Inline isolation technology to reduce methane emissions during pipeline repair and maintenance

Neil Mackay BEng CEng IMechE

STATS Group

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1 ABSTRACT

Operators can often encounter difficulties in isolating sections of their pipeline to facilitate essential safe repair or maintenance activities. Inline isolation pigs provide fully proven and monitored dual seal barriers that ensure the safe breaking of containment on pressurised systems in compliance with the highest industry standards.

Inline isolation tools significantly reduce, and in some cases eliminate, the requirement to vent or flare harmful emissions into the atmosphere during maintenance activities. One of the most significant environmental advantages is the substantial reduction in greenhouse gas emissions verses venting the pipeline. In the case of long, large diameter gas pipelines, this can prevent the potential discharge of thousands of tons of greenhouse gases into the atmosphere.

Following the completion of maintenance activities, a reinstatement leak-test of the replaced valve or pipework can be performed while the isolation is still in place, providing an alternative to golden welds.

A real-world example is discussed where a double block inline isolation tool facilitated pipeline modification, resulting in reduced project costs and production downtime, while significantly minimising the discharge of emissions.

The utilisation of inline isolation tools not only enhances the efficiency and safety of pipeline repair and maintenance but also aligns with increasing demand to reduce emissions and create a more sustainable energy infrastructure for the future.

2 INTRODUCTION

National Gas Transmission (NGT), formerly National Grid, own and operate the National Transmission System (NTS), the backbone of British Energy. The NTS feeds homes and businesses the essential gas required for everyday life in the UK. In 2023, for the first time NGT conducted an Isolation Joint replacement at the Lochside Multi-Junction Feeder 24 using STATS Remote Tecno Plug® (RTP) pipeline isolation pig, instead of traditional methods. The RTP provided a fail-safe, leak-tight double block and monitor isolation, keeping the 48” pipeline fully pressurised at 56 bar for 56km to the nearest block valve upstream. Crucially, the RTP has helped to reduce NGT’s emissions and will enable the undertaking of critical repair activities more responsibly, supporting them to achieve their net-zero ambition.

3 SOLUTIONS

3.1 OVERVIEW

Traditionally, an IJ replacement onshore would be conducted by isolating the pipeline section with available inline valves. This would be done during the summer months and by taking a short shutdown when demand is lower and/or where sufficient gas can be delivered to the area through alternative flow routes (Feeders). The isolated pipeline would then be depressurised by either;

- Venting gas in the isolated section to atmosphere
- Gas recompression (cross-compression) to 7 bar and then venting the remaining 7 bar to ambient
- Displacement to nitrogen using traditional pigging

Alternatively, if inline valves aren't available or the pipeline cannot be shutdown, the IJ can be locally isolated using line-stopping equipment with a short temporary bypass to maintain supply.

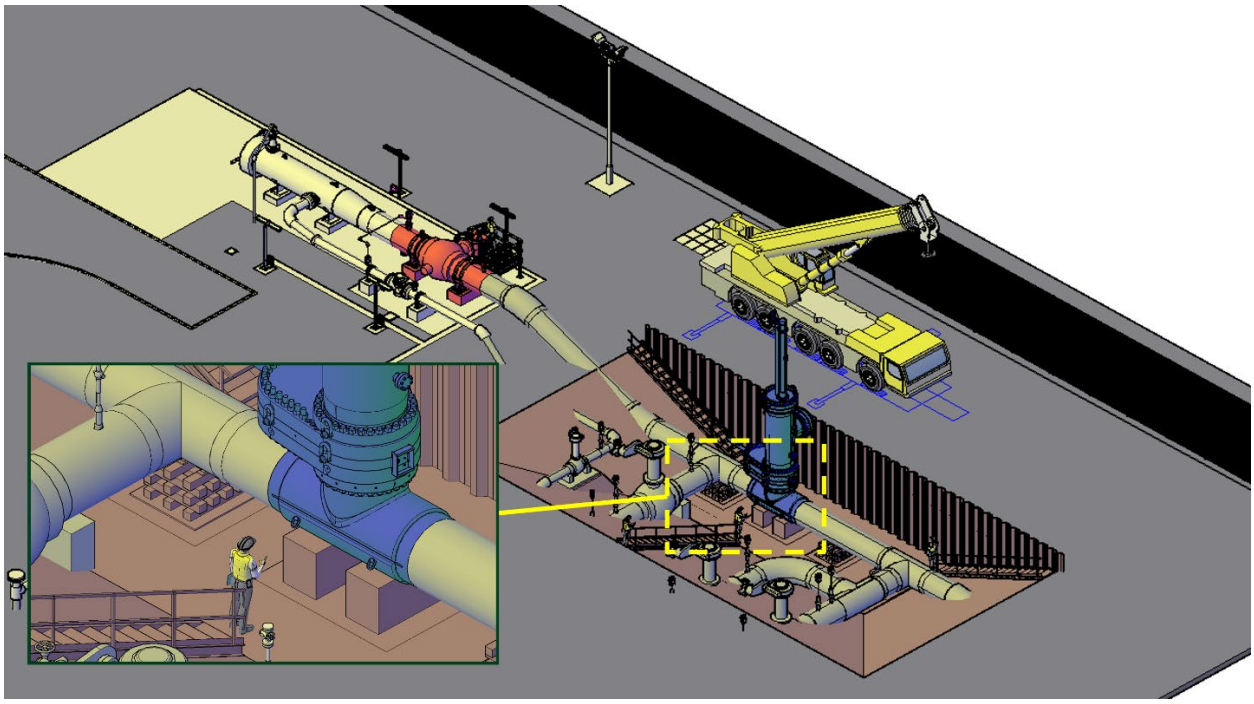
A summary of these traditional methods, developments in line stopping and an overview of the advent of in line isolation plugging are summarised in sections 3.2 to 3.6.

