Membrane Treatment of Liquid Salt Bearing Radioactive Wastes

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ABSTRACT

The main fields of introduction and application of membrane methods for preliminary treatment and processing salt liquid radioactive waste (SLRW) can be nuclear power stations (NPP) and enterprises on atomic submarines (AS) utilization.

Unlike the earlier developed technology for the liquid salt bearing radioactive waste decontamination and concentrating this report presents the new enhanced membrane technology for the liquid salt bearing radioactive waste processing based on the state-of-the-art membrane unit design, namely, the filtering units equipped with the metal-ceramic membranes of “TruMem” brand, as well as the electrodialysis and electroosmosis concentrators.

Application of the above mentioned units in conjunction with the pulse pole changer will allow the marked increase of the radioactive waste concentrating factor and the significant reduction of the waste volume intended for conversion into monolith and disposal. Besides, the application of the electrodialysis units loaded with an ion exchange material at the end polishing stage of the radioactive waste decontamination process will allow the reagent-free radioactive waste treatment that meets the standards set for the release of the decontaminated liquid radioactive waste effluents into the natural reservoirs of fish-farming value.

INTRODUCTION

The main fields of introduction and application of membrane methods for preliminary treatment and processing salt liquid radioactive waste (SLRW) can be nuclear power stations (NPP) and enterprises on atomic submarines (AS) utilization.

Sewage solutions of such enterprises have as a rule a complicated chemical and radiochemical composition at these enterprises.

For an example, at FGUP MP «Zvezdochka» of Russian atomic shipbuilding center in Severodvinsk town of Arkhangelsk region, liquid radioactive waste arising as a result of atomic submarines repair and technical service are salt solutions of low level radioactivity, in which contents of long-lived radionuclides of caesium-137 and strontium-90 exceed maximum allowable concentrations in more than 1000 times. Besides, they contain chemical contaminants such as chlorides, nitrates, phosphates, and sulphates also exceeding maximum allowable concentrations. It is necessary to mark that total salinity of the waste is in the range from 2500 up to 3500 mg/l.

TECHNOLOGY

One of well-known methods for desalination and purification of such salt solutions is an electrochemical one – electrodialysis, which currently is ecologically pure and economic. Electrodialysis has a number of unchallenged advantages in comparison with methods methods of distillation (evaporation) and reverse osmosis, because at electrodialysis there is no change of phase in solution; it works at low pressure (0,1 – 0,2 MPa); the process can be easily automated, and the use of impulse changing the poles to prevent sludging in concentrating chambers of electrodialysis apparatus does not requires to apply any chemical reagents. Application of electrodialysis for similar salt solutions was even positive.

Nowadays electrodialysis is applied for purification of liquid salt radioactive waste from radionuclides and chemical impurities till normed levels both by radionuclide and chemical composition [1-2].

At GUP MosNPO «Radon» a membrane technology for processing liquid salt radioactive waste of low level radioactivity both for deep desalination, and for high concentrating liquid radioactive waste [3-7].

By using the mentioned patents, a modular mobile installation ECO-3M was created. The installation has already successfully been applying during six years at FGUP MP «Zvezdochka» in Severodvinsk town of Arkhangelsk region.

General view of some ECO-3M modules is represented on Figure 1.
Table 1 gives operational data on composition of initial and purified salt liquid radioactive waste in the installation ECO-3M.

Research engineering and experimental development works conducted at GUP MosNPO «Radon» allowed improving the membrane technology of salt liquid radioactive waste processing by applying modern constructions of membrane apparatus. The developed construction of dynamic-filtering apparatus with metal-ceramic membranes and an electroosmotic concentrator are considered among them. Use of these apparatus in a scheme of SLRW processing allows refusing sorption apparatus and maximally decreasing volume of radioactive concentrate, being supposed to further solidification and disposal.

Figure 2 demonstrates the filtering apparatus of dynamic type with metal-ceramic Trumem membranes. Trumem membranes are two-layer membranes, which consists of a stainless steel support and a thin ceramic layer of titanium dioxide with pore sizes from 0,1 up to 1 μm; or monolayer membranes of stainless steel with pore sizes from 2,5 up to 10 μm. They have a high mechanic durability, large lifetime, high porosity and high productivity.

Figure 3 demonstrates an electroosmotic concentrator with ion exchange membranes of EDK-60 type. The electroosmotic concentrator has an original construction with static brine chambers. This allows obtaining a concentrate with high salinity in the range 150 – 250 g/l depending on initial solution composition.

