Near-bit Geosteering Drilling Technology

Science & Technology Management Department

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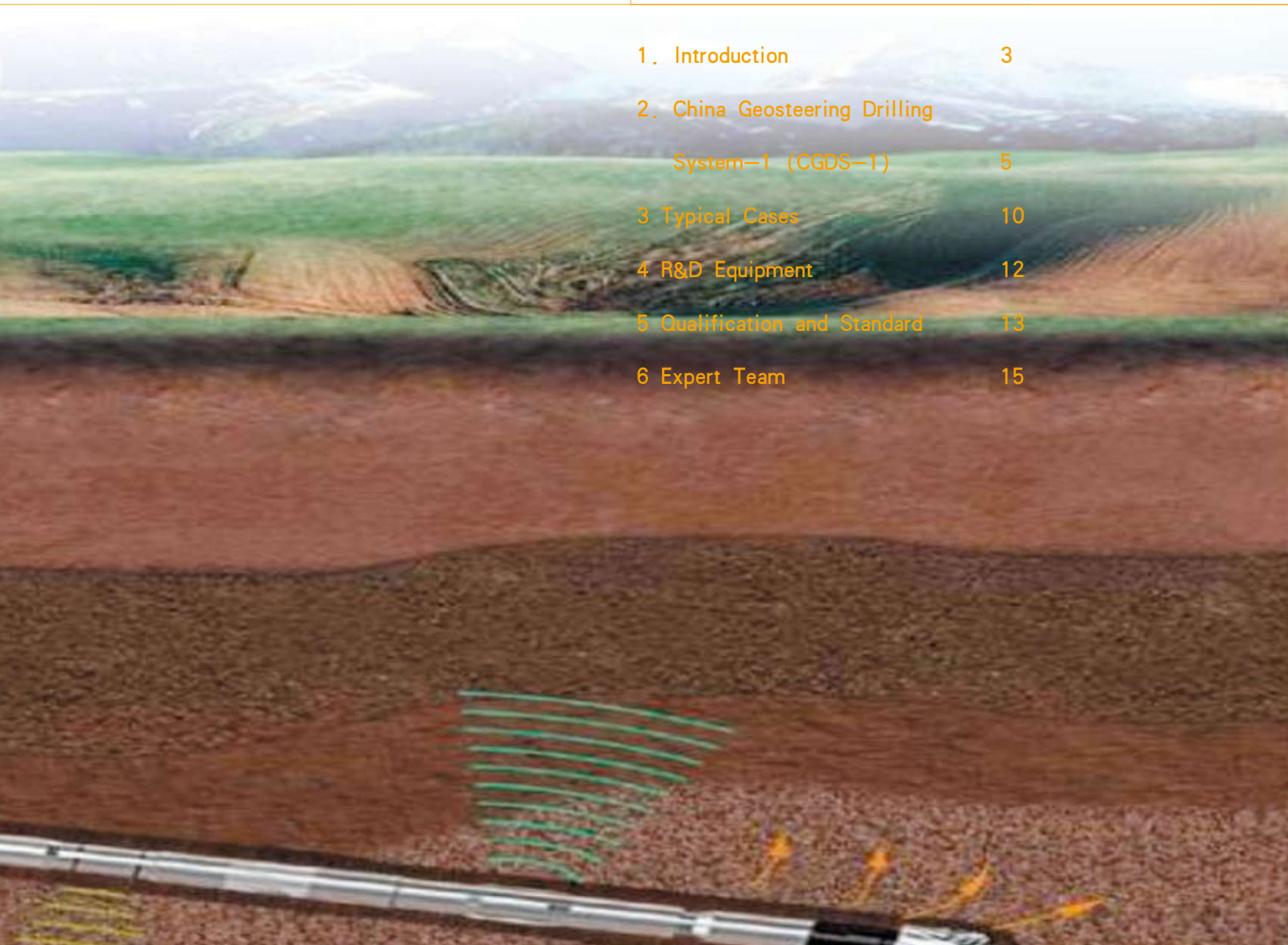
CHINA NATIONAL PETROLEUM CORPORATION

CNPC's Near-bit Geosteering Drilling Technology provides safe and efficient drilling plan for you!

