

Integrated Technology of Well-logging Acquisition-Processing-Interpretation

Science & Technology Management Department

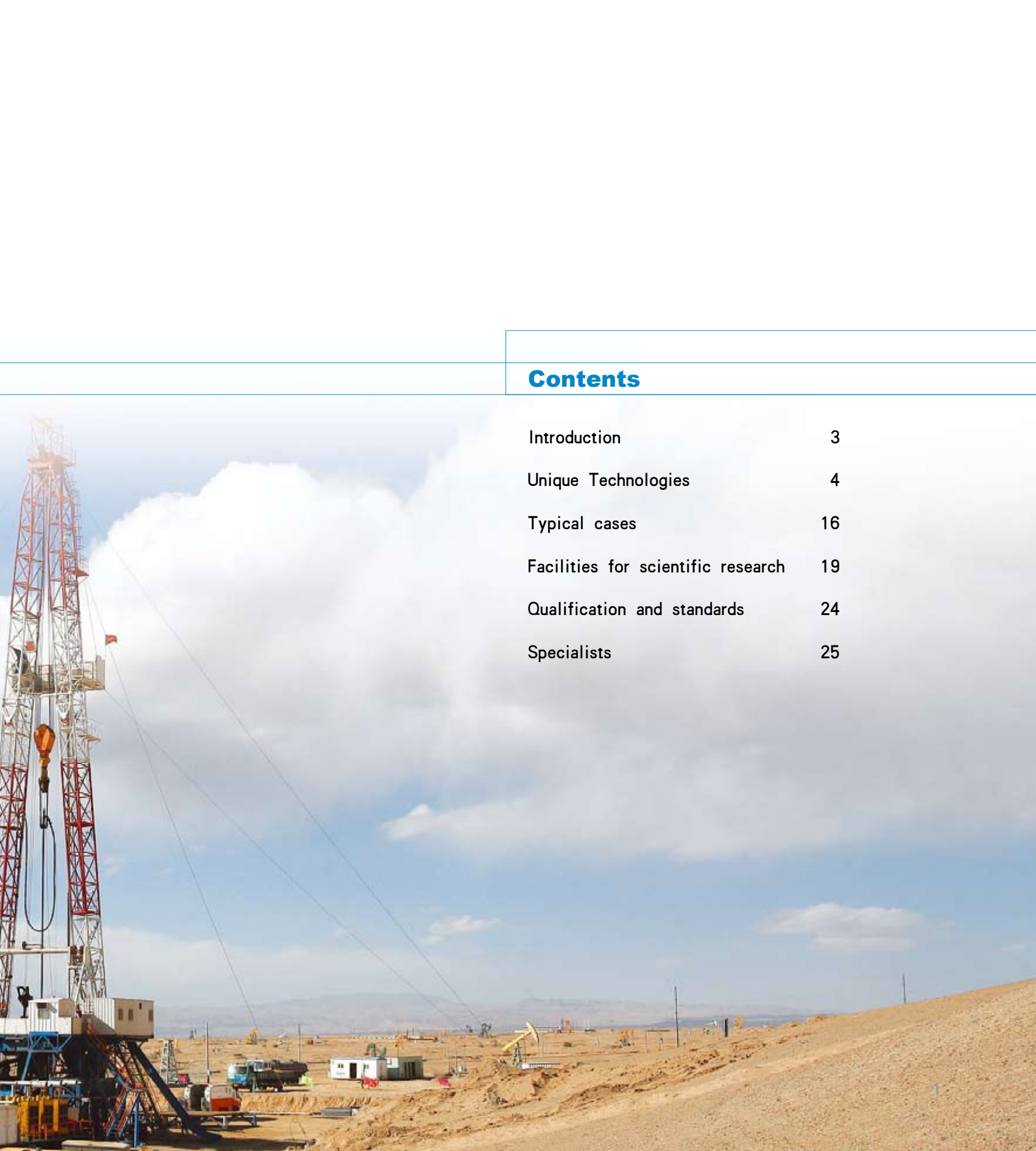
2011



CHINA NATIONAL PETROLEUM CORPORATION

*CNPC provides you with advanced logging
equipment and quality services!*





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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 of 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 RMB 1, 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 10rd 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 Integrated Solution of Well Logging Data Acquisition, Processing and Interpretation is one of the representative for major innovations of CNPC.

