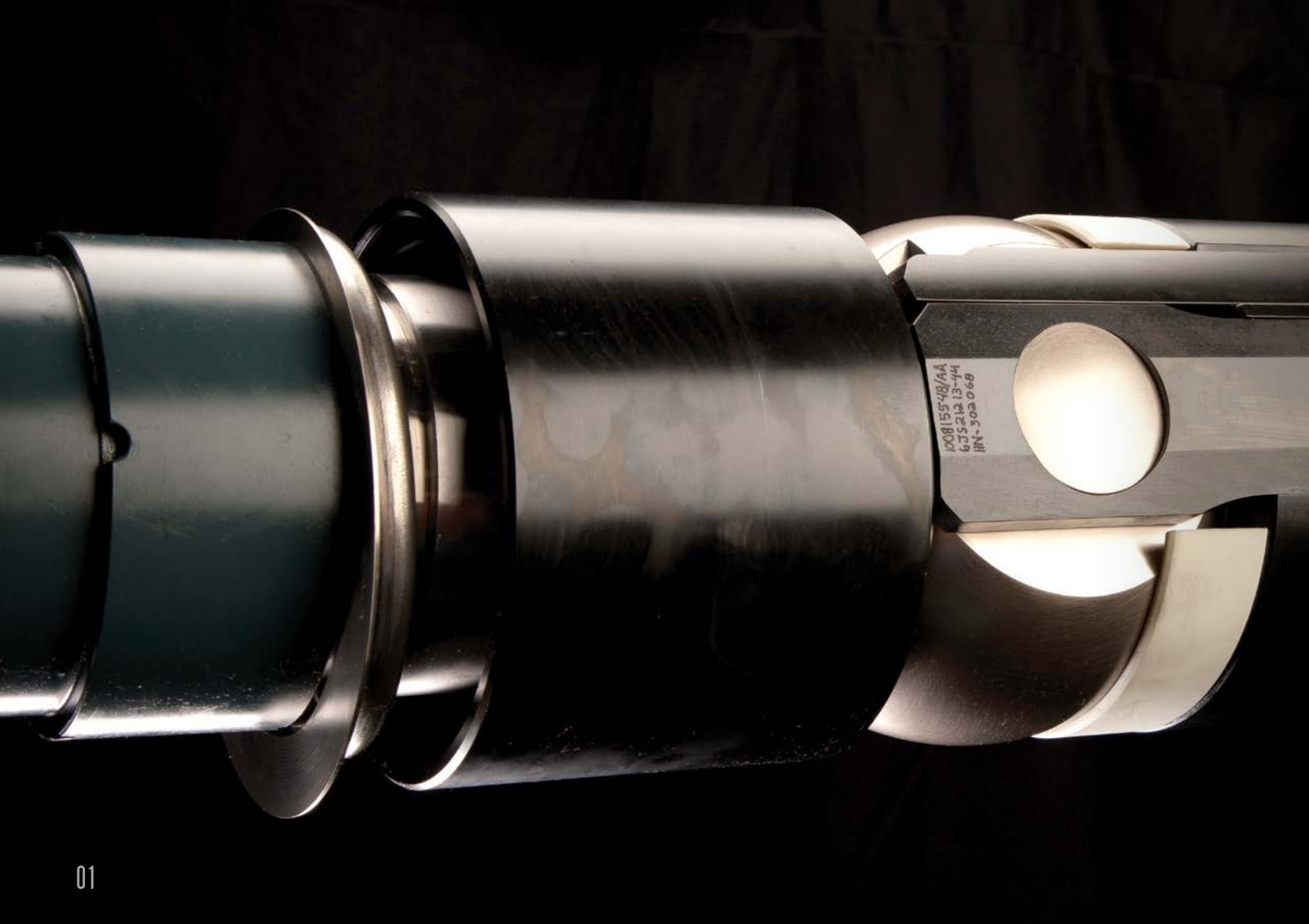




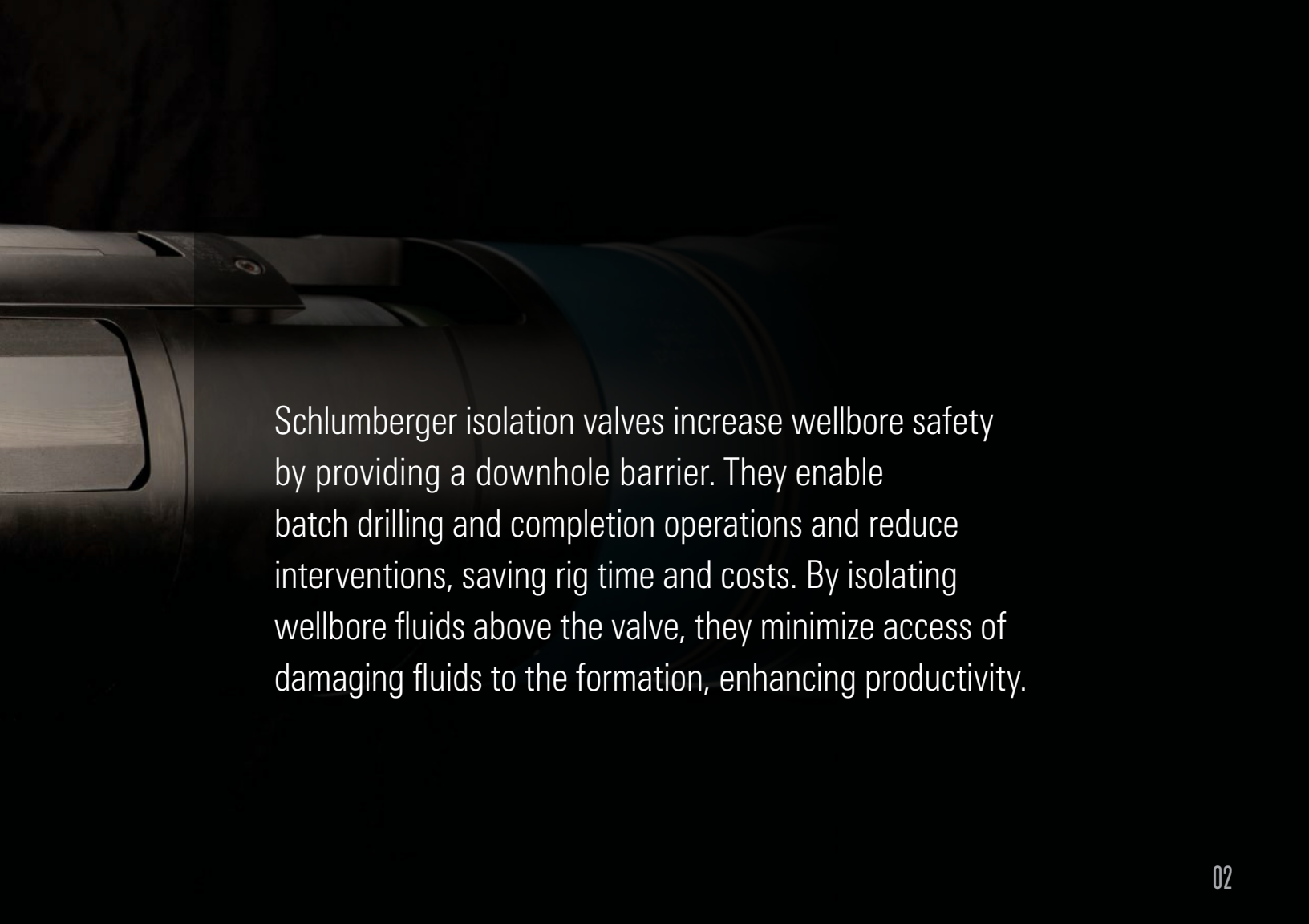
## Isolation Valves

Effective well control with unsurpassed reliability and interventionless actuation





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HN-302068



Schlumberger isolation valves increase wellbore safety by providing a downhole barrier. They enable batch drilling and completion operations and reduce interventions, saving rig time and costs. By isolating wellbore fluids above the valve, they minimize access of damaging fluids to the formation, enhancing productivity.

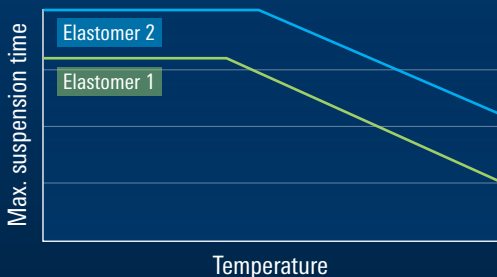
# Proven Reliability

More installations than all other manufacturers combined

Now incorporating a series of innovative design improvements that meet the highest API/ISO standards, Schlumberger isolation valves continue to be the valves of choice for reliable wellbore isolation, especially in challenging applications such as deep water and HPHT.

