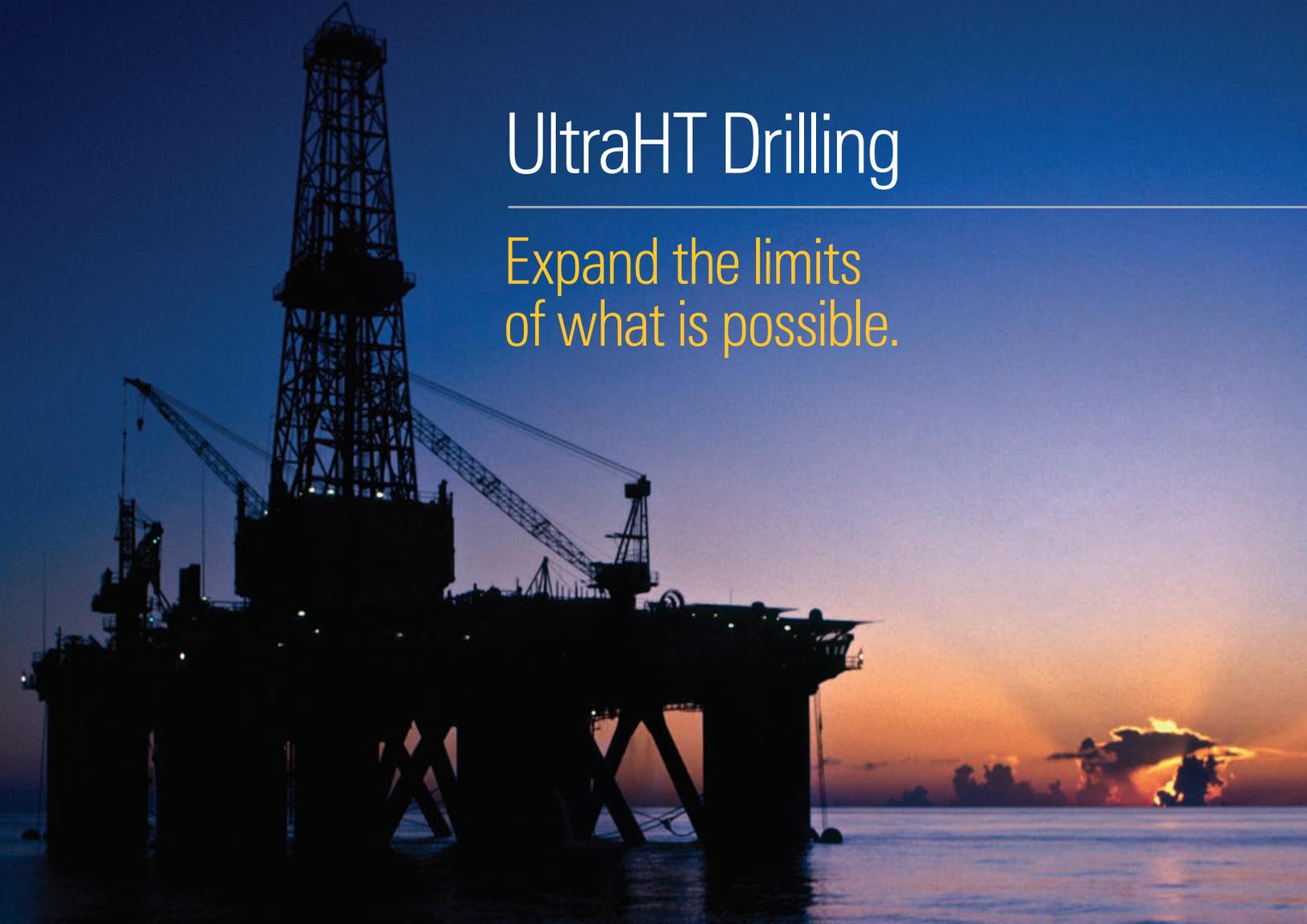


ICE UltraHT Drilling Services

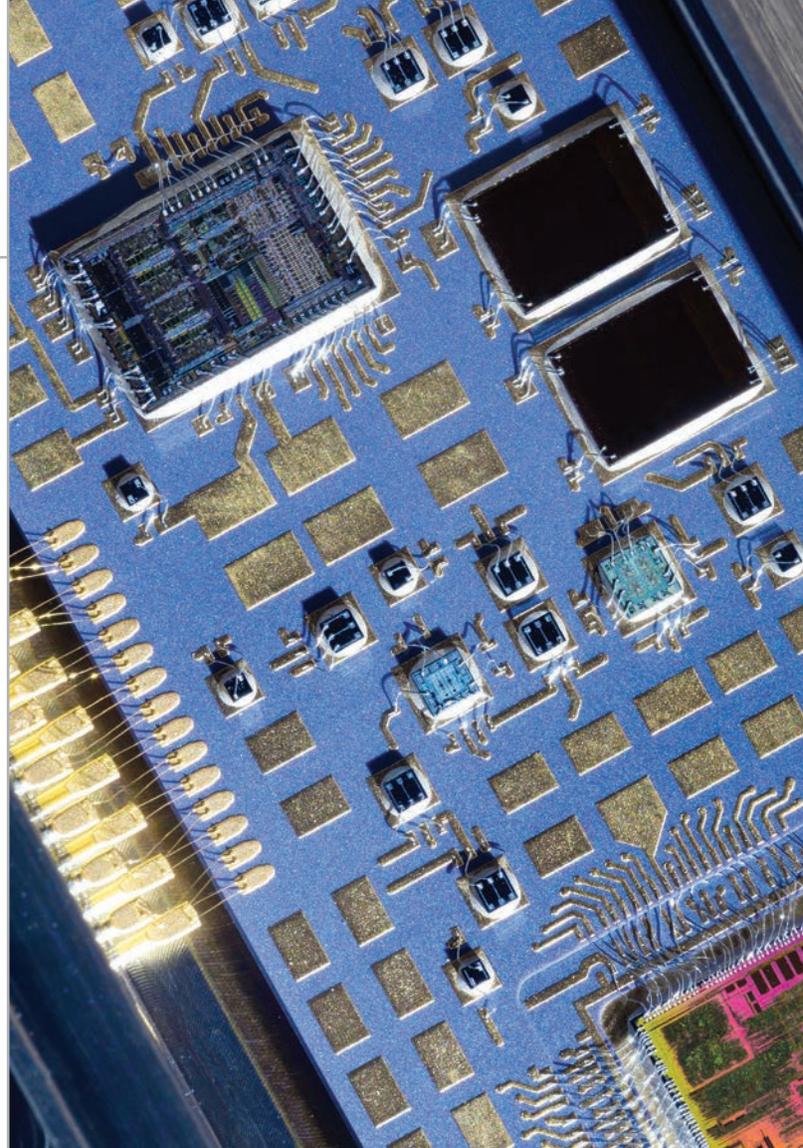
A silhouette of an offshore oil rig is shown against a sunset sky. The rig's complex structure, including a tall derrick and various cranes, is dark against the bright orange and yellow light of the setting sun. The sky transitions from a deep blue at the top to a bright orange near the horizon, where the sun is partially obscured by dark clouds. The rig's legs are visible, extending into the dark water of the ocean.

UltraHT Drilling

Expand the limits
of what is possible.

Operating at 200 degC [392 degF], ICE ultraHT drilling services expand your ability to accurately and efficiently reach targets in ultrahigh-temperature reservoirs without special operating procedures.

Engineered with proprietary ultraHT-rated ceramic electronics that are ruggedized for extreme down-hole conditions, the PowerDrive ICE* ultraHT RSS and the TeleScope ICE* ultraHT MWD service, together, form the first complete BHA specifically designed to operate at 200 degC. The ICE ultraHT drilling services build on 30 years of drilling innovation, making advanced drilling and telemetry a reality in ultrahigh-temperature wells.

