

Make Better Decisions

Get critical knowledge through non-intrusive monitoring during fracture operations

At the intersection of precision, reliability, efficiency and cost, pressure and pump charts have been the best compromise in monitoring downhole operations. When uncertainty arises, hours or days can often be wasted on trial-and-error methods to solve operational problems.

Additional operational or downhole data can be gathered using microseismic, tracers, or cameras, but not all of these can be used concurrently with standard operations, and furthermore, they are generally too costly or time consuming to use on every well.

Finally, there is technology available that allows operators to acquire that data at a minimal cost. The ePLUS[®] Retina[™] monitoring system is a cost-effective way to verify downhole events and completion system operations, independently from other measurements. Using Retina, operators can troubleshoot quickly and effectively with accurate information during stimulation operations.

OVERVIEW

Lost stages correlates directly to lost production and ultimately, lost revenue. Similarly, shift sleeve malfunctions or ball failures during fracturing operations result in lower production and lower ultimate recovery.

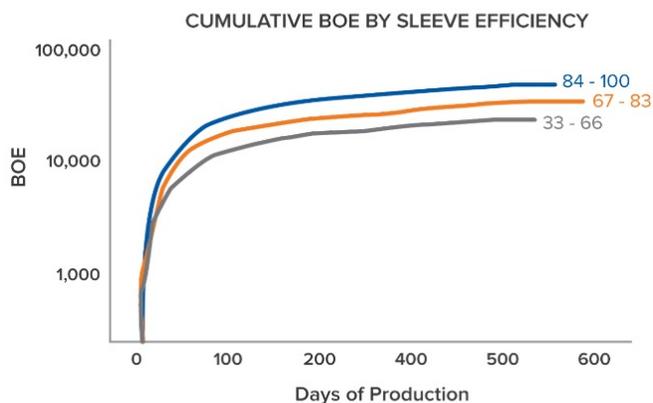
This was demonstrated in a U.S. Midcontinent¹ study, showing that successful ball seat landings correlate to higher production.

Specific downhole events during completion operations have been correlated to distinct pressure signatures, such as a ball landing on seat or a port sleeve shifting.

However, many operations are not associated with pressure, such as ball launches, or perforation charge detonation.

The Packers Plus ePLUS Retina monitoring system is an innovative technology that uses a proprietary array of sensors to collect and analyze signals from multiple locations on the wellsite. This portable system operates independently from conventional measurement equipment, without interfering with concurrent surface or downhole operations.

The Retina user interface combines real-time measurements from two different types of sensors: acoustic and pressure. A sampling rate of 10,000 data points per second offers more detail and accuracy than standard data van readings, providing operators with real-time confirmation and confidence in key decisions.



Completion systems showing 84-100% sliding sleeve shifting efficiency achieved higher cumulative production—estimated \$2.4 million per well of incremental revenue.

¹ Van Sickle, S. et al. 2015. Economic and Operational Analysis of Systematically Deploying New Technologies in Two US Unconventional Plays. SPE 176984.

A better understanding of downhole operations can improve critical decisions, which affect a wide range of operations, and save valuable time and resources on site. Potential benefits of Retina include:

- Improving safety
- Increasing multi-stage stimulation efficiency
- Verifying millout operations

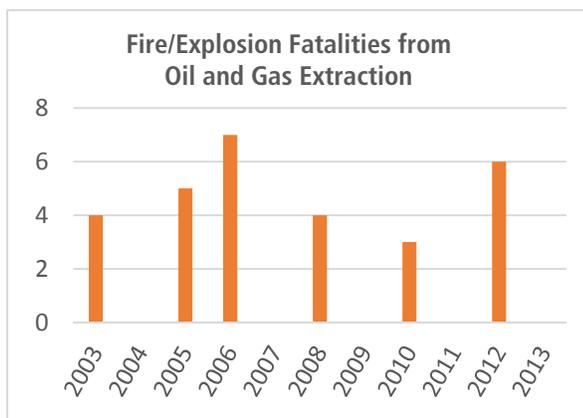


Connectivity between the wellhead, Retina data acquisition box, data van, and Retina laptop.

IMPROVE SAFETY

From oil and gas extraction activities in the United States alone, 28 fatalities occurred between 2004 and 2014 due to fire or explosion². The wellhead is a dangerous area where these incidents can happen, due to high pressure, explosive potential, or sour gas. This area of the site is often called the red zone.

