



Intelligent Pipeline Detector

Science & Technology Management Department, CNPC

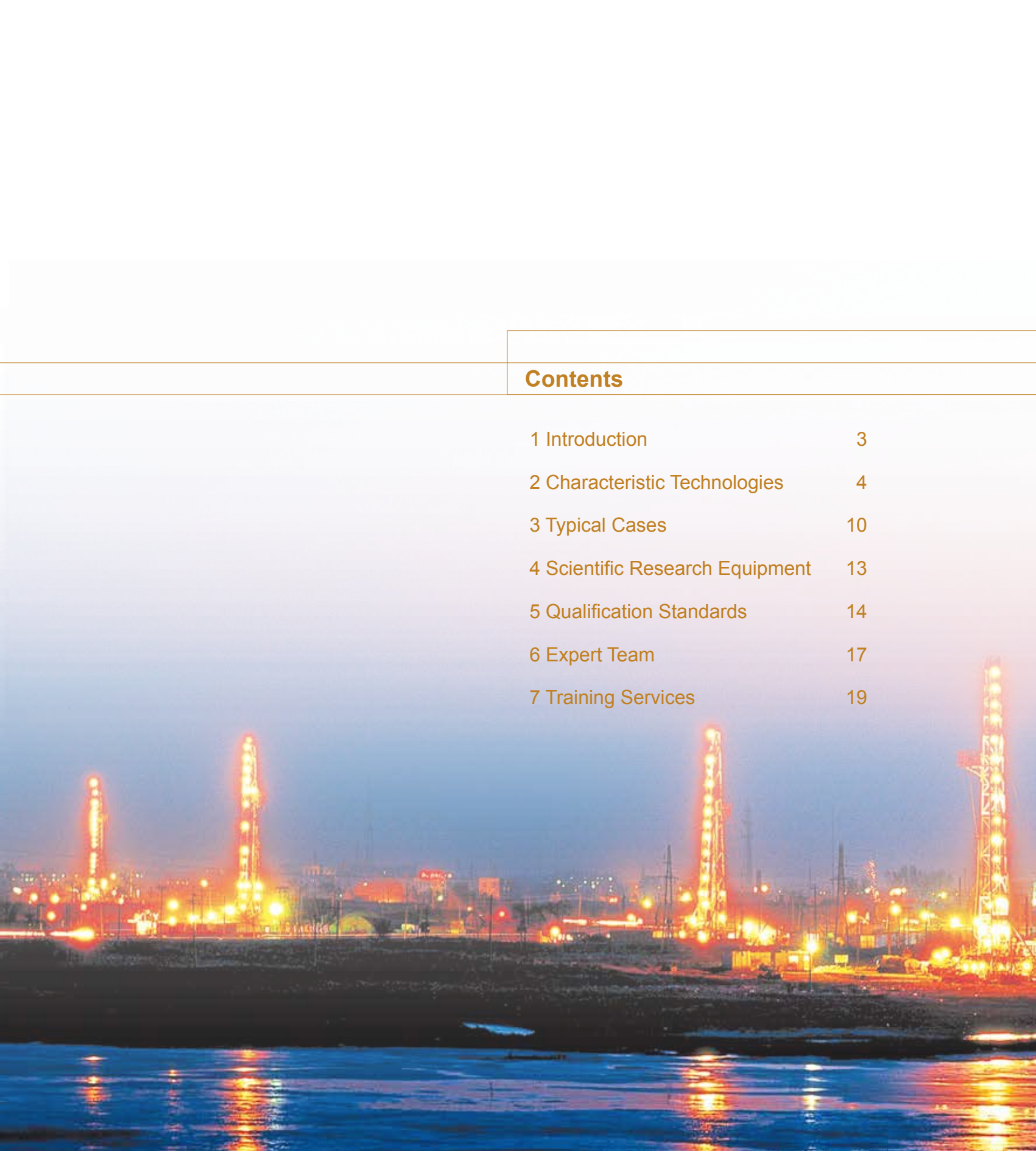
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CHINA NATIONAL PETROLEUM CORPORATION

*The Safety Examination Expert of
Oil and Gas Pipeline !*





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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.

The intelligent pipeline detector is one of representatives for major innovations of CNPC.

