



Reliable Subsea Gas Lift System Meets the Challenge for Statoil's Norne Satellites' Development

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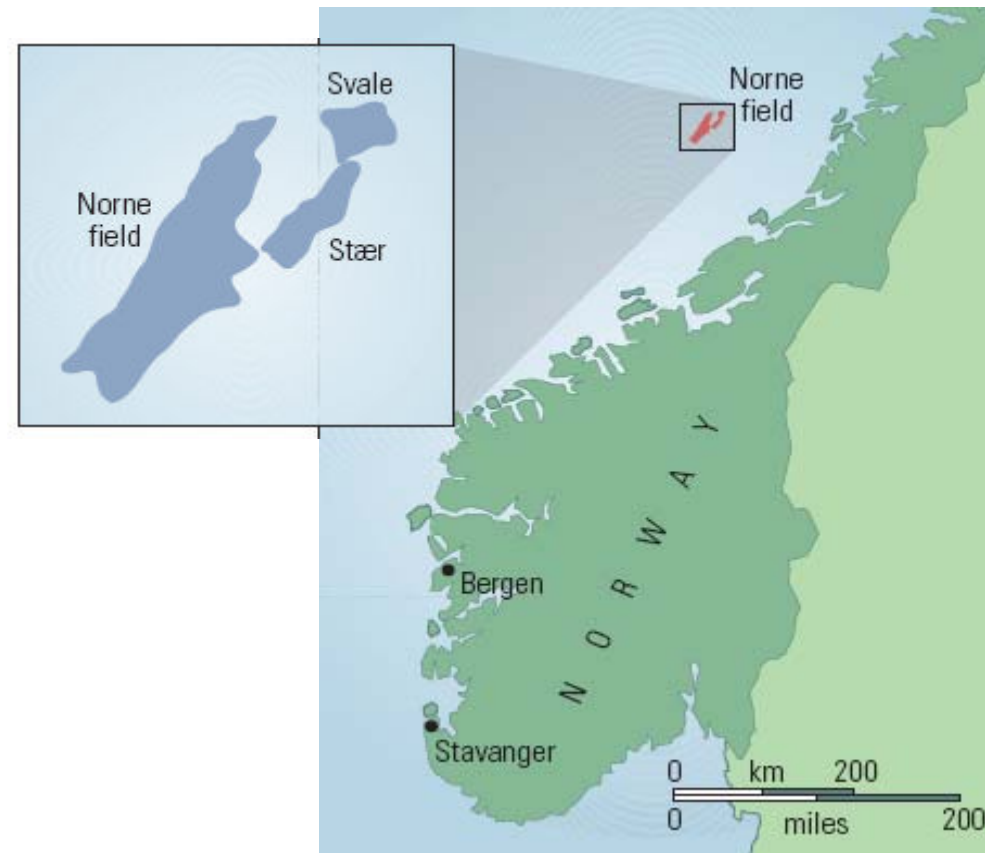
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Agenda

