Cyclic High Pressure Gas Injection Development Technology of Condensate Gas Reservoir

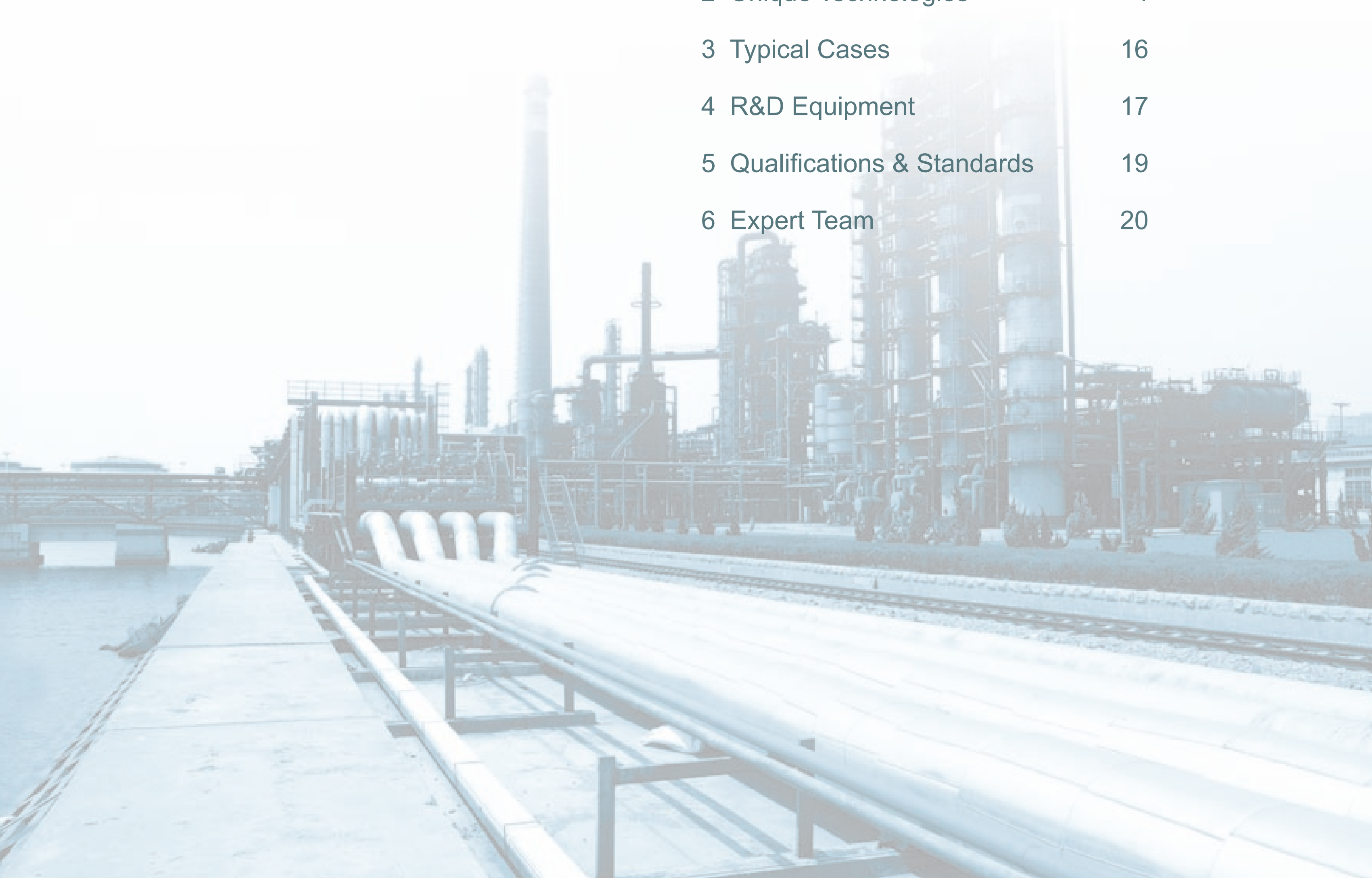
Science & Technology Management Department

2013

CHINA NATIONAL PETROLEUM CORPORATION

Cyclic High Pressure Gas Injection makes Condensate Gas Reservoir Development Effective and Sustainable!

Contents



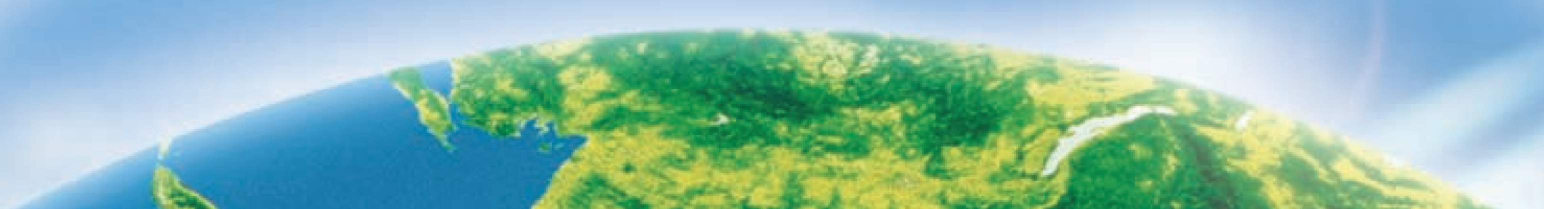
China National Petroleum Corporation (CNPC) is a state-authorized investment agency and a state holding company. On July 1998, with the implementation of the Institutional reform of the State Council, CNPC was reorgnized to become an integrated oil company of cross-regions, cross-industries and cross-countries, 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 2012 CNPC produced 110 million tons of crude oil and 79.82 billion cubic meters of natural gas, while crude processing volume reached 191 million tons. The total revenue of RMB 2,690 billion with a profit of RMB139.1 billion had been achieved the same year.

