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Application Research on Risk Evaluation of Salt Cavern Type Gas Storage Reservoirs

Jieying Liu, Cuiying Lu, Ying Liang, Yong Gao
School of Chemistry and Chemical Engineering Yulin University, Yulin 719000, China.

Abstract: Along with the construction scale of China's underground gas storage reservoirs as well as the continuous expansion and enhancement of investment efforts, greatly reducing the probability of occurrence of safety accidents in underground gas storage reservoirs, and realizing the maximization of resource utilization on the basis of effective guarantee of its operational stability and high efficiency, so as to make its own economic benefits to get a significant increase has become the top priority of the management of the storage reservoirs at the present stage and the work of the future development. Based on this, this paper briefly describes the risk assessment method of salt cavern type gas storage, and analyzes its application in depth for reference.
Keywords: Salt Cavern Gas Storage; Risk Assessment Method; Application Analysis

Introduction

In the deep development and promotion of environmental protection and governance, coupled with the continuous expansion of the carbon emission reduction market scale, natural gas occupies an increasingly prominent position and role in China's development and social life. In recent years, China's urbanization construction process has been significantly enhanced, the rapid growth of the national economy, people put forward new requirements and standards for natural gas, thus further accelerating the pace of efficient and stable development of underground gas storage business has become the focus of attention of the relevant industries and the focus of the work at this stage.

1. Risk assessment method for salt cavern type gas storage reservoirs

This paper discusses and analyzes the risk assessment method of underground gas storage facilities based on the fault tree.

First, the construction of the fault tree. The failure of underground gas storage facility is regarded as the top event, and the leakage and the decrease of injection and extraction capacity are regarded as the secondary events. Among them, A represents the intermediate event of atmospheric leakage, B represents the intermediate event of underground leakage, C represents the intermediate event of operation interruption, and D represents the intermediate event of slow operation.

Second, the failure consequence calculation. For the failure consequences of leakage, the core of the calculation lies in the calculation of the leakage rate of different leakage levels. Combined with the actual conditions of leakage through the stratum and atmospheric leakage, small and large leakage can be constructed with the help of Beggs to construct the flow blocking model:

$$q_{sc} = \frac{C_n p_1 d_{ch}^2}{\sqrt{\gamma_g T_1 Z_1}} \sqrt{\left(\frac{K}{K-1}\right)\left(y^{\frac{2}{k}} - y^{\frac{k-1}{k}}\right)} \quad (1)$$

Where, denotes the gas flow rate in units of; denotes the pressure at the leak point in kPa; K denotes the specific heat capacity of natural gas; y denotes the pressure ratio,; denotes the external pressure at the leak point in kPa; denotes the hole specification in millimeters; denotes the constant, which takes the value of 3.7915; denotes the temperature inside the well, K; denotes the temperature at the gas compression factor under pressure; denotes the relative density of natural gas.

2. Application analysis of risk assessment of salt cavern type gas storage reservoirs

2.1 Example Overview

This paper discusses a salt cavern underground gas storage reservoir as an example, the overall volume of the reservoir salt cavern reaches nearly 110,000 cubic meters, the storage medium is natural gas, the relative density of natural gas is maintained at 0.575, and the operating pressure of the reservoir is maintained at the range of 7-14 MPa, the temperature of the middle layer of the salt cavern reaches 326.15 K, the selected outer diameter of the injection and extraction tubing is controlled at 177.8 millimeters, and the overall temperature of the wellhead can reach 298.15 K. The temperature of the salt cavern can reach 298.15 K. The pipeline type selected for connecting the salt cavern well site with the inlet valve group of the gas injection and extraction station is 16Mn seamless steel pipe with specifications, the overall length of which can reach nearly 3 kilometers, the pressure is effectively controlled at 17.5 MPa, and the overall yield strength should fully satisfy the standard and requirements of 245 MPa.

2.2 Risk factor assessment of gas storage facilities

The risk assessment unit of the underground gas storage facility can be divided into the injection and extraction pipeline column unit, the wellhead device unit and the gas storage cavity unit from a broad perspective. Based on the initial shape of the salt cavern underground gas storage reservoir accident impact factor model as the basis and foundation, coupled with relevant information and data as well as literature to support and support, for underground gas storage reservoir risk assessment unit to carry out accurate identification of risk factors [1].