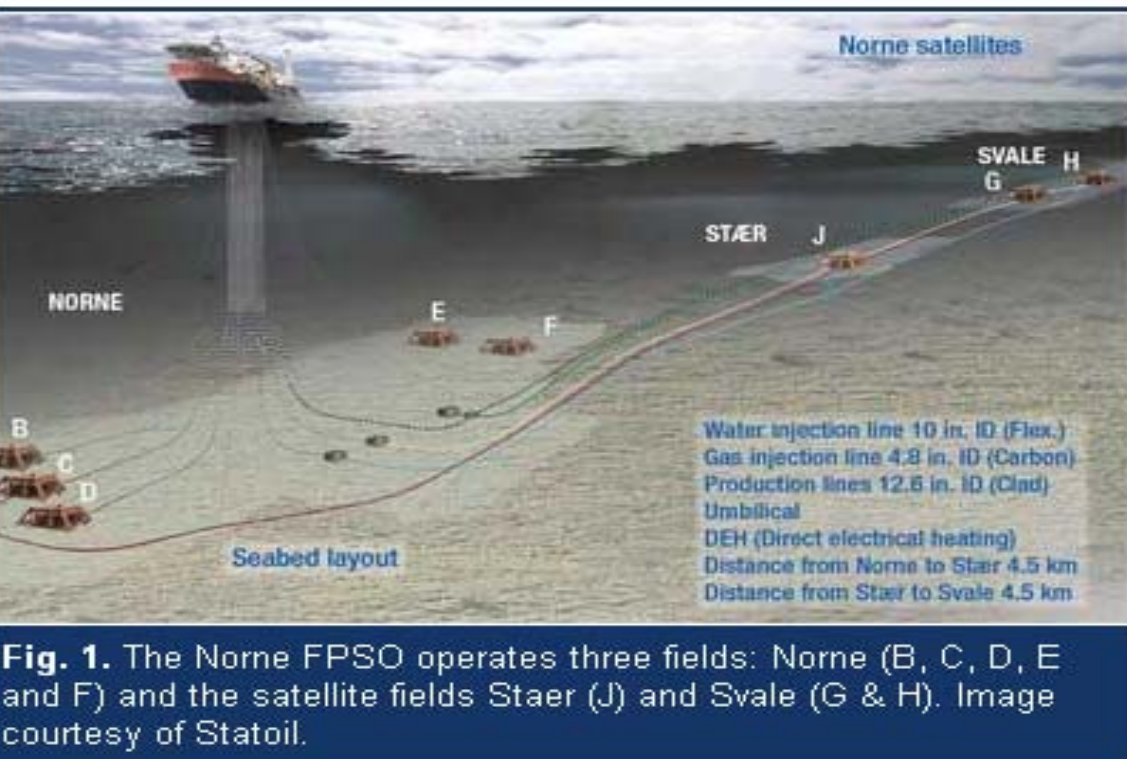
- Introduce challenges of Statoil's Norne Satellites development
 - Sub-sea development offshore Norway
- Review solution implemented
 - Summary of valve development and testing
- Well performance to date
 - Gas lift operation and valve pressure integrity testing

Norne Satellites Development – Offshore Norway



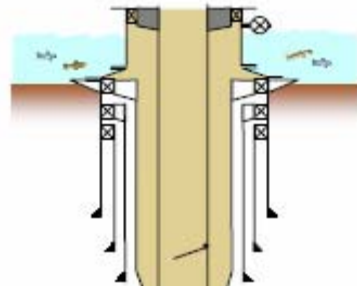
- Subsea development approx 125 miles (200 km) from northern Norwegian coast
- Latitude 66 degrees north
- Norne field with two satellite fields, Staer and Svale
- Staer approx 2.8 miles (4.5 km) northeast of Norne
- Svale similar distance northeast of Staer
- Water depth 1,245 ft (380 m)
- Maximum reservoir depth 8,150 ft (2,484 m)

Norne Satellites Development – Subsea Configuration



- Five production wells
- Three water injection wells for pressure support and displacement
- Worry of sand production and water breakthrough
- High gas injection pressures, 3335 psi (230 bar) at FPSO
- High gas injection rates required, approx. 8.82 mmscf/d (250,000 sm³/d) per well
- Valve reliability
- Tubing integrity – Norwegian Petroleum Safety Authority barrier requirement

Typical NSAT Completion



Packer setting depth 2555 m MD

SPM with gas lift valve

Intervall

Zone #1: Åre 2.5	: 34 m MD	2646 m RT – 2703 m RT
Zone #1: Åre 2.4 – 2.3	: 116 m MD	2704 m RT – 2810 m RT
Zone #1: Åre 2.2 – 2.1	: 106 m MD	2812 m RT – 2911 m RT
Zone #1: Åre 1	: 74 m MD	2911 m RT – 2952 m RT

Depths must be verified once well has been TD'ed and logs are processed.

