

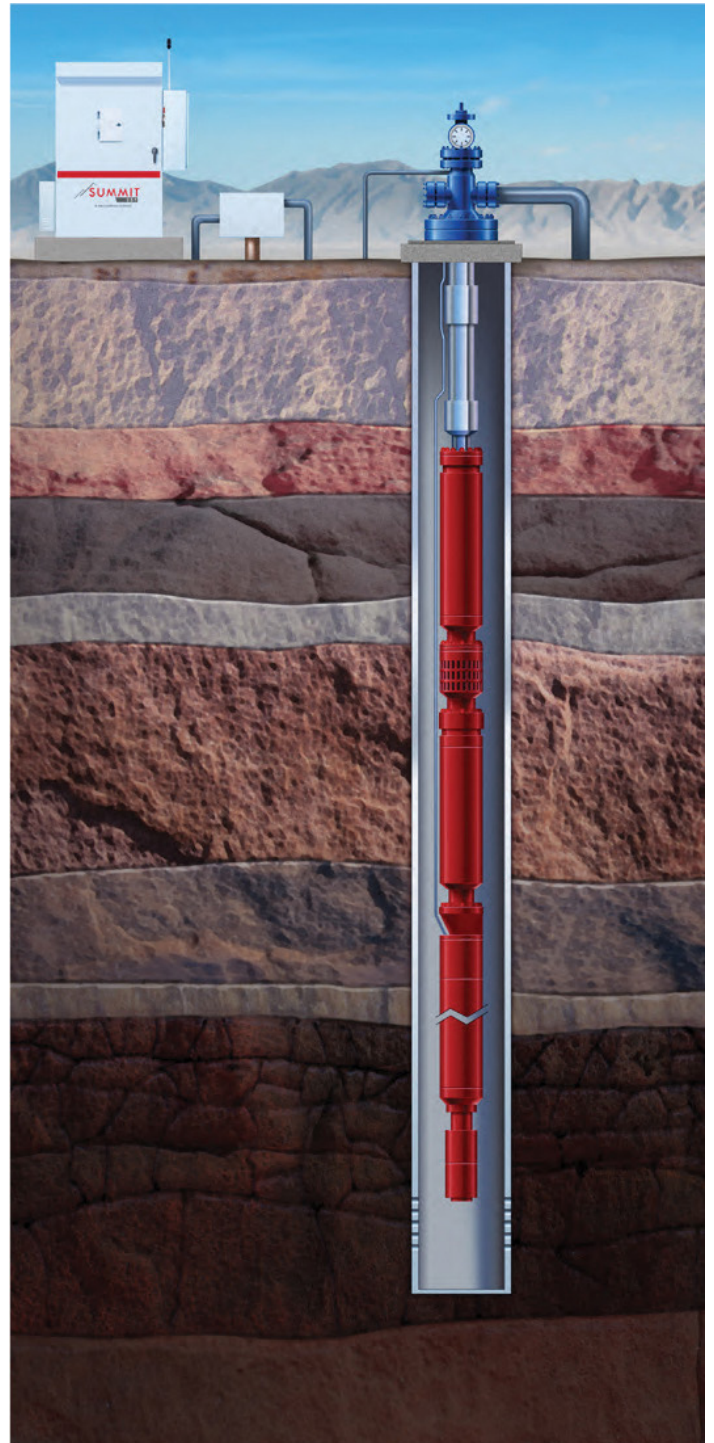


# Summit ESP<sup>®</sup> products and services

Reliable, durable, and efficient electric submersible pumping and horizontal pumping system technology



We provide integrated electric submersible pumping (ESP) systems and horizontal pumping system (HPS) solutions to enhance daily well production and total reservoir recovery. Our commitment to providing superior technology and exemplary customer service raises the standards of the artificial lift industry.





# Tiger Shark® IV 400 Series Flexible Extended-Range Pumps

## Designed to provide a flexible extended operating range and longer run life in deep high-pressure wells

The Tiger Shark® IV (TS4) 400 series of high-performance electric submersible pumps (ESP), offered by Summit ESP® – A Halliburton Service, is the next-generation pump designed with an enhanced bolt design providing an increase in allowable discharge pressure up to 6,200 psi without welding or collaring, setting a new industry standard ahead of major competitors. This new design also allows for a 33% increase in pull rating and improves assembly efficiency while also reliably extending the pumps' operating range and run life in the most challenging environments with high discharge pressure — anywhere in the world.

### BUILT TO LAST

Summit ESPs Tiger Shark pumps stand as a designation of robust engineering, setting the standard for reliability and longevity. The pumps' consistent performance under the most demanding conditions is impressive.

These pumps consistently exceed expectations. Our unwavering commitment to quality and service not only enhances production efficiency but also instills a sense of trust and dependability. Tiger Shark pumps are reliable for maximizing well productivity and optimizing production.

*"Summit ESPs Tiger Shark pumps are a testament to robust engineering. They are our go-to choice for reliability and longevity in the field. They consistently outperform and outlast, making them an ESP industry favorite."*

- Production Supervisor

### FEATURE HIGHLIGHTS

The TS4 pumps feature new technological advancements designed to solve the challenges of both conventional and unconventional wells, which can include significant amounts of abrasive material that need to be pumped, along with fluids exceeding normal pressure operating limits

- Enhanced bolt design provides an increase in allowable discharge pressure up to 6,200 psi, eliminating the need to weld or collar pumps
- Enhanced bolt design allows for a 33% increase in pull rating, reflecting an advancement in assembly efficiency
- Abrasion-Resistant Overlap (ARO) bearing system extends run life in highly abrasive environments and allows for secondary torque transfer even if the key is eroded\*. It also widens the operating range, allowing for operations in flow rates as much as 15% lower than a standard XR bearing system pump
- XRange® Xtreme (XRX) advanced bearing system provides upthrust protection, thus enabling a wider operating range\*

\* Application-specific option



**Tiger Shark® IV (TS4) 400 series pumps: The only choice for deep, high-pressure wells**

The TS4 400 series pump is highly dependable, enhancing performance with a newly designed threaded connection that eliminates the need to weld or collar, and increases reliability in deeper wells where higher discharge pressure typically occurs. These specialized advancements have resulted in first-rate pump performance in extremely abrasive and high-pressure wells.

**Tiger Shark IV 400 series pump features and benefits**

**FEATURES AND BENEFITS**

Enhanced bolt design provides an increase in allowable discharge pressure without welding or collaring, with the pump capable of up to 6,200 psi

Enhanced bolt design allows for a 33% increase in pull rating, reflecting an advancement in performance and efficiency

Dual sealing system with backup rings designed for deep high-pressure wells

Abrasion-Resistant Overlap (ARO) bearing system extends run life in highly abrasive environments and allows for secondary torque transfer even if the key is eroded\*. It also widens the operating range, allowing for operations in flow rates as much as 15% lower than a standard XR bearing system pump

Abrasion-resistant XRange® Xtreme (XRX) bearing system allows for the widest operating range, and this additional up thrust protection allows for more range to the right side of the curve\*

Top snap trap sleeve interlocks shaft and snap ring to provide secondary retention in the running position

Exclusive Erosion Buster® technology provides abrasion resistance to the diffusers and pumps' housing

Enhanced and highly reliable abrasion-resistant flange sleeve module design improves run life and increases uptime performance

Abrasion-resistant RingLock high thermal expansion material (HTEM) bearing system is standard on all 400 series pumps, and this exclusive HTEM ring provides secondary bushing retention

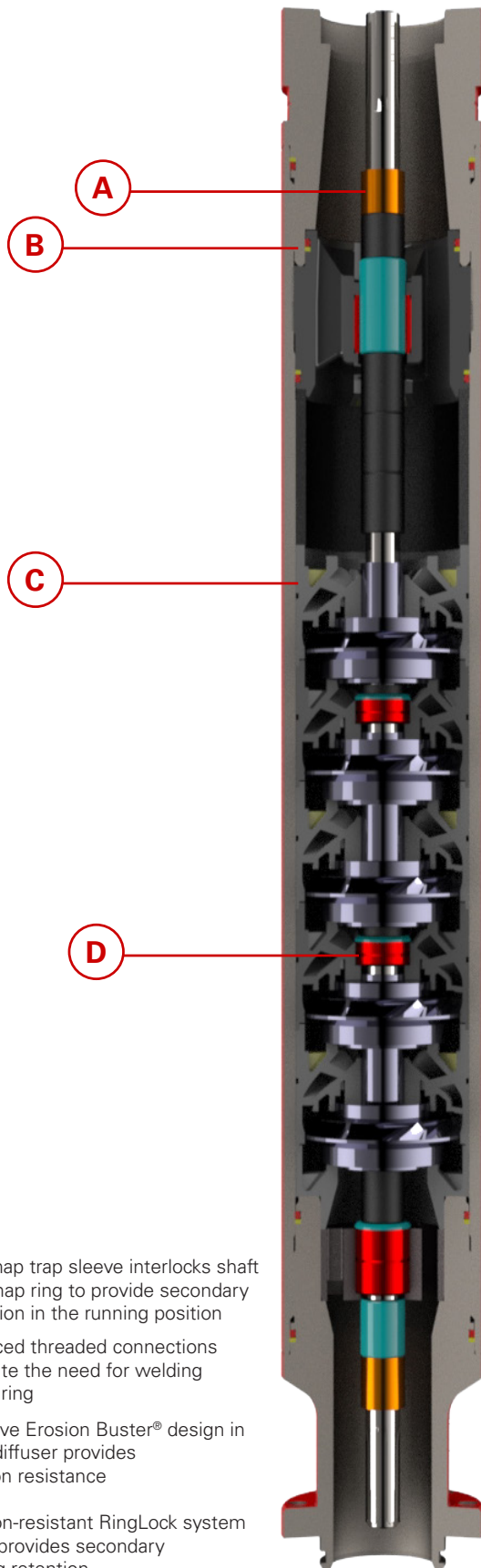
Coating options for stage metallurgy offer reduced corrosion and erosion while providing chemical protection

Wide flow range stage designs allow for extended operation in dynamic wells (see pump curves for capacities)

