# On-Line Diagnostics of Subsea & Surface Pipelines


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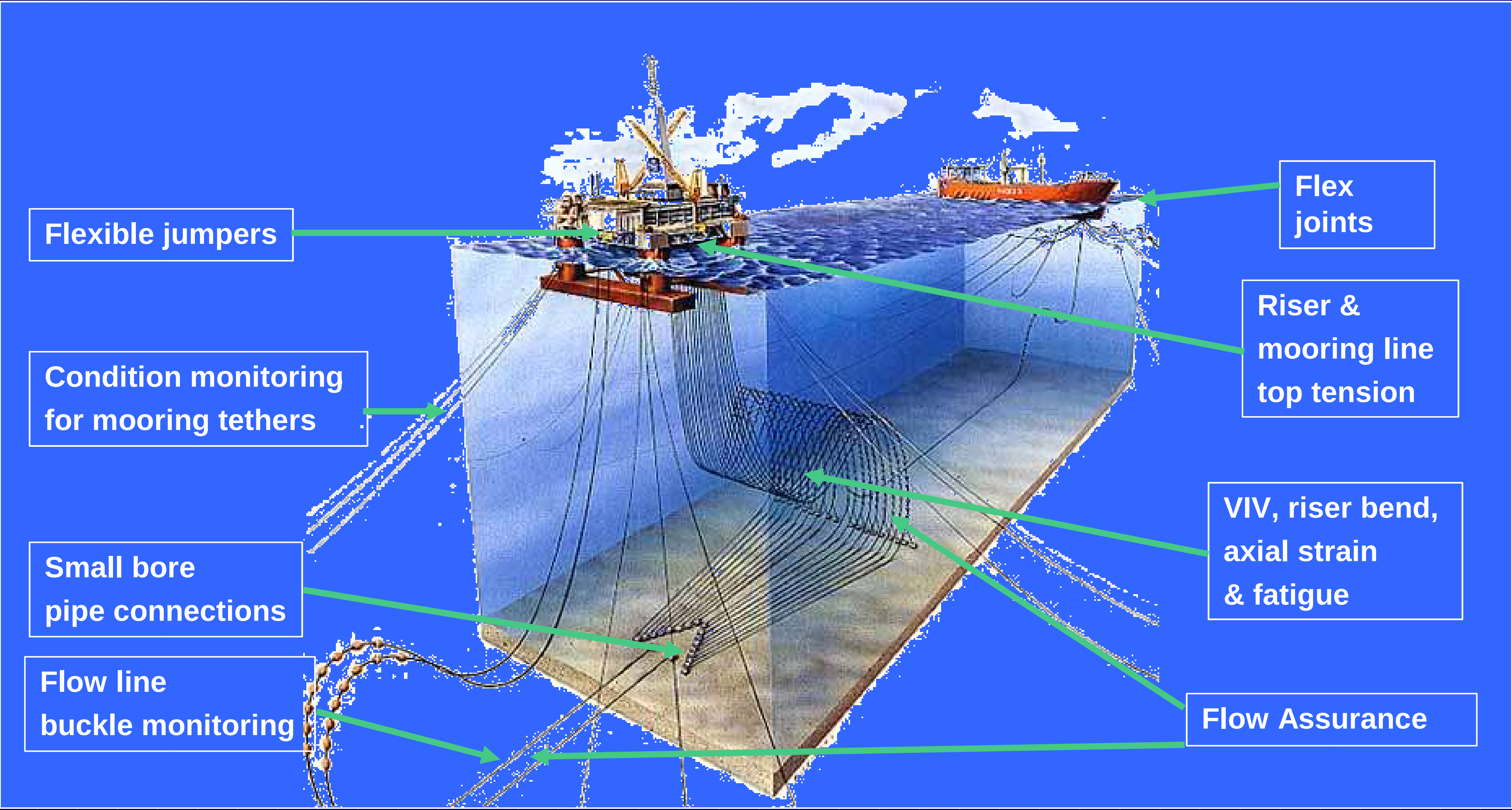
# AGENDA

- Risk Assessment and Modelling of High Risk Segments
- Monitoring Systems – Applications and Benefits
- Case Study of Gas Pipeline Leakage Detection

# Multiple Solutions…..



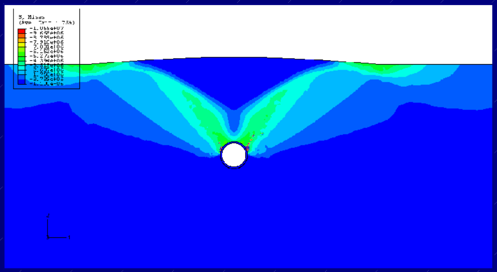
# Risk Assessment

- Critical zones of a flowline route can be subjected to detailed risk analysis.
  - *Structural mechanics*
  - *Structural dynamics*
  - *Thermal design & thermal/ structural interaction*
  - *Finite element analysis*
  - *Computational fluid dynamics*
  - *Near surface soil-structure interaction*

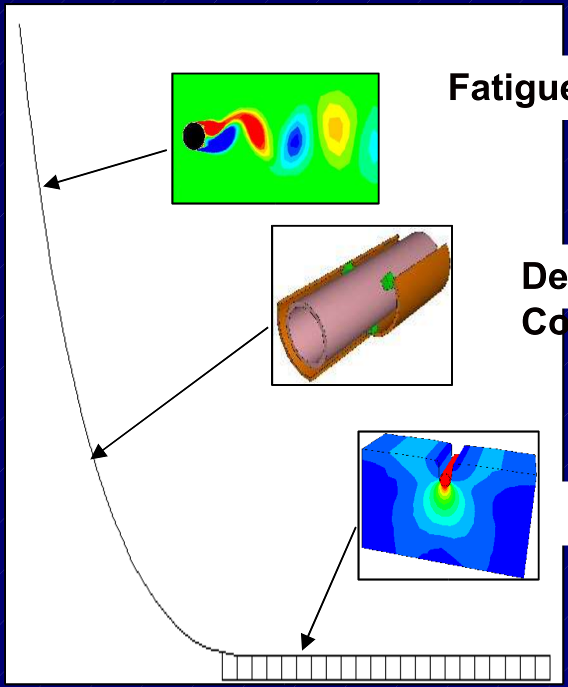
# Vital Input to Initial Design

**Buried Flowline-**

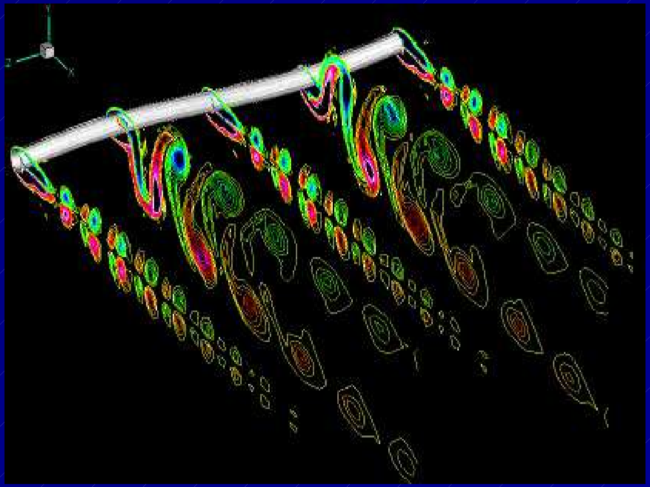
**Seabed Interaction for upheaval buckling**