Åre 2.5

Åre 2.4 – 2.3

Åre 2.2 – 2.1

Åre 1

Triassic

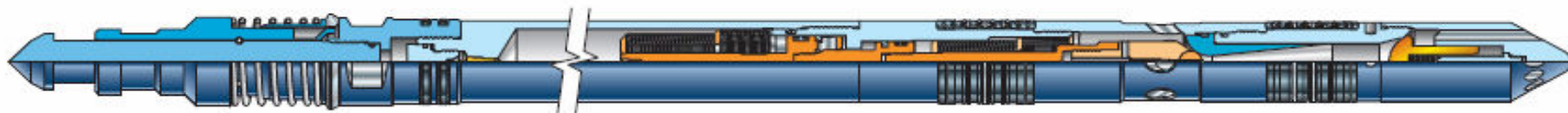
XLift Gas Lift System Designed for Deep Water and Subsea Installations

- Gas lift applications are in more aggressive conditions
 - Deeper points of gas injection at higher injection pressures are required to achieve desirable liquid production rates
- Reliability
 - Robust gas lift equipment that has been dynamically tested for endurance, integrity and reliability including: liquid flow erosion testing, high volume gas injection testing and gas injection performance.
- Operation efficiency
 - Improved gas flow geometry stabilizes liquid production increasing the run life of the system.

XLift™ Gas Lift System

- Fit-for-purpose deepwater / subsea HP gas lift system
 - Significantly improved reliability and efficiency
 - Endurance tested for high reliability
- Newly designed gas lift valve and side pocket mandrel
 - IPO valve operating pressure range – 2,000 to 5,000 psi at depth
 - Orifice valve operating pressure – 7,500 psi at depth
 - Patented edge-welded high pressure balanced bellows system
 - Optimized injection gas flow path for improved efficiency
- Positive sealing check valve system
 - Tubing pressure integrity during ALL phases of operation
- Reliable deeper injection depths
 - Higher production rates achievable

XLift XLI Injection Pressure Operated Gas Lift Valve



Technical Specifications:

Injection Pressure Operated (IPO), 1-3/4" O.D., overall length 34.063"

Operating characteristics – 7,500 psi max, 350°F max / 32°F min

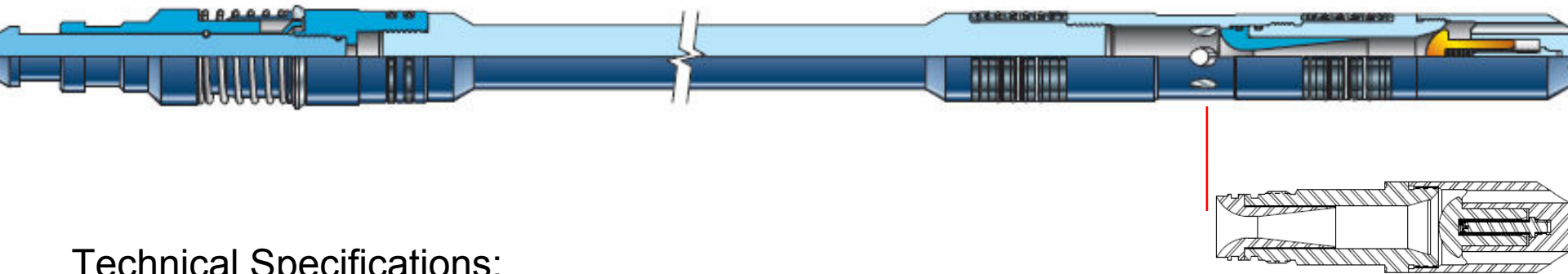
Bellows intensifier arrangement to reduce internal Nitrogen gas charge pressure

Maximum dome charged to achieve 5,000 psi operation - 3,200 psi @ 32°F

Venturi orifice size range – 8/64" to 20/64"

Premium body materials and elastomers

XLift XLO Orifice Valve with Positive Sealing Check Valve



Technical Specifications:

1-3/4" O.D., overall length 34.063"