During plug-and-perf completions, real-time verification of charges detonating is valuable information. Perforation guns that do not detonate as expected are a major safety risk, particularly when they are brought to surface to be defused manually. Charges may fire unexpectedly if there are problems with the wireline.



In post-stimulation operations, confirming ball recovery and monitoring debris flowback is also valuable safety information. These confirmations reduce the need for personnel to enter the red zone and reduce the risk of accidents.

² U.S. Bureau of Labor Statistics

INCREASE MULTI-STAGE STIMULATION EFFICIENCY

Pressure signatures can be unclear because of low bottomhole pressure, varying pump rates, or low data acquisition rate, while other events are not detected using pressure. This results in an incomplete picture of completion operations.

A ball launch is a surface event that is not detected with pressure measurements. Automatic ball launchers are commonplace for multi-stage, ball-drop completions. While ball launchers are meticulously set up and verified multiple times, the ball launch event has no direct indicators—that is, the ball leaving the apparatus and moving down the wellhead cannot be verified. This event is only confirmed later with a pressure increase resulting from the ball landing on the seat.

Fluid can be wasted to flush the ball in cases where balls are frozen to the launcher (during winter operations, for example) or stuck for other reasons, such as debris in the fluid.

A ball launch can be seen distinctly on Retina charts. By eliminating issues regarding surface events and providing verification of surface events with accurate, real-time information, operators can troubleshoot effectively and eliminate hours or days of trial and error problem solving.

VERIFY MILLOUT OPERATIONS

In post-stimulation operations, operators can confirm ball recovery during flowback, or identify a milling motor stall or burnout. Motor stalls can occur if fluid circulation is lost, if jets are plugged, or if the torque is too high. When multiple balls have been launched for one stage, millout can be a challenge.

Operators can use Retina to verify that flowback and millout parameters are achieving the desired results.



Multiple balls spinning during millout.

CASE STUDIES

Charge Detonation

Retina sensors are intrinsically safe and rated for use onshore or offshore in Zone 1, commonly known as the red zone.

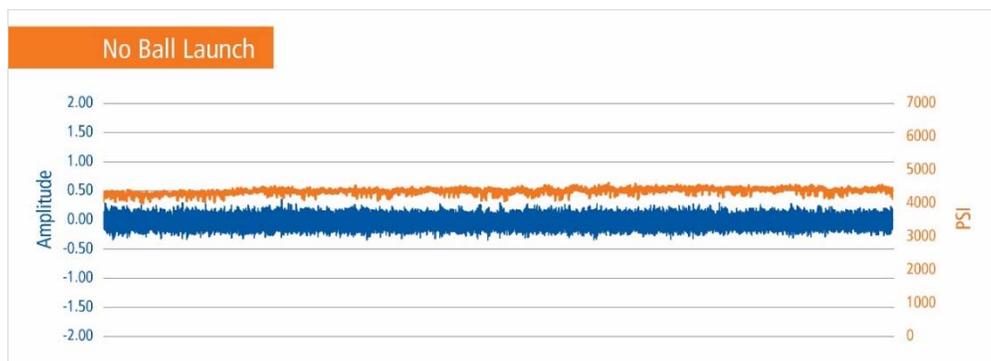


6 detonations in a perforation cluster captured by Retina (pressure data removed for clarity).

On a plug-and-perf completion in the Anadarko basin, Retina sensors recorded the detonation of a cluster of charges occurring within 2 minutes. This provided the operator with valuable certainty, in real time.

Ball Launch

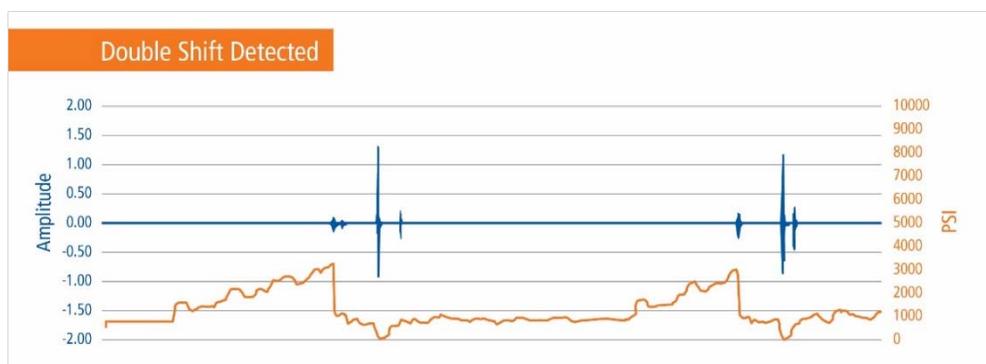
During stage 5 of a 16-stage completion in Texas, ball launch and seat indications were not seen by either the data van or Retina.