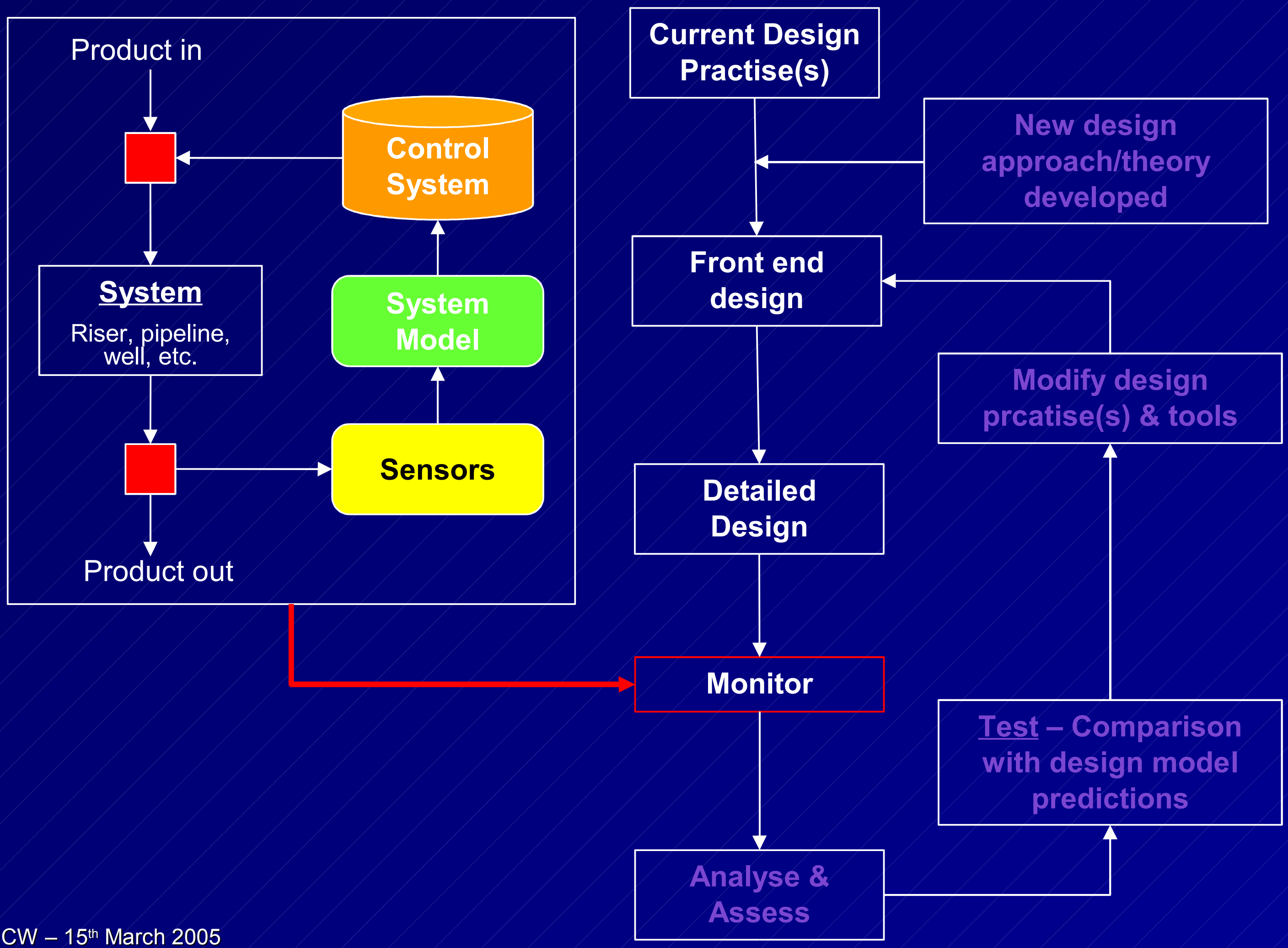
**Catinery Risers**




**Time-domain VIV (coupled FE-CFD analysis)**



# A Novel Approach to Monitoring

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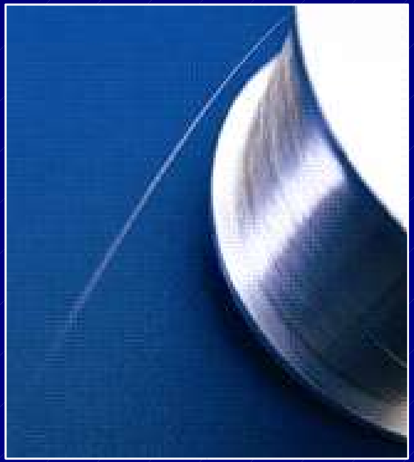
# The Use of Optical Fiber and Other Sensor Systems



- Improve Operational Efficiency
  - Flow Assurance
  - Reduced Downtime
- Reduction of Risk or Failure
  - Fatigue Analysis
  - Joint Leakage Prevention
  - Leakage Detection

# Optical Sensors -the enabling technology

- Utilises intrinsic properties of fiber, not merely communicating of data.
- No electronics at sensor locations
- High temperature performance >300ºC
- Extremely small <500μm
- Intrinsic Safety
- High reliability and stability
- Immune to EMI
- Distributed Sensors provide Complete Coverage
- Long Range

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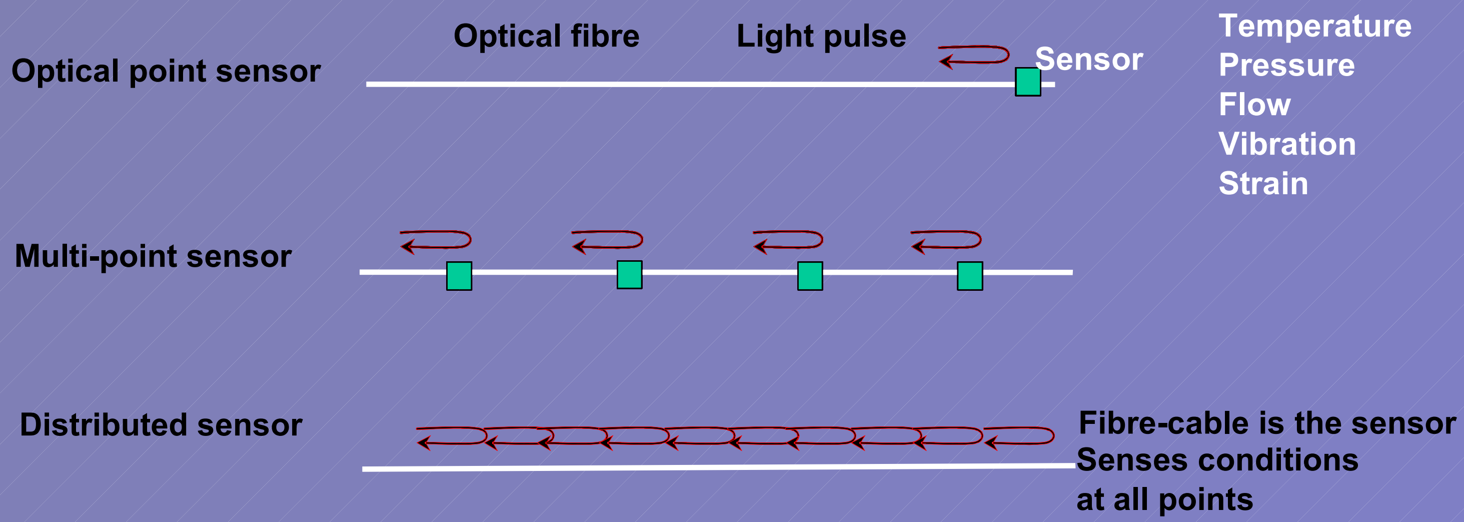
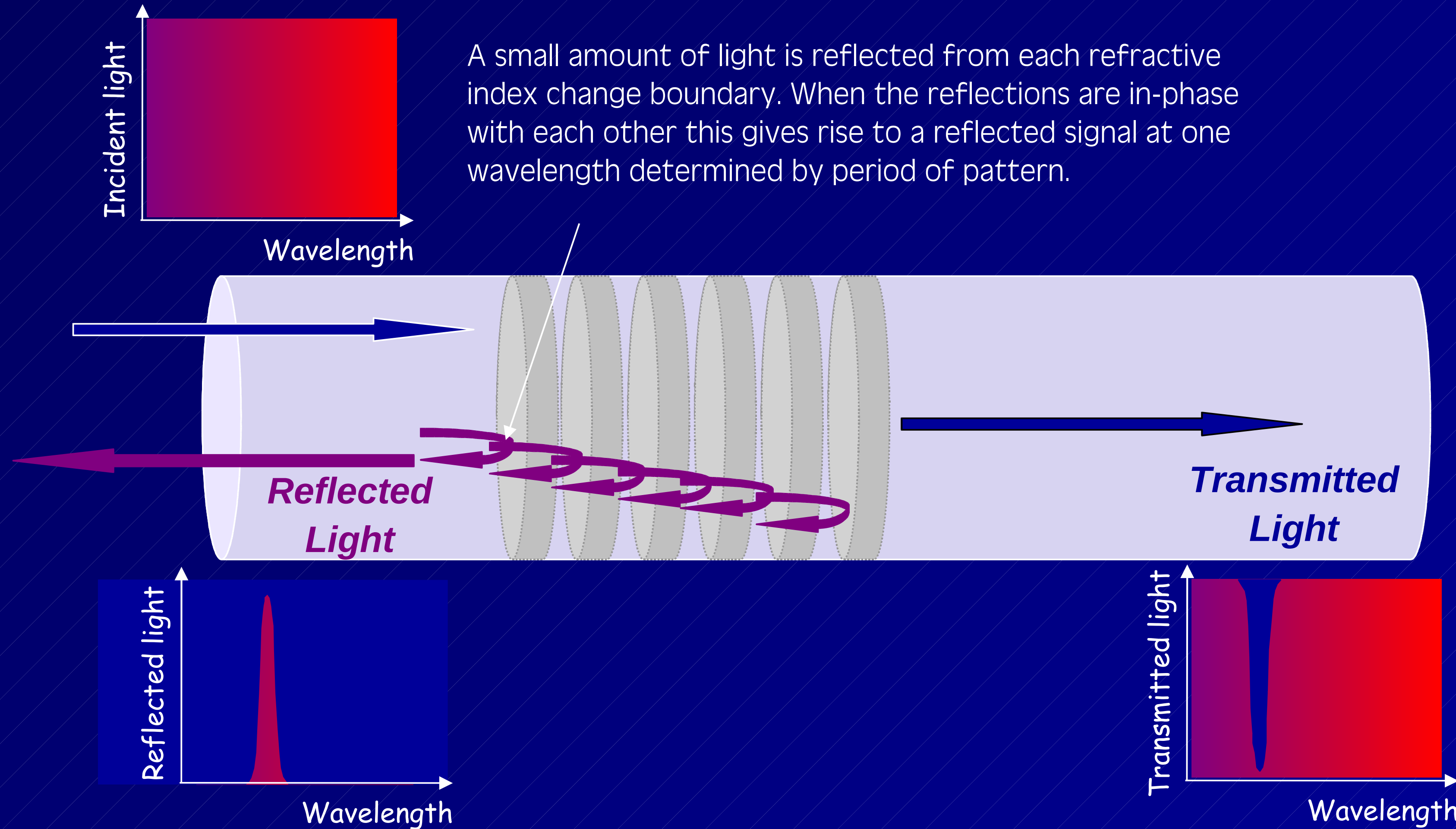
# Distributed Fibre Optic Sensing



# Typical Operation of Optical Sensor

A small amount of light is reflected from each refractive index change boundary. When the reflections are in-phase with each other this gives rise to a reflected signal at one wavelength determined by period of pattern.