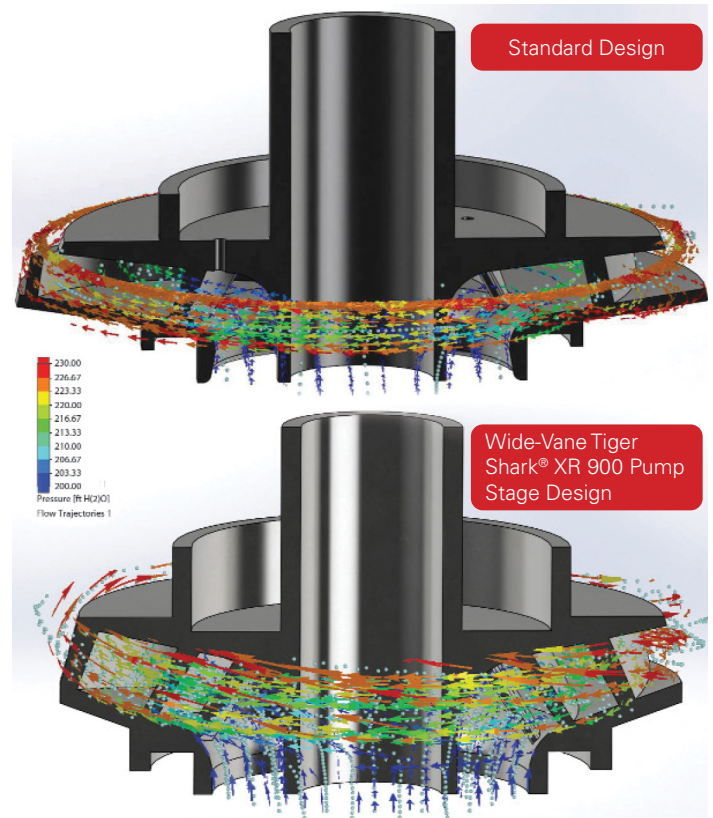
High-efficiency stages reduce the total cost of ownership and operation (see pump curves for efficiency rates)

\* Application-specific option





- A** Top snap trap sleeve interlocks shaft and snap ring to provide secondary retention in the running position
- B** Enhanced threaded connections eliminate the need for welding or collaring
- C** Exclusive Erosion Buster® design in every diffuser provides abrasion resistance
- D** Abrasion-resistant RingLock system HTEM provides secondary bushing retention



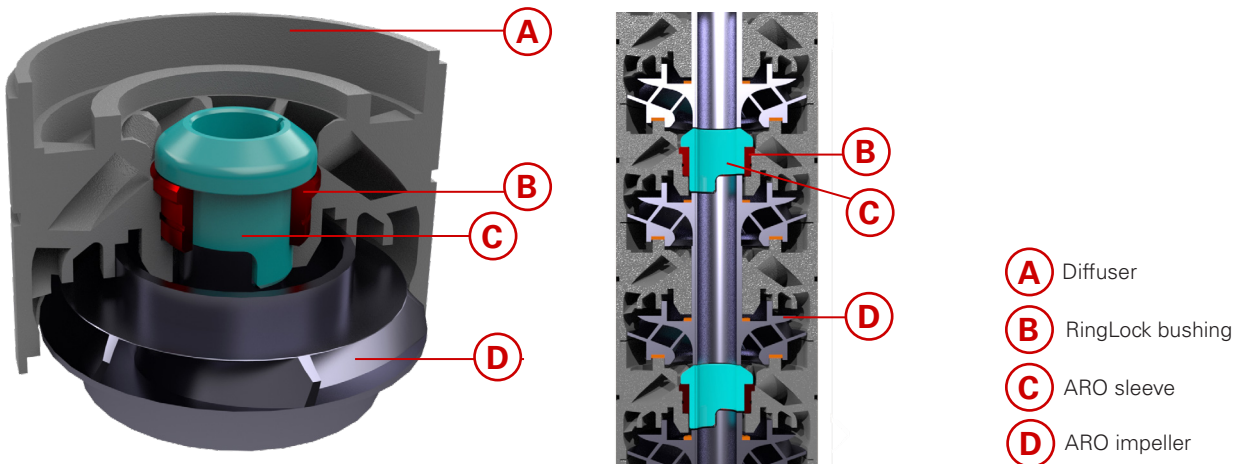
**Top** — State-of-the-art computational fluid dynamics (CFD) program is used to predict performance of new pump stages. By incorporating CFD modeling into each step of our iterative design process, our engineers can quickly refine the design features and rapidly deliver an optimally efficient, high-performance stage to market. Numerical methods are used to digitally test the pump long before parts are manufactured.

**Bottom left, wide-vane design** — Tiger Shark® XR 900 pump stage design offers 150 percent vane opening expansion to increase gas and solids handling capabilities while maintaining high efficiency and lift.

**Bottom right, sand wedge design** — Erosion Buster® design redirects fluid path inward and into the primary flow path, thus decreasing wear on critical areas, hence increasing run time.

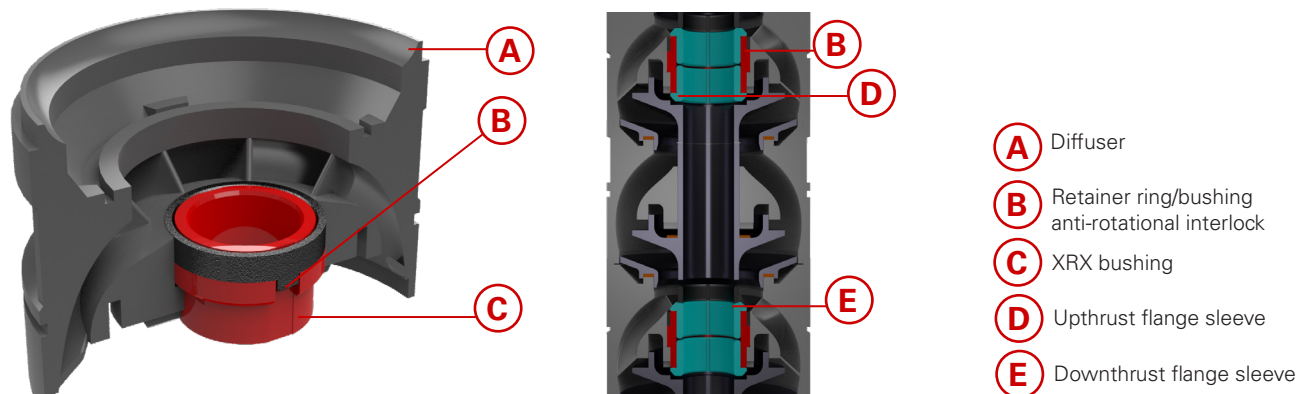
## Tiger Shark IV (TS4) 400 series pump technology

### Abrasion-resistant overlap (ARO)



**Abrasion-Resistant Overlap »** Bearing system that provides additional run life in extremely abrasive environments and allows for secondary torque transfer if the key is eroded. This is an application-specific option.

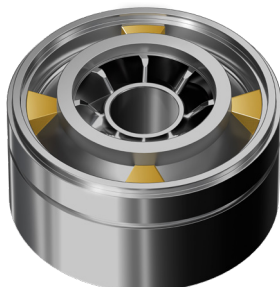
### XRange® Xtreme (XRX)



**XRange® Xtreme »** Abrasion-resistant bearing system that allows for the widest operating range. This additional upthrust protection allows for more range to the right side of the curve. This is an application-specific option.

### Erosion Buster®

» Design that redirects fluid path inward and into the primary flow path, thus decreasing wear on critical areas and increasing run time.



\* Consult your Summit ESP® representative for low-flow and high-gas applications.

# Hydro-Helical® gas separator

The Hydro-Helical® gas separator sets a new industry standard for flow rate, performance, and reliability. The first new downhole dynamic gas separator design in decades, the Hydro-Helical gas separator achieves extreme separation efficiency at high flow rates up to 40% greater than conventional separators. This translates to more oil production in higher gas applications.

The Hydro-Helical gas separator harnesses the kinetic energy of fluid using proprietary technologies designed for stability, efficiency, and reliability. This innovative new gas separator represents the latest in computational fluid dynamics design vetted on our fully instrumented, transparent two-phase test system.

## Innovative ideas, Rigorous testing

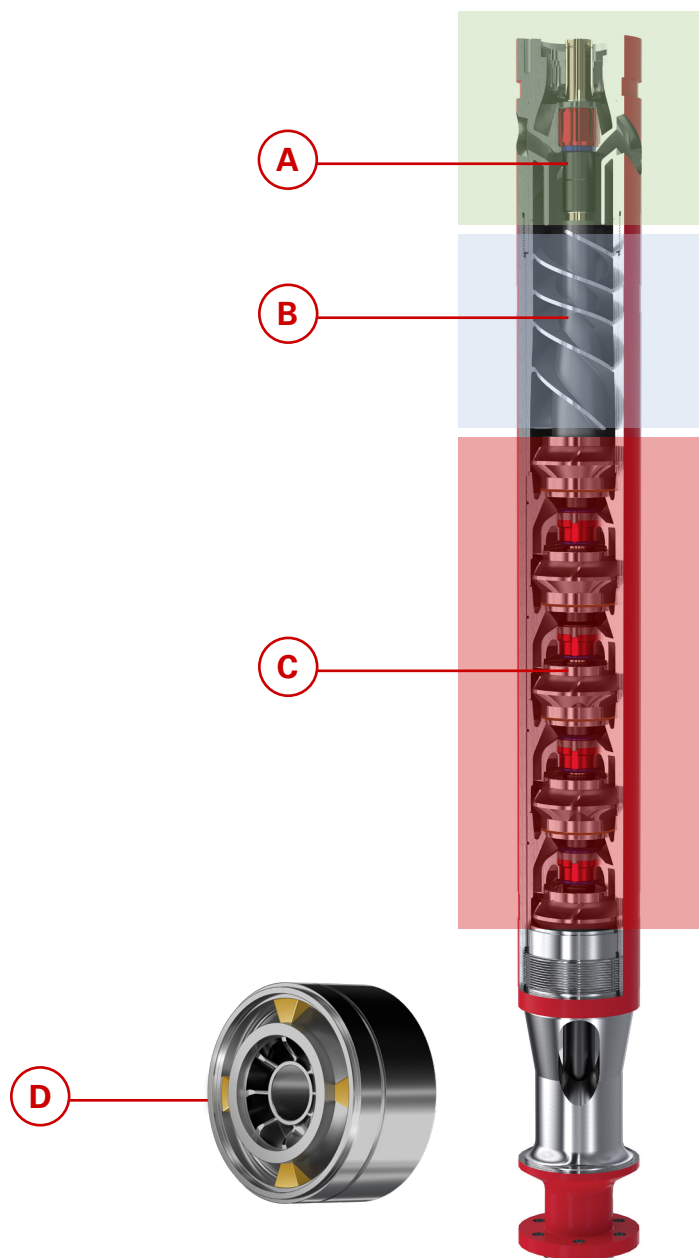
Our two-phase test system uses transparent components that allow visual examination of flow conditions of both gas and liquid, internal and external to the gas separator. Multiple instrumentation, designed within the gas separator and throughout the system, collects pressure and flow data.

