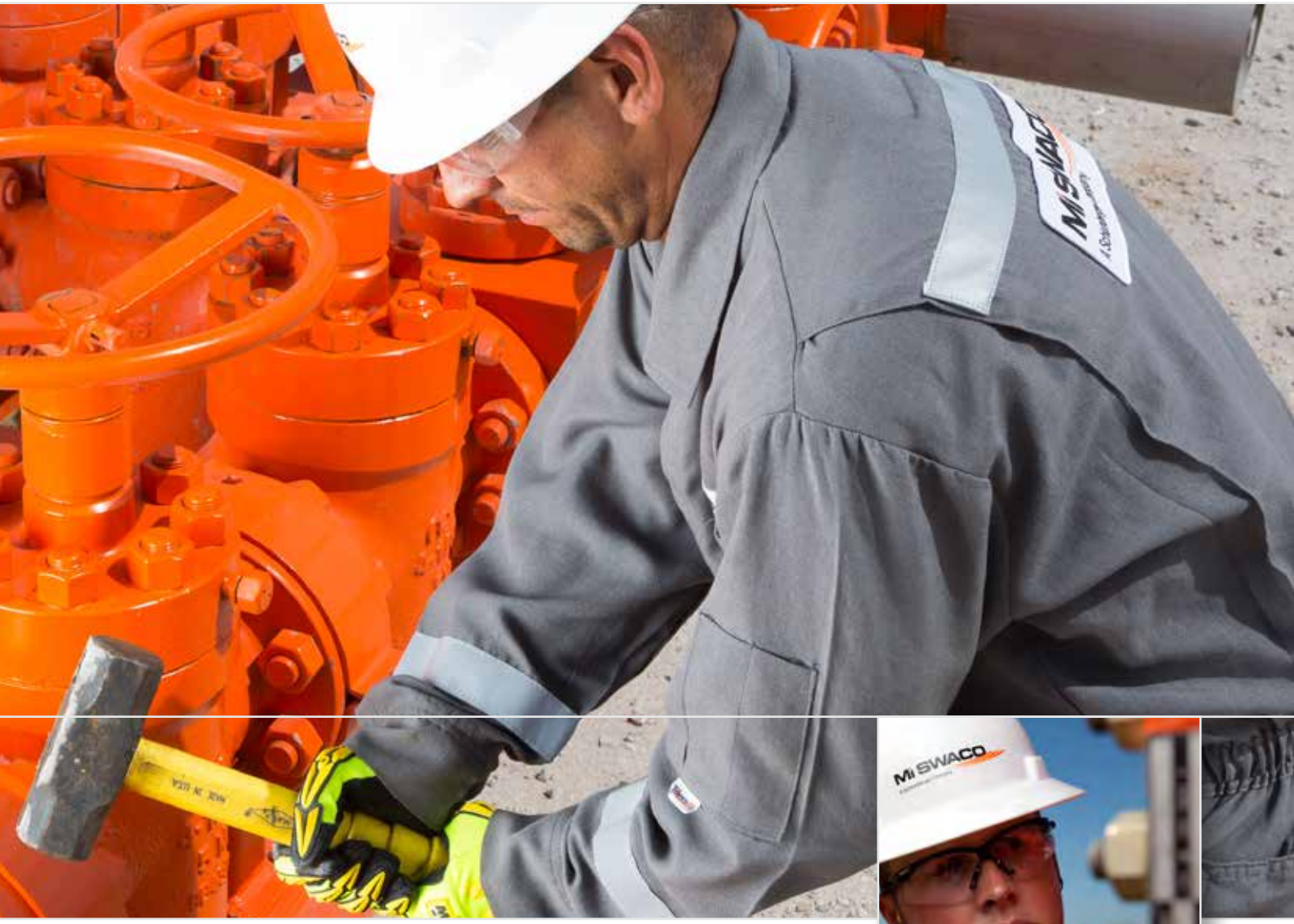
MI SWACO
A Schlumberger Company



Drilling Chokes

Ultimate pressure control for the most challenging applications

Drilling Chokes: Advanced technology to meet the challenges of well pressure control, MPD and UBD drilling in challenging environmental conditions

Controlling downhole pressure continues to be the most complicated issue operators confront daily. Extreme pressures left uncontrolled can lead to catastrophic results, but the inability to manage high equivalent circulating densities (ECD) in low-pore pressure applications can also severely restrict production and raise costs considerably. The stakes are even higher in today's drilling world in which deeper and more complicated well paths have become the norm. Heading off high-pressure influx and keeping your well under control requires careful matching of the right choke for your application and downhole conditions.