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# Intelligent Pipelines
# Sensor Types and Applications

| Parameter | Temperature | Strain | Acoustic |
|---|---|---|---|
| Applications | ▪ Flow Assurance<br>▪ Leakage Detection | ▪ Pressure<br>▪ Curvature<br>▪ Fatigue<br>▪ Shape<br>▪ Position<br>▪ Tension<br>▪ Degradation | ▪ Leakage Detection<br>▪ Intrusion Detection<br>▪ Flow Regime |
| Mode | Single Point, Multi-point & Distributed | | |



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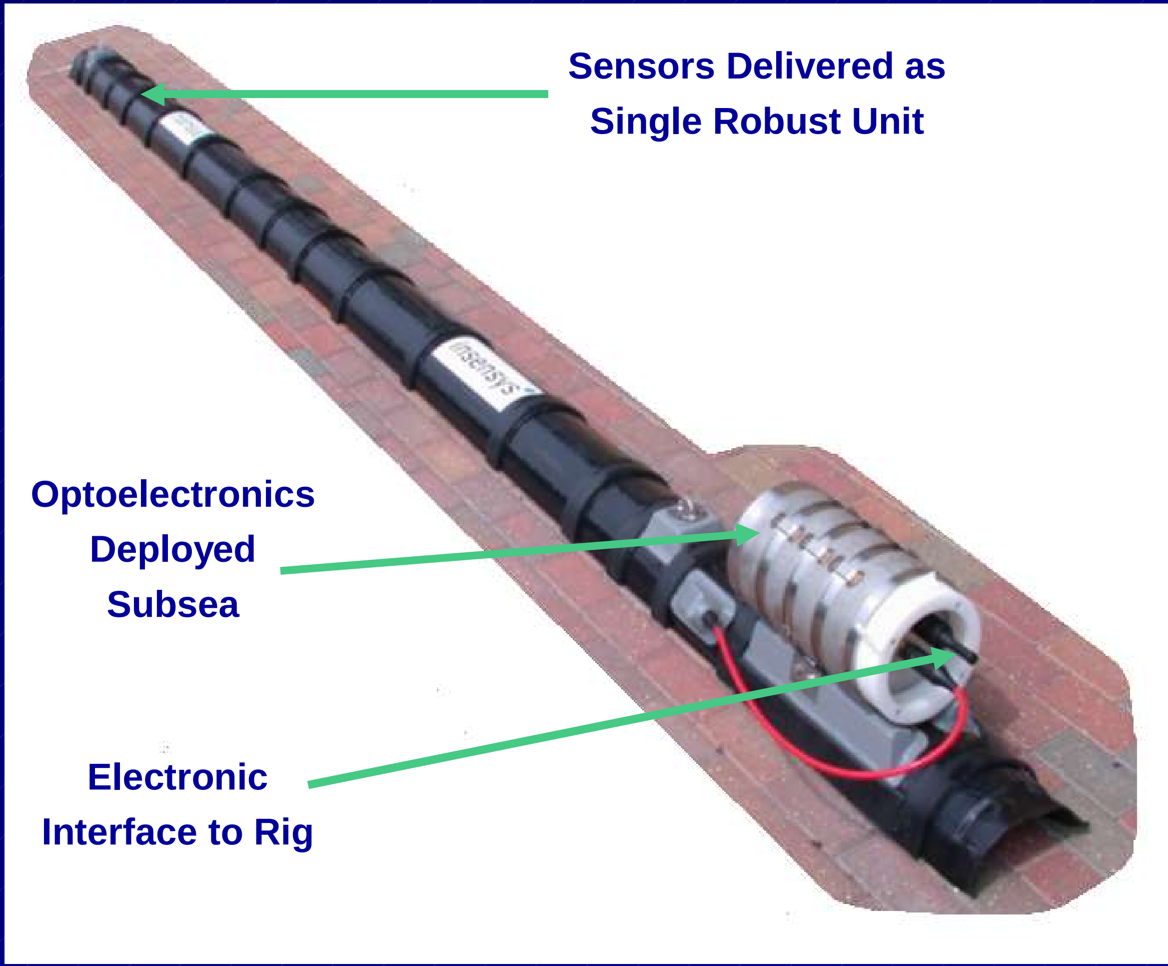
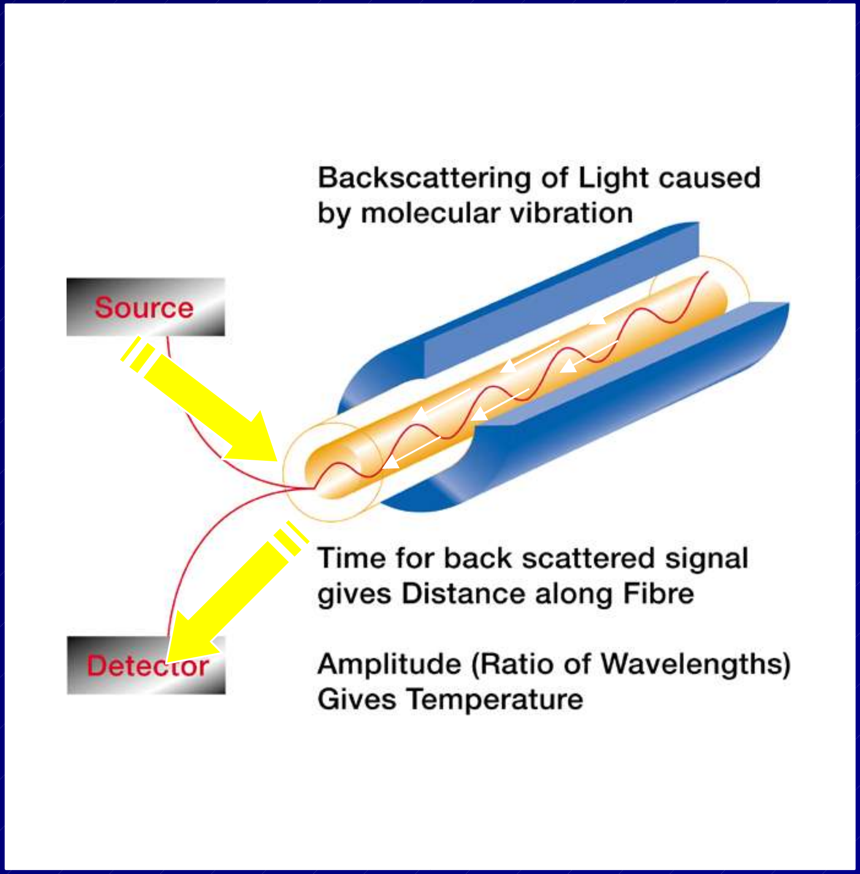
# Application of Strain Monitoring

Assembly is clamped onto existing riser for Strain and Bend Data

**Compatible with Existing Equipment and Methods**



# Operation of DTS



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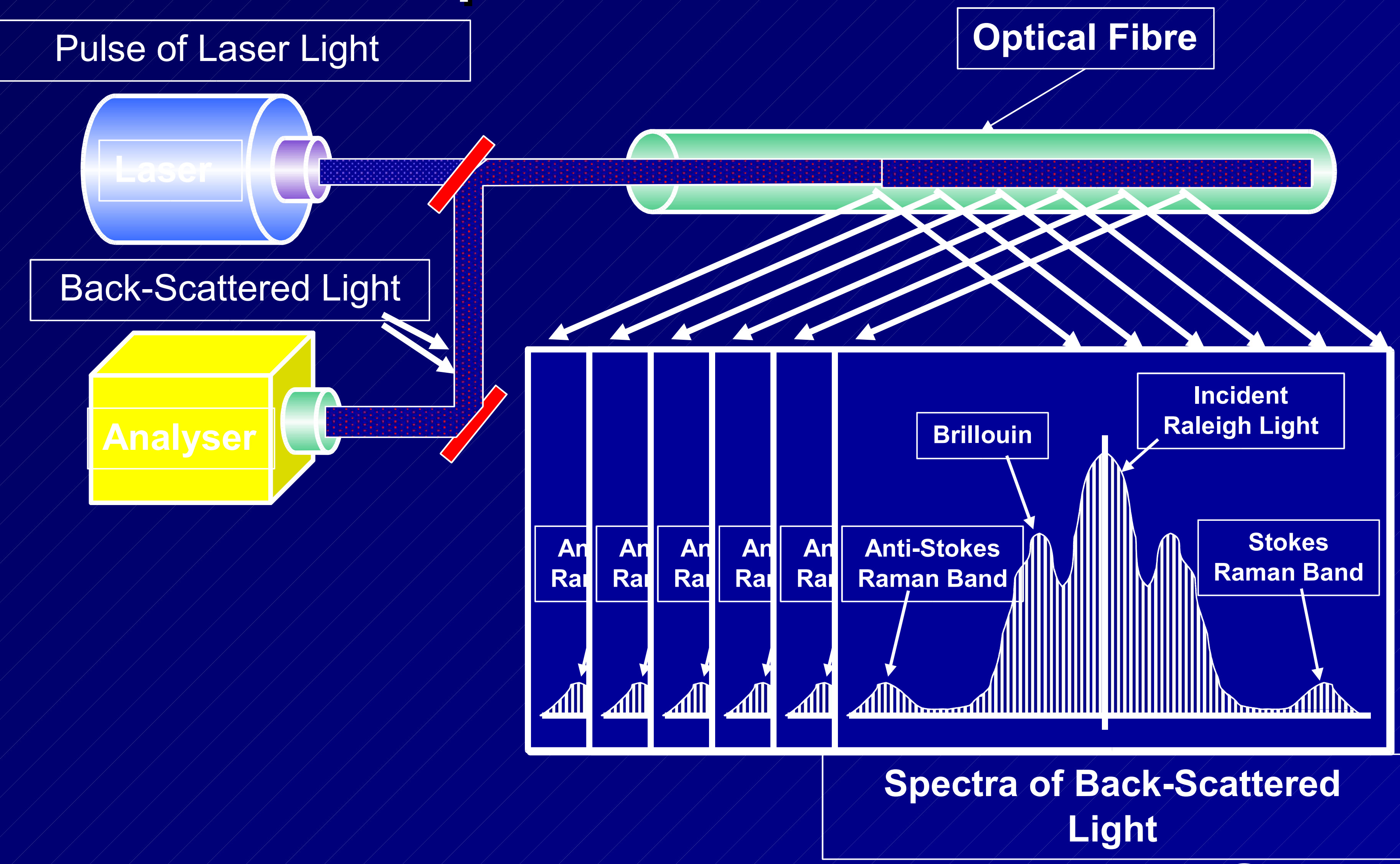
# Operation of DTS

