

LEAP800 Logging System

Science & Technology Management Department, CNPC

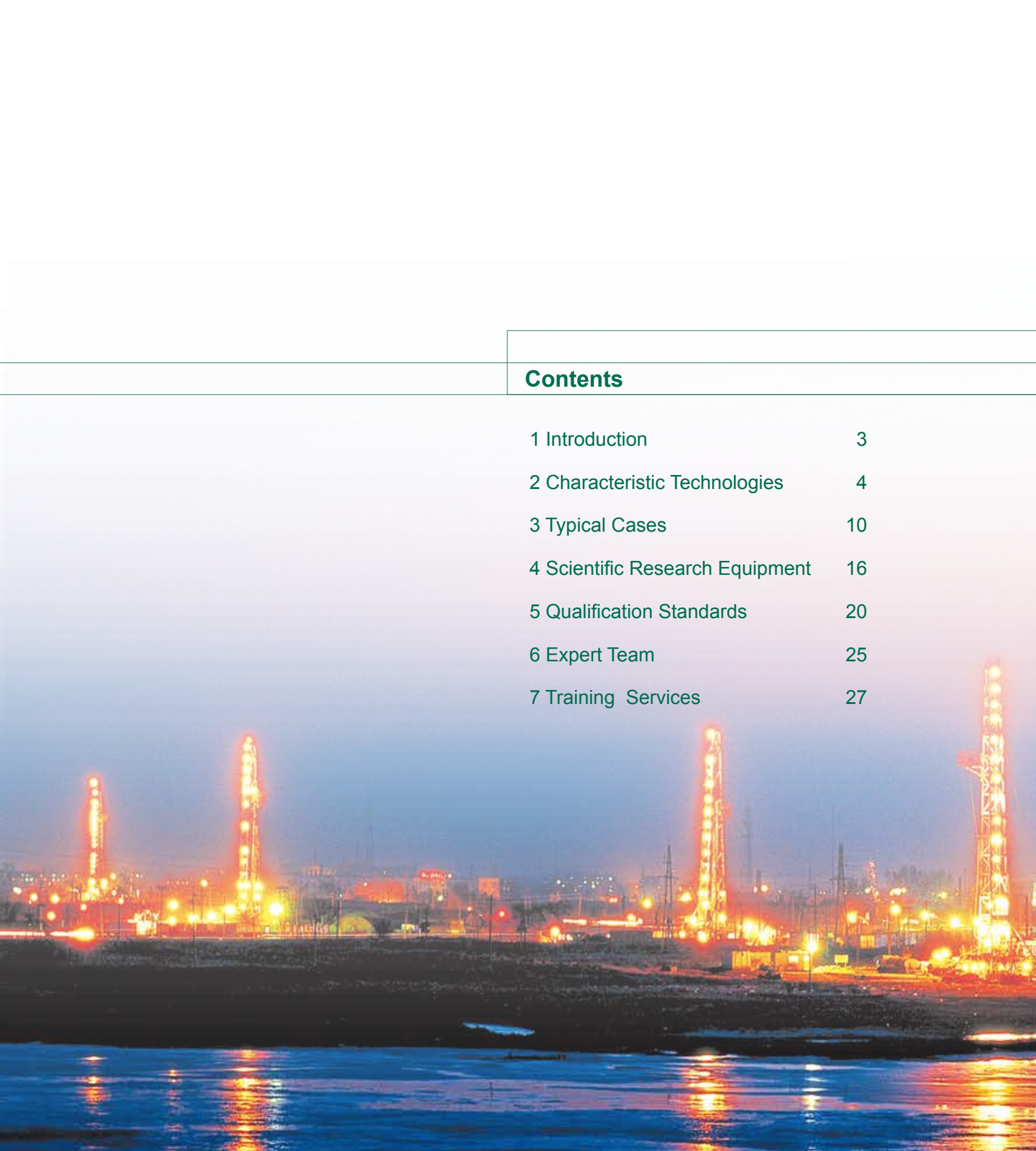
2015



CHINA NATIONAL PETROLEUM CORPORATION

LEAP800 : Better Technology, Better Services!





Contents

| | |
|---------------------------------|----|
| 1 Introduction | 3 |
| 2 Characteristic Technologies | 4 |
| 3 Typical Cases | 10 |
| 4 Scientific Research Equipment | 16 |
| 5 Qualification Standards | 20 |
| 6 Expert Team | 25 |
| 7 Training Services | 27 |



CNPC

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.

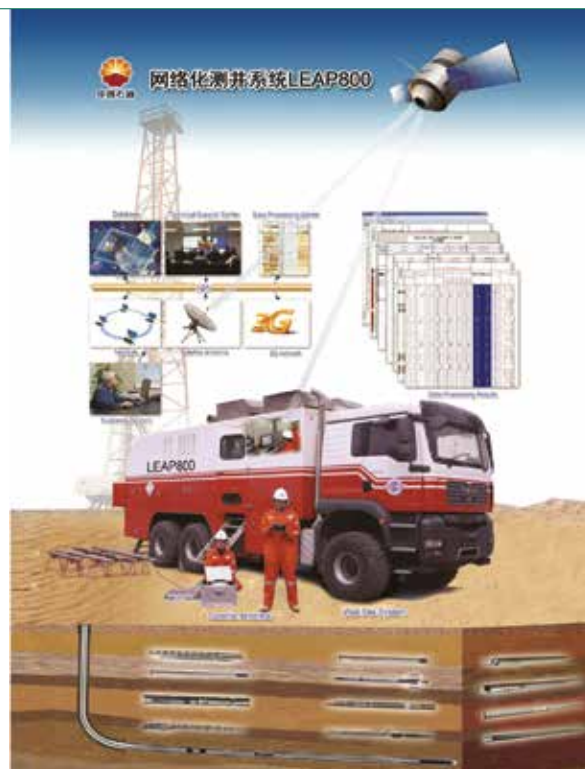
The LEAP800 logging system is one of representatives for major innovations of CNPC.

