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Comprehensive Energy-Saving Technology for RTO Flue Gas Waste Heat Utilization

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ABSTRACT

In the automobile painting workshop, the oven will discharge harmful exhaust gas, the exhaust gas can be reused through the TNV system, the natural gas can meet the emission standard to the atmosphere after burning, and the high temperature gas discharged TNV the system can carry considerable heat. Utilization can effectively improve the economic benefits of the factory. At present, the more mature scheme is to heat the high temperature exhaust gas through the heat exchanger, which can reduce the steam consumption of the factory. Based on the analysis of the comprehensive energy saving content of waste heat utilization of RTO flue gas, this paper hopes to provide some reference and reference for readers.

1. Introduction

High temperature gas discharged from the TNV system of automobile painting workshop can effectively improve the economic benefit of the factory. At present, the more mature scheme is to heat the high temperature exhaust gas through the heat exchanger to reduce the steam consumption in the factory.

2. Research on Mechanism of Regenerative Exhaust Gas Oxidation Device

Generally, the mechanism of comprehensive energy-saving utilization technology of RTO flue gas waste heat is organic waste gas, which is mainly produced in the manufacture of automobile paint spraying room and the operation of various drying equipment. These large amounts of organic waste gas are discharged from pipes[1]. After it is operated and transported to the RTO equipment, it is incinerated at high temperature and recovered and utilized, and the heat energy generated when the exhaust gas is burned by the ceramic heat storage body of the RTO equipment is finally discharged. Generally speaking, the temperature of the gas released into the atmosphere after the use of thermal energy is about 250°C. 1 Considering the safety factors, it is necessary to reduce the flue gas temperature to about 120°C. Before it is discharged As a result, the flue gas temperature has been reduced from 250 to 120°C, and there is still room for recovery. Therefore, aqueous media can be used in this process to maximize thermal energy and convert cold water into hot water to complete flue gas temperature drop and hot water prepa-

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ration. The prepared hot water can be transported to every hot water link needed in the automobile manufacturing process, and can also be fully utilized in the hot water boiler.

3. A probe into the Key Points of RTO Waste Heat Control System

RTO flue gas waste heat systems usually include different energy use areas. Therefore, equipment in each energy use field has relatively independent requirements for automation. At the same time, there is an inseparable relationship between production and energy consumption in different regions. Waste heat equipment usually has obvious application advantages in hot water heating and safety protection. Therefore, the relationship between the electrical control cabinets in each area is naturally more complex. Perfect and stable automatic control system is the key premise of safe production of automobile. RTO key points of flue gas waste heat control system usually include the following aspects:

In order to make full use of the RTO flue gas waste heat system, the basic conditions are first adjusted so that the flue gas pipe pneumatic valve is in place and the flue gas passes through the heat exchanger. Instead, it is necessary to ensure that the waterway is still in its original state. By controlling the position of the three-way control valve, water can pass through the waste heat exchanger from beginning to end. In the channel system, the initial setting of the channel valve and the flow of water must be determined during commissioning[2]. To avoid warning when the exhaust temperature is too low, the amount of water is too high, the water temperature is too high or the amount of water is too low. At the same time, in the temperature control of the RTO exhaust heat exchanger, the temperature is controlled in the range of 110 to 120, and the exhaust gas condenses in the heat exchanger, and the long-term corrosion will damage the whole heat exchanger.

When the RTO flue gas waste heat system receives the starting signal of the boiler room pump, the flow information is displayed on the switch of the inlet pipe flow object. The pneumatic valve in the flue gas pipe needs to be automatically converted to make the flue gas always available. It passes through the waste heat exchanger from beginning to end. At the same time, the RTO system needs to respond and operate accurately when receiving relevant information about boiler room pump. The backup signal of the pump ensures that the flue gas pipe can switch the pneumatic valve. When the boiler chamber receives the flue gas pneumatic valve, the forced signal should be switched and the pump should be stopped after 30 minutes. If the smoke temperature is too low and less than 120°C, an alarm signal should be issued. Therefore, the temperature probe must be connected to the inlet and outlet of the exhaust pipe. When the flue gas temperature drops below 120°C, a low temperature alarm is issued to regulate the channel three-way valve, thereby reducing the amount of water in the waste heat exchanger and protecting the RTO system[3].

When low temperature baking technology is used in automobile manufacturing, generally speaking, the RTO exhaust temperature of the paint factory is usually low, so the waste heat of the flue gas can not be comprehensively utilized. When organic waste gas is incinerated or refined through the RTO system, the temperature of the flue gas discharged at this time is usually 30-40 higher than that of the organic waste gas. The oven temperature is usually about 80 ohms for the bumper paint room and the bathroom paint room, but the exhaust gas temperature is usually 110-120 due to RTO refining, this cold flue gas is not very useful. Therefore, the comprehensive energy saving technology RTO flue gas waste heat utilization must fully consider this aspect.

The automatic control system used by the RTO must control the temperature of the flue gas to prevent excessive exhaust temperature of the RTO from damaging the heat exchanger. Since the furnace temperature in the RTO is usually as high as 800 ohms, if the pneumatic switch valve used in the RTO can not switch normally in this state, replace the high temperature gas in the RTO furnace and store it in the heat storage[4]. In this case, the RTO exhaust gas temperature will continue to rise, thereby damaging the heat exchanger. Remember that in RTO settings, the automatic control system should avoid excessive temperature and consider how to control RTO exhaust in case of extreme failure of the whole system.

Automatic air valve switching for flue gas piping must be carried out in accordance with relevant orders. To avoid automatic air valve failure and burn down the drying room. When switching between automatic throttle, make sure the throttle is open so that the unwanted throttle can be closed. As long as the hot air and bypass valves associated with the RTO system are always open, they should always be open.

4. Planning of Exhaust Gas Treatment System for Automobile Painting

In the planning process of automobile painting exhaust gas treatment system, it is necessary to consider reducing the energy consumption rate of the treatment process, re-

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ducing the system investment and operation cost, and reducing the production of automobile painting exhaust gas. According to this plan, the current mainstream automobile painting waste gas treatment system is planned to use automobile painting waste gas for recycling production, manufacturing closed production space, thus reducing the purpose of automobile painting waste gas treatment, At the same time, the heat cycle utilization ratio and energy consumption of automobile painting waste gas treatment are improved[5].

4.1 Waste Gas Recycling Measures in Automotive Painting Workshop

In order to reduce the treatment capacity of automobile painting exhaust gas, the closed space can be used for the production mode of circulating air for automobile painting, but considering the protection and health needs of personnel, it can not be realized. In order to solve this problem, there are two main ways to solve this problem. The first is to send fresh air in the personnel station, and the circulating air is used in other positions without personnel demand. Compared with the original new wind, the pressure of automobile painting exhaust gas treatment has been greatly reduced. Another solution is to improve the intelligent level of robot work, replace human intervention, through machine programming, the robot in the closed workshop to complete the car painting operation, only after the completion of automotive painting waste gas treatment, It reduces the energy consumption level of automobile painting waste gas treatment system and achieves the function of energy saving and emission reduction. Compared with the latter, the first way belongs to the semi-new air conditioning system. The original traditional air conditioning system is a new air conditioning system mode. In terms of energy consumption of air conditioning, the improved air conditioning can also reduce the consumption of cold and hot energy and electric power.

4.2 Heat Recovery and Utilization of Exhaust Gas Treatment System in Automotive Painting and Painting Workshop

The exhaust gas treatment system of automobile painting workshop mainly depends on the method of mixed natural gas combustion after concentration to realize the treatment of toxic and harmful waste gas. The burning exhaust gas will cause air heat pollution and energy waste directly into the atmosphere. The most efficient and feasible way to recycle is to adjust the temperature of the air conditioning system and to heat the fresh air system inside the workshop[6]. Including air conditioning in the flash drying oven after painting the car, its fresh air heating can also use waste gas to burn waste heat.

4.3 Comparison and Comparison of Automobile Painting Exhaust Gas Combustion Device

The volatile organic compounds in the exhaust gas of automobile painting workshop are decomposed into water and carbon dioxide after combustion to achieve harmless treatment. In the application of combustion equipment, there are two main structural forms: RTO and TAR. The latter emission temperature can reach more than 300 degrees Celsius. TAR the emission temperature is low, only about 100 degrees celsius, it needs independent heating device, the economy of its own recycling residual temperature is poor, but it can still carry out hot water preparation, air conditioning heating and other waste heat utilization equipment, plus heat pump system, the temperature difference can be used more, more waste heat resources can be recovered. Because the waste heat utilization system involves the cooperation between many systems, it needs to be considered as a whole in the planning stage, and the reserved space and the water load of the system equipment need to be considered as a whole[7].

4.4 Energy-Saving Planning for Other Automotive Painting Waste Gas Treatment Systems

The biggest problem in the process of indirect utilization of waste heat treated by automobile painting exhaust gas is that it contains more impurities, which is easy to block and attach to the surface of heat exchanger, which results in the decrease of heat transfer coefficient of heat exchanger and can not reach the planning and design conditions. In the face of this kind of problem, the best solution is to use the waste heat inside the painting workshop, especially in the system to prevent pollution related other systems. For example, the waste heat is treated by painting and painting exhaust gas in automobile, which is used for moisture drying and volatile treatment in solid waste, reducing the moisture content of solid waste, reducing the fluidity and volume of solid waste, and increasing the treatment efficiency[8]At present, from the point of view of reducing occupational diseases, many developed countries have gradually used robotic arms to replace manual operations, which can not only achieve a substantial increase in work efficiency, but also reduce human injury and reduce economic investment in personal protection and protection. The unmanned automobile painting workshop can completely use the full circulation air conditioning system, add the equipment such as exhaust gas mixing and

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solid filtration in the circulation process, form a closed workshop and negative pressure control, reduce the pollution to the environment, reduce the waste heat energy consumption of air conditioning fresh air, and reduce the waste gas treatment capacity of automobile painting.

5. Conclusion

To sum up, the waste heat reuse system is a process of boiling water, in which the purpose of the automatic control system is to ensure the safe and stable operation of the waste heat reuse system, that is, the water can not be boiled or dried. First of all, the wind pressure is used to control the speed of the fan to ensure the constant pressure in the air duct. On this basis, the system exhaust temperature is used to control the flow rate of circulating water to ensure that the exhaust temperature is not too low.

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Identification of Structural Parameters Based on HHT and NExT

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ABSTRACT

Signal processing approaches are widely used in the field of earthquake engineering, especially in the identification of structural modal parameters. Hilbert-Huang Transformation (HHT) is one new signal processing approach, which can be used to identify the modal frequency, damping ratio, mode shape, even the interlayer stiffness of the shear-type structure, incorporating with Natural Excitation Technique (NExT) method to take information from the response records of the structure. The stiffness of the structure is of great importance to judge the loss of its bearing capacity after earthquake. However, all of modal parameters are required to calculate the stiffness of the structure by use of HHT and NExT, which means that the response records shall contain all of modal information. However, it has been found that the responses of the structure recorded only contain the former order modal information; even it is excited by earthquake. Therefore, it is necessary to found a formula (formulas) to calculate the stiffness only using limited modal parameters. In this paper, the calculation formulas of the interlayer stiffness of shear-type structure are derived by using of the flexibility method, which indicate that all of interlayer stiffnesses could be worked out as long as any one set of modal parameters is obtained. After that, Taking Sheraton-Universal Hotel subjected to North Bridge earthquake in 1994 as an example, HHT and NExT are used to identify its modal parameters, the derived formulas are used to calculate the interlayer stiffnesses, and their applicability and accuracy are verified.

1. Introduction

Hilbert-Huang Transform (HHT), a signal processing method, was firstly put forward by Dr. Norden E. Huang of National Aeronautics and Space Administration (NASA) in 1998. The main innovations embodied in this method are the present of the concept of the Intrinsic Mode Function (IMF) and introduction of the method of Empirical Mode Decomposition (EMD). A signal is first decomposed into IMFs by the EMD, and then, Hilbert spectrum is obtained through Hilbert transform, marginal spectrum of the signal can also be obtained [1-3]. The Hilbert spectrum can present precise description of instantaneous frequency and amplitude, embodies higher presentation compared with Fourier spectrum and Wavelet spectrum. Thus, it is quite applicable to analyze nonlinear and non-stationary signal, and has been applied in many fields since it is raised.

In the modal parameters identification field, the researchers have put forward two methods, namely, using HHT and RDT to identify modal parameters of linear structure and using HHT and NExT to identify modal parameters of linear structure [4]. The former only can identify the modal fre-

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quency and the damping ratio, while the latter can identify the mode shape and the interlayer stiffness of the shear-type structure besides the modal frequency and the damping ratio. However, all of modal parameters are required to calculate the stiffness of the structure by use of HHT and NExT, which means that the response records shall contain all of modal information. However, it has been found that the recorded responses of the structure only contain the former order modal information; even it is excited by earthquake. Therefore, it is necessary to found a formula (formulas) to calculate the stiffness only using limited modal parameters. This paper firstly introduces the principle of HHT and NExT used to identify the structural parameters and points out its limitation, then, derives the calculation formulas of the interlayer stiffnesses of shear-type structure by using of the flexibility method, which indicate that all of interlayer stiffnesses could be worked out as long as any one set of modal parameters is obtained. After that, Sheraton-Universal Hotel is firstly reduced as the four-floor shear-type structure based on the lumped mass method, then, the first three modal frequencies, damping ratios and vibration modes of this structure are identified by using of HHT and NExT, the referenced data are the seismic records obtained in North Bridge earthquake in 1994, and the interlayer stiffnesses are worked out. Finally, the earthquake responses calculated by the elastic time-history analysis based on the identified structural parameters are compared with the seismic records, and the results show that the identified structural parameters are valid.

2. Principle of HHT and NExT Used to Identify Structural Parameters

The motion equation of multi-degree linear system is given by

$$[M]\{\ddot{x}\}+[C]\{\dot{x}\}+[K]\{x\}=F(t) \tag{1}$$

where $[M]$, $[C]$ and $[K]$ are the mass matrix, damping matrix and stiffness matrix, respectively; $\{x\}$ is the displacement vector of the structure; $\{\dot{x}\}$ is the velocity vector; $\{\ddot{x}\}$ is acceleration vector; $F(t)$ is the seismic excitation. If $\{\phi_1\}$, $\{\phi_2\}$,…, $\{\phi_n\}$ represent the mode shape series, they are independent due to their orthogonality. According to the linear algebra theory, the victor $\{x\}$ with n dimensions can be described by the linear combination of n independent vectors, so the displacement vector of linear structure $\{x\}$ can be expressed as

$$\{x\}=\sum_{j=1}^{n} q_j\{\varphi_j\} \tag{2}$$

where $q_j\,(j=1,2,\cdots,n)$ are the canonical coordinates of the mode shape, and $\{\phi_j\}$ is the j[th] mode shape. Substituting Equation (2) into Equation (1), suppose the mode shape is orthogonal to the damping matrix, Equation (1) can be written as

$$\ddot{q}_j+2\xi_j\omega_j\dot{q}_j+\omega_j^2 q_j=\{\phi_j\}^{\mathrm{T}}F(t)/m_j \tag{3}$$

Assuming $F(t)$ is the ideal white noise, it can not be obtained wholly, and thus, the traditional modal identification methods can not be used to identify the modal parameters. However, a good discovery is that the correlation function of the response of the linear structure under white noise excitation is similar mathematically to the impulse response function [5]; therefore, it can be substituted by the cross-correlation function between the responses of two floors. If every floor has the response record after earthquake, the response record of the i[th] floor is taken as the reference point, and the cross-correlation function between the response of the j [th] floor and that of the i[th] floor can be expressed as [6]

$$R_{ji}(\tau)=\sum_{r=1}^{n}\frac{\psi_{jr}G_{ir}}{m_r\omega_{dr}}\exp(-\xi_r\omega_r\tau)\sin(\omega_{dr}\tau+\theta_r)\,(j=1,2,\cdots,n) \tag{4}$$

Where ψ_{jr} is the j[th] element of the r[th] mode shape; G_{ir} is a constant only related with i and r; m_r, ξ_r, ω_r and θ_r are the modal mass, damping ratio, circular frequency and phase angle, respectively; and ω_{dr} is the damped circular frequency. $R_{ji}(\tau)$ can be decomposed into m IMFs and one trend term by use of EMD. Ideally, m is equal to n, and the n terms at the right side of Equation (4) are the IMFs obtained through EMD. But, generally, m is greater than n, so it is required to find out the IMFs with physical significance. Here, it is recommended to find out the right IMFs through observing their Hilbert spectrums.

The r[th] IMF of the j[th] cross-correlation function can be expressed as

$$R_{ji,r}=\frac{\psi_{jr}G_{ir}}{m_r\omega_{dr}}\exp(-\xi_r\omega_r\tau)\sin(\omega_{dr}\tau+\theta_r) \tag{5}$$

The amplitude $A(\tau)$ and phase $\theta(\tau)$ of $R_{ji,r}$ can be denoted as [7]

$$A(\tau)=\frac{|\psi_{jr}|G_{ir}}{m_r\omega_{dr}}\exp(-\xi_r\omega_r\tau)\ ,\quad \theta(\tau)=\omega_{dr}\tau+\theta_r \tag{6}$$

Solving the natural logarithm of $A(\tau)$ in Equation (2-6) and the derivation of $\theta(\tau)$ can obtain

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$$\ln A(\tau) = -\xi_r \omega_r \tau + \ln \frac{|\psi_{jr}| G_{ir}}{m_r \omega_{dr}} \tag{7}$$

$$\omega(\tau) = \frac{d\theta(\tau)}{d\tau} = \omega_{dr} \tag{8}$$

From Equations (7) and (8), $\xi_r \omega_r$ and ω_{dr} can be solved through the amplitude and phase spectrums of $R_{ji,r}$ obtained through Hilbert transform, and $\omega_{dr} = \sqrt{1-\xi_r^2}\omega_r$, thus ω_r and ξ_r also can be obtained. It is worth mentioning that the building may enter the nonlinear condition after strong motion, and some locations may be damaged, consequently, the dynamic characteristics of the structure will change [8]. Therefore, $\ln A(\tau)$ and $\theta(\tau)$ will not be the ideal straight lines, and they shall be divided into several segments, and then each segment can be changed into one straight line through least-square linear fitting. Hence, for a specific instant τ_0, ω_r and ξ_r can be calculated according to the above equations, while the r[th] mode shape can be obtained through the n amplitude spectrums corresponding with ω_r, and the signs in the mode shape are determined by the phase difference, which can be obtained through the n phase spectrums [6].

All of mode shapes obtained form the principle mode matrix $[\Phi] = \{\{\varphi_1\}\{\varphi_2\}\cdots\{\varphi_n\}\}$. And according to the theory of structural dynamics, it obeys the following three orthogonal relations

$$[\Phi]^{\mathrm{T}}[M][\Phi] = \begin{bmatrix} m_1 & 0 & \cdots & 0 \\ 0 & m_2 & \cdots & 0 \\ \cdots & \cdots & \cdots & \cdots \\ 0 & 0 & \cdots & m_n \end{bmatrix} = [M^*] \tag{9}$$

$$[\Phi]^{\mathrm{T}}[K][\Phi] = \begin{bmatrix} k_1 & 0 & \cdots & 0 \\ 0 & k_2 & \cdots & 0 \\ \cdots & \cdots & \cdots & \cdots \\ 0 & 0 & \cdots & k_n \end{bmatrix} = [K^*] \tag{10}$$

$$[\Phi]^{\mathrm{T}}[C][\Phi] = \begin{bmatrix} c_1 & 0 & \cdots & 0 \\ 0 & c_2 & \cdots & 0 \\ \cdots & \cdots & \cdots & \cdots \\ 0 & 0 & \cdots & c_n \end{bmatrix} = [C^*] \tag{11}$$

m_r, k_r and c_r denote the r[th] elements of diagonal matrixes $[M^*]$, $[K^*]$ and $[C^*]$, respectively. Generally, $[M]$ is assumed to be constant, so, if $[\Phi]$ is determined, $[M^*]$ will be determined. And $k_r = m_r \omega_r^2$, $c_r = 2m_r \xi_r \omega_r$, so, $[K^*]$ and $[C^*]$ will also be determined. Conducting the inverse transformation to Equations (10) and (11), $[K]$ and $[C]$ will be obtained. Then, the interlayer stiffness also can be solved by $[K]$.

From the above description, it can be seen that, in order to obtain the mass matrix $[K]$, the principle mode matrix must be determined firstly, which means that all of modal parameters must be identified. However, the recorded responses of the structure under earthquake or other excitations always only contain the former order modal information, and it is impossible to take all of modal parameters. Therefore, it is necessary to found a formula (formulas) to calculate the stiffness only using limited modal parameters.

3. Derivation of Interlayer Stiffness of Shear-Type Structure

According to Equation (1), the characteristic equation of the shear-type structure can be expressed as

$$([I] - \omega^2[\delta][M])\{Y\} = \{0\} \tag{12}$$

where $[\delta]$ is the flexibility matrix. Suppose $r_i = 1/k_i$, in which k_i is the interlayer stiffness of the i[th] floor, the flexibility matrix $[\delta]$ can be written as

$$[\delta] = \begin{bmatrix} r_1 & r_1 & r_1 & \cdots & r_1 \\ r_1 & r_1 + r_2 & r_1 + r_2 & \cdots & r_1 + r_2 \\ r_1 & r_1 + r_2 & r_1 + r_2 + r_3 & \cdots & r_1 + r_2 + r_3 \\ \vdots & \vdots & \vdots & \vdots & \vdots \\ r_1 & r_1 + r_2 & r_1 + r_2 + r_3 & \cdots & r_1 + r_2 + \cdots + r_n \end{bmatrix} \tag{13}$$

where $[M]$ is the mass matrix of the structure. Suppose m_i is the interlayer mass of the i[th] floor, the mass matrix $[M]$ can be written as

$$[M] = \begin{bmatrix} m_1 & & & \\ & m_2 & & \\ & & \ddots & \\ & & & m_n \end{bmatrix} \tag{14}$$

Suppose $\{Y\}$ is the principle mode matrix. Due to the orthogonality, the j[th] mode shape $\{Y_j\}$ satisfies the following equation

$$\begin{bmatrix} Y_{j1} \\ Y_{j2} \\ Y_{j3} \\ \vdots \\ Y_{jn} \end{bmatrix} = \begin{bmatrix} r_1 & r_1 & r_1 & \cdots & r_1 \\ r_1 & r_1 + r_2 & r_1 + r_2 & \cdots & r_1 + r_2 \\ r_1 & r_1 + r_2 & r_1 + r_2 + r_3 & \cdots & r_1 + r_2 + r_3 \\ \vdots & \vdots & \vdots & \vdots & \vdots \\ r_1 & r_1 + r_2 & r_1 + r_2 + r_3 & \cdots & r_1 + r_2 + \cdots + r_n \end{bmatrix} \begin{bmatrix} \omega_j^2 m_1 Y_{j1} \\ \omega_j^2 m_2 Y_{j2} \\ \omega_j^2 m_3 Y_{j3} \\ \vdots \\ \omega_j^2 m_n Y_{jn} \end{bmatrix} \tag{15}$$

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Equation (15) can be written as

$$\begin{cases} Y_{j1} = \omega_j^2 m_1 Y_{j1} r_1 + \omega_j^2 m_2 Y_{j2} r_1 + \cdots + \omega_j^2 m_n Y_{jn} r_1 & (1) \\ Y_{j2} = \omega_j^2 m_1 Y_{j1} r_1 + \omega_j^2 m_2 Y_{j2} (r_1 + r_2) + \cdots + \omega_j^2 m_n Y_{jn} (r_1 + r_2) & (2) \\ Y_{j3} = \omega_j^2 m_1 Y_{j1} r_1 + \omega_j^2 m_2 Y_{j2} (r_1 + r_2) + \cdots + \omega_j^2 m_n Y_{jn} (r_1 + r_2 + r_3) & (3) \\ \vdots \\ Y_{jn-1} = \omega_j^2 m_1 Y_{j1} r_1 + \omega_j^2 m_2 Y_{j2} (r_1 + r_2) + \cdots + \omega_j^2 m_n Y_{jn} (r_1 + r_2 + \cdots + r_{n-1}) & (n-1) \\ Y_{jn} = \omega_j^2 m_1 Y_{j1} r_1 + \omega_j^2 m_2 Y_{j2} (r_1 + r_2) + \cdots + \omega_j^2 m_n Y_{jn} (r_1 + r_2 + \cdots + r_n) & (n) \end{cases} \tag{16}$$

Subtracting Sub-equation (n) by Sub-equation (n-1) obtains

$$r_n = \frac{Y_{jn} - Y_{jn-1}}{Y_{jn} m_n \omega_j^2} \tag{17}$$

Then, the interlayer stiffness of the nth floor can be given by

$$k_n = \frac{Y_{jn} m_n \omega_j^2}{Y_{jn} - Y_{jn-1}} \tag{18}$$

Likewise, subtracting the adjacent two sub-equations in Equation (16), the interlayer stiffnesses of the floors except the first floor and the nth floor k_i can be given by

$$k_i = \frac{\sum_{i}^{n} Y_{ji} m_i}{Y_{ji} - Y_{ji-1}} \omega_j^2 \qquad i = 2,3 \cdots n-1 \tag{19}$$

And the interlayer stiffness of the first floor can be given by

$$k_1 = \frac{\sum_{i=1}^{n} Y_{ji} m_i}{Y_{j1}} \omega_j^2 \tag{20}$$

4 Identification of Structural Parameters of Sheraton-Universal Hotel

4.1 Strong Motion Observation Scheme

Sheraton-Universal Hotel is a 20-storey reinforced concrete frame structure, located in Hollywood, north of Los Angeles, CA, USA, 34.1380 degrees north latitude and 118.3590 degrees west longitude. This region is in the southeast corner of San Fernando Valley, with high earthquake frequency. Thus, Sheraton-Universal Hotel was selected as the strong earthquake observation object when it was in construction, and was set with the strong motion array with five observation plane, ten observation points and sixteen channels before the occurrence of North Bridge earthquake in 1994, and the concrete observation scheme is shown in Figure 1. The five observation planes were set on the basement, third, ninth, sixteenth and top floors, two observation points were set at each plane, one was set at the west side, and the other was set at the east side. For the third, ninth, sixteenth and top planes, the basement, the observation point in the west had two orthogonal channels, arranged vertically and horizontally, while the observation point in the east only had one channel arranged horizontally. For the basement plane, the observation point in the east had two channels arranged vertically and horizontally, and one channel perpendicular to the plane, and it was the only one with three components; while the other observation point only had one transversal channel. In the North Bridge earthquake, occurred on 17th, November, 1994, Sheraton-Universal Hotel obtained sixteen suits of strong motion records with the sampling interval of 0.02 s and each suit of record contained the displacement, velocity and acceleration information. The longitudinal acceleration records are used to identify the structural parameters, and the longitudinal acceleration recorded on the ninth floor is shown in Figure 2.

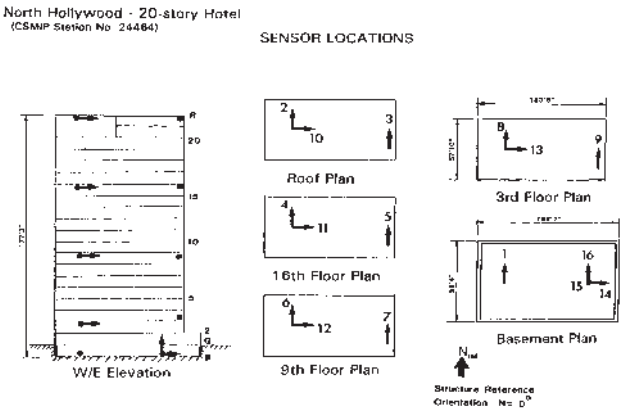

Figure 1. Sensor locations

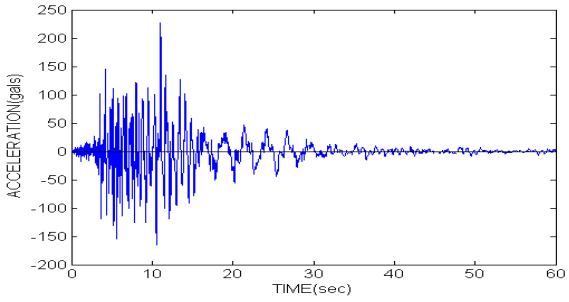

Figure 2. Longitudinal acceleration record on the ninth floor

4.2 Identification of Structural Parameters

It was reported that Sheraton-Universal Hotel was

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little damaged after North Bridge earthquake on 17th, November, 1994. Figure 2 shows that the vibration of the structure is gradually damped after 20 seconds, similar to free damping oscillation; therefore, it can be taken as linear structure. Suppose the base of the structure is rigid, and the mass is concentrated on the third, ninth, sixteenth and top floors, which are connected with each other by the stiffness component and damping component, as shown in Figure 3.

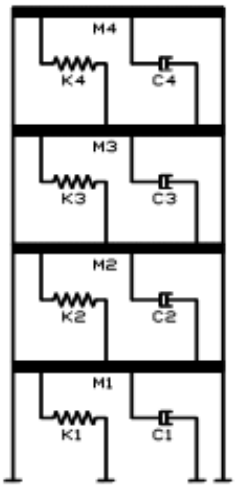

Figure 3. Structural Model

Taking the ninth floor as the reference floor, based on the longitudinal acceleration records, the former three modal parameters are identified by use of the method described above, listed in Table 1 and Table 2. According to the first modal frequency and mode shape, the interlayer stiffness of the structure after 20 s can be worked out by use of Equations (18), (19) and (20), listed in Table 3.

Table 1. Identified modal parameters

	The first order		The second order		The third order	
	f_1/Hz	ξ_1	f_2/Hz	ξ_2	f_3/Hz	ξ_3
Floor 3	0.359	6.5%	0.995	3.2%	1.195	4.7%
Floor 9	0.367	6.9%	1.075	4.4%	1.155	4.1%
Floor 16	0.35	5.9%	0.956	3.3%	1.215	4.6%
Roof	0.366	6.9%	0.987	3.2%	1.179	4.5%

Table 2. Mode shapes in the longitudinal direction

	The first order	The second order	The third order
Floor 3	1.000	1.000	1.000
Floor 9	0.902	0.138	-0.172
Floor 16	0.629	-1.061	1.058
Roof	0.374	-0.526	0.324

Table 3. Structural parameters

	Floor 3	Floor 9	Floor 16	Roof
lumped mass(kg)	410999	1325571	2291849	19298820
Interlayer stiffness ($\times 10^8$)	6.825	9.46	7.754	9.586

4.3 Verification of Identified Results

The mass matrix, stiffness matrix and damping matrix of the structure are obtained in Section 4.2, the acceleration records of the basement after 20 s can be taken as the excitation of the structure, and the displacement, velocity and acceleration records at 19.98 s can be taken as the initial conditions, thus the seismic responses of the third, ninth, sixteenth and top floors can be obtained through elastic time-history analysis method. The identified parameters can be verified through comparing the calculated seismic responses with the seismic records, which are given in Figure 4~7. The solid lines denote the calculated results while the dotted lines denote the seismic records. It is indicated that, the calculated displacement results agree well with the records, so, the identified results by use of the method described in Section 3 are good. There exists big difference between the calculated displacement results on the third floor and the displacement records; the main reason is that the third floor mainly reflects the vibration characteristics of the base.