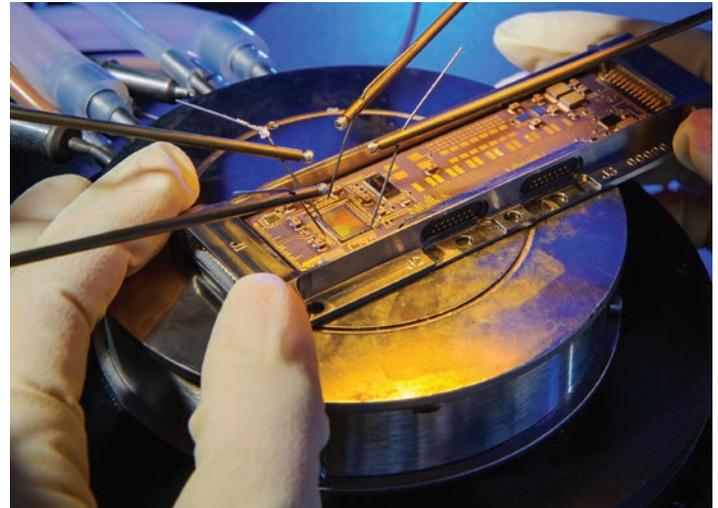




**Fully functioning
after 2,000 hours
of testing at temperatures
exceeding 200 degC**

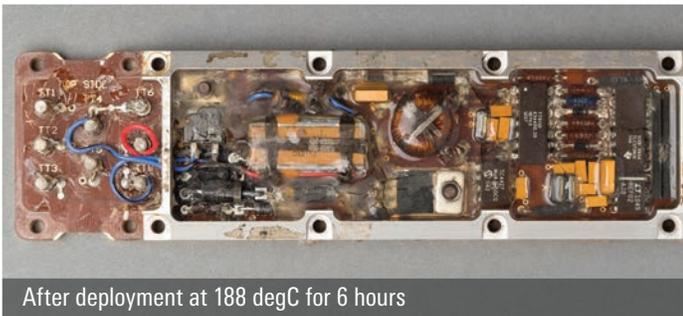
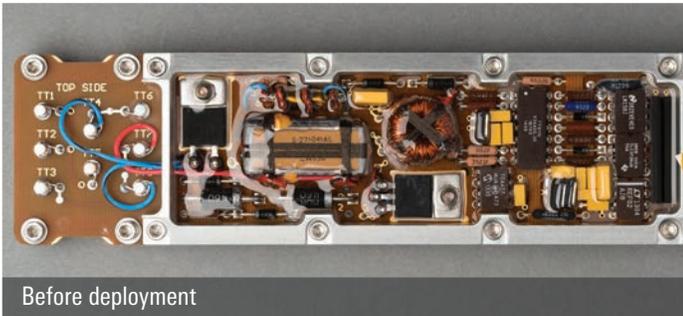
Proprietary ultraHT-rated electronics

To bring the advantages of the PowerDrive* rotary steerable systems and TeleScope* MWD services to ultrahigh-temperature reservoirs, Schlumberger revolutionized the process for manufacturing the ceramic components used in modern electronics. The result: multichip modules mounted on a ceramic substrate and hermetically sealed in inert gas, ready for the rigors of downhole use.

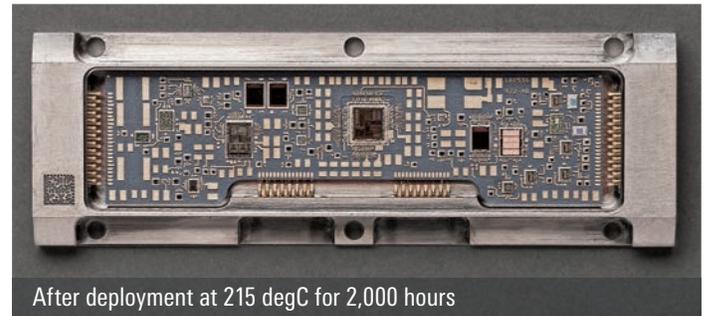
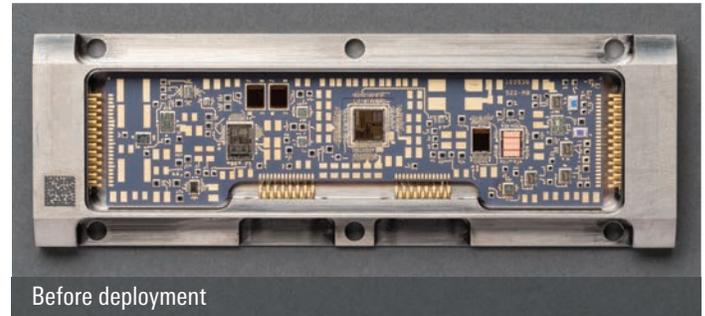