Specialists at M-I SWACO, a Schlumberger company, have put decades of experience, expertise and field-proven technical performance into developing a line of drilling chokes that have become the industry standard for the most demanding and specialized offshore and onshore applications. Our chokes are uniquely designed for a range of highly pressure-sensitive applications, including Managed Pressure Drilling (MPD), Underbalanced Drilling (UBD), Coiled-Tubing (CT), frac-plug drill-out, frac flowback, ECD control, H_2S applications, well-control and clean-up operations.

Safely getting the most from the well

Features

- Line of chokes from 3K to 15K psi pressure ratings
- Designed for offshore and onshore applications
- Tungsten-carbide wear sleeves
- SUPERCHOKE† designed with rotating disc for flow control
- VERSA-CHOKE† designed for position-based control
- AUTOCHOKE designed to automatically adjust fluid flow to regulate casing pressure
- ECHOKE† designed with electric motor and electronic console that replaces the air-over-hydraulic console for cold-weather service

Benefits

- Delivers precise, reliable pressure control
- Includes highly responsive control consoles
- Helps manage ECD
- Increases operational life
- Reduces effects of abrasive solids
- Provides effective control in wide temperature, pressure range
- Controls easily during transition periods
- Simplifies predictable casing and drillpipe pressure control
- Eliminates leakage
- Provides reliable control in cold temperatures
- Allows 'hot swapping' of actuators
- Provides excellent flow characteristics
- Reduces costs of well control, fluid-loss
- Minimizes environment impact
- Promotes safe operations

M-I SWACO helps you do just that with its growing portfolio of industry-recognized drilling chokes and control consoles that provide precise and reliable pressure management for your most critical applications. Led by our pacesetting and unequaled AUTOCHOKE and SUPERCHOKE technologies, we offer a wide range of high-performance drilling chokes from 3K to 15K psi (207 to 1,034 bar) pressure ratings, ensuring a responsive control option for all your offshore and onshore pressure management requirements.

As a widely acknowledged leader in pressure control, M-I SWACO has engineered a line of chokes considered best in class for shutting in the well, determining circulating pressure, breaking circulation, and maintaining near constant downhole pressure. Our innovative AUTOCHOKE automatically maintains near-constant casing, drill pipe and bottom-hole pressure. Our ECHOKE uses electronic servo control to provide more accurate control and improved performance in cold temperatures. The VERSA-CHOKE is the latest addition to our suite, and is designed for advanced well-control applications.

In addition to helping manage wellbore pressures, our drilling chokes also provide control over fluid loss and water consumption to help minimize a project's environmental footprint and reduce costs. When the pressure is on, more operators count on the well-documented dependability, precision and responsiveness of M-I SWACO drilling chokes.

The M-I SWACO AUTOCHOKE

The uniquely engineered AUTOCHOKE is the cornerstone of the M-I SWACO portfolio and continues to set the standard for high-pressure drilling chokes. The 3K, 10K and 15K AUTOCHOKE units provide automatic, precise pressure control and incorporate the best choke technology available for pressure intensive UBD and MPD applications. This pacesetting choke automatically regulates casing pressure under all conditions, including:

- Regulating mud pump start-up or shutdown;
- Making and breaking drillpipe connections; and
- Automatically adjusting the orifice size to compensate as mud and gas flow alternately through the unit.

The AUTOCHOKE is highly effective in H_2S and abrasive-fluid applications. With its capacity to automatically maintain casing pressure, the AUTOCHOKE makes stripping pipe simpler and safer. As drillpipe is lowered into the hole, an equal volume of fluid under pressure is automatically displaced through the high performance choke.