Contents



China National Petroleum Corporation (CNPC) is a state-authorized investment agency and a state holding company. As an integrated oil company of cross-regions, cross-industries and cross-countries, it adopts modern enterprise system to realize the integration of upstream and downstream operations, internal and external trade and production and marketing. CNPC has 17 upstream companies, 33 downstream companies and 36 large-scale marketing companies. It is China's largest producer and supplier of oil and gas, and also one of the largest refined oil products and petrochemicals. In 2010 CNPC produced 105 million tons of crude oil and 72.5 billion cubic meters of natural gas, while crude processing volume reached 135 million tons. The total revenue of RMB1,720 billion with a profit of RMB172.7 billion had been achieved the same year. Its profit is among the highest of the domestic enterprises in China.

CNPC was ranked 10th in Fortune Global 500 in 2010 and 5th among global top 50 oil companies.

CNPC strictly follows by the combined strategies of increasing resource capacity, expanding market shares and consolidating the international role, and persists in regarding technical innovation as a key framework to advance technological progress. To develop its core businesses, focuses will be placed on the solutions of key bottleneck technologies and key proprietary technologies. Thanks to continuously improving of the technical innovation system, optimizing the configuration of technological resources and strengthening the construction of strong talent teams, CNPC's technological creativity has been considerably upgraded. Consequently, a large number of technologies have been developed independently, with its own intellectual property.

The Near-bit Geosteering Drilling Technology is one of representatives for major innovations of CNPC.

1 INTRODUCTION

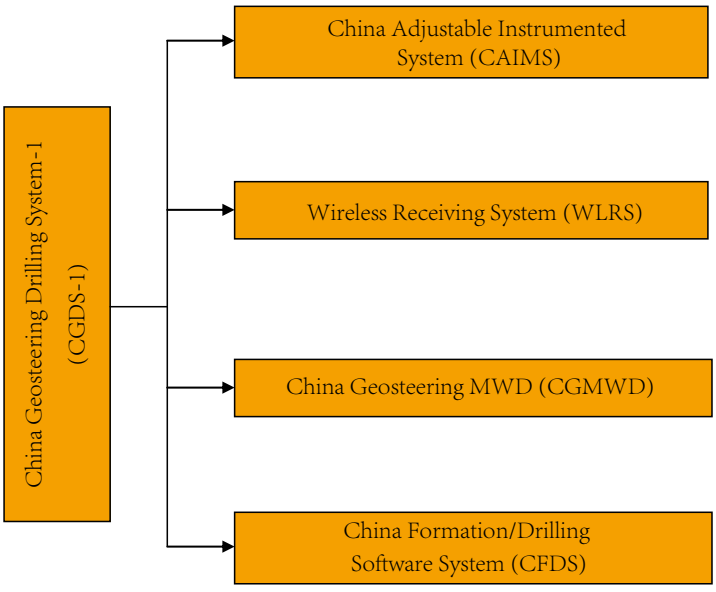
The Near-bit Geosteering Drilling Technology is the new and advanced technology for well drilling in the 21st century commonly acknowledged by the international drilling industry. By integrating machine, electric power, fluidization system, measurement while drilling (MWD), transmission, decision and control of information, the Near-bit Geosteering Drilling System has the functions of "measure, transmission, guiding", i.e. via measuring geologic parameter and engineering parameter of bit, bidirectional information transmission between downhole and ground, and ground control and decision, which steers a bit to discover on time and exactly drill into hydrocarbon reservoir and keeps relatively high probability of penetration in hydrocarbon reservoir. Thereby the discovery rate and output of oil and gas well are increased and the goal of increasing reserves and output of oil and gas is reached. This kind of preponderance is even more obvious in horizontal well for thin beds, wherefore the technology is called "navigation missile" into the ground by industry participants.

China Geosteering Drilling System-1 (CGDS-1) is the drilling equipment whose independent

intellectual property is owned by CNPC. In the course of its development, 12 national patents for invention (6 authorizations have been obtained) and 23 proprietary technologies of CNPC are declared. This system could be used to measure 3 geologic parameters of near-bit, 2 engineering parameters of near-bit and 3 controlled variables for well path. Its angle build-up rate conforms to the requirement of long to middle radius, its signal transmission depth is 5,000m and transfer rate of data is 5bit/s.

On Dec. 28, 2006, CNPC held the promotion conference for China Geosteering Drilling System-1 (CGDS-1). CGDS-1 has been industrialized. Till May 2010 the system has been applied to 28 wells in Jidong, Liaohe, Sichuan, Jianghan oilfields, etc.

