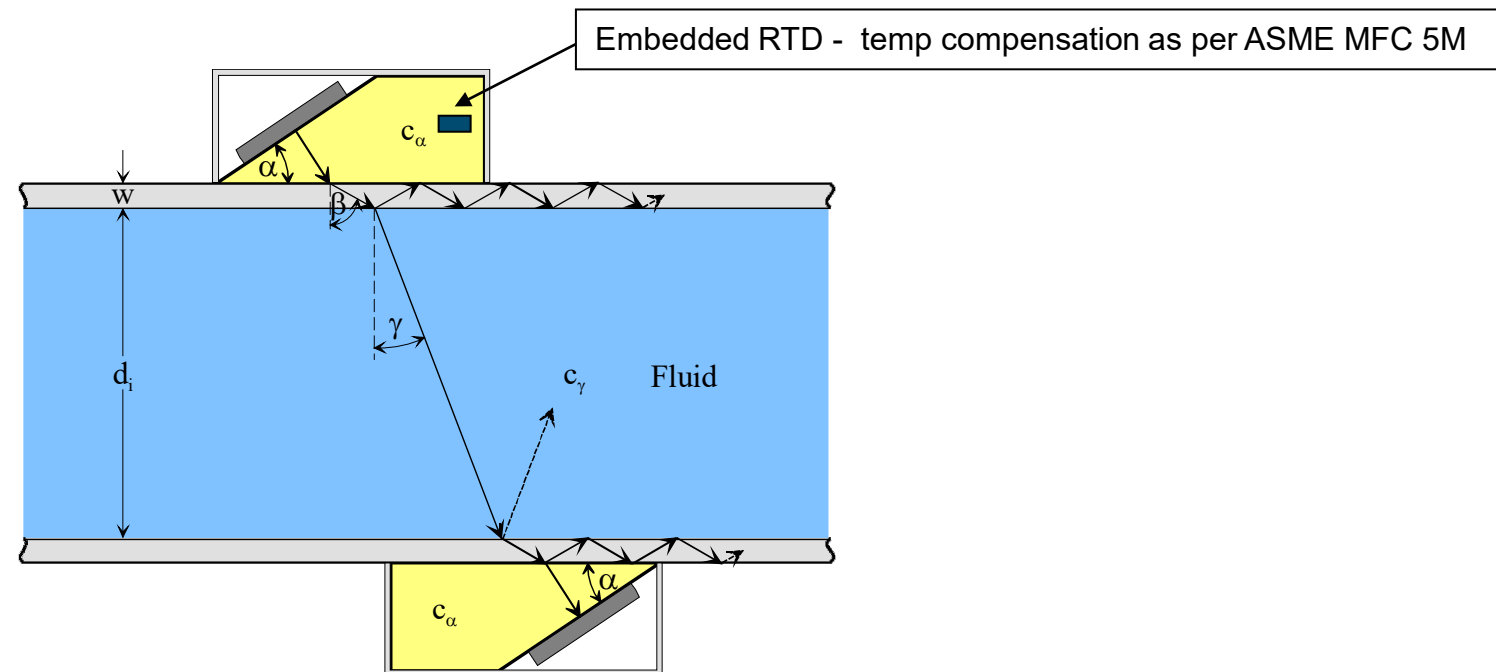


➤ ... also with four measurement channels available

Low Flow Applications

What do we need to measure low flows accurately?

The first thing we need is temperature compensation on the transducer. The embedded RTD does just that. Without it, we get drift from temperature and the low flow is hidden by a low flow cutoff.



Source: Flexim Americas Corporation

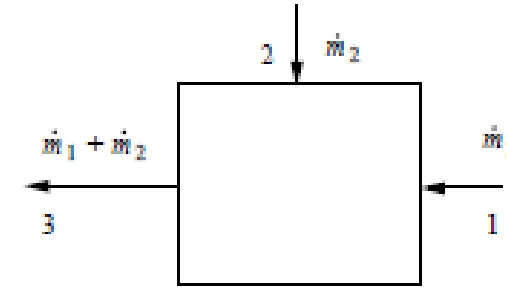
Field Trial – Flexim Flow Meters for Attemperator Block Valve Leak-by Detection

Methodology

- Mass Balance - A mass balance across the attemperator was used to calculate the expected spray flow using steam flows, steam temperatures before and after and spray temperature and the associated enthalpies.



▪ Open (mixing)



$$\dot{m}_1 h_1 + \dot{m}_2 h_2 = h_3 (\dot{m}_1 + \dot{m}_2)$$

- Comparison to Mass Balance – The Flexim Ultrasonic Flow Meter was compared to the Mass Balance
- Comparison to DP Transmitter – The Flexim Ultrasonic Flow Meter was compared to the DP Transmitter
- Observe data with tight shutoff – We asked operations to manually isolate a downstream valve and observed the change in flow

