



AEInnova

Alternative
Energy Innovations

AEInnova

Steam Leaks Detection

2026

SENSING A MORE
SUSTAINABLE INDUSTRY



LESS
BATTERIES



LOWER
EMISSIONS



A MORE
EFFICIENT
INDUSTRY

FROM
INDUSTRY HEAT
TO A CLEANER
TOMORROW

PRODUCT PORTFOLIO: InduEye™ VibroSense 3



Predicts steam trap & valves locks (open / close), degradation, fluctuation for energy efficiency

THERMOELECTRIC MODULE (TEG)

Harvests heat from the pipe surface

INDUEYE® VIBROSENSE

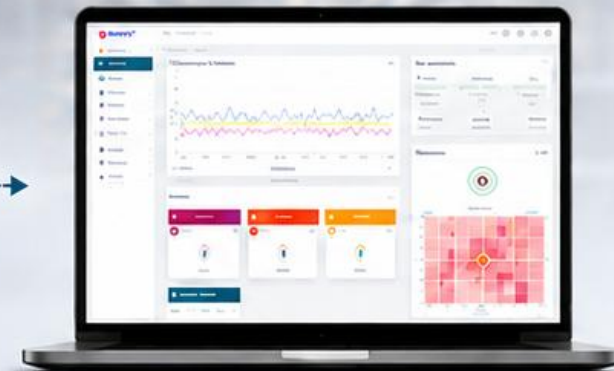
- 2 temperatures (TempSense -100°C–350°C)
- Vibration (VibroSense, 10 Hz–5 kHz)

Continuous steam leaks process in valves, traps, etc

- 2 temperatures TempSense (-100°C–350°C) + vibration VibroSense (10 Hz–5 kHz)
- Standard LoRaWAN
- Up to 99% detection (2 temperature solutions <60%)
- Real-time (continuous data acquisition)
- Real edge computing (2 temperatures, RMS in BW, kurtosis, counts per minute...)
- DAEVIS or HMI



THE CLOUD PLATFORM



Early detection of steam leaks & valves locks



Reduce unplanned downtime and maintenance costs



Extend equipment lifetime and reliability



Improve energy efficiency and sustainability

STEAM TRAP MONITORING SOLUTIONS COMPARISON

SAME INSIGHT. VERY DIFFERENT APPROACH.

FEATURE		AEINNOVA InduEye™ LeakSense 		BATTERY-POWERED WIRELESS SOLUTIONS 		WIRED / MANUAL SOLUTIONS 	
	ENERGY SOURCE		THERMAL GENERATION (TEG) / PROCESS HEAT		BATTERY (1–2 years)		MAINS POWER or handheld (no power)
	MAINTENANCE		NO MAINTENANCE		BATTERY REPLACEMENT (1–2 years)		REGULAR MAINTENANCE and calibration
	OPERATIONAL EFFORT		AUTOMATIC 24/7 MONITORING		FIELD VISITS to replace batteries		MANUAL INSPECTIONS by trained personnel
	SENSOR TECHNOLOGY		ULTRASOUND + 2 external temperature sensors		ULTRASOUND (+ 2 external temperature sensors)		ULTRASOUND + 2 external temperature sensors
	DATA INTEGRATION		CLOUD + HMI (SCADA, OPC-UA, MQTT, Modbus...)		CLOUD / GATEWAY (proprietary platforms)		LOCAL PC / MANUAL (export and analysis)
	WIRELESS RANGE		LONG RANGE (LoRaWAN, up to 2–14 km)		SHORT TO MEDIUM RANGE (BLE, Wi-Fi, proprietary)		NO WIRELESS (cabled or handheld)
	INDUSTRIAL CERTIFICATIONS		ATEX, IECEx, CE, MIC, FCC, ANATEL...		ATEX, IECEx, CE, MIC, FCC, ANATEL...		ATEX, IECEx, CE, MIC, FCC, ANATEL...
	DEPLOYMENT		FAST & SIMPLE (retrofit, no wiring)		FAST (but periodic visits)		MORE COMPLEX (wiring or handheld campaign)
	INSPECTION COVERAGE		CONTINUOUS (real-time / periodic)		PERIODIC (limited by battery life)		SPOT (periodic manual routes)



HEADACHES IN DAILY OPERATION



NO HEADACHES

- ✓ No battery logistics
- ✓ No field visits
- ✓ No unexpected downtime
- ✓ No manual data collection
- ✓ No safety risks for maintenance staff
- ✓ Focus on insights, not maintenance



FREQUENT HEADACHES

- ✓ Plan and execute battery replacements
- ✓ Access to critical/hazardous areas
- ✓ Risk of missed or failed replacements
- ✓ Additional labour and safety requirements
- ✓ Gaps in monitoring when batteries are empty



OPERATIONAL HEADACHES

- ✓ Manual inspection routes
- ✓ Trained personnel required
- ✓ Limited inspection frequency
- ✓ Data analysis and reporting effort
- ✓ Higher risk of undetected failures
- ✓ Exposure to hot/noisy/hazardous environments

FROM WASTE HEAT TO A CLEANER FUTURE.

