Schlumberger

FORTRESS Isolation Valve

Debris Testing to Higher Standards

Confidence in Completions

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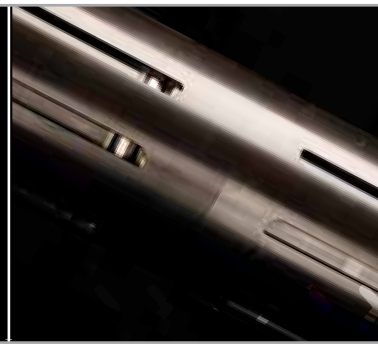


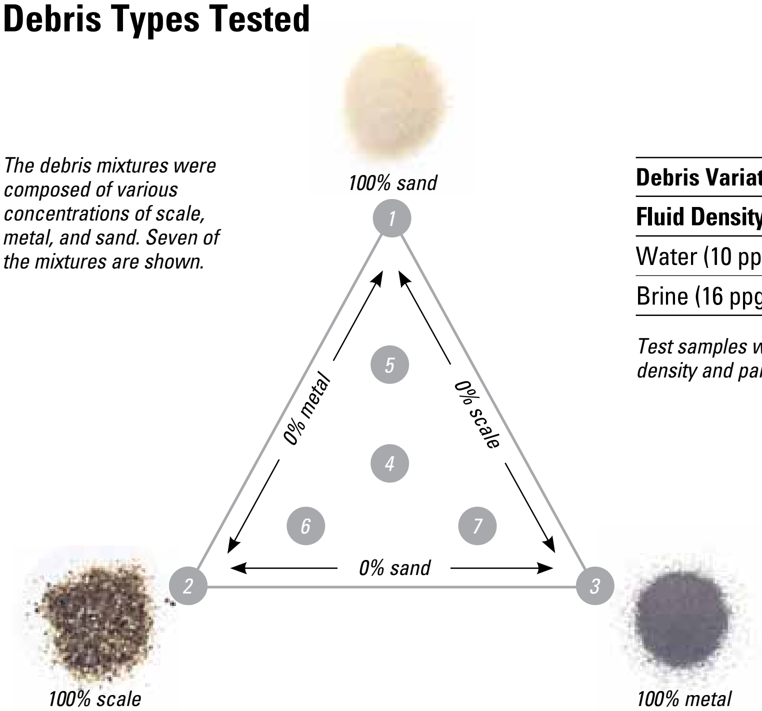
Schlumberger has been known for its isolation valve technology since 1996, when we installed the industry's first FIV* formation isolation valve. Since then, we have installed more than all other manufacturers combined—over 1,200 valves—giving us more experience than other manufacturers, more opportunities to see the valve in action, and a greater understanding of its design.

Setting the standard

Our isolation valves have continually set the standard for barrier valve performance and reliability. We wanted to take field performance of a new design to a higher level. From customer feedback, experience, and our own field tests, we knew that debris accumulation was one of the biggest factors affecting performance. We therefore launched a study to better understand the effects of debris and the relationship of debris to the pressure required for remote actuation.

In 2010, the International Standards Organization issued ISO Standard 28781, which provides guidelines on testing subsurface barrier valves, including the effects of debris. As the industry leader for this technology, we broadened the scope of our testing to include not only the new standard but also how and to what extent debris affected valve performance.

Debris Types Tested



The debris mixtures were composed of various concentrations of scale, metal, and sand. Seven of the mixtures are shown.

Debris Variations	
Fluid Density	**Particle Size**
Water (10 ppg)	Small (300 mesh)
Brine (16 ppg)	Large (100 mesh)

Test samples were also varied by fluid density and particle size.

Over time, debris settles out of a fluid and becomes more dense, filling in voids.

ENERGY CONSUMED IN VALVE OPERATION

A remote trigger generates the energy available for operation. Actuating the valve requires a set amount of this energy. Debris consumes even more. Actuation energy plus debris-consumed energy cannot exceed the total available energy.

Quantifying the effects of dirt
Our plan was to quantify how debris affected valve performance and incorporate lessons learned into a modified design.

Using our field experience, we developed different debris mixtures in varied concentrations of scale, sand, and metal for a comprehensive representation of the most common types of downhole debris.

During the test, debris accumulated in and around the ball section.

These concentrations were further varied by particle size: small (300 mesh) or large (100 mesh). Finally, to round out the samples, we tested the effect of fluid density by using water-base mud and brine at 10 and 16 lbm/galUS, respectively. The result was 30 different debris mixtures.

Consuming the available energy
Isolation valves open and close as a result of the actuation energy applied. This energy, or force, is supplied by the trigger and can be customized according to well requirements. Actuation expends a set amount of this energy, with debris consuming even more.

