GE Oil & Gas

Subsea Integrity Monitoring – Naxys Acoustic Leak Detector for major operator's deep water project

GE imagination at work

Innovation Qualification Expertise

Content

- Business Case
- Recommended practice
- Sensor coverage
- Installation & Interface
- Performance Leak Detection
- Regulations
- Condition Monitoring

Subsea Leak Detection

CAPEX ↑

OPEX →

INCENTIVE

- Risk reduction
- Reputation
- Cost of lost production
- Availability ↑
- Performance/production ↑
- OPEX ↓
- CAPEX ↓

PUSH

- Regulations
- Polluter pays
- Public
- Insurance?

DnV GL Recommended Proactice 2016

GL

DNV

RECC

RECOMMENDED PRACTICE
DNV-RP-F302

DNVGL-R

SELECTION AND USE OF SUBSEA
LEAK DETECTION SYSTEMS

2016

APRIL 2010

Offshore leak detection

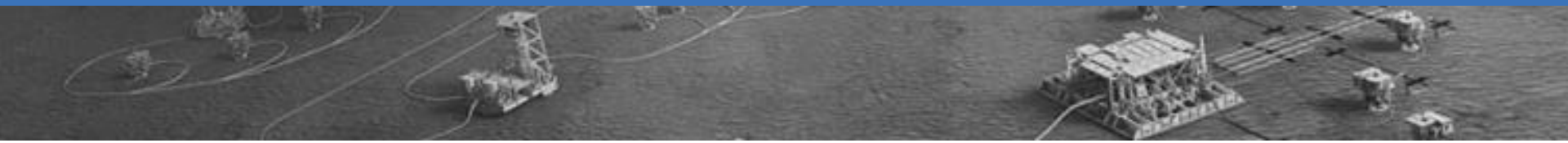
Definitions cont.

Sensor coverage is described as:

— regional coverage, meaning that they can cover the entire field development or more
— area coverage, meaning that they can cover a large area of the field but not full field coverage
— local coverage, meaning that they will cover an area close to the sensor.

The accuracy of the placement, the range covered and positioning parameters vary from technique to technique. Some techniques require contact with the leaking medium, and can detect a leakage in their vicinity but cannot determine the location of the leak. Sensors using these principles are named point sensors. These sensors may be an option for monitoring of high risk leak points. Some of the sensors can also be used for additional purposes, including condition monitoring. This can potentially result in early warnings and allow the operators to take actions before an incident escalates into a leak. In the table below (subsea techniques) "leak positioning" refers to the capability of a single sensor. System configuration and processing software may enable leak positioning.

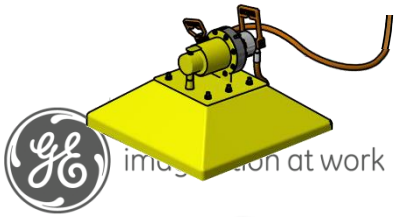
SUBSEA LEAK DETECTION



POINT SENSING

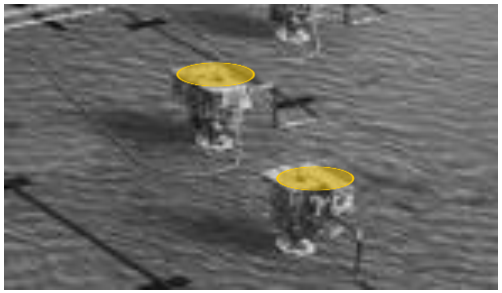
Direct contact with the leaking medium is required.

NAXYS A1 delivered since 2014

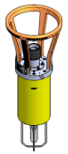


LIMITED/LOCAL AREA

Limited detection range to a few meters

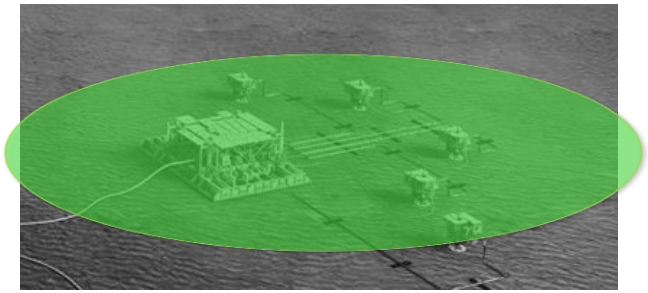


NAXYS A3 delivered since 2010



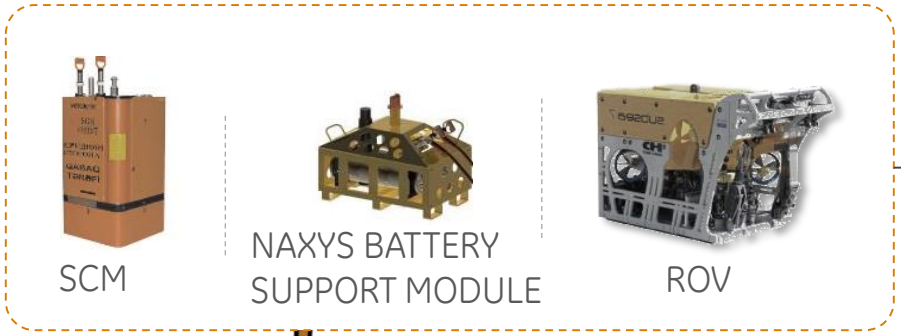
WIDE AREA & Condition Monitoring

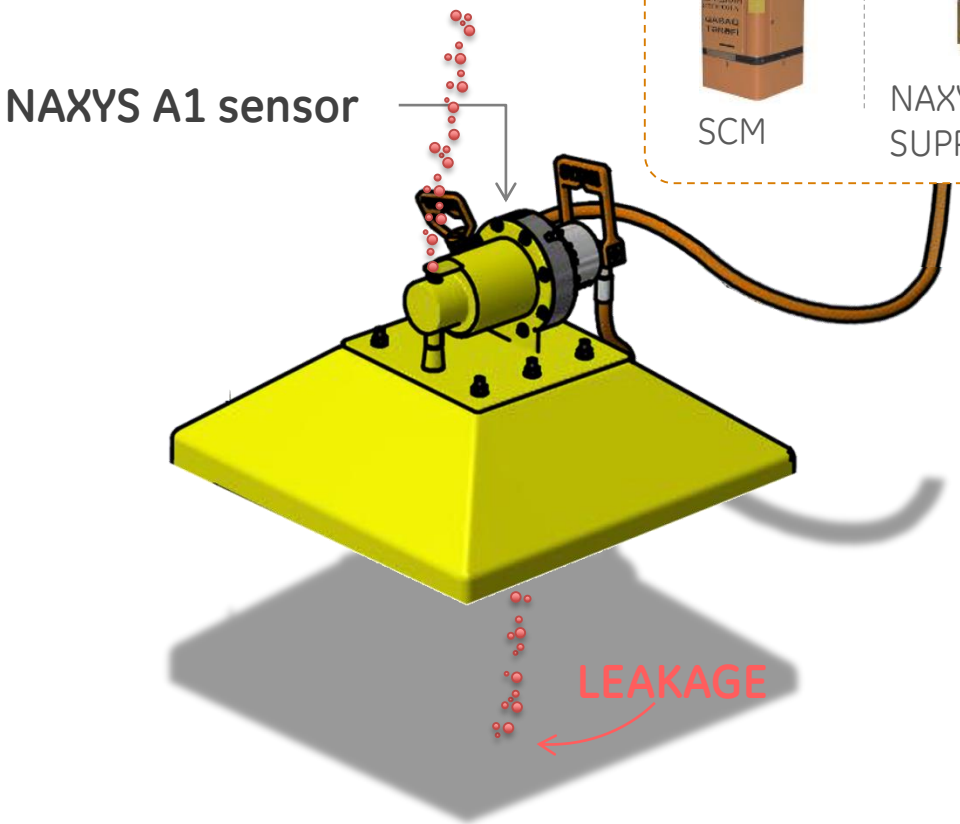
Covers an extended area e.g. entire subsea structure and adjacent infrastructure



