Multiphase Compression - Enabling increased recovery in long subsea tiebacks

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Unexploited gas reserves in long tieback subsea reservoirs

Unexploited gas is remains in the remote subsea reservoirs, typically because of:

- Rapid loss of pressure support from the reservoir
- Friction losses in long flow lines
- Flow regime effects, typically liquid build up in long flow lines
- Water production creating hydrate formation when the gas is cooled down in the pipeline

Gas compression can increase the recoverable reserves.

It is not unusual that more than 50% of the reserves remain in the reservoir when subsea fields are abandoned.
Alternative 1: Gas Compression at Production Plant

- **Tieback distance:** 100 km
- **Plateau production rate:** 1 BScf/d

- **Export pressure from plant:** 60 bara (870 psig)
- **Minimum arrival pressure at plant:** 15 bara (217 psig)
- **Pressure drop along pipeline:** 40 bar (580 psi)
- **Minimum reservoir pressure:** 55 bara (797 psig)
Alternative 2: Subsea Wet Gas Compression

Tieback distance: 100 km
Plateau production rate: 1 BScf/d

Export pressure from plant: 60 bara (870 psig)
Pressure drop along pipeline: 40 bar (580 psi)
Flowline inlet pressure: 60 + 40 bara: 100 bara (1450 psig)
Minimum reservoir pressure: 55 bara (797 psig)

Pressure drop along pipeline: 40 bara (580 psi)
Export pressure from plant: 60 bara (870 psig)
Minimum reservoir pressure: 55 bara (797 psig)
Plateau production rate: 1 BScf/d
Tieback distance: 100 km

Subsea Compression

Pressure drop along pipeline: 40 bara (580 psi)
Export pressure from plant: 60 bara (870 psig)
Minimum reservoir pressure: 55 bara (797 psig)
Plateau production rate: 1 BScf/d
Tieback distance: 100 km
Initial reservoir pressure: 150 bara. (2175 psig)
Gas Compression at Production Plant

- **Power Consumption at plant**
- **55 MW** Compression Ratio: 4.0
- **Gas Export**
- **Topside Compression**
- **Gas Pipeline**
- **Production Manifold**
- **Reservoir**

**Gas Production MMscfd**
- Max. Flow
- Min. Flow

**Distance**
- 10 km
- 20 km
- 30 km
- 40 km
- 50 km
- 60 km
- 70 km
- 80 km
- 90 km
- 100 km

**Pressures**
- 15 bar
- 50 bar
- 100 bar
- 150 bar

**Time**
- 0 years
- 5 years
- 10 years
- 15 years
- 20 years

**Power Consumption at plant**
- 55 MW

**Compression Ratio**
- 4.0

**Optimize**
- From Pore to Process

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- A Schlumberger Company
Subsea Gas Compression

- **Power Consumption subsea**
  - **20 MW**
  - Compression Ratio: 1,8

- **Gas Export**
  - **Max. Flow**
  - **Min. Flow**

- **Gas Pipeline**

- **Reservoir**

- **Subsea Compression**

- **Gas Production MMscfd**
  - 0
  - 5 years
  - 10 years
  - 15 years
  - 20 years

- **Pressure Levels**
  - 15 bar
  - 30 bar
  - 45 bar
  - 60 bar
  - 75 bar
  - 90 bar
  - 100 bar
  - 100 bar

- **Distance**
  - 10 km
  - 20 km
  - 30 km
  - 40 km
  - 50 km
  - 60 km
  - 70 km
  - 80 km
  - 90 km
  - 100 km

**Optimize from Pore to Process**

OneSubsea
A Schlumberger Company
Gas production cases

- Natural Production
- Topside Compression
- Subsea Compression

Gas Production MMscf/d

- Max. Flow
- Min. Flow
Summary of the two scenarios

**Compression at plant**

- **Increased gas reserve exploitation**
- **Compressor power requirements**
- **Extended plateau production**

**Subsea compression**

- **Remaining gas**

**Compression at plant**

- **55 MW** Compression Ratio: 4.0

**Remaining gas**

**Subsea compression**

- **20 MW** Compression Ratio: 1.8
Subsea Wet Gas Compression is the compression of unprocessed well stream from a gas field

Depending on pressure and temperature, liquid in form of condensate or water my typically represent 0-5% of volume

Liquid and gas will flow in layers, as annular, mist, droplet or slug flow and this will change over time

The unprocessed well stream will also contain solid particles as sand, asphaltenes, wax, scale and/or hydrates
Requirements for a Subsea Wet Gas Compression System

1. Capable of handling all flow regimes including **Liquid Slugging**
2. Operate safely at **100% liquid** (such as during start-up)
3. Inherently robust for **Process Solids**
4. Operate stable at all speeds and capacities without any critical speed, stone wall or surge constraints
The OneSubsea Multiphase Compressor
The OneSubsea Multiphase Compressor

Electric Motor 1

Electric Motor 2

World’s first and only true wet gas compressor

Compressor

INLET

OUTLET
The OneSubsea Multiphase Compressor Technology has been developed over the last 25 years.

All subsea components are based on an unparalleled experience of close to 2,500,000 operating hours with subsea pumps.

The Multiphase Compressor Technology includes:

- Contra rotating impeller shafts
- Multiple stages without diffusers
- Surge free blade design
- Integrated flow mixing
- Field proven motor, seals and bearing technologies -
Mechanical robustness in general is taken from the experience OneSubsea has with more than 85 Subsea Pumps and close to 2,500,000 accumulated running hours under water during the last 20 years.
Dry gas compression with upstream separation
OneSubsea Multiphase Gas Compression
Gullfaks Subsea Compression System

Subsea Wet Gas Compression 15 km south of Gullfaks C will increase recovery from the Gullfaks South Brent reservoir with 22 mill oil equivalents. Combined with later low pressure production the recovery rate will increase from 62% to 74%.
Gullfaks Subsea Compression System
Gullfaks Subsea Compression System
Field operating experience

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<th>Description</th>
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</tr>
</tbody>
</table>

Differential pressure

GVF

Total flow rate

Speed

Power
Summary

The OneSubsea Multiphase Compressor

- Game changing technology for gas compression
- Operates on unprocessed well stream
- Operates in all liquid fractions 0 – 100%
- Operates in all flow regimes
- Surge free operation – no anti-surge system required
- Potential for significant increase in recovery rates
- Cost effective solution for long gas tie-backs
Thank you.