Advantages

- **High pressure rating**
  - 3K psi (207 bar)
  - 10K psi (689 bar)
  - 15K psi (1,034 bar)
- **Maintains casing pressure**
  - Dynamically positioning shuttle
  - Automatically adjusts fluid flow to regulate casing and drillpipe pressures
- **Precise control and reduced cost**
  - The precise control of the AUTOCHOKE can dynamically change bottomhole pressure (BHP) when managed pressure drilling is required
  - Reduces fluid-loss costs: Automatic adjustment during well control operations minimizes the occurrence of over-pressuring the formation and the resultant fluid loss
- **Frac plug drill-out operation**
  - The dynamic shuttle allows proppant slugs to flow through the AUTOCHOKE while maintaining a constant fluid return stream. The hard-faced wear sleeve and tungsten carbide downstream sleeves stand up to the highly abrasive sand flow of frac operations
- **Compliance**
  - M-I SWACO designs, manufactures, and monograms in accordance with API 6A and API 16C, and in compliance with NACE MR0175
  - Optional third-party certifications available
- **High-capacity**
  - High-capacity: 3 in (76 mm) choke bore. Improves flow characteristics at throttle point and through choke bore
  - Self-cleaning orifice: Reduces plugging
- **Over-pressure protection**
  - The operator can dial in the desired maximum casing pressure and the AUTOCHOKE automatically opens to protect the well from overpressure
- **Downstream choke-bore protection**
  - Tungsten-carbide sleeves: Extended-wear sleeves increase in-service life, reducing the effects of abrasive solids and protecting the API ring gasket
- **No-leak shut in seals and long-life materials**
  - Metal-to-metal and elastomer-to-metal seals: Constructed of long-life components for severe service operations: tungsten-carbide static trim, reversible dynamic trim, hardfaced shuttle nut and internal removable body sleeve

AUTOCHOKE control console

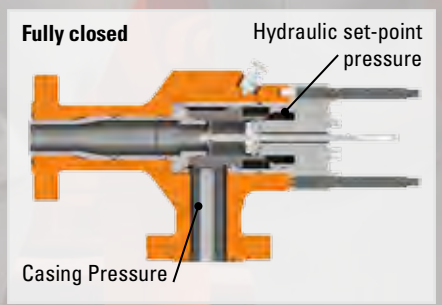
The AUTOCHOKE console is constructed of stainless steel and includes drillpipe and casing-pressure gauges, a hydraulic set-point regulator and gauge, and a hand-operated hydraulic backup pump.
The AUTOCHOKE console is equipped with an electronic position indicator, digital pump-stroke-rate meter, timer and clock.

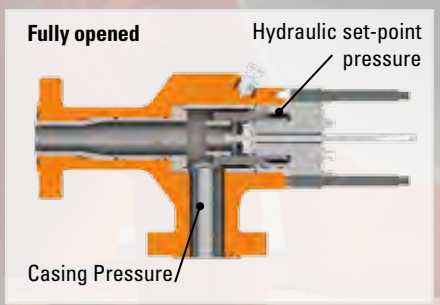
How it works

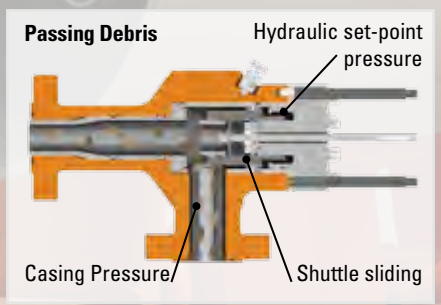
The unique design of the AUTOCHOKE features a dynamically positioning shuttle that moves back and forth on an axis housed inside a hardfaced wear sleeve. The dynamic trim seats into the 3 in. (76 mm) diameter orifice in the static trim piece. Hydraulic pressure, which is adjusted through a set-point pressure regulator, is applied to the backside of the shuttle. This creates a pressure-balance between the casing pressure of the well and the hydraulic pressure of the AUTOCHOKE unit.