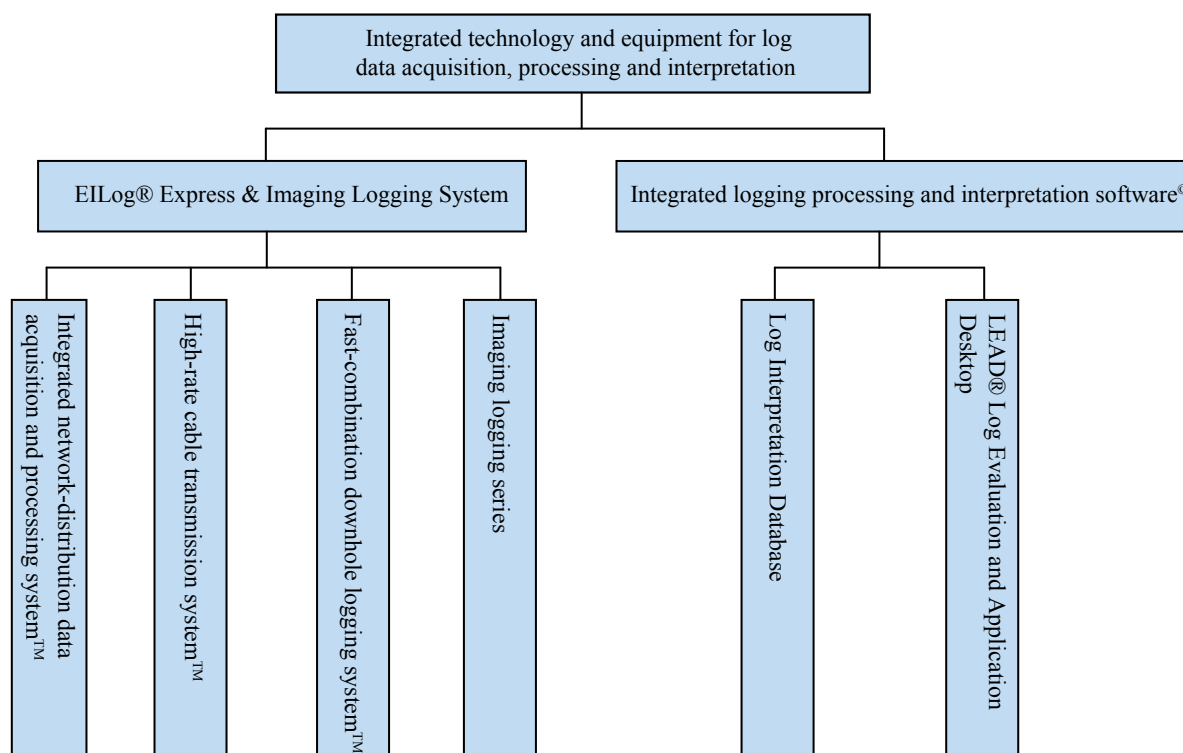


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INTRODUCTION

CNPC is dedicated to the research, development and services of the integrated technology for acquisition, processing and interpretation of well log data, and it possesses a large number of excellent professional talents, complete equipment and technologies, specialized research institutions and service teams, providing series of technical supports and services for well logging, perforating, mud logging, etc.

The Integrated Solution of Well Logging Data Acquisition, Processing and Interpretation includes two unique series of technologies: EILog® Express & Imaging Logging System and LEAD® Log Evaluation & Application Desktop and Interpretation Software.



2 UNIQUE TECHNOLOGIES

EILog[®] Express & Imaging Logging System

EILog[®] Express & Imaging Logging System can render a full line of wireline logging services, including logging in openhole and cased-hole, perforating and coring operations. It possesses capabilities of processing complete conventional logging parameters once only, as well as varied imaging logging operations. The system consists of four matching technologies, including integrated data acquisition and processing, high-rate cable transmission, fast-combination downhole logging and serialized imaging logging.

EILog[®] Express & Imaging Logging System is regarded as an integration, combined of computer technology, microelectronic technology, information technology and new material technology, helps the client to obtain accurate, complete and high-quality raw data and such interpretation results of high resolution open-hole logging, cased-hole log and engineering log.

The system can solve the difficulties in formation evaluation, such as the hydrocarbon reservoirs in low porosity and low-permeability, low resistivity, complex lithology, etc.



EILog[®] Express & Imaging Logging System

Integrated network-distribution data acquisition and processing system™

The system enable the client to enjoy such instant services as network share of well logging information, real-time logging, real-time quality monitoring and log data management, and help the client to present integrated data acquisition and processing schemes in borehole/cased-hole logs and perforating/coring operations.

It is composed of four patented technologies (bus-oriented base plate of cPCI acquisition module, etc.) and a set of computer software—ACME well log data acquisition management platform.

- Features

- ① Network-distribution system architecture with the remote transmission and control capability.
- ② VxWorks real-time multi-tasking operating system is used in front-end acquisition.
- ③ The cPCI bus with the acquisition module shows good performance and high reliability.
- ④ Software decryption for multiple coding signals is achieved by widely applying FPGA and DSP techniques.
- ⑤ Object-oriented software design aids in realizing the dynamic addition.
- ⑥ Logging combinations of multiple views and multiple templates present plot output functions.
- ⑦ The physical construction design with a desktop workbench makes the operating space more human-friendly.



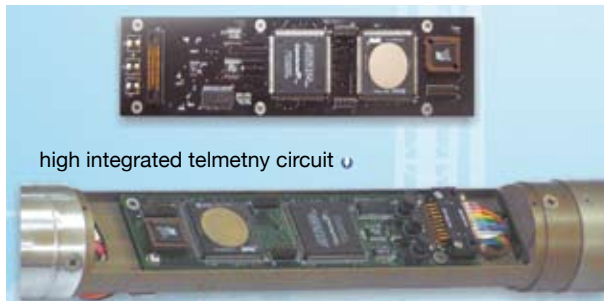
High-rate Cable Transmission System™

The High-rate Cable Transmission System™ provides a link between the downhole and the surface by using half duplex operation mode, execute downhole data upload and surface command download, with its transmission rate and code error rate directly determining the quality of the system and logging as well as the magnitude of matching tools. It used to help the client implement data transmission at 2 rates of 100kbps and 430kbps in the conventional/imaging logging.

High-rate Cable Transmission System™ incorporates 7 patented technologies such as continuous inclinometer data acquisition unit based on NIOS soft-core CPU, etc.

• Features

- ① COFDM technique for modulation, QAM coding for subchannel, obviously improving frequency spectrum utilization ratio and increasing interference-resistant ability.
- ② Enhanced TCM coding error correction and error resend mechanism and increased system reliability.
- ③ A self-adapting equalization technique is used for the cables with different frequency characteristics.
- ④ CAN bus is used in hole, and its protocol is simple and clear and its tool interface is convenient and flexible.
- ⑤ NIOS technique is used in FPGA to fulfill CAN bus functions and to enhance the downhole circuit integration level.
- ⑥ An integrated PCI interface in the FPGA chip is used at surface to enhance the surface acquisition circuit integration level.