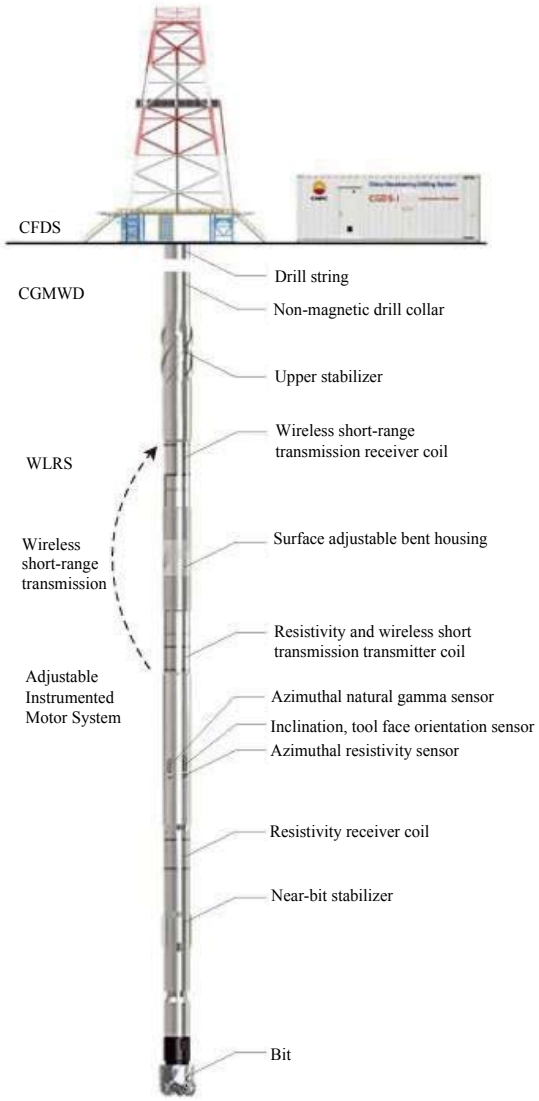
In May 2009, CNPC obtained the "Certificate of National Independent Innovation Product" for China Geosteering Drilling System-1 (CGDS-1), and obtained the second prize of 2009 National Technology Innovation Award for "Near-bit Geosteering Drilling System and Industrial Application".



2 CHINA GEOSTEERING DRILLING SYSTEM-1 (CGDS-1)

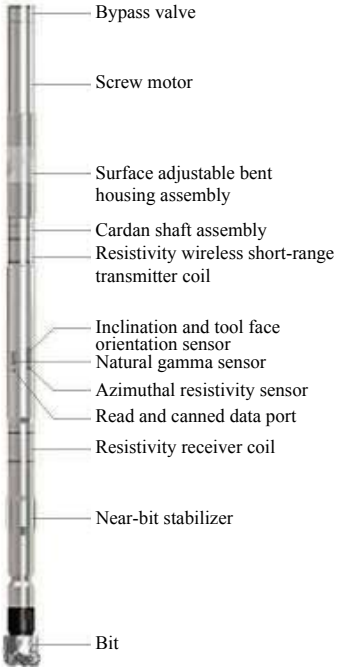
CNPC owns two sizes of Near-bit Geosteering Drilling System: CGDS172 and CGDS203.

China Geosteering Drilling System-1 (CGDS-1) is composed of CAIMS, WLRS, CGMWD and CFDS.



1. China Adjustable Instrumented Motor System (CAIMS)

From top to bottom, CAIMS is composed of bypass valve, screw motor (i=5/6), cardan shaft assembly, near-bit adjustable instrumented pup joint, surface adjustable bent housing and transmission shaft assembly with near-bit stabilizer.



Sketch of CGDS-1 CAIMS

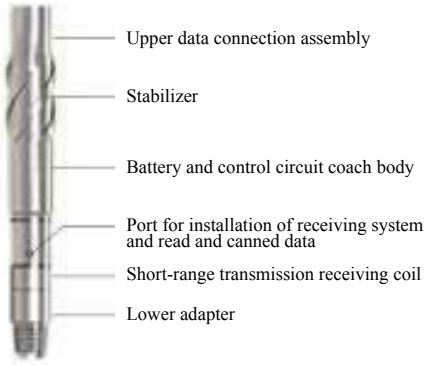
2. Wireless Receiving System (WLRS)

WLRS is mainly composed of upper data connection assembly, stabilizer, battery and control circuit coach body, short-range transmission receiver coil and lower adapter. Its top is connected with CGMWD while its bottom with motor.