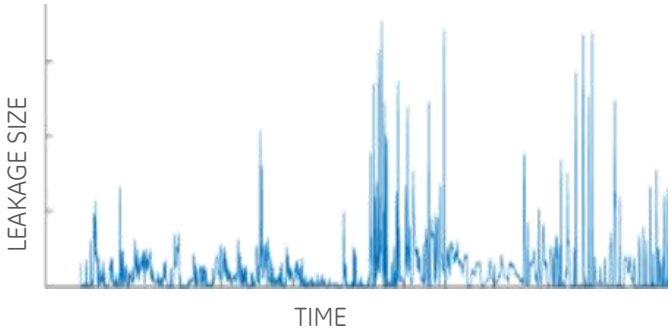
NAXYS A10 delivered since 2006

NAXYS A1 - POINT SENSOR





LEAKAGE TREND MONITORING:



LEAKAGE STATUS:

OK WARNING ALARM

Informed Decisions

- Availability ↑
- OPEX ↓

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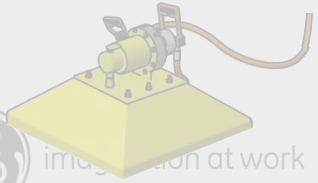
SUBSEA LEAK DETECTION

POINT SENSING

Direct contact with the leaking medium is required.

NAXYS A1 delivered since 2014



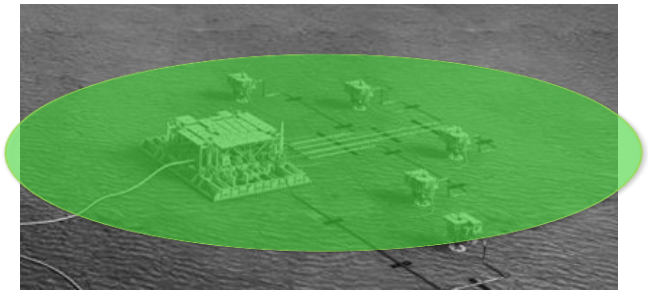
LIMITED/LOCAL AREA

Limited detection range to a few meters

NAXYS A3 delivered since 2010

WIDE AREA & Condition Monitoring

Covers an extended area e.g. entire subsea structure and adjacent infrastructure



NAXYS A10 delivered since 2006

TECHNOLOGY – SUBSEA SENSING

- **One monitoring system for:**
  - Subsea Leak Detection
  - Vibration Monitoring
  - Machinery and process monitoring
- **Stand-alone & non-intrusive**

LEAK DETECTION

- Early detection
- Wide area coverage
- Directional
- High sensitivity

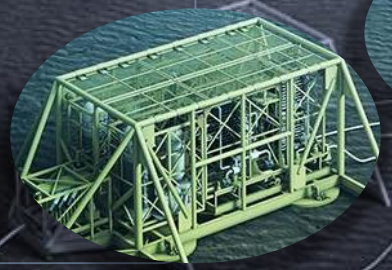
VIBRATION DETECTION

- Early detection
- Structural, Flow lines, Riser

MACHINE & PROCESS MONITORING

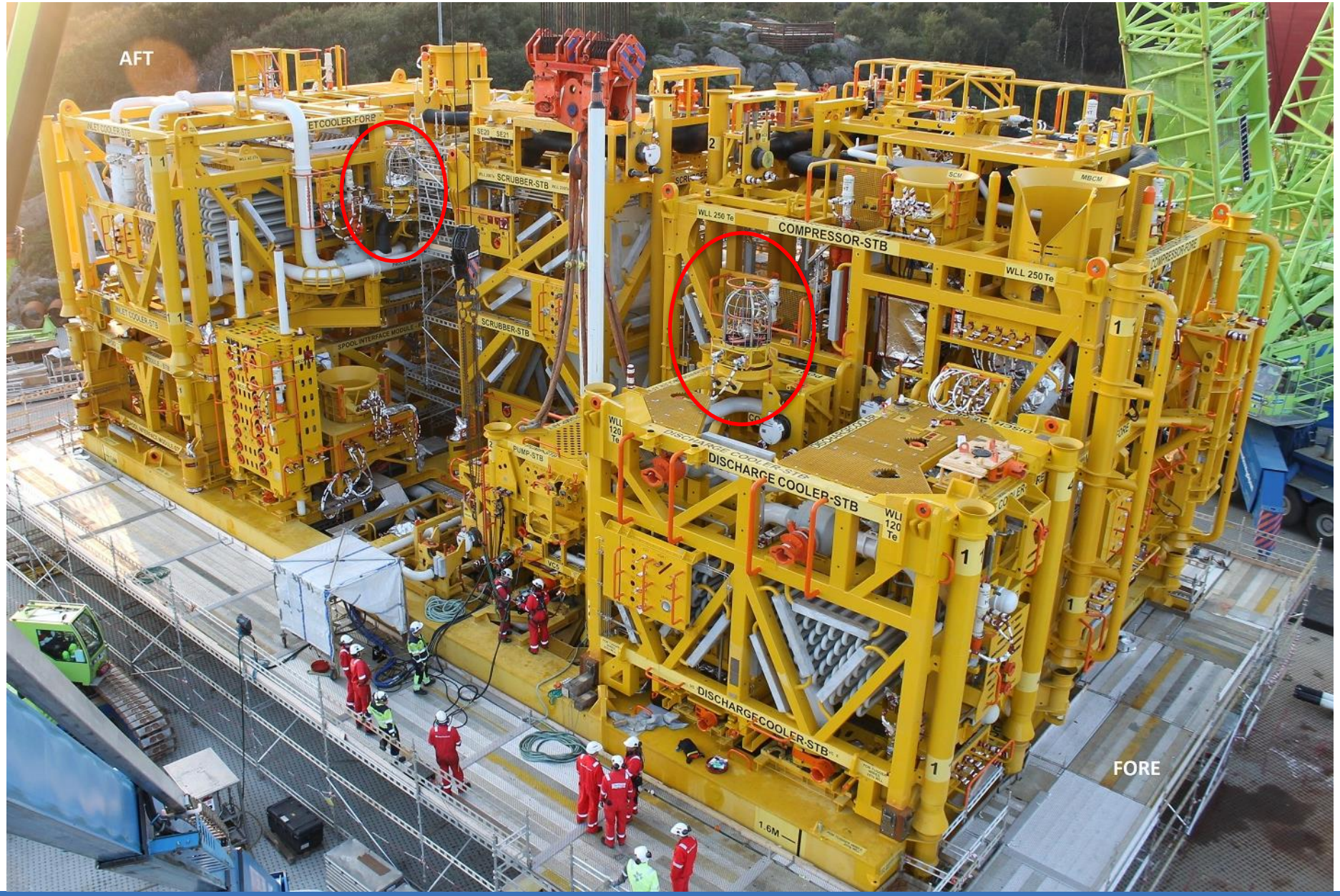
(Compressor, Pump, Transformer, ...)