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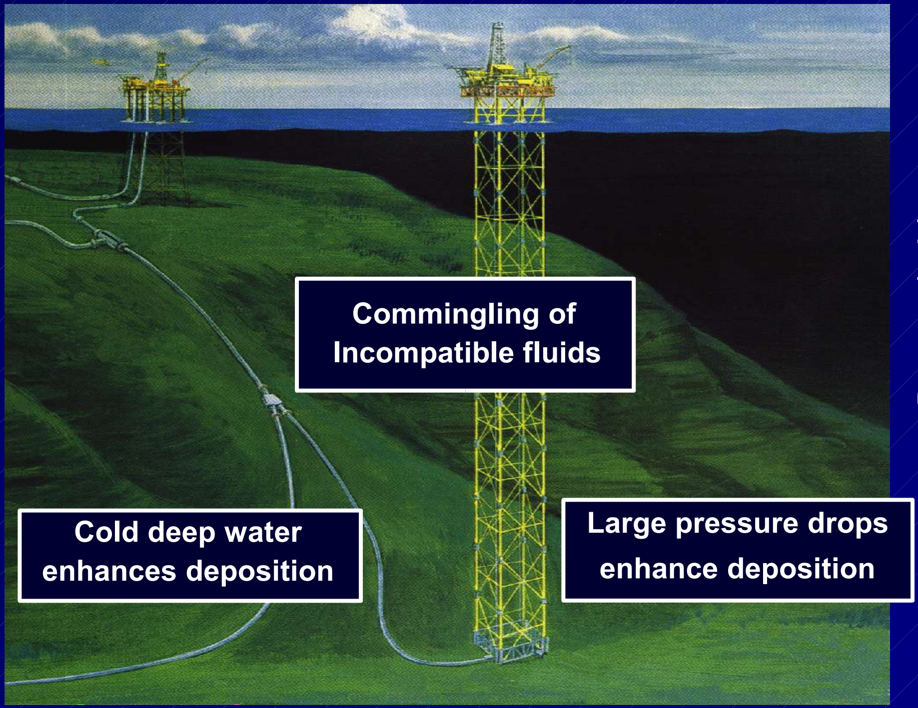
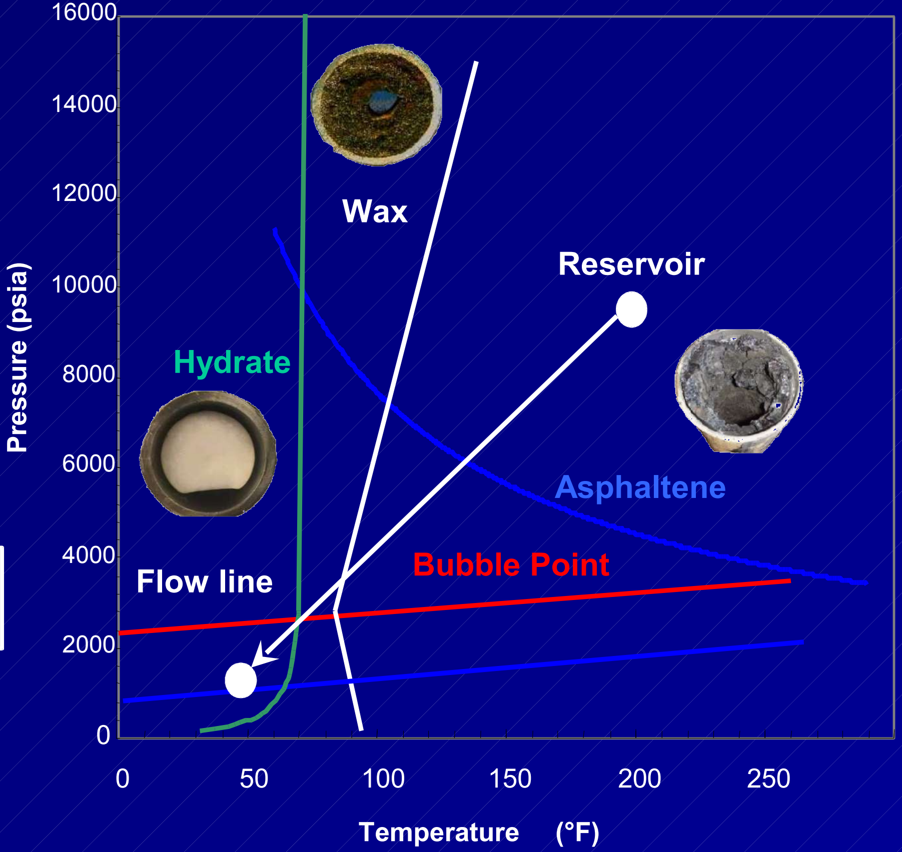
# Flow Assurance Became a Serious Issue in the Subsea and Deepwater Environment



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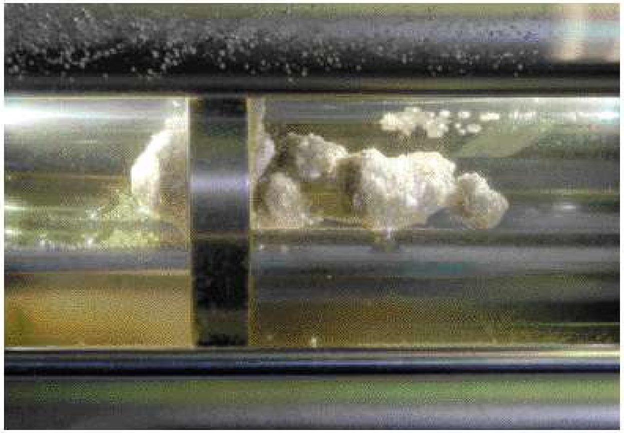
# Flow Assurance Using DTS

- Monitor flowlines to ensure they remain above their critical temperature – preventing wax or hydrate forming conditions.
- Optimise energy for active heating system – target savings: 7 – 12%.
- Optimise chemical injection.
- Minimise downtime during start-up – target improvement 25%
- Reduce pigging operations by knowing true deposition conditions within the pipe.
- Monitor efficiency of artificial lift/gas lift operations .
- Monitor thermal performance of insulation over time to enhance subsequent designs – and to reduce capital cost.

# DTS Trial for Hydrate Identification

**The formation of hydrates is an exothermic reaction.**

**The melting process for hydrates in endothermic.**



*Gas hydrate blockage*

**Thus a distributed temperature sensor will be able to identify where and when hydrate formation commences**



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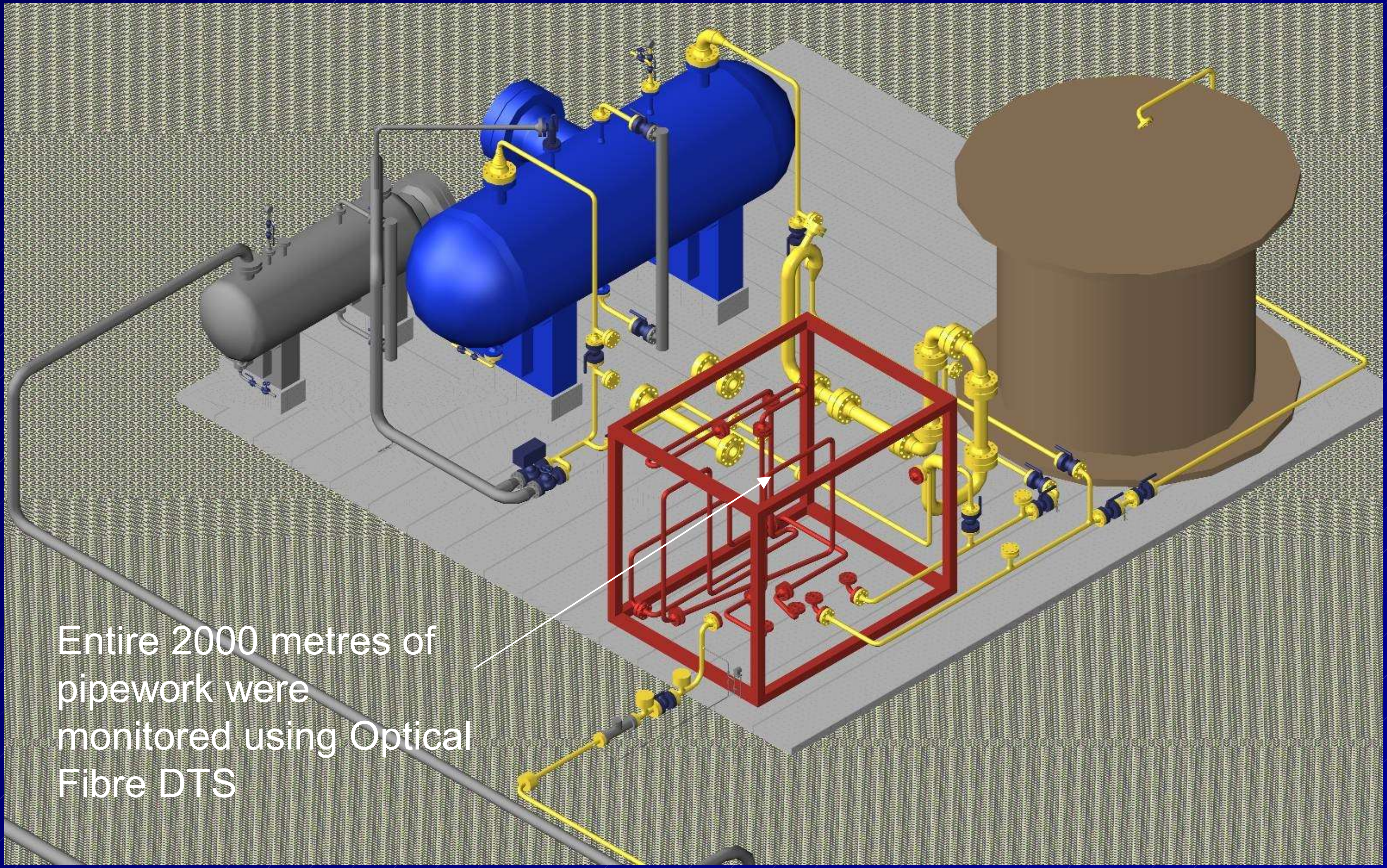
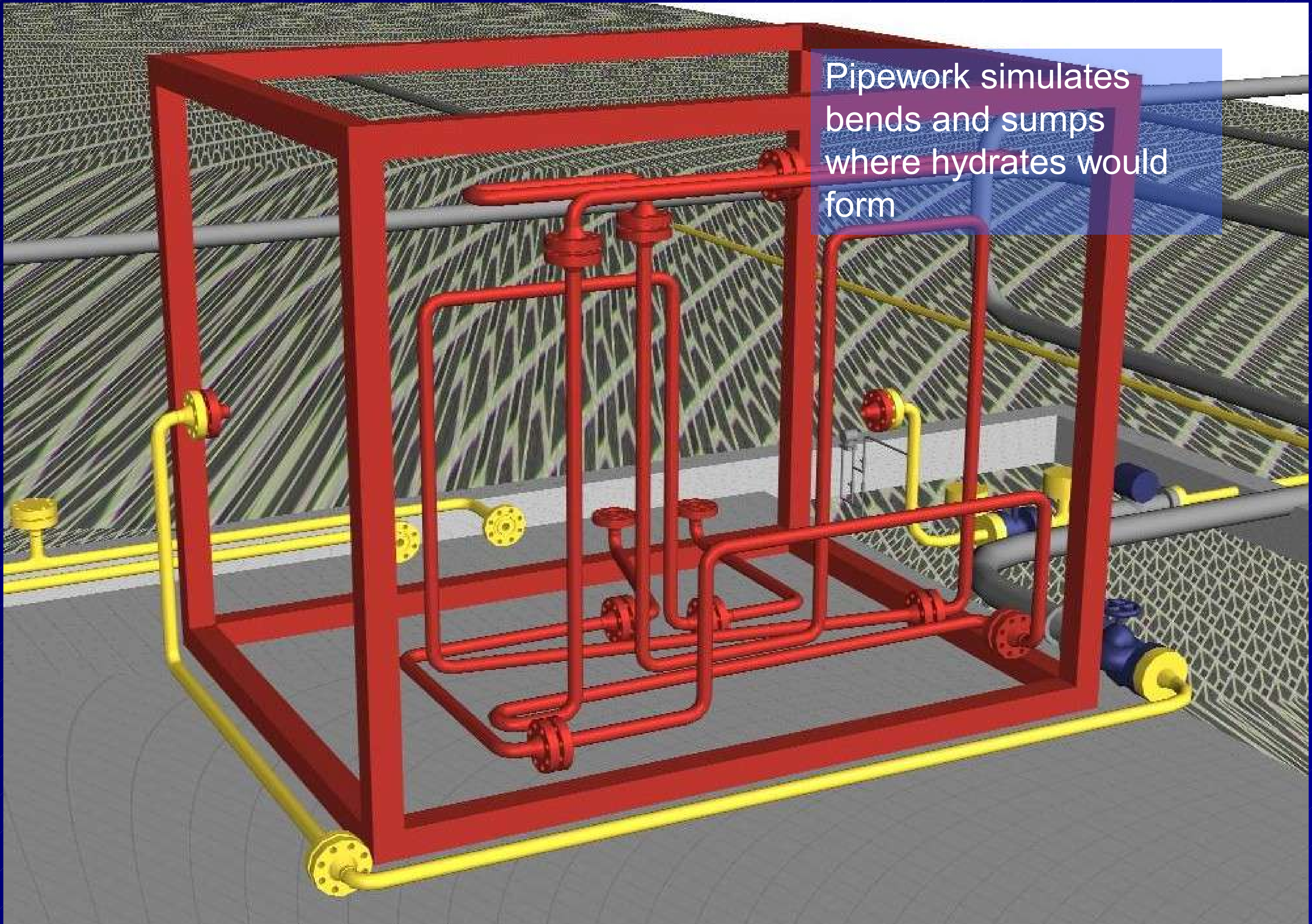
# Test Arrangement



