



DRMTS CBM Remote Intersection Technology

Science & Technology Management Department, CNPC

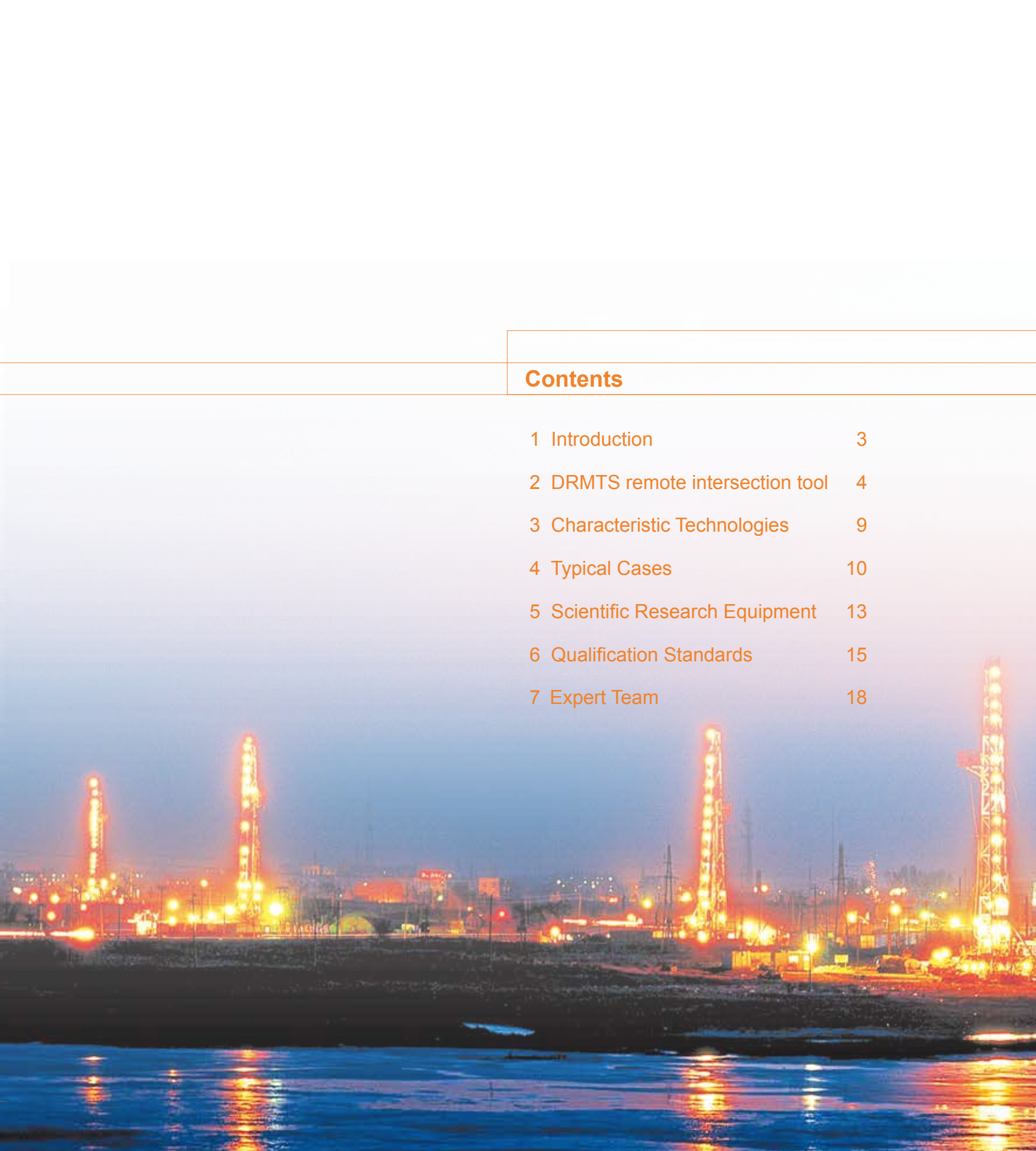
2015



CHINA NATIONAL PETROLEUM CORPORATION

*DRMTS : “Magical Threading Needle” Causes
Coal Beds to Have Unlimited Potential!*





