# Condition Monitoring of 'Ageing' Subsea Control Systems

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## Subsea Control System

- Topsides Equipment
  - Master Control Station (MCS)
  - Electrical Power Unit (EPU)
  - Hydraulic Power Unit (HPU)
  - Topsides Umbilical Termination Unit (TUTU)
- Subsea Equipment
  - Umbilical (Hydraulics, Electrics & Chemicals)
  - Umbilical Termination Assembly (UTA)
  - Subsea Distribution Unit (SDU)
  - Electro-Hydraulic Jumpers
  - Subsea Control Modules (SCMs)
  - Instruments (Pressure, Temperature, Position)
  - Xmas Tree Valves & Manifold Valves

## Subsea Control System



## So what goes wrong ?

- Hydraulic Leaks
  - Major Leaks
  - Weeps & Seeps
- Insulation Resistance (IR)
  - Sudden Loss
  - Gradual Degradation

## Hydraulic Leaks

- Major Leaks
  - Hose Rupture
  - Directional Control Valve (DCV) Temporary Misalignment (Interflow)
  - DCV Failure
- Weeps & Seeps
  - Hose Fittings become loose
  - DCV wear
  - Valve Seal wear

## Monitoring for Hydraulic Leaks

- Major Leaks are easy to identify
  - Sudden Pressure Loss
  - Increased Usage of Fluid (HPU Tank Level or Flow)
- Weeps & Seeps are far less obvious and need much greater scrutiny
  - Long term data capture to allow analysis & trending
  - Comparison against other similar subsea data points

## Monitoring for Hydraulic Leaks



## Monitoring for Hydraulic Leaks



## Insulation Resistance

• What is Insulation Resistance



## Insulation Resistance

#### • How do we measure it



## Insulation Resistance

- Sudden Loss
  - EPU trip (over-current)
  - Total attenuation of comms
- Gradual Degradation
  - Continuously reducing IR
  - Intermittent Line Insulation Monitor (LIM) trips
  - Intermittent comms error / losses

## Monitoring of IR

- LIM Readings
  - IR is a constantly changing value
  - Long term data capture to allow analysis & trending
  - How often to log ?
  - Differences in trace obtained from different log periods
  - Cyclic nature of reading
  - How long until it fails ?

#### What else should we be monitoring ?

- HPU Fluid Cleanliness
- HPU Pump run / stop cycle
- HPU Pressure Control
- EPU Voltage
- EPU Current
- EPU Power Factor
- Umbilical Capacitance
- MCS Modem Errors
- SCM Comms Errors
- All SCM Housekeeping Data
- All important process data

## Case Study

- Triton Electrical Integrity
  - Initial Degradation
  - Increased Instability
  - Ultimate Failure

#### 2007

#### Triton LIM Data 08/02/2007 - 10/03/2007



#### January 2009

#### Triton EPU Ch1 - Ch4 LIM Data 01/01/2009 - 31/01/2009



Date Time

## April 2009

#### Triton EPU Ch1 - Ch4 LIM Data 01/04/2009 - 30/04/2009



### June 2009



Triton EPU Ch1 - Ch4 LIM Data 01/06/2009 - 30/06/2009

# July 2009



## Jul 2010



### Oct 2010



## RAG Analysis by Month (2009)

| EPU Channel | March | April | May | June | July | August | Sept |
|-------------|-------|-------|-----|------|------|--------|------|
| Channel 1   |       |       |     |      |      |        |      |
| Channel 2   |       |       |     |      |      |        |      |
| Channel 3   |       |       |     |      |      |        |      |
| Channel 4   |       |       |     |      |      |        |      |
| Channel 5   |       |       |     |      |      |        |      |
| Channel 6   |       |       |     |      |      |        |      |
| Channel 7   |       |       |     |      |      |        |      |
| Channel 8   |       |       |     |      |      |        |      |
| Channel 9   |       |       |     |      |      |        |      |
| Channel 10  |       |       |     |      |      |        |      |
| Channel 11  |       |       |     |      |      |        |      |
| Channel 12  |       |       |     |      |      |        |      |

## IR Analysis

- Art
- Science
- Engineering Experience
- Actually a bit of all 3

## Benefits of Integrity Monitoring

- Monthly Report £2500 per system per asset (£60k p/a)
- Electrical Jumper ~ £5k
- Electrical Jumper Lead time 12~16 weeks
- DSV Lead time 2~?? weeks
- Planned DSV Repair Cost £400k
- Unplanned DSV Cost £700k+
- Lost Production Revenue £300k £??MM
- Proactive rather than Reactive

#### Subsea Controls Integrity Monitoring

- Thank you for listening
- Any Questions ?