If the casing pressure is higher than the hydraulic pressure, the shuttle opens, which increases the orifice size.
If the casing pressure is lower than the hydraulic pressure, the shuttle closes, decreasing the orifice size. As the shuttle moves, it regulates the flow of fluid or gas from the well through the orifice.
The set point pressure applied to the backside of the shuttle assembly is adjusted by a pressure regulator and measured by the set-point gauge located on the choke control panel.
The annulus pressure is applied to the front side of the shuttle assembly.

An increase in annulus pressure or a decrease in the hydraulic set-point pressure will cause the shuttle assembly to move away from the static trim, increasing the orifice size. This allows fluid to flow from the well and decrease the casing pressure until it equals the set-point pressure.







The M-I SWACO SUPERCHOKE

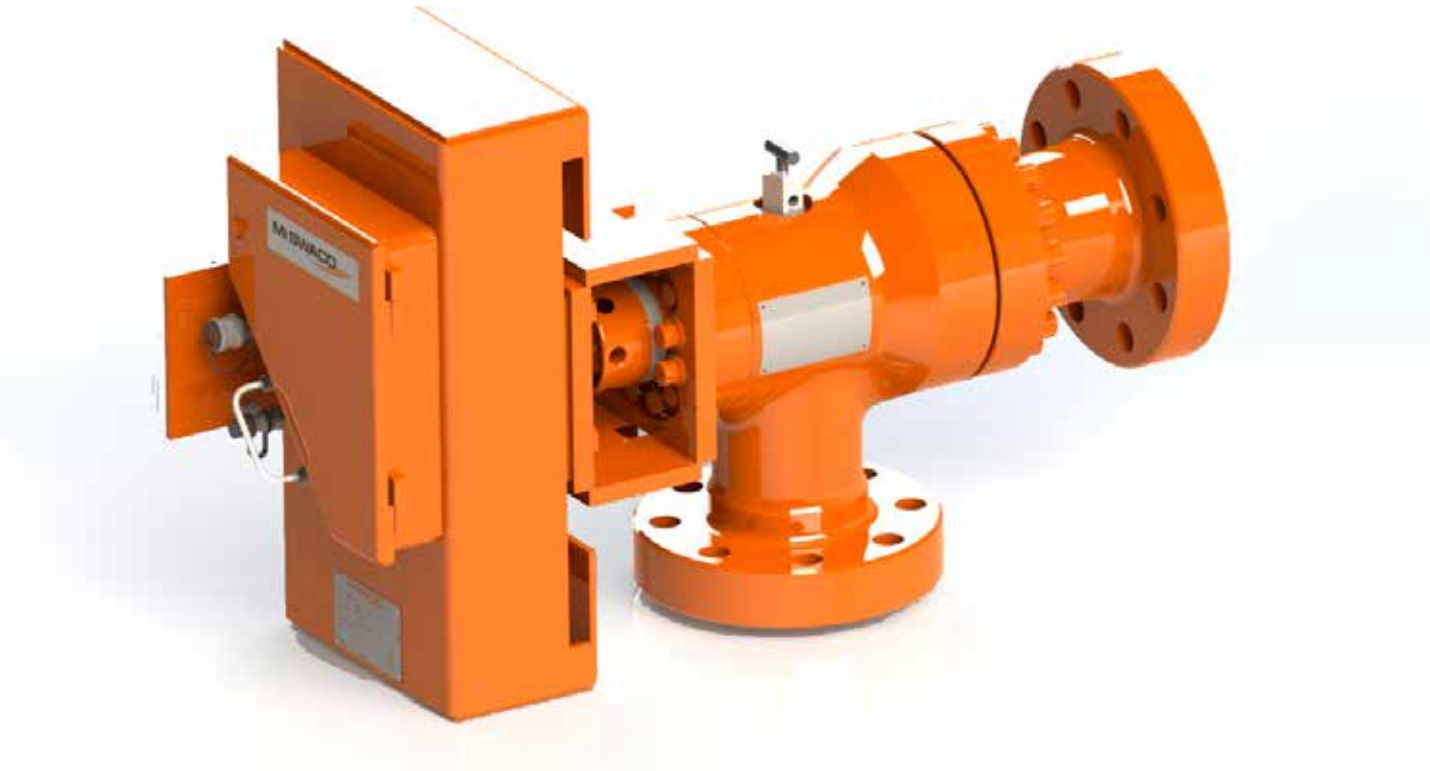
The highly advanced 5K, 10K and 15K SUPERCHOKE has become one of the industry's most widely used chokes, particularly for well kill and high-pressure applications. The SUPERCHOKE delivers easy, precise and reliable well pressure control during transition operations, such as mud pump start-up or shut-down. The SUPERCHOKE is equally effective when mud and gas are flowing alternately through the choke. It is designed and manufactured for H_2S service and abrasive fluid applications.