SELF-POWERED MONITORING. LOWER EMISSIONS. HIGHER EFFICIENCY.

InduEye™ LeakSense turns wasted thermal energy into useful data, avoiding battery emissions and helping to reduce Scope 1 and Scope 3 emissions in line with decarbonisation goals.

1 AVOID BATTERY EMISSIONS

No batteries. No replacements. No waste.

CONVENTIONAL BATTERY SOLUTIONS



- Battery manufacturing ~ 60–70
- Electronics & housing ~ 10–20
- Transport & packaging ~ 5–10

Total per battery ~90 kg CO₂ eq.

InduEye™ LeakSense



- No battery production 0
- Electronics & housing ~ 10–20
- Transport & packaging ~ 5–10

Total per device (10 years) ~10 kg CO₂ eq.

2 HARVEST WASTE HEAT

Generate clean electricity from the process.

Residual heat from steam trap and process lines



InduEye™ Thermo 1

0.5 W continuous power



~4.4 kWh per year (per device)



This is electricity that would otherwise need to be supplied from the grid or a battery. We recover it from wasted thermal energy, with zero additional fuel and zero emissions.

3 REDUCE PROCESS EMISSIONS

Detect and fix steam leaks earlier.



Continuous monitoring detects leaks early.



Less steam loss, lower fuel consumption.



Direct reduction of Scope 1 emissions.

TOTAL CLIMATE IMPACT PER DEVICE (10 YEARS)

~320–365 kg CO₂ eq. avoided

~450 kg CO₂ eq.

5 battery replacements (2 years per battery)
5 x 90 kg = 450 kg

~10–12 kg CO₂ eq.

(harvested electricity)

~10 kg CO₂ eq.

(device w/o battery)

Net impact (10 years) ~320–365 kg CO₂ eq. avoided

WHY IT MATTERS



Supports decarbonisation strategy
Reduces operational emissions (Scope 1) and supply chain emissions (Scope 3).



Improves energy efficiency
Recovers valuable thermal energy and reduces fuel consumption.



Safer and more reliable operations
Continuous monitoring without manual battery changes in hazardous areas.



Scalable impact
From pilot to fleet deployment across multiple sites.

CONTRIBUTES TO KEY SUSTAINABILITY GOALS



“Turn waste heat into lower emissions.”

STEAM TRAPS: MEASURABLE ENERGY IMPACT

Potential steam losses from a single leaking steam trap (Spirax Sarco data, 14 barg)



TYPICAL STEAM LOSSES AT 14 BARG

Based on Spirax Sarco steam trap orifice data¹

Equivalent leak orifice	Steam loss (kg/h)	Steam lost (tonnes/year) (8,400 h/year)	Thermal energy loss (MWh/year)
● 3 mm	19	160	124
● 5 mm	53	445	346
● 7.5 mm	121	1,016	790
● 10 mm	214	1,798	1,398
● 12.5 mm	335	2,814	2,188

KEY MESSAGES



A single leaking steam trap can waste hundreds of tonnes of steam per year.



Increases boiler fuel consumption, water treatment costs and CO₂ emissions.



15–30% of steam traps can fail in service in many plants (depending on industry and maintenance).²



Continuous monitoring with InduEye™ LeakSense 3 detects failures early and reduces energy losses.

FROM LEAK TO BUSINESS IMPACT

Example calculation for a 5 mm equivalent leak (14 barg, 8,400 h/year)



Steam loss
53 kg/h
(~445 t/year)



Thermal energy loss
(at 14 barg)
346 MWh/year
(0.778 kWh/kg)



Boiler fuel input
@ 85% efficiency
407 MWh/year



Fuel cost
(30 €/MWh)
€12,200/year



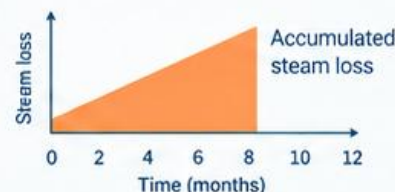
CO₂ emissions
(0.2 t/MWh)
81 tCO₂/year

EARLY DETECTION REDUCES ACCUMULATED LOSSES

Periodic / manual inspection



Failures can remain undetected for months until next inspection.



