THE FLOATING DESALINATION COMPLEX GEYSER-1

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Abstract

A conventional floating desalination complex, GEYSER-1, is presented which is capable of producing 40 000 cubic meters per day (m^3/d) of fresh water from brackish water or seawater. The complex includes a water intake system, a preliminary water preparation system, a high-pressure pump house and a power installation based on diesel or a gas turbines with service equipment. GEYSER-1 can be transported to the place of operation either by a heavy lift ship or by towing.

1. GENERAL FEATURES OF THE COMPLEX

The conventional floating desalination complex GEYSER-1 is designed for desalinating brackish water and seawater with a total dissolved solids (TDS) content of up to 41 grams per liter. The complex's output is 40 000 m^3/d of fresh water having a salinity of not more than 500 mg/liter according to international standards for fresh water.

The complex represents a floating installation on which the desalination and power equipment is mounted.

Block Dimensions

Length, m	96.4
Width, m	24.0
Depth, m	10.0
Draught, m	4.3
Displacement, tons	7 900

The dimensions are defined by the requirements for locating the water pretreatment equipment, desalination units, and power plant equipment and systems aboard the ship.

Total displacement and corresponding maximum draught are defined by the requirement for positioning on the inner bottom a series of fuel tanks with nearly 1000 tons of fossil fuel supply.

The complex has to be placed either in areas of naturally protected water (a fjord, a gulf, a lagoon), or a man-made sheltered facility. Water depth must be not less than 6 meters at low tide. The mooring system is capable of providing normal operating conditions for the equipment under sea conditions of up to Beaufort number 3 and wind forces of 40 meters per second.

Plant installation in areas where wind velocity does not exceed 25 m/s (according to historical statistical observations) is possible with application of either standard anchors or using conventional mooring to a floating wharf. Final choice of the type of mooring has to be made depending on the specific conditions at the site. If necessary, an option of mooring in the open seawater area could be considered, but in such a case additional investments would be required that have not been taken into account in the present economic evaluation.

All of the complex's characteristics comply with the rules of the Russian Register for sea vessels.

In addition to the equipment required for mooring in the operating location, the vessel's facilities include equipment for mooring fuel supply and technological service ships. A deck-mounted crane of approximately 3.2 tons rated load capacity allows for loading/unloading replacement equipment during maintenance work.

Fresh water supply, brine discharge and seawater intake are performed through pipes, and the method of laying them is devised to fit site specific conditions. To compensate for movement of the complex due to the sea motion, ball joints equipped with linear compensators, or special flexible hoses are provided. Systems for water intake and pretreatment, a high-pressure pump house and a diesel (or, possibly, gas turbine) power plant with service systems are components of the floating desalination complex. The complex's equipment is housed in four ship's compartments.

2. WATER INTAKE SYSTEM

Depended on site specific conditions, the water intake could be directly through the vessel's sea bays or through special piping from a remote intake.

Water supply to the desalination complex is performed by D1 600-90 type pumps of 1000 cubic meters capacity each, through two independent pipes, with each pipe being capable of providing full production capacity.

Water intake by pumps is carried so as to attain maximum removal of impurities in the water intake path. A specific layout of the water intake path would be chosen (e.g. with cyclone separators, outer filters, etc.) which would help provide maximum efficiency of water purification, as the situation requires.

3. FEED WATER PRETREATMENT SYSTEM

The raw seawater entering the feed water pretreatment system is filtered and put through a chemical treatment process.

The basic means of removal of suspended impurities from the raw water is multi-media filters (single-, double-, or triple-layer). To increase the efficiency of filtration, a coagulating agent, typically Fe or Al based salts, is injected into the raw water. The filters are filled with expanded clay aggregate, coal and silica sand. Once the water has been filtered, it is put through chemical treatment. The filters are placed in separate cases. Final purification would be done using cartridge filters.

To prevent synthetic materials (which form part of cartridge filters and reverse osmosis elements) from affecting oxidants (in particular, NaClO), a solution of $NaHSO_3$ (which also suppress the biological processes on the surface of the desalinating installation) is added to the feed water entering the filters.

The addition of acids or inhibitors to the raw water (hexametaphosphate, tripolyphosphate, polyacryl and others) eliminates the deposition of chemical elements, inherent in the raw water, on the membrane surfaces. The choice of specific water treatment

regime providing the required quality of raw water can be established from the results of site specific tests.

4. HIGH-PRESSURE PUMP HOUSE

Seawater supply to the desalination units is performed by high pressure pumps. SPE1650-75 type pumps take water from the purified water tank and feed it to the desalination unit at a pressure of 6.5 MPa. The water in the tank is regeneratively preheated up to a temperature of 60 degrees Celsius. The pumps feed four independent assemblies, each of them consisting of nine desalination units. The pump's output is nearly 500 cubic meters per hour, and the total number of high pressure pumps is six, taking into account two reserve pumps.