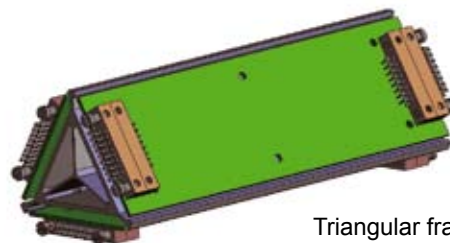
Fast-combination Downhole Logging System™

The system has achieved the integrated fast-combination logging, which mainly consists of GR, GR spectroscopy log, SP, compensated neutron log, compensated/litho-density log, compensated/digital acoustic log, high-resolution dual lateral log, dual induction and 8 lateral log, micro-spherically focused resistivity log, caliper, deviation, azimuth, hole temperature, mud resistivity, pressure, casing collar log, acoustic/digital acoustic variable density log, microelectrode and electrode system (0.4m, 2.5m and 4.0m). 18 conventional logging curves, including three -resistivity curves of deep, medium and shallow resistivities, and three porosity of density, neutron and acoustic, as well as GR, SP, caliper, hole temperature, deviation, etc. in a single trip.

The fast-combination Downhole Logging System™ involves 31 patented technologies such as sonde for HTHP-resistant micro-spherically focused and density combination log, etc.

• Features

- ① Strong combination logging capability and high logging efficiency. All conventional well log data are desired in a single trip and the logging operation time efficiency is increased on average by over 30%.
- ② Higher integration level and better system stability. The circuit thick-film integration, detector reuse, measuring circuit share, highly reliable electromechanical assembly, etc. are utilized so as to shorten the tool length, enhance the integration level and reliability of the system, and improve the repeatability and consistency of logging curves.
- ③ Complete tool categories and excellent performance. The matching logging tools such as digital acoustic log and high-resolution dual lateral log, etc.



Triangular frame



Density and micro-spherically focused detector reuse

2. Microresistivity Circumferential Imaging Logging (MCI) System™

The Microresistivity Circumferential Imaging Logging (MCI) System™ provides the client high-resolution formation resistivity images that surrounding the borehole, and is designed to make fracture identification, thin-bed evaluation, lithological demarcation, formation anisotropy evaluation and analysis of sedimentary facies and structure. It is an important method to carry out the reservoir logging evaluation and analysis of geologic characteristics in the complex anisotropic reservoirs.

The system contains the patented pads for HTHP micro-resistivity scanning imaging logging tools.

• Features

- ① High reliability. Such new technologies are used as large-scale circuit integration, new high-power hydraulic pressure decentralizer, new pad button configuration and seal structure of connecting pieces to improve the system reliability.
- ② High Resolution. The highest resolution is 5mm and the borehole coverage is over 60%.
- ③ Multiple measurement patterns. 3 patterns for fast scan, slow scan and dip measurements are realized simultaneously at 430kbps transmission rate.



New technological pad



3. Multipole Array Acoustic Logging (MPAL) System™

The Multipole Array Acoustic Logging (MPAL) System™, through different acoustic logging modes of monopole, cross dipole and quadrapole, not only be conduct the conventional acoustic logging, measure formation shear wave velocities in all zones and evaluate formation anisotropy, but also to make lithologic identification, prediction of production, rock mechanical behaviors, hole stability and of over-pressured formations, evaluation of fracturing results and pore fluid types, estimation of formation permeability, etc.

The Multipole Array Acoustic Logging (MPAL) System™ incorporates 3 patented technologies of the quadrapole acoustic transmitting transducer, etc.

• Features

- ① In addition to the conventional acoustic log, MPAL can also perform the shear wave velocity logging directly in all formations (including the soft formation).
- ② MPAL can be used to evaluate formation anisotropy in different modes of acoustic logging, such as monopole, cross dipole, quadrapole, etc.
- ③ The special configuration design of the tool can satisfy the requirement for the acoustic logging in the highly-deviated well.



- ④ The inter-board high-rate serial data transmission bus and control command bus are applied to assure the communication, control and data acquisition of the tools.

4. Ultrasonic Imaging Logging (UIT) System™

The Ultrasonic Imaging Logging (UIT) System™ uses the ultrasonic echo mode to perform 360° scanning around the borehole, in order to obtain sidewall acoustic amplitude and time images which are visualized and cover full borehole. It can be used not only in the open hole for its wide application and easy operation to reflect borehole geometry and identify fractures, vugs and bedding, and also in the cased hole to inspect perforating quality, investigate casing failures and evaluate cementing quality

