

# Creation of technology for desalination of saturated diethylene glycol substance in East Berdak gas complex preparation plant

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**Abstract.** This article delves into a range of intricate challenges stemming from the salting issues associated with saturated diethylene glycol substance within the East Berdak complex gas preparation unit of the Ustyurt gas production department at JSC "Uzbekneftgaz." The scholarly discourse encompasses an in-depth exploration of the rigorous scientific inquiry undertaken by a dedicated research team, inclusive of comprehensive laboratory analyses, with a focal emphasis on devising effective solutions to mitigate the challenges posed by diethylene glycol salting. A significant portion of the article is dedicated to elucidating the existing desalination techniques employed to counteract the salting phenomena. A thorough exposition is offered on the novel approach developed as a countermeasure, with a juxtaposition to the conventional methods currently in use. Noteworthy attention is accorded to elucidating the intrinsic distinctions between the newly crafted methodology and the pre-existing solutions, underscoring the innovation inherent in the proposed approach. In essence, this article delves into the complexities and intricacies surrounding diethylene glycol salting issues within the East Berdak complex gas preparation unit. By synthesizing meticulous scientific research, laboratory analyses, and an innovative problem-solving approach, it offers a comprehensive understanding of the challenges posed by diethylene glycol salting and endeavors to pave the way for an efficient, contextually relevant, and effective solution.

## 1. Introduction

Currently, 123 oil, gas and gas condensate fields are operating within JSC "Uzbekneftgaz". In modern mines, diethylene glycol (DG) is used more often for drying gas. More than 700 tons of DG are used annually in the mines of JSC "Uzbekneftgaz" for the complex preparation of gases [1, 2]. Desalination, i.e. regeneration, of diethylene glycol substance in natural gas purification and drying facilities is one of the main problems [3].

Physical properties of diethylene glycol. Diethylene glycol is a clear viscous liquid. Hygroscopic, has a sweet taste. Soluble in water, lower alcohols, acetone, aniline, phenol and chloroform [4]. It is sparingly soluble in benzene, diethyl ether and carbon tetrachloride. It is poorly soluble in mineral and vegetable oils [5].

Chemical properties of diethylene glycol. The presence of two hydroxyl groups in the diethylene glycol molecule leads to the formation of intramolecular and intermolecular hydrogen bonds with other substances (water, amines) containing an electronegative atom.

Diethylene glycol saltation causes the following problems [6, 7]:

1. Increase in costs for gas drying;
2. Deterioration of regeneration properties of diethylene glycol substance;
3. Rapid failure of devices, increase in repair costs.

These problems listed above are the problems that can lead to the economic weakening of the oil and gas industry today.

In the proposed method, ion exchange processes are important. Below is detailed information about the ion exchange process.

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Ion exchange is a reversible interchange of one kind of ion present in an insoluble solid with another of like charge present in a solution surrounding the solid with the reaction being used especially for softening or making water demineralised, the purification of chemicals and separation of substances [8].

Ion exchange usually describes a process of purification of aqueous solutions using solid polymeric ion-exchange resin. More precisely, the term encompasses a large variety of processes where ions are exchanged between two electrolytes [9]. Aside from its use to purify drinking water, the technique is widely applied for purification and separation of a variety of industrially and medicinally important chemicals. Although the term usually refers to applications of synthetic (human-made) resins, it can include many other materials such as soil [10].

Typical ion exchangers are ion-exchange resins (functionalized porous or gel polymer), zeolites, montmorillonite, clay, and soil humus. Ion exchangers are either cation exchangers, which exchange positively charged ions (cations), or anion exchangers, which exchange negatively charged ions (anions). There are also amphoteric exchangers that are able to exchange both cations and anions simultaneously. However, the simultaneous exchange of cations and anions is often performed in mixed beds, which contain a mixture of anion- and cation-exchange resins, or passing the solution through several different ion-exchange materials.