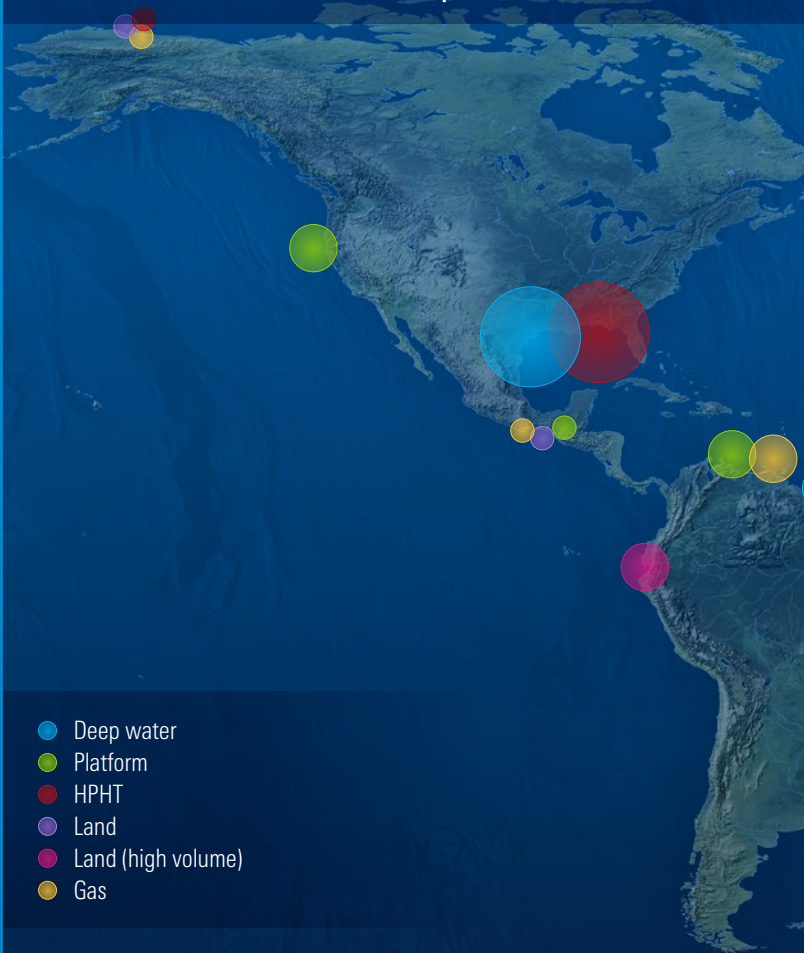
## Expanded suspension envelope

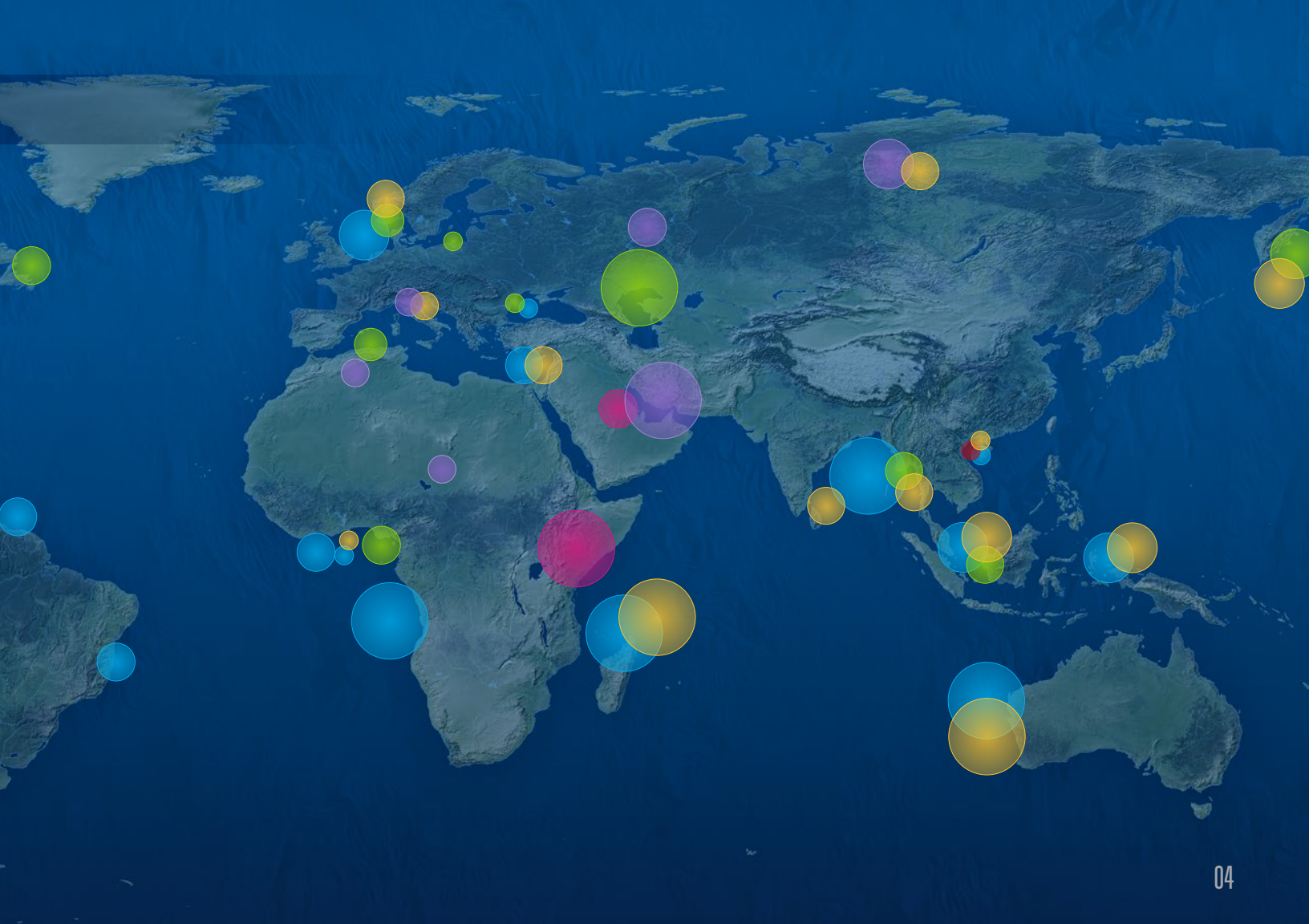
Within our established program of continuous performance improvement, one area of focus is extending the viability of isolation valves as long-term barriers. An integrated approach that includes intelligent seal selection, debris management, and contingency shifting options is helping operators execute cost-effective batch drilling and completion programs that necessitate multiyear well suspension.



Determination of suspension time with different elastomers conducted through accelerated life testing.