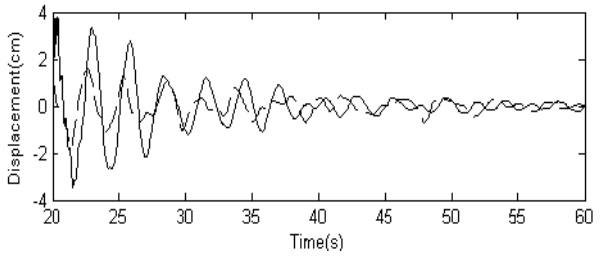

Figure 4. Comparison between seismic records and calculated results of the third floor

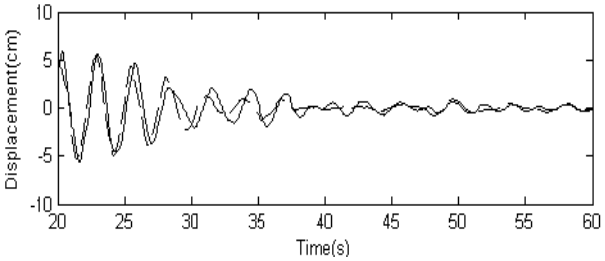

Figure 5. Comparison between seismic records and calculated results of the ninth floor

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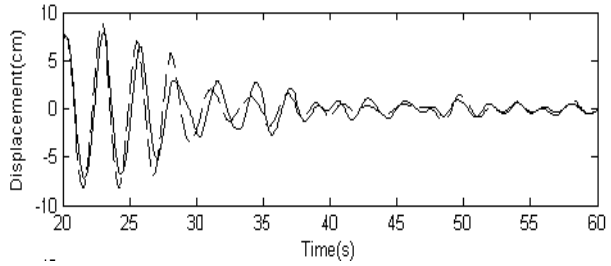

Figure 6. Comparison between seismic records and calculated results of the sixteenth floor

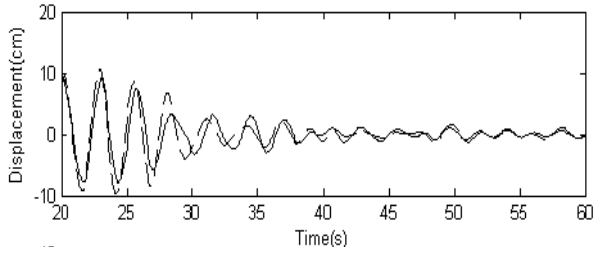

Figure 7. Comparison between seismic records and calculated results of the top floor

5 Conclusions

This paper points out the limitation of HHT and NExT used to identify the structural parameters of the structure, which is that all of modal parameters shall be identified firstly, and derives the calculation formulas of the interlayer stiffnesses of shear-type structure by using of the flexibility method which indicate that all of interlayer stiffnesses could be worked out as long as any one set of modal parameters is obtained. Therefore, these formulas obtained can solve this limitation. And the example of Sheraton-Universal Hotel shows that these formulas are quite applicable to identify structural parameters together with HHT and NExT.

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The Evolution and Trend Analysis of Rural Planning Research Hotspots under the Background of Territorial and Spatial Planning

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ABSTRACT

Under the background of the new round of land and space planning, the research on rural planning in China is undergoing positive changes. Based on the past emphasis on engineering thinking and planning technology, it has entered the field of planning strategy and planning guidance. The extended development trend shows a research trend of intensified integration with public management disciplines and government governance theories. The intervention of government regulation research will provide a solid theoretical guarantee for the rural revitalization strategy that focuses on planning and planning first. In order to study the rural planning hotspots and trends in the context of territorial and spatial planning, using CiteSpace software to map rural areas from the perspectives of the number of articles, authors, publishing organizations, keyword co-occurrence networks, keyword clustering analysis, hotspot evolution, prominent word analysis, etc. The knowledge map was planned and visualized comparative analysis was carried out.

1. Introduction

In the 19th National Congress of the Communist Party of China in 2017, General Secretary Xi Jinping put forward the strategy of rural revitalization. He pointed out that the strategy of rural revitalization is a grand strategy of the party and the country, and planning must go ahead and strengthen the leading role of planning. Rural planning has gradually received extensive attention from scholars. The weak vision of rural planning under the long-term "urban-rural dualization" system has led to difficult, mismatched, unreasonable, and lack of theory in rural planning; slow rural development, deteriorating ecological environment, "one thousand villages", lack of regional characteristics, and public Many problems such as imperfect and unbalanced service facilities and municipal infrastructure have brought great obstacles to the realization of the rural revitalization strategy.

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Urban planning is one of the important public policies for the government to regulate urban spatial resources, guide urban and rural development and construction, maintain social equity, and protect public safety and public interests[1]. At the"Symposium on the Integrated Development of Urban-Rural Planning and Public Management Disciplines" in June 2016, Professor Huang Yan, then Deputy Minister of Housing and Urban-Rural Development, took the lead in pointing out that "if you look at complex urban issues using engineering. It has exposed the shortcomings of ineffective methods and inappropriate tools, and will not use public policies, management systems, social construction and other methods to solve complex urban problems." [2] Also pointed out many problems based on literacy, concepts, and talent training methods. It is very difficult to explore the expansion of urban planning to public policy and public management[2].

In May 2019, the State Council issued the "Several Opinions of the Central Committee of the Communist Party of China and the State Council on Establishing a Territorial and Spatial Planning System and Supervising Implementation" (hereinafter referred to as the "Several Opinions"), stating that: It is also possible to prepare township-level territorial and spatial planning for several townships as a unit"[3], which not only enhances the overall planning and policy flexibility of town-level territorial and spatial planning, but also because of the introduction of national governance and public regulations into the territorial and spatial planning system. The concept of public management has brought great challenges to the study of rural planning. The in-depth integration of urban and rural planning disciplines and public management, national governance and government regulatory tools are a new topic facing the territorial and spatial planning system, and it is also the ultimate goal of its development.

With the implementation of "Several Opinions", this research aims to sort out the changing trends of research hotspots in the field of rural planning under the background of land and space planning, and focus on the changes in the perspective of government regulation and public management.

2. Research Methods and Data Sources

Using the Citespace software based on the JAVA platform as a visual analysis tool for the "rural planning" literature research, using the principle of co-word analysis to draw a key word co-occurrence map in the field of rural planning, and through keyword cluster analysis to obtain the research topics in this field The relationship between. Nowadays, domestic Citespace research usually uses the literature in CNKI as the research data source. However, due to the small sample of core literature literature, there is a general lack of analysis of core journal data, which reduces to a certain extent. The scientificity and persuasiveness of the conclusion.

In order to enhance the scientificity and persuasiveness of the research conclusions, this paper selects the core documents in the China Knowledge Network (CNKI) as the data source; because the relevant documents and documents after the national spatial planning are mainly concentrated after 2010 [4], combined with The background conditions for the new territorial and spatial planning of the "Several Opinions", this article sets the publication time of the retrieved documents to 2010 to 2020, and the retrieval time to May 19, 2020.

The search criteria were "Subject='Country Planning'" for advanced and precise search, and 1051 document samples were obtained. After excluding invalid documents such as newsletters, conference introductions, newspapers, and documents that are not very relevant to the research topic, while retaining the words "village planning" "beautiful village" "rural revitalization" "rural landscape planning", and "rural landscape planning" A total of 470 valid literature samples were screened for the research topics such as "ecological planning".

3. Overall Characteristics of Rural Planning Research

The amount of articles published is an important indicator reflecting the amount of information in a publication. It is usually also a measure of the level of subject development, scientific and technological output and scientific research achievements[5]. Professor Li Hongyi believes that the research and analysis of the amount of articles represents this The depth and breadth of a subject research[6]. An in-depth analysis of the number of 470 sample documents of "Rural Planning", as shown in Figure 1, shows the overall evolution law: low-level equilibrium → sudden increase → stability → rapid increase.

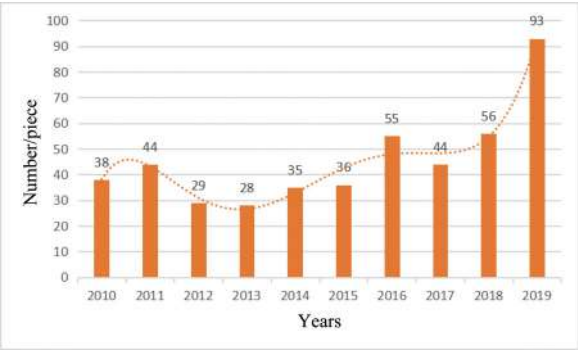

Figure 1. Trends in the amount of articles published (2010-2019)

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In the context of "dualization" of urban and rural development, the amount of rural planning publications from 2010 to 2015 was in a low-level equilibrium stage; there was a large increase in 2016, which is similar to Zhao Hongjuan[7] using the period from 2004 to 2018 as the time period. The conclusions drawn from the research on all the literature data of CNKI under the same search conditions are consistent. Zhao Hongjuan believes that the 2015 Ministry of Housing and Urban-Rural Development's "Guiding Opinions on Reform and Innovation to Promote Rural Planning Work in a Comprehensive and Effective Way" was released, highlighting the importance of rural planning. Attracted more practitioners to participate in the thinking of rural planning [8]. The author of this article analyzes the mutation map (Figure 8) and evolution time zone map (Figure 6) of Citespace, and believes that it is the result of the policy guidance and attention increase of the "beautiful countryside" in 2016.

In 2017, when the rural revitalization strategy was proposed, Zhao Hongjuan's publication volume doubled and surged. The reason for the surge was that the deployment of the national strategy for rural revitalization made rural planning attract unprecedented attention from the planning academia [7]; and the core literature in this article in 2018. However, it remained stable and did not show any growth. The reason is that the unprecedented focus on the long-term weak background of rural planning before the lack of accumulation of theory and experience, so that the research on the "planning first" and "strengthening planning guidance" proposed in rural revitalization will be conducted in the short term. Lack of corresponding support and insufficient depth.

The number of publications in 2019 showed a doubling and a sharp increase. At this stage, through the accumulation of research on rural revitalization and the background of the issuance and implementation of the "Several Opinions", the number of authors who conducted research in the field of rural planning under the background of the new land and space planning increased, and rural planning The field is gradually being valued by scholars and has become a hot spot of current research and attention.

4. Research Hotspots and Trend Analysis

4.1 Keyword Co-Occurrence Analysis

Research-centric, high-frequency keywords can reflect the research hotspots of a certain subject area for a period of time. Based on the viewpoint of knowledge theory research[9], keywords reflect the author's main point of view, and also highly condensed and condensed the author's article content. Generalize. Through the analysis of key words in the literature related to rural planning, research hotspots in this field can be better discovered. In the Citespace parameter setting, set Node Types to "Key Word", and the other parameters remain unchanged, perform visual analysis, and obtain the rural planning keyword co-occurrence knowledge map. Keywords are represented as nodes in the graph. Each keyword corresponds to a node. The centrality of the node is used to measure the connection effect of network nodes in the overall network. The higher the centrality, the larger the node, which means it is a staged research hotspot[10]. Sorting statistics according to centrality and word frequency, according to the frequency of keyword appearances and intermediary centrality ranking results show that keywords such as rural planning, rural revitalization, urban-rural planning, rural tourism, beautiful villages, and rural landscapes appear most frequently in the past decade. Research hotspots are concentrated; it can be seen how to realize the rural revitalization strategy through the research on rural planning. The core goal of research in the field of rural planning in the future.

According to the statistics of centrality and word frequency, the distribution table of high-frequency keywords in rural planning research is obtained (as shown in Table 1). The keywords of urban and rural planning and Rural Revitalization in Figure 1 have the highest frequency in Table 1, which are 76, 27 and 27 respectively, and the centrality reaches 0.61, 0.33 and 0.29 respectively, which is the most critical node and turning point in the field of rural planning research, It is a hot research topic at present.

Table 1. Top 10 key words of rural planning research

Serial number	key word	frequency	Centrality particular	year	Serial number	key word	frequency	Centrality particular	year
1	Rural planning	76	0.61	2010	6	Rural landscape	18	0.19	2010
2	rural vitalization	27	0.33	2018	7	rural	15	0.09	2011
3	Urban and rural planning	27	0.29	2010	8	Overall planning of urban and rural areas	14	0.19	2010
4	rural tourism	24	0.17	2010	9	New countryside	11	0.01	2010
5	Beautiful countryside	22	0.15	2015	10	Rural Governance	10	0.05	2015

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4.2 Keyword Cluster Analysis

The research topic of the paper highlights the keywords of academic literature. The distance between keywords is studied by clustering algorithm, and keywords with similar content are clustered and classified, and cluster groups of different topics can be found to characterize academic research in different periods. Appearance, the dynamics of academic research in a certain period of time can be captured through a specific focus point[11]. Studies have shown that the Q value is generally in the [0,1) interval, and Q>0.3 means that the divided community structure is significant. When the S value is 0.7, the clustering is highly efficient and convincing, if it is 0.5 Above, clustering is generally considered reasonable[12]. The module value Q=0.5948 and the average contour value S=0.5494. The results show that the keyword clustering structure shown is significant and the classification is reasonable.

According to the cluster name and the main keywords contained in the cluster, we can further study the specific connotation of specific topics (Table 2). According to the analysis of Figure 2 and table 2, the research on rural planning since 2010 is mainly based on the theory of urban and rural planning. Under the strategy of "Rural Revitalization", it has been carried out around rural tourism, beautiful countryside, rural governance and other aspects.

According to the analysis of Table 1 and table 2, the study of rural planning from 2010 to 2020 did not pay attention to the study of land spatial planning. In the same way, the hot keywords of land and space planning (Table 3) do not appear high-frequency words of rural planning. The weak relationship between rural planning and land spatial planning means that there is a lack of integration of land use planning, regional planning and Urban-Rural Planning in rural planning research for a long time.

Table 2. Key words clustering table of rural planning

Cluster number	Cluster name	frequency	Contour value	Main keywords included
#1	Overall planning of urban and rural areas	100	0.590	Urban rural integration, rural tourism, beautiful countryside and village planning
#2	rural vitalization	72	0.500	Rural revitalization, planning strategy, rural and pastoral complex
#3	plan	48	0.470	Planning, evolution, urban and rural land use, land development rights
#4	landscape planning	49	0.250	Rural landscape, new countryside, ecological civilization and landscape planning
#5	sustainable development	26	0.070	Rural governance, rural construction, public goods and sustainable development

Table 3. Top 10 key words of land spatial planning research

Serial number	key word	frequency	Centrality	Serial number	key word	frequency	Centrality
1	Land space planning	157	0.54	6	Space Governance	12	0.11
2	spatial planning	47	0.29	7	Special planning	12	0.10
3	Multi planning in one	36	0.47	8	Ecological Civilization	11	0.10
4	Territorial space	27	0.22	9	Use control	10	0.09
5	Spatial planning system	27	0.18	10	rural vitalization	9	0.03

The six clusters of rural planning, rural tourism, rural revitalization, rural areas, beautiful villages, and urbanization constitute the main research sections of rural planning in the past ten years. Compared with the clustering done by Zhao Hongjuan[7] in 2018, this paper are more rural revitalization clusters. The main keywords of this cluster include: planning guidance, planning paths, planning strategies, rural development, rural revitalization, land and space planning, use control, etc. It can be seen that after 2018, under the background of rural revitalization strategy, rural planning research has begun to undergo transformation, and more attention has been paid to the guidance, path, strategy, and regulation of rural planning, which are strategic and government regulatory research fields with strong public management attributes. It also indicates that under the new background of land and space planning, in order to deal with new opportunities and challenges, break the single barrier of engineering thinking, and integrate planning research with public management and government regulation is the transformation and evolution direction of rural planning research.

5. Research Hotspot Evolution and Trend Analysis

Through the hot spot evolution and frontier dynamic analysis of the retrieval data, we can get the specific evolution path of the key points of rural planning research in each period, as well as the generation node, peak node and cooling node of the hot spot, so as to more intuitively summarize the hot spot evolution law of rural planning. Although the research of Zhao Hongjuan [7] (2018) and Sun Ying [13] (2017) did not draw the timeline map of CiteSpace, their research evolution rules obtained

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through literature research and field research, such as Sun Ying's research conclusions on public participation, rural governance, new urbanization and planners; Zhao Hongjuan's research conclusions on foreign planning experience and rural landscape characteristics are in line with the linear law presented in this paper, which proves the scientificity and reliability of her research. The rural planning from 2018 to 2019, starting from the Rural Revitalization node, will be the research hotspot of land and space planning, planning strategy, targeted poverty alleviation, big data, etc., and the prospect of Sun Ying's planning method of paying attention to practice, exploring multiple needs, and constructing the theoretical method of rural Planning [13]; Zhao Hongjuan's proposal that rural planning becomes the driving force of Rural Revitalization and is suitable for implementation is consistent with the prediction of evolution trend, which confirms the scientificity and feasibility of CiteSpace in the field of hot spot analysis and evolution trend prediction of rural planning.

According to the time dimension, the evolution of rural planning hotspots is analyzed: rural planning → rural tourism → beautiful countryside → Rural Revitalization → planning guidance and planning strategies are the main evolution trends in this research field. This evolution law reflects the promotion of the public policies proposed by the state for rural areas to the research hotspots in the field of planning. With the establishment of the land and space planning system in the new era, the research focus of rural planning has evolved from the Rural Revitalization in the National Rural Revitalization strategic plan (2018-2022) put forward by the state in 2018 to the planning strategy and planning guidance after the release of several opinions in 2019, which has more public management policy nature, It also brings a lot of pressure and challenges to the rural planning which is still in the traditional thinking mode of "planning on planning" and "technology on technology".

6. Dynamic Analysis of Research Frontiers

Research front (Research front) shows the new progress and new trends in scientific research, and is the subject and direction of research with innovation, development and interdisciplinary [14].Kleinberg believes that Burst Detection is suitable for identifying emerging research frontier concepts, and it can dig out keywords with low frequency but high frequency change rate[15]. Using Brust Terms to detect mutation words, the frontier research fields of rural planning in each period of mutation words, their strength and mutation time are shown in Figure 2.

Figure 2. Major mutations in rural planning

Burst Detection shows that the Brust intensity of rural tourism is relatively insufficient, but the mutation time is the earliest and the duration is the longest. It is the main component of my country's rural planning research before 2015; the strongest mutation word is the new rural and Beautiful Country, New Countryside and New Countryside Construction are the main lines of research before 2012, and Beautiful Country is the main line of research that has continued since 2015. The theories and empirical cases are relatively mature. However, the frequent occurrence of "rural revitalization" in the key words did not show a sudden change, indicating that with the deployment of the national strategy for rural revitalization, rural planning has received extensive attention from planning scholars, but the long-term disadvantaged background of rural planning has made scholars think about rural areas. The research on "planning first" and "strengthening planning guidance" proposed in the revitalization process lacks scientific theoretical support and experience accumulation. It needs to be further strengthened in terms of how to transform traditional thinking, break professional barriers, and embody strategic planning strategies and planning guidance. The depth of research. At present, the research of rural planning is entering a new era of land and space planning led by rural revitalization, fully integrating the theory of public management disciplines and government control tools, improving the sustainability and operability of rural planning strategies, and firmly planning ahead in the rural revitalization strategy The theoretical foundation of the plan and strengthening the leading function of planning are the top priorities for future rural planning research.

7. Conclusions and Prospects

Through the visual analysis of the knowledge map of Citespace, it is concluded that the current rural planning research has not formed a core author group, and there are more independent research among scholars and little overall contact; the overall cooperation of the publishing

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organization is less, the subject area is single, and the professional departments and majors of universities are concentrated. Planning and Design Institute: Urban and rural planning and rural revitalization are currently the most critical nodes and turning points in the research field of rural planning. How to realize the strategy of rural revitalization through research on rural planning is the core goal of research in the field of rural planning in the future; After 2018, the research on rural planning has begun to undergo transformation, paying more attention to the guidance, path, strategy, and regulation of rural planning in strategic and government regulatory research fields with strong public management attributes. It also indicates new developments in land and space planning. Under the background, in order to cope with new opportunities and challenges, the planning concept of single engineering thinking to solve problems represented by "planning on planning" and "technology on technology" is gradually being broken, exploring the depth of urban and rural planning and public management disciplines Integration, the use of public management related theories and government control tools to implement the goals of "planning first" and "strengthening planning guidance" proposed in the rural revitalization strategy, and improving the sustainability and operability of rural planning strategies are the future of rural planning research The research hotspots and evolutionary trends of rural planning are also the top priority of future rural planning research. We believe that with the release of the "Several Opinions" and the introduction of public governance concepts, the development context in the field of rural planning will surely become clearer and effective, the planning leading role of the rural revitalization strategy.

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Analysis and Related Suggestions on the Whole Process Engineering Consulting Service Mode at Home and Abroad

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ABSTRACT

This paper first introduces the basic connotation of China's whole-process engineering consulting. Immediately, analyze the organization model, service procurement model and charging standards of foreign whole-process engineering consulting (international terminology full-life cycle engineering consultant). Second, discuss the government's role in the development of engineering consulting from two aspects: service management and market access. Finally, combined with the above analysis, the specific problems faced in the implementation process of the whole process engineering consulting are compared. Provide relevant suggestions on how companies and individuals respond to industry development trends.

1. The Basic Connotation of Domestic Whole-Process Engineering Consulting

1.1 Policy Requirements

In March 2019, the National Development and Reform Commission and the Ministry of Housing and Urban-Rural Development issued the "Guiding Opinions on Promoting the Development of Whole-Process Engineering Consulting Services" Fagai Investment Regulations [2019] No. 515. Encourage construction units to entrust consulting units to provide full-process consulting services such as bidding agency, survey, design, supervision, cost, and project management. Meet the integrated service needs of construction units. Enhance the synergy of the project construction process.

1.2 Development Status

After several initial development stages of engineering consulting in my country, including the immature concept of engineering consulting, the unclear scope boundary, and the unclear content. At present, the breadth and depth of engineering consulting have been significantly improved. It is in a stage of concentrated and rapid development. Guobanfa [2017] No. 19, Development and Reform Investment Regulations [2019] No.515 and other related policies clarify the scope of the whole process of engineering consulting, organization methods and service technical standards. However, the government's policy documents have not yet been transformed into specific and quantifiable implementation regulations. The real progress of the pilot project

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of the whole-process engineering consulting service is not satisfactory.

1.3 Practice of "1+N" Model

Shanghai Tongji Engineering Consulting Co., Ltd. is one of the first pilot units of whole-process engineering consulting in China. Propose a "1+N" whole-process engineering consulting model. It is also the current mainstream service model. "1" refers to the engineering consulting management service chain that runs through the entire process of the project. It is the integrated management of planning, organizing, controlling and coordinating each stage of project decision-making, implementation and operation. "X" refers to a single project consulting management service in the whole process of project consulting management services. The consultant can undertake one or more of the professional engineering consulting services according to the needs and wishes of the client. Including preliminary engineering consultation, engineering survey, engineering design, bidding and procurement, cost consultation, engineering supervision, operation and maintenance consultation and BIM consultation.

2. Analysis of the Basic Content and Practical Problems of Foreign Engineering Consulting in the Whole Process

2.1 Organizational Model

There are two types of internationally-used whole-process engineering consulting service organization models-American and German. The core difference between the two is whether planning and design services and management services are undertaken by one unit.

2.1.1 American Model

In the American model, the owner signs a contract with a company. This company undertakes the phased or whole process of engineering consulting. In the project decision-making, implementation, and operation stages. The role of the enterprise at each stage varies due to the different engineering organization models. The three common engineering organization models in the United States are DBB (Design-Bid-Build), DB (Design-Build), and CM (Construction Management).

In the DBB model, the implementation of engineering projects must be carried out in stages in the order of design, bidding, and construction. The rights, interests and responsibilities of the owner, design unit, and contractor are relatively clear. Taking the design unit as an example, the designer self-regulates. In the design stage, after the initial design of the designer is approved by the owner. The designer chooses an architect as the project manager to assist in the deepening of the design and construction drawing design. In the bidding, the designer is based on its own professional knowledge and understanding of the project at the design stage. Complete the technical description of the bidding document. Assist the owner to analyze the bid price and complete the bidding. During the construction phase, the design unit is only responsible for quality observation of the construction. And review whether the construction party designed and constructed in accordance with the construction drawings. Whether the materials used meet the original requirements.

In the DB model, design and construction are entrusted to a single unit. The two form an overall team, and the team leader is often taken by the construction unit. The DB contractor itself manages the design and construction. The level of the contractor has a greater impact on the design quality. Therefore, this model has higher requirements for the management ability of the enterprise. Usually, the owner entrusts a certain proportion of design work such as construction drawing design to the unit. Entrust the conceptual design and preliminary design to other design units. Or the owner directly designates the design unit in the contract.

The CM model contracts the project in stages. Construction is carried out at the same time as the design, this mode can effectively shorten the construction period. CM model is divided into agency type and risk type. The core difference between the two is whether the entrusted unit has contracted the construction work. The former means that the owner has signed contracts with the engineering consulting unit and the construction unit respectively. In the latter, the contract includes both engineering consulting services and construction contracting work. The construction contracting here is different from the general construction contracting. The entrusted unit shall obtain the consent of the owner when selecting construction subcontracting.

2.1.2 German Model

In the German model, the owner is associated with two types of engineering consulting companies, namely, planning and design and project control and management. The first type of planning and design services includes not only basic design, but also extended service content. Specifically, basic services refer to the preparation of basic materials, concepts, prelimi-

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nary, deepening, approval, and construction drawing design. Extended service runs through all stages of the project. Including the bidding preparation and bidding and contracting work before construction. Construction monitoring, acceptance, related design and project management during construction. As well as project inspections, filing, related design and project management during the warranty period. The second type of company is responsible for project control and management.

In terms of contracting methods, the owner can choose to sign contracts with two units separately. You can also choose to sign a contract with a consortium or cooperative. Project management, supervision, or cost consulting companies can all become members of consortia or cooperatives. Regardless of the contract method, the designer is the main body.

2.2 Purchasing Mode

The United States generally does not adopt competitive bidding laws. This is because engineering consulting costs account for a relatively small proportion of the entire project investment and service quality has a greater impact on engineering safety, progress, and quality. It is meaningless to pursue cost reduction at the expense of service effects. On the other hand, the specific workload, scope and content of the work are vague, and pricing cannot be clearly defined.

The commonly used procurement models are mainly divided into three categories. Including design competition, agreement review and proposal and negotiation. Among them, design competition and agreement review are common modes of procurement design work. As the name suggests, the organizer issues the design tasks of the competition project. Select the optimal design plan from many participating units. The protocol review is slightly different from the design competition. Participating design units are either recommended by professional institutions, or the owner sends an invitation to interested design units. Rank the submitted design materials according to the scoring principle, and select the best design unit.

2.3 Fee Standard

At present, the common international charging methods mainly include the following. For example, fixed price contracts, calculations on time, wages plus a certain percentage of other expenses, costs plus handling fees, calculations based on construction ratios, etc. Among them, the fixed price contract refers to the clear engineering tasks and clear service content. If the risk does not exceed the scope agreed by the parties to the contract, the price will be fixed and no adjustment will be made. When calculating on time, the engineering consulting company charges by the hour. Employment costs are generally 2.5 to 3 times the hourly rate for engineers. Calculated by construction ratio means that the service fee is charged according to a certain percentage of the project budget. Generally 1%-5%, this method is more common in the world.

The German national standard is relatively clear, according to the "Statutory Standards for Architects and Engineers Service Fees" (HOAI). The standard divides the whole process into nine stages. In addition to stipulating the service content of each stage, it also formulated relevant regulations on service fee standards and the proportion of remuneration at each stage. The charging standards for the whole process of engineering consulting in my country are not clear. At this stage, most of the individual costs are superimposed. On this basis, increase the costs incurred in the organization and coordination of all parties. Although this method is relatively simple, it encourages engineering consulting companies to improve consulting quality. Encouraging companies to adopt mergers and acquisitions, or joint operations to broaden the upstream and downstream of the industrial chain will not help much. When the contracted parties have a long-term cooperative relationship. On the cost basis, part of the cost saved by the consulting company for the owner can be used as an additional cost. In this way, the improvement of service quality of consulting enterprises is encouraged.

3. The Role of the Government in the Development of Whole-Process Engineering Consulting

3.1 Service Management

Foreign engineering consulting has a high degree of marketization. Under the guidance of laws and regulations, relevant policies, and standards, market order is effective. In developed countries where the engineering consulting market is mature. Industry norms, industry self-regulatory associations and internal corporate systems are combined. Better restraint on market behavior and escort the healthy development of the industry. Specifically, the government formulates industry overall plans, relevant laws and regulations, policies, and various service standards. Industry associations transform government laws and regulations and related policies into specific rules and regulations to restrict

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the behavior of members. At the same time, in order to maintain the authority of the industry association among member companies. Industry associations not only assist the government in the self-discipline management of the engineering consulting market. It must also represent the legitimate rights and interests of companies and consultants. In addition, industry associations are also responsible for promoting the healthy and high-quality development of the industry. Including formulating professional education standards, formulating vocational continuing education and training plans, vocational qualification management, and holding regular academic exchange activities.

At present, the level of my country's consulting industry is not high enough, and the market system is not perfect. The government mainly plays a guiding role, and the market operation still focuses on the internal management system of the enterprise. Such loopholes often lead to phenomena such as mutual borrowing of qualifications, false and unfair competition among enterprises. Further hinder market development and form a vicious circle.

3.2 Market Access

Foreign countries have stricter requirements on the personal qualifications of practitioners. The government's management model of qualifications is more reasonable. Professionals form related organizations such as the society. Register with the government and organize professional qualification examinations after being recognized. And conduct exam certification management for candidates. Candidates who pass the exam must be registered with the government before they can engage in engineering consulting related work. In doing so, on the one hand, the government conducts examination qualification management through the society. It is convenient for the government to control the market access of the engineering consulting industry. On the other hand, candidates who pass the exam are registered by the government as the rule maker. Can effectively restrain the professional behavior of practitioners.

In my country, enterprise qualifications are the center, and personal qualifications are supplemented. One reason for this situation is that most of the large-scale construction project owners in my country are state-owned enterprises. The audit system is relatively strict and requires higher qualification management for enterprises. Foreign countries are only allowed access to practitioners who have a qualification certificate. There are no qualification requirements for consulting companies.

4. Actively Follow the Development Trend of Engineering Consulting Throughout the Process

Through the above comparison of several major characteristics of the whole process engineering consulting industry, government, enterprises and individuals at home and abroad, we can get the following lessons:

For the government, the organizational model can be inspired by the experience of the American and German models. Construct a development model of full-process engineering consulting in line with my country's national conditions. In the procurement mode, the owner can use quality and cost as the basis for selection. Use proposals and negotiations, design competitions, agreement review and other methods to select high-quality cooperation units. Regarding the charging standards, my country currently uses multiple fee stacks and prescribed rewards to calculate fees. Can learn from foreign experience. According to the specific conditions of the project such as whether the content of the consulting service is clear. Choose a fixed price contract, charge according to the investment ratio, and charge by stages, etc. to choose the most suitable plan.

For enterprises, use financial means to merge and reorganize enterprises. Extend the upstream and downstream of the industrial chain and expand the scale of enterprises. Actively learn from foreign excellent enterprises that can undertake the entire process of engineering consulting business. Such as AECOM in the United States, ARCADIS in the Netherlands and ARUP in the United Kingdom. Broaden industry types. Cultivate a group of high-quality compound talents with international vision. Give full play to the advantages of professional technology and management capabilities. Make reasonable use of BIM tools to improve the ability of information integration. Promote industry innovation and sustainable development.

For individuals, high-quality, comprehensive talents are the talent trend of the industry. With the further improvement of the government's market access rules. Individual qualification requirements will be more stringent. Participate in the qualification examination as soon as possible before the relevant national systems are perfected. Prepare in advance for the development of the engineering consulting industry. It is not difficult to find after studying the whole process engineering consulting service model. This way of integrating multiple services requires practitioners. It has comprehensive strength including design, construction, and man-

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agement capabilities. This undoubtedly puts forward higher requirements on the overall quality of designers.

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Study on Quality Control of Concrete Raw Materials in Road and Bridge Construction

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ABSTRACT

The main material of concrete is a construction building material composed of water and mineral mixture and cement and chemical additives in the corresponding proportion and below the standard. In the process of making concrete material, slurry and cement are needed to mix, then cement slurry and sand are mixed into mortar according to the corresponding proportion, and aggregate is added to mortar to form concrete building material. In the process of concrete preparation, the most important construction link is mixing, which needs to be fully stirred to make the performance of concrete meet the construction needs. In the process of concrete construction technology development, both mix ratio and production technology have become more and more mature, but there are still some problems, which have an impact on the quality of concrete[1]. Therefore, this paper discusses the quality control of concrete raw materials according to the construction process of road and bridge.

1. Introduction

Nowadays, in the construction of road survey engineering projects, the proportion of concrete raw materials is more than that of total cost input in the implementation of the project, and in the actual use process, Concrete material itself is the main compression structure, so the quality of concrete will affect the service life and safety of road bridges. Therefore, strengthening quality control and management of concrete raw materials is an effective way to improve the construction quality of highway bridges.

2. Importance of Quality Control of Concrete Raw Materials in Road and Bridge Construction

Because for road survey projects, the main purpose of implementing construction work is to make transportation and transportation have a more stable infrastructure to provide corresponding services. To our country economy development and the development of transportation cause all play the very good promotion function. Therefore, in the actual construction process, it is necessary to perfect and strengthen the quality control measures to ensure the construction quality of concrete, so that the construction quality of road and bridge projects can be guaranteed in essence. In the actual construction process, the proportion of raw materials in the concrete will directly affect the quality of the final concrete, thus affecting the construction quality[2]. Therefore, in the process of construction quality control, it is necessary to start from the link of concrete raw materials, and to make the construction quality control by strengthening various quality management measures.

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3. Quality of Concrete Raw Materials for Road and Bridge Construction

3.1 Excessive Temperature Change of Raw Materials for Concrete

In the process of concrete allocation, the most important construction link is mixing[3]. The change of external temperature and humidity will directly affect the mixing time and the final concrete quality. Therefore, in the process of concrete configuration, if the mixing of concrete raw materials is not completed in accordance with the prescribed time, the quality of raw materials will be greatly reduced compared with the final ideal level. The most common problems in concrete mixing are uneven mixing and material stratification. For road and bridge concrete construction, the temperature change of external environment will make the construction technology of raw materials change to a great extent. In order to ensure the temperature change before and after construction, it is necessary to extend the construction period to ensure the temperature of concrete materials[4].