No ball launch or seat signatures.

Not wanting to spend time shutting down operations and taking the wellhead apart to confirm the ball launch, the operator proceeded to stimulate the well as if the ball had landed. When the ball for stage 6 was launched, it dislodged the stage 5 ball that was still in the launcher. Both balls traveled down the wellbore, landing and shifting stage 5 and 6 just 45 seconds apart. The 2 events for each stage were clearly captured by Retina.

From this information it can be inferred that Stage 4 was stimulated twice, and stage 5 not at all. Moreover, the cost and revenue lost in one of 16 stages is significant. With estimated drilling and completions expenses of approximately \$5 million, each stage costs \$312,500. Potential revenue from production is also lost, and reserves in the field remain untapped.



Double shift event resulted in a loss of \$312,500, not including revenue from lost production.

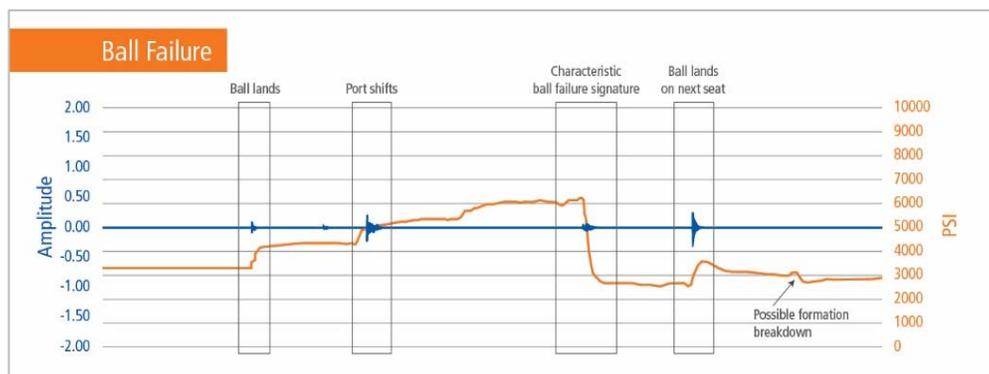
Sleeve Shift and Ball Seal Verification

Retina has been used to confirm ball seating and sleeve shifting events in a variety of ball-drop completion systems. During a third-party ball-drop completion, several actuation balls were verified to have extruded through the seat.

In each instance, the failure was seen as an abrupt decrease in pressure along with a Retina acoustic indication. This form of dual verification is only possible using the sensitive instrumentation specifically developed for Retina.

A ball failure results in a missed stage, and overall production is lost if the failure is not identified and the stage is left untreated.

Historically, operators have had to guess or spend time interpreting whether a lack of pressure was due to a sleeve not opening, a ball not seating, or a missing pressure signal. Using Retina, it is possible to verify any or all of these scenarios and take corrective action, removing guess work and eliminating costly delays during fracture operations.



Characteristic ball failure signature, followed by indication of ball landing on the next seat.

High Sampling Rate Detects Sleeve Shift

During a completion in the Granite Wash formation in Texas, a ball landed on the seat and shifted the sleeve, but was not detected by the data van.

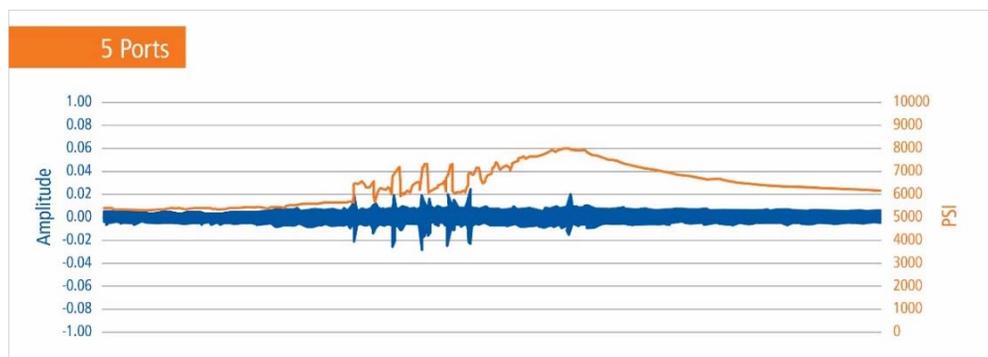


Retina shows the ball landing on seat and shifting, both within 0.4 seconds. The pressure signature was not seen in the data van.

