Acoustic emission Testing to support Process Safety

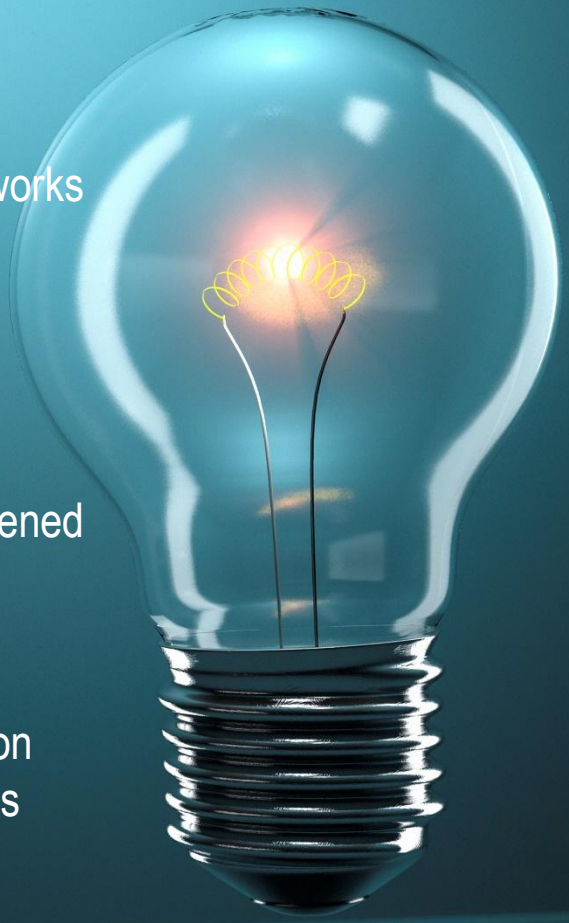
Your asset is alive.
Also, between the
periodic inspections!

Rainer Semmler

Closing the gaps in the classic inspection strategies:

ZDF television **Prudhoe bay oil spill at pipeline owned by BP Exploration 2nd March, 2006**
Germany

- Periodical inspections done according to regulatory frameworks
- All suppliers did a good job
- Authorities audited our inspection strategy and found nothing to complaint
- The shutdowns were not shortened



But: Suddenly we got the explosion and the leak we and the authorities understand, more has to be done, but what? What exactly?

The Answer is: **Doing things differently with a more comprehensive approach**

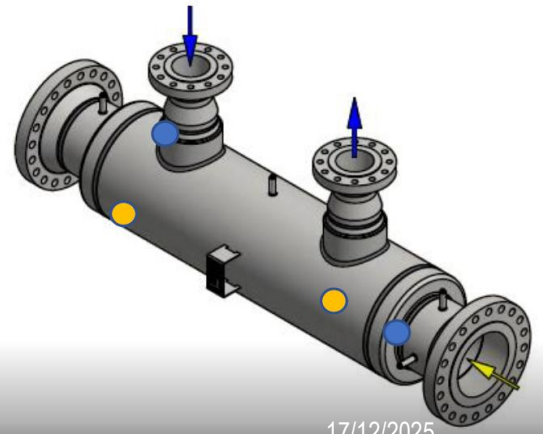
Are there any potential solutions?