Durability in Extreme Downhole Conditions

Non-HT-rated electronic board



UltraHT-rated multichip module



The non-HT-rated electronic board failed after being exposed to 188 degC [370 degF] for approximately 6 hours. The ultraHT-rated multichip module, however, has full functionality after being tested to 215 degC [419 degF] for 2,000 hours.

TeleScope ICE

UltraHT MWD Service

Applications

Real-time well placement and drilling optimization in ultraHT reservoirs

Benefits

- Expand normal operating window to 200 degC
- Optimize well trajectory and landing with precise real-time data
- Mitigate risk with real-time drilling dynamics
- Reduce well construction time and cost
- Maximize ROP while obtaining high-density data
- Survey in static mode without cycling pumps

Features

- Proprietary ultraHT electronics
- High-density data transmission of
 - Continuous and static survey
 - Internal and annular pressure
 - Azimuthal gamma ray
 - Shock and vibration
- Compatible with the PowerDrive ICE RSS and all other Schlumberger BHA components

The TeleScope ICE MWD service enables high-speed transmission of survey and formation evaluation data critical for real-time drilling optimization and well placement in HT and ultraHT reservoirs.

Precisely position ultraHT wells

The TeleScope ICE service helps you geosteer accurately and mitigate drilling risk in ultraHT wells. This service maximizes the amount of information available and optimizes well trajectory in real time to effectively target productive zones.

Eliminate additional BHA and gyro runs

The ability to receive real-time measurements when developing HT and ultraHT reservoirs reduces well construction time and cost by eliminating additional BHA and gyro trips.



The ICE ultraHT drilling service BHA—TeleScope ICE MWD service and PowerDrive ICE RSS.

PowerDrive ICE

UltraHT RSS

The PowerDrive ICE RSS operates durably at 200 degC, bringing the benefit of a fully rotating RSS to ultraHT reservoirs. Designed with ultraHT-rated electronics, the PowerDrive ICE RSS assures reliable, uninterrupted performance in extreme downhole conditions.

Maximize performance by eliminating special operating procedures

The PowerDrive ICE RSS enables standard drilling operations in reservoirs with extreme temperatures. By eliminating performance-limiting procedures, such as controlled drilling parameters and additional off-bottom circulation, this fully rotating RSS helps you maximize ROP.

Drill to target reservoir with precision

The PowerDrive ICE RSS provides precise directional control and automatic steering.



Applications

- UltraHT drilling of 3D complex wells
- Drilling performance optimization
- Extended-reach drilling
- Accurate well placement

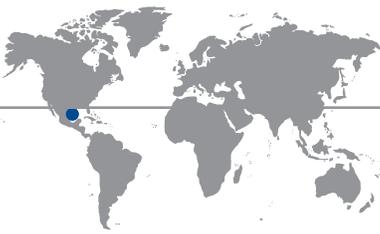
Benefits

- Expand normal operating window to 200 degC
- Reduce cost by eliminating trips
- Eliminate additional off-bottom circulation to ensure integrity of tools

Features

- Proprietary ultraHT electronics
- Innovative pad actuation design with metal-to-metal seals
- Multiaxis continuous inclination and azimuth measurements
- Automatic hold inclination and azimuth capability
- Compatible with the TeleScope ICE service and all other Schlumberger BHA components

Case Studies



PEMEX increased ROP by 16%, saving 9 operating days and USD 1.35 million using the PowerDrive ICE RSS.