This empirical testing concept shows that the Hydro-Helical gas separator consistently outperforms conventional designs. In fact, studies indicate that performance of a single Hydro-Helical gas separator even exceeds conventional tandem gas separators.

The Hydro-Helical gas separator solves difficult problems that plague conventional systems including:

- Fluid remixing and inefficient separation due to regions of turbulent flow
- Ineffective fluid separation patterns due to high pressure differential across the separator
- Limited maximum flow rate and pump compatibility from ingestion of fluid through exit ports
- Flow losses, recirculation, and gas ingestion in tandem configurations

- A** **Intake, Crossover and Exit Ports** » Individually optimized, creating superior overall performance.
- B** **Vortex Inducer** » Stationary helix vortex inducer creates greater than 95% separation efficiency.
- C** **Fluid Moving Stages** » Proprietary stage design avoids pressure differentials that cause gas locking.
- D** **Erosion Buster®** » Proprietary design redirects fluid path inward and into the primary flow path, reducing erosion and wear on critical areas.





# Defender® seals

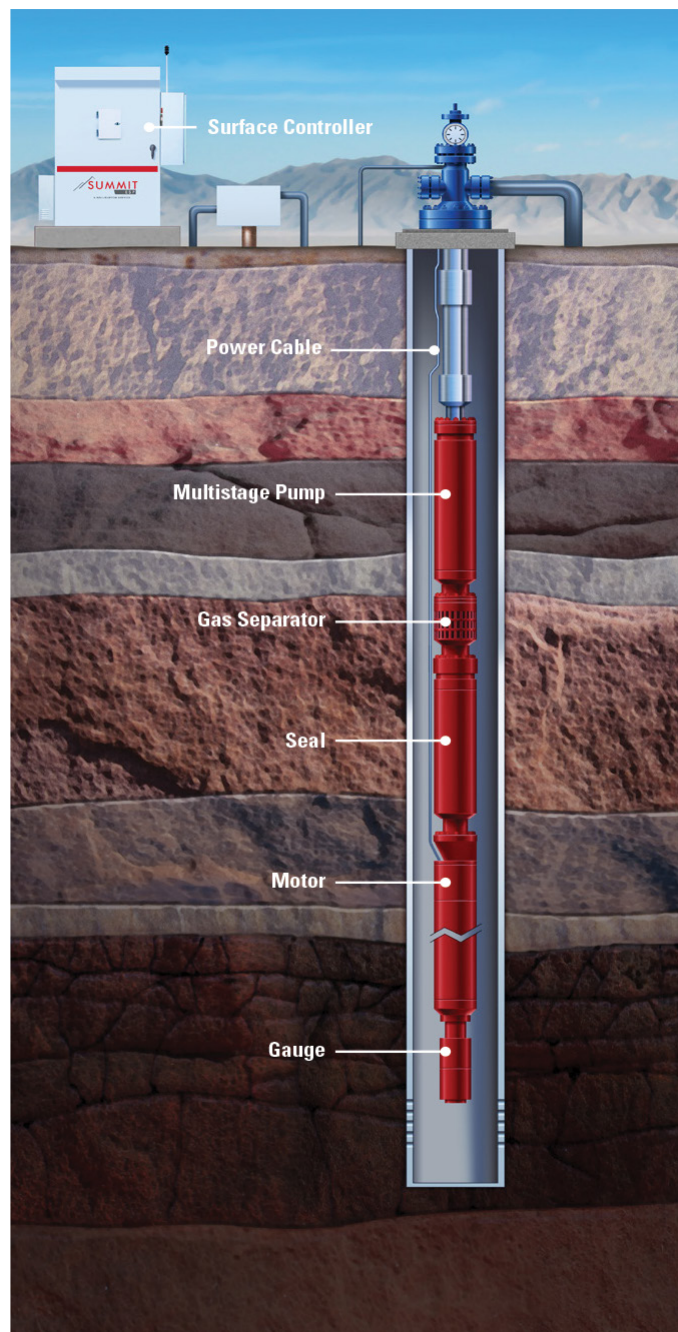
## Advanced seal extends ESP operational life

Summit ESP® – A Halliburton Service has developed the Defender® super sand seal to operate in extreme downhole environments. Configured for each application, the Defender seal is designed to extend the operational life of electric submersible pump (ESP) systems with extreme redundancy and design that prevents wellbore abrasives from damaging the seal and motor sections.

The tool's sealing mechanisms are designed to extend the operational life of ESP systems by equalizing downhole pressure and preventing the intrusion of damaging wellbore fluids. Configurations for Summit ESP seals can be customized for service in extreme downhole environments.

In our standard ESP systems, the seal section is located between the intake and motor, where its principal functions are to protect the motor and support the downward thrust generated by the pump. The seal is equipped with a shaft-mounted thrust runner that transfers downthrust forces from the pump shaft to a heavy-duty thrust bearing that is fixed to the housing. The positioning of this bearing allows Summit ESP pumps to be run in tandem configurations without the need for integrated thrust-handling capabilities.

In a typical installation, an ESP system is submerged in fluid and lowered often several thousand feet into the wellbore. As well fluid enters the wellbore, the fluid column above the ESP increases, generating a pressure differential between the motor oil and the fluid in the annulus. Summit ESP seal sections equalize the pressures while preventing motor damage by blocking the invasion of wellbore fluids. Furthermore, Summit ESP seals are designed to handle the thermal expansion of motor oil during regular operation of the pumping system.



## Features

- Automatic sand flush head design
- Protected pressure relief design
- Customizable bag configurations
- Single or tandem configurations
- Modified for high horsepower and extreme conditions
- Enhanced high-load (EHL) bearing

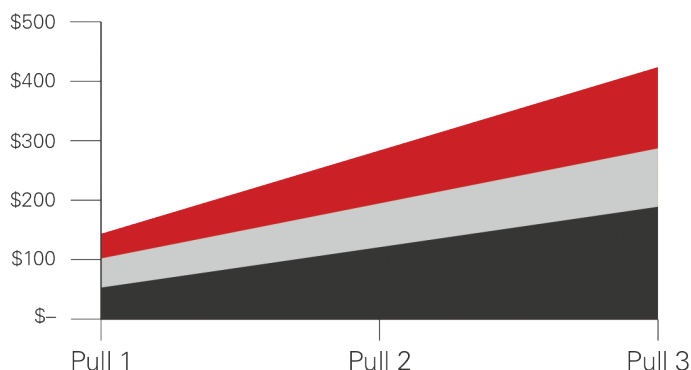
## Benefits

- Upthrust bearing requires no locking ring, spacer or shims, and allows shaft movement to be set with high accuracy
- Exit ports prevent the swirling effect of abrasives, which destroys shaft seals and radial bearings
- Reduces downtime
- Mitigates issues with thermal expansion of motor oil

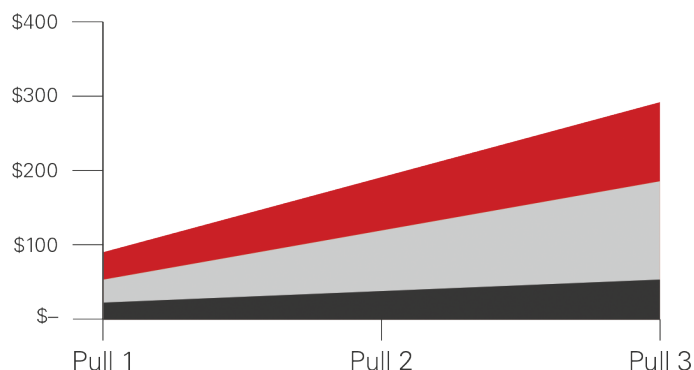
## Defender® seals significantly reduce operator's costs

These charts illustrate that the deployment of the Defender® super sand seal avoided significant cost for the operator over a 24-month period.

Well 1 Annual Failure Cost = USD 410,000\*

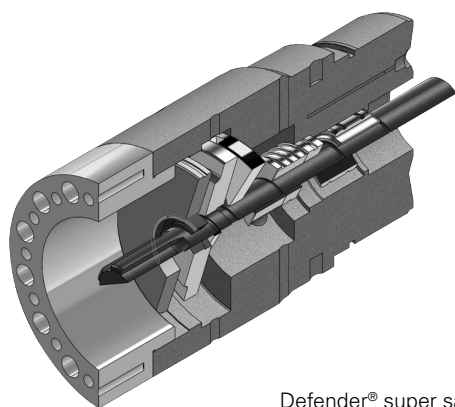


Well 2 Annual Failure Cost = USD 290,000\*



Consumables Pull Cost Deferred Production

\* USD 85/bbl and USD 4/Mcf used to calculate deferred production value



Defender® super sand seal

Seal section chambers are installed as either labyrinth or bag configurations. Labyrinth configurations permit well fluid to enter a chamber through a top-mounted vent port, thereby allowing pressures to equalize. The well fluid, which typically is heavier than motor oil, migrates to the

bottom of the chamber where it is isolated from the next chamber, by virtue of a breather tube designed to allow only clean, non-damaging motor oil floating at the top of the chamber to pass between chambers.

