How much data you need to run your Gas Turbine efficient?

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Nederlandse gasturbine gebruikersconferentie 2022
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Nieuwegein

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Introduction

Over 10 years experience in Turbine automation

- Valmet Automation
  Product Manager for Gas Turbine & Compressor Automation
  Working for the Turbine Business Unit in Finland responsible for global technical support for customers and Valmet regions.

Over 15 years experience in rotating equipment and oil & gas

- OEM & ISP
  Engineering and Technical Advisor
- Utilities
  Rotating equipment maintenance responsible
- Oil & Gas
  Equipment design and maintenance

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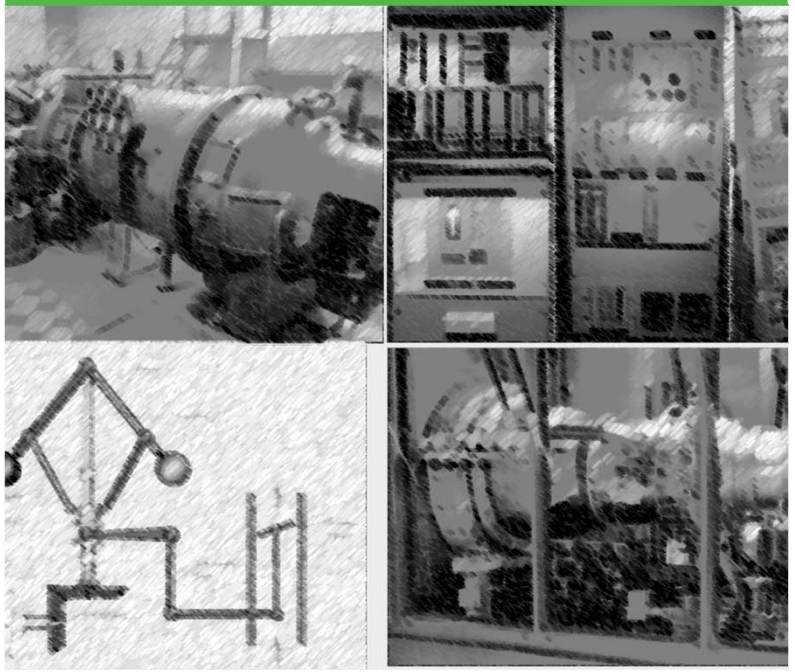
Outline

How much data do you need to run your Gas Turbine efficient?

- Where did we come from – *Measurements & Control*
- Where we are now – *Data and control*
- What is the future – *Data and prediction*
- Valmet Industrial Internet (VII) – *The future of engine controls*
- Recap – *What do we gain and what are the trade offs*

time capsule / memory lane / good ol' days, what could go wrong / WHY! / NOT NOW!



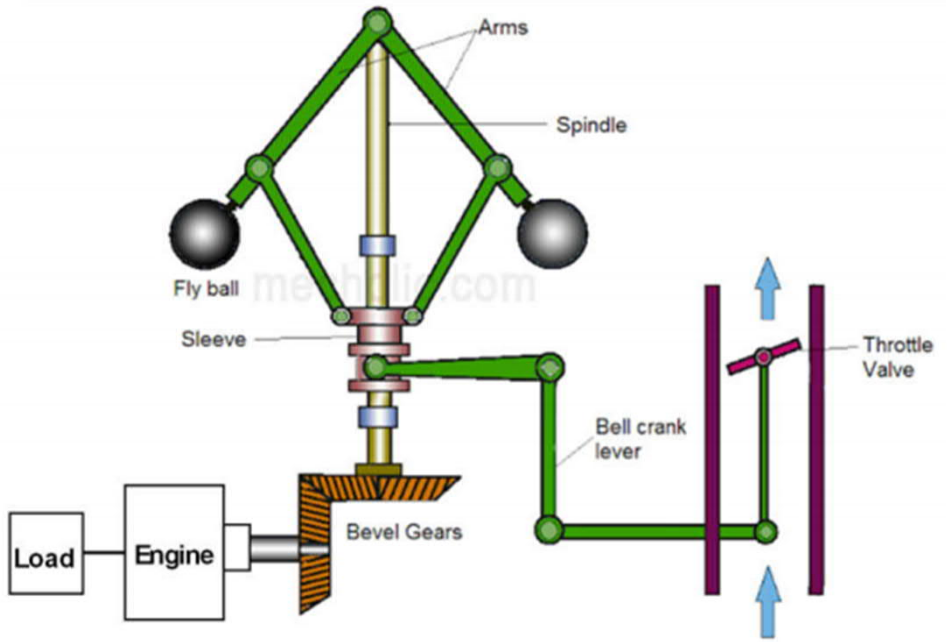
Where we came from

Measurements and controls

How much data do you need to run your Gas Turbine efficient?

Where we came from - *Measurements and controls*

Old turbine
- Gauges for pressure and temperature



Speed governor
- Based on mechanical installation

How much data do you need to run your Gas Turbine efficient?

Where we came from - *Measurements and controls*

How was it to control

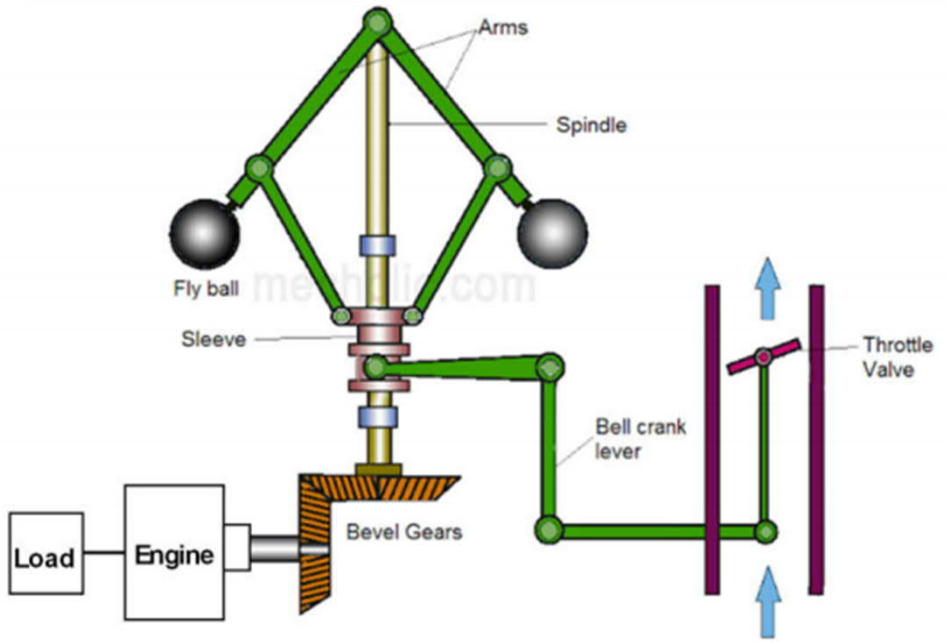
Start up based on mechanical sequence
- ‘open loop control’
- Make sure it is back in ‘closed loop’ control

Physical check up on machinery
- Lubrication levels
- Monitoring gauges and register values at walk arounds
- Listen to the machine

Labor intensive

On top of YOUR machine

At trip or shut down
- Look at all important data and register
- Put the machine in safe position



How much data do you need to run your Gas Turbine efficient?

