Retrofitting pigging functionality in unpiggable pipelines using type approved double block and bleed isolation plugs

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Introduction

Some pipelines cannot be thoroughly inspected or maintained, using standard operational pigs or In Line Inspection (ILI) tools. This is counterproductive and may even be a pipeline safety and integrity non-compliance issue.

This paper briefly discusses pipeline piggability issues and then describes two Double Block and Bleed (DBB) pipeline isolation tools that are DNVGL Type Approved.

One is a piggable isolation tool and the other is a non-piggable tool that is installed via a hot tapped penetration into the live pipeline.

A case study example is then used to demonstrate how these double block and bleed isolation tools have been used to remove unpiggable features from a pipeline system and how pigging facilities (launchers and receivers) have been successfully retrofitted, in a timely, safe manner, without affecting production.

Pipeline Piggability

The inability to run pigs through a pipeline may be due to the original pipeline design that included unpiggable components, fittings or features i.e. such as butterfly valves, plug valves, mitred bends, bore restrictions or substantial changes in pipeline diameter.

It may be that the pipeline was designed to be piggable. However, some of the “future” pigging facilities (isolation valves, pig launchers, receivers or kicker-line pipework) were not actually installed.

In some cases, even though the pipeline was originally piggable, this may no longer be the case. The loss of piggability or the development of pigging issues could be due to system degradation or damage such as dents or buckles or it could be due to the accumulation of wax, scale or sand within the pipeline.
Type Approved Double Block Pipeline Isolation Tools – Both Seals Fully Proved In-Situ

BISEP™ Double Block & Bleed Isolation Tool:

The BISEP™ is a double block and bleed Isolation tools that can be installed into a pipeline via a single full bore hot tap penetration – requiring only one penetration for each double block and bleed isolation.

BISEP™ Description

The BISEP™ (Branch Installed Self-Energised Plug) key components are a spherical dual seal, (Double Block and Bleed) sealing head, clevis arm providing full pressure structural retention and a pressure competent launcher. The tool is hydraulically operated with fail-safe actuation (self-energisation) via the pipeline pressure differential.

BISEP™ Key Features

The BISEP™ is housed in the pressure rated launcher tube. The launcher tube facilitates testing of the sealing head integrity prior to deployment. The launcher is connected to the hot tap valve and leak tested.
**BISEP™ Deployment - into the Pipeline**

The deployment cylinder on the launcher drives the spherical head through the hot tap penetration into the pipe where it is rotated 90 degrees, towards the pressure threat.

![Deployment Image](image)

**BISEP™ Set Sequence**

The rotation of the sealing head is done hydraulically to ensure full control. The spherical shape of the head ensures that it can rotate freely inside the pipeline. Head rotation orientates the reaction shoulder against the clevis arms.

Once the head is fully rotated, the seals can be activated. Initial activation is provided by the internal hydraulic cylinder. This axially compresses the two seals, the resultant radial expansion causes them to compress against the pipe wall.

The boundary, once established, offers dual leak-tight barriers. The annulus between the seals can be pressurised, or depressurised to test the seals. The testing of the dual seals are performed in the isolating direction, this requires the isolated section to be vented to ambient. Thus on a mid-line isolation, both BISEPs™ at either end of the isolation require to be installed and set prior to the isolation being verified. This pressure venting can be performed using the BISEP™ launcher vent ports as the BISEP™ hot tap penetrations are in the isolated zone.
Fully Proving the Double Block Isolation

BISEP™ initial condition – pressure equalised across the tool

After the BISEP™ has been deployed into the pipeline both seals are compressed by “squeezing” the tool hydraulically. Initial sealing is confirmed by applying pressure to the cavity between the primary and secondary seal. This cavity is referred to as the annulus.

The annulus between the seals is piped through the launcher to give external access which allows the pressure to be raised, if required, to ensure a suitable differential pressure can be locked in for the secondary seal test.

The pressure behind the BISEP™ is then vented to apply full differential pressure across the BISEP™. The Secondary seal integrity test is then done.
Secondary Seal Integrity Test

Secondary seal test – full differential pressure

The secondary seal test is done with full pipeline pressure locked into the annulus and pressure behind the BISEP™ vented to ambient. The locked-in annulus pressure is monitored for any decay to prove the sealing effectiveness of the secondary seal. The secondary seal is proved at full pipeline pressure, in the correct direction.