CNPC was ranked 4th among the world's largest 50 oil companies and 6th in Fortune Global 500 in 2012.

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.

Cyclic High Pressure Gas Injection Development Technology of Condensate Gas Reservoir is one of representatives for major innovations of CNPC.

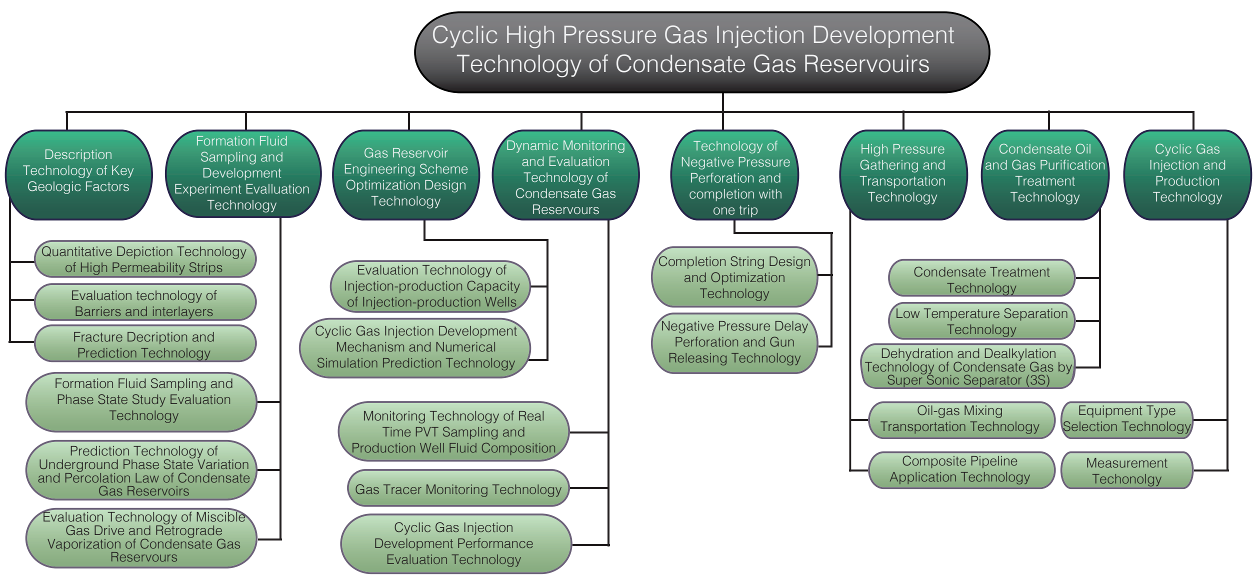
CLEAN ENERGY SUPPLY FOR BETTER ENVIRONMENT



1 INTRODUCTION

Condensate gas reservoirs generally refer to the gas reservoirs which the heavy components and a small quantity of high molecular hydrocarbons accumulated underground are dispersed in natural gas in uniform vapor state under the temperature and pressure of reservoir. Through over 20 years of scientific research and field research according to the features of condensate gas reservoirs such as complex variation of formation fluid phase states and complex percolation law, CNPC has made a significant breakthrough in the fields including geologic and gas reservoir engineering, gas production technology, surface process, etc. and has formed cyclic high pressure gas injection development and relevant matching technologies for condensate gas fields including 8 major technology series and 20 unique technologies involving description of key geologic factors, formation fluid sampling and development experiment evaluation, gas reservoir engineering scheme optimization design, dynamic monitoring and evaluation of condensate gas reservoirs, integrated negative pressure perforation and completion, high pressure gathering and transportation technology, condensate oil and gas purification treatment technology and cyclic gas injection and production technology.

In addition, CNPC has successfully developed the condensate gas reservoirs such as Yaha, Kekeya and Dazhangtuo and has greatly increased their condensate oil recovery ratio by 22%, 18.2% and 14.9% respectively.