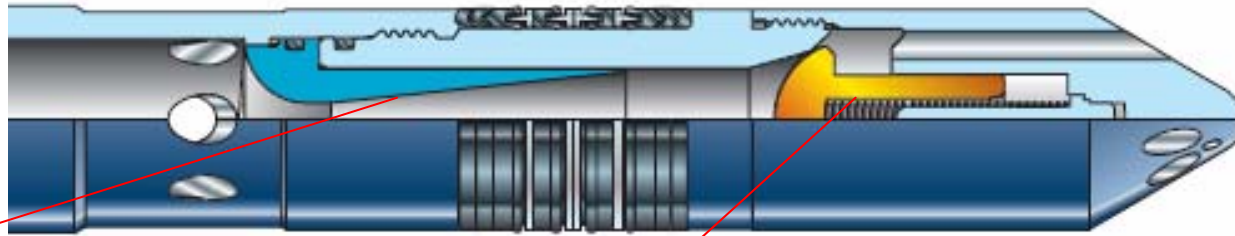
Operating characteristics – 7,500 psi max, 350°F max / 32°F min

Check valve test pressure - 10,000 psi

Venturi orifice size range – 8/64" to 24/64"

Premium body materials and elastomers

1-3/4" XLift Gas Lift Orifice and Check Valve Advantage



Venturi Orifice

Venturi nozzle (various sizes available)

Gas entry holes tapered to nozzle inlet

Optimized gas flow path

Critical flow achieved with 10% delta pressure

Reverse Flow Check Valve

Normally closed

Positive seal, only open during gas or fluid flow from casing to tubing

Metal-to-metal seal surfaces, no elastomers

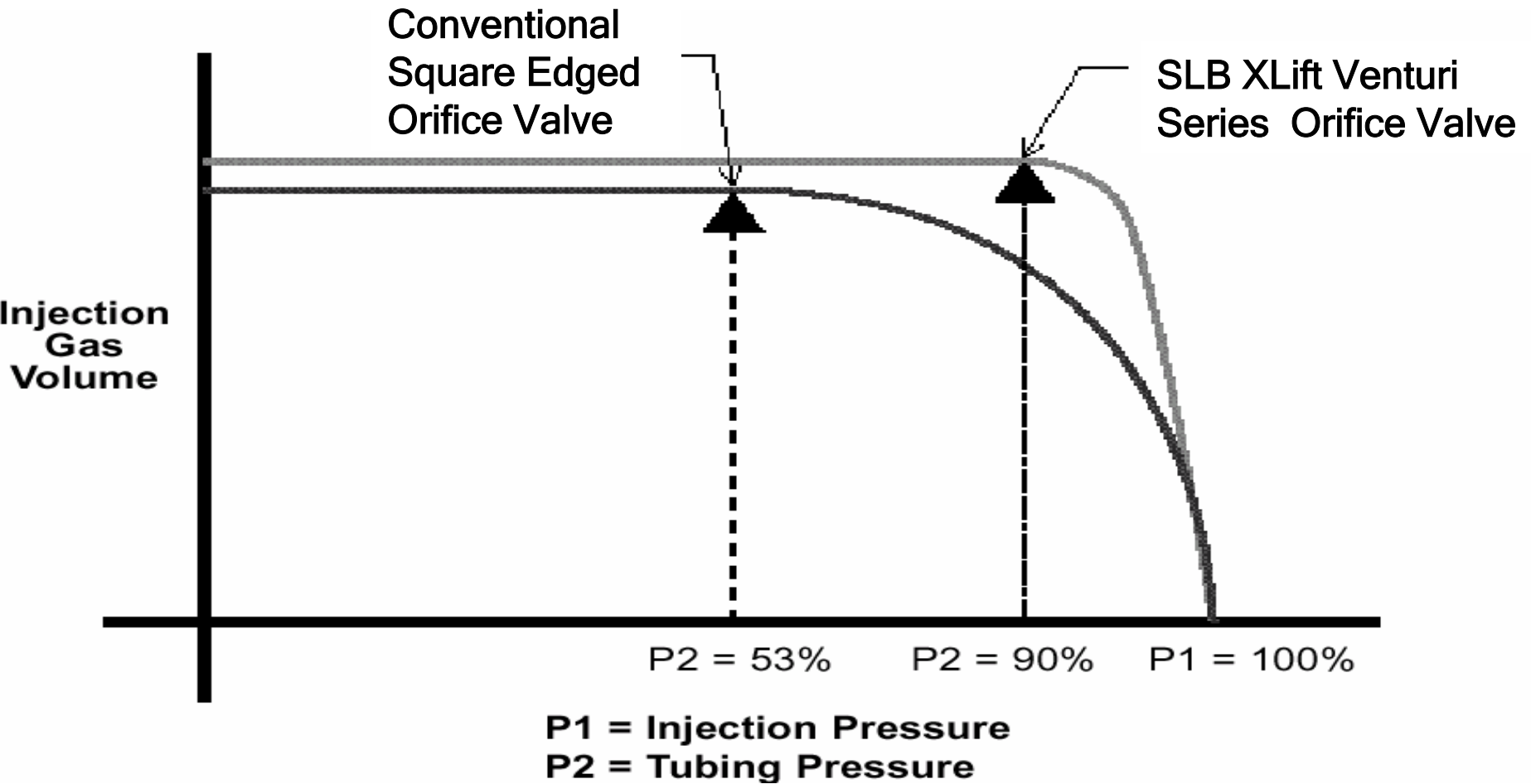
Due to unique geometry, flow velocity does not affect the check dart sealing surface