>2,500 Installations for >50 Operators Since 1996

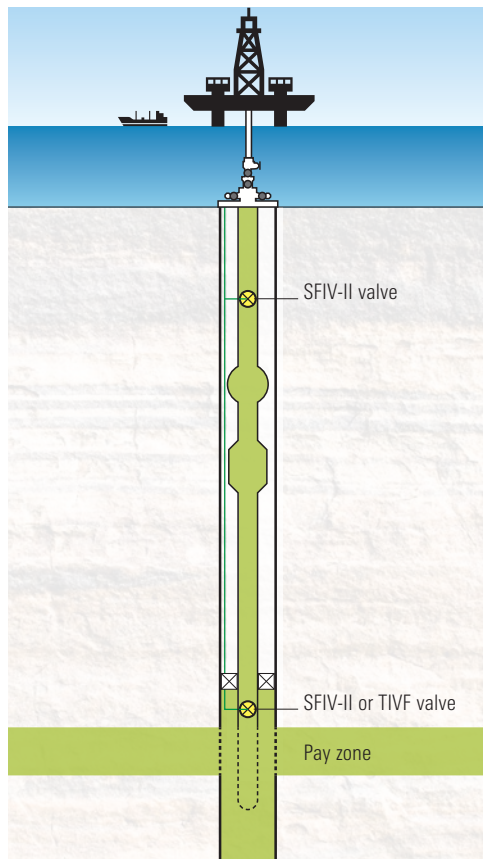




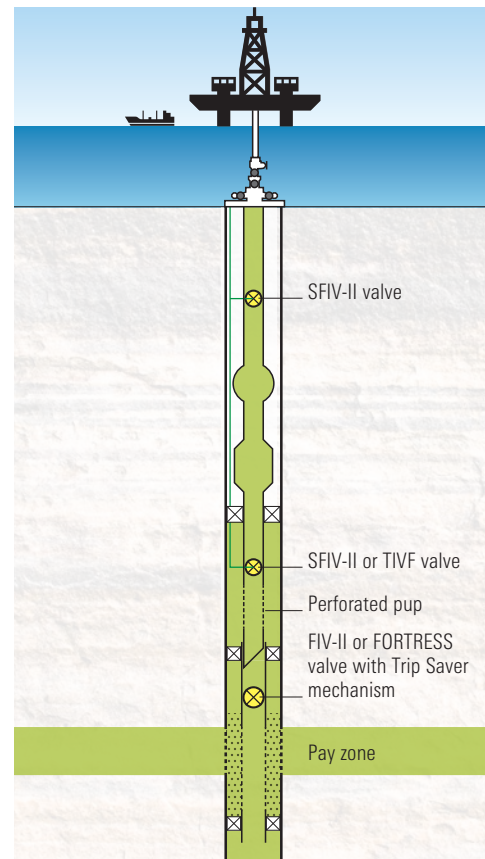


# Applications

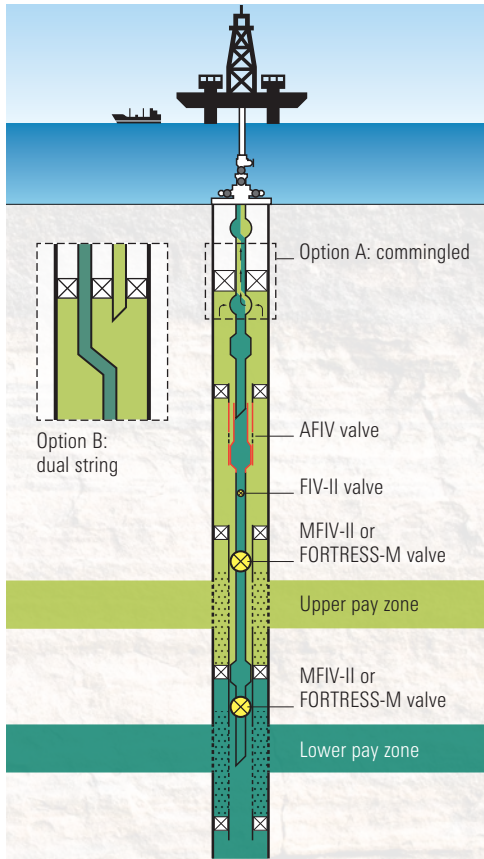
Isolation valves—either a single valve or various types in combination—can be used in a wide range of completion designs to meet your requirements. Some of the many options available are illustrated here.



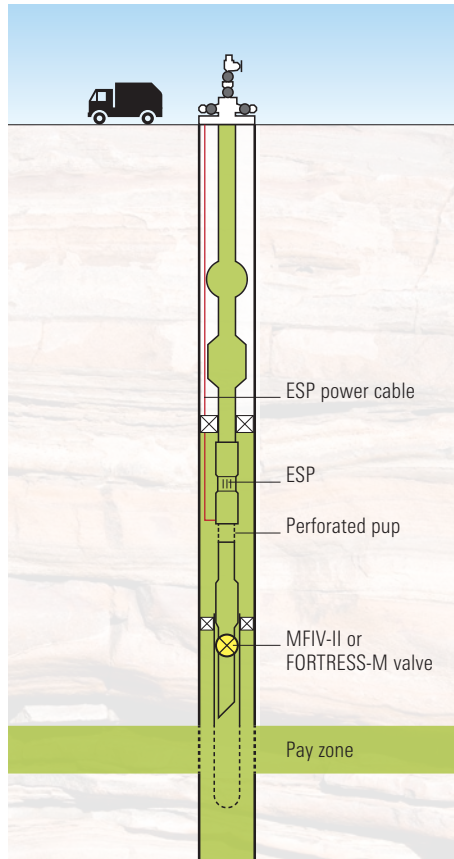
*Single-zone, single-stage completion.*



*Single-zone, two-stage gravel-pack completion.*



*Selective, multizone, multistage gravel-pack completion.*



*Single-zone, two-stage completion with ESP.*

# Open Valves Without Intervention

## Trip Saver one-time remote-opening mechanism

Trip Saver\* one-time remote-opening mechanism provides one interventionless opening, using a predetermined number of tubing pressure cycles applied against the closed valve, for the following valves

- FORTRESS\* premium isolation valve
- FIV-II\* formation isolation valve
- AFIV\* annulus-controlled shrouded isolation valve
- TIVF\* flapper-seal tubing isolation valve.

When the opening cycle is reached, the mechanism provides the actuation energy to open the valve. Before the remote-opening mechanism is actuated, most of these valves can be mechanically opened and closed multiple times. The FORTRESS valve is available with a choice of trigger options for the Trip Saver mechanism as well as in a mechanical version.

An integral indexing mechanism enables you to conduct various operations—including tubing pressure tests, packer setting and testing, gravel packing, and temporary well suspension—before the valve opens and reestablishes communication with the reservoir.

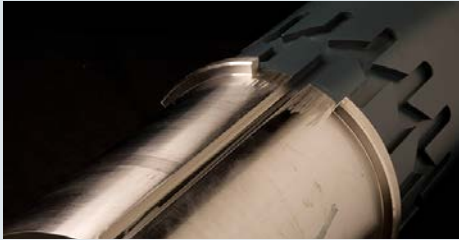




Trip Saver mechanism now offers more operational versatility than ever with a choice of two triggers.



Nitrogen (N<sub>2</sub>) trigger



Wellbore pressures up to



Spring (S) trigger



Wellbore pressures up to



- ⚠️ Reduced safety concerns — no precharged downhole N<sub>2</sub> chambers
- ⚙️ Up to nine times more opening force than other mechanisms in the market
- 💧 Improved debris tolerance with trigger internals operating in clean hydraulic fluid
- ✓ Ability to confirm the number of cycles available before running the valve in the hole

# FORTRESS

## Premium isolation valve



Wellbore pressures up to 19,000 psi [110 MPa]



Up to 375 degF [191 degC]

Mechanical



N<sub>2</sub>

S



Trigger options



The FORTRESS premium isolation valve is the result of field experience, customer feedback, and extensive testing to understand the effects of debris accumulation on the energy required to activate isolation valves.

### Greater debris tolerance

This bidirectional barrier valve accommodates deepwater and other severe-debris environments—such as those created by underbalanced perforating and sand control operations—where actuation requires more force. Numerous design features enhance debris tolerance (for example, by minimizing gaps where debris tends to collect, hence reducing friction and improving the shifting profile).