OFFERING ENERGY SOURCES, CREATING HARMONY

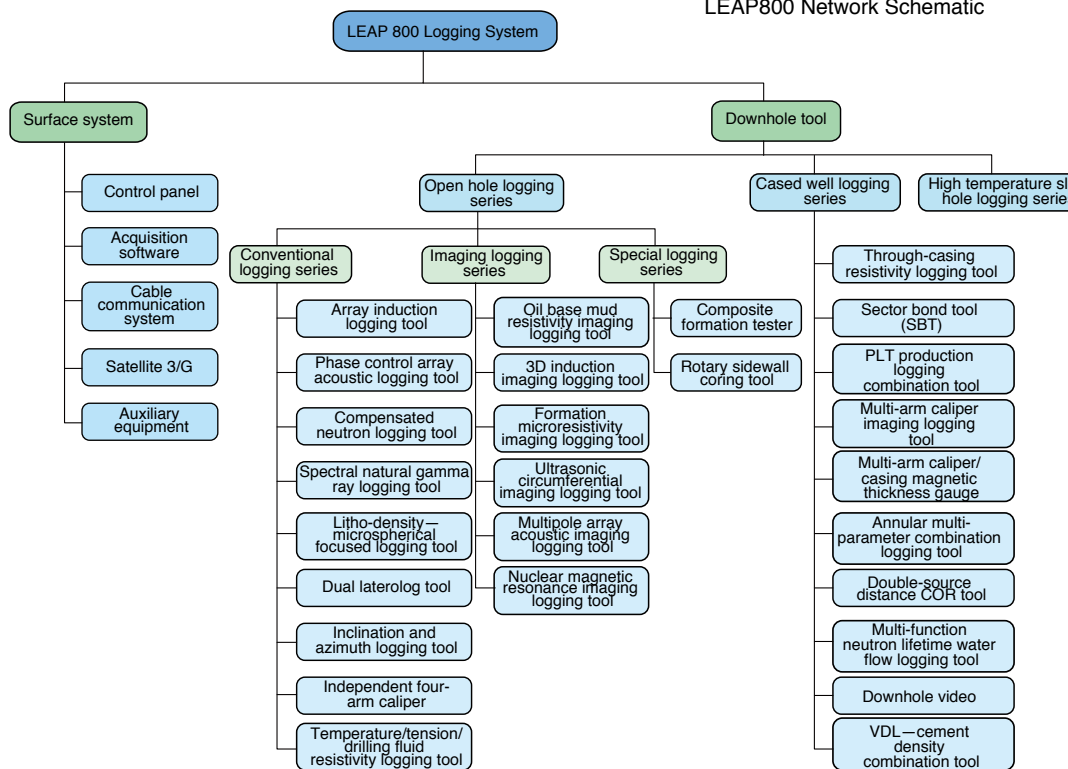
1

INTRODUCTION

LEAP800 logging system uses the modern network communication and electronic technology and provides a complete set of oilfield technology services involving conventional logging, imaging logging, production logging, engineering logging, perforation, coring, etc. The system is characterized by short downhole tool combination, quick logging speed, drilling time saving, supporting remote control at logging site, etc., and multiple technical indexes of the system take the lead in the world.



LEAP800 Network Schematic

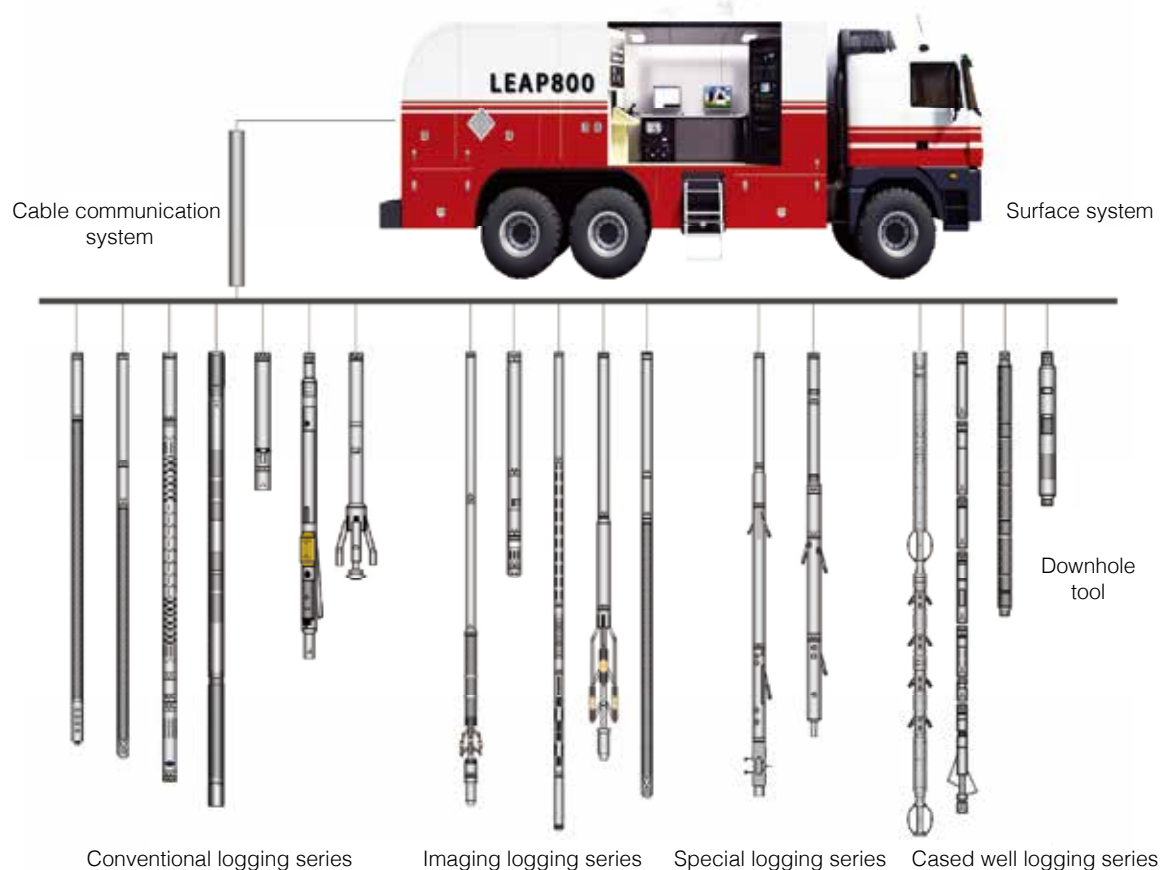


Technology infrastructure diagram of LEAP800 logging system

2 CHARACTERISTIC TECHNOLOGIES

LEAP800 logging system consists of two parts such as surface system and downhole tool. The system has excellent performance and prominent advantageous characteristics and is highly modular and networked. The system has advanced network management mode and functions in any tool combination, network diagnosis of failure, remote software upgrading, etc.

The data transmission rate reaches 1Mbps and takes the lead internationally. The acquisition software of LEAP800 logging system is based on Net framework, has uniform structure and high compatibility, and supports all logging service items; with the object-relation mapping technology, data formats can be converted flexibly. The matching interpretation



LEAP800 logging system composition schematic

and processing software CLFLog-GeoMatrix can run in three mainstream operating systems and quickly integrate high-end logging processing and interpretation methods on a uniform platform with high quality, thereby realizing integration of domestic and overseas processing and interpretation software.

