Experimental Tests of Ultrasonic Decontamination of Metal Radioactive Waste - 9012

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ABSTRACT

The paper discusses the results of testing of pilot plant for metal radioactive waste (MRW) ultrasonic decontamination developed by the authors. The testing was carried out both on simulated and real MRW. The plant includes the following units: a bath for decontamination with ultrasonic radiators, tanks for water and decontaminating solution, a unit for cleaning washing water and conditioning the spent decontaminating solution. As real MRW the stainless steel SFAC (spent fuel assembly casing from nuclear submarine) fragments having surface contamination from some hundreds to 18 thousand particles/cm^2*min (up to 300 Bq/cm^2) were used. Tests have shown a principle opportunity of SFAC cleaning up to background level values. During tests the pilot plant was additionally equipped with units for cleaning of washing water, conditioning of spent decontaminating solution and blowing of gas emissions. 10 m^3 of SFAC fragments have been decontaminated. The radioactive waste volume reduction factor was 35. The cost estimation of MRW treatment on ultrasonic pilot plant has been carried out.

INTRODUCTION

Decontamination of the radioactively contaminated metal surfaces is carried out, as a rule, in technological processes with the purpose of minimization of the radiation dose rate from the operated equipment and improving the safety of workers. It is carried out on the routine operated equipment and by means of special decontaminating reagents and in routine modes. Liquid decontamination is used, as a rule, for metal surfaces.

At decommissioning of nuclear industry objects, nuclear power plants, defense waste, research nuclear facilities, the significant amount of metal radioactive waste such as plants, separate metal fragments and other metal waste products contaminated by radioactive substances are generated. The volume of decommissioning waste and material are very large. According to the estimates available, the volume of decommissioning waste accumulated amounts 12.4 million tons including about 2 million tons of the waste in Russia. Today some tens of nuclear submarines require cutting and recycling at their decommissioning and may pose an urgent problem in the near future.

The problem is that there are practically no specialized enterprises for metal radioactive waste treatment. Besides, not all of the enterprises having metal radioactive waste (RW) inventory have plants for metal RW decontamination and for waste conditioning. Traditionally, there is no required engineering infrastructure for decontamination of the waste inventory on-site.

Therefore, development of plant and a method for decontamination of decommissioning waste which could be realized at enterprises having large metal radioactive waste inventory but not having plants for their treatment including secondary radioactive waste conditioning is another source of trouble.

Take for example the territory for interim storage in Andreev Guba where, as a result of the Navy activity, large volumes of decommissioning SRW (solid radioactive waste) has accumulated including metal products of various dimensions, such as:

- large dimension metal thick-walled SRW stored both on the open areas and in deepen repository;

- thin - walled metal waste products;
- spent fuel assembly casing (SFAC) stored in bulk on the open areas and in containers in deepen repositories;
- chains for (SFAC) handling in cooling ponds ;
- other handling equipment, etc.

Use of such RW decontamination method on-site allows to direct “clean” and "conditionally clean" metal products (including products made of stainless steel) for melting at the specialized enterprises and to reduce volume of RW to be directed to conditioning and long-term storage.
Most widely for metal RW decontamination the liquid methods consisting in metal components treatment by various decontaminating solutions, including a combination of such treatment with other ways of process activation. One of such ways is decontamination with application of ultrasonic process (1).

Experimental Part
The authors have developed and constructed pilot plant for ultrasonic decontamination of metal RW (Fig.1). The basic units of the plant are a bath for decontamination 1, a tank for preparation of decontaminating solution 2, a tank for water 3, a power entrance cabinet with ultrasonic generators 4.