## 2. Materials and methods

Ion exchangers can have binding preferences for certain ions or classes of ions, depending on the physical properties and chemical structure of both the ion exchanger and ion. This can be dependent on the size, charge, or structure of the ions. Common examples of ions that can bind to ion exchangers are:

H<sup>+</sup> (proton) and OH<sup>-</sup> (hydroxide).

Singly charged monatomic (i.e., monovalent) ions like Na<sup>+</sup>, K<sup>+</sup>, and Cl<sup>-</sup>.

Doubly charged monatomic (i.e., divalent) ions like Ca<sup>2+</sup> and Mg<sup>2+</sup>.

Polyatomic inorganic ions like SO<sub>4</sub><sup>2-</sup> and PO<sub>4</sub><sup>3-</sup>.

Organic bases, usually molecules containing the amine functional group -NR<sub>2</sub>H<sup>+</sup>.

Organic acids, often molecules containing -COO<sup>-</sup> (carboxylic acid) functional groups.

Biomolecules that can be ionized: amino acids, peptides, proteins, etc.

Along with absorption and adsorption, ion exchange is a form of sorption.

Ion exchange is a reversible process, and the ion exchanger can be regenerated or loaded with desirable ions by washing with an excess of these ions.

## 3. Results and discussion

As a result of the research carried out by the scientific team, the following was determined:

1. A saline DG solution was prepared for the condition up to 240 g/l in laboratory conditions and the chemical composition of the solution was determined.
2. Methods of regeneration of the prepared DG were analyzed and an optimal retardation method was selected.
3. An experimental test device for desalination of DG processed by the retardation method was prepared and preliminary results were obtained.
4. The main materials and auxiliary reagents used for the retardation method were selected.
5. The amount of initial expenses for the retardation method was determined.

The following information was found when the content of diethylene glycol substance used as an absorbent in the process of drying (dehydrating) moisture in the natural gas taken from the wells in the East Berdaq gas field was studied by physical and chemical methods (Fig. 1).

As can be seen from Fig. 1, the amount of Cl salt in DG was 31200 ppm, and the amount of Ca salt was 4820 ppm. There is a Precipitation method of desalination of DG solutions that is used in Central Asian countries. We can see the comparative difference between the proposed Retardation method and the deposition method in Table 1 below.

**Table 1.** Comparative difference between the proposed Retardation method and the deposition method.

<b>Retardation method</b>	<b>Deposition method</b>
1. The process is slow	1. The process is fast
2. There is a lot of waste water	2. There is little waste water
3. DG is completely desalted	3. DG is less purified, 10-20 g/liter remains
4. Energy consumption is low	4. A lot of energy is spent
5. Reagents are very cheap	5. The cost of reagents is moderate and imported
6. Local regeneration reagents are available	6. Regeneration is carried out in a column
7. The equipment is simple and requires little money to develop	7. The equipment is complex and expensive, and is a fire hazard

Analyzed result

Sample Information

Sample name	NOZG +30%
File name	NOZG +30%
Application	Jidkost'
Date	2023/ 1/27 10:01
Analyzed by	
Counts	1
Comment	Jidkost'

Analyzed result(FP method)

No.	Component	Result	Unit	Stat. Err.	LLD	LLQ
1	Total	885	mg/cm2			
2	S	74.6	ppm	4.56	11.3	33.8
3	Cl	31200	ppm	36.8	2.92	8.75
4	K	517	ppm	13.3	13.7	41.2
5	Ca	4820	ppm	29.1	7.03	21.1
6	Ti	19.1	ppm	1.94	4.90	14.7
7	V	7.34	ppm	0.874	2.06	6.17
8	Mn	(15.6)	ppm	2.48	5.84	17.5
9	Fe	52.0	ppm	2.45	3.72	11.2
10	Cu	7.18	ppm	0.628	1.30	3.90
11	Br	158	ppm	0.978	0.396	1.19
12	Rb	517	ppm	0.332	0.886	2.66
13	Sr	170	ppm	0.847	0.485	1.46
14	Ag	6.85	ppm	0.638	1.14	3.42
15	Sa	19.8	ppm	1.32	2.78	8.34
16	Te	18.6	ppm	2.04	5.24	15.7
17	Ba	121	ppm	6.99	18.4	55.3
18	U	7.55	ppm	0.453	1.08	3.25
19	H2O	96.3	mass%			