2.1 Surface System

LEAP800 surface system is a new generation quick logging platform based on modular and networked design concept. Each panel is an independent function module and interacts with logging computer data based on standard TCP/IP network protocol. The system has high integration degree and supports multiple open hole and cased hole logging services. LEAP800 surface system supports LEAP800 logging services, Excel2000 logging services, production well logging services and perforation and coring logging services as well as LEAP-NET remote communication system and 3G remote communication system and is compatible with SONDEX instrument.

LEAP800 surface system realizes direct interconnection of computers with downhole tools and has functions such as dynamic connection and random combination of tools, software automatic identification, network diagnosis of failure and remote control, online upgrading, etc. With the advanced combination capacity and compatibility of the logging host of the system, the system can rapidly integrate and control any down hole tools provided by different manufacturers to complete the corresponding logging functions. The software, hardware and modular communication system of the tool are highly uniform and have very good stability and reliability.



Surface Cabinet of LEAP800 Logging System

◆ Cable communication

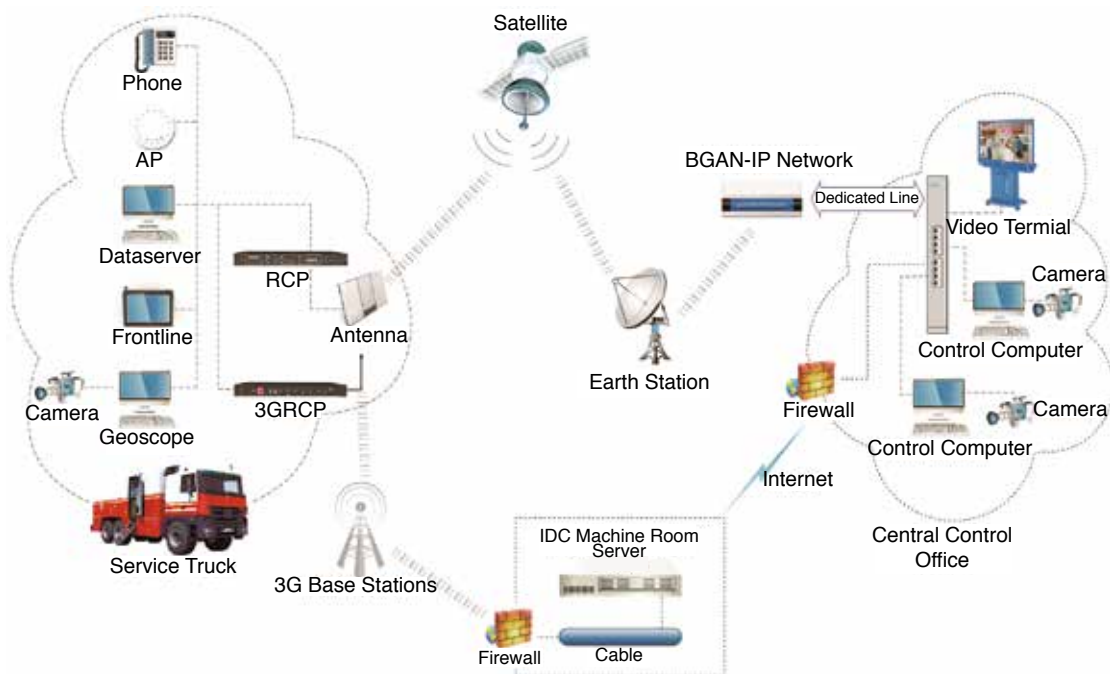
LEAP800 communication system uses network protocol and uniform communication hardware for convenience of connection of newly developed tools. The cable transmission system can realize high speed data transmission on logging cables with limited bandwidth and has full-duplex communication capacity. The system can provide data transmission rate of more than 1000kbps upgoing and more than 50kbps downgoing on 7000m cable and reaches international advanced level. The system has high transmission rate and high reliability and meets the requirements of large data volume transmission of logging tools.

◆ Remote control

LEAP800 remote control system LEAP-NET realizes broadband network access through Internet, mobile communication network and BGAN satellite communication. The system can realize real time audio and video data transmission among central control office—site acquisition unit—customer terminal, i.e. headquarters to site and site to site and is characterized by audio and video data transmission in real time, global data sharing, non-site technical support and remote control. The system has expert technology support function round the clock seven days per week and can realize global seamless



LEAP800 logging remote control



Remote control schematic of LEAP800 logging system satellite/mobile communication

network connection and real time site monitoring, so that global experts “arrive at” site in person to help engineers solve emergent technical problems.

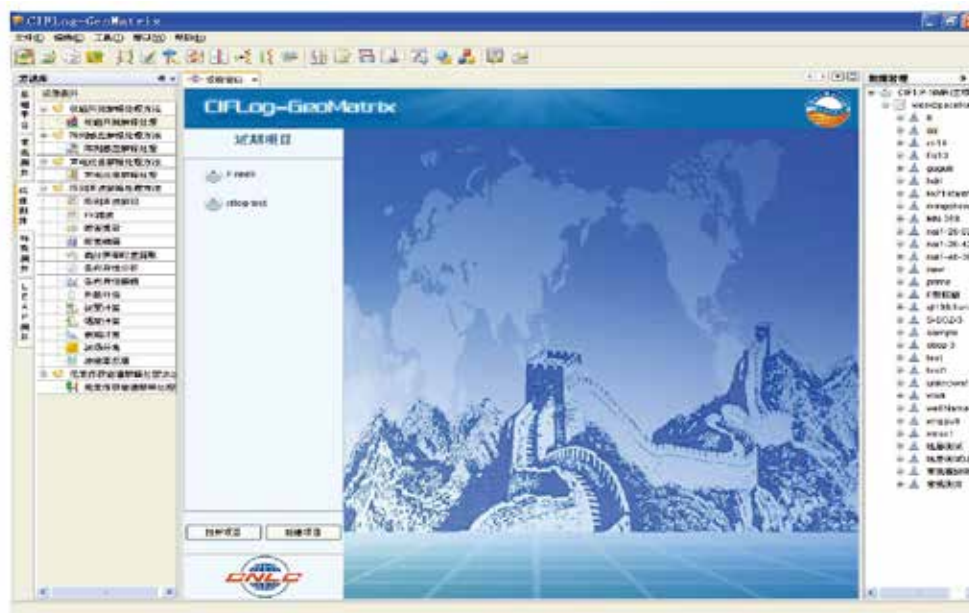
◆ Integrated logging data interpretation and processing software

LEAP800 logging system can run in three major mainstream operating systems using CIFLog-GeoMatrix integrated logging data interpretation and processing software. The software supports multi-computer language operation and can quickly integrate high-end logging processing and

interpretation methods on a uniform processing and interpretation platform with high quality, thereby realizing integration of domestic and overseas interpretation and processing software for the first time.