3.2 Higher Early Strength of Cement

For concrete, one of the most important raw materials in the process of configuration is the cement of cement fiber reinforcement. The most important problem is that the early strength is relatively high, but the later strength growth efficiency is not high. Or there is a stop to growth. In fact, for cement and concrete, in the process of concrete configuration, strength theory is a theory put forward by construction enterprises in order to shorten the period of concrete demoulding, mainly to improve the turnover efficiency of formwork. But in the process of practical use, the early strength of concrete is too pursued, so the wrong idea is transmitted to the concrete enterprise by the construction unit, and then to the cement production enterprise[5].In order to meet the actual requirements of engineering project construction, some cement production enterprises increase the early strength of cement by adding early strength agent and grinding. However, the strength of cement itself can not be significantly improved in the later stage, so the quality of the final concrete is affected, and the main reason for the decrease of concrete durability is that the early cement strength is higher [6].

3.3 Quality Problems of Concrete Admixtures

The so-called admixture refers to the need to add some admixtures in the preparation of concrete raw materials, so that the frost resistance, expansion and ductility of concrete can be improved, but in the actual configuration process, if the quantity of these admixtures is too large, the quality of concrete structure itself will decline. Therefore, it is necessary to carry out all-round test work in the actual construction process to ensure that the admixture added conforms to the best mix ratio, and to pay attention to the construction details in all aspects in the practical application process. In the actual construction process, some construction workers rely on their own work experience not to explain the use of admixtures, resulting in the addition of admixtures can not improve the performance of concrete, but also reduce the quality of concrete[7].

3.4 Other Issues

In the process of concrete preparation, because of the lack of natural gypsum, many cement manufacturers use desulphurized gypsum instead of natural gypsum, which makes the compatibility of cement and admixture very low. Moreover, because a large amount of cement is needed in the process of concrete preparation, the supply of cement becomes tight, the cement strengthening time produced by some enterprises is relatively short, and the surface temperature is also relatively high[8]. For the technical staff of concrete enterprises, it is necessary to select some cement produced in large factories when selecting cement raw materials, and to carry out batch testing. The strength and stability of cement and other related data indicators are determined.

4. Quality Control Measures of Concrete Raw Materials for Road and Bridge Construction

4.1 Reasonable Sample Extraction and Testing

For road and bridge engineering projects, there are a lot of materials to be prepared in the actual construction process, so in the process of preparing materials, it is necessary to determine the specifications, categories and batches of different materials[9]. In the development of material quality testing, need to rely on sample extraction to complete quality testing. Sample extraction also needs to follow the principle of the same specification, the same category and the same batch, and then scientifically plan the quantity and weight of the sample according to the working efficiency of the experimental site and the staff. In the process of testing, the quality supervision and management staff should take the current industry standard system as the guide, and then combine the construction site situation of the project construction to improve the serious and responsible attitude of the work.

4.2 Increased Emphasis on Data Management

For concrete preparation, the influence of each data on

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the final quality of concrete can not be ignored, so it is particularly important for concrete enterprises to strengthen data management. The so-called data is not only the data reflected in the development process of enterprises, but also the data formed in the construction process of road and bridge projects. These data can make the road and bridge construction quality problems appear timely data feedback, and then form the corresponding solutions. Therefore, the formation of data needs to make a good record of the whole process, and can not arbitrarily change the data results[10].

4.3 Enhanced Mix Ratio Testing

In the process of concrete preparation, the influence of mix ratio on concrete quality is very important, so the inspection of concrete mix ratio should be strengthened in an all-round way. This is also the most important way to ensure that the bearing capacity of concrete meets the actual construction needs. Taking impermeable concrete as an example, in the process of mix ratio design and testing, it is mainly completed according to the following steps. The first is to discuss the mix ratio configuration of impermeable concrete, the second is to determine the water consumption in the design process of concrete mix ratio, and the third is to calculate and determine the amount of sand and stone used in the process of concrete configuration. Then the mix ratio is preliminarily determined. Finally, based on the mix ratio designed and obtained by the laboratory, the final concrete mix ratio is determined according to the benchmark configuration ratio[11].

4.4 Improving Admixture Quality Control

In the process of concrete preparation, quality control technology is carried out for admixture. The staff need to check the production certificate of admixture and the relevant data such as test qualification report. And need to have technical personnel to do admixture review and re-inspection work. Only after all the inspection work is completed and meets the needs of design and construction can the admixture be used as the adding material and applied in the process of concrete mixing.

4.5 Control of Fine Aggregate Raw Materials

In the process of concrete preparation, fine aggregate and coarse aggregate are one of the main raw materials for concrete preparation. In the process of practical use, the most commonly used fine aggregate is sand, and sand can be divided into artificial and natural. In natural sand, rock particles with particle size within 5 mm are called natural sand, while artificial sand is a small particle size sand material made of waste slag powder after crushing. To carry out quality control for selenium aggregate, it is mainly necessary to carry out all-round detection and recording of material gradation, fineness modulus and harmful content, especially the harmful substances contained in the interior. Not only will the strength of concrete itself be affected, but also the safety of construction workers and the users of later buildings will be seriously endangered.

4.6 Full Implementation of Construction Requirements

In general, because the construction area and coverage of road and bridge projects are relatively wide, the quality requirements of concrete are higher. In order to meet the higher requirements of concrete in the actual construction process, it is necessary to ensure the strength and durability of concrete by ready-mixed pumping in the actual construction process. Moreover, in the actual construction process, it is necessary to analyze and control the construction environment temperature and humidity of concrete reasonably, so as to ensure that the temperature and humidity of concrete working environment meet the performance requirements of concrete. It will not affect the durability and other properties of concrete itself. Moreover, all the construction processes need to be completed strictly according to the corresponding construction specifications, and the construction links and construction procedures should be strictly controlled. In addition, it is necessary to strengthen the quality supervision system of engineering projects, because in the construction process of engineering projects in China, the phenomenon of imperfect quality supervision system still exists, so in the process of carrying out quality control work, There are still loopholes that some managers will neglect[12].

5. Conclusion

To sum up, for the control of concrete raw materials in road and bridge engineering, the main purpose is to ensure the construction quality of road and bridge engineering projects. Therefore, it is necessary to improve and improve the current problems of road and bridge, concrete quality control and raw materials, and make up for the shortcomings in the quality inspection and management of raw materials. Improving the quality inspection level of concrete raw materials is basic engineering.

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The Effection Analysis of Geotechnical Investigation on Foundation Pit Supporting Construction

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Construction effect

ABSTRACT

With the continuous development of the construction industry, the density of engineering construction and the difficulty of underground construction are also increasing. As an important construction protection measure, foundation pit support construction is widely used in underground construction. Starting from the characteristics of foundation pit support construction, this paper analyzes the influence of geotechnical investigation on foundation pit support construction, and analyzes the problems that need to be paid attention to in the survey process.

1. Introduction

Foundation pit support is an effective and popular construction method that can ensure the safety of underground structure construction and surrounding environment of foundation pit by supporting, reinforcing and protecting the side wall of foundation pit and surrounding environment. As the supporting structure of buildings, the construction quality of foundation pit supporting construction determines the performance of ground buildings. For this reason, the rationality and scientificity of foundation pit supporting construction should be fully considered in the construction process. Before the foundation pit construction, the first step is to excavate. In order to ensure the foundation pit support construction can be carried on smoothly and guarantee the construction quality of the whole construction, the staff must master a large number of soil and hydrological data by means of a comprehensive geotechnical investigation, so as to be able to adopt the protective measures in a targeted way and improve the safety and quality of foundation pit support construction. The main contents of geotechnical engineering investigation include: field drilling, laboratory test, undisturbed soil sampling and in-situ test. In the process of geotechnical investigation, the constructors carry out detailed investigation on the soil conditions, geological conditions and hydrological conditions of the area the project located, and than formulate a set of scientific and orderly construction scheme. Through a series of rigorous and scientific geotechnical investigation, it lays a good foundation for the follow-up construction.

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2. Concept and Characteristics of Foundation Pit Support Construction

2.1 The Concept of Foundation Pit Support Construction

Foundation pit support is a measure to further strengthen, support and protect the side wall of foundation pit and surrounding environment on the premise of ensuring the safety of underground structure and surrounding environment[1]. By utilizing foundation pit support construction, we can ensure the stability around the foundation pit, prevent structural collapse, landslide and other phenomena, in the meanwhile, we can effectively protect the adjacent buildings and underground pipelines from damage during construction.

2.2 The Construction Characteristics of Foundation Pit Support Construction

2.2.1 Regional

The construction of foundation pit support engineering has significant regional characteristics. Different construction sites have different engineering geological and hydrogeological conditions, which cause great differences in the practical operation of foundation pit engineering. There are also differences in different areas of the same city, so engineers should adjust measures to local conditions and make building plans according to local conditions[2].

2.2.2 Comprehensiveness

Foundation pit supporting construction is a systematic project with strong comprehensiveness. Foundation pit supporting construction involves the knowledge of Geotechnical engineering and structural engineering[3]. At the same time, it is also affected by many complex factors in the actual operation. It is necessary to comprehensively consider the structural characteristics and properties of buildings, adverse geological phenomena, groundwater depth conditions, etc. In order to standardize the construction, the relevant departments of construction have formulated the relevant construction regulations of foundation pit supporting construction, classified the safety level according to the severity of the damage consequences, and systematically standardized the foundation pit support engineering, which has become the main normative document of construction.

2.2.3 Uncertainty

The construction of foundation pit support project has uncertainty[4], the main reasons are as follows: first of all, the geotechnical survey data and raw materials are inaccurate and incomplete; the second is that the practical experience and technical level of foundation pit designers also determine whether the foundation pit support type is reasonable and effective; thirdly, the changes of surrounding environment and seasonal changes will lead to the form of foundation pit support different, therefore in the construction of foundation pit support engineering, we should analyze the specific problems and attach importance to the combination of theory and practice.

2.2.4 Temporary

On account of the foundation pit needs to excavate the ground structure, in order to prevent the collapse or large settlement displacement of the soil around the foundation pit, it is necessary to set up the foundation pit support system[5]. The foundation pit support system is a temporary structure, which is no longer needed after the underground engineering construction is completed. Generally speaking, the safety reserve of foundation pit support system is small and has a great risk. Monitoring shall be carried out during the construction of foundation pit project and emergency measures shall be taken. In case of danger in the construction process, it is necessary to rescue in time.

3. Concept and Main Objectives of Geotechnical Investigation

3.1 Concept of Geotechnical Investigation

Engineering investigation is an important link in the process of engineering construction, which refers to identifying, analyzing and evaluating the geological conditions, environmental characteristics and geotechnical engineering conditions of the construction site according to the requirements of the construction project. After the engineering investigation, the detailed data obtained after the survey should be sorted into the survey report according to the actual geological conditions of the project, so as to provide detailed and reliable data support for the foundation pit design[6]. Therefore, in order to ensure the rationality and scientificity of foundation pit design, the investigation work must be done well.

3.2 Main Objectives of Geotechnical Investigation

3.2.1 Accurate Description of the Properties of Rock-Soil Mass

It is an important aspect of the preliminary work of geotechnical investigation to deeply and accurately understand and describe the properties of Rock-Soil Mass.

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Geotechnical investigation is a complicated as well as special investigation work. The main investigation indexes include the distribution, distribution area, mechanical properties, hydrogeological conditions of the overall construction environment and the corrosiveness of Rock-Soil Mass

3.2.2 Find out the Groundwater Burial Condition

It is also necessary to find out the buried situation and type of groundwater, the change of groundwater level and its amplitude and law, the permeability of each soil layer, and analyze the hydrostatic pressure, hydrodynamic pressure and buoyancy of groundwater and their influence[7]. The underground water level directly affects the stability of foundation pit engineering, which may cause sudden gushing, quicksand or piping and other emergencies. Therefore, it is necessary to comprehensively grasp the underground water situation of foundation pit and put forward corresponding prevention measures.

3.2.3 Understand the Influence of Excavation Construction and Meteorological Factors

The construction of the project may be affected by external environmental factors, including not only natural factors but also human factors. Finding and obtaining relevant information about the possible impact of these factors in time will help to avoid related unfavorable factors through scientific methods in the later construction, and minimize the adverse impact [8] .

4. Influence of Geotechnical Investigation on Foundation Pit Supporting Construction

Geotechnical investigation is the foundation and prerequisite of construction. Before foundation pit supporting construction, the first technical link is to carry out foundation pit excavation. In order to ensure the safety of the foundation pit support construction, it is necessary that construction personnel could fully grasp the geotechnical conditions of the construction site, including engineering characteristics, structural characteristics, hydrogeological conditions, and the distance of the survey area. This requires attention to the control of the following processes: one is the geological environmental factors of the survey; the second is the rationality of the foundation pit support plan; the third is the scientific formulation of a plan for groundwater treatment. After mastering the above elements, a scientific and reasonable foundation pit support plan based on the research results can be formulated. In addition, for areas with dense underground pipeline networks, it is also necessary to investigate the pipeline layout, burial depth, layout range, etc., and obtain data that can provide guiding opinions on construction engineering design and foundation pit design. At the same time, the construction groundwater level and distribution are also the focus of the survey. Following according to the characteristics of foundation pit supporting construction, we analyze the influence of geotechnical investigation on foundation pit supporting construction which are mainly reflected in the following aspects:

4.1 The Influence of Geotechnical Conditions on the Foundation Pit Support Construction

The soil quality of the foundation pit is the key content of geotechnical investigation, and it is an important foundation for subsequent survey work, and an important basis for selecting survey methods and supporting technologies. The main content of the survey includes the distribution of rock-soil mass and the characteristics of the geological section of the distribution area[9]. The difference in soil quality will directly affect the selection of the survey method and the support technology adopted for the foundation pit support. For example: when the soil layer is a soft soil layer, it is demanding for survey technology requirements. After the excavation of the foundation pit, the survey report should be checked carefully. It is also necessary to check whether there are ancient wells or ancient tombs and other cultural relics underground to avoid soil damage caused by the agitation of the soil. On the other hand, the drainage of the foundation pit is also need to be checked, in order to avoid problems that affect the safety and stability of foundation pit construction, such as softening or freezing of the soil layer due to insufficient drainage.

4.2 The Influence of Hydrological Conditions on the Foundation Pit Support Construction

The survey of hydrological conditions in the process of geotechnical survey includes the conditions of the groundwater level and the conditions of aquifers. The groundwater level directly determines the stability of the foundation. First of all, in the process of geotechnical survey, the groundwater level should be surveyed. The law of water level changes, the reasons for the rise and fall of the water level should be grasped and found. So as to provid guiding opinions for the development of survey work. Secondly, aquifers are also the focus of investigation. Investigation elements including: the burial depth of water layer, water level and the formation conditions of the water layer, the type, direction and speed of each water layer.

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4.3 The Influence of Slope Stability on the Foundation Pit Support Construction

Slope is an important structure for project construction, and its stability directly affects the stability of project construction[10]. From the perspective of foundation pit support technology, the slope stability survey should also include the stability of the anti-heave performance of the bottom of the foundation pit [11], the permeability of the pit base and side walls and the nature of the slope structure. In addition, attention needs to be paid to deformation problems during construction.

4.4 The Influence of Actual Operation on the Foundation Pit Support Construction

The existing actual operation problems of foundation pit support construction mainly include the following two aspects. On the one hand, due to the change of construction period, the influence of building materials and the influence of human factors, there will be differences between the foundation pit design plan and the actual construction plan. The main reasons for the large error are: construction units rush to the construction period and cut corners; the knowledge of construction designers is limited, the design scheme is improper, and unrealistic, etc. On the other hand, because the slope repair is not in compliance with the specifications, during the design support construction, the foundation pit support slope repair does not meet the design requirements owing to the operator's technique and construction technology. In the process of foundation pit excavation, there are problems of over-excavation and steep excavation, which do not meet the design requirements. These problems resulting in irregular engineering procedures, which in turn leads to potential safety hazards. In recent years, the causes of foundation pit accidents such as collapse of foundation pits and gushing soil are all due to factors such as vicious competition, which have led to inadequate implementation of geotechnical investigation and inaccurate survey reports, which leaves serious security risks to subsequent foundation pit design and construction.

5. Technical Points for Supporting Foundation Pits of Different Types of Geotechnical Engineering

5.1 Supporting Technology in Support System

Support system support technology is mainly aimed at the rational application of support systems based on building materials to enhance the effect of foundation pit support. Popular materials are: steel, steel pipe, reinforced concrete and reinforced concrete composite supports, etc. With the help of supporting building envelope of underground mixing piles, cement mixers and bored piles to limit the displacement of the enclosure structure, thus can achieve the target of enhancing the compressive resistance of construction and effective support.

5.2 Supporting Technology in Water Retaining System

The supporting technology in the water retaining system can effectively block the external seepage water. Popular materials are: deep cement mixing piles, jet grouting piles, compaction grouting, underground connecting walls and locking steel sheet piles. Reasonably using water retaining system support technology can avoid system leakage during construction and ensure the stability of the foundation pit support system.

5.3 Supporting Technology in the Earth Retaining System

The earth retaining technology of the retaining system is to form a supporting row of piles or a retaining wall to block the earth pressure outside the pit. Commonly used building materials are: steel sheet piles, reinforced concrete slab bricks, deep cement mixing piles, bored piles and underground continuous walls.

6. Precautions for Geotechnical Investigation and Foundation Pit Support Construction

6.1 Improved Support Measures for Deep Foundation Pits

First of all, it is very important to apply designers with strong professional ability and comprehensive quality to carry out design work. The complete professional knowledge of construction personnel can ensure the overall project quality; Secondly, it is needed to strictly review the quality of construction materials, various equipment, purchase and transportation of construction materials[12]. The quality control of the link can ensure the construction quality at the source; the last is the scientific and reasonable use of construction equipment. The quality, accuracy and performance of various advanced equipment directly affect the construction quality, and the stable operation of the equipment lays a good foundation for the smooth construction.

6.2 Reasonable application of geotechnical investigation

Firstly, we must strengthen the scientific nature of the

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construction technology before construction. On the bases of the analysis of various basic data, using advanced survey technology and comprehensive application of information technology, we can optimize the survey and design plan, improve the level of survey design and improve the foundation pit support, ultimate, protect the quality of construction.

7. Improving the Quality of Geotechnical Investigation Work and Foundation Pit Support Construction Plan

7.1 Project Management and Standard Work Process

The process of geotechnical investigation starts from the signing of the contract and extends to the project delivery stage. The degree of standardization determines the quality of the project[13]. Therefore, it is necessary to standardize the geotechnical survey work process and strengthen project management to effectively achieve standardization and scientific surveys. The accuracy of the exploration work requires not only on-site investigation, but also analysis and verification of indoor tests to ensure the accuracy of the survey data[14]. Strengthening project management is divided into original data management and project evaluation management. The original data should be properly kept. The contents of all survey reports should be reviewed to analyze whether the data and surveys can actually meet the needs of the project itself. Emphasis on project management. After each stage of geotechnical investigation work is completed, review should be carried out. In the final inspection, after the indoor test stage, only review and modifycation has been carried by the engineering review and evaluation team can the final project delivery be carried out.

7.2 Formulate the Most Reasonable Foundation Pit Support Plan According to Local Conditions

Before carrying out the foundation pit supporting work, the corresponding foundation pit supporting implementation plan shall be formulated according to local conditions. Taking a deep foundation pit project as an example, the excavation depth of less than 6 m generally will not fail, but once the excavation depth exceeds 6 m, the geological issues and the original municipal underground pipe network design must be considered comprehensively. Areas with different geological and soil conditions require different foundation pit support schemes. The designer should use the geological survey report and the foundation pit excavation sideline, basement structure, surrounding environment map and other reference materials provided by the design unit to conduct an overall analysis of the engineering geotechnical parameters, determine of profile soil parameters, determine the section soil layer parameters, and formulate reasonable, economic and safe foundation pit support plan, and finally optimize and adjust the plan.

7.3 Establish a Responsibility System to Strictly Grasp the Quality of Foundation Pit Support Construction

In order to avoid the problem of uneven quality of foundation pit support engineering caused by human factors, relevant government departments should urge the construction unit to establish a responsibility system that the person in charge of the project is the first responsible person. If problems occur, they will be severely punished. A strict review system and random inspections of construction should be conducted. In addition, the construction unit should also take safety production as the first element, strictly grasping the quality of the foundation pit support project to ensure the orderly and safe development of the project, and be a construction unit with conscientious production and construction.

7.4 Strengthen Personnel Training

Whether it is geotechnical investigation work or foundation pit support construction, it is a technology-oriented work. Upgrading technology can effectively improve construction quality[15]. It is important to continuously strengthen personnel training and improve professional quality. In this way we can improve the accuracy of survey and the quality of foundation pit support. Social progress will drives the development of science and technology, and the scientific and technological research and development of scientific research departments will promote the development of 8. Conclusion

In recent years, the construction industry of our country has developed vigorously, the scale of construction projects is constantly expanding, and the technical nature of construction projects is also increasing. In this context, the quality of construction projects has received more and more attention. As the most important construction link in the modern construction process, foundation pit support construction should improve the level and quality of construction technology to ensure the overall construction technology and construction quality problems. Geotechnical investigation work is the prerequisite of foundation pit support construction, which directly affects the quality of foundation pit support work. In order to improve the

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construction quality of foundation pit support construction, increasing the intensity of geotechnical engineering investigation is the key. Through detailed geotechnical engineering survey, it can ensure the smooth development of foundation pit support construction and ensure the quality of the project. This article analyzes the influence of geotechnical investigation on the construction of foundation pits, hoping to promote the overall development of the construction of foundation pits.

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Study on Ground Engineering and Management of Carbonate Oil Field A under Rolling Development Mode

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ABSTRACT

Carbonate rock has the characteristics of complicated accumulation rules, large-scale development, high yield but unstable production. Therefore, the management and control of surface engineering projects of carbonate rock oil and gas reservoirs faces huge difficulties and challenges. The construction of surface engineering should conform to the principle of integrated underground and ground construction and adapt to the oilfield development model. This paper takes the newly added area A of the carbonated oil field as an example to study the ground engineering under the rolling development mode and aims to provide the constructive ideas for the surface engineering under rolling development mode. The overall regional process design adheres to the design concept of "environmental protection, efficiency, and innovation", strictly follows the design specifications, and combines reservoir engineering and oil production engineering programs, oil and gas physical properties and chemical composition, product programs, ground natural conditions, etc. According to the technical and economic analysis and comparison of area A, this paper has worked out a suitable surface engineering construction, pipeline network layout and oil and gas gathering and transportation plan for area A. Some auxiliary management recommendations are also proposed in this paper, like sand prevention management and HSE management for carbonate reservoirs.

1. Introduction

1.1 Art of Carbonate Reservoirs

Carbonate reservoirs occupy an extremely important position in global oil and gas resources. According to statistics from IHS, carbonate oil and gas resources account for about 70% of the global oil and gas resources, proven recoverable reserves account for about 50%, and production accounts for about 60% [1]. Carbonate oil and gas reservoirs are widely distributed in North America, the Middle East, Central Asia and other regions. The main types are reefs, grain beaches, dolomites and weathered crusts. They are usually large in scale and have a buried depth of less than 3 000 m. The Luo, Cretaceous and Neogene are dominated by porous media. Carbonate oil and gas reservoirs abroad are mostly based on continuum theory for development and design; in terms of drilling and completion and engineering technology, a series of technologies such as complex structure wells have been developed to increase production and recovery. China is also very rich in carbonate oil and gas resources. According to the results of the national oil and gas resource dynamic evaluation in 2015, the petroleum geological resources are 340×10^8 t and the natural gas geo-

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logical resources are 24.3×10^{12} m^3, accounting for 27.0% of the total oil and gas resources. And 26.9%. In recent years, with the development of carbonate oil and gas fields such as the Tahe Oil Field, Puguang Gas Field, and Anyue Gas Field, the production of natural gas and crude oil has increased rapidly, becoming an important area for China's oil and gas exploration and development, and for increasing oil and gas reserves and production. Compared with carbonate oil and gas reservoirs in other countries, China's carbonate oil and gas reservoirs have an old geological age, deep burial, and have undergone multiple stages of tectonic movement transformation. Porous reef beaches are mainly dolomite, making development more difficult [2].

Due to the complex geology of carbonate reservoirs and rapid decline in production, surface engineering projects have the following management and control difficulties [3]:

(1) The geological environment is changeable, and the production scale is difficult to support. Compared with the construction and development of other oil reservoirs, it is prone to problems such as disconnection between the ground and the ground, the mismatch of production and construction scale, and overcapacity, and the investment risk is high.

(2) Production capacity construction. Surface engineering project construction is a complex open system with strong integrity, multiple joints, large internal and external coordination workloads, and features large investment, short construction period, multiple construction units, intensive technology, and harsh geographic and natural environment.

Therefore, for the exploration and development of carbonate oil and gas reservoirs, an integrated mechanism of exploration and development should be adopted, and underground exploration and development and surface engineering construction should be considered as a whole, so that the underground production can be matched with the construction scale of surface storage and transportation projects, and project management and control should be strengthened. So as to realize the dynamic optimal allocation of resources and obtain good economic benefits.

1.2 Typical Carbonate Reservoir - Tahe Reservoir

Tahe Oilfield is currently the only large-scale marine carbonate oil and gas field discovered in the Tarim Basin. Due to the complex accumulation conditions, the diverse forms of fractured-vuggy reservoirs, complex oil and gas distribution, and extremely special reservoir types, they are completely different from existing ones. The fracture-type or pore-type oil reservoir- Tahe reservoir has the following basic characteristics.

(1) The burial depth of the reservoir is generally between 5300 and 7000 m, and it is one of the deeper carbonate reservoirs that have been developed in the world [4].

(2) The diversity of storage space covers almost all types of carbonate storage space, including large-scale caves, dissolved pores, dissolved pores and structural fractures. Large-scale caves are the most important storage space. Dissolution pores are only developed in local areas. Fractures are the main connecting channels, forming three main types of reservoirs: cavernous reservoirs, fracture-dissolved cavernous reservoirs and fractured reservoirs collective [5].

(3) Strong heterogeneity and strong separation. Different reservoir types are spatially interwoven to form fracture-cavity units with different connectivity, pressure systems and oil-water interfaces, and strong heterogeneity [6].

(4) Complicated development rules. Due to the different types of reservoirs in fracture-cavity units, different reserves and energy scales, the development rules of different fracture-cavity units are also different. There are not only units with insufficient energy, rapid pressure drops, and rapid decline in output. But also, units with sufficient energy, units with slow pressure drop, fast water content rise, and rapid decline in output [7].

(5) Since the capillary force can be neglected in the karst cave reservoir, the fluid flow in the karst cave has the characteristics of pipe flow, and the fluid flow in the fracture conforms to the characteristics of seepage. Therefore, the fluid flow in the fractured-vuggy reservoir of Tahe Oilfield has pipe flow characteristics. Coupling characteristics of flow and seepage [8].

(6) Tahe Oilfield has the characteristics of high temperature, high pressure, super thick, super viscous and high sulfur content. Due to the deep burial and early accumulation of the reservoir, the temperature of the reservoir is as high as 140 ℃ , the average pressure is above 60 MPa, and the crude oil density in the main block is above 0.98 g/cm^3, and the main block is as high as 1.04 g/cm^3. Crude oil at 50°C has a viscosity of 1 000 mPa·s, up to 1,300,000 mPa·s in some areas. In addition, it has the characteristic of high H_2S content [9].

The particularity of carbonate fracture-cavity reservoirs in the Tahe Oilfield determines that the development and construction of this type of reservoir are a process of continuous and rolling evaluation, confirmation of reserves, and rolling development and construction of productivity. The continuous optimization of rolling development, rolling production construction and development plan design runs through the whole process of production capacity construction of fracture-cavity reservoirs.

1.3 Principle of Ground Project in Carbonate Reservoirs

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When considering the construction of surface engineering in carbonate rock oilfields, the construction concept of "the ground is subordinate to the underground, and the ground adapts to the underground" should be established. According to the actual conditions of carbonate rock underground, timely optimize and adjust the ground construction. In particular, in view of the large uncertainty and short production life of carbonate reservoirs, we vigorously promote standardized design and skid-mounted construction to maximize reuse of equipment, reduce investment and maximize benefits [10]. Vigorously develop the "one well, one strategy" differentiated management model to improve oil well management. The strong heterogeneity of fracture-vuggy carbonate rocks determines the severe separation of the reservoir, and a connected fracture-vuggy unit is an oil and gas reservoir. Differences in storage space types, combination relationships, spatial distribution, reservoir size, water body energy, and completion methods have led to different development characteristics and effects. Therefore, it is necessary to formulate "one well, one reservoir" and formulate "one well, one strategy". Based on the development stage and dynamic and static geological data, a variety of oil and gas well production management strategies have been explored, and a differentiated management model of "one well, one policy" has been initially formed. Different methods are adopted according to the stage of the well. A reasonable working system should be adopted for stable production wells. When the production changes drastically, targeted measures should be considered. According to the characteristics of the fracture-cavity unit and the well, the intermittent production well adopts targeted measures such as acid fracturing, mechanical production, water injection for oil, and water injection pressure cone. The long shut-in well considers sidetracking when there is no potential for acid fracturing, layer modification, and water shutoff. According to the characteristics of the fracture-cavity unit, the single-well karst-cavity unit with insufficient energy was injected with water to replace the oil, and the multi-well fracture-cavity unit was subjected to unit water injection development tests. By sorting out the "lying wells", the efforts of sidetracking were increased, the utilization rate of single wells was increased, and the pace of exploration and development was accelerated. The "one well, one strategy" differentiated management model has played an important role in improving the recovery of fractured-vuggy carbonate reservoirs. Based on the construction principle of the integration of underground and ground in carbonate oilfields, this paper conducts research on the construction of surface engineering in the newly added area A in carbonate oilfields, aiming to provide ideas for surface engineering to adapt to the rolling development and construction of oilfields.

2. Data of A field

2.1 Design Principles

(1) To make full and reasonable use of the pressure energy of the oil and gas field, and the topographical features of the block, plan in a unified manner, consider the characteristics of the production data of the oil and gas field, and rationally design the surface engineering plan.

(2) Combining the overall process design of the gathering and transportation process in the geographical planning, rationally designing the layout of the gathering and transportation pipeline network, making overall plans and reducing the investment in project construction.

(3) To adopt mature gathering and processing technology, apply high-efficiency equipment, achieve the purpose of simplifying the process, reliable technology, saving investment, and ensuring the long-term stable operation of the gathering and processing system.

(4) Adhering to the concepts of innovation, efficiency, safety and environmental protection, highlighting the characteristics of carbonate oil and gas field development plans and gathering and transportation technology.

(5) To implement relevant national, industry and local regulations strictly, save energy and reduce consumption, and do a good job in environmental protection and production safety guarantees.

2.2 Overview of A Area

Area A is a new block in an oil field, which is a carbonate reservoir. Its surface contour is shown. Area A is between 1040 m and 1070 m above sea level. Currently, there are 6 old wells in area A, they are W1, W2, W3, W4, W6, W6 respectively. The location distribution is shown in Figure 1.

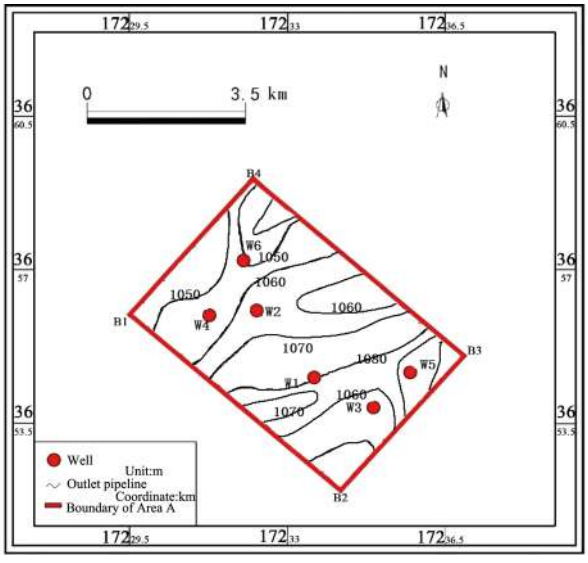

Figure 1. Location and contour map of area A

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According to the production demand of the oil field, 6 new production wells are needed to be added. The locations of the 12 wells are shown in Figure 2.

