ENHANCED PERFORMANCE BACK-CHECK TECHNOLOGY FOR GAS LIFT VALVES

Stephen Bisset, Flowco

Matthew Gautreau and Tommy Hunt, JMI

ABSTRACT

Effective back-check performance is critical in gas-lift systems to prevent reverse flow during injection shut-in. As well-integrity requirements strengthen, operators require barrier solutions that do not impede unloading efficiency or gas-lift performance.

This paper presents a Patented, barrier-rated 1-inch back-check system engineered to maximize flow capacity while delivering reliable reverse flow isolation. The design increases flow area and positions the check mechanism outside the primary flow stream during injection, protecting it from solids and erosive flow while maintaining low pressure drop and high injection efficiency.

Performance verification using CFD-based flow path optimization, pressure and temperature qualification testing, erosion and solids-tolerance testing, extended cycling and flow endurance trials, and successful field runs. Achieved all acceptance criteria for seal integrity, pressure-drop performance, and actuation reliability.

This technology builds on the proven 1.500-inch platform originally developed for wireline retrievable applications and further development with double-barrier mandrel systems, which established the benchmark for redundant well-integrity protection in gas-lift completions. The 1-inch design utilizes that barrier-qualified back-check technology, delivering high flow efficiency and reliable isolation performance without reliance on a dual-valve mandrel configuration.

This development sets a new standard for flow-efficient, barrier-qualified gas-lift performance in modern completions.

Introduction

API 19G2 is the industry standard, governing flow-control devices installed in side-pocket mandrels. Within gas-lift valves, the primary flow-control component is the reverse-flow back-check, which performs two critical functions. First, it must prevent the backflow of produced fluids into the injection conduit—whether annulus or tubing—depending on the production regime. Second, it must allow the efficient flow of injection gas to support effective unloading and continuous gas-lift operation, directly impacting well productivity.

A long-standing challenge in gas-lift systems has been designing back-check mechanisms that can withstand erosive injection flow while maintaining reliable sealing performance during shut-in conditions. More recently, increased emphasis on well-integrity and barrier compliance has expanded this challenge to include prevention of reverse gas flow into the injection conduit. In response to these evolving requirements, API 19G2 was updated to include V0 validation criteria, aligning gas-lift back-check performance with industry barrier-qualification standards.

While API 19G2 has traditionally focused on wireline-retrievable devices—most commonly 1.500-inch valves used in international and offshore applications—the domestic land market predominantly relies on 1-inch tubing-retrievable gas-lift systems. This paper describes the transition of a barrier-qualified back-check design from a proven 1.500-inch wireline-retrievable platform to a 1-inch tubing-retrievable system, addressing domestic market requirements of maintaining flow efficiency, erosion resistance, and barrier performance.

Back Check Technology Description

Across the global oil and gas industry—particularly in international offshore operations—there has been an increasing emphasis on strengthening the ability of downhole components to act as positive barriers, preventing the uncontrolled release of fluids and gases from the flow conduit into the surrounding environment.

Over the past two decades, API standards have progressively tightened to incorporate V0 validation requirements, which address the prevention of gas leakage across the designated barrier within a component’s design. Most recently, API 19G2—covering flow-control devices installed in side-pocket mandrels—was revised to include V0 validation requirements. ***V0 qualified devices have become a standard operator requirement for deepwater developments, North Sea operations, and other high-profile projects. This new device enables deployment of a barrier-qualified check valve across a broader range of applications where service conditions demand high mechanical integrity and resistance to severe operating environments, while preserving a streamlined internal flow path that maintains GLV performance.***

One of the primary challenges in achieving an efficient back-check design for gas lift valves that complies with V0 requirements is the impact of erosive flow on the check mechanism and seat. The standards-mandated requirement for repeatable sealing performance has historically been compromised by erosion of the check dart and seat surfaces. The most effective way to address this limitation is to remove the check dart from the primary flow path during injection through the valve, or to increase the flow area around the check dart.