2.2 Downhole Tools

LEAP800 logging system can connect a complete set of logging tools involving conventional logging, imaging logging, special logging, cased hole logging, high temperature slim hole logging series, etc. The



Chinese interface of CIFLog-GeoMatrix logging interpretation software

conventional logging system includes array induction, phase control array acoustic logging, dual laterolog, neutron logging, density logging, etc. Imaging logging series includes 3D array induction imaging, oil base mud resistivity imaging, dipole array acoustic logging, NMR, formation micro-resistivity scanning imaging

logging, ultrasonic circumferential imaging logging, etc. Special tools include rotary sidewall coring tool, formation tester, VSP logging tool, etc. Cased hole logging series includes conventional 7-parameter logging, SBT, through-casing resistivity logging tool, etc.



Downhole tools of LEAP800 logging system

Among the high-precision downhole tools of LEAP800 logging system, the array induction logging tool has broken the limitation of the traditional induction logging tool which is applicable to only formations with the resistivity lower than $200\Omega \cdot m$, and has realized the measurement within a large dynamic range from $0.1\Omega \cdot m$ to $1000\Omega \cdot m$. The phase control array acoustic logging tool realizes stable and accurate automatic measurement without real time engineer's intervention and has good post-casing P-wave slowness measurement capacity and high-precision acoustic amplitude measurement capacity. The 3D array induction imaging logging tool can measure the horizontal and vertical resistivity of formations and accurately describe formation

anisotropy and radial intrusion features in high-inclination wells and horizontal wells, thus improving the accuracy of evaluating complex reservoirs. The oil base mud resistivity imaging logging tool uses unique current transmitting and measuring technology, thus realizing injection and measurement of current in formations and solving the difficult problem on circumferential resistivity imaging in non-conductive mud environment. The through-casing resistivity logging tool uses nano-volt level signal acquisition and processing technology. The detection performance of the tool is equivalent to that of foreign tools and its temperature and pressure resistance indexes are better than those of imported like products.

3

TYPICAL CASES

Since 2010, 282 wells-times of field tests and commercial logging with LEAP800 logging system have been performed in Shengli oilfield, Huabei oilfield, Liaohe oilfield, Jilin oilfield, Naiman oilfield in Inner Mongolia and Kazakhstan. The operation scope has covered oil and gas wells with different

lithologies, different well types and different mud types in different oil areas in 15 oilfields, and high-quality stable logging results have been obtained. The system has obtained good economic benefits and has been highly appreciated in the industry.



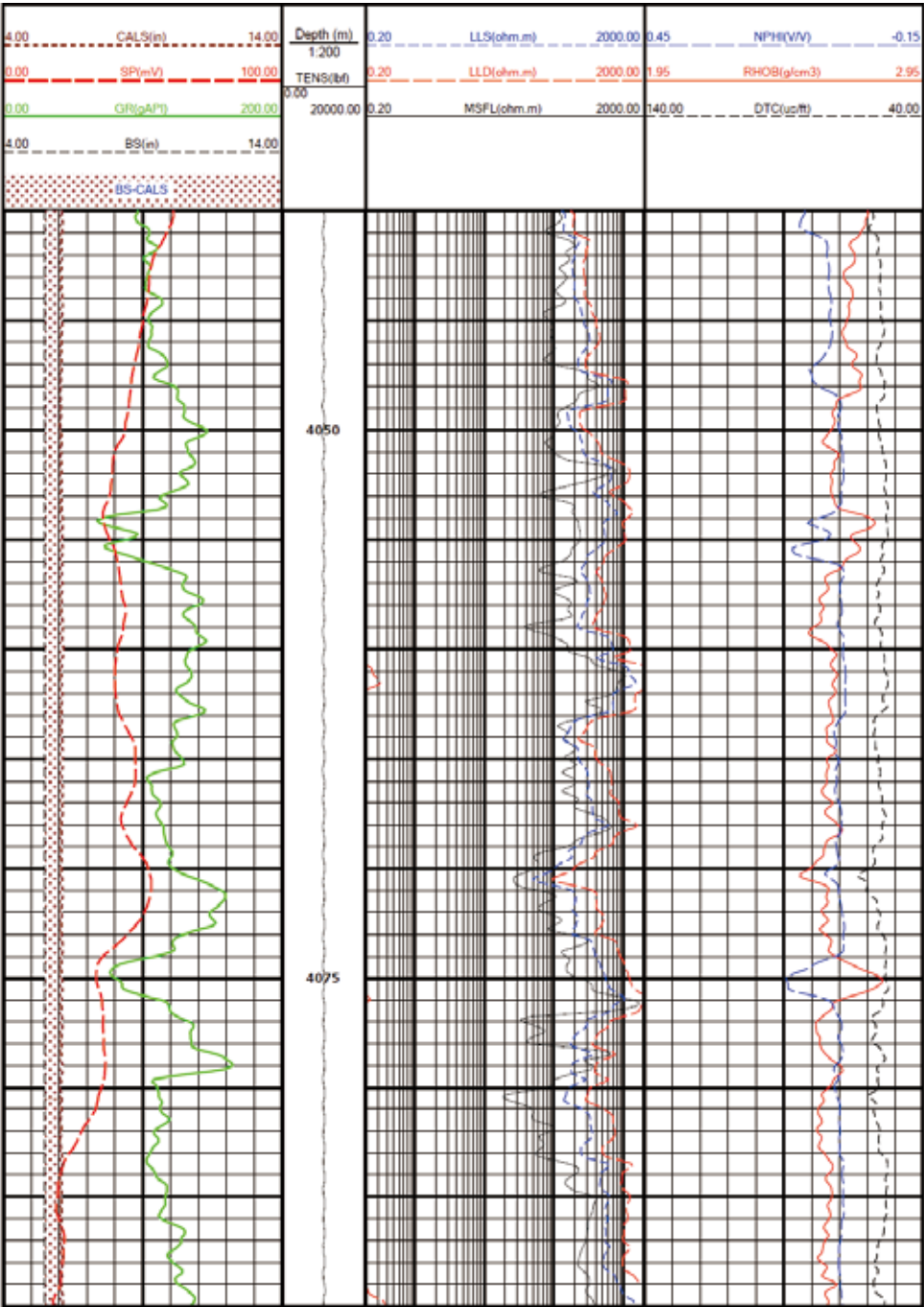
Oil and gas field logging site with LEAP800 logging system

