Dynamic Analysis of Wen 23 Gas Storage

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Abstract. Wen 23 Gas Storage is reconstructed from Wen 23 Gas Field of Zhongyuan Oilfield, it is an underground gas storage of exhausted gas reservoir type.Two injection production cycles have been run since the establishment of the database, and the third injection production cycle is about to be completed, this paper focuses on the sealing, connectivity and current operation status of Wen 23 gas storage and low production factors of low production wells. The current operation status of Wen 23 gas storage is summarized in order to provide some reference for the subsequent production and operation of the gas storage.

Keywords: Underground gas storage Closure Connectivity Injection production well.

1. Introduction

Wen 23 underground gas storage is located in the northeast of Wenliu Town, Puyang City, Henan Province, it is reconstructed from the main block of the depleted Wen23 Gas Field, structurally located at the high part of Wenliu Structure in the north of the central uplift belt of Dongpu Depression, and is the largest underground gas storage in central and eastern China. The designed storage capacity is 10.4 billion m3, the working gas volume is 4 billion m3, the maximum daily gas injection capacity is 24 million m3, and the maximum daily gas production capacity is 39 million m3.

The connected pipelines of Wen 23 Gas Storage mainly include: Yuji Pipeline, Zhongkai Pipeline and E'ancang Pipeline. It is the junction hub between the natural gas storage and transfer center and the natural gas pipeline network, and is responsible for peak shaving of the natural gas market in North China, emergency gas supply, smooth pipeline operation and other important tasks.

2. Comprehensive geological evaluation

2.1. Tectonic characteristics

Wen 23 gas field is structurally located at the high part of Wenliu structure in the north of the central uplift belt of Dongpu Depression, and the structure is generally an anticline with complex faults inherited and developed on the background of bedrock uplift, Regional Class III fault divides the gas field into four independent fault block areas, including main block, east block, west block and south block; The gas bearing formation is the fourth member of Shahejie Formation of Lower Tertiary, with burial depth of 2750~3120m; The reservoir is developed, the sand layer is thick, the plane is relatively stable, and the internal connectivity is good; The physical property is mainly low porosity and low permeability. The reservoir porosity is 8.86~13.86%, and the permeability is 0.27~17.12mD; Methane content is 89.28%~97.13%, and condensate content is 10-20g/m3; The original formation pressure is 38.62-38.87MPa, and the original formation temperature is 113-120℃. It is a layered sandstone dry gas reservoir with massive characteristics. The upper limit operating pressure of Wen 23 gas storage is 38.6Mpa, and the lower limit operating pressure is 15MPa.

2.2. Caprock effectiveness evaluation

The upper overburden of Wen 23 Gas Reservoir is a set of salt gypsum rock composed of pure salt layer, thin gypsum mudstone interbed and salt rock filled fractures, the salt gypsum rock is

thick(300~600m), widely distributed, and has strong sealing property. Therefore, under the condition that the faults in this area are very developed, hundreds of meters of salt gypsum rock distributed in a large area is a good regional cap rock for natural gas in the fourth member of Shahejie Formation of Wen23 Gas Field, which has good gas tightness. A good regional cap rock plays an important role in the enrichment and accumulation of Wen23 Gas Field, and also provides a unique sealing condition for the construction of gas storage.

2.3. Fault sealing evaluation

2.3.1. Sealing evaluation of boundary fault

The boundary faults of Wen 23 Gas Reservoir include Wen Xi Fault, Wen 68 Fault, Wen 104 Fault and Wen 105 Fault. Among them, Wen Xi Fault is a regional fault with good sealing performance, and the remaining faults are block faults. The sealing performance is evaluated by the pressure rise of 6 monitoring well.

Wen 68 fault: By comparing the formation pressure in the main block with the pressure fluctuation of three monitoring wells (W69-8, W69-2 and W69-6) in Wen68 Fault, it is judged that Wen68 Fault is relatively stable andhas good sealing property after two rounds of injection and production cycles.