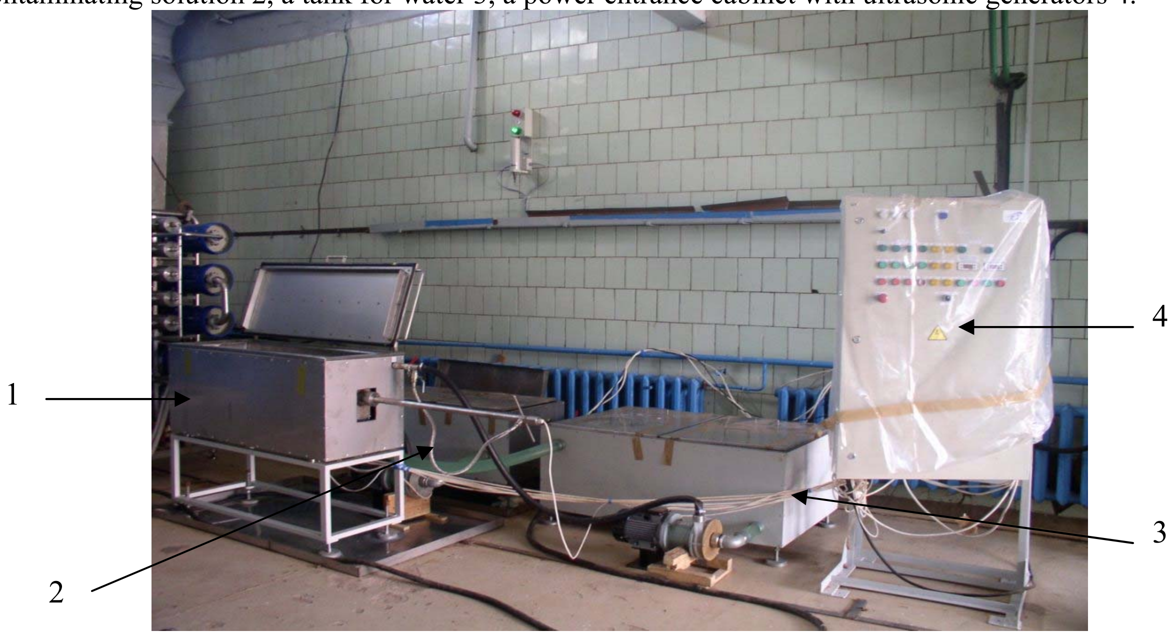
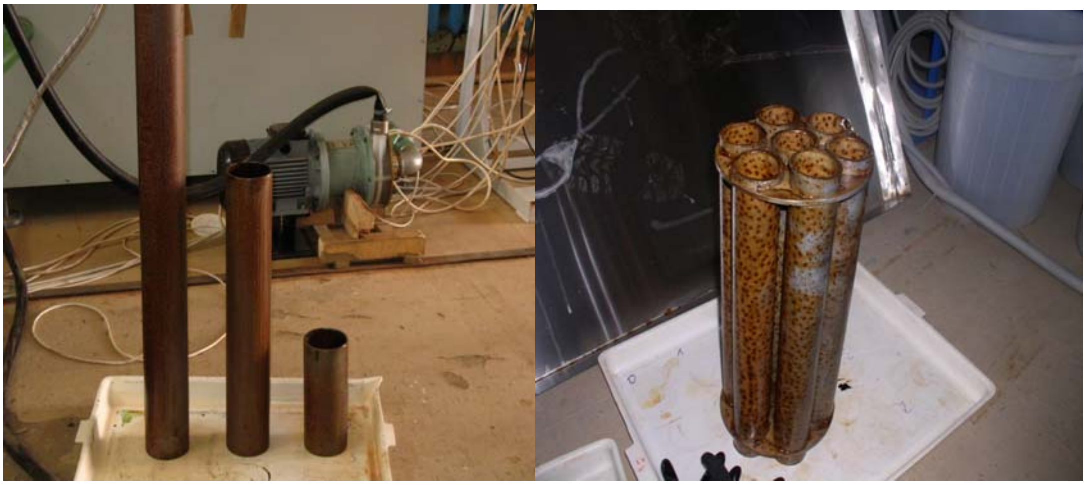


Fig. 1. Overall view of the pilot plant

Testing of this plant on simulators of RW has been carried out at Moscow SIA Radon. Use of the plant for decontamination of real SFAC waste being in interim storage at Andreev Guba site has been examined. The SFAC waste are the pipes of diameter 0.057 m and height 2.35 - 3.06 m mounted in assemblage by 7 pipes. As real metal radioactive waste the SFAC waste of different types contaminated by ^{137}Cs, ^{90}Sr radionuclides were chosen. Overall view of corrosion-proof pipes and simulators of SFAC samples treated with the purpose of fixing the radioactive contamination on their surface is shown in Fig.2.



a) b)

Fig. 2. Overall view of pipes (a) and SFAC samples (b) before decontamination

The plant was tested on samples of corrosion-proof pipes of diameter 0.088м and height 0.2 – 0.8 m. In result of tests the operation modes and optimum decontaminating solution compositions for achievement of the maximum decontamination factors have been determined.

For decontamination acid and alkaline water detergents solutions together with complexon and corrosion inhibitor additives were used.