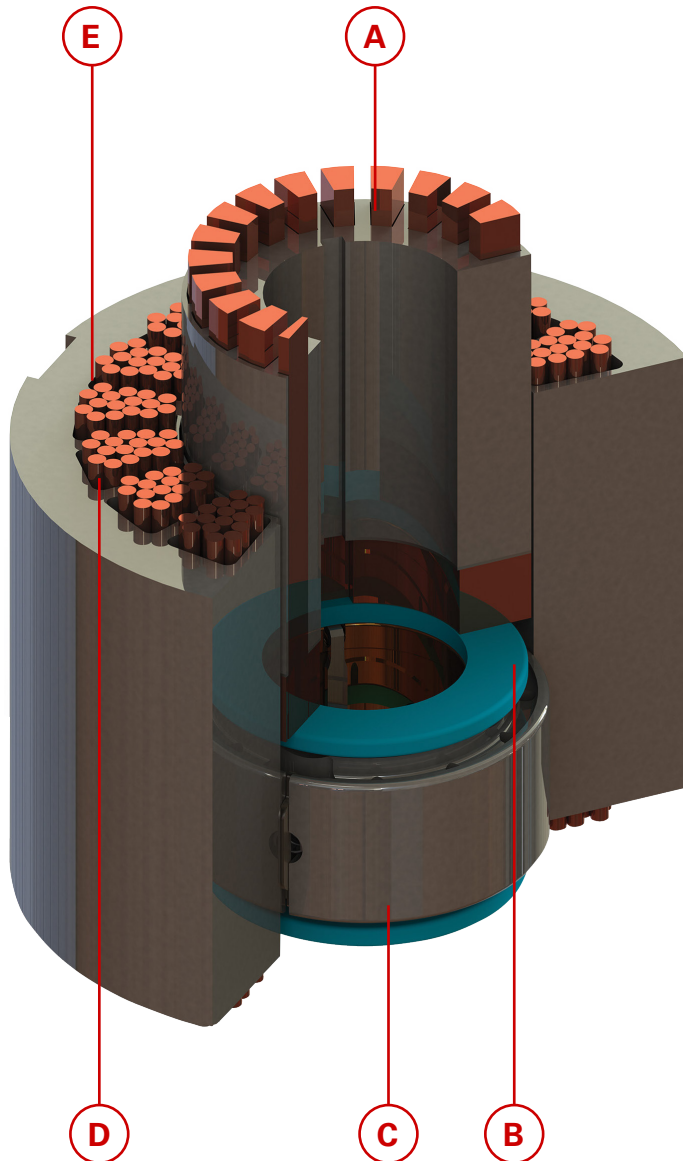
Bag seals use a flexible elastomer bag contained within the seal housing to segregate and protect the motor oil from well fluid. As with a labyrinth seal, wellbore fluid is allowed to enter the housing through a vent port to create pressure equilibrium, but the bag acts as a flexible barrier to prevent contamination of the motor oil. Generally, both style chambers may be used in vertical applications, and bag seals are used when the pump must be set in a wellbore with a horizontal deviation of more than 45°. In high-horsepower applications or those with extreme reliability concerns, Summit ESP seals can be run in tandem configurations.

# Corsair™ motors

## Surpassing industry standards in construction and performance

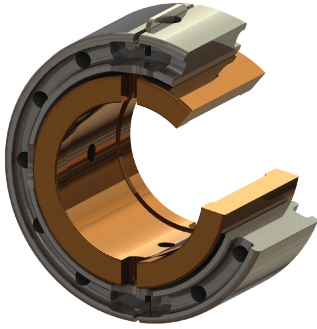
Summit ESP® – A Halliburton Service offers the new standard in electric submersible motors. Corsair™ motors provide the operator with the highest levels of performance in the harshest downhole environments. The Summit ESP Corsair motor matches the construction of what the industry has called premium motors.

The Summit ESP Corsair motor can be upgraded to include compliant tungsten carbide bearings and insulation that combines polyimide insulation with PEEK, providing the best of both worlds by combining the dielectric strength of polyimide and the temperature rating of PEEK.

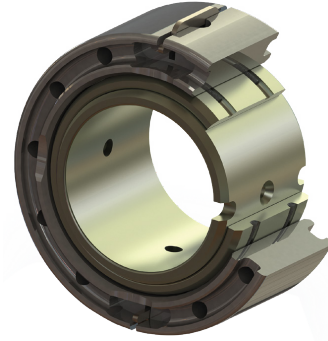


- (A) Shaped rotor bars >>** New design utilizes shaped rotor bars, resulting in less current waste and a more efficient motor.
- (B) Non-recessed rotors >>** More copper eliminates the need for inserting motor bearings into recessed areas – thus reducing friction and heat, and improving reliability and performance.
- (C) Self-aligning, wide-profile, Big Foot™ bearings >>** Larger wide-profile bearing increases heat transfer, reducing internal motor temperatures. Large wide-profile motor bearing also distributes side loads over larger areas, thus reducing fretting damage in the stator laminations.
- (D) Standard double-wrapped polyimide insulated windings >>** This feature provides added protection that improves reliability.
- (E) Precision hand-wound stators >>** These stators allow more room in the slot for additional copper wire, thus increasing efficiencies and performance. Hand-winding also reduces the potential for damaging wire during construction, further increasing reliability and performance.





**Big Foot™ thick bronze sleeve bearing >>** Wide-profile, larger bearings increase heat transfer, thus reducing internal motor temperatures while distributing side loads over a larger area and decreasing fretting damage in the stator laminations. Big Foot bearing carriers use positive locking tabs that eliminate spinning inside the stator bore. The bronze sleeve utilizes sled keys that do not require full-length keyways, allowing the sleeve to maintain roundness and concentricity and reducing optional contact between the carrier and sleeve.



**Big Foot™ abrasion resistant A/R bearing >>** Big Foot bearings can easily be upgraded to the self-aligning carbide option by using the same bearing carrier. Exact clearance is maintained, since the bushing and sleeve are made from the same material. The self-aligning bushings reduce vibration while providing precise concentricity between the carrier, bushing, and sleeve – all while being subjected to harsh environments.

## Corsair™ motor features and benefits – 375, 420, 456, and 562 series

FEATURES	BENEFITS
Precision hand-wound stators	Allows for more room in slots for additional mag wire, increasing efficiencies and performance. Hand-winding vs. machine-winding allows for exact placement of mag wire at every turn, thus reducing wire-to-wire rub and damage during construction, and increasing motor reliability.
Non-recessed rotors	More copper eliminates the need for inserting motor bearings into recessed areas – thus reducing friction and heat, and improving reliability and performance.
Self-aligning, wide-profile, Big Foot™ bearings	Larger wide-profile bearing increases heat transfer, reducing internal motor temperatures. Large wide-profile motor bearing also distributes side loads over larger areas, thus reducing fretting damage in the stator laminations.
All-steel, closed-slot stator construction	This type of construction optimizes motor performance.
Non-magnetic, positive-locking bearings	This feature optimizes bearing performance during operation.
Shaped rotor bars	More copper provides increased efficiency.
Standard double-wrapped polyimide insulated windings	This standard feature offers added protection and improved reliability.
Head and base bushings made of self-aligning carbide	Exact clearance is maintained because both bushing and sleeve are made from the same material. These self-aligning bushings reduce vibration.
Increased lubrication slots	Custom-blended oils are used with increased-lubrication slots to reduce mechanical wear and improve reliability and runtime.

# Triton® gauges

## The next generation of downhole gauges

Summit ESP® – A Halliburton Service proudly presents the next generation of downhole gauges with leading-edge, data acquisition technology that provides superior surveillance capability and asset protection. Triton® 7 channel (T7-125 or T7-150) or Triton 8 channel (T8-150) downhole gauges can be used with a variety of electric submersible pump (ESP) motors using specially-designed, bolt-on adapters.

Reservoir life cycles can be improved by using Triton downhole gauges in conjunction with proactive data evaluation philosophies, to prevent or reduce formation damage caused by over-production. Data acquisition supplies intake fluid temperature and intake pressure data, which help identify water or gas break-through. The

acquired data can then be transmitted via Modbus protocol or SCADA to a surveillance center through Summit ESPs well surveillance and remote control service. Analysis can then be performed by our team of petroleum engineers to ensure continuous operation and optimized production, which helps increase run-life and reduce OPEX.

Triton downhole gauges are easy to install, easy to operate, and use a waterproof wye-point connection. Telemetry to the surface is accomplished by superimposing DC signals on a traditional 5 KV ESP power cable. At the surface, these signals are translated into usable data values by the Triton Surface Interface (TSI) and are displayed on the advanced technology Summit ESP ACS®-15 variable speed drive (VSD) operator interface.

FEATURES	BENEFITS
Sealed electronics	Gauge communication maintained if fluid penetrates ESP motor/seal assembly
Industry-leading transducer accuracy	High reliability of gauge operation – less chance of damage
Downhole data displayed directly on VSD interface	Better data reliability and accessibility
Remote access via SCADA and Summit ESP Well Surveillance and Monitoring Service	Improved decision-making capability based on current information
Adaptability for RS-485, Ethernet, AO, DI, competitive ModBus maps	Configurability for special applications
Custom alarming and notification configured directly on VSD	Optimization of well production
24/7 asset monitoring	Improved production and equipment run life – continuous asset health knowledge
Easy integration into Summit ESP VSDs and switchboards	Less time and cost for startup
Compatible with all ESP OEM providers	Lower installation cost
Slim hole compatible – 3.75-inch OD	Easily installed with ESP 375/338 series equipment
Stainless steel metallurgy (optional)	Improved corrosion resistance
Industry-leading 20,000-pound connection weight	Allows adding more accessory equipment to string

# Hercules™ horizontal pumping system

## Versatile horizontal surface pumping systems for conventional or unconventional plays

Summit ESP® – A Halliburton Service offers a horizontal surface pumping system as an efficient alternative to positive-displacement, split-case, and other surface pumping options. The system design is based on proven electric submersible pumps (ESPs) already in use in thousands of downhole applications. The multistage centrifugal pump is mounted securely on a modular skid, powered by a two-pole motor, and protected by a robust thrust chamber.