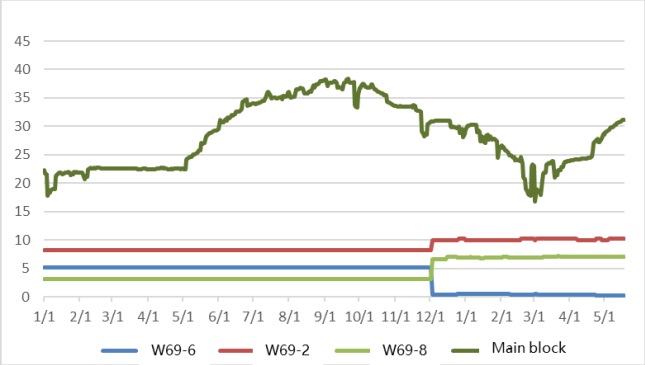

Figure 1. Comparison Diagram of Internal and External Pressures of Wen 68 Fault

Wen 104 fault: By comparing the formation pressure in the main block with the pressure fluctuation of monitoring well W23-29 of Wen104 fault, it is judged that Wen104 fault is relatively stable and has good sealing property.

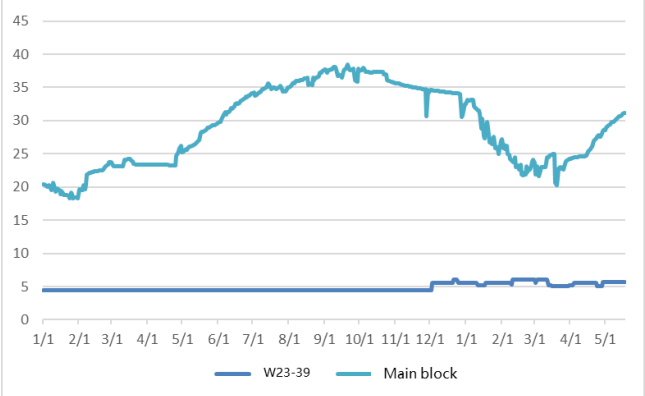

Figure 2. Comparison Diagram of Internal and External Pressures of Wen 104 Fault

Wen 105 fault:By comparing the formation pressure in the main block with the pressure change of two monitoring wells (WC108 and W108-7) of Wen105 fault, WC108 and W108-7 have obvious pressure rise during the second round of gas injection, which indicates that the sealing of Wen105 fault is weakened.

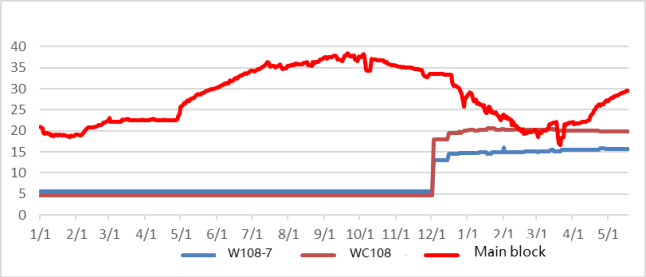

Figure 3. Comparison Diagram of Internal and External Pressures of Wen 105 Fault

2.3.2. Sealing evaluation of boundary fault

Through comparison, it is found that there is a significant pressure difference between blocks Wen 105 and 23-5, and the pressure of block Wen 23-5 does not change significantly with the pressure fluctuation of block Wen 105. It can be judged that the two blocks belong to different pressure systems, and the fault sealing is good.