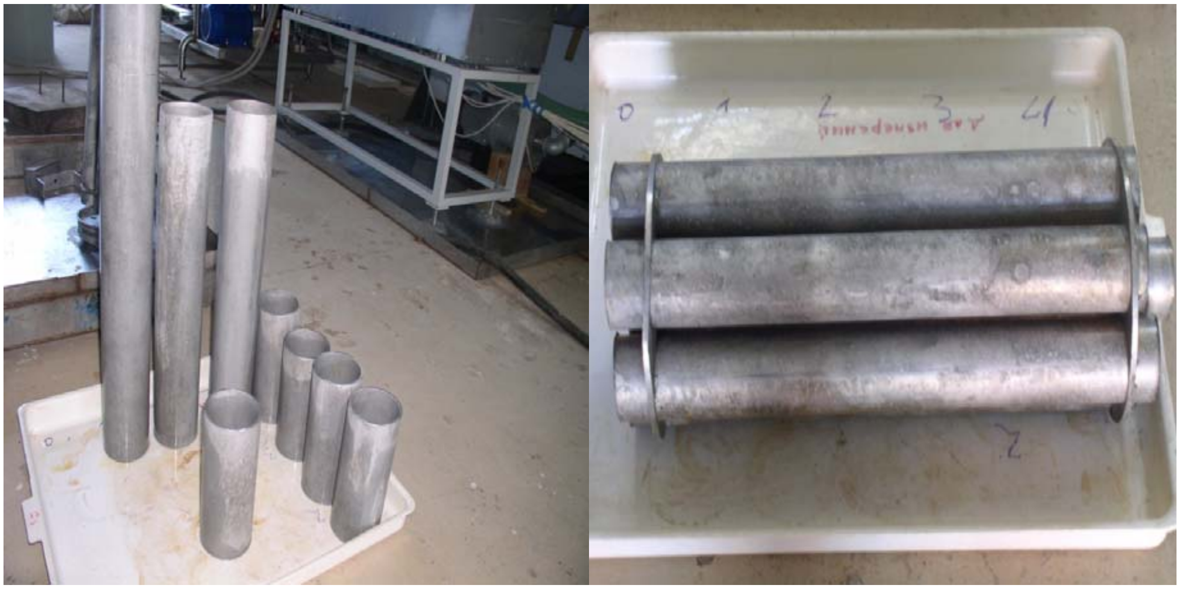
The temperatures of decontaminating solution were room, 40^o and 50 ^{0}C. Time of treatment was in the range from 2 to 20 minutes.

Tests have shown that the use of ultrasonic process in a combination with treatment by decontaminating solutions raises the decontamination efficiency, at that, the increase in treatment duration from 2 to 20 minutes and the increase in temperature from room temperature to 50 ^{0}C also increases an efficiency of metal surface cleaning.

Ultrasonic decontamination of simulated metal waste by acid solutions is effective for cesium and strontium radionuclides. The reached decontamination factors (depending on decontamination conditions) are the following:

- For the pipe samples - from 20 to 1000;

Overall view of the pipe samples and SFAC fragments after decontamination is shown in Fig. 3. Fig.3 shows that the oxide film formed in result of samples surface treatment by hydrochloric acid containing Cs^{137} and Sr^{90} isotopes for obtaining simulated radioactive surface contamination has been removed from samples surface.



a) б)

Fig. 3. Overall view of pipes (a) and simulators of SFAC fragments (b) after decontamination

