Reference List

Ref	Project	Client	Dia's	Total kms	Remarks
1	Åsgard	Statoil	28x42	8520	RFO train
2	NorneHeidrun	Statoil	10x16	850	RFO Flexible riser
3	Optopig®	Pipecare	40x42	250	Camera vehicle
4	Yadana	Pitchford Consultants for TFE	36	750	Continuous bore
5	NH Optopig®	Pipecare	10x16	Run due 2004	Camera vehicle
6	Gas Unie	Pipecare	28x42	Run due 2004	Modified Åsgard pig
7	Yadana	Pitch Consultants for TFE	36	Run due May 2004	As 4 above plus modified seal package

Thanks to Pipecare, Statoil and to GE-PII for some of the illustrations
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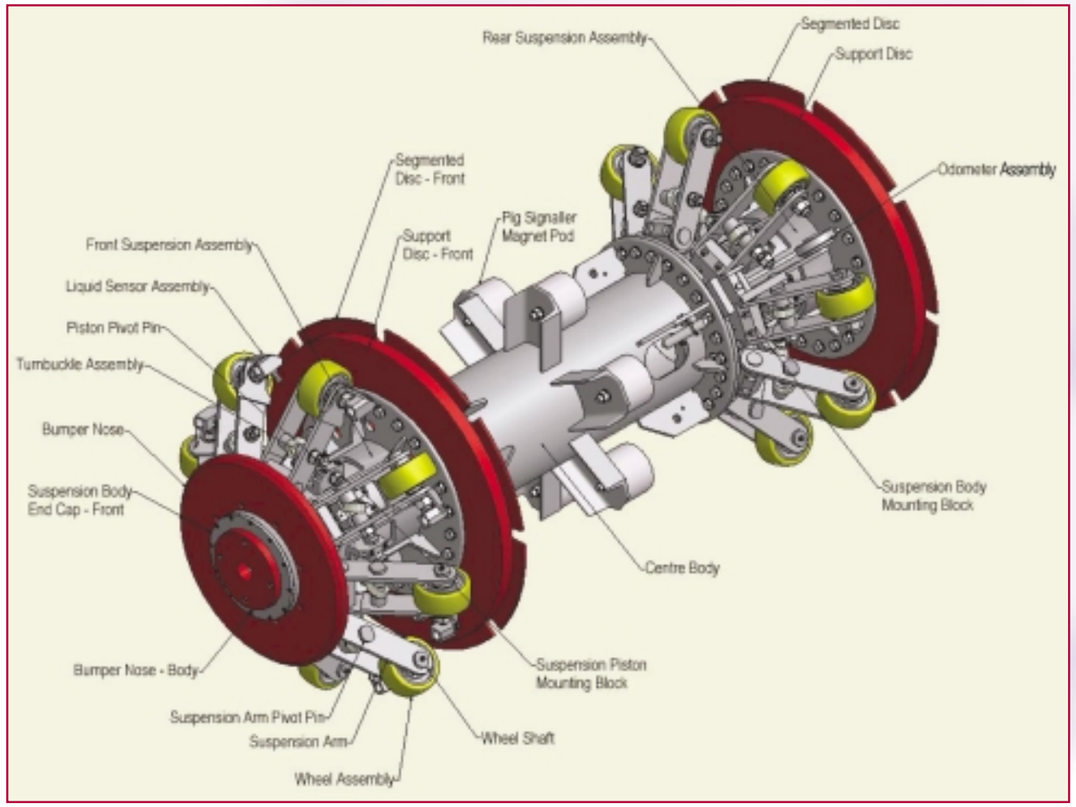
FTL SEALS TECHNOLOGY
SEALING, BEARING AND ENGINEERED SOLUTIONS

VARIPIG

The benefits of a true multidiameter suspension system

The Varipig or centreline multidimensional suspension system (CMSS) was designed and patented* as a direct result of the pipeline pig functional requirements for the Statoil Åsgard pipeline RFO commissioning project in 1998. FTL Seals Technology (FTL), founded in 1973, is a company of Mechanical Engineers with the philosophy of providing solutions to solve customers problems based on sound mechanical engineering principles.



