DRILLING AND COMPLETION PROBLEMS RELATED TO UNDERGROUND GAS STORAGE WELLS

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1. INTRODUCTION

In the Federal Republic of Germany (FRG) we have a well developed gas market. More than 15% of the total energy consumption is covered by natural gas. The country is however largely dependent on gas imports. The imported gas comes mainly from the Netherlands, North Sea and UdSSR (Sibiria). The domestic natural gas production participates with some 40% of the total consumption in the order of $60 \times 10^9$ m$^3$ (Vn) and is highly used for peak shaving. Nevertheless an increasing need for underground gas storage is seen to secure the demand which shows high seasonal, weekly, and daily changes in consumption structure. The total usable capacity for gas in underground storage in the FRG at this time amounts to $5 \times 10^9$ m$^3$ Vn. In salt caverns the storage capacity is roughly $1 \times 10^9$ m$^3$ Vn and the aquifer storage amounts to $4 \times 10^9$ m$^3$ Vn. In addition about $1.7 \times 10^9$ m$^3$ Vn storage capacity is under construction with $1 \times 10^9$ m$^3$ Vn favour of gas caverns.

2. DRILLING FOR UGGS

The average depth for UGGS in the FRG is about 1000 m with extremes from 200 to 3000 meters. As the purpose of UGGS mainly is peak shaving the diameters of the bore holes are 17-1/2" and 12-1/4". The corresponding casing sizes are 13-3/8" or 9-5/8". Tubing sizes vary from 5-1/2" to 9-5/8". Gas tightness of cementation, casing and tubing strings must be guaranteed. This requires careful planning, drilling and completion. The following presentation is divided into drilling and completion problems related to underground gas storage wells for salt caverns and aquifer structures.

3. GAS CAVERNS DRILLING AND COMPLETION

North Germany has plenty salt domes which can be used for UGGS. The drilling and completion problems related to the development of salt caverns are as follows:

1. Verticality
2. In-gage bore holes
3. Cementations
4. Oriented coring for the entire salt section.

Verticality
It is mandatory that the bore holes for a salt cavern follow as strictly as possible a vertical course. Though deviated
drilling technic is highly developed and navigation tools are available. The objective to drill an almost perfect vertical hole is difficult.

Large size drill collars, well positioned stabilizers and carefully designed drilling fluids are necessary to achieve the goals. An in-gage-hole is important to allow the stabilizers with minimum clear ance to bit size to be effective. The optimum placement theory for positioning of the stabilizers within the drillstring is valuable help to drill vertical holes.

In-gage-holes

As mentioned before only in-gage-holes give the chance to drill a vertical section. In salt sections supersaturated mixed salt muds, containing all salt types expected in the salt sections are used when waterbased drilling fluids are applied. It is well known that the solubility is strongly dependent on temperature. The right amount of oversaturation has to be maintained during the whole drilling process. As at surface temperatures the salt crystals have the tendency to settle in the tanks. The mud in the suction tank has to be carefully controlled with respect to salt content, and if necessary, extra salt has to be added before circulation is started or continued.

In the case of oilbased drilling fluids it was found, that the required mud density must be about 3 points higher in spec. density as compared to supersaturated salt muds in the same salt section. This is due to the fact that the salt behaves plastically and with time the drilled diameter is reduced. This shows that even a supersaturated salt mud dissolves permanently the salt at the walls of the bore hole and thus helps to keep the hole in-gage. Only an in-gage-hole gives the chance for a good job vitally important to a gas well.

Cementation in the salt section

The critical portion of the salt cavern with respect to gas leakage is the top section of the cavern. It is an art to perform the process of shaping this top section to the designed configuration. The cementation of the casing extended into the salt section requires too a most careful planning.

Often a salt blended cement is used like Magneset with the disadvantage that this cement is less strong than API Class G cement and easily corroded.

In the FRG a special cement for long salt sections was developed, called HMR (High Magnesium Resistant Cement), s. Fig.1 and 2.

This cement is mainly used for gas wells completed to produce from formations underlaying the massive salt sections in Northern Germany. After long research and testing the cement, though not in accordance with known API Class G cements, has been used with extremely good success. The advantage of HMR cements in comparison to Class G cements are as follows:
- increased strength
- low heat developement during curing process
- high resistance against aggressive fluids and Mg salts.