3.2 LINE STOPPING

Line Stopping is a two-stage process that starts with drilling (hot tapping) into the pressurised and usually flowing pipeline. Thereafter the line stopping tool is deployed through the hot tapped hole to initiate a temporary isolation.

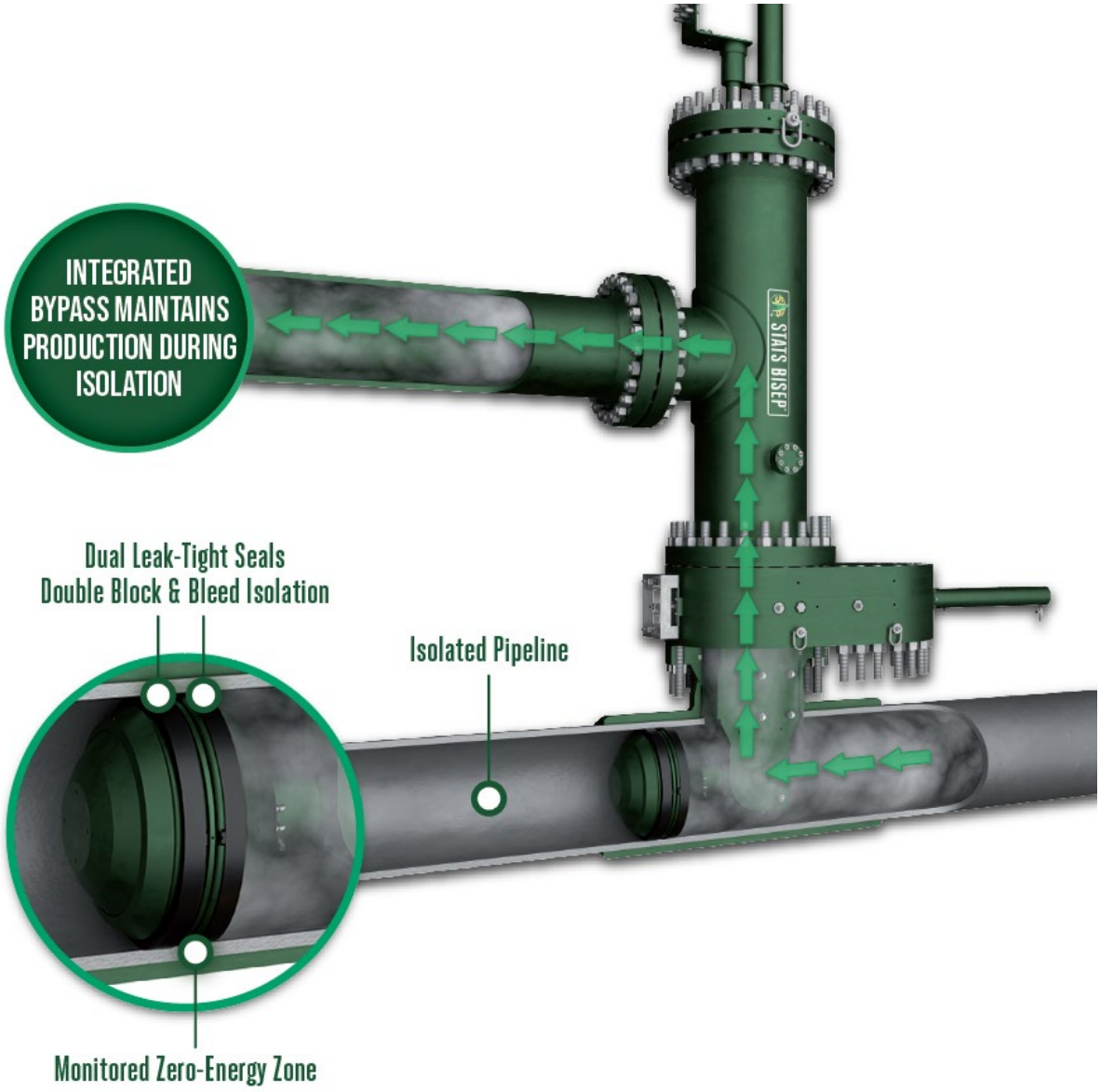
Line Stopping for IJ replacements is less common in onshore UK gas transmission due to costs and risks associated with excavations, in-service welding of tee's, hot tapping (drilling) and leaving buried flanged fittings behind which could become a future leak source. There is simply more equipment, personnel and work to be undertaken compared with isolation pigs. However, line stopping is particularly advantageous in either; mid-line repairs many kilometres from pigging facilities, non piggable or pig access constrained pipeline systems.