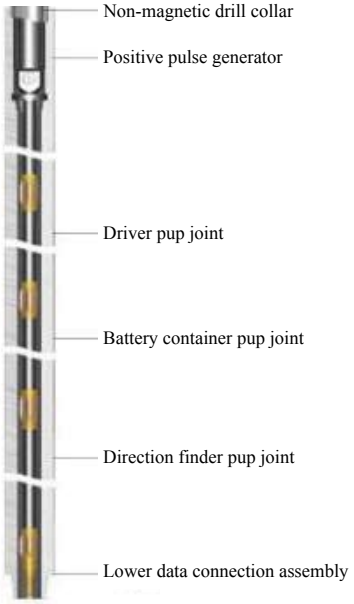
3. China Geosteering MWD (CGMWD)

CGMWD is composed of the hardware system of downhole instrument and corresponding software.

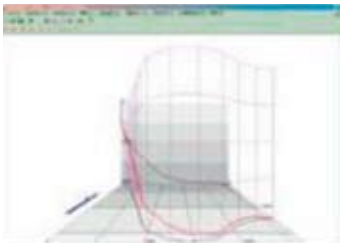
Downhole instrument system is composed of positive pulse generator (transfer rate reaches more than 5 bit/s), driving controller pup joint, battery container pup joint, direction finder pup joint. The software for downhole instrument is composed of Main Control Module, Orientation Module, Driver Module and Battery Module.



Structural Sketch for WKRS



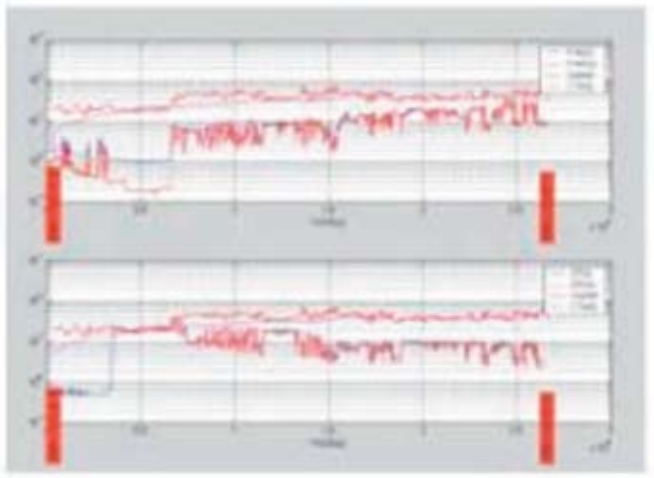
Display Interface of Ground I nstrument Roomand Console



Orbit Design Interface

4. China Formation/Drilling Software System (CFDS)

CFDS is mainly composed of hardware such as Ground Sensor, Front End Receiver and Ground Signal Processing, software such as Data Processing Analysis, Design of Well Drilling Orbit and Steering Decision and modules such as Valuation of Effect, Data Management and Chart Output.



Technical Parameters for China Geosteering Drilling System-1 (CGDS-1)

Main Performance Parameters for CGDS-1

	Index	
	CGDS172	CGDS203
OD	Φ172	Φ203
Maximum OD	Φ190	Φ215
Hole size	Φ216~Φ244	Φ24~Φ311
Whipstocking capability	middle, long radius	middle, long radius
Transmission depth	greater than 4500m	greater than 4500m

	Index	
	CGDS172	CGDS203
Maximum working temperature	125°C	125°C
Type of pulse generator	positive pulse of mud	positive pulse of mud
Upload transfer rate	5 bit/s	5 bit/s
Short-range transmission data rate	200 bit/s	200 bit/s
Stream time	200 h	200 h
Near-bit measuring parameters	Resistivity, azimuthal resistivity, azimuthal gamma, angle of inclination, gravity tool face orientation, temperature of bit	Resistivity, azimuthal resistivity, azimuthal gamma, angle of inclination, gravity tool face orientation, temperature of bit
Maximum pressurization	140MPa	140MPa
Maximum allowance of impulsion	10000 m/s^2(0. 2ms, 1/2sin)	10000 m/s^2(0. 2ms, 1/2sin)
Maximum allowance of vibration	150 m/s^2(10~200Hz)	150 m/s^2(10~200Hz)
Flow rate of motor	19 ~38 L/s	19 ~38 L/s
Pressure drop of motor	3. 2 MPa	3. 2 MPa
Output drilling rate	100 ~200 r/min	90 ~160 r/min
Operation torque	3660 N. m	5000 N. m
Recommended weight on bit	80 kN	120 kN
Output power of motor	38 ~ 76. 6kW	38~77 kW
Distance between near-bit resistivity measuring point and motor subsurface	0. 48 m	0. 48 m
Distance between azimuthal resistivity measuring point and motor subsurface	1. 7 m	1. 7 m
Distance between azimuthal natural gamma measuring point and motor subsurface	1. 88 m	1. 88 m
Distance between near-bit inclination/ gravity tool face measuring point and motor subsurface	2 m	2 m
Length of adjustable instrumented motor	8. 4 m	9. 1 m
Length of wireless receiving pup joint	1. 94 m	1. 94 m
CGMWD length	7. 85 m	7. 85 m
Total length of CGDS-1 downhole instrument	18. 2 m	18. 9 m
Connecting thread	upper end: 4 1/2 IF (4 IF) lower end: 4 1/2REG	upper end: 6 5/8 REG lower end: 6 5/8 REG

