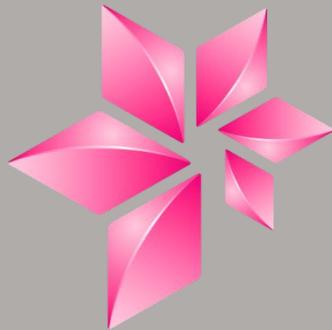


Multi-diameter, bi-directional Pigging for Pipeline Pre- commissioning

The Alve Pigging Experience



Statoil

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Pig Testing at K-Lab, Kårstø

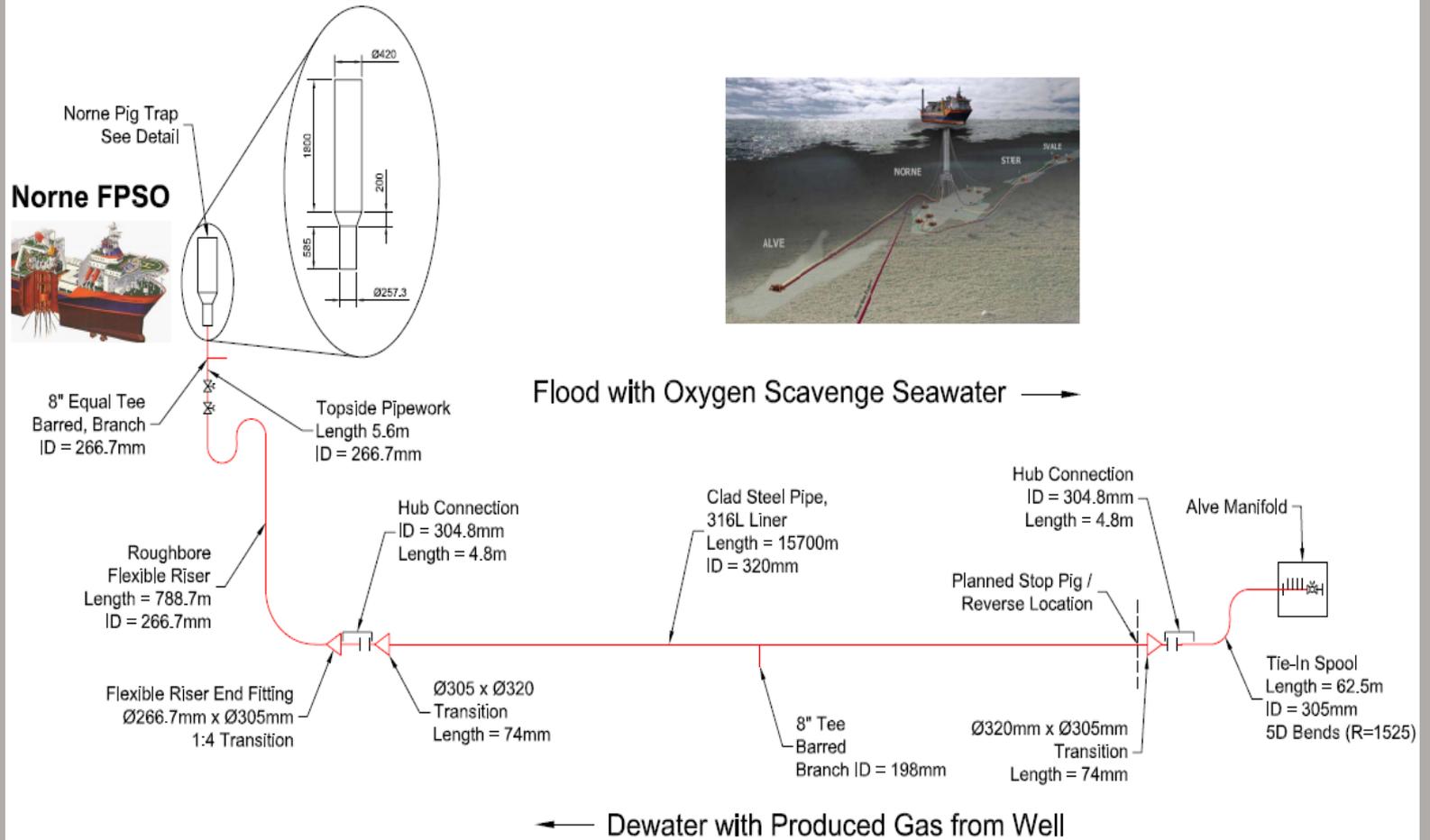


Dewaxing R&D



Dual Diameter Pigging

Alve Field Overview

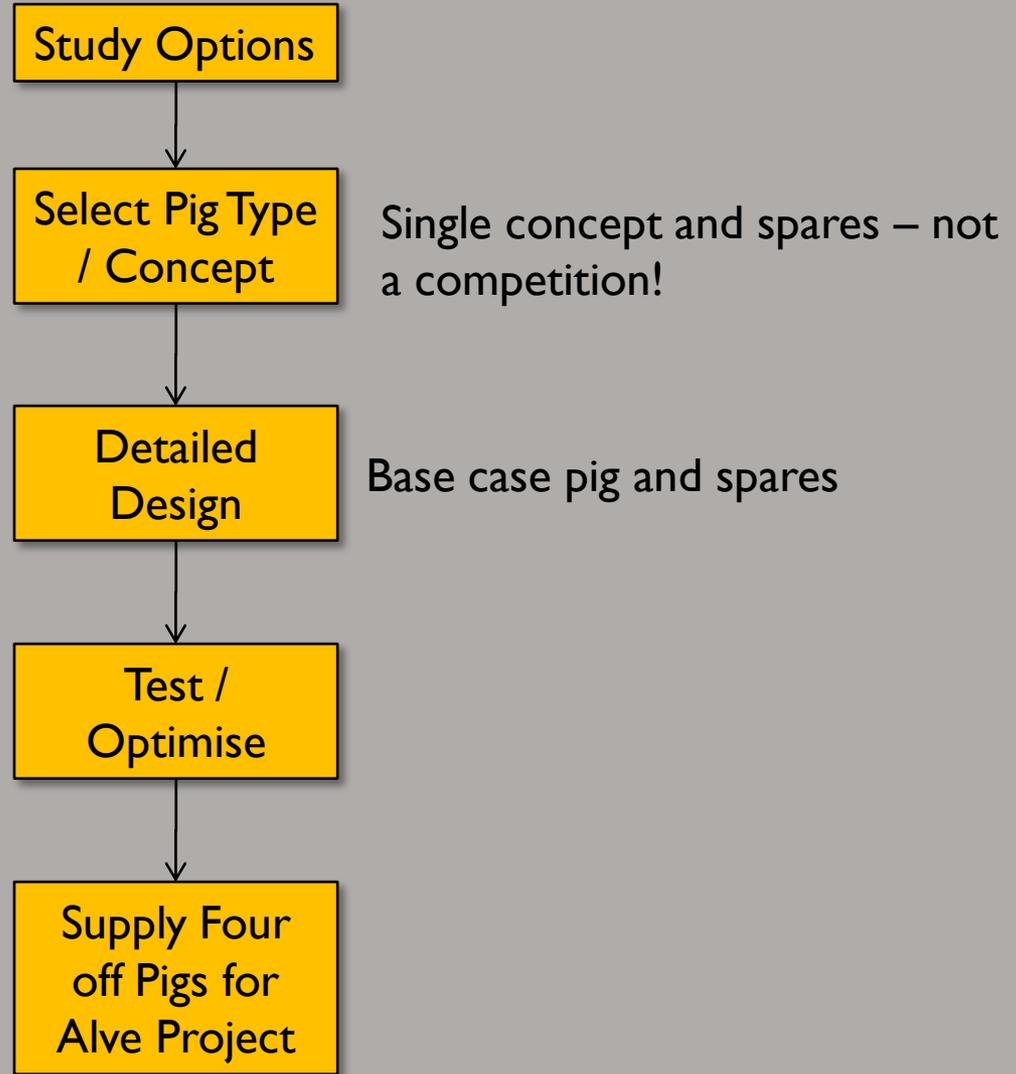


- 10" x 12" Pipeline – 25% increase in diameter;
- 12" 5D bends – no bends in 10";
- Pigging facilities only topside Norne (No launcher/receiver subsea);
- Vertical launch and receipt;
- RFO Philosophy – two scenarios.

Pig Functional Requirements

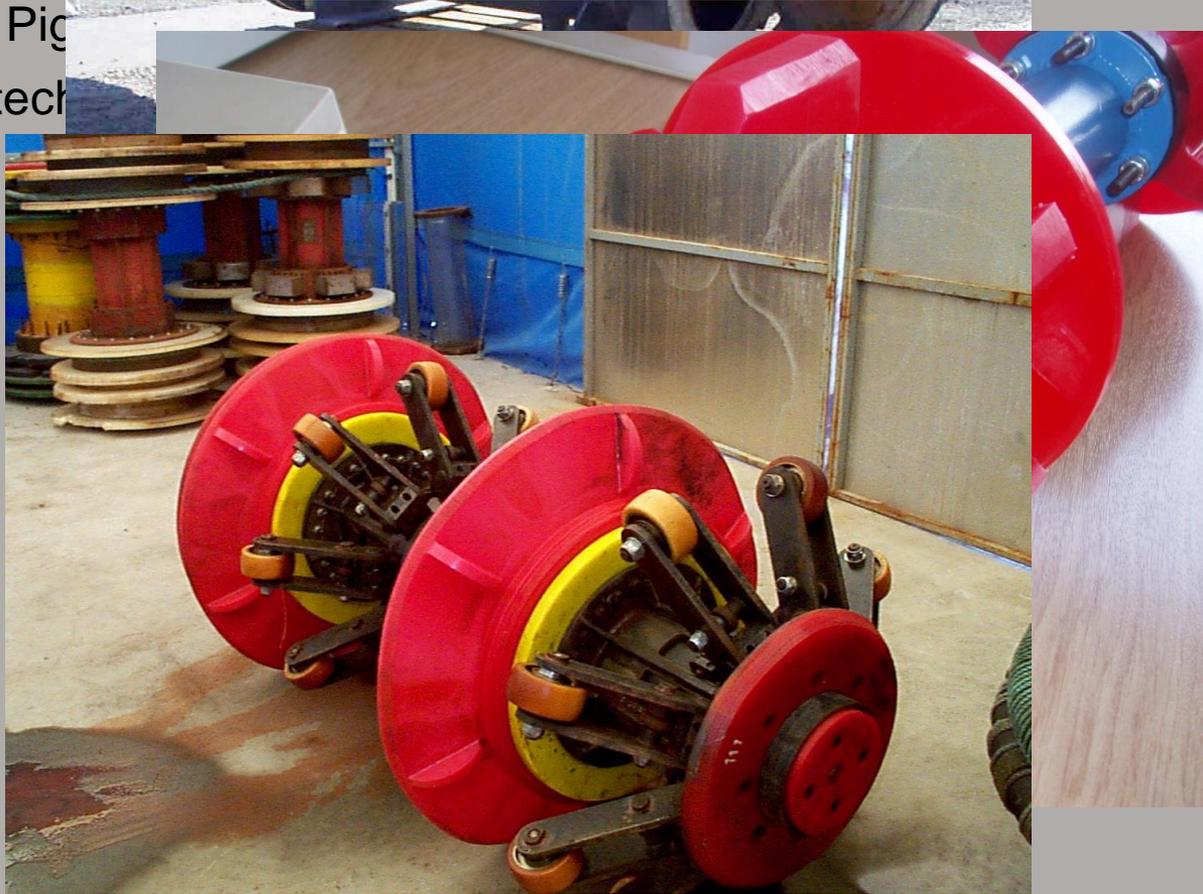
- The pigs must be fully bi-directional with high sealing ability in both directions;
- Low flow rates were expected, in the region of 300-400 l/min resulting in pig velocity of 0.03 m/s to 0.08 m/s. The pig must be able to operate at such low velocities;
- Good seal efficiency and pig support/centralisation were required to ensure safe negotiation with minimum bypass through all components along the system. The risk of gas bypassing on return to Norne could result in hydrate formation;
- Ratio between pig flip differential pressure (pressure to flip the seals forward and cause them to fail) and running differential pressure to be at least 5:1;
- The drive differential pressure in all pipeline components was requested to be less than 7 bars;
- Pigs to be fitted with isotope holder for tracking purposes;
- Pig handling to be considered for vertical launch and receipt.

