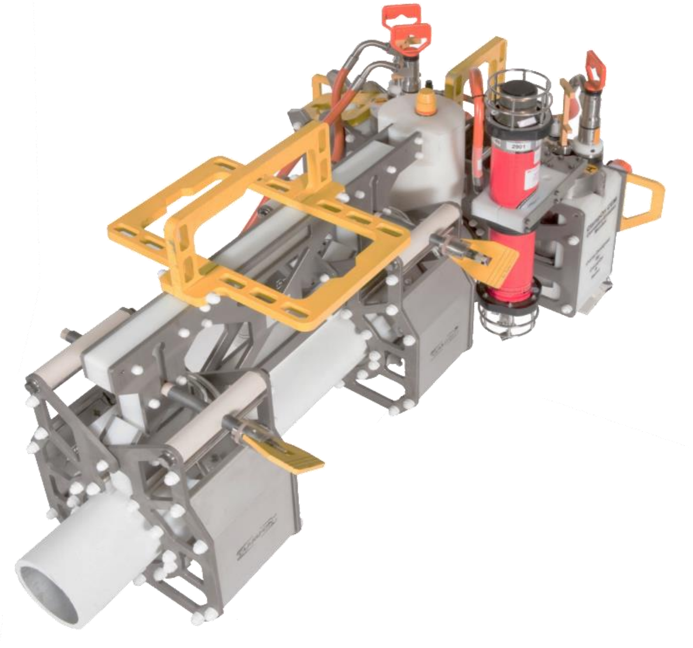
Increased performance and safety

by means of subsea instrumentation

Olav Brakstad
ClampOn AS

Agenda

- Introduction
- Integrity/condition monitoring
  - Corrosion/erosion
  - Vibration



Introduction

Industry focus on safety and integrity

Subsea requirements

- More information
- Reliability
- Long lifetime

ClampOn

- "Sand monitoring experts"
- Wide range of ultrasonic instruments and capacities

One technology, different applications

- Sand Monitor
- PIG detector
- Leak Monitor
- Well Collision Detector
- Cracking detector
- Wall Thickness Monitor
- Corrosion Under Insulation
- Vibration Monitor
- Corrosion-Erosion Monitor

Corrosion-erosion monitoring

Background

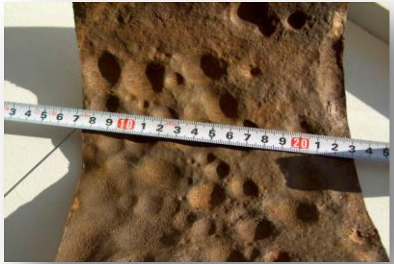
Subsea corrosion & erosion

- Integrity damage
- Production stop
- Expensive
- Spill
- Pollution
- Major problems

Background

Corrosion

- Cause; sour gas/condensate
- Effect; loss of integrity
- Remedy; anti corrosion agents



Erosion

- Cause; Sand production
- Effect; loss of integrity
- Remedy; reduce sand production

Continuous monitoring

Maintaining system integrity

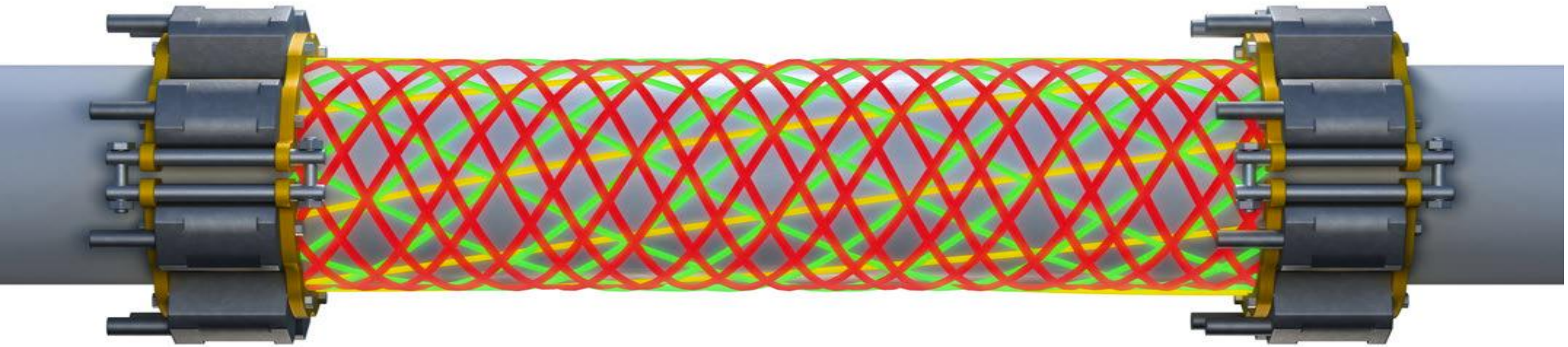
- **No loss of containment**
- **Avoid safety hazards**
- **No environmental damage**
- **Maintain uptime**
- **Minimize inspection &repair costs**

ClampOn Corrosion-Erosion Monitor

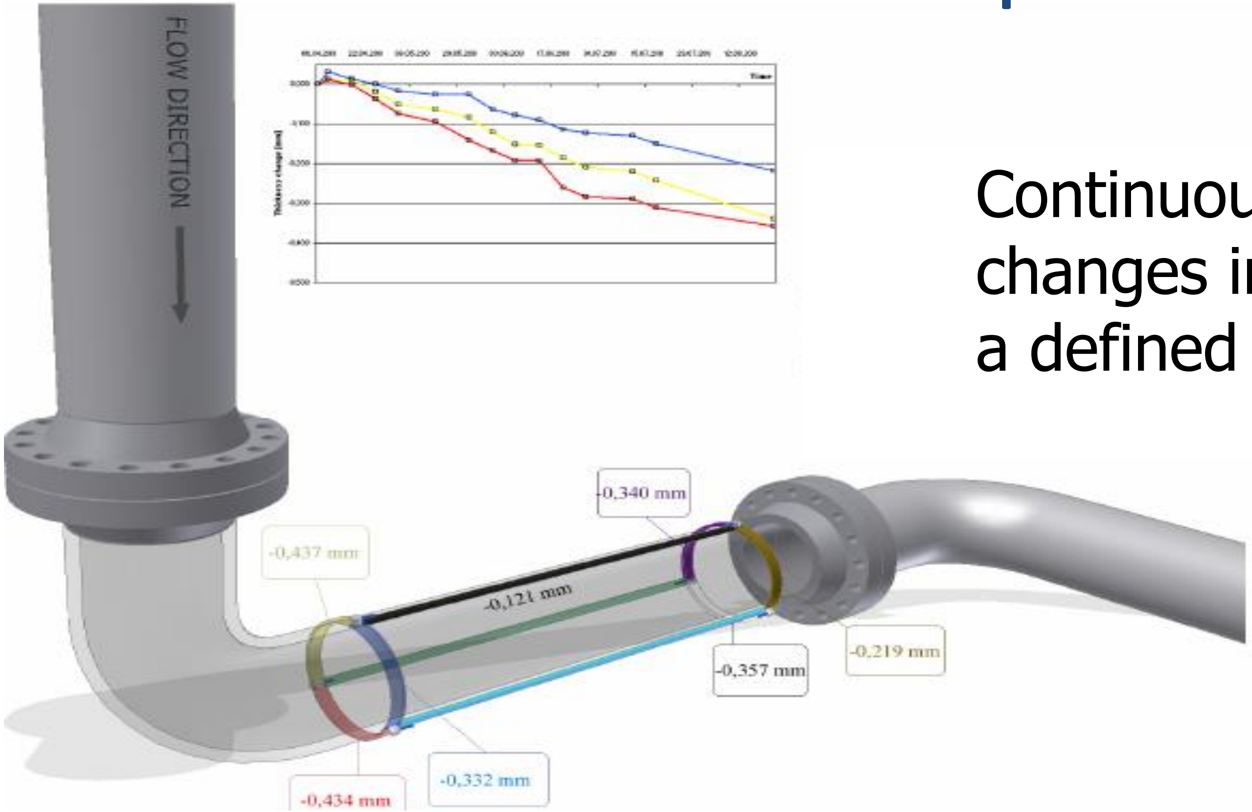
AKA:
Continuous
area wall thickness
monitoring

What is it?

Permanent active acoustic, non intrusive wall thickness monitoring system



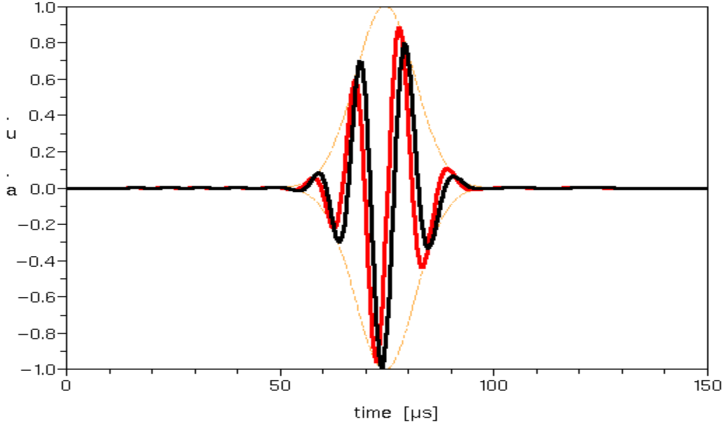
What does it provide?