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China National Petroleum Corporation (CNPC) is a state-authorized investment agency and a state holding company. On July 1998, with the implementation of the Institutional reform of the State Council, CNPC was reorganized to become an integrated oil company of cross-regions, cross-industries and cross-countries, it adopts modern enterprise system to realize the integrations of upstream and downstream operations, internal and external trade, production and marketing. CNPC's business covers six main sectors: oil and gas operations, petroleum engineering service, petroleum engineering construction, petroleum equipment manufacturing, financial services and new energy development. In 2014 CNPC produced 113.67 million tons of crude oil and 95.46 billion cubic meters of natural gas, while crude processing volume reached 150.2 million tons. The total revenue of RMB 2,730 billion with a profit of RMB173.4 billion had been achieved the same year.

CNPC was ranked 3th among the world's largest 50 oil companies and 4th in Fortune Global 500 in 2014.

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.

DRMTS CBM Remote Intersection Technology is one of representatives for major innovations of CNPC.

OFFERING ENERGY SOURCES, CREATING HARMONY

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INTRODUCTION

Coalbed methane (CBM) is associated with coal and commonly known as “gas”. CBM belongs to unconventional natural gas and its main component is methane. As a high-efficiency clean energy source, CBM contains enormous economic benefits, but coal reservoirs have low pressure, low permeability and low water content in general, thus seriously restricting high-efficiency development of CBM. The remote intersection technology in horizontal well development modes represents the most effective key core technology for low permeability CBM development.

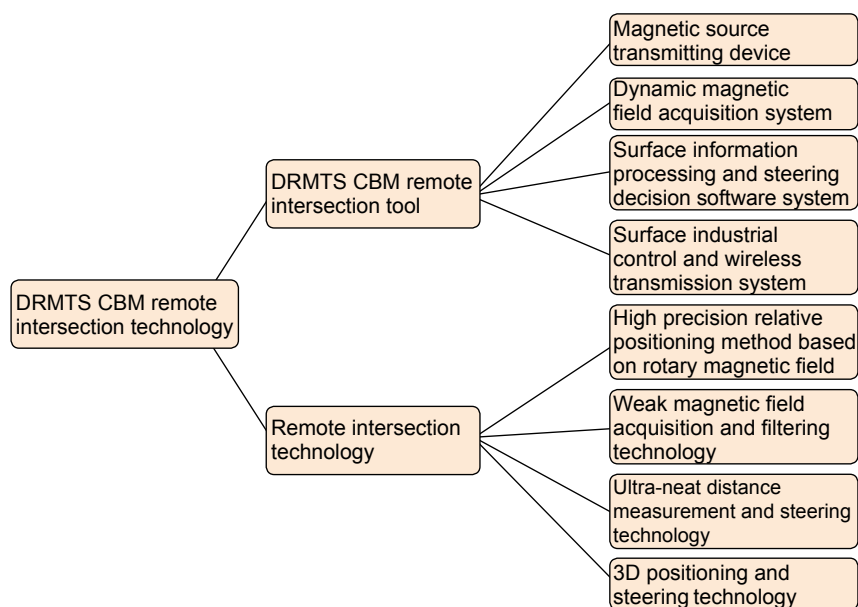
DRMTS CBM remote intersection technology integrates near-bit adjacent well position measurement, transmission, magnetic steering decision and control while drilling and has functions including “measurement, transmission and steering”.

CBM horizontal wells are led to directly connect vertical drainage production wells through the measurement of the relative angle and distance between the bit and the target bottom hole, two-way downhole and surface information transmission and surface control decision, thereby building drainage production channels for horizontal wells.

DRMTS CBM remote intersection tool is CNPC's drilling equipment with independent intellectual property rights and has 4 invention patents and 2 utility model patents, and with the tool, 1 enterprise standard has

been formulated. The effective measurement distance of the tool reaches 80m and its magnetic signal resolution is 0.1nT. The tool can realize near-distance measurement of around 1m and perform 3D steering connection. The tool has “point-to-point” precise steering capacity and can complete the operation of directly connecting vertical well fiberglass casing.