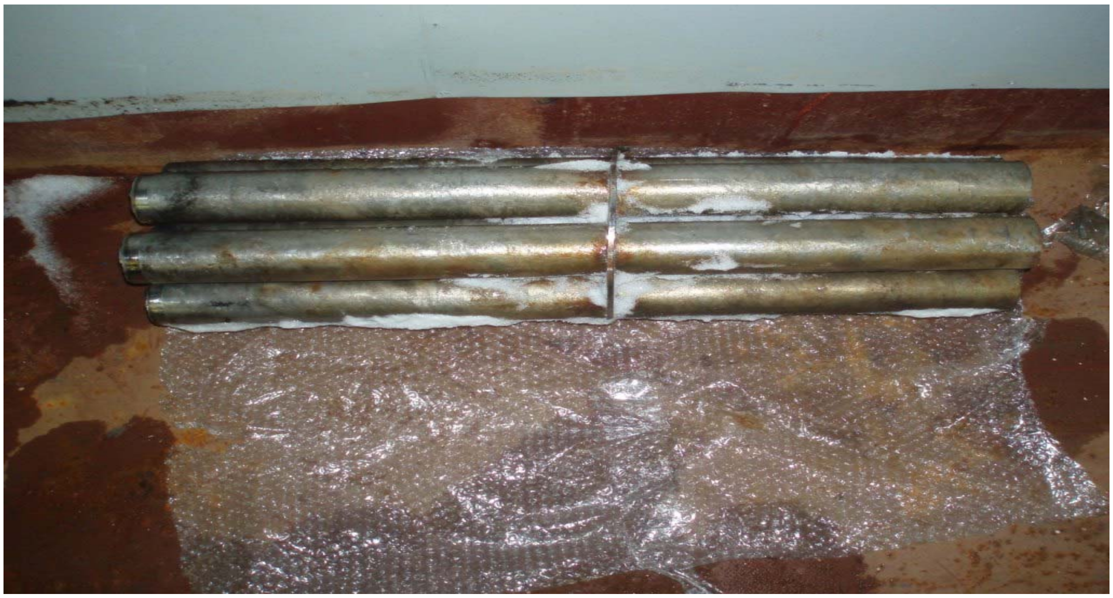
During tests the decontaminating solution compositions and modes of ultrasonic treatment of samples to be decontaminated have been optimized. The problem of foaming in a decontamination bath has been solved. The optimum dimensions of the SFAC fragments have been determined.
The results of SFAC fragments decontamination are given in Table 1.

Table 1. The SFAC fragments decontamination with rotation on the pilot plant
(60 particles/cm^2*min ~ 1 Bq/cm^2)

Type of the decontaminating solution (DS), treatment regime	Contamination level, particles/cm^2*min				Decontamination factor
	Before the decontamination		After the decontamination		
	Outer surface	Inner surface	Outer surface	Inner surface	
DS 1, T = 40 ^{0}C, τ = 20 min, rotation	520, 352, 423, 460, 623, 470, 750, 711	1521, 1424, 1070, 2300, 2564, 1554	1, 2, 3, 4, 7, 5, 0, 0, 2	0, 6, 0, 5, 5, 9, 1, 2, 4, 11, 4, 0, 4	346
DS 2, T = 40 ^{0}C, τ = 20 min, rotation	518, 756, 521, 656, 956, 769, 622, 1035, 775	1368, 1405, 1098, 1334, 1138, 1004, 1020, 1853, 1297, 1503, 2149, 1664, 1689, 1554	0, 0, 0, 0, 6, 4, 6, 2, 1	0, 0, 0, 0, 6, 4, 6, 2, 1	516

As is shown in the table, the ultrasonic decontamination in acid solutions allows cleaning the simulated SFAC waste fragments from cesium and strontium radionuclides effectively. The following decontamination factors were reached:

· For simulated SFAC fragments (depending on conditions) - from 90 to 516;
Further the tests of the plant have been continued in branch N 1 of the SevRAW in Andreev Guba on the real stainless steel SFAC fragments having surface β-contamination ranged from several hundreds to 18 thousand particles/cm^2*min (up to 300 Bq/cm^2). Tests have been carried out on SFAC fragments of two types, divided on three fragments. Overall view of the fragments before and after decontamination is shown in Fig. 4.



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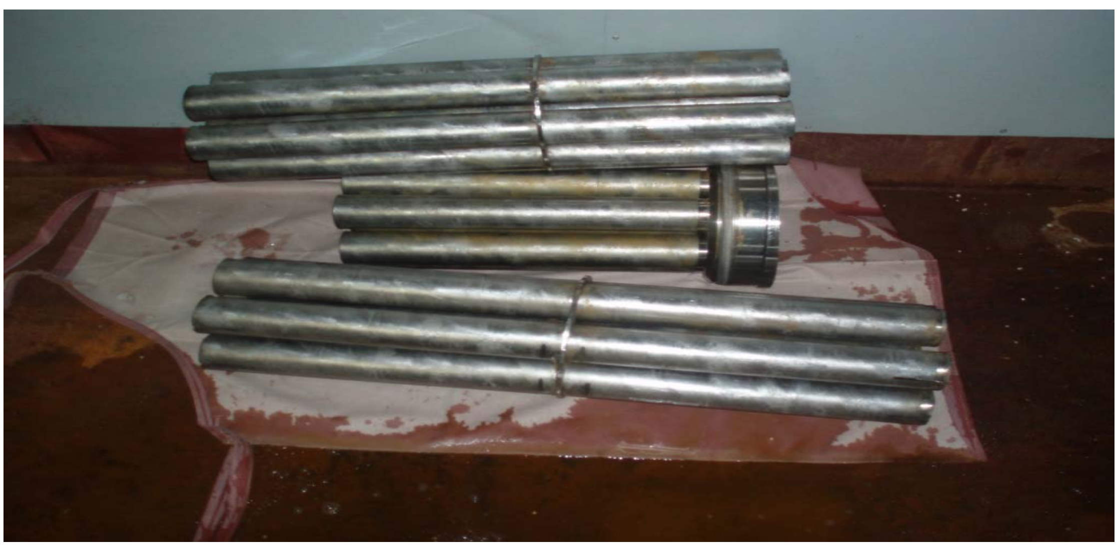