Figure 1 presents the CFD analysis of the revised back-check design. Compared with the previous tortuous flow path, which created a bottleneck at the check dart, a streamlined geometry has been used that has an increased flow area around the check dart, as further highlighted in Figure 2 (section A-A).

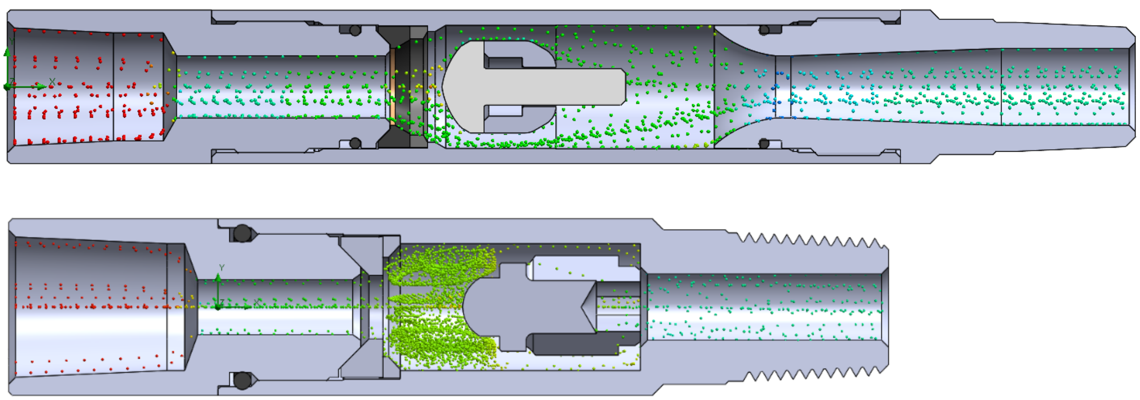

Figure 1: CFD Analysis on revised back check mechanism

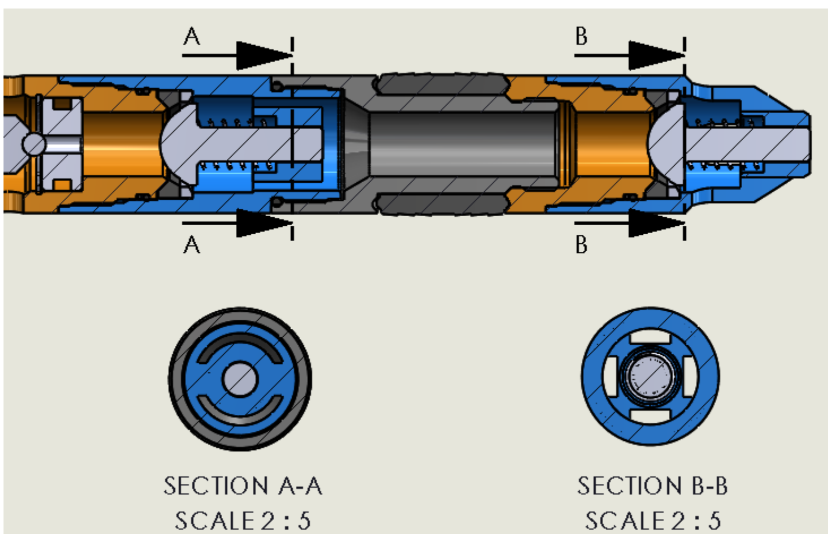

Figure 2: revised check design with double back check

The improved mechanism geometry addresses both key functions by redirecting flow around the check dart, thereby reducing erosive effects, while also lowering the pressure drop across the valve. As shown in Figure 3, the increased effective flow area allows for the inclusion of a secondary back check in the 1-1/2” wireline retrievable valve without adversely impacting erosion resistance or pressure drop. The revised design ensures that, when injection is paused, the back check is activated with only a minimal differential pressure requirement.