3.1 Comprehensive Application of LEAP800 Logging System

Well xx in Liaohe oilfield has 4733m depth and the whole interval is 987m. The well was drilled with water base mud. LEAP800 comprehensive logging

was performed in the well in Jul. 2011. The test result indicates that most curves have good repeatability and consistency and the tool is stable.

| Well No./ measurement interval | Logging item | Description |
|--------------------------------|-----------------------------------|--|
| Well xx/4040-4090m | GR | Good form and able to indicate lithology very well |
| | Hole diameter | Stable hole diameter in the whole interval |
| | SP | Good form and very good consistency with porosity curve |
| | Dual laterolog | Can reflect oil layers, poor oil layers and dry layers very well |
| | Micro-spherically focused logging | High resolution and very good consistency with dual laterolog curve |
| | Lithology density | Very good form and very good consistency with neutron and photoelectric absorption interface index curve |
| | CNS | Very good form and very good consistency with density and photoelectric absorption interface index curve |
| | Interval transit time | Very good form and very good consistency with neutron and density curve |

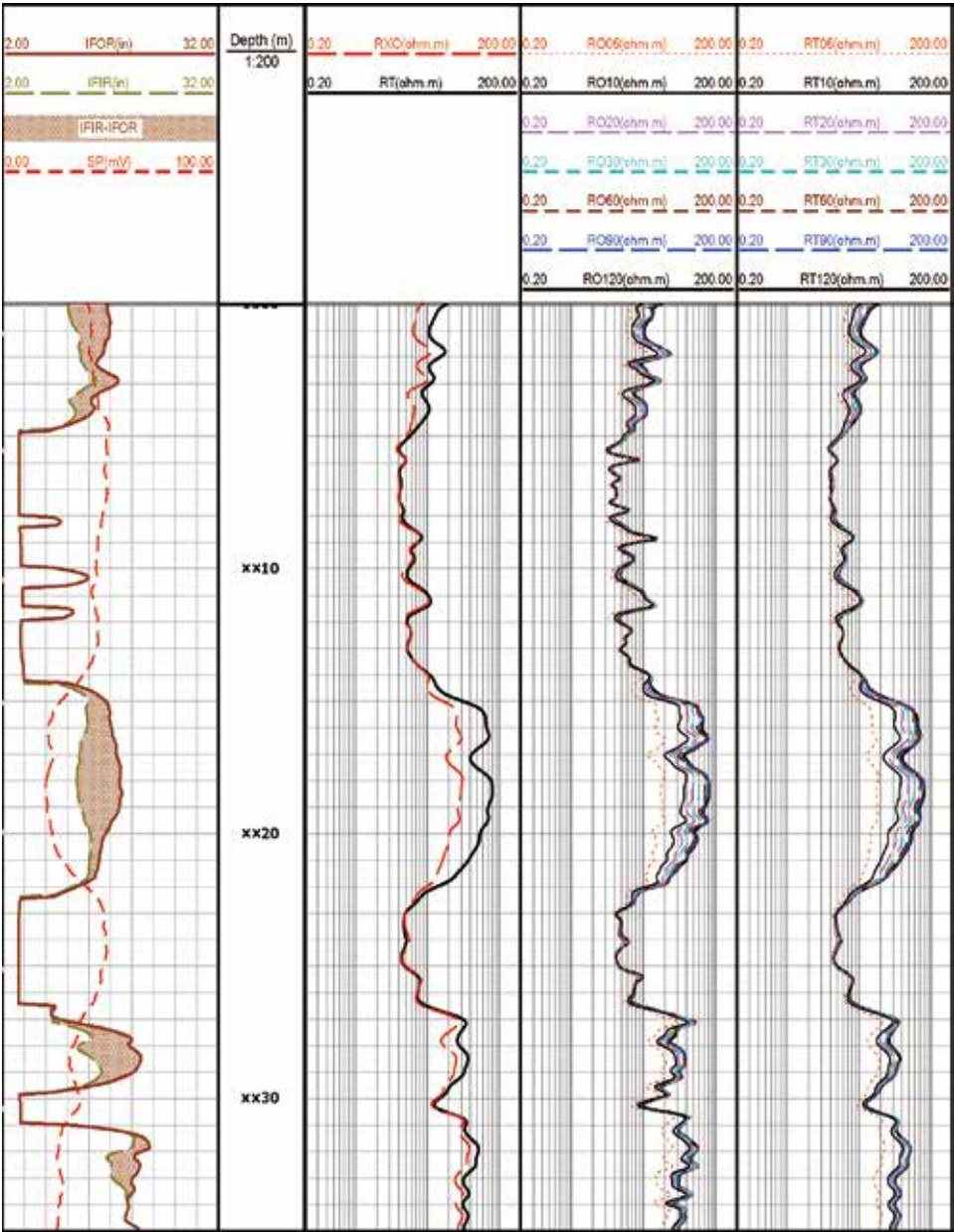


LEAP800 comprehensive logging curve chart of well X1

3.2 Application of Array Induction Logging Tool

LEAP800 logging was performed in well X2 with its structure located in Naiman oilfield in the central north section of Shuanghe anticline, central depression

belt, Naiman sag, Kailu basin, Naiman Banner, Inner Mongolia in Jun. 2010. The logging result shows that most curves have good repeatability and consistency and accurate values.