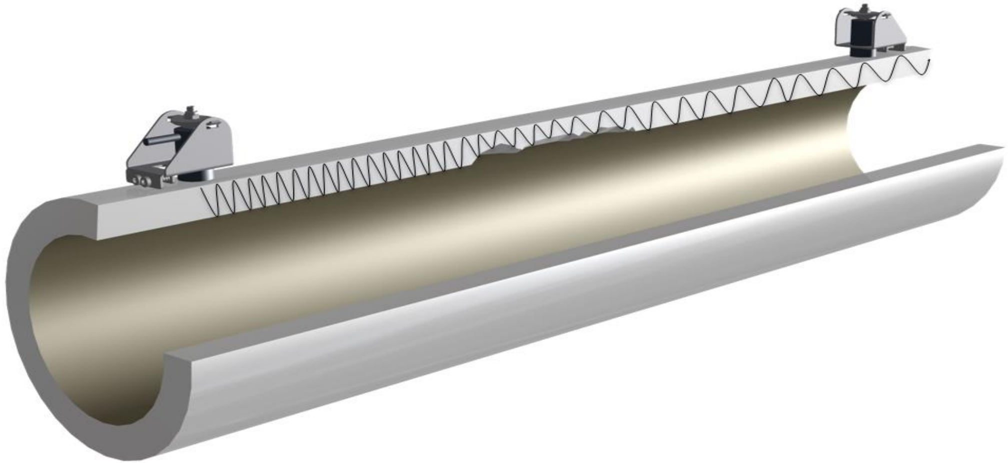


Continuous monitoring of changes in wall thickness on a defined pipe section

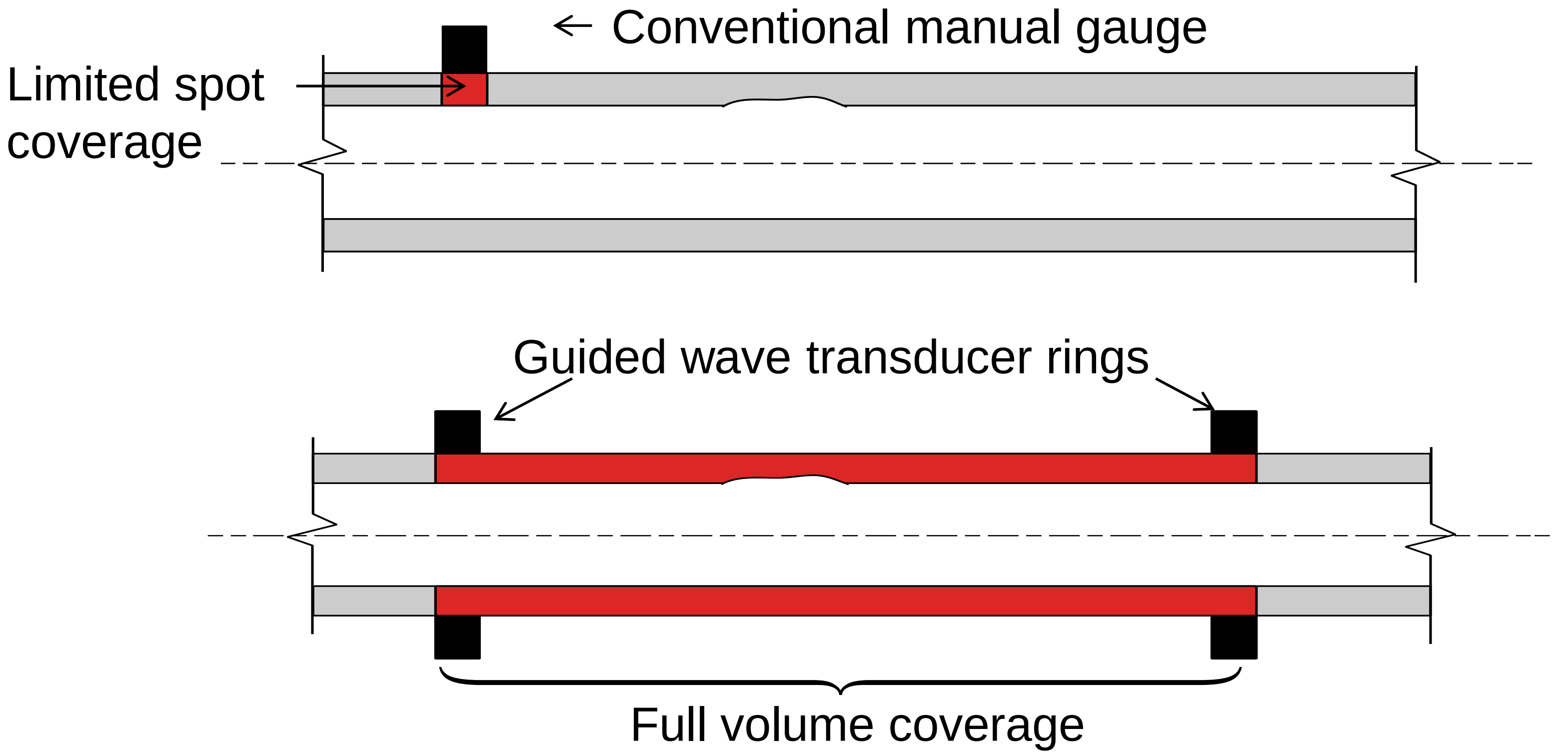
How does it work?

- Guided waves
- Change in WT -> change in signal shape



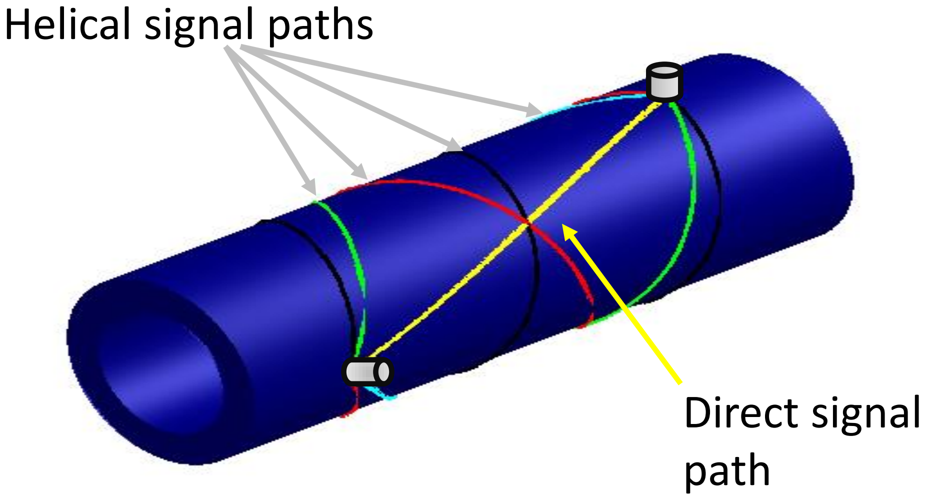


Why guided waves?



CEM Coverage Area w/GWT

Guided wave propagation in pipe structures is complicated by the presence of wave-paths that wrap around the structure. In the case of a circular cylinder the paths are helixes



Signal Paths:

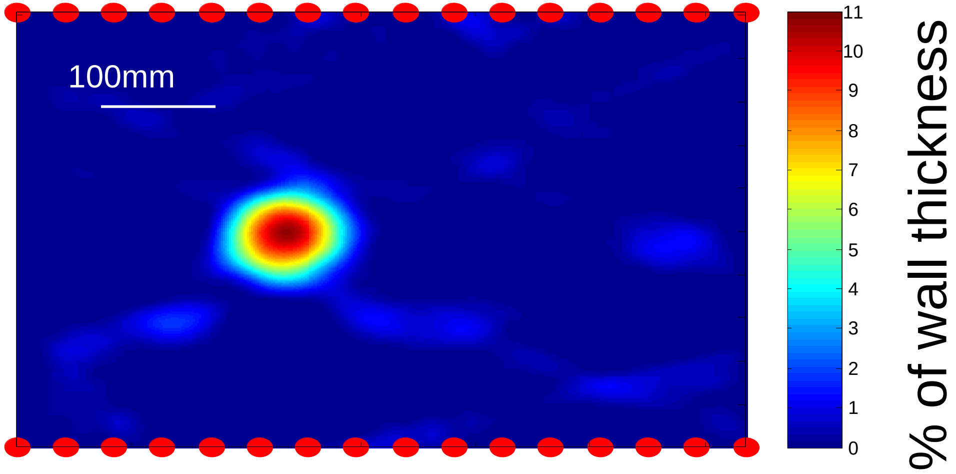
- Direct
- Helical Clockwise
- Helical Counter clockwise
- Double Helical Clockwise
- Double Helical Counter clockwise

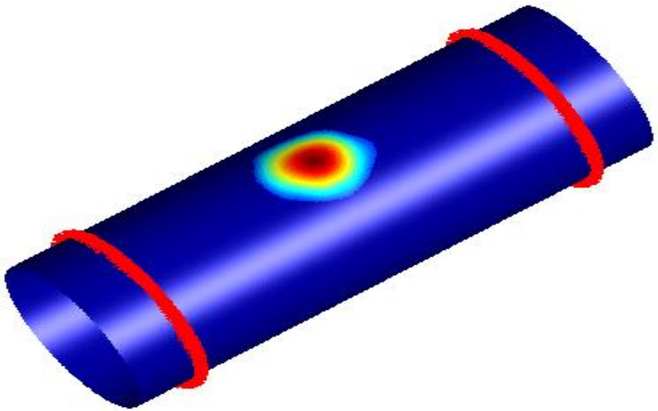
5 Signal Paths per transducer

Reconstructed wall thickness loss map

The reconstructed maximum depth is in excellent agreement with the max depth estimation from ultrasonic spot measurements at 20MHz which yielded 0.78±0.05mm

Maximum Depth 0.79 mm





Software GUI.

CorrPRINT®

Tomography Results w/EDM

EDM = Electrical Discharge Machining

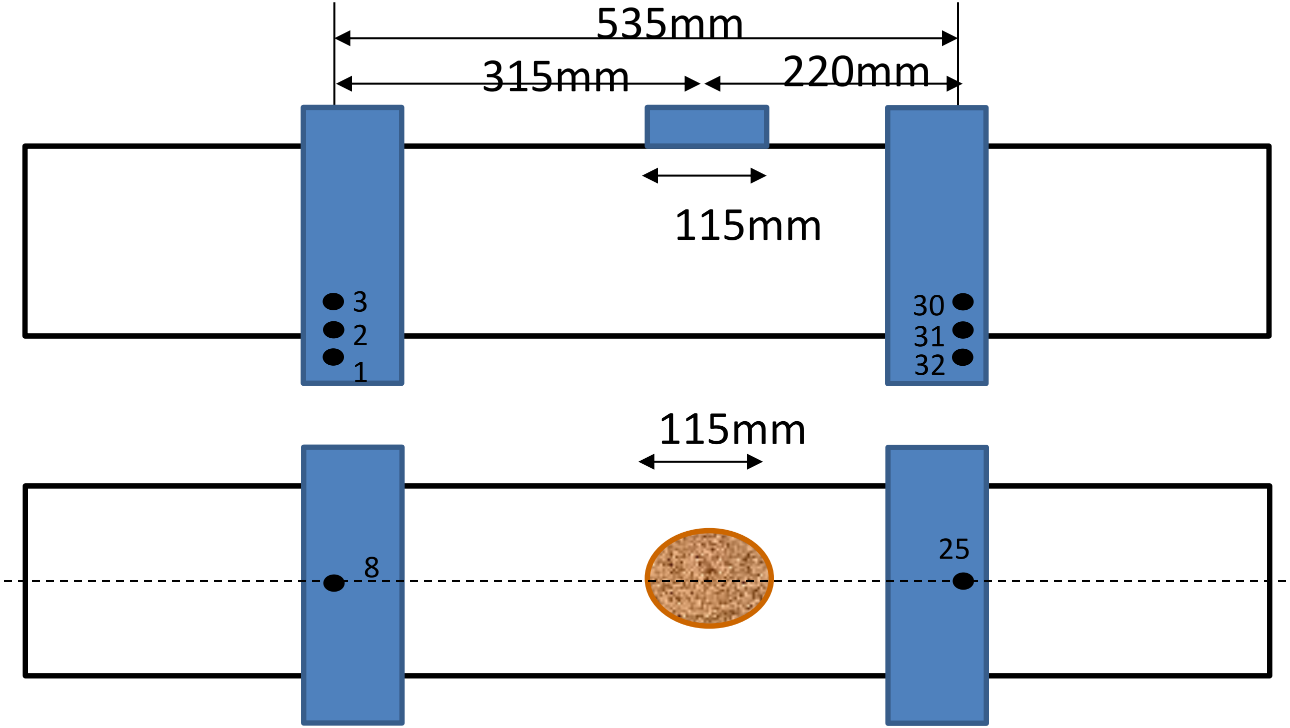
Defect #1

A copper electrode was machined to pipe surface shape and we eroded out in 12 different steps with increasing steps of 20um, 40um etc steps