- **Use of different technical methodologies for inspection**

- **Permanent monitoring of critical components and structures**

Integration of AT in comprehensive Asset Health Monitoring

Acoustic emission Testing

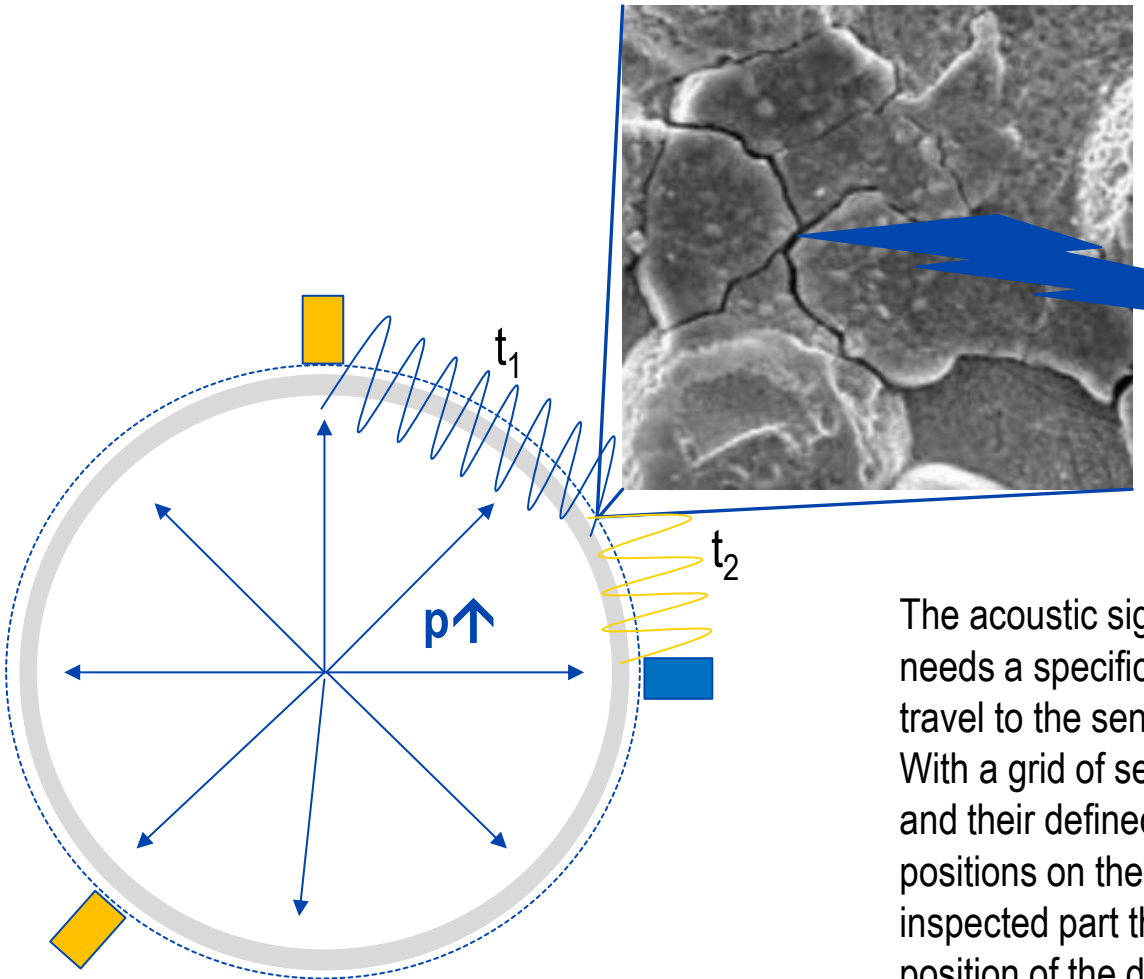


What is Acoustic emission Testing?

“Acoustic emission Testing (AT) is non-destructive testing (NDT) method that detects and monitors the release of ultrasonic stress waves from localized sources when material deforms under stress. These stress waves, or acoustic emissions, are generated by various defects within the material, such as cracks, flaws, or material fatigue”

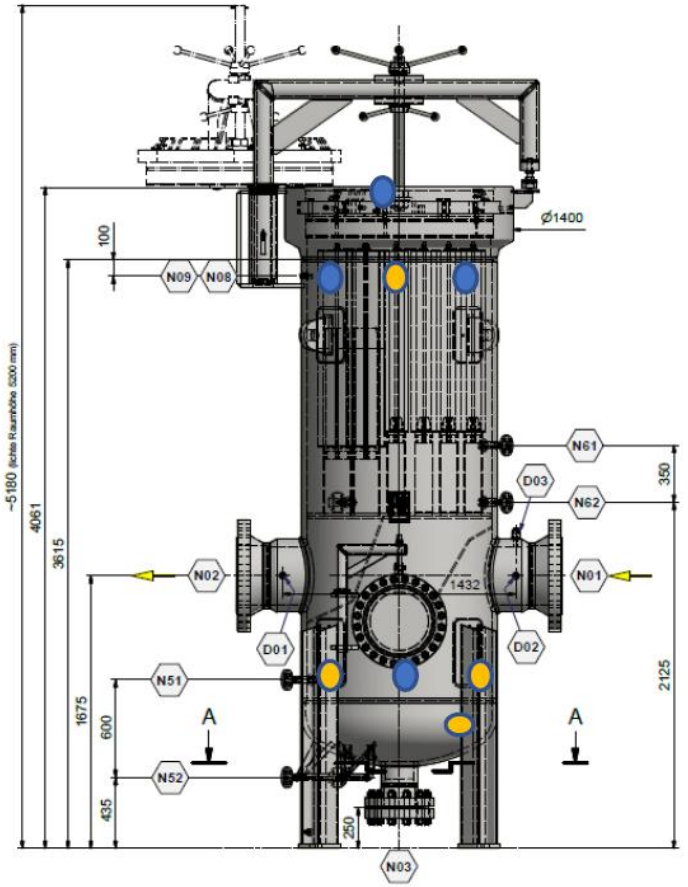
With this method, changes in the structure of the material can be detected before they reach a critical state. In addition, more precise assessments are often possible than with conventional pressure and visual inspections.