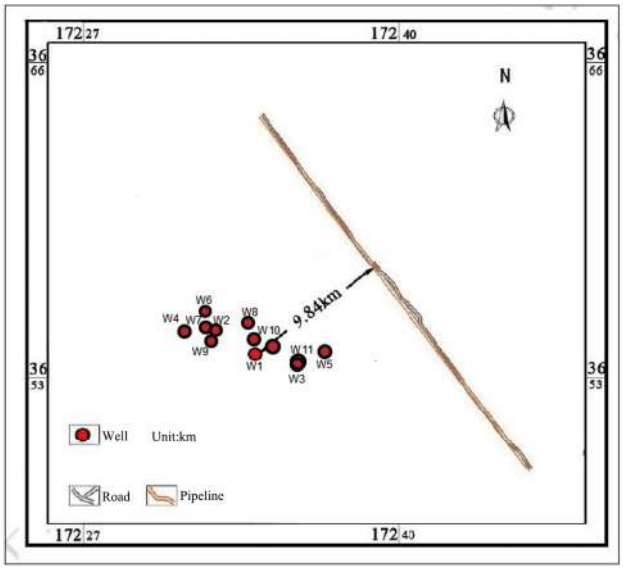

Figure 2. Lacation layout of all the wells (Note: Well W3 and W11 are relatively close, but not coincident)

The coordinates of the boundary inflection point and the position of the oil well are shown in Table 1.

Table 1. Boundary inflection point and oil well location

Name	X-axis coordinate (m)	Y-axis coordinate (m)
B1	17229480	3666990
B2	17234170	3661970
B3	17236960	3666020
B4	17232220	3669060
W1	17233690	3664640
W2	17232310	3666080
W3	17234930	3663860
W4	17231270	3666940
W5	17236740	3664670
W6	17232010	3667200
W7	17231652.28	3656298.04
W8	17233307.15	3656630.45
W9	17231920.64	3655394.68
W10	17233554.52	3655523.36
W11	17235239.37	3654078.46
W12	17234313.99	3654970.73

2.3 Natural and Social Conditions of Area A

The surface of area A is covered by yellow sand, and the main landforms are dunes and depressions between dunes. The climate is arid, rainless and windy and sandy. The annual average temperature is 10.1°C. The highest temperature is 41.3°C, and the lowest temperature is -26.4°C. The area has very little precipitation and evaporation. The annual average precipitation is 24.6 mm, and the evaporation is 2606.9 mm. It belongs to a typical warm-temperate continental extreme arid desert climate. The annual average ground temperature in area A is 12.4℃. The area is within the range of the oilfield highway network. Conveniently, the relative positions of 12 wells in the entire oilfield are shown in Figure 3.

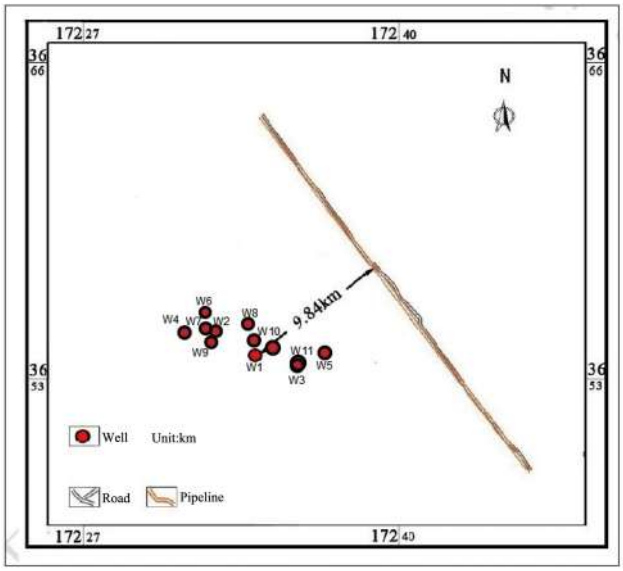

Figure 3. Schematic diagram of traffic in area A

According to GB 50350-2015 "Oil Field Oil and Gas Gathering and Transportation Specifications", the design of oil and gas gathering and transportation projects in the desert and Gobi areas should be suitable for the harsh environmental conditions in the desert and Gobi areas, and effective sand prevention measures should be adopted in the design of stations and lines. Utilize natural resources such as solar energy and wind power in desert areas and carry out comprehensive planning and effective utilization [11].

2.4 Design Basis

According to GB 50350-2015 "Code for Design of Oil and Gas Gathering and Transportation of Oilfields", the design capabilities of equipment and pipelines of oil production wellsites should be based on the oil, gas, and water output of a single well provided by the oilfield development plan and the amount of liquid or gas lift [11]. The gas volume is determined. The production days of oil wells should be calculated as 330d for self-blowing wells.

The design capacity of water-bearing crude oil treatment and transportation facilities of various stations

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should be determined according to the daily oil production of the oil wells under the jurisdiction of the oilfield development plan, the water content of crude oil and the amount of liquid mixed in the collection process.

2.4.1 Production Data

Area A generally adopts the water injection rolling development model. The area generally follows the principle of efficient development and has the characteristics of phased development and large fluctuations in daily output. The regional rolling development data are shown in Table 2. This requires that the ground project needs to be constructed in phases during construction, and the equipment should be integrated, and skid mounted as much as possible to adapt to rolling development.

The overall output of area A is shown in Figure 4-Figure 6, the regional production data of each year is shown in Table 3 and the maximum production data in Table 4.

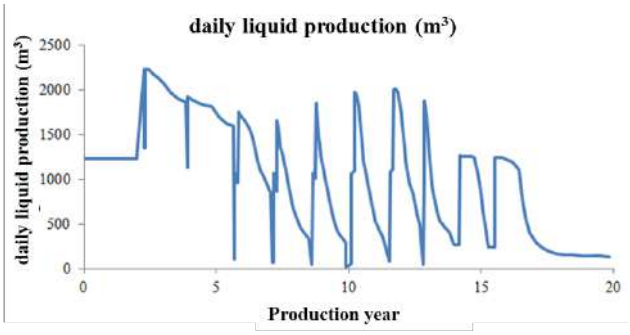

Figure 4. Changes in daily fluid production in area A

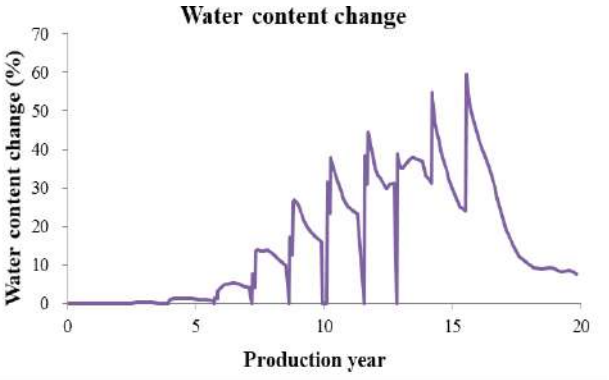

Figure 5. Change of total water content in area A (Note: Due to the braising plan, the water cut per day will fluctuate)

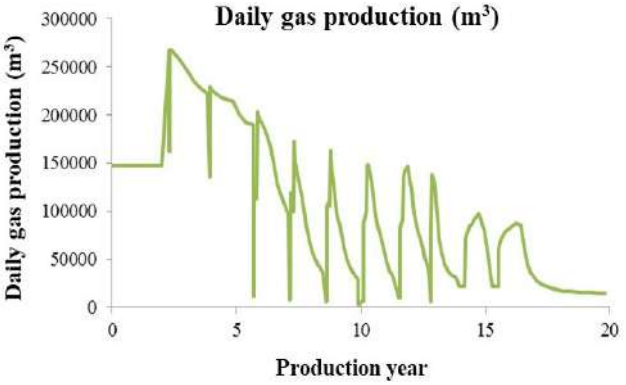

Figure 6. Changes in daily gas production in area A Table 3 Production data in each year

Table 2. Rolling Development Data Sheet

	Unit	Well	Production (m^3/d)	Measures	Well type	Water injecti on cycle	Water injecti on time (a)	Simm ering time (d)	Well-openi ng	Daily water injection (m^3/d)
Phase 1	S2	W5	150	Acid pressure	old	-	-	-	-	-
		W3	150		old	-	-	-	-	-
		W11	200		New horizontal well	8	2	5	200	600
	S4	W4	150		old	8	2	5	150	600
	S6	W6	200		old	8	2	5	200	600
	S9	W1	150		old	8	2	5	150	600
	S10	W2	200		old	8	2	5	200	600
Phase 1	S1	W12	200	acidification	New horizontal well	8	2	5	200	600
	S3	W10	200		New double branch well	8	2	5	200	600
	S5	W7	150		New vertical well	8	2	5	150	600
	S7	W8	150		New vertical well	8	2	5	150	600
	S8	W9	150		New vertical well	8	2	5	150	600
adjust ment	S2	W9-side	-	-	New vertical well	Water injection time: 15th year, injection-production ratio: 1:1.3				

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Table 3. Production data in each year

Production year	Daily oil production (m^3)	Daily fluid production (m^3)	Daily gas production (m^3)	Wellhead pressure (MPa)
1	1230	1230	147600	4
2	1230	1230	147600	4
3	2057	2064	246947	4
4	1860	1882	223270	4
5	1675	1695	201051	4
6	1558	1636	186987	4
7	813	848	97561	4
8	1134.259	1134.259	110359.2	4
9	641.5561	641.5561	62182.96	4
10	377.0353	377.0353	36238.1	4
11	282.0535	282.0535	19009.27	4
12	256.0271	256.0271	13884.14	4
13	262.0571	262.0571	13297.91	4
14	343.9455	343.9455	16574.81	4
15	372.3046	372.3046	18572.9	4

Table 4. Maximum production data

Maximum daily oil production (m^3)	Maximum daily fluid production (m^3)	Maximum daily gas production (m^3)	Maximum water content (%)
2057	2064	246947	0.62

It can be seen from the above table that with the implementation of the water injection development plan, the single-day liquid production and water content fluctuate greatly. This requires the oil and gas treatment process to consider the gradual increase in the water content of the combined station, and the processing capacity can meet. The processing demand when the liquid volume is the largest and the moisture content is the highest.

2.4.2 Crude Oil Evaluation

According to the data provided, the properties of surface crude oil are shown in Table 5.

Table 5. Statistics of surface crude oil properties

	Surface crude oil density (g/cm^3)	Viscosity(mPa·s) (60℃)	Freezing point (℃)	Sulfur content (%)	Gum & Asphaltene	Wax content (%)
Range	0.7931~0.8092	1.678~2.887	-30~-4	0.139~0.302	0.06~1.24	4.2~13
Average	0.8032	1.96	-17	0.19	0.39	8.87

The composition analysis of degassed crude oil in area A is shown in Table 6. Degassed crude oil refers to the composition of oil well fluid after degassing once on the ground. The components of the bottom-hole oil stream are not accurately provided, and the components of the ground degassed crude oil in adjacent areas can be calculated as the stable feed components of crude oil.

Table 6. Component analysis of ground degassed crude oil adjacent to area A

Component	Formation oil (Mol%)
CO_2	0.307
N_2	0.697
C_1	9.911
C_2	1.379
C_3	0.613
nC_4	1.631
C_6	1.872
C_7	2.474
C_8	3.868
C_9	3.316
C_{10}	2.741
C_{11}	4.347
C_{12}	7.826
C_{13}	6.966
C_{14}	8.694
C_{16}	13.271
C_{16+}	30.200
total	100

Crude oil in Area A has the characteristics of "light weight, low viscosity, sulfur, less gum & asphaltene, and high wax content". In combination with the analysis of crude oil components and related specifications, the following treatments should be done in the process of crude oil gathering and transportation:

(1) Although crude oil is sour crude, it contains less sulfur, and most of the active sulfur can be removed in conventional crude oil processing procedures, such as oil-gas separation, crude oil dehydration, and crude oil stabilization. The desulfurization industry is combined with the above process.

(2) The crude oil is high waxy crude oil, so wax prevention measures must be taken to prevent pipeline blockage caused by wax scaling.

(3) Crude oil has the characteristics of "low density, low viscosity, and low condensation" and good flow characteristics. The pressure energy of the wellhead oil flow should be fully utilized to appropriately increase the pressure of the gathering and transportation system.

2.4.3 Nature of Natural Gas

The proportion of dissolved gas in area A is 0.6103~0.9030, and the average value is 0.7601.

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The statistics of natural gas properties are shown in Table 7.

Table 7. Statistics of natural gas properties

	Relative density	Methane (%)	Ethane (%)	CO_2 (%)	N_2 (%)	H_2S (mg/m^3)
Range	0.6103~ 0.9030	61.1~ 89.6	6.41~ 16.9	0.03~ 10.9	1.26~ 12.4	0~ 26800
Average	0.7601	72.16	8.6	3.77	6.82	7466

Area A is methane gas with medium carbon dioxide, medium nitrogen, and medium sulfur. The analysis of the given components shows that the sum of the molar components of the above components is not 100%. It can be seen that the natural gas in area A contains approximately average 8.27% (mole fraction) of C3+ component.

The presence of H_2S and CO_2 in natural gas will cause corrosion of equipment and pipelines, and the combustion of sulfides will pollute the atmosphere. Therefore, natural gas without removal of these impurities cannot be used as commercial gas, and acid gas in natural gas must be removed.

For qualified commercial natural gas, its gas quality should meet the gas quality index requirements in the national standard GB17820-2012 "Natural Gas" [12], see Table 8.

Table 8

Project	Class One	Class Two	Class three
High heat ① (MJ/m^3)	≥36	≥31.4	
Total sulfur ① (mg/m^3)	≤60	≤200	≤360
Hydrogen sulfide ① (mg/m^3)	≤6	≤20	≤360
Carbon dioxide%(V/V)	≤2.0	≤3.0	—
Water dew point ②③, ℃	Under the pressure of the junction point, the water dew point should be 6℃ lower than the lowest ambient temperature under the conveying conditions		

① The standard reference condition of gas volume in this standard is 101.326KPa, 20℃.

② Under transportation conditions, when the buried temperature of the pipe top is 0℃, the water dew point should not be higher than -6℃.

③ For natural gas entering the gas pipeline, the pressure of the water dew point should be the highest transmission pressure.

2.4.4 Formation Water Properties

Area A is methane gas containing carbon dioxide, nitrogen and sulfur. The presence of H_2S and CO_2 will cause corrosion of equipment and pipelines, and the formation water contains Cl-. The co-existence of the three will aggravate the gathering and transportation pipelines. Corrosion conditions, and different H_2S and CO_2 corrosion environments, the selection of pipeline materials will also be affected, and the corrosion environment needs to be judged first.

In an environment where CO_2 and H_2S coexist, the partial pressure ratio (p_{CO2}/ p_{H2S}) of the two is usually used to determine the corrosion mode: when p_{CO2}/ p_{H2S} is less than 20, it is the H_2S corrosion zone; when p_{CO2}/ p_{H2S} is between 20 and 600, it is the H_2S and CO_2 mixed corrosion zone; When p_{CO2}/ p_{H2S} is greater than 600, it is a CO_2 corrosion zone.

The calculation shows that the main corrosion type of gathering and transportation pipelines is H_2S corrosion, and sulfur-resistant pipelines are mainly considered when selecting pipeline materials.

2.5 Overall Design Plan

The surface of area A is covered by yellow sand, and the main landforms are dunes and depressions between dunes. The climate is arid, with little rain and windy sand, and belongs to a typical warm-temperate continental extremely arid desert climate. Oilfield development is carried out in the desert hinterland because of its extremely harsh natural environment, no social support, long transportation distance, and a large investment, it is a challenge to the surface technology. Under these conditions, it will be difficult to meet the needs of desert oil field development by adopting the conventional construction mode in the mainland. Therefore, it is necessary to fully rely on Area A The oilfield road network and pipelines built within.

Since the data does not clearly indicate the type and purpose of the pipeline that has been built, combined with the current gathering and transportation status of the Tarim Oilfield and the Tahe Oilfield and other desert oilfields, assumptions are made about the type of pipeline, and the pipeline is assumed to be a crude oil export pipeline. Natural gas transmission pipeline. (Even if it is assumed to be a natural gas pipeline, a new crude oil pipeline is required, which is equivalent to the same assumption, so we will not discuss it again).

Based on this assumption, the overall regional process design adheres to the design concept of "environmental protection, efficiency, and innovation", strictly follows the relevant design specifications, and combines reservoir engineering and oil production engineering programs, oil and gas physical properties and chemical composition, product programs, and ground natural conditions Through the technical and economic analysis and comparison of multiple schemes, a closed process flow of oil and gas gathering and processing suitable for Area A was developed.

(1) The overall flow of gathering and transportation

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technology

In general, the first-level and half-distributed oil and gas mixed transportation technology is adopted, and based on the three low and one high characteristics of "low density, low viscosity, low condensation, and high wax content" of regional crude oil, in order to make full use of oil well fluid pressure energy and heat energy, Naturally no heating (no heat preservation) and oil collection method of wellhead throwing and wax removal.

(2) Gathering pipeline network layout

In view of the small area under regional jurisdiction, relatively concentrated wellhead locations, fewer wellheads, and large production and pressure fluctuations, the first-level and half-station deployment method where oil from a single well enters the station directly is used, and the production distance and minimum are the goal Function, using the ant colony algorithm to optimize the joint station site selection and well group division, and finally adopt a valve group division method that is convenient for management and reduces investment.

(3) Piping design

In terms of pipeline design, from the perspective of controlling the influence of slug flow, rationally utilizing the pressure energy of oil well fluids and controlling the average flow rate of the liquid, a suitable end point of the pipeline is obtained to calculate the pressure, and then the pipe diameter and hydraulic calculation of the pipeline are inversely calculated to try to make the later stage simmered When the well plan is implemented, the pipeline will not have bad hydraulic conditions, and the pressure of the gathering and transportation system will be appropriately increased. At the same time, it also considers the flow guarantee measures along the oil and gas mixed transportation, such as natural gas hydrate prediction, pipeline wax removal, slug flow control and erosion control.

(4) Oil and gas treatment technology

The design of the oil and gas processing technology has always been centered on the construction principles of adapting to the water content of crude oil and adapting to the reservoir development plan, closely combining the physical properties of the oil and gas of the block, and taking into account various process flows.

Crude oil processing unit: Make full use of the characteristics of "low density, low viscosity, and low condensation" of crude oil, combine oil and gas separation with crude oil dehydration, and adopt a dehydration process of one-stage thermochemical precipitation during stable production period + two-stage thermochemical precipitation during water injection period; The crude oil stabilization process of negative pressure flash evaporation + steam stripping desulfurization is adopted to shorten the process and reduce investment.

Natural gas processing unit: In view of the characteristics of natural gas containing H_2S and CO_2 and low water content during stable production period, the purification process of first MDEA desulfurization followed by TEG dehydration is adopted. The subsequent sulfur recovery process is suitable for medium sulfur recovery and also has tail gas treatment. Low-temperature Claus process; the use of shallow cooling process natural gas condensate recovery process for calorific value verification.

(5) Joint station yard design and supporting engineering

Strictly following the current national regulations, taking into account environmental protection and energy saving, the process flow and layout of the joint station were designed, and the area's supporting sewage treatment, fire safety, power supply system, communication system and other parts were designed in detail.

3. Ground Process

3.1 Ground Production Scale

The scale of ground construction should match the reservoir development plan and the production allocation plan, and generally follow the design principles that adapt to the changes in the water content of the oilfield and the development plan. It is proposed to build a joint station to process crude oil and natural gas. The corresponding production capacity scale is shown in Table 9.

Table 9. Designed production scale

Crude oil processing capacity	2050m^3/d
Natural gas processing capacity	246947 m^3/d
Adaptation principle	Adapt to changes in moisture content
Years of stable production	7~8 a
Design life	20 a

3.2 Overall Layout of Gathering and Transportation Technology

3.2.1 Basis for the Overall Layout

(1) The selection of the gathering and transportation process should be based on the determined oil and gas reserves, reservoir engineering and oil production engineering schemes, and full consideration should be given to the area of the oil field, the type of reservoir structure, the oil and gas reserves, the scale of production, and the expected

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changes in the water cut of the oil field. Well oil production, single well gas production, well oil pressure and oil temperature, etc.

(2) Petroleum physical properties. Crude oil physical properties include crude oil components, wax content, glue content, impurity content, density, pour point and viscosity-temperature relationship, etc.; natural gas physical properties include natural gas components and the content of acid gases such as H_2S and CO_2.

(3) Well layout methods, oil displacement methods and oil production methods of the oilfield, as well as expected well pattern adjustments and changes in oil displacement methods and oil production processes during development.

(4) The geographical location of the oil field, natural conditions such as meteorology, hydrology, engineering geology, seismic intensity, and the industrial and agricultural development of the oil field, transportation, power, communications, distribution of residential areas and supporting facilities, and other social conditions.

(5) The successful experience and failure lessons of similar oil fields have been developed.

3.2.2 Principles of Overall Layout

(1) to meet the requirements of oilfield development and exploitation. The oil and gas gathering and transportation process should be based on the requirements of reservoir engineering and oil production engineering to ensure the safety and reliability of oilfield development and production, and coordinate production and transportation, and produce qualified oil and gas products according to quality and quantity.

(2) to meet the requirements of oilfield development and development design adjustments, and adapt to the requirements of dynamic changes in oilfield production. The selected gathering and transportation process should have strong adaptability and flexibility to make adjustments, and minimize the workload of the reconstruction of the gathering and transportation process. When the gathering and transportation process is partially adjusted, try not to affect the normal production of the oil field. It should be able to collect various production information of the oil gathering system in time so that the operator can take corresponding measures.

(3) to carry out the principle of energy conservation. The gathering and transportation process should reasonably utilize the pressure energy of the oil and gas well fluid, reduce the midway transfer of oil and gas, and reduce the power consumption. At the same time, the heat energy of the well flow should be used reasonably, and the equipment and pipelines should be well insulated. Reduce the temperature of oil and gas processing and transportation. Pay attention to the use of high-efficiency energy-saving equipment and energy-saving technology to minimize the energy consumption and production costs per unit of production.

(4) to make full use of oil and gas resources to increase the degree of airtightness from the wellhead to the mine oil depot or user, so as to minimize the oil and gas loss during the gathering and transportation process.

(5) to implement the principle of "less input, more output" and increase economic efficiency. The oil and gas gathering, and transportation process design of an oil field should be closely integrated with reservoir engineering, drilling engineering, and oil production engineering. Overall consideration should be given to the specific requirements of oilfield development in stages. Comprehensive planning, implementation in phases, combining the above ground and underground, unified demonstration and optimization, and ensuring good overall economic benefits for oilfield development and construction. At the same time, various safety production regulations and design regulations stipulated by the state and industry should be observed.

(6) to pay attention to protecting the ecological environment. When determining the oil and gas gathering and transportation process plan, engineering measures to eliminate pollution and protect the environment must be considered. In the feasibility study section of major projects, an evaluation report on the environmental impact of the project must be submitted to the relevant state department approval.

3.3 Overall Process Design of Gathering and Transportation

3.3.1 Gathering and Transportation Process Layout

In order to concentrate the oil and gas from each single well in the oil field for transportation, measurement and purification, it is necessary to adopt different crude oil gathering and transportation processes according to the actual conditions of each block and the nature of the oil product to achieve full utilization of oil and gas data, formation pressure, and energy saving. Consumption and the purpose of convenient management. There are many kinds of oil and gas gathering and transportation process. According to the form of oil and gas gathering and transportation system, it can be divided into first-level (or first-level and half), second-level and third-level station gathering and transportation processes.

According to GB 50350-2015 "Oil Field Oil and Gas

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Gathering and Transportation Design Code", the oil and gas gathering and transportation design should be based on the technical and economic comparison to determine the station deployment method [11]. The specific situation can also adopt the half-level arrangement method.

Due to the small scale of area A, it is not suitable for the three-level deployment of stations, and mainly considers the first-level (first-and-a-half) or second-level deployment of stations.

(1) First-level half-distribution station process

The gathering and transportation process of the first-level semi-distributed station is "wellhead→metering station→joint station", and the flow chart is shown in Figure7.

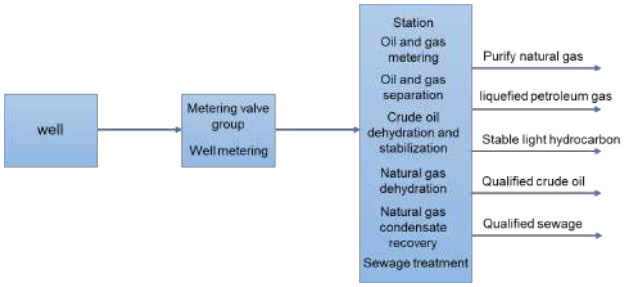

Figure 7. The flow chart of the first-level station

Generally, one metering station is set up for every 8-12 oil wells. If the metering period of oil wells is appropriately extended to shorten the time for metering without a well, the use range of the metering device can be increased. The use range of each metering device can be according to the following formula:

$$n_m = \frac{W}{\frac{24T}{t}}$$

Where n_m is the number of metering devices to be installed in the development oil area; W is total number of oil wells in development oil area; T is oil well metering cycle, that is, how many days are required to measure once; t is the time of continuous measurement for each oil well in hours.

The value of the above formula is the number of oil wells that can be measured by each metering transposition. According to this metering range, one metering device can be shared for several metering valve groups. A metering device is set to form the gathering and transportation process of the first-level and semi-distributed station; there is no need to design a metering valve group, and each oil well is directly set up in the metering device of the joint station for measurement, forming an oil area and measuring at the joint station to form a deployment process.

(1) Secondary cloth station

The secondary station deployment process refers to the station deployment form consisting of "wellhead→metering station→combined station". According to the different transportation modes, it can be divided into the oil and gas distribution process of the secondary station and the oil and gas mixed transportation of the secondary station. Process.

1) The oil and gas distribution process of the secondary station

Oil well products are transported to the sub-well metering station through pipelines. After gas-liquid separation, the output values of single well oil, gas and water are measured respectively. After the oil-gas-water separator exits, the oil and gas are respectively transported to the joint station. Water-containing crude oil enters the crude dehydration device and crude oil stabilization device perform dehydration and stabilization. The petroleum vapor flashed from the natural gas and the stabilization tower enters the natural gas dehydration device and the natural gas condensate recovery device for processing to produce qualified oil and gas products. The effluent and oily sewage are treated on-site. The flow diagram of the oil and gas separation process is shown in Figure 8.

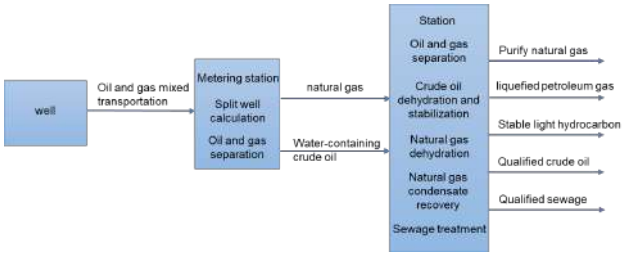

Figure 8. The diagram of the oil and gas separation process

2) The oil and gas mixed transportation process of the secondary station

After the output value of oil, gas, and water is measured separately at the sub-well metering station, the product of a single well is mixed with the gas and liquid and then enters the centralized processing station through the oil gathering pipeline for centralized oil and gas separation, crude oil dehydration, crude oil stabilization, natural gas dehydration, and natural gas condensate recovery Wait for the treatment process to obtain qualified oil and gas products, and the produced water will be reinjected after centralized treatment. The oil and gas mixed transportation process block diagram of the secondary distribution station is shown in Figure 9.

 DOI: https://doi.org/10.30564/frae.v4i1.3157

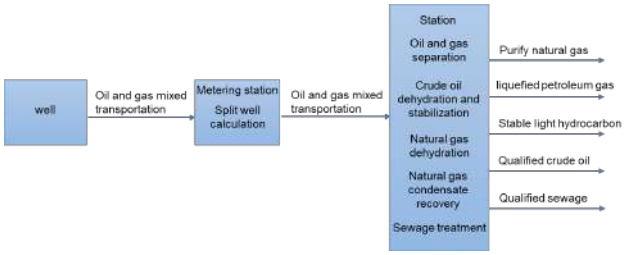

Figure 9. The diagram of oil and gas mixed transportation process

According to the application situation of the current domestic oilfield gathering and transportation layout methods, the three layout methods to be adopted have their own technological characteristics and applicable occasions, see Table 10.

Table 10. Process characteristics and applicable occasions of the three layout methods

Layout	Process characteristics	Applications
First-level	Since most metering stations are simplified to metering valve groups, and the metering valve group to the metering device is connected by metering pipelines, the gathering and transportation process is greatly simplified. Compared with the second-level deployment station process, this kind of first-level and half-distribution station process engineering The amount is greatly reduced, and its engineering investment is significantly reduced.	Many oilfields at home and abroad, especially those developed in recent years, including oilfields in desert areas, all adopt the first, half or first level station gathering and transportation process, thus simplifying the process and reducing investment.
Two-level (oil & gas separation)	The specificity of this process is single well entry, centralized periodic metering in sub-wells, which simplifies well site facilities, separate treatment of oil and gas. Different delivery processes are used for oil output, oil gathering, and gas gathering pipelines. The disadvantage is oil. Gas separation and transmission and gas gathering systems are complex, and dew point treatments need to be dispersed at multiple locations. The amount of engineering is large, equipment, steel, and investment consumption are large.	This process is suitable for oil fields with relatively large gas and oil but not high wellhead pressure. Using this separation process can reduce wellhead back pressure and increase the transmission capacity from the metering station to the joint station.
Two-level (oil & gas mixed)	This process can make full use of the formation energy, no pump connection is needed from the wellhead to the joint station, which simplifies the gas gathering system, is easy to manage, and saves a lot of investment. It is currently widely used in various domestic oil fields.	This process is suitable for oil fields with low gas-oil ratio and small gathering and transportation radius, but the crude oil is stable and the natural gas condensate recovery device has poor adaptability when the processing volume varies greatly.

When considering the layout of the gathering and transportation process, the size of area A, the location of wellheads, and production changes should be considered comprehensively, and each single well in the block has the characteristics of higher wellhead pressure (4 MPa) and faster production decline after stable production period. , In order to make full use of the formation energy to ensure the relative stability of the total output of the oil-gathering pipeline in the later stage, it is advisable to adopt the transportation method of mixed oil and gas.

The wellhead layout of the production well in area A is shown in Figure 10.

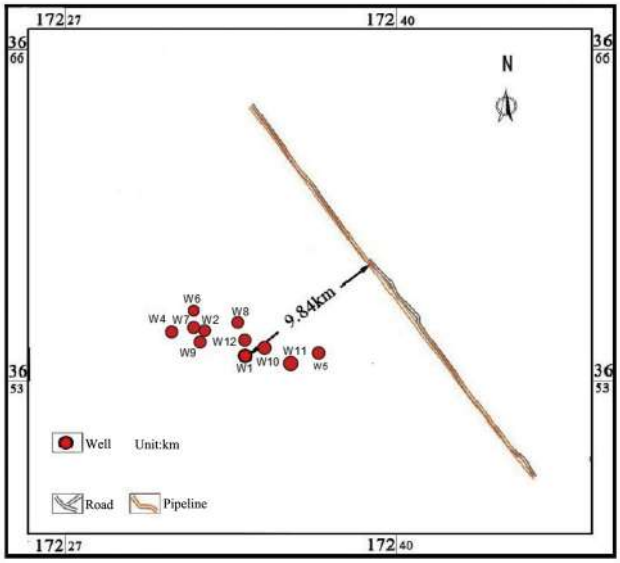

Figure 10. Wellhead layout of area A

It can be seen from the above figure that the area of the pipeline in area A is small and the location of the wellhead is relatively concentrated. In order to facilitate centralized management, simplify the process and reduce the project investment. It can be simplified to the first-level and half-distributed station based on the mixed oil and gas transmission at the second-level station. In the end, the overall gathering and transportation process of the first-level and half-station oil and gas mixed transportation are adopted.

3.3.2 Comparison and Selection of Oil Collection Technology

In order to facilitate the collection and transportation of oil fields, the process measures are taken to complete the task of collecting and transporting oil and gas are called oil gathering processes. Because of the large differences in the physical properties of crude oil in many oil fields in my country, even in different areas of the same oil field, the nature of the crude oil is not the same. Therefore, oil collection methods are also diverse. To sum up, the oil field collection technology mainly includes heating oil collection, liquid oil collection technology, heat source accompanied by heat preservation

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oil collection technology, non-heating oil collection technology, etc.

According to GB 50350-2015 "Oil Field Oil and Gas Gathering and Transportation Design Specification", the basic process of oil field oil and gas collection should adopt the wellhead unheated single pipe process, wellhead heating single pipe process, double pipe liquid mixing process, single pipe loop water mixing process [11]. Each the selection of the typical process should be combined with the industry standard "Oilfield Surface Engineering Construction Planning and Design Code" SY/T 0049 [13].

