

G3i Seismograph

Science & Technology Management Department, CNPC

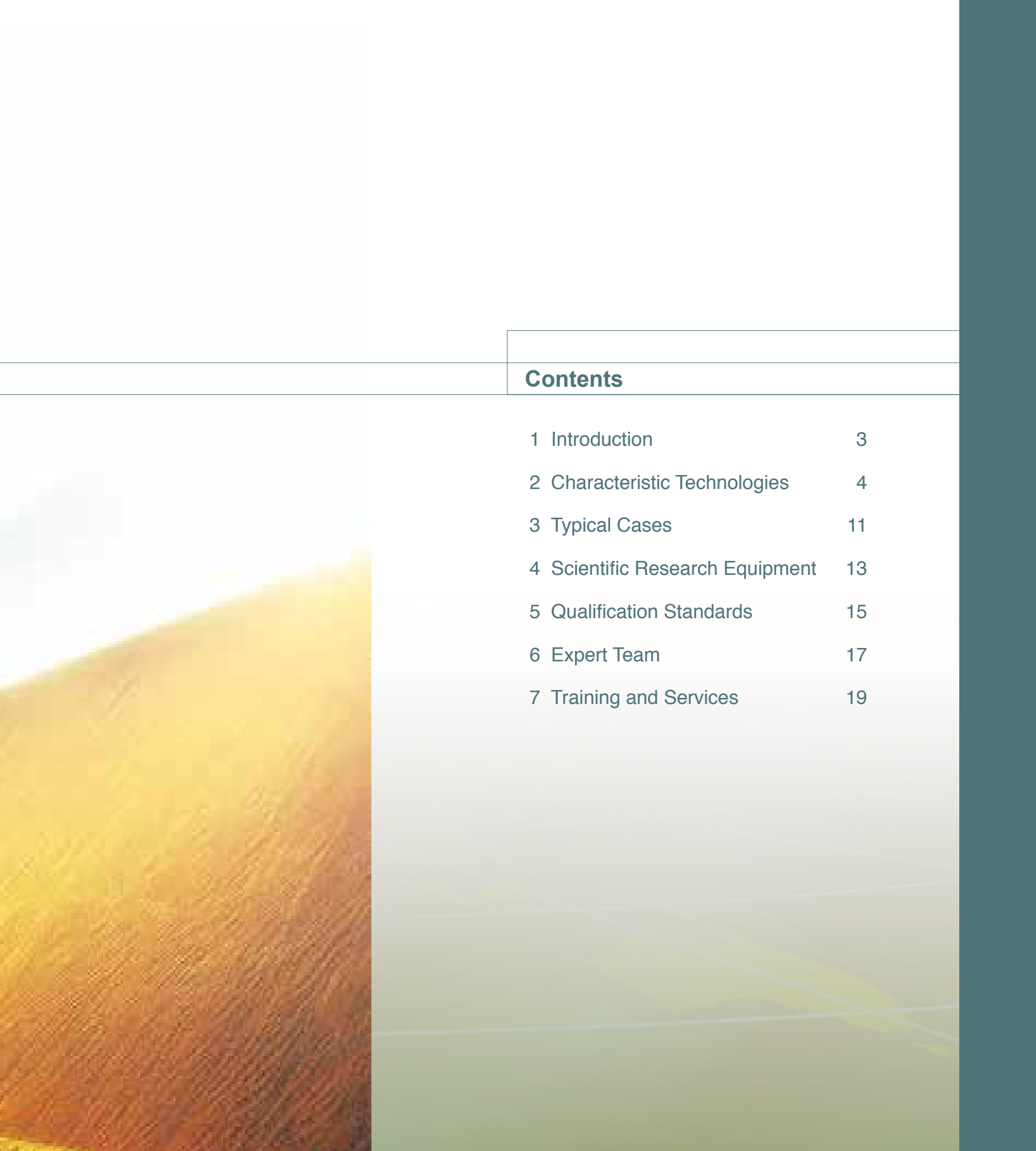
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CHINA NATIONAL PETROLEUM CORPORATION

The background of the slide is a photograph of a desert landscape. In the foreground, there are large, smooth sand dunes with a golden-brown hue. To the left, a drilling rig or seismic acquisition vehicle is parked on a flat, arid plain. The sky is filled with soft, white clouds, and the overall lighting suggests a bright, sunny day.

