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Automated plant for removing radionuclides from liquid radioactive waste by reverse osmosis

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Liquid radioactive waste (LRW) can contain large amounts of emulsified petroleum products and suspended corrosion particles on which radionuclides concentrate. The optimal approach to removal of radionuclides in different physicochemical forms is using adsorption methods together with baromembrane methods such as microfiltration, ultrafiltration, and reverse osmosis. Alexandrov NITI has developed an automated reverse osmosis plant system with remote monitoring and control features including cleaning of reverse osmosis elements. The plant comprises a microfilter, reverse osmosis filter (ROF), unit for cleaning the reverse osmosis elements, low-pressure pump, high-pressure pump, chemical analysis unit, control unit and power control unit. The plant has a filtration capacity of 500 l/h, operating power of 5 kW max, operating pressure of 5 MPa max (at ROF) and removes at least 95% of dissolved salts from LRW with a salt concentration of 10 g/l max and activity up to 10 kBq/l and produces concentrated solutions of up to 50 g/l salt content. The cleaning unit is designed to prepare maximum 150 liters of washing solutions heated to 35oC and clean the reverse osmosis filter. The reverse osmosis elements are cleaned every day using the final water of the plant system and every month using chemical solutions prepared from the final water. The most efficient washing solution is 1.5% solution of citric acid with pH = 4-5. The plant performance is monitored by measuring the solution conductance with the chemical analysis unit and the treatment process is automatically controlled by the control unit equipment. The control and monitoring process does not require presence of the operator in the plant equipment location area. The plant operation is controlled remotely from the operator workstation in another room where the dose rate is below 0.6 μSv/h. Experiments demonstrated that the general demineralization efficiency of the plant was about 75. The system removed almost all petroleum, surfactants, and corrosion products. Alkali metals were removed by ion exchange (pH is reduced). At the same time, the efficiency of radionuclide removal was higher than the general demineralization efficiency. The reverse osmosis efficiency for removal of radionuclides was almost 1000 and even reached the value of 10000 for Sr-90. The chemical cleaning removed fouling consisting of 85% calcium, about 5% magnesium, about 5% iron, and about 1.5 % aluminum species. The specific activity of the washing solutions was 1·106 Bq/l max with Sr-90 being the main source.

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