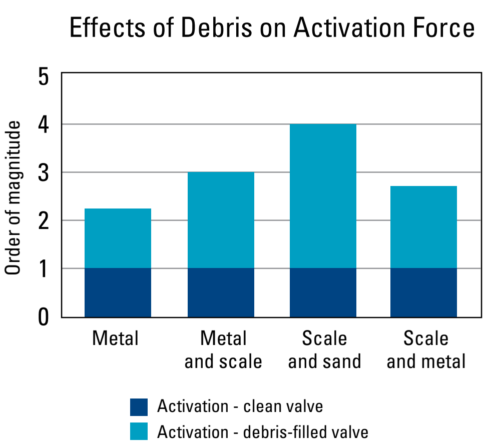
Debris completely clogged the mechanical section.

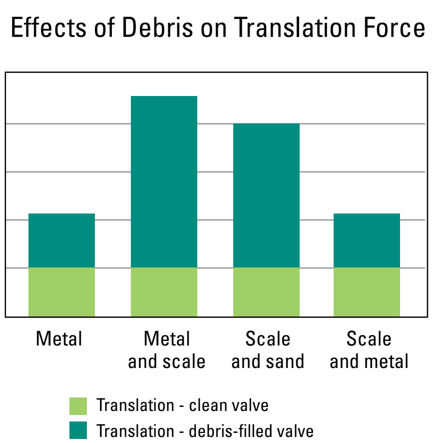
Establishing a baseline
We then measured the force required to actuate a conventional valve in the 30 different mixtures, testing activation and translating forces separately. These results served as the baseline.

Results showed that the mixtures affected the activation and translating forces differently, with the degree of variation greatly depending on the type of mixture. In all cases, the debris-filled valves required more energy to operate than did the clean valves.

From the group of 30 mixtures, we identified the four worst debris combinations in which to test the conventional valve. For example, compared with the clean valves, valves filled with the scale and sand mixture required four times the activation force and four times the translating force. Similarly, valves filled with the metal and scale mixture required three times the activation force and up to four times the translating force.

Exceeding the total available
In actual downhole debris-laden environments, increases in these two forces could exceed the total available actuation force and thus prevent a valve from operating.





Left: Clean valves expended a constant amount of activation force, whereas the energy required by debris-filled valves varied greatly according to mixture type, in each case requiring from one to three orders of magnitude more than the clean valves.

Right: The translation force required by clean valves was also constant. As with activation force, the force required by the debris-filled valves varied, requiring from one to three-and-a-half orders of magnitude more than the clean valves.

Debris Testing to Higher Standards

Modifying the design
From the extensive debris testing, we better understood the impact of debris on actuation energy and developed design modifications to minimize these effects.

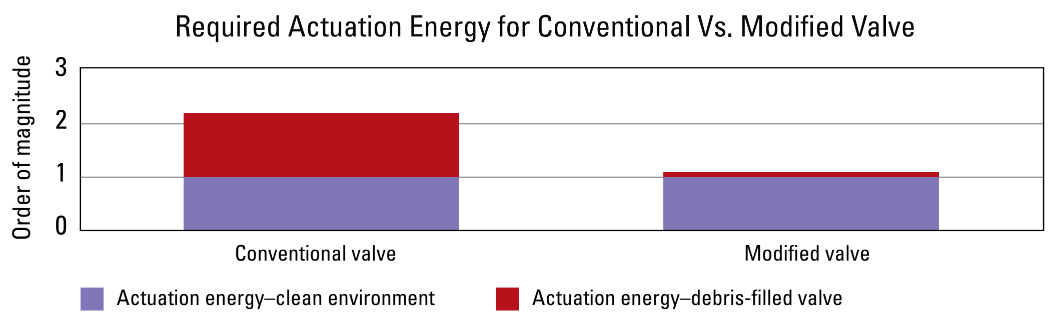
We made the following changes:

- The ball was modified to eliminate gaps and passages where solids could accumulate and prevent the ball from rotating.
- The mechanical section now has a full 360° shifting profile that maximizes the force applied by the shifting tool.
- The displacement-type design and flush ID minimize contact of the moving parts with wellbore fluids.
- The shifting profile is protected from the main flow path to minimize the places for debris to collect.
- Wiper rings on both ends of the mechanical section reduce the amount of solids entering the collet housing.

Validating the new design
To validate the modified valve, we compared its performance with that of the conventional valve.

Our tests showed that the actuation force required by the conventional valve increased on average 123%, whereas that required by the modified valve increased on average only 15%. In other words, the new design clearly met our goal of minimizing the effects of debris.

Presenting the FORTRESS valve
When this enhanced valve was combined with the Schlumberger patented Trip Saver* one-time remote opening mechanism (a trigger that maximizes the amount of available actuation energy), the result was a versatile new barrier valve that is more predictable, more consistent, and more reliable than any other valve in the industry: the new Schlumberger FORTRESS isolation valve.



The force required to actuate clean and debris-filled conventional valves was compared with that required by clean and debris-filled modified valves. The effects of debris more than doubled the actuation force required by the conventional valve, whereas the effects of debris increased the force required by the modified valve only slightly.

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