5. DESALINATION UNITS

Pretreated seawater is fed by high pressure pumps to the desalination units arranged within the confines of an international class sea container having dimensions of 6.0 by 2.5 by 2.6 m. Each unit comprises 150 tubular membrane filtration elements, each having an output of 0.33 cubic meters per hour and 99 per cent salt rejection. To match the seawater supply and fresh water production rates, the units are grouped in four independent assemblies, of nine desalination units per assembly.

General Features of Assembly

Number of membrane elements	1 350
Number of units	9
Fresh water output, m^3/hr	445
Raw water consumption, m^3/hr	1 270

It is proposed to equip the desalinating units with DuPont membranes.

Detailed information on the desalination units can be provided by the manufacturer, PO Proletarsky Zavod, St. Petersburg.

6. ELECTRIC POWER INSTALLATION

Power requirements for the desalination unit's pumps are roughly 13 700 kW (8.2 $kW \cdot h/m^3$). When used in the brine discharge line, an energy recovery turbine can reduce the electric power consumption to about 10 500 kW (6.2 $kW \cdot h/m^3$).

An electrical power supply system consisting of five ADG-5000 diesel generators, manufactured by PO "Russky Diesel", St. Petersburg, is incorporated in the complex.

General Features of the ADG-5000 Diesel Generator

Rated power, kW	5 000
Electric current parameters	
Voltage, kV	6.4
Frequency, Hz	50
Specific fuel consumption, grams/kW·h	205
Overhaul period, hours	11 000
Original life, hours	60 000

The motors operate on a heavy fuel.

Using a set of spare parts and accessories supplied, it is possible to repair the diesel generators without removing the complex from operation. The electric power distribution system permits the paralleling of any three generators. In addition, a potion of the electric power can be supplied for shore loads, and a gaseous fuel could be used for the motors.

The fuel storage in the onboard fuel tanks guarantees 15 days of operation. The fuel storage can be expanded to 25 to 30 days, as an option, with a corresponding increase in draught and displacement.

7. TRANSPORTING THE COMPLEX TO THE PLACE OF OPERATION

The general dimensions of the complex permits placing it in the hold of the heavy lift ship "Boris Polevoy". Preliminary discussions regarding the transportation of an analogous object had been carried out in 1990, with a positive result. The speed of the heavy lift ship is 14 knots.

When the occasion requires, if transportation by heavy lift ship is too expensive, the complex could be towed by sea. The transportation scheme is analogous to the one for docks and non-propelled crane ships, and will be presented in the project.

8. ECONOMICAL ASPECTS

It is planned that the complex be manufactured at Baltsudoproekt, St. Petersburg. The cost of building the complex were calculated based on shipyard construction. Market pricing has been used to establish basic prices for raw materials and standard equipment.

The prices for desalination units, diesel generators, Pelton turbines and high pressure pumps reported by their manufacturers have been used in the evaluation. The cost of the complex would be US $22 million. The raw materials, spare parts and subcontractor services would cost about US $11.5 million. The costs for transportation, coast preparation and placement of the complex depend on the site specific conditions.

If a location is chosen where the wind force does not exceed 20 meters per second, and the depth allows for placing the complex no further than 50 to 100 meters from the coast, and if the transportation time by a heavy lift ship of the "Boris Polevoy" class does not exceed 20 days, then general expenses for manufacturing the desalination complex might run as high as US $23.5 million.

The price of fuel has been estimated both for the case of energy recovery (with a hydraulic turbine) and without energy recovery.

With the cost of the heavy fuel at US $120 per ton and a specific fuel consumption of 215 grams/kW, the annual expenses for fuel and lubricating oil would be:

- with energy recovery US $3.22 million
- without energy recovery US $2.29 million

The maintenance crew amounts to 21 men. The annual expenses for the crew are estimated, provided that a Russian crew is employed and the salary of a crew member is US $80 per day. General annual expenses for the crew would be US $610 000. The annual expenses for repair, technical services and maintenance, with membrane elements replacement excluded, is estimated in terms of per cent and is equal to US$ 0.8 million.

The annual cost of membrane element replacement during the 25 year service life would be equal to US $1.7 million, if the set of elements for a 40 000 m^3/d output is replaced every 3 years, and their cost is US $5 million.

The cost of chemicals for pretreatment of the raw water, final treatment of the fresh water and membrane element scale removal should be nearly US $0.33 million, according to information provided by DuPont.

The annual operating expenses are as follows:

- with energy recovery US $6.7 million
- without energy recovery US $5.83 million

The specific expenditures for desalinating 1 cubic meter of seawater with the proviso that the initial investments are repaid in 6.5 years, would be:

- with energy recovery US $0.78 per cubic meter
- without energy recovery US $0.70 per cubic meter

After examining site specific conditions, the options for accommodating the crew onboard the floating complex, expanding the fuel storage, and supply of a portion of the electric power for coastal loads can be studied to suit the client's requirements.