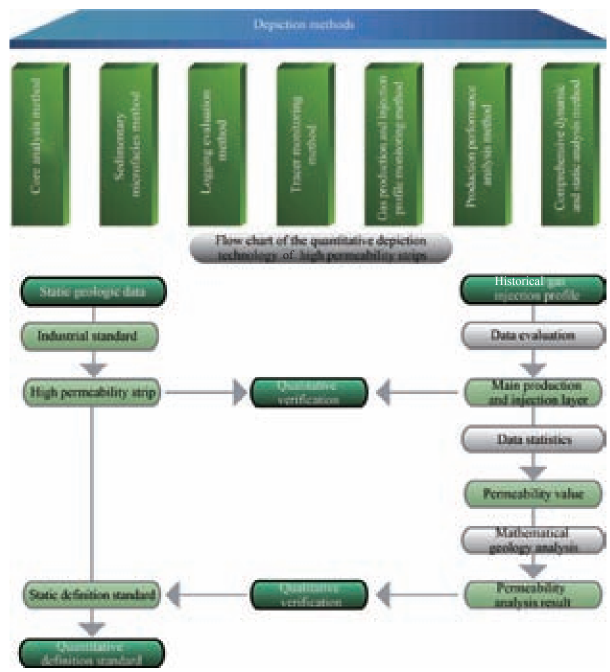
2 UNIQUE TECHNOLOGIES

2.1 Description Technology of Key Geologic Factors

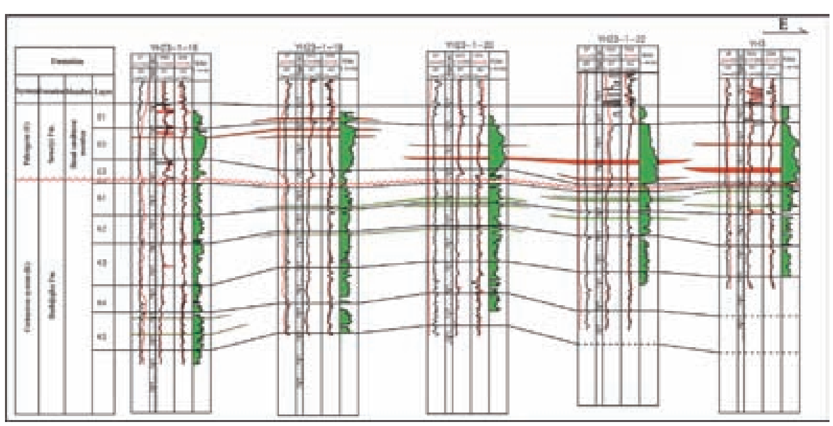
2.1.1 Quantitative Depiction Technology of High Permeability Strips

The quantitative depiction technology of high permeability strips is used to quantitatively depict the 3D spatial distribution features of high permeability strips using dynamic and static data and is of much significance to preventing injected gas from breakthrough along high permeability strips and improving gas injection sweep efficiency in the development process of condensate gas reservoirs. Depiction methods include core analysis method, sedimentary microfacies method, logging evaluation method, tracer monitoring, gas production and injection profile monitoring, etc.

The method of "mutual verification and mutual correction with dynamic and static data" can be used to quantitatively depict the 3D spatial distribution features of over 0.4m high permeability strips.



Flow chart of the quantitative depiction technology of high permeability strips



High permeability strips in Yaha condensate gas field

2.1.2 Evaluation Technology of Barriers and Interlayers

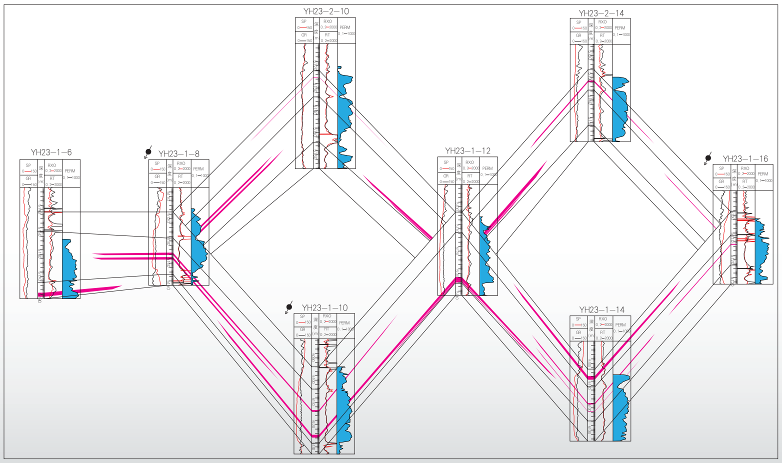
The technology is used to identify the barriers and interlayers from different types of geneses, to depict the form of the barriers and interlayers of different types and different scales as well as their distribution law in 3D reservoir spaces and predict their impact on development.

Work flow:

- Identification and classification of cores
- Relation of lithology vs. physical property
- Relation chart of lithology vs. physical property
- Depiction of barriers and interlayers in a single well
- Statistical analysis of thickness, density and frequency
- Genesis prediction and spatial distribution depiction
- Comprehensive evaluation of development impact

2.1.3 Fracture Description and Prediction Technology

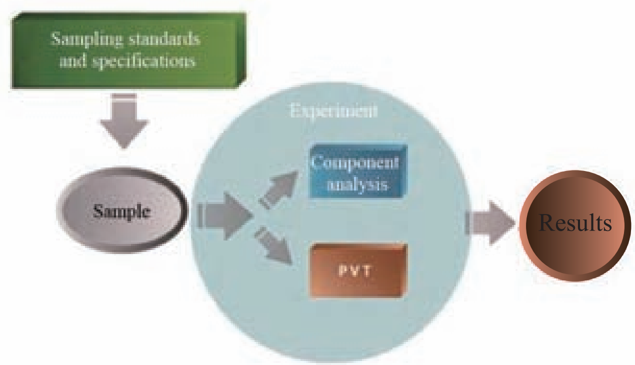
The fracture description and prediction technology is used to quantitatively describe the development and distribution features of fractures in 3D spaces of single wells and reservoirs using dynamic and static data involving outcrop, core, well logging, well test, etc. The description methods include core observation, rock slice observation, well logging data interpretation, surface outcrop observation, seismic data interpretation, etc.. The prediction methods include rock formation curvature method, ancient structure stress field method, known well points constraint method, combined ancient and current earth stress method, etc.



Fence diagram of barriers and interlayers in Yaha condensate gas field

2.2 Formation Fluid Sampling and Development Experiment Evaluation Technology

The study of phase state features is crucially important in the development process of condensate gas reservoirs and runs through the whole service life of gas reservoir development. CNPC has studied, developed and formed the sampling technologies for accurately obtaining representative fluid samples and the experiment technologies for finely describing condensate gas fluid property variation features under formation conditions. CNPC has formulated sampling standards and specification and invented precise wellhead sampling units. Condensate gas fluid phase state data can provide necessary physical property parameters of fluids for gas reservoir engineering, gas production engineering, integrated surface gathering and transportation and processing engineering design, economic evaluation and late gas field development adjustment.