How does acoustic emission testing work as an inspection method?

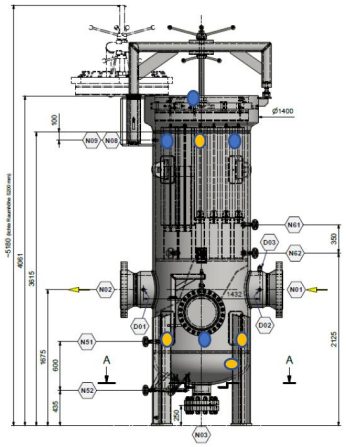


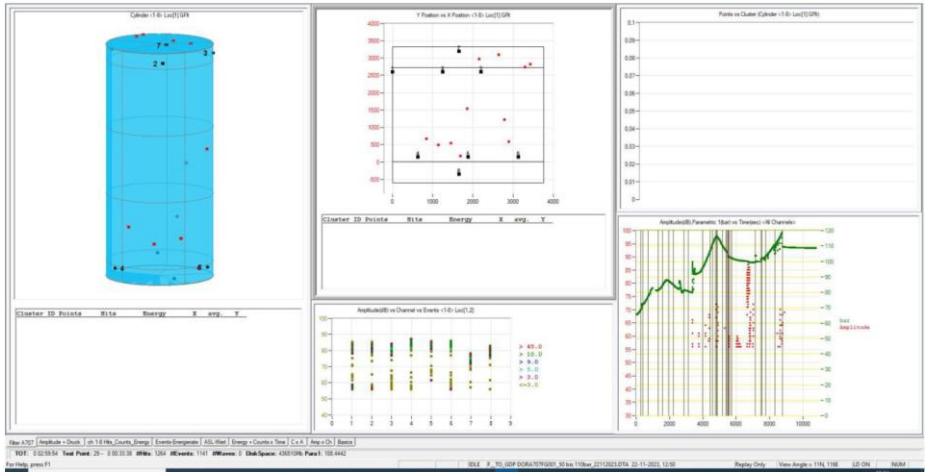
Acoustic signal already caused under stress by a small defect even smaller than a detectable crack.

The acoustic signal needs a specific time to travel to the sensor. With a grid of sensors and their defined positions on the inspected part the position of the defect can be located.