### Applications

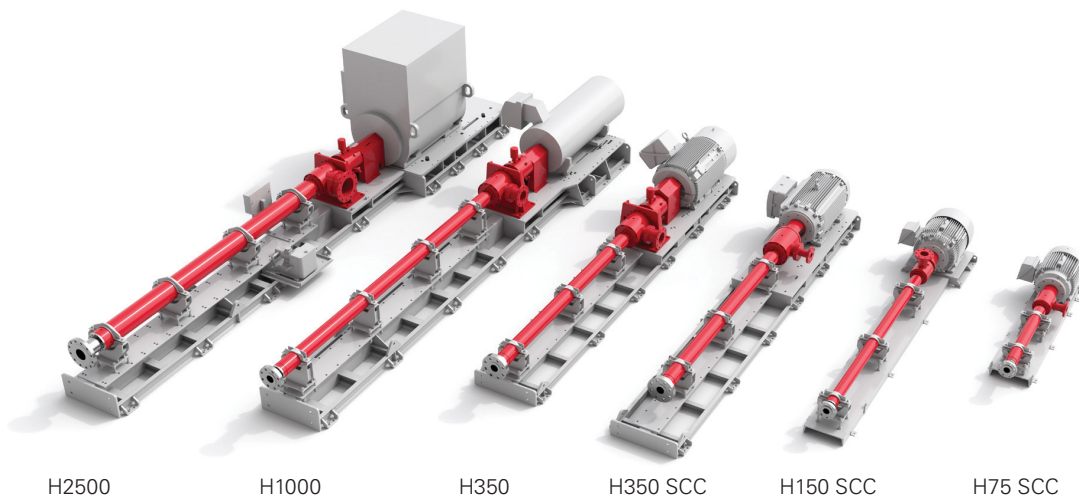
- Produced salt water disposal (SWD) and injection
- Crude oil transfer/boosting
- Liquid CO<sub>2</sub> boosting/injection
- Lean amine pumping (gas treating)
- NGL/light hydrocarbon, crude oil pipeline booster
- Cavern storage/salt dome leaching
- Boiler/steam-generator-feed pumps
- Jet pump – power fluid pumps
- Lease automatic custody transfer (LACT) booster
- Mine dewatering

### Benefits

- Lower initial operating and maintenance costs
- Modular design with short lead times on new and replacement equipment
- Flexible designs from 800 BPD to 70,000 BPD (23 USgpm to 2,000 USgpm)
- Back pull-out thrust chamber
- A single low-pressure mechanical seal
- Minimal noise and vibration; pulse-free flow
- Health, safety, and environment (HSE) friendly

## Summit ESP® Close-Coupled (SCC) surface pump

For applications of 20 hp to 350 hp, the SCC surface pump uses the motor bearings to absorb pump thrust and is ideal for smaller water injection, amine, crude oil transfer, or LACT applications.



H2500

H1000

H350

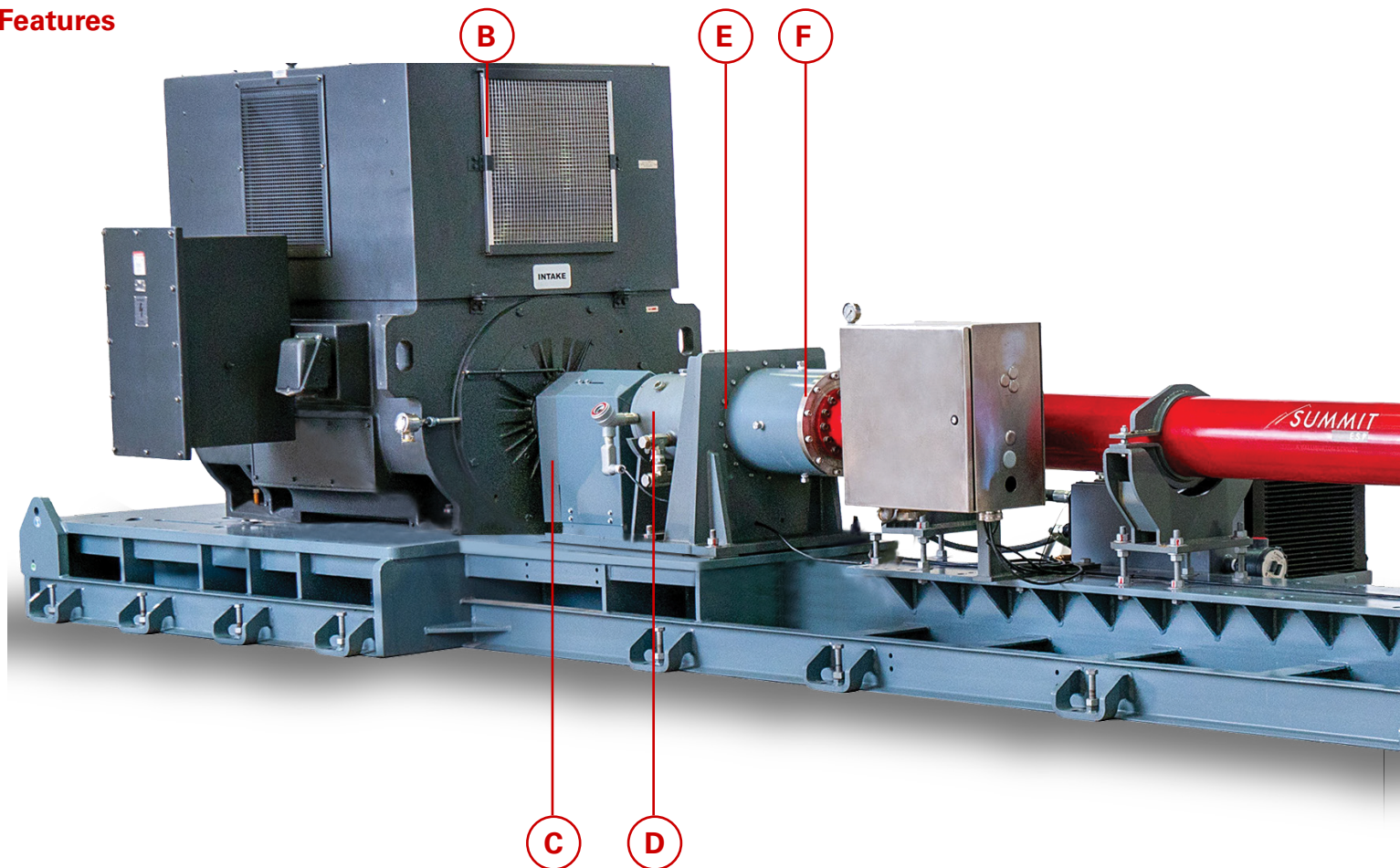
H350 SCC

H150 SCC

H75 SCC



## Features



### A. Heavy-Duty skid

- Modular skid, designed using extensive finite element analysis (FEA)
- Hoist mounting points to simplify installation

### B. Motor

- Power units available from 20 hp to 2,500 hp (15 kW to 2,000 kW)
- Electric motor options include TEFC, WPII, TEAAC, with area classification Class I Div II; other options available
- Diesel, natural gas engine, steam or gas turbine

### C. Balanced spacer coupling

- Maintenance free and helps reduce vibration
- Facilitates quick mechanical seal replacement without breaking pump or piping connections

### D. Thrust chamber

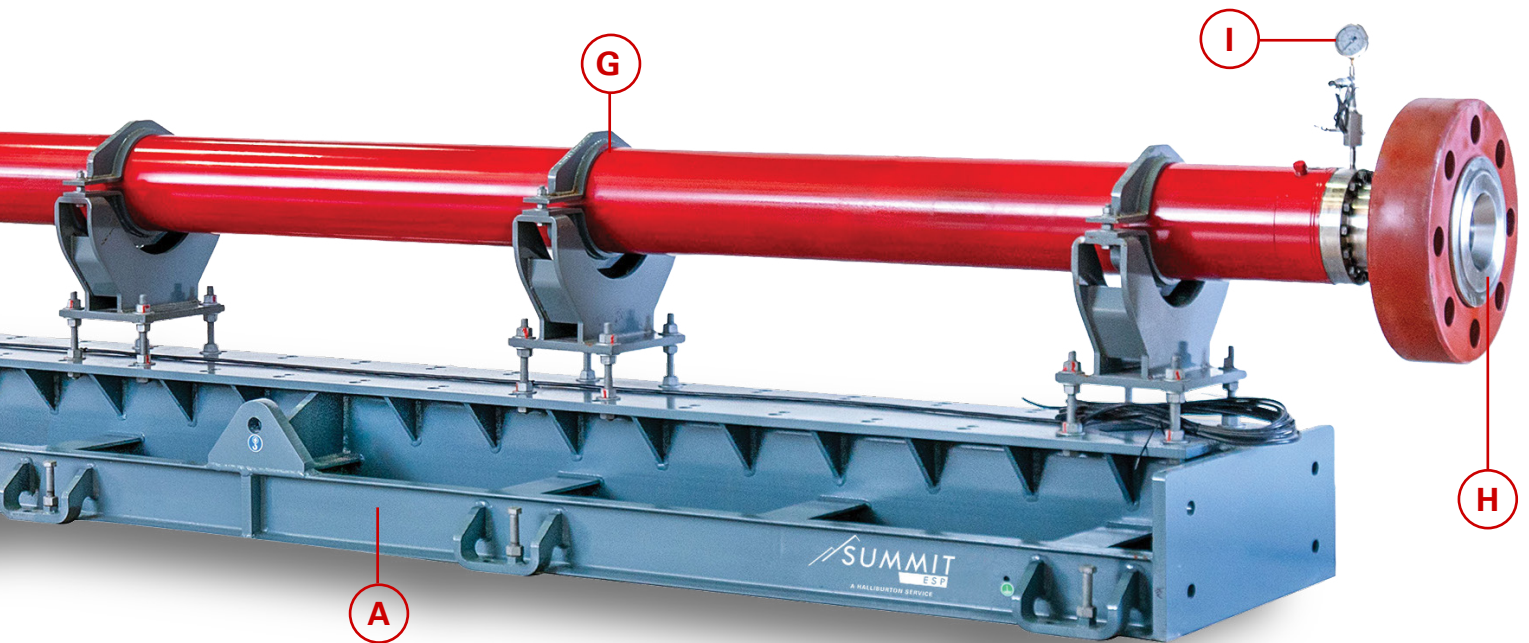
- Designed for increased reliability, seal support, and access
- Back pull-out for quick seal changeout
- Seal failure will not contaminate thrust chamber
- Minimal routine maintenance required

### E. Mechanical seal

- Single seal assembly, exposed only to intake pressure
- Available in component or various cartridge seal designs
- API 682 and all applicable API flush and quench plans to meet customer and application requirements



Whether your application is upstream/midstream (using produced water injection, CO<sub>2</sub> injection, or crude oil transfer) or downstream (using natural gas liquids or amine for gas sweetening), we have the right solution for your needs.