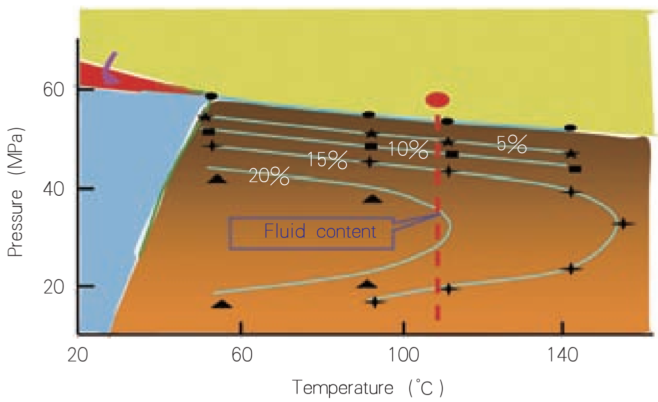


2.2.1 Formation Fluid Sampling and Phase State Study Evaluation Technology

The technology can be used to precisely meter oil and gas production and obtain representative PVT samples. The mercury-free high pressure solid deposition detection system (SDS) can be used to carry out experiment studies of constant mass expansion and isometric depletion as well as gas-liquid-solid three-phase variation rules. In addition, according to phase state experiment data and thermodynamics theory, phase state equations can be corrected to meet the requirements of fluids of different properties and to accurately describe the phase state features such as liquid appearance conditions and quantity, etc.

Pressure:150MPa
Accuracy:0.1MPa
Temperature:200.1℃
Accuracy:5℃

High-sulfur PVT instrument



Fluid pressure—temperature curve of Vaha condenstate gas field

2.2.2 Prediction Technology of Underground Phase State Variation and Percolation Law of Gas Reservoirs

The technology can be used in prediction of the dew point of condensate gas in porous media, constant-volume depletion phase equilibrium calculation and evaluation of condensate gas phase state features, and to predict the impact of porous media on phase state variation and accurately calculate the phase state variation of rich condensate gas with high wax content. In addition, the technology can be used to complete critical flow saturation tests at high temperature, thus obtaining gas-water relative permeability curves and balance oil-gas relative permeability curves and predicting the underground phase state variation and percolation law of condensate gas reservoirs.

DBR-JERFRI Formation PVT tester

1.Pressure. 0 ~ 70.00MPa Accuracy. 0.01MPa

2.Temperature. 0 ~ 200.0 Accuracy. 0.1℃

3.Volume. 0 ~ 130mL Resolution. 0.01mL

USKA2370-601 Formation PVT tester

1.Pressure.0 ~ 70.00MPa, Accuracy. 0.01MPa

2.Temperature.0 ~ 200.0 Accuracy. 0.1℃

3.Volume.0 ~ 380ml Accuracy. 0.01mL

2.2.3 Evaluation Technology of Gas Drive and Retrograde Vaporization of Condensate Gas Reservoirs

The technology is used to predict the migration law of injected dry gas in reservoirs and the retrograde vaporization effect of condensate oil at different pressures and to guide the injection-production optimization and adjustment and to increase condensate oil recovery ratio. Yaha long cores and PVT barrel gas injection experiments indicate that the underground condensate oil retrograde vaporization phenomenon shows three vaporization dynamic states obviously.

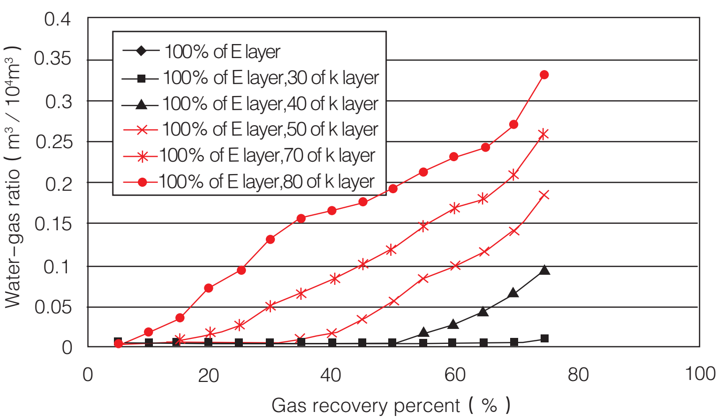
- Condensate oil vaporization effect after the pressure is lower than the maximum retrograde condensation pressure;
- Condensate oil re-vaporization effect in the pressure holding process;
- Condensate oil retrograde vaporization effect in the process of pressure increasing;

The injected dry gas can be used to vaporize both the intermediate hydrocarbons and over C_{20+} heavy hydrocarbons in condensate oil.

2.3 Gas Reservoir Engineering Scheme Optimization Design Technology

The gas reservoir engineering scheme optimization design is the key to the success of condensate gas reservoir development. The gas reservoir engineering scheme optimization design technology integrates multiple technologies, such as evaluation technology of injection-production capacity of injection-production wells, perforation scheme optimization technology, cyclic gas injection development mechanism and numerical simulation prediction technology, etc.

Long core gas injection displacement equipment



Relation of gas recovery percent vs. water-gas ratio of well YH23-1-14 at different opening degrees

2.3.1 Evaluation Technology of Injection-Production Capacity of Injection-Production Wells

2.3.1.1 Evaluation Technology of Gas Injection Capacity and Gas Production Capacity

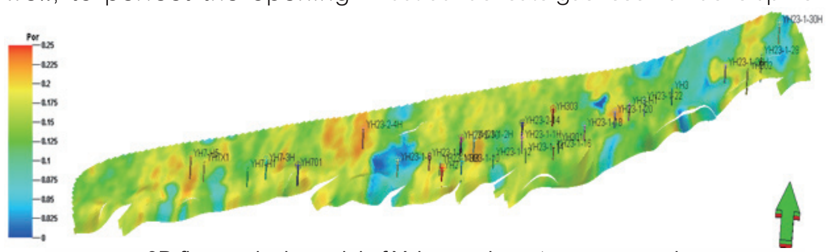
By integrating the results of phase state variation, percolation law, well test interpretation, formation coefficient, geologic study, etc. of condensate gas reservoirs, the production capacity equation (gas production well) and injection equation (gas injection well) of each single well are established, and reasonable gas production and gas injection rate are worked out for a whole gas reservoir and each well.