PEMEX Improves Trajectory and Saves 9 Days with Ultrahigh-Temperature RSS

Recover trajectory to drill to target

PEMEX was drilling the 8½-in section of a 3D development well in HT formations offshore Mexico and expected to encounter static temperatures exceeding 165 degC [329 degF] and pressures up to 15,000 psi. With no commercially available RSS rated beyond 175 degC [347 degF], PEMEX selected a packed BHA. The possibility of veering off track was known to be a risk with the packed BHA, but PEMEX determined that a temperature-related tool failure was a greater risk.

While drilling, the BHA encountered very abrasive formations and veered off track. Lacking precise directional control and unable to reach the desired target, PEMEX pulled the BHA out of hole. To drill this section to planned TD, PEMEX needed a tool that could recover the tangent section and withstand the formations' elevated temperatures.

Use field-tested PowerDrive ICE ultraHT RSS to correct trajectory of 3D well

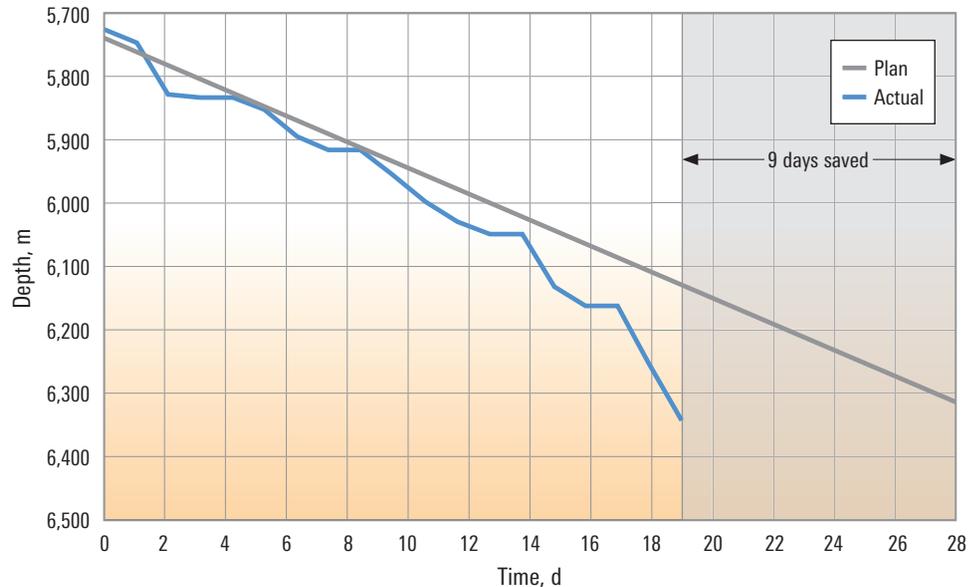
During the drilling of the 8½-in section, a field test of the PowerDrive ICE* ultraHT RSS concluded, and the tool became available. Schlumberger recommended using the ultraHT RSS to correct the trajectory of the borehole and drill the section to TD.

Rated to 200 degC [392 degF], the PowerDrive ICE ultraHT RSS is specifically designed to improve reliability in wells with extreme heat. At the time the well was drilled, the operating windows of all commercially available RSSs were limited by the plastic components in their electronic circuit boards. These parts begin to deteriorate, melt, and cause downhole failure at 180 degC [356 degF]. Designed with ultraHT-rated multichip modules that are ruggedized for downhole use and a bias unit with metal-to-metal seals, the PowerDrive ICE RSS provides operators with precise directional control in HT and ultraHT environments.

Recovered 8½-in section and saved PEMEX 9 days of rig time

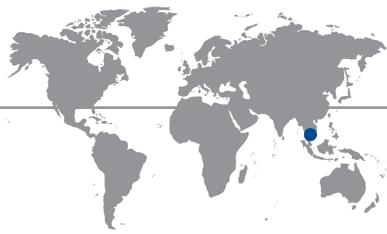
PEMEX used the ultraHT RSS to improve the azimuth of this wellbore from 77° to 57°. This RSS drilled the wellbore from 6,160-m [20,210-ft] MD to section TD at 6,340-m [20,800-ft] MD and encountered temperatures that reached 163 degC [325 degF] while drilling and 173 degC [343 degF] while static. The maximum pressure was 16,000 psi.