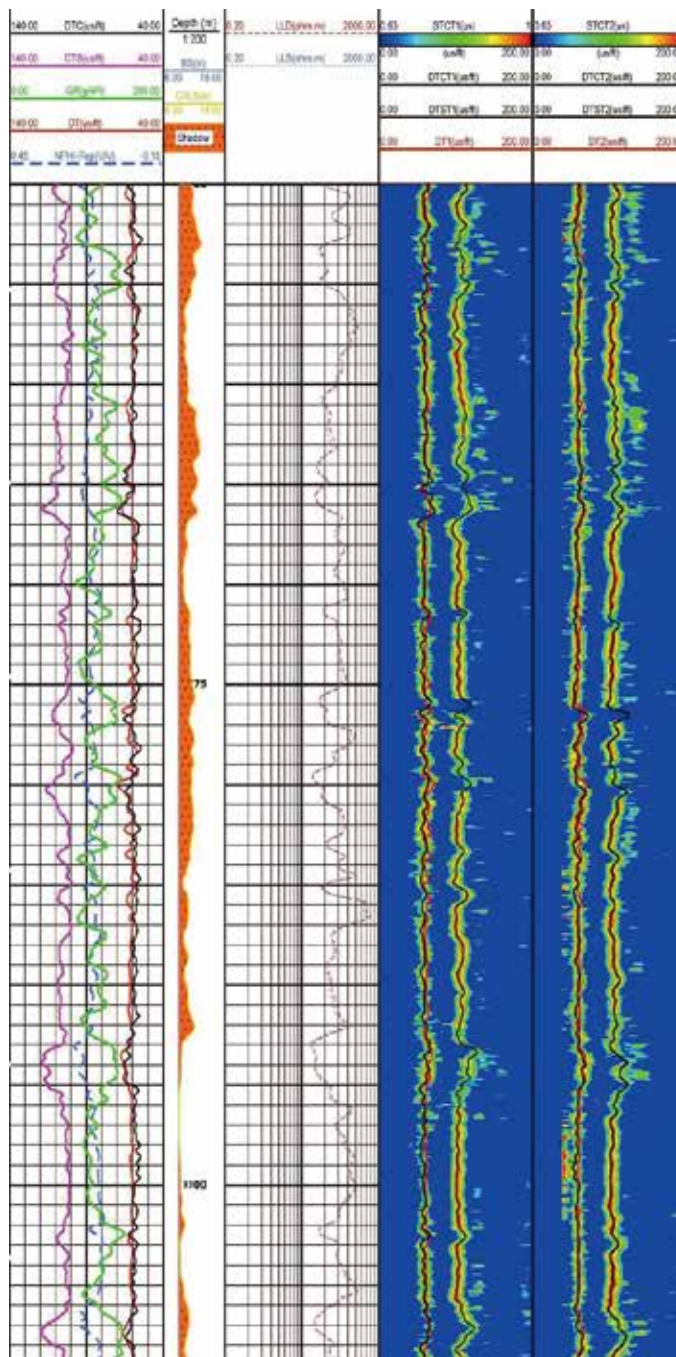


Array induction logging curves of well X2

3.3 Application of Phase Control Array Acoustic Logging Tool

LEAP800 logging was performed in gas well X3 in Fulongquan gas field of Jilin oilfield in Sept. 2010.

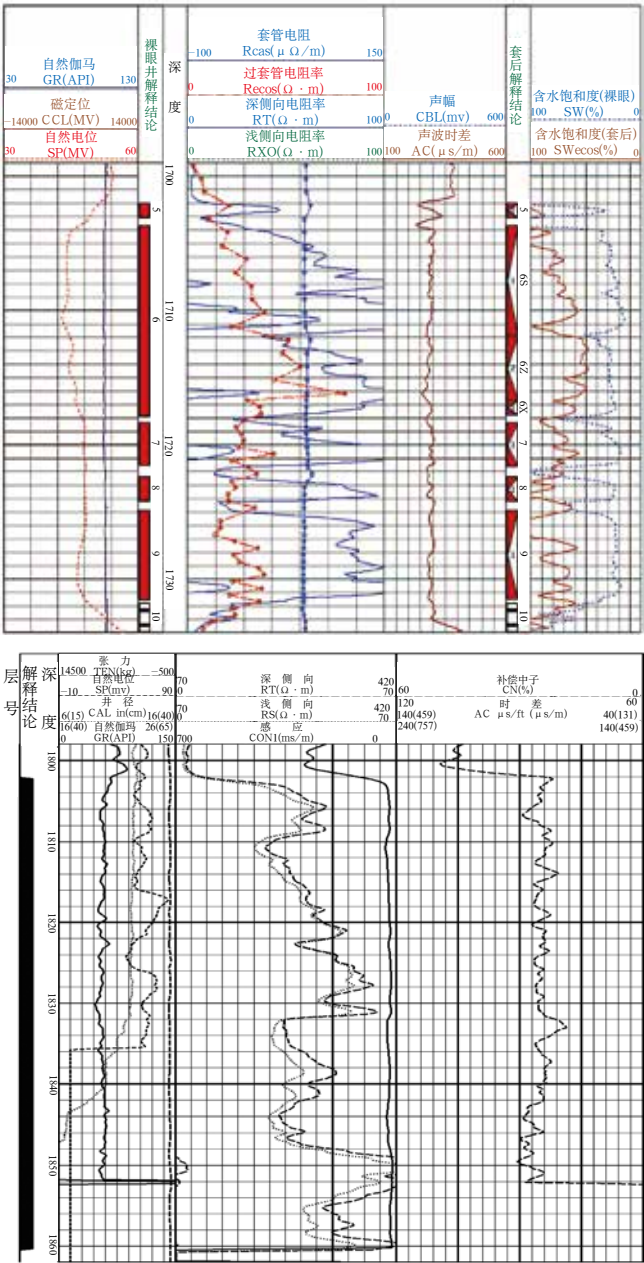
The logging data reflect integrally good reflection of the phase control acoustic logging tool, clear and stable waveform, no strong interference and good DTC repeatability and consistency of P-wave.



Phase control array acoustic logging curves of well X3

3.4 Application of Through-casing Resistivity Logging Tool

The through-casing resistivity logging tool can search the horizons rich in remaining oil in a block, thus providing bases for well pattern adjustment and new well deployment in the block. Early in 2007, the through-casing resistivity logging was performed in the three wells in block C of Liaohe oilfield. The oil bearing property of the interval 1712-1716.8m in well X4 is good, and the through-casing resistivity value is high and over 50Ω·m. A comprehensive analysis shows horizons rich in remaining oil. According to the through-casing resistivity logging result, horizontal well X4-H1 has been deployed in the horizon with high resistivity. The daily liquid production and daily oil production of the well were 26t and 7t respectively in the early stage.



Through-casing resistivity logging tool curves of well X4

4

SCIENTIFIC RESEARCH EQUIPMENT

CNPC has perfect logging tool test equipment and detection means, including many high-end precise instruments and large inspection and testing equipment, e.g. power analyzers, signal generators, acoustic real time data acquisition and processing systems, LCR meters, logic analyzers, frequency spectrum analyzers, air purifiers, AOI optical inspection instruments, high temperature ovens, HTHP simulation wells, various calibration devices, simulation derricks, etc.

