



# Electric Submersible Pumps for the Petroleum Industry



**Wood Group ESP**  
**The ESP Specialists™**  
[www.woodgroup-esp.com](http://www.woodgroup-esp.com)

Oklahoma City, Oklahoma  
(facilities photo on back cover)



Comodoro, Argentina



Maracaibo, Venezuela



Jebel Ali, UAE



Midland, Texas



Nisku, Alberta



Duri, Indonesia

## A MESSAGE FROM THE PRESIDENT OF WOOD GROUP ESP

Headquartered in Oklahoma City, Wood Group ESP was established in 1983 as an esp equipment testing and service company. In 1992 we purchased a major submersible pump manufacturing company that had been in business for over 30 years. Wood Group ESP has since emerged as a leading manufacturer of electric submersible pumps and control equipment. Our focus is on the pursuit of innovation in the application of petroleum industry electric submersible and surface pump systems. Our philosophy is to provide unparalleled service, quality cost-effective products and the technological advances to enhance performance.

Wood Group ESP introduced the application of field maintenance programs, equipment testing, well performance testing, performance-based contracts, radial-stabilized bearings, flame-spray corrosion coating, gas separators and many more of the industry's major innovations.

Our recently developed high-efficiency pumps and motors offer options for abrasion and corrosion-resistant materials, advanced downhole and surface monitoring capabilities and improved operating temperature. We have expanded booster and transfer pump applications with our SPS™ (Surface Pumping System). This versatile, low-maintenance product is an excellent alternative in applications where high pressure movement of fluids is required. Operating under ISO 9001 certification, our primary Technology and Manufacturing Center is located in Oklahoma City, USA. We now have Distributive Manufacturing and Repair Centers located in key oil-producing regions worldwide and over 30 sales and service centers within our 19 operating regions.

Our SmartArchitecture™ performance model demonstrates our commitment to reducing operating costs and maximizing production through the integration of an information to knowledge pro-active decision making process.

In the petroleum industry, success is measured by performance. Routinely our customers ask us to test their wells, optimize ESP performance, service all their ESP equipment and provide and manage their inventories. Each month we deliver detailed performance reports on pull rates, surface and subsurface activity, power consumption, production efficiencies and other key performance indicators. We then strive to improve performance the next month.

Some call us a leading manufacturer of electric submersible pumps. Others call us the best ESP service supplier in the world. Operators all over the world continue to call us because they know we'll improve their operational performance.

Joe Brady  
CEO and President

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## THE TOTAL PACKAGE

Wood Group ESP designs and manufactures artificial lift and surface pumping systems based on a SmartArchitecture model, which consists of:

- Downhole and surface pumps and assemblies
- Surface controls and communication systems
- Data management and reporting capabilities.

When combined, these components provide operators a versatile information-to-knowledge management tool that helps them optimize their oil fields and process facilities.

Sub pumps were once consid-

ered to be economic only in high-volume applications. Today, Wood Group ESP offers electric submersible pumps in a wide capacity range from 70 to 64,000 BFPD (barrels fluid per day). These include designs for onshore and offshore applications in casing sizes of 4.5-in. and larger to depths up to 15,000 ft. With only the wellhead, and fixed or variable-speed controller visible at the surface, these ESP systems offer a small footprint and low-profile option for virtually all artificial lift applications.

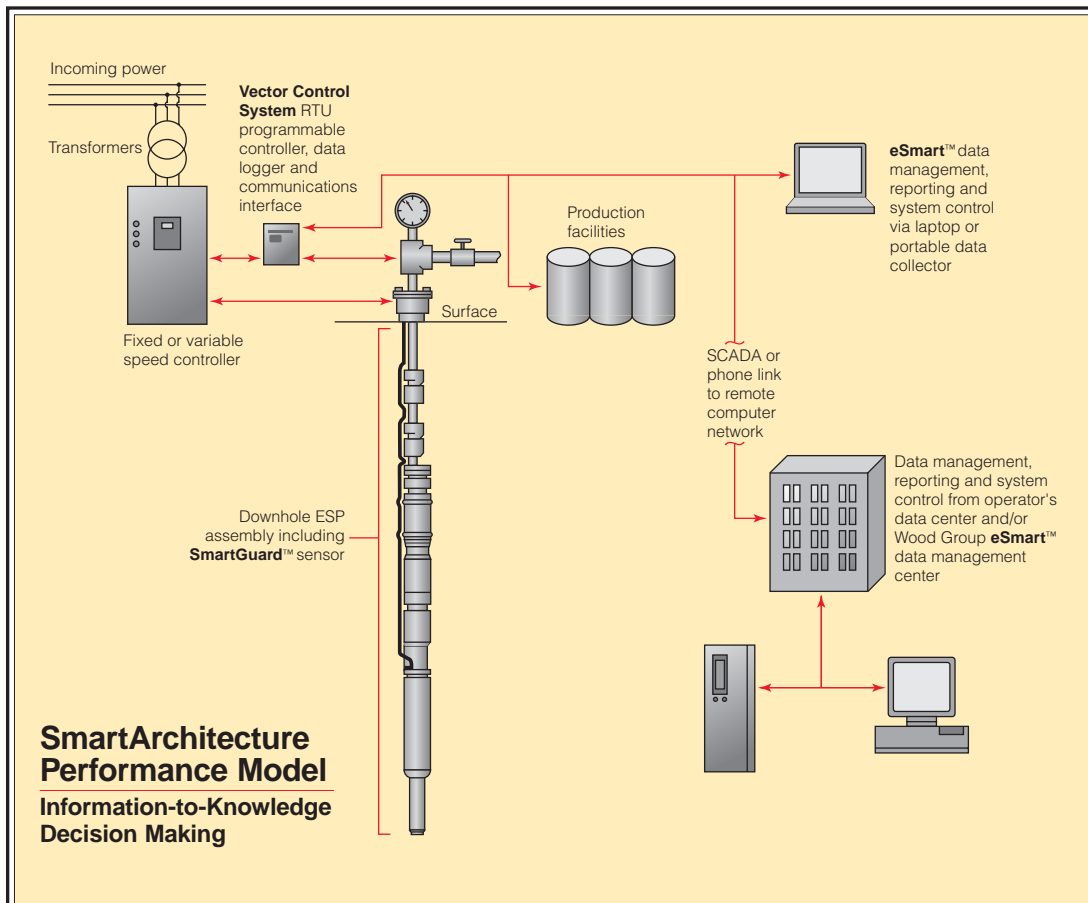
Wood Group ESP offers a full array of abrasion and corrosion-resistant pump equipment,

power cables, fixed or variable speed controllers, downhole sensors, and data communication and control panels. The typical application is to provide artificial lift for oil, water and brine well production. The systems can also be used for pipeline booster service, waterflood injection, mine dewatering, fire protection, irrigation, direct injection, cavern storage, commercial water systems, geothermal industrial applications, coal bed methane and gas well de-watering.

## REMOTE MONITORING, CONTROL AND SYSTEM ANALYSIS

The SmartArchitecture model allows complete monitoring of

the entire ESP system, local and remote data logging, as well as control and interface via any Web-based Microsoft® software program. Its versatile design capability facilitates knowledge-based decision making. Complete system control, data processing and analysis is possible in real time from any computer anywhere in the world. The SmartArchitecture model is key to allowing proactive well or process system maintenance and improving performance on a continuous basis. It's like having an engineer on every well.



### Downhole parameters monitored/controlled

- Wellbore intake pressure
- Pump discharge pressure
- Wellbore fluid temperature
- Motor oil or winding temperature
- Vibration
- Current leakage

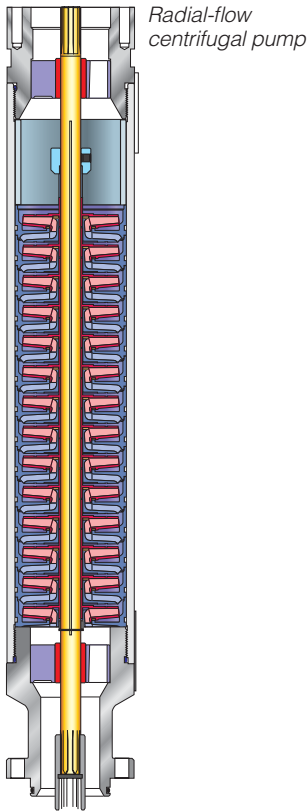
### Surface parameters monitored/controlled

- Tubing pressure
- Casing pressure
- Flow rate
- Chemical pump control
- Tank levels
- Phase current/voltage
- Restarts
- Run/downtime
- Power consumption
- Power quality
- Cathodic protection status
- Other physical parameters

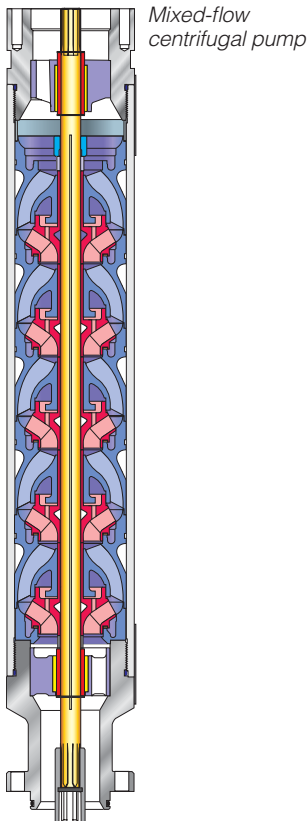
### Data management, reports, trend analysis

- Online controller setup
- Alarm code data/paging
- Exception conditions
- Well attributes
- Preconfigured reports
- Graphical trending
- Performance analysis/history
- Well optimization analysis
- Integrated with other apps
- Client/server architecture





Radial-flow centrifugal pump



Mixed-flow centrifugal pump

Wood Group ESP's multistage centrifugal submersible pumps consist of a rotating impeller and a stationary diffuser that can be stacked in either floater or compression configurations to meet the most demanding performance requirements. Corrosion-resistant impellers and diffusers are cast from a Niresist high-nickel iron containing destructive-resistant properties. For more severe environments optional radially-stabilized corrosion-resistant pump materials, including various stage coatings and boron diffusion hardening processes, are available.