*G3i Seismograph :
New Generation Large-Capacity Wired
Acquisition System!*



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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.

G3i seismograph is one of representatives for major innovations of CNPC.

OFFERING ENERGY SOURCES, CREATING HARMONY

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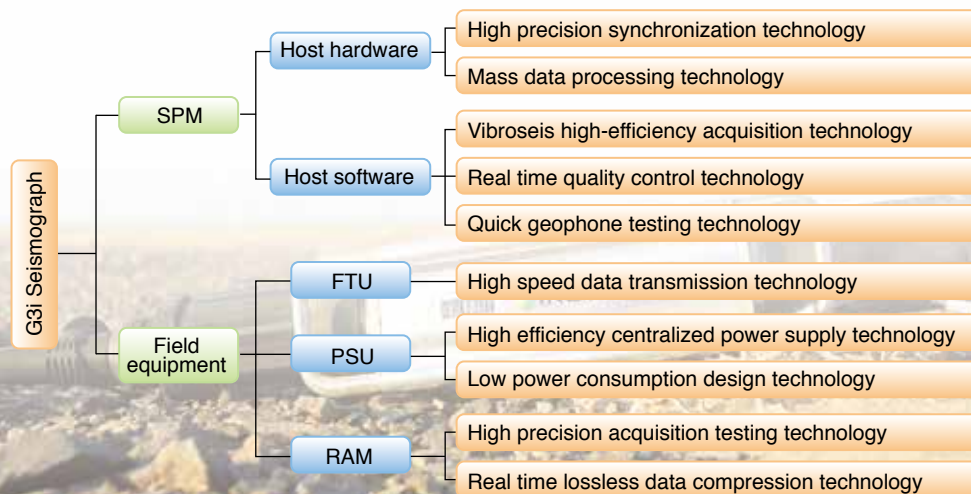
INTRODUCTION

G3i(Generation 3 innovation) seismograph is a set of wired seismograph used in land petroleum exploration and is characterized by strong real time channel capacity, low power consumption, high stability, etc. G3i seismograph is a new generation seismic data acquisition system developed independently by CNPC fully utilizing many years of technological innovations and field operation experience according to the current petroleum exploration and development needs and the exploration technology development direction.

The band/channel capacity of G3i seismograph can reach over 100000 channels, which can not only meet the needs of conventional seismic data acquisition but

also support the acquisition of seismic data with large channel number and high density. Compared with international like instruments, G3i seismograph has advantages in band/channel capacity, single-channel power consumption, transmission speed, quality monitoring, etc. The integral performance of G3i seismograph reaches international leading level and it can complete comprehensive seismic exploration tasks with high precision and wide band.

CNPC is willing to apply G3i seismograph with international advanced level in domestic and foreign exploration and development and provide better services for oil and gas prospecting.