# Pipework Detail



Pipework simulates bends and sumps where hydrates would form

# RESULTS

•From the thermal traces generated by the optical fiber DTS it could clearly be seen that the hydrates were formed at the sumps within seconds of the hydrate forming conditions being generated.

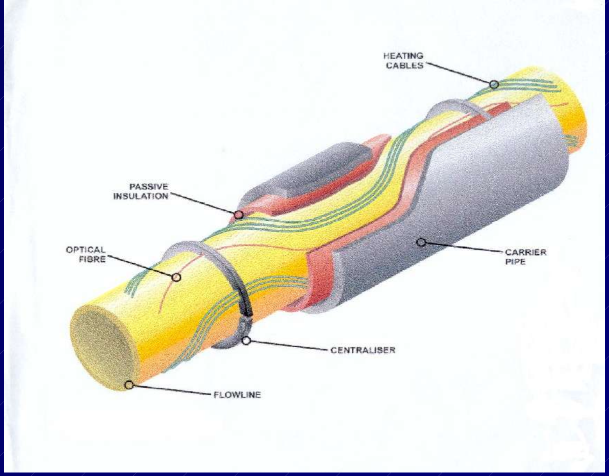
•When the system was de-pressurised, hydrate disassociation could be seen by a localised cooling effect.

# Hydrate Identification

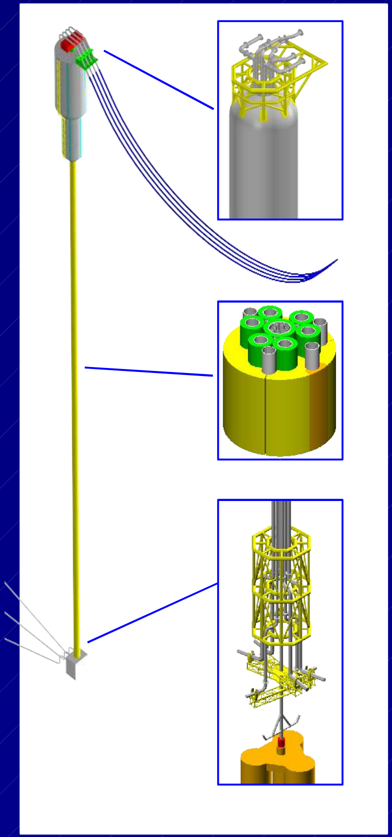
- DTS can be used in 2 ways:
  - To monitor for potential hydrate-forming conditions to permit mitigation processes
  - As a identification system for the early forming of hydrates – both where and when – and subsequently as a monitor to ensure mitigation processes have been effective.

# Typical Applications Subsea

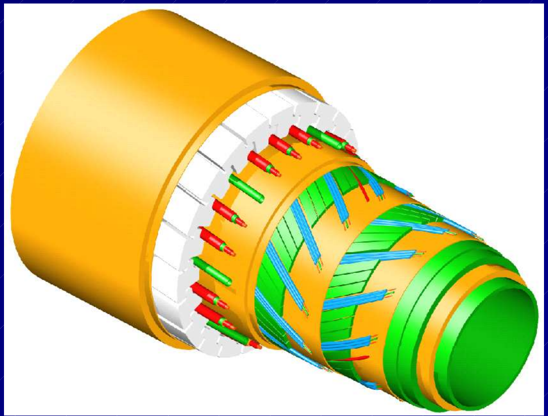
Heated Pipe-in-Pipe




Riser Towers



Flexibles



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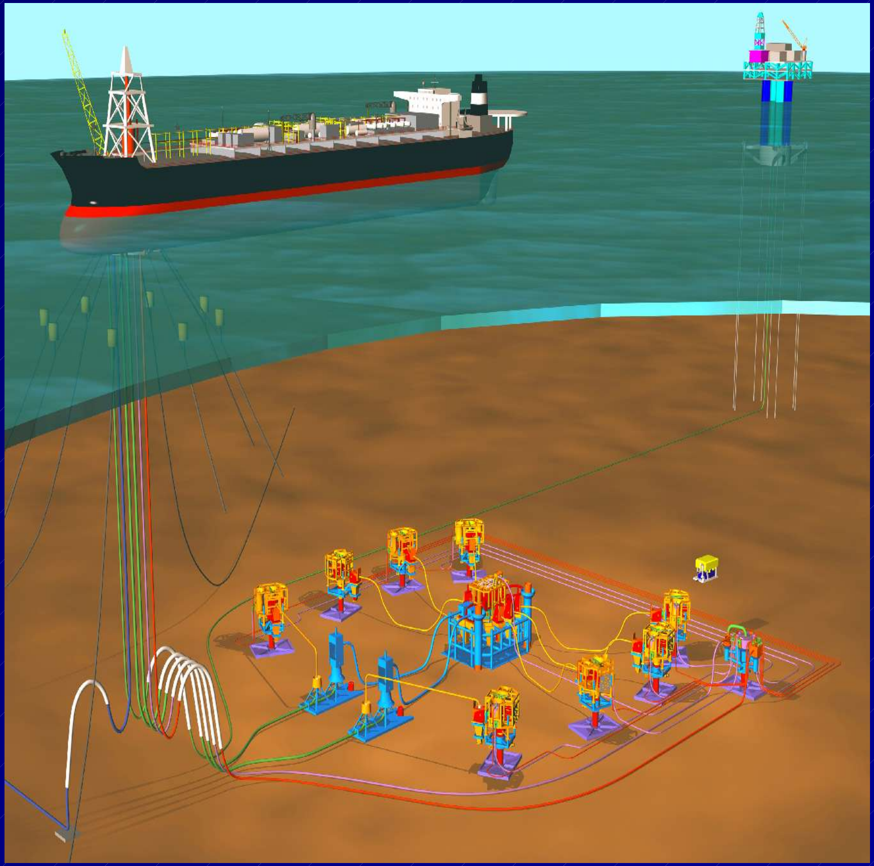
# Total Dalia

- Accuracy better that 0.5degC
- Algorithm development to correct optical fibre values for actual fluid temperatures.
- On-line data feedback to thermal model to permit optimisation decisions.