Acoustic & Electric monitoring
Continuous & synchronous
Early detection of changes/faults

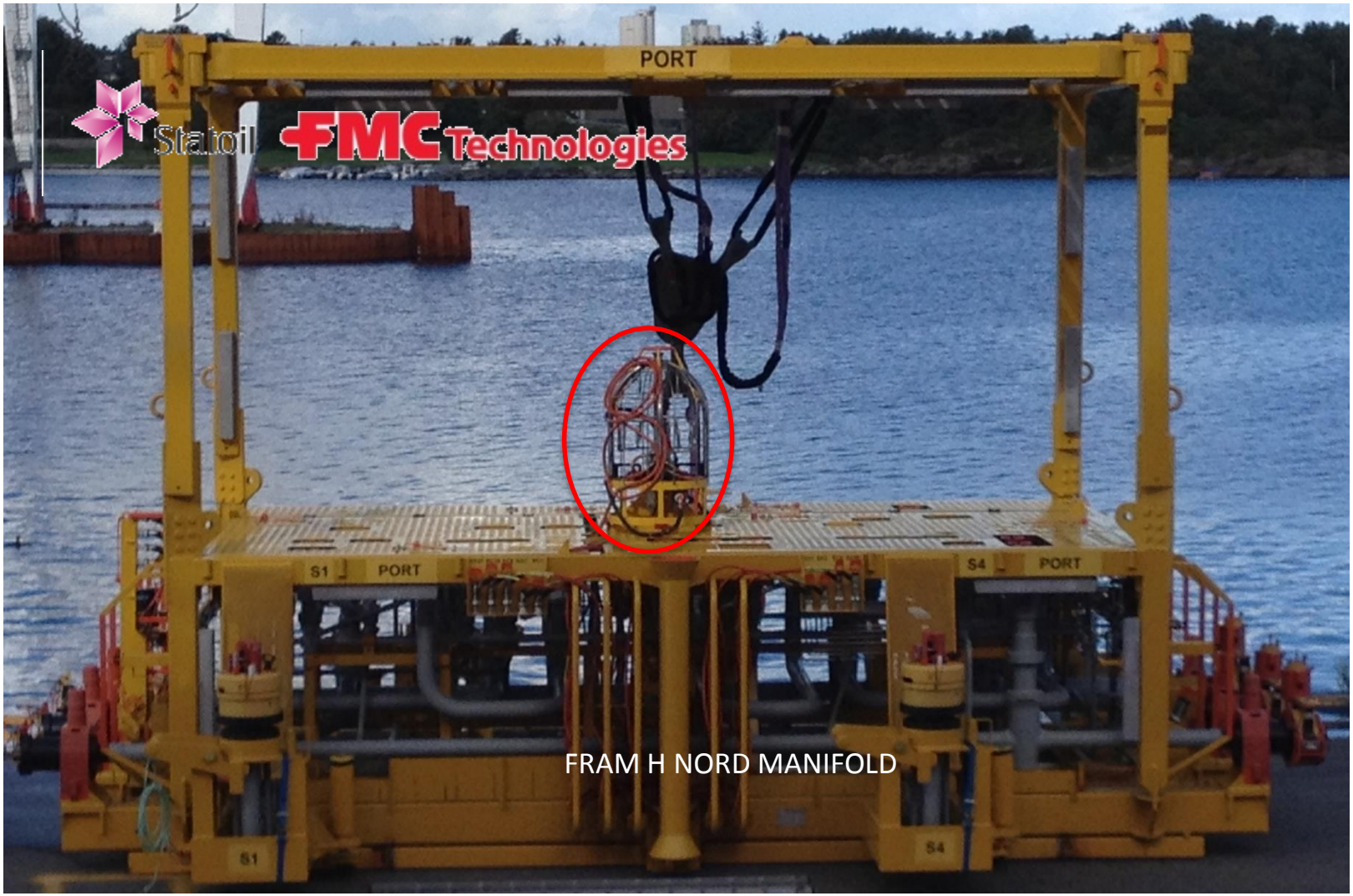


Installation & Interface

A10 on Aasgard Subsea Compressor System



Naxys A10 mounted on a manifold

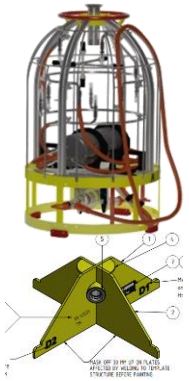


imagination at work

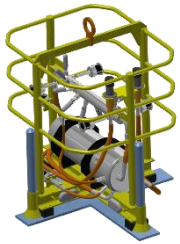
3 alternatives for mounting Naxys A10 onto a manifold

Landed onto any horizontal surface having a footprint of 1 m diameter. Suitable for retrofit installation by ROV.

Docking station (cross) pre-welded onto subsea installation. Suitable for new structures, installation dry or by ROV.



Docking station (guide post) pre-welded onto subsea installation. Suitable for new structures, installation dry or by ROV.

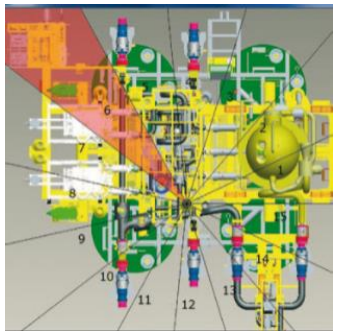


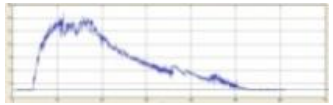
imagination at work

Naxys system overview

TOPSIDE

- Early warning
- User-friendly interface
- Status:
  - OK
  - Warning
  - Alarm
- Trend values





Field-proven interface to major system integrators

SCM

Download
- Calibration
- Configuration
- Software updates

Status Message
- *Ethernet (SIIS Level 3)*
  RS485, CAN, IWIS,
  Modbus/TCP, FTP, UDPIP

A10 installed subsea and connected to the Subsea Control Module (SCM)