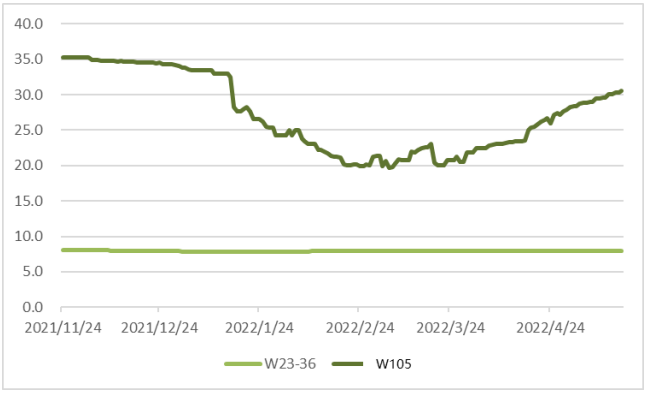

Figure 4. Pressure Comparison Diagram of Block Wen 105 and 23-5

Through comparison, it is found that there is a significant pressure difference between Wen 106 and 109 blocks, and the pressure of Wen 106 block does not change significantly with the pressure fluctuation of Wen 109 block. It can be judged that the two blocks belong to different pressure systems, and the fault sealing is good.

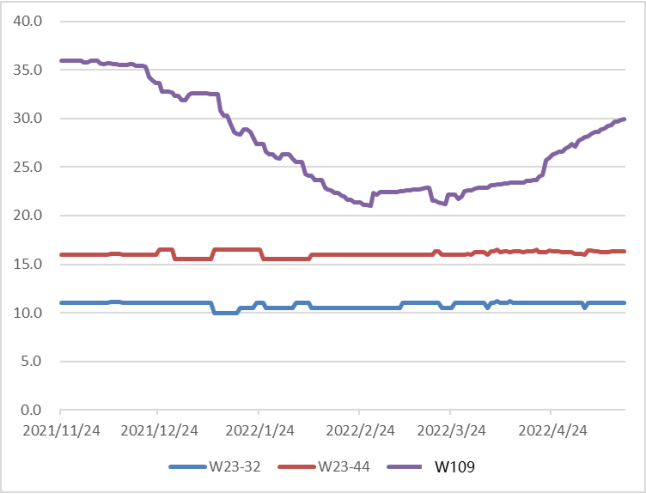

Figure 5. Pressure Comparison Diagram of Block Wen 106 and 109

By analyzing the pressure curves of Block Wen 22, 103, 105 and 109, the pressure difference is generated due to the different well opening systems of each block during the gas production period, and the pressure of each block tends to be uniform during the injection production interval after the shutdown. It is believed that these four blocks belong to the same pressure system, and the fault does not have obvious sealing.

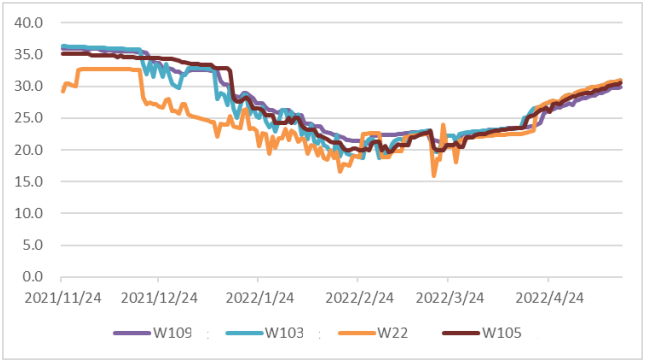

Figure 6. Pressure Comparison Diagram of Block Wen 22,103,105 and 109

3. Running dynamic analysis

3.1. Fault sealing evaluation

In combination with sand body comparison and production performance, the reservoir connectivity is evaluated vertically and horizontally. Take 2 # injection production unit as an example: the connectivity of reservoir sand body in the vertical direction of the block is up to 85-90%, with good connectivity. Horizontally, according to the analysis of Well Cluster C3-10~C2-2~C2-4, the well spacing is relatively small (the well spacing between Well C3-10 and Well C2-2 is 189m, and the well spacing between Well C3-10 and Well C2-4 is 209m), the sand body connectivity map is connected as a whole, and the sand body is stable. After Well 2-2 and Well 2-4 are started, the oil pressure of Well 3-10 decreases significantly, which indicates that the reservoir connectivity in this well area is good.