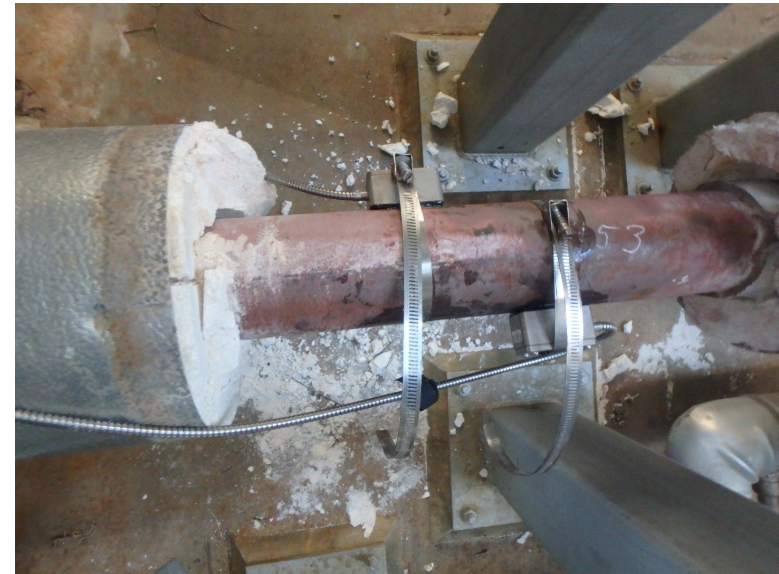
Application Details – F601 Portable FLEXIM

- Flexim Ultrasonic transducers were installed on the HF Lee Unit 01A HP and RH attemperator spray lines to evaluate flow detection effectiveness. The two sets of transducers go to a single flow meter that can accept both inputs. The HP spray line is 3" schedule 160 pipe and the RH spray line is 3" schedule 80 pipe. The goal is early detection of block valve leak-by to minimize damage from thermal shock. Photos of the installation are below:

RH Attemperator Spray Line



HP Attemperator Spray Line



HF Lee Application

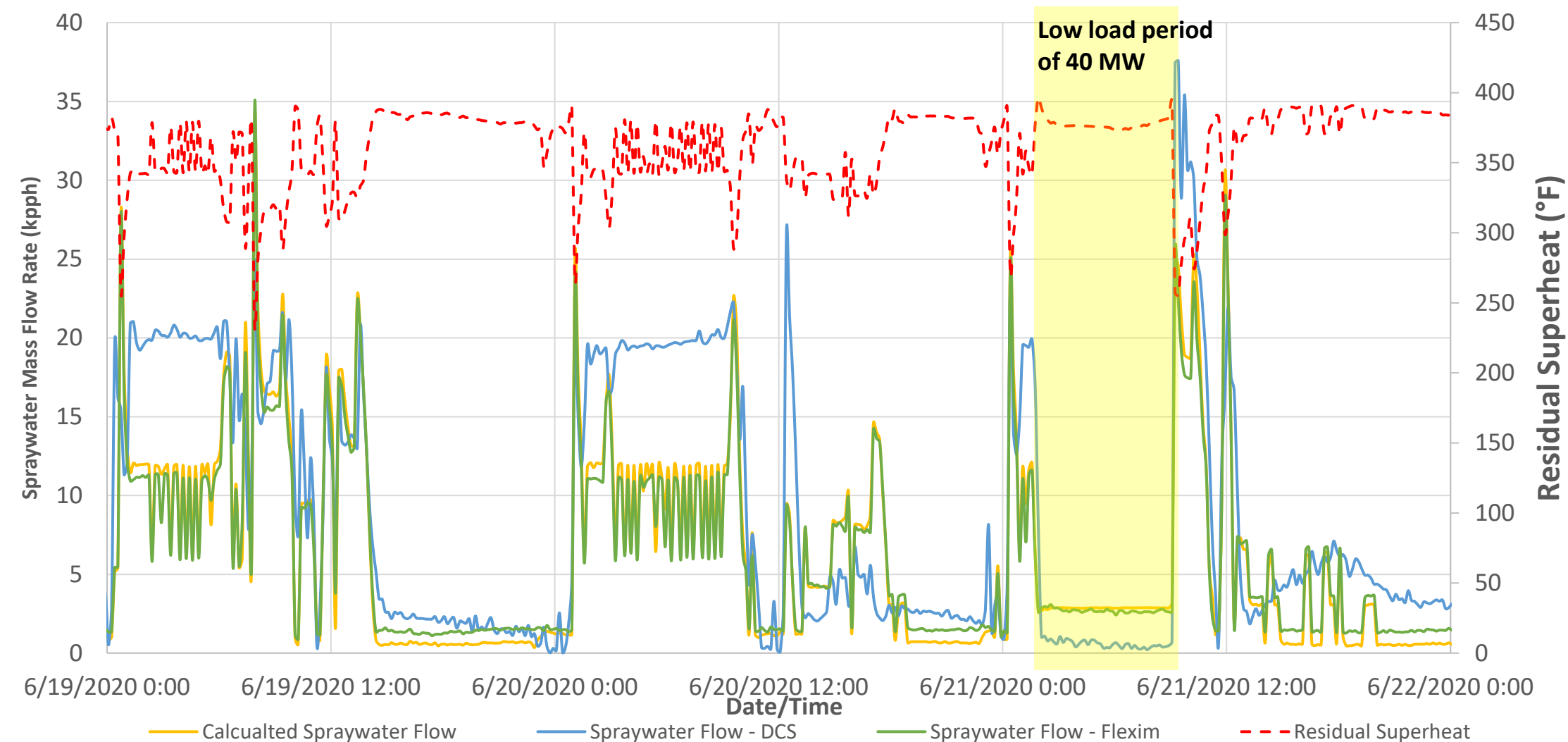
HF Lee HP Attemperator Liner Cracking

- 3x1 Vogt HRSG Units. Commissioned 2012
- All three HP attemperator spray liners have had cracking discovered
- CCI ring style attemperators
- HP attemperator spray block valve leak-by believed to be the root cause of the cracking
- Also, cold steam turbine startups leading to very low margins to saturation due to attemperator overspray
- Difficult to diagnose block valve leak-by using installed instrumentation due to it being more of an issued during startups and shutdowns

