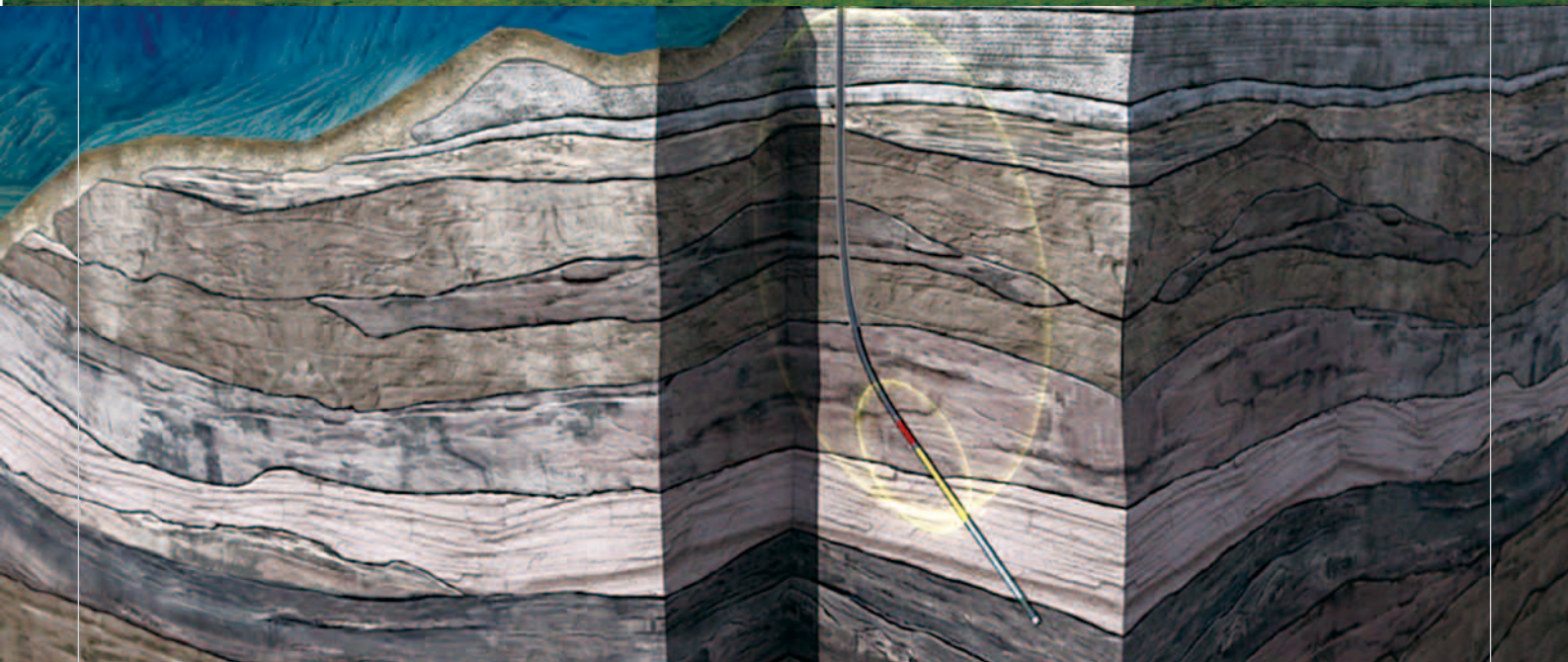


Innovative and Integrated Solutions for Oilfield Services



China National Petroleum Corporation

**As one of the world's
major providers of oilfield
engineering and technical
services, CNPC is dedicated
to facilitating oil and gas
field development and
boosting both reserves and
production.**



CGDS geosteering drilling system

CGDS integrates the technology of drilling, logging and reservoir engineering, and applies near-bit geological and engineering parameters and controlling method while drilling to ensure the well trajectory passes through reservoirs and is best located. The borehole orbits can be adjusted and controlled timely according to the formation features measured by CGDS, and the drilling bits are equipped with "eyes", which can identify oil/gas layers during drilling.

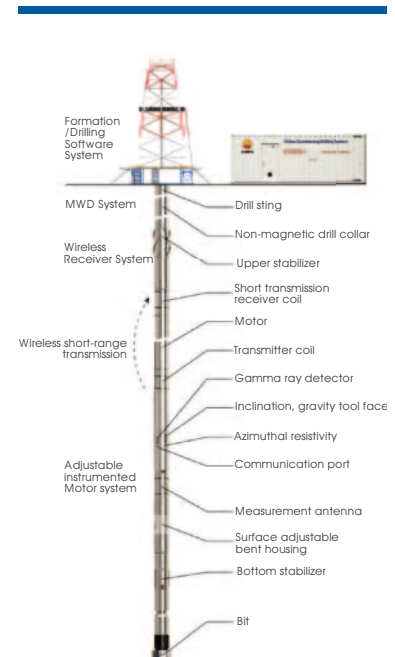
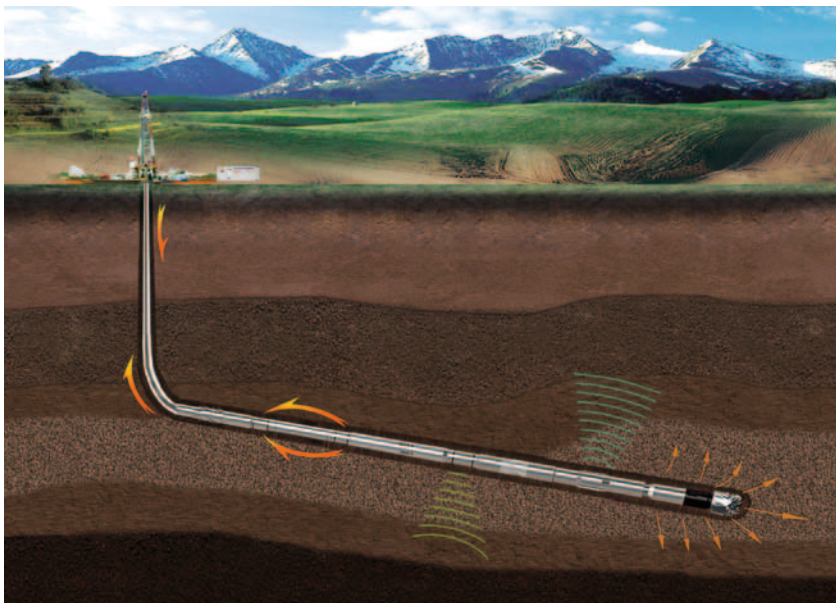
CGDS is configured with Adjustable Instrumented Motor System, Wireless Receiver System, MWD System and Formation/Drilling Software System. It has three functions including measuring, transmitting and steering:

Measuring Near-bit geological parameters (Bit Resistivity, Azimuthal Resistivity, Azimuthal Nature Gamma Ray) and near-bit engineering parameters (Inclination, Tool Face) are measured and the information is sent by wireless transmission technology to the receiving system across steering screw motor.