The PowerDrive ICE RSS performed reliably in these harsh conditions and increased ROP by 16%, saving PEMEX 9 operating days and USD 1.35 million. The RSS achieved an average ROP of 3.84 m/h [12.59 ft/h], setting a record for the field. Previously, the highest average ROP for an 8½-in section in this field was 3.30 m/h [10.82 ft/h], which was drilled using a conventional motor. PEMEX plans to use the ultraHT RSS in three future HT offshore wells.



The PowerDrive ICE RSS recovered the tangent section and drilled to section TD 9 days ahead of schedule by increasing ROP by 16%.

Case Studies



By eliminating a BHA trip and a gyro run, PTTEP saved 12 hours of rig time and decreased operational costs by USD 167,000.

PTTEP Eliminates BHA Trip and Gyro Run, Saving 12 Rig Hours in 204-degC Well Offshore Thailand

Find more efficient way to develop ultraHT wells

PTT Exploration and Production Company Limited (PTTEP) drills more than 50 gas wells each year with static reservoir temperatures greater than 200 degC. These ultraHT wells are located in the shallow water of the Gulf of Thailand and are typically deviated. The established method for developing ultraHT wells in this field involves drilling until a circulating temperature of 175 degC [347 degF] is reached and tripping out of hole to remove measurement technologies to protect electronic components. The remainder of the well section is drilled blindly to TD, followed by a gyro trip to determine the position of the wellbore.

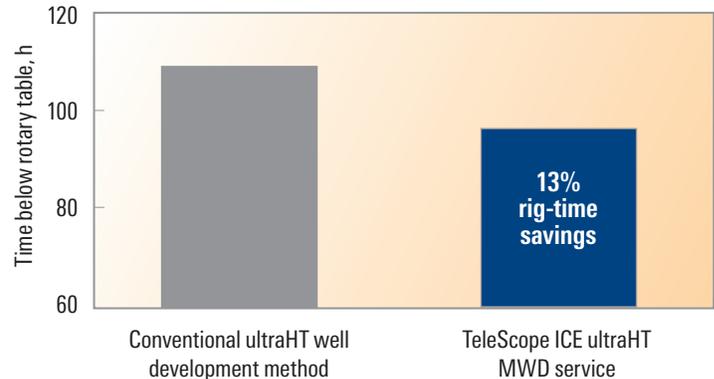
While planning the 6½-in section of a ultraHT well in the Arthit field, PTTEP began searching for a more efficient method of developing its ultraHT wells.

Obtain real-time downhole measurements with ultraHT MWD service

Schlumberger recommended using the TeleScope ICE ultraHT MWD service, a high-speed telemetry service designed to obtain real-time downhole measurements in harsh drilling conditions. Using proprietary ultraHT-rated electronics that are ruggedized for extreme temperatures, the TeleScope ICE service operates normally at 200 degC. This capability enables real-time well placement and would eliminate the BHA trip and gyro run that PTTEP typically performs.

Drilled 204-degC well to TD in one run, saving two trips and USD 167,000

In its first field run, the TeleScope ICE service performed reliably in reservoir temperatures of 204 degC and circulating temperature of 186 degC [367 degF]. Despite these harsh drilling conditions, PTTEP obtained real-time downhole measurements and drilled the well to total depth in one run. By eliminating a BHA trip and a gyro run, PTTEP saved 12 hours of rig time and decreased operational costs by USD 167,000.



The TeleScope ICE service enabled PTTEP to eliminate a BHA and gyro trip in the 6½-in section, which saved 12 hours of rig time and reduced time below rotary table by 13%.