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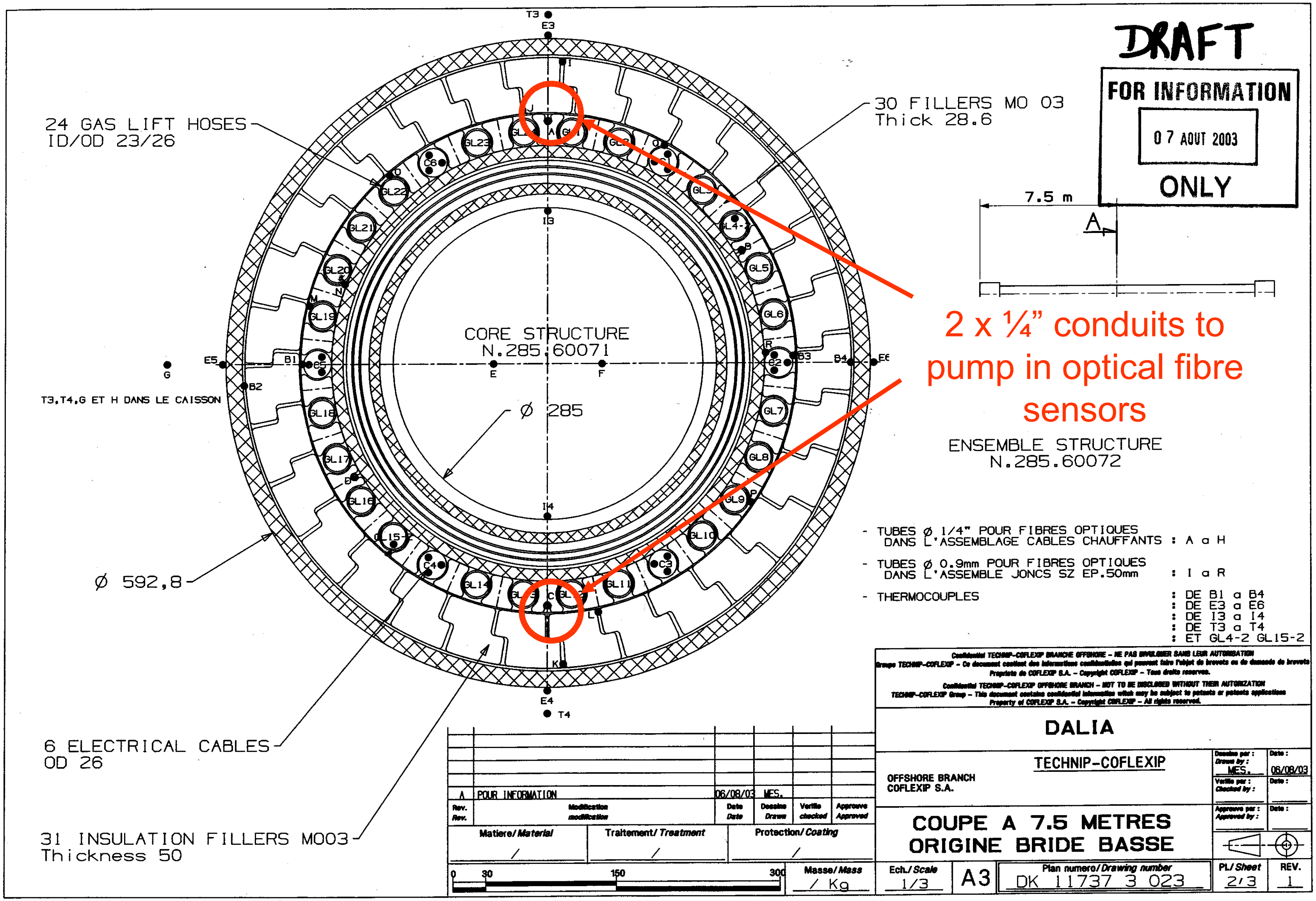
# Total's Dalia Development in Angola

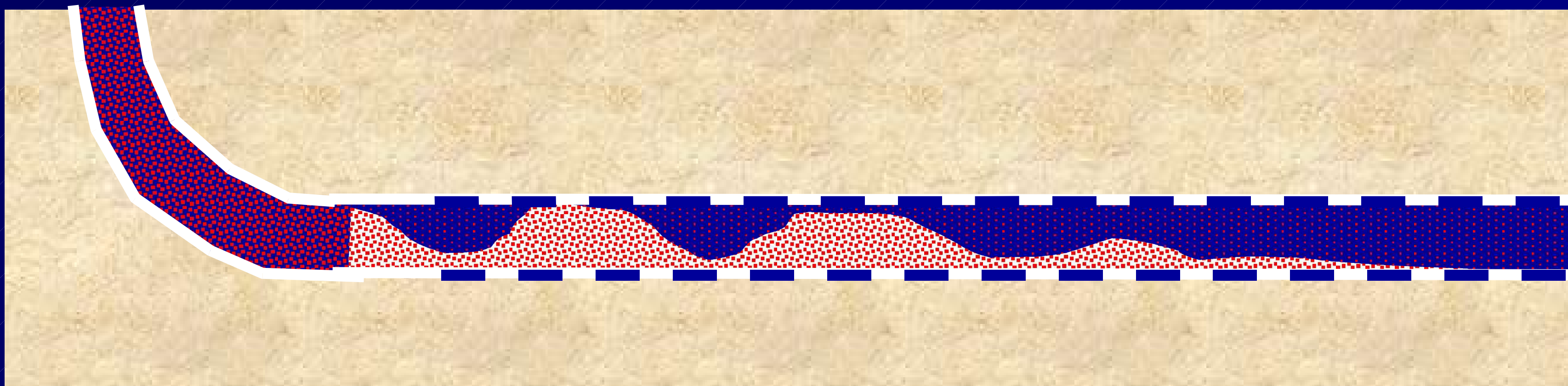


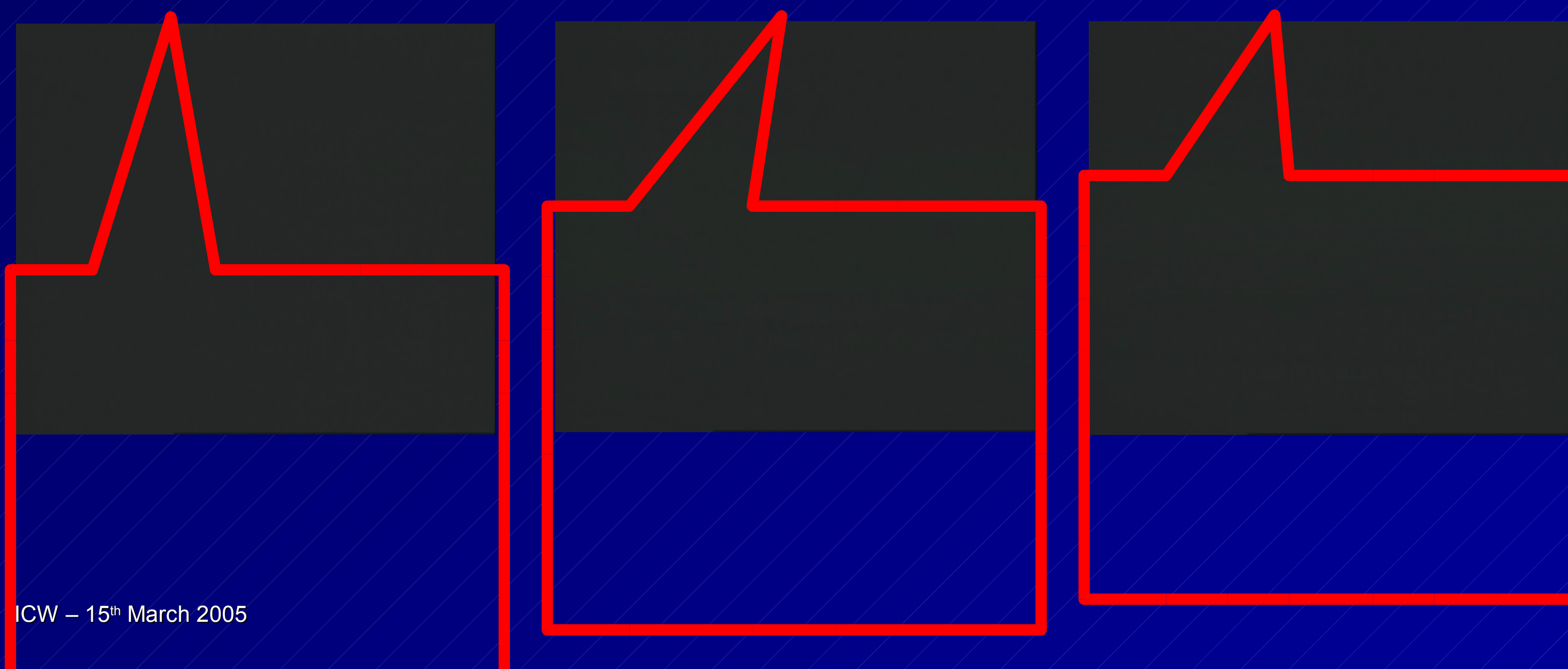
# Total’s Dalia Development in Angola

- 8 Flexible Risers – each approx 1500 metres long
- Electrical Active Heating IPB System (Integrated Production Bundle)
- Prime Contractor – Technip.
- Traditional Pumped Installation
- IPB Fabrication commenced Q2-2004.
- Installation commences Q2-2006

# Acoustic Flow Regime Effects

Bubble Flow | Slug Flow | Stratified Flow





# Prevention of Flange Leakage

- A recent study in USA revealed that out of 127 reported pipeline leaks, 14 were attributed to faulty joints or seals.
- One method to mitigate this is to ensure that flanges are tightened correctly, optimising the seal.
- Tightening bolts using torque alone is not sufficient to ensure correct loading.
- Friction variances can be eliminated by measuring the load within each bolt, ensuring optimum performance and minimum risk.