InduEye™ LeakSense 3 (continuous monitoring)



Early detection enables quick maintenance action and avoids most of the losses.



1. Spirax Sarco. Steam trap monitoring. Typical steam losses for orifice sizes at 14 barg. (SB-S34-01).

2. U.S. DOE. Improving Steam System Performance. Typical failure rates 15–30% in plants without regular maintenance, <5% with regular maintenance.

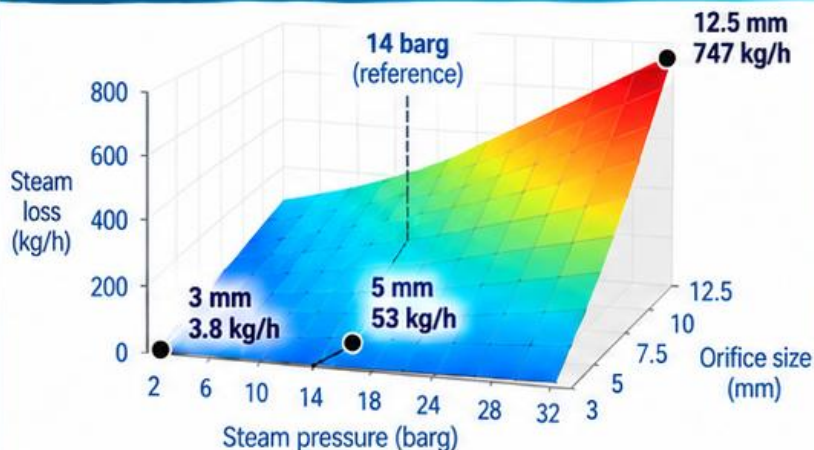
Assumptions (AEInnova calculation): steam enthalpy 2,800 kJ/kg (0.778 kWh/kg) at 14 barg, 8,400 operating hours/year, boiler efficiency 85%, natural gas cost 30 €/MWh, CO₂ emission factor 0.2 tCO₂/MWh.

STEAM TRAP LEAKS: ENERGY AND ECONOMIC IMPACT

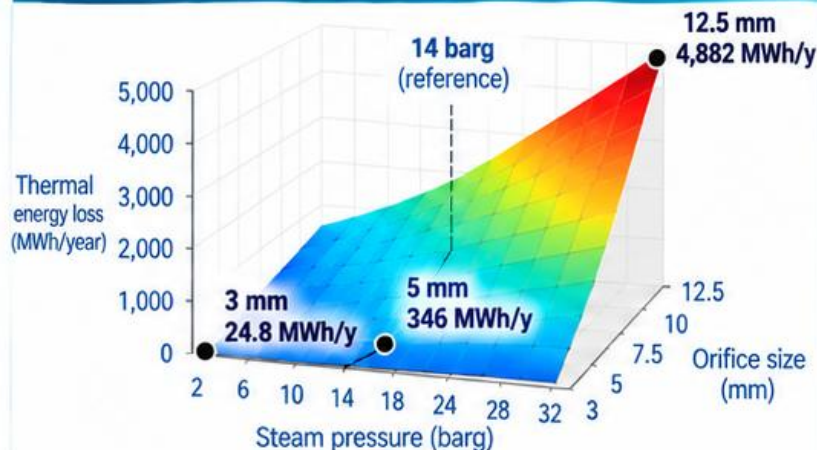
Estimated impact for different steam pressures and leak orifice sizes

Based on Spirax Sarco steam loss data (6, 14 and 32 barg) and critical flow scaling (proportional to absolute pressure). Operating time: 8,400 h/year.

Steam loss (kg/h)



Thermal energy loss (MWh/year)



Fuel cost (€/year) (at 30 €/MWh, 85% boiler efficiency)



Examples at 14 barg (Spirax Sarco data)

Orifice size (mm)	Steam loss (kg/h) (Spirax Sarco)	Steam lost (t/year) (8,400 h/y)	Thermal energy loss (MWh/year) (0.778 kWh/kg)	Fuel energy input (MWh/year) ($\eta = 85\%$)	Fuel cost (€/year) (30 €/MWh)	CO ₂ emissions (t/year) (0.2 t/MWh)
3	19	159.6	124.2	146.1	4,384	29.2
5	53	445.2	346.4	407.5	12,225	81.5
7.5	121	1,016.4	790.8	930.4	27,910	186.1
10	214	1,797.6	1,398.5	1,645.3	49,359	329.1
12.5	335	2,814.0	2,189.3	2,575.7	77,269	515.1

KEY MESSAGES



Steam losses increase rapidly with pressure and orifice size.



