Application of Stress Measurement Technology to the Monitoring & Inspection of Flexible Risers
MAPS® Stress Measurement Technology

- Patented method of stress measurement
  - ferromagnetic materials
  - absolute biaxial stress
  - stress magnitude and direction
  - stress depth profiling
  - accurate to a few % of material yield

- Portable, rapid, non-contacting, non-destructive
  - dynamic with potential velocities $>7\text{ms}^{-1}$
  - measurement through most engineering coatings
Application to Flexible Risers

- **Deployment**
  - installed external to the outer polymer layer; no compromise to riser integrity
  - integrated within a new build or retro-fitted onto existing riser

- **Wire break detection**
  - extended range; from termination to splash zone
  - resolution to individual wire; monitors accumulation of damage
  - not reliant on transient signals
  - links to both outer/inner tensile armour layers
Dynamic Testing - Riser Load Measurements

The image shows a stress-strain diagram with several phases highlighted:

- **Pressurisation**
- **Cyclic bending**
- **Tensioning**

The diagram includes a graph with time on the x-axis and stress on the y-axis, illustrating the progression of load tests over time.

The graph also shows a comparison between 'Calculated stress' and 'MAPS-FR Stress data'.
Wire Break Qualification – No Breaks

00:00 to 06:00 hrs
Wire Break Qualification – Wire Break No 1

Pipe Extension & Rocking Angle for 31 October 2011

00:06 to 12:00 hrs
Wire Break Qualification – Wire Break No 2

Pipe Extension & Rocking Angle for 31 October 2011

12:00 to 18:00 hrs
Stress Re-distribution Following Wire Break

Increasing tension

Progressive stress increase following wire break

Stress reduction due to wire break
Stress Re-distribution Following Wire Break

Increasing tension

FT1

29/10 20:34 – 30/10 03

FT2

Change in MAPS Stress Signal Due to Wire Break

Sensor Number

Inner Wire Layer

Outer Wire Layer
Post Test Forensic Examination
Correlation with Wire Break Observations

|               | 21 | 22 | 23 | 24 | 25 | 26 | 27 | 28 | 29 | 30 | 31 | 32 | 33 | 34 | 35 | 36 | 37 | 38 | 39 | 40 | 41 | 42 | 43 | 44 | 45 | 46 | 47 | 48 | 49 | 50 | 51 | 52 | 53 | 54 | 55 | 56 | 57 | 58 | 59 | 60 | 61 | 62 | 63 | 64 | 65 | 66 | 67 | 68 | 69 |
|---------------|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|
| Nov-10            |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |
| Nov-14            |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |
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MAPS-FR-V1 Equipment Disabled

Riser Failure
Application to Inspection of Flexible Risers

• Single probe scanner
• Sensing individual wires through:
  – full circumferential scan, or
  – axial scan along the wire helix pitch
MAPS-FR: Summary

- **Deployment**
  - installed external to the outer layer; no compromise to riser integrity
  - integrated within a new build or retro-fitted onto existing riser

- **Wire break detection**
  - extended range; from termination to splash zone
  - resolution to individual wire; monitors accumulation of damage
  - links to both outer/inner tensile armour layers
  - not reliant on transient signals

- **Stress measurement**
  - provides real time condition monitoring data allowing input to fatigue/lifetime extension assessments
  - layer by layer: tensile armours, pressure armour & carcass

- **Inspection**
  - wire break detection capability possible with single probe; either in circumferential or axial scanning mode depending on access