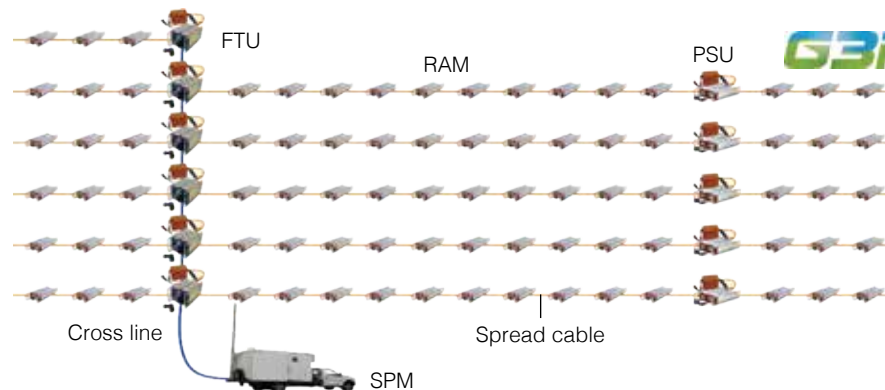
G3i seismograph technology frame

2

CHARACTERISTIC TECHNOLOGIES

G3i seismograph consists of host system (SPM), acquisition unit (RAM), power source unit (PSU), cross unit (FTU), spread cable and crossover cable (optical cable). The whole system works

collaboratively and realizes the functions such as seismic source excitation, data acquisition, data analysis, data storage, etc.



G3i seismograph system composition

Technological advantages of G3i seismograph

(1) The real time channel capacity of G3i seismograph can reach over 100000 channels, which can not only meet the needs of conventional seismic data acquisition but also support the acquisition of seismic data with large channel number and high density;

(2) G3i seismograph supports high efficiency acquisition mode with multiple vibroseises such as Slip-Sweep, DSSS/DSSSS, ISS, V1, etc. and realizes

zero waiting time of slide sweeping;

(3) G3i seismograph uses the low power consumption and high efficiency power supply design technology to reduce the power consumption of the whole system. The average power consumption for a single channel is only 235mW, which reaches international leading level;

(4) With the professional geophone tester function, G3i seismograph can be used to quickly test geophones on site in detail.

2.1 SPM

The SPM of G3i seismograph completes control and management of the whole system as well as seismic data collection, processing, storage, recording, etc. The SPM uses high performance servers and self-developed optical fiber interface cards to improve the performance and stability of the system. G3i seismograph provides three types of SPMs:

Portable SPM: real time channel capacity of 6000 channels;

Standard SPM: real time channel capacity of 60000 channels;

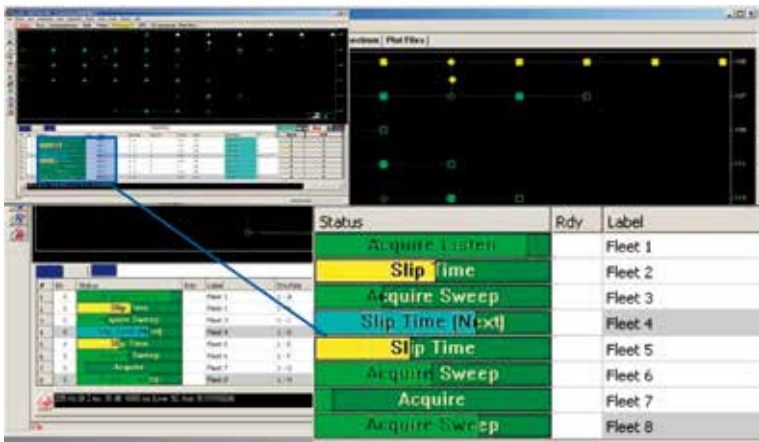
Expanded SPM: real time channel capacity of 100000 channels.



The SPM has the following features:

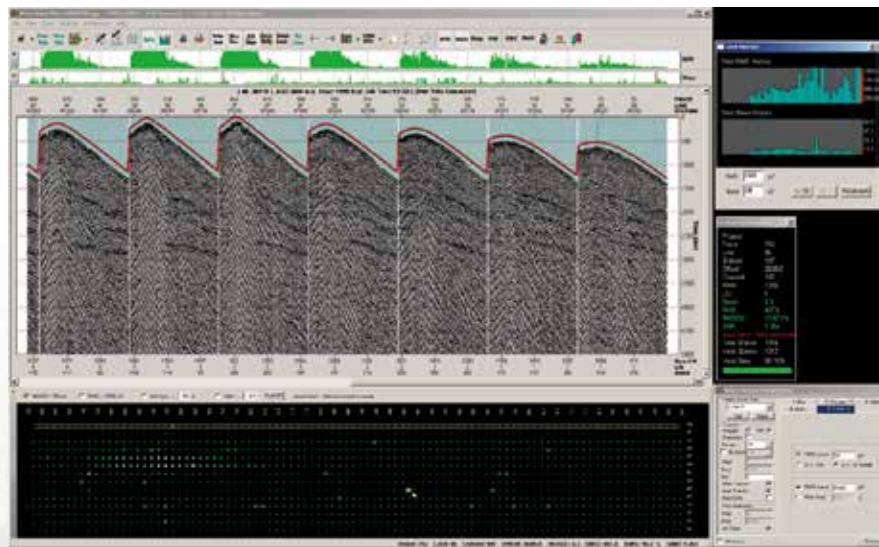
(1) Supporting multiple excitation modes including dynamite source, vibroseis, air gun, hammer, etc.;

(2) Supporting the high efficiency acquisition operation mode with multiple vibroseises such as Slip-Sweep, ISS, DSSS/DSSSS, V1, etc. and realizing zero waiting time of slide sweeping;



High-efficiency acquisition control with seismic source

(3) Supporting real time data quality control (QC) technology, real time calculation, displaying various QC analysis results;



Real time quality control

(4) Integrating professional simulation geophone tester function and performing quick and detailed test of simulation geophones.

Count	TP	Noise μV	Pulse %	Freq Hz	Damp %	Sens V/M/S	Resis Ω	Leak Mohm	THD %	Vel cm/s	Imped Ω
	T1-G	<=	<=	<=	<=	<=	<=	>=	<=	N/A	<=
	T1-G	10.00%	5.00%	10.00%	7.00%	5.00%	0.50	0.2000	N/A	10.00%	
		0.0	9.4	65	19.655	282	>9.99	0.0095	N/A	522	
		0dB	0dB	0dB	0dB	0dB	0dB	0dB	0dB	0dB	
1	T1-G	0.0	9.8	71	19.820	285	>9.99	0.0126	2.415	537	
2	T1-G	0.2	9.8	70	19.706	283	>9.99	0.0134	2.407	530	
3	T1-G	0.0	9.7	69	19.495	282	>9.99	0.0134	2.405	525	
4	T1-G	0.3	9.7	68	19.154	282	>9.99	0.0136	2.404	519	
5	T1-G	0.0	9.6	69	19.414	283	>9.99	0.0134	2.406	523	
6	T1-G	0.4	9.7	69	19.247	283	>9.99	0.0149	2.412	523	
7	T1-G	0.0	9.7	69	19.271	283	>9.99	0.0143	2.409	522	
8	T1-G	0.0	9.7	70	19.650	282	>9.99	0.0152	2.409	529	
9	T1-G	0.0	9.6	67	19.164	282	>9.99	0.0165	2.410	521	
10	T1-G	0.0	9.4	65	19.049	284	>9.99	0.0272	2.406	516	
11	T1-G	0.0	9.6	65	19.374	283	>9.99	0.0245	2.405	521	
12	T1-G	0.0	9.7	67	19.469	276	>9.99	0.0282	2.403	523	
13	T1-G	0.0	9.8	67	19.514	278	>9.99	0.0271	2.402	524	
14	T1-G	0.0	9.5	68	19.151	278	>9.99	0.0156	2.408	510	
15	T1-G	0.0	9.6	68	19.168	276	>9.99	0.0166	2.405	510	
16	T1-G	0.0	9.4	66	18.752	272	>9.99	0.0134	2.406	516	
17	T1-G	1.2	9.6	66	18.797	276	>9.99	0.0133	2.409	516	
18	T1-G	1.4	9.6	65	19.122	281	>9.99	0.0082	2.408	530	
19	T1-G	0.0	9.4	66	18.848	284	8.65	0.0088	2.408	523	
20	T1-G	0.0	9.5	67	19.145	280	>9.99	0.0088	2.408	525	

Geophone testing

2.2 RAM

The RAM of G3i seismograph acquires analog seismic data from the seismic geophone, converts the data into a digital signal and then transmits it

to the FTU via the spread cable. Each RAM has four channels and uses the station-line separation structure.