Because the crude oil in area A has the characteristics of light weight, low viscosity, low condensation, good fluidity, and high wellhead temperature (56°C), the main consideration is the wellhead heating single-tube oil collection technology and the wellhead unheated single-tube collection technology. Oil craft.

(1) Single tube heating oil collection process

Heating and heat preservation to reduce the viscosity of crude oil is an oil gathering process widely used in various oil fields in our country. The single pipe heating oil gathering process refers to wellhead heating, a gathering pipeline, and oil gathering technology for mixed oil and gas transportation. The metering station is arranged at 8~10 At the appropriate position of the well, the oil and gas mixture from each single well is first heated by a water jacket heating furnace, and a single pipeline is used to concentrate the mixed oil and gas into the metering station, and then enter the metering separator to measure the oil and gas respectively to complete the metering. After the oil and gas are mixed again into the oil gathering pipeline and exit the station. The oil wells that are not used for a single well metering are generally mixed with oil and gas to the metering station, and switched directly into the outbound oil gathering pipeline through the valve group of the main office. Before the station enters the production separator, the total amount of oil and gas are respectively measured, and then mixed again into the oil gathering pipeline out of the station, and transported to the centralized processing station or the joint station. Figure 11 shows the heating and thermal insulation oil collection of the secondary distribution station flow chart.

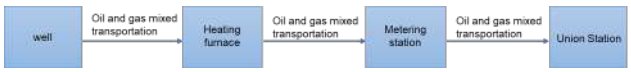

Figure 11. Flow chart of heating, heat preservation and oil collection at the secondary distribution station

The technical characteristics of the oil collection process are:

1) There is generally a water jacket heating furnace on the well site. In addition to heating the oil well products, it can also be used to achieve hot oil circulation and wax removal. The metering station has simple equipment, only one oil collection pipeline, saving steel, and complicated geological conditions The oil well is more adaptable.

2) The water jacket heating furnace on the well site brings inconvenience to management and it is difficult to realize automation; the pipeline needs to be cleaned when the well is stopped or in operation, otherwise the pipeline will be blocked; for the gas less or less gas oil well, sometimes the well site water jacket furnace Need to lay another gas supply pipeline.

The wellhead heating single-tube oil gathering process is mainly suitable for crude oil whose freezing point is higher than the temperature of the oil and gas gathering and transportation environment. The single well crude oil production is greater than 10t/d, and the production gas-oil ratio is greater than 30m3/t, and the oil production well can produce continuously.

The water jacket heating furnace is an indirect heating furnace. During normal operation, the water in the water jacket occupies 1/2 to 1/3 of its volume. Natural gas is sprayed into the fire tube through the burner to burn, and the heat is transferred to the water and steam. Then transfer the heat to the crude oil in the coil to increase the temperature, reduce the viscosity, and increase the fluidity. The water jacket heating furnace has a finalized product. When selecting, first calculate the heat load required to heat the oil and gas product, and then Some products are selected. In order to improve the level of assembly and speed up oilfield construction, the separator and the water jacket heating furnace have been combined together, called the metering separator-water jacket heating furnace combined device.

The heating furnaces of the metering station and the crude oil centralized processing station are also selected according to the heat load, but the heating furnaces of the centralized processing station have a larger load, and tube heating furnaces are generally used. However, the number of heating furnaces should be determined according to the temperature drop along the line. Normal When the amount of heat dissipation along the line is the smallest, the heating furnace bears the smallest heat load, and one unit should be allowed to shut down for maintenance; when the amount of heat dissipation along the line is the largest, the heat load borne by the heating furnace can also meet the requirements. Consider from the aspects of operation management and convenient maintenance. The number of heating furnaces is best not less than 2, but not more than 4.

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(2) Naturally does not heat the oil collection

Naturally non-heating oil collection is a method that does not take any measures to stop heat tracing or heating and carry out non-heating transportation. Generally used in oil fields with good crude oil properties, high oil temperature, and high-water content crude oil production periods.

The main feature is good fluidity. The thermal and hydraulic conditions of the oil-gathering pipeline are relatively good. Basically, the gathering and transportation without heating can be realized without additional measures.

Naturally unheated gathering and transportation can be realized for oil wells under the following conditions:

1) The wellhead temperature of light and medium crude oil and the end temperature of pipeline transportation are higher than the wax precipitation temperature of crude oil.

2) The wellhead temperature of light and medium crude oil and the end temperature of pipeline transportation are lower than the wax precipitation temperature, but higher than the degassed crude oil freezing point and wax prevention temperature. When the ground temperature along the line is lower than the crude oil freezing point, measures to remove blockage are still needed.

3) For light and medium crude oil under the condition of transportation temperature, the viscosity of degassed crude oil is low, the gas-oil ratio is high, or the oil is produced mechanically, measures for wax removal, wax prevention, and electrothermal blocking removal are required.

4) The natural water content of the water-bearing crude oil is higher than 60%, and the oil output temperature at the wellhead is higher than the minimum allowable gathering and transportation temperature.

Considering that the crude oil in area A is low-viscosity and low-condensing light crude oil, and the temperature of a single well is relatively high (56°C), if the end temperature of the pipeline transportation can be higher than the waxing temperature of the crude oil, the natural non-heating oil collection process can be used.

Since the wax precipitation point of crude oil is not given, referring to the temperature relationship between wax precipitation point and freezing point in high wax content oilfields in China, combined with the wax content in area A, the wax deposition curve of formation oil is simulated using PVTsim software, as shown in Figure 12. The wax deposition temperature of the formation oil under the conveying pressure is -5°C (12°C above the freezing point).

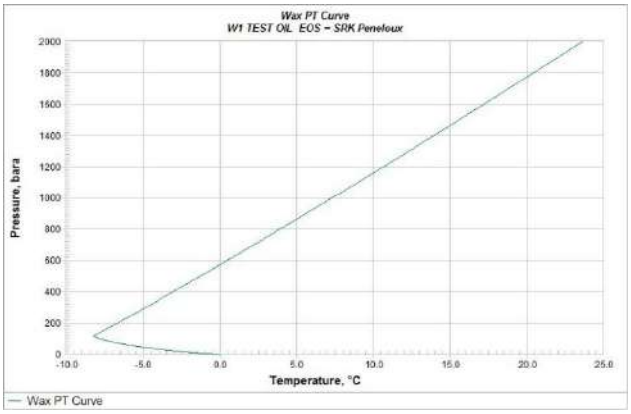

Figure 12. Wax deposition curve of formation oil

After determining the wax precipitation point, use the OLGA software to perform thermal calculations on the delivery pipeline and the collection pipeline without the insulation layer. The temperature drop along each pipeline is shown in Figure 13-14, and the calculation results are shown in Figure 13-14 and Table 11.

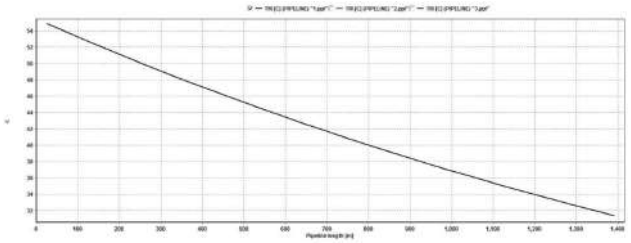

Figure 13. Temperature drop along the outlet pipeline

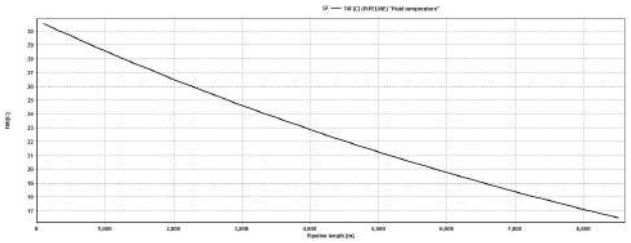

Figure 14. Temperature drop along the oil gathering pipeline

Table 11. Thermal calculation results

Pipeline type	Starting temperature	End temperature	Insulation thickness	greater than the wax precipitation point
Outlet pipeline	56℃	31℃	0 mm	yes
Gathering pipeline	31℃	16.7℃	0 mm	yes

It can be seen from the above table that without the insulation layer, the oil product has good flow performance and the oil collection pipeline has better thermal and hydraulic conditions. The natural non-heating process can fully meet the transportation requirements. Therefore, the

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overall area is adopted the mixed transportation of oil and gas in the first-level station + natural non-heating overall gathering and transportation technology.

3.4 Wellsite Process

Area A generally adopts the integrated gathering and transportation process of first-level mixed oil and gas transportation + natural non-heating at the half cloth station. In addition to the valve block metering function, the well site does not require heating process design. Combining the nature of crude oil and oil products and the corrosion of the transport medium, The well site also needs to design the process of throwing wax and adding corrosion inhibitors.

(1) Valve group metering

In order to reduce equipment investment, the valve group metering uses a three-phase separation metering device to separate gas, liquid (emulsified oil) and free water, and then measure the amount of gas, liquid and free water, and the water content of the emulsified oil.

Especially after the oil field enters the water injection development stage, the water cut in the produced fluid increases. Under such conditions, the use of a three-phase metering device is an effective means to ensure the accurate metering of oil wells.

(2) Throw the ball to remove wax

The crude oil transported by the pipeline belongs to the high waxy crude oil. Although the pipeline terminal temperature is greater than the wax precipitation temperature under the condition of the designed delivery volume and the annual average ground temperature. However, when the pipeline is in a situation where the delivery volume fluctuates greatly (especially the later delivery attenuation) and the outside world Under extreme temperatures, the thermal condition of the pipeline will change, and it is even possible that the end temperature is lower than the wax precipitation temperature, so that the oil will be waxed. With the deposition of wax crystals in the pipeline, the effective flow area of the pipeline will be reduced. Even blockage occurs, so it is necessary to set up a pitching ball to remove wax at the wellhead.

Regularly throw balls (usually reusable plastic balls or disposable chemical balls) from the wellhead to the oil gathering line to remove part of the wax on the pipe wall and maintain the normal flow of crude oil. The ball cleaning is usually determined according to the degree of wax accumulation Wax cycle. Balls from the wellhead to the metering valve group are put in from the wellhead, and the metering valve group is taken out; from the metering valve group to the joint station, the ball is put in by the metering station, and the joint station is taken out. The ball can be pitched with automatic ball throwing device or manual device.

This method requires the wellhead to have a ball-balling device, the metering valve group has a ball-receiving or ball-balling device, rationally use the formation energy, and use the ball-through method to remove the wax and debris on the pipe wall to ensure the smooth flow of the pipeline and safe production. The wax removal ball generally has Steel balls, rubber balls and chemical balls. The ball diameter is generally 2~3 mm less than the inner diameter of the pipeline. The automatic ball throwing device and electromagnetic heating ball receiving device have been manufactured.

(3) Addition of corrosion inhibitor

In order to alleviate the corrosion of pipelines and equipment caused by H_2S and CO_2 dissolved in water, a certain amount of corrosion inhibitor must be added to the wellhead. Corrosion inhibitor means that metal corrosion can be significantly slowed down when it exists in a very low concentration in the environmental medium. The rate is to prevent metal corrosion. According to the influence of corrosion inhibitors on the electrode process, the corrosion inhibitors can be divided into anode corrosion inhibitors, cathodic corrosion inhibitors and mixed corrosion inhibitors. Anode corrosion inhibitors have effects on the anode process. Retarding effect, such as complex salts, nitrite, sodium benzoate, etc.; cathodic corrosion inhibitors have a retarding effect on the cathode, such as polyphosphate, zinc salt, arsenic ion, etc.; mixed corrosion inhibitors on the cathode and anode processes All have blocking effects, such as silicates, alkaloids, etc.

According to GBT 23258-2009 "Code for Corrosion Control in Steel Pipelines", anode corrosion inhibitors can be used to slow down the corrosion of media containing low concentrations of oxygen [14]. Cathodic corrosion inhibitors can be used to slow down the corrosion of H_2S and CO_2, so the cathode type is selected Corrosion inhibitor.

① Adding method

The corrosion inhibitor for gathering pipelines can be continuously injected, intermittently injected, or combined with intermittent injection. Considering the corrosion and management of the pipeline, the continuous injection method is adopted, and the continuous injection device adopts gravity. Type filling device.

② Filling amount

The amount of corrosion inhibitor that is continuously injected is usually determined by the water content in the conveying fluid and is generally determined by the concentration of the corrosion inhibitor of 100 to 1000 ppm.

The corrosion inhibitor dose can be estimated by following formula when applying corrosion inhibitor to the pipeline:

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$$W=2.4DL$$

Where W is processing capacity in liter; D is pipeline diameter in cm; L is pipeline length in km.

According to the wellhead production, the corrosion inhibitor dosage is 0.245 mL/d, and the daily injection volume per well is 0.020 mL.

3.5 Ground Process Summary

The overall regional process design adheres to the design concept of "environmental protection, efficiency and innovation", strictly follows the design specifications, and combines reservoir engineering and oil production engineering schemes, oil and gas physical properties and chemical composition, product schemes, ground natural conditions, etc., through multiple schemes According to the technical and economic analysis and comparison, we have worked out a closed process flow for oil and gas gathering, transportation and processing suitable for Area A.

(1) The overall flow of gathering and transportation technology

In general, the first-level and half-distributed oil and gas mixed transportation process is adopted, and based on the three low and one high characteristics of "low density, low viscosity, low condensation, and high wax content" of block crude oil, in order to make full use of oil well fluid pressure energy and heat energy Adopt the oil collection method of natural non-heating and wellhead throwing to remove wax.

(2) Gathering pipeline network layout

In view of the small area under the jurisdiction of the block, the relatively concentrated location of wellheads, the small number of wellheads, and the large fluctuations in production and pressure, the first-level and half-station deployment method is adopted in which oil from a single well enters the station directly, and the production distance and minimum The objective function is to use ant colony algorithm to optimize the joint station location and well group division, and finally adopt a valve group division method that is convenient for management and reduces investment.

4. Pipeline Design and Flow Assurance

4.1 Gathering Pipeline Network Layout

4.1.1 Principles of Oil and Gas Pipeline Selection

The design of oil and gas gathering and transportation pipelines should comply with the current national standard "Code for Fire Protection Design of Oil and Natural Gas Engineering" GB 50183 [15]. The selection of oil and gas gathering and transportation pipelines should meet the following requirements:

(1) It is advisable to take it straight, not to damage the existing structures along the line, and occupy less cultivated land;

(2) It should form a corridor belt with other production pipelines, roads, power supply lines and communication lines in the oil field;

(3) Pipelines of the same nature and similar buried depths should be radiated in the same trench;

(4) It is advisable to choose favorable terrain for laying, and avoid low-lying water accumulation zones, local saline-alkali zones and other highly corrosive zones and low sections with poor engineering geology.

The altitude of area A is between 1040 m~1070 m, and the terrain is gentle, which is conducive to the laying of oil and gas pipelines. The surface of area A is covered by yellow sand, and the main landform is dunes and depressions between dunes. There are no built structures and cultivated land, which is good for pipeline selection. A The line selection of the block gathering and transportation network should take into account many factors such as the layout of the pipe network, the site selection, etc., take direct wiring, conduct technical and economic comparisons, and select the best plan.

4.1.2 Layout of the Outlet Pipeline Network

The oil pipeline mainly has a single well direct entry, cluster well entry, single well series connection, and valve group entry and other layout methods.

Combining the layout of the oil wells in area A and the layout of the gathering and transportation process, the layout of the oil pipeline can choose to directly enter the station from a single well or to enter the station in series with a single well. It is advisable to conduct a technical and economic comparison to repeatedly demonstrate the specific layout method.

(1) Single well comes into the station

A single well comes into the station with a typical radial pipe network, which simplifies the well site facilities, see Figure 15.

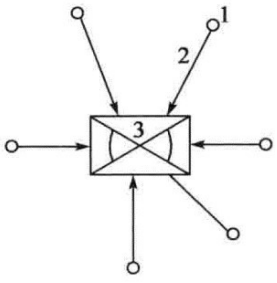

Figure 15. Schematic diagram of the structure of a single well with oil directly entering the station

1- Wellhead; 2- Output pipeline; 3- Gathering station or joint station

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(2) Series connection between wells

The single well oil pipeline is connected to the nearest oil well site, and the gas coming from the related well sites is connected in sequence. According to the layout of the oil well, the oil gathering trunk line enters the gathering station radially in different directions. The structure diagram is shown in Figure 16.

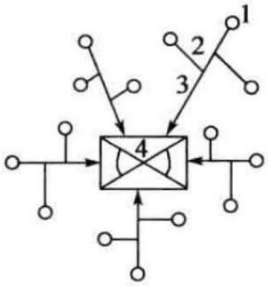

Figure 16. Schematic diagram of single well series connection structure

1- Wellhead; 2- Output pipeline; 3- Oil gathering trunk line; 4- Oil gathering station or joint station

The advantage of this form is that the construction of the connection between the pipeline and the trunk line of the newly-built well can be carried out at the well site, without the need for air defense and replacement of the original trunk line. The reason is that two gate valves have been set up between the built single well gas production pipeline and the trunk line. When the oil coming from a new well is entered, the two gate valves can be closed, the pipeline between the two valves can be removed, and the straight pipe section can be replaced with a tee. In this way, the oil from the new well can be connected from the tee between the two gate valves to ensure The wellhead of a single well is built without fire, the trunk line is not vented, and the normal operation of the gas production trunk line will not be affected when the oil is connected to the newly-built well. In addition, the construction access or inspection road of the production pipeline in series can make full use of the front of the single well station Road, the disadvantage of this form is that the pipeline is slightly longer.

However, with the development of oilfields, the pressure of oil wells has continued to drop, and there is a problem that the pressure drop rate of a single well at a later stage does not match the pressure system of the oil pipeline. When the shut-in pressure cannot reach the pressure of the oil pipeline system, the oil pipeline The natural gas will be transported back to low-pressure wells, forming a phenomenon of "backflow" in the low-pressure wells, resulting in a significant reduction in the limited delivery capacity of the main oil pipeline.

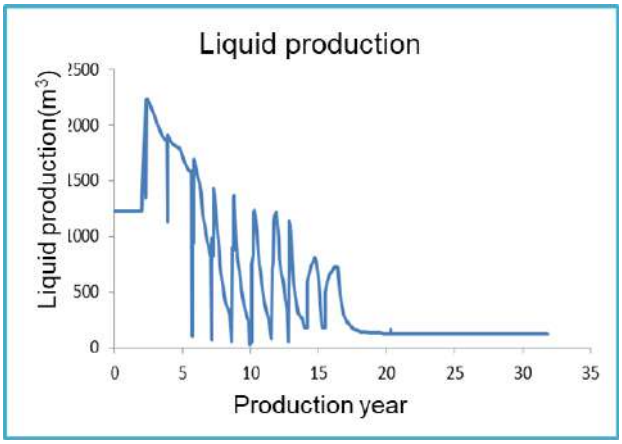

Figure 17. Liquid production in area A

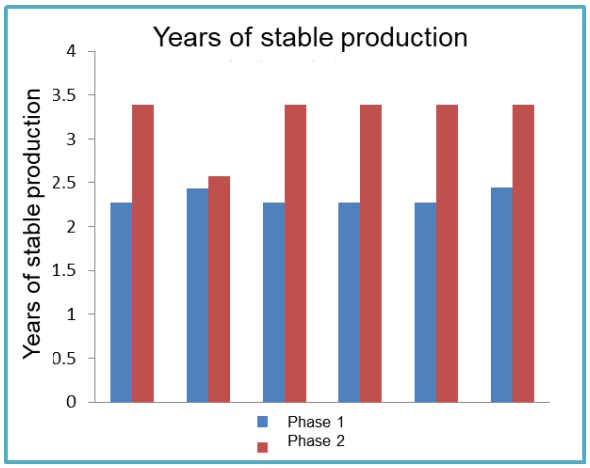

Figure 18. Years of stable production of a single well

Area A is a carbonate oil field, with large production fluctuations (Figure 17), rapid pressure decay, and rolling development in the area, with different stable production years of single wells (Figure 18), in order to adapt to the efficient development process of Area A For the production and pressure fluctuations, it is not advisable to adopt the layout of single wells in series, and finally adopt the layout of the output pipeline of single wells directly into the station.

4.1.3 Gathering pipeline network layout

Gathering pipeline network layout can be roughly divided into the following three categories and combined pipeline network:

(1) Radial gathering and transportation network

The flow of the radial gathering pipeline network system is centered on a metering station (metering valve group) or a joint station, and the pipeline is connected to multiple well stations in a radial form. This type of pipeline network is suitable for relatively concentrated wellheads or small areas. The oil field can also be used as a

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basic unit in the multi-well oil gathering process. Oil and gas are produced from the wellhead and transported to the metering station (metering valve group) or joint station after the wellhead is throttled. The basic form of the pipeline network is shown in Figure 19.

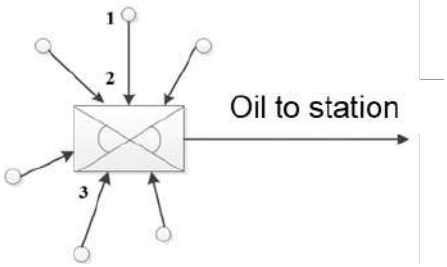

Figure 19. Schematic diagram of the system flow of radial gathering and transportation network

1- Wellhead; 2- Output pipeline; 3- Gathering station; 4- Gathering pipeline

(2) Gathering system process of branched gathering and transportation network

The branch-shaped gathering pipeline network is in the same shape as branches, and an oil gathering trunk line is arranged along the long axis of the structure. The oil and gas collected from the oil wells on both sides of the trunk line are integrated into the gathering trunk line and transported to the destination. The characteristics of the pipeline network. The oil gathering branch line is relatively short, which is convenient for the nearby oil and gas input of oil wells to be watched. It is suitable for oil fields with long and narrow oil and gas reservoirs and large well pattern distances. It can meet the needs of rolling development and phased construction of oil fields. However, the pipeline network is usually single well combining the oil gathering process flow, so there are many stations. After the oil and gas are produced from the well, they are choked, heated, separated and metered at the well site and then enter the gathering pipeline and sent to the metering station or joint station. The processed oil and gas are transported outside. The flow chart of the simple branch-shaped gathering and transportation network system is shown in Figure 20.

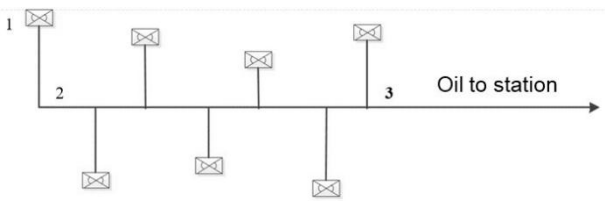

Figure 20. Schematic diagram of the gathering and transportation system of branched gathering and transportation network

1- Single Well Station (Oil Gathering Station); 2- Oil Gathering Branch Line; 3- Oil Gathering Trunk Line

(3) Gathering system flow of ring-shaped gathering and transportation network

The loop-shaped gathering and transportation pipeline network gathering, and transportation system process is suitable for large square, round or oval oil fields. Oil fields with the above conditions are not suitable for use if the terrain conditions are complex and in deep mountainous areas. The pipeline network gathering and transportation system process is shown in Figure 21.

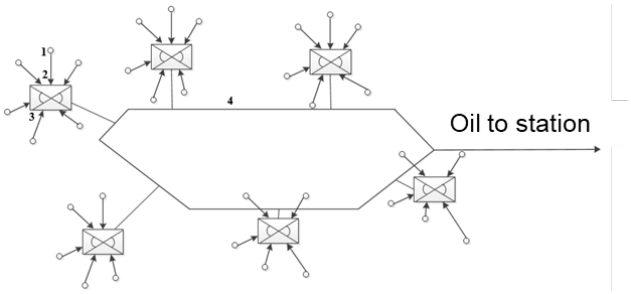

Figure 21. Schematic diagram of the gathering and transportation system of the ring-shaped gathering and transportation network

1- Wellsite; 2- Oil Gathering Trunk Line; 3- Oil Gathering Station; 4- Oil Gathering Trunk Line

The advantage of the flow of the gathering and transportation system of the ring-shaped gathering and transportation network is that the gathering stations in the oil field can be connected to the downstream purification plant or the first station of the export through the nearest oil gathering trunk line after gathering oil from the surrounding oil wells, which has certain flexibility; The total investment of the project is relatively large, which is only suitable for the development of large oil fields with large area and scattered oil wells.

(4) Process of combined gathering and transportation pipeline network gathering and transportation system

Various pipe network structures have their own advantages and disadvantages and are suitable for different specific use occasions. Due to the relatively large oil production area, the distribution of gas wells, single well production and topography, and road traffic conditions are very different. Therefore, most gas gathering pipe networks can only adopt a mixed structure including branched, radial and ring structures, especially the combination of the previous two structures is the most common.

Because the area under jurisdiction of A is small and the number of single wells is small, there is no need to adopt a combined method for pipeline network layout. The selection of the gathering and transportation pipeline network layout should be based on the specific conditions of the A area and the application of the three basic pipeline network layouts Circumstances, the advantages

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and disadvantages of the three basic pipe network layout methods are shown in Table 12.

Table 12. Advantages and disadvantages of the three basic network management layout methods

Pipe network layout	Advantage	Disadvantage
Radial pipe network	(1) The single well device is simplified, unattended can be considered, and the production and management costs are low; (2) In the later stage of oilfield development, booster units can be centrally located on stations and used together, with relatively low production costs and convenient management.	(1) The oil production pipeline adopts the oil and gas mixed transportation method, and the pipeline pressure loss is relatively high; (2) When the conveying medium is acid medium, the corrosion in the pipe is serious and the safety is poor; (3) The total length of the gathering and transportation pipeline is longer than that of the branch-shaped gathering and transportation network, and the steel consumption is more.
Branch pipe network	(1) Separating air and night in a single well is beneficial to reduce pipeline pressure loss and slow down corrosion; (2) The oil-gathering branch line can be connected to the nearest oil-gathering trunk line, which is conducive to shortening the length of the pipeline and saving steel and line investment.	(1) Because single crystals need to be equipped with gas-liquid separation and metering devices, there are many production personnel, it is inconvenient to focus on management, and the investment in single well stations is relatively large; (2) When boosting is required in the later stage of oilfield development, the booster unit can only be installed at the well site, and each well is boosted separately, which is difficult to use collectively.
Loop pipe network	After collecting oil from the surrounding oil wells, the oil gathering stations can be connected to the downstream purification plant or the first export station through the nearest oil gathering trunk line, which has a certain degree of flexibility.	The total investment of the project is relatively large, which is only suitable for the development of large oil fields with large area and scattered oil wells.

According to the specific conditions of the oil field, combined with the corresponding oil gathering process, comprehensive comparison is made from the aspects of technical reliability, safety of gathering and transportation system, and ground engineering investment, and adopts radioactive pipeline network layout.

4.1.4 Principles for Station Selection

The site of the oil and gas gathering and transportation station should be determined in accordance with the overall surface planning of the oilfield and the local town planning, taking into account the direction of the gathering and transportation pipeline. The selection of the site should comply with the current industry standard "Oil and Natural Gas Engineering General Drawing Design Code" SY/T 0048 [16].

According to GB 50350-2015 "Oilfield Oil and Gas Gathering and Transportation Design Code" [11], the selection of station site should follow the following principles:

(1) The area of the station site should meet the requirements of the general layout, and the land should be economized. It is not suitable to occupy cultivated land in areas where wasteland is available.

(2) Station sites in desert areas should avoid wind vents and mobile desert areas, and sand prevention measures should be taken.

(3) The layout of various stations with different functions should be comprehensively considered. Metering stations and oil collection valve groups should be jointly constructed with gas distribution stations and water injection stations; oil, gas, and water treatment stations that are related to each other in technology should be combined Construction; the mine oil depot should be built in a suitable location on the edge of the oil field; the railway outbound oil depot should be close to the railway station or railway line to facilitate connection.

(4) The fire separation distance between the station yard and the surrounding facilities, noise control and environmental protection should comply with the advanced national standard "Code for Fire Protection Design of Petroleum and Natural Gas Engineering" GB 50183 [15], "Code for Design of Noise Control in Industrial Enterprises" GB/T 50087 [17] and "Industrial relevant regulations of "Enterprise Design Sanitary Standard" GBZ 1 [18].

The surface of area A is covered by yellow sand, there is no arable land, and wasteland can be fully utilized, but it should be in a desert area, and the station should take measures to prevent sand. The contest question does not indicate whether area A is in a windy or mobile desert area. Suppose area A Stations can be built at a suitable location in area A that is neither in a vent or in a mobile desert area. Since the area is in the internal road system of the oilfield, it is advisable to give priority to relying on existing roads in order to facilitate transportation.

In terms of station function, combining the overall gathering and transportation process technology of area A, the construction scale of area A and the area of area A, and following the principle that oil, gas, and water treatment stations should be jointly constructed in terms of technology, they should be built with both oil and gas. A joint station with water treatment function can be constructed only one.

4.1.5 Optimization of Gathering Pipeline Network Layout

In order to reasonably determine the structural layout

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of the oil and gas gathering and transportation pipeline network, with the output distance between well stations as the objective function, the connection relationship between well stations and the joint station site as optimization variables, a well group optimization model was established. Small window ant colony algorithm was used to solve , Convert the well-station connection relationship into path selection, calculate the heuristic factor according to the corresponding output and distance of different pipe sections, use the total output distance under different path schemes as the evaluation index of information accumulation, and ensure the well-type and integration by controlling the ant state transfer process Constraints such as the output radius and the processing capacity of the metering station effectively avoid the generation of infeasible solutions.

The objective functions often used in well group division include the shortest pipeline length, the minimum output distance and the smallest pipeline network construction investment. Among them, the lowest construction investment is the objective function to best reflect the economics of the pipeline network, but when calculating pipeline parameters and construction costs. More production data are required and the process is complicated. Here, the output distance and the objective function closely related to the pipeline construction cost are used to optimize the well group, and a better grouping scheme can be obtained through the ant colony algorithm.

Objective Function

After the number of gathering and transportation stations such as station is determined, the well-station connection relationship and the metering station site are used as optimization variables, and the well group division model is established with the objective function of the production distance between wells and stations and the minimum:

$$\min F(U,V)=\sum_{i=1}^{N_s}\sum_{j=1}^{N_w} \delta_{ij} Q_{ij} L_{ij} \tag{4.1.1}$$

$$\delta_{ij}=\begin{cases}1, well_j \in station_i & (i=1,2,\ldots N_s; j=1,2\ldots,N_w)\\ 0, well_j \notin station_i\end{cases} \tag{4.1.2}$$

F is the objective function, that is, the sum of the production distances between well stations; U is the station site; V is the grouping relationship variable; Ns and Nw are the number of joint stations and the number of wellheads respectively; δij is the decision variable for the connection relationship; Qij is the joint station stationi to the wellhead Transmission volume of pipeline between wellj, t/d; Lij is the length of pipeline between stationi of the joint station and wellhead wellj, km.

Constraints

Each well site can only belong to one metering station (valve group) or joint station, namely:

$$\sum_{i=1}^{N_s} \delta_{ij}=1 \tag{4.1.3}$$

Well type constraint, that is, the number of well sites under the jurisdiction of each metering station cannot exceed the maximum value P, the expression is as follows:

$$\sum_{j=1}^{N_w} \delta_{ij}=1 \tag{4.1.4}$$

The expression of the processing capacity of the metering station:

$$Q_i^L \le \sum_{j=1}^{N_w} \delta_{ij} Q_{ij} \le Q_i^H \tag{4.1.5}$$

Where QiL and Q ^{H} are the minimum and maximum processing capacity, t/d. Gathering and transportation radius constraints of the measuring station:

$$\delta_{ij} L_{ij} \le R \tag{4.1.6}$$

Where R is gathering radius, km.

The feasible domain of site optimization:

$$U \subset U_D \tag{4.1.7}$$

Where U_D is the area range of the gathering well site, that is, the coordinate range of the optimized search.

Layout Optimization

The ant colony algorithm was first used to solve the traveling salesman (TSP) problem. The calculation results of some classic TSP examples show that it has better optimization performance than other intelligent algorithms. Well group division and pipeline network layout are used as optimization problems of discrete variables. After proper transformation, it can be transformed into a path search problem, which can be solved by ant colony algorithm. The main steps are as follows:

Step1 Establish a production distance data table. Ac-

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cording to the number of designated stations, the initial station location is generated by a random function in the well site area, and the distance from each well site to different metering stations is calculated based on the well site data, and then the total production distance matrix is obtained.

Step2 Establish a window array. In the total solution space of the ant's path search, inferior solutions account for a large proportion. In order to narrow the search range of the solution space, reduce the possibility of inferior solutions, and speed up the algorithm convergence speed, it is for each metering station Set up window arrays respectively, and place all well sites within the gathering and transportation radius in the corresponding window arrays. Randomly generate the sequence of each ant visiting the metering station to reduce the interference of the window array on the natural optimization process of the ant population. The starting point is determined by the state transition function.