Figure 4 shows a functional technological scheme of improved purifying installation, which applies only membrane apparatus.

Advantages of pointed scheme are the following:

- non-reagent;
- independent energy supply – i.e. completed with an energy supplier;
- simplified stage of pre-purifying and increase of purification reliability and quality at use of metal-ceramic membranes;
- exclude of sludging not readily soluble compounds in electrodialyzer due to use of impulse changing the poles in the electric supply scheme [8];
- high salinity of radioactive concentrate, which considerably decreases waste volumes directed to conditioning and storing;
- increase of solution after-purification degree at use of ion exchange fiber in the electrodialyzer of deep desalination, at that the fiber is regenerated by electric current.

CONCLUSION

1. Constructions are developed and new membrane apparatus for liquid radioactive waste purification are made.

2. Original technology of salt liquid radioactive waste purification with the use of only membrane apparatus is developed.

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Radiometric and spectrometric composition of initial and purified LRW.

Table 1.

№	**Radionuclide**	**Specific radioactivity of initial LRW, Bq/l**	**Specific radioactivity of purified LRW , Bq/l**
1	Caesium-137	38000	7,8
2	Caesium-134	1270	0,4
3	Cobalt-60	46620	18,0
4	Iodine-129	0,1	0,1
5	Nickel-63	370	218
6	Antimony-125	310	7,0
7	Carbon-14	320	140
8	Strontium-90	4950	1,5

General views of of modular mobile installation «ECO-3M»