Wood Group ESP has introduced an array of high-efficiency, low-volume and high-volume pumps. These pumps have wider vane openings to help produce lower gravity

fluid, handle more gas and reduce the effects of sand and scaling. We have also designed our systems to have some of the highest efficiency and head per stage ratings of any in their pump class range.

### Features

- Production rates from 70 to 64,000 BFPD
- Operating depths up to 15,000 ft
- High-efficiency stage design
- Abrasion and corrosion resistant materials
- Center tandem housings (radial or mixed flow, floater or compression)
- 100% factory tested to API RP 112S standards
- ISO 9001 quality standards
- Monel-trim fasteners
- Optional coating and materials

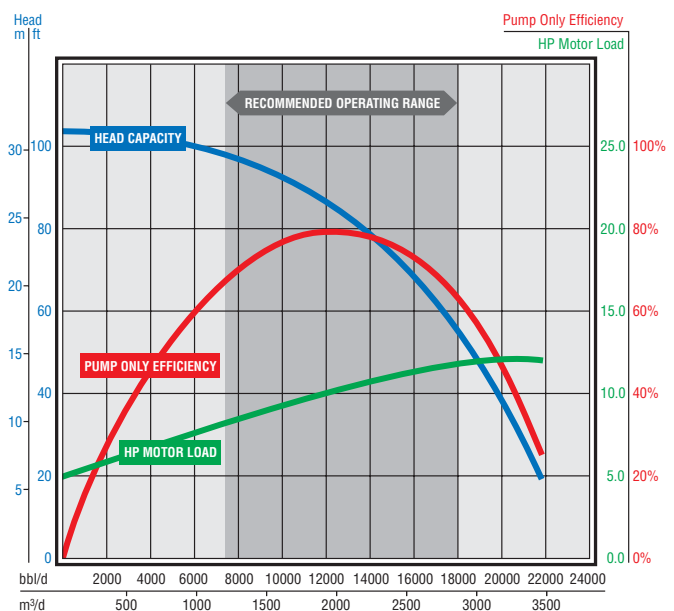
- High- and ultra-high-strength shafts
- Wider vane openings

### Benefits

- Up to 1500 horsepower applications
- Low operating costs
- Protection from H<sub>2</sub>S or corrosives for extended run life
- Best-of-class inventory management (flexible assembly, repairs and modifications)
- Quality and workmanship results in fewer field failures and extended run life
- International standard compliance for quality assurance
- Fewer stages and housings required
- Wide-vane pumps produce lower-gravity fluid, handle more gas and reduce solids and scaling

### SUBMERSIBLE PUMPS

| Pump Series (O.D.-in.) | Normal Operating Range bbl/d | m <sup>3</sup> /d |
|------------------------|------------------------------|-------------------|
| TA (3.38)              | 250 to 2800                  | 40 to 445         |
| TD (4.00)              | 70 to 10500                  | 11 to 1650        |
| TG (5.13)              | 1300 to 6750                 | 200 to 1100       |
| TE (5.38)              | 750 to 19500                 | 120 to 3100       |
| TH (5.62)              | 700 to 33000                 | 1100 to 5250      |
| TJ (6.75)              | 4000 to 37000                | 632 to 5900       |
| TM (8.62)              | 12500 to 45000               | 2000 to 7150      |
| TN (9.50)              | 22000 to 64000               | 3500 to 10200     |



Typical pump performance curve for a 6.75-in. O.D. single-stage pump @ 3500 rpm

The intake section of a submersible pump functions as a suction manifold, feeding the well fluid to the pump. In standard applications, an intake section can be a simple inlet hole adapter attached between the seal section and the pump housing. In applications with higher gas/oil ratios (GOR) and lower bottom-hole pressures, the well fluid may contain significant amounts of free gas. A gas separator, designed to separate free gas from the well fluid before it enters the pump, replaces the intake section.

The rotary gas separator, with three abrasion-resistant bearings standard, comprises three distinct stages. In the first stage, a low NPSH (net positive suction head) impeller is used to impart energy to the fluid. In the separation chamber, a spinning steel rotor is used to generate centrifugal forces to separate fluids based on density differences. In the crossover section, the lighter density fluids are

ejected from the gas separator to the well's annulus and heavier fluids are directed to the pump. Gas separators are designed with special metallurgy and bearing systems to extend their operational lives in adverse well conditions.

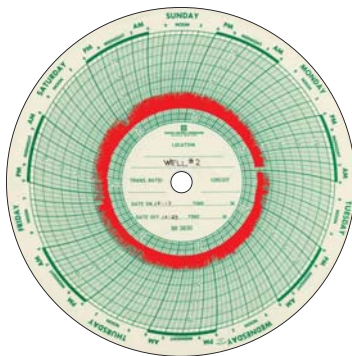
In applications where the amount of free gas cannot be handled efficiently by rotary gas separators, tandem rotary gas separators, a high-volume XGVS™ separator or an XGC® gas compressor can be used. The XGVS uses a vortex separation chamber and the XGC system introduces a compression chamber downstream from the tandem gas separators. The compression chamber allows free gas to be compressed back into the solution while simultaneously breaking large gas bubbles into an increasingly homogenized solution, which a submersible pump can handle without gas locking. Gas separation assemblies are available in TA (3.38 in.) through TJ (6.75 in.) series options.

## Features

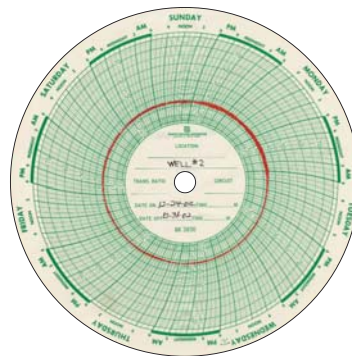
- High-efficiency balanced rotors
- Standard 3 abrasion-resistant bearing system
- Capable of handling high GOR wells
- Monel corrosion-resistant trim standard

## Benefits

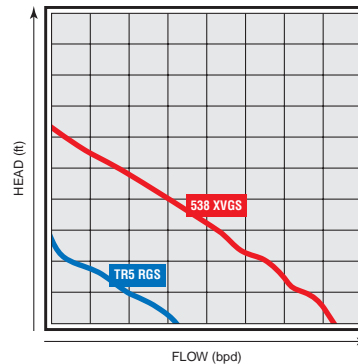
- Extend run time
- Increase mean time between failures
- Low NPSH impeller and blender XGC reduce gas interference
- High-volume XGVS separator designs improve system efficiencies
- Minimize pump downtime and restarts
- Provide optimization of production rates