Step3 Define the heuristic function. The heuristic function represents the a priori and deterministic factors on the path when the ant is searching for optimization. It is a measure of the visibility of each well site when the ant is transferring from the metering station, and it should be directly related to the objective function. Here, the heuristic information between nodes is defined as the reciprocal of the production distance of the pipe section, namely θij, so that the wellsite corresponding to the pipe section with a small production distance value has the opportunity to be selected first.

$$ij = \frac{1}{Q_{ij} L_{ij}} \tag{4.1.8}$$

Step4 Pheromone update rules. Pheromone changes on the path include the accumulation of new information and the volatilization of existing information, so that the optimization process can not only make full use of the searched path information, but also provide for the generation of new paths. Opportunity. A cycle period is for all ants to complete the site sequence visits. The calculation formula for the volatilization and accumulation of pheromone after one cycle is:

$$ij(t+1) = (1- \quad) \quad ij(t) + \Delta \quad ij \tag{4.1.9}$$

$$\Delta \; ij(t) = \sum_{k=1}^{m} \Delta \; ij^{k}(t) \tag{4.1.10}$$

Where $ij(t)$ is the amount of pheromone on the path between two nodes; r is the pheromone volatilization coefficient; $\Delta \; ij(t)$ is the pheromone increment on the path from node i to node j in the cycle at time t, and its value is proportional to the solution containing the path The quality is positively correlated, which is the cumulative effect of all ants; m is the total number of ants; k is the kth ant.

In order to make full use of the overall information of each feasible solution and improve the global convergence of the optimization process, the accumulation rule of path pheromone by each ant is calculated according to the Ant-Circle model:

$$\Delta \; ij^{k}(t) = \begin{cases} \dfrac{Q}{F} & \text{including } (i,j) \\ 0 & \text{without } (i,j) \end{cases} \tag{4.1.11}$$

Where Dt k (t) is the pheromone increment of the kth ant on the path from node i to node j in the cycle at time t; Q is the pheromone intensity, where 1 is taken; Fk is the kth ant in this cycle The objective function value corresponding to the feasible solution, that is, the sum of the pipe network output distances, is calculated by formula (4.1.3).

Step5 State transition function. Each ant is constantly moving between different nodes. The state transition probability from the current node i to the next node j is the result of the combined effect of the pheromone and the heuristic function on the path connecting the two nodes. The state transition probability calculation formula for:

$$P^{k}(t) = \begin{cases} \dfrac{[\; ij(t)] \; [\; ij \;]}{\sum [\quad (t)] \; [\quad]} & , j \in allowed \\ 0 & \end{cases} \tag{4.1.12}$$

where α,β is the importance factor of the pheromone and the heuristic function respectively; Allowedk is the set of nodes that the kth ant is allowed to visit at the current moment; is (t) is the pheromone value on the path between node i and node s at time t; Heuristic function on the path between node i and node s. is (t) is at time t.

The control of the state transition process is the key to ensuring that the constraints are met. The taboo table of each ant is dynamically updated with the optimization process to ensure the uniqueness of the membership. Each ant is from the intersection of the window array and the non-taboo elements Select a feasible solution; if the intersection is empty, it means that there is no feasible solution within the gathering and transportation radius. Stop the optimization calculation of the station. Every time the next well number to be transferred is obtained based on the roulette method, it is judged whether the well meets

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the measurement. The processing capacity constraint of the station. If it is satisfied, add the well number to the solution set that the ant has constructed; if not, discard the well number. When the number of wellsites belonging to the station reaches the well-type constraint value after optimization also stop the optimization calculation of this station.

Step6 Optimize the station site. After completing the well group division, take each metering station and its well-sites as the research object to optimize the station site. Taking the distance and minimum pipeline output between the well stations as the objective function, the optimal station is calculated by the variable scale method Site. The optimized site is re-used as the initial site of the well group division program. Return to Step 1, and terminate the calculation when the quality of the pipeline network layout is no longer improved or the number of cycles reaches the upper limit.

(1) Process station

According to the data provided, area A is within the range of the oilfield highway network and the transportation is convenient. In this case, the joint site selection should be based on the existing traffic conditions, combined with the location of the wellhead, and the joint station calculated by the ant colony algorithm The relative inner position of the block road network is shown in Figure 22.

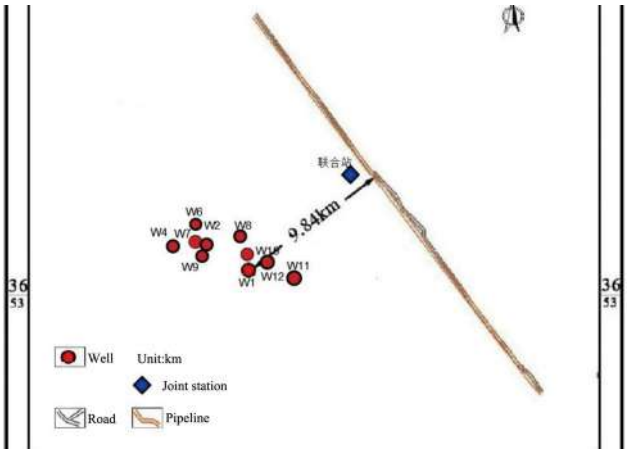

Figure 22. The relative position of the process station in the area road network

(2) Division of well groups

According to the size of area A and the number of wellheads, one valve group or two valve groups can be set. Because the number of wellheads is small and relatively concentrated, there is no need to set up three valve groups.

Use ant colony algorithm to divide one metering valve group and two metering valve groups into well groups:

1) Layout of a valve group

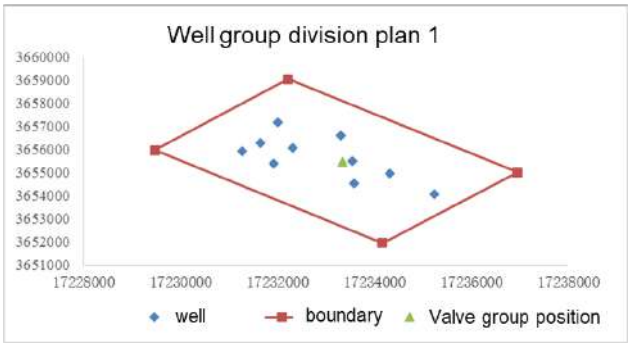

Figure 23. The layout of a metering valve group

2) The layout of the two valve groups

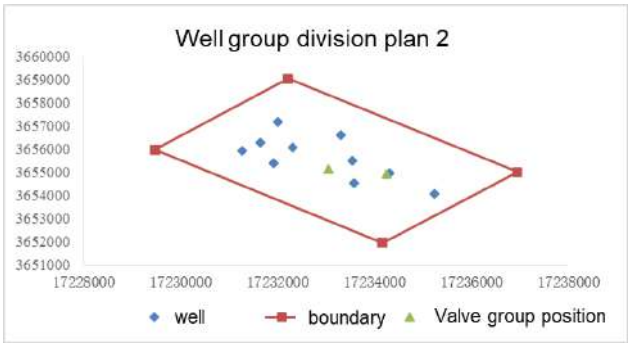

Figure 24. Layout of the two valve groups

Table 13. Comparison results of two valve group division methods

Well group division method	Length of oil outlet pipeline	Oil collection line length	Sum of output times distance	Recommend
Plan 1	16.01 km	8.61 km	24.98 ´10^5 $m \times t / d$	Yes
Plan 2	14.21 km	10.79 km	29.22 10^5 $m \times t / d$	no

It can be seen from the above table that the division method of one valve group is adopted. Although the oil outlet pipeline is relatively long, the distance between the oil collection pipeline and the output is smaller. In the division method of two valve groups, the investment of the pipeline and valve group is relative to one valve. The group situation is relatively large, and area A has the characteristics of rolling development, large output fluctuations, and stepped decline in output. Setting a valve group is more suitable for the needs of rolling development, and can better take into account the phased layout of the first and second phases, and comprehensive technical and economic comparisons. Choose a valve group to divide the wells. The overall layout of the gathering pipeline network is shown in Figure 25 and the relative position in the highway network is shown in Figure 26. The distance from each wellhead to the valve group is shown in Table 14.

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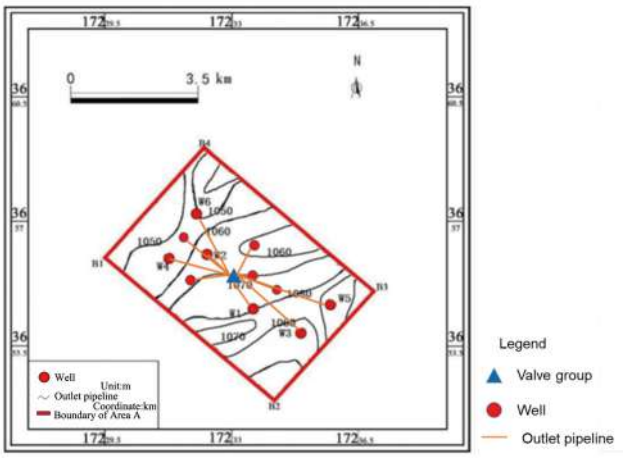

Figure 25. The overall layout of the gathering and transportation network

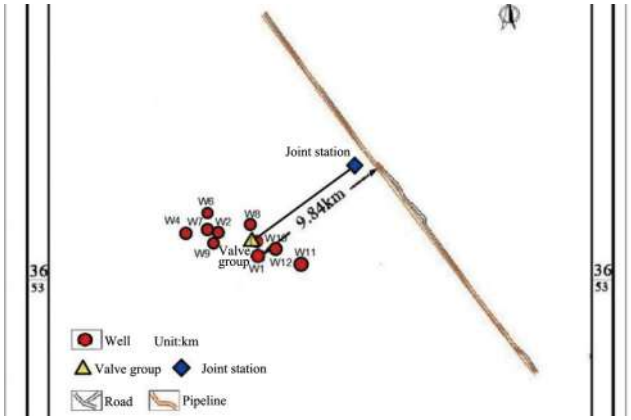

Figure 26. The relative position of the gathering and transportation network in the road network

Table 14. The length of the pipeline from each wellhead to the valve group

Pipeline name	Pipeline length	Pipeline name	Pipeline length
W1-Valve group	969.97 m	W7- Valve group	2536.59 m
W2- Valve group	1189.65 m	W8- Valve group	2174.39 m
W3- Valve group	2227.08	W9- Valve group	1872.69 m
W4- Valve group	2270.57 m	W10- Valve group	1154.98 m
W5- Valve group	2517.67	W11- Valve group	1416.48 m
W6- Valve group	2116.34 m	W12- Valve group4	224.81 m

Layout Phase

After determining the overall well division plan using a valve group, in order to meet the needs of the rolling development of the oilfield, the pipeline network needs to be constructed in stages. The rolling development plan is shown in Table 2.

(1) Layout of the first-phase gathering and transportation network

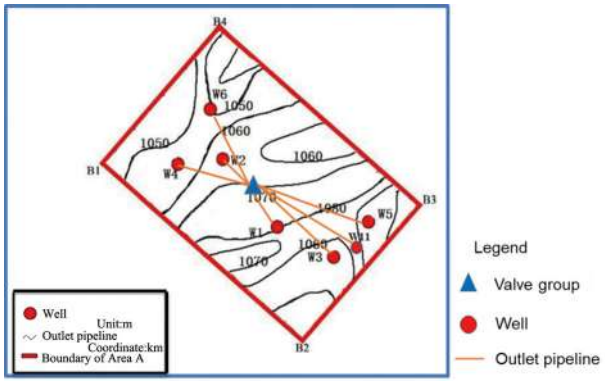

Figure 27. Phase I Gathering and Transportation Pipeline Network Layout

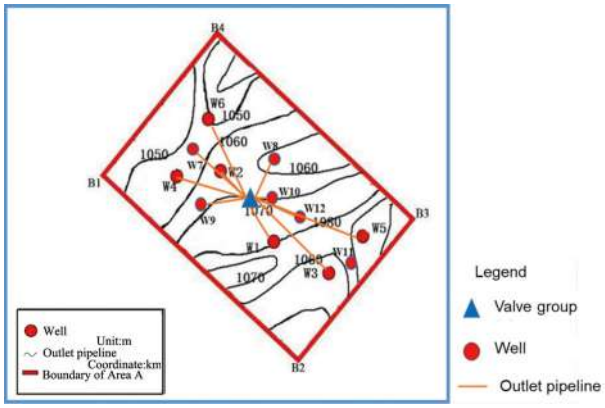

Figure 28. Phase II Gathering and Transportation Pipeline Network Layout

4.2 Gathering Pipeline Design

4.2.1 Material Selection for Gathering and Transportation Pipelines

The selection of materials for the pipes and accessories of the oil and gas gathering and transportation pipelines should be determined after technical and economic comparisons based on the design pressure, design temperature, medium characteristics, and application areas. The steel pipes and steel used should have good toughness and weldability.

The natural gas in area A is methane gas containing H_2S and CO_2. H_2S in natural gas gathering and transportation chemical pipelines and equipment will cause metal hydrogen-induced cracking (HIC) and sulfide stress cracking (SSC). Due to hydrogen atoms Existence causes the fracture toughness of the pipeline, the physical, chemical, and mechanical properties of the material to decrease, and it is easy to cause pipeline damage during operation, thereby destroying the safety of the pipeline and affecting the service life of the pipeline. The CO_2 in the medium

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will cause metal to the material Weightless corrosion, that is, general electrochemical corrosion, the general corrosion resistance and stress corrosion resistance of the pipe must be considered when selecting the pipe material.

Based on the previously calculated H_2S and CO_2 partial pressure ratio, it can be determined that the corrosion environment in the pipeline is mainly H_2S playing a leading role. Therefore, when considering the selection of pipeline materials, it should be considered as sulfur-resistant pipes.

Principles for selecting materials for sulfur-resistant pipelines and equipment

(1) Principle of safety and reliability

In general, the sulfur content and acid value (pH value) in the feed gas under normal operating conditions of the pipeline should be used as the basis for the design and selection of materials, and the combination of the maximum sulfur content and the highest acid value that may be achieved under the most severe operating conditions For the corrosion caused by the metal at the time, the appropriate material should be selected from the aspect of safety and reliability. For a uniform corrosive environment, it is necessary to avoid the emergence of the "material-medium environment combination" where the wall thickness of the pipeline components is sharply reduced. The corrosion rate should not be greater than 0.26 mm/a. The occurrence of "material-medium environment combination" with severe local corrosion should be avoided, such as pitting, crevice corrosion, scouring corrosion, abrasion corrosion, etc. When it is unavoidable, other effective methods should be adopted. Preventive measures. For stress corrosion environments, the occurrence of "material-medium environment combination" of stress corrosion cracking should be avoided as much as possible. When selecting low-grade materials due to the high uniform corrosion rate, and changing to high-grade materials, consider the possibility of occurrence. Other more dangerous types of corrosion, such as localized corrosion or stress corrosion cracking. The components of each pipeline with the same operating conditions should be selected from the same or equivalent materials. The branch pipeline connected to the main pipe, the purge steam pipeline, etc. A valve and the pipeline before the valve should be made of materials with the same or equivalent performance as the main pipe, and the same corrosion allowance should be taken.

(2) Economic principle

When designing and selecting materials, comprehensively consider the service life of pipeline components, costs, construction and normal maintenance costs, so that the comprehensive economic indicators are reasonable. Under normal circumstances, standardization and serialization of materials are preferred. For uniform corrosion environments, if the selection is low Grade materials will produce a larger corrosion rate; when selecting high-grade materials, it can be determined through a comprehensive economic evaluation.

(3) Consider the influence of pipeline structure

Fully consider the influence of factors such as the velocity of the medium in the pipeline, flow pattern, phase change and other factors on material corrosion. When serious erosion and corrosion are foreseeable, effective measures such as increasing the flow area, reducing the flow rate, and upgrading local materials should be taken. For directly welded pipelines, equipment and components, avoid using dissimilar steels, especially in environments that may cause serious galvanic corrosion, dissimilar steels should not be used.

(4) Combining equipment components

When designing and selecting materials, fully consider the supply situation of the market, especially the supporting supply of pipeline components. The use of new materials and new products, and fully understand its usability, reliability, manufacturing performance, (welding) construction performance and related. The supporting supply of pipeline components and the cost is determined on the basis of other aspects. In principle, new materials should be appraised by a qualified organization and have successful industrial application experience.

(5) Combined pipeline construction

Consider the feasibility of pipeline component construction. For pipelines that require post-weld heat treatment, the effect of heat treatment on the performance of pipeline components should be considered.

Material selection for gathering and transportation pipelines

(1) Selection of anti-SCC carbon steel

When selecting materials for anti-SCC carbon steel, the H_2S partial pressure of the block should be combined with the PH value of the conveying medium.

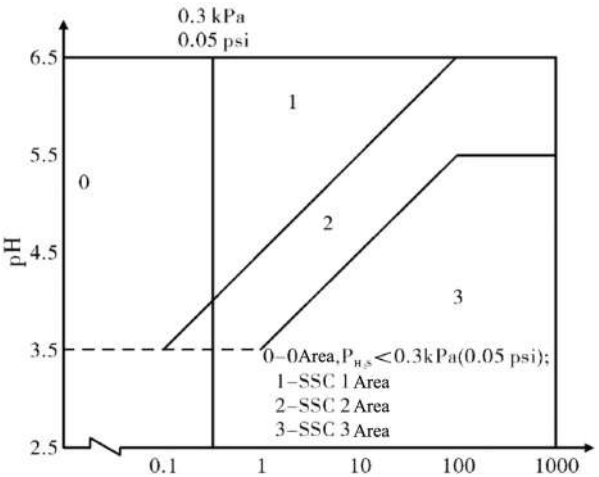

Figure 29. Division of SCC environmental severity

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The discontinuity of H_2S partial pressure lower than 0.3 kPa (0.06 psi) and higher than 1 MPa (160 psi) in Figure 29 reflects the uncertainty when measuring low H_2S partial pressure and beyond the range of H_2S partial pressure (including low and high H_2S) uncertainty of steel performance.

According to the "Requirements for Anti-sulfide Stress Cracking Metal Materials for Natural Gas Ground Facilities" (SY/T0699-2006) [19], the implementation standards for pipes used in acid environments are shown in Table 15.

Table 15. Pipes used in acidic environment

Material category	Standard	Grade	Environmental restrictions	use
Carbon steel	GB 3087	10,20	SCC	Equipment shell, takeover, collection pipeline, pipe fittings, etc.
	GB 6479	20,20		
	GB 6310	20G		
Carbon steel and Low-alloy steel	GB/T9711	S L246,L290,L360 steel	SCC 3 zone	Equipment tube bundle, collection gas pipeline, pipe fittings, etc.
		S L416,L460 steel	SCC 1 area SCC2 zone	
	API Spec 6I	B steel, X-42 To X-62 steel	SCC zone 3 product specification level is PSL2	
		X-6 to X-66 steel	SSC 1,SSC 2 zone	
Corrosion resistant alloy	SY / T6601	LC30-2242(N08826)	Used as any equipment and parts, there is no restriction on the temperature, PH2S, chloride concentration in the mining environment, any combination of original pH value and elemental sulfur	Collection gas pipeline, pipe fittings, etc.

In terms of strength, the use of high-strength grade steel can save steel. However, excessive emphasis on high-strength thin-walled pipes will bring unfavorable factors such as pipeline instability, poor fracture resistance and poor seismic resistance. SSC 3 zone recommends L246, L290, L360 steel Grade, L416, L460 steel grade is recommended for SSC Zone 2.

At present, the selection of pipeline materials for typical domestic sulfur-bearing oil and gas fields is shown in Table 16.

Table 16. Selection of pipeline materials for some domestic sulfur-bearing oil (gas) fields[20-22]

Oil (gas) field name	H_2S content	CO_2 content	Pipe material selection
Puguang	Up to 17%	10.6%	Gas production pipeline Nickel-based alloy 826 Gas gathering line L360 QCS
Jingbian	1489. 67mg /m^3	6.12%	L360 NCS
Tarim Middle Ancient Block	0.69%	4.69%	Gas gathering pipeline L360 NCS

The average content of H_2S in area A is 0.49%, the average content of CO_2 is 3.77%, and crude oil contains 0.19% sulfur. Considering the relevant specifications and the current application status of sulfur-resistant oil (gas) fields at home and abroad, see the pipeline steel grade and material selection Table 17.

Table 17. Pipeline steel grade and material selection

Pipeline name	Steel grade and material selection
Oil collection line	L360 NCS
Outlet pipeline	L245 NCS

4.2.2 Gathering Pipeline Design

Phase state judgment

Before carrying out gathering and transportation pipeline design, hydraulic calculation, and thermal calculation, the phase state of the conveying medium in the pipeline should be judged to determine single-phase gathering and transportation or multi-phase gathering and transportation, and the pipeline design and hydraulic power should be carried out according to the corresponding phase state calculation method and thermal calculation.

Use HYSYS software to judge the fluid phase state at the wellhead at 4 MPa and 56°C. The phase state diagram is shown in Figure 30.

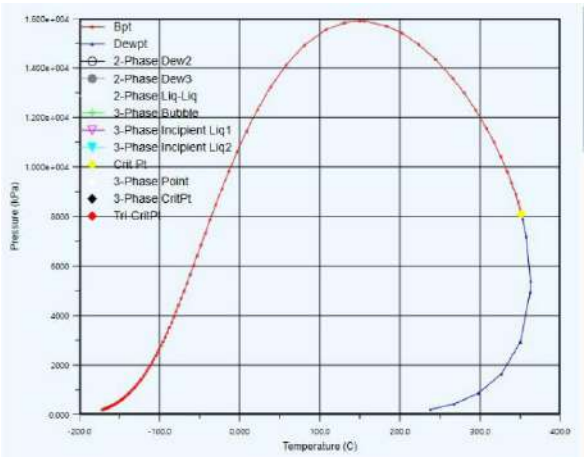

Figure 30. Phase diagram of conveying fluid

Design output

Considering the fluctuations in the delivery volume during the oil delivery process from the oilfield, a certain margin should be left when determining the pipeline design delivery volume. The designed delivery volume of the oil outlet pipeline should be 1.1 times the oil delivery volume during normal operation, corresponding to each designed output capacity of the single well oil pipeline is shown in Table 18.

Table 18. Designed output capacity of each oil pipeline

Well	Design output (t/d)	Well	Design output (t/d)
W1	147.64	W8	98.43
W2	199.90	W9	157.48
W4	98.43	W10	196.85
W6	196.85	W11	196.85
W7	157.48	W12	196.85

Design pressure

When determining the design pressure of each production pipeline, the wellhead pressure and the annual pressure attenuation should be combined to meet the delivery pressure requirements under the design delivery volume. After OLGA hydraulic calculations and demonstrations, the design pressures of the delivery and collection pipelines seen in Table 19.

Table 19. Design pressure of pipeline

Pipeline type	Design pressure
Outlet pipe	4.2 MPa
Gathering pipe	3.7 MPa

Buried depth of pipeline

Oil and gas gathering and transportation pipelines should be laid in the ground. The laying depth of buried pipelines should be determined comprehensively according to the terrain along the line, ground load conditions, thermal conditions and stability requirements. The minimum thickness of the buried pipeline should meet the current national standard "Gas Pipelines". The relevant provisions of the Engineering Design Code GB 50251 [23] are shown in Table 20. The purpose of the minimum buried depth of the pipeline is to prevent the pipeline from being damaged by external machinery. It is the minimum requirement from a safety perspective.

Table 20. Minimum covering thickness (m)

	Dry land	Paddy field	
First level	0.6	0.8	0.5
Level 2	0.8	0.8	0.5
Level 3	0.8	0.8	0.5
Level 4	0.8	0.8	0.5

Area A is located in an arid area with yellow sand on the surface, and at the same time is a first-class area with no people around. The minimum covering thickness of the oil and gas gathering pipeline is 0.6 m.

Use the OLGA software to test the temperature drop of the pipeline with a buried depth of 0.8 m, 1 m, and 1.2 m (Figure 31). From the figure, it can be found that the temperature drop curves of the three different buried depths are almost the same. All the buried depths can meet the requirements of pipeline insulation and transportation technology.

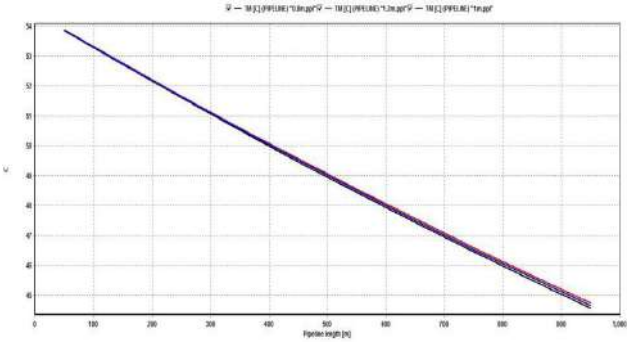

Figure 31. Three types of buried depth pipeline temperature drop curves

According to the process requirements of the pipeline and combined with the transportation economy, the reasonable buried depth is 1 m.

Pipeline anti-corrosion coating

Applying a protective coating on the surface of the pipeline is an important method to prevent metal corrosion. Its function is to isolate the metal construction surface from the soil medium, and increase the corrosion battery circuit to hinder the corrosion effect, thereby slowing the metal corrosion rate.

Existing anti-corrosion layer materials, such as petroleum asphalt, coal tar enamel, polyethylene adhesive tape, fusion bonded epoxy powder, three-layer composite structure PE, etc., have different performances and advantages and disadvantages in long-term use. The structure, advantages and disadvantages and applicable temperature of the anti-corrosion layer are shown in Table 21.

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Table 21. The structure and service conditions of the outer anti-corrosion layer

	Asphalt	Coal tar enamel	Polyethylene Adhesive tape	Three-layer composite structure PE	Fused epoxy powder
Primer material	Asphalt primer	Coal tar primer	Pressure sensitive adhesive or butyl rubber	Epoxy powder primer	—
Anti-corrosion layer material	Petroleum bitumen, with glass mesh	Coal tar enamel, use glass mesh	Anticorrosive adhesive tape	Epoxy powder + copolymer +	Epoxy powder
	cloth as the middle strengthening layer, and plastic cloth outside	cloth or glass felt as the middle strengthening layer, and wrap the glass felt	(inner tape), protective adhesive tape	polyethylene	
Anti-corrosion layer structure	3~5 layers of asphalt, total thickness 4~7mm	1~3 layers of enamel paint, total thickness 3~5mm	One layer of primer, one layer of inner belt, and one layer of outer belt, total thickness 1.8~3.7mm	One layer of primer, hot extruded or wrapped, with a total thickness of 1.8~3.7mm	The paint is fused on the pipe wall to form a thin film with a thickness of 0.3~0.5mm
Applicable temperature (C)	-20~70	-20~70	-30~60	-40~70	-30~110
Mouth method	Pour bitumen on site or heat shrinkable sleeve	Coal tar primer thermal wrap tape or thermal shrink sleeve	Polyethylene fused sleeve or heat shrink sleeve	Polyethylene fused sleeve or heat shrink sleeve	Epoxy powder electrostatic or ion spraying heat shrinkable sleeve
Advantage	Low price and wide sources	Low water absorption, penetrating rhizome, resistant to bacterial corrosion	Good electrical insulation, high mechanical strength, low water absorption	Mechanical properties, low temperature resistance and electrical insulation	Strong mechanical properties and bonding properties, good resistance to cathodic disbondment and temperature resistance
Disadvantage	Low mechanical strength, poor low-temperature toughness, high water absorption, easy to be corroded by bacteria, and easy to age	Mechanical degree and low temperature toughness are poor, and environmental pollution is great	Poor adhesion, easy to age in the sun	High quality requirements for steel pipe surface treatment, painting and on-site patching, and higher prices	Poor toughness and impact resistance, sensitive to water absorption, strict requirements for construction quality

Considering the corrosion of the pipeline transportation medium, the cost of the external anti-corrosion layer, the difficulty of construction, and the operating temperature of the pipeline, a 3-layer PE external anti-corrosion layer is adopted.

Pipe diameter and wall thickness

(1) Pipe diameter

Under the specified delivery volume, increasing the pipe diameter can reduce the pressure required for oil delivery and reduce the oil delivery power, but the pipeline construction cost and heat energy consumption increase. Under a certain delivery volume, only for a certain range of flow rates. It is the most economical.

There are many factors that affect the economic flow rate of the pipeline, such as the size of the flow, the transportation distance, the nature of the crude oil, the price of fuel and power, the estimated indicators of materials and equipment, and the investment in infrastructure. According to GB50350-2015 "Oilfield Oil and Gas Gathering and Transportation Design Code" [11], the liquid velocity of the gathering pipeline should be 0.8m/s~2m/s.

Considering the fluid transportation requirements, design pressure, pressure drop size, liquid economic flow rate and other factors, three groups of pipe diameters are selected for preliminary selection of the oil outlet pipeline and the oil gathering pipeline.

The optimization process is illustrated by taking W1-valve group as an example, and the primary pipe diameter is shown in Table 22.

Table 22. Primary selection pipe diameter table

W1-Vavle group	Case 1	Case 2	Case 3
Outer diameter of pipe	D68	D70	D73

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The OLGA software is used to perform hydraulic calculation and economic flow rate verification of the above three groups of pipe diameters to select the best pipe diameter. The hydraulic calculation results are shown in Figure 32, the average flow velocity is shown in Figure33, and the verification results are shown in Table 23.

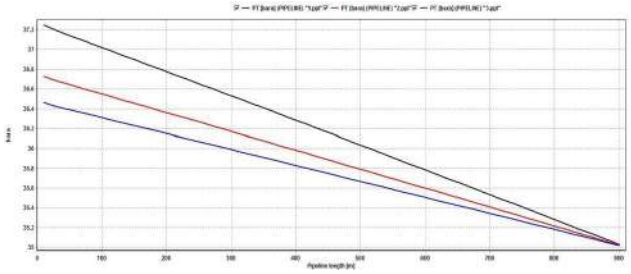

Figure 32. Pressure drop along the path under three groups of pipe diameters

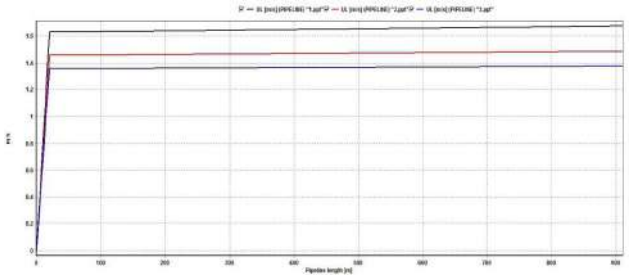

Figure 33. Average flow velocity of liquid under three groups of pipe diameters

Table 23. Trial calculation results of three groups of pipe diameters

Pipe diameter	Gathering pressure	Start and end pressure drop	Average liquid velocity
D68	3.73 MPa	0.222 MPa	1.63 m/s
D70	3.67 MPa	0.17 MPa	1.46 m/s
D73	3.64 MPa	0.144 MPa	1.36 m/s

Because the crude oil in area A has the characteristics of low viscosity and the pipeline length is short, the pressure drop of the three-phase mixed transportation of oil, gas and water is small, and the pressure drops of the three sets of pipe diameters are all in line with the requirements; and the average liquid velocity is 0.8 m/s ~2 m/s is in line with the economic flow rate requirements. In this case, in order to make full use of the wellhead oil flow pressure (4 MPa), the pressure of the gathering and transportation system can be appropriately increased, so the D68 pipe diameter is selected.

After repeated trial calculations and demonstrations by OLGA software, the outer diameter parameters of the oil gathering pipeline and the oil outlet pipeline are shown in Table 24.

Table 24

Pipeline type	Outer diameter of pipe (mm)	Pipeline type	Outer diameter of pipe (mm)
Oil collection line	219	W7- Valve group	73
W1-Valve group	68	W8- Valve group	63
W2- Valve group	73	W9- Valve group	73
W3- Valve group	77	W10- Valve group	73
W4- Valve group	63	W11- Valve group	73
W5- Valve group	77	W12- Valve group	73
W6- Valve group	77		

(2) Pipe wall thickness

The wall thickness of the steel pipe of the straight section of the oil and gas gathering pipeline should be rounded up to the standard wall thickness of the steel pipe. The calculated wall thickness of the pipeline should be calculated according to formula (4.2.1):

$$= pD + C$$

$$2sS\ Fft$$

Where d is pipeline calculation wall thickness in mm; p is pipeline design pressure in MPa; D is outer diameter of pipe in mm; F is strength design factor in dimensionless; s is minimum yield strength of steel pipe in MPa; C is corrosion margin added value in mm; t is temperature reduction factor, t=1.