PowerDrive ICE

UltraHT RSS

Specifications	675
Nominal OD, in [cm]	6.75 [17.15]
Overall length, ft [m]	34.26 [10.44]
Max. collar dogleg (sliding), °/100 ft [°/30 m]	16 [16]
Max. collar dogleg (rotating), °/100 ft [°/30 m]	8 [8]
Build rate, °/100 ft [°/30 m]	0 to 8 [0 to 8]
Flow range, galUS/min [L/min]	240–800 [908–3,028]
Max. rotational speed, rpm	350
Max. temperature, degF [degC]	392 [200]
Max. hydrostatic pressure, psi [kPa]	30,000 [206,843]
Max. sand content, % by volume	1
Collar upper connection	5½ FH box
Bit box	4½ Reg box
Bit box to inclination and azimuth point, ft [m]	13.30 [4.06]





TeleScope ICE

UltraHT MWD Service

Mechanical Specifications

Nominal OD, in [cm]	4.75 [12]	6.75 [17.1]
Max. OD, in [cm]	5.05 [12.8]	6.89 [17.5]
Collar length, ft [m]	31.9 [9.7]	31.9 [9.7]
Hole Size, in [cm]	5 $\frac{3}{4}$ to 6 $\frac{3}{4}$ [14.6 to 17.14]	8 $\frac{3}{8}$ to 9 $\frac{3}{8}$ [21.27 to 25.08]
Weight, lbm [kg]	1,540 [700]	2,650 [1200]
Max. dogleg		
Rotating, °/100 ft	15 (at up to 150 rpm)	8 (at up to 150 rpm)
Sliding, °/100 ft	30	16
Flow range, galUS/min [L/min]	150 to 400 [568 to 1,514]	275 to 800 [1,041 to 3,028]
Power supply	Downhole turbine	
Lost circulation material tolerance, lbm/bbl [kg/m ³]	Medium nutplug, 50 [142.5]	
Max. operating temperature, degF [degC]	392 [200]	
Operating frequency range, Hz	0.5–13.5	
Max. external pressure, psi [kPa]	30,000 [206,843]	
Max. shock	30 min at Shock Level 3 (>10 Hz above 50 g_n) 200,000 cumulative shocks above 50 g_n	

Measurements Specifications

Directional	Stationary	Continuous
Inclination accuracy, °	±0.1 (1σ)	±0.2 (1σ)
Azimuth accuracy, °	±1 (1σ) above 5° inclination	±2 (1σ)
Toolface accuracy, °	±1 (1σ)	±1 (1σ)

Gamma Ray (Average and Quadrant)

Accuracy, %	±5
Range, gAPI	0 to 1,024
Statistical repeatability	±5 gAPI at 100 gAPI and 100 ft/h, 3-point average
Vertical resolution, in [cm]	12 [30.5]

Annular and Internal Pressure Measurement

Accuracy, psi [kPa]	±30 [±206.8]
Range, psi [kPa]	0 to 30,000 [0 to 206,843]
Resolution, psi [kPa]	±1 [±6.8]

Drilling Mechanics Measurements

Vibration	
Range, g_n	0 to 60
Accuracy, g_n	±1
Resolution, g_n	±0.125
Shock	
Range, g_n	±500
Accuracy, %	±10
Resolution, g_n	1
Collar rotation	
Range, rpm	0 to 400
Accuracy, %	±10
Resolution, rpm	1



ICE UltraHT Drilling Services



PowerDrive ICE

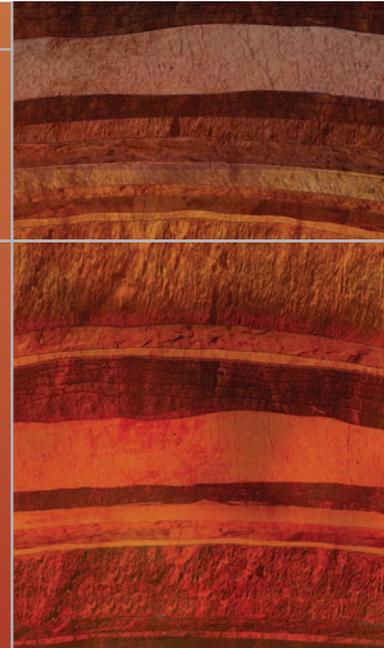
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