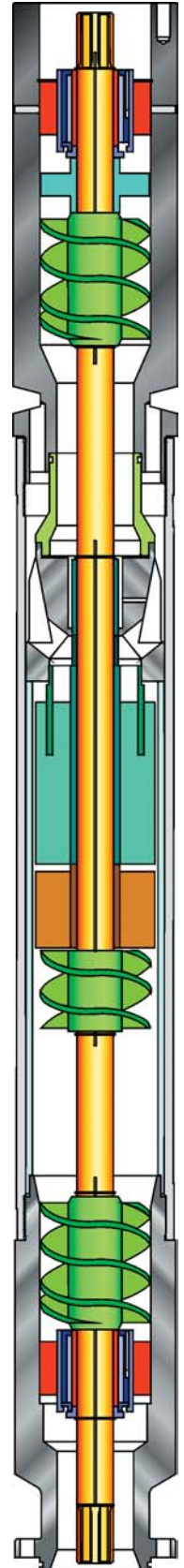
Amp chart indicating gas before XGC



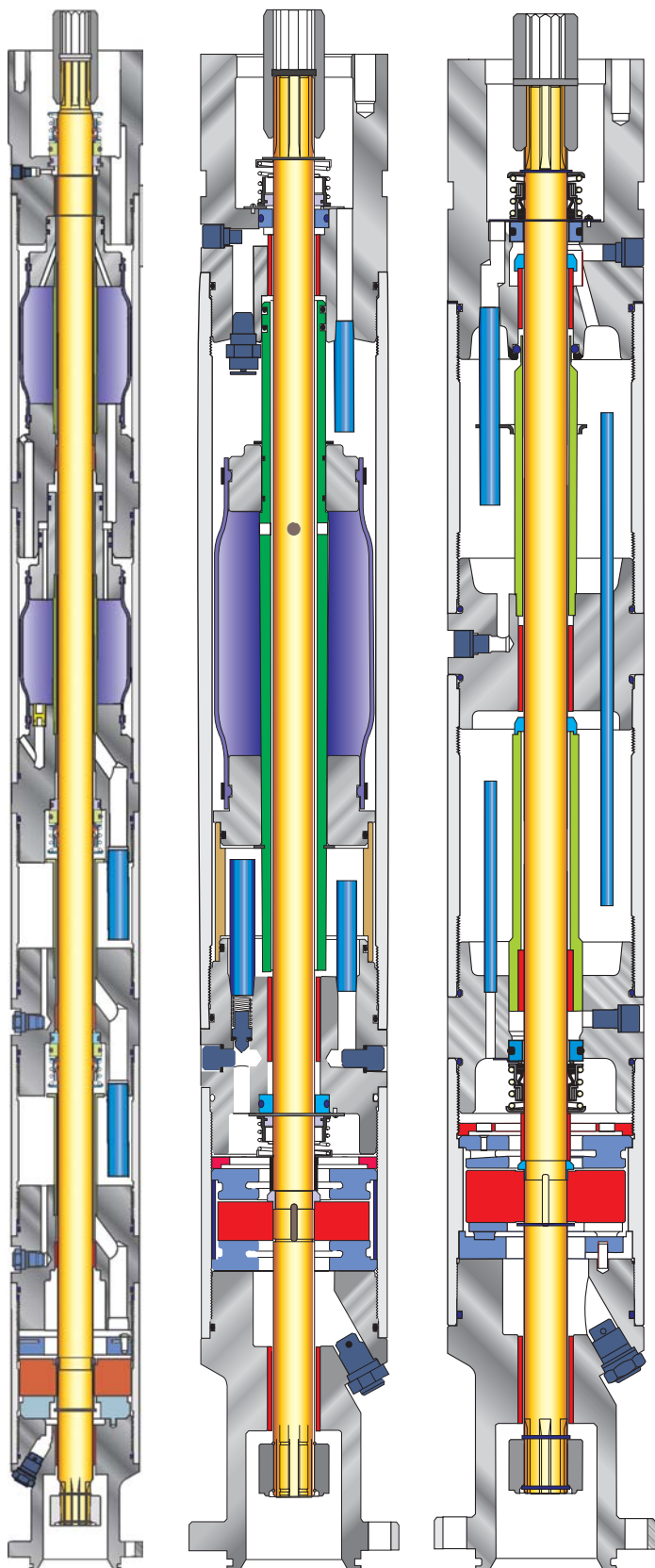
Amp chart indicating gas after XGC



Head vs. Flow (water only) performance chart for XGC gas compressor



XGC gas compressor



TR-5 AR

TR-SBG

TR-STD 98 L

The seal section is located between the motor and the intake and performs the following functions:

- Houses the thrust bearing that carries the axial thrust developed by the pump
- Isolates and protects the motor from well fluids
- Equalizes the pressure in the wellbore with the pressure inside the motor
- Compensates for the expansion and contraction of motor oil due to temperature changes in the motor

Seal sections can be used in tandem configurations for increased motor protection. They are available in both bag-type and labyrinth-style designs to meet specific applications.

- TR-SBG and TR-DBG seals have elastomeric bags that function as a positive barrier between the motor fluid and the well fluid.
- TR-STD seals feature a labyrinth-style seal, which creates a tortuous path of protection from well fluids.
- AR (abrasion-resistant) seals are designed to provide radial stabilization and minimize vibration transmitted to the motor. Up to four chambers in one housing are available.
- HT (high-temperature) seals incorporate specialized elastomers and thrust bearings for increased bottomhole temperatures.
- HL (high-load) seals employ increased load-carrying capabilities for compression or larger pumps and/or extremely deep applications.

## Features

- Tandem configurations for all sizes and applications
- Labyrinth and bag chamber combinations are available in most series
- High-volume oil chambers
- Multiple shaft seals
- Abrasion-resistant models available with tungsten carbide bearings
- High-load thrust bearings and high-temperature elastomers available in all models
- Corrosion resistant housings and flame spray coating optional
- 300 to 900 series designs for all casing configurations
- Up to four chambers in one housing
- AR seals maintain the largest shaft diameter and strength in the industry
- Corrosion-resistant, Monel-trim fasteners and plugs standard
- 100% of all units are factory tested

## Benefits

- Designs available for all environments including deviated and hot holes
- Versatile design reduces inventories
- High-volume and positive barrier seals reduce motor failure and extend run life
- Corrosion resistant trim reduces H<sub>2</sub>S and CO<sub>2</sub> related failures
- High-load thrust bearing adds greater pump thrust capacity

Wood Group ESP submersible two-pole, squirrel-cage, induction electric motors are manufactured in a variety of horsepower ratings, operating voltages and currents to meet extremes in pressure and temperature requirements. Wood Group offers four series of motors with outside diameters of 3.75 in., 4.56 in., 5.44 in. and 5.62 in. to operate in 4.5-in. and larger casing.

Wellbore fluids passing over the motor housing act as cooling agents. The motors are powered from the surface via submersible electric cable. High-temperature motors are available for applications with bottom-hole operating temperatures up to 350°F, and ultra-high temperature models are available for temperatures up to 500°F. Improved designs used in our high-efficiency motor line feature elongated pentagon-shaped rotor bars and open stator slots that increase flux utilization, lower copper losses and result in greater horsepower per length of motor. For extremely corrosive environments, motor housings, heads and bases are

offered in ferritic and stainless steel materials. For less-severe applications, the outer surfaces are carbon steel. The equipment can be treated with flame spray coatings for added corrosion protection.

Every motor is subjected to a battery of factory tests to confirm electrical integrity, no-load performance and bearing system performance.

### Features

- Newly designed system delivers up to 75% more horsepower
- Locked rotor bearings reduce friction and wear
- Tape-in or optional plug-in potheads are available
- Standard upper and center tandem models
- E-series motors offer the highest efficiency performance in class

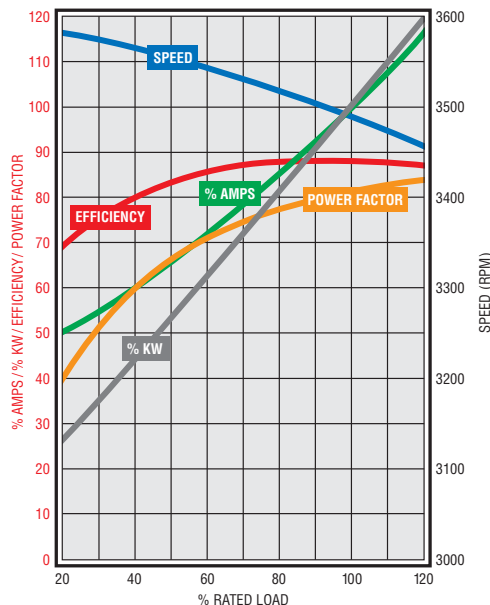
- Advanced micro-filter system in E-series motors maintains clean oil
- Standard Monel-trim fasteners and fill/drain valves
- All steel stators and involute splines provide efficiency and strength for harsh applications
- High-temperature options provide dependability up to 500°F

### Benefits

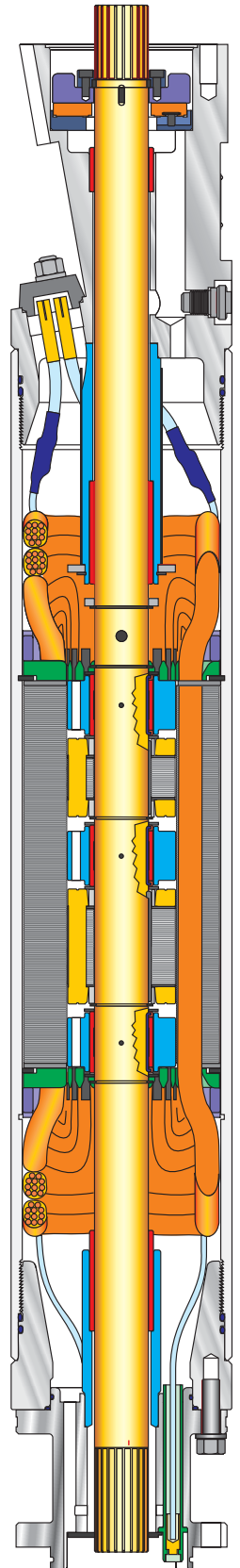
- Extended run life
- Less rig time during installation due to connection design
- Reduced inventory requirements due to system design
- Lower operating/power costs
- Clean motor oil extends run life
- Improved corrosion resistance
- Systems available for hostile environments

### HORSEPOWERS AVAILABLE

| Motor Size | 60 Hz HP     | 50 Hz HP     |
|------------|--------------|--------------|
| 375        | 7.5 to 127.5 | 6.3 to 106.5 |
| 456        | 10 to 480    | 8.3 to 400   |
| 544        | 20 to 800    | 16.7 to 667  |
| 562        | 200 to 1500  | 167 to 1250  |



Typical E56 motor performance



E56 high-efficiency motor





## VECTOR CONTROL SYSTEM RTUs ARE LIKE HAVING AN ENGINEER AT THE WELL

Our Vector Control System consists of two intelligent RTU programmable controllers: the VCS 1600 (fixed-speed) and the VCS 1800 (variable-speed). These controllers are the most comprehensive and flexible, open architecture, motor control devices available, offering accurate data and reliable performance.