DRMTS CBM remote intersection tool has been used to complete field intersection technical services of nearly 30 wells-times in blocks including Zhengzhuang and Shizhuang in Shanxi, Binxian and Liulin in Shaanxi, etc., with the success ratio of 100%. In addition, with the tool, “point-to-point” precise connection operation has been successfully performed.



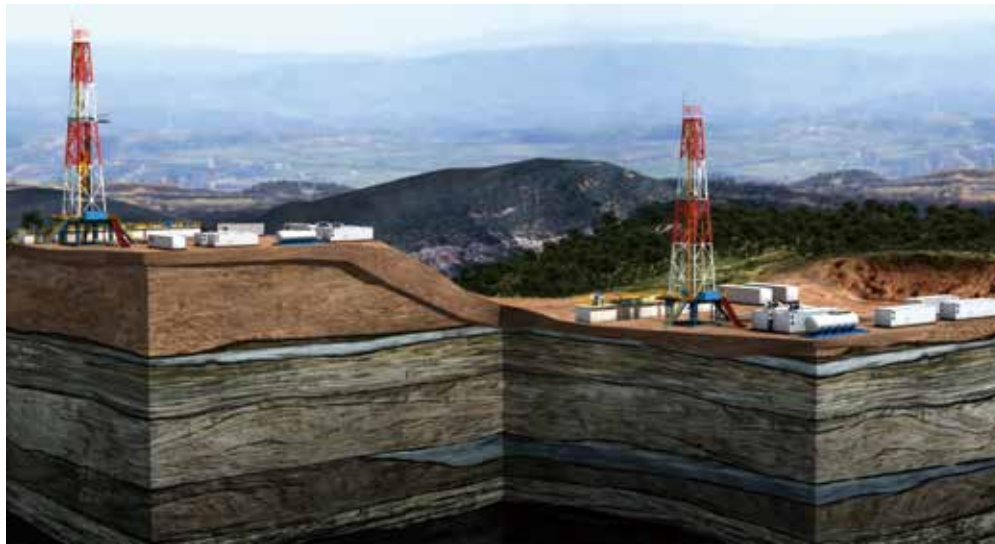
DRMTS CBM remote intersection technology technology frame work

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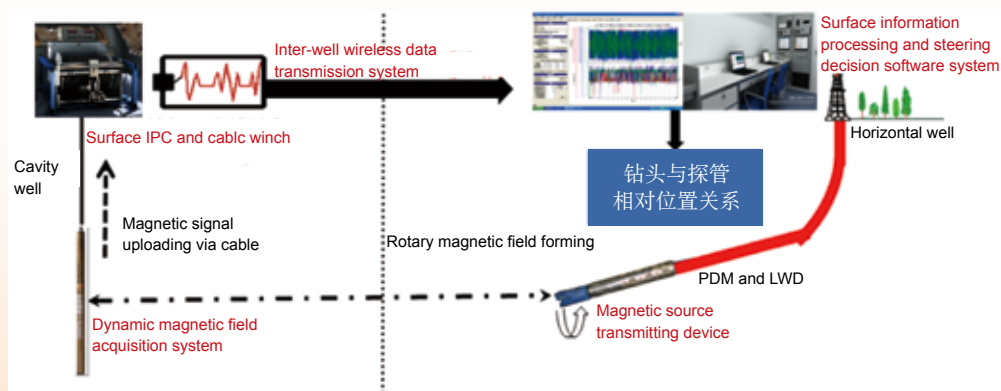
DRMTS REMOTE INTERSECTION TOOL

DRMTS CBM remote intersection tool consists of magnetic source transmitting device, dynamic magnetic field acquisition system, surface information

processing and steering decision software system and surface industrial control and wireless transmission system.