RAM

(1) Low power consumption, average power consumption 235mW for a single channel, which takes the lead among international like products;

(2) High data transmission rate, which can reach 30Mbps;

(3) The LED indicator light shows station body status in real time;

(4) Aluminum alloy housing, resistant to static electricity and electromagnetic interference, strong resistance to lightning stroke, and suitable for various land surfaces.



Suitable for various land surfaces

2.3 FTU

The FTU of G3i seismograph connects spread cable (survey line) and cross line. The data acquired by the RAM is forwarded via the cross line to the SPM

on the seismograph truck. The FTU integrates the function of the PSU and provides two-way power to the RAM.



FTU

(1) The real time band/channel capacity is 60000 channels; after using data compression technology, it reaches 100000 channels. The single-side real time band/channel capacity of survey line is 1800 channels; after using data compression technology, it reaches 2700 channels;

(2) Integrating the function of the PSU and RAM;

(3) The LED indicator light shows station body status in real time;

(4) Aluminum alloy housing, resistant to static electricity and electromagnetic interference, strong resistance to lightning stroke, and suitable for various land surfaces.

2.4 PSU

The PSU of G3i seismograph provides one-way power to the RAM. The PSU integrates the function of the RAM and each PSU has four channels.

(1) The centralized power supply (PDL) technology is used and electrical quantity is uniformly distributed to each RAM;

(2) Integrating the function of each RAM;

(3) The LED indicator light shows station body status in real time;

(4) Aluminum alloy housing, resistant to static electricity and electromagnetic interference, strong resistance to lightning stroke, and suitable for various land surfaces.



PSU

2.5 Spread cable

The spread cable is used to transmit data and commands between field stations; in addition, the PSU and FTU supply power to the RAM via the spread cable.

(1) The tensile strength is up to 318kg(700lb) and the spread cable is the cable with the highest strength-to-weight ratio in the industry;

(2) Cable joints are designed as 12-pin “quick locking joints”, so that the spread cable connects station units quickly and accurately;

(3) Provide cables with multiple lengths and tap spacing;

(4) The spread cable is compatible with multiple geophone taps.



Spread cable



Cross line (optical fiber cable)

2.6 Cross line

The cross line of G3i seismograph connects the FTU with the SPM.

(1) The cross line uses the optical fiber cable with Gigabit transmission rate, and the highest transmission rate reaches 1.2288Gbps;

(2) The cross line is designed with high tensile strength, which reaches 61.18kg(134.91b).

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TYPICAL CASES

3.1 Qaidam basin

G3i seismograph of 60000 channels was used in 3D acquisition in Xinjiang oilfield in Dec. 2013. Vibroseis DSSS was used in project operation. The project operation period is 40 days, the daily average

production efficiency 7269 shots, and the highest daily efficiency 12316 shots. This has created a new record of daily geophysical production efficiency in China and has been highly recognized by international large petroleum companies such as Shell, ENI, Saudi Aramco, etc.



Field operation site

3.2 Tuha basin

CNPC used G3i+low frequency vibroseis + DSS high efficiency acquisition mode to favorably complete industrial land exploration firstly using 1.5Hz low

frequency vibroseis globally in Kazakhstan in Aug. 2013. The average daily efficiency of field acquisition is up to 3157 shots, thus creating a record of seismic data acquisition in Central Asia.



