A Comparison of Double Block and Bleed Technologies

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Introduction

The term “Double Block and Bleed” is mostly used to define a level of isolation provided by valves in a pipeline or process system. The term is used to describe a safe method of isolation from a pressurised or hazardous medium to facilitate breaching of the pressure system for maintenance and modifications. This terminology is also utilised to identify the relative integrity of temporary isolation systems.

However, although “Double Block and Bleed” is a universally used term to specify a level of isolation, the definition of the term is by no means universal. For example:

The UK Health and Safety Executive guidance document, The Safe Isolation of Plant and Equipment, defines double block and bleed (DBB) as “an isolation method consisting of an arrangement of two block valves with a bleed valve located in between.”

**DBB Isolation Integrity Test (Two Valves)**

![Double Block and Bleed diagram – Two valves](image)

**Key**

<table>
<thead>
<tr>
<th>Symbol</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>V1</td>
<td>First (upstream) isolation valve from live system.</td>
</tr>
<tr>
<td>M1</td>
<td>Live side monitoring point (pressure gauge or vent/drain).</td>
</tr>
<tr>
<td>V2</td>
<td>Second (downstream) isolation valve from live system.</td>
</tr>
<tr>
<td>M2</td>
<td>Monitoring point between valves and break point (pressure gauge or vent/drain).</td>
</tr>
<tr>
<td>B</td>
<td>Bleed point between the isolation valves.</td>
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*Figure 1: Double Block and Bleed diagram – Two valves*
Testing and monitoring the effectiveness of the Isolation is specified in this guidance document which states (ref. article 165):

“Prove the integrity of all isolation points of an isolation scheme before proceeding with intrusive work (unless your risk assessment has indicated that the use of non-proved isolation is acceptable):

- each part of the isolation should be proved separately, e.g. prove each valve in a double block and bleed scheme;
- each part should be proved to the highest pressure which can be expected within the system during the work activity
- where possible, each part of the isolation should be proved in the direction of the expected pressure differential”

BP – Guidance on Practice for Safe Isolation and Reinstatement of Plant specifies Double Block and Bleed as:

“Double Block and Bleed consists of the closure of two block valves in series with an intermediate bleed valve. The integrity of both valves shall be tested separately and the bleed valve will then be left in the closed position between periodic integrity checks.”

Most other operators have similar specifications, however there is an acceptance on many that the bleed can be left open to accommodate acceptable upstream valve leak rates. Some even specify the size of the vent to ensure that the acceptable leak rate will not generate pressure in the void between the valves.

The BP Guidance then goes on to explain which types of single body valves can be assessed to provide the same level of isolation.
**DBB Isolation Integrity Test**  
*(BP-approved Double Sealed, Single Valve)*

![Diagram of DBB Isolation Integrity Test](image)

**Key**
- M1: Live (upstream) side monitoring point.
- M2: Monitoring point between valve and break point (downstream).
- C: Cavity drain (between seals).

*Figure 2: Single Double Block and Bleed valve diagram*

The accepted requirement for such valves is that both upstream and downstream barriers hold pressure in the correct direction. “Examples of such valves are suitably specified double wedge gate, parallel expanding gate, double seating ball valves etc. Double piston seal ball valves where the cavity pressure provides the downstream positive seal, should not normally be used and if they are to be used then they require specific Technical Authority approval.

![Diagram of Split gate Double Block and Bleed valve](image)

*Figure 3: Split gate Double Block and Bleed valve*

The most alarming use of the term “double block and bleed” is where it is used for ambient isolation tooling. This is commonly used in the USA and Canada with reference to tooling which is inserted inside open pipes to provide an ambient pressure vapour barrier for welding. These tools are often then relocated to locally pressure test the welds. These tools have two seals against the pipe wall, which have a pressure test capability to confirm leak tight sealing. This pressure test does not prove...
the isolation against any upstream pressure for either seal. Although this is a perfectly safe level of isolation for the ambient isolation and acceptable where the upstream vent is capable of preventing any pressure build up and safely removing hydrocarbons which flash off the pipe wall / condensate, it is a different type of isolation and describing it as “Double block and bleed” can offer confusion to the uninitiated. The “bleed” referred to is the capability to bleed the upstream through the tool in much of the literature.