Performance Verification and Testing

The 1-1/2 in. wireline-retrievable valve was successfully validated to the V0 grade in accordance with API 19G2. To achieve V0 classification, the valve assembly must first meet the requirements of V1 validation. Following this, the back-check assembly must be independently tested and validated to the V0 standard.

The back-check V0 testing program, as defined in API 19G2 (2nd Edition), Annex H, must be completed on a single device. The same device is required to successfully pass each test in the prescribed sequence. It should be noted that several major test stages are subject to repeated application in accordance with the program requirements

Major Testing Points

The V0 validation program was conducted in accordance with API 19G2, 2nd Edition, Annex H. The major testing stages included:

1. Low pressure (100 psi), ambient temperature, liquid test medium.
2. Maximum pressure (10,000 psi), ambient temperature, liquid test medium.
3. Low pressure, maximum temperature (300°F), liquid test medium.
4. Maximum pressure, maximum temperature (300°F), liquid test medium.
5. Low pressure (100 psi), ambient temperature, gas test medium.
6. Maximum pressure (10,000 psi), ambient temperature, gas test medium.
7. Low pressure, maximum temperature (300°F), gas test medium.
8. Maximum pressure, maximum temperature (300°F), gas test medium.
9. Liquid erosion testing at a flow rate of 1.5 bbl/min for a total volume of 600 bbl.
10. Gas flow testing began at 176.5 MMSCFD, increasing in 176.5 MMSCFD increments every five minutes until a maximum flow rate of 3.5 MMSCFD was achieved (20 flow-rate increments).
11. One hundred consecutive one-minute gas flow cycles at 3.5 MMSCFD, with each cycle initiating from zero flow and reaching the target rate.
12. Continuous gas flow for 24 hours at a constant rate of 3.5 MMSCFD.
13. Flow activation testing requiring the RFPD to activate within 25 psi of the applied pressure.
14. Mechanical function testing to confirm the dart repeatedly seated and unseated without external interference (gravity effects only).

Testing Results

A single device successfully completed and passed all testing criteria in the required chronological sequence, in full compliance with API 19G2, 2nd Edition, Annex H.

System Evolution

Following the successful validation of the 1-1/2" valve and back-check assembly, the decision was made to extend the barrier technology by incorporating a secondary back-check system into the valve mandrel.

Historically, side-pocket mandrels have presented challenges related to backfill during valve changeout operations. The industry has addressed this issue through various methods; however, the selected solution was to integrate a secondary set of back checks directly into the side-pocket mandrel to prevent backflow during valve retrieval and replacement (Figure 3).

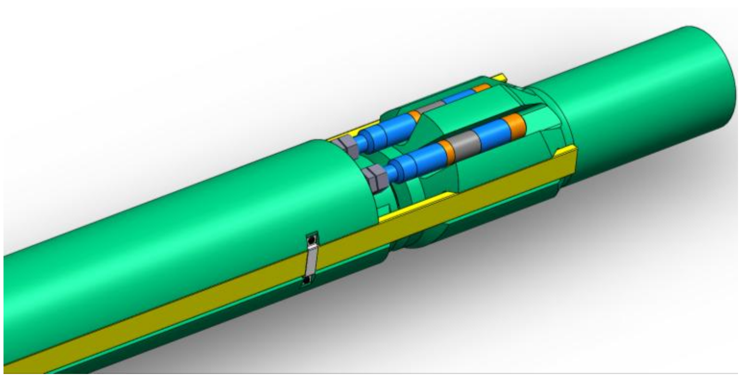

Figure 3: External Back Checks on Side Pocket Mandrel

Because these additional back checks were incorporated into the external diameter of the mandrel, careful consideration had to be given to the overall system running OD. To maintain dimensional compatibility, the back-check assembly was downsized to a 1 in. design.