Where we came from - *Measurements and controls*

Understand the behaviour

- Pre-checks before start-up important for success
- Understand why the start takes more time than usual
- Understand when the machine is running out of specification
- Realize what is going on when temperatures & pressures are deviating
- Accuracy of ‘data collection’ determines the fault analyzes

How much data do you need to run your Gas Turbine efficient?

Where we came from - *Measurements and controls*

Advantages

- Dedicated operators
- Machine drivers ‘owned’ the machines
  - Long experience lead to understand the behaviour
- Mechanical knowledge of machinery and components

Disadvantages

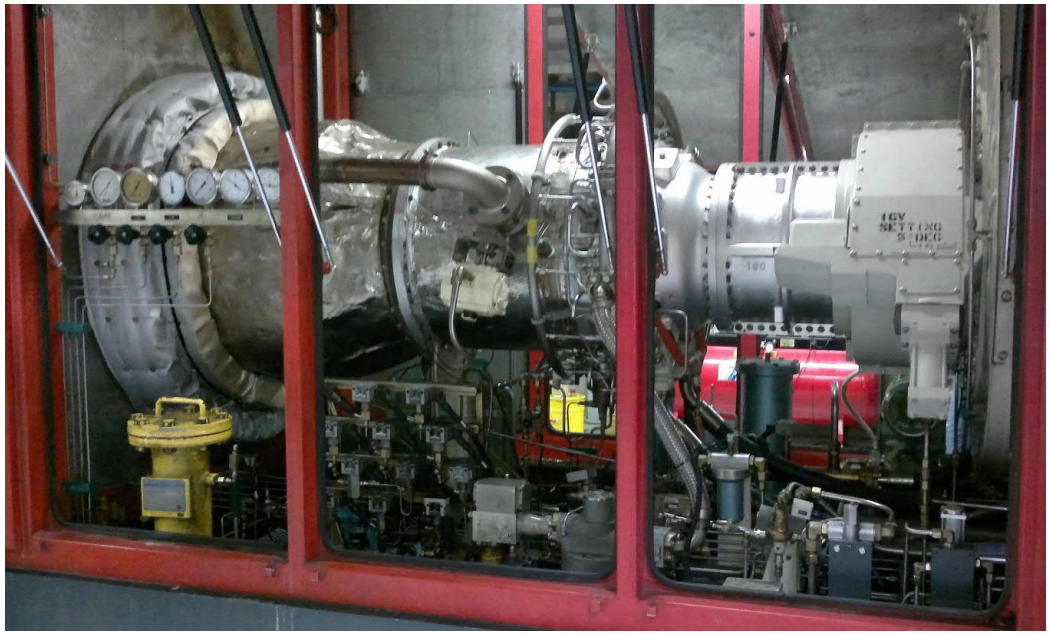
- Slow / long start ups
  - Pre-start checks
  - Lot of control actions to be taken before start-up
- Data collection
  - Labour intensive
  - Accuracy
- Understand the meaning of measurements deviations
- Time consuming monitoring
- Need for long experience
  - To fully understand behaviour at trip
  - Decide what is ‘good’ and what is ‘bad’

Where we are now

Data and control

How much data do you need to run your Gas Turbine efficient?

Where we are now - *Data and control*



Aging turbine

- Gauges as backup for pressure and temperature measurements
- Switches & mechanical feedback signals

Electronic Turbine Controller

- Digital controller
- Analogue and digital measurements
- Supervisory system

How much data do you need to run your Gas Turbine efficient?

Where we are now - *Data and control*

Yountimer turbine

- Extended measurements available for all process areas
- Gauges for back-up purposes and glance overview

Electronic Turbine Controller

- Digital controller
- Analogue and digital measurements
- Supervisory system
- Good HMI

How much data do you need to run your Gas Turbine efficient?

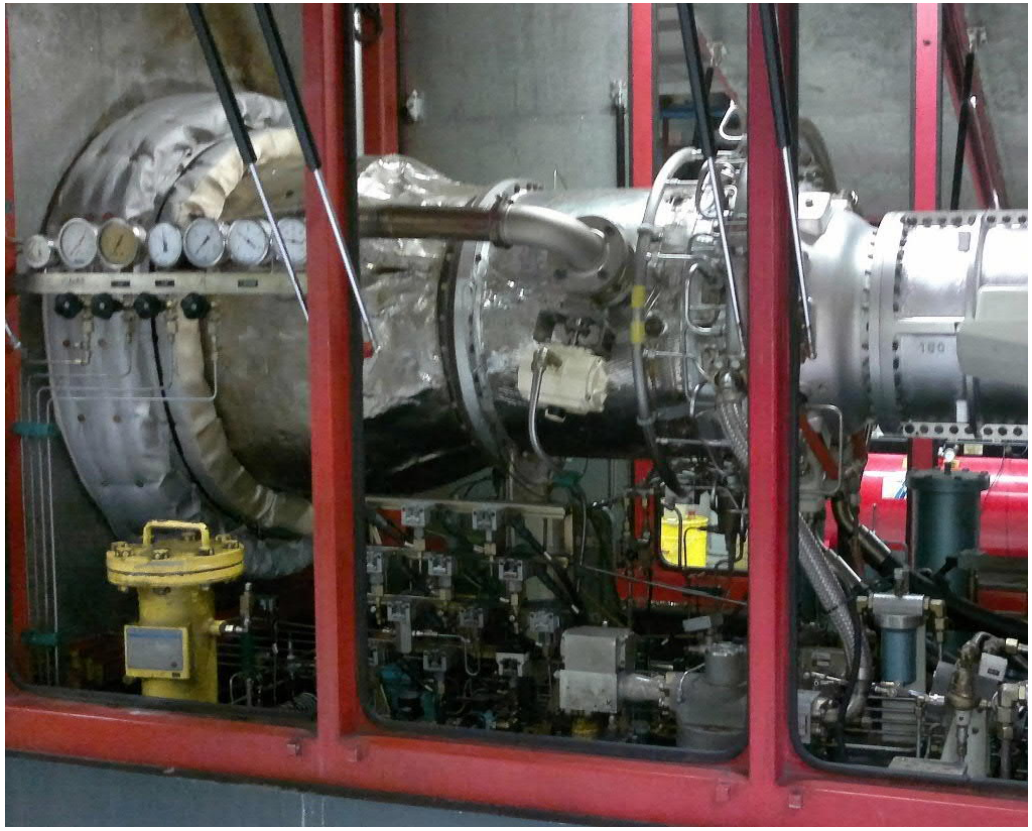
Where we are now - *Data and control*

How is it to control

- Start up follows a digital sequence
  - LED's show status where the start-up procedure is in its sequence
  - Switches and measurements are releasing for next steps
- Check up on the machinery
  - Most measurements are visual on the HMI
    - Lubrication, fuel system, temperatures
- Be with YOUR machine
  - Many measurements are fast & available in HMI
  - Some, if not many, measurements are on-skid
- At trip or shut down
  - Not all data is available for the operator or engineers from the controller.
  - With electronic data collection fault finding is made easier