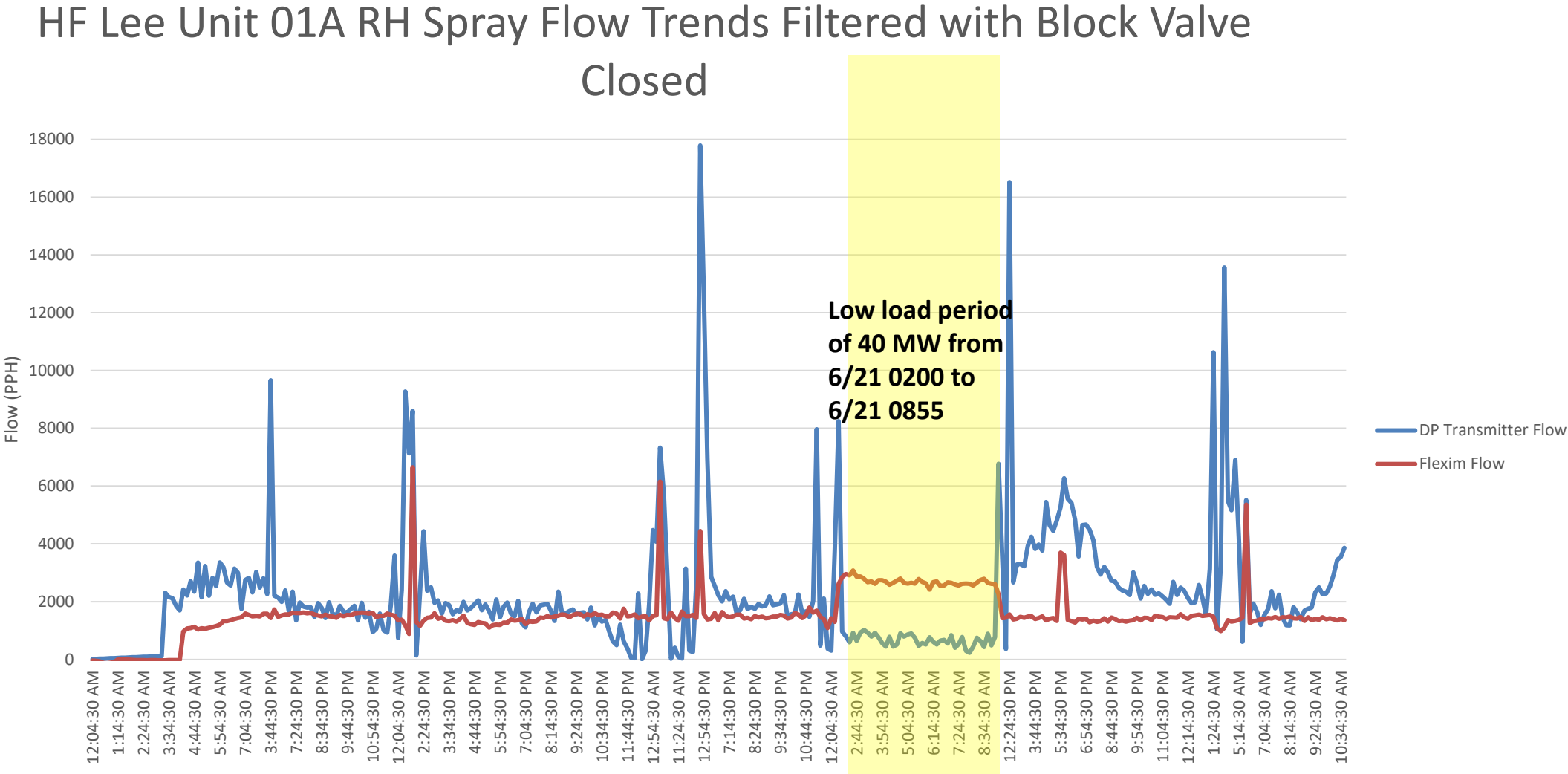


Field Trial – Flexim Flow Meters for Attemperator Block Valve Leak-by Detection

HF Lee Unit 01A RH Attemperator



Field Trial – Flexim Flow Meters for Attemperator Block Valve Leak-by Detection



Reheat Observations



The calculated spray flow matches up closely to the Flexim flowmeter



The graph filtered for block valve closed confirms block valve leak-by



When CT load is at low load of 40 MW, the Flexim flowmeter shows the highest leak-by flow confirming that during startup/shutdown and low load periods leak-by will be the highest due to larger DP across the block valve.