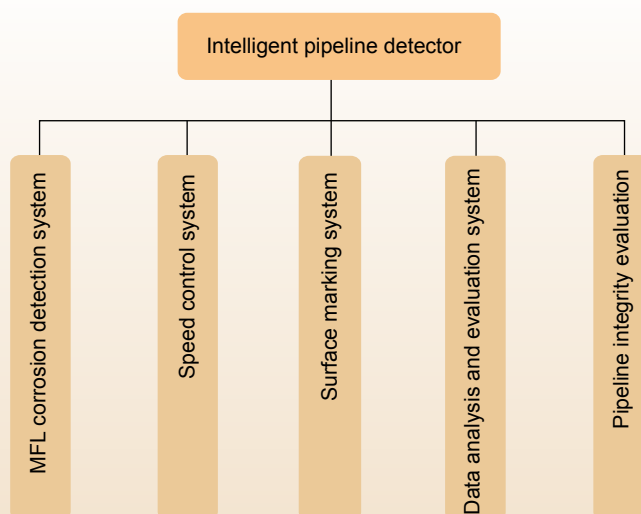
OFFERING ENERGY SOURCES, CREATING HARMONY

1

INTRODUCTION

China Petroleum Pipeline Bureau (hereinafter abbreviated to CPP) is a specialized pipeline engineering company of CNPC. Adhering to the concept of “creation and unlimited dedication” and the core values of “challenge, fineness, innovation, team and harmony”, CPP is devoted to building it into an internationally first-class international pipeline general contractor that ranks first in China. CPP has professional intelligent detection technologies and can provide users with “package” solutions and “one-

stop” services. CPP can provide oil, gas and slurry pipeline MFL correction detection technology services and perfect data analysis reports to users. CPP has provided relevant detection technology services to most oil and gas transmission pipelines in China and can perform periodical detection of long-distance oil and gas pipelines. CPP has entered overseas pipeline detection service fields including Sudan, Libya, Syria, Kazakhstan, Uzbekistan, India, etc.



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CHARACTERISTIC TECHNOLOGIES

The intelligent pipeline MFL detector is mainly used in base line detection of new pipelines and inner and outer wall corrosion detection of in-service pipelines. Internal detection can be performed for metal loss on a steel pipeline on the premise of no affecting its normal operation, for purposes of determining the magnitude and position of metal loss of inner and outer walls of the pipeline and making for risk evaluation, maintenance and repair of the pipeline. CNPC has intelligent pipeline MFL detectors of different apertures ranging from 6in to 48in.

2.1 MFL corrosion detection system

The intelligent pipeline MFL detector is suitable for oil and gas pipeline detection and is mainly used in baseline detection of in-service pipelines and new pipelines. The intelligent pipeline MFL detector can perform internal detection of metal loss on a steel pipeline, for purposes of determining the magnitude and position of metal loss of inner and outer walls of the pipeline and providing bases for safety operation, maintenance and management of the pipeline.

According to the form of the signal acquired by the probe of an intelligent pipeline MFL detector, it can be divided into uniaxial high definition intelligent pipeline MFL detector and triaxial high definition intelligent pipeline MFL detector.

The uniaxial high definition intelligent pipeline MFL detector can be used for 6in to 48in oil and gas pipelines.



Figure 2-1 The $\phi 1016$ intelligent pipeline detector



Figure 2-2 The intelligent pipeline detectors of different apertures

The uniaxial high definition intelligent pipeline MFL detection system is stable and reliable and has high precision. For its specifications, see Table 2-1.

Table 2-1 Specifications of the uniaxial high definition intelligent pipeline MFL detector

Type	Detected critical point	Depth precision, mm	Length precision, mm	Width precision, mm
Large area corrosion (Area ≥ 3A×3A)	8% wt	±12	±15	±20
Pit, point (Area < 3A×3A)	10% wt	±15	±12	±15
Axial poisoning precision	±0.1 (Crater position for relative reference)			
Circumferential poisoning precision	±5°			
Credibility	≥ 85%			

Note: wt(t) is normal pipeline wall thickness: A: when t < 10mm, A=10mm; when t ≥ 10mm, A=t.

The triaxial high definition intelligent pipeline MFL detector (Figure 2-3 and Figure2-4) can detect the magnetic leakage field at the defect position of a pipeline axially, circumferentially and radially. Defect size can be quantized more accurately and defect quantization precision can be improved using

circumferential and radial magnetic field components. The detector has obvious advantages in identifying axial narrow and long defects, welding seam defects and sag defects, realizes high definition detection and has irreplaceable advantages in defect identification and quantization.