How much data do you need to run your Gas Turbine efficient?

Where we are now - *Data and control*



Understand the behaviour

- Pre-checks before start-up important for success
  - Even with system feedbacks to HMI
- Understand why the start takes more time than usual
  - Not always visual what is going on when remote
- Understand when the machine is running out of specification
  - The data coming from the digital controller helps analyzing
  - Running out of spec is easier to see on the HMI.
- Realize what is going on when temperatures & pressures are deviating
  - Not all measurements are available from the HMI
  - Need to see and feel the machine for unusual behaviour
- Accuracy and signals availability of data collection system determines the fault analyzes

How much data do you need to run your Gas Turbine efficient?

Where we are now - *Data and control*

Advantages

- Operators understand the machines
- Mechanical knowledge of machinery and components
- More digital storage available
- More operational data to check for fault finding
- Faster controls
- Higher availability

Disadvantages

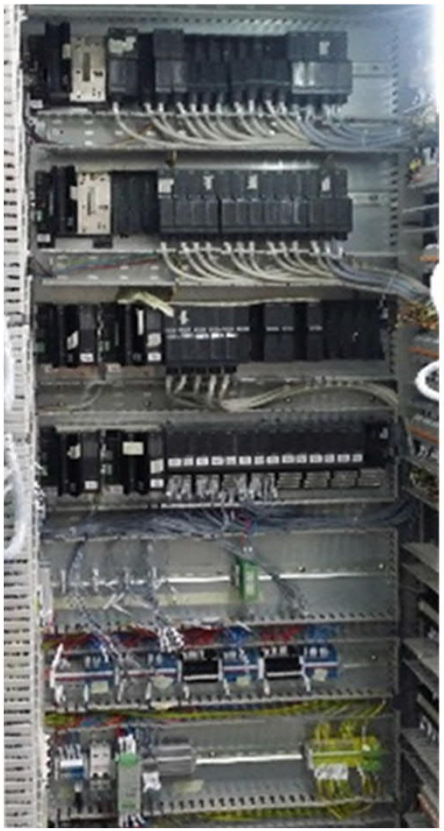
- Operators with less experience on machine & behaviour
  - More measurements available and computers decide.
- Time consuming monitoring
  - Not all data is available
- Some need to understand the meaning of measurements deviations
- Need for experience
  - To fully understand behaviour at trip

What is the future

Data and prediction

How much data do you need to run your Gas Turbine efficient?

What is the future - *Data and prediction*



Next generation turbines

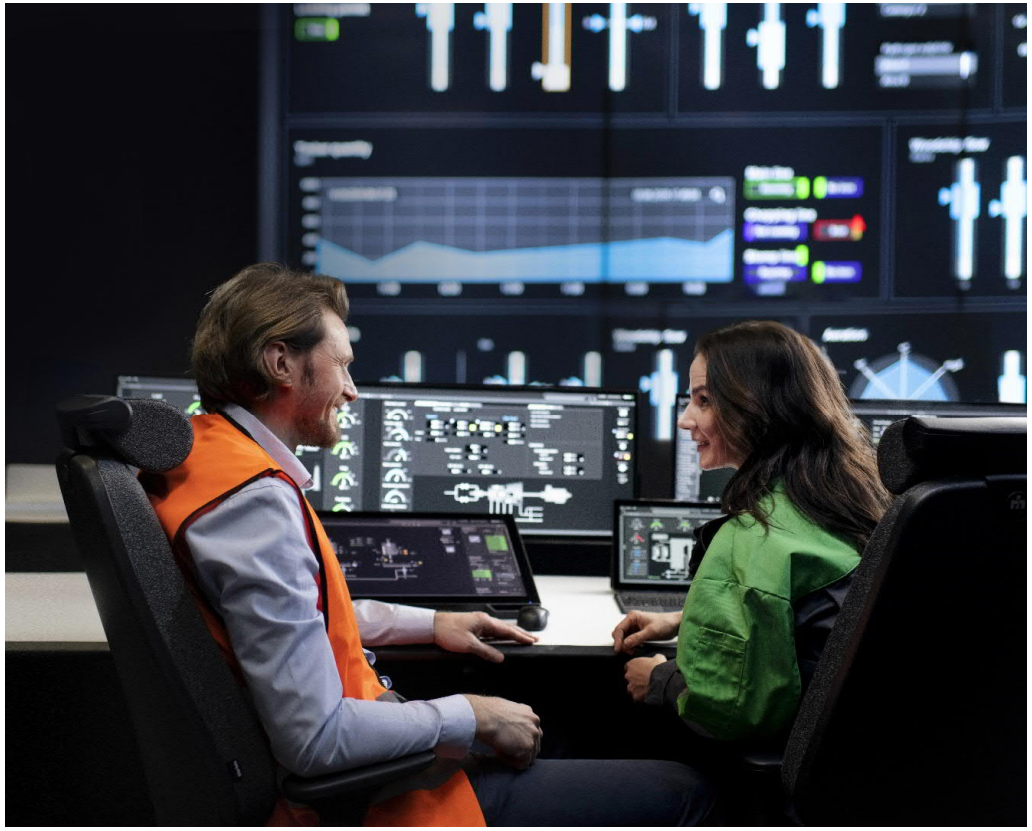
- Fuel flexible
- High efficiencies
- Complex controls & behavior

How much data do you need to run your Gas Turbine efficient?

What is the future - *Data and prediction*

How is it to control

- Start up follows sequences
  - User interface is interactive with the operator
  - The upper-level system is preparing operator for eventual actions
- Check up on the machinery
  - All measurements from the machine is used for big data analysis
  - Analysis tools predict equipment fail or maintenance requirements
- YOUR machine merged into the Industrial Internet.
  - All measurements are in the control system and support subsystem data analysis
  - Faulty data and/or missing data is taken care of by big data analysis
- At trip or shut down
  - All available data is used for fault finding by managing correlations and analysis tools



How much data do you need to run your Gas Turbine efficient?