10,000 PSI sealing (working) pressure

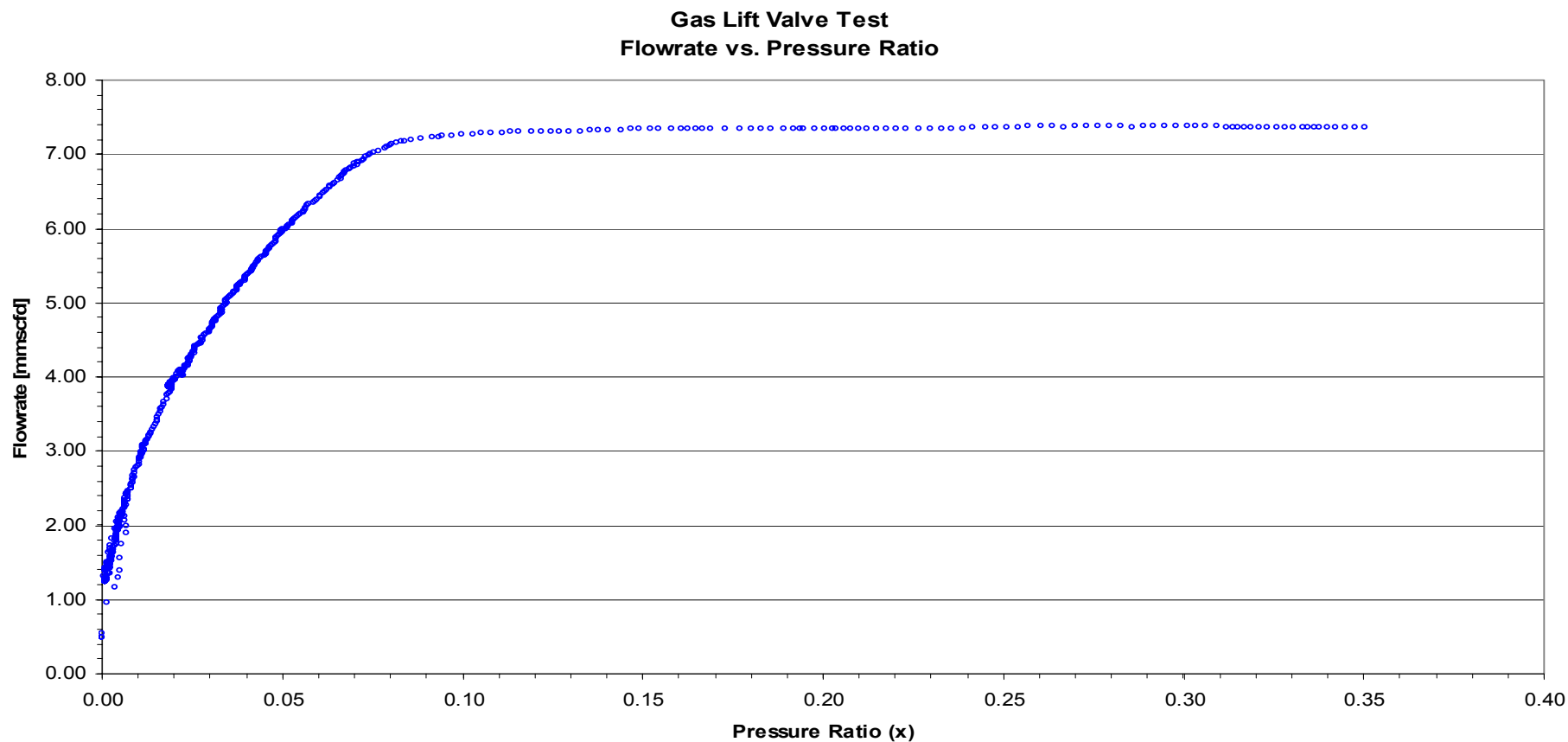
Integrity and endurance tested – liquid and gas