Before we can look at how temporary isolation tools can be assessed to provide an equivalent “Double Block and Bleed Isolation” we need to define a consistent definition which covers the high end intent while accommodating the practicalities of pipeline systems in which valves have acceptable leak rates.

**Double Block and Bleed – Definition**

The baseline definition for incumbent valves is two valves, tested and proven to full line pressure in a direction consistent with the required isolation with the void between them vented and monitored for pressure rise. Although this is idealistic other than on brand new plant, it does form a starting point for assessment.

The intent of this level of isolation is that no single failure can invalidate the isolation.

Failure (or inadvertent operation) of the primary valve would only allow pressure to enter the bled zone between the valves. The second valve would prevent any hydrocarbons (or other pipeline pressure) from affecting the worksite.

Failure (or inadvertent operation) of the secondary valve would only open the ambient void to the work site offering no direct risk. The primary valve would prevent any hydrocarbons (or other pipeline pressure) from affecting the worksite.

The requirement for the secondary valve to be tested to verify the isolation capacity is key to ensuring that any bypass of the primary valve is retained.

The requirement for the void between the valves to be vented to ambient is necessary to ensure that any pressure build up from a passing primary valve will be detected and that it can be vented to a safe area, whilst being retained by the secondary valve. Preventing any hydrocarbons or pressure from affecting the worksite.

This is a simple concept which is complicated by the reality of plant design and valve wear. The result is that most of the time two leak tight valves are not available.

As a result some practical compromise is usually required when incumbent pipeline valves are used to provide double block and bleed isolation. The first part of this is the definition of acceptable leak rates on valves. Most operators have an acceptable leak rate criteria based on pipe diameter, pressure, and hazardous nature of the fluid being isolated. Other factors such as available vent capacity and even firefighting capacity can also be used when assessing what leak rate can be safely accommodated. With this compromise, the secondary valve (downstream) is tested using pipeline
pressure to validate it is sealing within the documented acceptable leak rate. The void between the
valves is vented and locked in to measure the primary valve (upstream) leak rate. Once the leak rates
are accepted as within allowable levels, the bleed is opened to flare to ensure no differential pressure
builds across the downstream valve.

Where a single valve is to be used to offer equivalent isolation, the same rules should be applied. Where
the valve design energises both the upstream and downstream seals with the upstream
pressure, the valve can be considered for double block and bleed. However the single modes of failure
require to be assessed to ensure that sufficient safeguards are put in place to mitigate against these
failure modes.

One of the main single failure points is that a single actuator function can remove both the primary
and secondary seals at once, it is critical that inadvertent or accidental operation of the valve actuator
must be prevented from occurring , preferable by removing or locking the actuator, while the isolation
is in place.

Another potential single point failure is the ball or gate. With a single double block and bleed valve,
there is normally a single closure, with a seal on either side. However the pipe is a single skin and a
blind flange is similar to a gate which is bolted in place, so this can be mitigated against by ensuring
the valve design is to the same factor of safety as a blind.

As most pipeline valve seats are pressure assisted, it is important that the valve integrity is tested in
the correct direction, although we still see too often the valve cavity being depressurised to check
both the seats of a DBB valve at the same time.

Temporary Isolation Techniques

There are many occasions where the incumbent valves in a piping system are not sufficient to provide
the required isolation and the practicality of venting the pipeline pressure does not make that option
desirable or in some cases even viable. An example of this is ESDV maintenance on a subsea gas
pipeline where the venting of several hundred kilometres of 40” pipe is not viable.

Even where the pipeline can be vented to ambient, flash off from condensate or pipe bore deposits
need to be kept away from the worksite.

Temporary pipeline isolation has been performed by a variety of methods to various degrees of
integrity for decades. The earliest isolation techniques were crude with limited capability and integrity.
Examples include a mud pack, which needed the pipe vented in order to install, could not be effectively
tested and would not resist any substantial pressure that could build from flash.