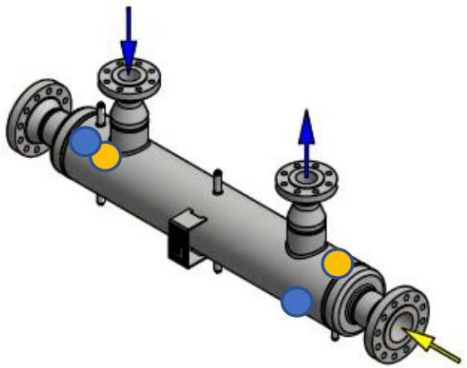


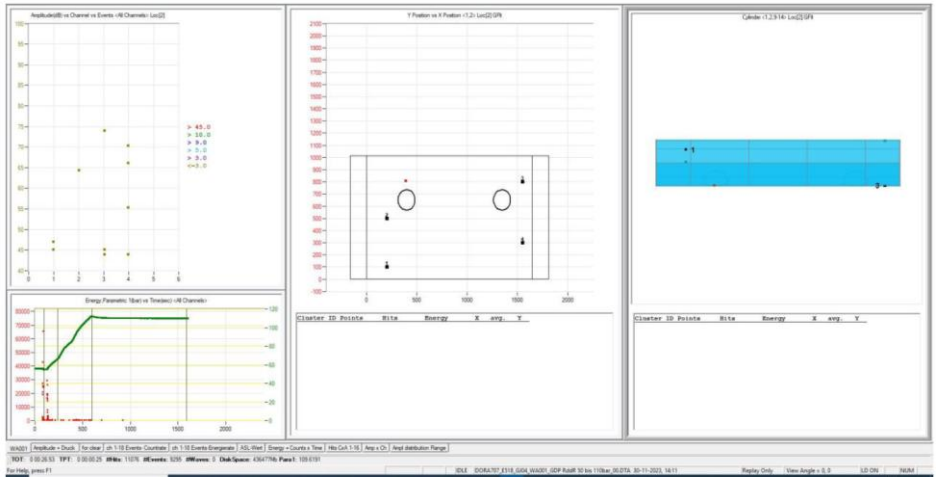
Some typical examples from practical application

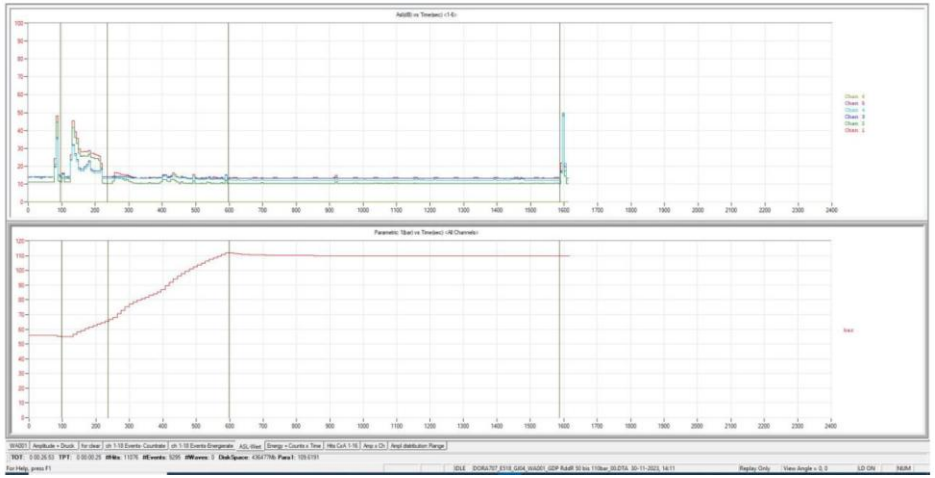




Red dots showing events during measurement
Events are classified
Class 1: Operation to be continued w/o further measures
Class 2: Additional local NDT (e. g. US) or VI required by certified pressure vessel inspector required
Class 3: Operation only to be continued with certified pressure vessel inspector approval after additional local NDT and VI







NDT: Non Destructive Testing (e. g. Ulra Sonic, Eddy Current, Dye Penetrant)
VI: Visual Inspection

What other options does AT offer besides the classic inspection?

“The functional principle is the analysis of (ultra-)sonic emissions that are generated by different processes in the material but also in a process.”

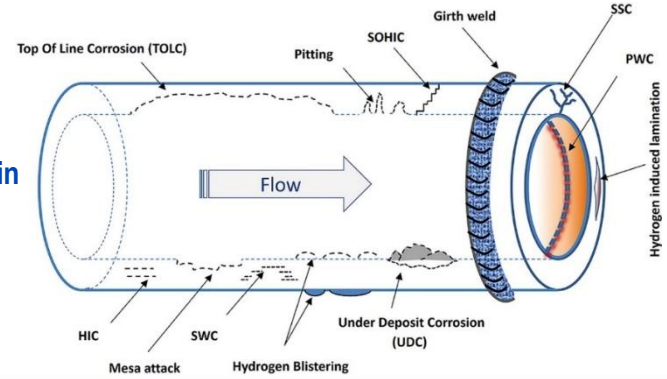
Potential sources for emissions in process are e.g. changes in a:

- **flow**
- **mixing process**

Enhancement of application possibilities also by evolving from spot inspection to online monitoring and including in a comprehensive monitoring concept!