Layout of CBM horizontal well drilling site

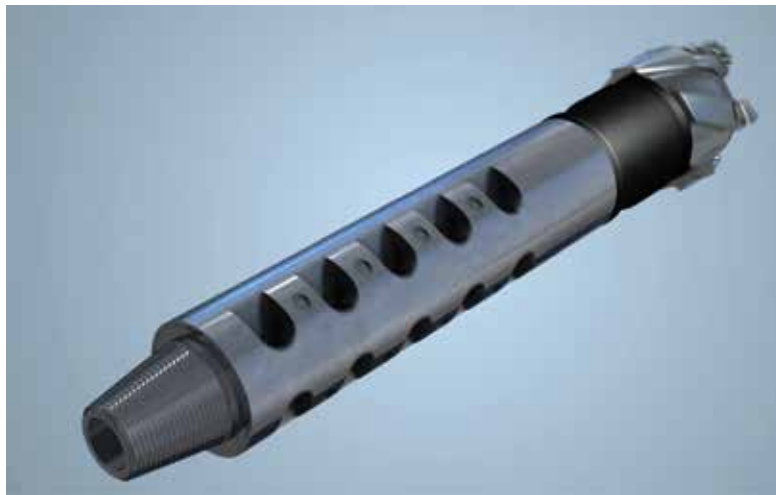


Tool System Structure Diagram

2.1 Magnetic source transmitting device

The magnetic source transmitting device is

installed behind the bit to transmit rotary magnetic field signals and has three OD series such as $6\frac{1}{2}$ in, $4\frac{3}{4}$ in and $3\frac{1}{2}$ in.



Magnetic source transmitting device

2.2 Dynamic magnetic field acquisition system

The dynamic magnetic field acquisition system

can measure the parameters including probe attitude, magnetic signal, etc. in real time by lowering cable to the bottom hole of a vertical cavity well. The magnetic field measurement resolution of the system is 0.1nT.

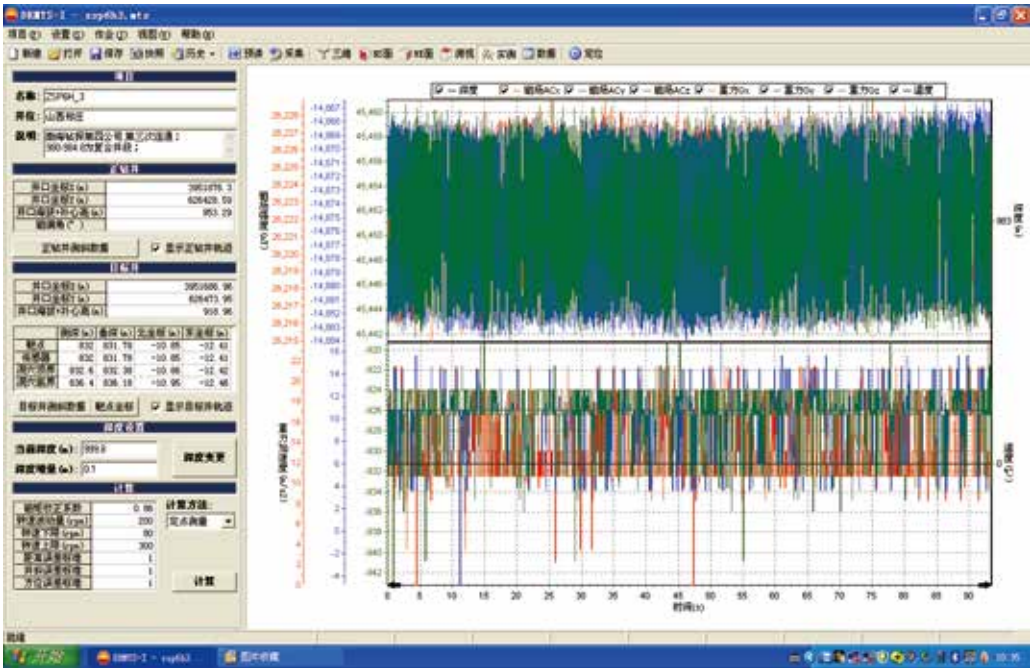


Dynamic magnetic field acquisition system

2.3 Surface information processing
and steering decision software system

The system includes rotary magnetic field model,
distance and angle measurement model, weak

magnetic field filtering method, compensated angle
interference correction method, etc. The system
has the capacity of rotary magnetic field positioning
calculation and acquisition data analysis and can
realize real time 3D display of well trajectory.