Figure 4: Mud pack isolation
The ability to retain pressure behind temporary isolation devices was first attained by the development of hot tap installed line stop tools which use lip seal technology deployed through a branch penetration, utilising the branch to provide a reaction for the mechanical restraint. These are traditionally deployed in conjunction with a gas bag. The gas bag is used as a secondary barrier with a bleed between the line stop tool and the bag to prevent any pressure build-up. This however does not equate to double block and bleed isolation since the gas bag can’t resist the pipeline pressure so could not be counted as a secondary barrier.

![Figure 5: Line Stop Tool with Gas Bag](image)

Two line stop tools in series with a vent between would be required for a double block and bleed level isolation.

In the mid-1970s, piggable mechanical plugs first came on the market which offered double barrier isolation in a single isolation tool. This isolation tool design utilises a compression packer and wedge shaped locks to provide the high pressure seal and axial restraint. These plugs were hydraulically operated, with a hydraulic tether and stuffing box assembly allowing the tool to be pigged into the pressurised pipe prior to setting.

The compression seals in relaxed condition comprise a ring whose outside diameter offers passing clearance on the pipe bore and an inside diameter which matches the outside diameter of a cylindrical support ring on the plug body. When axially compressed by the hydraulic cylinder, the static seal volume causes the seal to expand in the only free direction i.e. radially out to contact the pipe wall. Once the seal is restrained by the pipe bore, it is fully restrained so further activation load can no longer cause seal deformation. This additional actuation load generates rubber pressure in the packer which improves the seal on the pipe bore. This packer design seals on the pipe bore, front and back compression faces and the cylindrical support ring.

Secure plug locating is provided by an array of lock segments which grip the pipe bore with a tooth profile machined into the lock segment OD. The lock segments have a conical interface between the lock ID a conical lock bowl. In the unset location, the locks – lock bowl interface is extended so pulling the lock segments down to the lock bowl ramp with the associated reduction in the lock segment OD.
This ensures the lock segments are held radially clear of the pipe bore for pigging. The axial compression of the plug by the hydraulic cylinder causes the lock segments to run up the conical ramp of the lock bowl and engage with the pipe bore. Once the pipe bore prevents further lock movement, further actuation load generates a contact pressure with the pipe bore to engage the teeth.

The major advance in this technology was fail-safe features:

**Self-Energisation**

![Figure 6: Isolation Plug Self-Energisation](image)

The geometric configuration of this tool design takes advantage of the isolated pressure to assist with the plug activation. The isolated pressure acts on the plug pressure head pushing it towards the locks (fixed point restraint). This load acts in the same orientation as the hydraulic actuation system and is supported by the compression seal. The compression seal is in itself supported by the lock and lock bowl assembly and being fully restrained generates rubber pressure with the additional load. The ejection load then passes through the shallow conical taper of the lock bowl to generate a radial load to further energise the lock teeth into the pipe wall.

An axial load balance over the seal shows a pressure intensification on the seal rubber pressure:

\[ F_p - Ejection \ Load = Pipeline \ Pressure \times Cross \ Sectional \ Area \ of \ Pipe \]

\[ F_s - Seal \ Load = Seal \ Rubber \ Pressure \times Cross \ Sectional \ Area \ of \ Set \ Seal \]

Balance of forces \( F_p = F_s \)

Note: This is looking at seal pressure intensification and does not take account of Hydraulic actuation pressure

\[ \text{Seal Rubber Pressure} = \frac{\text{Pipeline Pressure} \times \text{Cross Sectional Area of Pipe}}{\text{Cross Sectional Area of Set Seal}} \]
This shows that as the isolated pipeline pressure increases, the rubber pressure in the seal increases by a factor >1. This factor is defined by the seal bore in the seal design and is normally in the order of 1.5.

The taper angle of the lock bowl also can be geometrically designed to generate a radial force intensification in a similar proportion.

The result of this design feature is that the isolation will be maintained by the isolated pressure, even with a total failure of the hydraulic system, providing a minimum differential pressure is maintained across the plug. This makes this isolation system **fail-safe**.