Using the latest advances in hardware, software and telecommunication technology, both units offer programmable control, motor protection, data acquisition and, most importantly, data memory with the capability for real-time data analysis. Modular construction and add-on options allow both the VCS 1600 and the VCS 1800 to be configured via a full array of systems for stand-alone operation or to be multi-tasked remotely from sites anywhere in the world.

Wood Group ESP VCS technology enables full web-based communication and control of the ESP system via any computer phone link or SCADA system. The system can even provide for the collection and plotting of downhole sensors and amp chart data to instantly analyze and plot trend data for proactive failure prevention or analysis.



Vector Control System VCS 1800RTU



Vector III VSD

## Features

- Fixed- and variable-speed models available
- Fully programmable for all motor control alarms and shutdown faults
- Analog and digital ports for input and output signals
- Memory options for data storage from 7 to 35 days
- Backspin and groundfault protection
- Fault and event logging module
- Output via permanent display, hand-held data collector, laptop computer, or SCADA RTU systems
- Onboard phone modem standard
- Windows®-based, menu-driven software for easy interface and data trending
- Fits into any switchboard or variable-speed drive

## Benefits

- Memory or real-time readout of all ESP parameters provide fault and failure detection
- Remote intervention reduces trips to well to make adjustments or to determine equipment status
- Data storage allows complete interpretation and facilitates trending plots
- Sensing of real-time downhole parameters allows ESP control and motor control from actual, not inferred, downhole conditions

- Storage of amp chart data eliminates collection and filing of cumbersome paper charts
- Remote control of ESP start, stop, alarm set points and speed variations
- Download software additions and updates remotely via Web communication

## VECTOR III VARIABLE SPEED DRIVES WITH VSG™ TECHNOLOGY

Using state-of-the-art technology, Wood Group ESP has developed the Vector III series of Variable Speed Drives (VSD) incorporating VSG (variable sine-wave generation) technology, which produces a near sine-wave output with low harmonic content. This results in better motor performance, extended motor and cable life, and lowers operating costs. VSDs allow conversion from constant Hz power to variable frequency. The performance of the pump and motor vary with the frequency, allowing the operator increased flexibility of their ESP installations. The VSD also provides soft starting, which is more beneficial to run life than a traditional "across the line" system startup.

Available in power levels to suit any ESP application, the Vector III VSDs offer field-proven performance and premier features not available in previous systems. The Vector III VSDs are available in NEMA 3R oilfield-rugged enclosures and with design features for 6, 12, 18



and 24-pulse operation. The Wood Group VSD is the only system to be fully compliant with IEEE 519 without the use of external filters and system modifiers. A variety of control functions are pre-programmed with our specially designed firmware allowing easy adjustment to motor speed, auto restarts, retries, delays, stopping methods and more. Programmable security codes prevent unauthorized parameter and control changes. Lockout features provide additional safety control. All settings are made digitally via the local keypad or via the optional remote VCS 1800 variable-speed controller.

## Features

- Programmable control for start, run speed, and stop function variable operation
- Provides near perfect sine wave output generation
- Low harmonic option provides IEEE 519 compliance without external filters
- No special air conditioning systems to maintain operational cooling
- Specially coated circuit board for corrosion protection
- Oilfield rugged NEMA 3 (IP 54) enclosures are standard
- Fully programmable options, event log and fault detection in up to seven languages
- Available in 380/480 volt 50/60 Hz, standard, arctic and desert configurations

## Benefits

- Allows variable-speed operation of any ESP system without damage to motor or power cable
- Enables flexible well operations to control pump-off or gas-lock shutdowns
- Allows periodic multi-rate well testing and reservoir data collection
- Reduces nuisance shutdowns and equipment re-sizing due to changing well conditions
- Eliminates harmonic feedback and overall system damage
- Provides full system control and communication from remote computer terminals
- Shipped fully assembled and ready to install
- No special housing, environmental or cooling systems to maintain
- Solid-state circuitry provides trouble-free field operation, reducing need for specially trained technicians to maintain, trouble shoot and repair systems
- Provides soft starting

## WOOD GROUP VECTOR SWITCHBOARDS (SWB)

Vector Switchboard control panels are weatherproofed and are available in two models (Model 3600 and Model 5000). A complement of optional accessories are available to accommodate various installations. Some standard features include: fused disconnects, recording ammeters, under/

over load protection, signal lights, timer for automatic restarts and instruments for automatic remote control.

## Features

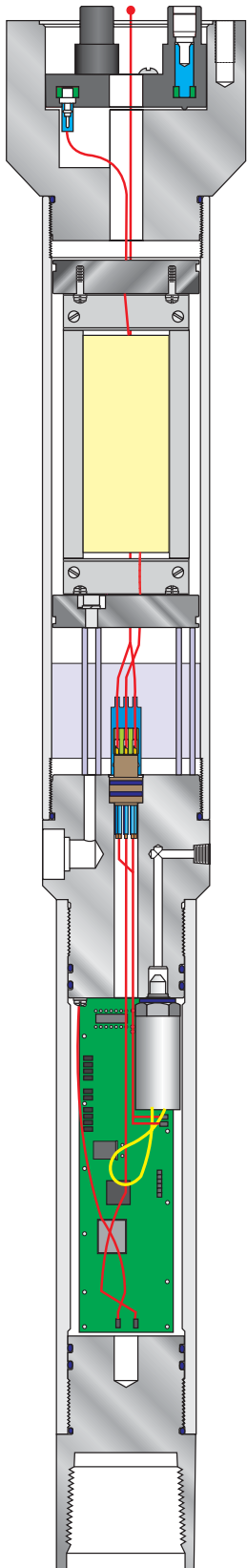
- Common enclosure for all models
- 7200 volt vacuum contactor common to all models
- A480R fuses are used exclusively to eliminate the need for 1500 volt and 2400 volt fuses and clips
- Isolated medium voltage compartment and other safety features such as mechanical and electrical door interlocks
- Factory wired for VCS intelligent RTU controller
- NEMA 3R enclosure with UV resistant painted finish

## Benefits

- Compact design capable of field upgrade
- Technology eliminates the need for multiple ranges and reduces spare part requirements
- Safety features help protect service personnel from contact with dangerous voltage
- Easily retrofitted with state-of-the-art control and communication devices
- Oilfield rugged for protection from extreme environments



Vector SWB



SmartGuard sensor  
 (adapters available for all  
 brands of motors)

Wood Group ESP's SmartGuard downhole sensor and surface interface system enables reliable and accurate retrieval of critical real-time ESP and wellbore performance parameters. Employing state-of-the-art transducers and linear calibration technologies, SmartGuard performance far surpasses conventional pressure and temperature sensors. Designed without moving parts, this robust, reliable and accurate sensing system provides oil-field-rugged construction. The standard SmartGuard III has 8-data channels to measure intake pressures, wellbore and motor oil or winding temperatures. Option IV includes pump discharge pressure, and Options V-VII add measurements of vibration, current leakage and flow rate. ESP system control

and alarms are achieved by real-time monitoring of actual downhole readings, reducing nuisance shutdowns caused by inaccurate overload and underload amp load settings. Surface interface can be accomplished via permanent digital readout, hand-held data logger or laptop computer. Use of our VCS intelligent RTU controller allows monitoring of data from any web-based computer anywhere in the world.