Defect #12

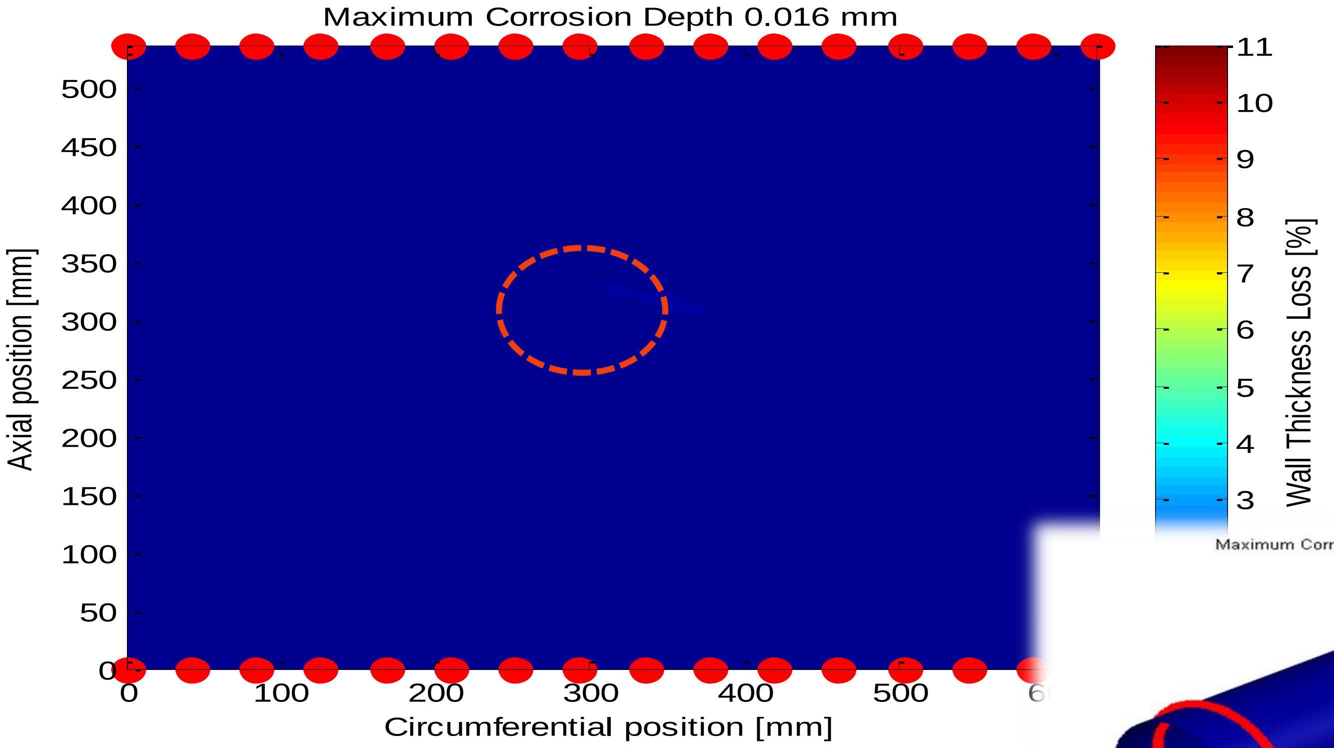
Transducer set-up

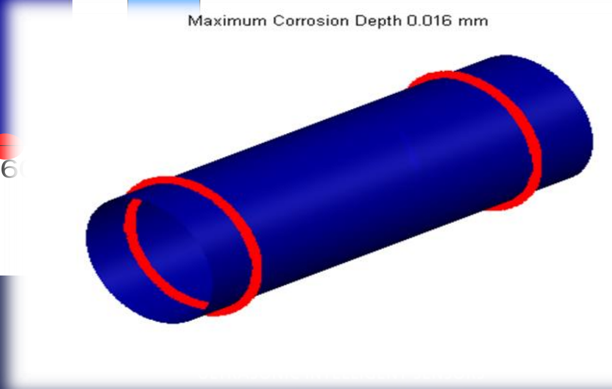
EDM Erosion –
"Slot" with oil & copper
115mm wide