Figure 2-3 The $\phi 1219$ triaxial intelligent pipeline detector



Figure 2-4 The $\phi 711$ triaxial intelligent pipeline detector

The triaxial high definition intelligent pipeline MFL detector can be used for 6 in to 48in oil and gas pipelines. For its specifications, see Table 2-2.

Table 2-2 Specifications of the triaxial high definition intelligent pipeline MFL detector

	Large area defect (4A×4A)	Pit defect (2A×2A)	Axial notch (4A×2A)	Circumferential notch (2A×4A)
Detection threshold (90% Detection probability)	5%wt	10%wt	15%wt	10%wt
Depth precision (80% Confidence level)	±8%wt	±10%wt	±15%wt	±10%wt
Length precision (80% Confidence level)	±10mm	±10mm	±15mm	±12mm
Width precision (80% Confidence level)	±10mm	±10mm	±12mm	±15mm

2.2 Speed control system

The speed control system consists of speed control unit and standby safety device and can be carried on the intelligent detector (Figure 2-5 and Figure 2-6). For the gas transmission pipeline with large displacement and high flow velocity, the speed control

unit controls the equipment running speed within a predetermined range and ensures the safety and effectiveness of pipeline detection by adjusting the discharging channel on the premise of not affecting the normal transmission capacity of the pipeline.

The speed control system developed by CNPC has filled up the gap in China and has reached the international advanced level in specifications.



Figure 2-5 The $\phi 1016$ triaxial MFL corrosion detection with speed control system



Figure 2-6 Opening of speed control system discharging device



Figure 2-7 MAGM surface marker



Figure 2-8 MAGM surface marker composition

2.3 Surface marking system

The surface marking system is the external positioning part of the whole intelligent pipeline detector and is the key equipment for eliminating the cumulative mileage error of the detector and accurately positioning pipe wall defects by recording the information when the detector passes through a marking point.

MAGM high-intensity magnetic surface marking system is the positioning instrument that is buried above a pipeline and performs time marking of the traveling process of the internal MFL detector. The system is an important component during intelligent pipeline detection.

2.4 Data analysis and evaluation system

The data analysis and evaluation system can analyze the pipeline signal detected by the intelligent pipeline detector, obtains the pipeline defect information and quantitatively identifies defects, thus finally obtaining an integral and accurate detection report.

The data analysis report can provide the following contents:

(1) Provide the accurate position and size of metal loss defects such as pipeline corrosion, mechanical

damage, tubular product defects, welding seam defects, etc.

(2) Provide the accurate position and size of geometric deformation defects involving pipeline sag, ellipticity, etc.

(3) Provide the specific position of pipeline accessories such as valves, tees, bends, flanges, anchoring piers, etc.

(4) Provide the pipeline information on pipeline wall thickness variation, pipe section length, welding seam and intersection point position, etc.

(5) Provide the specific position of the third party damage including boring, stealing oil, etc.

(6) Provide the GPS coordinates of pipeline features involving all defects, accessories, welding seams, etc. on a pipeline.