Transmitting Near-bit information is integrated into the positive pulser MWD System by data connection system, and MWD is used as information transmission channel to send the measured downhole information (partial) to surface processing system as the evidence for direction decision.

Steering Formation/Drilling Software System judges and decides "where to go" for the bit, after processing and interpreting the geological and engineering parameters measured near bit. Downhole motor is used as the steering tool to direct bit into objective oil/gas layer or to continue drilling in the oil layer.

CGDS is available in three different tool sizes CGDS120, CGDS172, and CGDS203 system for hole sizes from 6" ~9-5/8".



The CGDS can

Be applied to geological exploration directly and increase the discovery rate of prospecting wells.

Be suitable for the development wells in complicated formation or thin oil layers and increase the probability of penetration and recovery rate.

Reduce drilling costs and increase production and economic profit.

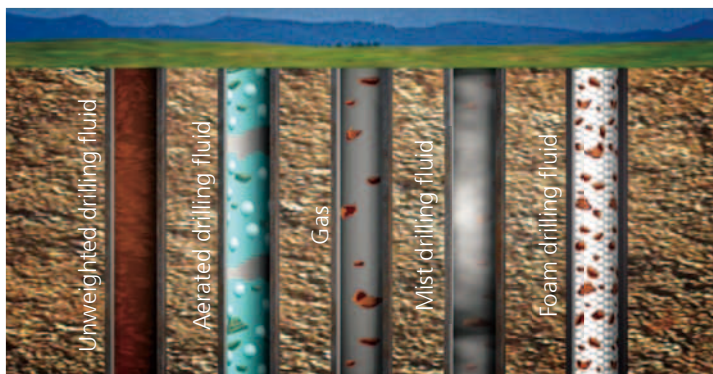
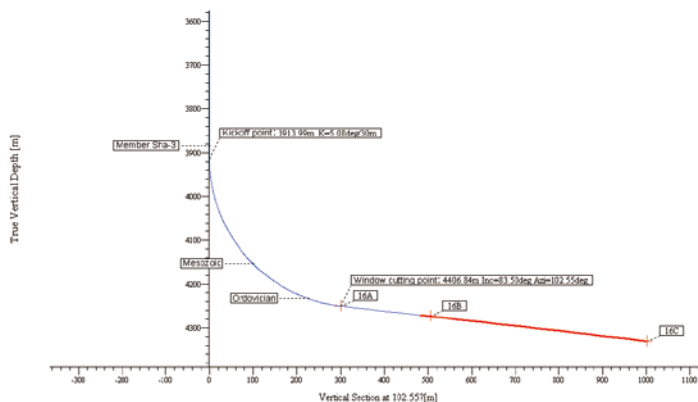


Underbalanced drilling/gas drilling

The supporting devices and downhole tools such as spin-type blowout preventer, snubber, air compressor, pneumatic hammer and pneumatic screw are successfully developed.

Underbalanced drilling using different types of medium, including light mud, dry air, aerated mud, foam and mist, is introduced together with a complete supporting process involving downhole casing valve, gel-type valve and snubbing equipment. Gas drilling using air, natural gas or nitrogen is also utilized to discover and preserve oil and gas reservoirs and facilitate the drilling process.

During 2005-2010, 1,005 underbalanced wells were drilled, representing 20% of the prospecting wells. Underbalanced drilling has played a critical role in discovering a number of oil and gas reservoirs such as Qiongxí in Sichuan Basin, Santanghu in Turpan Basin, Qikou in Dagang oilfield and volcanic reservoirs in Xinjiang. Among them, there are 226 wells using gas drilling, with the average drilling speed 4-15 times higher than that of conventional drilling approaches.



Lateral and fishbone well drilling

Drilling lateral and fishbone wells can effectively increase the contact area between horizontal intervals and reservoirs, and thereby boost the production per individual well.

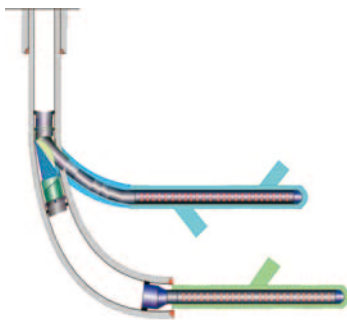
CNPC has made significant progress in lateral and fishbone well drilling.

Five sets of process engineering have been developed for the drilling of directional lateral wells, lateral horizontal wells, fishbone wells, multi-layer lateral wells, and underbalanced lateral wells.

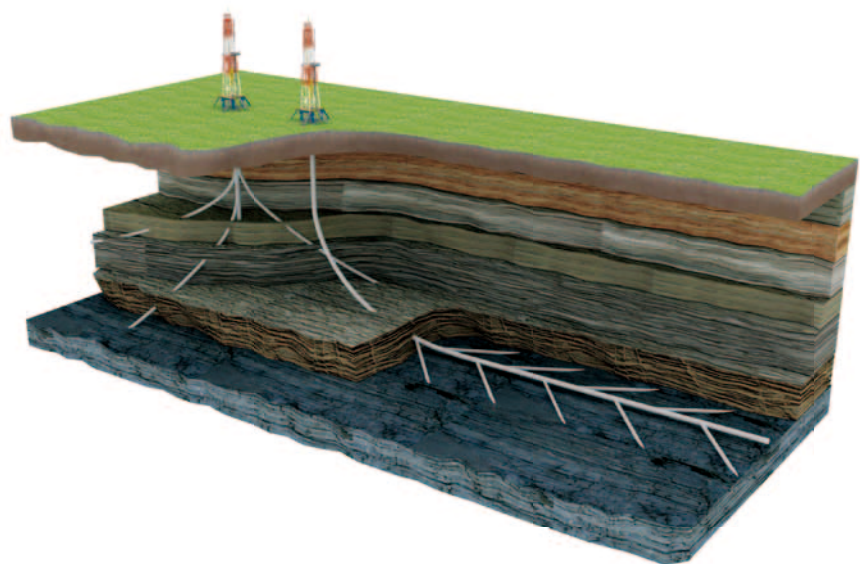
Remarkable results have been achieved in developing heavy oil reservoirs, low-permeability buried hill reservoirs, thin reservoirs, and coal bed methane reservoirs.