Result 2D-view

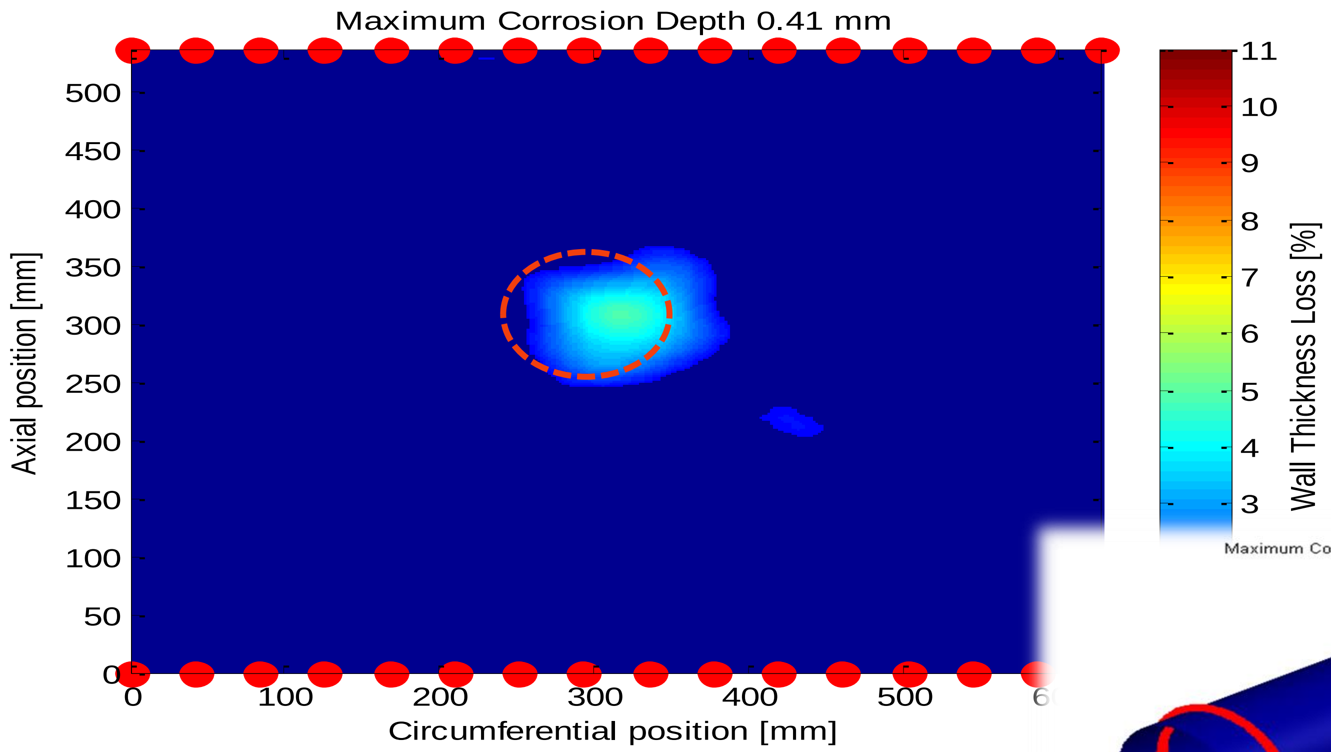
Defect #1

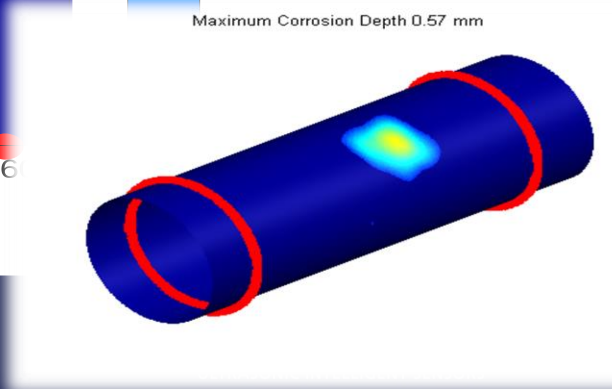




Defect #7

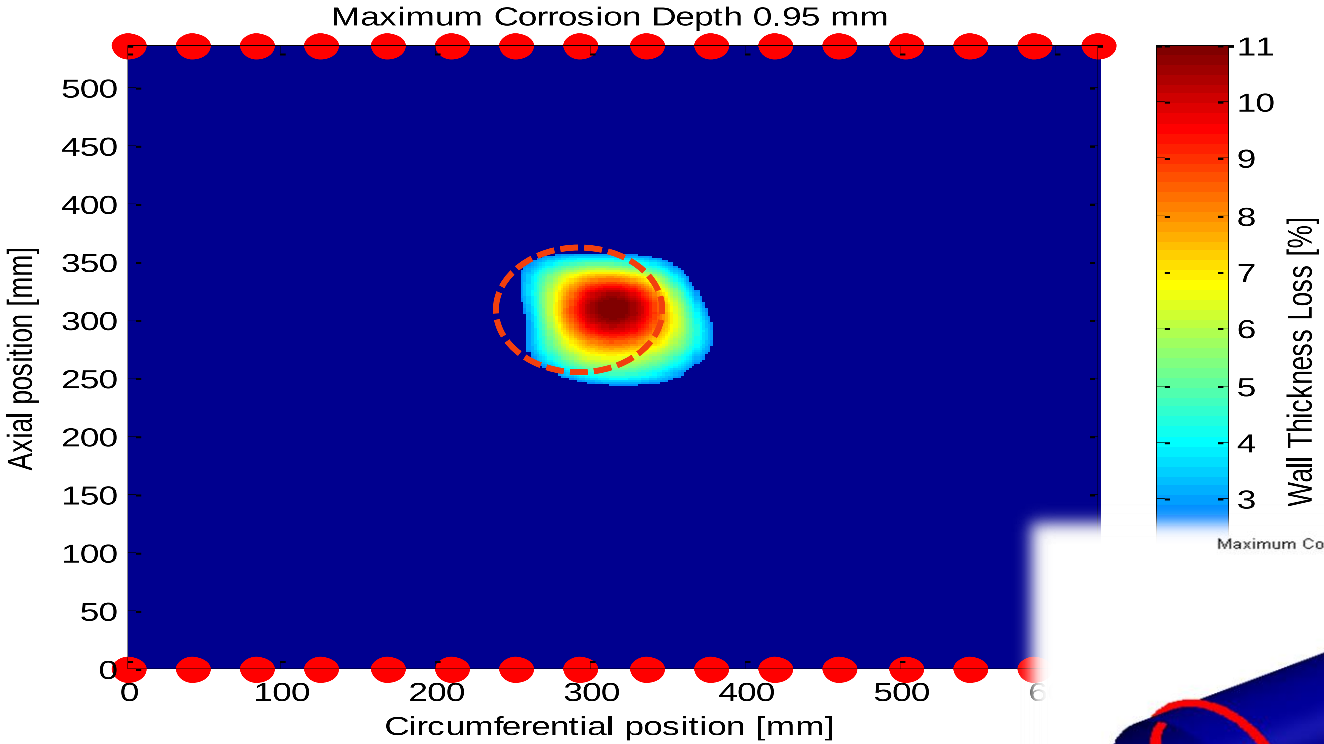
Result 2D-view

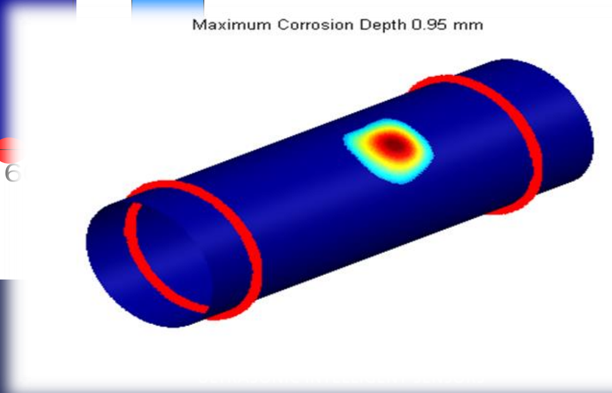




Defect #12

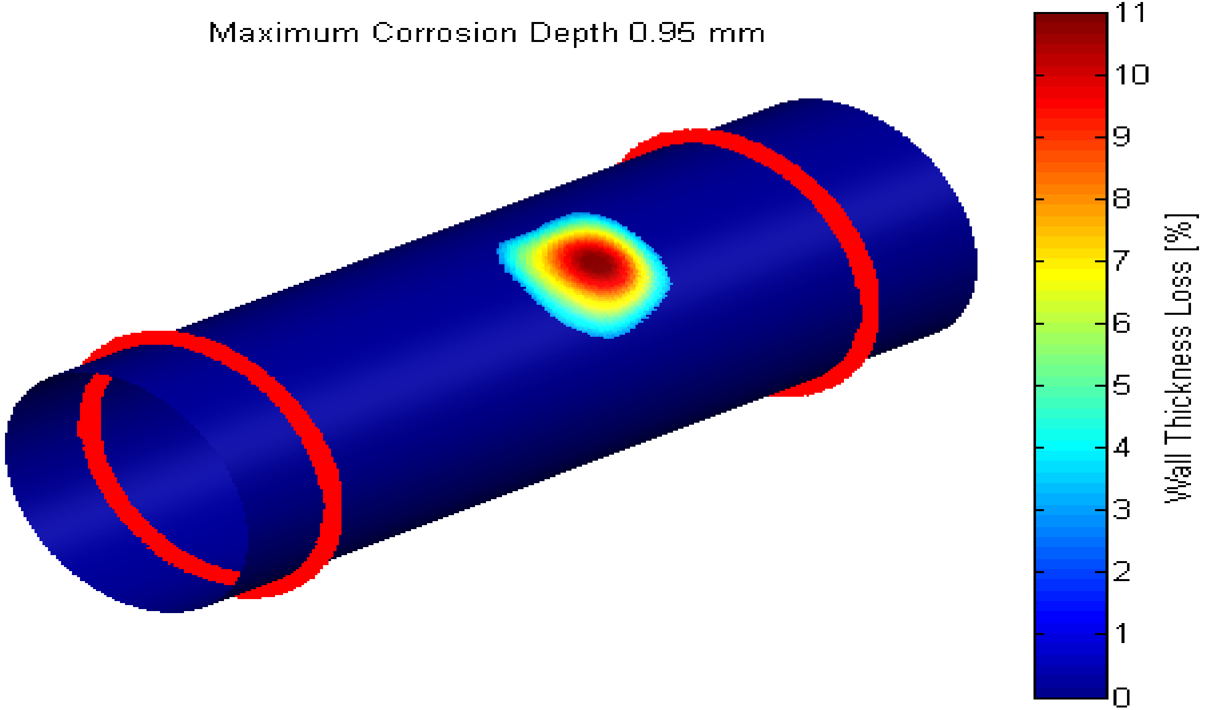
Result 2D-view



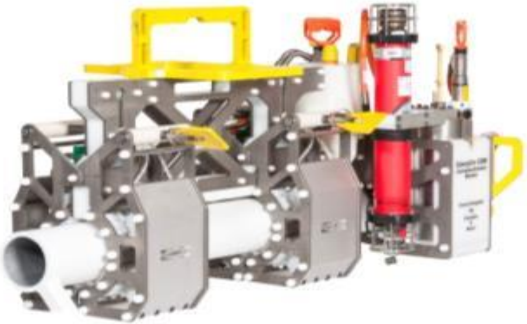


Defect #12

Result 3D-view



CEM Subsea



3 main alternatives

- CEM® for ROV installation
- CEM® non-ROV
- CEM® w/ ROV electronics

Retrofit/Brownfield

- Fully ROV installable
- Battery powered
- Wireless comms

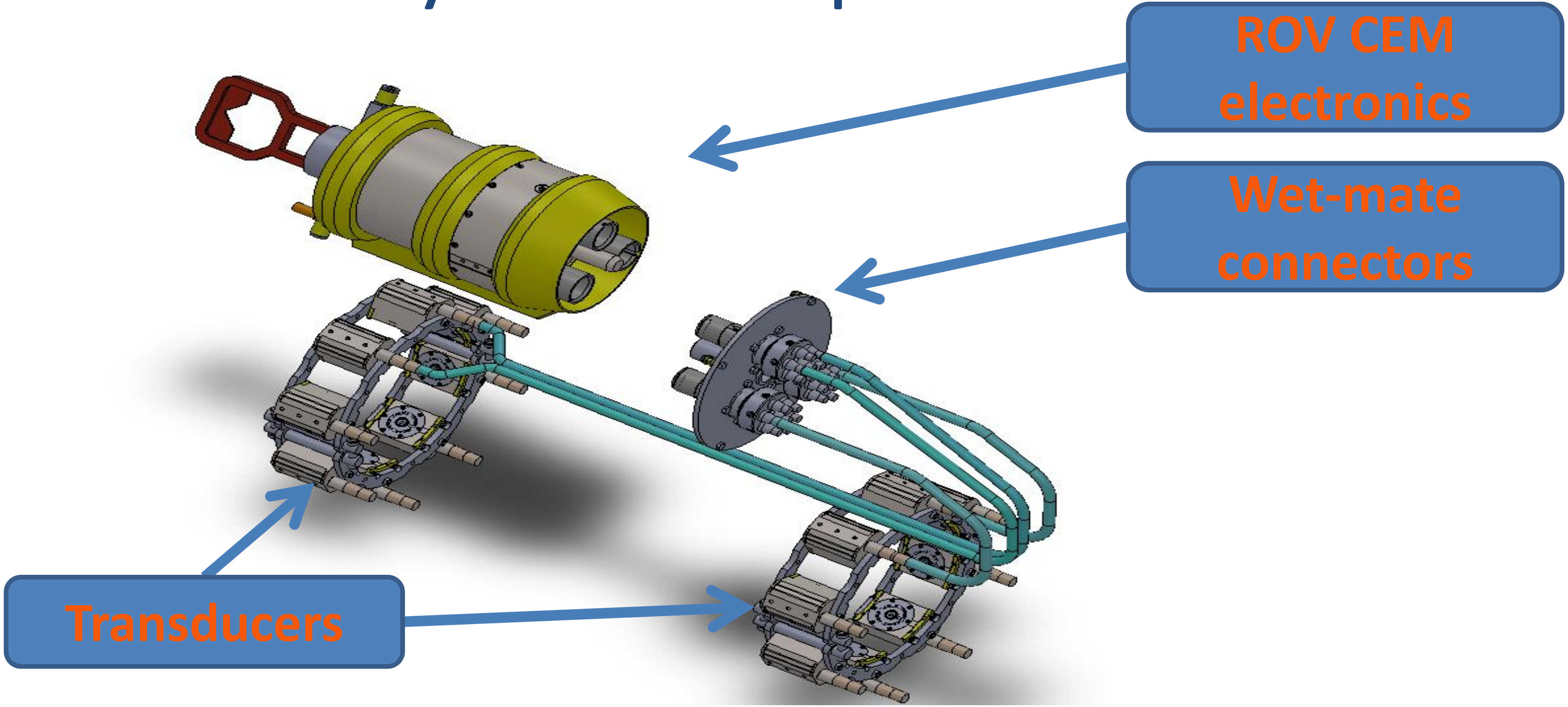
non-ROV

Non-ROV
retrievable
electronics

Preinstalled ROV electronics

- Transducers under insulation
- ROV retrievable electronics

System components:



Technical data

- **Pipe outer diameter (OD):** min 4” (100mm)
- **Pipe wall thickness (WT):** 2 mm to 35 mm (0,08” to 1,38”)
- **Distance between transducers:** 0.15 m – 2 m (78”) typical
- **Temperature :** -40 to 180 °C (-40 to 356 °F)