Significantly decreasing the energy lost to friction reduces the shifting-force variability caused by debris and optimizes the available actuation energy—predictably, consistently, and reliably—potentially enabling the valve to open under higher differential pressures. The new S trigger option further enhances performance with greater opening force. Three versions of the valve are available:

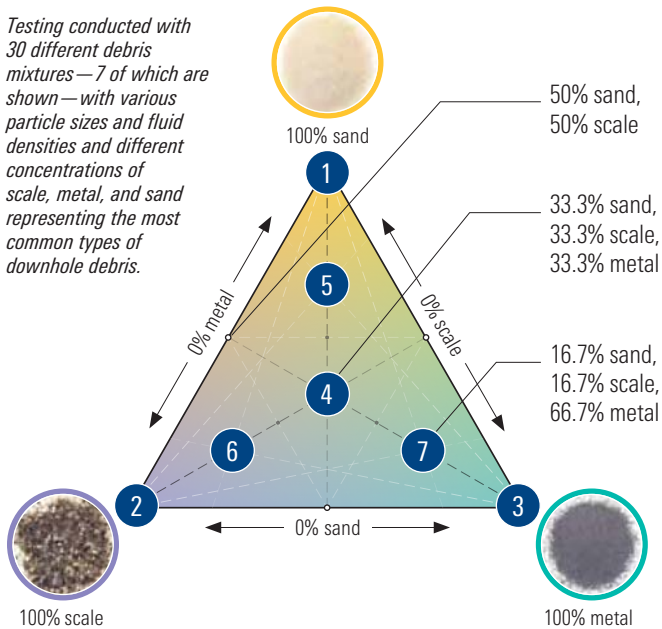
- FORTRESS-N\* nitrogen-triggered premium isolation valve
- FORTRESS-S\* spring-triggered premium isolation valve
- FORTRESS-M\* mechanically triggered premium isolation valve.

*Suitable for multiple applications, including intelligent, multizone, gravel-pack, frac-pack, and stand-alone screen completions; well suspension and temporary abandonment; and remedial workovers.*

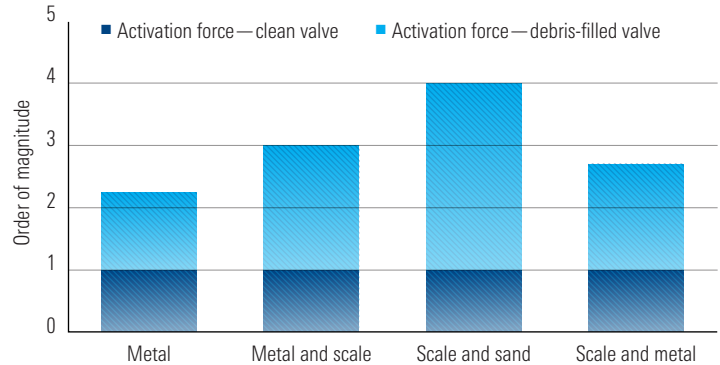
# FORTRESS valve debris testing

As the industry leader in isolation valve technology since the first installation in 1996, Schlumberger broadened the scope of its testing with FORTRESS valves to include how and to what extent debris affects valve performance.

Testing conducted with 30 different debris mixtures—7 of which are shown—with various particle sizes and fluid densities and different concentrations of scale, metal, and sand representing the most common types of downhole debris.



## Effects of Debris on Conventional Valve



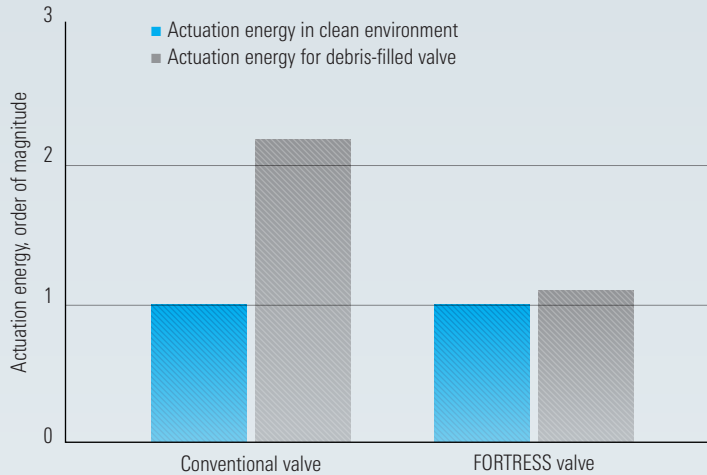
More force required to operate debris-filled valve.

Valve actuation requires a fixed amount of energy. For conventional valves, debris consumes even more. However, actuation energy plus debris-consumed energy cannot exceed the total available.

Measurements showed that debris-filled conventional valves require one to three orders of magnitude more force to operate than clean valves, depending on the type of debris.



### Actuation Energy for a Conventional vs. a FORTRESS Valve



*Just 15% more actuation energy required by a FORTRESS valve during tests in the presence of debris, compared with 123% more for a conventional valve.*

*Minimal impact of debris on FORTRESS valve (top) compared with conventional valve (below) under identical test conditions.*

# FIV-II

## Formation isolation valve



Wellbore pressures up to 9,000 psi [62 MPa]



Up to 325 degF [163 degC]

Trigger



N<sub>2</sub>



*Bidirectional-pressure-sealing ball.*

The FIV-II formation isolation valve serves as a bidirectional barrier that isolates fluids in the lower completion, enabling operators to transition seamlessly—without intervention—from the lower to the upper completion.

### Rigorous qualification and testing

The FIV-II valve qualification procedure exceeds API 19V/ISO 28781 V3 requirements. For example, the valve is qualified with gas to a zero-bubble leak rate across the ball sealing mechanism from below, under specified conditions. This tight acceptance criterion enables use of the valve as a barrier for well intervention operations and well suspension, before the Trip Saver one-time remote-opening mechanism is activated.