What is the future - *Data and prediction*

Understand the behaviour

- Pre-checks before start-up important for success
  - Big data and predictive control informs the operator prior to start which components are likely to fail
- Understand why the start takes more time than usual
  - Cloud based analysis tools and Industrial Internet tools shows the causes of delays
  - Impact of delays are shown on dashboards and reports
- Understand when the machine is running out of specification
  - The data coming from the control system forms the base for analyzing
  - Running out of spec is easier to see UI dashboards and digging into the issue is instantaneous.
- Realize what is going on when process data is deviating
  - Measurements not available from the UI is extrapolated based on correlations
  - The machine is now secondary for unusual behaviour analysis

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How much data do you need to run your Gas Turbine efficient?

What is the future - *Data and prediction*

Advantages

- Operators can see in a glance the machine status
- Anticipate to and optimize for situations
  - Avoid failures or failed starts
- Operators understand quicker what went wrong
- Less digital storage required with cloud-based analysis systems
- Operational data for fault finding is automatically used for analysis
- Improved successful start-up
- Higher availability & reliability
- Additional features easier to add to the system
  - Flex-fuel / multi fuel
  - Predictive power demand
  - Virtual power plant

Disadvantages

- Operators with less experience on machine
  - Analysis tools show what went wrong or what is about to go wrong
  - No real need to see the turbine for checking what is wrong
  - Shift from control to analysis for operators
  - Industrial Internet applications in cloud
- No real need to understand the meaning of measurements deviations
- Need for experience
  - When something is not covered by the tools, down-time can be very long

Valmet Industrial Internet (VII)

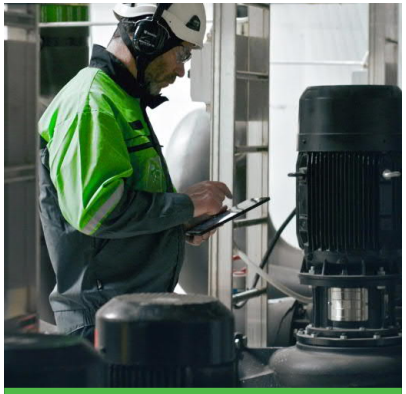
The future of engine controls

Valmet DNA Automation System

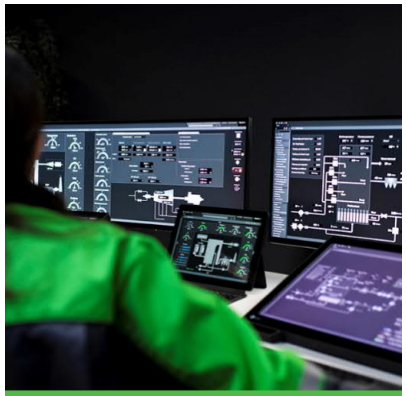
A single automation system for all needs - Asset Performance Management (APM)

Valmet DNA Automation System

Asset Performance Management (APM)



Condition monitoring



Process equipment monitoring

Field device management

Automation system management

SERVICES

Valmet Equipment Diagnostics Application

Monitoring equipment to enable predictive maintenance

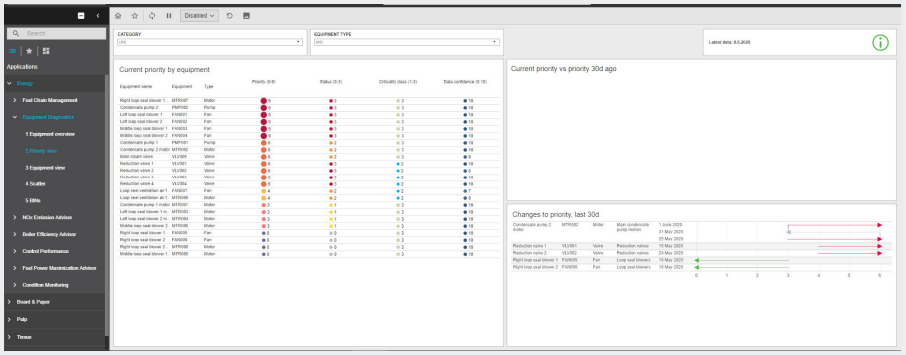
Valmet Equipment Diagnostics Application

- Enables predictive maintenance for equipment based on real-time process data
  - Tracks condition of process valves, pumps, motors and fans
  - Based on the difference of current equipment performance vs. original performance
- Lists the equipment in prioritized order based on significance to plant availability and the status deviation from the original condition

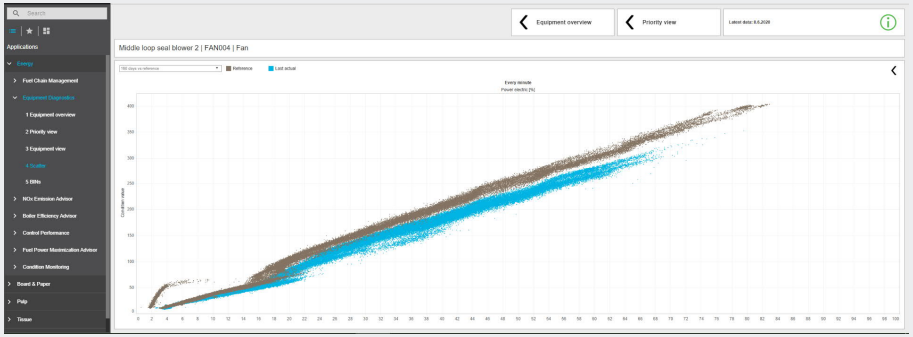
Benefits:

- Focused maintenance based on real-time equipment condition
  - Identifies deviations in key equipment
  - Tracks longtime wearing of equipment
  - Spots short term changes in equipment

Prioritized focus areas



Equipment current performance vs. reference



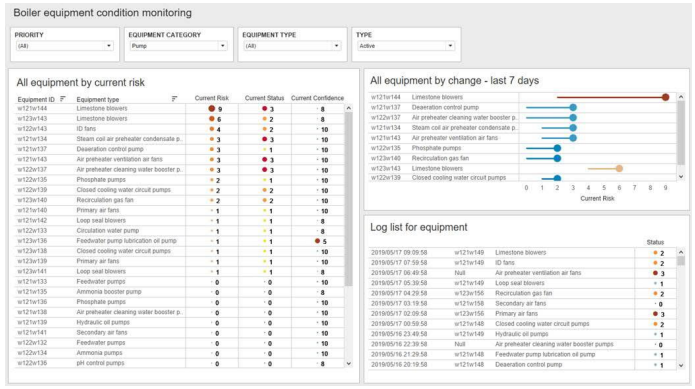
Valmet Equipment Diagnostics Application