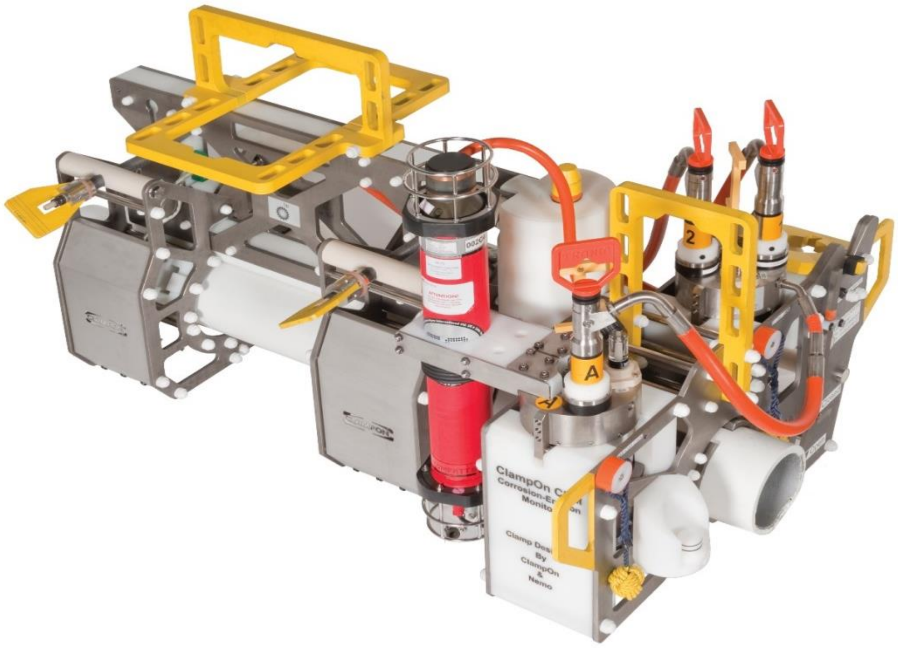
- **Power consumption:** Max 2.5 Watt
- **Sensitivity: better than 1% of the pipe wall thickness** (typical 0.1%)
- **Repeatability:** ±**0.04%**
- **Operation life:** 220 000 hours
- **Frequency range:** 30 to 300 kHz
- **Power Consumption:** Avg 6 Watt – Max 10 Watt (during operation)
- **Sensor electronics:** DSP 66-MIPS, A/D con. 24bit, 25-Years
- **Water depth:** 3000 Meters
- **Test pressure:** 345 BarA

Case example

BP - GOM

Application: corrosion

Type: standalone



Standalone, battery powered, onboard data storage, acoustic coms by Sonardyne modem, fully retrofitted

Case example

Total – Laggan - Tormore

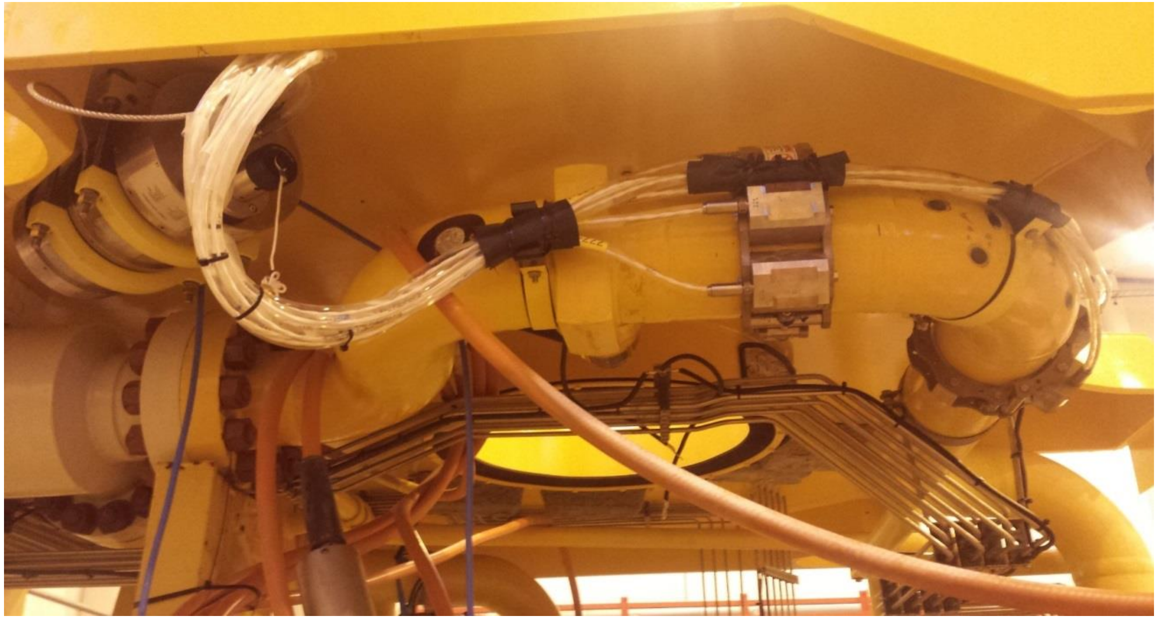
Application: Erosion

Type: Integrated

Integrated Non retrievable configuration, erosion monitoring

Case example

Statoil – Mikkel Åsgard & SVAN
Application: erosion
Type: standalone
QTY: 12



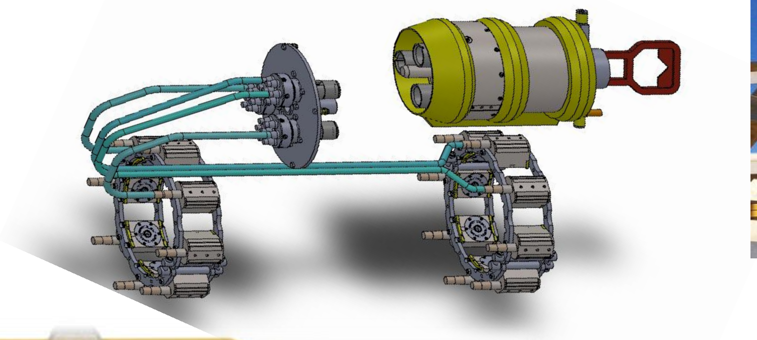
Fully integrated, frequent measurement trough bend

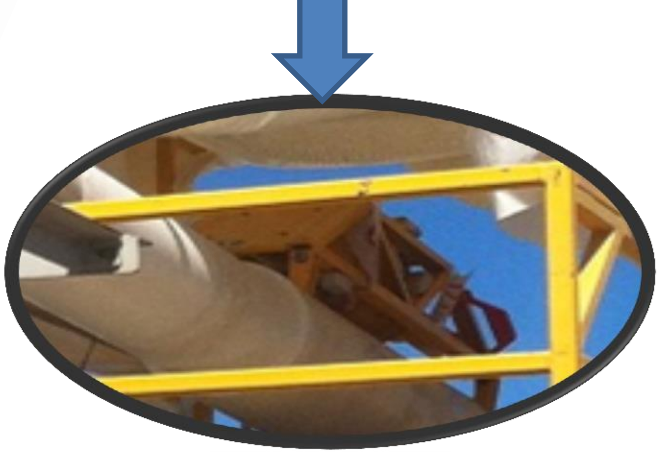
Case example

Murphy - Kikeh

Application: corrosion

Type: integrated





Integrated, connected to subsea controls.

Case example

Burullus – WDDM Ph 9a

Application: corrosion

Type: standalone

QTY: 8

Standalone, battery powered, onboard data storage

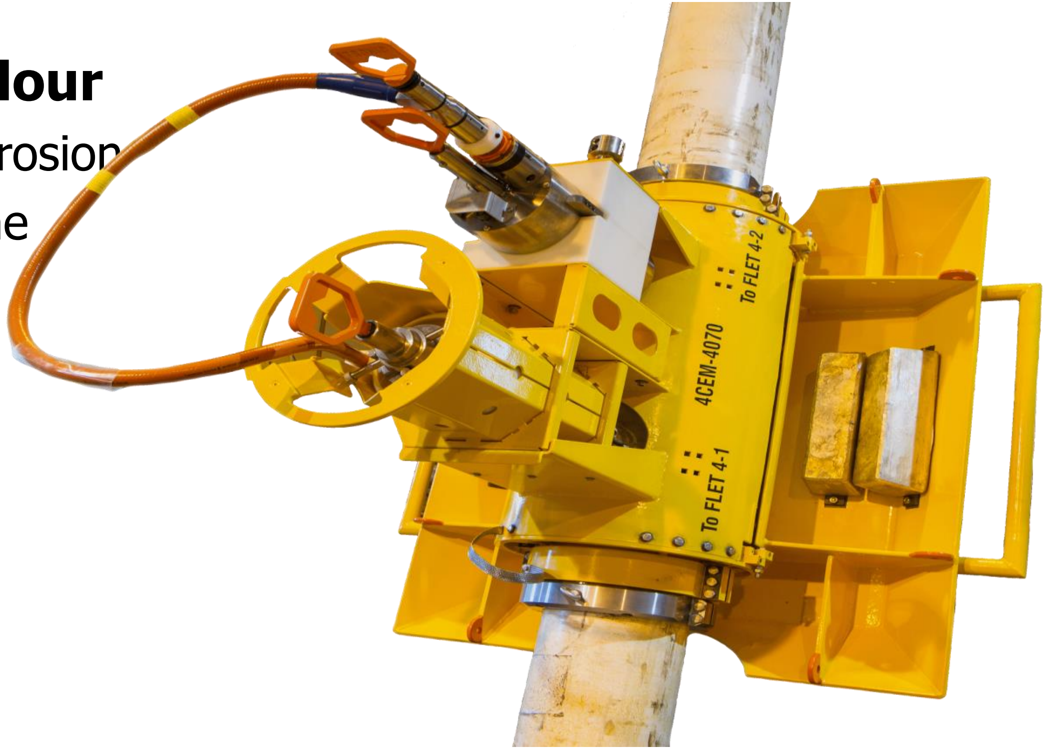
Case example

Total - Edradour

Application: corrosion

Type: standalone

QTY: 1



Standalone, battery powered, onboard data storage. Installed on pipeline prior to “reel out” 180 deg pivot