Development Strategy

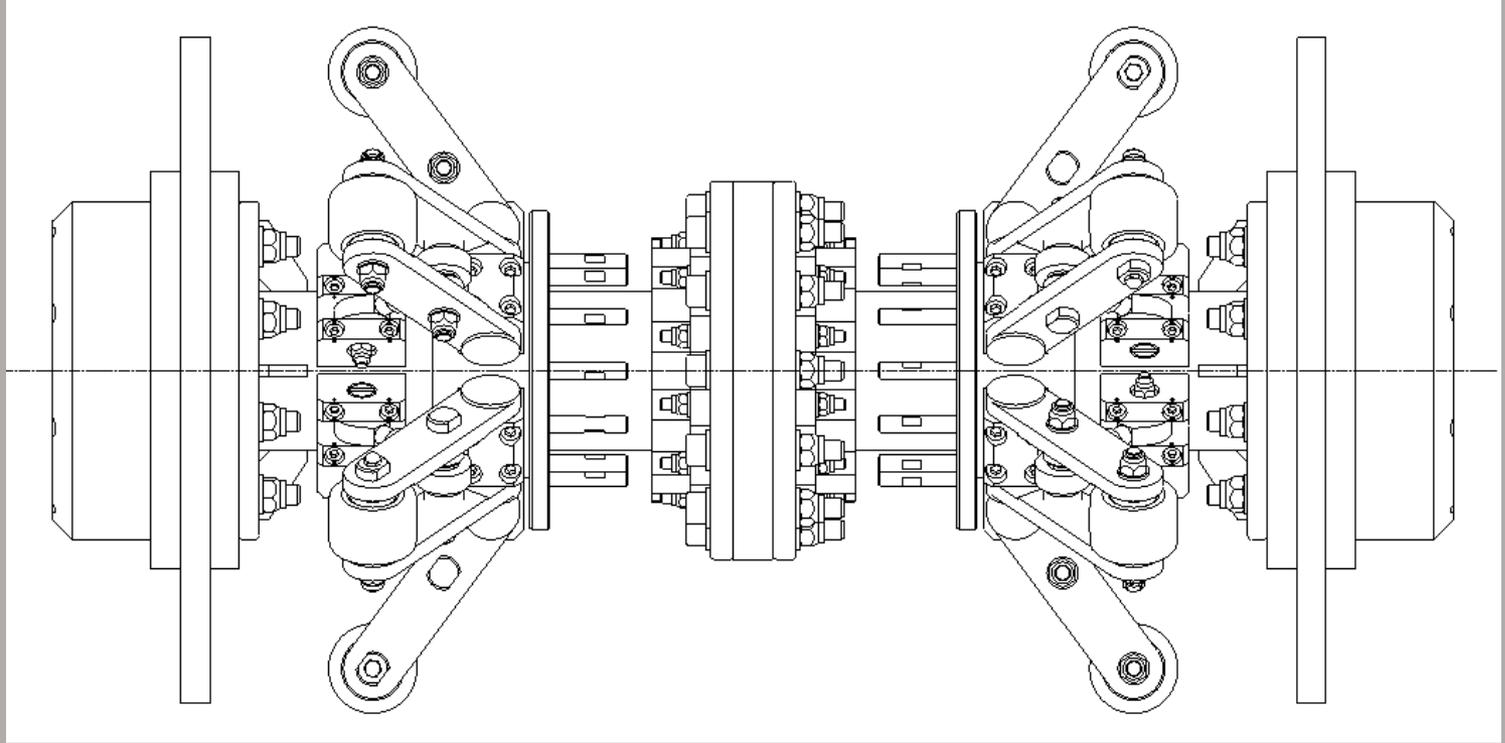


Pig Selection for Alve

- “Traditional”, V-slot supports;
- Paddle Pig from Pipeline Engineering;
- Wheel Pig
- Other tech

