# Technical and economic background for siting production of well-killing liquid at oil fields

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**Abstract.** Modern development of technology allows for significant reduction of operation costs in many processes, including production of well-killing fluid. Efficiency of manufacturers and prerequisites of its economic profitability are a composite of lower operating costs, application of innovative materials with lower prices together with the basic technologies of labor costs optimization. This paper proposes introducing new approaches in implementing removal of salt from associated water. A feature of this method is evaporation of salts from solution by thermocompressive vacuum evaporation. A project for formation water treatment assumes building a plant for a complex solution of the salt removal problem. One of the main objectives of the project is to achieve annual turnover of 30,000 t of dietary salt, as well as production of well-killing liquid in the amount of 40,000 t per year. The environmental component of the project it its important feature: first, the load on the water treatment system is lowered, as is the risk of unauthorized spills; second, the quality of produced dietary salt meets the requirements of GOST 13830-91 and SanPin 42-123-4089-91. Locations near the oil fields will allow achieving all the aforementioned objectives. The project will be profitable and advantageous in technological, economic and environmental sense. The optimal solution for import substitution: reduction of electricity costs for water transportation. Sale of new products and reduction of environmental load will also allow diversifying the industrial infrastructure of the oil-and-gas-producing region at the late stages of oil fields development and will make it possible to use the released labor force and energy facilities.

## 1. Introduction

Devonian formation water has great potentialities: it may be used in production of cement modifying agents and as a process liquid for well killing after some relevant treatment.

Use of waste and formation oil-associated waters as the hydromineral stock is connected to certain production and treatment issues due to a necessity to remove organic contaminants from the water. On the other hand, producing the formation water alone leads to undesirable consequences due to hydrodynamic connections between the formations and may lead to reduced oil production and premature increase in water cut [1-8].

## 2. Methods and materials

The results given in this paper are based on analysis of literature, as well as on experimental and analytical research.

## 3. Content of the method and assessment of its efficiency.

The authors have developed two methods for simultaneous production of oil and formation water that can be used on enclosed deposits allowing in the future obtaining hydromineral stock in parallel with oil and without detriment to the oil production [1, 2, 8, 9].

The first method (Figure 1, a) is applicable in cases when the oil-bearing formation is backed by a massive water-bearing bed whose thickness reduces with distance from the center of the field. By simultaneous and separate export of crude and formation water from the oil and water zones of the deposit with the wells 3, one may reach both reduced water cut of oil and reduced formation water contamination with oil. It is feasible with simultaneous injection of the formation water into the field by injection wells after extracting valuable chemical elements from it. Well 2 draws off the formation water from the central part of the oil deposit from the bottom level of the waterbearing bed until a low-pressure area is formed and a level of oil-water contact goes down.

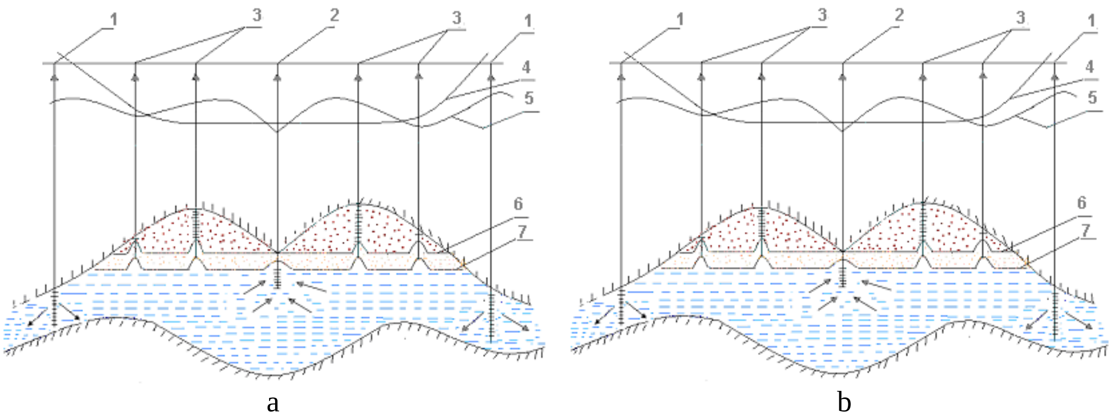


**Figure 1.** Methods of joint production of oil and a hydromineral stock
1 – flooded wells used as injection wells (a) or as water-supply wells (b); 2 – former injection wells used as water supply wells (a) or as injection wells for flooding with processed formation water (b); 3 – producer wells; 4 – initial location of the water intake piezometric surface; 5 – current location of the water intake piezometric surface; 6 – initial location of the oil-water contact; 7 – current location of the oil-water contact

Oil is directed to this area from the oil-bearing formation in such a way, that the oil well perforation zones end up above the oil-water contact level. Due to this, oil content of the well fluid increases while the oil is drawn off through peripheral producers 3. Thus, preliminary reduction in oil production is avoided and a uniform production is achieved, for both oil and hydromineral stock.