**Passive Unset**

In the case on loss of hydraulics, in the early days this could be caused by a hydraulic tether failure, the plugs were designed to passively unset when the pressure differential is removed. As the pipeline pressure can normally not be removed, this passive unset is achieved by raising the pressure inboard of the plug, which can only be achieved when the pipeline integrity is restored.

The earliest configurations of this plug design provided a single compression seal and used a high sealing pigging disc as the secondary seal. The void between the compression seal end and the pigging disc was vented and monitored for pressure build-up. However this would not pass a modern interpretation of double block and bleed isolation as the secondary seal was not pressure rated to the full pipeline pressure.

![Figure 7: Photo and diagram of early single seal isolation plug](image)

The second generation of this plug design added a second compression seal between the primary seal and the lock bowl. The two compression seals are separated by an annulus ring which is ported through the hydraulic tether to offer a bleed and monitor capability. Both these seals are fully energised by the pipeline pressure as well as the hydraulic activation.
These tools have been further developed over the years including being split into separate modules to assist with bend compliance during pigging. In the late 90’s remote control systems were introduced to remove the limitations of the hydraulic tethers. These increased the range of the isolation plugs which had previously been limited to pipe end activities. They also removed a pressure limitation which was based on the stuffing box restriction.

There are two plug designs currently on the market, one with two lock and seal modules, each similar to the original design, and the other based on the dual seal and single lock array. We will look at how the two designs compare to the Double Block and Bleed Isolation definition later in this document.

STATS has also taken the isolation plug self-energised, fail-safe, seal design to develop a hot tap installed isolation tool which can be installed through a single hot tap penetration and offer the advantages of both the mechanical isolation plug and line stop tooling.

The other mechanism which is used for temporary isolation is the use of freeze plugs, where a liquid –optimally water -inside the pipe is frozen, normally by the application of liquid Nitrogen. The solidifying process would generate an ice plug which both seals and grips the pipe. This isolation technique is attractive as it does not require full bore access to the pipe bore for installation and recovery, but does have some challenges, particularly the loading on the pipe from both the ice expansion and the cryogenic effect on pipe. There is also the asphyxiation potential with the Nitrogen evaporation and the potential total loss of isolation if the cooling system is compromised.

Double Block and Bleed Isolation Tooling

Double Block and Bleed is a valve definition, so all temporary isolation techniques and devices require to be risk assessed to validate that they offer an equivalent isolation level in the required application. In order to assess the comparison of isolation provided, we need first to identify the requirements.
Temporary isolation techniques offer different challenges to valves so can’t be assessed in a directly equivalent manner.

Valves are designed to be installed in pipes for many years and a high number of operations between maintenance. As a result they are normally provided with acceptable leak rates higher than those of a new valve. This, results in minimum bleed capacities being specified where an open bleed is used. The wear, erosion and corrosion associated with old valves can cause many concerns, although valves in good condition should always at a minimum provide a secure mechanical restraint.

Temporary isolation devices on the other hand are not permanently connected to the pipework and can be inspected and tested immediately before use and tend to be maintained after very few operations. The seals can be replaced for every deployment so offering a consistent level of seal integrity. The only limitation on this is pipe bore condition where the temporary isolation device seals against. All the high pressure isolation devices identified here do apply some local stresses to the pipe at the set location which need to be assessed.

The ability of the isolation integrity to be monitored is critical in the temporary isolation assessment. With valves, where an open bleed is used, the monitoring of the isolation is minimal, as a rise of pressure would indicate a loss of control over the isolation rather than an indication of deterioration of either the primary barrier or vent capability. The high specification of the BP requirement above, with the bleed locked in will offer the full monitor but may not be viable with valve leak rates.

The independence of control systems to ensure no single operation could invalidate both barriers, which is a cause for concern in the single double block and bleed valve, must be addressed in the assessment of temporary isolation devices.

Accidental operation, which causes restrictions in the use of ESDV valves in double block and bleed, is easier to control in temporary isolation systems since they tend to be independent of automated plant systems, however needs to be covered in a risk assessment.