① Design factor

According to GB50350-2015 "Code for Design of Oil and Gas Gathering and Transportation in Oilfields", when the pipeline transports sulfuric acid natural gas, the value of the design coefficient F should not be lower than that of the secondary area, and F is 0.6.

② Corrosion allowance C

According to the relevant specifications, the selection of the corrosion allowance C: For slight corrosion, it should not be greater than 1mm; when the pipeline contains acidic media such as water, hydrogen sulfide, carbon dioxide, etc., it should be determined according to the degree of corrosion and the anti-corrosion measures taken, preferably 1mm~4mm; In other cases, the corrosion allowance should not be calculated.

Block A adopts the method of oil and gas mixed transportation to collect oil. The oil production pipeline transports a mixture of oil and gas, and the natural gas contains hydrogen sulfide and carbon dioxide. During the development period, the water content is 0.016~0.62, especially the water injection development stage. High, the corrosion

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is more serious, the corrosion allowance can be 3 mm.

The design wall thickness results based on formula (4.2.1) are shown in Table 25.

Table 25. Wall thickness parameter table of oil collecting pipeline and oil outlet pipeline

Pipeline name	Design wall thickness (mm)	Pipeline name	Design wall thickness (mm)
Gathering pipeline	5.5	W7- Valve group	4
W1-Valve group	4	W8- Valve group	4
W2- Valve group	4	W9- Valve group	4
W3- Valve group	4	W10- Valve group	4
W4- Valve group	4	W11- Valve group	4
W5- Valve group	4	W12- Valve group	4
W6- Valve group	4		

Hydraulic and thermal calculation

The hydraulic and thermal calculation of the pipeline is mainly based on the block's gathering and transportation technology and the control of the average liquid velocity of the gathering pipeline in the corresponding specifications. The OLGA software was used to calculate the hydraulic and thermal power of the pipeline.

(1) Gathering and transportation technology: the overall gathering and transportation technology in area A is natural non-heating and non-insulated oil and gas mixed transportation technology.

(2) Flow velocity control: According to GB50350-2015 "Code for Design of Oil and Gas Gathering and Transportation in Oilfields", the liquid velocity of crude oil gathering and transportation pipelines inside the oilfield should be 0.8 m/s~2 m/s.

Table 26. Hydraulic and thermal calculation results of each pipeline

Pipe number	Temperature (℃)		Pressure (MPa)		Velocity (m/s)
	Starting temperature	End temperature	Starting pressure	End pressure	Average liquid velocity
Gathering pipe	31	21.45	3.52	3.0	1.34
W1-Valve group	55.5	37.97	3.73	3.504	1.63
W2-Valve group	55.6	38.59	3.84	3.503	1.87
W3-Valve group	55.5	29.75	3.88	3.504	1.53
W4-Valve group	55.34	20.2	3.89	3.502	1.25
W5-Valve group	55.4	29.65	3.89	3.503	1.53
W6-Valve group	55.2	29.45	3.88	3.504	1.52
W7-Valve group	55.88	24.38	3.92	3.503	1.42
W8-Valve group	55.8	20.85	3.87	3.504	1.27
W9-Valve group	55.86	28.66	3.82	3.504	1.85
W10-Valve group	55.9	39.19	3.82	3.506	1.83
W11- Valve group	55.77	36.26	3.86	3.505	1.83
W12- Valve group	55.9	51.9	3.57	3.5	1.93

4.3 Gathering Pipeline Flow Guarantee

4.3.1 Natural gas Hydrate Prediction

Because of the three-phase mixed transportation of oil, gas and water in area A, natural gas and water are present in the pipeline at the same time during the transportation process. When the water content of natural gas is saturated, liquid water is often present. It must be above 0°C. Under the conditions of temperature and the presence of liquid water, certain components in natural gas can form a white crystalline solid with liquid water, which looks like loose ice, which is natural gas hydrate.

The existence of natural gas hydrate will reduce the effective flow area of the pipeline, reduce the transportation capacity of the pipeline, and even cause ice blockage, making the pipeline unable to transport normally. Therefore, it is necessary to predict the formation conditions of natural gas hydrate and control the transportation temperature and transportation of the transportation medium. Pressure to avoid the formation of hydrates.

Combined with the overall oil and gas gathering and transportation and oil and gas processing processes in the region, there are two places where natural gas hydrates are easy to form. One is the process of fluid transport from the wellhead to the joint station, and the other is the process of throttling and pressure reduction of incoming liquid through the control valve In these two points, the prediction of natural gas hydrate should be done, and antifreeze should be added when necessary.

(1) Hydrate prediction during transportation

Use HYSYS software to simulate and predict the conditions for the formation of hydrates in the oil gathering pipeline during the stable production period. The prediction results are shown in Figure 34.

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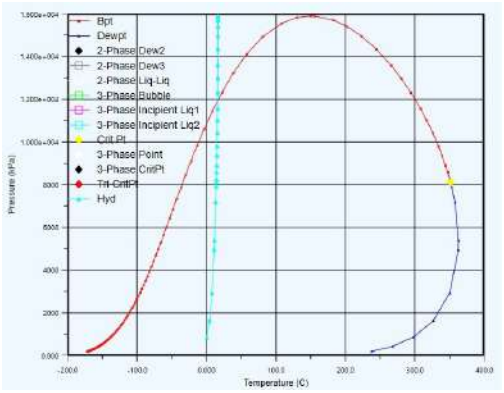

Figure 34. Natural gas hydrate formation curve of oil gathering pipeline

The delivery pressure of the entire oil outlet pipeline and the collection pipeline is in the range of 3~4MPa, and the delivery temperature is in the range of 21.5~56 ℃ . From the above figure, we can see that in this temperature and pressure range, no hydrate is formed during pipeline transportation. There is no need to add antifreeze at the wellhead.

(2) Prediction of inbound throttling and pressure reduction

Use HYSYS software to simulate the inbound throttling process. The calculation results are shown in Table 27.

Table 27. Incoming liquid throttling calculation

	Pressure	Temperature
Before throttling	3000 kPa	21.5 ℃
After throttling	600 kPa	17.73 ℃

According to the simulation calculation results, after the incoming liquid is throttled, the temperature is 17.3°C and the pressure is 0.6 MPa (which is consistent with the design pressure of the first-stage thermochemical sedimentation dehydrator). It can be seen from Figure 34 that the temperature and no hydrate is formed under pressure, and anti-freezing measures may not be taken, except when the external environment encounters extreme temperatures.

4.3.2 Wax Prevention Measures

According to the calculation results of the pipeline's hydraulic and thermal power, during the stable production stage, there is no wax crystal precipitation in the pipeline under normal transportation conditions, but when the block enters the water injection development, the output will follow the opening and closing of the well (determined by the braising well plan). The output changes greatly, and the overall output shows a decreasing trend. The pipeline is very likely to be in a poor operating state with low throughput for a certain period of time, which will inevitably affect the thermal condition of the pipeline, and extreme temperature conditions in the external environment cannot be ruled out. It is necessary to take certain measures to prevent wax deposition from affecting the operation of the pipeline after the block enters the water injection development stage.

(1) Wax deposition control measures

The wax deposition control mainly adopts four methods: heat preservation/heating, reagent injection, thermochemical wax removal and mechanical pigging. Since the block gathering and transportation process adopts the natural non-heating oil gathering method, the main consideration is to inject reagents, thermochemical wax removal and mechanical pigging to control the waxing of the pipeline [24].

1 Inject reagent method. By injecting chemical agents (solvents, dispersants, crystal modifiers) to change the aggregation characteristics or thermodynamic boundaries of wax crystals and hydrates, wax precipitation can be prevented. Thermodynamic inhibitors can reduce the activation energy to form hydrates and wax molecules. If there is no accident as the premise, the fluid temperature can be allowed to be lower, but the amount of inhibitors (such as ethylene glycol and ethanol) used is larger.

2 Thermochemical wax removal method (NG, Nitrogen Generating System) NGS (nitrogen generation) method is to melt the wax crystals on the pipe wall through the exothermic heat during the nitrogen generation reaction to achieve the purpose of wax removal. Petrobras used NGS to achieve good anti-condensation effects in the oil pipeline in the Campos Basin.

3 Mechanical pigging method. At present, the most commonly used method is to directly use a pipe cleaner to remove wax on the pipe wall by sweeping and scraping.

Taking into account the wax deposition that may occur in the pipeline flow process, combined with economy and technology, the mechanical pigging method is adopted, and a ball throwing wax removal device is installed at the wellhead.

(2) Throw the ball to remove wax [25]

Crude oil flows at low temperatures, and the precipitated paraffin is easily deposited on the pipe wall. The deposition of paraffin makes the actual flow diameter of the pipeline smaller, and the resistance increases rapidly, and finally causes the pipe to block. Regularly throws balls from the wellhead to the oil gathering pipeline (usually repeatable The use of plastic balls or disposable soluble chemical balls) to remove part of the wax on the pipe wall and maintain the normal flow of crude oil. Usually according to the degree of wax deposition to determine the throwing wax removal cycle. From the wellhead to the metering station

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from the wellhead, take out the metering station; between the metering station and the joint station, the metering station is used for input, and the joint station is taken out. The automatic pitching device or manual device can be used for pitching.

This method generally requires a ball delivery device at the wellhead, a ball receiving or delivery device at the metering station or metering transfer station, pipeline insulation, rational use of formation energy, and the same ball method to remove wax and debris on the pipe wall to ensure smooth and smooth pipelines. Safe production. The wax removal balls generally include steel balls, rubber balls and chemical balls. The ball diameter is generally less than the inner diameter of the pipeline 2~3 mm. The automatic ball throwing device and the induction heating ball receiving device have been manufactured.

4.3.3 Slug Flow Control

Slug flow control measures

Slug is a typical unstable working condition often encountered in gas-liquid mixed transportation pipelines, especially oil-gas-water mixed transportation pipelines. It is manifested by periodic pressure fluctuations and intermittent liquid plugs, which are often given to the design of gathering and transportation systems. And operation management caused huge suffering and safety hazards. Block A adopts the gathering and transportation technology of mixed transportation of oil, gas and water. During the transportation process, slug flow is extremely likely to occur. In order to minimize the harm of slug flow, combined with the specific process conditions, there are two main aspects. Control the slug flow[26]:

① In the pipeline design calculation, increase the terminal entry pressure and set the terminal entry pressure to 3 MPa;

② When the incoming liquid enters the station, the slug flow catcher is used to capture the slug flow.

(1) End point pressure

Generally speaking, 0.5 MPa is sufficient for the subsequent process when the oil comes to the joint station, but the end pressure is set to 3 MPa in the pipeline calculation, which is mainly based on the following three factors:

1) In consideration of the hazard of slug flow, in order to give certain control to the slug situation, reduce the influence of slug flow on pipeline flow, and ensure the safe and stable transportation of oil-gas-water mixture;

2) The pipeline design is carried out under the condition that the wellhead pressure (starting pressure) is 4MPa and the end pressure is 3MPa. On the one hand, the oil flow can make full use of the formation energy. On the other hand, the pipeline may be possible during the implementation of the later simmering plan. When the thermal and hydraulic conditions become bad due to the low capacity, it is not advisable to design the pipeline pressure drop too much from the beginning.

3) For the consideration of controlling the average liquid velocity within the economic velocity range.

This section mainly explains the reason for setting the calculated pressure at the end of the pipeline to 3MPa from the perspective of controlling slug flow, and it is also a measure to minimize the harm of slug flow.

Selection of Slug Catcher

In the gathering and transportation process of oil and gas fields at home and abroad, the common slug flow traps can generally be divided into container type and multi-tube (finger type) slug flow traps. These two types of traps are different in structure. Larger, but each has its own advantages in actual use.

(1) Positive displacement slug catcher

The usual types of container slug traps are horizontal and vertical. The horizontal type of container-type slug flow trap is more common, consisting of a single tank or multiple tanks, a buffer plate, a mist trap and a vortex preventer.

(2) Multi-tube slug catcher

Multi-tube slug flow traps are generally composed of a diverter, a slug separation section, a slug collection section and a slug storage section, a riser, a sinking pipe, and a balance tube bundle. Each of the multi-tube traps.The pipe sections are different in slope and length. Under certain circumstances, a non-slope effusion pipe section will be set for liquid-liquid stratification and liquid storage.

Internationally, it is generally recommended to use container-type slug traps for slugs below 100m3. For larger slugs, pipe-type slug traps are often used. In actual projects, performance and equipment investment, transportation, installation, and technical risks.

Catcher type	Features
Container slug catcher	(1) High gas-liquid separation efficiency; (2) Generally used to deal with small slugs; (3) In the case of processing the same slug volume (small slug volume), the container-type slug flow trap has a higher investment and a smaller footprint; (4) The container-type slug trap can be prefabricated and skid-mounted in the factory, and the installation time on site is short; (5) In the case of dealing with small slugs generated by onshore gas-liquid mixed pipelines, container-type slug traps are preferred
Tubular slug catcher	(1) Low gas-liquid separation efficiency; (2) It can handle thousands of cubic meters of slug; (3) The multi-tube slug catcher is relatively cheap and covers a large area; (4) The workload of welding and installation of multi-tube slug trap is large

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As far as the two types of slug traps are concerned, the technology is relatively mature, low-risk, and long-term procurement equipment. In summary, because the volumetric slug catcher can be prefabricated and skid-mounted in the factory and has a small footprint, the volumetric slug catcher is selected for this design.

4.4 Pipeline Design Summary

The overall regional process design adheres to the design concept of "environmental protection, efficiency and innovation", strictly follows the design specifications, and combines reservoir engineering and oil production engineering schemes, oil and gas physical properties and chemical composition, product schemes, ground natural conditions, etc., through multiple schemes According to the technical and economic analysis and comparison, we have worked out a closed process flow for oil and gas gathering and processing in Area A. In terms of pipeline design, from the perspective of controlling the influence of slug flow, rational use of oil well fluid pressure energy and controlling the average flow rate of the liquid, a suitable end-point calculation pressure of the pipeline is obtained, and then the pipe diameter and hydraulic calculation of the pipeline are inversely calculated to try to make the late simmer When the well plan is implemented, the pipeline will not have bad hydraulic conditions, and the pressure of the gathering and transportation system is appropriately increased. At the same time, it also considers the flow guarantee measures along the oil and gas mixed transportation, such as gas hydrate prediction, pipeline wax removal, and slug flow control.

5. System Supporting Engineering and Auxiliary Facilities

5.1 Anticorrosion

Area A is naturally methane gas containing H_2S and CO_2, and the crude oil is sulfur-containing crude oil, and the oil and gas mixed transportation gathering and transportation process is adopted. When H_2S and CO_2 are dissolved in water, it will corrode pipelines and production equipment, so it is necessary to control the corrosion of pipelines and production equipment.

The internal and external anti-corrosion design of oil and gas gathering pipelines should comply with the current national standard "Code for Internal Corrosion Control of Steel Pipelines" GB/T 23258 [27], "Code for External Corrosion Control of Steel Pipelines" GB/T 21447 [28], "Cathodic Protection of Buried Steel Pipelines" Relevant regulations of Technical Specification" GB/T 21448 [29].

5.1.1 Protection Range

The corrosion protection scope of this project includes 10 single-well, 1 metering valve group, 1 combined processing station, 1 built pipeline, oil field gathering pipeline and pipeline in the joint station.

5.1.2 Internal Corrosion Protection

According to GB 23258-2009 "Code for Internal Corrosion Control of Steel Pipelines" [30] and the temperament condition of Block A and gathering and transportation technology, the following internal corrosion control measures are taken:

(1) Pigging. Pipe pigs are used to remove dirt and deposits in the pipes, and regular pipe cleaning is combined with the addition of corrosion inhibitors and dehydration processes.

(2) Dehydration and removal of acid gas. The free water and acid gas are removed from the pipeline medium at the joint station.

(3) Add corrosion inhibitor. Add a cathode type corrosion inhibitor at the wellhead, which can be fully dispersed in the liquid for transmission to ensure that the pipeline and production equipment can be protected during the transportation process.

5.1.3 External Corrosion Protection

The anti-corrosion layer is the basic barrier for pipeline protection. The selection of anti-corrosion layer should be based on the terrain and soil conditions of the specific pipeline installation environment, combined with the use of domestic mature anti-corrosion layers, as well as reliable technology, reasonable economy, convenient management and maintenance, and strong on-site construction adaptability In order to select the principle, the outer anti-corrosion layer of the steel pipeline adopts three layers of PE, and the pipeline of the outdoor equipment adopts the polyurethane paint with good fire resistance.

5.2 Sand Prevention

According to GB 50350-2015 "Oil Field Oil and Gas Gathering and Transportation Specifications", the design of oil and gas gathering and transportation projects in the desert and Gobi areas should be suitable for the harsh environmental conditions in the desert and Gobi areas, sand-fixing and other wind-sand prevention measures are an essential link in the construction of oil and gas gathering and transportation projects.

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5.2.1 Comprehensive Control of Sandstorm

The comprehensive control of wind and sand includes engineering measures to prevent wind and sand, chemical sand fixation measures and plant sand fixation measures. The essence of these methods is to weaken the wind that causes wind and sand activities and reduce the amount of sand in the airflow to achieve the purpose of preventing wind and sand hazards.

(1) Engineering sand control measures [33]

Engineering measures to prevent wind and sand refer to the method of setting up artificial structures or covering the sand surface to control the occurrence of wind erosion and change the conditions of sand transportation and accumulation to achieve the prevention and control of wind and sand hazards. There are many types and forms of engineering measures, according to their functions. And the nature can be divided into several measures: solid, resistance, transmission (guide).

Sand fixation measures are to use heavy materials to cover the surface of the dunes to isolate the contact between wind and sand, or to set up sand barriers to reduce the surface wind speed to inhibit wind and sand activities. The main measures are to cover the dunes with heavy materials and set up various sand barriers.

Sand blocking measures are to set up various artificial structures at an appropriate distance on both sides of the building (usually 100~200 m) to block sand dunes and wind-sand flows from moving forward and make them stop near the structure, as the first front edge of the building There are many types of sand blocking measures for road defense lines, and they vary from place to place. Commonly used methods include high vertical sand barriers, sand blocking dikes and sand retaining walls.

Engineering sand control measures for stabilizing, blocking, and transporting (conducting) have their own conditions of use and scope. Comprehensive measures should be taken according to the natural conditions of the desert and the characteristics of wind and sand movement, such as erecting high-rise sand barriers on the outer edge of the sand-fixing belt. This kind of solid-resistance protection system is very effective. Block A can choose suitable engineering sand control measures according to the actual surface conditions and wind and sand environment.

(2) Chemical sand fixation

Chemical sand fixation has made great progress abroad. A batch of chemical sand fixation materials with good effects have been selected, such as asphalt emulsion sand fixation, Nerosine sand fixation, oil-latex sand fixation and sand agglomeration fixation, etc., which have been applied in production. Formula with bitumen emulsion, spraying process and planting sand plants, etc.

Emulsified asphalt sand fixation is to retain the diluted asphalt particles in the surface sand and cement the sand in a consolidation layer several centimeters thick to achieve the purpose of wind prevention and sand fixation. Because the consolidation layer has pores, it will not affect plant growth. It is easy to spray and quickly penetrate into the sand. It requires high dilution, dispersibility and stability of the emulsified asphalt. This property is due to the high dilution, dispersibility and stability of the asphalt. Determined by the nature and amount of emulsifier, bitumen emulsions are divided into two types: cationic and anionic according to their ion types.

According to the test data, 0.5kg of pitch black is used per square meter, and the storage life is 3~5a. Because the asphalt emulsion has strong adhesion to sand particles, it has low water quality requirements and low energy consumption. Although the cost is high, it is also effective the solid measures.

(3) Plants fix sand [34]

Preventing the hazards of sandstorms, engineering control measures and chemical sand fixation measures can be effective immediately, but they require a lot of materials and labor, and the preservation period is not long. Frequent maintenance and maintenance of science and engineering are usually regarded as a temporary protective measure. Plant sand fixation can not only weaken wind speed, change the nature of quicksand, and achieve the purpose of long-term sand fixation, but also adjust the climate and beautify the environment. It has many functions; but plant sand fixation is also a difficult and complex task that needs to be synchronized with engineering Before afforestation, a detailed survey and design should be carried out to determine the type of production conditions, tree species selection, forest belt planning and afforestation technical measures to ensure the survival and growth of the forest.

Block A can appropriately combine engineering sand fixation, chemical sand fixation, and plant sand fixation according to the actual surface conditions and wind-sand environment to fully realize sand control for oil and gas gathering and transportation projects.

Refer to the Tazhong 4 Oilfield Joint Station, which adopts multi-level and multi-variety sand-prevention and sand-fixing measures. First, a 1.2m high steel plate mesh and nylon mesh sand blocking wall are set around the joint station; 30m wide shrubs are arranged on the northeast and southeast sides of the main wind direction. Forest belt, dominated by drought-tolerant trees such as Haloxylon ammodendron, Saguaro jujube, and tamarisk;

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within the shrub belt is a 50m-wide grass grid sand-fixing belt; inside the grass-square sand-fixing belt is a 3m wide concrete pavement sand-fixing belt, which doubles as a fire belt and sidewalk There is also a 20m wide wind-proof green forest belt, among which shrubs are 15m wide, and trees are 5m wide. The trees are dominated by sand jujube, white elm, Populus euphratica, poplar tree, Xinjiang poplar, etc.; in the sand-blocking forest belt on the northwest side of the joint station, It is an experimental area for plant, flower and grass selection and open-field vegetable cultivation, as well as a greenhouse for soil-free vegetable cultivation experiment area; build concrete roads and grounds in some parts of the production plant area, and cover some places with concrete road slabs, and some places use concrete slats Surround the sand in a grid.

5.2.2 Sand Prevention in Pipeline Construction

In order to effectively prevent sandstorms, pipeline construction in desert areas should comply with the following requirements:

(1) Spoil and filling should be limited to the leeward side of the pipeline;

(2) The pipeline construction should be carried out simultaneously with the sand prevention and sand fixation project, and the engineering measures and biological measures should be combined;

(3) To prevent wind erosion of pipelines, fill soil and damaged ground should be covered with clay and stones, sprayed with asphalt sand fixation agent or protected by grass sand barriers, and plants can be planted in the sand barriers when conditions permit;

(4) Shorten the construction period and adopt the flow operation construction of excavation, pipe laying, backfilling, protection and planting at the same time;

(5) Minimize the width of the construction work zone as much as possible. Do not damage the surface and vegetation during the construction. The construction is completed in sections. Generally, the section is 3-5 km. If the excavation line is too long at one time, the pipe trench is easily buried by wind and sand, causing rework waste.

5.2.3 Wind and Sand Prevention of Communication Lines

Communication and transmission line settings:

(1) Communication and power transmission lines should not pass through tall moving sand dunes and severe wind erosion zones;

(2) The buried depth of the electric pole is 1.5~2.0 m. When backfilling, place a layer of grass or branches with an interval of 30~40 cm, and ram it in layers;

(3) Along the range of 2~3m around the pole, a high ring-shaped cone shall be built to connect gently to the ground and covered with stones or clay;

(4) Comprehensive reinforcement should be carried out within the range of electric poles and cable poles;

(5) Electrical equipment (transformers, power distribution panels, etc.) should strengthen outdoor dust, wind and heat protection measures.

5.3 Communication Engineering

The communication system should meet the needs of oilfield production management for communication services and should be able to provide a reliable communication channel for data transmission.

The construction of the communication system of this project is to provide a bearer network for the SCADA data, voice and video transmission of the crude oil long-distance transportation related process stations. At the same time, the video surveillance camera front-end and amplifying broadcast telephone terminals are set up for each process station. The communication system design should be adequate Make use of established resources, and should take into account the needs of short-term and long-term communications services.

According to GB50350-2015 "Oil Field Oil and Gas Gathering and Transportation Design Code", the determination of the communication mode of the oil field gathering and transportation station should meet the following requirements:

(1) The communication between stations and posts in the more concentrated areas of the oilfield should be mainly wired communication, and wireless communication is supplemented. The direct telephone between oil and gas gathering stations should use direct dedicated lines, oilfield private communication networks or public telecommunications network hotlines Function realization.

(2) For areas where the oil field is relatively dispersed and the marginal area is relatively independent, the communication between stations should mainly be wireless communication, and wired communication is the supplement. Large oil and gas stations in the oil field block, according to the geographical location and the communication requirements should be wired communication access or wireless communication access, and single-user stations should use wireless communication access.

(3) The voice communication of single well and measuring station should adopt wireless walkie-talkie mode.

The area of Block A is relatively small, and the oil wells and stations are more concentrated. Wired commu-

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nication should be the main method, and wireless communication should be supplemented. Single wells should use wireless walkie-talkies.

At present, the commonly used transmission methods at home and abroad are optical fiber communication, wireless broadband communication and satellite communication.

The selection of the system technical scheme of this project should save investment as much as possible on the premise of meeting the technical requirements, and the satellite communication method has a large investment, the capacity is small compared to the optical fiber communication, and the performance-price ratio is at a disadvantage. Therefore, the satellite communication method is not suitable for this project. No further discussion in this design. Optical fiber communication method has large transmission capacity, long relay distance, stable transmission quality, and no interference from external factors. The wireless broadband communication method has flexible networking, high transmission rate and convenient expansion.

According to the actual needs of this project, the communication system must not only be safe and reliable, but also save investment as much as possible. Therefore, a comprehensive analysis takes into account the actual situation of the project, but requires high transmission quality, and optical cable communication can be convenient and direct in the formal development stage. Incorporate into the newly-built optical fiber communication transmission network. Considering all aspects, the design recommends the use of optical fiber transmission communication as the communication transmission scheme of this project.

Taking into account the actual situation of the project, the optical fiber transmission system considers the use of multi-service uncompressed video optical transmission equipment networking. Install optical receiving equipment at the installation station, and install optical transmission equipment at the remaining stations. The system carries between the well site and the joint station. SCS data, video and control signal and voice transmission services.

5.4 Automatic Control

5.4.1 Automatic Control System

The production and operation management in this project area adopts the SCADA system. In order to ensure safe production and improve the management level, this project has set up a production monitoring system (ie SACDA system) for the entire block. The production monitoring system (SACDA system) is logically structured Divided into three layers:

The first layer is the production management, decision-making, and dispatch command system, which is a production monitoring system with the SCADA central control system as the core; the second layer is the monitoring system located in each station, which is the control and management of each production area; The third floor is a small station control system located in each intermediate station and valve room.

The central control system of the SCADA system (that is, the management, dispatch, and decision-making system of the central processing plant) is set up in the production dispatching command center of the loading station, and a complete and unified production database and application database are set up to conduct centralized production monitoring of each station under its jurisdiction, scheduling and management.

The station control system of the SCADA system is a monitoring system installed in the stations along the line. It is responsible for the data collection of the production process, processing and automatic control of the production process, and process management; and collects and monitors the production operation to realize the concentration of the production operation area Scheduling and management. At the same time, the production data and production information are uploaded to the central control system, and the production command and scheduling instructions from the control center are accepted to complete the concrete realization of the production plan.

5.4.2 Industrial Automation System in Oil Storage Area

The automation of the production process is an important technical means to improve working conditions, ensure quality, increase labor productivity, and reduce consumption. It is the core part of overall automated production and management, and an indispensable measure to realize modernization of oil depot operations and management.

(1) Classification of automatic control systems

The production automation system of the oil depot includes a wide range of contents, the main part of which is the automatic control system. At present, the most common automatic control system is divided into two categories, one is open-loop control, and the other is closed-loop control.

1) Open loop control system

The output of the control system does not affect the control effect of the system is called an open-loop control system. In an open-loop control system, there is no

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need to feed back the output to the input of the system for comparison with the input. There is a corresponding working status corresponding to it.

2) Closed loop control system

Any system whose output signal can directly affect the control function is called a closed-loop control system. The output quantity is sent back to the input end and the output quantity through a certain link for comparison. The system whose deviation acts on the controller to produce a control effect is also called a feedback control system.

The closed-loop control system is widely used in the petrochemical production process. Its advantage is that it has little effect on the response of the system when external disturbances or slight changes in the internal parameters of the system are caused by feedback, so it can be used with less precision and cost The low-level components constitute a precise control system, but the open-loop control system cannot. When external disturbance occurs or the parameters that control the remaining control objects change, the open-loop control system cannot complete the original control task, and its output can not maintain the original fixed corresponding relationship with the output. But from the perspective of stability, the open-loop system is easy to solve, and the closed-loop system will be unstable if the design is improper or the entire parameter setting is improper.

(2) Basic tasks of automatic control

The basic tasks of station automation are mainly to realize automatic control tasks such as office automation, industrial automation, fire automation, safety monitoring automation, data acquisition automation, and industrial closed-circuit television monitoring. The oil tank area automation system uses modern information and automation technology, which is convenient and fast. To understand the real-time operation of field equipment and historical production information, provide reliable data basis for production scheduling decision; at the same time, it can also quickly and timely effectively control the field equipment, so as to realize the efficient and safe operation of the oil depot.

1) Office automation uses computers to handle daily business operations, gradually realizing paperless office, and updating management methods and management models.

2) The industrial automation site is unattended, and the loading and unloading and receiving and dispatching of oil products are automatically completed by the computer in the remote (operation area or oil depot master control room). The storage and transportation of oil products and operation tickets can be generated and issued on the computer. Tracking on the computer at any time and inquiring about the progress of a certain operation. On-site problems can be reported to relevant management personnel in real time to solve them immediately. Administrative and business management personnel on the operation of the oil depot and the status of various resources (people, finances, materials) can be remotely controlled at any time.

3) Automatic fire alarm for fire hazards. Once a fire hazard occurs, the computer will start the fire-fighting facility to extinguish the fire and give an alarm at the same time.

4) Safety monitoring, automatic flammable gas automatic alarm, automatic patrol on duty personnel. When a dangerous situation occurs, the "emergency stop" system can be automatically activated, cut off the oil circuit and circuit connected to the dangerous part, and stop all related facilities.

5) Data acquisition automation real-time automatic acquisition of oil tank level, temperature, density, oil-water interface, pipeline flow, pressure, and converted to volume or weight by the computer, so that the oil depot at any time in and out and oil volume at a glance.

6) Industrial closed-circuit television visually monitors the situation in each key position and area of the entire oil depot in the operation area and the general control room of the warehouse, and video conferences can also be conducted.

(3) Industrial automation system structure

The design principle of industrial automation system is considered from the aspects of function, reliability, human-machine dialogue, performance ratio, etc. It is formed by connecting the acquisition control layer and the monitoring measurement layer through the field bus. The monitoring and measurement layer is connected to the ethernet through the server.

The acquisition control layer is mainly composed of on-site process equipment, instrumentation, programmable logic controller and field bus to realize the measurement and control of the process and resources of the tank farm in the oil depot.

The process equipment of the oil tank farm is composed of two parts: oil tank and pipeline. The oil tank involves instruments such as light-conducting level gauge, Ptl00 and pressure sensor, and the pipeline involves instruments such as mass flowmeter, temperature sensor and pressure sensor, which are used together to collect the scene data. At the same time, actuators such as pumps and valves are installed on the pipeline for process control. The measurement and control scheme based on programmable logic controller (PLC) is adopt-

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ed to ensure the high reliability of the system. The PLC uses a programmable controller and is controlled by the CPU. The DP port is connected to the distributed station ET200 to expand the system. There are two distributed racks. The data on the tank are connected to the main rack, and the pipeline signal is connected to the expansion rack.

In order to enhance the communication ability with the operating station computer, a communication processor is inserted in the acquisition control layer, and a network card is inserted in the monitoring and measurement layer computer, and the two are connected through a field bus to form a network. The monitoring and measurement layer is monitored by two Metering operation station composition. It has the functions of process monitoring, resource data supervision, data calculation, trend chart query, system alarm and user management. At the same time, due to the use of accurate metering algorithms (precision less than two ten thousandths) for data processing, the operation station The measurement accuracy is very high. The two monitoring and measurement operation stations are mutually backup to monitor the on-site process of the oil tank farm and measure the on-site data.

(4) Monitoring and measurement software structure

The monitoring and measurement layer has functions such as process monitoring, resource data supervision, data calculation, trend chart query, alarm and user management. Under the oil depot local area network environment, it obtains the data structure and information composition of each automated monitoring system, and designs and collects various types of monitoring Information database, providing data conversion interface, providing unified query and monitoring interface, realizing the unification and integration of oil depot automatic monitoring data information, forming an oil depot automated management system. The developed oil depot automated management system is convenient for centralized monitoring of oil depots and convenient online monitoring and query. And also provide support for the development of other management information systems.

(5) Automatic control function

The main functions of the control system are: data collection and processing, dispatch and execution of scheduling and operating commands, display of dynamic process flow, alarm and event management, real-time curve display, historical data collection, archiving and trend display, report generation and printing, Execution of standard configuration application software and user-generated application software, network communication monitoring and management, and trade settlement management.