Typical Gas Lift Orifice Valve Flow

Performance



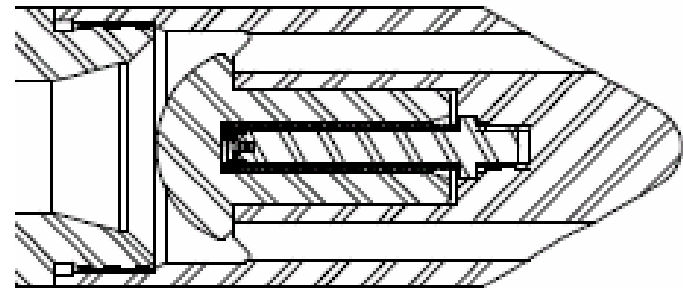
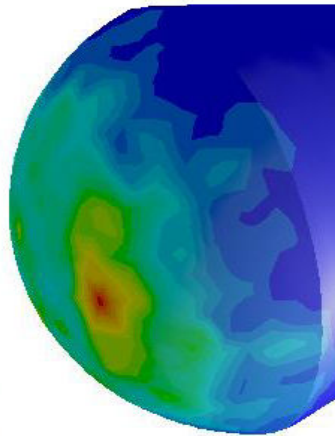
Example XLO XLift Orifice Valve Dynamic Injection Gas Flow Test



2,500 psi Upstream - XLift Orifice
Valve with 24/64" Port

Comparison of CFD* with Erosion Test Results

- Excellent agreement in location of erosion effects.
- Sealing surfaces are protected by flow path design.
- Leak rate significantly less than the current API and ISO leak rate criteria



* Computational Fluid Dynamics

Comparison of CFD with Erosion Test Results



Note the appearance of 3 zones of surface finish. Zone 1 extends to a diameter of approximately 0.6 inches with a surface finish of 63ra. Zone 2 extends to a diameter of approximately 0.9 inches with a surface finish of 32ra. Zone three has been unaffected by the erosive flow (and includes the lapped sealing surface.)