A "pig access constrained pipeline system" refers to a situation where pig trap isolation valves (indicated red in below image) are leaking, this leakage occurs at a rate that prevents the safe opening of the pig trap door. As a result, routine maintenance and Inline Inspection (ILI) pigging cannot be carried out. Additionally, Inline Isolation Pigs cannot be loaded, and line stopping is required to restore the pig trap to service by isolating the valve for repair or replacement (as shown below).



48" BISEP® Line Stopping Tool (blue) in use for a Pig Trap valve changeout (red), a technique also suitable for IJ replacements

Line stopping has developed over 70+ years and the latest technology on the market makes this option safer, more efficient and better for the environment than ever before. It provides the added benefit of a temporary bypass (if required) meaning the pipeline can remain operational (see below).



BISEP® with Integrated bypass to maintain flow while IJ's Valves etc are repaired/replaced

3.3 VENTING

National Gas report that ~11% of their total yearly emissions are from pipeline venting workscopes equating to ~542 tonnes of methane discharged[(1)].Venting the entire 48" Feeder 24 pipeline would equate to ~2215 tonnes of methane. While venting may still be used on smaller, lower pressure pipelines the sheer volume meant it was never seriously considered for the Lochside Multi-Junction IJ Replacement.

3.4 GAS RECOMPRESSION/CROSS-COMPRESSION

Gas Recompression Units (RCU) have been a valuable option onshore for National Gas and the Gas Distribution Networks for over three decades. RCU's, which are gas powered themselves, work by extracting gas from the isolated section requiring intervention for repair and reinjecting the gas back into an adjacent section. Currently the technology is limited to reducing the pipeline pressure to 7 bar

so the remaining gas is vented. At 7 bar this is not an insignificant volume totaling ~233tonnes of methane in Lochside 48" pipeline. And while figures like this have been vented in the past 'it is now paramount that all vented emissions are avoided or mitigated'[3].

National Gas Recompression Unit[2].

National Gas have invested and expect a new RCU to be commissioned in 2025 capable of bringing the pressure down to 1 bar. In pipelines of this scale 1 bar is not insignificant and thus National Gas have turned to the Remote Tecno Plug isolation pig technology to both reduce emissions and plan more essential workscopes where practical.

So why aren't RCU's used offshore? Simply this comes down to their footprint (they're mobile but transported via HGV on a 12m trailer) and the time taken to recompress. It takes a long time both to recompress the gas and then vent off from 7 bar to ambient, which would drive the economic case offshore quickly towards flaring or using pipeline isolation pigs which have been favored offshore now for decades. Existing facilities offshore also make it easy to flare the gas thus converting it to less damaging, but still less than ideal CO_2. Note that methane has a global warming potential 28x that of CO_2 over a 100 year period[3].

Back onshore, with only 3 Recompression units in National Gas' fleet and around 120 recompression projects completed last year, lead times for access to these units limits essential work that can be planned, further driving National Gas toward alternative methods such as the Remote Tecno Plug on piggable pipeline systems.

3.5 Nitrogen Displacement

Another popular method, Nitrogen displacement, involves pumping gaseous nitrogen by diesel driven heat recovery pumps or burner units to displace the hydrocarbon gas in the pipeline.