Applying the same design philosophy proven in the 1-1/2" back-check configuration, a 1" check valve was developed to deliver equivalent barrier performance within the reduced dimensional envelope.

Field Experience

Hydraulic fracturing of tight shale formations in the United States has been the primary driver of domestic oil production over the past two decades. Unconventional wells in plays such as the Permian Basin of West Texas and New Mexico have relied heavily on various forms of artificial lift to sustain production.

The fracturing process that enables these wells to produce also results in high initial water cut due to the recovery of injected frac fluids. Early production commonly contains significant solids, including sand and proppant.

Following completion, as the well transitions from natural flow to artificial lift operations, these wells typically undergo a period of natural flowback. Depending on completion design and operating strategy, this flowback may occur through the tubing, the annulus, or a combination of both.

The combination of high-velocity flow and entrained solids during this period creates highly erosive conditions. When artificial lift systems are subsequently introduced, the residual erosive environment can cause significant damage to downhole equipment. In gas lift applications, flow directed through the valve and back-check assembly can erode internal components, often resulting in irreversible damage to the back-check mechanism.

Industry Challenge and Design Objectives

Gas lift equipment used in the U.S. onshore market has historically been constrained by casing size and drift diameter limitations. The most common casing size, 5-1/2” restricts the tubing sizes that can be deployed to a range of 3-1/2” down to 2-3/8” In addition to tubing size, the outside diameters of downhole components—particularly gas lift equipment—must also be considered. As a result, 2-7/8” tubing is most commonly selected to balance mechanical clearance and operational flexibility.

These dimensional constraints significantly limit the available gas lift valve options, effectively restricting installations to 1” valves for both 1-1/2”. And 1“ gas lift valves, a primary design challenge is the reduced flow area through the valve. The maximum port diameters for these valves are approximately 0.500”. and 0.312” respectively, creating a bottleneck that restricts gas throughput.

This limitation is further compounded by the requirement for backflow prevention via an internal check valve. Over the service life of a typical gas lift valve, the internal components are exposed to high-velocity flow containing gas, liquids, and solids. Such conditions can lead to erosion of the valve internals, particularly the back check mechanism. This flow-induced loading can significantly degrade the back check’s ability to reliably prevent backflow when injection is shut in.

A further consequence of the reduced flow area is an increase in pressure drop across the valve. Pressure losses within a gas lift system are cumulative and therefore directly translate to higher surface injection pressure requirements. In U.S. land completions, where installations commonly include between 8 and 20 gas lift valves—and where many operators elect to run dual back-check configurations—these cumulative losses can significantly increase the required surface injection pressure.

1" Back Check testing for field application

As previously noted, the 1 in. back-check design was developed as an evolution of the original 1-1/2 in. valve that achieved API 19G2 V0 validation. All initial qualification and validation testing was conducted on the 1-1/2 in. model.

To demonstrate suitability for unconventional field applications, a dedicated erosion testing program was developed and executed at an independent third-party facility.

The test program consisted of a series of flow tests conducted at varying rates using a sand-laden slurry, followed by back-check pressure integrity testing. Figure 4 illustrates the test apparatus utilized, while Figure 5 presents representative return samples of the test fluid collected during the program.