At €30/MWh fuel, one leaking trap can cost from ~ **€900 to >€170,000/year** across the represented range.



Each leaking trap increases fuel consumption and CO₂ emissions.



Continuous monitoring with **InduEye™ LeakSense 3** enables earlier detection and maintenance action, reducing energy losses and emissions.



Data source (steam loss):

Spirax Sarco. Steam trap monitoring. Typical steam losses for orifice sizes at 6, 14 and 32 barg. SB-S34-01.



Calculation assumptions (AEInnova):

Steam enthalpy: 2,800 kJ/kg (0.778 kWh/kg). Operating time: 8,400 h/year. Boiler efficiency: 85%. Natural gas cost: 30 €/MWh. CO₂ emission factor: 0.2 tCO₂/MWh.

InduEye™ LeakSense 3 – OTHER POTENTIAL APPLICATIONS (NOT TESTED)

Suitable for valves and equipment operating under high and very high process conditions.
Continuous detection of leaks, stuck positions and abnormal behaviour.

STEAM TRAP

Very High

US + ΔT



- Internal steam leakage
- Stuck open / closed
- Degraded performance

VENT VALVE

Very High

US



- Internal leakage to atmosphere
- Continuous venting
- Reduced outlet temperature

BYPASS VALVE

Very High

US + ΔT



- Bypass left open
- Continuous steam flow
- Ideal for permanent monitoring

GATE VALVE

High

US + ΔT



- Seat leakage
- External leakage (body/seat)
- Suitable for critical isolation valves

GLOBE VALVE

High

US + ΔT



- Seat leakage
- Leakage between disc and seat
- Useful for position verification

BALL VALVE

High

US + ΔT



- Seat leakage
- Identify which seat is leaking
- Suitable for DBB configurations

PLUG VALVE

High

US + ΔT



- Internal leakage between plug and seat
- Creates baseline for pressure/flow
- Suitable for high severity services

CONTROL VALVE (on/off or modulating)

High

US + ΔT



- Seat leakage in closed position
- Cavitation or abnormal behaviour
- Position, RMS trend and diagnostics

PSV / SRV (SAFETY RELIEF VALVE)

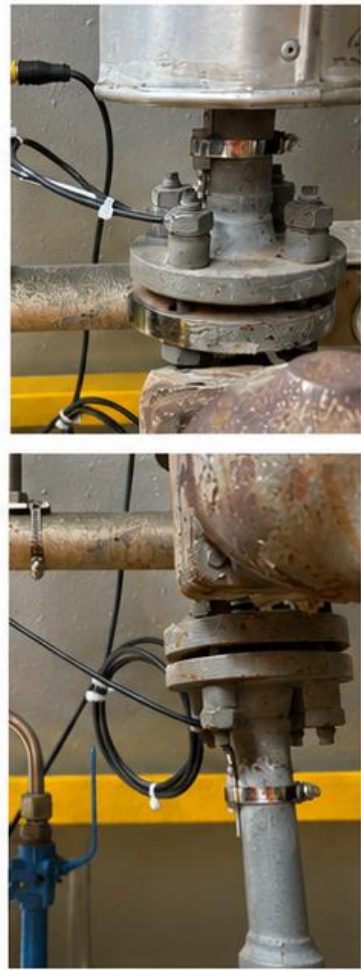
High

US + ΔT



- Early detection of lifting (simmer)
- Leakage after operation
- Monitor seat tightness

EXAMPLE IN AN OIL REFINERY / STEAM TRAP



Steam trap & valve leak detection

Early detection of steam leaks and losses



Dual temperature monitoring

Surface + process temperature



Ultrasound detection

Detects high-frequency ultrasound up to 50 kHz



100% batteryless

Powered by waste heat (thermoelectric)