#### F. Intake and suction flange (not shown)

- 316SS ANSI raised face flange is standard; other materials and types are available up to 3,000 psi (207 bar)
- Intake can be rotated in 90° increments to accommodate suction pipework

#### G. Pump

- Flow range of pumps covers 800 BPD to 70,000 BPD (23 USgpm to 2,000 USgpm)
- Discharge pressures up to 7,100 psi (500 bar)
- Mixed-flow stage design for reduced abrasive wear, optimal efficiency, and head per stage
- Ni-Resist iron is standard stage material; other materials available upon request
- Tungsten carbide or GRAPHALLOY® bearings are available for wear resistance or low-lubricity fluids, respectively
- Tiger Shark® pump option to reduce pump thrust

#### H. Discharge flange

- Lap-joint type, comprising 316SS wetted parts and CS flange, compatible with ANSI standards
- Available in raised face or RTJ classes up to 5,500 psi (380 bar)
- API flange options available for higher pressures

#### I. Instrumentation

- Standard offering is intake and discharge pressure transmitter and vibration switch
- Skid-mounted junction box is available to provide single-point wiring
- Available in standard and explosion-proof enclosures, and customizable to suit customer or application requirements

GRAPHALLOY® is a registered trademark of Graphite Metallizing Corporation

# Well surveillance and monitoring service

## Analyze and understand well conditions

Summit ESP® – A Halliburton Service uses a holistic approach to well surveillance. Backed with 24/7 monitoring services, this approach increases production, improves run life, and reduces downtime and labor. Monitoring is a key part of increasing production and extending run life. Maximizing run life requires flawless execution during every part of the electric submersible pump (ESP) run cycle.

### Operational benefits

Real-time well surveillance increases the return on investment of an ESP system and the multimillion-dollar investment in the well's production potential. Without the use of a monitoring system, optimizing an ESP can require extensive labor and onsite field service. Operators are forced to send field personnel to the wellsite to collect performance data and restart wells after nuisance shutdowns due to set points that quickly become irrelevant as well conditions change.

The Summit ESP well surveillance service eliminates the need for manual interventions. Set points can be adjusted without the need to send field personnel out to location. Operators are able to specify acceptable operating ranges via a remote computer or mobile device. If an operating parameter drifts outside of the specified range, the operators are automatically alerted through text messages, phone calls, or emails. This alert system allows for rapid intervention without the added expense and delays associated with dispatching field personnel to remote well locations where cell phones may not function.

Our full-service intensive monitoring platform arms analysts with all set points and logs, enabling them to act quickly and accurately in real time..

### Flexible systems

The well surveillance platform supports multiple SCADA systems that store key operating parameters in a centralized database for remote monitoring, analysis, and control.

Our proprietary web-based field service ticketing, dispatch, and applications engineering system gives our monitoring group a complete 360° view of each well's equipment and operations.

Effective applications are designed by incorporating lessons learned from operations, real-time monitoring, field optimizations, and the results of root cause analysis from previous runs.

The SCADA systems track and plot key parameters in real time, including motor current, variable-frequency drive (VFD), winding temperature, and pump intake pressure into an interface that has been optimized for readability. Operators and Summit ESP service professionals closely monitor trends and either remotely make any necessary adjustments or notify field personnel.



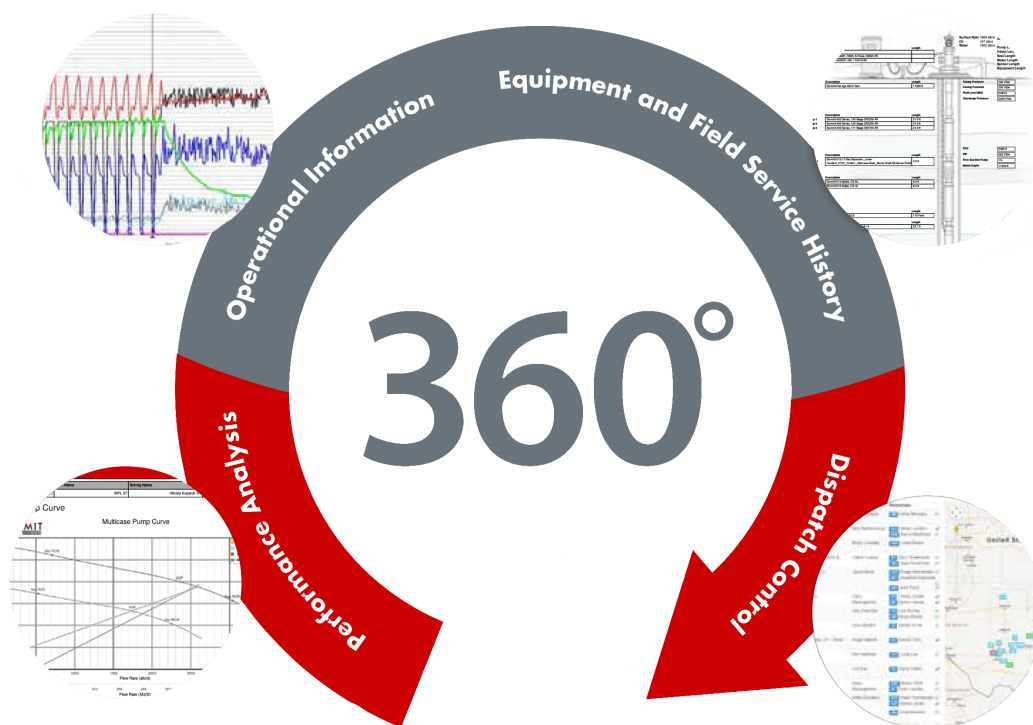
## Optimize performance

A team of degreed petroleum engineers continuously monitors wells on a 24/7 basis from our state-of-the-art monitoring center. For every newly installed system, our engineers configure personalized alerts that automatically notify field personnel and engineers of any problems. Each time a well is surveyed, our engineers reassess alerts to minimize nuisance alarms and optimize performance.

Using proprietary web-based applications engineering software, surveillance engineers mathematically model the operating conditions of downhole equipment and the

inflow characteristics unique to each well, allowing them to fine-tune operating conditions, maximize production, reduce operating costs, and extend run life.

Many operators hold regular weekly meetings with Summit ESP surveillance engineers and regional personnel, where they are presented with an overview of their wells' performance. These meetings allow operators to work together with diverse ESP experts to get the most out of their operations. Our surveillance engineers often also assist in monitoring wells on an operator's in-house SCADA well management systems.



### Operational information

Monitoring the SCADA parameters for each well is just the first part of the picture. The SCADA system itself allows engineers to understand the in-situ operational condition of the ESP – when to make remote adjustments and when to notify field personnel of any issues or shutdowns.

### Performance analysis

The Summit ESP monitoring service provides access to its proprietary web-based sizing system. Our web-based applications engineering software enables operators and applications engineers to quickly perform performance analysis on wells, model current operating conditions, and make recommendations on how to optimize production and extend run life.

### Equipment and field service history

Summit ESP well surveillance systems offer access to each well's equipment and field service history. Our proprietary web-based field service and equipment tracking system provides a comprehensive history of every well. It gives operators and applications engineers an immediate overview of currently installed equipment. Further, it provides a complete history of all field service interventions, previous problems with the wells, and what was done to fix those problems.

### Dispatch control

The Summit ESP dispatch system provides a complete view of all available field service technicians and their current locations. This real-time dispatch system allows customers and applications engineers to view the well and field via global positioning system data, see real-time locations of nearby field service technicians, and quickly dispatch them to wells that require immediate attention.

# Summit ESP ACS®-15 active front end drives

## Optimize performance of ESP or HPS equipment

Summit ESP® – A Halliburton Service presents the Summit ESP Adaptive Control System® (Summit ESP ACS®-15), the newest generation of variable speed drives (VSDs) featuring proven technology to ensure ultimate performance for your electric submersible pumping (ESP) or horizontal pumping system (HPS) equipment. With their rugged outdoor rated design, proprietary software, and plug-and-play capabilities, the Summit ESP ACS-15 active front end (AFE) drives offer reliability, flexibility, accuracy, and multilevel protection. The Summit View™ color touchscreen operator interface enables user-friendly operation.

The family of Summit ESP ACS-15 AFE VSDs is the ideal choice whenever input power quality needs to be maintained or when power provider constraints arise. Phase shift transformers or passive input filters are unnecessary, thus reducing installation footprint requirements.

The Summit ESP ACS-15 AFE system's robust design provides assurance for harsh-environment operations in all climates. State-of-the-art circuit boards feature a conformal coating, and all drive components reside in enclosures with cam-locking perimeter latches. This ensures door-seal integrity and ingress protection from unwanted contaminants.

Summit ESP ACS-15 AFE drives perform active harmonic cancellation. These drives, which are always IEEE-519 compliant under normal operating conditions, provide a power factor (PF) of .99 to unity (1.0) compared to other topologies that provide PFs of .95 to .98. Summit ESP's AFE drives are not influenced by changes in harmonic spectrum, system impedance imbalances, or typical voltage variations.



Summit ESP ACS®-15 drives provide quick response and adaptability to dynamic operating conditions attendant with your application. They also deliver asset protection, optimized production, reduced operating costs, and increased equipment life cycles.

## Improve power cost

Power costs are usually the largest expenditure for an oil-producing field. Summit ESP ACS®-15 AFE drives offer several operational benefits, depending upon the characteristics of your field's electrical distribution system.

These benefits include:

- Less kilowatt (kW) consumption
- Lower fuel-factor costs
- No PF penalties
- Fewer power system losses
- Additional power system capacity
- Cooler operating equipment

Use of the Summit ESP ACS-15 AFE drives provides:

- Lower electrical system losses
- Better voltage levels
- Cooler operation
- Extended run life

Summit ESP ACS-15 AFE drives offer:

- High power factors
- Increased system efficiency
- Possible elimination of PF penalties

Less reactive power (kVAR) is used as PF increases, thus reducing the amount of apparent power that the utility must provide to operate your equipment. This PF improvement helps reduce your operating costs.

From an electrical network viewpoint, reactive power is basically wasted power. Less apparent power demand may allow your power system to accommodate additional loading without more costs. Utility fuel factor costs may also decrease.

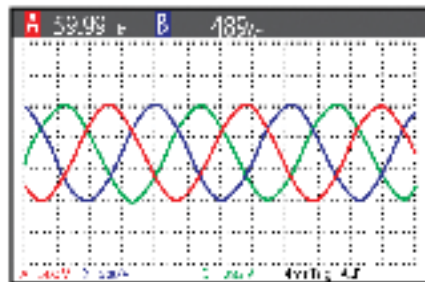
Extra savings with the use of Summit ESP ACS-15 AFE drives are realized on installation and wiring costs. The drives are three wires in and three wires out, and do not require additional harmonic mitigation devices such as phase-shift transformers or harmonic input filters. Therefore, the total drive solution requires less space; additionally, equipment is online quicker, installation costs decline, and revenue occurs faster.