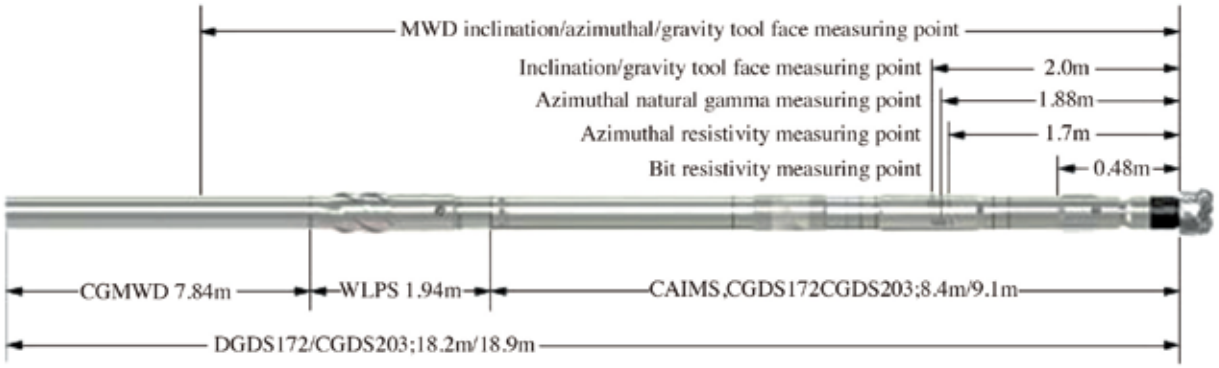
Technical Advantages of China Geosteering Drilling System-1(CGDS-1)

CGDS-1 provides three main functions for measuring, transmission and steering:

(1) Measuring near-bit geologic parameters (bit resistivity, azimuthal resistivity, natural gamma) and near-bit engineering parameters (inclination, tool face orientation), near-bit measurement information is transmitted over steerable motor to WLRS with wireless short-range transmission technology.

(2) Near-bit measurement information is fit into CGMWD by data connection system assembly, the measured downhole information is transmitted to CFDS passing CGMWD as information transfer channel, the measured information is the evidence for steering operation decision.

(3) The downhole steering motor (or combination of turntable drill tool) is taken as the implement tool for steering, the downhole measurement information is processed, interpreted, judged, decided by CFDS, and steering tool is directed exactly drilling into oil and gas target stratum or drilling ahead in oil zone.



Main Construction Parameters for China Geosteering Drilling System-1 (CGDS-1)

3 Typical Cases

In Dec. 2006, China Geosteering Drilling System-1 (CGDS-1) was used in Well Qi 604-Well Lian H2Z in Liaohe Oilfield. Well Qi 604-Well Lian H2Z are located in the block which is marginal oil sheet, its reservoir thickness is 2-3m, control degree of the oil layer is low, and attitude of the oil layer is changed badly. The working time of the instrument downhole was 30h. The results show that the data of MWD satisfy the operation requirement. After examination and verification of the geological engineers on site, it was considered that the MWD data curve basically reflected actual conditions of the oil layer. The application of CGDS-1 in the wells hugely increases predication accuracy of strata being waited to drill for engineering and geological technicians and enhances probability of penetration for oil layers further.

At the end of Jan. 2007, in Jidong Oilfield, field operation service in 3 horizontal wells were successfully finished, including Well LB-P8, Well L90¬P2 and Well L23-P8, with the accumulative footage of 2994. 5m and the accumulative working time of 860.5h. The results of field operation indicated that CGDS-1 meets the operation requirement of engineering, measurement parameters are exact and stable, and enhances probability of penetration for oil layers.

