Isolation Valves
Effective well control with unsurpassed reliability and interventionless actuation
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.

Suspension times with different elastomers were determined through accelerated life testing.
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.

Single-zone completion with alternatively deployed 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 before the valve opens and reestablishes communication with the reservoir, including tubing pressure tests, packer setting and testing, gravel packing, and temporary well suspension.
Trip Saver mechanism now offers more operational versatility than ever with a choice of three triggers.

- **Nitrogen (N₂) trigger**: Wellbore pressures up to 10,000 PSI. 10 to 15 CYCLES. Reduced safety concerns — no precharged downhole N₂ chambers.
- **Spring (S) trigger**: Wellbore pressures up to 16,000 PSI. 20 CYCLES. Up to nine times more opening force than other mechanisms in the market.
- **High-pressure (HP) trigger**: Up to 375 degF or wellbore pressures up to 25,000 PSI. 20 CYCLES. 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 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 and HP trigger options further enhance performance with greater opening force. Four versions of the valve are available:

- FORTRESS-N* nitrogen-triggered premium isolation valve
- FORTRESS-S* spring-triggered premium isolation valve
- FORTRESS-HP* high-pressure 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.

**Wellbore pressures up to 25,000 psi [172 MPa]**

**Up to 375 degF [191 degC]**

<table>
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<tr>
<th>Trigger options</th>
<th>Mechanical</th>
<th>N₂</th>
<th>S</th>
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Specially engineered valves enable suspension of high-pressure wells

An operator wanted to install isolation valves in three wells in a 50,000-bbl/d gas condensate field in Alaska. The valves had to withstand tubing pressures up to 16,000 psi. Schlumberger engineered a new version of the 2.94-in FORTRESS premium isolation valve with S trigger, increasing the absolute burst pressure rating from its standard 13,000 psi. The valves have performed flawlessly in these challenging conditions.
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.

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

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.

Actuation Energy for a Conventional vs. a FORTRESS Valve

![Graph showing actuation energy comparison between conventional and FORTRESS valves.](image)

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

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

**Up to 325 degF [163 degC]**

**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 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.

**MFIV-II**

- **Mechanically controlled isolation valve**
- **Mechanical shifting section.**
- **Bidirectional-pressure-sealing ball**
- **Ability to open and close multiple times**
- **API 19V/ISO 28781 V3 and Q1 barrier valve qualification**

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

**Up to 335 degF [168 degC]**

**Trigger**

**Mechanical**
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.
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.
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, eliminating the need for an intervention after Christmas tree installation was completed. The SFIV-II surface-controlled valve expedited well completions in deep water, saving the operator time and about USD 1 million per well.
The cost-effective RFIV* retrievable ESP isolation valve combines robust, field-proven isolation ball valve and circulating valve technologies. The highly debris-resistant ball section is the latest design used in our premium isolation valves. Both the ball valve and the circulating valve can be opened and closed multiple times from surface via shared single or dual control lines.

The RFIV valve protects formations from damage during completions and workovers. In addition, it facilitates ESP replacements and minimizes HSE concerns by enabling fluid circulation down the annulus and up the tubing to remove hydrocarbons and debris accumulated above the ESP. It is suitable for various well isolation and circulation applications.

** Supports rigless ESP replacement and protects reservoir **
By operating without intervention, the RFIV valve supports rigless ESP retrieval and replacement via technologies such as the Zeitecs Shuttle* rigless ESP replacement system or REDA Coil* CT-deployed ESP system, eliminating the need to pull out and replace the tubing string.

The ZEiTECS Shuttle system uses downhole electrical wet connector technology that enables standard ESPs to be “shuttled” through tubing on wireline, CT, or sucker rods and plugged into a downhole docking station without using a rig or hoist. Using this system with the new RFIV valve enables ESP replacement with significantly less time, cost, and risk compared with conventional ESP workover solutions.
Interventionless remote actuation to open and close as many times as required

Bidirectional-pressure-sealing ball

Ball section qualification to bubble-tight conditions and meeting or exceeding API 19V/ISO 28781 V1 and Q1, Type CC standards

Fullbore through-tubing access when ball valve is open

ZEiTECS Shuttle system.
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**
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.
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.
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.
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 m³/min] inside the casing.
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 and RFIV 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.
Isolation Valves