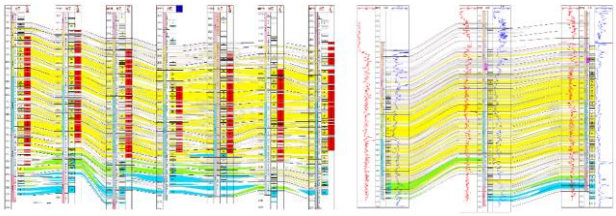

Figure 7. Sand body connection diagram

3.2. Injection production capacity evaluation

3.2.1. Classification of injection production wells

Based on the calculation of formation pressure and flow pressure, the gas production index and gas injection index of single well are evaluated. According to the gas injection and production index of single well, the single well is divided into Class I well, Class II well and Class III well. The causes of Class III well with low injection and production capacity are analyzed, and the basis is provided for the formulation of well switch system.

$$Q_i = I_i \cdot \left(P_{wf}^2 - P_r^2\right)$$

Where: Q_i-Daily inspiratory capacity,$10^4 m^3/d$; I_i- Inspiratory index, $10^4 m^3/d/MPa^2$; P_r- Formation pressure,MPa; P_{wf}- Bottom hole flow pressure,MPa.

According to the classification results, there are 17 Class I wells, accounting for 31%, 25 Class II wells, accounting for 46%, and 9 Class III wells, accounting for 17%. In addition, there are 3 abnormal wells, accounting for 6%.

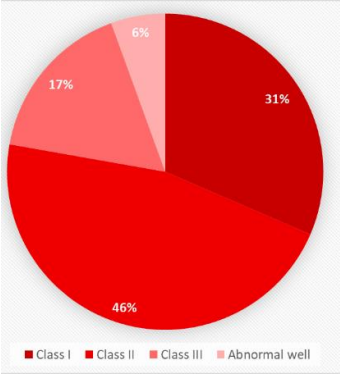

Figure 8. Classification of injection production wells

3.2.2. Analysis of key low production wells

Well C5-7 is a low production well in Wen 23 Gas Storage. During the major repair operation in 2020, a low damage and solid free protective fluid was used to protect the reservoir. However, a lot of liquid was lost, which still caused damage to the reservoir. The well entering fluid was 3809m3, the waste liquid recovered on site was 380m3, and the liquid entering the formation and wellbore was 3429m3. In addition, temporary plugging was implemented five times during the well killing process. The temporary plugging agent was 155m3, and the gel was 27m3. At present, the reservoir of this well is polluted, The production operation cannot be performed.

Well C3-8 and Well C5-4 may be polluted by the reservoir, with low injection production capacity. The two wells are located in a large fault block, and the reservoir thickness development is basically consistent with that of the surrounding wells. At the same time, the reservoir connectivity is good. From the perspective of geological reservoir development, the two wells should have the equivalent injection and production capacity of the surrounding wells, but the actual production conditions are quite different. It is analyzed that the reservoir may be polluted, but further test data verification is required.

4. Conclusions

1) The caprock of Wen 23 gas reservoir has good sealing property. Wen 23 salt in the overlying layer of the gas reservoir has pure lithology and good sealing property. At the same time, the mudstone interlayer between the target layer S_4^{3-8} and the upper part S_4^{1-2} of the gas reservoir is stably distributed, with an average thickness of 4.4m. The mudstone barrier at the bottom of Wen 23 salt and $S4^2$ ensures good sealing of the upper cap rock of the gas reservoir.

2) At present,Wenxi fault, Wen68 fault and Wen104 fault have good sealing performance, while the sealing performance of Wen105 fault tends to weaken. It is also necessary to pay attention to the pressure changes of monitoring wells outside the block and in the block. If necessary, tracer tests should be carried out to determine the fault sealing area and take corresponding measures in time.

3) The fault in the main block of Wen 23 Gas Storage is not sealed, and the reservoir in the main block has good overall connectivity, but there are some wells with poor injection and production capacity, such as Well RESERVOIR 5-7, Well RESERVOIR 5-4, and Well RESERVOIR 3-8, which need to be tested in time to identify the constraints and take acidizing and other treatment measures in time.

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