VARPIG the hydro pneumatic loading ram.

Customer problems are reduced to a set of functional requirements and through attention to detail monitored via an ISO 9001:2001 Quality Management system a solution to the particular problem is reached.

In the instance of Varipig it was resolved early on in the design procedure that a new and revolutionary approach had to be adopted if the functional requirements were to be met whilst at the same time upholding the philosophy of FTL.

By applying basic hydraulic cylinder design principals FTL decided that contrary to previous designs the support function of the pig should be completely separate from the sealing and drive function. Due to the expected high rate of wear that the sealing discs would have to withstand it was decided to take the hitherto unprecedented step for a commissioning pig to mount the whole unit on a self supporting and self centering suspension system.

A new and revolutionary approach had to be adopted if the functional requirements were to be met

The majority of previously designed commissioning pigs adhered to previous design concepts in that all functions of the pig could be met with a relatively simple low cost design. The Åsgard multi diameter gas transporter line however was totally different.

The pipeline length would be 710 km at 42” diameter and the last 500 metres would reduce to 28” diameter. Drive disc and support disc wear would be a critical consideration.

By carefully designing the suspension the potential to overload the wheel assemblies was avoided when passing from the larger to the smaller diameter pipeline sections. Furthermore, a slow rotary motion would be imparted to the whole pig train to even out the wear on the discs. The following describes our findings based on extensive running experience.

• European Patent App No 00912826.5

Centreline running

High efficiency pigging

In repeated testing it was found that Varipig suspension system will run within 0.2% of pipe centre line (1.0-2.0mm in a 42 inch flow line). This means that a major benefit of Varipig is that a high degree of pigging efficiency can be achieved making it particularly suitable for ready for operations (RFO) work including MEG swabbing.

In the Åsgard swabbing run six pigs were launched with glycol slugs between the first four pigs, and dry air between the last pigs. This was to pick up the remaining glycol and water in the line from pipe components such as tees. At the end of the run, the three glycol slugs were sampled and the percentage water content measured to indicate the efficiency of the operation. It was found that only 0.4% water in glycol was recorded in the last liquid slug, compared with 3% to 4% from previous dewatering.

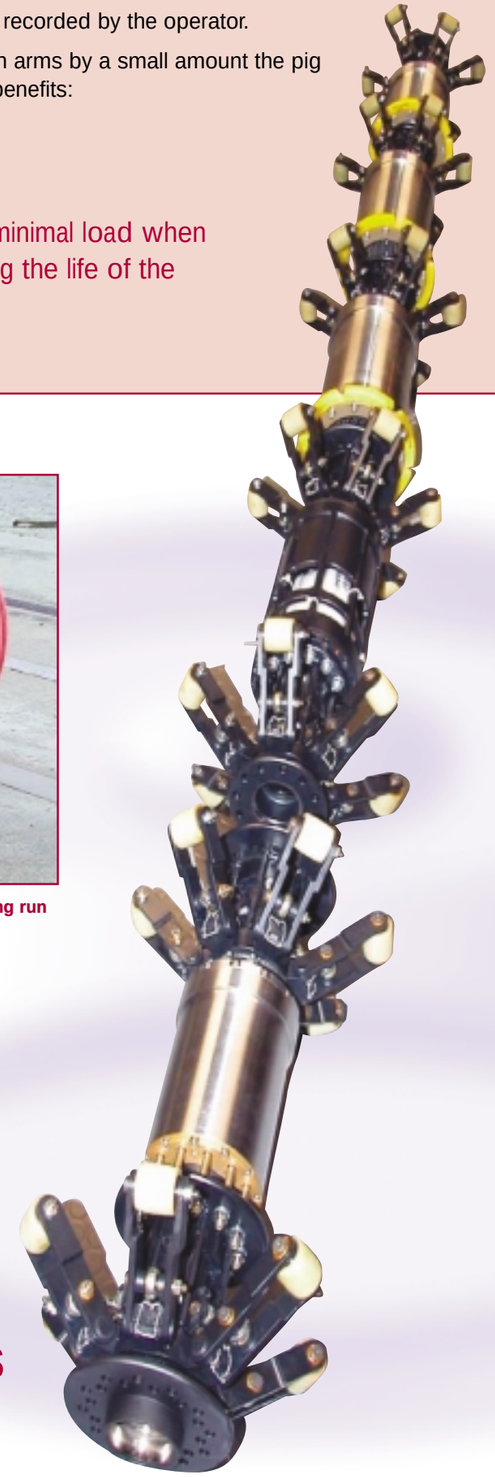
This was the most efficient Glycol Dewatering ever recorded by the operator.