◆ Electronic scientific research equipment



DC power analyzer



Acoustic real time data acquisition and processing system



LCR meter



Programmable AC/DC electronic load



Lock-in amplifier I



Lock-in amplifier II



Oscilloscope



Frequency spectrum analyzer



Logic analyzer



8¹/₂ multimeter



DC system power supply



Function signal generator

◆ Calibration device and testing equipment



Flow calibration device



Simulation derrick



Calibrating frame



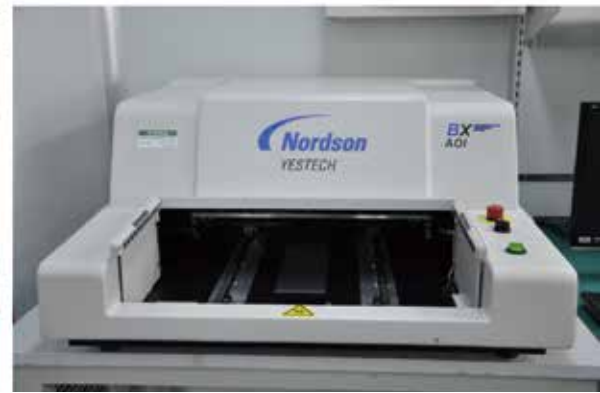
Large vibration table: used in vibration and impact test of cabinets and whole downhole tools and verification of vibration resistance and impact resistance of downhole tools, cases and cabinets after being well assembled and tested.



Nonmagnetic oven: used in high temperature test of array induction tools and verification of high temperature characteristic of array induction tools in nonmagnetic environment.

◆ Production equipment——SMT production line

Circuit boards are manufactured using screen printers, SMT and reflow ovens, tested by the testing equipment such as microscopes, AOI, etc., cleaned with deionized water, dried at high temperature and environmentally tested in the late stage. The production line has the capacity of manufacturing and producing high-quality high temperature circuit boards.



◆ Process quality control equipment

High temperature vibration test chamber: used in high temperature test and vibration test of circuit boards and cases;

Quick temperature-humidity hot test chamber: used in high and low temperature aging screening of circuit boards and verification of high and low temperature and humidity characteristic of surface cabinets;

Temperature impactation test chamber: used to check the encapsulation characteristic of electronic components depending upon great temperature change;

Electronic component aging test equipment: used in environmental stress screening of electronic components such as resistances, capacitors, transformers, power supplies, chips, etc. before their use to ensure the reliability of electronic components on circuit boards and products.

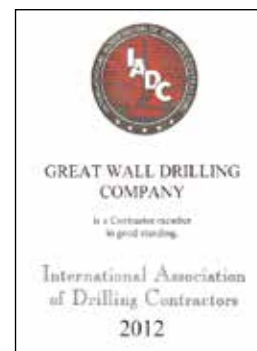
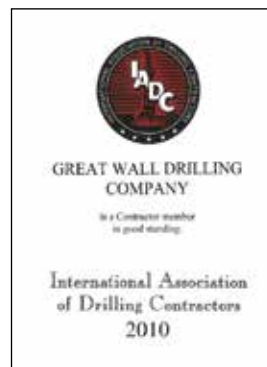


High temperature impactation test chamber, temperature impactation test chamber, quick temperature-humidity hot test chamber, electronic component aging test equipment.

5 QUALIFICATION STANDARDS

LEAP800 logging system was developed by CNPC GWDC. GWDC is the member of IADC, has grade I construction qualification in general drilling

engineering contracting, has obtained international grade (AAA) credit certificate and has passed CAQ GB/T and ISO9000 quality system certification.



LEAP800 logging system uses over 100 standards such as international electronic industry standards, military standards of America, IPC standards, China national standard, national military standards, standards of the Ministry of Machinery, standards of the Ministry of Aerospace Industry, petroleum industry standards, etc. 4 authorized invention patents, 64 utility model patents and 5 software copyrights have been obtained for R&D of LEAP800 logging system.

| No. | Patent No. | Patent name | Patent type |
|-----|---------------------|--|----------------------|
| 1 | ZL 2007 1 0001109.7 | Logging telemetry system using discrete multi-tone modulation mode | Invention patent |
| 2 | ZL 2008 1 0009664.9 | Downhole power supply and signal transmission system | |
| 3 | ZL 2009 1 0085550.7 | Acoustic detection device | |
| 4 | ZL 2009 1 0085549.4 | Acoustic detection device | |
| 5 | ZL 2008 2 0231617.4 | A through-casing resistivity logging tool leather bag sealing device | Utility model patent |
| 6 | ZL 2008 2 0231616.X | A through-casing resistivity logging tool push leather bag | |
| 7 | ZL 2011 2 0030359.5 | Petroleum logging truck and its surface system cabinet | |
| 8 | ZL 2011 2 0030363.1 | Petroleum logging truck and its integrated communication interface unit | |
| 9 | ZL 2011 2 0030361.2 | Petroleum logging truck and its used LED lighting system | |
| 10 | ZL 2011 2 0030362.7 | Petroleum logging truck and its middle hatch ladder | |
| 11 | ZL 2011 2 0030366.5 | A new air duct system used in logging truck air conditioner | |
| 12 | ZL 2011 2 0030367.X | A new logging truck central control cabin | |
| 13 | ZL 2011 2 0030358.0 | A vehicle console | |
| 14 | ZL 2011 2 0030357.6 | A new air duct system used in logging truck air conditioner | |
| 15 | ZL 2011 2 0070603.0 | A control box of logging system programmable power supply and the power box with the control box | |
| 16 | ZL 2011 2 0067291.8 | Remote failure diagnosis system and remote monitoring system for logging system | |
| 17 | ZL 2011 2 0059588.X | Downhole tool cable head voltage measuring system | |
| 18 | ZL 2011 2 0044017.9 | Communication echo elimination device | |
| 19 | ZL 2011 2 0053655.7 | A modified remote logging data transmission system | |
| 20 | ZL 2011 2 0210505.2 | A downhole logging tool bus system | |
| 21 | ZL 2011 2 0210548.0 | Downhole tool bus system | |
| 22 | ZL 2011 2 0184234.8 | Logging system | |

