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RECOMMENDED GUIDELINES FOR IMPROVEMENT OF OPERATING RELIABILITY AND WORK EFFICIENCY OF A BOREHOLE AT AN UNDERGROUND GAS STORAGE FACILITY

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ABSTRACT

Gas storage facility – natural or man-made tank for reserving large amounts of gas and control of its supply in accordance with irregularity of gas consumption. Underground gas storage facility – created in natural or man-made underground reservoirs. The greatest value are UGS which can hold hundreds of millions m^3 of gas and more. Special type of gas storage facilities – isothermal storage facilities for liquefied gas, designed for maximum load factoring, i.e. in case of a need for accelerated gas extraction[1].

A UGS set of engineer installations contains borehole for gas injection and extraction, compressor station, gas transmission system, gas cooling, drying and purifying units (separators, filters, absorbers and adsorbers). UGS boreholes are equipped with automatic down-hole deployment valves in order to rule out the possibility of uncontrolled flowing. Important condition for creation and exploitation of UGS – retention of its impermeability, i.e. prevention of possible gas leaks, primarily to the overlying permeable stratum.

Improvement of exploitation reliability and efficiency of UGS is a relevant issue, solution to which, first of all, depends on the accuracy of choice of a project facility, improvement of construction standards and boreholes servicing[2].

Key words: UGS – Underground Gas Storage facility, HAT – Hydrochloric Acid Treatment, WC – Water Coefficient, GDS – Gas Distribution Station, BFZ – Bottom-hole Formation Zone, Prover.

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INTRODUCTION

Underground gas storage facility "Akyrtobe" («Акыртобе») is situated in Kazakhstan, Jambyl Province, 60 Km north-east from Taraz, close to Akyrtobe village.

Akyrtobe UGS is the last gas consumption controller on the gas pipeline, which controls season and daily irregularity of gas consumption and is a stockpile for gas supply in Jambyl and Almaty regions of south Kazakhstan. The analysis of general geological situation in Almaty region denotes limited possibilities for creation of a new UGS, which would be closer to Almaty city and acceptable according to cost-performance ratio.

Therefore, considering the issue of provision of gas supply reliability in Jambyl and Almaty regions, Akyrtobe UGS becomes of a significant importance in the foreseeable future and has no substitute[3].

History and construction of "Akyrtobe" UGS

Land area of Akyrtobe zone is a semi-desert with occasional barchans. The climate is extremely continental, dry. Nearest pond is 30 Km away from the zone.

Akyrtobe structure was discovered in 1965 during seismic exploration works, and in 1972-73 was thoroughly inspected by seismic reflection method on the top of lower salt-bearing section of lower Permian.

From September 1973 until August 1977 on the site 35 exploratory boreholes were made, 34 of which penetrated collector bed, and one (#23) was drilled to control impermeability of the cover bed.

In January 1984, drilling of exploitation boreholes at eastern elevation cupola of Akyrtobe zone started. Later four more confirmation boreholes were drilled (#74-77).

The result of exploratory boreholes drilling proved there is elevation on the top of salt-bearing section of lower-higher Permian and a sequence of overlapping stratums in the basement of upper salt-bearing section, prospective as collector bed, cover and controlling layer to control impermeability of storage facility, was selected.

Almaty region is the end area of BGR (Bokhara gas-bearing region) – Tashkent – Bishkek – Almaty gas pipeline network. The length of this gas transmission system is 1342 Km. Gas pipeline route lies through the area of several states, can be defined by considerably complicated environmental conditions.

Almaty region climate is extremely continental with longer (up to 7 month) hot (up to 50^{o}C) summer period and relatively shorter (up to 3 month) cold (up to 25-30^{o}C) with sharp temperature falls winter period.

Main goal for UGS Akyrtobe for near-term prospective 3-4 years is to improve storage facility in the area of eastern cupola in the collector bed of gas storage site to 1st stage project ratio with active gas volume of 300 million m^3, cushion gas volume of 400 million m^3, and total gas volume of 700 million m$^{3-5}$.

Main issues of UGS development

At the start of extraction season of 2011-2012, gas volume in the stratum according to the balance was 662.1 million m^3. Highest layer pressure at the start of the extraction was 79 Kg/cm^2. The extraction season of 2011-2012 started on 28 October 2011 and continued for 193 day until 07 May 2012. Total of 122 million m^3 of gas was extracted during the season.

Average daily gas extraction rate in the season at the UGS was 0.805 million m^3 per day. Highest daily production rate was reached on 29.12.2011 and made 1.9 million m^3 per day. At the end of extraction period 2011-2012 average layer pressure rate at UGS was 66.4 Kg/cm^2. Maximum number of active extraction boreholes was 35 units.

During the extraction season of 2011-2012 planned extraction ratio for a season at the UGS could not be reached. Actual volume of extracted gas made 122 million m^3, which is 28 million m^3 of gas less than claimed extraction schedule (150 million m^3).