Field operation site

3.3 Junggar basin

G3i seismograph was used in 3D acquisition in Junggar basin in Dec. 2012. During operation, vibroseis was used in slide sweeping excitation and the seismograph experienced complex climate

involving low temperature (minimum temperature -33°C), rain, snow, etc. The field acquisition task of 407km^2 and 158150 shots was favorably completed within 44 days; the average daily acquisition efficiency was 3594 shots; the highest daily efficiency was 6200 shots.



Field operation site

4

SCIENTIFIC RESEARCH EQUIPMENT

The laboratory of INOVA R&D Center has 20 pieces (sets) of various instruments and R&D tools, including 4 pieces (sets) of symbolic units and 10 pieces (sets) of instruments and equipment reaching international advanced level. The integral equipment test level and capacity of the laboratory reach international advanced level.

4.1 Micro-focus X-ray welding spot testing system

High resolution 2D X-ray technology and computed tomography technology are combined in a system used mainly in real time X-ray testing of welding spots and electronic components. The system is used in welding testing of semiconductors, PCB and SMT small components and provides higher defect

coverage ratio while improving production efficiency. The system is used mainly in welding testing of G3i field station units.

4.2 High temperature dynamic burn-in testing system for integrated circuits

The high temperature dynamic real-time burn-in testing system for integrated circuits can be used to conduct high-temperature dynamic burn-in testing of digital and analog integrated circuits. The system can conduct burn-in testing of different components at the same time, automatically detect out failure components during burn-in testing, and randomly revise parameters according to the burn-in testing requirements of users. The system is used mainly in quality inspection of G3i station units, product analysis and component screening testing.



Micro-focus X-ray welding spot testing system (PCB analyser 160)



(SPIC-T) high temperature dynamic testing system for integrated circuits

4.3 High and low temperature test chamber

The high and low temperature test chamber provides a stable high and low temperature impaction test environment and uses a color LCD touch screen to set and display various operating parameters. The test chamber records a large quantity of sampling

data in real time and provides functions including over temperature protection, test product protection, equipment self-protection, operating personnel safety protection, etc. The test chamber is used to test various performance indexes of station units in the case of alternate variation of high temperature and low temperature of G3i station units.



High and low temperature test chamber

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QUALIFICATION STANDARDS

G3i seismograph was studied and developed by the globally leading land exploration equipment supplier—INOVA (Tianjin) Geophysical Equipment Limited controlled by CNPC. INOVA sets up its R&D departments in Zhuozhou and Xi'an of China, Calgary, Canada, Houston, US, and Edinburgh, UK. Many experienced international experts have formed

a global R&D team. INOVA sets up production plants in Xi'an and Calgary and is a large geophysical equipment company integrating R&D, production and marketing. The production plants in Xi'an and Calgary have passed ISO9001 : 2008 quality management system certification.



Intellectual property rights

1 enterprise standard has been formulated, and an application has been made for 16 invention patents, including 5 China patents and 11 US patents.

No.	Name of intellectual property rights	Type of intellectual property rights	Application No./ authorization No.
1	Checking Items and Technical Indicators for G3i Seismic Data Acquisition System	Enterprise standard	Q/SY BGP.K2852-2013
2	Clock synchronization over optical fiber	China invention patent	201210318928.5
3	Multi-pair power distribution	China invention patent	201210318494.9
4	Analog in power module	China invention patent	201210318927.0
5	Thread locking feature for use with connectors	China invention patent	201210318982.X
6	Sealing feature for use with connectors	China invention patent	201210318866.8
7	Seismic Frequency Sweep Enhancement	US invention patent	US 61/535.767
8	Method of Seismic Source Synchronization	US invention patent	US 61/596.729
9	Method of Seismic Source Independent Operation	US invention patent	US 61/596.660
10	Method of Seismic Vibratory Limits Control at Low Frequencies	US invention patent	US 61/596.676
11	Method of Seismic Source Synchronization	US invention patent	US 61/535.770
12	Clock Synchronization Over Fiber	US invention patent	US 61/590.662
13	Multi-Pair Power Distribution	US invention patent	US 61/590.670
14	High Precision Time Synchronization for a Cabled Network in Linear Topology	US invention patent	US 61/590.712
15	Analog in Power Supply Module	US invention patent	US 61/590.681
16	Thread Locking Feature for Use with Connectors	US invention patent	US 61/590.641
17	Sealing Feature Fore Use With Connectors	US invention patent	US 61/590.630