By offsetting the longitudinal axis of the suspension arms by a small amount the pig assembly is encouraged to rotate. This gives two benefits:

1) the drive disks are worn evenly

2) each wheel experiences an interval of minimal load when passing top dead centre, hence prolonging the life of the wheel/bearing assemblies.

Fig.1 One of the six Åsgard pigs following its 700+km dewatering run



A high degree of pigging efficiency can be achieved making it particularly suitable for ready for operations

Centreline running [2]

Low delta P drive pressure

The ability of the Varipig system to run on centreline gives a benefit to the pig manufacturer and the operator in that the traditional oversize on the outer diameter of the drive discs, to compensate for the wear in long dry gas pipeline runs, is now minimized. As there is less material in contact with the pipeline wall during the pigs journey the friction generated between drive disc and pipe wall is now much reduced.

Tests conducted at Statoil's "K lab" show that a drive pressure differential of approximately 0,2 bars is sufficient to move the unit smoothly along the pipe.

Fig.2 Norne Heidrun Optopig® test vehicle entering the 16inch spool piece. Note the even contact of the suspension wheels and the front drive disc holding back the water, used to drive the pig in this simulation.

Less Material Less friction

Figure 2 shows the Norne Heidrun Optopig® vehicle emerging from the 10inch section of the test loop into the 16inch spool piece. The reduction in delta P drive pressure also allows the design of the drive disc to be optimized with respect to the "flip over" pressure.

Centreline running [3]

Traversing vertical "Y" pieces

Because all suspension arms of Varipig are interconnected, the suspension can maintain its pipe diameter geometry with only two arms in contact with the pipe wall.

This feature offers an additional benefit to operators in that should off takes not be fully barred then there is little fear of loosing a wheel and suspension arm as is the case on some independently sprung systems where the suspension arms are fully independent of each other.

Fig.3 shows a development Varipig following successful trials for pulling a MFL inspection tool through a vertical dual diameter pipeline feature expanding from 16" to 20".

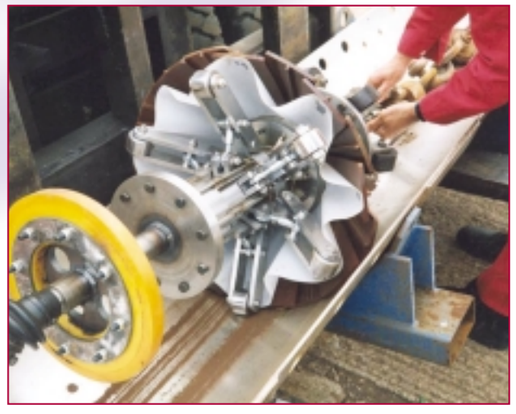


Fig.3 Varipig being used as a tow module on the front of a MFL tool.

Centreline running [4]

Progressing cleaning

The benefit that Varipig systems can guarantee at or near centreline running was recently exploited by a pipeline operator who was unsure what was in the line causing flow losses.

A programme of progressive cleaning was agreed by gradually increasing the interference between pipe wall and cleaning disk. However as the condition of the pipe was unknown (it was feared that there may have been a very high build up of debris) it was important that the cleaning/gauging pig remained in the centre of the line. See Fig 4.

Although the pig was designed to run in a fixed diameter pipeline of a nominal 36inch diameter the operators were not certain about the mechanical condition of the pipe. Should the pig encounter any pipeline defects along its journey then the self centring suspension system would be able to cope with the pipeline geometry.