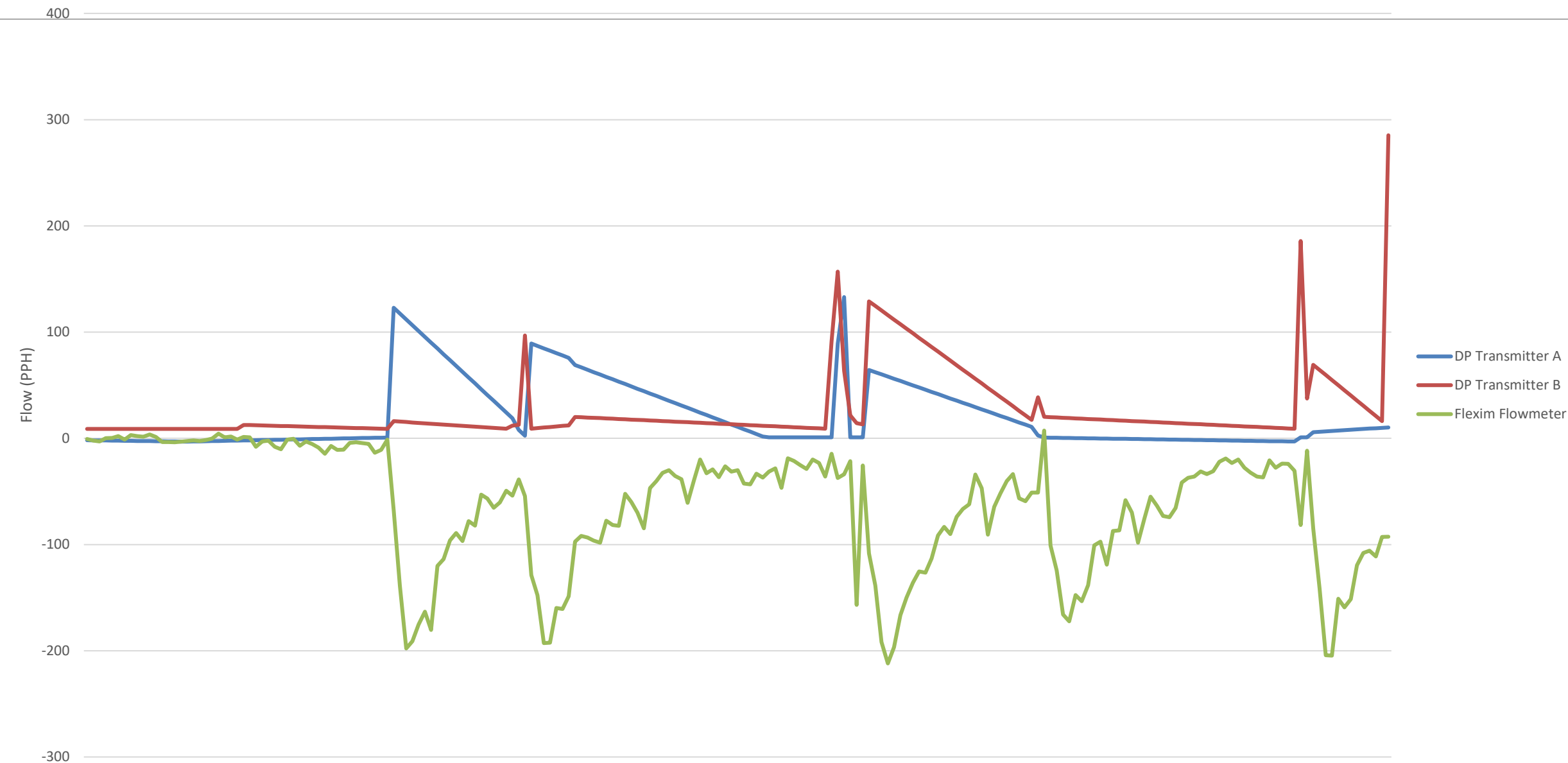


The installed DP flow transmitters are not very accurate. There is typically an offset between the DP transmitter versus the calculated flow and Flexim Flow.