Spectrum

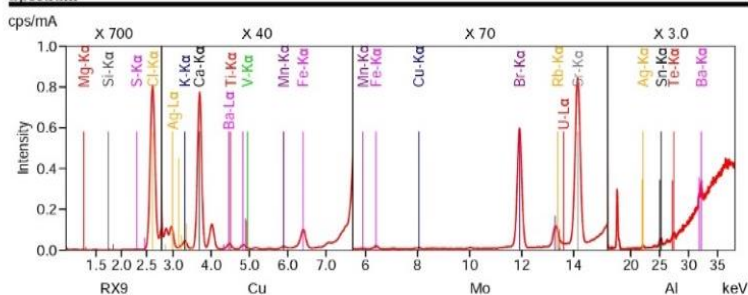


Fig. 1. Physico-chemical laboratory analysis of DG in process and its salt content.

DG solutions in the process of dewatering (regeneration) fill the walls of the DG regenerator and technological equipment with salt, complicating the heat exchange processes and thus causing energy consumption to increase several times and equipment corrosion (Fig. 2).

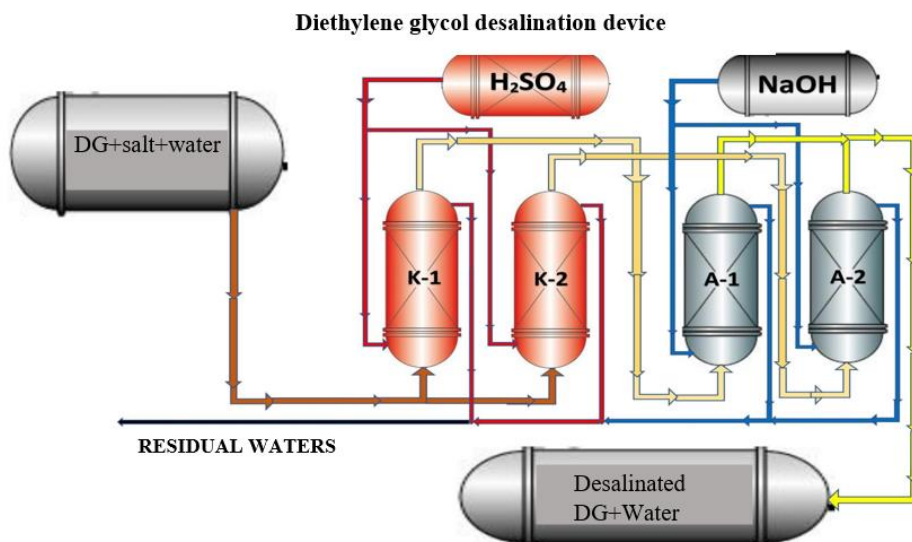
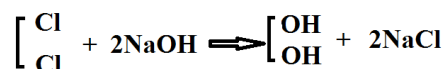
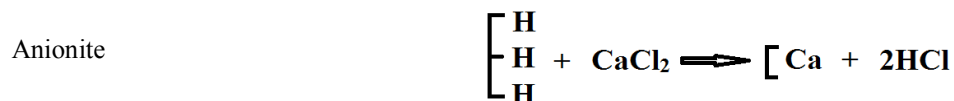


Fig. 2. Desalting device for DG solutions according to the retardation method.