For this to be most effective it would be done using a standard batch pig(s) to reduce gas mixing and displace the pipelines initial contents in the least amount of time and cost of Nitrogen. This means usually working on the whole pipeline for access to the pigging facilities (assuming the line is piggable) as opposed to an isolated section (using mid-line valves).

This option is particularly attractive for smaller diameter pipelines where displacement is relatively quick, e.g. hours/days not weeks and there is an abundance of nitrogen pumping suppliers in the market.

However, on larger diameter/length pipelines (24” and above) such in the case presented in this paper (48”), there are less available nitrogen pumping suppliers with the equipment to perform nitrogen displacements optimally.

Even assuming pipeline hydrocarbon gas volume and pressure can be reduced by displacement into an adjacent system by diligent Operators with this option available to them, e.g. to ~10bar, the volume of nitrogen, time and size of temporary equipment spread make this less attractive, notwithstanding the risks of handling liquid nitrogen and the emissions from diesel drive pumps.

Furthermore, after the IJ/repair works are conducted and the pipeline needs to be returned to service, a reverse displacement of nitrogen to gas is required and for this, usually the line is packed with Nitrogen as a buffer for the pig to reduce risks of an inline projectile. Adding further to the time and cost.

3.6 Inline Isolation Pig

STATS Group’s Inline isolation pig, the Remote Tecno Plug (RTP) has been in use for over 26 years with hundreds of successful projects completed for many different Operators across the world but was used for the first time in 2023 and furthermore in 2024 by National Gas in the UK and new Operators adopting the technology each year.

The RTP is loaded and launched like a standard pig, only carefully tracked and stopped at the desired isolation location. It is set and tested providing a fail-safe double block and monitor isolation. This process takes <24 hours, keeps the pipeline gas in and at full pressure so the main advantages are time, cost and emissions saved verses the traditional methods aforementioned for this application.

The details and project specifics of how the technology was deployed for National Gas are explained in Section 4.

48” Remote Tecno Plug on Loading Tray at the Lochside Multi-Junction

4 THE PROJECT

4.1 OVERVIEW

The IJ located at National Gas' Lochside Multi-Junction Facility (~7miles north of Montrose, Scotland) was nearing the end of its design life and needed to be cut out and replaced. The IJ was located on the Feeder 24 pipeline (48", 55 bar, 56km) which transports gas south from St Fergus.

4.2 PRE MOBILISATION

Prior to first use and for technology approval, National Gas undertook a Formal Process Safety Assessment of the technology and the RTP pigging/deployment methodology. This was followed by a pigging Factory Acceptance Test (FAT) at STATS facility in Kintore, Aberdeenshire in a purpose-built test-fixture created to replicate the exact pipeline specification onsite. Finally strain gauging of the X65 and X80 pipe was performed at the locks and seals locations to ensure no plastic deformation during the at MAOP conditions, covering common National Gas scenarios as well as on site at ~40% reduced pressure. This is not usually required as STATS carry out a pipe stress analysis, but NG needed reassurance for technology approval. Macro photography and measurements of the lock mark indentations left behind after setting of the tool was also taken and National Gas concluded that long term effects of these indentations on their pipeline system were negligible.

4.3 ISOLATION LOCATION

The IJ was located within the Multi-Junction fence and placement of the RTP around the fence boundary was discussed. Since the RTP can be tracked, set and monitored through ground without the need to excavate the pipe, the fence location would have been suitable under normal circumstances. However, with the strain gauging requirements for this first deployment a pit was required and unfortunately a ravine on the other side of the fence made excavation of a suitable pit unfeasible from a construction safety standpoint. The RTP therefore and unusually needed to be pigged ~280m into a nearby field/pit location.

4.4 PIGGING AND TRACKING

The RTP was launched on this project with readily available gas from an adjacent pipeline (Feeder 13) at slight overpressure which was cheaper, easier and safer to manage for National Gas than a temporary nitrogen spread over the pigging distance. The pressure in the adjacent Feeder was increased by National Gas to 5-7 bar above the pipeline to be isolated, to provide suitable propulsion (dP) for the RTP with contingency. The RTP was pigged at ~2m/min which was managed efficiently by National Gas using two plug valves in series on existing pipework, reducing the risk of commissioning, or operating a temporary equipment spread. These pigging velocities are much slower than regular pigs or inline inspection (ILI) tools, ensuring precision placement at the isolation location. This was particularly relevant on this scope for positioning at preinstalled external strain gauge locations (as part of the National Gas RTP approval process).

The RTP was accurately tracked throughout the pigging operations into and out of important features such as valves and bends using the onboard beacon function and magnetic pig signalers setup at strategic points (downstream of the valve, ground/below ground transition and downstream of the set location) on the pipeline for backup.