More than 80 lateral wells have been completed in the Liaohe, Jilin, Sichuan, and Daqing oil and gas fields, resulting in an output of 2-10 times that of neighboring wells in the same blocks.

Well Jing 52-H1Z, a 20-lateral fishbone well in Liaohe oilfield, has a 1,002m-long main horizontal interval, 3,331.19m footage of lateral bores, and the length of horizontal intervals totaled 4,333.19m.



The bilateral fishbone horizontal well An1-H8 at Liaohe Oilfield was successfully drilled by the composite using of lateral drilling, underbalanced drilling and air drilling technologies. DF-1 drilling and completion system was used to complete the well, effectively addressing technical challenges posed by tough strata, sidetracking for window cutting with high deviation angle, and liner replacement.



Fracturing stimulation

Including geological evaluation, adaption of fracture and well pattern, optimization of fracturing parameters, low damage fracturing fluid, integrated testing and diagnosis of fracture, and post-fracturing forced closure by quantitatively controlled relief. Productivity can be increased by 30-50%.

The core technology to economically and effectively develop low permeability deposits is to stimulate reservoirs for higher output. Fracturing for overall development of low permeability oilfields takes a block as a unit to realize an optimal matching between well pattern and the fractured crack system.

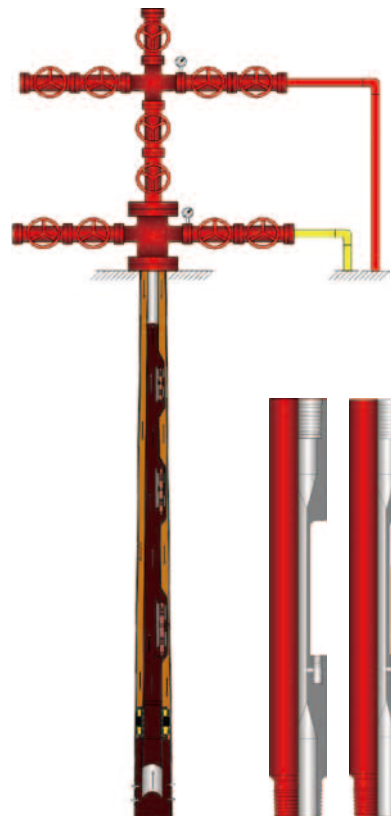
Multistage fracturing of horizontal wells adopts special, recyclable mechanical plugs, which can effectively separate the target intervals. After the operation, the tools can be recycled. As each segment of the reservoir is reconstructed in a balanced manner, the oil drainage area is increased.

Fracturing with controlled water cut adopts an oil-soluble temporary plugging agent with independent intellectual property rights. This agent forms a barrier layer that controls the height of cracks, and effectively limits their downward extension. The water cut is reduced and the recovery factor of bottom-water reservoirs is increased. Fast hydrating guar working with the continuous in-situ blending of fracturing fluid avoids deterioration and waste of the base fluid while significantly improving the operational efficiency.

In a new low-molecular-weight environmental-friendly fracturing liquid system (Patent No. 2005100428320), more than 50% of the flow-back liquid can be recovered. This minimizes the operational cost and environmental pollution. No-string-pulling separate-layer fracturing (Patent No. 200520079637.0) is able to reconstruct 2 or 4 layers in a single string pass, considerably reducing the operation cycle.

Our patented multi-crack fracturing features in-crack turning that creates new branch cracks in a trunk crack or interconnects more tiny cracks. This increases the drainage area, releases the oil in the "dead zone" out of the route of the original cracks, and increases both water-flooding efficiency and production per well.

Our solid expandable tubular package consists of 7 patented technologies which are used to patch and overhaul oil and water wells with corroded and perforated casings, while maintaining the maximal dimension of the completed well. The patch can be of dozens or hundreds of meters in one cycle. The patched casing can be of J55 steel grade in strength, which satisfies normal production.



Fracturing tools

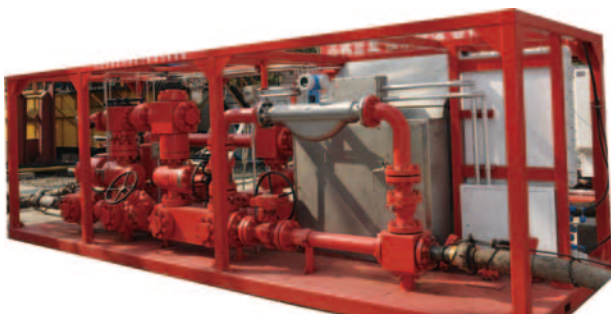


Precise PCD system

The system consists of a ground pressure control device (model PCDS-I and CQMPD-I) and downhole pressure logging-while-drilling (LWD) tools. In near- and under-balanced precise pressure controlled drilling (PCD), it monitors and controls the annular pressure and compensates for backpressure to avoid complex situations such as well kick and loss of circulating fluid in narrow windows of drilling fluid density.

Applications

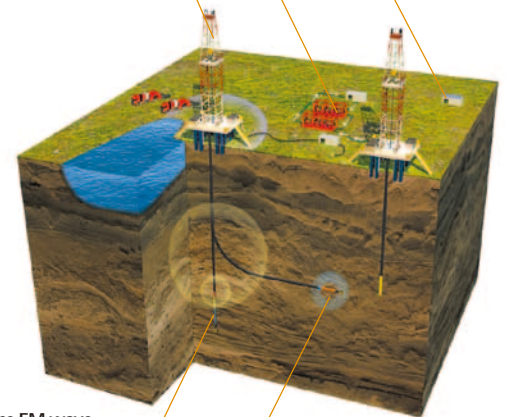
The system has delivered significant result in 19 well-times of field tests and industrial applications in Chuanyu and Nanpu oilfields. Performing stably, it has precisely controlled the bottom-hole pressure and addressed the challenging scenarios of drilling where "overflow coexists with loss of drilling fluid".