ATEX / IECEx certified

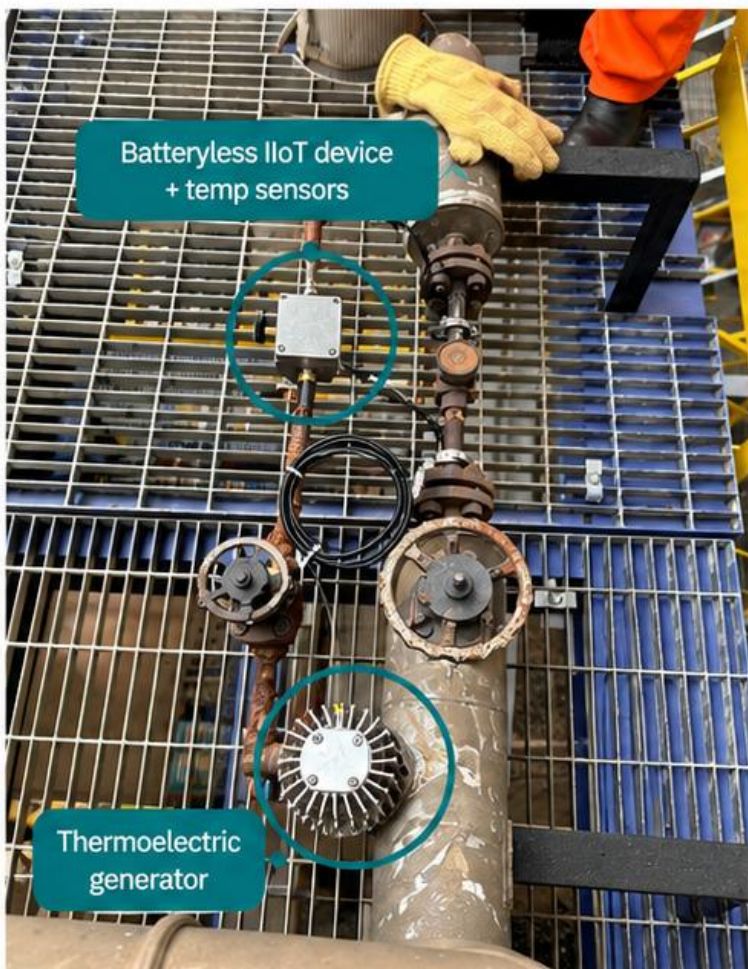
Safe for hazardous industrial environments



Reduce losses & emissions

Improve efficiency and support sustainability

EXAMPLE IN AN OIL REFINERY / STEAM TRAP



Process temperature monitoring
Surface temperature of critical equipment



Dual PT100 sensors
High accuracy ($\pm 0.1^\circ\text{C}$)



Wireless & batteryless
Powered by waste heat (thermoelectric)



Continuous monitoring
Real-time data for process optimization and asset integrity



ATEX / IECEx certified
Safe for hazardous industrial environments



Reduce downtime & improve efficiency
Early detection of temperature anomalies

EXAMPLE IN CHOCOLATE PROCESSING PLANT / STEAM TRAP



Steam trap & valve leak detection

Early detection of steam leaks and losses



Dual PT100 monitoring

Up to 200°C
(peak 250°C)



Ultrasound detection

Detects high-frequency ultrasound up to 50 kHz



100% batteryless

Powered by waste heat (thermoelectric)