Fig 4. 36 inch fixed diameter pipe line cleaning/gauging system

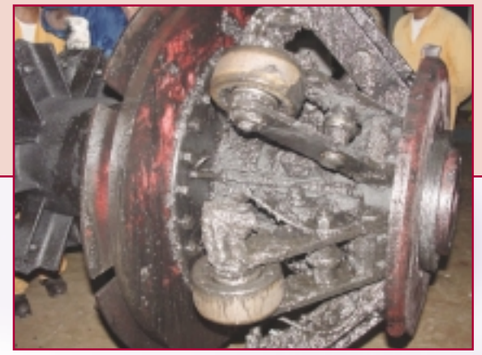


Fig 5 The cleaning/gauging pig following an initial run

Centreline running [5]

Stable camera platform

Pipeline tools fitted with Varipig offer a high degree of repeatability with regard to running on centre.

This performance is even maintained when negotiating pipeline features such as small diameter bends.

"Nose Diving", due to the weight of the pig when running horizontally can be a problem in long dry pipeline runs. The force generated by the suspension system is such that it is greater than the weight of the pig unit. By fitting a pair of Varipig modules a stable horizontal platform can be obtained.

This benefit is illustrated in Fig. 6 where an optical inspection tool, fitted with Varipig modules, ensures that the tool remains at or near the true geometric centreline of the pipe throughout its run.

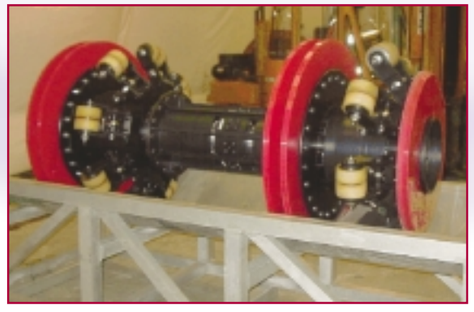


Fig.6 Varipig used as a stable platform for an optical pig system.

Wheel assemblies

Tested for operational performance on weld bead simulation test rig

To prove the operational performance of the wheel assembly (tyre/hub/bearings/stub shaft/seals/lubricants) with regard to load, distance and durability/bond integrity of the tyre material purpose built testing facilities have been developed by FTL, see Figs.7 and 8

The inner surface of a pipeline is normally in relatively good condition. However, there is one regular surface irregularity caused by the weld bead at the field joint.

The FTL test rig simulates the dynamic loads that a wheel would encounter inside a pipe line. When the test drum has rotated, the equivalent of 12 metres linear length, a PLC controlled weld bead can be introduced into the path of the loaded wheel assembly.

Fig.7 Roller assembly dynamic test facility featuring weld bead simulator

Wheel assembly loading is affected by calibrated compression springs which are set to simulate the mean load exerted on the wheels of the Varipig system when mounted on the vehicle for which the wheel assembly is intended. With the addition of a thermally insulated enclosure we are able to test the wheels at up to 45°C.