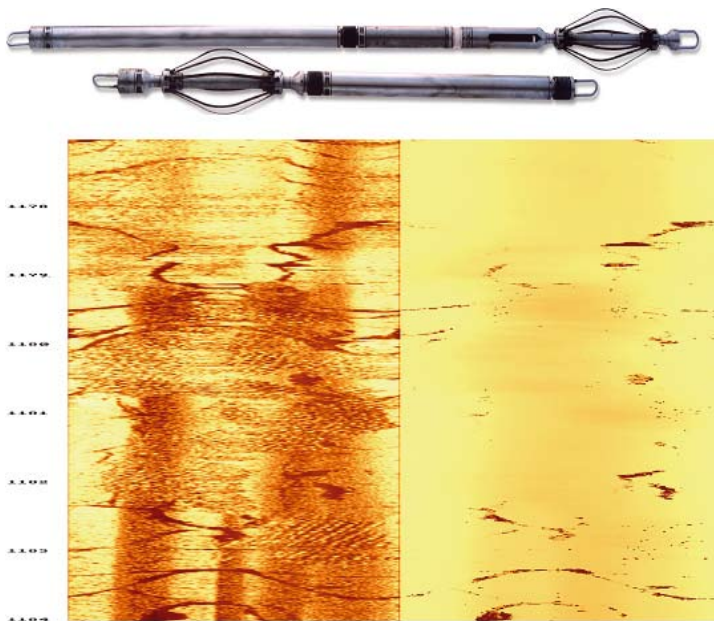
• Features

- ① Its acoustic system is powered by the hysteresis synchronous motor and its mechanical

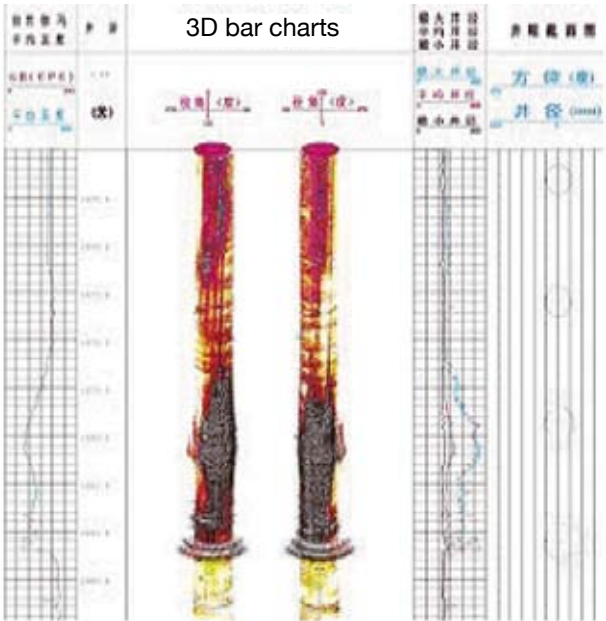
transmission is conducted using gears as a deceleration mechanism. Its transducers are made up of piezoelectric ceramics (1.5MHz and 0.5MHz), and perform a double usage of transmit and receive.

- ② The flux gate azimuth detecting sensor is reeled by using the double reeling. It is used to detect geomagnetic field and determine sonde detecting azimuth.
- ③ The new conductive wear-resistant material is selected to fabricate a contact slide ring, which can overcome the instable hidden defect of electromechanical coupling and shorten the tool's maintenance period.

Its transmitting circuit is designed according to the transducer characteristic parameters by reducing signal trailing and improving the signal/noise ratio and image quality of receiving signals.



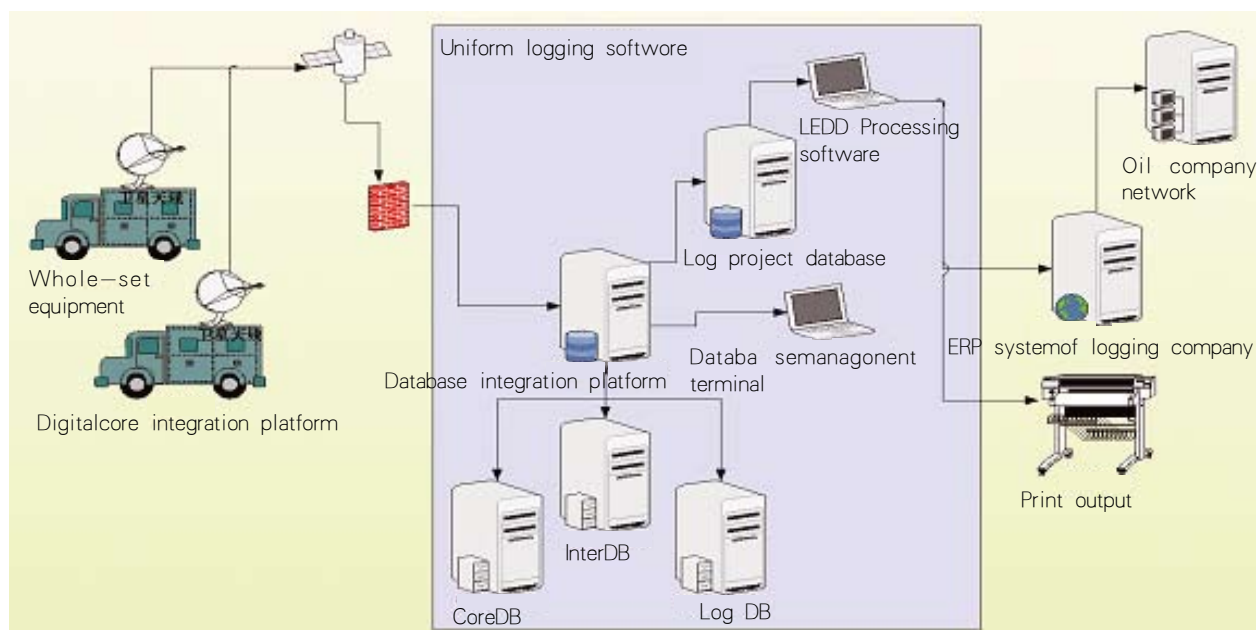
UIT ultrasonic imaging log can clearly reflect geological characteristics of bedding, fractures, etc. in Well XX



UIT ultrasonic imaging log can provide the casing corrosion and failure images in Well XX