Drilling engineering software ANYDRILL™ V1.0

Precise PCD system

XTG178 top drive casing running device



DREMWD wireless EM wave LWD system

DRMTS-I long-distance guiding device for horizontal CBM wells

Technical Features

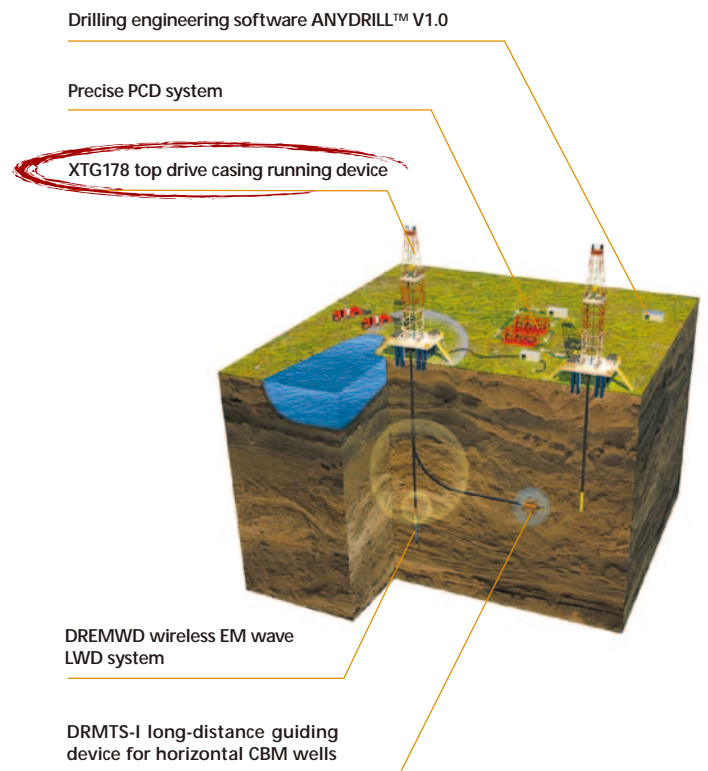
- < Precise pressure control
- < Closed loop monitor and control for multi-strategy and adaptive drilling
- < Precise monitoring on the outlet and inlet flows
- < Suitable to all drilling conditions

Technical Specifications

- < Rated pressure: 35MPa
- < Operating pressure: 10MPa
- < Control precision of bottom-hole pressure: ± 0.5 MPa
- < Suitable to formation temperature: 150°C
- < Suitable to formation pressure: 140MPa

XTG178 top drive casing running device

XTG178 Top Drive Casing Running Device precisely controls the makeup torque of casing running through a top drive and enables rotation, lifting, and circulation in safe and efficient casing running operations. It is the first of its type in China and a world-leading device.



Main Technical Specifications

Parameters Model	Casing	Rated lifting load	Rated operating torque	Pressure endurance of seal	Connecting screw	Product height
	in	t	kN.m	MPa	API	mm
XTG127	4-1/2~5-1/2	350	35	35/70	6-5/8 REG	2,540
XTG178	7	350	35	35/70	6-5/8 REG	2,540
XTG244	9-5/8	500	50	35/70	6-5/8 REG	2,540
XTG340	13-3/8	500	50	35/70	6-5/8 REG	2,540
XTG508	20	500	50	35/70	6-5/8 REG	2,540

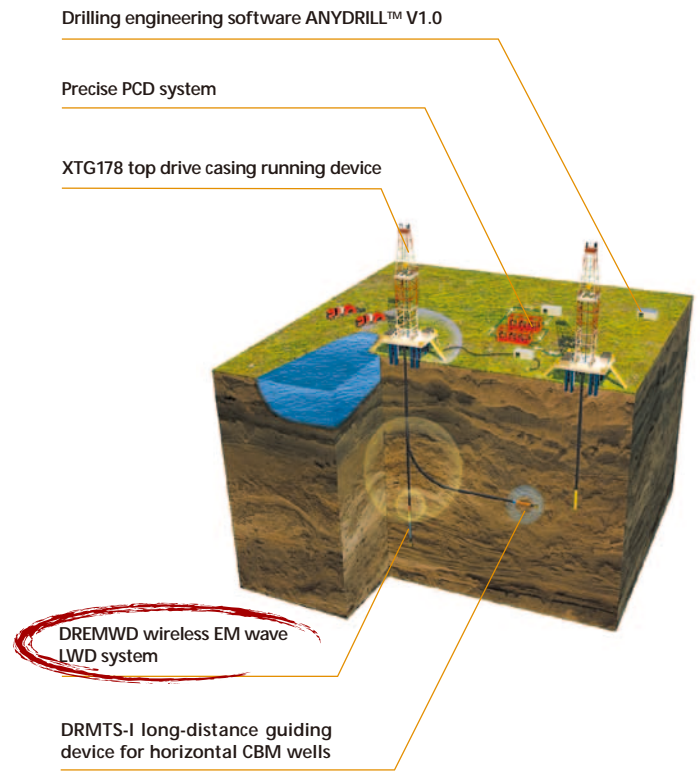
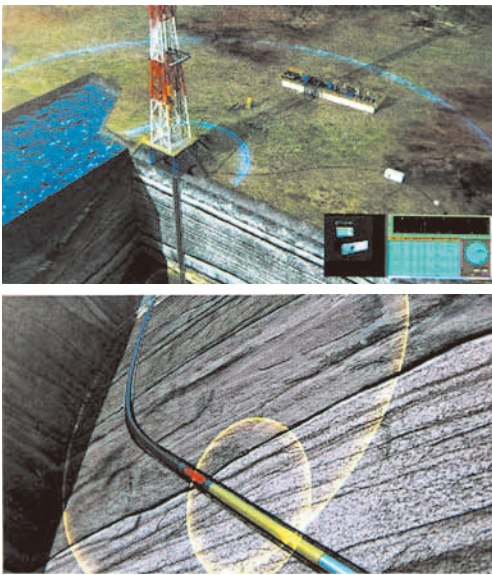
DREMWD wireless EM wave LWD system

DREMWD is a wireless electromagnetic (EM) wave logging-while-drilling (LWD) system independently developed by CNPC. It consists of downhole instruments and ground reception and detection devices. The system uploads downhole information through EM wave signals in real-time and logs well track, azimuthal natural gamma, and other parameters while drilling. Suitable to the oil, gas, and coal-bed methane (CBM) drilling with various circulating media, DREMWD is the first of its type in China and a technical leader in the world.