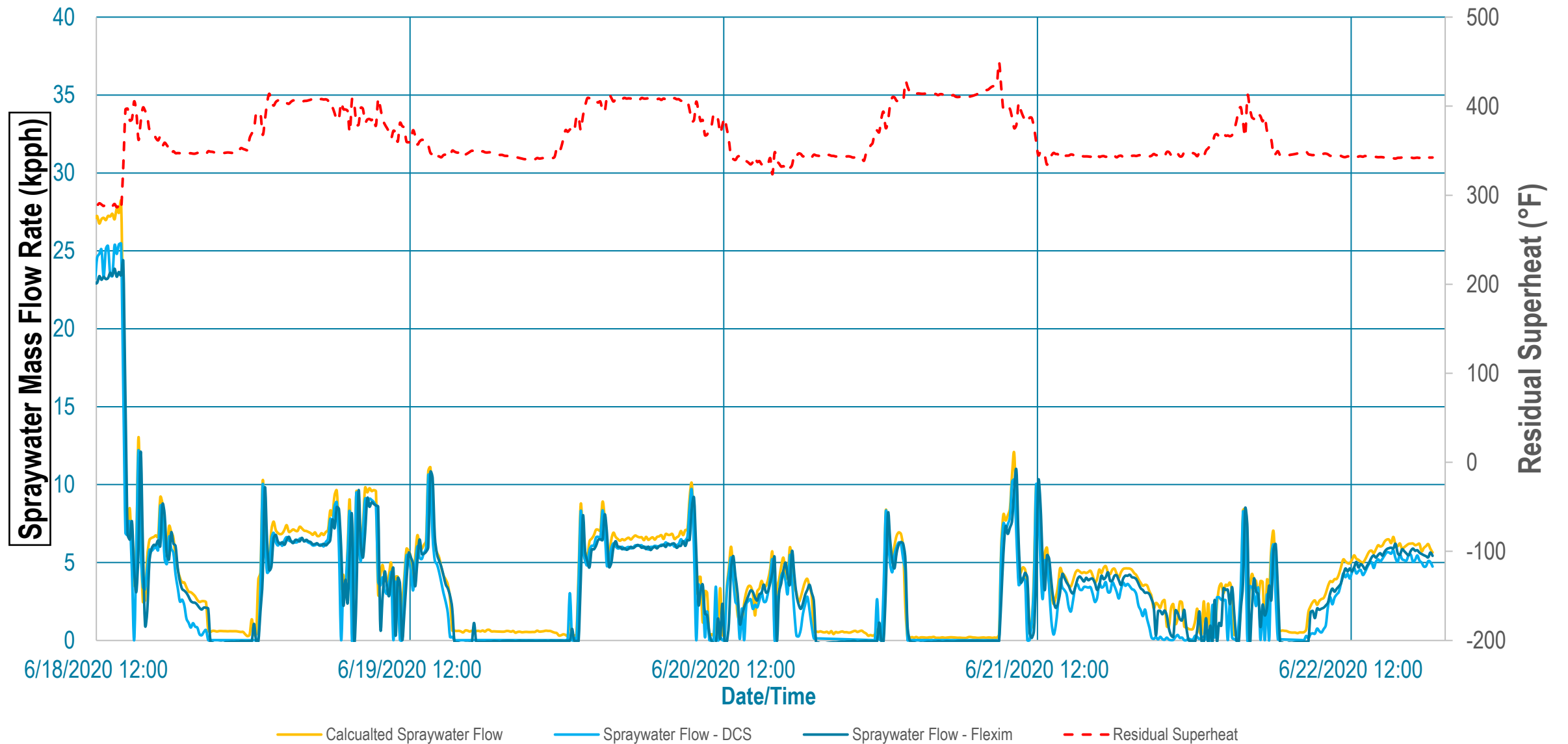


The DP transmitter is way off by large amount during low loads and startup/shutdowns and is not an accurate method of determining block valve degradation.

HF Lee Unit 01A HP Attemperator Spraywater Flow Sorted for Block Valve Closed



HF Lee Unit 01A HP Attenuator



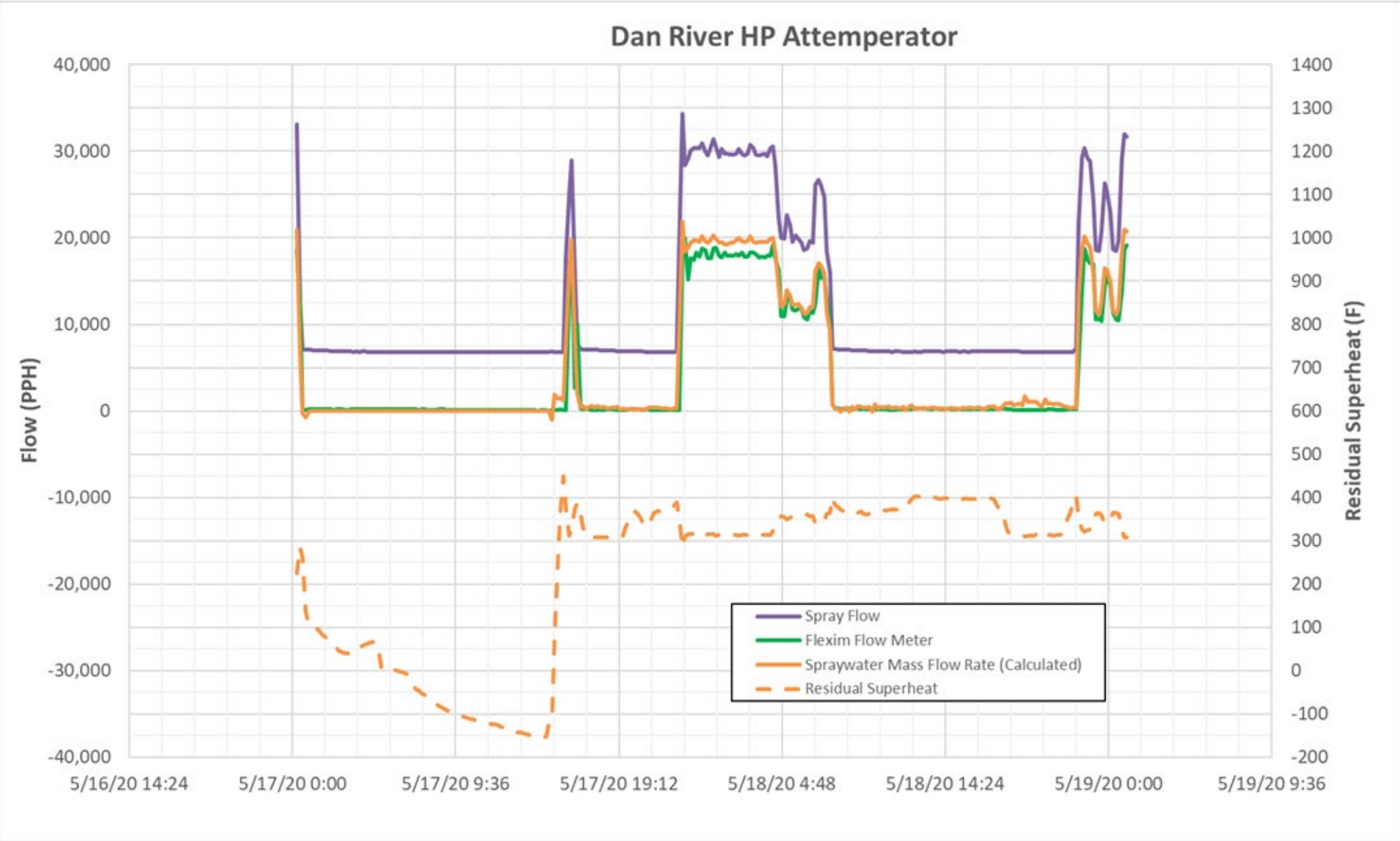
HP Observations

The calculated spray flow matches up closely to the Flexim flowmeter and the installed DP transmitter

The HP attemperator block valve was replaced last Fall and does not appear to be leaking by. Even during startup and shutdown the Flexim flowmeter is showing zero or negative values.