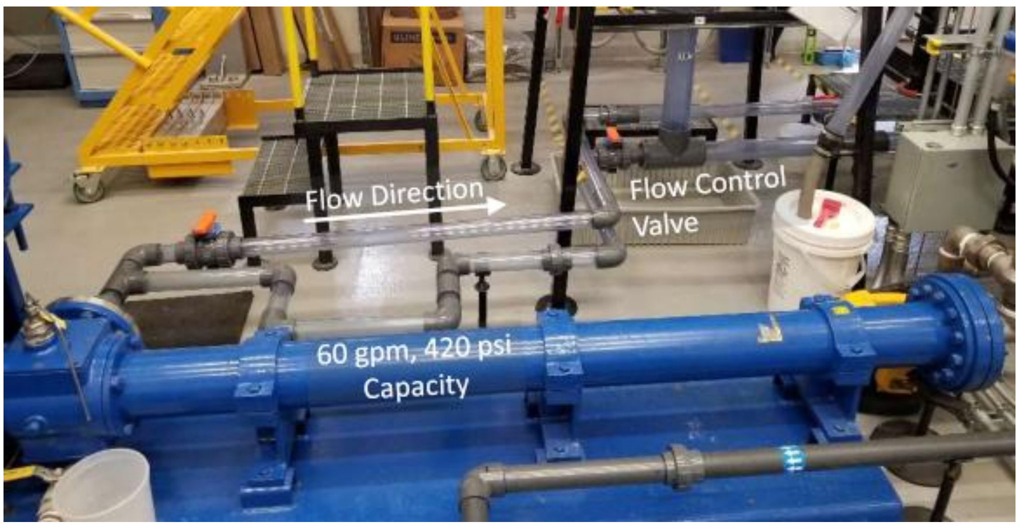

Figure 4: Flow Loop Test Apparatus

Figure 5: Hourly Return Samples

Test Procedure

400 bbl preliminary flow test using fresh water at 1 bbl/min.

400 bbl flow test using a 1% sand slurry at 0.6 bbl/min.

400 bbl flow test using a 1% sand slurry at 1.0 bbl/min.

After each sand slurry cycle, the system is flushed with fresh water before conducting a 200 psi back-check pressure test.

Throughout the test regime, the valve is monitored for its ability to withstand erosive flow, operate continuously without intervention, and maintain sealing integrity once in the closed position.

After each back-check test, the valve was disassembled and inspected. All wear and material damage were documented before proceeding to the subsequent testing stage.

Summary of Test findings

Multiple design configurations were evaluated, incorporating different check adapters, darts, and housing geometries to compare performance against the CFD models used during development.

The latest design iteration demonstrated an upstream pressure of less than 150 psi at 1 bbl/min during sand slurry flow. The selected geometry has proven capable of withstanding the severe erosive conditions imposed during testing.

The improved flow path, developed through CFD analysis, streamlines fluid movement to minimize erosive impact on the dart while protecting the primary sealing surface. The check pad is further safeguarded through the use of a proprietary check washer.

Increased material mass at the nose of the check dart has shown significant value in enduring extreme erosive conditions while continuing to divert flow around the 360° sealing surface located nearer the outer diameter.

Additionally, a venturi-style check adapter positioned downstream of the dart mechanism has been incorporated to promote smoother flow, reduce restriction, and minimize back pressure acting on the dart during injection.

Conclusion

This paper demonstrates how the successful design of an API 19G2 VO–qualified back check system, originally developed for use in a 1-1/2” wireline retrievable valve, can be effectively adapted for additional applications.

The design was first extended to function as a secondary barrier within a side pocket mandrel during barrier valve change-out operations. This secondary back check prevents unintended fluid or gas backflow, thereby protecting the annulus from unexpected wellbore events. To meet side pocket mandrel drift requirements, the design was further optimized and converted to a 1” configuration while maintaining barrier integrity.

Subsequent demand for improved erosion resistance in gas lift valves within the domestic U.S. land market led to broader application of the 1” back check design. Computational Fluid Dynamics (CFD) analysis was utilized to refine the internal flow path, significantly mitigating the effects of erosive flow. An additional benefit of the optimized geometry is a reduction in pressure drop across the back check.

Historically, it has been common practice in the domestic market to install two back checks per gas lift station to provide redundancy. While effective as a backup barrier, this approach increases overall system pressure drop. The revised barrier check design retains its barrier-rated heritage while providing sufficient protection to justify a single back check configuration. The resulting reduction in pressure drop lowers overall injection pressure requirements and contributes to improved surface compression efficiency and system optimization.