Field Applications

The system has been applied in 5 well-times of field tests and transmitted data from a depth of up to 2,876m without any relay at a max. uploading rate of 11bit/s.

In the directional drilling of a CBM well, the system precisely guided the drilling bit to its target after 320 meters of LWD footage for 67 hours.



Main Technical Specifications

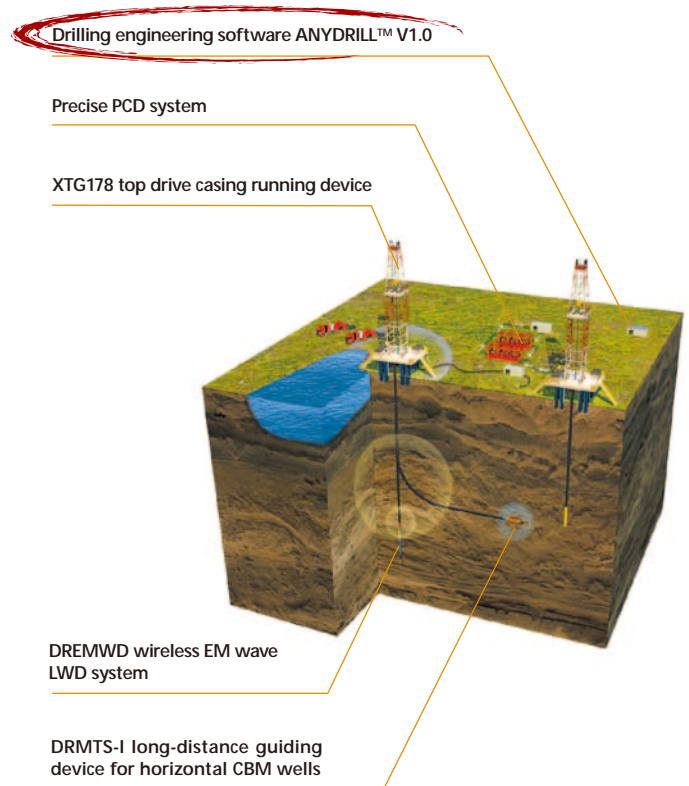
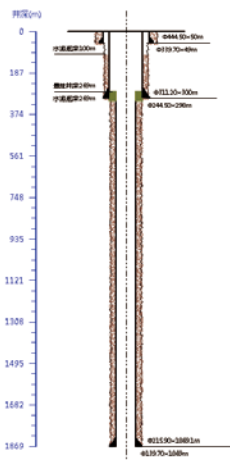
Suitable to bore	6", 8-1/2"
Measurement range and precision of inclination azimuth, and tool face azimuth	0°~180°±0.1°, 0°~360°±0.5°, 0°~360°±0.5°
Natural gamma	0~250API±3%FS, w/two natural gamma sensors
Data rate	3.5bit/s~11bit/s
Max. operating pressure and temperature	100MPa, 125°C
Output power of downhole turbine generator	30W~600W
Suitable to mud/gas displacement	15L/s~50L/s, 30m³/min~100m³/min

Drilling engineering software ANYDRILL™ V1.0

ANYDRILL™ V1.0 is a world-leading software package consisting of drilling data management, drilling engineering design and analysis, and other functional modules to carry out drilling engineering design, drilling data management, as well as professional analysis of rock mechanics, cementing, and drilling fluid.

Functions

- < Drilling data management
- < Formation pressure forecasting
- < Wellbore structure design
- < Drill bit design
- < Well track design
- < Drill string design
- < Hydraulic drilling design
- < Drilling fluid design
- < Casing string design
- < Cementing design
- < Well control design
- < Drilling scheduling
- < Generation of design reports



ANYDRILL™ V1.0 has been used in more than 1,000 wells at CNPC's Liaohe, Dagang, Tuha, Qinghai, Xinjiang, Yumen, and Sichuan oilfields, as well as Sinopec's Southwest Petroleum Bureau. Its abundant functions, accurate calculation, user-friendly interface, and ease of use have been proven to cater for the drilling engineering design and analysis in oilfields.



DRMTS-I long-distance guiding device for horizontal CBM wells

DRMTS-I is a long-distance guiding device for horizontal coal-bed-methane (CBM) wells. It steers horizontal CBM wells to precisely intersect with their vertical cave well by measuring with a rotary magnetic field. The device provides ultra-short-distance steering, inclination measurement, and 3D guidance. In fact, DRMTS-I is the first device independently developed by China to intersect horizontal CBM wells with their vertical cave wells and is comparable to its foreign counterparts.

Performance Specifications

Outer diameter of magnetic source (transmitter)	4 3/4"
Resolution of magnetic field measurement	0.2nT
Adaptable to temperature	-25~+85°C
Pressure endurance	35MPa
Azimuth measurement error	<0.40°
Distance measurement error	<5%
Effective range	70m~1m

DRMTS-I has successfully intersected wells in one pass in all its 6 well-times of field applications at Jincheng, Liulin, and Binxian.