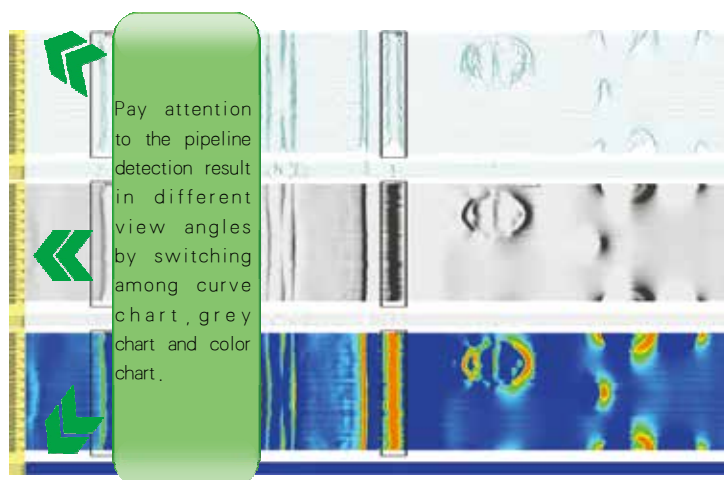


Figure 2-9 Pipeline detection data display chart

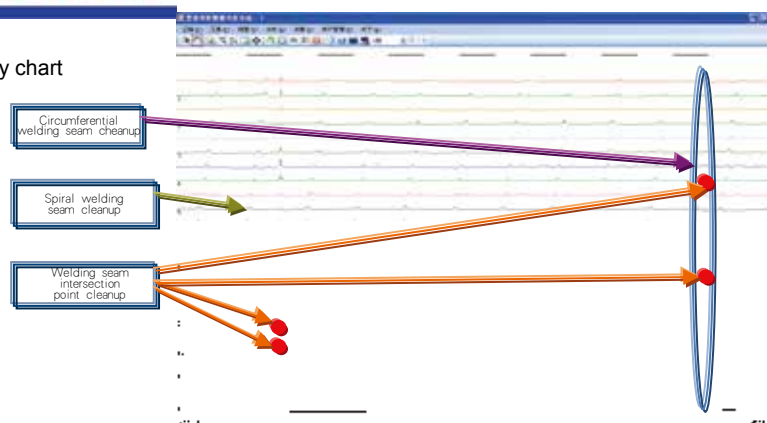


Figure 2-10 Pipeline detection data curve chart

2.5 Pipeline integrity evaluation

Pipeline integrity evaluation is intended to carry out residual strength evaluation and residual life prediction of defect pipelines using detection data, make suggestions on early-warning and repair work of hidden defects, reduce pipeline maintenance cost and ensure safe, stable and highly effective pipeline operation (Figure 2-11).

The integrity evaluation of defective pipelines:

(1) Evaluation of the residual strength of a single defect point;

(2) The evaluation result can be outputted in the form of report;

(3) The software has detailed data query function;

(4) The example data provided by standards or retrieval data can be used to verify the correctness of programming;

(5) Provide suggestions on maintenance and repair of defective pipelines according to the evaluation result;

(6) User management module.

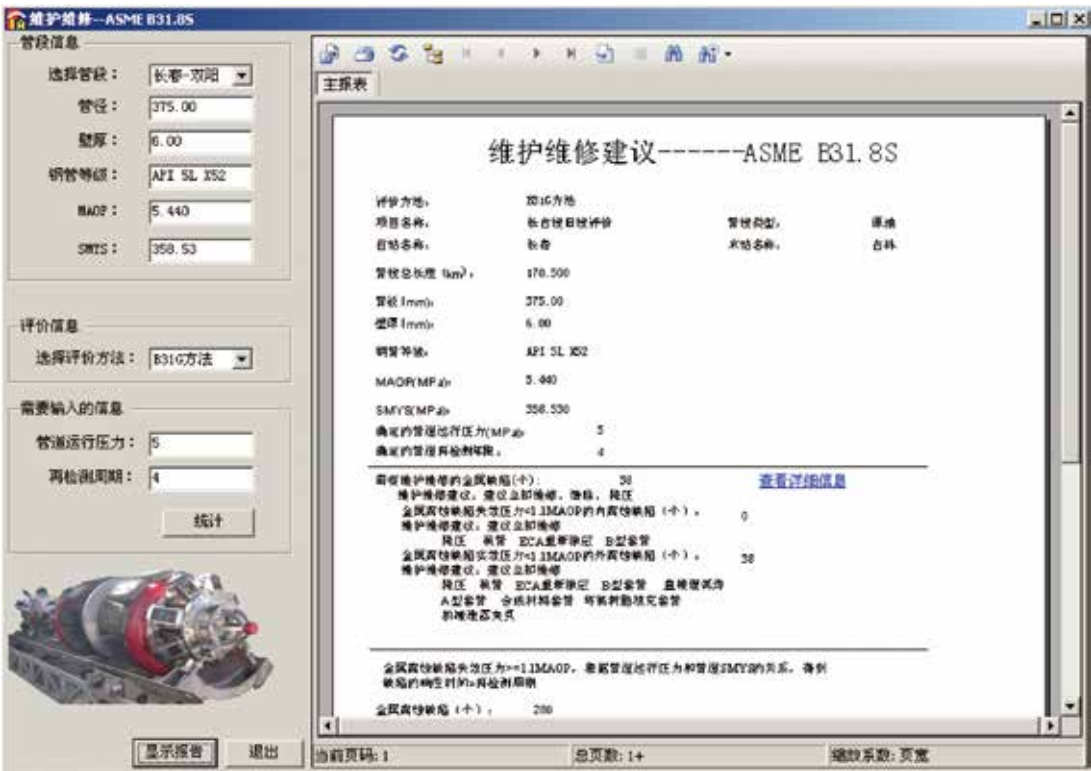


Figure 2-11 Analysis of evaluation data and provision of suggestions on maintenance and repair