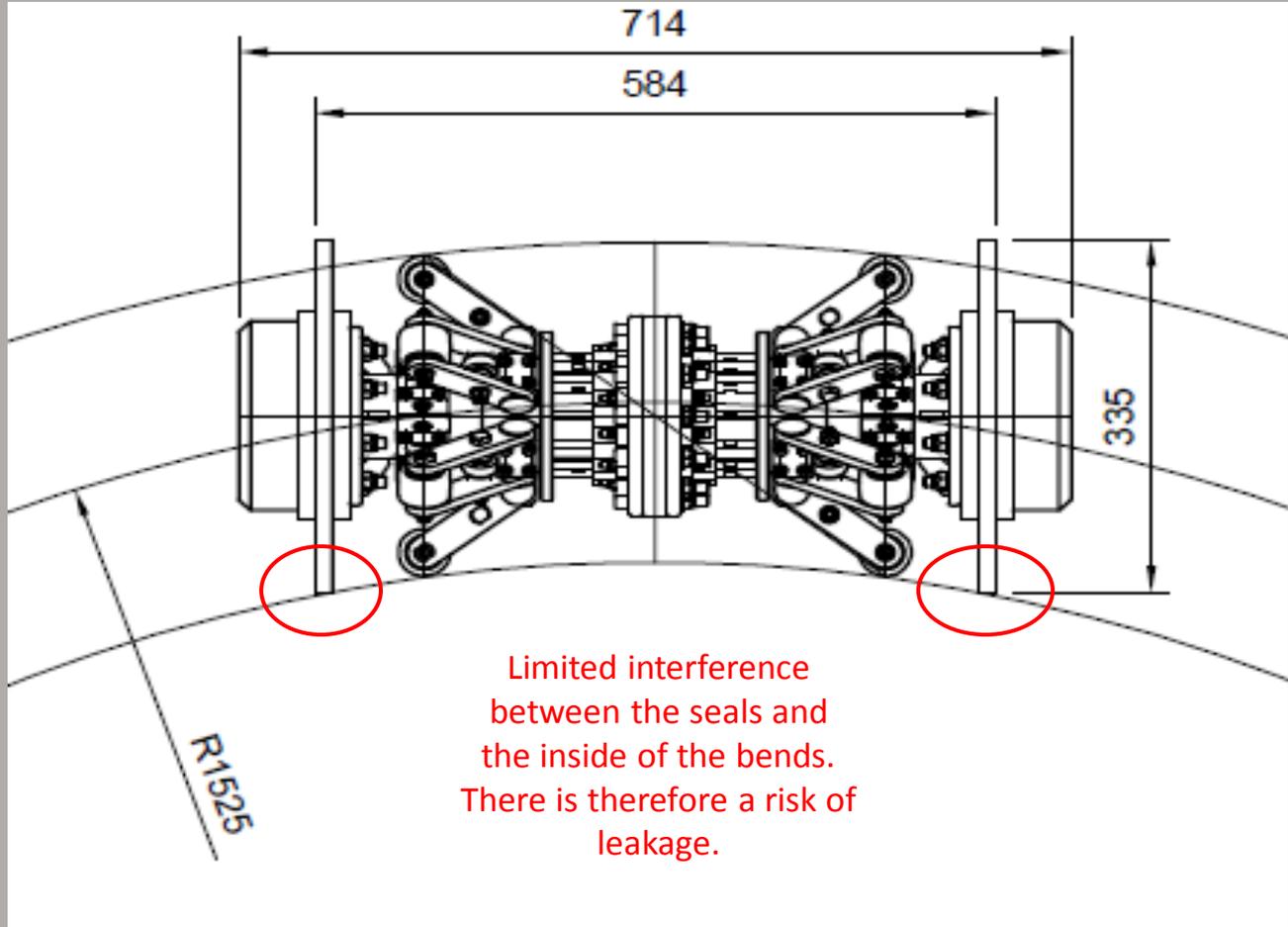


Initial Pig Concept

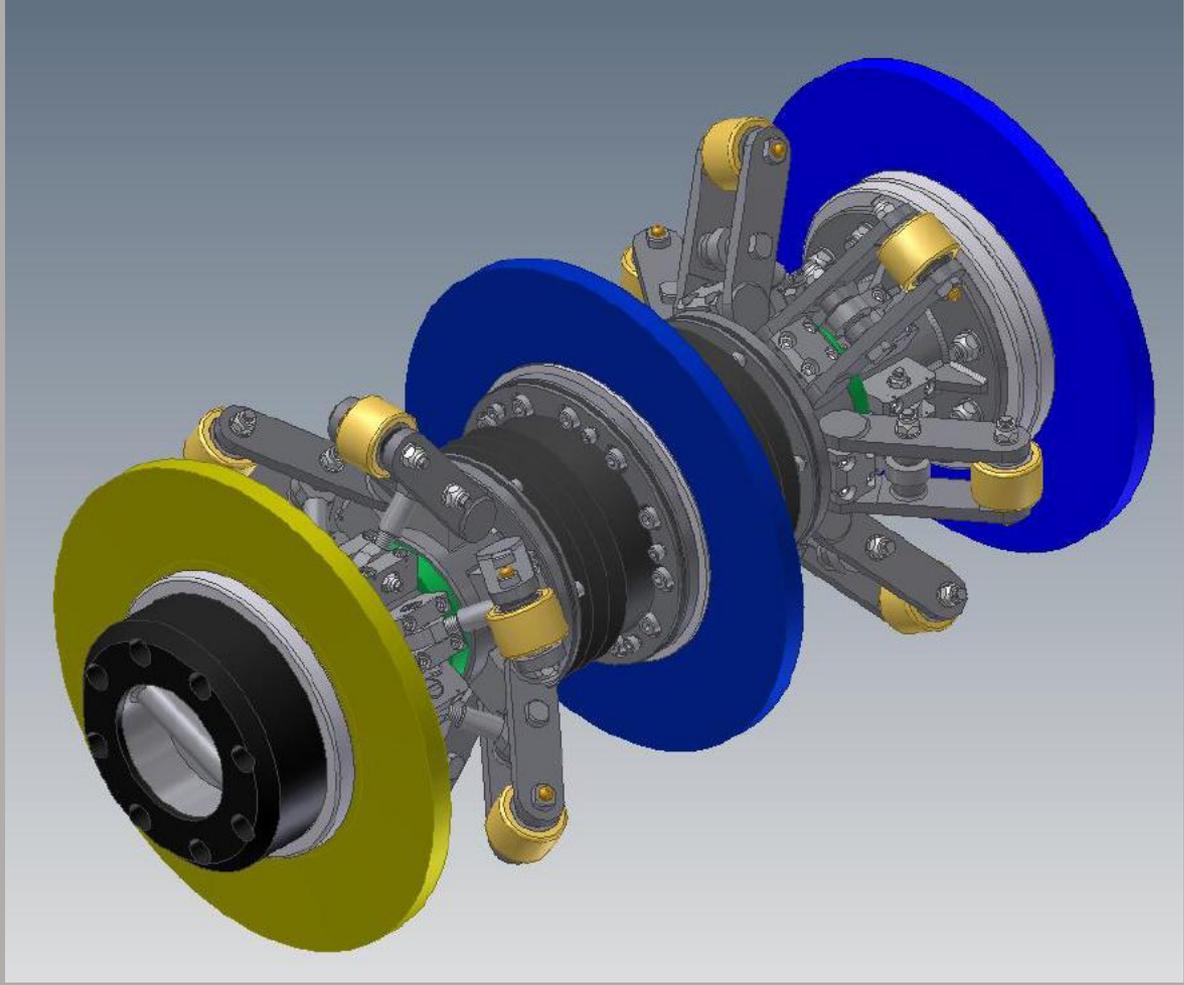


- Single seal for all diameters;
- Wheels in an axi-symmetrical layout.