Integrated Well Log Data Processing and interpretation Software[®]

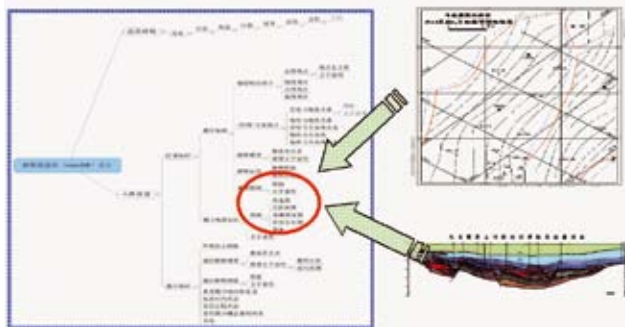
The Integrated Well Log Data Processing and Interpretation software[®] is composed of the log interpretation database, uniform data management platform, and large comprehensive well log data processing software system with interactive visualization integration. The software would be used to carry out the remote processing/interpretation and network collaboration, network management of log interpretation data, single-well log interpretation and multi-well evaluation, integrated application of openhole interpretation and cased-hole monitoring. To satisfy the need of comprehensive logging evaluation in the complex reservoirs, The software would.



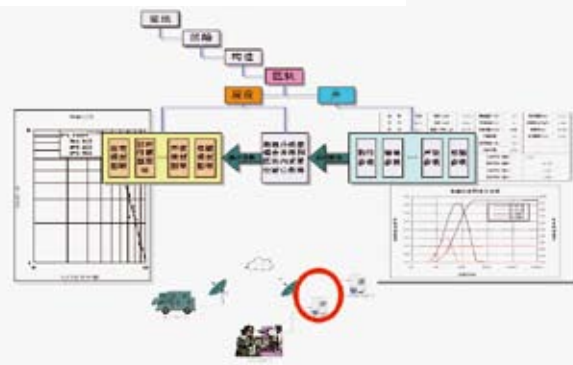
Log Interpretation Database

The Log Interpretation Database consists of the following 5 parts InterDB[®] interpretation knowledge base, CoreDB[®] digital core database, LogDB[®] well log database, ProjectDB[®] work area project database and InfoDB[®] information management database. It can be used to support various links of log interpretation flow.