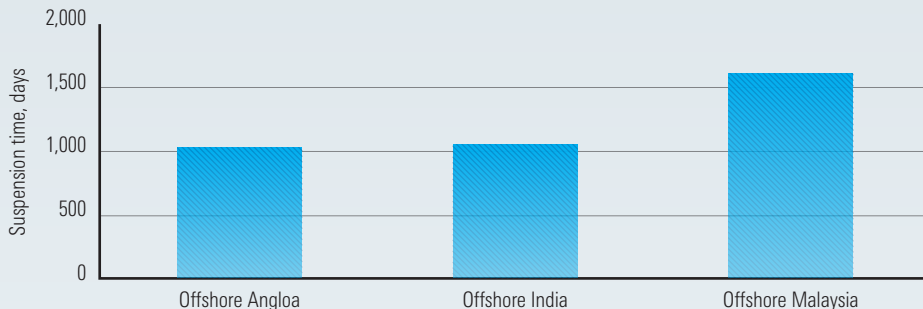
Ability to open and close mechanically multiple times before Trip Saver mechanism is activated

API 19V/ISO 28781 V3 and Q1, Type C barrier valve qualification



## FIV-II valves enable multiyear well suspension

Batch drilling and completion improves field development efficiency and is gaining popularity in deepwater environments. However, installing a subsea production system can take a long time. Several deepwater wells in West Africa and Asia were suspended for up to 1,600 days—more than 4 years—while the upper completions were installed. FIV-II formation isolation valves provided efficient barriers and were opened remotely using the Trip Saver mechanism, with zero NPT.



### **Offshore Angola**

*Provided an effective barrier for an openhole well at water depths of more than 3,500 ft [1,067 m] for 1,016 days.*

### **Offshore India**

*Prevented fluid loss and provided suspension for 1,027 days while waiting on the deployment of the upper completion.*

### **Offshore Malaysia**

*Protected drilled wells during the floating production, storage, and offloading (FPSO) development phase in water depths, greater than 3,658 ft [1,115 m]. The average suspension time of the 14 wells was more than 690 days, with the longest being 1,600 days.*



# MFIV-II

## Mechanically controlled isolation valve



Wellbore pressures up to 11,000 psi [76 MPa]



Up to 335 degF [168 degC]

Trigger



Mechanical



*Mechanical shifting section.*

MFIV-II\* mechanically controlled isolation valve is a bidirectional barrier valve that isolates fluids in the lower completion. It can be opened and closed multiple times with a shifting tool run on the end of washpipe, a perforating string, or CT.

### Qualification

The MFIV-II valve benefits from a qualification procedure that meets or exceeds API 19V/ISO 28781 V3 and Q1 requirements. For example, it is qualified with gas to a zero-bubble leak rate across the ball sealing mechanism from below under specified conditions. This stringent acceptance criterion enables use of the tool as a barrier before production starts; subsequently the valve can be used as a fluid loss control device for well intervention operations, well suspension, and temporary abandonment.

Bidirectional-pressure-sealing ball

Ability to open and close multiple times

API 19V/ISO 28781 V3 and Q1 barrier valve qualification

## MFIV-II valves prevent formation damage during ESP workovers

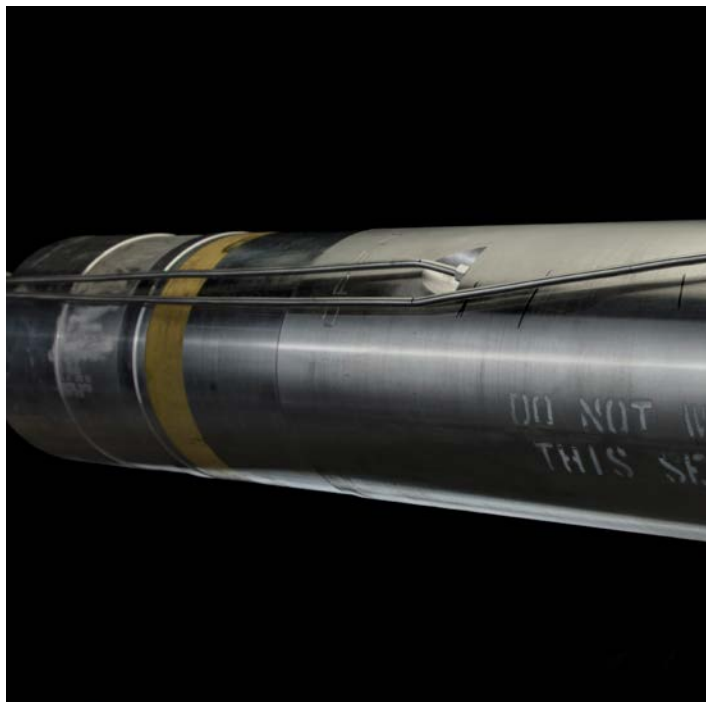
An operator in the Middle East wanted to install ESPs to enhance production but avoid the formation damage that occurs during ESP replacement, typically every few years. A conventional workover uses a kill fluid to establish well control, damaging the formation and increasing operational costs because of the fluid lost to the formation and the time needed to reestablish production.

Schlumberger proposed an integrated solution using the MFIV-II mechanically controlled isolation valve with the ESPs. The MFIV-II valve provided a two-way barrier that isolated the formation and contained reservoir fluids during pump replacements, increased wellbore safety, simplified completion operations, and enhanced production. After the success of the initial installation, the operator standardized this completion solution to all its offshore ESP installations.



# SFIV-II

## Surface-controlled bidirectional isolation valve



SFIV-II valve with two hydraulic control lines.



Wellbore pressures up to 15,000 psi [103 MPa]



Up to 300 degF [149 degC]

Trigger



Control line

Actuated through single or dual hydraulic control lines, the SFIV-II\* surface-controlled bidirectional isolation valve can be remotely opened and closed multiple times. It is typically run with the upper completion.

### Certified postproduction reliability

The valve is qualified for use before and during production or injection, maintaining its pressure integrity over its predetermined life cycle.