Piggability – problem at bend

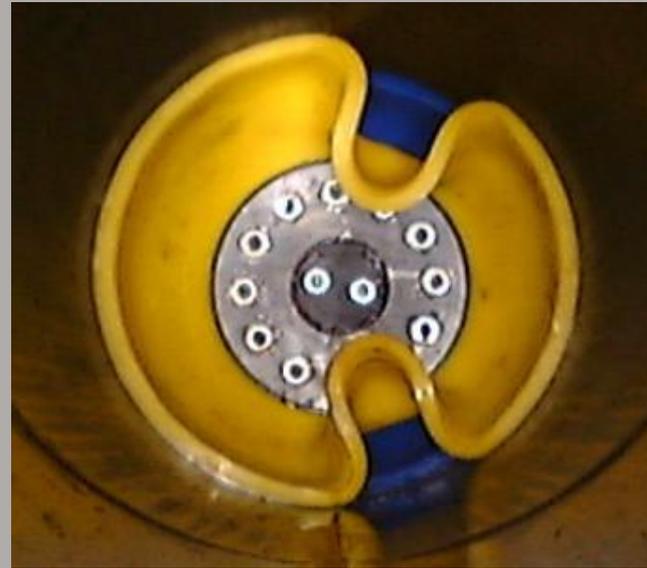


Final Base case pig design

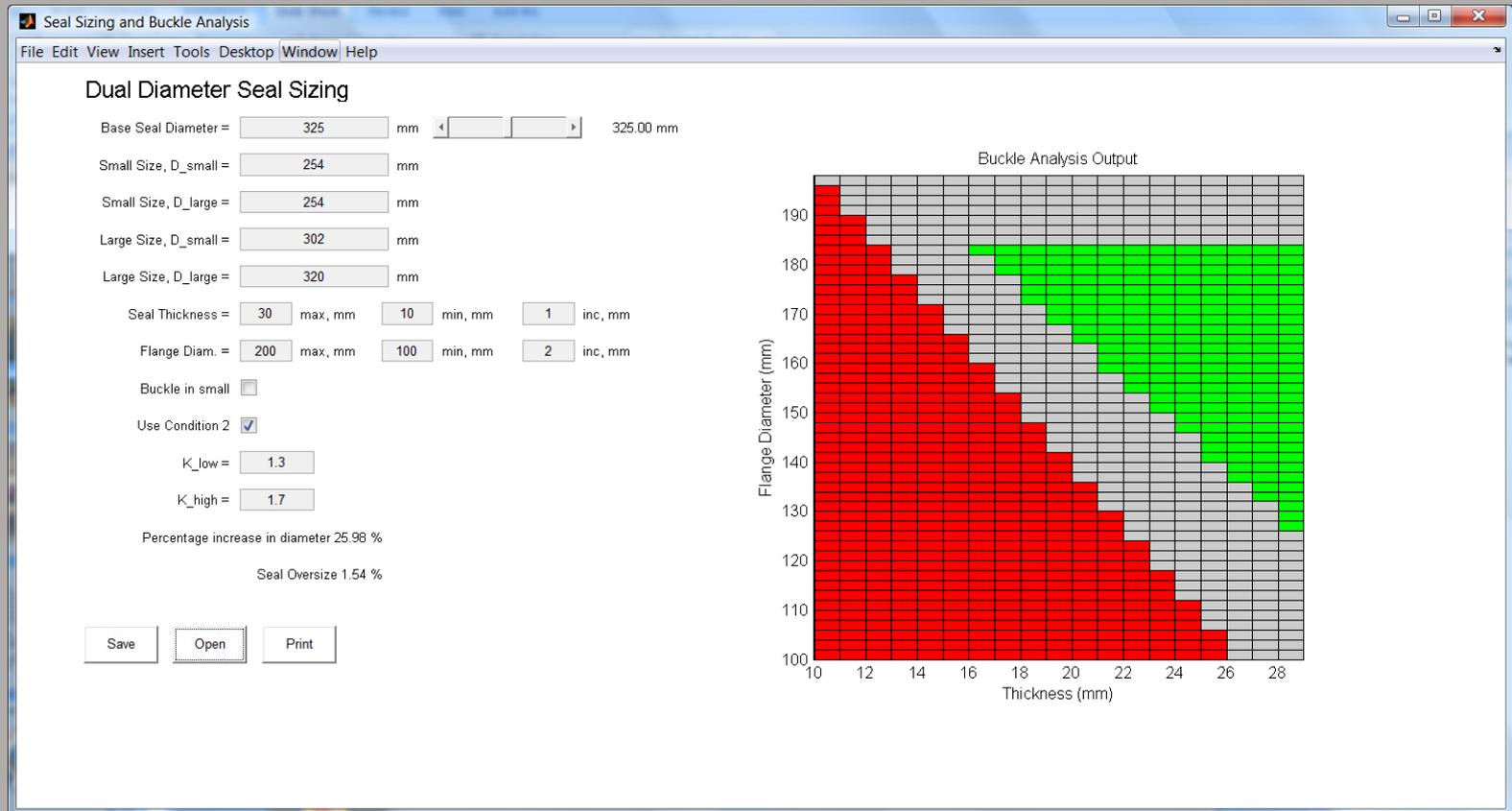


Buckling Modes

- No buckle;
- Buckles when forced, but recovers;
- Buckles only when forced but does not recover;
- Buckles even when not forced to do so.



Non-buckling Seal Design



Select seal size and parameters to avoid buckling in all diameters

Test Facility



Open ended testing with water drive



I can't see a thing...but it looks alright!

Allow sealing problems to be picked up and corrected

Test List

1. Full Facility Test;
 2. Reverse Pig in Full Facility;
 3. Initial Spool Test, 10”;
 4. Observation of rear of pig for buckling – buckle recovery test;
 5. Main pipeline test, 12” 320mm ID;
 6. Pig into 305mm ID section;
 7. Bend test;
 8. Flip test at bend;
 9. Manifold Tests – Contingency testing;
 10. Permanent Set Tests – leave in 10” overnight.
- Test at very low velocity 0.03 to 0.08m/s;
 - Measure running DP, DP to reverse pig, flip DP;
 - Observe leakage.