Remote intersection drilling engineering software interface

2.4 Surface industrial control and wireless transmission system

The surface industrial control and wireless transmission system includes surface IPC, cable winch and inter-well wireless data transmission system.

The surface IPC and cable winch are used to

control and lower the acquisition system and measure lowering depth, and the largest lowering depth is 1500m.

The inter-well wireless data transmission system consists of data transmitting device and data receiving device and is used in transmission between signal acquisition system and signal processing system, and the effective transmission distance is larger than 3km.



Surface IPC and cable winch



Inter-well wireless data transmission system

2.5 Tool specifications

- Magnetic field measurement resolution: 0.1nT;
- Applicable temperature: -25~+85℃ ;
- Effective measurement distance: 0.7~1m;
- Distance measurement error less than 5%;
- Can realize near-distance (1~5m) measurement function; signal are not saturated and distorted;
- Tool series: 6¹/₂in, 4³/₄in, 3¹/₂in.

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CHARACTERISTIC TECHNOLOGIES

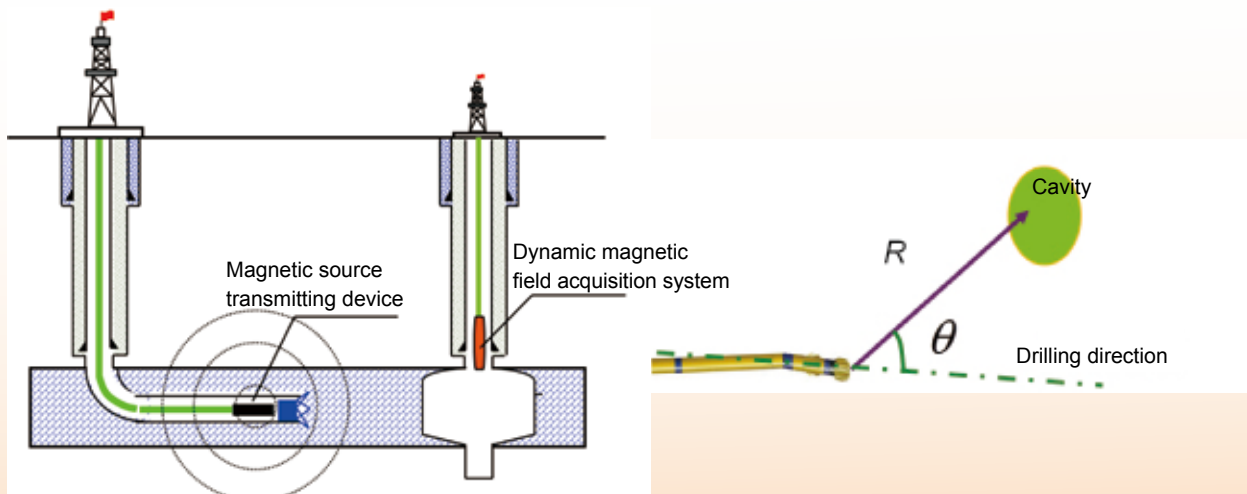
As a high-efficiency development mode, horizontal well is widely applied in the development of low permeability CBM. The remote intersection technology is a key technology in horizontal well construction.

With the remote intersection technology, CBM horizontal wells are led to directly connect vertical drainage production wells through the measurement of the relative angle and distance between the bit and the target bottom hole, two-way downhole and surface information transmission and surface control decision, thereby building drainage production channels for horizontal wells. The remote intersection technology includes high precision relative positioning method based on rotary magnetic field, weak magnetic field (0.1nT) acquisition and filtering technology, ultra-near distance measurement and steering technology and 3D positioning and steering technology.