Flexim flowmeter is showing negative values with the HP attemperator block valve closed. Both DP transmitters are showing a slight positive flow value, although they both trend towards zero, so it looks like there may be some initial flow oscillations when the block valve goes shut. Further troubleshooting or adjustments are needed to determine why the values are going so far negative with the block valve closed.

Field Trial – Flexim Flow Meters for Attemperator Block Valve Leak-by Detection



Permanent Installations

- First permanent installations completed at HF Lee (3x1) Spring of 2021
- Replaced one of the two attenuator spray water DP indicators for HP and RH – These units had two channels (A and B)
- Good comparison between the DP transmitter and the Flexim
- Moving forward with our CC other sites and this will be a fleet standard
- Some units only have one flow transmitter – Some sites to add the Flexim as additional instrumentation and others chose to replace the existing DP transmitter and re-use the wiring to the DCS.
 - Caution to check for any control logic inputs e.g. – drum level
- We installed one Flexim flow transmitter with two sets of transducers – one from the HP and one from the RH (close proximity)
- The loop is powered from the DCS to be consistent with other plant instrumentation.
- 4-20 ma signal sent back to the DCS
- Added temperature card and RTD inputs for mass flow rate calculation (flow was measured in PPH)

F721.MC FLEXIM Permanent Meter

FLEXIM F721 installed.



Device set-up – even without power supply of the device

- Connection of device via USB to a laptop – no additional power supply necessary
- Installation of dataset for set-up or
- Complet new configurationn of the device
- Read-out of measurement date and diagnostic values



FLUXUS H721 Liquid Hydrocarbon Meter

Communication – ready for Industry 4.0:

- Bi-directional communication possibilities for convenient remote control, parameterization and online diagnostics at a plant's SCADA system or even via internet
- Bus-communication via FF, HART, Modbus, Profibus PA, BacNet (also input parameter transfer of i.e. pressure, temperature or density via Bus communication possible)
- Ethernet and USB interface for fast and easy parametrization directly in the field without external power supply as well as providing additional bidirectional communication capabilities