### Features

- Robust design, no moving parts, vibration resistant
- Up to eight data channels and 35 days of data memory
- Communicates via the ESP power cable
- Integral advanced linear calibration
- Rated to 302°F (150°C)

*Surface interface unit enables viewing of data via a permanent, hand-held or laptop computer data display.*



*Surface interface unit coupled to the SmartGuard sensor provides superior, stand-alone data collection and monitoring.*



*The sensor can also be interfaced with the VCS intelligent RTU to provide the highest degree of system control, protection and data storage/communications.*



- Continues recording with ESP in the off mode, which allows pressure buildup testing
- Fully compatible with power cable meggings
- Completely compatible with cathodic protection systems
- NEMA enclosed surface interface and readout system
- Accuracy to 0.1% psi/bar, temperature to 34°F (1°C)
- Adaptable to all ESP brand motors
- Corrosion-resistant housing materials or flame spray coatings available
- Field-proven reliability and accuracy
- Electronics completely segregated from motor or well fluids

### Benefits

- Allows accurate and dependable monitoring of ESP and well parameters
- Allows system control based on measured data, not inferred system performance
- Control ESP motor shutdown by absolute motor operating temperature measurement
- Encapsulating electronic circuitry improves dependability and ensures long life
- Communication via ESP cable eliminates costly I-wire, special telemetry cables and additional wellhead connectors of other systems
- Surface interface circuit can be integral part of RTU controller, eliminates expensive additional surface equipment installation and maintenance
- Data is web-accessible via SCADA systems

Wood Group ESP offers a complete cost-effective range of power cables for electric submersible pumps. All are designed to perform under the most stringent well conditions. Available in configurations of flat or round, these specially engineered and manufactured cable systems provide dependability in the harsh, hot, gassy and corrosive conditions found in most ESP applications.

A variety of materials, duty ranges and constructions allow selection of a particular cable for specific applications. This individually tailored selection criterion provides for the most cost-effective supply of power cable available to the industry. Wood Group ESP also provides a complete line of motor lead extension cables as well as land, offshore and Arctic spooling equipment. We also provide full-service cable repair, computerized cable testing and splicing services.

## Features

- Temperature ranges from -50°F to 450°F, voltage from 3 to 5 KV
- Selections include specially formulated polyethylene, nitrile, EPDM insulations and jacket compounds
- Lead sheaths available for highly corrosive, hot and gassy environments
- Flat or round construction with galvanized, stainless, or Monel interlocked armor
- Kapton tape and nylon braids add extra protection
- High-conductive annealed and tinned copper stranded or solid conductors
- Crush and corrosion resistance
- High-dielectric rigidity and tensional strength
- Decompression tolerant
- Computer tested to exacting IEEE and API-RP standards

## Benefits

- Superior reliability standards result in extended service life and fewer production disruptions (i.e., less downtime)
- Rugged construction allows cable reuse and lower inventory requirements
- All-steel, high-strength shipping reels provide greater cable protection and less damage during handling
- Computerized cable testing ensures the integrity of new and used cable



Motor lead extension with connector



Various power cables



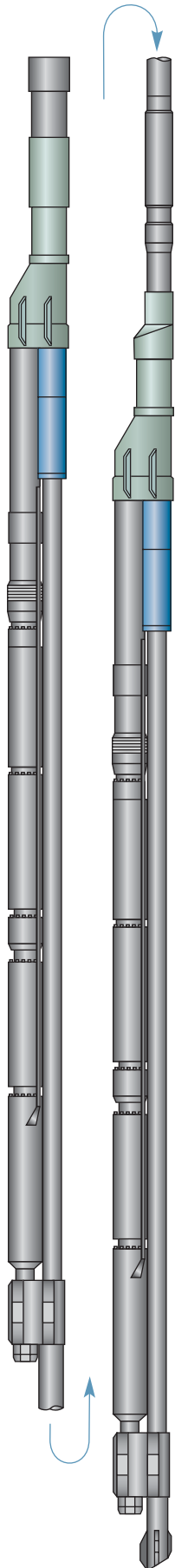
Modern spooling service equipment in all regions

## CABLE SPECIFICATIONS

| Model    | Temp. Rating<br>°F<br>(°C) | Shape<br>Round/Flat | Voltage<br>Rating<br>(kV) | Insulation<br>Material | Jacket<br>Material | Extra<br>Protection | Application                                       |
|----------|----------------------------|---------------------|---------------------------|------------------------|--------------------|---------------------|---|
| PL205    | -30 to 205<br>(-34 to 96)  | R / F               | 3, 4, 5                   | PP                     | Nitrile Rubber     | Tape and Braid      | General use, oil resistant, high lateral strength |
| PL300    | -22 to 300<br>(-30 to 149) | R                   | 3, 4, 5                   | EPDM                   | Nitrile Rubber     | Tape and Braid      | Medium temperature, gassy conditions              |
| PL300-RE | -22 to 300<br>(-30 to 149) | R                   | 3, 4, 5                   | EPDM                   | EPDM               | Tape and Braid      | Moderately gassy wells, higher temperatures       |
| PL450    | -50 to 450<br>(-40 to 232) | F                   | 4, 5                      | EPDM                   | Lead               | Braid               | Hot, corrosive, gassy wells                       |

Other power cables are available, including models for highly specialized applications.





*Special purpose equipment allows the application of redundant ESP systems*

Our Technology Development Center located in Oklahoma City employs a large group of talented engineers with diverse specialties. Experienced teams of our engineers have developed specialized application equipment and techniques for the most demanding and unique well conditions.

Custom testing loops are used to conduct rigorous performance tests of new equipment designs. We have specially designed testing laboratories for motors, pumps, gas compressors and separators, power cables and downhole sensors. We also can provide equipment endurance and other specialized testing. This is in addition to the standard equipment performance testing that we do in our ISO 9001 certified manufacturing plant and distributive manufacturing centers. We test 100% of all equipment that we manufacture.

Some of the special purpose systems we provide include:

### **WAG PUMPS**

Tertiary recovery projects in many fields require water alternating gas injection to prolong field life. Wood Group ESP has developed special pumps for these applications. They feature enhanced housing and

shaft metallurgy and specialized stage coatings to resist corrosion and abrasion in severe CO<sub>2</sub> or other harsh environments.

### **DOWS SYSTEMS**

Downhole Oil Water Separation requires special equipment to allow efficient and clean separation and re-injection of liquids in disposal zones. Wood Group ESP has combined several special technologies to offer a field proven separation system at rates approaching 10,000 BFPD. We have proven that our technology and efficient separation techniques allow disposal of unwanted water into the same wellbore as the produced oil. The result is vastly lower operating costs and unwanted environmental costs and contingencies.

### **DUAL COMPLETION ESP SYSTEMS**

Special purpose equipment allows the application of a redundant ESP system deployed with the primary ESP installation. The totally redundant system can be activated should the primary system fail or experience operating difficulties. The dual completion ESP system reduces the cost of a well intervention and allows continued well production, even in the event of a primary failure. Wood Group ESP offers complete system hardware,

including any necessary Y-block and wellhead penetration equipment.

### **STEAM FLOOD APPLICATIONS**

Steam injection applications require specialized ESP systems that are capable of withstanding exceptionally high wellbore operating temperatures, perhaps up to 500°F. We have developed customized equipment with special tolerance pump clearances and motor designs, high-temperature elastomers, and ultra-high-temperature motor features and windings, to address these special applications.

### **COAL BED METHANE (CBM) SYSTEMS**

CBM systems have been developed to deploy in these demanding and specialized applications, which often involve highly corrosive and abrasive conditions. Our CBM systems allow use of low-temperature motors for cost-effective reductions in equipment specification. Wood Group ESP offers complete systems suited for these special conditions at economical investment levels.

### **DEVIATED HOLE CONDITION ESP SYSTEMS**

Applications in highly deviated wells have always presented special challenges for ESP

users. Wood Group ESP has developed ESP BEND™ proprietary software that is based on actual laboratory bend testing of all ESP components. ESP BEND predicts the effects of casing deviations. Our application engineers use this program to assist clients with real and scientifically derived answers to questions about equipment performance in deviated conditions.

### BOTTOM DISCHARGE SYSTEMS (BDS)

These systems allow the injection of fluids from one producing zone into another zone in the same wellbore. The re-injection of these fluids allows re-pressurization of one zone from another without the need to pump the producing zone to the surface. This often eliminates the need for costly, high-maintenance, leak-prone surface equipment and the environmental issues associated with producing unwanted liquids to the surface.

### COILED TUBING DEPLOYMENT

Using lower cost coiled tubing units to install sub pumps provides a lower overall cost to the operator. Operators have been looking for more economical ways to deploy electric submersible pumps for many years. Our Standard Intake System

(SIS) and Bottom Intake System (BIS) in conjunction with a unique cable suspension system and Multi-inflatable Packer System (MIPS) make the entire package possible. SIS employs standard design equipment while BIS requires specially designed pumps and seals to complete the package. Our system prevents any damage to the downhole cable or coiled tubing while running. Additionally, it requires no special fittings. It is now possible to run and pull submersible pumps without a more expensive drilling or workover rig. Not only is our installation technology faster and safer than conventional deployment, it eliminates the costs associated with a drilling or workover rig. It also allows live well intervention and is most often employed in applications where space becomes a significant factor, or where operating conditions are extreme.