In Nov. 2008, the system was used in Well Huan 127-Well Lian H205 in Liaohe Oilfield.

(1) The geological and engineering parameters of MWD data are stable, upload transmission of data and

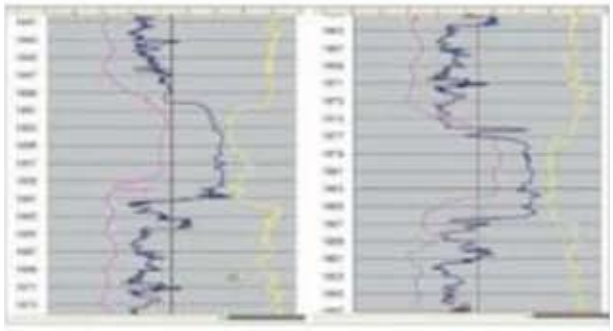
Test for downhole instrument of CGDS-1 is conducted after tripping out

CGDS-1 is tripped out of wellhead

System test is conducted before operation

ground decodification are fast and exact. For CFDS, its interface is good and operation is convenient; operating life of motor is long, gauging nipple and motor of CAIMS are relatively independent and it is easy to maintain on site. CGDS-1 works steadily and bears relatively high dependability, which can satisfy the requirement for industrial application.

(2) The MWD result of geological parameters, such as near-bit azimuth resistivity, bit resistivity and azimuthal natural gamma, reflects the variation trend of reservoir that is verified by actual drilling



results. Compared with the present domestically used imported products, the CGDS-1 has obvious advantage of near-bit measurement and the important direction to enhance probability of penetration for oil and gas, pinpoint landing, etc.

In Feb. 2010, this technology was applied in Well Haoping 2 of Jianghan Oilfield. Well Haoping 2 is located in Haokou Block in Jianghan Oilfield, the block belongs to Haokou structural nose in Qianjiang Sag, and it has thin oil layer and complex geological structure belonging to ultrathin oil layer (minimum reservoir thickness is 0.66m), so it is difficult to operate. Since the measurement point of CGDS can reflect the variation of formation lithology ontime, it makes Party A of the project cognize the formation more timely and distinctly, provides timely and exact stratigraphic information to geological staffs as well as timely visual evidence for decision of further engineering implementation, and enhances probability of penetration for drilling.

4 R&D Equipment

For CGDS-1, its scientific research and development environment is at high side, equipment condition is advanced, and in 2008, National Drilling Engineering Laboratory was established in CNPC.

Team of Scientific Research and Development

National Engineering Laboratory of Oil and Gas Drilling Technology

Test System of Electric Vibration for Triaxial Synchronous Vibration

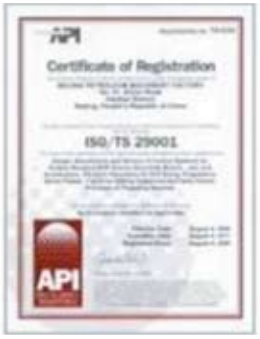
Removal and Mounting Machine for Downhole Instrument and Tools of MWD

Tempering Test Cabinet for Nonmetal Full-size Drill Collar

5 Qualification and Standard

1.Qualification

In 2000, CNPC has passed ISO9001 quality system certification, and has obtained the certification document of ISO9001 quality management system certification persistently, has the qualification to undertake technical service provided by technology research of oil and gas well drilling engineering and products.



2. Standard

In the advanced development process of Near-bit Geosteering Drilling Technology, many API well drilling standards were cited, and a series of enterprise standards and industry standards were researched and established independently.

3. Patent

CNPC owns 26 patents for China Geosteering Drilling System-1 (CGDS-1), including 12 patents for invention.

4. Certificate of National Independent Innovation Product

6 Expert Team

Su Yinao

(Professor, Member of China Engineering Academy, Director of State Engineering Laboratory of Oil and Gas Drilling)

He has long been engaged in technical research and application of drilling engineering, his multiple items of innovation efforts in research of drilling mechanics, path control and downhole tools occupy international advanced stage. He has proposed the frontier of "Downhole Control Engineering" and presides to tackle key problem of associative leading edge technology. He has obtained 1 second prize of China Technology Innovation Award, 1 first prize and 2 second prize of National Science and Technology Progress Award, and 18 national patents for invention. He has published 7 monographs and more than 150 research papers.

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