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EXPERT TEAM



Glenn Hauer

As the person responsible for G3i seismograph project, he is responsible for R&D, application and popularization of G3i seismograph. He was engaged in seismic data processing in Canada in the early years. He once took charge of R&D of multiple seismographs. He has been long engaged in R&D management, popularization, etc. of seismographs and has over 30 years of technical experience in seismographs and relevant industries.

Tel: +1.281.568.2005

Email: Glenn.Hauer@inovageo.com



Tim Hladik

As the person responsible for G3i seismograph research and development, he is responsible for R&D management of G3i seismograph. He was once engaged in seismograph hardware development work in Canada. He has participated in or taken charge of overall design and development of large seismographs many times and has over 20 years of seismograph R&D experience.

Tel: +1.403.537.2168

Email: Tim.Hladik@inovageo.com



Brian Klatzel

He is the person responsible for the development of the host software system of G3i seismograph. He was once engaged in R&D of seismic data processing software and seismic exploration instrument software in Canada. He has taken charge of architecture design and development management of multiple software products and has over 30 years of experience in seismic instrument related technology and software.

Tel: +1.403.537.2143

Email: Brian.Klatzel@inovageo.com

EXPERT TEAM



Ai Hua

He is the person responsible for the firmware development of field stations of G3i seismograph. He was once engaged in the development of firmware and embedded software for land seismographs in Canada. He has participated in the development of firmware and embedded software for seismographs many times and has over 10 years of seismograph firmware development experience.

Tel: +1.403.516.3082

Email: Hua.ai@inovageo.com



Jiang Geng

Senior engineer. He once held the post of instrument operator and acquisition team leader of an exploration team of BGP. He is responsible for management of electronic, measurement and seismic instruments and matching equipment and offshore exploration management work. He has over 30 years of experience in application, management and development of seismographs.

Tel: 0312-3737918

Email: Jiang.geng@inovageo.com



Luo Fulong

Professor level senior engineer. He is responsible for testing, application and perfecting of G3i seismograph. He once took charge of testing, perfecting and popularization of multiple seismographs. He has over 30 years of experience in operation, testing, development and perfecting of seismographs.

Tel: 0312-38202843

Email: luofulong@cnpc.com.cn



Luo Lanbin

Senior engineer. He is engaged in operation, maintenance, technical service, development, etc. of seismographs. He is responsible for hardware development of "ES109 10000-channel seismographs". He has over 10 years of experience in application of seismographs and nearly 10 years of development of seismographs.

Tel: 0312-3737923

Email: Luo.lanbing@inovageo.com

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TRAINING AND SERVICES

Provide various levels of training courses in multiple languages. In addition, training can be performed in each region and training schemes for specific products can be formulated as needed by customers.



Training site

Experienced field technical support personnel and professional maintenance service centers are widely distributed in Asia, America, the Middle East and Europe and timely provide the best services.



Field services



技术依托单位联系人：

罗兰兵 先生

电 话：0312-3737923

Email: Luo.lanbing@inovageo.com

Contact of the Technical Support Unit：

Mr. Luo Lanbing

Tel: 0312-3737923

Email: Luo.lanbing@inovageo.com

中国石油科技管理部联系人：

刁 顺 / 窦红波 先生

电 话：86-10-59986059/59982528

Email: sdiao@cnpc.com.cn/ douhb@cnpc.com.cn

**Contact of Science&Technology
Management Department,CNPC：**

Mr. Diao Shun/Dou Hongbo

Tel: 86-10-59986059/59982528

Email: sdiao@cnpc.com.cn/ douhb@cnpc.com.cn