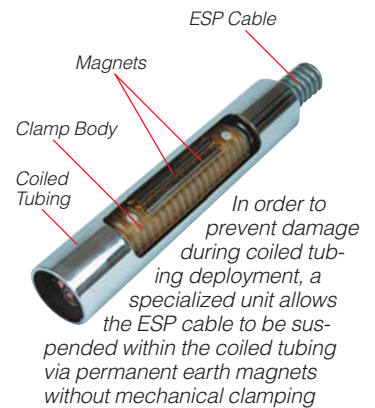
### HIGH TEMPERATURE (HT) WELLS

Submersible pumps are being installed with increasing frequency in higher temperature reservoirs. Higher temperatures are encountered as well depths become deeper. In order to extend equipment run life in wells with high bottom hole temperatures, Wood Group ESP has made important changes to the material and

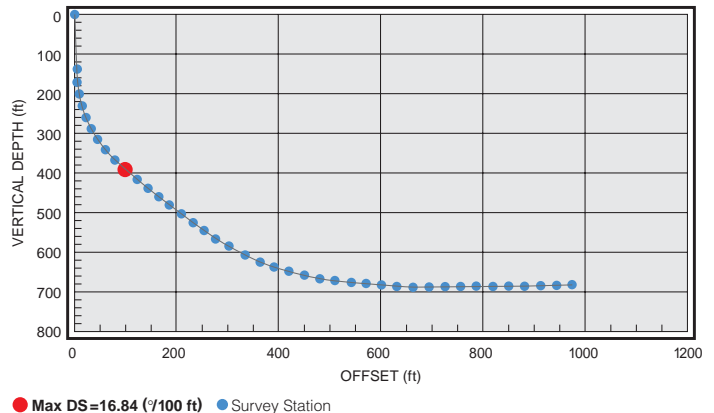
design of downhole motors. Insulation systems have been improved and new varnish processes have been employed as a winding encapsulation material to increase performance. Additionally, rotating clearances in the motor have been modified to provide additional thermal expansion made necessary due to high motor temperatures. In order to select the proper horsepower for a specific application, it is important to note that motor temperature rise is a function of horsepower load, motor design, motor voltage, voltage waveform and heat dissipation characteristics of a particular well application. Wood Group ESP has the technology and experience for all types of ESP applications, including the demanding requirements of HT wells.



Coiled tubing deployment



### Well Offset vs Vertical Depth



Wood Group ESP engineers use proprietary ESP BEND software to predict the effects of casing deviation on downhole equipment



Wood Group ESP maintains 30 sales and service centers in 19 operating regions around the world. Our fully equipped and professionally staffed centers operate 24 hours per day.

Each service center maintains a complete stock of pumps, motors, seals, cable and parts. And each is networked to a centralized manufacturing and inventory control system.

All Wood Group ESP products and systems are supported by experienced service personnel who assist in equipment installation, change-outs and system optimization. Our service technicians are thoroughly trained on all brands of submersible equipment. We provide component repair, motor dryout and rewind services, and equipment testing and evaluation to ensure maximum performance from our customers' wells.

Our well installation and spooling crews are thoroughly trained and equipped to provide safe, effective and efficient run and pull services.

### PORTABLE WELL TESTING

Additionally, we offer portable well testing systems (the Optimizer™) with downhole equipment and trailer mounted surface systems. By employing the latest technology in portable variable frequency controllers, downhole pressure sensors, and fluid level devices, we can test new or existing wells to determine productivity as well as economic viability.

A complete test unit is designed to produce in a predetermined range of volumes based on the general well data. Static pressures and fluid levels are recorded prior to start-up. Production rates are recorded

at several speeds or frequencies, and a PI and IPR curve is developed for each well.

Whether defining the production characteristics of a new well or evaluating an old well, Wood Group ESP can design a testing program to ensure an accurate test and proper equipment selection to optimize production potential for your well before making investments in equipment purchases. Proper sizing of the submersible equipment by variable frequency well testing can:

- Extend run life and reduce operator costs of the permanent installation
- Provide multi-rate drawdown pressure analysis and produce real IPR curves
- Ensure proper sizing and selection of ESP equipment
- Optimize electrical and equipment purchases
- Help determine the best method of artificial lift
- Provide confidence in the design decision process

### TRAINING AND HSE

Wood Group ESP offers intensive and thought-provoking, competency-based training that

helps clients and employees maximize the production, run life and efficiency of their artificial lift operations. The wide range of classes provides a broad understanding of reservoir, well and submersible pump system design, selection, installation, operations and performance optimization.

Courses range from the fundamentals and principles of submersible pump artificial lift to the latest methods and technologies in increasing operational efficiency. Each integrated module emphasizes the importance of quality control in the data and calculations for artificial lift design, accurate sizing processes, options and considerations to achieving the design criteria, installation critical factors and key operations monitoring of downhole and surface equipment.

We are committed to the creation and perpetuation of a positive, progressive safety culture based upon three primary tenets: communication, trust and training. This is accomplished through an integrated safety and environmental management system (IS/EMS) based upon international standards such as ISO 14001 and BS 8800, as well as Wood Group's HSE guidance policy.



Expert installation



24-hour field service



Spooling services



Optimizer portable well-testing units



Our extensive equipment component testing programs are designed to reduce the cost of equipment repair or replacement to a fraction of full repair/replacement costs. Wood Group ESP equipment testing services provide rapid turnaround on repairs of all brands of ESP equipment. Our procedures conform to hydraulic institute IIEEE and API-recommended practices and standards.

## MOTOR TESTING

Motor testing determines the mechanical integrity of the prime mover. Inspections of the electrical and thrust-bearing assemblies are performed to reduce new motor start-up failures and extend motor run life. Phase I and Phase II dry-out services can be conducted without disassembling the motor.

## PUMP TESTING

This service determines if a pump can be confidently re-run and provides a fingerprint for future performance comparison. Wood Group ESP is capable of testing all brands of submersible pumps to the original manufacturers' specifications, allowing for an inexpensive means of validating pump performance. All test results are stored in our eSmart database. This assures that you have an accurate historical record of your equipment for future reference.

## SEAL TESTING

Seal tests further reduce operating costs by allowing the re-use of some seal sections. Typically, the seal section is replaced after every use. Our thorough testing of the seal, thrust bearing and dielectric strength of the oil allows this equipment to be re-run with confidence.

## COMPUTERIZED CABLE TESTING

These tests allow the integrity of new, used or repaired cable to be evaluated. Again, by employing our proprietary eSmart database, we can track the cable from well-to-well over its useful life. Our cable testing procedures follow the IIEEE 1017-1985 acceptance test for new cable.

## Features

- 100% function testing of all new components
- Simple pass-fail analysis
- All testing to API or IIEEE standards
- Each component individually tested
- Fully computerized process
- Data archived for later analysis and review
- Certifies new and used equipment
- Specialized adapters provide ability to integrate all brands of equipment

## Benefits

- Cost effectively allows inventory usage and reduction
- Quantifies status of new and used equipment
- Provides permanent record of performance and benchmarks reliability
- Reduces infant mortality failures (i.e., saves money)
- Tests conducted at less than 10% to 20% of full repair or replacement costs
- Over 70% of all tested equipment is returned to service



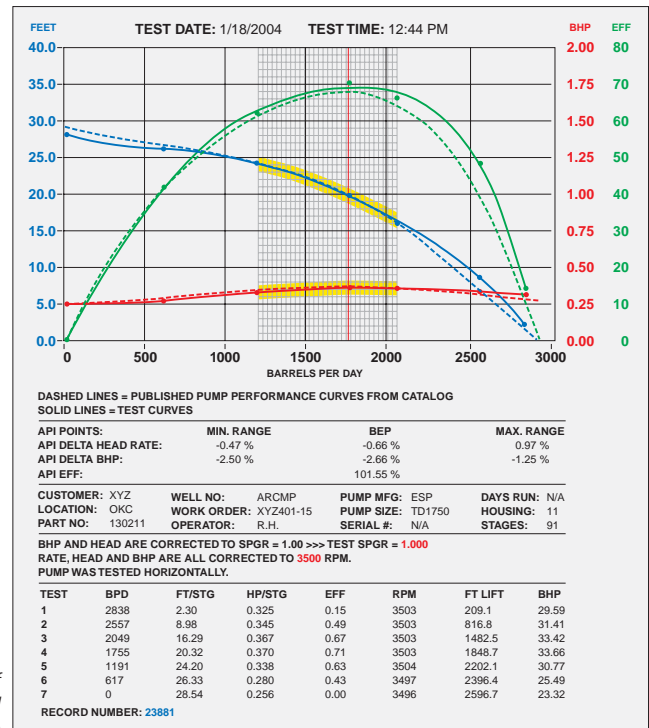
Pump test bench



Seal testing



Motor testing



Pump test printout of remanufactured TD1750 ESP pump



Worldwide manufacturing, repair and maintenance centers

Wood Group ESP has pioneered the use of distributive manufacturing centers (DMC). These modern manufacturing centers are fully equipped for the local manufacture of down-hole assemblies including pumps, motors, seals, motor lead cables and surface pumping systems. Currently we have seven of these facilities located in key producing regions around the world:

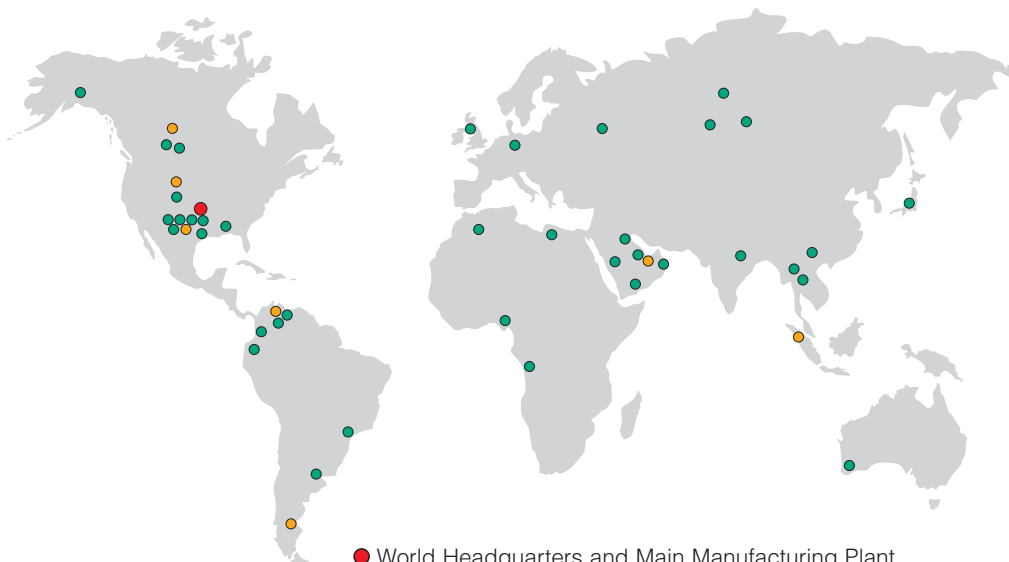
- Comodoro, Argentina
- Nisku, Alberta Canada
- Duri, Indonesia
- Jebel Ali, UAE
- Maracaibo, Venezuela
- Casper, Wyoming
- Midland, Texas

These facilities also provide equipment testing and repair services on all brands of ESP equipment. The development

of local manufacturing, testing and repair expertise allows us to provide complete localized service in real time. Customers no longer have to wait for the main factory to open in the U.S. to get answers to pressing questions.

### Benefits

- Allows direct local contact for technical support
- Provides local stock of parts and assemblies
- Allows the manufacturing and assembly of parts or systems on short notice
- Unique or locally used items are sufficiently inventoried for quick delivery
- Fully computerized inventory and access to eSmart data bases
- Provides direct access for customer witness testing
- Direct link to root cause failure analysis
- Speeds delivery and simplifies transportation, reducing costs and lead times



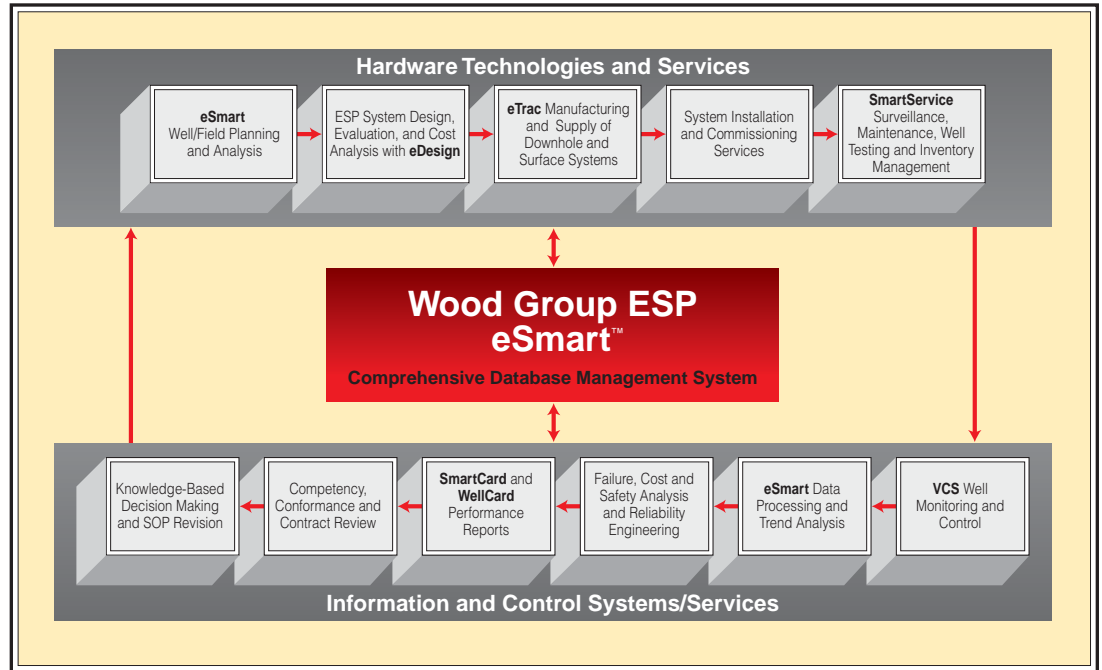
- World Headquarters and Main Manufacturing Plant
- Distributive Manufacturing and Repair Centers
- Other Sales and Service Locations

Our SmartSolutions Integrated Decision Management tools and services provide life-of-the-well options for total well performance and optimization. Based on our extensive eSmart database, the goal of knowledge-based decision making is a three-step process:

- **Collect Data**—in conjunction with the eSmart database, collecting data from a variety of sources in the field assures that all pertinent information is available for analysis
- **Analysis**—the data can be analyzed at the wellsite or remotely from any desktop by using sophisticated analytical tools
- **Decision Making**—with the proper information, key personnel can collaborate and make informed decisions about production operations

## ESMART DATABASE SYSTEM

Our eSmart System houses one of the industry's most comprehensive databases of submersible equipment. From engineering and manufacturing data, to installation, commissioning and servicing information, data on each ESP system is entered into the eSmart database. The system provides historical records of installed equipment organized by categories. This enables the operator to pull reports based on runtime, horsepower, depth, size of equipment or numerous other parameters. The real-time data can be used to benchmark, analyze, forecast or monitor the performance of all your wells.



*SmartSolutions™ Integrated Decision Management for Total Well Performance and Optimization*

Using our SmartService™ programs, installation and removal information about the submersible equipment, its condition, well information and electrical setup is recorded and updated by our field service technicians. Customer inventories are maintained and are provided with shipping and receiving reports. Equipment test data and failure analysis data are stored for future fingerprinting. All data can be accessed via our secure web site. Twenty standardized reports ensure worldwide compliance and uniformity.

## SMARTSERVICE FIELD PROGRAMS

Wood Group ESP has developed proprietary VCS well monitoring processes to evaluate the performance of the well, reservoir and lifting equipment.

Our SmartService maintenance, surveillance and testing programs provide a proactive means of preventing failures and optimizing well performance. By involving each well, and by tracking production, lifting costs, wear rates, fluid levels, changing well conditions and other parameters, Wood Group ESP identifies solutions and opportunities before operators are forced into a reactive equipment pull due to a failure.

We have also pioneered detailed SmartCard™ and WellCard™ performance reporting services to aid in knowledge-based decision making.

## FAILURE ANALYSIS

Our Reliability Engineering services were established to assist clients in the identification of product failure modes,

the isolation of root causes, and the ability to take corrective actions and avoid recurring equipment problems. An extended run-life team reviews all failure modes. This combined effort supports the worldwide field-incident reporting program in gathering information, evaluating failures and reporting results.



*The eSmart data entry and reporting system can be accessed at the wellsite or from remote computers.*





### SPS MARKET APPLICATIONS

#### Oil and Gas

- Produced water injection
- Produced water disposal
- Waterflood injection
- Pipeline booster
- CO<sub>2</sub> flood injection/booster
- Crude oil transfer
- Cavern storage pumps
- LPG/NGL/Amine services
- Condensate transfer
- FPSO fluid handling
- Power fluid pumps for downhole jet/piston pumps

#### Mining

- Dust suppression
- De-watering
- Hydraulic power fluid
- High pressure transfer
- Coal fines slurry

#### Industrial

- Industrial process pumps
- Reverse osmosis
- Geothermal injection
- Wash-down
- De-scaling
- Pipeline booster
- High pressure transfer

### BRINGING OUR DOWNHOLE EXPERIENCE TO THE SURFACE

The Wood Group SPS incorporates the same high-efficiency pumps that the company employs for downhole applications. For 15 years, the SPS pump has proven to be an extremely cost effective and

reliable solution for produced water injection applications. More recently, building on this successful track record, the SPS product line has been expanded to handle higher and lower flow rates and pressures, with different material and design configurations to

match an increasingly diverse installation base.