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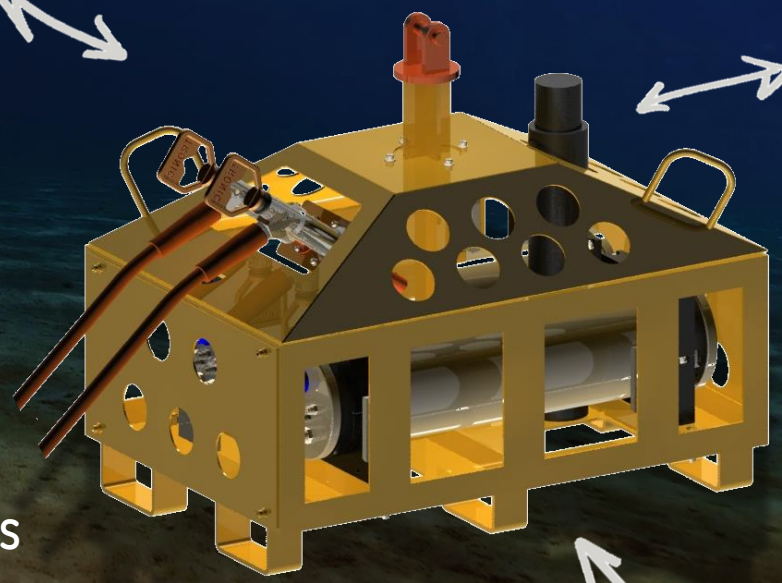
NAXYS SUBSEA SUPPORT UNIT

POWER, CONTROLS, DATA MANAGEMENT, DATA TRANSFER

POWER

- Battery power
- Externally powered (e.g. from SCM)



EXTERNAL DATA TRANSFER & COMMUNICATION

- Through SCM
- Through ROV
- Cable to surface

Realtime data

- Acoustic communication to surface
- Pop-up buoy with satellite communication
- Retrieval of module and transfer of stored data

AUXILIARY INSTRUMENTS

- ACCELEROMETER
- LEAK DETECTOR
- CONDITION MONITORING
- PRESSURE SENSOR
- PIG DETECTOR
- SAND DETECTOR
- ANY OTHER SENSORS

COMMUNICATION, DATA PROCESSING & STORAGE

- Instrument power & communication interface (4-20mA, CanOpen, RS485, Ethernet)
- Data processing (digitization, compression, etc)
- Storage of data
- Duty cycling control (user defined)

FRAM H NORD MANIFOLD

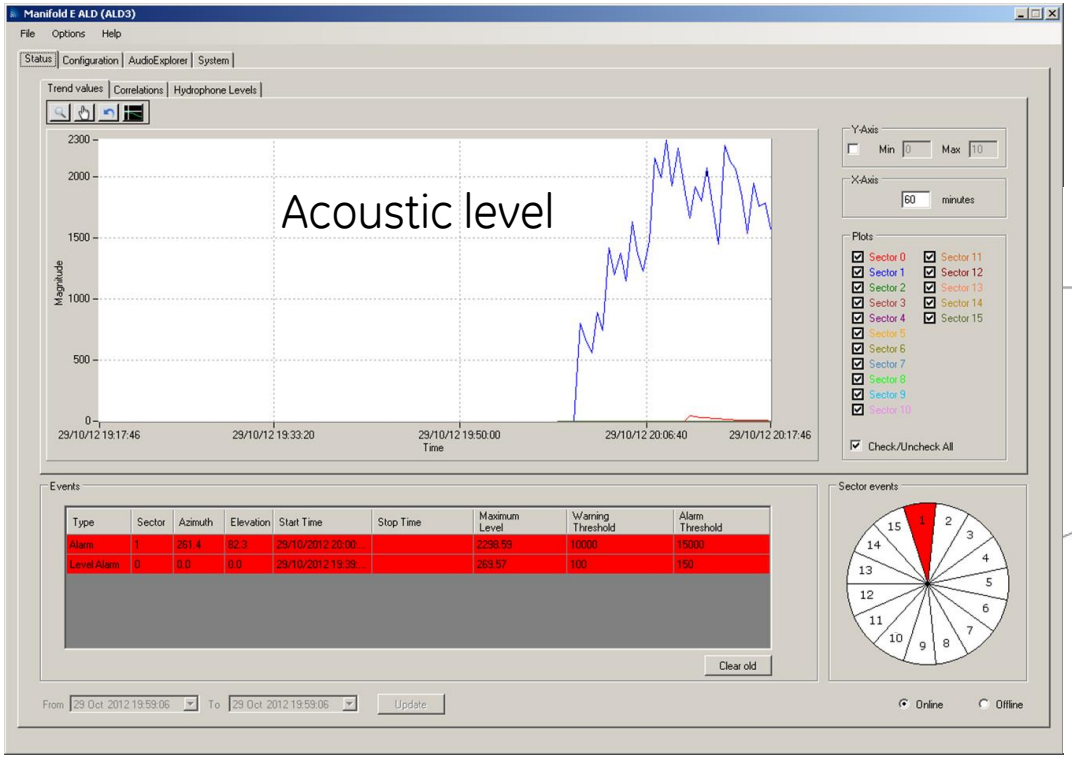
Leak detection Performance

"During commissioning of the ALD units on Ormen Lange template A and B we saw an impressive ability to detect and determine the direction of small and large simulated leakages"