Test flange using truload bolts



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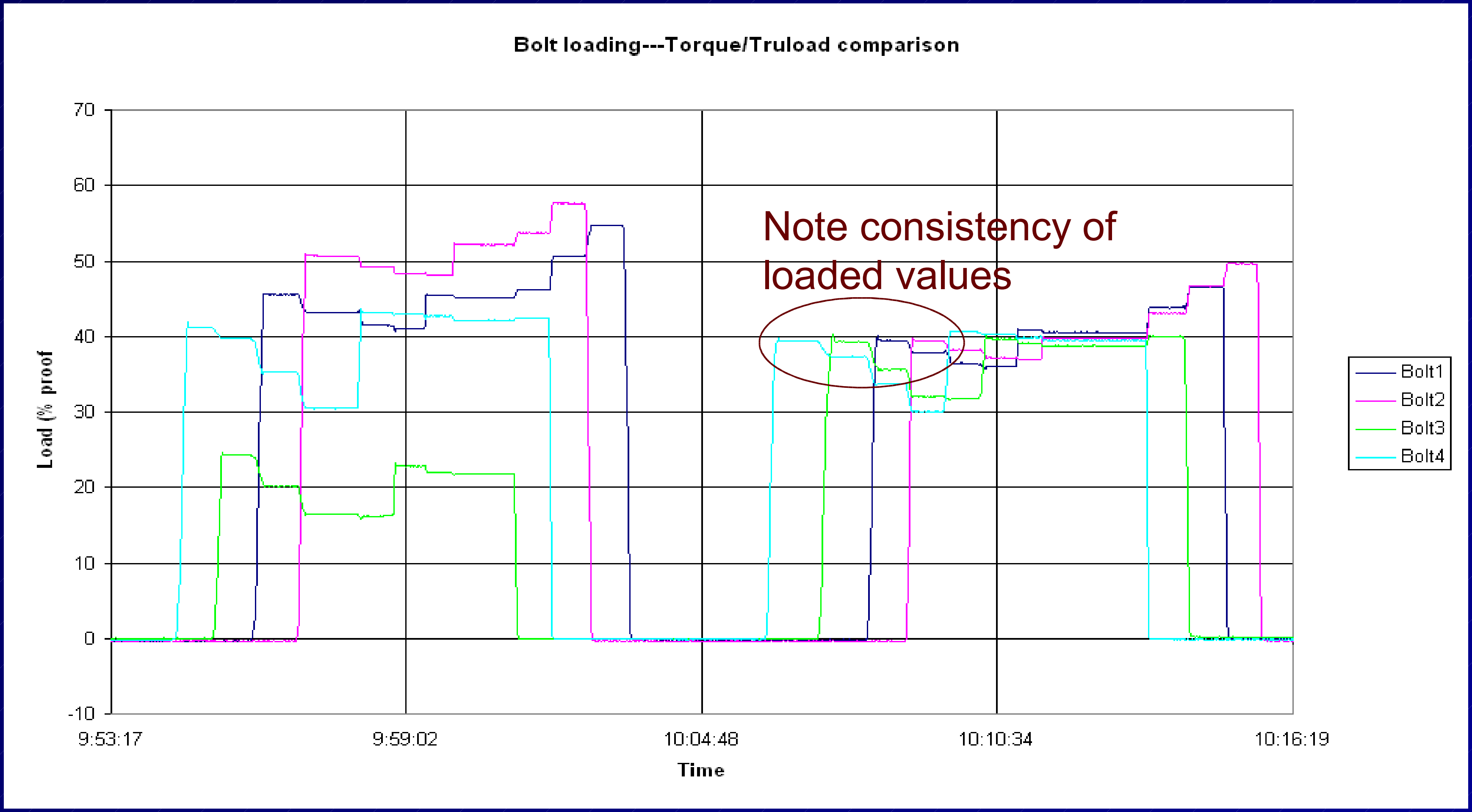


With the bolts tightened to the same torque, the variance in load was over 75%, with one bolt (un-lubricated) only loaded to 50% of expected value.

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# Case Study – Gas Leakage Detection using Optical Fiber DTS



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# Leak Detection Trial In Multiphase Pipeline for BP

- Multiphase pipe carries gas and liquid phase so conventional mass balance leak-detection techniques not accurate - hence DTS technology proposed
- Mechanism involves monitoring pipeline temperature profile to detect cold spot at leak site due to Joule Thomson (JT) effect
- Objective was to detect leakage of 0.2% mass flow of 160 bar methane at 300mscfd
- JT effect simulated by releasing nitrogen at 160Bar through 2.5mm diameter orifices in buried sample of 660mm dia pipe



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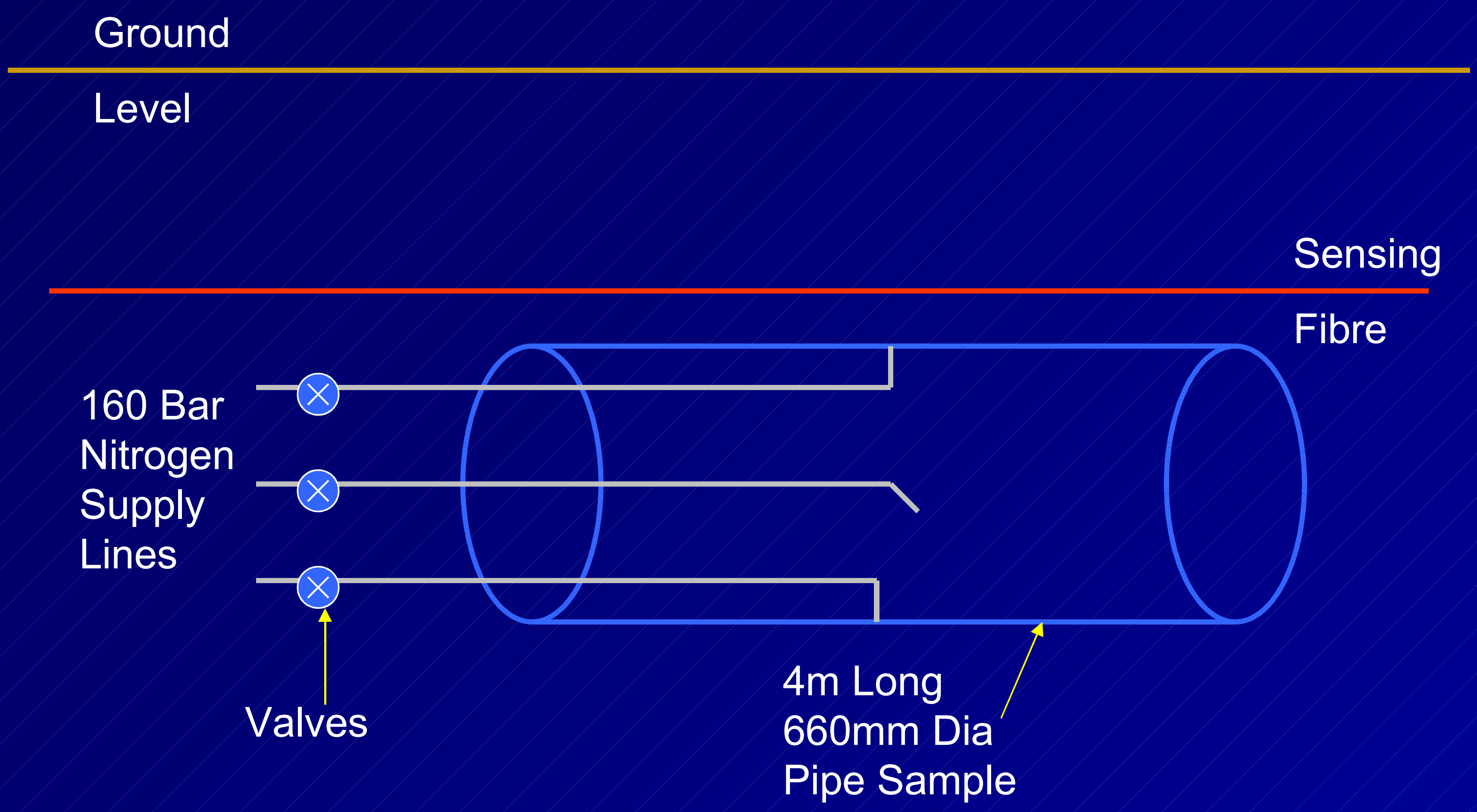
# Leak Detection Trial Schematic

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# Integrity Monitoring – Gas Pipelines

26”Pipeline Section in Soil Chamber showing gas discharge hoses



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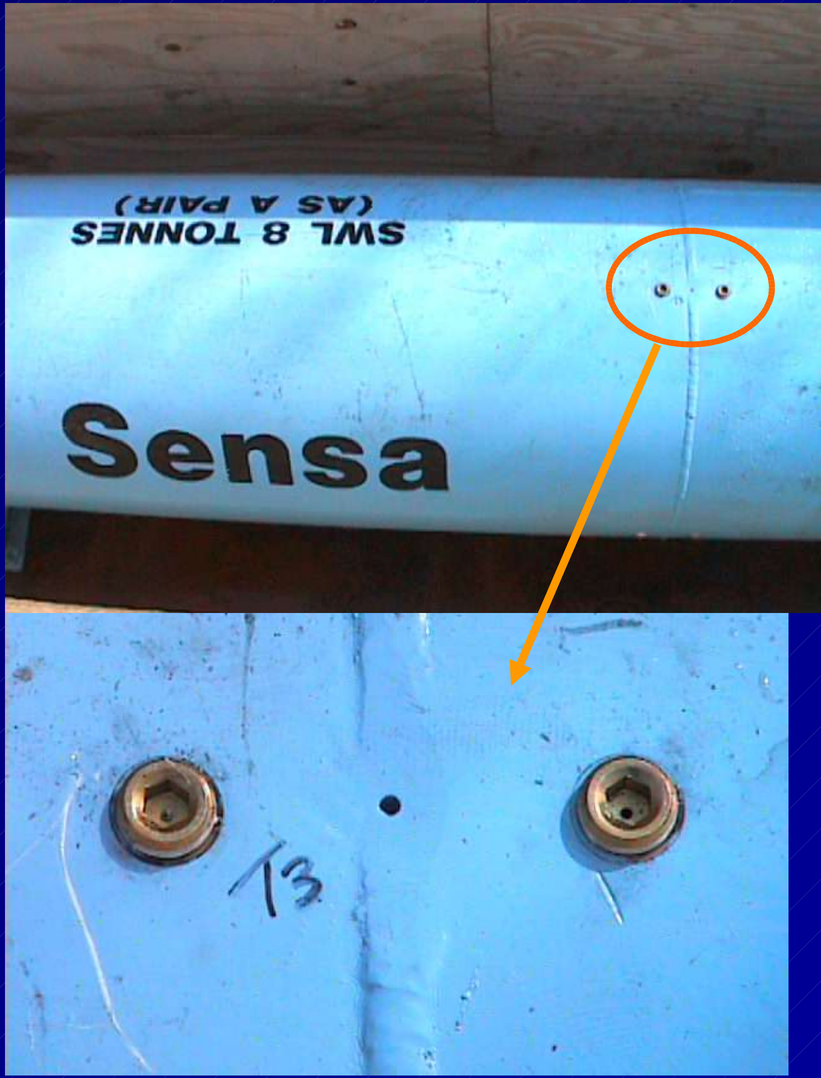
# Integrity Monitoring – Gas Pipelines