### Expanded range of applications

In addition to the valve's usual applications, using two SFIV-II valves to provide mechanical well suspension barriers in subsea wells enables use of the "tree-by-wire" technique, eliminating an intervention to run a tubing hanger plug before installing the Christmas tree. This operation can also be conducted with one SFIV-II valve in combination with another isolation valve in the lower completion. For modern completion configurations, the SFIV-II valve removes the need for a traditional lubricator valve during interventions.

### Insensitive to depth

A balanced piston design has made the valve insensitive to setting depth. Consequently, it can be run as deep and close to the formation as required, minimizing storage effects when the well is shut in for production buildup tests.

## SUCCESS STORY

Interventionless remote actuation to open or close as many times as required

Fail-as-is feature to prevent accidental closing or opening in case of hydraulic system failure

Qualification to API 19V/ ISO 28781 V1 and Q1 standards

Gas-tight, bidirectional Type-CC sealing across the barrier valve

Fullbore through-tubing access when valve is open

## Schlumberger isolation valves expedite well completions in deep water

An operator offshore West Africa wanted efficient and reliable reservoir isolation after gravel packing each well. The FIV-II formation isolation valve was installed below the gravel-pack packer, stopping fluid loss after packing was completed and isolating the reservoir for installation of the upper completion.

Business objectives required installation of the upper completions before the subsea Christmas trees were delivered, but the barrier policy necessitated an additional barrier below the tubing hanger. The SFIV-II surface-controlled valve was installed above the subsurface safety valve to provide a bidirectional testable barrier, and the well was subsequently suspended. Surface operation of the SFIV-II valve eliminated an intervention after Christmas tree installation was completed. The flexibility provided by the isolation valves saved the operator time and about USD 1 million per well.





# AFIV

## Annulus-controlled shrouded isolation valve



Wellbore pressures up to 10,000 psi [69 MPa]

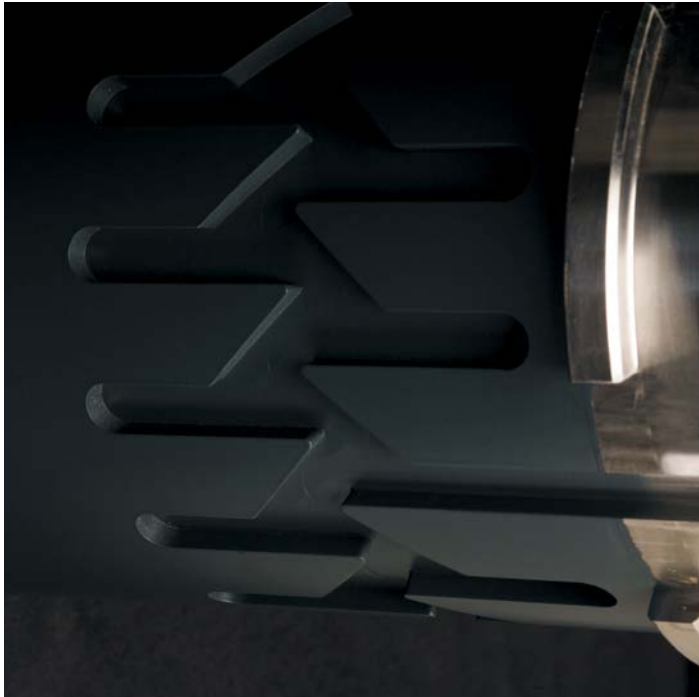


Up to 250 degF [121 degC]

Trigger



N<sub>2</sub>



*Trip Saver mechanism in AFIV valve.*

The AFIV annulus-controlled shrouded isolation valve is used in multizone intelligent completions to selectively produce from the upper or lower zone. The upper zone is produced through the AFIV valve's internal annulus. A sleeve-type barrier, not a ball, isolates the tubing from this annulus. By separating the upper and lower zones, the AFIV valve enhances production and simplifies completion operations.

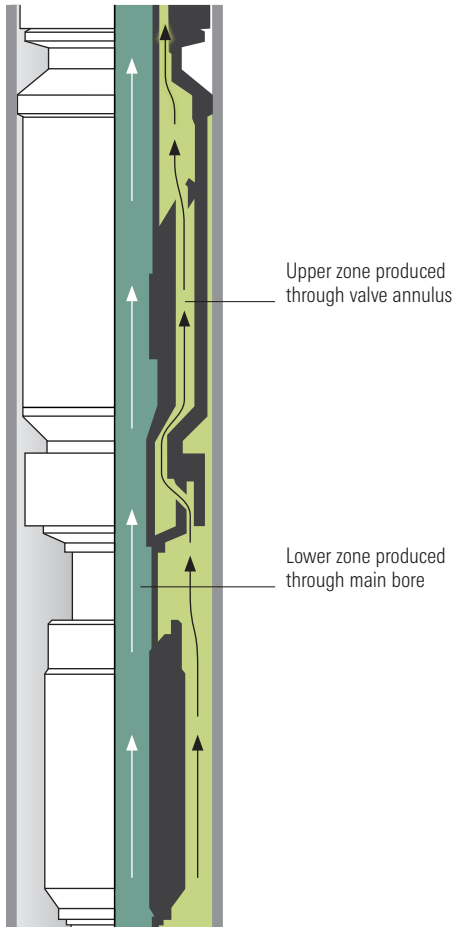
The valve isolates upper zone fluids within the lower completion while production tubing is run. Refer to the schematic on page 6.

### **Suitable for well suspension and temporary abandonment**

All AFIV valves are qualified and tested at assembly to meet stringent acceptance criteria, enabling their use for well suspension and temporary abandonment operations before the Trip Saver mechanism is activated.

Ability to mechanically open and close multiple times before actuation of Trip Saver one-time remote-opening mechanism

Bidirectional-pressure-sealing barrier sleeve



*AFIV valve schematic showing flow paths.*

## SUCCESS STORY

### AFIV and FIV-II valves improve production and save time in deepwater multizone gas wells

An operator used gravel or frac packs to complete 10 multizone wells in a deepwater 450-MMcf/d gas field offshore Indonesia. The number of zones in each well ranged from two to five. FIV-II and AFIV valves were used to isolate the reservoir zones during installation of the upper completion, protecting the reservoir from damage and improving wellbore safety.