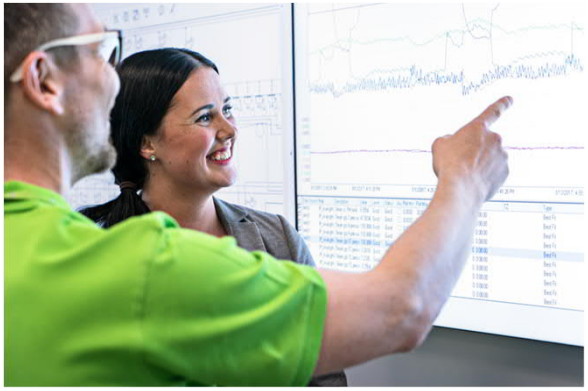
From data to equipment status

Flow of process data from DCS (e.g. Pressure, flow and valve opening)

Automatic evaluation of DCS data through equipment related embedded formulas

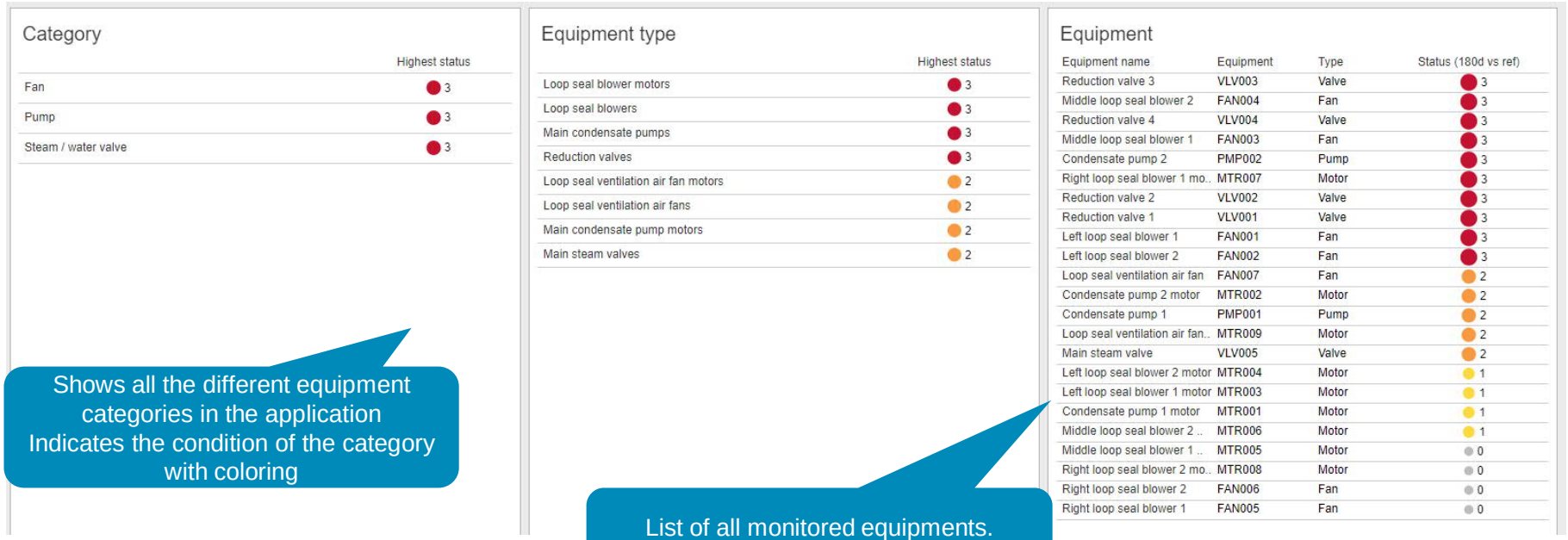
Online data presented in dashboard, gives equipment condition status





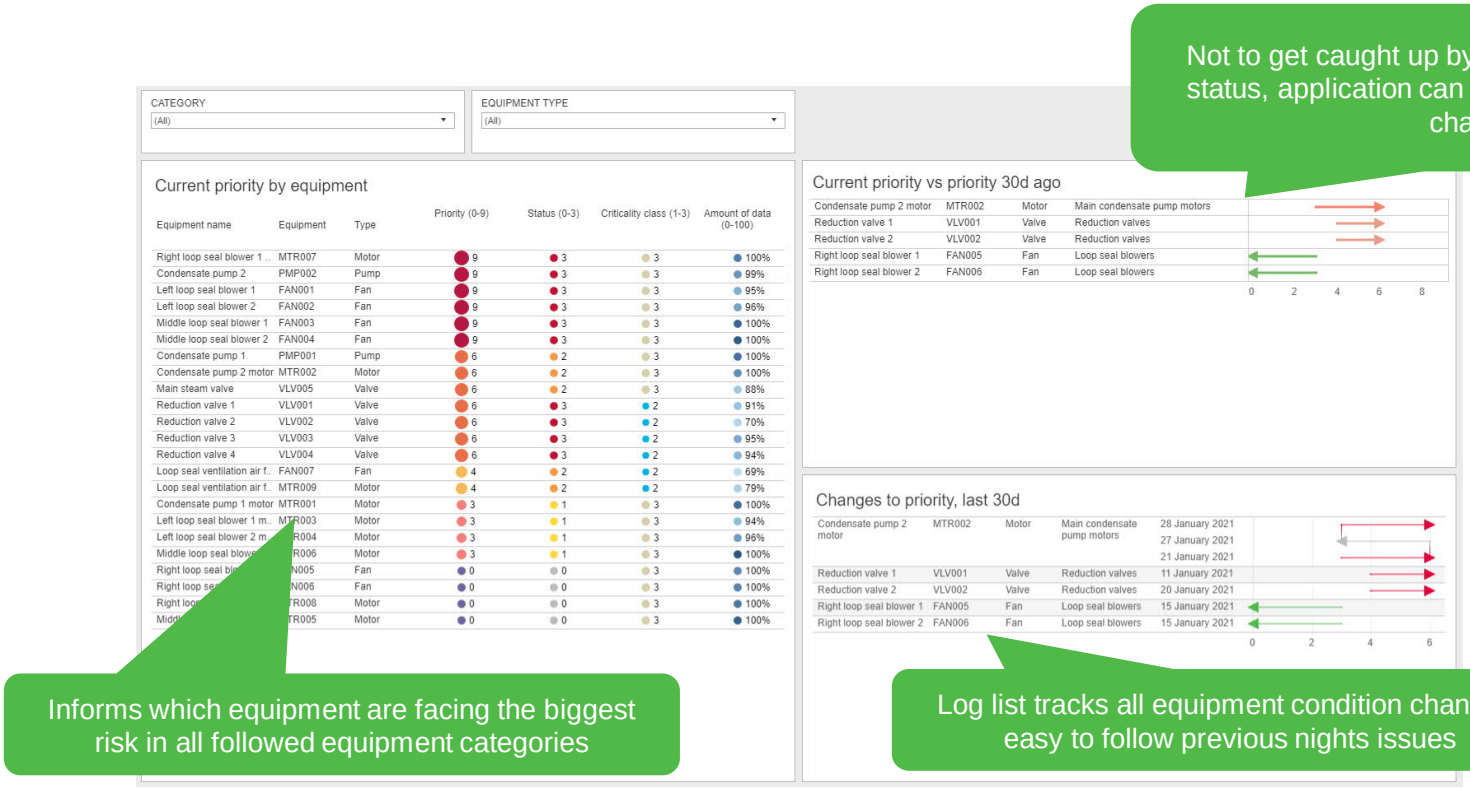
Extract from the application – Equipment overview