Where assessing the integrity of an isolation, we therefore need to assess the following:

- Two independent barriers
- Ability to test both barriers in the correct direction to verify the isolation integrity
- Any single failure modes are understood and addressed. E.g. single bulkheads such as in double block and bleed valves
- Bleed limitations
- Monitoring capability
- Seal integrity
- Restraint integrity
- Exposure to single seal
- Stability of isolation under unstable loading from pressure fluctuations
- Effect on the piping system
These are all assessed initially in a FMECA for the tooling then a HAZID on the deployment for STATS supplied equipment.

This paper will look at the STATS Tecno Plug™ and BISEP™ in detail then compare with alternative technology.

**Tecno Plug™**

The current Tecno Plug™ is derived from the dual seal tethered isolation plug deployed by Tecnomarine Systems since the mid 1980’s. The basic concept is for two compression seals mounted in series outboard of a taper lock array. There are several configurations from single to triple module with the multi module configurations being connected by structural ball joints. The basic loading and operation is the same for all varieties.

The most compact plug is the single module dual seal Tecno Plug™. This plug is designed to be set in tight spaces, e.g. between two valves or between a pig trap valve and production tee to allow production to be maintained while the valve maintenance is progressed. This plug can however, be pigged round 3D bends so can also be used for long distance pigging jobs.

The single module Tecno Plug™ has two compression seals in series, supported by an array or 6 or 8 lock segments arrayed around a single lock bowl. The advantage of arraying the contingent lock segments in a single array is that both seals are fully energised by the differential across the plug. In this configuration, the loading across the plug from the differential pressure which energised the seals and locks does not change with a change in annulus pressure, unlike the alternative design with two separate lock rings.

The Tecno Plug™ is normally deployed with a remote control system which comprises a control module pigged in with the plug that sets and monitors the plug under instructions communicated...
through the pipe wall with ELF communications. The assessment of the isolation integrity needs to cover both the isolation plug and control system.

When deployed, the isolation plug is hydraulically activated by the control module. This causes the internally mounted hydraulic cylinder in the Tecno Plug™ to contract so setting the locks and seals to create the initial barrier. Once the plug is confirmed as set, the pressure inboard (portion of the pipe to be isolated) is vented generating a pressure differential across the plug module. As the pressure differential is applied, the trapped fluid in the annulus between the seals is compressed due to the seal compression. The other effect is that the hydraulic pressure in the actuation system drops. The remaining hydraulic set pressure once the pipe is fully vented is locked in by pilot operated check valves to ensure it is maintained, even with loss of power in the control module.
• Both seals properly tested with full differential pressure
• Zero-energy zone between the seals during isolation

*Figure 10: Tecno Plug™ seal verification cycle*
Once inboard pressure is fully vented the Tecno Plug™ secondary barrier is tested in situ to above the pipeline pressure in the correct orientation. This proves the integrity of the secondary seal. The annulus is then vented to the tail pressure and locked in. This allows the primary seal to be tested to the full differential pressure. Although the annulus will settle at a few bar above the small volume (~3 litres for a 30”) plug combined with the low pressure (~5 bar/ ~70 psi) does not offer a substantial risk.

The isolation is then monitored for an extended period prior to breaching the pipe integrity. The standard period is 12 hours for a high pressure isolation.

This offers the closest monitoring to the valve scenario. Both barriers are proven in-situ to full pipeline pressure and the void between the seals is bled to ambient and locked in for monitoring. As the isolation plugs offer high integrity sealing, this annulus pressure is not anticipated to require venting during the isolation. However, if the annulus pressure did rise, then the loading on the seal would be unchanged and the system has already been tested to the secondary seal loading so does not go outside the tested condition.

Once the isolation certificate is issued, the control system is put in watchdog mode which automatically monitors the Tecno Plug™ sensors and transmits changes to alert the operator. The plug will not accept any command which will change the status while in watchdog which locks the system from inadvertent operation. The hydraulic unset is also limited and high pressure isolations can’t be unset hydraulically without equalising the pressure first.

Single failure assessment of this plug is to the extent that the ¼” outboard monitor is protected by a shuttle valve to protect from a leaking fitting.