Case example

Total - Edradour

Application: corrosion

Type: standalone

QTY: 1

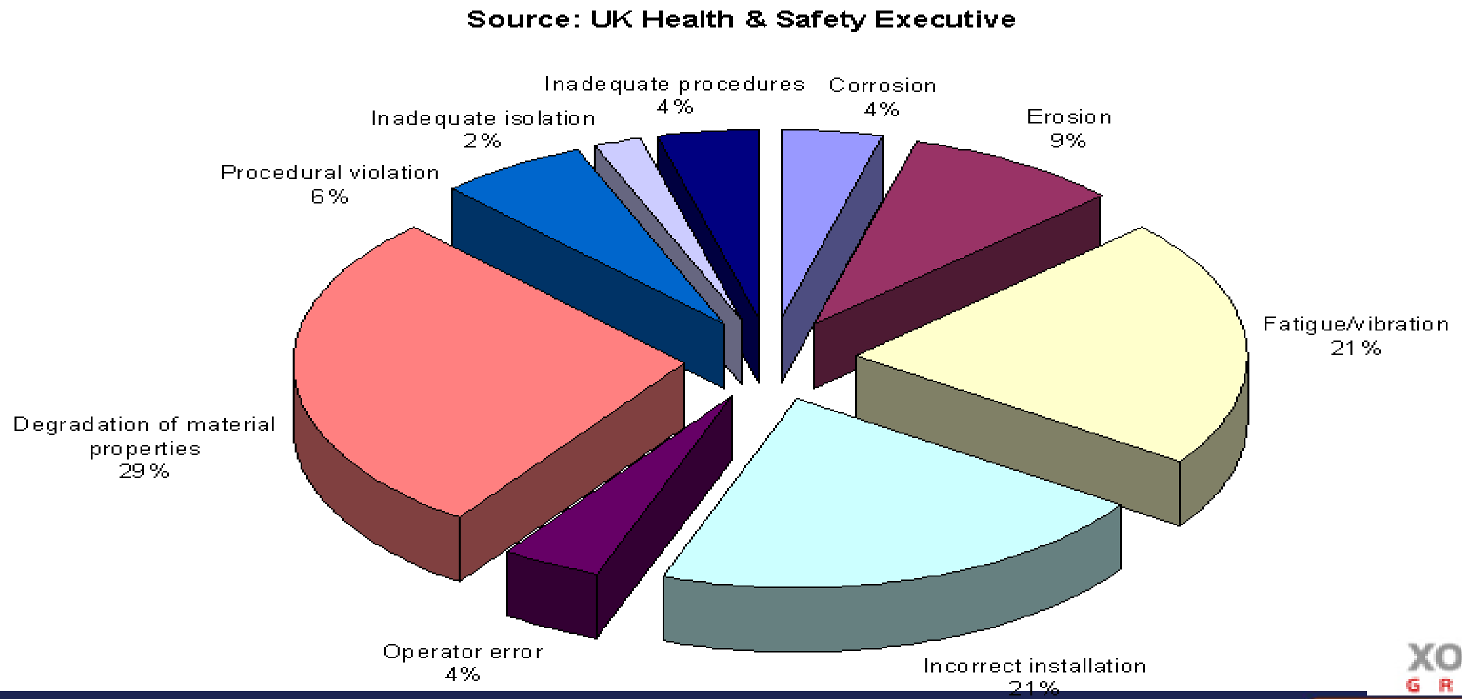
Mechanical interface testing, pivoting

Vibration

monitoring

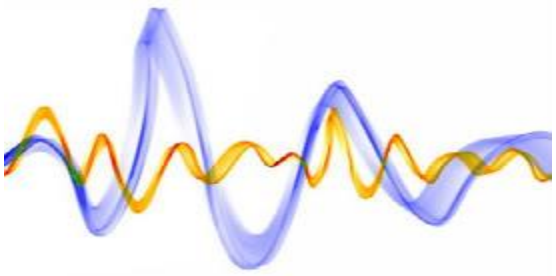
Background

Topside causes of pipework failure



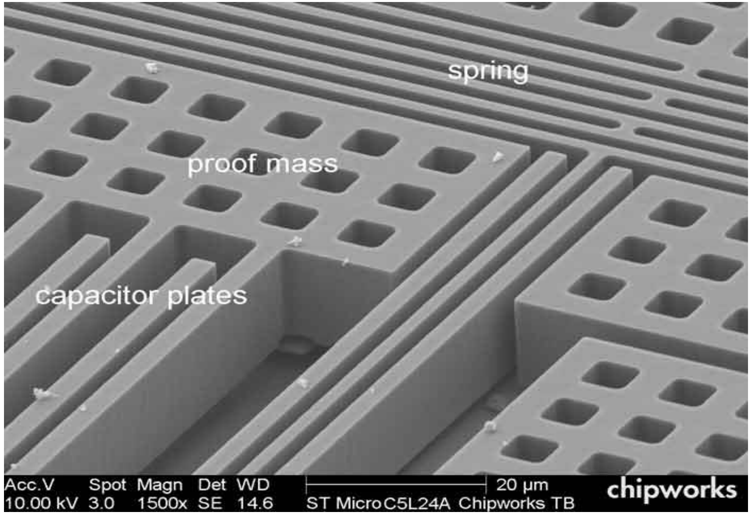
Modes of vibration - subsea

- VIV – Vortex Induced Vibration
  - Low frequency – 0,01-2Hz
- FIV – Flow Induced Vibration
  - Medium frequency – 2-50Hz
- FLIP – Flow Line Induced Vibration
  - High frequency – 50-1000Hz
- Pumps, compressors etc.

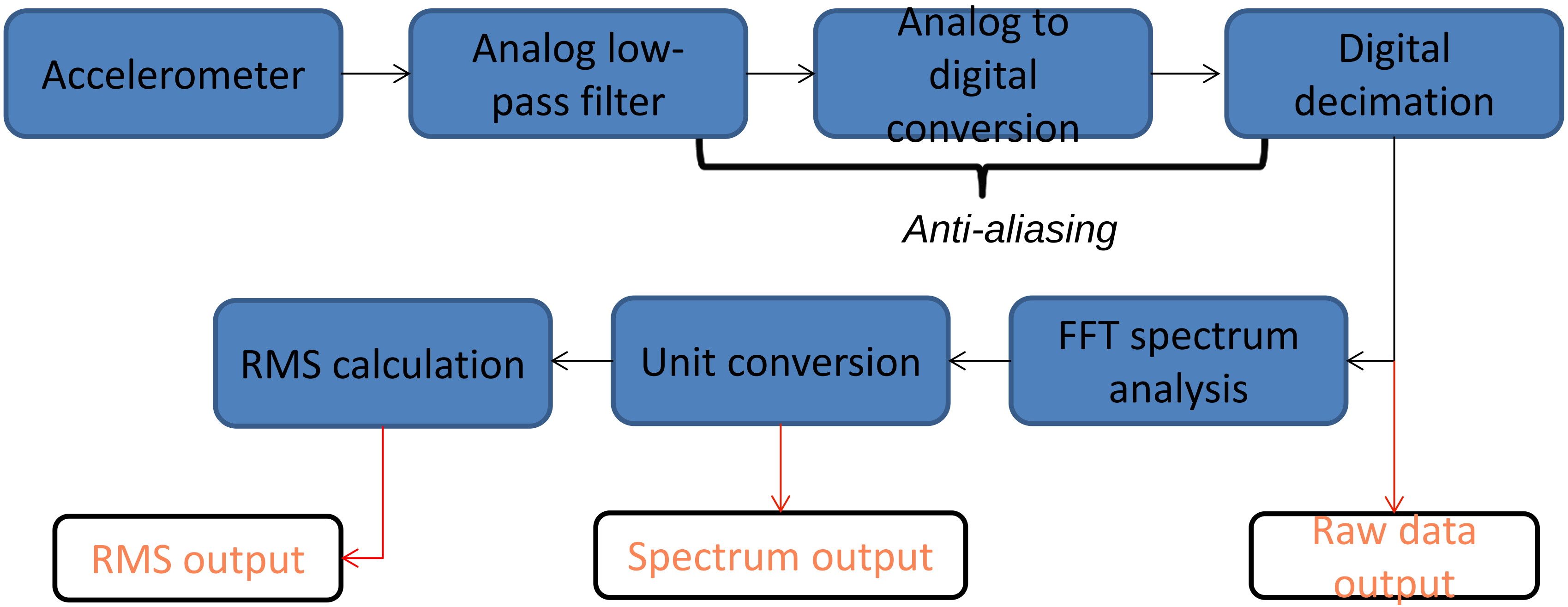


Working principle

- MEMS accelerometer
- Acceleration in three dimensions
- Digital Signal Processor (DSP)
- Numerical integration
- Convert acceleration to velocity or displacement

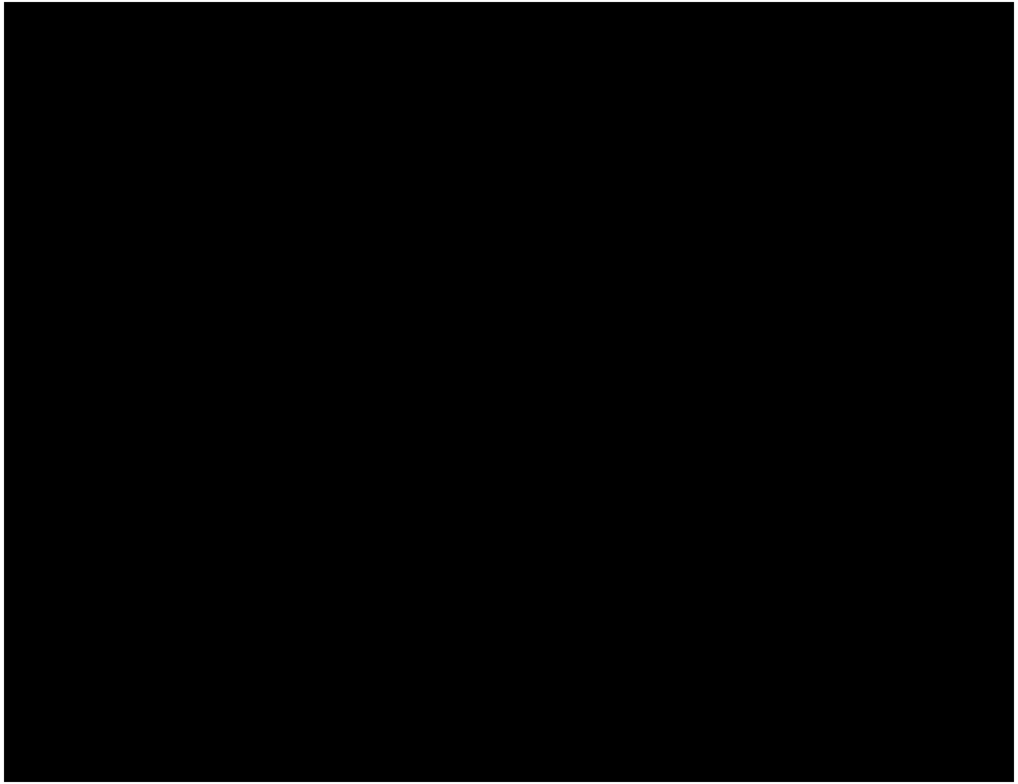


Data processing
ClampOn vibration monitors



Integrated/permanent solution

- Real-time data
- Instant alarm
- Always present
- Data from 0-day
- Fatigue estimate
- No running costs
- SIIS L2 and 3



Integrated/permanent solution

Pros:

Real-time data

Always present

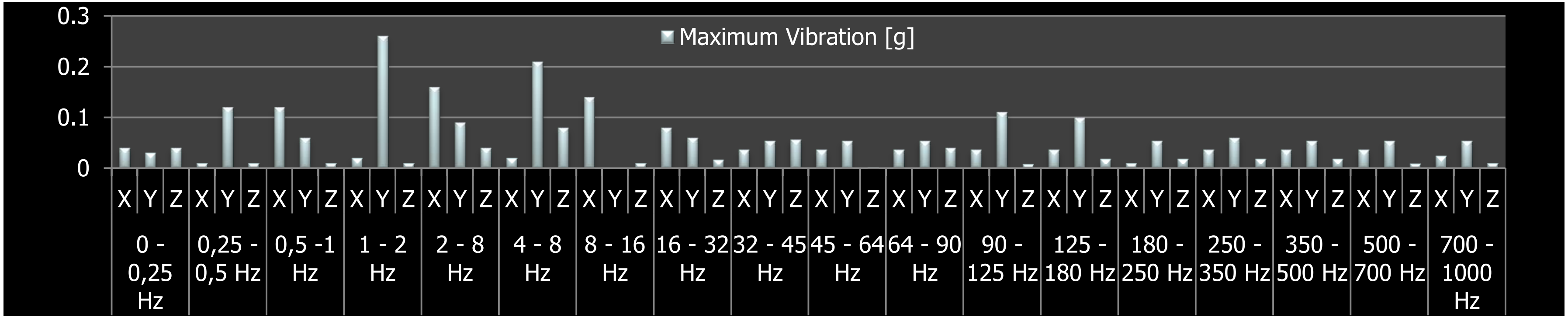
No running cost

ASVD

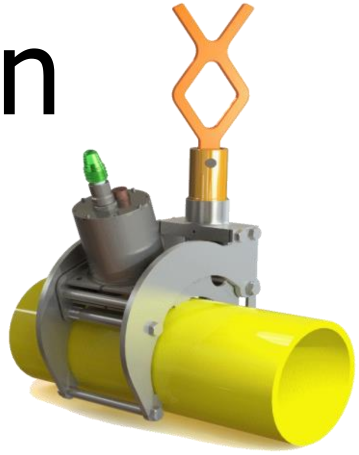
Cons:

Limited bandwidth (SIS L2 & RTU)

Difficult to retrofit



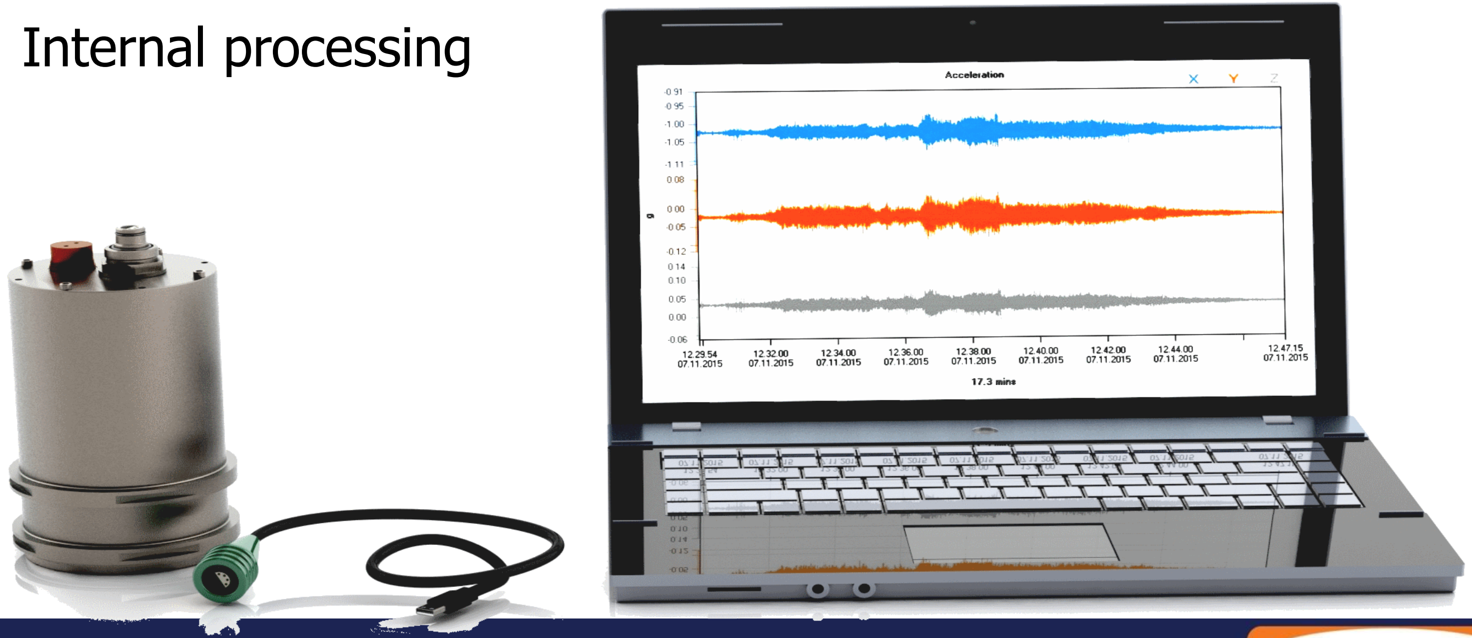
Temporary / inspection



- Stand-alone
- No integration
- Internal battery
- 6 month operation per charge
- Local indication
- Light weight
- Mechanical and magnetic fixtures
- No bandwidth restrictions
- Continuous raw data logging

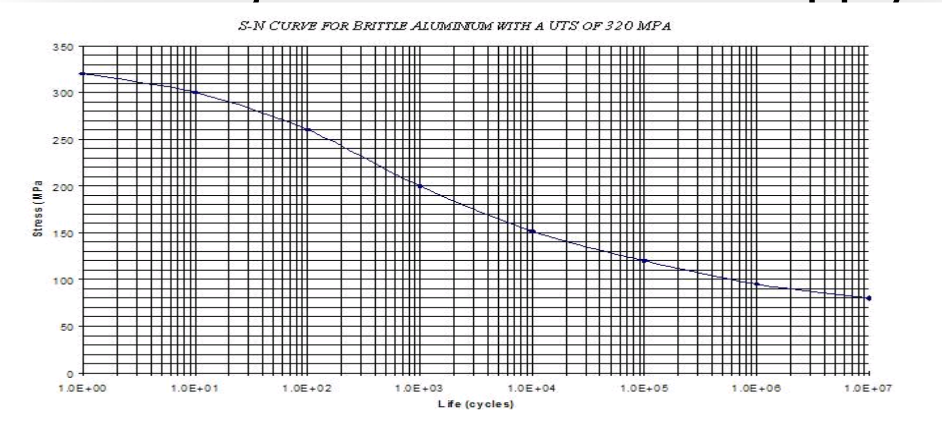
Temporary / inspection

- USB interface
- “Flash drive” mode
- Internal processing



Analysis of vibration data

- Precise analysis based on spectra or raw data typically performed by a third party
- Simplistic approach: RMS Velocity is approximately proportional to fatigue. Rules of thumb apply.

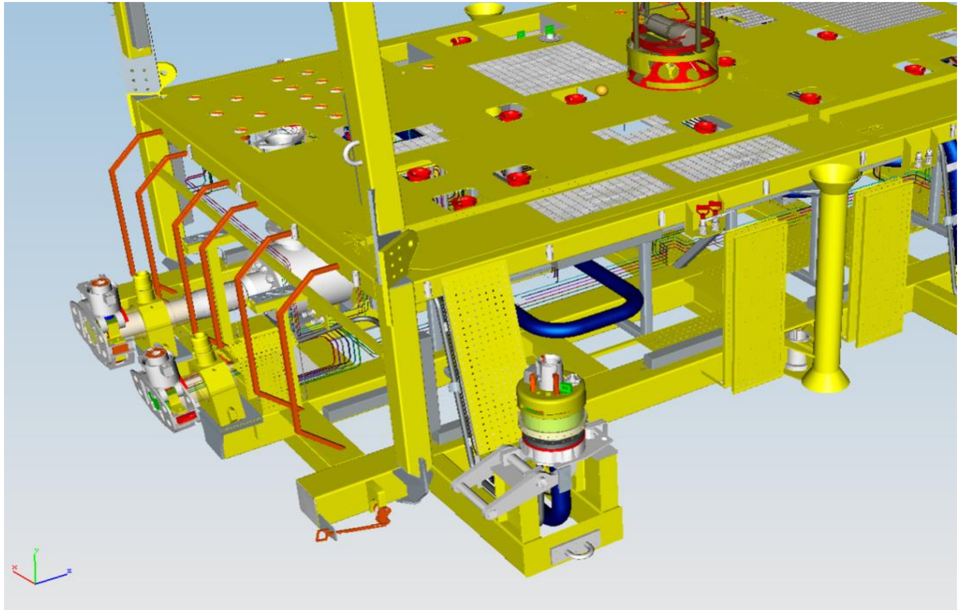


Field Case – Statoil – Visund Nord

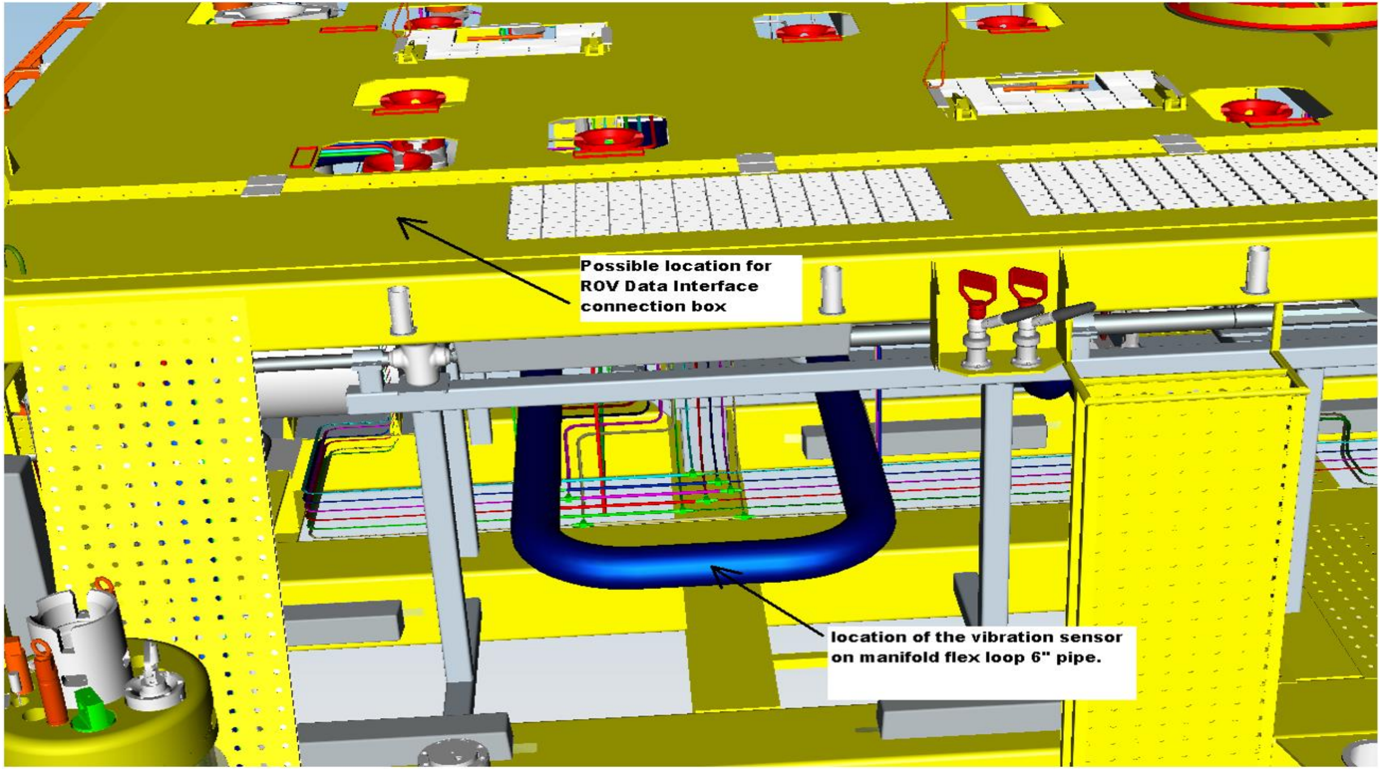
Potential risk of Vibration on flex loop