Overall information on the followed equipment



Extract from the application – Priority view

Prioritization view helps in daily work by filtering the information you need



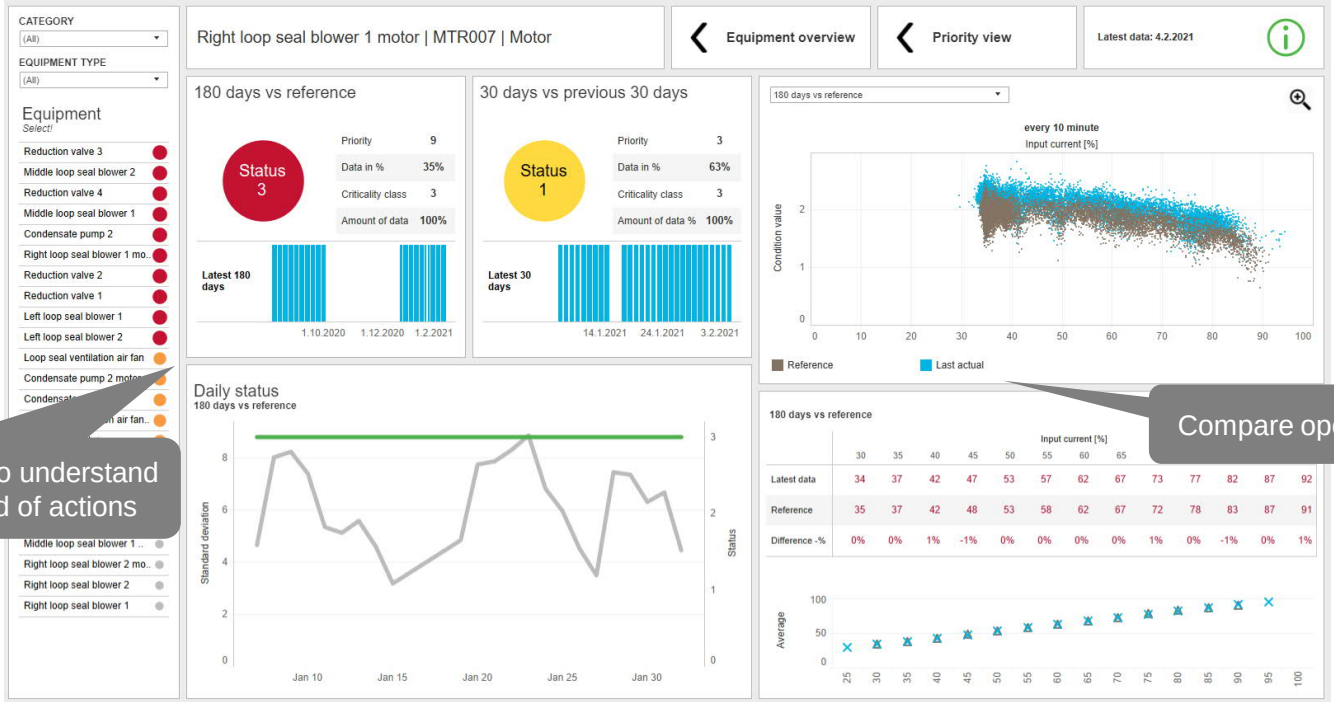
Not to get caught up by just following up current status, application can also indicate longer term changes

Informs which equipment are facing the biggest risk in all followed equipment categories

Log list tracks all equipment condition changes, easy to follow previous nights issues

Extract from the application – Equipment view

Details for each equipment: Status, deviation, history



Follow status and deviation to understand condition and possible need of actions

Compare operation to reference period

Valmet Equipment Diagnostics Application

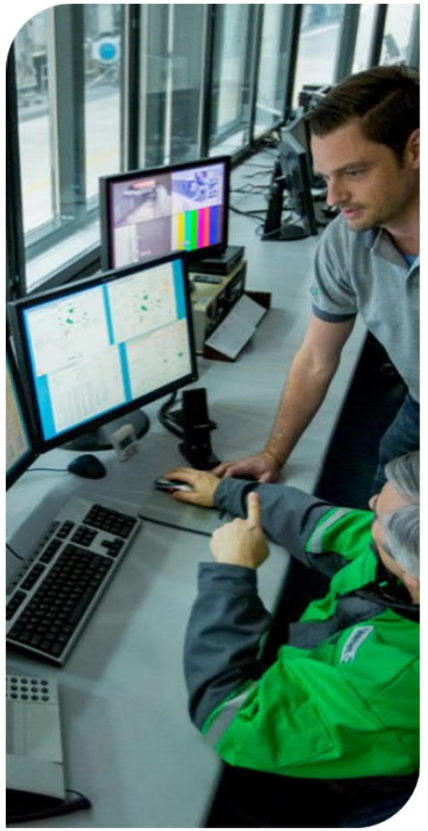
Put your process data into work to prevent unplanned downtime

What?

- Cloud based equipment monitoring application evaluating condition by analyzing process data
- Identifies abnormal operation using machine learning
- Prioritization centered user interface for continuous maintenance planning
- System compares the current status to the reference period, detects anomalies and visualize deviation speed
- No need to install supporting condition instruments

Why?

- Continuous follow up of equipment status enables in an early stage to detect issues
- Prioritization of issues gives input to resourcing and daily problem solving
- Support optimized maintenance work and avoidance of unplanned shutdowns



Recap

- We came a long way since first machine controls
- Old tech works but for full use of potential, upgrading to newer systems should not been seen as a burden or money pit
- New technologies and Industrial Internet can get most out of your machine
  - Predictive maintenance
  - Failure avoidance
  - System flexibility

- Knowledge on machinery is disappearing due to intelligent features of new systems
- Focus shift of operators to predictive behaviour controls

- Be open with new tech and embrace the future potential.