Three modes of SUPERCHOKE operation:

- **Normal operations**
  - Power to the control console is supplied by rig air to provide hydraulic power to the SUPERCHOKE
- **If rig air is lost**
  - Activation is manual with hydraulic pump located on control console
- **If hydraulic lines are severed**
  - Activation is manual with bar provided on the choke indicator head

Advantages

- **Multiple pressure-sensitive applications**
  - Well kicks
  - Well testing
  - Well clean-up operations
- **High pressure rating**
  - 5,000 psi (345 bar)
  - 10,000 psi (689 bar)
  - 15,000 psi (1,034 bar)
- **Dependable choke-disc design**
  - Heavy-duty, diamond-lapped tungsten-carbide discs honed to near-perfect flatness. Rotation of actuator fork allows finite regulation of the opening size from full-open to full-close
- **Positive closure**
  - A 17° dead band overlap beyond the full-close position ensures closure even if the plates become worn from extended exposure to abrasives-laden fluid flow. Quality of the seal is not affected by pressure drops and surges. In fact, the seal improves under pressure
- **Tungsten-carbide sleeves**
  - Increase in-service life. Extended wear sleeves reduce the effects of abrasive solids and protects the API ring gasket
- **Versatility**
  - Ideal for offshore and onshore applications
- **Certifications**
  - Designed, manufactured, and monogrammed in accordance with API 6A, API 16C, and NACE MR0175
  - Optional configurations available to P-X Temperature rating (-20F to 350F), PR2, PSL3G, and Material Class EE-NL for H2S service
  - Optional certifications to ABS CDS, DNV ES-E-101, CE and PED marked, NORSOK Z-016, and NORSOK D-002
  - Customized certifications available



SUPERCHOKE control console

M-I SWACO choke-control consoles are available to control either a single or dual SUPERCHOKE unit. These consoles are equipped with either standard hydraulic or optional digital casing and drill-pipe gauges, pneumatic position indicator and digital pump-stroke rate meter.

How it works

The advanced design of the SUPERCHOKE employs an adjustable orifice size that ranges from a maximum area of 1.92 in^2 (12 cm^2) to total shutoff. The control panel provides hydraulic power to the actuator mounted on the SUPERCHOKE, which in turn rotates the tungsten carbide discs within the SUPERCHOKE to control orifice size. The control panel is comprised of a control lever, a master air supply valve, a choke position indicator, drill pipe and casing pressure gauges and pump stroke counter and rate meter. The hydraulic pump and hydraulic fluid reservoir are located beneath the console. Should air supply be interrupted, an included hand-operated hydraulic pump provides power to control the SUPERCHOKE.

The M-I SWACO ECHOKE

The M-I SWACO ECHOKE is a remotely operated, electrically actuated and variable-speed version of the SUPERCHOKE and is ideally suited for cold temperatures and similarly harsh environments.

The ECHOKE incorporates an electric actuator, a local drive box and the electronic remote console. The ultra-reliable ECHOKE local drive box replaces the large choke console currently required for hydraulic operation.
A single operator can easily carry the small, highly portable remotely controlled actuator control panel to the drill floor.

The predominate benefit of the ECHOKE in harsh operating conditions is remote delivery of a high degree of control, safety and speed in well-control situations.
The ECHOKE has exhibited excellent high-torque performance. The variable speed drive allows the ECHOKE to deliver faster open and close speeds.