Main reasons for undersized relative to the claimed gas extraction schedule ratio are:

- Dynamic water flooding of the boreholes
- Absence of effective control system over the exploitation of certain exploitation boreholes of UGS.

Analyzing the dependence of increasing water factor and tabular pressure on increasing gas extraction by PKHG (picture 1) can be observed following:

From the diagram it is seen that low (nearly equal to 0) water factor is marked when extracting gas till 50 million m^3. After extracting 55 million meter cubed at average tabular pressure marked 74 Kgf/cm^2 (in OE 608.4 million m^3 of gas, December, 16, 2011) water factor start to increase.

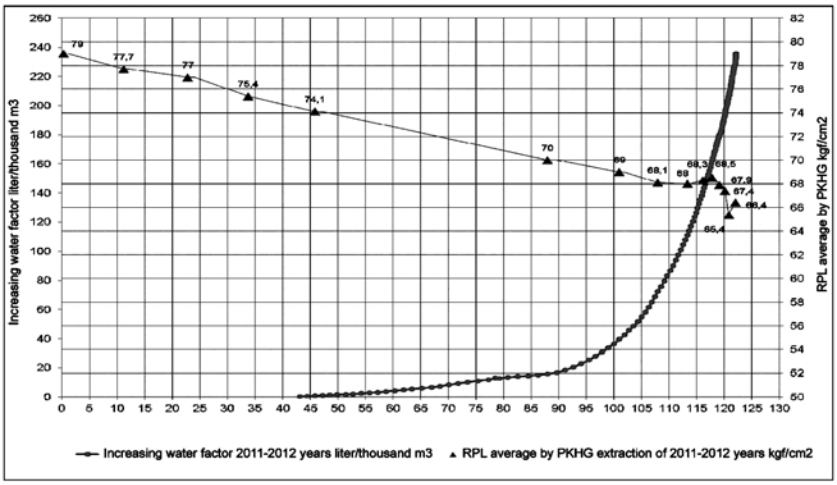

Fig. 1: Dependence of increasing water factor and RPL from increasing gas extraction in period

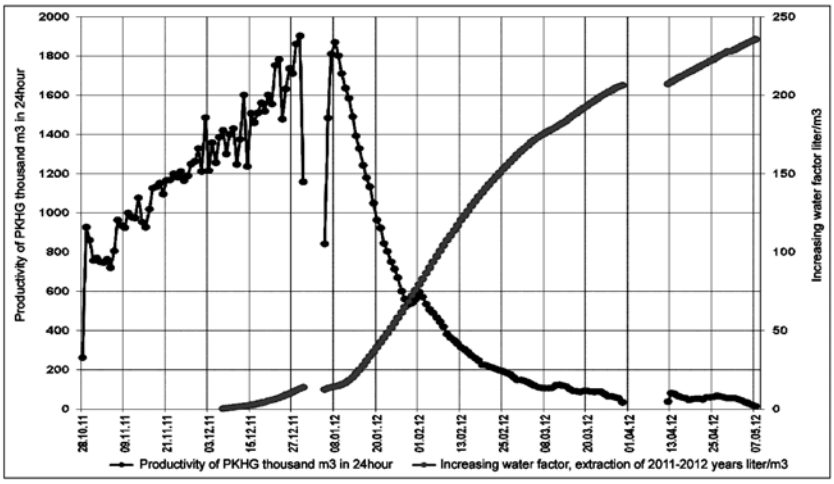

Fig. 2: Dependence of twenty-four-hour productivity on increasing water factor

Analyzing twenty-four hour productivity from increasing water (see picture) the following can be observed:

- In the beginning of extraction period (from October, 28, 2011 up to December, 6, 2011) water factor is equal to 0.
- From December, 7, 2011 to December, 17, 2011 water factors remains stable with insignificant oscillation (+/- 3 Liters/thousand m^3).

- Starting from December, 17, 2011 to December, 30, 2011 water factor is increasing to 7.4 Liters/ thousand m^3 in twenty-four-hour.
- From January, 1, 2012 water factor began substantially to increase (13.5 Liters/thousand m^3) and by the end of extraction period reached to 235 Liters/thousand m^3 in twenty-four-hour.
- Certain dependence of water factor on the quantity of attached wells to the extraction is not observed. Since water factor increases in proportion to the increasing gas extraction practically month later after the beginning of the extraction period.

Thereby in extraction period of 2011-2012 years after extraction of 55 million m^3 of gas the active watering of wells is noted at average tabular pressure in place 74 Kgf/cm^2. It brings to the decrease of twenty-four-hour productivity of storage in spite of operating fund PKHG "Akyrtobe" nearly fully involved in extraction.

Productivity increasing methods

Technology of full repair with water isolation of reservoir bed perforated water-saturated part and hydrochloric acid processing of wells is suggested to use to instant decrease of water factor in wells of PKHG Akyrtobe. To define the effectiveness of certain methods on conditions of PKHG Akyrtobe experiences were made in hydrochloric acid processing of wells.