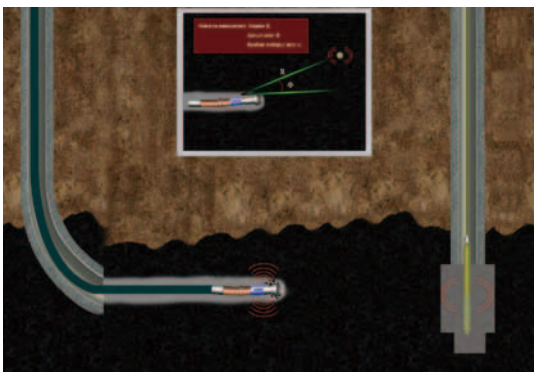
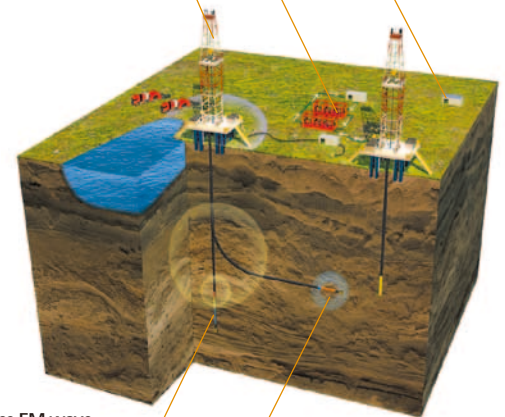
Drilling engineering software ANYDRILL™ V1.0

Precise PCD system

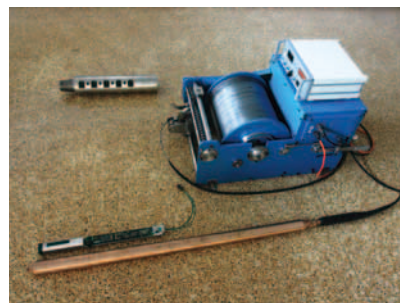
XTG178 top drive casing running device

DREMWD wireless EM wave LWD system

DRMTS-I long-distance guiding device for horizontal CBM wells



Intersection between a horizontal well and a vertical well guided by DRMTS-I



Major instruments and devices of DRMTS-I

GW-MLE mud logging unit

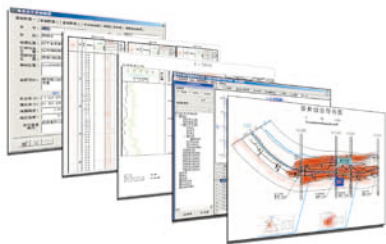
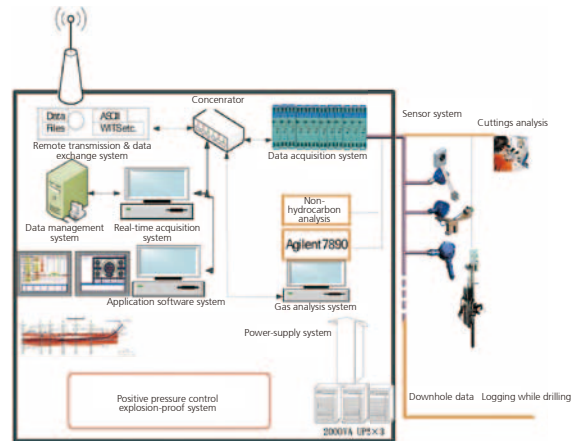
With 1 Patent of Invention, 4 Patents of New Technology, and 7 Copyright Registrations of Software, the GW-MLE mud logging units are providing services for 18 clients over the world on 93 wells, and achieved an 87% coincidence rate in reservoir interpretation and a 100% prediction rate on abnormal drilling operations.

Hardware

Include sensors, acquisition interface, gas analysis, data process, positive-pressure explosion-proof system.

Software

The PM3.0 system software of GW-MLE mud logging unit has 3 versions: Chinese, English, and Spanish for different operation areas, including real-time acquisition, data management, application program, and data transmission system. It increases the data acquisition precision by using double-depth compensation for deep water operation, lag time adjustment with equivalent diameter of wellhole, amending displacement with ratio, vertical-depth calculation with definite curvature method and data storage in multi-conditions.



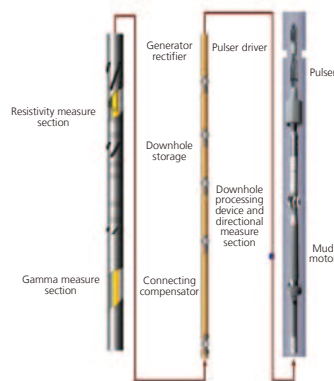
System Functions

- < The system software includes Oil-gas Interpretation System, Mud Logging Steering System, and Geological Data Process System.
- < RDT system is composed of wellsite data acquisition, data remote control, data process and multi-well analysis system.
- < Application of the new technologies: double depth compensation of deep water, lag time adjustment with equivalent diameter of wellhole, amending displacement with ratio, vertical-depth calculation with definite curvature method and data storage in multi-conditions.
- < Multi-language version software of PM3.0 can meet the different needs of different countries.
- < Geological Data Process System output standardization, intelligentialization, digitization of geological data.
- < Oil-gas Interpretation System provides the fast interpretation & evaluation of reservoir in wellsite.
- < Mud Logging Steering System provides real-time track of the well trajectory to increase the drilling ratio.

GW-LWD (BWR)

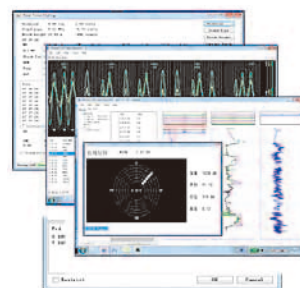
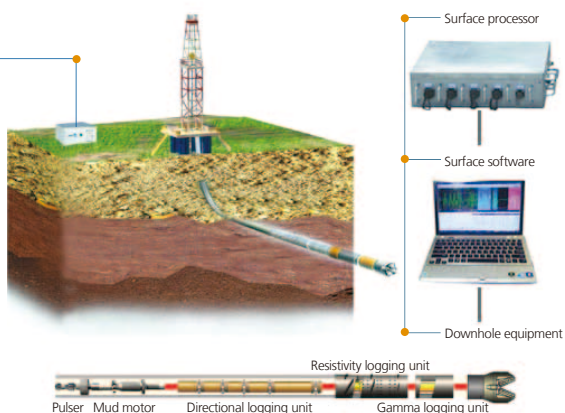
Downhole Equipment

- < Pulsar
- < Mud motor
- < Electromagnetic logging instrument
- < Transmitting compensation technique
- < Resistivity logging curve
- < Storage 32 measure parameters
- < Dual 64M storage system with 300h continuous logging