Three methods of ECHOKE operation:

- Electronic control using the remote console on the drill floor.
- Electronic control using the local drive box near the choke manifold.
- Manual control at the choke, using the actuator hand-wheel.

Advantages

- **Multiple pressure-sensitive applications**
  - Well kicks
  - Well testing
  - Well clean-up operations
- **High pressure rating**
  - 5,000 psi (345 bar)
  - 10,000 psi (689 bar)
  - 15,000 psi (1,034 bar)
- **Cold weather service**
  - The electric motor and electronic console replace the air-over-hydraulic console and improve reliability in cold weather environments
- **Small footprint**
  - The quiet and space-saving design of the remote console allows it to be located in the driller's cabin
- **Reduced cabling requirements**
  - The ECHOKE unit requires only one communication cable between the remote console and local drive box
- **Variable-speed drive**
  - The operator can easily control the choke opening and closing speed, allowing for precise choke positioning adjustment during critical well-control situations
- **Faster open/close speeds**
  - The 8 seconds from full-open to full-close is faster than a hydraulically actuated choke
- **Motor and drive power requirements**
  - Holding, 100% speed, .472 Amps
  - Moving, 100% speed, .832 Amps
- **Choke body power requirements**
  - Moving, 50% speed, 1.248 Amps
  - Moving, 100% speed, 2.176 Amps
  - With 10,000 psi (690 bar):
    Moving, ~1% speed, 1.44 Amps
    Moving, 50% speed, 2.152 Amps
    Moving, 100% speed, 3.624 Amps
- **Certifications**
  - Designed, manufactured, and monogrammed in accordance with API 6A, API 16C, and NACE MR0175
  - Optional configurations available to P-X Temperature rating (-20F to 350F), PR2, PSL3G, and Material Class EE-NL for H2S service
  - Optional certifications to ABS CDS, DNV, CE and PED marked, NORSOK Z-016, and D-002
  - Customized certifications available

The M-I SWACO VERSA-CHOKE

The M-I SWACO 15K VERSA-CHOKE was engineered for advanced well-control applications, requiring large trim with high pressure and temperature ratings. The highly flexible VERSA-CHOKE is ideally suited for high-end pressure management, managed pressure drilling (MPD), underbalanced drilling (UBD), frac plug drill-outs and frac flowback.

Unlike intrinsically pressure-balanced chokes, the position-based VERSA-CHOKE is controlled by specially designed hydraulically driven actuators. Unique to the modular VERSA-CHOKE is the capacity to easily "hot swap" actuators without having to disassemble any internal components, thereby reducing maintenance time. Both piston-style and worm-gear style actuators are available. The piston-style actuator is designed for use on the 5K VERSA-CHOKE, while the worm-gear actuator is designed for use with any pressure VERSA-CHOKE. All actuators are designed to withstand without failure the full rated backpressure of the choke.

The VERSA-CHOKE is available in reversible 1 ½, 2 and 3 in. trim sizes. The capacity to reverse trim, which is common to all pressure ratings, doubles the operational life of the choke. Moreover, trim size can be changed by only changing internal components. The modular design also allows customized configurations to meet project-specific installation and operating conditions. Flange sizes of up to 4 $^{1}/_{16}$ in are available and custom spool lengths can be provided to meet custom applications upon request.