Details of a typical leakage arrangement

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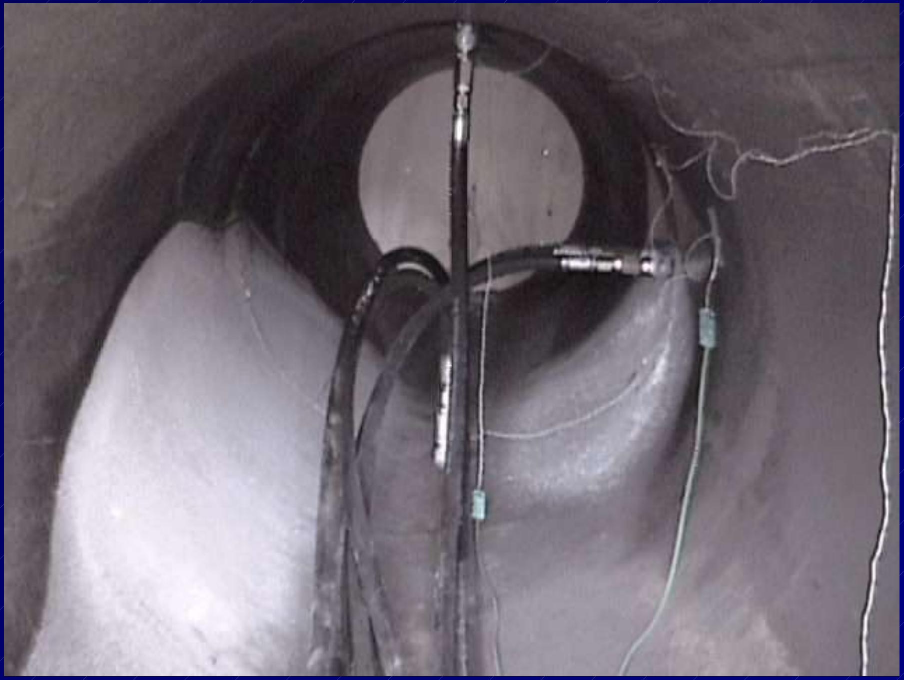
# Integrity Monitoring – Gas Pipelines



Internal View of the Pipeline showing the gas discharge hoses going to 3 x 2 positions.

Note build up of ice on inner wall



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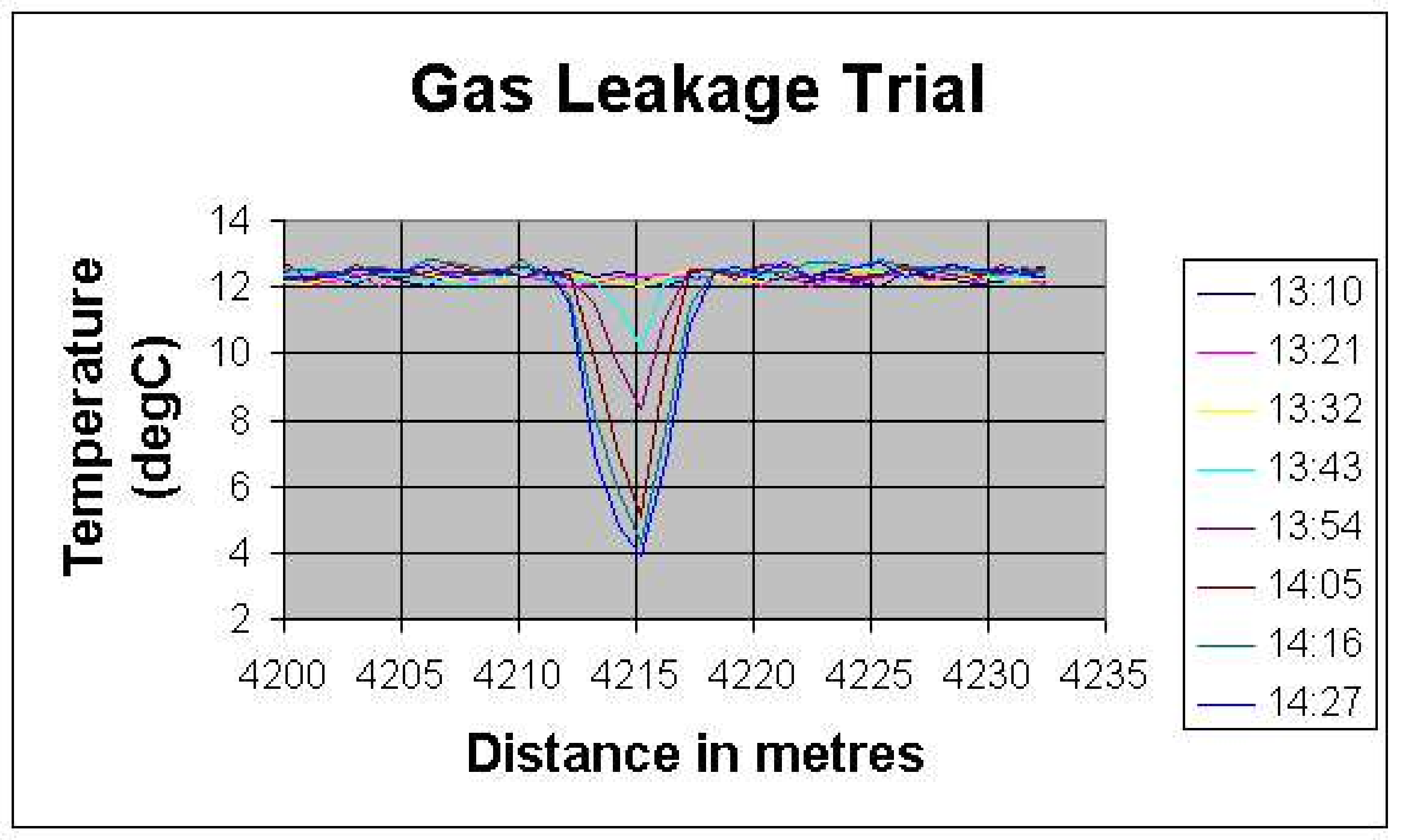
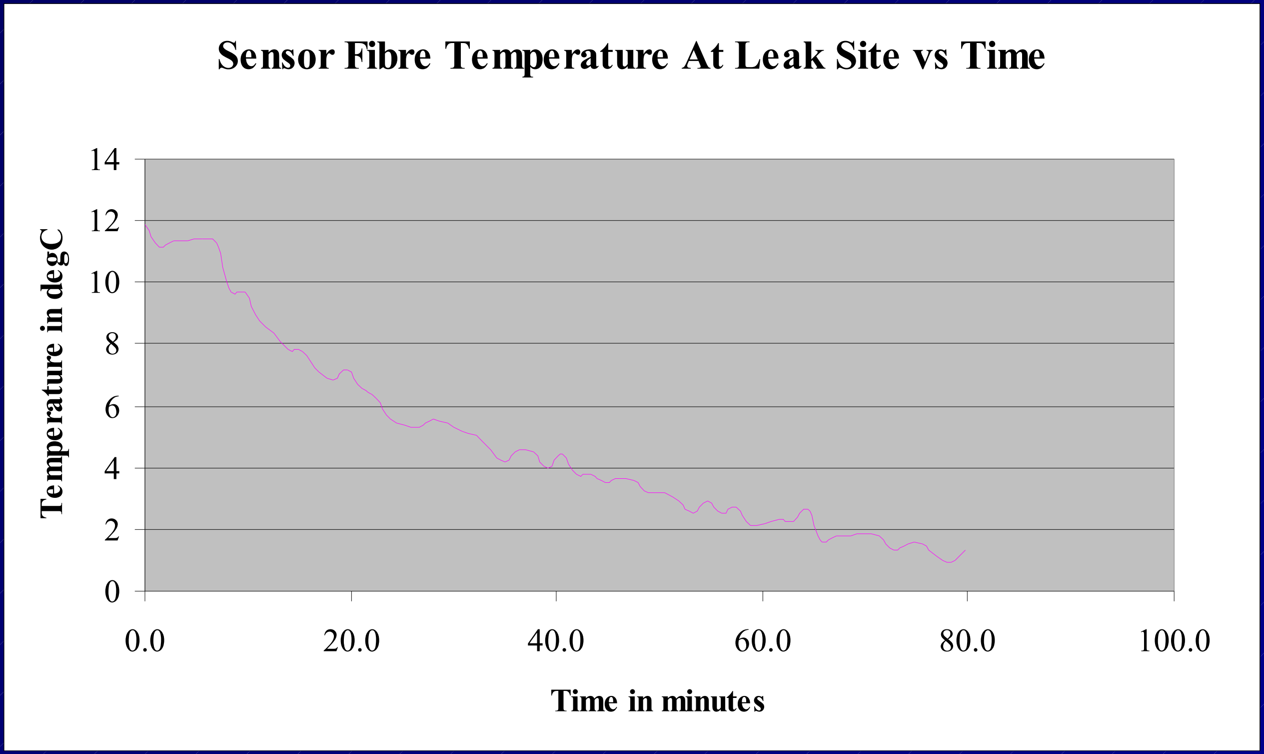
# Integrity Monitoring – Gas Pipelines




The leakage is identified after approx 10 minutes and the temperature continues to drop over the next hour.
Accuracy of location is +/- 1metre (up to 10,000m)

# Sensor Temperature vs Time




Conclusion: DTS is capable of detecting gas leakage rates equivalent to minimum detectable levels (0.2%) of alternative mass transfer technologies in only a few minutes



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# Conclusions

- It can be seen that the use of advanced sensor systems coupled with analytical modelling programmes will deliver new levels of information to provide operational savings, increased asset life, maintaining production whilst increasing reliability and minimising risk.

With thanks to the following for input/permission for this presentation:

ChevronTexaco

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Technip

Oceaneering

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