Condition after few years in service

Beside material degradation also deposits & fouling cause a change in the emissions compared to “zero-measurement” at a defined time



Current inspection practice and corresponding limitations

Disadvantages of current practices

PPPP-Effect
(**P**osition, **P**eople, **P**rocedure, **P**robe)

Spot measurements have
a large error band width, so:

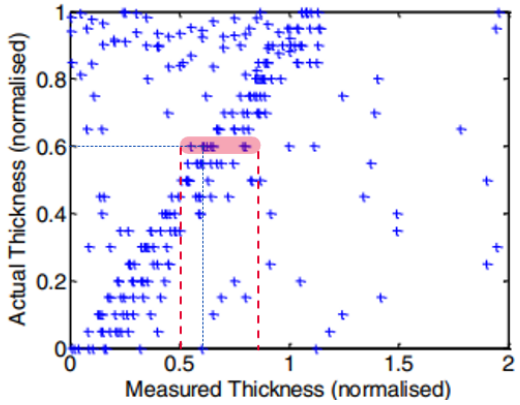
Not appropriate for prediction
of corrosion trends or changes in
process conditions

Not frequent enough to derive
corrosion trends or changes in process
conditions

Increasing inspection frequency
means higher costs

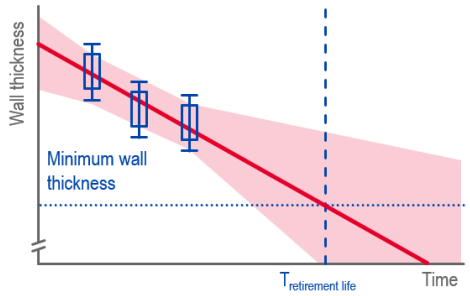
Failure prediction requires
dynamic FFS (Fitness for Service)
information

Measurement errors associated with manual ultrasonic thickness measurements on a corroded and retired steel sample

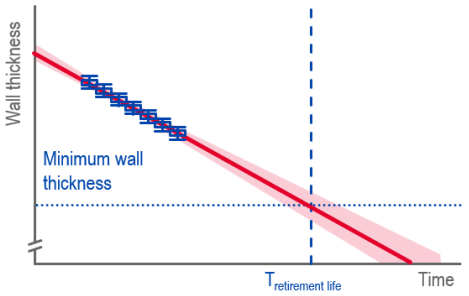


Trend estimation using…

…manual inspection



…permanently installed monitoring



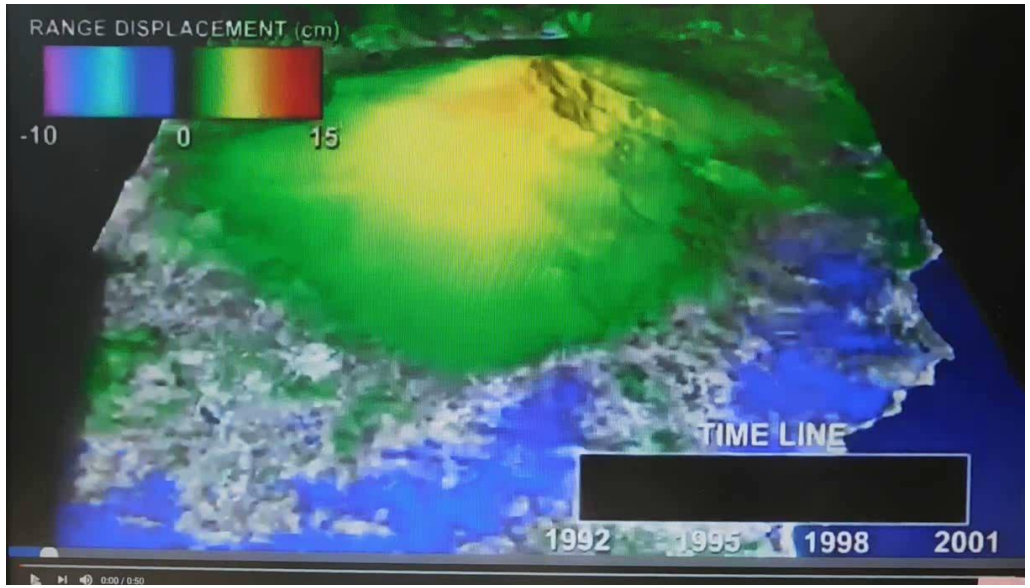
Are there any potential solutions?