LoRaWAN connectivity

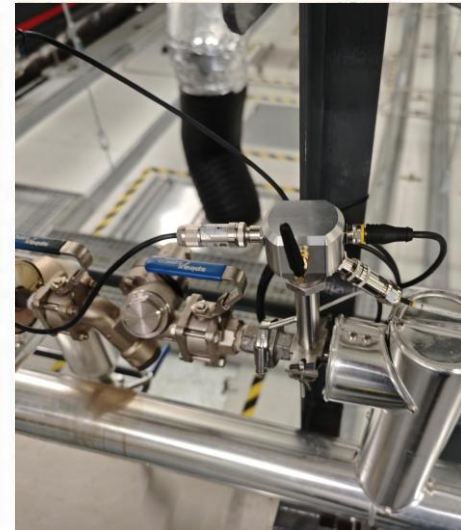
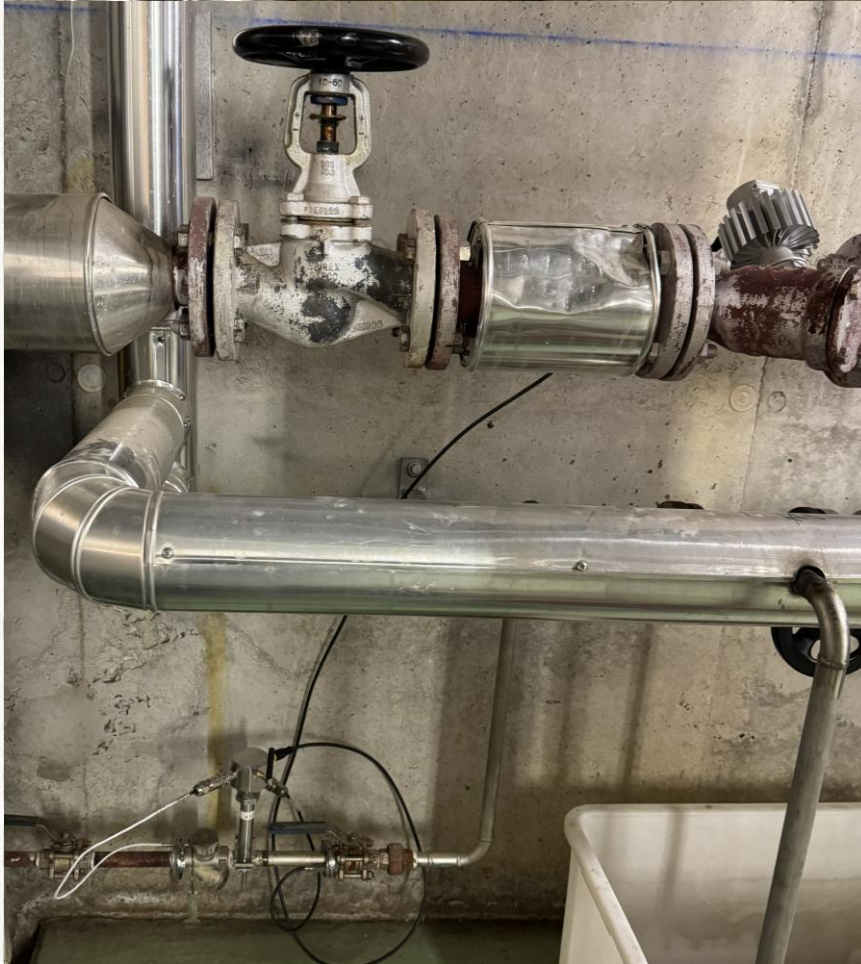
Wireless up to 2 km (indoor/outdoor)



Reduce steam losses & emissions

Improve energy efficiency and support sustainability

EXAMPLE IN A PHARMA PLANT / STEAM TRAP



**Steam trap & valve
leak detection**
Early detection of steam
leaks and losses



**Dual temperature
monitoring**
Surface + process
temperature



Ultrasound detection
Detects high-frequency
ultrasound up to 50 kHz



100% batteryless
Powered by waste heat
(thermoelectric)



ATEX / IECEx certified
Safe for hazardous
industrial environments



**Reduce losses
& emissions**
Improve efficiency and
support sustainability

DAEVIS DATA TREATMENT & VISUALIZATION

Measured indicators for advanced valve and steam trap diagnostics

THERMAL INDICATORS



Inlet temperature (Tin)

Temperature at steam trap inlet.
Detects steam presence and process conditions.



Outlet temperature (Tout)

Temperature at steam trap outlet.
Indicates discharge efficiency and traps blocked.



Temperature differential (ΔT)

$T_{out} - T_{in}$.
Key indicator for trap condition (closed, open or normal).

ULTRASOUND INDICATORS



RMS 20–30 kHz

RMS value in 20–30 kHz band.
Sensitive to high-frequency steam leaks.



RMS 30–50 kHz

RMS value in 30–50 kHz band.
Complementary band for different trap/valve types.



Maximum RMS & Peak

Maximum RMS and peak values.
Detects impulsive events and severe leaks.

OPERATION INDICATORS



Crest factor (CF)

Peak / RMS ratio.
Characterizes transient steam flow (e.g. trap opening).



Kurtosis

Signal shape indicator.
Helps identify abnormal behavior.



Pulses per minute

Number of opening pulses (ppm).
Indicates trap cycling and health.

SYSTEM STATUS INDICATORS



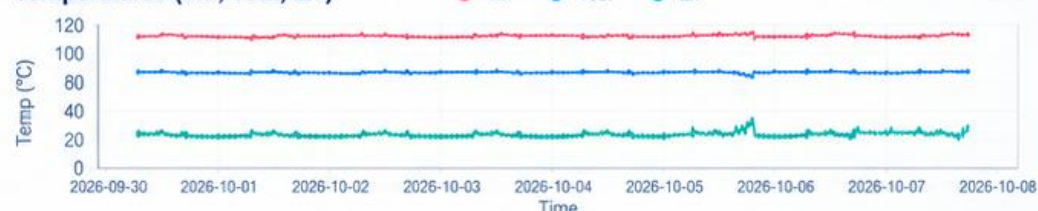
Generator status (TEG)
Generated electrical power level.
Confirms energy availability and self-powered operation.