4.5 Setting, Testing and Purging

Once the plug reached the isolation location pigging was halted and the plug was commanded to hydraulically activate engaging the locks and dual elastomer seals against the pipe wall. The locks mechanically restrain the tool in the pipeline and the dual seals provide a double block and monitor isolation.

Once the pipeline was depressurised back towards the pig launcher/receiver the plug becomes self-energised by differential pressure, making it 'fail- safe' in the event of a failure of the plugs internal hydraulics. Each seal is individually tested to confirm a leak-tight isolation, and an isolation certificate was issued by STATS confirming it was safe to break containment. The annulus (void) between the seals was continuously monitored for pressure build-up.

48" IJ Removal

Clamshell Cutting Operation complete, 48" IJ Removed

Once the 48" IJ replacement scope was completed, and the 'golden weld' results were confirmed, the pipeline section was purged with Nitrogen, pressure across the plug was equalised and the tool was hydraulically unset, removing the locks and seals from the pipewall. The RTP was then pigged back towards the launcher/receiver in a controlled manner using pipeline gas and by depressurising the pipeline at the launcher / receiver. The RTP is designed and engineered to ensure that it will not swage

the pipe, leaving only minimal lock mark indentations behind (typically 0.1-0.5mm), this has been independently verified to confirm they will not lead to future corrosion or integrity issues.

While golden welds are the common approach in onshore gas pipelines to date in the UK, it is also common practice with inline isolation plug technology to add a leak test module to the RTP train and use it as a hydrotest barrier. The leak test module faces the worksite (IJ + new welds) while the standard RTP maintains its leak tight double block and monitor isolation against the pipeline gas. The leak test module is separately operated.

4.6 CHALLENGES

National Gas purged gas to nitrogen to air before breaking containment, which took longer than expected (~2 weeks) due to suspected condensate in the low point (ravine). This was a project specific issue which is unlikely to occur on future deployments and was due to the nature of the pipeline topography in proximity to the site between the RTP and the pig launcher/receiver and the unusual requirement for an excavation at the isolation location.

Following review of a manufacturing drawing it was discovered that one of the tee's on the pigging route was oval due to poor manufacturing, luckily this was picked up during detailed engineering and cross checked with ILI caliper data. The RTP was adapted to ensure the hard OD of the plug in the unset condition could traverse the tee resulting in successful execution first time.

5 SUMMARY

Venting, recompression, nitrogen displacement and line stopping operations onshore will continue to be used in the future, however, following the success of this project, National Gas now have another qualified option in the toolbox, with the Remote Tecno Plug.

This case history was presented not to showcase technical challenges and lessons learned but instead to highlight the benefits of this technology, in terms of efficiency and emissions savings;

- It took ~24 hours to install, pig, set and test the plug, saving significant time verses traditional techniques.
- Emissions were reduced 24x, discharging 9.5tonnes of gas (plug) vs. 233tonnes (recompression).
- Gas not discharged using the RTP was the carbon equivalent of switching off 1760 gas boilers for a year or 5,930,000 miles in a ford fiesta, which is the equivalent of removing ~1000cars off UK roads for a year.
- Sales value of gas not vented (saved) by using the plug equated to £125K.

In recognition of the emissions savings and the first use of the RTP on the NTS, STATS Group received the 'Project of the Year' Award from the Institution of Gas Engineers and Managers (IGEM) in 2024.

6 FUTURE WORK

Onshore in the future, especially if legislation becomes stricter relating to greenhouse gas emissions for pipeline operations and maintenance, despite some additional time and cost, new technologies will be deployed to reduce emissions to as low as reasonably practicable.

For example, low pressure/volume vacuum/recompression units much smaller than National Gas' planned 1 bar RCU's could be deployed for pigging activities. These units prevent hydrocarbon gas discharge during launching/receiving activities and have already been deployed successfully in North America in conjunction with STATS line stopping equipment for near emission less midline pipeline isolations.

7 FINAL THOUGHT

The United Nations Environment Programme global methane emissions report states that existing technologies can reduce methane emissions by 30% by 2030. The greatest potential for cost saving is in the oil and gas sector, where captured methane adds to revenue instead of being discharged to atmosphere[4].

The technologies the UN refer to don't require innovation funding or development and have an existing track record. These technologies are available now and can have a real impact, technologies like the Remote Tecno Plug (10"-56") and the BISEP (3" to 56"). Both tools are DNV Type Approved and available for use onshore and offshore.

8 ANIMATION

For an animation of the project case study presented in this paper please refer to the following link:

Lochside Multi-Junction

9 REFERENCES

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