Advantages

- **Multiple pressure-sensitive applications**
  - Advanced pressure control
  - MPD/UBD
  - Frac plug drill-out
  - Frac flowback
- **High pressure rating**
  - 5 K (345 bar)
  - 10K (689 bar)
  - 15K (1,034 bar)
- **Position-based control system**
  - Worm-gear hydraulic actuator (available for all pressure ratings)
  - Piston-style hydraulic actuator (available for 5K choke only)
- **Ease of maintenance**
  - Actuators can be changed out without having to disassemble any internal components
  - Quick-change internal components
- **Configuration flexibility**
  - Modular design and components allows configuration to be customized to specific operating conditions
  - Trim can be changed from 1 ½, 2 to 3 in. by only changing internal components
  - Available with API 6A material class and EE-NL NACE trim to 350°F.
  - Available with multiple API flange sizes up to 4 $^{1}/_{16}$ in
  - Spool length and size can be configured to meet custom applications
- **Certifications**
  - Designed, manufactured, and monogrammed in accordance with API 6A, API 16C, and NACE MR0175
  - Optional configurations available to P-X Temperature rating (-20F to 350F), PR2, PSL3G, and Material Class EE-NL for H2S service
  - Optional certifications to ABS CDS, DNV, CE and PED marked, NORSOK Z-016, and D-002
  - Customized certifications available

M-I SWACO Drilling Chokes prove themselves in the field

Texas: Pressure, flow rate changes no match for 15K AUTOCHOKE

The Situation

The operator required a more consistent and cost-effective solution for managing flow during the highly abrasive environment common to frac plug drill-out operations. The desired pressure control solution would be used to drill out 14 plugs in a Carthage, TX field.

The Solution

The operator deployed the 15K AUTOCHOKE in an attempt to effectively and accurately control near constant BHP while reducing plugging, choke cutout, and non-productive time.

The Results

Throughout the multi-plug drill-out, the responsiveness of the 15K AUTOCHOKE was fast and predictable, requiring minimal manual adjustments during the operation. Feedback from the crew members was positive, with emphasis on the reduced amount of required control and minimal wear to the internal components.

Louisiana: SUPERCHOKE kills well in one circulation, removes guesswork

The Situation

The operator planned to re-enter a well that had been permitted to 15,000 ft (4,572 m), but encountered a host of formation problems that prohibited drilling past 11,850 ft (3,612 m). Successfully drilling the re-entry required overcoming the lost circulation, high pressure and differential drill string sticking experienced in the original well. Using drilling fluid densities of 15.2 lb/gal (1.8 sg) or lower would generate a kick while weights higher than 15.6 lb/gal (1.8 sg) would lead to lost circulation.
The objective was to overcome these potential issues and drill 2,000 ft (610 m) into the formation. The re-entry drilling program eventually would require a well control operation to be conducted.