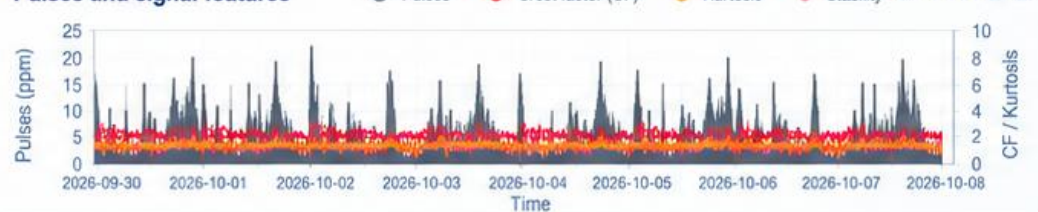
Radio signal (RSSI/SNR)
Link quality to the gateway.
Ensures reliable communication and network performance.

EXAMPLE DATA FROM A STEAM TRAP (Zoetis) IN DAEVIS

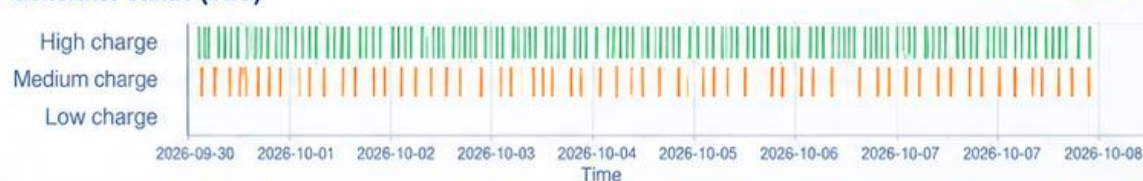
Temperatures (T_{in} , T_{out} , ΔT)



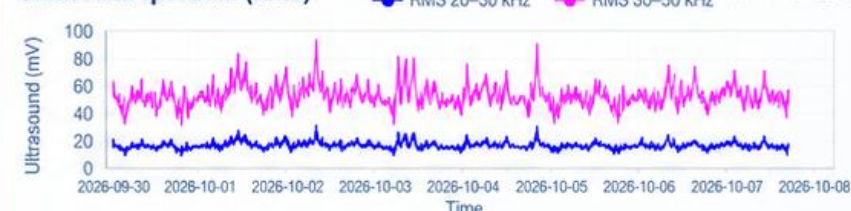
Pulses and signal features



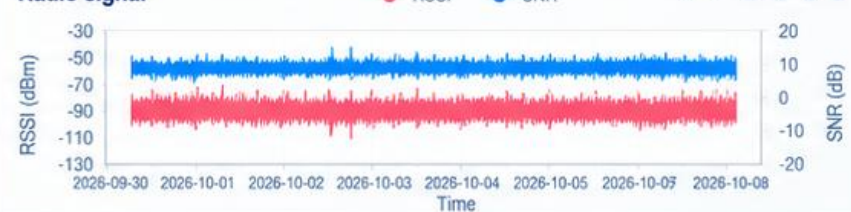
Generator status (TEG)



Ultrasound spectrum (RMS)



Radio signal



Generator status as a process indicator

The generator electrical power level reflects the steam process condition. Low or unstable power indicates reduced steam availability, often caused by fouling or inefficiencies in the steam system.



In this example, **the generator is producing low power** due to a dirty steam system, with alternating conditions throughout the period.