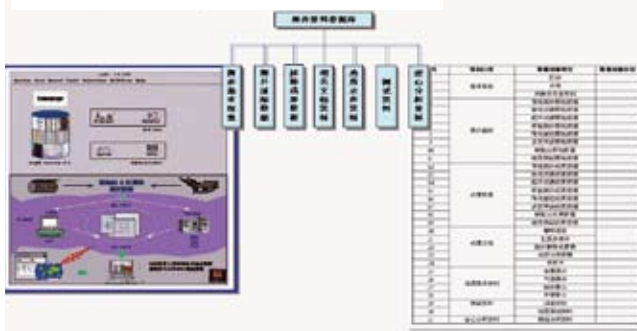
Entry data—interpretation



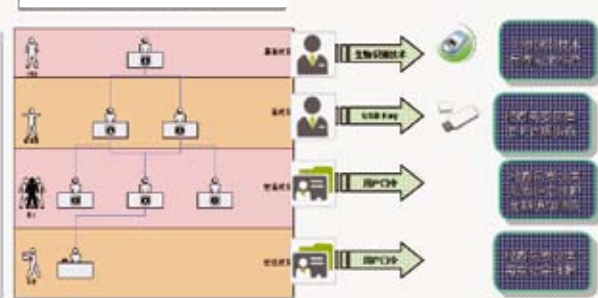
Entru data—digital core database CoreDB



Entry data—well log database LogDB



Data safety management

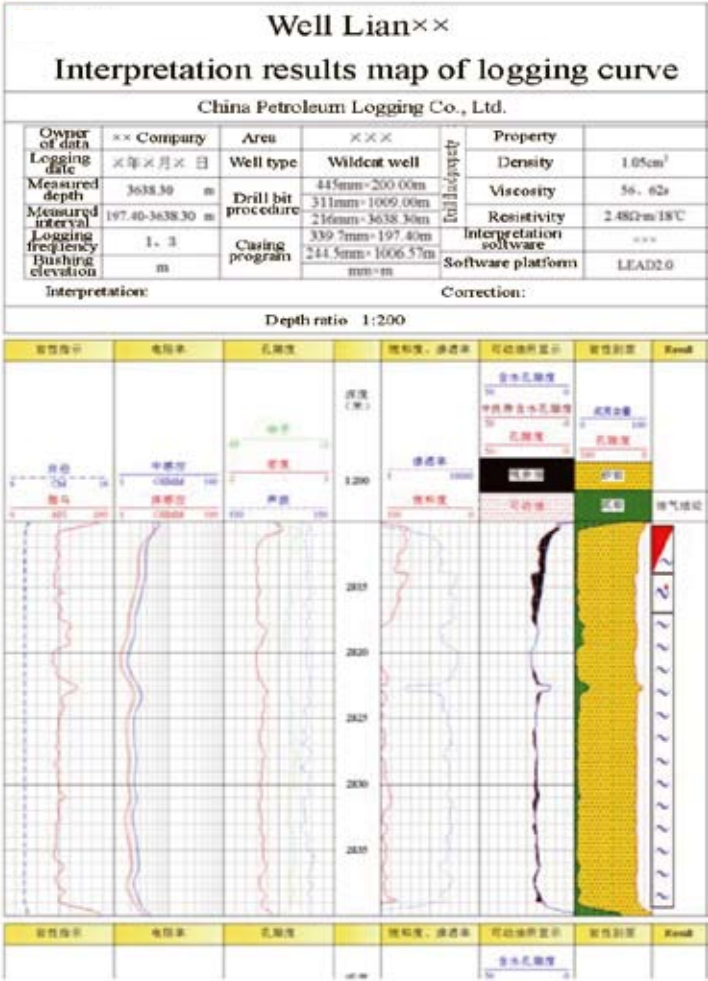


LEAD® Log Evaluation and Application Desktop

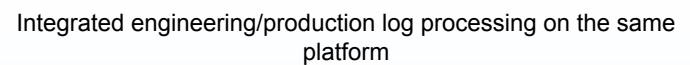
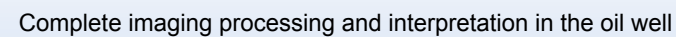
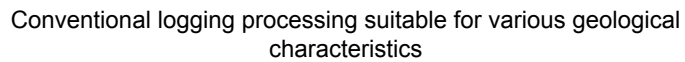
The new-generation well log data processing and interpretation software LEAD® can be used to process data of different logging, includes conventional, electric and acoustic imaging, array induction, nuclear magnetic resonance, production and engineering. And to satisfy the needs of wellsite quick-look interpretation, refined log interpretation and integrated reservoir evaluation, helping the client to implement the integrated logging evaluation in the complex oil and gas reservoirs and to discover oil and gas zones in a timely and exact manner.

LEAD® holds 3 items of right of computer software wit authorship right and obtains the national key new product certificate.

LEAD® software has currently been installed and widely applied in Qinghai Oilfield, Jidong Oilfield, North China Oilfield, Greatwall Drilling Company, South Petroleum Company and Daqing Drilling Company, etc., with the total accumulation of more than 300 sets being installed, which have processed the data from over 10,000 wells and presented remarkable application results.