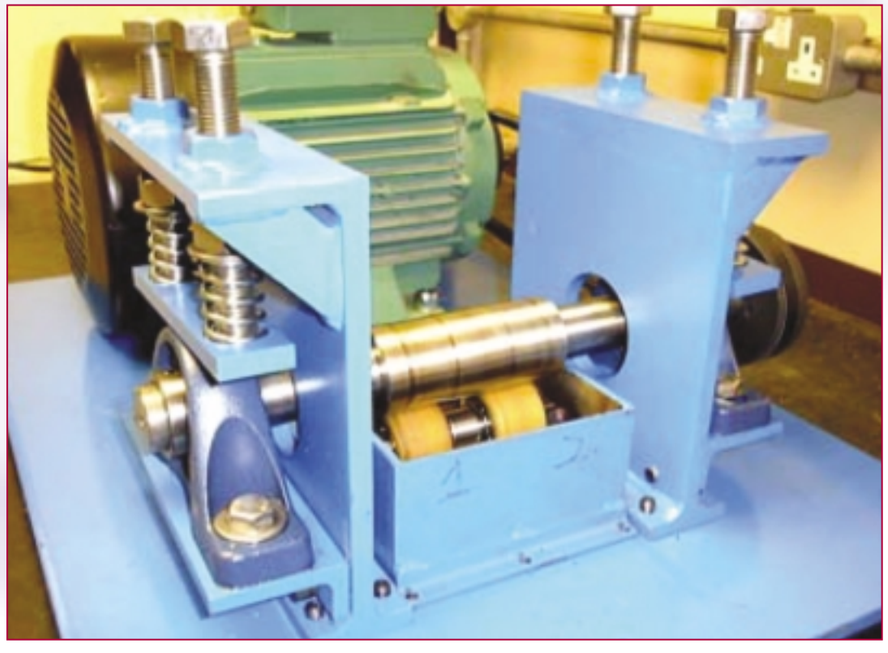


Fig.8 A further wheel assembly endurance test rig has been commissioned for smaller wheel applications. Here the loading principle is similar to the larger machine. The automatic weld bead feature is currently not available on this test rig.

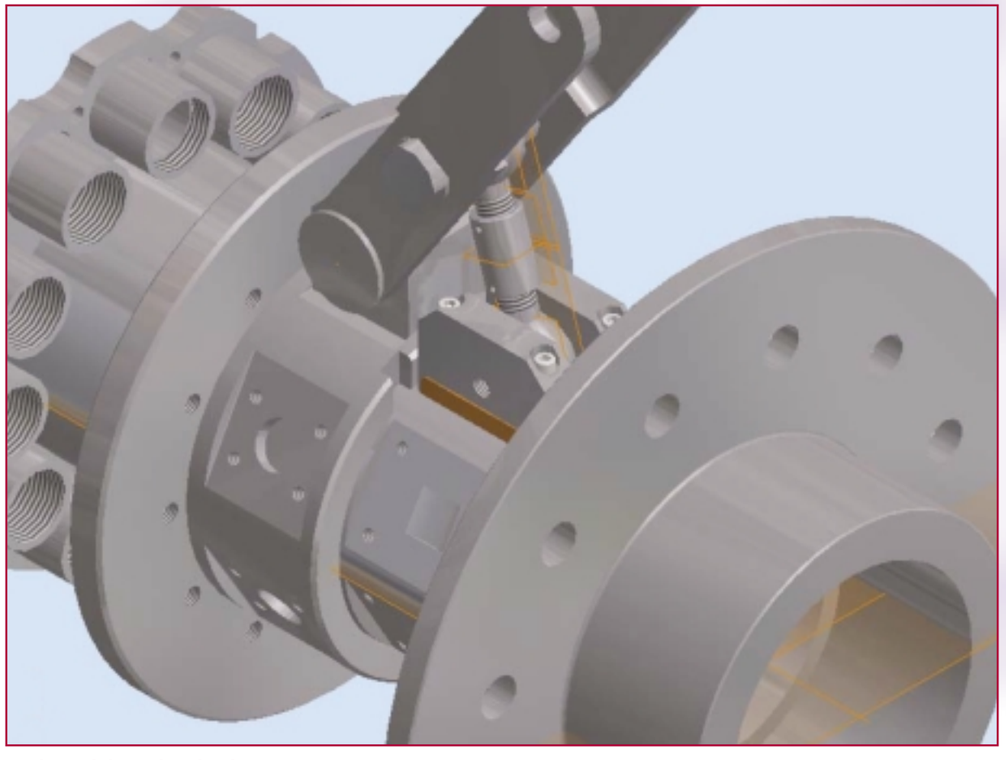
In house engineering, Design and manufacture

FTL Seals Technology employs a full time in house engineering design team equipped with the latest 3D solid modelling CAD software which enables us to fully evaluate the suspension geometry prior to manufacture.

We have an unrivalled knowledge to offer our customers in solving complex multi diameter pipeline pigging problems.

We are able to offer full Design and Feasibility studies for particular projects.

Communication is the key to success and we willingly share this information with our customers, and in turn their customers, by all current data transfer methods.



Horizontal thrust bearing hanger arrangement