to be continue

| No. | Patent No. | Patent name | Patent type |
|-----|---------------------|---|-------------|
| 23 | ZL 2011 2 0113644.3 | Downhole tool cable head voltage direct measuring device | |
| 24 | ZL 2011 2 0241902.6 | Flexray bus based logging bus system | |
| 25 | ZL 2011 2 0289083.2 | Logging communication system | |
| 26 | ZL 2011 2 0312818.9 | Cable core switching device | |
| 27 | ZL 2011 2 0335253.6 | Equipment for rectifying acoustic environment pressure in acoustic amplitude logging | |
| 28 | ZL 2011 2 0339302.3 | Equipment for rectifying acoustic transmitting voltage in acoustic amplitude logging | |
| 29 | ZL 2011 2 0373367.X | Slip-ring SP measuring electrode | |
| 30 | ZL 2011 2 0373728.0 | Frame type dual-attitude induction logging tool calibration device | |
| 31 | ZL 2011 2 0369439.3 | Machinable ceramic precision tubular coil insulator | |
| 32 | ZL 2011 2 0374166.1 | Electromagnetic isolation pressure-bearing connector | |
| 33 | ZL 2011 2 0374224.0 | Electromagnetic isolation normal pressure connector | |
| 34 | ZL 2012 2 0075418.5 | A logging tool calibration device | |
| 35 | ZL 2012 2 0075390.5 | A 3D array induction calibration device | |
| 36 | ZL 2012 2 0119048.0 | System for eliminating direct wave interference in acoustic logging and acoustic logging tool | |
| 37 | ZL 2012 2 0208110.3 | System for eliminating direct wave interference in acoustic logging and acoustic logging tool 2 | |
| 38 | ZL 2012 2 0303851.x | A device for high pressure test of housing | |
| 39 | ZL 2012 2 0353703.9 | Three-axis quadrature coil array and tabular insulator | |
| 40 | ZL 2012 2 0353655.3 | Induction logging parallel plane coil and induction logging equipment | |
| 41 | ZL 2012 2 0448592.x | A device for ultrahigh pressure test | |
| 42 | ZL 2012 2 0444027.6 | Fixed structure for transformer unit and transformer assembly | |
| 43 | ZL 2012 2 0443217.6 | Fixed structure for transformer sub and transformer sub | |
| 44 | ZL 2012 2 0423651.8 | A pressure bearing joint for induction logging tool and mud resistivity measurement | |
| 45 | ZL 2012 2 0376686.0 | Tote cart used in induction logging tool calibration site | |
| 46 | ZL 2012 2 0390302.0 | A circuit framework | |
| 47 | ZL 2012 2 0522002.3 | A cable tray for drawer type electronic equipment cabinet | |
| 48 | ZL 2012 2 0499884.6 | Spindle assembly for induction logging tool probe sub | |

to be continue

| No. | Patent No. | Patent name | Patent type |
|-----|---------------------|---|--------------------|
| 49 | ZL 2012 2 0516471.4 | A shield assembly for logging tool adapter base | |
| 50 | ZL 2012 2 0531164.3 | Non-inductive hot air circulating oven for secondary heat exchange | |
| 51 | ZL 2012 2 0592766.X | A vibration reduction structure for radioactive logging tool probe | |
| 52 | ZL 2012 2 0611145.1 | A device for installing circuit board in vibration table | |
| 53 | ZL 2012 2 0611435.6 | Power module test process equipment | |
| 54 | ZL 2012 2 0611484.X | Workbench for laser marking | |
| 55 | ZL 2012 2 0611254.3 | An electronic component test equipment | |
| 56 | ZL 2012 2 0611742.4 | A test board for testing of electronic components in batches | |
| 57 | ZL 2013 2 0200239.4 | Platform for testing at least the planeness of radial coils of 3D array induction logging tool | |
| 58 | ZL 2013 2 0200276.5 | Platform for testing at least the concentricity of axial coils of 3D array induction logging tool | |
| 59 | ZL 2013 2 0200194.0 | Platform for testing at least the central linearity of radial coils of 3D array induction logging tool | |
| 60 | ZL 2013 2 0200110.3 | Platform for testing at least the integral linearity of the probe sub of array induction logging tool | |
| 61 | ZL 2013 2 0200072.1 | Platform for testing at least the cylindricity of axial coils of 3D array induction logging tool | |
| 62 | 201320586775.2 | Transmitting signal synthesis device for induction logging tool and induction logging device | |
| 63 | 201320550302.7 | Detection logging tool with improved mechanical structure suitable for HTHP slim hole oil and gas wells | |
| 64 | 201320536083.7 | Disassembling and assembling tool for threaded connecting pieces | |
| 65 | 201420014701.6 | Portable caliper calibrator for multi-arm pusher | |
| 66 | ZL 2012 2 0303838.4 | Through-casing resistivity electrode probe | |
| 67 | ZL 2012 2 0745343.7 | Through-casing resistivity push electrode device and its energy compensated hydraulic cylinder | |
| 68 | ZL 2012 2 0599621.2 | Hydraulic self-sealed joint for through-casing resistivity logging tool | |
| 69 | 2011SR003212 | LEAP800 logging data acquisition software | Software copyright |
| 70 | 2013SR006984 | WellScope CGM vector graph browser software | |
| 71 | 2013SR013405 | WellScope CGM virtual printer drive software | |
| 72 | 2013SR006670 | WellScope CGM vector graph generator software | |
| 73 | 2011SR104233 | THCR through-casing resistivity acquisition software | |



6

EXPERT TEAM

CNPC has a research & development system of over 100 scientific researchers with doctors as backbone and masters as the main body concentrating on logging method research, electronic technology research, software development,

mechanical design, general assembling test, IT, etc., is devoted to R&D of worldwide high-end logging technology and equipment, and has the innovative capacity of research on logging equipment and technology with the highest level in the world.



Chen Wen

Doctor. He is specialized in electronic circuit and system. As a core member, he is responsible for R&D of LEAP800 networked downhole tool bus system and has participated in the development of LEAP800 networked downhole logging surface system and high speed cable transmission system.

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Ma Zhengjiang

Master. He was engaged mainly in site operation of logging systems such as Excel2000LOGIQ LEAP600B etc. and acted as the team engineer and project manager in 1996—2007. The regions where he worked in this period include Tarim oilfield and Liaohe oilfield and the countries and regions including Iran, Iraq, Oman, Africa, etc. He is engaged in site test and popularization of LEAP800 logging system from 2007 to now. He has plentiful experience in popularization and site application of the logging system.

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Liang Xiaobing

He acts as the deputy director of the Electronic Research Institute of Logging Technology Research Institute and the leader of the induction logging tool project. He takes charge of R&D of LEAP80 array induction logging tool and 3D array induction logging tool. He has a deep understanding of and plentiful field application experience in design and development of electrical logging tools.

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Zhou Zhengzhi

Master, LEAP800 logging system acquisition software development and test engineer. He was engaged in the development of logging and logging interpretation related software all the time before participating in LEAP800 logging system project.

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7

TRAINING SERVICES



LEAP800 Logging System Training Course—
Site Guidance by R&D Experts

LEAP800 Logging System R&D Center—Logging Technology Research Institute

LEAP800 logging system has perfect domestic and overseas technical support systems, and a series of Chinese and English training courses have been formulated. The training contents cover surface system principle and operation, telemetry bus system principle and operation, array induction



Closing Ceremony for LEAP800 Logging
System Training Class

system principle and operation, phase control acoustic system principle and operation, WellScope acquisition software principle and operation, LEAP800 conventional tool principle and operation training, etc. The perfect training system and high quality training courses will ensure favorable and highly effective application of LEAP800 in global logging engineering operations.



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