The second method (Figure 1, b) is applied when there are zones in the deposit with active marginal water. A number of flooded wells 1 is used to produce formation water, while in the center of the deposit, a certain number of water injection wells are selected for return injection of processed hydromineral stock. The rest of the wells 3 are oil producers [1-2].

Such an arrangement of water producers and injection wells reduces energy costs for injection of return water and extraction of the hydromineral resource. In addition, influence of bottom and marginal water on the oil producer well is reduced, leading to reduced water cut. These methods may be applied throughout the field or in its individual areas [8, 9].

It is known that during repair and insulation works the wells are killed. While performing working operation it is important to prevent the release of process fluids. The nature of this process is equalizing the formation pressure with a hydrostatic column of liquid with a predefined density. The well-killing liquid with a predefined density is prepared with imported calcium chloride, zinc bromide, etc..

The amounts of calcium chloride-based well-killing liquid with a density of 1300 kg/$m^3$, utilized in various oil companies average out at: PAO Tatneft – 10,000 t; OAO Samarneftegas, a branch of PAO NK Rosneft – 15,000 t; OAO Udmurtneft, a branch of PAO NK Rosneft – 1,000 t; ANK Bashneft – 2,500 t; PAO Orenburgneft – 3,500.

These data were obtained by surveying the companies' technical services.

The authors developed a design of a plant for complex processing of formation waters. The project involves processing these waters with the aim of production of dietary salt (30,000 t annually, which completely cover the demand of Tatarstan in this salt) and concentrated brine that may be used in the oil industry for preparation of well-killing liquid with the density of 1300 kg/$m^3$. The projected production volume of the well-killing liquid is 40,000 t annually.

The authors propose processing of the formation water to produce the well-killing liquid by the evaporation method. For the evaporation plants, the following variants were considered:

1. All-Russian R&D Institute of Salt Working – VNIIG (Saint Petersburg).
2. SverdNIIkhimmash (Yekaterinburg).
3. Balcke-Dürr (Germany) (its dimensions are shown in Figure 2).

The VNIIG's variant of the evaporation plant with immersion combustion is unacceptable for its environmental performance. A thermocompressor vacuum evaporation plant by Balcke-Dürr was selected as a model unit. Analysis of plants from other global producers shows that they have competitive weaknesses as compared to Balcke-Dürr equipment [3, 10-12]. Evaporation units from Seidack that are currently in operation at Slavyansk Saltworks are known for regular vacuum breaking action with periodic unloading of the pulp slurry collector. Seidack equipment is prone to excessive encrustation with salt. It requires being washed each shift to remove the incrustation. Usolsk Saltworks used steam-chest evaporators sourced from Wegelin and Hübner. These units have low productivity and required to be stopped often for washing. Due to this, we propose the evaporation unit produced by Balcke-Dürr as one of the operating variants. However, notwithstanding all its technical advantages and operational economy, the Balcke-Dürr evaporator has a high price, which is especially true after weakening of ruble in the late 2008 and early 2009. Thus, at the first stage of construction, we shall consider the domestic variant, proposed by SverdNIIkhimmash.

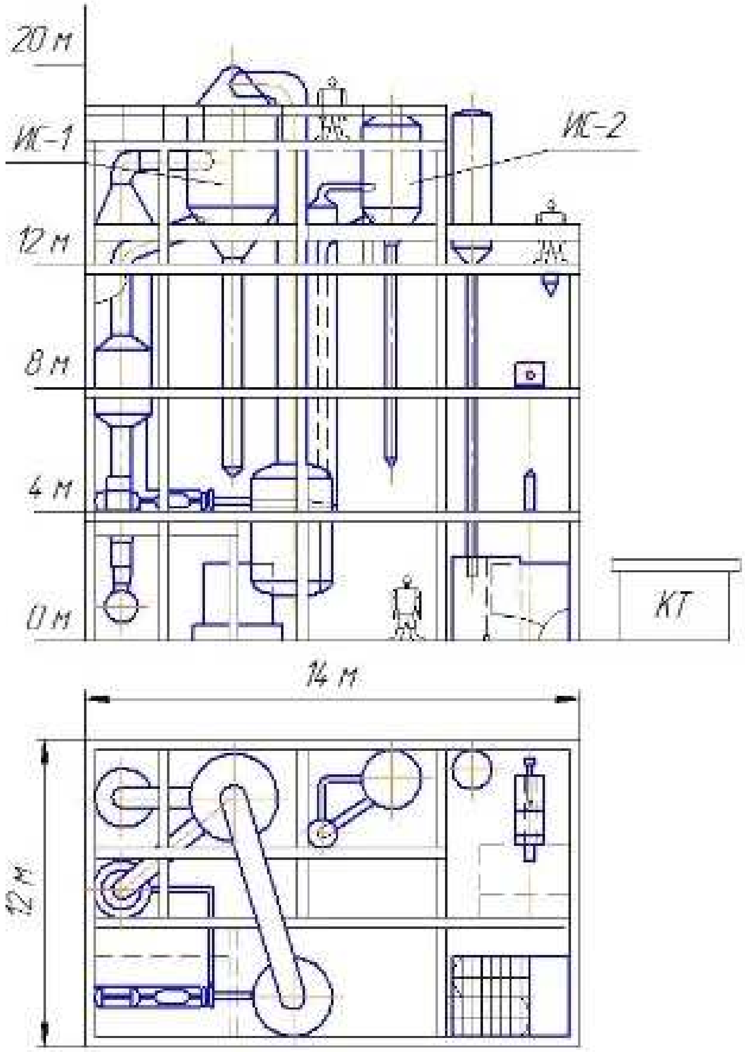


**Figure 2.** A diagram of the evaporator.

Processing of formation water is founded upon the following physical and chemical processes:

1) treatment of the primary formation water to remove mechanical admixtures, iron salts and oil residues;

2) evaporation of the formation water, concentrating salts in the evaporator.

When the calcium chloride concentration in the brine reaches a certain value, it precipitates and becomes suitable for food applications. The salt samples meet all the requirements of GOST 13830-91 and meet the requirements of SanPin 42-123-4089-91 for heavy metals, which is supported by test certificate issued by the specialized standardization laboratory of the All-Russian R&D Institute of Salt Working, licensed with Gosstandart of Russia.

Separation of sodium chloride from the rest of the brine takes place in centrifuges, then it is washed from calcium salts in the primary formation water; then it is centrifuged again to separate solids from liquid and dried. Finished salt then proceeds to packaging. The concentrated brine, rich in bromine and iodine, proceeds to a bromine extraction unit.

Salt samples produced from the formation water are on par with the samples of dietary salt produced by Bassol and Mozyr Saltworks in all parameters. For its chemical composition, radioactive and heavy metals content, the salt produced is within the range provided for dietary products and meets the requirements of TU 9192-076-00209527-96 Devonian Dietary Salt of Tatarstan. A flow chart of salt and well-killing liquid production is shown in Figure 3.

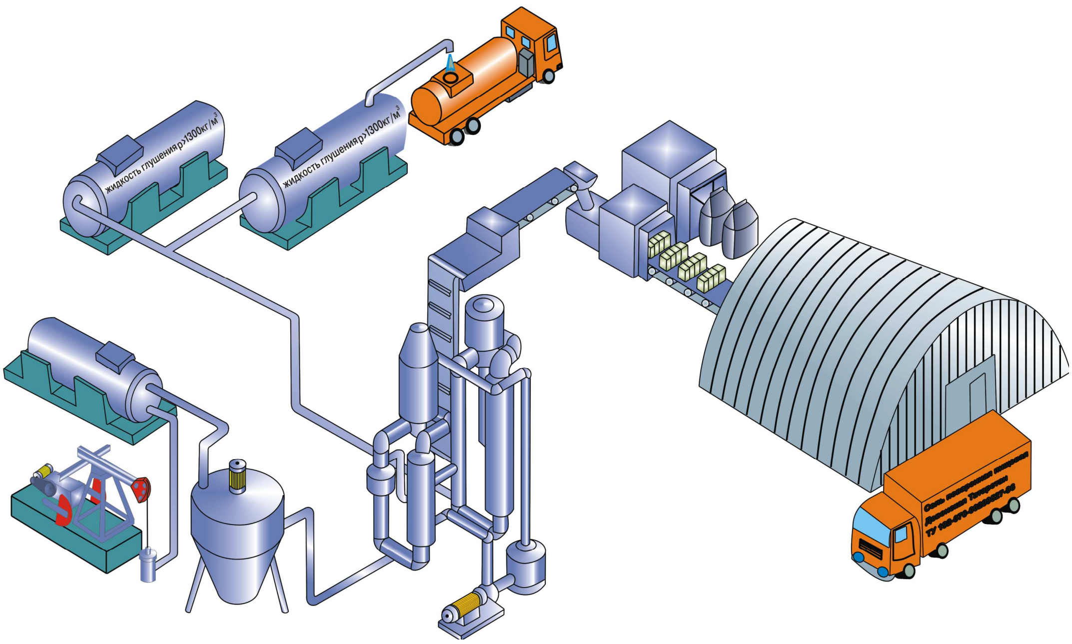


**Figure 3.** Flow chart of salt and well-killing liquid production.

To produce salts for various applications at the same unit, it is recommended to change the evaporation modes, i.e., mother liquid volumes of various density but with the same set of mineral salts suitable for production of the well-killing liquid are prepared from the formation water. Continuous separation of salt from the mother liquid in evaporators will allow increasing the salt density. In the beginning, this process provides coarse salt that contains neither magnesium nor calcium chloride. With increased density of the mother liquid, the size of sodium chloride crystals reduces, and admixtures content increases in the precipitated salt (mainly calcium chloride and magnesium). Varieties of salt appropriate for various purposes are produced when the mother liquid density changes while the initial composition of the formation water stays the same [3, 11].

## 4. Conclusions

Technical and economic background for production of the well-killing liquid shows that it will allow diversifying the industrial infrastructure of the oil and gas producing region at the late stages of oil fields development and will make it possible to use the released labor force and energy facilities to obtain a significant economic effect.

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