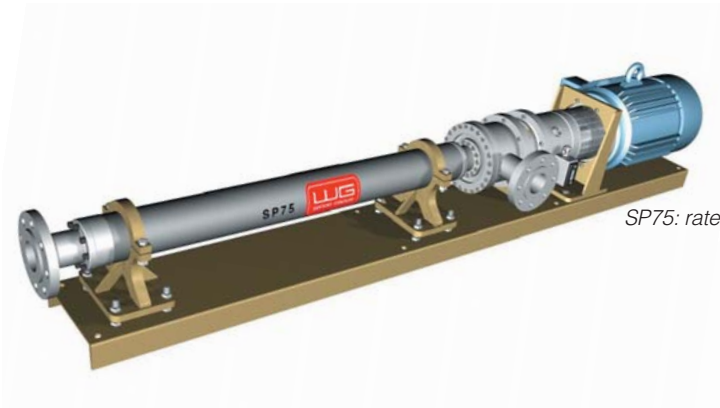
As a result of successful application in new markets, the SPS has become a popular alternative for many services where plunger (triplex, quintiplex), split-case centrifugal, or vertical turbine pumps (VTP) were previously employed.

### SPS™ OPTIONS

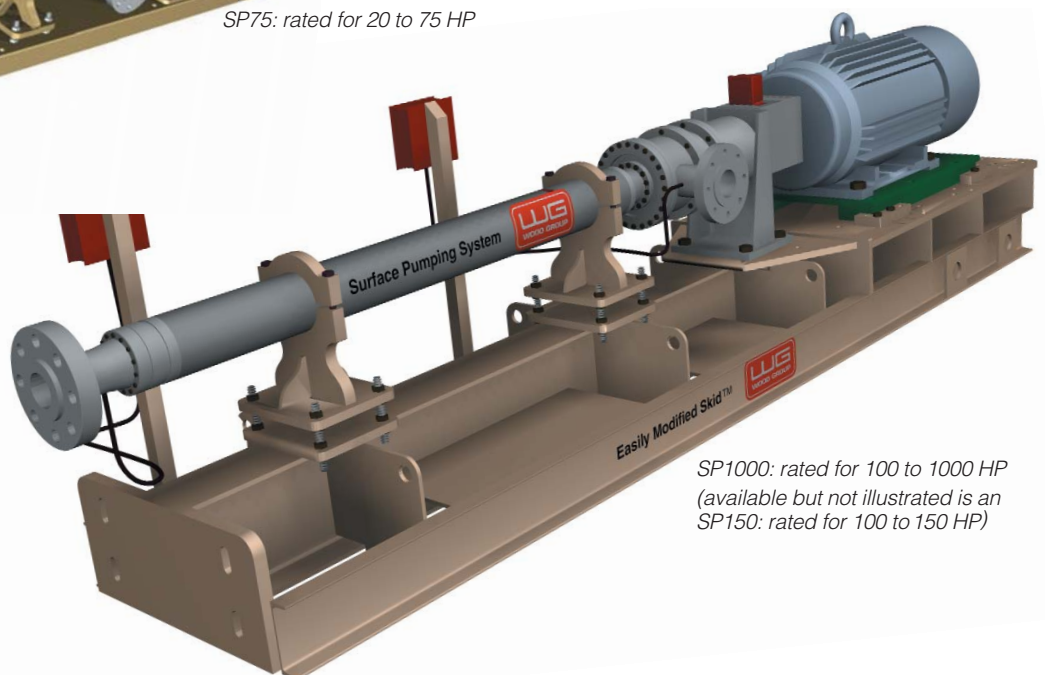
|                                  |  |
|----------------------------------|--|
| <b>Drive systems</b>             | Electric, Gas or Diesel  |
| <b>Electric starting options</b> | Across the line/D.O.L.<br>Solid-state reduced voltage  |
| <b>Speed control</b>             | Electric Variable Speed Drive (VSD)<br>Mechanical-hydraulic or magnetic  |
| <b>Suction pressure</b>          | 0 to 3000 psi<br>(class 150 to 1500 flange rating)   |
| <b>Discharge pressure</b>        | 0 to 6000 psi  |
| <b>Mechanical Seals</b>          | Component or cartridge seals<br>API 682 single, double and tandem designs<br>Dry running seals<br>API flush and quench plans |

### Features

- Modular design concept
- Minimal routine maintenance requirements
- Ease of repair and replacement of components
- Single low-pressure mechanical seal



SP75: rated for 20 to 75 HP



SP1000: rated for 100 to 1000 HP  
(available but not illustrated is an SP150: rated for 100 to 150 HP)

- Short lead-times
- No gear reducers, v-belts or other associated equipment to maintain
- Low noise and vibration levels
- No pulsation.

### Benefits

- High pump availability (minimal down time)
- Low initial and whole-life cost
- Capable of operating unattended for extended periods
- Adaptable for changing duty conditions with minimal investment
- Low environmental impact.



SP1000 (2) water injection,  
 SP1000 (2) oil transfer  
 Well Test Service Vessel, GOM



SP1000 jet pump power fluid application  
 Venezuela



SP1000 CO<sub>2</sub> pipeline injection  
 Mississippi, USA



SP1000 waterflood injection installation  
 Oman, Middle East

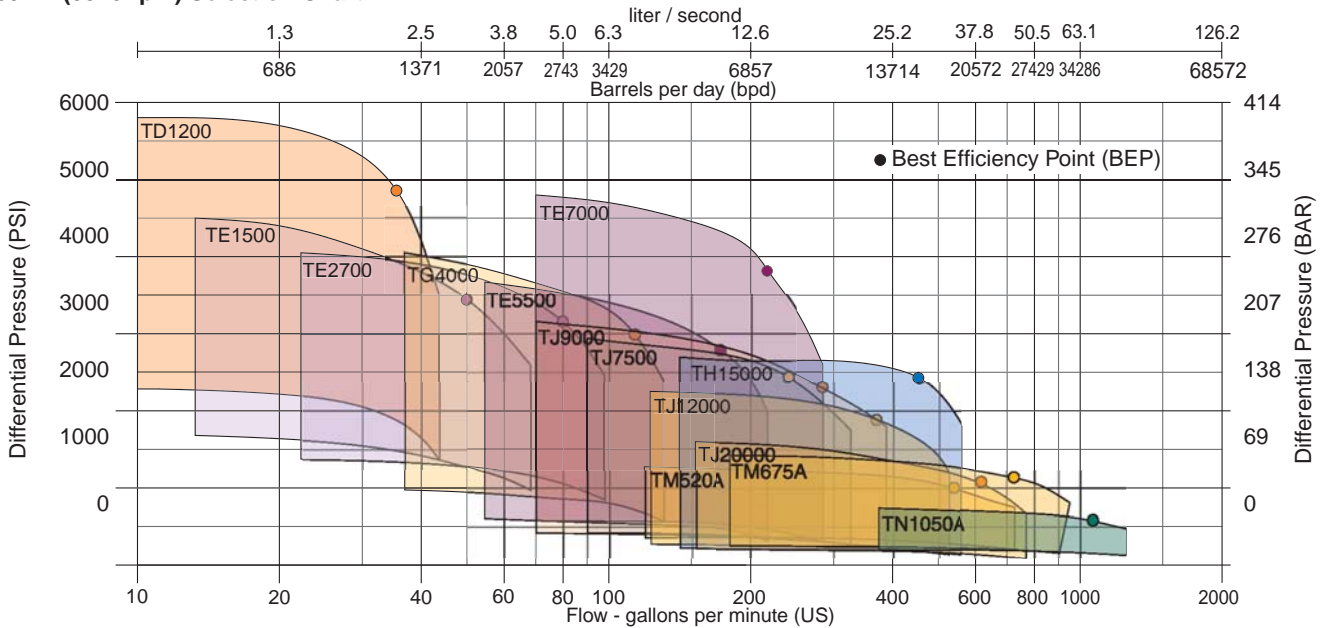


SP1000 (3) parallel water injection  
 Texas, USA



SP75 amine gas service application  
 Texas, USA

### 60 Hz (3570 rpm) Selection Chart



For higher pressures or flows SPS are operated in parallel or series.

Typical Performance chart



Wood Group ESP

# Worldwide Sales and Service



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Fax 405-527-7161 or 9582

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Artesia, New Mexico  
Tel 505-746-4614  
Fax 505-746-4519

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Tel 505-392-7999 or 7899  
Fax 505-392-8190

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Tel 432-699-7401  
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Toll Free 888-586-8909  
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Contact your local Wood Group ESP representative:

\*Manufacturing facility, in addition to sales and service

All information is presented as a general guide only. For specific product/service data please contact the Wood Group ESP location nearest you.