Comparing this to the Double Block and Bleed Criteria:

- Both primary and secondary seal are capable and tested to the pipeline pressure in the correct direction during the deployment
- Annulus between the seals is vented and locked in minimising exposure from loss of secondary seal integrity
- Effect of the loading on the pipe is well understood and engineered for the application. All plugs are tested in equivalent pipe to hydro-test pressures
- Both seals and the locks are fully activated by the differential pressure and by hydraulic activation pressure. Two totally independent actuation systems
- Control system locked from inadvertent operation
- Automatic monitor of outboard pressure, inboard pressure, annulus pressure, hydraulic set pressure, hydraulic unset pressure. These sensors would give advance notice of any change of status in the system. There is the ability to intervene in a controlled manner if required
Looking at the Failure Modes:

The pressure head is a steel disc similar in design to a blind flange with the design to 1.5 times the isolation plug design pressure. As the standard Tecno Plug™ working pressure is in excess of 3000 psi and most deployments are less than 2000 psi, then this offers additional contingency. Every isolation tool is tested in similar pipe to the code hydro-test pressures prior to deployment. This compares to valve gates which only require a 1.1 times MAOP test pressure.

The front compression seal is the primary barrier. This seal is held activated by both the differential pressure and hydraulic set pressure, both of which would require to be lost to invalidate the activation. Failure modes assessed are a leak developing and a catastrophic loss of seal. These are highly unlikely events, however the consequences need to be assessed. A leak past the primary seal would only restore the annulus pressure to the pre-vented plug status which had already been tested. The secondary seal is proven as a full barrier. The Tecno Plug™ control system allows controlled venting of this pressure if required. A catastrophic failure of the primary seal could allow movement of the pressure head towards the taper locks. The Tecno Plug™ is therefore designed to accommodate this movement to the extent of the full loss on the primary seal rubber volume. However, additional to this defence, the seal would not extrude onto the pipeline pressure as the pipeline pressure is acting against it. Extrusion towards the secondary seal would be limited by the free volume around the annulus ring so a full seal loss is not possible. The plug design has however been designed to accommodate total loss of this seal.

The annulus ring is a solid steel plate under compression which is supported across the surface with the compression seals and is designed of sufficient thickness to retain rigidity.

The rear compression seal is the secondary seal. This seal activation is maintained by both the differential across the plug and the hydraulic set pressure, whether there is pressure between the seals or not. The seal is tested as part of the Tecno Plug™ deployment and held during the isolation with minimal pressure locked in the annulus. This seal is assessed for two failure scenarios. Firstly a leak developing. A leak in this seal would be identified by the loss of the small pressure in the annulus. The small volume and pressure minimises the potential hazard. The second hazard assessed is the catastrophic loss of the secondary seal. Like the primary seal the Tecno Plug™ stroke is designed to accommodate this movement. However like the primary seal, the seal movement is limited. For the seal to move forward into the annulus, the limited free annulus volume would prevent seal loss. If the seal moved backwards, the movement would be limited by the locks. Hence the catastrophic seal failure also protected against by the nature of the design.

The lock bowl is a solid steel ring designed to take the full test pressure in a similar manner to the annulus ring and pressure head.

The taper lock segments have more than 100% contingency arrayed around the lock bowl. This ensures that eccentric pipe surface degradation (e.g. 6 o’clock corrosion) can be accommodated. The locks are fully engaged by both the hydraulic set pressure and the differential pressure across the plug.
in a similar manner to the seals. These locks are tested to the full pressure during the isolation plug deployment and the loading from the differential pressure is constant with pipeline pressure. The alternative of axially separating the contingency locks, placing a set between the seals, would result in the loading on the lock grip changing if the annulus between the seals changes—offering the potential on an untested condition being generated during an isolation. STATS have assessed this risk as being more hazardous than a single fully tested and stable grip.

Tecno Plugs™ have been accepted by most major operators over the last 20 years.