Valmet


Valmet
FORWARD

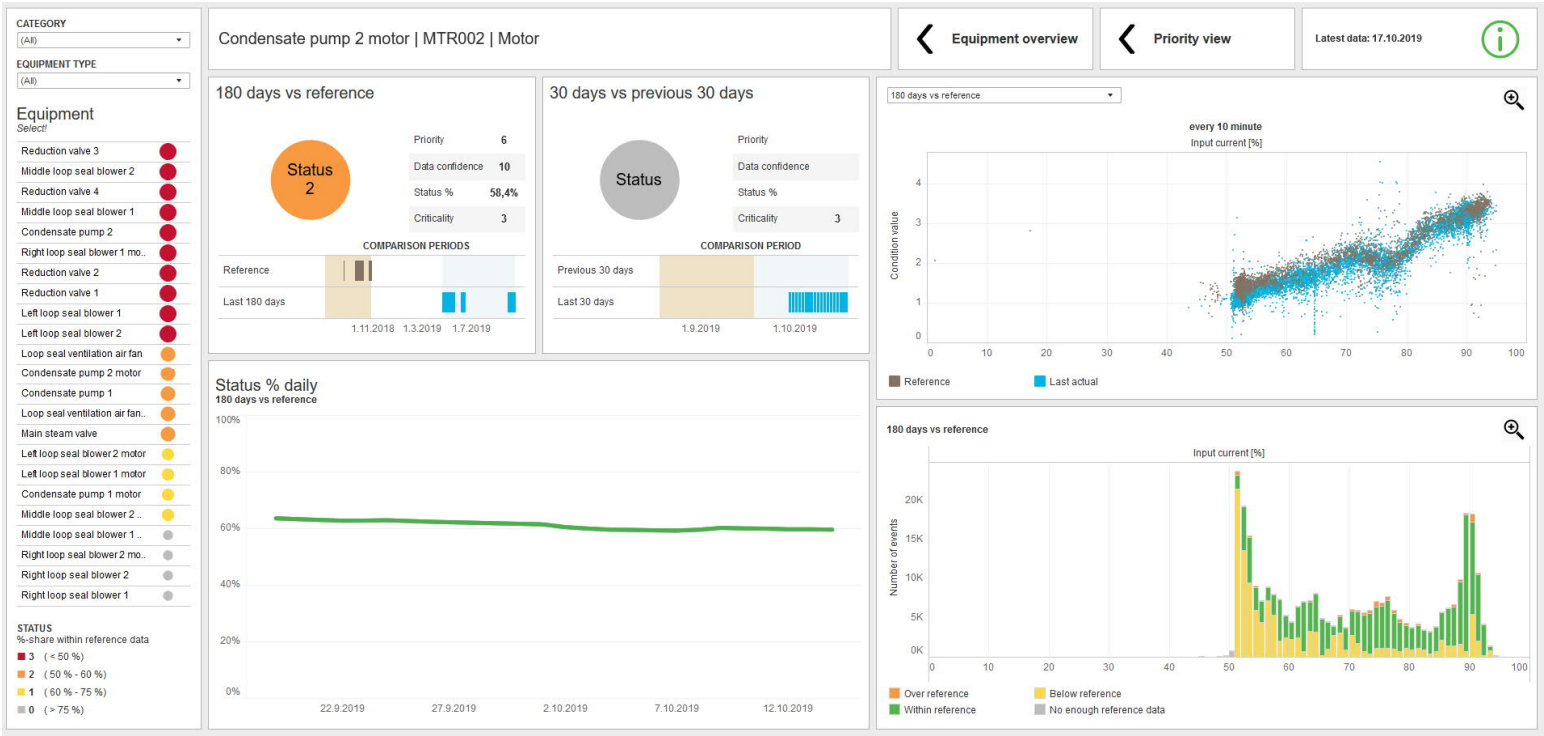
Equipment diagnostics

Example cases

Case 1: Change in motor temperature

Not all change is negative, but it is good to be aware of it

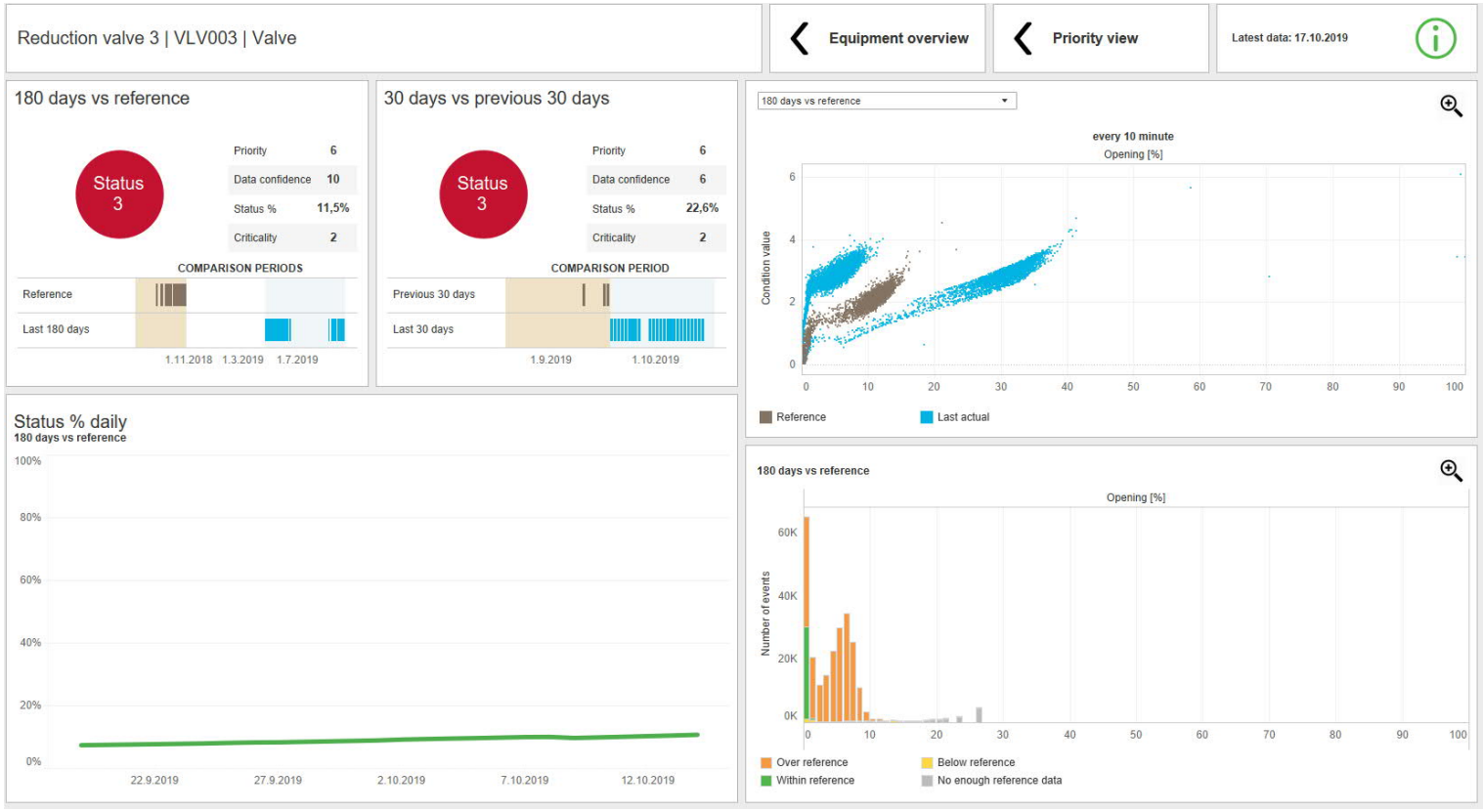
- Latest equipment to change was motor MTR002
- It is seen that the performance is fluctuating around the status level change limit (60%)
- The recent values are mostly a bit below the reference group
- However, since this is a motor, the condition parameter is the **maximum winding temperature difference from median**
  - Situation has actually improved, since the maximum difference has been reduced
- If the level seems consistent, the new data could be made into the new reference data.