Primary Seal Integrity Test

Primary seal test – full differential pressure

Once the secondary seal has been verified, the annulus between the seals is vented to ambient using the external piped connection. The vented annulus is then locked-in and monitored for pressure build up. The full pipeline pressure is thus applied across the primary seal proving the BISEP™ primary seal in the correct isolated direction.

After the Secondary and Primary seal tests are complete, the annulus is monitored, providing a zero energy zone between the seals which is monitored for the duration of the isolation.
Self-Energisation

A vital safety feature of the BISEP™ is self-energisation (self-locking), where the differential pressure across the BISEP™ head generated by the isolated pipeline pressure, acting across the tool, retains the seal activation independent of the hydraulics.

The axial movement of the pressure head is retained by the seal and, once fully constrained by the pipe bore, the compressed seal generates a contact pressure to create the seal.

The pipeline pressure acts on the whole pressure head, generating an axial force towards the seal. The annular nature of the seal ensures that the seal contact area is significantly less than the disc area of the head so the rubber pressure in the seal is held above that of the pipeline pressure. This has two benefits. Firstly the pipeline pressure can’t pass a seal at higher pressure and secondly this high rubber pressure is highly compliant to pitting, seam welds and poor pipe bore condition.

The self-energisation pressure from the pipeline pressure must be sufficient to overcome the initial load to compress the seal out to the pipe wall. This load is defined as the self-energisation pressure, which is the minimum differential pressure across the tool which will maintain the seal in the case of total loss of hydraulic pressure and normally in the region of 10 bar (150 psi).

This axial load then acts on the annulus ring which in turn is retained axially by the secondary seal. Thus the secondary seal is pressurised by the differential across the sealing head in a similar manner to the primary seal. The secondary seal is retained by the seal support head which is a leak-tight head equivalent to the pressure head. This seal support head bears on two solid clevis arms, each one capable of taking the full load. The clevis arms are axially retained by the hot tap penetration and fitting.

The assessment above is simplified and does not take account of the hydraulic actuation load which is additional to the differential pressure load. This hydraulic set load is retained and monitored during the isolation to ensure that a loss of pipeline pressure would not result in a loss of either barrier.
Isolation Monitoring

During the period of isolation the following circuits can be monitored:

- Annulus between the seals
- Hydraulic set
- Hydraulic unset (normally vented)
- Body vent – this is the cavity inside the core of the spherical head

Any change in the status of the isolation would cause a change in these circuits which would provide sufficient warning to either address the change or clear the worksite.

The connection to the annulus does provide the ability to vent any rise in annulus pressure in a similar manner to a double block and bleed valve. Although this is very rarely required due to the sealing effectiveness of the hydraulically compressed and pressure energised elastomeric seals.

On top of this ability, there is the ability to raise the hydraulic set pressure if required to improve the seal, or reduce the hydraulic pressure to reduce the load on the seal.
Tecno Plug™ Description

- Piggable Double Block and Bleed (Dual Seal) mechanical isolation plug (available as tether controlled or fully remote controlled with through wall communication system)
- Plug module provides dual sealing and locking function

Tethered Tecno Plug™ DBB isolation for Valve Replacement

Fully Proved Double Block Isolation

- Both seals are fully tested at isolation pressure
- Both seals are dual energised (isolated pressure and hydraulic control system)
- Pressure is not trapped between the seals during isolation

Double Block Verification - Seal Testing Sequence

Prior to setting the plug the pipeline pressure will be equal on both sides of the plug
Secondary Seal Verification - Full Differential Pressure Leak-Off Test

1. Plug confirmed set once slight increase in annulus pressure
2. Upstream pressure vented to ambient at launcher
3. Plug engagement with pipe wall confirmed by plug position monitoring
4. During secondary seal test annulus pressure slightly above pipeline pressure
5. Annulus pressure between seals is monitored for pressure leak-off
6. Secondary seal integrity proven with full differential pressure

Primary Seal Verification - Full Differential Pressure Build-Up Test

1. Upon completion of secondary seal verification test:
2. Vent annulus pressure to ambient (small volume vented to upstream side)
3. During primary seal test annulus pressure vented to ambient and pipeline pressure is at full isolation pressure.
4. Annulus pressure between seals is monitored for Pressure Build-Up
5. Primary seal integrity proven with full differential pressure
6. Throughout isolation period a Zero Energy Zone is provided between two fully proven seals.