Retina's high resolution sampling rate captured the events, showing that they both occurred within 0.4 seconds. This confirmation allowed the stimulation to continue without downtime.

Cemented Limited Entry Stimulation

Retina was used to monitor a cemented limited entry ball-drop stimulation in the Sooner Trend of the Meramec formation in the U.S. Midcontinent region. The Retina signatures gave the operator confidence that all sleeves in each stage were open before pumping the treatment.



Retina confirms the ball actuating 5 ports.

High Stage Count Ball-Drop Stimulations

An operator working in the Bakken completed a 49-stage and a 50-stage well in North Dakota, using Retina to monitor both completions.

The high stage count of these completion systems were accomplished with non-standard ball and seat size increments of less than 1/16". To mitigate extremely tight tolerances and the possibility of seat erosion, an anti-erosion coating was applied inside the tools.

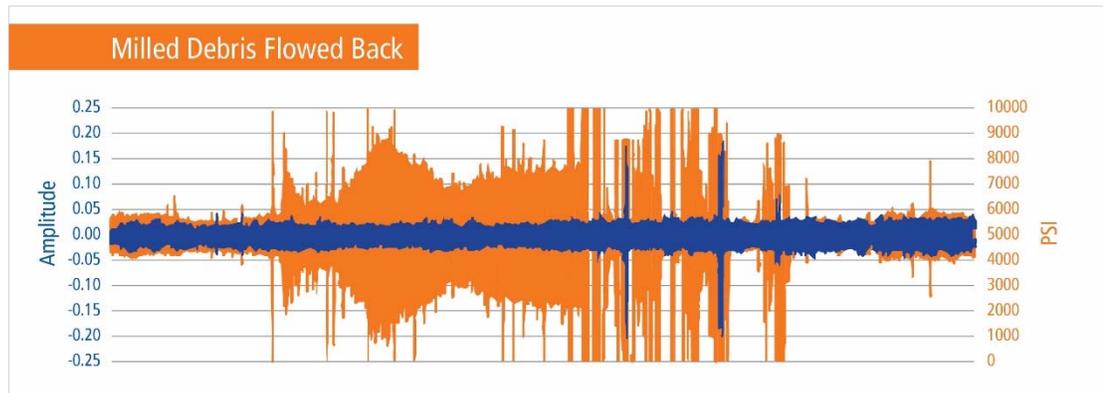
Completion System	Pumping Hours	Lateral Length (ft)	Fluid (bbl)	Proppant (million lb)
50-Stage	50	9,660	73,600	5.2
49-Stage	52	9,682	69,900	4.9

Retina confirmed a 100% success rate for each ball launch, ball seat, and sleeve shift event. The 49 stage and 50 stage completions were done quickly, averaging one stage per hour.

Post-Stimulation Operations

Retina was used to monitor cleanout operations from a plug-and-perf completion in the Permian Basin, detecting:

- The mill functioning
- Proper circulation and debris flowback
- Indication that a debris-filled sweep was flowing to surface



During milling operations, milled debris was observed flowing back using Retina. This information indicated that a sand-filled sweep was returning to surface.

The monitoring process also lowered safety risks, since the plug catcher in the red zone did not have to be continually monitored.

CONCLUSION

Stakes are high during on-site operations. Operators want as much information as possible to be able to run a completion efficiently, and troubleshoot problems effectively and immediately, with minimal downtime.

The goal of Retina is to foster an environment for confident decision-making to save time and costs. Retina offers benefits in addition to visualizing well operations, including:

- **Improving safety:** By verifying perforation and millout events, workers have fewer reasons to be in the red zone
- **Increasing accuracy and lowering costs:** Detecting events with exact timing allows operators to both troubleshoot more effectively, and optimize completions by using fewer resources
- **Reducing uncertainty:** Independent confirmation lowers operational risk and gives operators the confidence to make decisions

Retina has successfully monitored over 60 operations, both onshore and offshore.

FURTHER RESOURCES

Packers Plus is a completion technology company dedicated to providing high quality solutions that work the first time. To this end, Packers Plus offers systems for a variety of applications, including cemented liner, open hole, and high pressure and high temperature applications.

Packers Plus' knowledgeable and experienced specialists have been dedicated to providing customized solutions for clients around the world over 15 years.

Explore more solutions, case studies, and news at packersplus.com.