Lars Kristian Asbjørnsen, Shell

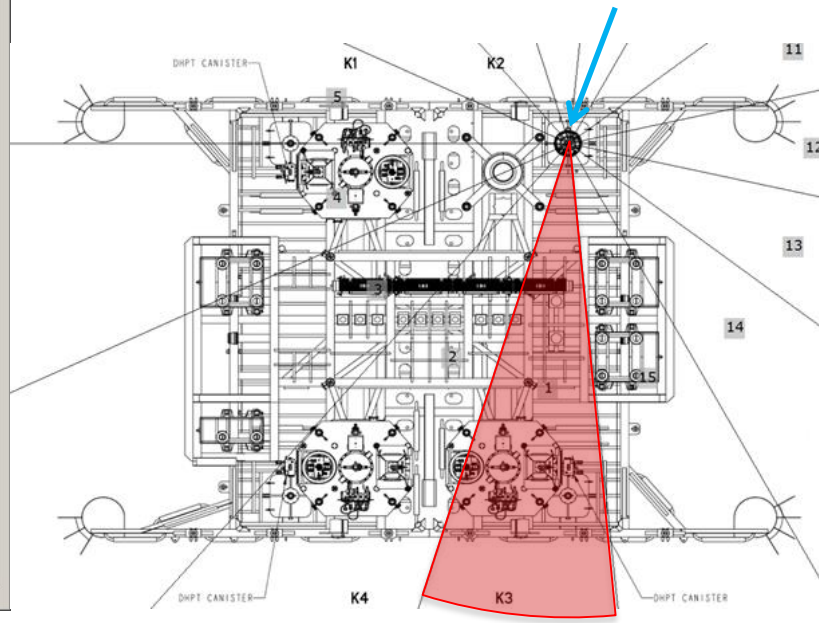
NAXYS A10 – wide area coverage

DETECTION OF WATER INJECTION LEAKAGE TO SEA



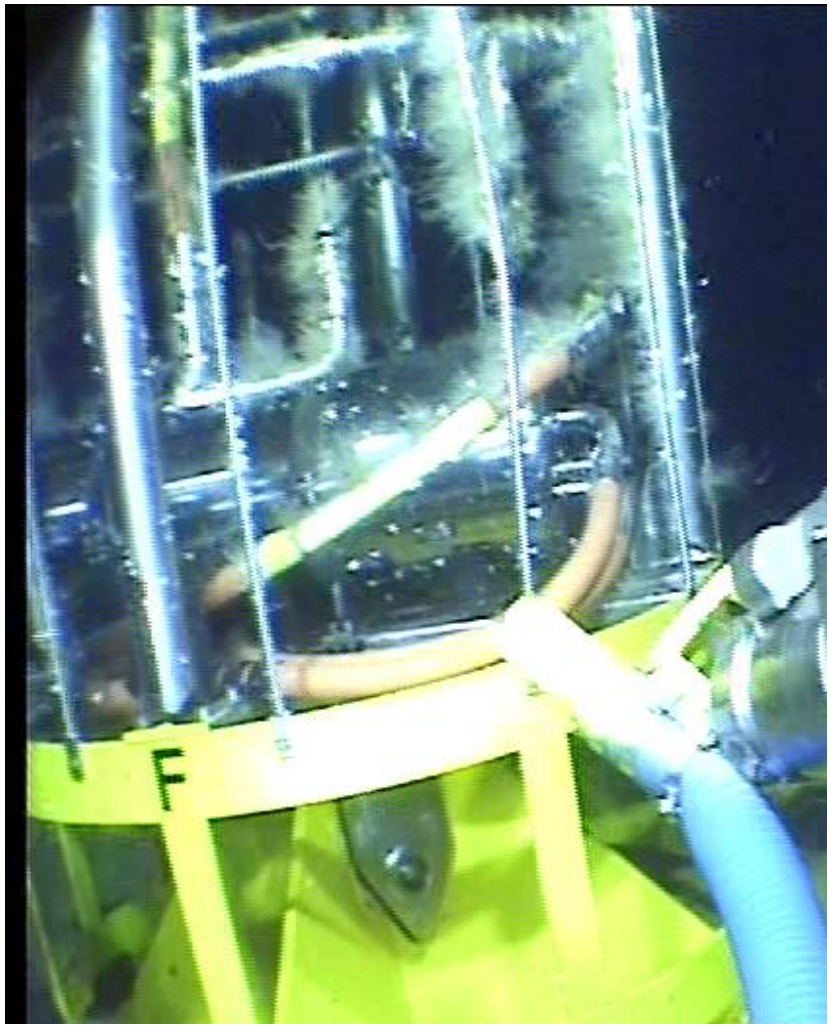
Warning and sector indication

Location of Naxys A10



Sector 1

No measurable impact of marine growth



Testing by SINTEF 2007

SINTEF

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Fax: (+47)73 59 11 02 (aut.)

Enterprise No.:
NO 936 882 331

REPORT

TITLE

Subsea Leak Detection Phase 3
- Comparative experimental tests of different detection principles (Naxys version)

AUTHOR(S)

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Alf G. Melbye, SINTEF Materials and Chemistry

CLIENT(S)

Oljeindustriens Landsforening (OLF)

REPORT NO.			
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SUMMARY

The Norwegian Oil Industry Association (OLF) has initiated a series of projects on Subsea Leak Detection and the present study is Phase 3 of these projects. This report presents results from comparative experimental tests of different leak detection principles suitable for continuous monitoring of subsea installations and templates. The purpose of the tests was to elucidate inherent strengths and limitations of the different detection principles.

Five different detection principles have been tested: Two types of point sensors; capacitance and semi-conductor, and three types of detectors suitable for area coverage; optical camera, passive acoustic and active acoustic. Both crude oil and gas leakages have been discharged during the experiments.

The results show that all the systems work well; however with different strengths and limitations. It is concluded that the best possible leak detection monitoring of a subsea field is obtained by combining at least 2 -3 different systems, which are both complementary and overlapping.

4.1.3 Conclusions

The main conclusions from the tests with the ALD passive acoustic system are:

- The system detects both gas and crude oil leakages very well, and is well suited for area coverage.
- Gas leakages are in general easier to detect than crude oil leakages.
- The most important parameter for detection is the pressure difference across the leakage opening, due to the creation of acoustic noise. If the pressure difference is above around 5 bar, leakages are easily detectable within a range of at least 10 m.
- The detection is also dependent upon the distance to the leakage and the size of the leakage opening.
- Localization of the leakage is possible.
- Other leaking fluids should also be easily detected, as long as there is a pressure difference across the leakage opening that generates sufficient acoustic noise.

Table 4.6 Results from gas leakage experiments with nozzle sizes 0.17 and 2 mm and varying distance and pressure difference.

Nozzle	Distance	ΔP	Detection
0.17 mm	2 m	5 bar	Ok
0.17 mm	2 m	4 bar	Ok
0.17 mm	2 m	3 bar	Ok
0.17 mm	2 m	2 bar	Ok
0.17 mm	2 m	1 bar	Weak, but ok
0.17 mm	4 m	5 bar	Ok
0.17 mm	4 m	2 bar	Ok
0.17 mm	4 m	1 bar	Very weak, **not ok**
2 mm	4 m	10 bar	Ok
2 mm	4 m	5 bar	Ok

Table 4.7 Results from crude oil leakage experiments with varying nozzle size, distance, and pressure difference.

Nozzle	Distance	ΔP	Detection
0.7 mm	2 m	15 bar	Ok!
0.7 mm	2 m	10 bar	Ok
0.7 mm	2 m	5 bar	**Not ok**
0.7 mm	6 m	15 bar	Ok!
0.7 mm	6 m	10 bar	Ok
0.7 mm	6 m	7 bar	Very weak, but ok
0.7 mm	6 m	5 bar	**Not ok**
2 mm	2 m	5 bar	Ok!
2 mm	2 m	4 bar	Weak, but ok
2 mm	2 m	3 bar	**Not ok**
2 mm	6 m	5 bar	Ok!
2 mm	6 m	4 bar	Weak, but ok
2 mm	6 m	3 bar	**Not ok**

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Regulations, recommnedation and requirements