IECEEx
certified



HART
COMMUNICATION PROTOCOL



PROFI
BUS



M-Bus

BACnet
International

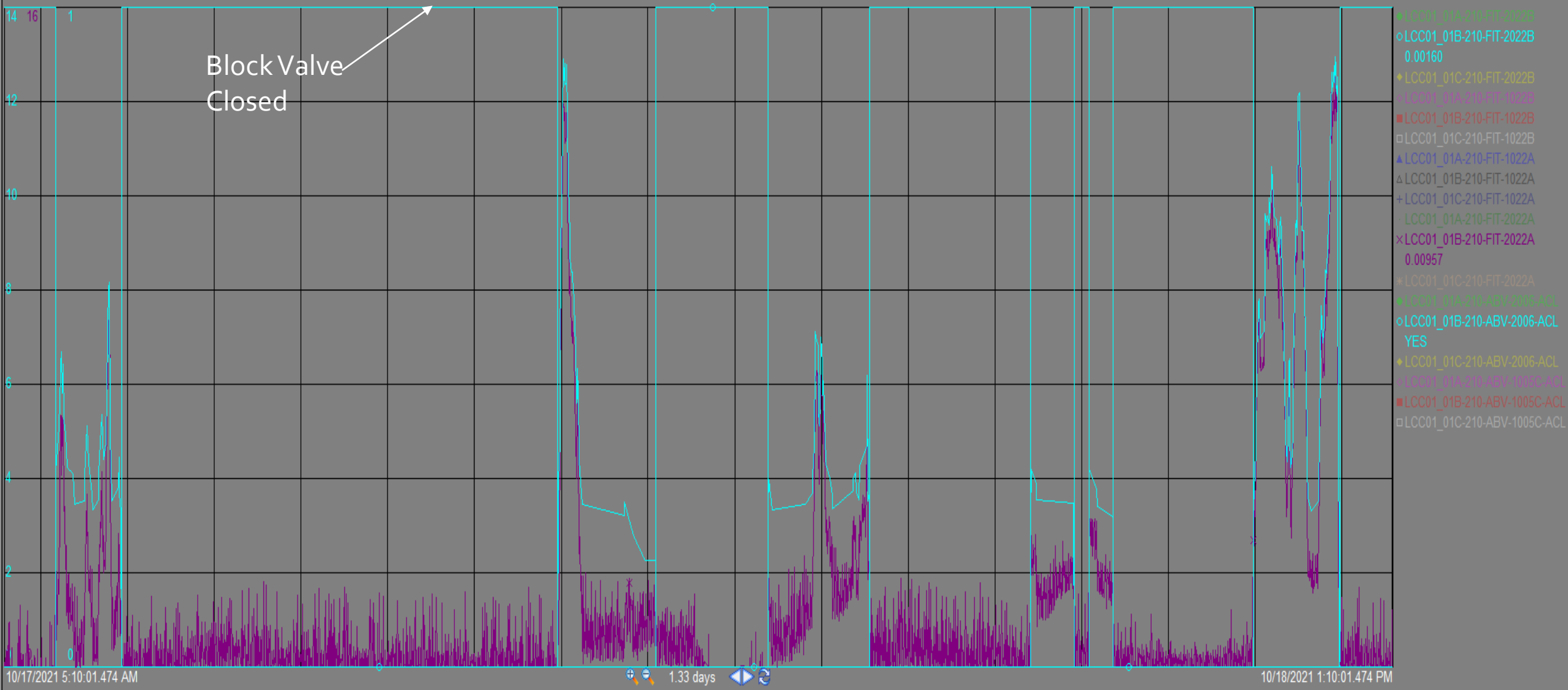
FLUXUS H721 Diagnostics

Real time Diagnostics with the FluxDiag software

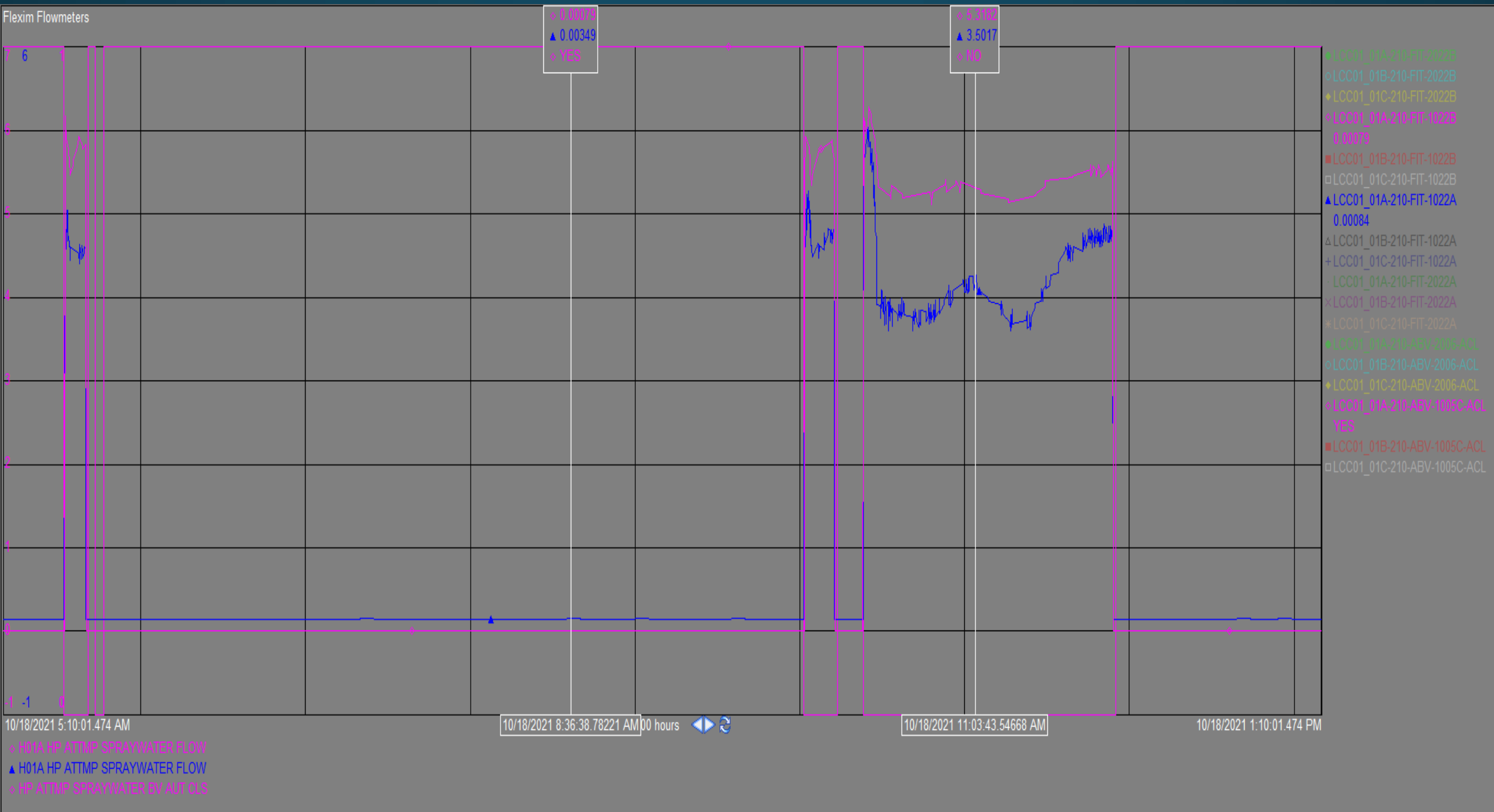
- Graphical online monitoring of measurement and diagnostics
- Total control of the measurement (start and stop, parameter, measurement mode)
- Offline/Online parameterisation of the device
- Access to ALL settings in the device
- Read/write/change of complete setup
- Possibility to copy a complete setup (save and write on another device) → fast multiple device parameterisation
- During commissioning / start up, measurement snaps can be shown in the FluxDiag software
- Free selection of connection interface (RS485, USB, TCP/IP)