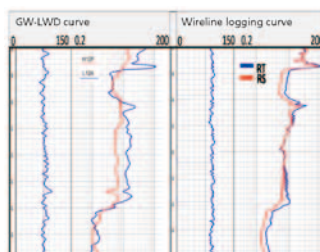


LWD Software V1.0, including 6 related modes

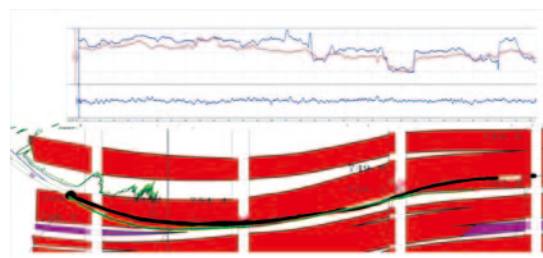
- < Downhole instrument communication setting part
- < Pulse signal decoding part3. data base part
- < Depth trace part
- < Data display for the driller screen part
- < Log presentation processing part



GW-LWD curve compare with wireline logging curve in DU 84-XING 2065 well, Liaohe Oilfield



Geology steering usage in DU 84-H 2065 well, Liaohe Oilfield



DML mud logging unit

Collect and transfer composite information such as data of geology, gas engineering and drilling fluid with high automation level, simple operation and easy maintenance.

DML Drilling Parameter Indicator

Realize real-time monitoring of drilling engineering parameters, drilling fluid volume, hydrogen sulfide and combustible gas data to ensure safe, fast and quality drilling operations. The data acquisition server, touch screen terminal and junction box are explosion-proof designed, with powerful system function and intellectualized audible and visual alarm. It is applicable for both onshore and offshore operation.



- < High automation and reliability
- < 32 simulation channels, 8 pulse signal channels, 4 output channels, with high extensibility
- < Powerful software and simulated gauge display
- < Intellectualized calculation model
- < Data remote transmission
- < Build-in micro-UPS

DML Low-power Wireless Sensors

- < 16 signal channels, 256 survey points, extendable
- < Wireless transmission distance $\geq 200\text{m}$
- < Environment temperature range - 35-70°C, humidity 90%
- < Data accuracy 99.5%
- < Power battery 6V, (volume: 200x100x75mm, weight: about 3Kg, can repeat charging: 500 times)
- < Working current $\leq 30\text{mA}$
- < Protective level: IP68
- < Explosion-proof level: Exia II C T6



Data Remote Transmission System

With wireless communication medium of satellite, CDMA(C network) and GPRS(G network) to realize information acquisition, processing, remote client terminal displaying and sharing, covering basically all the operation procedures at wellsite.



Wellsite Information Integrated Transmission System

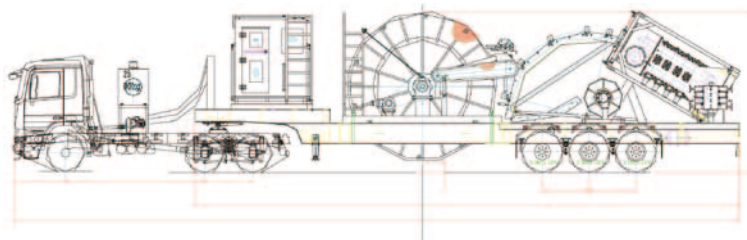
- < Wide Band satellite transmission station used
- < Wellsite LAN Centre
- < Drilling engineering parameters acquisition and transmission
- < Directional drilling parameters acquisition and transmission
- < Mud logging remote transmission
- < Wellsite video live and remote monitoring system
- < Wellsite video meeting system
- < Wellsite information integration and distribution system



Coiled tubing technology and equipment

Breakthroughs are achieved in core technologies such as injector head of the coiled tubing. A series of fittings for 3/8"-2-3/8" coiled tubing is developed independently. The critical issues in tubing material and manufacturing are solved. The first production line for coiled tubing in Asia is constructed, making China the second country in the world having the proprietary knowledge of coiled tubing manufacturing.

A dozen of coiled tubing operations and supporting tools are devised, including fracturing acidizing, sand washing, unclogging and plugging etc. These techniques are used in more than 200 wells in Sichuan, Dagang, and Liaohe oilfields with satisfactory results.

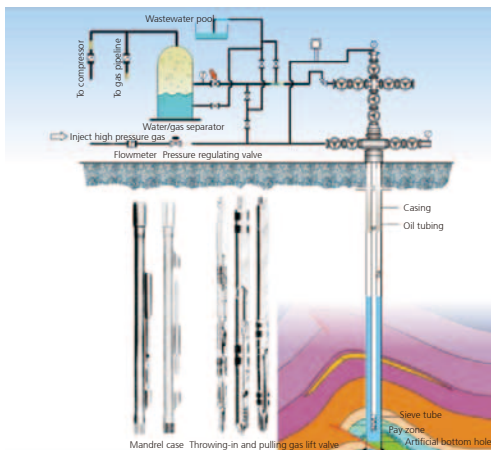


Applications

The equipment has worked excellently in staged fracturing, CT acidizing, sand washing and flushing, velocity string, SAGD well testing operations in Liaohe, Dagang, Jidong, Changqing, and Southwest oil and gas fields. For example, it successfully perforated 48 holes and fractured 4 layers in hydraulic jet fracturing operations in well Qiang-1-44-15 in Liaohe Oilfield. After being fractured, the well produced 13 tons of crude oil a day, 2.6 times as many as any of adjacent wells.



Gas lift oil recovery



Flow chart of conventional gas lift dewatering gas production technique

In oil and gas field development, gas lift is a cost-effective artificial lift technology that utilizes the energy in gas wells for oil recovery with minimal energy consumption and initial investment.

CNPC launched its gas lift research in the 1990s, and has developed 29 unique technologies in eight categories, as well as 97 specifications, 48 types, and five categories of gas-lift tools. We offer one-stop services for the planning of gas lift engineering projects, gas lift design and optimization, the manufacturing, debugging, and detecting of gas lift tools, gas lift troubleshooting and completions, and production management.

By applying gas lift to production initiation at new wells and as a stimulation measure, we have exclusively developed the gas-lift-based fracture flowback technique and drainage gas recovery technology, as well as the auxiliary wireline operation technology for gas lifting.