The waveform snapshots shown below demonstrate how ACS-15 AFE VSDs provide significantly improved voltage and current sinusoidal waveforms compared to other drive topologies. As waveforms become more sine wave shaped, harmonic content declines and fewer harmonics are reflected into the power grid. Operating power costs are greatly influenced by the amount of input harmonics resident on the system.

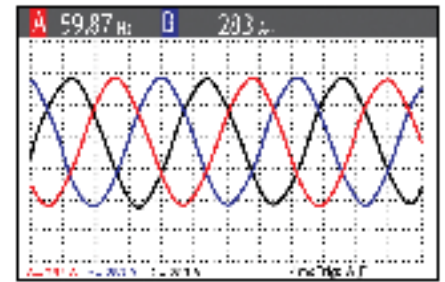


Waveform comparison of Summit ESP ACS®-15 drive input vs. 6-pulse inputs

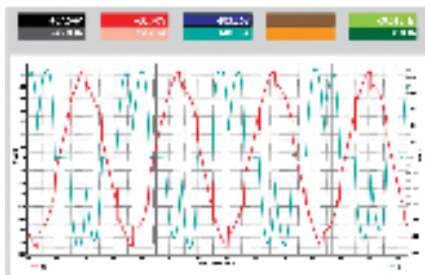
Less than 4% THD for voltage and current



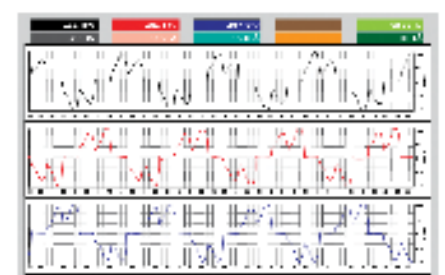
Voltage snapshot of Summit ESP ACS®-15 AFE drive



Current snapshot of Summit ESP ACS®-15 AFE drive



VSD with 6-pulse front end – Six-step variable voltage inverter (VVI) voltage and current snapshot



VSD with 6-pulse front end and passive harmonic input filter – current snapshot

# DuraHard® coatings



## DuraHard® 3 coating

### Basic reduced friction and corrosion resistance

Summit ESP® – A Halliburton Service offers a multilayer slick, non-stick coating that has enhanced bonding over traditional Teflon coating. Summit ESP DuraHard® 3 coating reduces friction on running surfaces, which minimizes the formation of scale and pump plugging.

Suitable for application in:

- Wellbore fluids with scaling and/or asphaltene tendencies
- Temperature resistant up to 500°F (260°C)s

**Turnaround: 2–5 days**



## DuraHard® 7 coating

### Enhanced abrasion and corrosion resistance

Summit ESP DuraHard® 7 high-phosphorous nickel coating provides additional, non-molecular surface hardness to stage materials (impeller and diffuser surfaces). Heat treatment provides uniform coating to all surfaces. DuraHard 7 coating is recommended in applications with a significant presence of heat, abrasives, and/or corrosion. An analysis of well fluid or sand particles is recommended to determine the ideal solution.

Suitable for application in:

- Corrosive environments
- Recently fractured wells with uniform
- Cased-hole applications where sand control is not 100 percent effective
- Temperature resistant up to 500°F (260°C)

**Turnaround: 2–5 days**



## DuraHard® 15 coating

### Extreme abrasion and corrosion resistance

The Summit ESP premium DuraHard® 15 molecular bond coating provides hardness comparable to carbide materials, but has added ductility and can be used to coat and bond steel components. DuraHard 15 coating is recommended in applications with a severe presence of heat, abrasives, and/or corrosion. An analysis of well fluid or sand particles is recommended to determine the ideal solution.

Suitable for application in:

- Highly corrosive well fluids
- Recently fractured wells with uniform or non-uniform sand particulates
- Wells with very high angular abrasive sand and formation fines
- Wells with quartz sand
- Openhole wellbores or wellbores with no sand control
- Temperature resistant to over 500°F (260°C)

**Turnaround: 2 weeks**

**Left** - Slick, non-stick coating

**Middle** - Nickel coating

**Right** - Molecular bond coating



# Avenger® motor lead extension

## Outperforms in corrosive high-temperature accelerated life tests

### Overview

A weak point in the electric submersible pump's (ESP's) electrical system is the pothead electrical connection (also known as the motor lead extension or MLE) because it is required to act as both an electrical connector and a seal to the motor. Additionally, high wellbore temperatures and the heat generated from the motor can lead to premature motor failure.

Summit ESP engineers have developed the Avenger™ MLE as a cost-effective solution that is reliable in both high-temperature and gassy wells. To prove the design and pinpoint any deficiencies, the Avenger MLE has been run through a number of accelerated life test protocols (ALTPs), which were created in partnership with some of our customers. These tests were performed at our research and development facility. Using a pressure vessel with 4,000 psi of carbon dioxide (CO<sub>2</sub>) and nitrogen, a mixture of water and diesel fuel to simulate well fluids, and with temperatures cycled up to 500°F (260°C) for seven days, engineers tested both our legacy and Avenger MLE designs, as well as two other competitor potheads.

When the testing was completed, two fatal flaws were noted on the competitors' MLEs related to the internal rubber seal swelling because of thermal expansion and the impregnation of gases. Both flaws resulted in an electrical failure of the competitors' ESP, while the Avenger MLE was still functioning perfectly.



*Summit ESP® engineers have designed the Avenger® MLE to outlast competitor designs.*

### FEATURES

- Sealed internally, using an O-ring within the motor head to protect the seal
- Protection against corrosive gases provided by a lead washer seated in a groove on the face of the pothead
- Rubber component in the seal reduced by 90 percent to mitigate swelling issues
- Surpasses the industry in thermal ratings up to 450° bottomhole temperature (BHT)
- 24-hour availability of any length MLE due to rapid assembly, which is conducted in half the time of competitor MLEs
- Historically proven tape-in connection creates a 260 percent longer arc path than is typical of the industry
- Made in the U.S.



# High performance cables

## Complete line of technically advanced cables

Summit ESP® – A Halliburton Service provides a complete line of high performance cables designed to the exact standards required for electric submersible pump (ESP) systems. To maximize operational longevity, all Summit ESP cables are tested to the latest API and IEEE recommended practices, as well as to the stringent Summit ESP specifications for each specific line.

The Summit ESP EPDM (ethylene propylene diene monomer) cable uses an insulation compound specially formulated to be oil-resistant while maintaining excellent electrical properties. For additional protection, a lead jacket or an additional EPDM jacket is applied over the insulation to add strength and provide an added shield to the insulation.

### SELF cable

The workhorse of the cable product line is the SELF (Summit EPDM Lead Flat) cable. SELF cable is designed to operate over a wide temperature range from –40°F (–40°C) to 450°F (232°C). A corrosive-resistant lead sheath is extruded over the insulation, making the cable impervious to gas or chemical penetration. This lead jacket barrier protects the insulation in wells that have hot and gassy conditions, and is the only true protection against gas decompression, which commonly occurs within the cable when gas is present. The cable is designed for environments where H<sub>2</sub>S is greater than 3 percent or where CO<sub>2</sub> content is high.

### SELR cable

The SELR (Summit EPDM Lead Round) cable uses an EPDM insulation and lead jacket over each phase. The phase wires are then twisted together, and an EPDM jacket is extruded over all three phases in a round configuration. This cable is designed to operate in a range from –40°F (–40°C) to 450°F (232°C) in environments where H<sub>2</sub>S is greater than 3 percent or where CO<sub>2</sub> content is high.



### SEER cable

The SEER (Summit EPDM EPDM Round) cable uses an EPDM insulation and EPDM jacket in a round configuration. The three-conductor cables are designed to operate in a range from –60°F (–51°C) to 400°F (204°C). SEER cable is the right selection for hot wells that do not have issues with sour gas or gas decompression, which commonly occurs within the cable when gas is present.

### SENF and SENR cables

The SENF (Summit EPDM Nitrile Flat) cable and SENR (Summit EPDM Nitrile Round) cable utilize a specially formulated low-swell nitrile jacket to protect the EPDM insulation from downhole environments. SENF and SENR cables are designed to operate from –30°F (–34°C) to 280°F (137°C) in operations with less than 10 percent CO<sub>2</sub> and H<sub>2</sub>S concentrations below 2.5 percent.

Summit ESP also offers polypropylene- insulated cables with options of both lead and nitrile jackets. The Summit ESP polypropylene-insulated cable product line uses a thermoplastic compound that delivers excellent electrical properties and operates best in wells with cooler downhole temperatures.

### Features

- Industry-standard, solid-copper conductor
- Superior insulation compounds for all cables
- Robust lead sheath for extreme well conditions
- Armor offered in galvanized steel, 316L stainless steel, and MONEL® nickel-copper alloy
- Optional capillary tubes for chemical treatment
- All standard cables are 5-KV rated

### SPLF cable

The Summit ESP SPLF (Summit Polypropylene Lead Flat) cable utilizes a corrosive-resistant lead sheath extruded over the polypropylene insulation, making the cable impervious to gas or chemical penetration. This lead jacket barrier protects the insulation in wells that have gassy conditions, and is the only true protection against gas decompression within the cable. SPLF cables are designed to operate in a temperature range from –40°F (–40°C) to 250°F (121°C) and in environments where H<sub>2</sub>S is greater than 3 percent or where CO<sub>2</sub> content is high.

### SPNF and SPNR cables

The Summit ESP SPNF (Summit Polypropylene Nitrile Flat) cable and SPNR (Summit Polypropylene Nitrile Round) cable utilize a specially formulated low-swell nitrile jacket to protect the polypropylene insulation from downhole environments. SPNF and SPNR cables are designed to operate in a temperature range from –30°F (–34°C) to 205°F (96°C) and for operations with less than 10 percent CO<sub>2</sub> and H<sub>2</sub>S concentrations below 2.5 percent.

### Benefits

- More decompression resistant
- Insulation and jackets compounded for longer life
- Lead sheath impervious to fluid and gas intrusion
- Armor profiled for maximum protection
- Round cables are phase identified for easy installation
- Extended operational life

# SandRight® solids fallback preventer

## Sand management tool

### Overview

The SandRight® solids fallback preventer deters damaging solids from entering the electric submersible pump (ESP) during power shutdown events. Its unique design features preserve the ESP, especially in wells subject to dislodged formation and frac sands. Unlike other solutions in the industry, it maintains the ability to execute through-tubing chemical treatments while also resisting paraffin/scale buildup by using superior materials.