b

Fig. 4. View of the SFAC fragments before (a) and after (b) decontamination

Results of the SFAC fragments decontamination by different decontaminating solutions are given in Table 2.

Table 2. Results of the SFAC fragments decontamination
(60 particles/cm^2*min ~ 1 Bq/cm^2)

Type of the decontaminating solution (DS), treatment regime	№ measurement point, contamination level, particles/cm^2*min		Decontamination factor
	Before the decontamination	After the decontamination	
DS 1, T = 50 ^{0}C, τ= 20 min	I - 18000 III - 720 VI - 6130	I – 1000 II - 30 III – 15 IV – 20 V - 9 VI - 36	44.1
DS 2, T = 50 ^{0}C, τ= 30 min	I – 60 II - 120 III – 280 IV – 60 V - 102	I – 24 II - 54 III – 42	2.88
DS 3, T = 50 ^{0}C, τ= 60 min	I – 1800 II - 642 III – 684	I – 54 II - 35 III – 54	21.7
DS 4, T = 50 ^{0}C, τ= 30 min	I – 300 II – 90 III – 310 IV – 120 V - 14400	I – <6 II – <6 III – 12 IV – <6 V - 6	846

Thus, the principle opportunity of SFAC fragments decontamination up to background level values has been demonstrated on one of the tested compositions.

During tests the pilot plant was equipped with units for cleaning of washing water, conditioning of spent decontaminating solution and blowing of gas emissions. The basic elements of cleaning unit are the membrane filter and the filter-container filled by selective sorbents MDM and T-35. The basic elements of conditioning unit are a 200-liter drum with disposable mixer for cement compound preparation on the basis of spent decontaminating solution.

During these tests nearby 10 м^3 of SFAC fragments have been decontaminated. The radioactive waste volume reduction factor was 35 in result of SFAC fragments ultrasonic decontamination and the subsequent conditioning of secondary RW.

By the radiation monitoring results the decontaminated waste were divided into three streams:

- Metal waste of "unlimited" use with specific activity of below clearance levels;
- Metal waste of "limited" use with specific activity higher than clearance level by a factor of 1 - 10;
- Metal radioactive waste with specific activity lower than initial waste specific activity.

Collection and storage of the mentioned above waste streams are carried out separately.

At SFAC fragments decontamination the secondary conditioned RW are generated:

- Drums with cement waste form on the basis of spent decontaminating solution;
- Filter-container with accumulated in it radionuclides which are concentrated onto a sorbent at cleaning washing water.

The cost estimation of the SFAC decontamination on the pilot plant has been carried out. The estimated cost amounts to 12 rubles/kg taking into account conditioned secondary RW storage.

CONCLUSION

Pilot plant for metal radioactive waste ultrasonic decontamination was developed by the authors. The testing of plant was carried out both on simulated and real waste (MRW). As real MRW the stainless steel SFAC (spent fuel assembly casing from nuclear submarine) fragments having surface □contamination up to 300 Bq/cm^2 were used. Tests have shown a principle opportunity of SFAC cleaning up to background level values. During tests the pilot plant was additionally equipped with units for cleaning of washing water, conditioning of spent decontaminating solution and blowing of gas emissions. 10 m^3 of SFAC fragments have been decontaminated. The radioactive waste volume reduction factor was 35. The cost estimation of MRW treatment on ultrasonic pilot plant has been carried out. By these test results plant for metal radioactive waste decontamination with use of ultrasonic process can be developed.

REFERENCES

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