**Tecno Plug™ Examples**

In 2001 Tecnomarine deployed a 40” remote plug for Statoil, isolating a 110 bar gas pipeline, 800 km long to allow a welded in ESDV valve to be stripped and maintained. This was the first remote Tecno Plug™ deployment and was preceded by a 3 day HAZOP to assess the risks. As a result of this first deployment Statoil isolated 2 further 40” export lines the following year.

![Figure 11: Remote Plug being loaded into pig trap](image)

One of the challenges in the oil and gas pipeline industry is the presence of Hydrogen Sulphide in the pipeline medium. The presence of H₂S in the pipeline fluid greatly increases the risks. The consequences of even a small leak can prove fatal. STATS standard Tecno Plugs™ are designed to be NACE complaint, providing the correct sealing packer material is used. STATS are working in Qatar, where the sour content can be measured in several per cent instead of ppm. Here we use a HNBR seal specifically designed for sour service and have isolated 38” and 36” pipelines for two of the major operators. We had to qualify the seals for 9% hydrogen sulphate. In this application the minimising of the product retained by a single seal is an important factor making the Tecno Plug™ an obvious choice.
BISEP™ – Branch Installed Self Energised Plug

The BISEP™ is the Double Block and Bleed line stop tool which has been developed by STATS. It uses Tecno Plug™ seals mounted on a spherical head to provide the dual barrier isolation.
The BISEP™ offers all the dual seal advantages of a Tecno Plug™ but with some additional features.

- The pressure head, primary seal annulus ring and secondary seal operate in a similar manner to the Tecno Plug™.
- The BISEP™ is however installed through a hot tap penetration so instead of the taper locks, the BISEP™ is restrained by two solid clevis arms, each of which can resist the full test pressure.
- The BISEP™ also has a secondary leak tight pressure head mounted to the rear of the secondary seal.
- The BISEP™ had permanent hydraulic connection through the launcher. This would allow continuous safe venting of any primary seal bypass.
- The BISEP™ can accommodate back pressure to test the completed pipework.
- The BISEP™ can be utilised in conjunction with a Tecno Plug™ to allow hot tap fittings to be removed so removing the hazard of welding onto live lines and the long term security of split welded fittings.

STATS have developed a system, first used to remove an 18” dead leg for BP in the UK, where a mechanical hot tap clamp is used to provide a cold work branch. The clamp is a dual seal variety which allows the assembly on the pipe to be pressure tested. A hot tap machine and valve then generates a penetration in the pipe for the deployment of the BISEP™.

The BISEP™ is then deployed to provide double block and bleed isolation so facilitating the removal of the dead leg. Once the dead leg is removed, a temporary launcher complete with Tecno Plug™ is attached and pressure tested against the back of the BISEP™. This new verified boundary allows the BISEP™ to be removed leaving access to deploy the Tecno Plug™. The Tecno Plug™ is then deployed outboard of the mechanical hot tap clamp and set to provide Double block and bleed isolation.

The clamp and pipe with hot tap penetration can then be removed under the Tecno Plug™ isolation. In the 18” application there was a flange break immediately on the 36” by 18” tee allowing a quick and permanent solution. This Tecno Plug™ was designed with a mechanical lock and retention which allowed the plug to be abandoned in the branch and blinded behind it. The length of the plug was designed to fill the branch so effectively removing the dead leg.

![Figure 14: BISEP™ Deployment during testing](image-url)
The whole operation was conducted under cold work conditions with double block and bleed isolation throughout.

BISEP™ and Tecno Plug™ seals are rated for leak tight operation. The picture below shows a BISEP™ head where the seals were set on hot tap swarf and attained a leak tight seal. The swarf can clearly be seen on the BISEP™ seals.

Figure 16: BISEP™ head after successfully sealing on hot tap swarf
The competitive design with two lock and seal modules required half the pipeline pressure to be trapped between the seals. Operationally this makes testing both seals in situ to full pressure impractical. The loading on each module will also change as the pressure between the modules changes, potentially to an untested condition.

*Figure 17: Competition design with two lock and seal modules*

The volume between the modules at half the pipeline pressure (Orange in sketch) is significantly larger than the Tecno Plug™ and is only isolated from the worksite by a single seal.