Case 2: Valve condition

Shows the status before and after maintenance

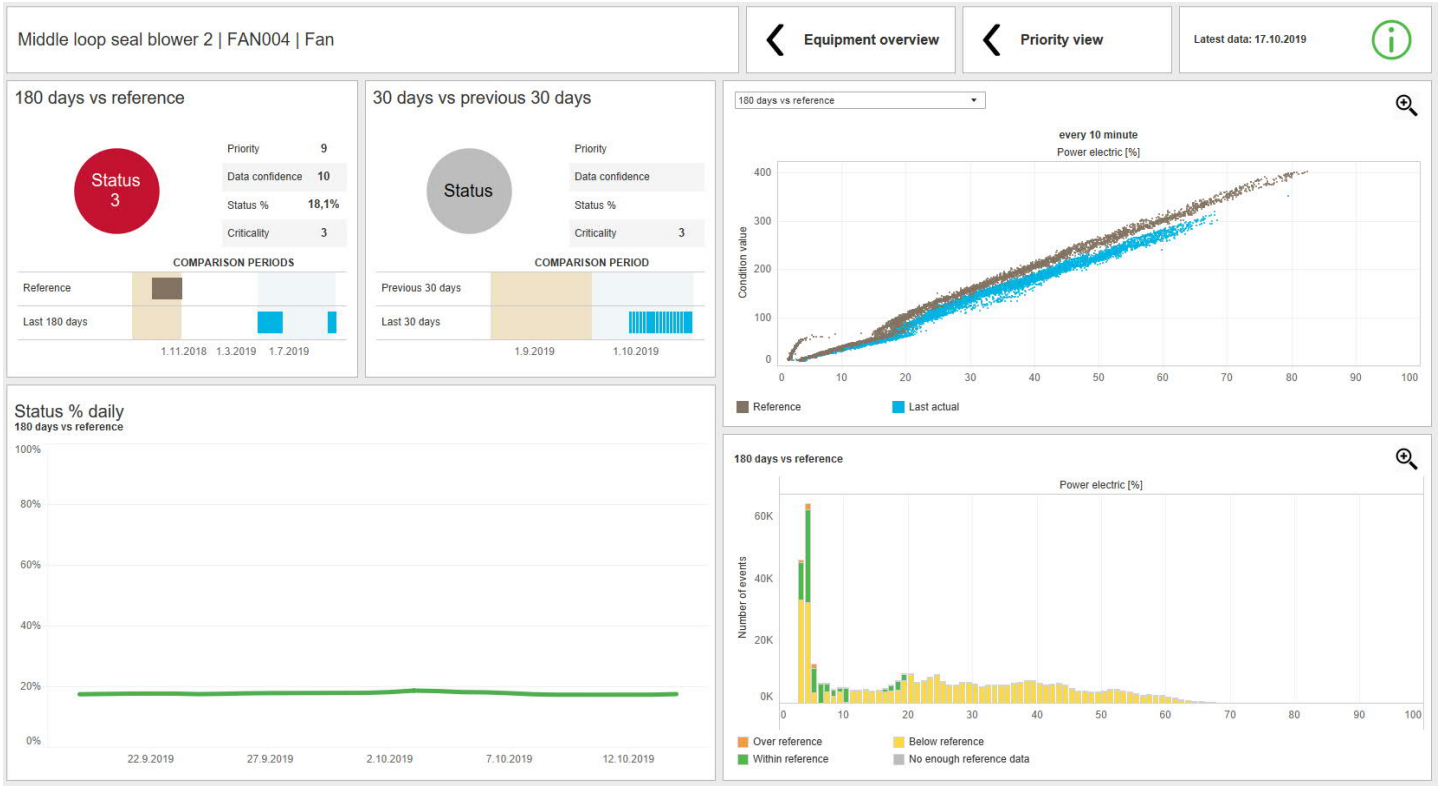
- The equipment in the worst condition is VLV003, where only 11% of operating data goes where it should
- Upon examination, the reference is in a clearly different location than the latest data
  - The upper blue curve is before a shutdown
  - The lower blue curve is after shutdown, where the valve had its internal parts replaced
- It is seen that the new data group has better operating values (more consistent **Cv**) and the valve is utilized in a wider operating range (35% vs. 15%)
  - It is concluded that the maintenance was a success
  - After a period of operation, the new data should be made the new reference data



Case 3: Fan deviation

Catches small, long-term deviations in the machinery

- FAN004 is giving high readings about the change in operation.
- The condition parameter – **power transferred to the fluid** – is lagging below the reference curve
- Local maintenance orders a check on the system
- It is discovered that the gas ducts are dirty and clogged, preventing the air from flowing normally
- The ducts are cleaned in the next shutdown, and performance returns to normal
  - Showcases how the system can catch small deviations in equipment operation, or in the immediate surroundings
- System evaluates overall process conditions, not only mechanical issues



Case 4: Inefficient pump

System catches phenomena occurring outside the monitored equipment

- Recently, pump PMP002 performance has been dropping consistently
- The condition parameter for pumps is the **power transferred to the fluid**, and since the latest data falls below the reference, power must be lost somewhere
- The pump system is examined, and a leakage is found in the pump minimum flow valve
- The valve is replaced in the next shutdown