Buckle Recovery Test Video

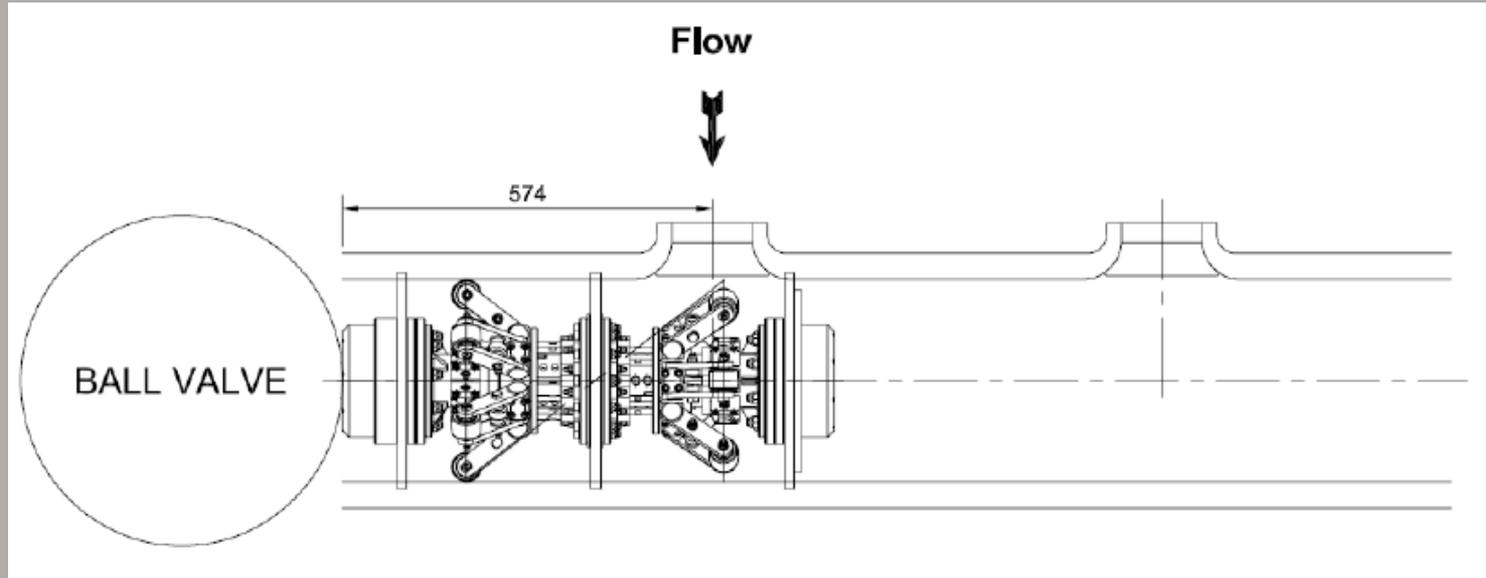


Pig Parameters

PARAMETER	DRIVE DP	FLIP DP
257 mm / launch into 10"	2.2 bar	nan
267 mm ID straight pipe	1.8 bar	7.2 bar
323 mm ID straight pipe	0.1 bar	1.2 bar
305 mm ID straight pipe	0.3 bar	1.6 bar
305 mm ID bend	0.5 bar	1.3 bar

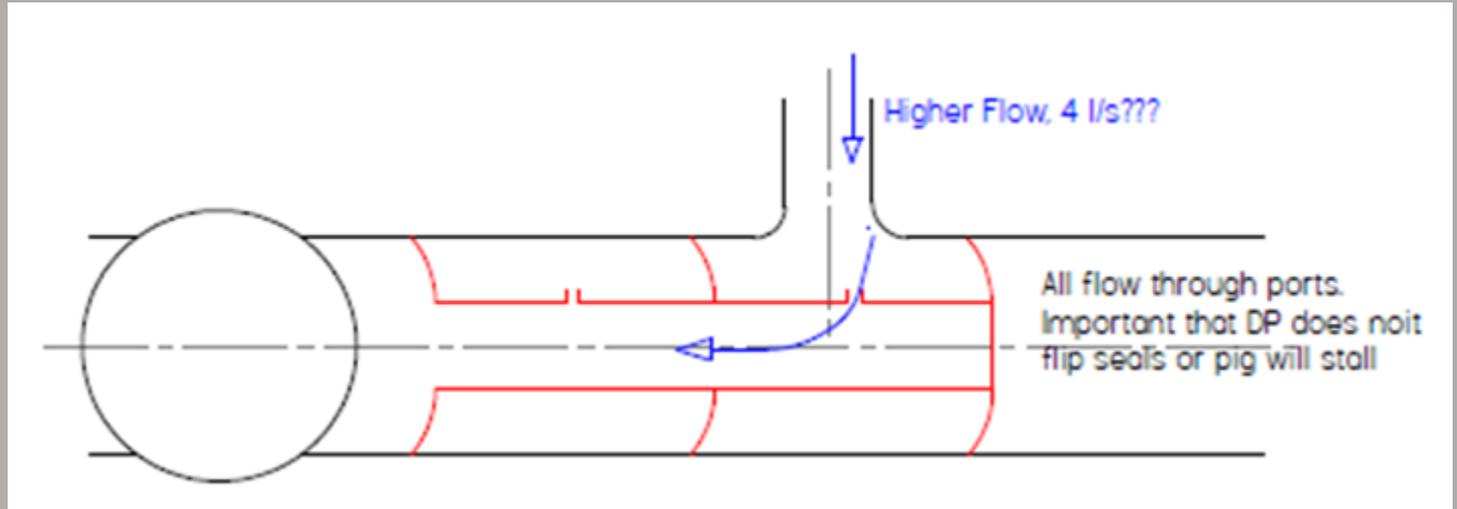
- Tests performed at low velocity, 0.03 to 0.08 m/s;
- No visible leakage from seals (forward leakage);
- Pig reversible from 305mm straight pipe;
- Flip capacity ratio acceptable;
- No problem with permanent set;
- Non buckling performance of seals acceptable.

Problem...Contingency Reversal from Manifold



If leading pig travels as far as the manifold, then can it be reversed?