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TYPICAL CASES

3.1 Internal detection engineering of the high temperature and high wax oil pipeline with a long single section (320km) downstream of areas 1, 2 and 4 in Sudan

The pipeline downstream of areas 1, 2 and 4 in Sudan belongs to Great Nile Petroleum Company and is the artery of transmission of the crude oil of oilfields in the south of Sudan. CNPC carried out internal

detection of the $\phi 711$ and $\phi 813$ pipelines using the intelligent pipeline detector in 2001 and 2007, with the detection length of 1505km. The difficulties such as high temperature (75°C), high wax content, long single section distance (320km) and others were overcome, and pigging, detection and site excavation and verification of the whole pipeline were completed. This has ensured safe operation of the pipeline and has been highly appreciated by the Owner.



Figure 3-1 The $\phi 711$ intelligent pipeline detector



Figure 3-2 Pig launching for intelligent detection of $\phi 711$ pipeline

3.2 Triaxial intelligent pipeline detection project for West-East NG Transmission Line 1 with large displacement and high pressure

According to the features of West-East NG Transmission Line 1 such as large displacement, high pressure, high flow velocity, etc., CNPC used the

triaxial intelligent pipeline MFL detector with a speed control system to carry out internal intelligent pipeline detection with the detection distance of over 1300km in Sept. 2013. After the detection, data is good and the excavation result is consistent with the data analysis report. This has been highly accepted and appreciated by the Owner.



Figure 3-3 The $\phi 1016$ triaxial intelligent pipeline detector



Figure 3-4 The $\phi 1016$ triaxial intelligent pipeline detector

to be continue

CPP undertakes pipeline detection engineering in CNPC. CPP has successfully entered the international markets in Sudan, Syrian, UAE, India, Central Asia, etc., in addition to the detection markets including SINOPEC, CNOOC, Sinochem Group, Shell (China), etc.

List of some projects
Internal detection technology service project for West-East NG Transmission Line (Lunnan—Kongquehe)
Detection of submarine gas pipeline of Shanghai Oil and Gas Company
Internal detection engineering for Sege gas transmission pipelineK106—terminal pipeline
Huage oil transmission pipeline detection engineering
Internal detection of Zhanmao petrochemical pipeline

List of some projects
Intelligent detection project for Wanghua branch of west pipeline
Internal detection project for Lunku gas transmission pipeline
Qing—Ha oil pipeline detection project
Detection of Nanjing Ganghua natural gas “Men-zhan—Tiexinqiao” pipeline
Internal detection engineering for China Aviation Oil pipeline
Suzhou urban gas high pressure pipeline detection engineering
Shenzhen gas pipeline detection engineering
Detection of the north trunk line of Shell Changbei Natural Gas Processing Plant
Maguang oil transmission pipeline detection

4

SCIENTIFIC RESEARCH EQUIPMENT

4CNPC has built a national oil and gas pipeline laboratory (pipeline engineering test base), which is fitted with a pipeline monitoring/detection professional laboratory. CNPC has the largest intelligent pipeline detector testing center and various testing units for pipeline technology research and has successfully developed a series of intelligent detectors with international advanced level.

The national engineering laboratory can perform

detector traction tests at different speeds and a calibration test on the mechanical dynamic performance and MFL technical performance of detection equipment. A defect test database is established according to different standard defect models on test pipe sections. The pipeline detection laboratory has established a foundation for safe and reliable application of pipeline detectors in industrial site.



Figure 4-1 Experiment center for traction test



Figure 4-2 Traction test



Figure 4-3 Linear test bench of national engineering laboratory



Figure 4-4 Rotary test bench of national engineering laboratory

5 QUALIFICATION STANDARDS

CNPC has industrial and domestic and foreign professional qualifications in oil and gas pipeline detection field and over 40 oil and gas pipeline detection patents.