2.3.1.2 Perforation Optimization Design Technology

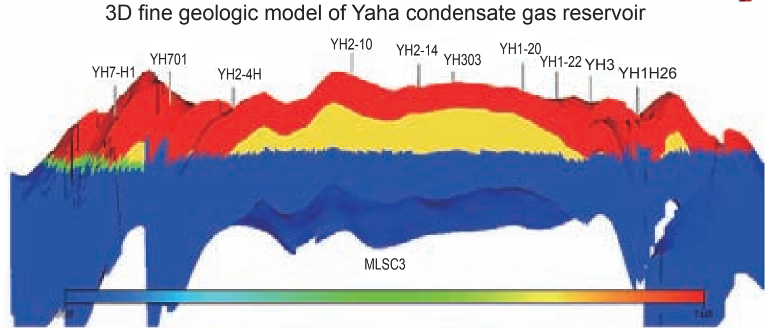
The geologic factors, gas reservoir factors and engineering factors are comprehesnsive considered. The perforation intervals of injection-production wells are optimized to increase the production and injection capacity of a single well, to perfect the opening degree and to realize injection-production balance of well clusters. In addition, production wells can have full effects and gas reservoirs can reach the optimal pressure holding degree and the highest swept degree, thus reaching the best development effect.

2.3.2 Cyclic Gas Injection Development Mechanism and Numerical Simulation Prediction Technology

The technology can be used to Realize the optimization design of gas injection opportunity, injection agent composition and reinjection ratio in the gas injection development mode, and to predict the impact of formation retrograde condensation on condensate oil recovery ratio; and also can be used to better control the impact of reservoir heterogeneity, barriers, interlayers and reservoir fractures on the gas injection development effect and to optimize well deployment, gas injection scale and gas injection period in the development process of condensate gas reservoirs, thus providing scientific bases for working out condensate gas reservoir development plans.



3D fine geologic model of Yaha condensate gas reservoir



Fluid distribution map of Yaha condensate gas reservoir

2.4 Dynamic Monitoring and Evaluation Technology of Condensate Gas Reservoirs

The dynamic monitoring and evaluation technology of condensate gas reservoirs is a set of evaluation technology developed by CNPC according to the condensate gas field development experience of many years and used to analyze and judge condensate gas field performance in terms of well fluids, tracers, etc., obtaining relevant performance indexes and evaluate them. The technology can be used to provide effective guidance to real time PVT sampling, to analyze well fluid composition and to accurately judge formation fluid migration law and condensate gas field development effect and is an important tool for guidance to condensate gas field development.

2.4.1 Monitoring Technology of Real Time PVT Sampling and Production Well Fluid Composition

The monitoring technology of real time PVT sampling and production well fluid composition can be used to effectively solve the problems about difficult sampling, inaccurate sampling, etc. of condensate gas wells caused by unfavorable factors such as large variation of well bore and formation temperature and pressure, different separation-out degrees of condensate oil, complex GOR variation law, large difficulty in downhole sampling, etc. For the technology, sampling conditions have been worked out; sampling procedures have been normalized and integrated high pressure physical property experiment equipment has been provided. The technology is applicable to various condensate gas resources. At present, the technology has been popularized in multiple gas fields of CNPC and has obtained good application effects.

Fluid sampling unit diagram of Yaha condensate gas reservoir

2.4.2 Gas Tracer Monitoring Technology

The technology is used to understand the underground motion law of injected gas and effect relation of injection-production wells and to evaluate the gas drive effect and to provide bases for injection-production optimization and adjustment.

2.4.3 Cyclic Gas Injection Development Performance Evaluation Technology

The technology involves dynamic reserves calculation of condensate gas reservoirs, judgment of injected gas channeling, utilization ratio calculation of injected gas and 12 technical evaluation parameters including volume swept coefficient etc. Cyclic gas injection performance evaluation methods and standards have been established; dynamic monitoring methods for cyclic injection gas have been improved. The dynamic evaluation coincidence rate reaches 90%; the coincidence rate of quantitative evaluation of gas injection swept efficiency and edge water advance speed is 94%.

2.5 Technology of Negative Pressure Perforation and Completion with One Trip

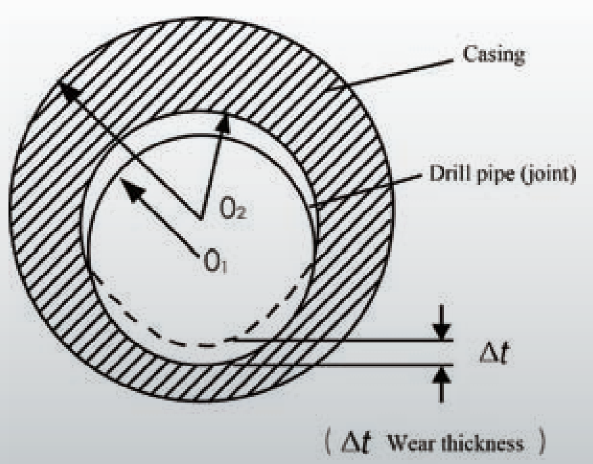
2.5.1 Completion String Design and Optimization Technology

The integral design of a completion string is fulfilled considering its safety factors, anticorrosion factors, proration production requirements, etc.. In addition, The mechanical analysis and safety evaluation of the string in different operating conditions is carriedout. The performance parameters and combination mode of all parts of the string according to the evaluation result is optimized, so that the completion string can meet production requirements and also ensure the safety of a gas well within its whole service life.

2.5.2 Negative Pressure Delay Perforation and Gun Releasing Technology

The technology is organic combination of tubing conveyed negative pressure perforation technology with packer completion technology. After perforation, the gun releasing device provides passages for subsequent operations including fracturing, acidification, production logging, etc.