Regeneration with cationite H<sub>2</sub>SO<sub>4</sub>



Analyzed result

Sample Information

Sample name	ROEG 15%
File name	ROEG 15%
Application	Jidkost'
Date	2023/ 1/27 10:11
Analyzed by	
Counts	1
Comment	Jidkost'

Analyzed result(FP method)

No.	Component	Result	Unit	Stat. Err.	I.I.D	I.I.Q
1	Total	885	mg/cm2			
2	S	46.5	ppm	4.97	13.4	40.1
3	Cl	40100	ppm	45.0	3.48	10.4
4	K	621	ppm	14.9	14.5	43.6
5	Ca	6130	ppm	33.7	7.36	22.1
6	Ti	27.1	ppm	2.21	5.19	15.6
7	V	9.17	ppm	0.976	2.24	6.71
8	Mn	18.0	ppm	2.54	5.80	17.4
9	Fe	53.9	ppm	2.48	3.71	11.1
10	Cu	6.09	ppm	0.630	1.41	4.22
11	Zn	3.09	ppm	0.414	0.962	2.89
12	Br	199	ppm	1.10	0.397	1.19
13	Rb	5.70	ppm	0.360	0.969	2.91
14	Sr	208	ppm	0.930	0.483	1.45
15	Ag	6.49	ppm	0.626	1.07	3.20
16	Sn	15.6	ppm	1.23	2.54	7.62
17	Ba	128	ppm	6.63	16.8	50.5
18	Hf	(5.10)	ppm	1.54	4.16	12.5
19	U	8.15	ppm	0.465	1.11	3.32
20	H2O	95.2	mass%			

Spectrum

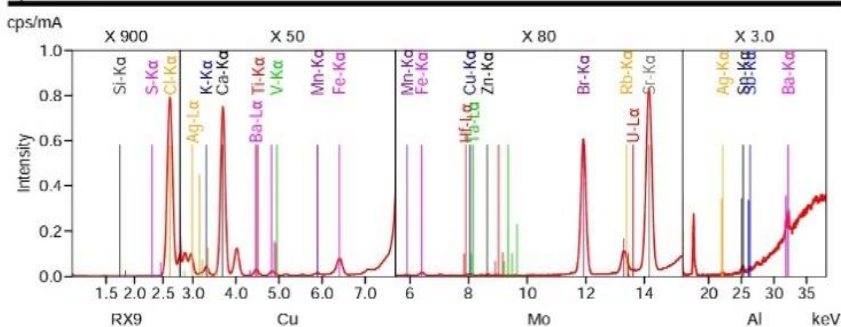


Fig. 3. Physico-chemical laboratory analysis of regenerated DG and changes in salt content.

Ion exchange process is included in the desalting of DG solutions by the retardation method. As you can see in the Fig. 2, there are cationite solutions in 2 containers and anionite solutions in 2 containers. After this first cationite is saturated, the second one is activated and the first one is in the process of regeneration of H<sub>2</sub>SO<sub>4</sub>. Anionite is done in the same way. Anionite and cationite brands are changed depending on the type of salts contained in the gas extracted from the wells. This makes the device universal for gas purification in all mines and underground gas storage facilities.

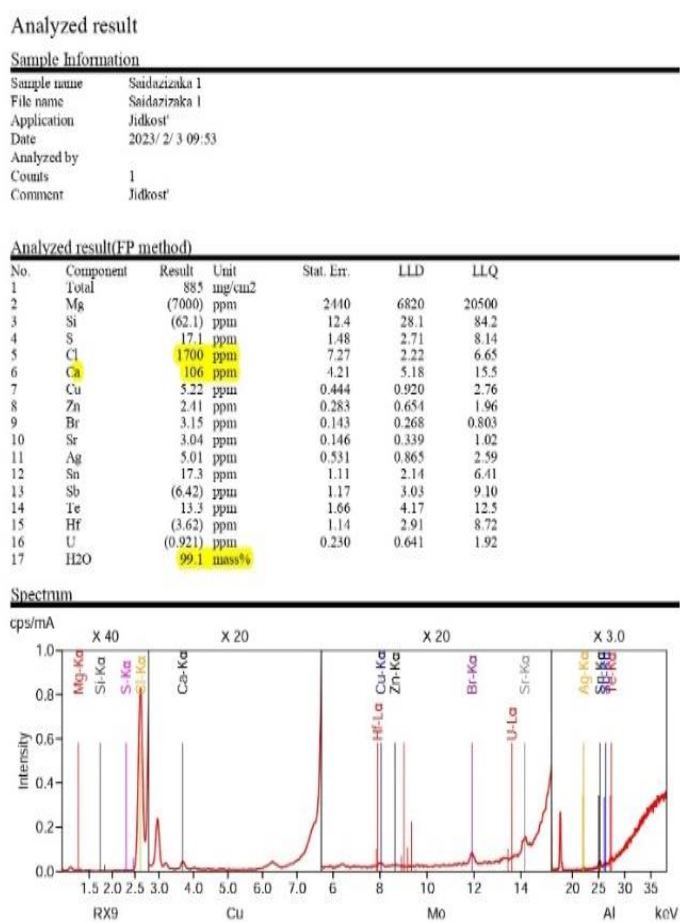
The following ion exchange process takes place during the salinization of saturated diethylene glycol in the East Berdak complex gas preparation unit:

The physico-chemical analysis of the DG samples used in the East Berdak mine was carried out by the scientists of Tashkent State Technical University named after Islam Karimov. As a result of the analysis, it was found that the regenerated DG contained 4.8% salt (Fig. 3).

Experiments were conducted by mixing samples of DG solutions in the laboratory devices created by our scientists. As a result of the experiment, the DG solution was purified from salts. Physico-chemical analysis of the obtained samples revealed that 0.9% salt remained (Fig. 4).

The Fig. of 99.1% shown in the Fig. shows the sum of DG and water content. According to the results of the analysis, the amount of chloride ion in the regenerated DG solution decreased from 40,100 ppm to 1,700 ppm in the purified DG solution. As a result, the amount of chloride ion decreased more than 20 times.

Also, the amount of calcium ion in the regenerated DG solution was 6130 ppm. As a result of purification of DG, the amount of calcium ion was reduced to 106 ppm, resulting in a 55-fold reduction.



**Fig. 4.** Reduction of salt content in DG according to the laboratory results conducted using the retardation method.

The DG desalination method proposed by our scientists in production gives good results, it was considered an efficient technology (Table 2).

**Table 2.** Spending and economic efficiency

Price of one ton of DG, UZS	-	12 000 000,00
Annual amount of DG saved, tons, price of saved DG, UZSs	25.00	300 000 000,00
Expenses for reagents and materials in one year, UZSs	-	172 333 000,00
One-year economic effect, UZS	-	127 667 000,00

Considering this result in Uzbekistan, the amount of 700 tons of DG used in one year decreased by 20% to 140 tons of DG (taking into account that the import price of 1 ton of DG is 12 million UZSs, it is 1 billion 680 million som per year) economy expected to be done. In addition, many problems such as energy consumption, prolonging the service life of equipment can be solved.

In addition, membrane technologies are now being used to clean small volumes of gases at low cost. A membrane acts as a curtain to separate two liquids or substances. In this case, a membrane is placed to clean the gas from water and mechanical particles, even salt, and the extracted gas is pumped under high pressure. Water vapor, liquids, mechanical particles, and salt are trapped by the membrane and pure natural gas is extracted. Synthetic membranes made of polymers such as polyamide or cellulose acetate or ceramic materials can be used for gas drying.

The use of the above-mentioned method in the conditions of Uzbekistan requires a lot of money. Because almost all gas drying devices in Uzbekistan are designed for adsorption and absorption methods.

#### 4. Conclusions

1. After desalination of the DG solution in the proposed method, DG is purified from water, salt accumulation is not observed in the device, and energy consumption is sharply reduced (during drying, the temperature is lowered from 125 °C to 112 °C);
2. During the drying process, the consumption of DG is saved up to 20-25% (27 thousand USD is saved);
3. Normative technical documents projects are developed and approved. (temporary technological regulation, technical conditions, technical economic basis).
4. The damage caused to the environment will be reduced several times;
5. The operating period of the devices in the enterprise increases;
6. Additional operational costs are reduced.
7. Additional gas is obtained due to the use of wells producing salt.

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