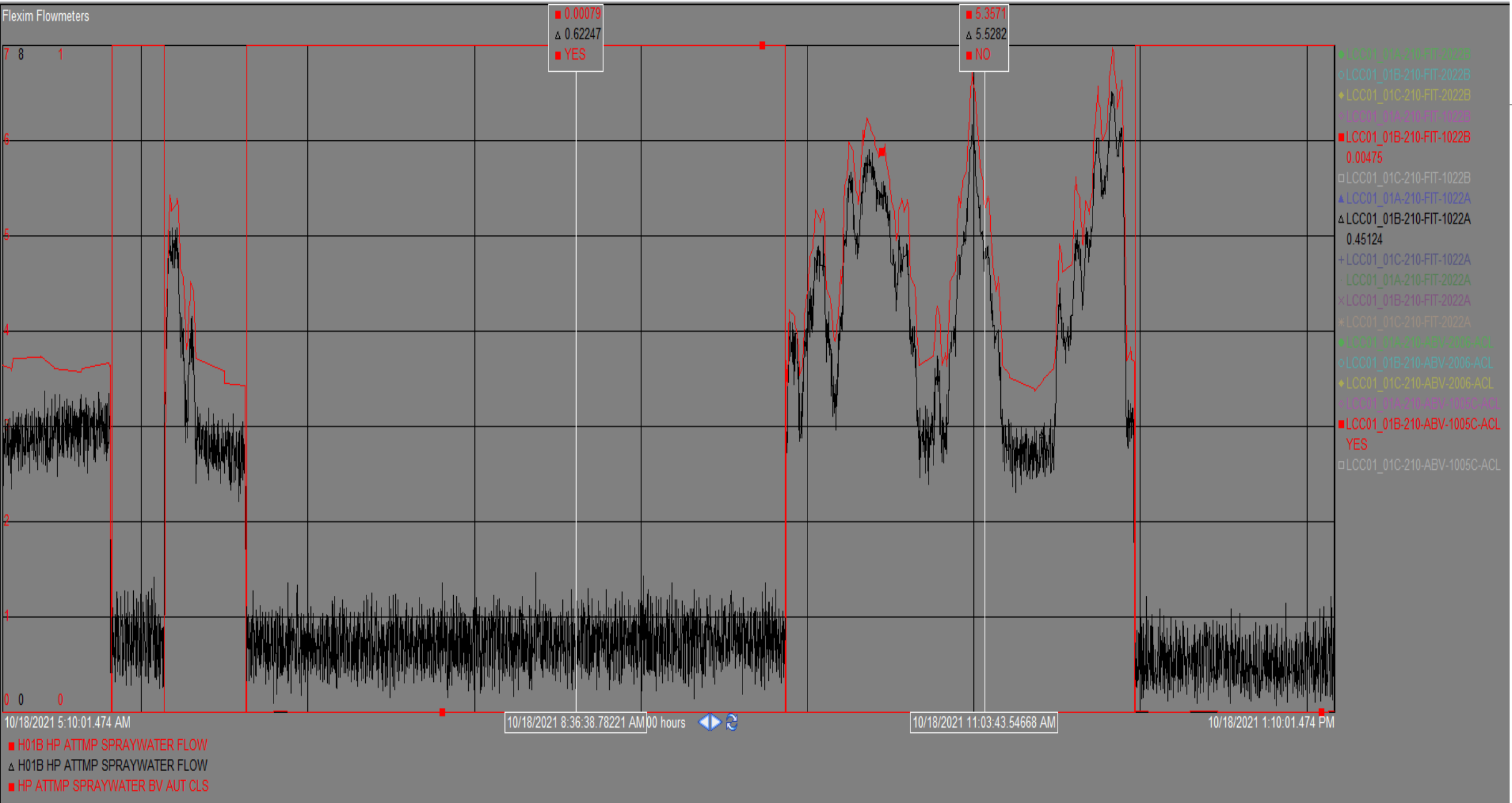


Flexim Flowmeters



○ H01B RHTR ATTMP SPRAYWATER FLO
✕ H01B RHTR ATTMP SPRAYWATER FLO
○ RHTR ATTMP SPRAYWTR BV AUT CLS





■ 0.00079
Δ 0.62247
■ YES

■ 5.3571
Δ 5.5282
■ NO

- LCC01_01A-210-FIT-2022B
- LCC01_01B-210-FIT-2022B
- ◆ LCC01_01C-210-FIT-2022B
- ✕ LCC01_01A-210-FIT-1022B
- LCC01_01B-210-FIT-1022B
0.00475
- LCC01_01C-210-FIT-1022B
- ▲ LCC01_01A-210-FIT-1022A
- Δ LCC01_01B-210-FIT-1022A
0.45124
- + LCC01_01C-210-FIT-1022A
- LCC01_01A-210-FIT-2022A
- ✕ LCC01_01B-210-FIT-2022A
- + LCC01_01C-210-FIT-2022A
- LCC01_01A-210-ABV-2006-ACL
- LCC01_01B-210-ABV-2006-ACL
- ◆ LCC01_01C-210-ABV-2006-ACL
- ✕ LCC01_01A-210-ABV-1005C-ACL
- LCC01_01B-210-ABV-1005C-ACL
YES
- LCC01_01C-210-ABV-1005C-ACL

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10/18/2021 8:36:38.78221 AM

00 hours

10/18/2021 11:03:43.54668 AM

10/18/2021 1:10:01.474 PM

- H01B HP ATTMP SPRAYWATER FLOW
- Δ H01B HP ATTMP SPRAYWATER FLOW
- HP ATTMP SPRAYWATER BV AUT CLS

Future Potential / Additional Benefits – Flexim Flow Meters for Attenuator Block Valve Leak-by Detection

We now need to determine the optimal valve replacement / repair strategy based on observed leak-by

The control valve in this system will experience the same benefits, where the flow through the valve at a given valve position may be trended over time to determine a “wear” rate

This technology may be expanded to the Bypass Attenuators in the future as the benefits exist for this system as well

The need for block valve leak-by detection is even higher for sites with steam atomizing attenuators



FLEXIM
when measuring matters



Questions?