The operation process: the magnetic transmitting

device is run in a horizontal well, and the measuring probe is run in a vertical cavity well; the relative position relation (relative distance R and deflection angle θ) between the bit and the cavity is measured using the intersection tool in real time; then an accurate target spot is provided for directional drilling; finally the bit is led to connect the vertical drainage production well at bottom hole.

The remote intersection technology has two major outstanding advantages: (1) it has static distance measurement capacity and “point-to-point” precise steering capacity and can complete the operation of directly connecting vertical well fiberglass casing; (2) it has the capacity of inclination deviation measurement and can perform 3D steering connection, thus greatly improving operation maneuverability and success ratio.



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TYPICAL CASES

CNPC launched DRMTS remote intersection tool in Dec. 2011. Successful development of the tool was successively reported by three-dimensional media such as CCTV, QQlive, etc. and printed media such as the Xinhua News Agency, the People's Daily, Guang Ming Daily, Economic Daily, etc., thereby generating great social influence.

In 2010-2014, DRMTS has been used to complete

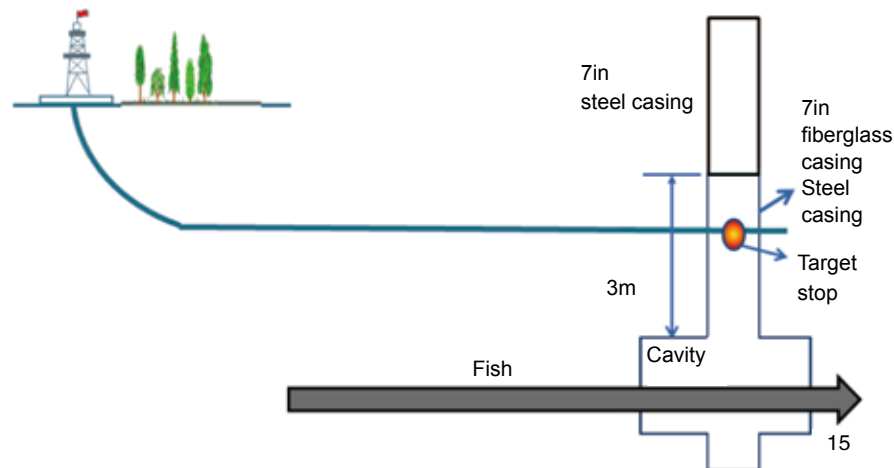
field intersection technical services of nearly 30 wells-times and has experienced crucial tests under various complex conditions in blocks including Zhengzhuang and Shizhuang in Shanxi, Binxian and Liulin in Shaanxi, etc., with the connection success ratio of 100%. In addition, with the tool, "point-to-point" precise connection operation has been successfully performed.



4.1 Accurate realization of “point-to-point” connection and successful hitting of fiberglass casing

DRMTS remote intersection tool was used to complete “point-to-point” precise connection of well ZSP6H with well ZSP6V, and magnetic positioning operation was performed in the interval 51.76~1.5m from the cavity. After RIH, magnetic field signals