Requirement for reversal

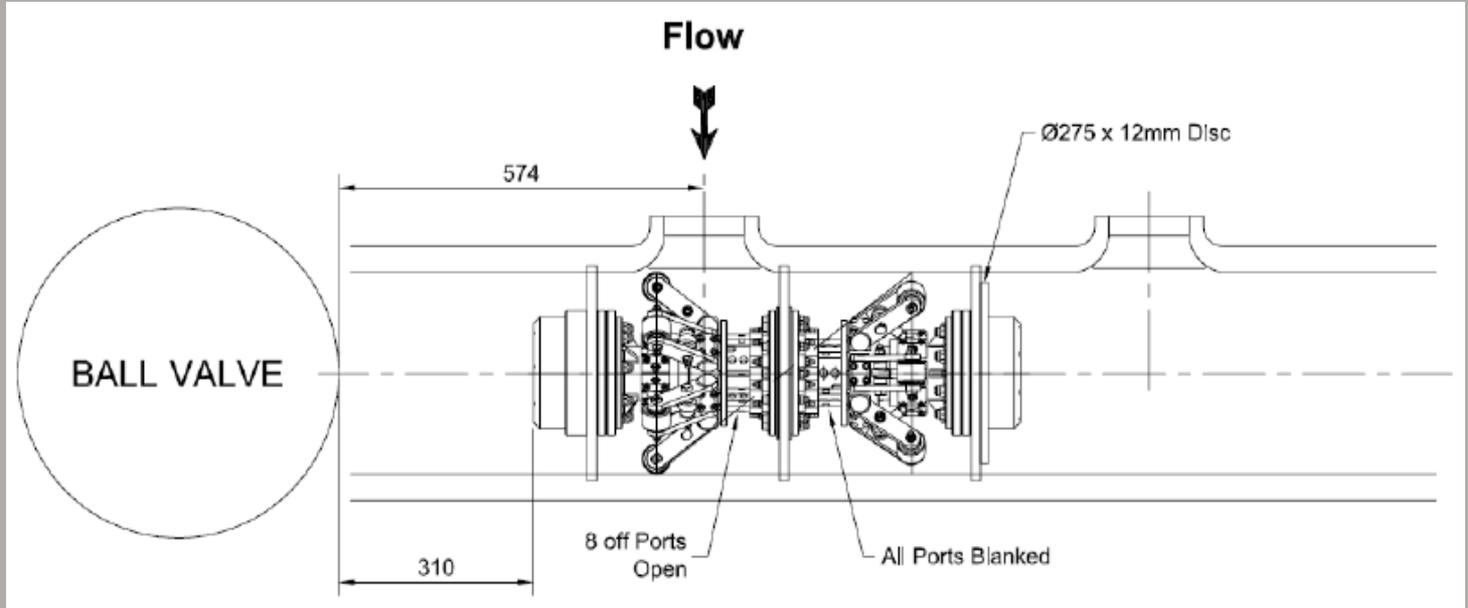


1. Pig stopped at the ball valve. Bypass ports open to transfer pressure;
2. Start flow. Leaks past rear seal;
3. Increase flow and pressure starts to build;
4. Increase flow further, pressure eventually flips seals and starts to reverse pig;
5. Finally pig moves but bypass ports need to be big enough to allow all the flow past or else the seals will flip and the pig will stall again.

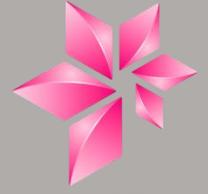
Testing at the Manifold



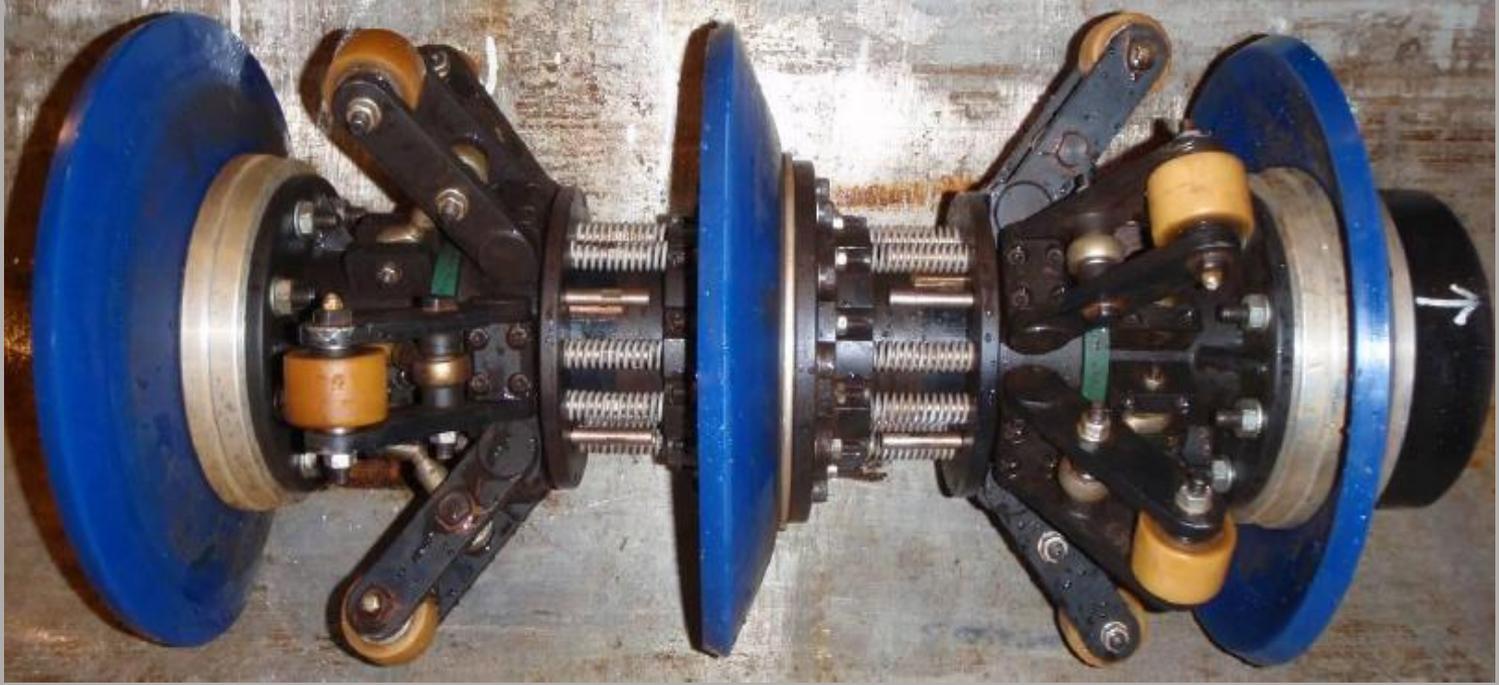
Final Position from where reversal was possible



Final Pig Design for Alve Pipeline RFO



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Future Developments...

- 12" x 16" Dual Diameter, Bi-directional Pig – 40% Increase in Diameter



Thank You.