Self-Energisation/Self-Locked - Isolation Fail-safe Feature (Dual Redundancy Activation)

The isolation plug has two separate activation mechanisms: Both seals and the locking grips are activated by the differential pressure across the tool (Self-locked) and both seals and the locks are activated by the internal hydraulics. This provides dual redundancy in activation. Both separate activation mechanisms need to be removed to unset the plug.
Case Study Example - Retrofitting Pigging Facilities to an Existing Pipeline

A pipeline intervention and isolation operation was recently successfully completed on a 30\" liquid CO2 Pipeline. The purpose of the project was to install full bore inline isolation valves and new pipeline tie-in facilities. This was done without affecting pipeline throughput.

The following sequence of activities differs slightly from the actual project as it does not just show the installation of inline isolation valves and tie-in facilities; it shows the installation of permanent pig launcher and receiver facilities.

30\" pipeline dual BISEP™ isolation with 24\" bypass

All the intervention and isolation equipment was designed to full class 900 pressure rating 2250psi and was hydrostatically strength tested to 3350psi. The fully proved double block isolation was maintained for 24 days at pipeline operating pressure of 1850psi.
Initial Pipeline Intervention, Bypass Fitted and BISEP™ Isolations Installed

1) Weld on, inspect and test the permanent bypass hot tap fittings; either side of the section to be removed.
2) Install permanent and bypass valves and perform bypass hot taps
3) Recover hot tap cutter and coupon and close the isolation valves
4) Remove hot tap machine
5) Install permanent bypass pipe work, with kicker line tees and valves.
6) Leak test the new pipe work connections
7) Open the bypass isolation valve
8) Fit temporary (reusable) size on size mechanical hot tap fitting clamps with hot tapping valves
9) Leak-test hot tap clamp seals and carry out the hot taps
10) Recover hot tap cutter and coupon and close the hot tap slab valves.
11) Fit BISEP™ launchers onto slab valves
12) Leak-test flange connections, open slab valves and deploy BISEP™ tools into the pipeline
13) Hydraulically actuate the BISEP™ tools to create double block and bleed isolations either side of the section to be removed.
14) Vent the section between the BISEP™ tools, via BISEP™ launcher vent ports
15) Fully prove secondary (inboard) seal integrity with full pipeline operating pressure by applying and monitoring the pressure in annulus void between the primary and secondary seals.
16) Vent annulus pressure and monitor for pressure build-up to fully prove the primary seals using full pipeline operating pressure.
17) Once the Double Block Isolations are fully proved, flush and purge the section between the BISEPs™ via their launchers – no additional hot tapping required.
18) Then remove the section of pipe between the BISEPs™
Tecno Plugs™ used to Remove Temporary Hot Tap Fittings

1) Once pipe section between the BISEPs™ is removed
2) Fit the temporary Tecno Plug™ launchers to the bare pipe ends – the temporary launchers are mechanically locked and sealed onto the outside of the pipe with dual seals.
3) With the BISEPs™ still deployed pressurise the Tecno Plug™ launchers to prove they are locked securely onto the pipe and are leak-tight: the BISEPs™ can withstand a reverse pressure that is 150% of the pipeline pressure.
4) Then equalise the pressure across the BISEPs™, unset the BISEPs™ and recover into launchers
5) Deploy the Tecno Plugs™ beyond the BISEP™ hot taps – inboard of the bypass tees.
6) Hydraulically set the Tecno Plugs™ then vent the pressure behind them, via launcher vent ports.
7) Fully prove secondary (inboard) seal integrity with full pipeline operating pressure by applying and monitoring the pressure in annulus void between the primary and secondary seals.
8) Vent annulus pressure and monitor for pressure build-up to fully prove the primary seals using full pipeline operating pressure.
9) Once the Tecno Plug™ Double Block isolations are fully proved, flush and purge sections behind the Tecno Plugs™.
10) Then cut the pipe behind Tecno Plugs™ and remove the temporary equipment.
Permanent Pig Receiving and Launching Facility Installation

1) Before the Tecno Plugs™ are removed
2) Weld on the permanent launcher and receiver isolation valve tie-in flanges
3) Install the isolation valves, the launcher and receiver and their kicker line pipe work
4) Leak-test all new flange connections
5) Then unset both Tecno Plugs™ and remove them using the new pigging facility isolation valves.

Note: If the Launcher/Receiver isolation valves do not provide Double Block and Bleed (DBB) isolation in a single valve body then additional isolation valves should be installed to ensure pig loading and retrieval can be done safely.