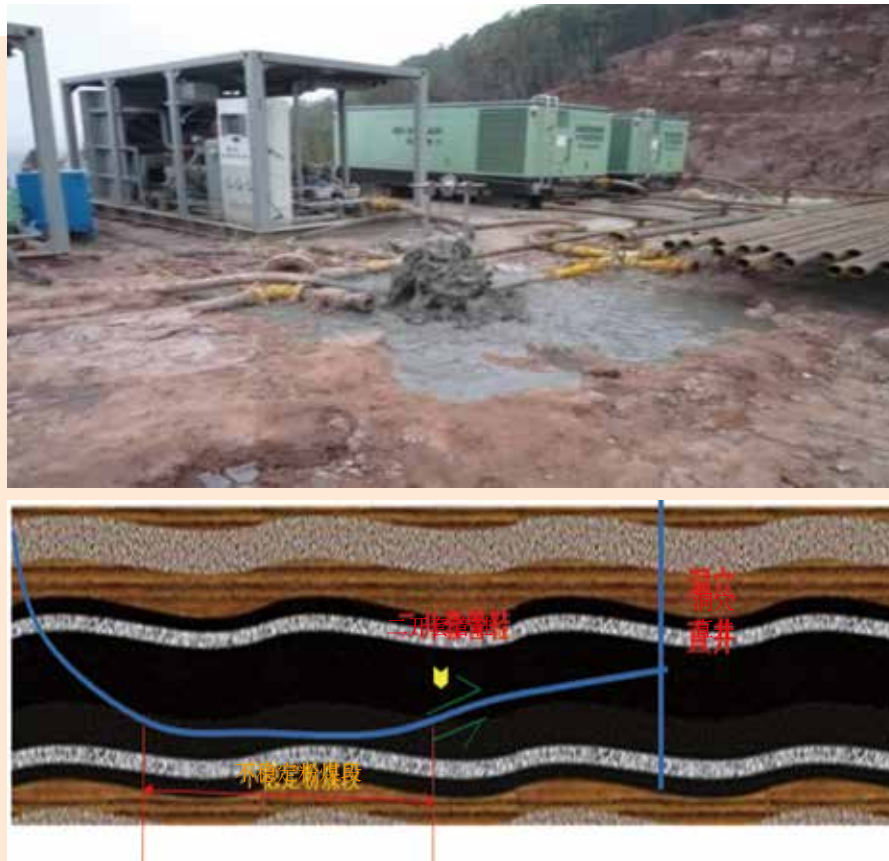
were acquired and steering was started; at this time the measured azimuth deviation was 9.2° . In case of being 1.5m from the vertical well, the azimuth deviation was adjusted to be -1.7° , the distance to the target center was 4.5cm, and the preset 7in fiberglass casing at 1.4m from the coal bed top was successfully hit. This has created the precedent of “point-to-point” accurate connection of two wells without cavity building in advance.



4.2 Creating the composite connection mode “pre-connection in the second spudding + connection in the third spudding”

Well ZP4-10 is located in Zhengzhuang block, Qinshui basin, Shanxi Province. During drilling operations, coal beds were drilled at 70° inclination and the well trajectory would penetrate through the fine coal in the bottom of 3# coal bed; therefore, it was decided that the composite connection mode

“pre-connection in the second spudding + connection in the third spudding” was used to carry out steering drilling. DRMTS intersection tool began precise positioning and steering of 81/2in hole at 80m from the cavity and led it to 22m from the cavity, with the azimuth deviation of 0.6°. 43/4in magnetic source transmitting device was used in the third spudding to carry out magnetic steering, and the steering operation was ended at 1.5m from the cavity, with the azimuth deviation of 2.1°. After continuing drilling by 1.4m, the two wells were connected.

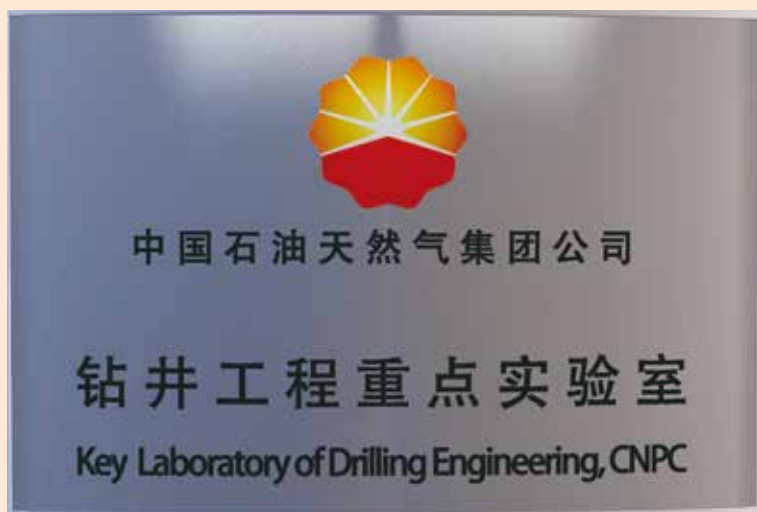


Construction hole connection trajectory

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SCIENTIFIC RESEARCH EQUIPMENT

Rely on the National Engineering Laboratory for oil and gas drilling technology and CNPC Key Laboratory of Drilling Engineering and have matching advanced equipment.