Statoil

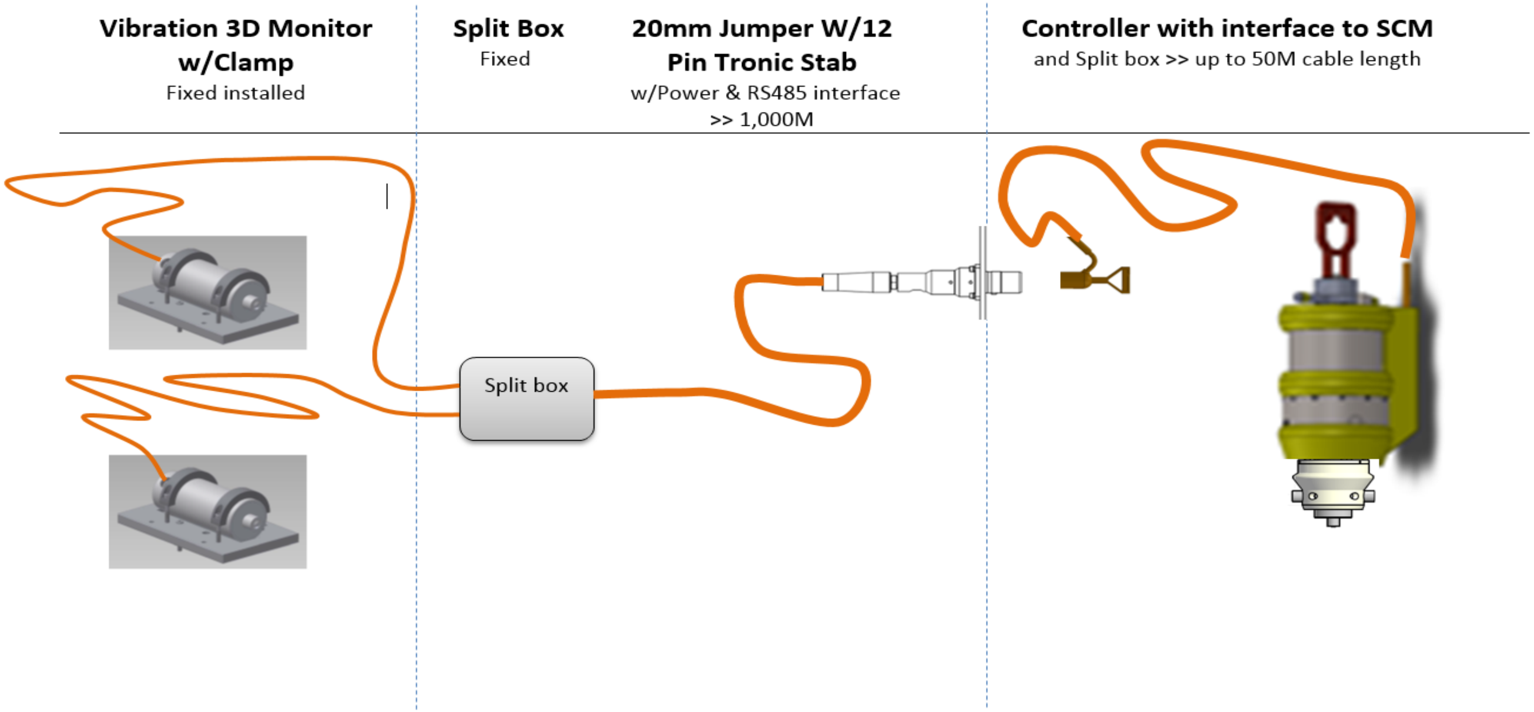
FMC Technologies



Field Case – Statoil – Visund Nord



Field Case – Statoil – Visund Nord



Field Case – Statoil – Visund Nord

Field Case - BP - Azerbaijan

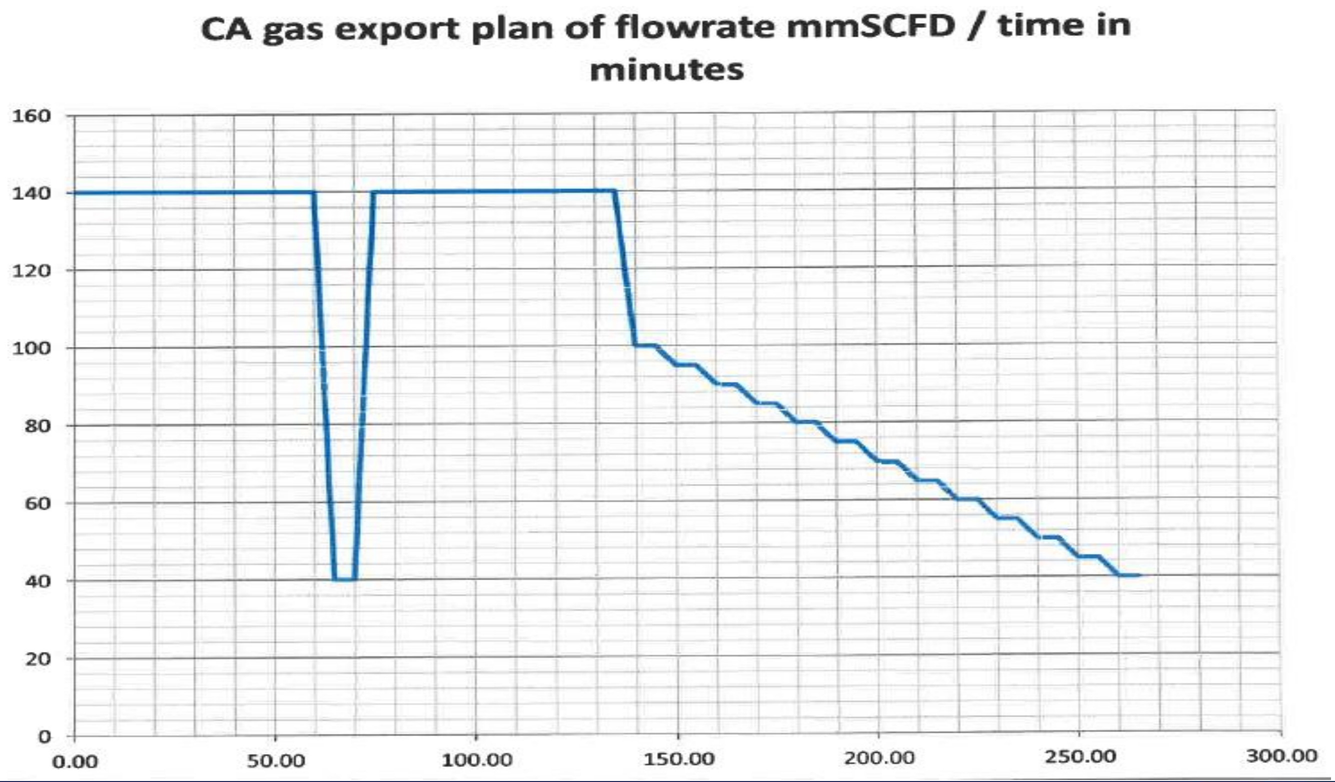
Flow back ESD Valve

- Flow conditions creates vibration - why
- Can it be monitored and bandwidth
- Type of mounting fixture?
- Installation locations

Scenario

- Valve in vibration
- How often and amplitude
- Under what operation conditions
- Valve WILL wear out …
  in worst case stop the production from the platform

Valve flapping movement



Field Case – Statoil - Skuld

Flex loop vibrations

- Calibrate calculation model
- Find maximum safe flow rate
- Direct cable communication

Statoil

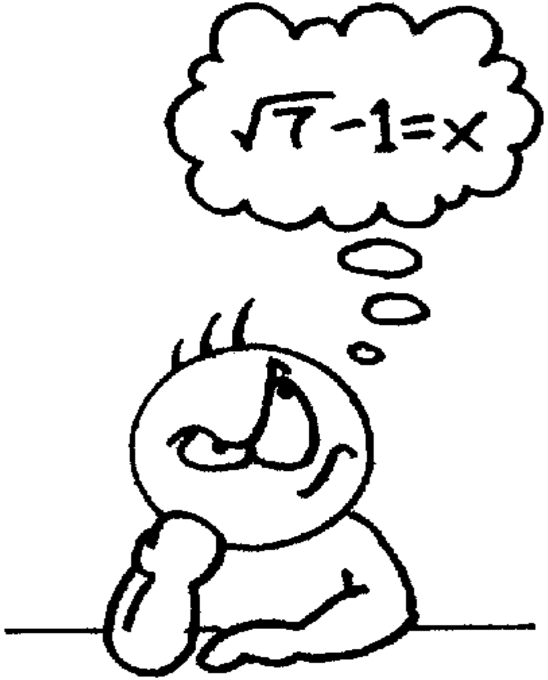
Conclusions

Online monitoring of corrosion/erosion;

- Greater control
- Increased uptime
- Reduced risk

Vibration monitoring;

- Complement vibration modelling
- Actual situation report
- Online/permanent
- Standalone/inspection



Questions?

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