The technology can be used to realize negative pressure perforation, to better clean perforation passages, and to reduce the perforation compaction degree, and to carry out automatic gun releasing operation and one-time perforation of a completion string. This improves completion efficiency and also avoids secondary pollution caused by well killing.



Schematic of crescent wear

2.6 Oil-gas Mixing Transportation Technology

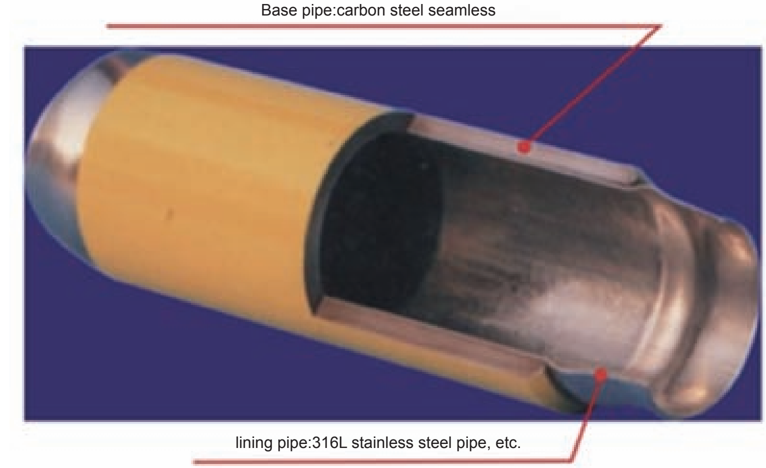
2.6.1 Oil-gas Mixing Transportation Technology

The oil-gas mixing transportation technology is used to collect and transport the carried liquid including oil, water, etc. depending upon natural gas pressure. In general, the liquid is transported on a mixed basis to an oil and gas treatment plant or a centralized treatment station for treatment. With the technology, the process flow can be simplified and the equipment and gathering and transportation pipelines to be used can be reduced. The system has very good sealing property for convenience of operation management, and the one-time investment and operation cost are relatively low.

2.6.2 Dual Composite Metallic Pipe Technology

The dual composite metallic pipes consist of two pipes of different materials: outer pipe and inner pipe. The outer pipe acts as bearing pressure and the inner pipe as anticorrosion. The outer base pipe bears the working pressure of the piping system. The materials of the outer base pipe include high strength carbon steel and alloy steel such as 16Mn, 20G, L245, X42, X80, etc. The inner liner pipe meets the anticorrosive requirements of the piping system. In general, according to different corrosive media, relevant corrosion resistant alloy materials are selected (e.g. 304, 316L, SAF2205, Alloy825, etc.). The composite dual metallic pipes have very good economic efficiency and safety. The technology includes corrosive environment analysis, material selection technology, welding technology, etc.

Oil-gas mixing transportation metering separator



Schematic of the composite dual metallic pipes

2.7 Condensate Oil and Gas Purification Treatment Technology

2.7.1 Condensate Recovery Technology

The technology is used to recover the alkanes including ethane, propane, butane, pentane, hexane, etc. from natural gas, which is also called recovery of light alkanes. The recovery technology mainly includes three methods such as adsorption method, oil absorption method and condensation analysis method.

2.7.2 Low Temperature Separation Technology

The low temperature separation technology is used to remove water and heavy hydrocarbons in natural gas by reducing natural gas temperature. There are three methods such as pressure cooling, expansion refrigeration, and refrigerant refrigeration.

Low temperature separation technology of refrigeration method by refrigerant

Treatment technology of condensate adsorption method

Treatment technology of condensate condensation separation method

Low Temperature Separation Technology of Pressure Cooling Method

Low Temperature Separation Technology of Expansion Refrigeration Method

Treatment Technology of Condensate Oil Adsorption Method

2.7.3 Dehydration and Dealkylation Technology of Condensate Gas by Super Sonic Separator(3S)

The principle of the super sonic separator (hereinafter abbreviated to 3S) technology: sharply reduce temperature through acceleration to supersonic speed with a Laval nozzle depending upon the pressure of natural gas itself, and thus separate the water vapor and heavy hydrocarbons from natural gas and realize gas-liquid separation. Compared with J-T valve refrigeration, expander refrigeration, molecular sieve dehydration and TEG dehydration, the technology has advantages such as low energy consumption and high benefit. The technology can be used in deeper dehydration and dealkylation, thereby increasing natural gas condensate production, improving natural gas quality and obtaining higher economic benefit.

Field 3S separator

2.8 Cyclic Gas Injection and Production Technology

2.8.1 Gas Compressor Type Selection Technology

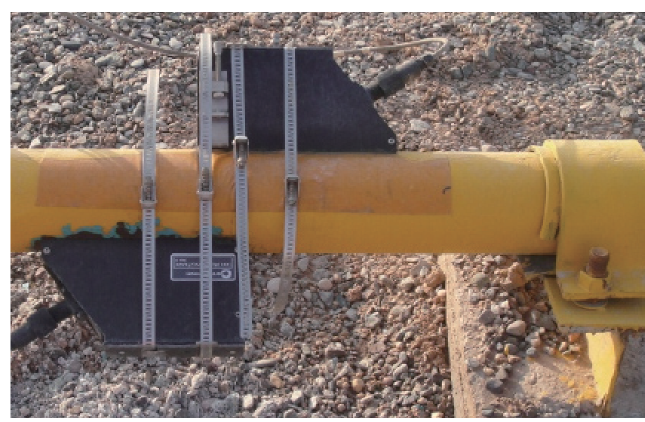
The natural compressor type selection technology is an economic and reasonable type selection technology summarized and formed in terms of three aspects such as drive mode, engine type and lubricating oil according to high pressure injection gas compressor management experience.