Two practical examples

Permanent monitoring of critical components and structures and processes

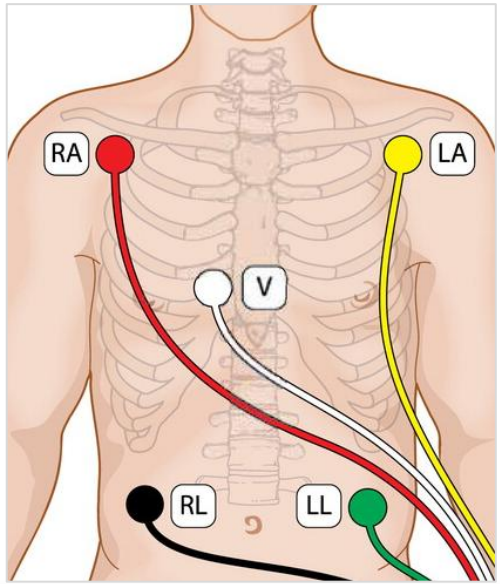
1

Volcano



2

Human body



?

And the Mechanical Integrity of critical plant parts?

The challenge or why **Asset Health Monitoring**?

*We keep comply with all **regulatory frameworks.** We perform all **periodical inspections** according to **standards**. Therefore, we were all very **surprised by the failure** that led to this **explosion**.*

BP Senior Speaker
ZDF November 12, 2006

Example: Our ultrasonic sensors which can be used

Data transmission
Online (24/7) or download on PC

High temperature measurement
-30 ºC to 500 ºC

Minimum wall thickness
3 mm (soon 2 mm +)

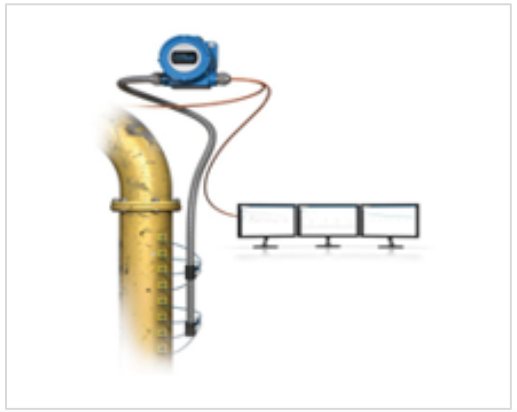
Resolution
0.020 mm

Max. number of probes per PM box
8 – 16

Storage capacity
Up to 3,000 measurements

Equipment
for ATEX Ex II 3G areas

Advantage: Significantly reduced number of negative surprises.

