All Electric Subsea Production
System Optimization and Digitization

Rory MacKenzie
Deep Offshore R&D Program
Subsea Electrical Technologies
STIMULUS FOR ALL ELECTRIC SYSTEMS

- Reduced Environmental Impact
- Frontier Deepwater and ultra long step-outs
- Cost reduction of Deepwater developments
- Simplify future field extensions
- Enable Subsea Processing
- Improve Safety (topside)
- Improve long term reliability and Digitization
AE SUBSEA PRODUCTION SYSTEM – KEY BENEFITS

HSE
- Removal of hydraulic fluid
- Supply, transportation, storage
- Spillage, contamination, subsea intervention
- Removal of high pressure storage
- Reduced carbon footprint

CAPEX/Installation/OPEX
- Removal of hydraulic infrastructure and fluid cost
- Reduced size and weight of subsea structures
- Reduced field expansion requirements
- Improved predictive maintenance

Functionality
- Control, Speed, Feedback, Condition Monitoring
- Hybrid options – eDHSV and eChokes on conventional EH systems
- Frontier deep water, ultra long offset, subsea processing

Reliability/Availability
- Technology transfer – Medical, Aeronautics, Defense, Automotive
- Improved redundancy options
- Simpler control system
- Realtime health checks
Valve control - EH

- **Valve Open**: Spring force is balanced by hydraulic pressure.
- **Pinch close**: Hydraulic pressure increases, overcoming the spring force.
- **Valve close**: Further increase in hydraulic pressure closes the valve.

**Graphs**:
- **Hydraulic Pressure**:
  - Crack open: Hydraulic pressure remains constant.
  - Valve Open: Pressure increases gradually.
  - Valve close: Pressure increases sharply.

- **Torque**:
  - + Hyd - Bore - SF: Torque increases gradually.
  - + Bore – Hyd - SF: Torque decreases gradually.

- **Spring**
- **Force (kN)**
  - Closing force: Force decreases with stem travel.
  - Counter force: Force increases with stem travel.

**Diagram**:
- Components: Piston, ROV stem, Spring, Seal friction, Production bore, Actuator body.
Valve Control - AE

Crack open

Torque

+ Hyd - Bore - SF

Valve Open

Pinch close

+ Bore – Hyd - SF

Valve close

Time

Subsea & Drilling Brazil Conference – Nov 2019
AES – Current actuator Technology

<table>
<thead>
<tr>
<th>Project</th>
<th>Units</th>
<th>Year</th>
<th>Application</th>
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<td>XT - Valves &amp; Choke</td>
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<td>Johan Sverdrup</td>
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<td><strong>Reported orders</strong></td>
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<td><strong>2018+</strong></td>
<td><strong>Mainly Valve actuation</strong></td>
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- Direct drive (AC or DC – High Power)
- Battery assisted (Low Power – 24V)
- Fail-As-Is
- Spring Fail-Safe
- Electrical Fail-Safe (No Spring)
- ROV Retrievable
- Integrated
- >10 Million hours fault free operation
K5F All ELECTRIC subsea production system

- Development & Qualification launched in 2005
- E-XT manufacture and test completed 2008
- **Phase 1** deployed in May 2008
  - Hydraulic DHSV
  - Electric Actuator reliability – 100% to date
  - Power distribution/Hydraulic system failures experienced
- **Phase 2** development launched in Nov. 2013
  - Deployed July 2016
  - Business driven decision to include electrical e-DHSV to address hydraulic leak issues July 2014
  - System design improvements implemented
# AES Lessons Learnt and Opportunities

## Lessons Learnt

- Electric Actuator reliability
  - Zero failures
  - No degradation identified
- Condition monitoring
  - Operation validation
  - Identification of failures
  - Long term trend analysis
- Improved valve control
  - Partial stroke
  - Adaptable valve speed/Torque
- Power distribution failures
  - Connector insulation breakdown
  - Improved electrical isolation

## Future Opportunities

- Reduce cost and improve reliability
- Subsea power storage
  - Simplify power distribution system
  - Remove springs
    - Reduce power requirement
    - Reduce size/weight of XT’s and Manifolds
- Minimize complexity
  - Simplify redundancy philosophy
  - Challenge design margins
  - Challenge valve timing requirements
  - Improved XT and Manifold designs
  - Improve reliability
Electric Actuator Development JIP’s

Key development objectives:

- Reduce cost of Subsea Production Systems
- Minimize system complexity
  - Improve reliability and increase production availability
- Improve functionality
  - Better condition monitoring, operation validation and control
- Improve Safety and Environmental impact
- Industry readiness by 2021

❖ TechnipFMC JIP Launched in July 2018
❖ Aker Solutions JIP Launched in July 2018
❖ OneSubsea JIP – Proposal under negotiation
❖ Baker Hughes JIP Launched in 2018
❖ Wittenstein JIP – Launched in Oct 2019
❖ Reliability studies for Spring vs Battery fail safe designs
❖ Potential ANP Levy JIP’s in Brazil being progressed
❖ Development of industry standard AE specifications
All Electric – Joint Operator Specification

• **Target:**
  - Industry standardization by development of industry aligned specification for Subsea All-Electric technology
  - Utilizing existing regulations, requirements & interfaces as a framework
  - Integrating the SPS suppliers into the review cycle
  - Completion targeted within 2019
  - API 17F & API 17D implementation

• **Recommended Publications:**
  - IOGP to administrate document until next revision of API 17F
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