Authority Requirements	Naxys technology

PETROLEUM SAFETY AUTHORITY NORWAY

CLIMATE AND POLLUTION AGENCY

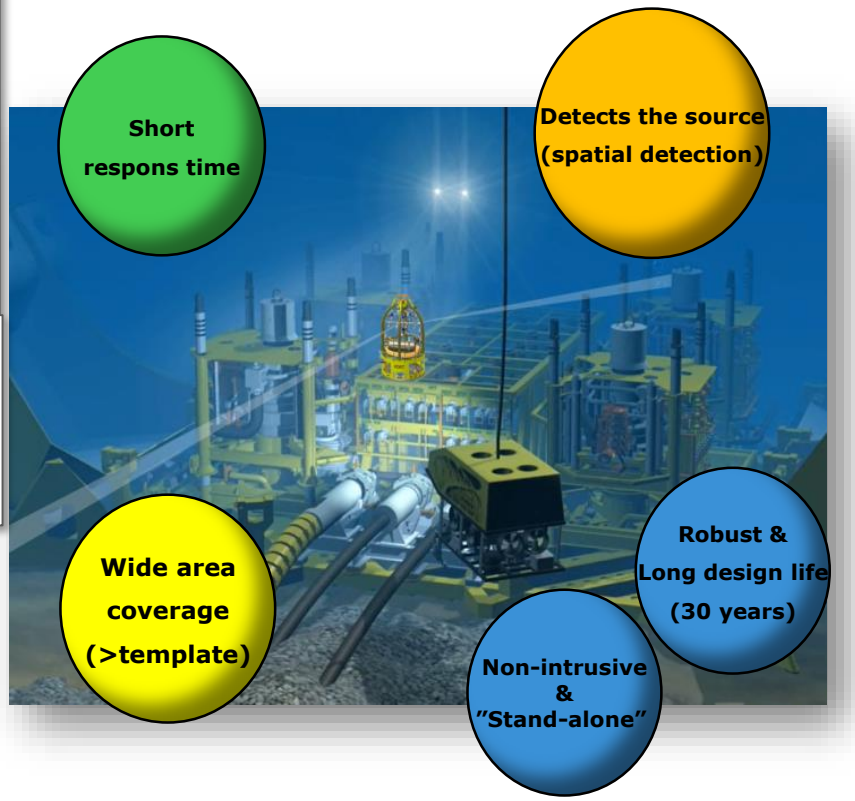
DNV

RECOMMENDED PRACTICE DNV-RP-F302

The Activities Regulation (Norway)

§ 57 Remote measuring of acute pollution
The operator shall establish a remote measuring system that provides sufficient information to ensure that acute pollution from the facility is quickly discovered and mapped so that the amount and spread can be determined.

It has recently been stated by the Norwegian authorities in relation to future production in the Arctic region that there is a need for "***early warning system based on detecting leaks at the source***"