1) Process monitoring

The process flow chart shows the distribution of oil in the tank area, the process flow direction and the operating status of the equipment, the liquid flow direction in the pipeline, the temperature, the pressure, and the working status of the pumps and valves. In addition, the process flow screen can also be effective in accordance with the process requirements control. The resource data include a single tank map in the reservoir area, an inspection map and overall resources. The single tank map shows the detailed information of each oil tank. The inspection map shows several main parameters of the tank from an overall perspective. The overall resource map follows Different standards (such as oil type, tank type, etc.) for overall parameter statistics and display.

Instrument measurement can only get oil level height and temperature, and actual production needs to calculate the volume and quality of oil products and other related data based on these data. This requires data calculation and processing based on high-precision measurement algorithms, and the calculation results are passed Real-time images. Historical curves and other methods are vividly displayed.

2) CCTV monitoring system

The oil depot closed-circuit television monitoring system plays a role in the safety of the reservoir area, assisting leadership decision-making, inquiry of accident responsibility, and historical record preservation. The realization functions are: each reservoir area establishes an independent monitoring system, and places several monitors in the duty room. View the situation of each monitoring point, can freeze frame, focus, zoom in, multi-screen split, etc. It can be considered to realize the linkage function with the fire protection system, the oil distribution system, etc. The video data of each warehouse area can be transmitted to the central control located in the office building via optical fiber Indoors, the central control room can view the situation of any monitoring point as needed. A large TV wall is set up in the central control room to fully understand the situation of the entire storage area, and the oil depot leader can issue corresponding instructions in time according to the specific situation.

3) Security monitoring and alarm automation system

Install temperature detectors on each oil tank in the tank farm, and install combustible gas detectors in the fire dike of the tank farm. Once these detectors send out an alarm signal, the operator can use the TV monitoring system in the station control room or after confirmation on site. Start the foam fire extinguishing system and the

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cooling water sprinkler system to quickly extinguish the fire. Set up combustible gas detectors in important places such as the oil pump room, metering device area, and wharf, and install smoke detectors in the station control room and engine room. In the event of a fire, sound and light alarm signals are issued immediately so that the staff on duty can take timely measures.

Safe production is the primary task of oil depots, and regular patrols are an important means to ensure safe production. In order to effectively manage patrols, a patrol system can be used.

The automatic emergency shutdown system is designed to immediately stop the related power equipment to block the flow of oil when an abnormal situation occurs in the oil depot. It is a highly reliable independent control system. The system can automatically or according to the abnormal area or location. Perform the following functions manually:

① Alarm to the district control room and the central control room of the oil depot, display strong flashing information, turn on the alarm bell at the same time, and output the alarm print (time query, alarm nature, alarm location information);

② Immediately stop operation and block the oil pump unit;

③ Close the inlet and outlet valves of related pumps and the inlet and outlet valves of related oil tanks;

④ Change the relevant oil sending and receiving operation process;

⑤ Before restarting, all locking equipment is reset.

In order to ensure the safe production of the oilfield and realize the centralized monitoring, control and management of the oilfield gathering and transportation network and station yard, this project has set up a set of supervisory control and data acquisition (SCADA system). This area the block automatic control system is divided into three layers from the logical structure: The first layer is the block management center system, which is set in the central processing station. The main function is data acquisition and analysis, remote control and dispatching command; the second layer is the station control system, Set in the central processing station, mainly for data collection, monitoring and control and chain protection of the process variables and equipment operating status in the station, and transmit data to the management center system and receive scheduling commands; the third layer is the field data acquisition system, which is set in The well site is responsible for data collection, monitoring and data upload of the production and operation status of each well site. According to the automatic control system in this project, it has high integration (that is, high level of automatic control). The control center can automatically control the control station and reduce it. The characteristics of station yard personnel and convenient operation and maintenance are very suitable for the system station yard with simple technology, fewer and scattered stations, and investment in target blocks that do not increase too much.

5.5 Power Supply and Distribution System

The power load level of the oilfield station shall comply with the relevant regulations of the current national standard "Code for Design of Power Supply and Distribution System" GB 50052 [31] and the current industry standard "Code for Design of Oil and Gas Field Transformation and Distribution" SY/T 0033 [32], and shall be combined with oilfield oil and gas gathering and transportation engineering The characteristics of the production process and the loss and impact caused by interruption of power supply are divided into Chengdu. The power load level of the oilfield station should meet the following requirements:

(1) Electricity load such as oil depot (pipeline transmission) and light hydrocarbon storage depot should be level one;

(2) The electric load of the mine oil depot (transport by railway), crude oil stabilization station, transfer station, water discharge station, dehydration station, booster station, gas injection station, mechanical oil well row, etc. should be Class II;

(3) For stations dealing with natural gas condensate, when the design capacity is greater than or equal to m3/d, the power load should be level II;

(4) When the design capacity of the booster station is greater than or equal to m3/d, the prime mover of the compressor is an electric motor, or when the prime mover adopts a gas engine, and the unit's lubrication and cooling equipment and meters are powered by an external power source Second level;

(5) The electrical load of self-injection wells, mechanical oil production wells (including cluster wells), metering stations, and oil collecting valve groups should be level three.

According to relevant regulations, the joint station in Block A should belong to the second-level power load station, and the second-level compliance should adopt two-circuit power supply.

5.5.1 Power Supply System

(1) Engineering power supply

The project relies on the local power grid for power

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supply. All single well stations and joint stations are within the economic power supply radius of the local 10KV overhead power grid, so 10KV overhead lines are used for power supply. Each station is equipped with box-type substations according to load levels. Each station is equipped with integrated UPS power supplies , Provide automatic control and communication system power supply, provided by the electric power professional.

(2) Laying method of distribution lines

The power distribution adopts copper core insulated cables, the indoor part is buried in the ground through steel pipes, and the outdoor part is directly buried in the ground using armored cables.

The lighting circuit adopts copper core insulated wires that pass through steel pipes and is darkly distributed along the walls and in the roof insulation layer. The lighting circuits of explosion and fire hazard places adopt steel pipes.

(3) Electric lighting distribution design

Install emergency lighting for accidents in the transformer and distribution rooms of each station.

The electrical lighting of explosion and fire hazardous locations should meet the explosion-proof requirements.

The illuminance standard is in accordance with the "Code for Architectural Lighting Design" GB50034-2004. According to the different lighting requirements, the lighting source should be selected from equipment products that meet the relevant national standards. The road lighting in the station is planned to use sodium-mercury mixed light source, and the light pole uses steel column and polychloride. Ethylene power cable is buried in the ground, photoelectric automatic control and manual control.

(4) Distribution of communication and instrument automation system

Communication and instrument automation do not allow intermittent power supply, so the uninterrupted power supply device (UPS) is used. For the UPS power supply device, see the communication and automatic control section.

5.5.2 Lightning Protection for Buildings

Make full use of the steel bars of the buildings as lightning protection devices. The steel bars of the column foundation are connected to each other through steel columns, steel roof trusses, reinforced concrete columns, roof trusses, roof slabs, crane beams and other components or lightning protection devices to form a whole; The main metal objects that do not take cathodic protection, such as equipment, pipelines, and frameworks in buildings, should be connected to the grounding device for direct lightning protection or the protective grounding device of electrical equipment.

5.5.3 Anti-static Measures

Outdoor overhead process metal pipelines shall be equipped with anti-static grounding devices at the entry and exit devices or facilities, the boundary of the explosion danger zone and the tank body of the tank area. All pipelines, equipment, and metal conductors that may generate static electricity during the production and storage process should be used Anti-static grounding.

5.5.4 Grounding

According to the requirements of "Code for Lightning Protection Design of Buildings" (GB50057) and "Code for Grounding Design of Industrial and Civil Power Installations" (GBJ65), all buildings, stations and process pipelines shall be provided with necessary lightning protection and anti-static grounding according to the requirements of the regulations. , Working grounding and protective grounding.

A ring-shaped closed shared grounding grid is installed outside the substation and distribution room of each station, and the grounding resistance is less than 1Ω. The metal shells and process equipment of all live equipment are protected by grounding.

Buildings that need protection from direct lightning strikes use Φ10 galvanized round steel as lightning protection strips, and Φ10 galvanized round steel as down conductors. Metal pipes protruding from the roof and reliable connection between components and roof lightning protection devices.

There are no less than 2 connection points between the lightning protection induction grounding trunk line and the grounding device in all buildings. The metal pipes leading into and out of the building should be connected to the lightning protection grounding device at the entrance and exit. The building is grounded once at about 25m, and its impact ground resistance is not more than 100Ω.

Indoor equipment, structures, pipes and other major metal objects should be connected to the lightning protection grounding device or the protective grounding device of electrical equipment nearby. All pipes and equipment installed outdoors that may cause electrostatic hazards should be connected into a continuous electrical path and Grounding. Grounding resistance is not more than 30Ω.

A bare metal bracket shall be provided on the outside

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of the entrance of an explosive environment as an anti-static facility and shall have obvious signs. The metal bracket shall be grounded. In the production process, use anti-static shoes, anti-static work clothes, anti-static gloves and other personal electrostatic protection facilities; There should be an electrostatic testing instrument, so as to know the amount of static electricity carried by oneself before entering the explosion-proof place in order to take measures. The anti-static grounding resistance is not more than 100Ω.

The grounding device preferentially uses the foundation steel bars of the building as a natural grounding body, and the artificial grounding grid uses hot-dip galvanized flat steel.

5.6 Fuel Gas System

According to GB50350-2015 "Oilfield Oil and Gas Gathering and Transportation Design Code", the fuel used in oilfield stations should be natural gas as fuel gas. When fuel gas is used as fuel, the fuel gas system should meet the following requirements:

(1) The hydrogen sulfide content in the fuel gas should not be higher than the current national standard "Natural Gas" GB 17820 [12] for the three types of gas quality requirements;

(2) The gas supply pipeline of the heating furnace and boiler should be equipped with a gas-liquid separator, and pipeline heating measures should be taken when necessary;

(3) When the pressure of the fuel gas is too high or unstable to meet the requirements of the burner, a voltage stabilizing device should be installed. The fuel gas stabilization device should not be connected to life or other gas pipelines;

(4) The fuel gas pipeline before entering the burner should be equipped with a quick shutoff valve, a vent valve and a regulating valve.

The block fuel gas system uses the wet gas flashed during the treatment process, and the HYSYS process simulation calculation shows that the fuel gas flashed during the process treatment meets the requirements for three types of gas in the "Natural Gas" GB 17820 and can be used.

5.7 Building Structure

In order to improve the seismic level, the designed seismic intensity is 7 degrees, and the basic seismic acceleration value is 0.1g. Generally, buildings and structures shall adopt seismic fortification measures according to the corresponding fortification intensity. First, select a structural system that meets the requirements of seismic fortification intensity. Layout, modeling treatment, etc. try to avoid and reduce weak links in earthquake resistance. The structural layout of the structure is conducive to the formation of an effective energy-absorbing and dissipating structure. According to the "Classification Standard for Seismic Protection of Construction Engineering" (GB50223-2008) [35], according to the "Building"Code for Seismic Design" (GB50011-2010) [36] is in accordance with the requirements for seismic fortification intensity of the region to be increased by one degree. Seismic measures are taken. Except for the control center building, compressor room, and flare tower, the seismic fortification category is Category B. Other buildings and structures are in accordance with Category C considerations.

The surface of Block A is covered by yellow sand, and the main landforms are dunes and depressions between dunes. The climate is arid, rainless and windy and sandy. The annual average temperature is 10.1°C, the highest temperature is 41.3°C, and the lowest temperature is -26.4°C. There is very little precipitation in this area. The amount of evaporation is large. The annual average precipitation is 24.6 mm, and the evaporation is 2606.9 mm. It belongs to a typical warm temperate continental extreme drought desert climate. Architectural design focuses on heat insulation in summer and heat insulation in winter. According to the "Code for Thermal Design of Civil Buildings" (GB50176-93) [37], the building should have an orientation, shape coefficient, flat elevation not to be too convex, and building exterior window area not to be too large. Large, using double-layer windows, painting thermal insulation coatings and other aspects to consider building thermal insulation.

5.8 Water Supply and Drainage System

5.8.1 Water Supply

The well station is an unattended station, and its effluent can be intermittent equipment, site washing and mining area greening. The water produced at the wellhead is stored on-site and transported to the water treatment plant in a centralized manner. The central treatment station is a manned station and the source of water for production in the station can rely on the nearby river water source, drinking bottled water for drinking water.

5.8.2 Drainage

The rainwater and production and domestic sewage of each station are discharged by a split system, and the rainwater is drained naturally on a vertical slope. The

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well station is mainly used for washing wastewater, which contains only mechanical impurities such as sediment, and is discharged on the spot; the water produced by the well station is a small amount of sewage for maintenance Sewage storage tanks are used for storage, and are regularly transported by sewage tank trucks to the central treatment station to be treated together with the sewage production in the station. The sewage in the central treatment station is discharged into the sewage tank after treatment, and transported to the sewage treatment system by the tanker for treatment.

5.9 Firefighting System

The fire protection design of this project follows the principle of "prevention first, combining prevention and fire protection", strictly implements relevant regulations and specifications, and achieves safe production, reliable technology, convenient and practical, economical and reasonable. The process equipment of each well station and central processing station is fully considered. Reliability and flexibility of the measures to cut off the gas source. According to the "Code for Fire Protection Design of Petroleum and Natural Gas Engineering" (GB60183-2004) [38], each well station in this project belongs to the five-level station, and the fire water supply system may not be installed, and each station is configured separately A certain number of different types and different specifications of mobile fire extinguishing equipment.

The central processing station is a three-level station, with a fire-fighting water supply system and mobile fire-fighting appliances. In addition, two heavy-duty fire trucks are installed in the living base as the fire-fighting cooperation force of the processing plant. A fire occurred in one place. According to a fire occurred at the same time and the facilities with the largest water demand were designed. Fire control system: independent fire water supply system pipe network, manual fire alarm button in the production area. When a fire occurs, manually after confirmation Start the fire pump and open the fire hydrant to put out the fire.

5.10 Heating and HVAC

(1) Design principles

Strictly follow the current national standards of thermal engineering and HVAC, compromise documents formed by the current national standards, and design based on the principles of practical, advanced, and economical. Use high-efficiency, low-consumption, and low-pollution equipment to implement "safety and reliability" "The guiding ideology of ", simplify the process, achieve the purpose of saving investment and reducing operating costs. Full consideration of environmental protection, soil and water conservation and energy saving.

(2) Heating

According to the requirements for heat parameters such as the production heat load of the process equipment of each station in the block, the winter heating heat load of each building in the plant area, the heat load of the process heat tracing, etc. Heating. The scale of the heating station is 2 fully automatic heat-conducting oil furnaces, a single heat load is 8000kW, and the operation mode is 1 use and 1 standby; according to the heat load of the domestic hot water of the operation base and the heating load of the building unit in winter According to the requirements of the parameters, it is proposed to use a hot water boiler to heat the operation base. The design scale of the boiler room is 2 hot water boilers, a single heat load is 1.4MW, and the operation mode is 1 use and 1 set.

(3) Keep the room warm

The control room uses a heat pump type cabinet air conditioner with auxiliary electric heating to meet the requirements of cooling in summer and heating in winter. In the duty room, in order to meet the requirements of process equipment and instruments for ambient temperature and humidity, air conditioners and electric heating devices are installed.

(4) Ventilation

The plant ventilation adopts a combination of mechanical ventilation and natural ventilation. Some production plants emit toxic gases during production and operation. In order to reduce the concentration of toxic gases to the range allowed by sanitary requirements or to eliminate indoor waste heat, natural air intake can be used. The forced ventilation method of mechanical exhaust set up an axial fan or roof fan for full ventilation to remove harmful gases and indoor waste heat.

6. HSE Risk Management

"HSE" is the abbreviation of Health, Safety and Environmental Management System. H is Health, S is Safety, E is Environment, and HSE management system is a common management method in the international petroleum industry.

6.1 HSE Management of Long-distance Pipeline

6.1.1 Analysis of Hazardous Factors for Long-distance Pipelines

(1) Long-distance crude oil pipelines are transported

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by surface, buried, etc. In the season of heavy precipitation, natural geological disasters such as mudslides, landslides, landslides caused by flash floods and floods caused by river floods often occur in the region. These disasters may cause damage to the pipeline.

(2) Factors such as poor pipeline anti-corrosion quality, mechanical damage to the anti-corrosion layer caused by pipeline construction, soil moisture, salt, alkali, and underground stray current will cause pipeline corrosion, and in serious cases, cause pipe perforation and cause accidents.

(3) When the pipeline is cleared during the operation period of the external pipeline, there may be too many corrosion products in the pipeline, which will cause the pig to be stuck, thereby forming an overpressure pig, which will cause the risk of pipeline and equipment holding back and rupture.

(4) Due to the incomplete purge and replacement of the device before it is shut down for maintenance, or the maintenance site is not well separated from the toxic medium, the maintenance personnel may be in a limited space during the process of disassembly, knocking, hot work, dynamic welding, etc. Poisoning or suffocation.

6.1.2 Safety Protection Measures of Pipeline System

The safety of pipeline system engineering generally includes the safety of design, construction, operation management, external transportation, etc. There are many emergencies on pipelines and gathering and transportation facilities, such as pipeline leaks and fires. First of all, different measures should be taken according to different emergencies to ensure that the damage and impact of the emergencies on the public, environment, and property are minimized. Considering the safety during the design, construction and operation of the project, it should meet the relevant regulations in SY618-1996 "Safety Regulations for Oil and Gas Pipelines".

(1) Security measures

Reasonable use of advanced and mature design technologies and products at home and abroad; follow national safety production regulations, design documents comply with standards; strictly divide the scope of hazardous areas, and propose corresponding technical requirements, measures, supporting settings and operating points during design, and implement hazardous Provisions for grade division; fully consider the integrity and reliability of the oil pipeline safety system. Carry out hierarchical management on the safe operation of pipelines. Responsibility is assigned to people. Production management and operation personnel should have a strict job responsibility system; prepare safety management regulations and regular inspection plans; formulate and enforce safety training plans for all employees; establish engineering technology Files and records of accidents; establish a complete system of line inspection, maintenance, and transformation; formulate and strictly implement regulations on labor safety and health.

(2) Environmental protection measures

1) Influencing factors of engineering environment

The environmental impact of the project during the construction period mainly comes from the construction of station yards, construction access roads and pile yards, leveling construction belts, excavation of pipe trenches, construction machinery, vehicles, and trampling of soil, etc. Impact on land use types and agricultural production. In addition, the exhaust and noise emitted by various machinery and vehicles during construction, the amount of solid waste discarded during construction, and the wastewater generated by pipeline pressure testing will also have a certain impact on the environment. However, such impacts caused by the construction are temporary, and will disappear within a short period of time after the construction is completed (Table 28). The specific construction measures should be worked out according to the surrounding soil, vegetation, and environmental characteristics of the block, and a reasonable construction site and access road should be designed to isolate the agricultural block as much as possible, protect the vegetation, and control the waste and noise generated by the construction operation Within a reasonable range to minimize the impact on the environment.

Table 28. Environmental impact analysis of engineering construction team

Construction type	environmental impacts
Construction site and construction access road	Destruction of surface vegetation and soil structure
Pipe trench excavation	Change soil, affect vegetation growth and development
Construction transportation and photo album work	Produce multi-phase pollutants, exhaust gas, exhaust gas

(2) Environmental impact during operation

The impact of various stations and pipelines on the environment during operation is relatively small, mainly air pollution and water pollution. The air pollution mainly comes from the discharge of pollutants from various stations. This kind of discharge is mainly the CO_2 produced by burning natural gas or crude oil during the operation of the equipment into the atmosphere; in the event of an accident, the crude oil in the system must be emptied for inspection and repair work ; The period

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of pigging operations varies from 10d to 30d, each time the crude oil is discharged from several cubic meters to tens of cubic meters; the overpressure of the system in the first station and the loading station of the outbound transportation will empty the crude oil, and the probability of this situation is small. According to relevant information, compared with the analog survey, the frequency of occurrence is 1-2 times/year, and the duration of each time is 2-5 min. The water pollutants discharged from the first station and the loading station are mainly domestic sewage. In addition, there is a small amount of wastewater discharged during the pigging operations at each station.

In addition to domestic garbage, solid waste discharged from the first station and the loading station of the outbound transportation will also generate a small amount of solid waste during dust removal and pigging operations. The main components are dust, welding slag and iron oxide powder. Through the above comprehensive analysis, the corresponding pollutant control system was worked out (Table 29).

Table 29. Pollutant control measures

Type of pollutant	Treatment measures
Water pollutant	The sewage discharged from the plant, the sewage from the pipe cleaning, and the clean water from the device maintenance are collected and collected into the sewage tank and then loaded and transported to the central treatment plant for treatment; the domestic sewage treatment is discharged after reaching the standard.
Waste residue	The waste generated during the short-term pigging operation enters the sewage tank, and a small amount of domestic garbage is regularly sent to the garbage treatment plant.
Noise control	Choose throttling, blowout prevention devices and metering equipment that meet noise standards.

(3) Energy-saving measures

Crude oil can not only transport large amounts of energy, but also consume energy. Therefore, conscientiously implementing the relevant energy-saving technology policies of the state and group companies, actively adopting energy-saving technologies and equipment, using energy reasonably, striving to reduce energy consumption, doing a good job in energy conservation, and economically and rationally delivering crude oil are important goals of the project design. According to the characteristics of well site and pipeline operation, the energy consumption of this project mainly includes the following aspects: fuel gas consumption of self-provided small generator set; fuel gas consumption of heating furnace; fuel consumption of external pumps and loading pumps; production water, Electricity; Consumption in the event of an accident in the pipe network system or policy maintenance. From the perspective of energy saving, the following measures have been formulated:

1) Set up pipeline cut-off valves to divide the pipeline into several small sections to reduce the crude oil loss of the oil pipeline;

2) Imported products such as high-efficiency energy pumps and other energy-saving equipment and pipeline shut-off valves are used.

6.2 HSE Management of Station

6.2.1 Analysis of Hazardous Factors in Stations

(1) The main accident hidden points of the station are pressure vessels such as external pumps and oil storage tanks. The low-carbon steel inner tube with a certain corrosion resistance is selected for the heating furnace in this design station. From the perspective of its working environment, there is a large range of fluid disturbances, and the change of crude oil composition affects its working life under certain conditions. At present, there is no full-scale monitoring means, so it should pay special attention to the production operation. If periodic inspection or replacement measures are not adopted, it is easy to cause corrosion, hydrogen embrittlement, explosion, fire and other major accidents [39].

The working conditions of the oil storage tank are also more complicated. Although internal anti-corrosion measures are adopted, they may also cause leakage or burst due to factors such as blockage, local pitting corrosion and valve failure, and cause major fire accidents. In addition, arcs and electric sparks caused by short circuit, grounding of the shell, and separation of contacts of the electrical equipment in the station may cause fire and explosion.

(2) Hidden dangers in station yards are the most prone events, mainly the hazards of crude oil leakage. Often caused by corrosion of pipes and devices and seal failure, or incomplete cleaning before maintenance.

(3) Hidden danger of emergency overpressure system. Generally, emergency shut-off valves are used to limit crude oil emissions during system process design, but when a certain emergency situation occurs in the treatment plant, only full venting measures can be taken, resulting in short-term excessive leakage, which is easy to produce pollution and cause human and animal environments influences.

6.2.2 Security Measures for Stations and Yards

(1) Safety precautions

Strict implementation of the "Design Standards for

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Industrial Enterprises" (GBZ1-2002). Conscientiously implement the principle of "safety first, prevention first", and implement the current standard specifications in the design, so that the joint station, the first station of overseas transmission, and the loading station can meet the safety and health requirements, and all devices achieve long-term and stable production. The safety and health of employees in the process are not compromised. Therefore, the following protection work should be done:

1) Explosion-proof

The focus of explosion protection is on piping systems, pressure vessels and electrical installations. For the former, inspection and regular maintenance should be strengthened, and for the latter, it should be carried out in strict accordance with the "Code for Design of Electrical Devices for Explosive and Fire Hazardous Environments" (GB50058-92).

① Safe and reliable process equipment that is not easy to leak and low noise is used in the station.

② Seriously check the quality of equipment, materials and construction and installation quality, and minimize the unsafe factors; all pipes are made of seamless steel tubes that meet the standards, have good processing performance and good weldability; the welders must be qualified Certified welder; construction personnel should operate in strict accordance with relevant specifications to ensure the quality of the project.

③ The overall layout of the station is in accordance with the design specifications to ensure the safe distance of each area.

④ Lightning and anti-static measures are taken at the station. Lightning protection belts are installed, and the process equipment and pipelines are grounded to avoid possible natural gas leakage and fire or explosion due to lightning strikes or static sparks.

⑤ All pressure vessels in the station comply with the design, manufacture and safety management regulations of pressure vessels.

2) Fire protection

Strictly implement the "Code for Fire Protection of Petroleum and Natural Gas Engineering Design" (GB50183-2004) and set up a water fire protection system throughout the site; the safety emergency rescue station shall be on duty 24 hours to meet the fire protection requirements.

① Process fire protection. The process design adopts safe and reliable equipment materials, strict construction quality requirements to ensure the quality of the project; formulate strict and correct fire protection measures for repairs, be equipped with corresponding firefighting facilities, and have full-time and part-time firefighting supervisors on-site supervision.

② Prevention of fire and explosion. Provide employees with safety and fire prevention education and training so that employees can grasp the correct knowledge and skills of fire prevention and fire extinguishing, set up safety fire prevention supervision posts, and implement fire prevention policies that focus on prevention and combining prevention and control.

3) Anti-noise

① Select low-noise equipment, and pay attention to controlling the speed of fluid entering and exiting the separator in the design of the separator. The flow rate of fluid entering and leaving the separator can also be controlled by adjusting the opening of the valve during production.

② Reduce or limit the working and staying time of staff under high-decibel noise, and conduct regular medical examinations for staff who often work in noisy environments.

(2) Environmental protection and pollution prevention

This project fully considers the requirements of environmental protection in the design, strictly in accordance with environmental protection standards, and has adopted effective treatment measures for wastewater, waste gas, waste residue, noise and other pollution sources discharged during the production process.

① Sewage treatment

According to the requirements of the State Administration of Work Safety and the State Environmental Protection Administration, all water that may cause pollution to the environment will be monitored and discharged after passing and discharged into the sewage treatment plant if it fails. The volume of the accident pool takes into account the collection of fire water, rainwater and possible leaking liquids, which can ensure the pollution of the army's water environment in the event of an accident. The project wastewater mainly comes from the production wastewater discharged intermittently by the process equipment such as tail gas treatment, the initial rainwater in the plant area, the wastewater from the engineering shutdown and maintenance of the equipment, domestic sewage, etc. Sewage treatment and drainage shall implement the first-level discharge standard of the Comprehensive Wastewater Discharge Standard (GB8978-1996).

② Waste disposal

The wastes generated in this project mainly include waste residue and waste gas. Waste residues need to be transported to the garbage disposal station for treatment. The waste gas can be burned as fuel or directly emptied.

(3) Energy-saving measures

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In order to reduce the energy consumption of the station, such as the combined station, the first station of overseas transmission, and the loading station, the following energy-saving measures have been adopted:

① Select energy-efficient electrical equipment with advanced technology to increase the power factor of the power supply network and reduce the energy consumption of the power grid and electrical equipment itself.

② Adopt high-efficiency heat-insulating material, perfect heat preservation structure, and reduce heat loss of equipment and pipeline.

③ Recover steam condensate as much as possible to improve the recovery rate.

6.3 HSE Management System Construction and Operation

6.3.1 HSE System Construction

Combined with the characteristics of the block, on the basis of extensive research on domestic and foreign safety management experience and lessons, combined with the understanding of previous field practice, a series of related systems have been formulated to form a complete HSE management system.

(1) Regulations on safety management of construction engineering

Strengthened the supervision and management of the safety production of the construction teams of construction projects. The safety and environmental protection department of the block construction project headquarters is fully responsible for the work safety supervision and assessment of each unit, and formulates corresponding safety and environmental protection measures for the construction unit, and strictly implements the pre-construction acceptance regulations according to the construction characteristics of the block.

(2) Work area safety and environmental protection training and education management system

Strengthen the safety and environmental protection training and education of the participants in the work area. All management and technical personnel in the work area should be considered: safety management, HSE and other qualification certificates.

(3) Notification of safety management of contractors in the work area

The project contractor is required to apply for safety construction qualification review to the safety and environmental protection department after obtaining the construction project contractor's construction qualification issued by the project management department. The project contractor must conduct HSE training and issue an HSE certificate after being evaluated by the safety and environmental protection department.

(4) Regulations on traffic safety management in construction area

According to the climate and road conditions of the work area, please refer to the unit insisting on carrying out traffic safety education for all personnel and regularly carrying out team safety activities. The vehicle must strictly control the speed of the vehicle according to the road signs; it must master the changes in the rainy season and the river; check the braking system after the vehicle passes the water, drive at a low speed for a distance, and wait until the braking performance is restored before driving at normal speed.

6.3.2 HSE System Implementation

In order to ensure the effective implementation and operation of the above-mentioned HSE safety system, in line with the principle of "focusing on management outside and promoting learning internally", the following work is carried out to connect and promote each other to ensure that the HSE system penetrates into all links.

(1) Implement graded safety supervision and management system

Established a unit supervision system and strengthened safety supervision and management responsibilities, and each grassroots unit of Party A and B is the grassroots execution unit of enterprise safety management as shown. The headquarters set up a safety and environmental protection department, and all participating units set up safety and environmental protection supervision agencies; each grassroots department is equipped with a full-time safety and environmental protection supervisor.

(2) Improve the grade requirements of engineering design and construction operations

The engineering design shall be carried out in strict accordance with the geological design, and the security measures for the inspection of engineering gathering and transportation shall be inspected. The Safety and Environmental Protection Department of the headquarters took the lead in organizing an expert group to carry out risk identification and risk assessment on key risk wells.

(3) Organize safety education and training for all employees

Pre-job training and education strictly follow the requirements. All staff who enter the area, no matter what position they have been engaged in or what professional training they have received, must strictly follow the principle of "training before going to work" and receive special training in safety and environmental protection projects to ensure that they have Improve the safety and

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environmental awareness and skills of the specific situation of the block.

6.4 Emergency Support System

In order to fully standardize emergency management work, establish and improve the emergency response mechanism of the region, quickly, orderly and efficiently organize various emergency response operations, rescue people in distress, and minimize the casualties and property caused by emergencies For loss and environmental damage, according to relevant national regulations, emergency plans for various accidents have been specially formulated.

6.4.1 Classification and Classification of Emergencies

(1) Classification of emergencies

According to the occurrence process, nature and mechanism of emergency events, through hazard identification and risk assessment, the block emergency events are divided into several aspects, so that different emergency treatments can be carried out for different emergency events. And the implementation of measures.

(2) Classification of emergencies

In order to effectively deal with all kinds of emergencies, according to the nature of the emergencies, the degree of harm, the scope of impact, the size of influence, casualties and property losses, it is divided into four levels from high to low: I (group company) level , II (headquarters) level, III (participation unit) level, IV (basic unit) level. The participating units shall classify the determined emergency events according to the nature, severity, controllability, impact range and other factors of the emergency event, and according to the setting of the organization.

6.4.2 Principles of Emergency Work

(1) Safety first, prevention first, all hands-on, comprehensive management, ecological protection, and pollution prevention

Emergency rescue work should follow the principle of prevention first and unremitting standing, strengthen the awareness of prevention, strive to reduce the occurrence of attempted incidents, make unremitting efforts to prevent accidents, and make all preparations for responding to emergencies to ensure the normal progress of all production.

(2) Putting people first, reducing harm, focusing on prevention, combining prevention with prevention

Effectively perform the management, supervision, coordination, and service functions of the functional departments of the headquarters and take the protection of employees' life and health as the primary task. The headquarters and all participating units should make full use of the rescue forces of the enterprise, unit and nearby society, and establish an emergency rescue system with clear responsibilities, rapid response, powerful command and effective measures. Use the required resources and take necessary measures to minimize emergencies and the resulting casualties, hazards and environmental pollution.

(3) Integrate resources and coordinate responses

Integrate the existing emergency resources within the enterprise, make full use of social emergency resources, realize the organic integration of organization, resources, and information, and form an emergency management mechanism with unified command, responsiveness, complete functions, coordinated order, and efficient operation.

(4) Rely on technology to improve quality

Strengthen scientific research and the development of emergency technology, use advanced monitoring, monitoring, early warning, prevention and emergency response technologies and equipment to give full play to the role of experts, provide scientific and technological content and command level for handling emergencies, and avoid the occurrence of times Health, derivative incidents; strengthen publicity and education to improve the overall quality of employees' self-rescue, mutual rescue, and emergency response to various emergencies.

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