No well control issues were encountered during upper completion installation as a result of effective isolation of the multiple producing zones. At a rig spread rate of USD 650,000/d, the savings in rig time represented a significant benefit. Minimizing formation damage resulted in exceeding the target production rate once the well began to flow. Additionally, use of intelligent completions expedited well cleanup to an average of 3–4 days for 3–5 zones.





# Flapper-seal tubing isolation valve



Wellbore pressures up to 8,500 psi [59 MPa]

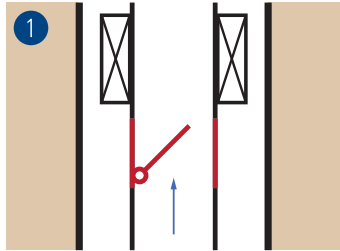


Up to 300 degF [149 degC]

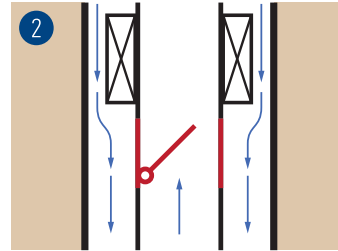
Trigger



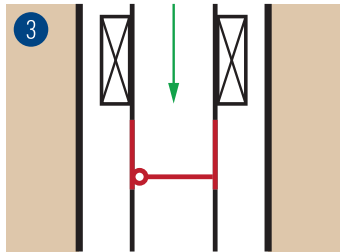
N<sub>2</sub>



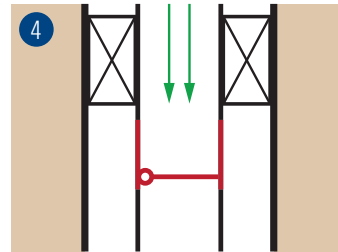
Automatic filling of tubing while running in.



Annulus fluid circulation.



Tubing pressure test before setting packer.



Hydraulic setting of packer.

■ TIVF valve    → Well fluid    → Pressure

Typically run below the production packer with the production tubing string, this interventionless tool allows automatic filling of the tubing, multiple completion pressure tests before and after setting the packer, annulus fluid circulation, and hydraulic setting of the packer before cycling open to allow fullbore through-tubing access. A modified version of the Trip Saver one-time remote-opening mechanism allows 10 pressure cycles before opening a port to a dedicated packer-setting control line. The packer can subsequently be set by simply applying tubing pressure against the closed flapper. Five more pressure cycles can be applied before the TIVF valve opens.

## Eliminate multiple interventions

A typical completion sequence consists of

1. testing the tubing during running of the completion and after tubing hanger installation
2. circulating the packer fluid
3. setting the packer
4. testing the packer
5. reestablishing communication through the tubing to the lower completion string.

The TIVF valve offers the capability of conducting all these operations without intervention. Eliminating three to seven interventions reduces completion time—which is especially useful in horizontal wells, where each intervention with wireline or CT significantly increases risks and costs.

Interventionless opening with Trip Saver one-time remote-opening mechanism

Fullbore through-tubing access after flapper is opened

#### SUCCESS STORY

## TIVF valve eliminates up to three interventions per well in deep water

An operator was completing several deepwater, subsea, high-angle wells in approximately 4,590 ft [1,400 m] of water. The TIVF valve was run in the closed position, allowing the tubing to autofill. When the valve was at the required depth, tubing pressure was cycled to test the tubing and subsequently set the production packer. The TIVF valve was later opened by the Trip Saver mechanism. Using the valve eliminated up to three interventions per well.



# Cleanup Subs

## Debris removal above ball-type isolation valves



Schlumberger provides two tools for clearing debris that may have accumulated above the sealing ball of an isolation valve. This debris can hamper or prevent valve operation. A cleanup trip before opening the valve minimizes the risk.

### Jetting sub

An eccentric body design, off-center exit port at the bottom, and 12 side ports around the circumference deliver superior performance compared with conventional designs. The port nozzles create high-pressure jets at low surface pump rates, improving penetration in thick and hard debris.

The sub is used with the multifunction circulating tool from M-I SWACO, a Schlumberger company, or similar technology that enables high-rate circulation for lifting the loosened debris to surface.

### Circulation sub

When the cleanup string does not include a circulating tool, the isolation valve circulation sub is used instead of the jetting sub. A large exit port at the end

enables a higher flow rate—up to 25 bbl/min [3.975 m<sup>3</sup>/min] inside the casing.

*Jetting sub with multiple exit ports equipped with nozzles that create high-pressure jets.*



# ReSOLVE

## Instrumented wireline intervention service

ReSOLVE\* instrumented wireline intervention service features a selective universal shifting tool (UST) that can be used to

- open and close the FORTRESS, FIV-II, MFIV-II, and AFIV valves
- open the SFIV-II valves
- open the packer setting port of a TIVF valve or lock the flapper in the open position.

The service provides real-time monitoring, dynamic tool control, and verified downhole actuation.

### Components engaged with compliant profile keys

The UST is paired with an anchor and linear actuator. To engage a valve, the UST radially extends profile keys with a specified preload force. The extended keys remain compliant to navigate well geometry and can retract fully to enable the tool to pass restrictions. Once the UST is latched into the valve's profile, the anchor secures the tool in the well, and the linear actuator extends or retracts to shift the valve.

### Confirmation of actuation provided in real time

The speed, force, and displacement of the anchor and linear actuator are controlled automatically downhole according to parameters set by the operator at the surface, providing unparalleled remote control of the tool. Precise, detailed measurements are reported as movements occur to provide real-time positive confirmation that the valve has shifted. Bidirectional, high-speed digital telemetry enables dynamic control.



*High-expansion UST with closed (top) and fully expanded (bottom) profile keys that remain compliant to navigate well geometry.*

# Isolation Valves



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[slb.com/fiv](https://slb.com/fiv)

**Schlumberger**