Inward Leak Detection

LEAKAGE: Water to Water

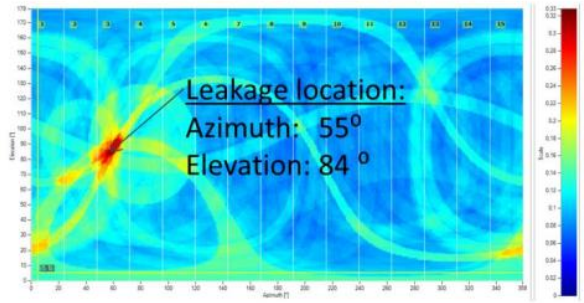
NOZZLE: 2mm and 1.5mm

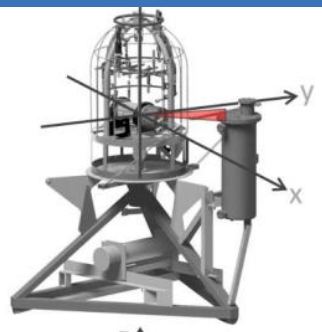
DEPTH: 210m and 100m

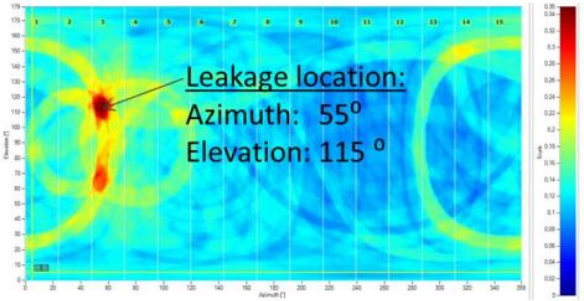
LEAKAGE: Water to Gas

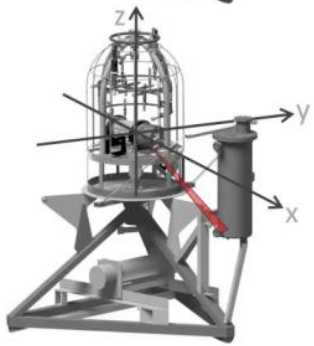
NOZZLE: 2mm and 1.5mm

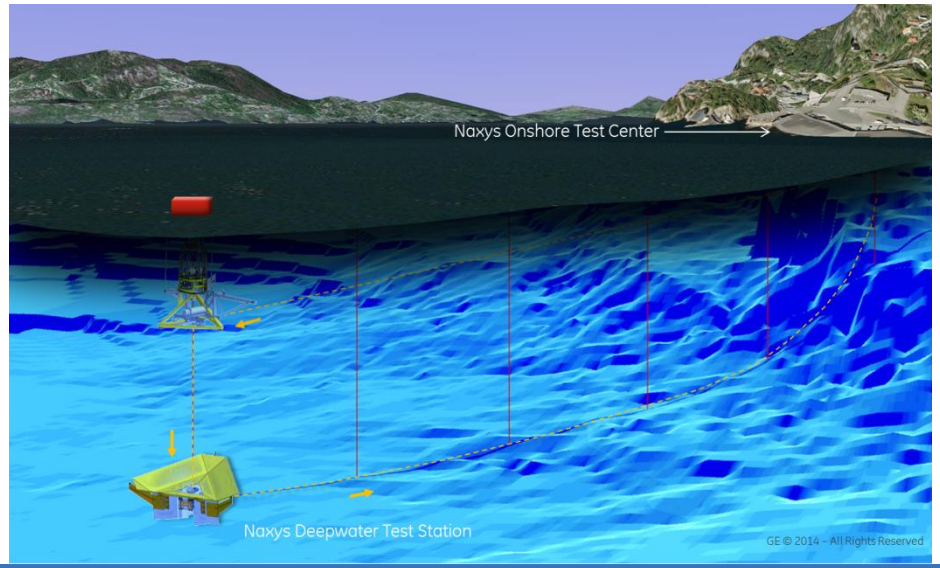
DEPTH: 210m and 100m







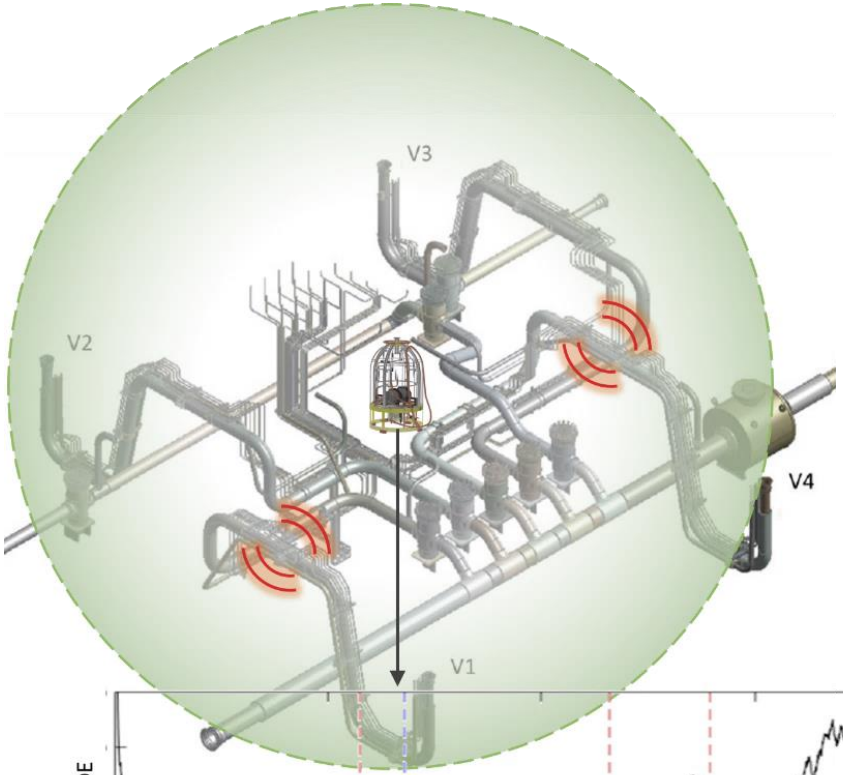


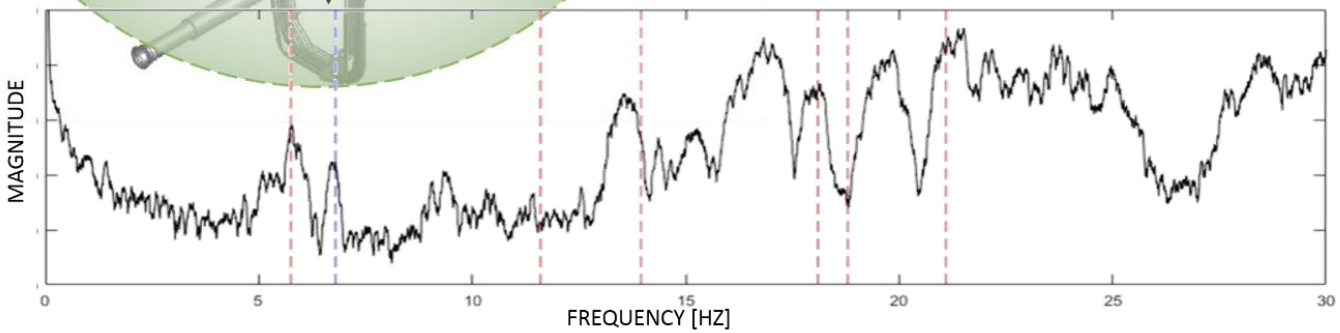


Dual Use

Leak & Condition Performance Monitoring

Detection of flow induced vibrations and choke cavitation





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Naxys monitoring Pazflor pumps (Total Angola)

DETECTION OF ABNORMAL CONDITION

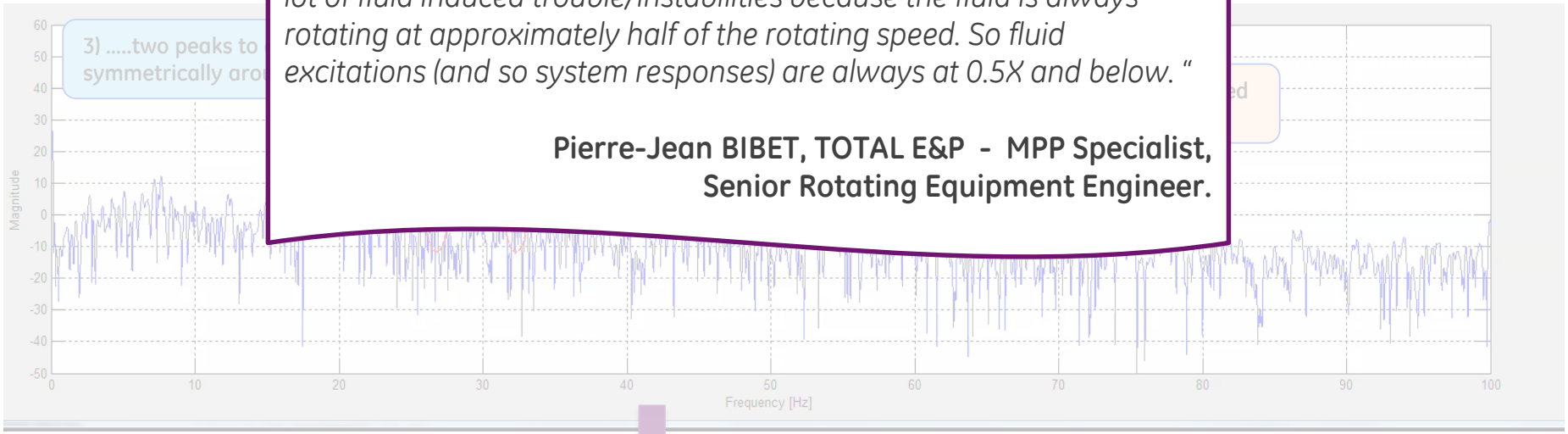
Sub-synchronous frequencies detected for one of the Pazflor pumps when running close to 3600 RPM

- ALARM
- WARNING
- NORMAL

"Detecting Sub-synchronous frequencies (SSF) noise is a very value feasibility of the Naxys acoustic system, because this is where a lot of mechanical troubles or Offset running condition manifest. SSF reveal a lot of fluid induced trouble/instabilities because the fluid is always rotating at approximately half of the rotating speed. So fluid excitations (and so system responses) are always at 0.5X and below. "

Pierre-Jean BIBET, TOTAL E&P - MPP Specialist,
Senior Rotating Equipment Engineer.

The movie shows fre… es period.
When shaft speed is … o.