Multi-functional and fine-visual log presentation

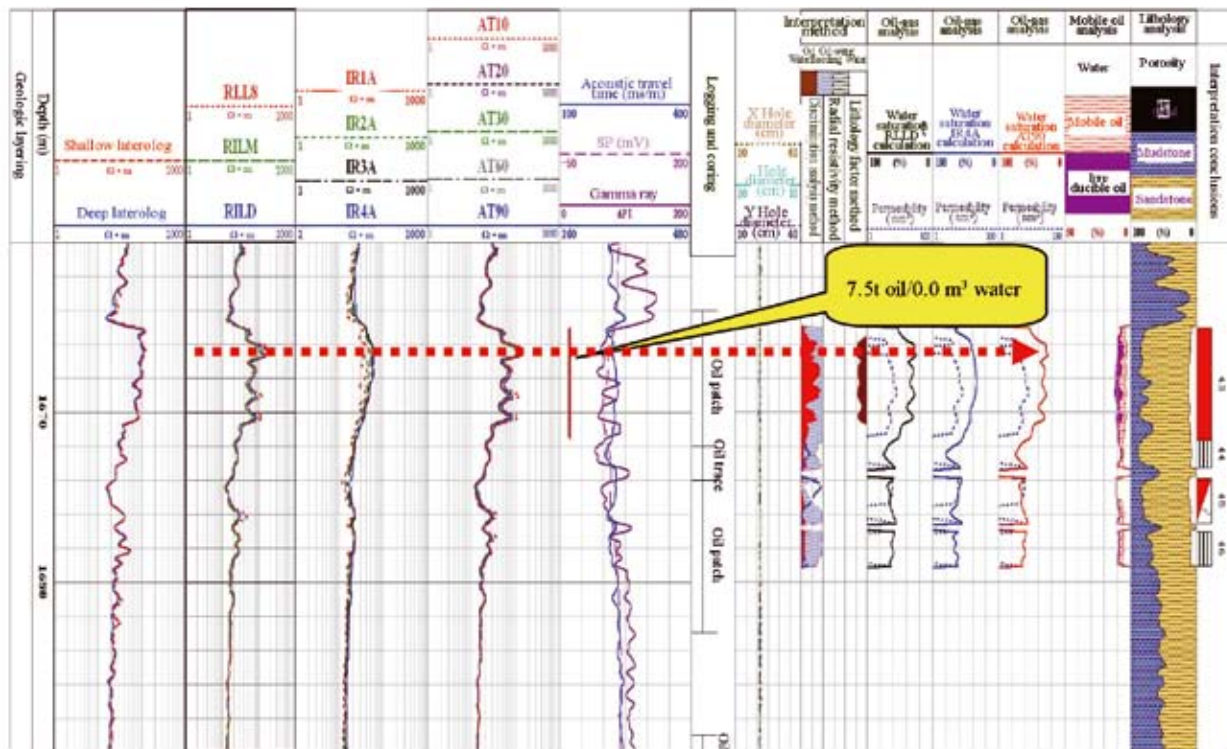


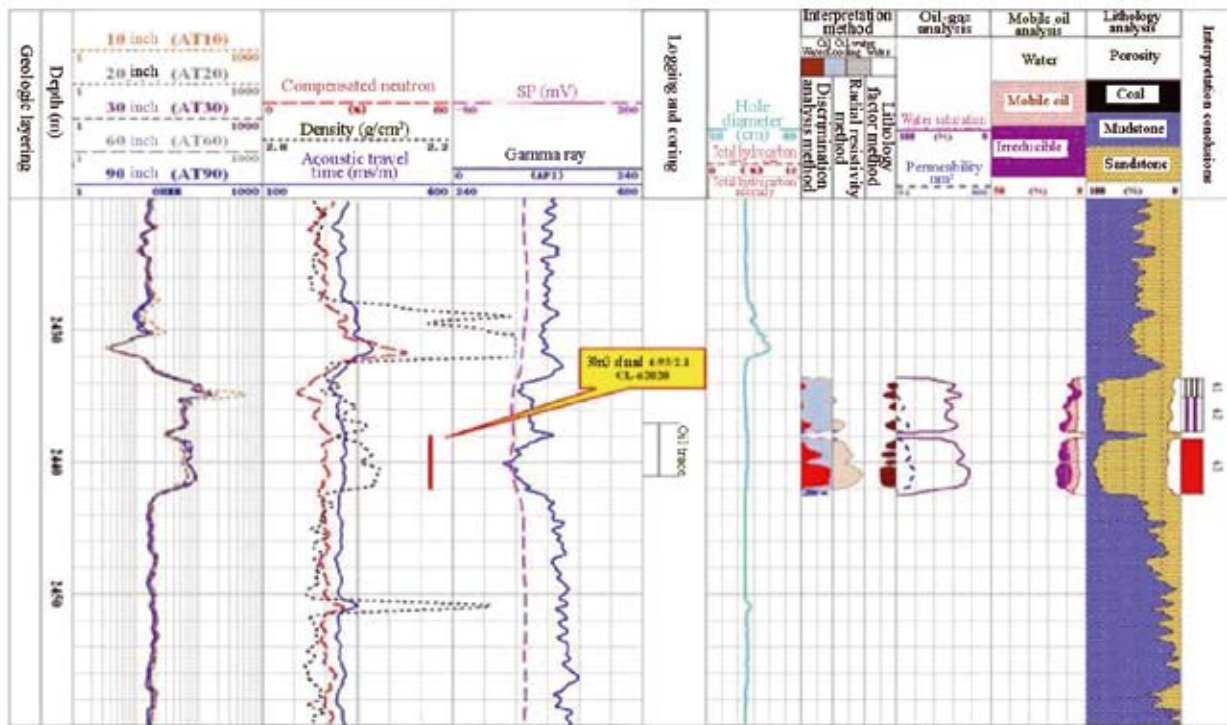
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TYPICAL CASES

Array induction logging tool

The array induction logging tool (MIT) was successfully applied in Jilin Oilfield, Changqing Oilfield, North China Oilfield, Tuha Oilfield and Qinghai Oilfield in China, as well as in other countries like Uzbekistan. In particular, since it was put into application in Changqing Oilfield, it has been used to make the log interpretation of 114 wells up to now with its data qualification rate of 100% and its superior quality rate of 92.10%, to discover new multiple oil and gas zones that were verified by the production test, which has obviously improved the interpretation coincidence rate in the exploration wells and become the sharp “weapon” of discovering and identifying oil and gas zones in Changqing Oilfield.





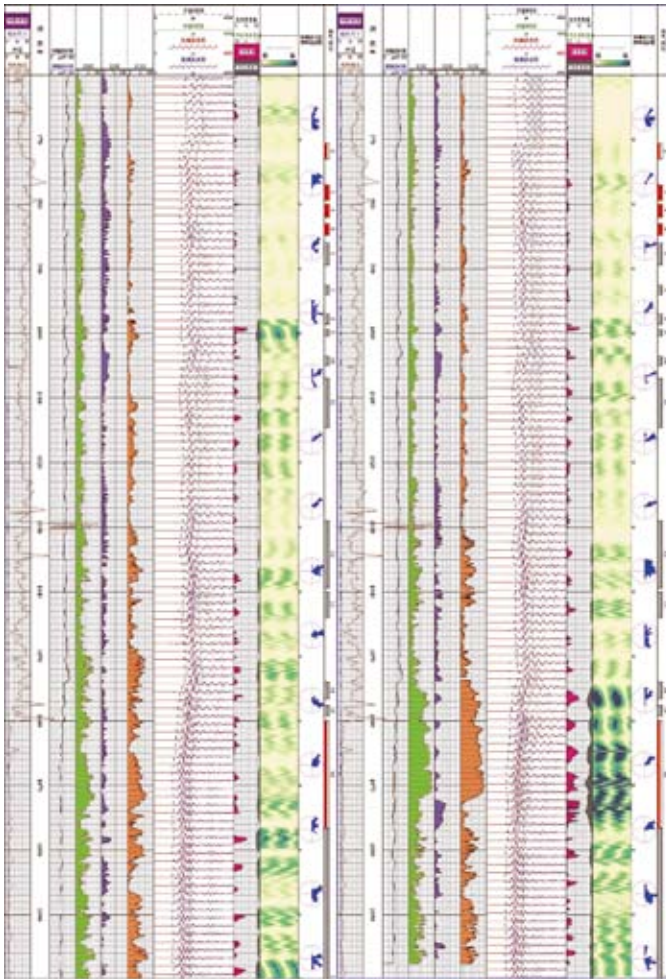
Array acoustic logging tool

The multipole array acoustic logging tool (MPAL) was used to detect the fracture development level and vertical fracture extension height after perforating and fracturing in cased hole in the sandstones of Erlan Oilfield in Inner Mongolia, which achieved the good application results. The anisotropic figure before and after fracturing with MPAL in Well BaXX made the comparison of the processed array acoustic data anisotropy before and after fracturing which following the perforation of the oil interval in the well. In the figure, the perforated interval and adjacent zone shear waves present the high anisotropy that responds to the formation fracturing treatment. Before fracturing, the daily oil production was 0.72 ton by swabbing test, while after fracturing, the daily oil production was 6.33 ton and the daily water production was 1.59m³.