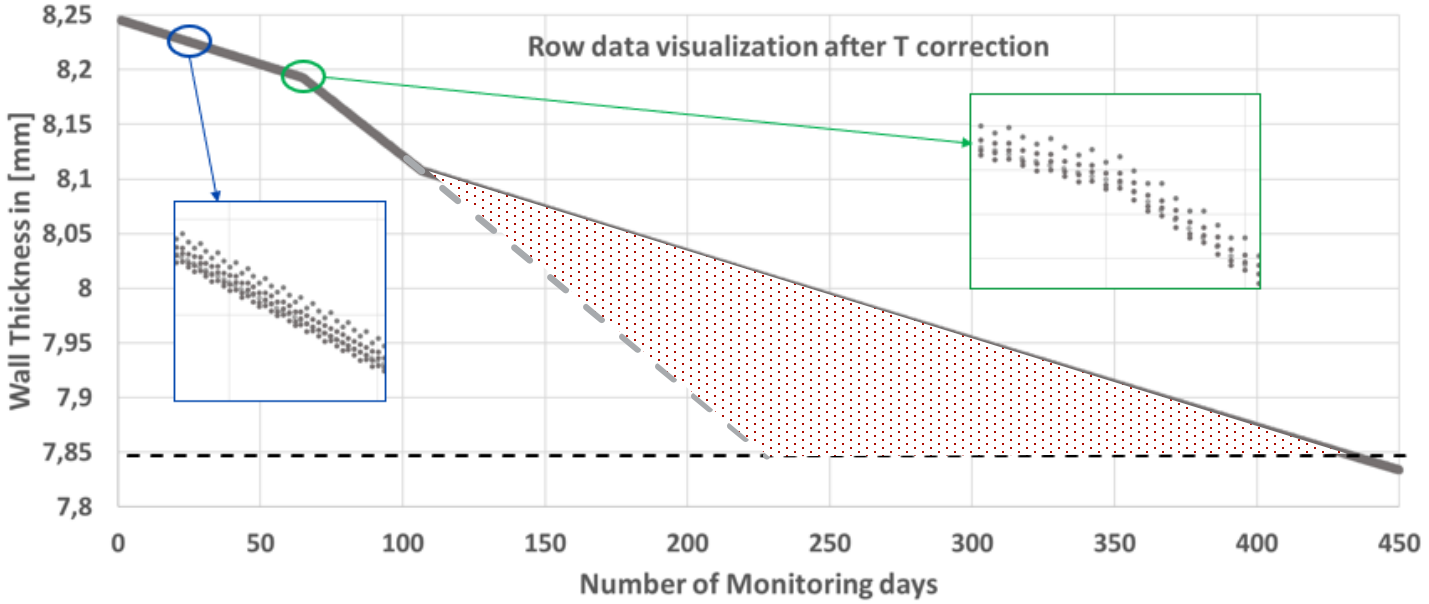


Value added of Asset Health Monitoring data for process safety

Detecting impact of processing parameters on Mechanical Integrity

Advantages of AHM system:

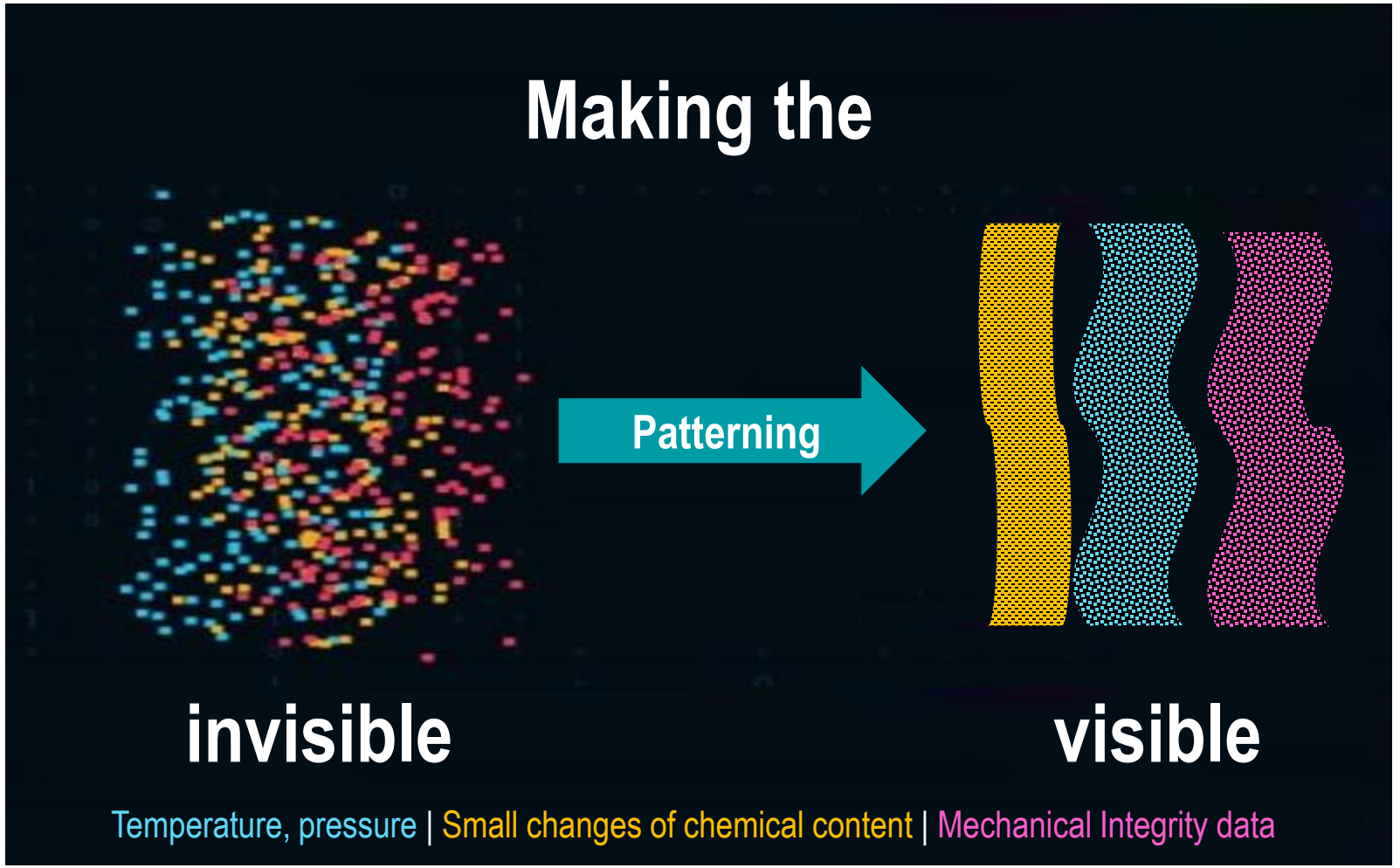
- Use BIG DATA for pattern recognition
- Detect influence of changing process parameters on Mechanical Integrity
- Support optimization of process parameters to achieve higher plant availability and plant longevity
- Inform operators on time before major negative consequences arise
- Support RCM and RBI approach