Medium pressure unit for gas injection in Yaha gas field

2.8.2 Cyclic Gas Injection and High Pressure Gas Flow Measurement Technology

The technology meets the requirements of flow measurement when gas pressure exceeds 42MPa and flow rate exceeds $50\times10^4 m^3/d$; the measurement accuracy is 1%~5%. The pipeline outside clamping mode is used for convenience of installation and dismantling. The equipment doesn’t directly contact the measured medium, has no moving part, runs reliably and is free of maintenance. In addition, the equipment has a large measurement range and can be used to measure two-way flow rate.

Yaha cyclic gas injection pressure is up to as high as 42MPa, the pipeline wall thickness is 17mm and the ratio of pipe diameter to wall thickness is 4.68. Successful flow measurement has been obtained.



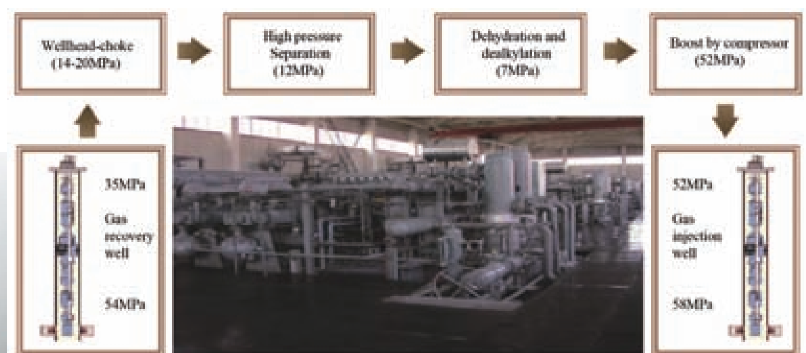
Field outer claming type flow meter and data reader

3 TYPICAL CASES

Yaha condensate gas field is located in Kuqa County, Xinjiang and has the OGIP of $279\times10^8m^3$ and the original condensate oil in pace of 2236×10^4t. The initial pressure of the gas reservoir is 56.4MPa, the saturation pressure 52.9MPa and the condensate oil content $537g/m^3$. The gas reservoir is a condensate gas reservoir with HTHP, high wax content, small formation-saturation pressure difference and extra-high condensate oil content.

Since 2000, Yaha condensate gas field has been produced using the early cyclic gas injection development mode. In the early stage, the gas field had 8 gas injection wells and 13 gas production wells, the gas injection pressure was up to as high as 52MPa, and the daily gas injection scale reached $350\times10^4m^3$.

In 2011, the average formation pressure of E+K System in Yaha condensate gas field was 45.6MPa and the pressure holding degree 82%; the average formation pressure of N_1j Formation was 48MPa and the pressure holding degree 88%. Till the end of 2011, the cumulative increased oil production was 128×10^4t, the cumulative increased gas production $25\times10^8m^3$, the sales income 5.34 billion Yuan, and the newly increased profit and tax 4.65 billion Yuan, Tremendous economic benefits were obtained while maintaining the annual production 50×10^4t of Yaha condensate gas field.



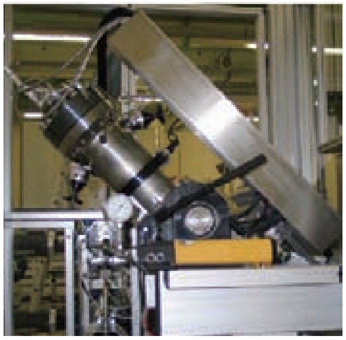
Flow chart of the Yaha condensate gas field cyclic gas injection

Yaha operation area

4 R&D EQUIPMENT

4.1 High Pressure Fluid PVT Experiment Devices

There is high pressure PVT experiment equipment meeting different experiment requirements, including high pressure (70MPa) experiment equipment with different PVT barrel volumes, ultra-high pressure (150MPa) experiment equipment meeting the requirements of high-sulfur gas, etc. The equipment can be used to carry out experiment studies of constant mass expansion and isometric depletion as well as gas-liquid-solid three-phase variation law.



Ultra-high pressure (150MPa) PVT experiment device

Pressure 70MPa, 130mL PVT barrel experiment device

Pressure 70MPa, 380mL PVT barrel experiment device

Pressure 70MPa, 380mL PVT barrel experiment device

4.2 Long Core Gas Injection Displacement Experiment Device

The equipment can be used to study the migration law of injected dry gas in reservoirs, the retrograde vaporization effect of condensate oil at different pressures and the mixed-phase of injected gas, with which, to provide guidance to injection-production optimization and adjustment and to increase condensate oil recovery ratio.

Long core gas injection displacement experiment equipment

Miscible gas drive evaluation experiment equipment

4.3 HTHP Multiphase Fluid Percolation Experiment Devices

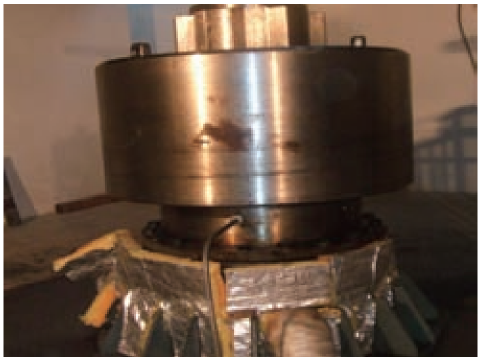
With the equipment, the impact of porous media on the phase state variation and percolation features of gas, condensate oil and formation under formation conditions can be studied. In addition, the equipment can be used to complete critical flow saturation tests at high temperature, thus obtaining gas-water relative permeability curves and balance oil-gas relative permeability curves, predicting the underground phase state variation and percolation law of condensate gas reservoirs and providing bases for numerical simulation calculation.