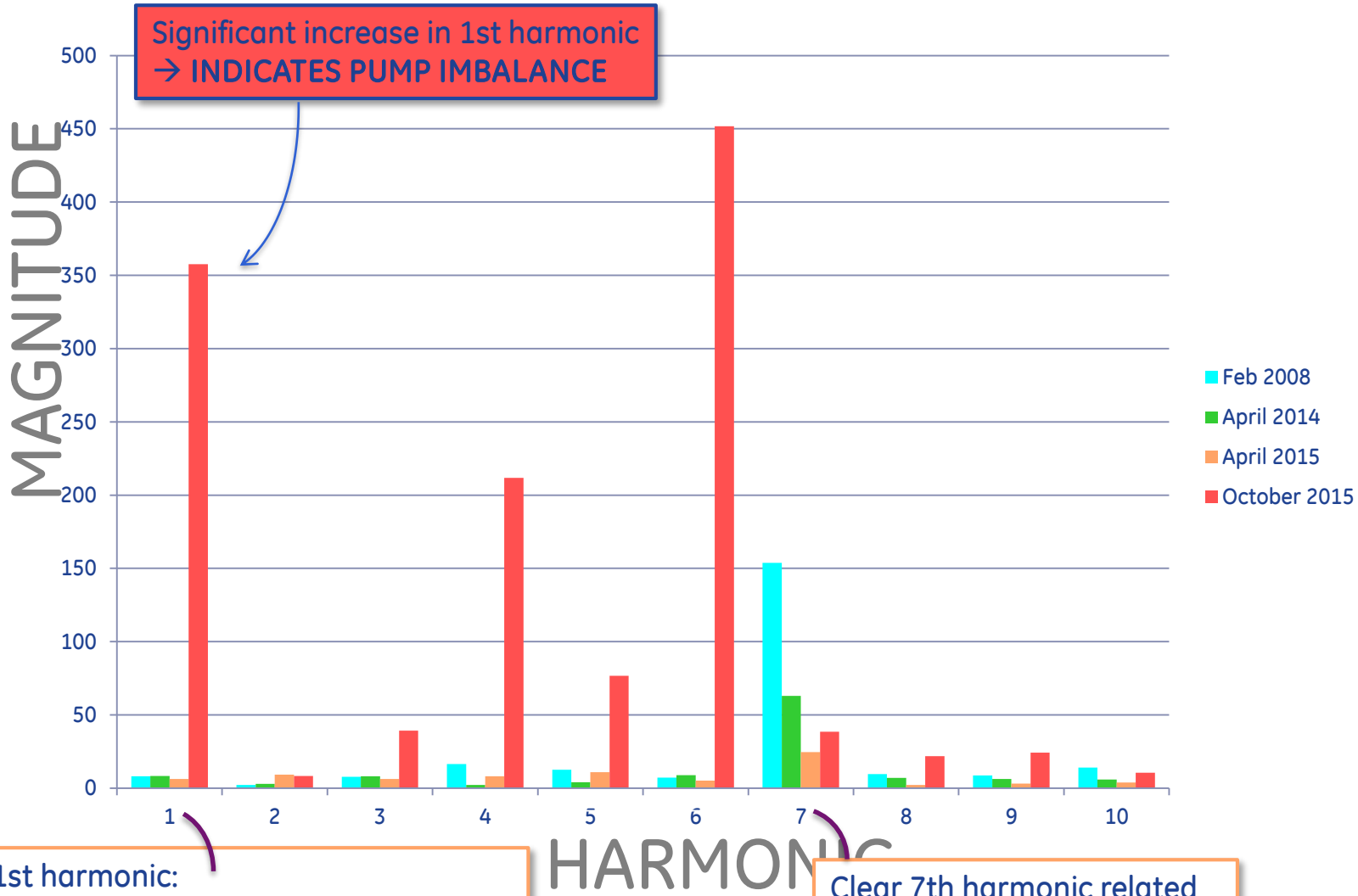


To continue

here to
ideo

RECOMMENDATION TO OPERATOR:
Avoid specific shaft speed close to 60Hz/3600 RPM causing sub-syncroneus vibrations

PUMP HARMONICS

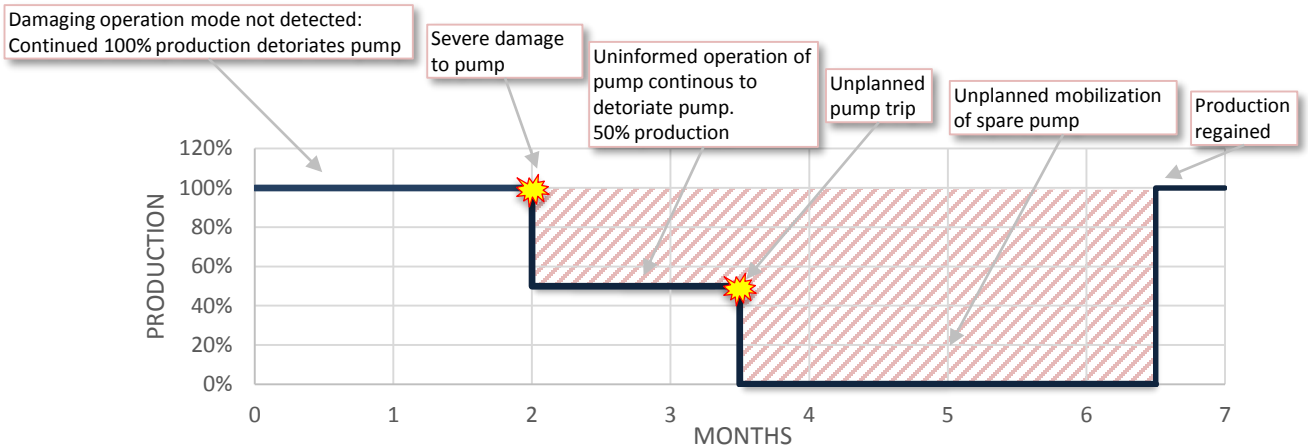


1st harmonic:
- Related to pump imbalance
- 2008: Low value, pump well-balanced

Clear 7th harmonic related to pump charachteristics

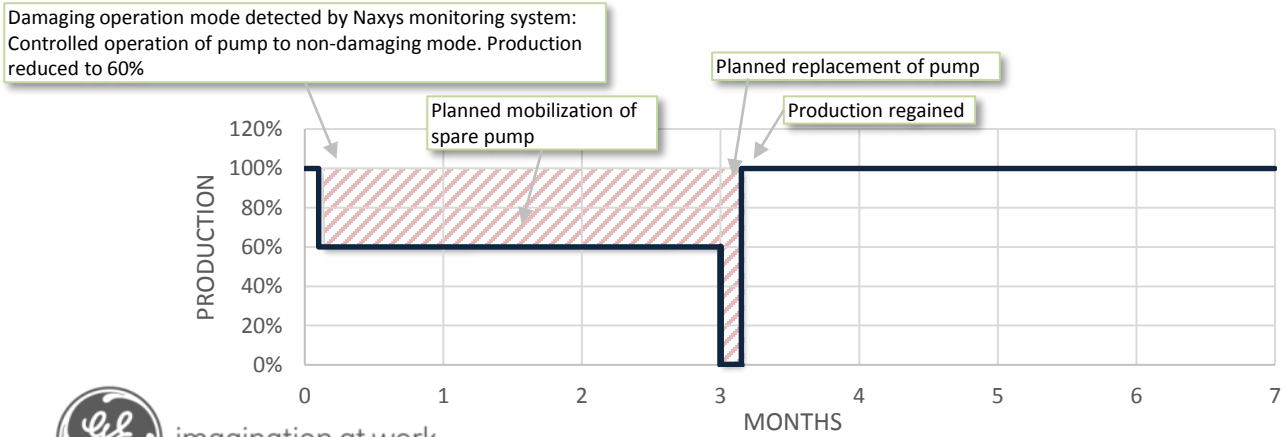
Business case: Acoustic Monitoring of Subsea Pump

a) No monitoring system to detect damaging pump condition. Operating with limited information



Production loss: $39.4 MM

b) Naxys monitoring system detects damaging condition and provides information that supports pump operation



Production loss: $13.7 MM

$25.7MM saved by utilizing Naxys acoustic & electric monitoring for informed decision support

Assumptions:
Production 7000 bbl/day
Oil price: $50 per bbl.

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