### How It Works

When an ESP is shutdown, solids hovering in the production tubing above the ESP are a major issue, especially in unconventional applications. These solids fall back to the pumps and become lodged in the pumps' stages. Restart attempts can overstress motors, accelerate pump wear, overheat cable and/or result in catastrophic failure. The SandRight tool not only protects pumps from permanent damage due to solids fallback, but also significantly increases an ESP's runtime in unconventional applications.

### Advantages

The SandRight tool is compact, is easily deployed, and out-performs all other solutions on the market. Its unique sand fallback prevention capabilities address all known issues with most fallback preventers – such as erosion/corrosion, paraffin buildup, incompatibility with desanders, and jamming issues – while retaining the ability to perform through-tubing chemical treatments. Specifically, it helps:

- Achieve economical ESP run-times in applications with sand issues
- Decrease total number of hard start events
- Decrease severity of hard start conditions (high current, rocking starts, etc.)
- Extend ESP runtime beyond what is capable with using other sand management tools/techniques
- Eliminate premature ESP failures when integrated into a total solution (including desander, tubing and casing transducers, and Summit ESP® Well Surveillance and Monitoring Service)
- Integrate faster and easier into the ESP system



Forum® Energy Technologies is the licensor of licensed SandRight products.



## Features

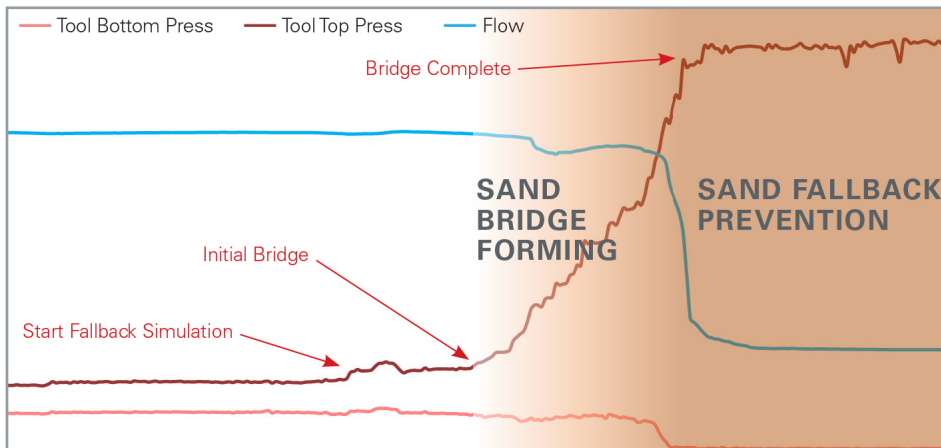
- Plate-flow design
- Directional and graduated passageways
- Hardened and corrosion-resistant metallurgy
- Inert coatings on all wetted surfaces
- Continuous fluid communication passageways

## Benefits

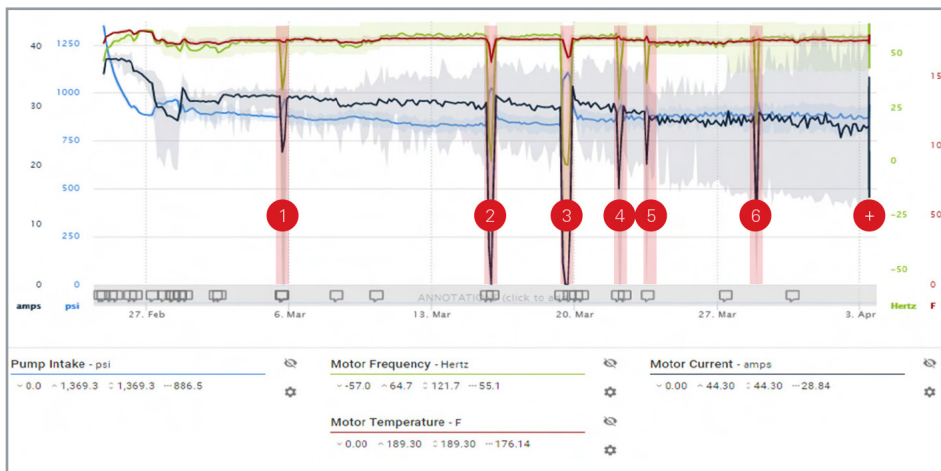
- Stops sand from flowing in reverse direction
- Creates a 'leak-off' effect for wide range of sand concentration and flow rates
- Provides higher abrasion resistance for long wear
- Resists paraffin and scale build-up
- Supports gas management and through-tubing treatments

## Basic operation

1. Shutdown occurs and sand falls back towards the ESP.
2. Sand bridging forms in the SandRight tool, thereby restricting passage of sand.
3. Pumps are success-fully restarted.
4. Sand column above the SandRight tool is re-fluidized and pushed/flowed toward the surface.



Lab tests show sand fallback simulation and bridge forming validation.



Field tests show continuous restarts with low stress on the electric submersible pump system.

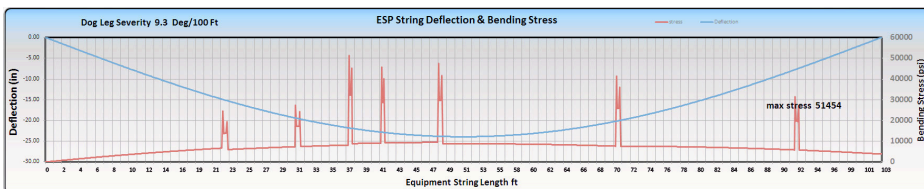
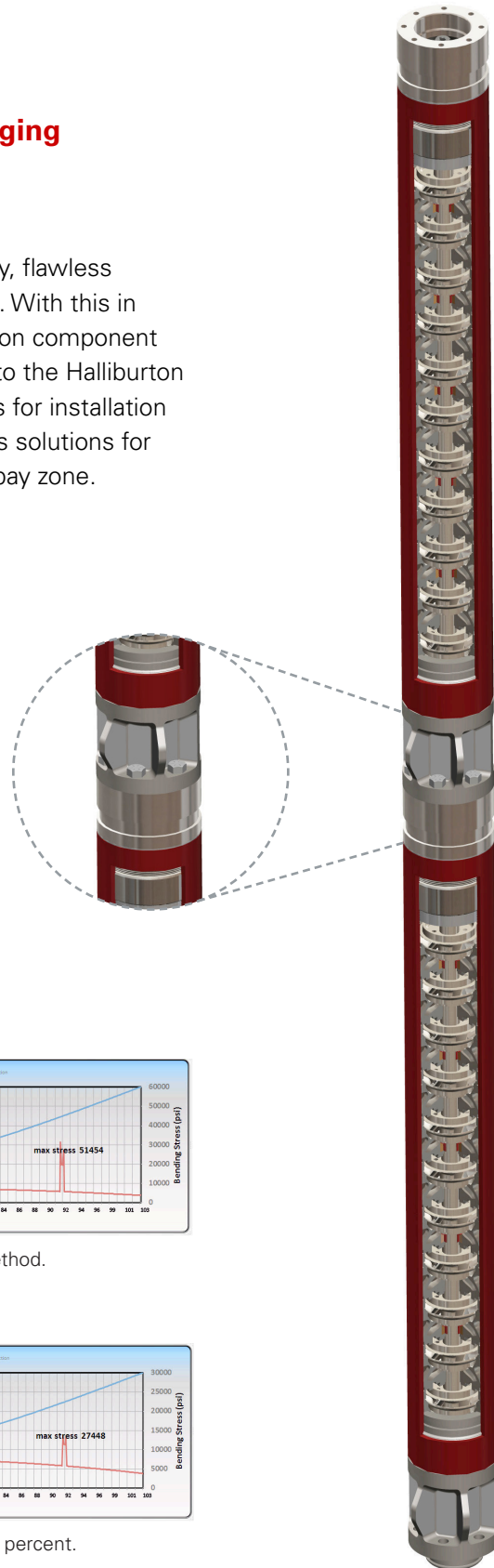
# Deviator™ Flange

## Increased flange connection strength for challenging well applications

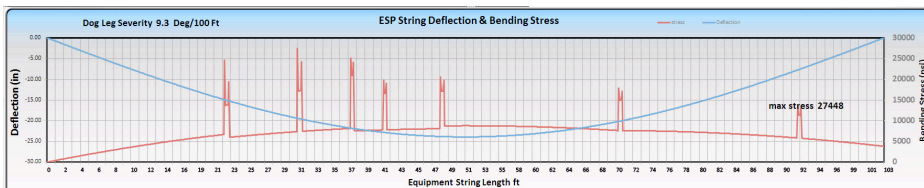
### Overview

Summit ESP® – A Halliburton Service is committed to reliability, flawless execution at the wellhead, and the lowest total operating cost. With this in mind, we have developed an innovative, value-added connection component to our electric submersible pump (ESP) system. This addition to the Halliburton product line is ideal for horizontal or deviated wells, and allows for installation into wells with significant doglegs. The Deviator™ flange offers solutions for greater recovery of reserves by setting the ESP closer to the pay zone.

The Deviator™ flange design allows ESP systems to go deeper in the well and closer to the production zones, supporting stable well performance and lower operating cost. Utilizing high-strength materials enables installation into wells with dogleg severity (DLS) up to 18°/100 feet.



Flange stress shown above reflects a standard pump-to-pump connection method.



With the Deviator™ flange connection, stress is reduced by approximately 47 percent.

## Features

- Larger stainless steel cross-sectional area
- Armored cage-like configuration
- Double O-ring connection

## Benefits

- Increased stiffness prevents permanent deformation
- Extended bars protect the cable
- Redundant sealing prevents leaking
- Resists paraffin and scale build-up
- Prevents tool from jamming
- Supports gas management and through-tubing treatments

## Standard Materials

COMPONENT	STANDARD MATERIALS
Head/Base	Stainless Steel
O-Rings	EPDM/Aflas®
Fasteners	MONEL® Alloy K-500 (UNS N05500)

## System benefits

- Improved durability in extreme operating environments
- Enhanced design for challenging well environments
- Strengthened ESP components for a more reliable, efficient, and durable production system



Aflas® is a registered trademark of Asahi Glass Co., Ltd.

MONEL® is a trademark of the Special Metals Corporation group of companies.



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**For more information, contact your local Halliburton representative or visit us on the web at [www.halliburton.com](http://www.halliburton.com)**

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