HTHP multiphase fluid percolation experiment Devices

4.4 HTHP Experiment Devices for Perforation Equipment and Downhole Tools.

Its highest working temperature is 210˚C , the highest working pressure is 200MPa. These devices can be used to study the product performance change law of perforating bullet and gun and matches downhole fools under HTHP.

High pressure pressurization system



HTHP kettle equipment

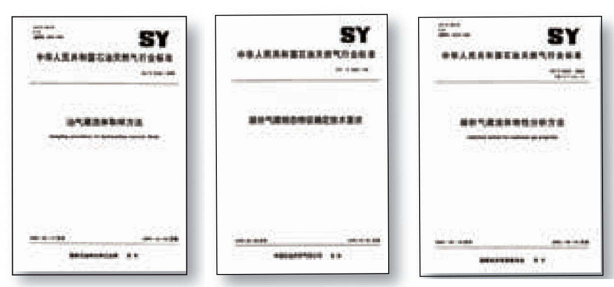
5 QUALIFICATIONS & STANDARDS

- Quality system certificate No.: 3001Q10377R0M
- CNPC HSE management system certificate
- SY/T 5128—1997 General technical conditions for shaped charge perforators for oil and gas wells

- Patent 1: a precise gas sampling device, ZL 2010 2 0138366.2.
- Patent 2: a condensate gas wellhead sampling device, ZL 2009 2 0106557.8.
- Patent 3: a liquid container positioning sampling device, ZL 2010 2 0251939.2.

Industrial standards

- Reservoir fluid sampling methods
- Technical requirements for determination of phase state characteristics of condensate gas reservoirs; analytic
- methods for physical properties of fluids in condensate gas reservoirs



6 EXPERT TEAM

Sun Longde Academician of the Chinese Engineering Academy, doctor, professor level senior engineer. He has long been engaging in comprehensive studies of gas fields and condensate gas fields. He has made innovations in phase state studies, development plan design, etc. of condensate gas fields. He was once awarded with 3 grade I national science and technology advance prizes and 4 grade I ministerial prizes. Over 40 papers and 6 works published.

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Song Wenjie Gas reservoir engineering expert, doctor, professor level senior engineer. He has long been engaging in comprehensive studies of gas fields and condensate gas fields. He has made innovations in phase state studies, miscible gas drive, percolation law, etc. of condensate gas reservoirs. He was once awarded with 2 grade I national science and technology advance prizes and 2 grade I ministerial prizes. Over 20 papers and 4 works published.

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Wang Tianxiang Gas reservoir engineering expert, professor level senior engineer. He has long been engaging in comprehensive studies of gas fields and condensate gas fields. He has made innovations in high pressure gathering and transportation, purification treatment, etc. of oil and gas. He was once awarded with 1 grade I national science and technology advance prize and 2 grade I ministerial prizes. Over 10 papers and 2 works published.

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Jiang Tongwen Gas reservoir engineering expert, doctor, professor level senior engineer. He has long been engaging in comprehensive studies of gas fields and condensate gas fields. He has made innovations in phase state studies, development mechanism, numerical simulation, etc. of condensate gas reservoirs. He was once awarded with 1 grade I national science and technology advance prize and 3 grade I ministerial prizes. Over 40 papers and 5 works published.

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Li Xunji Surface engineering expert, senior engineer. He has long been engaging in comprehensive studies of gas fields and condensate gas fields. He has made innovations in high pressure gathering and transportation, purification treatment, etc. of oil and gas. He was once awarded with 2 grade I provincial and ministerial prizes. Over 15 papers and 1 works published.

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Wang Zhenbiao Development geology expert, professor level senior engineer. He has long been engaging in comprehensive studies of gas fields and condensate gas fields. He has made innovations in development mechanism and development methods of abnormal high pressure gas reservoirs as well as reasonable development and EOR of condensate gas reservoirs. He was once awarded with 2 grade I national science and technology advance prizes and 4 grade I ministerial prizes. Over 10 papers and 1 work published.

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Wang Rujun Gas reservoir engineering expert, senior engineer. He has long been engaging in comprehensive studies of gas fields and condensate gas fields. He has made innovations in cyclic gas injection development mechanism and numerical simulation of components. He was once awarded with 1 grade I national science and technology advance prize and 1 grade I ministerial prize. Over 10 papers and 3 works published.

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Li Ruyong Gas reservoir engineering expert, professor level senior engineer. He has long been engaging in comprehensive studies of gas fields and condensate gas fields. He has made innovations in cyclic gas injection performance monitoring, performance evaluation, etc. of condensate gas reservoirs. He was once awarded with 1 grade I national science and technology advance prize and 3 grade I ministerial prizes. Over 10 papers and 2 works published.

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Zhu Weihong Development geology expert, professor level senior engineer. He has long been engaging in comprehensive studies of gas fields and condensate gas fields. He has made innovations in studies of high permeability strips, barriers and interlayers, fracture description, etc. He was once awarded with 1 grade I national science and technology advance prize and 3 grade I ministerial prizes. Over 30 papers and 4 works published.

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Teng Xueqing Drilling engineering expert, senior engineer. He has long been engaging in comprehensive studies of gas fields and condensate gas fields. He has made innovations in completion string design, negative pressure delay perforation, etc. of condensate gas fields. He was once awarded with 1 grade I national science and technology advance prize and 2 grade I ministerial prizes. Over 10 papers and 2 works published.

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Wang Xinyu Gas reservoir engineering expert, senior engineer. He has long been engaging in development of condensate gas fields and especially has unique views on and attainments in gas injection development of condensate gas fields, huff and puff gas injection of single wells, etc. He was once awarded with 1 grade I national science and technology advance prize. 6 papers published.

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