RELEVANCE OF EACH INDICATOR BY VALVE / STEAM TRAP TYPE AND RECOMMENDED RMS BANDS

Indicator	What it indicates	Thermodynamic steam trap	Thermostatic steam trap	Inverted bucket steam trap	Float & thermostatic steam trap	Isolation valve (on/off)	Control valve (modulating)	Safety valve (relief)	Recommended RMS bands (configurable)	
									Band 1 (low-mid freq.)	Band 2 (mid-high freq.)
T_{in} / T_{out} / ΔT	Process condition, discharge efficiency	✓	✓	✓	✓	✓	✓	✓	–	–
RMS 20–30 kHz	High-frequency leaks, turbulence	✓	✓	✓	✓	✓	✓	✓	20 – 30 kHz	30 – 50 kHz
RMS 30–50 kHz	Complementary band, different types	✓	✓	✓	✓	✓	✓	✓	30 – 50 kHz	50 – 80 kHz
Max RMS & Peak	Impulsive events, severe leaks	✓	✓	✓	✓	✓	✓	✓	15 – 30 kHz	30 – 60 kHz
Crest factor (CF)	Transient flow, trap opening	✓	✓	✓	✓	✓	✓	✓	15 – 30 kHz	15 – 60 kHz
Kurtosis	Signal shape, abnormal behavior	✓	✓	✓	✓	✓	✓	✓	15 – 30 kHz	30 – 60 kHz
Pulses per minute	Trap cycling and health	✓	✓	✓	✓	✓	✓	✓	10 – 30 kHz	20 – 50 kHz
Generator status (TEG)	Energy availability (self-powered)	✓	✓	✓	✓	✓	✓	✓	–	–
Radio signal (RSSI/SNR)	Communication link quality	✓	✓	✓	✓	✓	✓	✓	–	–



Highly relevant



Relevant (optional)



Not relevant

DAEVIS DATA TREATMENT & VISUALIZATION

Advanced and flexible alarm logic to detect any type of valve or steam trap condition

1. CREATE COMPLEX ALARMS COMBINING ALL MEASURED INDICATORS

DAEVIS allows creating flexible alarm logic using any measured parameter and logical operators (AND, OR, >, <, =) to detect any type of valve or steam trap condition.

Create new alarm

Logic operator:

AND

OR

Variable *

Tin

Operation *

>

Target Value *

100

×

Variable *

Tout

Operation *

<

Target Value *

60

×

Variable *

ΔT

Operation *

<

Target Value *

20

×

Variable *

RMS 20-30 kHz

Operation *

<

Target Value *

10

×

+ Add condition

+ Add group

2. EXAMPLE ALARMS FOR STEAM TRAPS

Example 1: Thermostatic steam trap CLOSED (blocked – no condensate evacuation)



The inlet temperature remains high, the outlet temperature is low, there is no temperature drop, and no ultrasonic activity (no pulses).

Typical alarm configuration:

Tin	> 100 °C	AND
Tout	< 60 °C	AND
ΔT	> 20 °C	AND
Pulses	= 0	AND
RMS 20-30 kHz	< 10	AND
RMS 30-50 kHz	< 10	

Example 2: Steam trap OPEN (leaking steam)



The inlet and outlet temperatures are high, there is continuous steam flow with high ultrasonic activity and a high number of opening pulses.

Typical alarm configuration:

Tin	> 100 °C	AND
Tout	> 90 °C	AND
ΔT	< 20 °C	AND
Pulses	> 5	AND
RMS 20-30 kHz	> 30	OR
RMS 30-50 kHz	> 50	

3. ALARM MANAGEMENT IN DAEVIS

Enable/disable alarms, manage subscriptions and edit them easily.

Alarms

Filter

Name	DevEUI	Criticality	Sensitivity	Conditions	Status	Last check	Actions	Off/On	Alarm subscription
STEAM002 - Lock closed	0C5023497134720	10 min	-	(Tin > 90 AND Tout < 85 A...	✓	07-10-2026 10:33:18			
Temperatura condensat	7083065260070066	10 min	10 %	Tin>90	✗	04-09-2025 19:28:45			
Temperatura condensats	7083065260070068	10 min	10 %	Tout>80	✓	04-09-2025 15:29:36			

Items per page:

10

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4. NODE CONFIGURATION (BI-DIRECTIONAL LORAWAN)

Reconfigure the node remotely via DAEVIS to adapt measurements to each application.

Equipments/ NOD-0017-2600005 - NOD-0017-2600005

General Information Data and statistics Parameter Queries Configurations

Node configurations

Cadence (seconds):

600

Ultrasound Cadence (cycles/trigger):

1

Ultrasound Gain:

2

Ultrasound Sample Time (seconds):

120

+ Save configuration

5. EXPORT DATA AND GRAPHS

Export any time-series graph instantly in PNG, PDF or Excel format.



Temperature





AEInnova

Alternative
Energy Innovations

HARVESTING
INDUSTRY'S
POTENTIAL

THANK YOU

LET'S BUILD A MORE SUSTAINABLE INDUSTRY TOGETHER

Batteryless Industrial IoT.
Real impact. No maintenance.



WEBSITE
www.aeinnova.com



PHONE
+34 902 440 21



RAÚL ARAGONÉS
raul.aragones@aeinnova.com



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NO LIMITS.



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INDUSTRIAL IOT POWERED BY HEAT