SEM-SERNO fatigue testing machine



DR-7-002 microcomputer-controlled
electrohydraulic servo pressure tester



DR-7-006 + reaction kettle

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QUALIFICATION STANDARDS

Qualification

DRMTS intersection tool has multiple qualifications, has passed ISO9001 quality system certification and

API Q1 certificate and is qualified in oil and natural gas drilling engineering research, product provision and technical services.



Standards

DRMTS carries out API drilling standards, and 1 enterprise standard has been formulated and issued.



Patents

DRMTS has proprietary intellectual property rights and 6 patents, including 4 invention patents and 2 utility model patents.

No.	Patent name	Patent No./ application No.	Patent type
1	A positioning method for determining the relative position between downhole bit and target spot in a CBM horizontal well	201010585308.9	Invention patent
2	Surface test method and test device for remote intersection tool	201110446707.1	Invention patent
3	A fluxgate sensor signal processing circuit	201210165746.9	Invention patent
4	A filtering method and device in horizontal well rotary magnetic field positioning	201210159636.1	Invention patent
5	A rotary magnetic source sub for CBM horizontal well intersection	201020672954.4	Utility model patent
6	Surface test carriage for remote intersection tool	201120557141.5	Utility model patent



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EXPERT TEAM



Su Yinao

Academician of the Chinese Engineering Academy, Oil and gas drilling engineering expert, Ph.D. candidate supervisor. He has been long engaged in the study and application of drilling engineering technology. He has proposed the new field “downhole control engineering” and taken charge of the research on frontier technologies involving geosteering etc. His science and technology achievements were awarded with 2 grade I national science and technology advance prizes, 1 grade II national science and technology advance prize, 6 provincial and ministerial prizes and 18 national patents. As the consulting expert of DRMTS tool, he was responsible for overall scheme consultancy and technical guidance.

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Zou Laifang

Professor level senior engineer, senior technical expert. He has been long engaged in R&D, popularization and application of drilling engineering technologies and tools. As the main R&D and organization person, he has participated in national 863, 973, “eleventh five-year plan”, “twelfth five-year plan” key special projects. His research achievements were awarded with multiple provincial and ministerial prizes. As the consulting expert of DRMTS tool, he was responsible for overall technical consultancy, customization, popularization and application.

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Shen Ruichen

Professor level senior engineer, senior technical expert, Ph.D. candidate supervisor. He has been long engaged in the development of CBM drilling and completion equipment and engineering research. He has participated in over 40 national, CNPC’s and PetroChina’s subjects. His research achievements were awarded with over 10 provincial and ministerial prizes and 15 patents. As the person in charge of DRMTS tool subject, he was responsible for overall technical scheme formulation, R&D progress and integral coordination.

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Tian Zhonglan Professor level senior engineer, senior technical expert, ost doctorate. He has been long engaged in the study and application of CBM drilling and completion technologies. His research achievements were awarded with 7 provincial and ministerial prizes and 18 patents. He was responsible for carrying out the overall scheme and ascertaining all research work and personnel in the development process of DRMTS tool.

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Qiao Lei Senior engineer, doctor. He has been long engaged in the R&D and field application of CBM drilling and completion tools. His research achievements were awarded with 3 provincial and ministerial prizes. Over 10 papers written by him have been published. He was responsible for completing tool mechanism model, software development, indoor and field test, etc. in the development process of DRMTS tool.

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He Aiguo Senior engineer. He has been long engaged in the study and field application of CBM drilling and completion. His research achievements were awarded with 3 provincial and ministerial prizes and 10 patents. He was responsible for completing equipment hardware development, field tester upgrading and reconstruction, etc. in the development process of DRMTS tool.

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