ELog® Express & Imaging Log

EILog® express & imaging log has been successfully applied in Daqing Oilfield, Liaohe Oilfield, Changqing Oilfield, North China Oilfield and Jidong Oilfield, totally having completed 16,000 logging jobs at one time success rate of up to 95%, and the single well operation time was shortened on average of 6 hours. Its resultant identification accuracy reached over 90%.

In the oversea market, EILog® express & imaging log was used to have successfully completed 21 logging jobs in Uzbekistan, among which 10 times of imaging. Several oil and gas zones were newly discovered by means of the logging evaluation and the oil well production was raised to 60 tons from the original of 6 tons.



LEAD[®] Log Evaluation & Application Desktop and Interpretation

LEAD[®] Software been used to process the data from accumulatively over 10,000 logging jobs, resulting in the improvement of log data interpretation efficiency. It has been widely applied in CNPC Logging Co.,Ltd as, software dominant as well as in Qinghai Oilfield Academy, South Logging Company, CNOOC Service Company, Greatwall Drilling Company, No.2 Daqing Well Logging Company of Jilin and. In addition*, (it has been used in teaching and scientific research) in China Petroleum University, Xi'an Petroleum University and Yangtze University, etc.

*good performanle has been achieved in teaching and seientific research throagh applying the software

4

FACILITIES FOR
SCIENTIFIC
RESEARCH

Manufacture Base for Complete Logging Tools

CNPC owns the largest manufacture base to produce logging tools in China. With many production lines for complete set of EILog[®] logging tools, array induction log tool (MIT) and multipde array a coustic(MPAL). The productivity has reached 40 complete sets of EILog[®] logging tools and imaging series of 60 array induction tools(MIT). In the meantime, it owns such auxiliary specialized testing equipment as HTHP testing system, shock testing system, high/low temperature testing system, dry/humidity testing system, induction tool calibration device, continuous inclinometer calibration device, etc.



Complete set of EILog[®] logging tool production line



Array induction tool (MIT) production line



UltraPoreTM-300 porosity testing system



CMS300 multi-parameter automatic core measuring system



UltraPeamTM-400 permeability testing system



Core NMR analyzer



Ultrasonic core scanning and imaging tool

Key Logging Laboratories

The key petroleum logging laboratories for CNPC are equipped with the most sophisticated experimental facilities, model test and calibration pit group as well as 40 sets of log interpretation workstation systems. With service capability of integrated processing and interpretation of well log data, such key logging laboratories have passed QHSE international quality system certification and obtained the national laboratory metrological certification.



First-level calibration well group of compensated neutron and density logging unit



First-level calibration well group of neutron lifetime logging unit

Well Logging Calibration Center

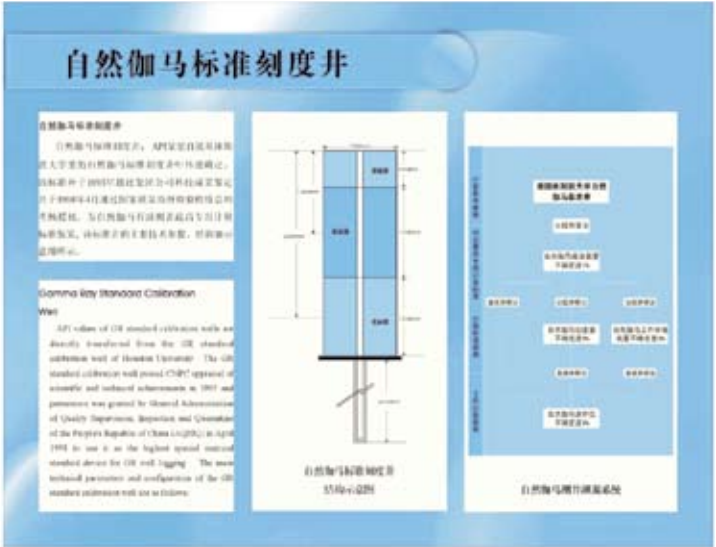
CNPC Well Logging Calibration Center is equipped standard devices with the highest measurement standards in the domestic industry and working measurement standard devices. It is capable to transfer equal quantity value of performing verification, adjustment and calibration and also responsible for drawing up measurement testing standards and specifications of CNPC logging tools.



Second-level calibrator of density



Second-level calibrator of
compensated neutron



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QUALIFICATION AND STANDARDS

Enterprise Qualification



Technical Standards.

CNPC has franced 29 enterprise standards, including one product coding denomination and identification standard, 23 product standards, three logging acceptance standards and two universal component standards, for the equipments and technologies of the integrated well log data acquisition, processing and interpretation.

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SPECIALIST TEAM



Sun Baodian Senior logging specialist and key of CNPC logging laboratory academic committee member. He is mainly engaged in such research subjects as optimized well log data interpretation methods, carbonate log interpretation workstation software, oil remaining distribution logging mechanism and new logging methods during high water-cut or especially high water-cut, focused induced polarization and SP logging tools, interpretation methods in low-resistivity oil zones, etc. More than 20 articles were published.



Chen Wenhui Senior logging specialist. He has been engaged in development of logging acquisition software, responsible for development of the ACME 1.0/2.0 logging acquisition software for EILog[®] complete logging equipment for a long time.



Yu Chunhao Senior logging specialist. He has been engaged in development of well log data processing and interpretation software, responsible for development of the LEAD[®] 1.0/2.0 software for a long time .



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