Mobile Equipment for Transportation and Storage of Water Reserves

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Abstract. In conditions of reduced freshwater reserves, the problem of its extraction of transportation and storage requires scientific justification of the relevant technical and technological solutions and the development of technical means. The article offers a mobile drinking water module. The design of the module provides for its placement in a thermally insulated container including a system of heating, power supply, distribution, filling and disinfection of water. For the development of the drinking water module, modern technical solutions are used to reduce the heat loss of the tank due to the use of a composite material and a cable of electric heater system. Reduction of microorganism propagation activity in water is provided by ultraviolet treatment and disinfection through ultraviolet gate. The design of the container is designed taking into account the possibility of its transportation in all modes of transport as a separate cargo unit. With the device of belts for loading and unloading. For loading into cars without the use of crane equipment, extendable outriggers are installed in the container, which can be used to install the container on water distribution sites. Mobility of the drinking module is ensured by the inclusion of a diesel generator unit in its composition. The tank of the module is made of stainless steel ensuring the safety of water without the formation of harmful impurities in it, and the coating of the tank with a composite material creates the effect of a thermos. The function of filling and distributing water from the tank is implemented using a distribution column with a vortex pump of a system of shut-off valves and hoses for supplying water. Experimental studies of mobile module operation have been performed. It was established that in order to maintain the water temperature in the tank at 10 °C at an ambient temperature of minus 30 °C, the heating system should not be switched on. The innovative design of the heat insulated layer reduces the thermal conductivity of similar water storage tanks made of traditional materials by 4 times. The proposed design of the mobile drinking module provides the possibility of creating clean water reserves for catering and household supplies.

1. Introduction

Providing special teams with drinking water in special conditions remains an unresolved and relevant scientific task. In order to ensure uninterrupted supply of water to consumers in various climatic conditions, it is required to develop new technical and technological solutions that ensure its intake, delivery, distribution and maintenance for more than 10 days without changing quality indicators.
2. Relevance and scientific importance

For transportation and short-term storage of drinking water with food supply to small groups of people in various natural and climatic conditions, a module of drinking water (multifunctional, with a capacity of 5000 liters) was developed. Structurally, it consists of aggregate and process compartments. They are located in a thermally insulated container of constant volume KK 6.2 (Figure 1), which includes heating, power supply, fire extinguishing, drain-filling and ultraviolet water decontamination systems (UV gate).

![Figure 1. View of drinking water module:](image)

1 – container; 2 – cap; 3 – dispensing column; 4 – door; 5 – water supply sleeves; 6 – band clamp; 7 – water tank; 8 – diesel generator set DSU8-P27, 5–VM1; 9 – heating and ventilation plant OVU-95; 10 – filtering plant FVUA-100A-24; 11 – spare parts racks; 12 – water level sensor PMP-052; 13 – saddle support; 14 – process equipment for water distribution.

It should be noted that the walls of the container are made as a result of the composition of materials: aluminum sheet – 2 mm (external), polyurethane foam – 90 mm and glass composite material – 2 mm (internal) without joints in a single sandwich structure. This ensures operation of the module at operating ambient temperatures from minus 60 °C to plus 50 °C, relative air humidity up to 98 %, wind speed up to 30 m/s. The glass composite layer reduces the need for maintenance (no painting is required), meets sanitary and epidemiological requirements and thermostatability.

3. Problem statement

Equipping the module with hydraulic handling devices makes it possible to increase the efficiency of loading and unloading operations (no additional technical means of loading and unloading are required). The module is structurally a cylindrical tank made of food stainless steel with a wall thickness of 2 mm, with the function of intake, supply, pumping, disinfection and storage of drinking water [1–3].

Immobility of the water tank (Figure 1) inside the container body is ensured by its rigid fixation to the floor by means of three belt clamps 6 and saddle supports 13. Band clamps cover the container and are fixed with their ends to saddle supports on which it is placed. Embedded elements are included in the container floor structure, in which saddle supports are attached by bolted connection.

Power supply for operation of systems and operation of pumps (main and spare) providing water intake, supply and pumping is performed from diesel generator plant DGU8-P27, 5–VM1 8 kW power installed in the unit compartment [4].

The drain-filling system includes: a dispenser column with a vortex pump; system of shut-off devices; hoses for supplying water from composite materials; filling restriction system with overflow protection.
Storage of water in conditions of low temperatures in the proposed structure of the tank is based on recovery of heat losses of the heating and heat insulation system of the module and directly the tank itself by inclusion of a heating and heat insulation layer in its structure.

The vessel heating system includes: 31 RV heating cable, fasteners for fixing the cable to the steel grid; junction boxes, control and power supply system and thermal control system. It is mounted directly on the container (Figure 2), while the cable runs around the circumference of the tank in turns.

Figure 2. Water tank cable heating system:
   а – type of cable heating system; б – assembly of the heating section on a steel grid; 1 – heating section; 2 – steel mesh; 3 – mounting unit; 4 – connecting box; 5 – power cable.

The design distance between the turns is 12-15 cm. A switching device is provided for connecting the electric heating cable to the power network. At the same time, switching ensures the use of not only mobile power plants, but also stationary electric networks. For connection to external network in spare parts package includes power cable 45 m long and grounding device. The use of this kind of cable is determined by its linear power, which is higher than the linear power of analogues (11 VR, 17 VR, 27 VR) [5].

Despite an increase of 3.5 times the linear power of the heating cable 31VR compared to the cable 11VR, its cost is only 10 % higher. The power of the power supply DES-8 provides the necessary demand (2.7 kW) for the operation of the system and compensation for heat losses at a water temperature in the tank of 3 °C [6-9].

Compensation (reduction) of heat loss is provided due to heat insulation by a layer of polyurethane foam, which has a closed porous structure and provides low thermal conductivity (0.019-0.003 W/m), low mass (45-60 kg/m³) and has high adhesion (1.5 kg/cm²) with metals. Heat-insulating layer is arranged over heat-tracing cable, which is structurally combined into flexible mat due to connection of turns with mounting wire [10-14].

It should be noted that the thermal insulation layer provides short-term thermal insulation in extreme cases (in case of failure of the heating system) without draining water from the tank.

4. Practical importance
In order to assess the operability of the proposed technical solution, experimental studies were carried out, which made it possible to obtain the following results [15-17]:

1. Proposed system for compensation of heat loss and maintenance of liquid temperature up to 10 °C at ambient temperature up to minus 30 °C does not require activation of heating system.
2. Treatment of the container with rigid polyurethane foam and formation of a heat-insulating layer of the container surface with a thickness of 100 mm provides ease of flow of complex, non-standard circuits, cranes, gate valves; corrosion protection; minimum thermal conductivity coefficient; high frost resistance; easy repair of the damaged layer; creation of seamless, monolithic coating.

5. Conclusions
Thus, unlike existing tanks, in order to reduce thermal conductivity, a design of a heating and heat insulation layer is proposed, which includes an electric heating cable in the form of a flexible mat mounted on the surface of a water tank and a heat insulation layer mounted on its surface with a calculated thickness of 100 mm of polyurethane foam. The design of the heating and heat insulation layer performs the function not only of maintaining the temperature of water, but also of heating it.

Geometric and weight and size characteristics of the module provide the possibility of its transportation in various types of road transport (KamAZ, Ural can be used as the base chassis; caterpillar conveyor DT-30PM-32, DT-30PM-33) and the possibility of its transportation by rail (gondola, platform), river (river container ships), sea (container ship, barge, etc.) transport and aircraft (AN-12, IL-76, AN-124), including on the outer suspension of the helicopter (Mi-26).

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