XLO XLIft Orifice Valve Liquid Flow Test

Fluid Unloading Qualification Test – 800 Barrels at 1.5 bbl/min

Test #	Date	Time From	Time To	Type of Test	PSI	Amb. temp °F	Leak Rate (scf/hr)	Gal/ Min	BBL/ Min	Gallons Total	BBL Total	BBL Tested
Initial	01/16/06	1:00p	1:20p	Leak	101	61.1	0	n/a	n/a	n/a	n/a	n/a
1	01/17/06	6:00	8:40	Flow	500	75.9	n/a	54.34	1.294	8766.75	208.73	208.73
2	01/17/06	9:00	9:25	Leak	101	66.1	0	n/a	n/a	n/a	n/a	n/a
2	01/17/06	9:40	12:00	Flow	500	82.9	n/a	54.3	1.293	17591.9	418.85	210.12
3	01/17/06	12:00p	12:20p	Leak	101	65.8	0	n/a	n/a	n/a	n/a	n/a
3	01/17/06	1:13p	3:50p	Flow	300	88.3	n/a	66.25	1.577	26414.1	628.91	210.05
4	01/17/06	3:50p	4:15p	Leak	100	71.6	0	n/a	n/a	n/a	n/a	n/a
4	01/18/06	7:30	10:30	Flow	300	90.6	n/a	66.41	1.581	36365.7	865.85	236.94
5	01/18/06	11:00	11:30	Leak	100	74.6	0	n/a	n/a	n/a	n/a	n/a

Table 1.0 (Running log of test data and results)



Photo 3.0 (Dart after 800 bbl liquid flow test)



Photo 4.0 (Nozzle ID after 800 bbl liquid flow test)



Photo 7.0 (Venturi Orifice after 800 bbl liquid flow test)

Additional Performance Testing - Norne Specific

- In collaboration with Statoil, additional testing was performed in Norway
 - Gas flow testing at Statoil's Karsto Metering and Technology Laboratory (K-Lab)
 - Fluid at International Research Institute of Stavanger (IRIS)
- Objectives of the tests were
 - Qualify the system's operation under dynamic pressures and throughput
 - Verify the pressure integrity as a key component of the tubing pressure barrier envelope
 - Allow wells to be completed without Annular Safety Valve (ASV)
 - Meet the rigorous requirements of the Norne Satellites well completion schedule
- Meet the Norne project specific pressure barrier requirements of the Norwegian Petroleum Safety Authority

Norne Gas Lift Performance to Date

- Water breakthrough occurred relatively early in field life and reservoir pressure is depleting faster than expected
 - Gas lift initiated on first two wells Oct 2005
 - Subsequent wells kicked off Jan, April and Sept 2006
- Gas injection rates fine tuned to each well, optimize individual well production and flowline capacity
 - Current injection rates range from 7.8 to 11.0 mmscf/d (220,000 to 310,000 sm³/d)
 - Injection pressures range from 3110 to 3140 psi (214 to 216 bar)
 - Well production rates average from 5400 to 7550 bbl/d (850 to 1200 m³/d), water cut 20% to 60%
- Regular inflow / integrity testing
 - All five wells categorized as “Green”
 - Testing interval increased from one month to six months

NSAT Gas Lift Valve Operating Leak Rate Criteria

NSAT offshore test procedure

- Green leakage level, \leq SCSSV leakage criteria 0,4 litre/min
 - Consequence – continue normal production and test frequency
- Yellow leakage level, \leq 10 litre/min

(Ref topside hydrocarbon leak criteria of 0,1 kg/s. This gives 10 litre/min at downhole conditions)

 - Consequence – Continue normal production, keep 1 month test frequency on the GLV
- Red leakage level, $>$ 10 litre/min
 - Consequence – Shut in the well (close DIACS valves, SCSSV, PWV). Monitor pressure in production tubing and annulus.
Risk evaluation shall be performed with involvement from PSA. Result of this work will be the basis for decision to continue production.
 - Lift gas shut in, annulus pressure bled down to create 70 bar (1015 psi) differential across valve
 - 0.4 litre/min equates to zero pressure build up over 6 hour hold period
 - 10 litre/min equates to between 8.9 and 11.3 bar (129 and 165 psi) pressure build up over 6 hour hold period

Conclusions

- XLift system continues to meet the Norne Satellites gas lift challenge
 - Continuous, stable, high gas injection rates for over two years
 - Confirmed through regular monitoring, production and inflow tests
- Operating in accordance with Norwegian Petroleum Safety Authority pressure barrier requirements
- Wells completed without Annular Safety Valve (ASV)
- The positive-sealing check valve proved invaluable during continued system integrity testing