Combined with the actual work and relevant information and data, it can be seen that the risk assessment unit is susceptible to the influence and interference of a variety of risk factors in the actual work process. In terms of the deep root causes of the failure of the risk assessment unit, it is mainly due to the inadequacy and shortcomings in management, such as insufficient safety supervision, the overall rationality of the relevant rules and regulations and lack of science [2]. In addition, continuous high-intensity work or insufficient time and experience in the field is also the root cause of the failure of the unit. The surface direct factors are direct impact or even failure of the direct risk factors, for example, in terms of pipeline units, the surface direct impact factors mainly include the failure of the internal corrosion protection coating or overpressure; and for the measurement of pressure regulating units, the surface direct impact factors can be divided into signal processing unit failure and sealing system failure and other conditions.

2.3 Risk assessment structure analysis

Combined with the construction of the salt cavern underground gas storage risk assessment method for salt cavern wells, gas injection and recovery station and single well pipeline to carry out risk assessment application analysis work.

First, in the case of salt cavern wells, under the most serious condition of wellhead rupture, the personal risk calculation structure of the residents and well site staff in the area of 50 meters away from the wellhead is as follows. Fully combined with the construction of personal risk acceptability guidelines () can be derived, the relevant staff and nearby residents in the area of 50 meters from the salt cavern personal safety risk to meet the standards and requirements of the acceptable line, in the risk tolerance zone, but also need to strictly follow the ALARA principle to carry out the relevant measures for the development and planning work, in order to fully meet the relevant standards and requirements and to achieve effective control of the risk on the basis of feasible range. The risk is effectively controlled on the basis of fully meeting the relevant standards and requirements and within the feasible range. For the economic risk caused by leakage and reduced injection capacity, the data shown in Table 1: compared with underground leakage, the economic risk of atmospheric leakage is higher, which is mainly due to the relatively high probability of atmospheric leakage, but also very easy to cause slow operation [3]. Therefore, the attention and degree of importance to the events of atmospheric leakage or slow operation should be further improved by combining the fault tree. For example, in the slow operation state, the probability of hydrate plugging and equipment failure should be effectively controlled [4].

Secondly, the results of the risk assessment of the gas injection and production station and the relevant data parameters can be concluded that the risk level of the compressor system, the processing system and the pipeline system are compared comprehensively, and the risk of the first two is much higher than the risk of the management system, and the compressor has the highest risk; as for the processing system, the risk assessment of the system can be classified into the risk of the air-cooler, the risk of the buffer tank, the risk of the filtration separator and the risk of the cyclone separator. For the piping system, for the 34 pipelines under pressure, the pipeline P2112-P2118 from the compressor outlet to the buffer tank outlet has the highest risk, and the fundamental reason for the high risk value of the pipeline is due to its overall pressure and temperature. With the help of scientific and reasonable risk ranking, the high-risk unit is further clarified, and then the risk analysis can be completed by making full use of the HAZOP method [5].

Third, for the single-well pipeline, should be fully integrated with the actual situation, and as a basis and foundation of the pipeline is divided into 7 sections, with the help of risk assessment, the data parameters are to meet the requirements and standards of low and medium risk.

By virtue of the risk assessment work carried out for the salt cavern underground gas storage reservoirs, it can make the management personnel of the gas storage reservoirs have a deep understanding and comprehensive grasp of the risk level of all kinds of facilities and equipments, and use this as the basis for the development of a more effective, reasonable and feasible control and prevention of risk programs, so that the probability of disasters and accidents can be greatly reduced.

Conclusion

Salt cavern type gas storage system as a whole has a certain complexity and diversity, risk factors are diverse, need to pay extra attention to its safety. Effectively strengthening the safety level of salt cavern type gas storage, ensuring the stability and continuity of its operation has become the center of gravity of the work of gas storage managers. Carrying out risk assessment for salt cavern-type gas storage reservoirs can provide necessary support and strong assistance for scientific management of gas storage reservoirs, and at the same time provide a strong guarantee for the safety of people's lives and property as well as the healthy and stable development of the society, so that the probability of catastrophic accidents can be effectively controlled and the economic benefits of salt cavern-type gas storage reservoirs can be further improved.

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Funded Project: Yulin Industry-University-Research Cooperation Program, “Research on Oil and Gas Exploitation and Energy Equipment - Applied Research on Risk Evaluation of Wellbore and Surface Injection and Extraction System of Salt

Cavern-type Reservoirs", No. CXY-2021-104-02.

About Author: Jieying Liu, (1983-) Female, Yulin, Shaanxi Province, Associate Professor, Master's Degree, graduated from Xi'an Petroleum University in 2012, majoring in Petroleum and Natural Gas Engineering, with research interests in Pipeline Corrosion Protection.