List of patents

No.	Country	Patent type	Patent No./application No.	Patent name
1	China	Invention patent	ZL200710119096.3	Pipeline MFL detector circuit board structure
2	China	Invention patent	ZL200710118862.4	Mechanical system of pipeline MFL detector
3	China	Invention patent	ZL200710100234.3	Floating ring of buried steel pipeline corrosion detector probe
4	China	Invention patent	ZL200710100232.4	Sprint of pipeline corrosion detector probe
5	China	Invention patent	ZL200710100233.9	Packaging structure and packaging process of buried steel pipeline corrosion detector probe
6	China	Invention patent	ZL200710117985.6	Cable connection circuit of pipeline MFL detector probe
7	China	Utility model patent	ZL200620158737.7	Hinge of pipeline corrosion detector probe
8	China	Utility model patent	ZL200620158739.6	Pipeline corrosion detector probe slider
9	China	Utility model patent	ZL200620158735.8	Floating leather cup mechanism of pipeline MFL detector
10	China	Utility model patent	ZL200620173569.3	Electric wire joint packaging structure of pipeline corrosion detector probe
11	China	Utility model patent	ZL200620158743.2	Steel brush of pipeline MFL detector
12	China	Utility model patent	ZL200620158736.2	Support roller of pipeline MFL corrosion detector
13	China	Utility model patent	ZL200720149475.2	Pipeline detector sending device
14	China	Utility model patent	ZL200720149474.8	Pipeline detector retrieving device
15	China	Utility model patent	ZL200720149476.7	Leather cup overturning testing device
16	China	Utility model patent	ZL200820109870.2	A pipeline caliper measurement pig
17	China	Utility model patent	ZL200820122972.8	A PUR elastic probe arm
18	China	Utility model patent	ZL200920105973.6	A pipeline deformation detector probe mechanism
19	China	Utility model patent	ZL201020597198.3	A pipeline MFL detector magnetic circuit structure
20	China	Utility model patent	ZL201120119976.2	A two-way pig for pipeline pressure control drainage
21	China	Utility model patent	ZL201120054104.2	Full digital 3D MFL signal acquisition system for metal pipeline corrosion defects
22	China	Utility model patent	ZL201220386773.4	Internal detection device for pipe wall axial crack defects based on magnetostrictive effect
23	China	Utility model patent	ZL201220379813.2	Probe mechanism of oil and gas pipeline crack detector

6

EXPERT TEAM

CNPC has a first-class detection expert team with over 30 professor level senior engineers as the core and can provide users with perfect technical services and consultancy schemes.



Cao Chongzhen

Pipeline detection expert, senior engineer. He has been engaged in technical service business involving pipeline detection, pipeline plugging, maintenance, rush repair and so on for many years. He has undertaken the R&D of multiple detection and equipment plugging projects and organized multiple domestic and foreign pipeline technology service and construction projects. He has plentiful theoretical knowledge and practice experience. He has obtained over 10 patents. Over 10 papers written by him have been published.

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Li Jiuchun

Pipeline detection expert, professor level senior engineer. He once served as the principle of the high definition MFL detection equipment R&D project. He has organized foreign pipeline engineering detection projects in Sudan, Syrian, etc., and domestic pipeline engineering detection projects. He has obtained over 20 patents. Over 10 papers written by him have been published.

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Bai Shiwu

Pipeline detection expert, professor level senior engineer. He has organized and completed multiple national, provincial and ministerial NDT research projects. He has obtained 10 national patents. 5 monographs and over 30 papers written by him have been published.

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Chang Liangeng Pipeline detection expert, senior engineer. He has been engaged in pipeline detection services for many years. He has organized and completed multiple national and CNPC's research projects. He is experienced in the detection field. He has obtained over 10 patents. Over 10 relevant papers written by him have been published.

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Chen Chongqi Pipeline detection expert, senior engineer, technical lead of national scientific research projects. He has participated in completing multiple pipeline detection research tasks. He has obtained over 10 patents. Over 10 relevant papers written by him have been published.

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7

TRAINING SERVICES

CNPC has comprehensive technical service advantages. CNPC can independently complete a series of technical services involving pipeline detection and pipeline excavation verification, and all these technical services are completed by our professional technical personnel, thus avoiding the fact that some foreign enterprises provide only 1 to 2 professional foreign technical personnel. Other work including in-depth cleaning and pigging, detection sending, tracking, receiving, excavation verification, etc. is completed by the Owner or externally-employed personnel, thus avoiding a series of trouble to the Owner or a series of problems such as equipment

sticking and blockage, misoperation, etc. caused by externally-employed nonprofessional personnel.

Establish a perfect after-sales service system. The most important value of detection is data report. Our company provides the Owner with data report training services; in addition, when the Owner performs pipeline maintenance and repair as per the data report, our company can provide site guidance services and makes every effort to solve the Owner's worries.

Our company has quick response capacity, we can timely reach the site and provide technical services according to the time required by the Owner.



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