Hydrochloric acid processing of wells was done on purpose to assess the abilities of productivity increase of wells in the issue of mud fill zone destruction and cleaning the ways of gas got into wells.

As the experimental wells were chosen #55, 67, 71 situated in the area of gas-distributing point #2. Before and after hydrochloric acid processing in these wells pending 30 minutes pressure and temperature on prove, annular pressure were measured on five throttle of 6.4; 8.0; 10.0; 12.7; 14 millimeters.

Thereby taken information lies on the basis of the account of tabular, bottom hole and high mentioned pressures and temperature, gas overpressure factor, also its flow at different working conditions, line and areal filtration factor.

Concrete results of wells showed in Table 1.

Table 1: Results of hydrochloric acid processing in wells of PKHG Akyrtobe

Before HAP	**After HAP**
Well No.71	Well No.71
A = 0.9 B = 0.0797	A = 0.7 B = 0.0236
Absolute open flow:	Absolute open flow:
Qa.s.d. = 276 m^3 of gas. The optimum flow rate for drawdown 6.5 Kgf/cm^2 -112 m^3 gas.	Qa.s.d. = 505 m^3 of gas. The optimum flow rate for drawdown 6.5 Kgf/cm^2 -191 m^3 gas.
Total production in the atmosphere of 15.7 thousand m^3 of gas, of which 13.8 thousand m^3 in research and 1.9 thousand m^3 for pipes blowing.	Total production in the atmosphere of 19.0 thousand m^3 of gas, of which 15.5 thousand m^3 in research and 3.5 thousand m^3 for pipes blowing.
Well No. 67	Well No. 67
A = 9 B = 0.1015	A = 7 B = 0.0745
Absolute open flow:	Absolute open flow:
Qa.s.d. = 209000 m^3 of gas. The optimum flow rate for drawdown 6.5 Kgf/cm^2 -73000 m^3 gas.	Qa.s.d. = 505000 m^3 of gas. The optimum flow rate for drawdown 6.5 Kgf/cm^2 -86000 m^3 gas.
Total production in the atmosphere of 15.5 thousand m^3 of gas, of which 14 thousand m^3 in research and 1.5 thousand m^3 for pipes blowing.	Total production in the atmosphere of 15.7 thousand m^3 of gas, of which 14 thousand m^3 in research and 1.7 thousand m^3 for pipes blowing.
Well No. 55	Well No. 55
A = 1 B = 0.0843	A = 1 B = 0.0636
Absolute open flow:	Absolute open flow:
Qa.s.d. = 268000 m^3 of gas. The optimum flow rate for drawdown 6.5 Kgf/cm^2 -100000 m^3 gas.	Qa.s.d. = 308000 m^3 of gas. The optimum flow rate for drawdown 6.5 Kgf/cm^2 -115000 m^3 gas.
Total production in the atmosphere of 15.9 thousand m^3 of gas, of which 14 thousand m^3 in research and 1.9 thousand m^3 for pipes blowing.	Total production in the atmosphere of 16.0 thousand m^3 of gas, of which 14 thousand m^3 in research and 2.0 thousand m^3 for pipes blowing.

In general, by results of acid treatment in a well No. 71 absolute open gas flow increased by 83%, and an optimum production rate increased by 70.5%. On a well No. 67 the figures were 19.6% and 17.8%, and the well No. 55 14.9% and 15%, respectively.

It is recommended to carry out the acid processing (AP) of wells at the end of the period of filling of UGS i.e. when the pressure in the wells and the most adequate for the development of them after treatment, besides the well bore and the hole-bottom region drained pumped gas.

In the process of pumping a pressure on bottom-hole pressure must not exceed the hydraulic fracturing.

In terrigenous reservoirs the main colmatant is silt and clay, so therefore for processing the following acid structures and sequence of their injection are recommended:

Acid composition: 1-2% hydrofluoric acid + 5.10% acetic acid (formic or citric* acid) + 10-15% methanol.

Sequence of operation

- Before carrying out the oil well acidizing in the well pump in water solution of chloride ammonium (NH4Cl) of 0.5-0.7 m^3 per meter thickness excavated part of the formation, in order to stabilize clays;
- Then to pump in a well acid solution of 1.5-2.5 m^3 per meter thickness of the excavated part of the formation;
- Press through the pumped solutions in layer gas within 2.5-3.0 hours;
- Close a well and to sustain within a day;
- Blow a well, taking into account the environmental protection legislation of the Republic of Kazakhstan[6].

CONCLUSION

The conducted works testify in expediency and necessity of acid processing of wells. In this regard, the most important and a priority task in Akyrtobinsky UGS as from the point of view of current indicators' increasing – on daily capacity, amount of gas extraction in the season, water breakthrough and water factor reducing, and the prospects of its output to the design performance is the problem of intensification of wells using the methods of acid treatment.

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