Filtration module

Ultra-filtration module

Electrodialysis module

Fig.1

General views of filtering apparatus with Trumem metal-ceramic membranes

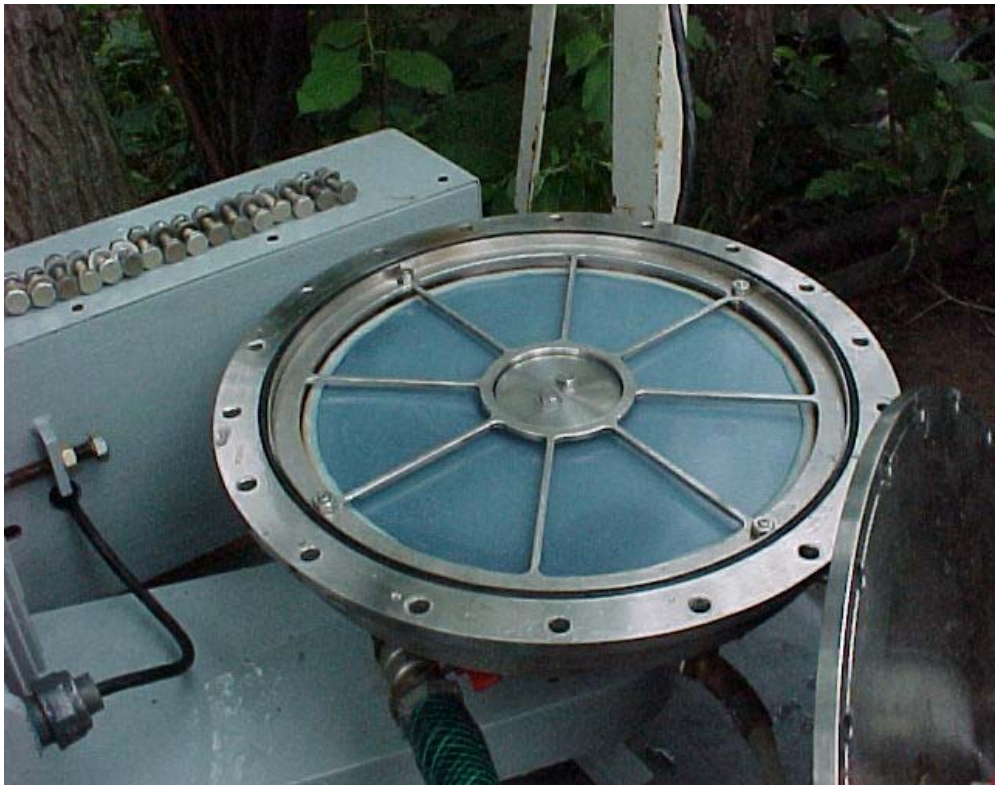
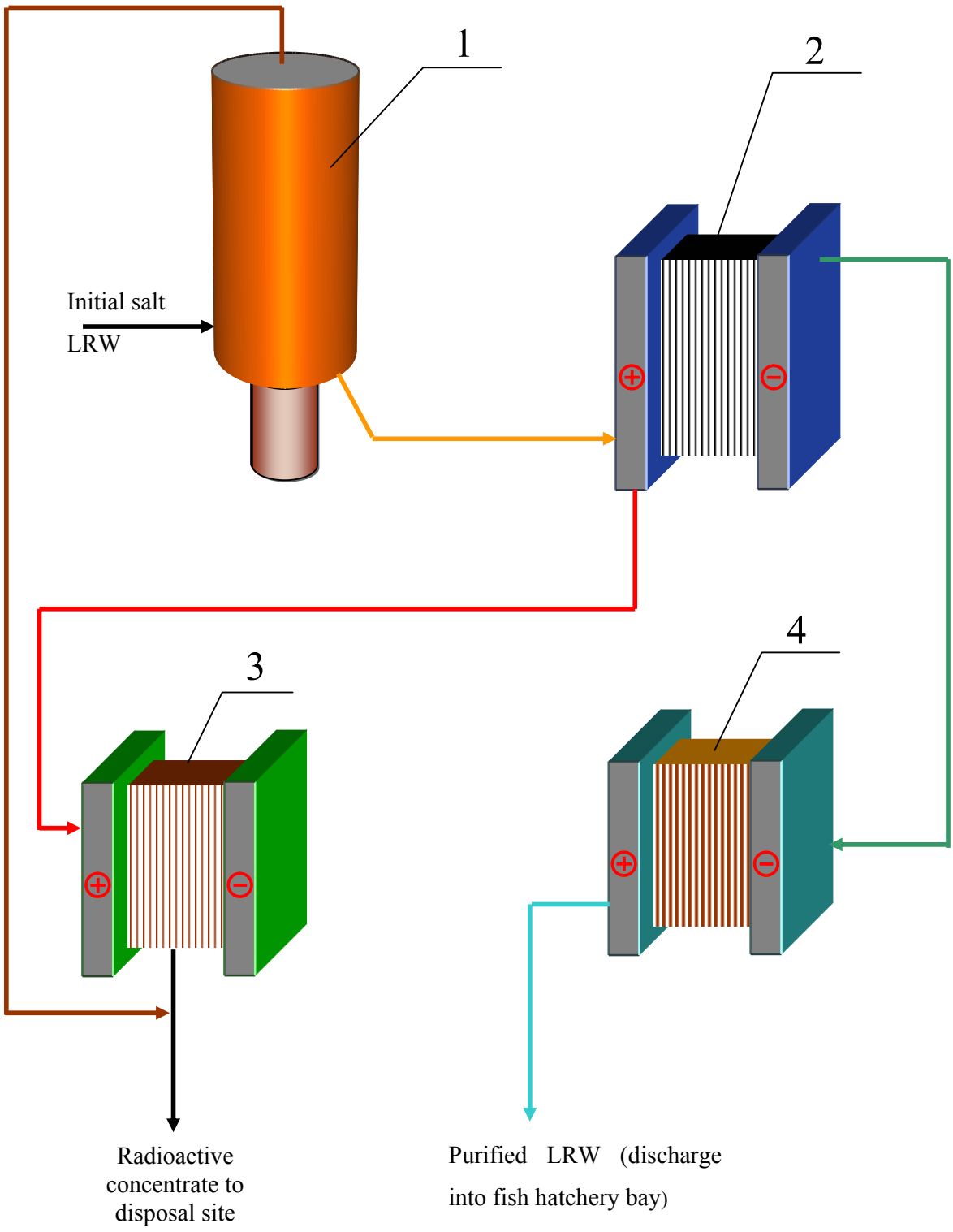


Fig.2

General views of electroosmotic concentrator of EDK-60 type with ion exchange membranes

Fig.3

Functional technological scheme of membrane purification installation



1. – filtering apparatus of dynamic type with Trumem membranes
2. –electrodialyzer with ion exchange membranes of EDMA-8 type for LRW desalination
3. – electroosmotic apparatus of EDK-60 type for LRW concentrating
4. – electrodialyzer with ion exchange fibers of VION type EDG-500 for LRW deep after-purification

Fig.4