The Solution

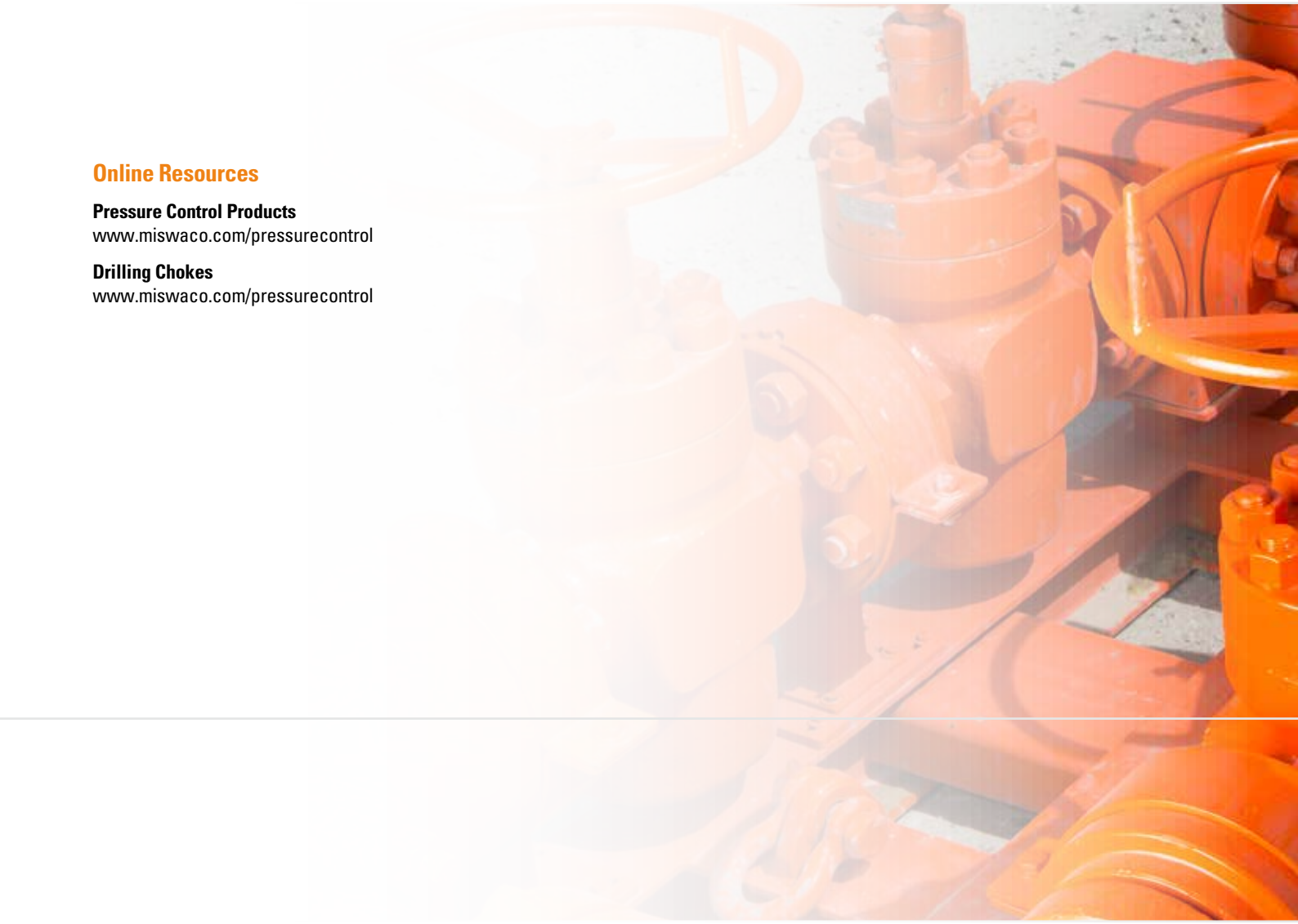
For the re-entry, M-I SWACO recommended the operator employ its SUPERCHOKE engineered for precise pressure control in well control, well testing and well cleanup operations, as well as in high-pressure drilling applications.
The SUPERCHOKE would overcome the deficiencies of a conventional control panel in which the fixed orifice size in the valve is opened or closed by controlling plates, sleeves, or pin-and-seat elements with a joystick located on a control panel.
In a kill operation, the constant adjustment required with the joysticks made it nearly impossible to hold casing pressure, initial circulating pressure (ICP) and final circulating pressure (FCP) during pump start up, drill-pipe schedule, or when gas was being produced. M-I SWACO also looked at the re-entry as prime opportunity to again validate the advantages of the SUPERCHOKE as a single-circulation well kill technology.

The Results

After the well kicked at 2,425 ft with a 14.9 lb/gal (1.7 sg) oil-base drilling fluid in the hole, the SUPERCHOKE was activitated and successfully killed the well in one circulation. The operator was able to proceed with drilling 2,000 ft of the targeted formation, while skirting the fracture gradient between 15.2 and 15.6 lb/gal equivalent mud weights. Throughout the operation, the FCP and drill-pipe pressures never deviated higher than 50 psi and allowed the operator to easily maintain constant drillpipe pressure or FCP until the kill weight mud reached the surface at 6,700 strokes. The capacity to kill the well in one circulation saved significant rig time, while giving M-I SWACO personnel the ability to record pertinent data to validate the efficiency of the SUPERCHOKE as a viable well control technology.
As demonstrated in this application, a key advantage of the technology is removing the guesswork from critical well-kill operations.

Put our Drilling Chokes to work for you

To meet the diverse needs of our customers, our Drilling Chokes are available for both purchase and rental, and include service maintenance.
To find out more about how our high-performance Drilling Chokes are controlling pressures for our other customers worldwide, contact your local M-I SWACO representative.



Online Resources

Pressure Control Products
www.miswaco.com/pressurecontrol

Drilling Chokes
www.miswaco.com/pressurecontrol

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