Find pattern in **big data** to improve process safety and achieve higher plant longevity

Asset Health Monitoring

Example to show benefits



Some apparently unconnected events are thus revealed to be connected

Surprises in Mechanical Integrity decrease

Plant availability increases

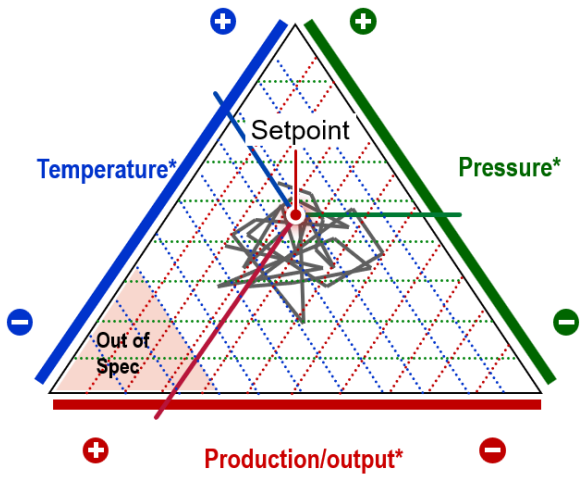
Profitability and safety increase

Using AHM data pool and process data

Optimization of operating parameters using Machine Learning (ML) and a digital plant / process twin

From traditional process control with fluctuations / suboptimal performance…

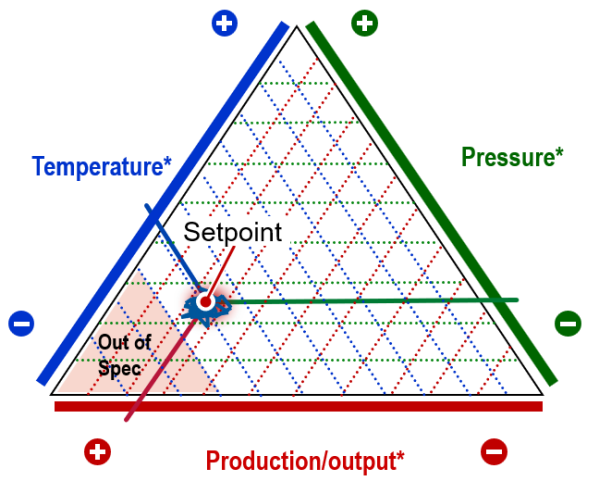
higher variability of important process parameters requires wider safety margins relative to optimal conditions



ML based Optimization

… to optimized operation with minimized fluctuations

optimization reduces variability by factor 10 →
higher production rate, more stabil process, lower costs



*alternative parameters can be defined as necessary based on focus of optimization - the graphs is are qualitative and not quantitative illustration only

Real data available for HAZOP instead of design data

More accuracy and reliability in defining limits for safety devices

Plant availability increases

Profitability and safety increase

Asset Health Monitoring and process optimization for process safety: Value added

Complementary solution to traditional services and to RCM and RBI services
Predict and plan maintenance based on Mechanical Integrity data
Use **big data** pattern recognition to **determine optimum process parameters**

The Solution…

Permanently mounted swarm of sensors

Collecting data of both:
Mechanical Integrity and processes

Using artificial intelligence for:

- Trending and patterning
- Prediction of lifetime
- Optimization of plant output

…& AT / online acoustic emission measurement is part of it!

Thank you!

Questions? Contact us!

GL Process Safety Management

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Add value. Inspire trust.