Gas-lift-based fracture flowback is a unique technology in which high-pressure gas-lift tools are installed to the fracturing string. Without pulling out the string after the fracturing operation, the rapid flowback of fracturing fluid is realized by gas lift. This technology has delivered a 100% success rate during engineering. In equivalent conditions, it can shorten the flowing back period from the conventional 15-20 days to 1-2 days, with a fluid cleanup rate of up to 100%.

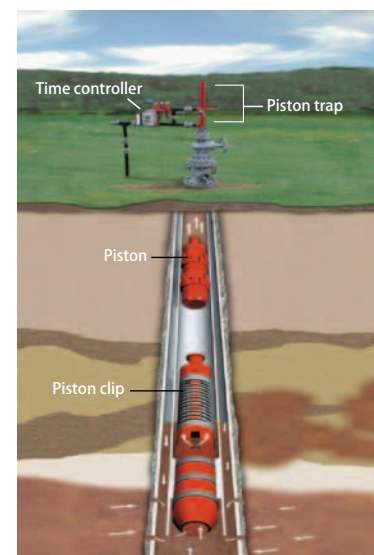
Drainage gas recovery by gas lift is a technology that uses the unloading principle of gas lift production to discharge the water deposited at the bottom of a gas well, thereby reduces bottom-hole flowing pressure in order to resume the normal production of gas wells and increase individual well output. In

China's Sichuan and Chongqing regions, gas-lift drainage is an important production measure and significantly improves the recovery of those fields with water-bearing gas reservoirs.

Wireline operation is a technology in which a wireline truck is used to run down the wireline-operation tools through the oil tubing for downhole operations, including downhole testing, running and pulling of downhole gas lift valves and plunger-lift tools, turning on or off of the downhole control sliding sleeve, downhole fishing, handling and prevention of downhole accidents, and other special operations. It allows output allocation, troubleshooting and production data testing. Its many advantages include straightforward operation, short operation cycles, and no damage to reservoirs. CNPC has now developed 29 tools for the needs of wireline operation in 60.3mm (2 3/8") and 73mm (2 7/8") tubings.

These technologies have been deployed in China's Tuha, Tahe, Yumen, Qinghai, Tarim, Karamay, Changqing, and Jidong oilfields, as well as in CNPC's overseas service markets in Kazakhstan and Sudan. Satisfactory results have been achieved in reservoir development, with the oilfield recovery rate increasing from less than 2% to more than 3%.

The Zhanazhol oilfield in Kazakhstan has been developed for almost 30 years. By applying gas lift technology, CNPC shortened the flowing back cycle and the production cycle, and increased the average daily production per individual well by 18.8 metric tons. Currently gas lifting has been applied to more than 250 oil wells in Zhanazhol oilfield, and daily output of gas lift wells takes more than 67% of the total in the whole field.

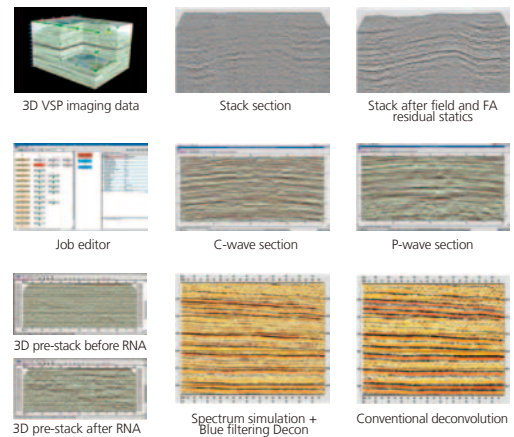


GeoEast — an integrated seismic data processing and interpretation software system

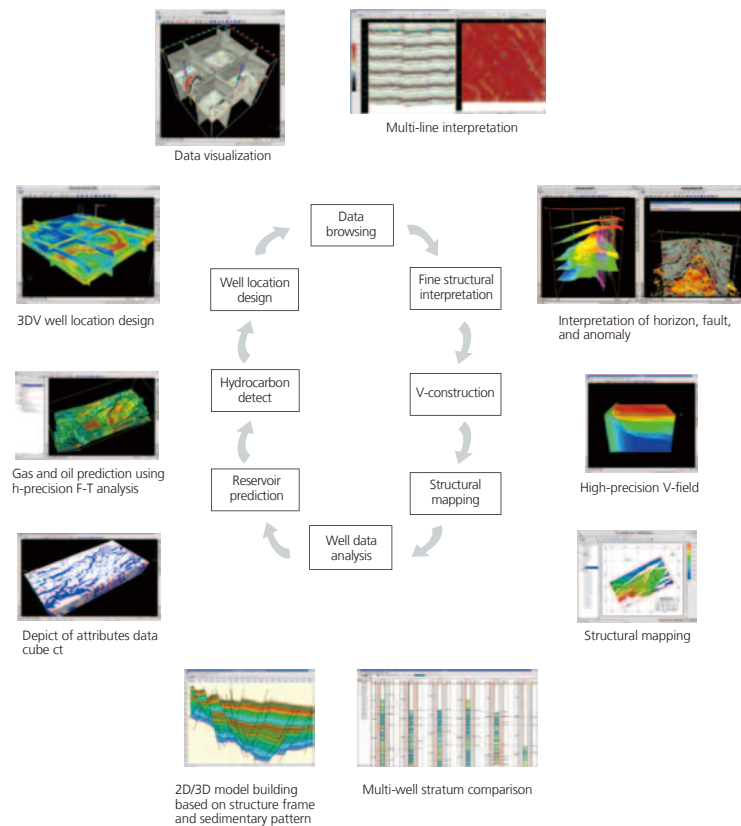
GeoEast provides a unified data platform, a unified display platform and a unified development platform. It supports data sharing, visualized interaction and a collaborative mode for processing and interpretation. With the flexible, modular and scalable architecture, GeoEast can be customized to a workstation or a PC-Cluster version to meet the needs of on-site processing and large processing centers.

- < Land, VSP, OBC, marine streamer, and multi-component data processing
- < Structural interpretation, reservoir prediction, and parameter inversion
- < Integrated processing and interpretation
- < Open development environment

Data Processing Techniques



Data Interpretation Techniques







Innovative | Integrated

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