

**Role and Place of the Joint-Stock Company “ECOMET-S”  
in the System of Solid Radioactive Waste Treatment  
Generated at the Nuclear Power Plants of the Russian Federation - 9218**

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**ABSTRACT**

In this work the existing situation and ways of solving the problem of solid radioactive waste (SRW) management, resulting from the nuclear power industry are considered. It is shown, that one of the ways to manage SRW is transferring the task to a specialized enterprise. Such an enterprise in Russia is the Joint-Stock Company (JSC) “ECOMET-S”, whose main activity is providing services for processing and disposal of radioactive metal waste. They reduce the volume of SRW, ship it for burial and return metal return to industry for unlimited use. The basic provisions of the system of radioactive metal waste (hereinafter RMW) management developed by JSC “ECOMET-S” are given. Information referring to technology and enterprise industrial capacity is represented. The results of the JSC “ECOMET-S” activity for processing and disposal of low-activity radioactive metal waste from the Nuclear Power Plant (hereinafter NPP) of the Russian Federation are shown.

**INTRODUCTION**

Processing and disposal of the radioactive waste (hereinafter RAW) is the most important component of solving the problem of RAW management safety in Russia. RAW management impacts the development of the nuclear power industry in the Russia. In November, 2005, the Russian Federation ratified “Joint Convention on the Safety of Spent Fuel Management and the Safety of Radioactive Waste Management”. That placed obligations upon Russia in the area of improving the safety of RAW and spent nuclear fuel management. Thus, using an the up to date RAW management system for the nuclear industry is the primary means of ensuring nuclear and radiation safety in the Russian Federation.

**The Existing Situation and the Ways of Solving the Problem of RAW Management at the Nuclear Power Plants**

RAW problem of the nuclear power industry and, in particular at the nuclear power plants (NPP) of Russia, nowadays has the following circumstances:

- large quantity of accumulated waste;
- high consumption of the storage cells for radioactive waste;
- inadequate technical systems for conditioning, storage and transportation of the radioactive waste;
- necessity of improving of the existed practice of RAW management so it can meet up to date ecological, technical and economic requirements;
- active and increasing influence of the public on the all issues, connected with ecological aspects of the NPP operation.

At the present time several hundreds of thousands of tons (approximately 600,000.t) of RMW have been accumulated and annually up to 10 thousand of tons of RMW are generated. The total volume of RMW is expected to increase considerably as a result of NPP decommissioning. At present time RMW

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management is limited to placement in different kinds of storage cells, often with other solid RAW or storage at open sites, especially for large-sized equipment.

One way of managing nuclear power plant RWM is to transfer the task to a specialized enterprise.

Global experience shows processing and storage are addressed by specialized private companies. Such companies possess high flexibility and efficiency and have the possibility to attract investments, concentrate finances and material resources.

JSC "ECOMET-S" is the enterprise, having wide practical experience of SRW management, including RMW from NPP. Long-term experience and actual results in the area of SRW management show that JSC "ECOMET-S" services correspond to the tendencies of the world wide developments and practice.

### **JSC "ECOMET-S" Activity in the Sphere of Technologies Development upon RAW Management**

The Closed Joint Stock Company "ECOMET-S" was established in 1994 with the purpose of introducing conservation of nature, resource saving and ecological technologies in the area of solid radioactive waste (SRW) generated from operation of nuclear fuel and oil-and-gas complex facilities. Processing RMW to return most of the mass to industry for unlimited use reduces SRW volumes directed to long-term storage (burial).

From 1995 the enterprise activity has been performing within the target purpose of "Radioactive metal waste processing and disposal", approved by the Government of the Russian Federation Direction No. 1197-p of September, 1<sup>st</sup>. The Program Contractor is the Ministry of Nuclear Energy; functions of the head Executor of the Program were placed on JSC "ECOMET-S".

For solving the problem of RMW management by the enterprise, complex technology for processing and disposal, producing considerable reduction of the RMW volume (20-80 times) directed for burial, and considerably reducing of the total costs for their processing and burial, was developed. The technology is based on decontamination and re-melting metal at the final phase of RMW management, which allows most of the metal to be recycled to industry.

The specialists of "ECOMET-S" were able to develop a RMW management system which returns decontaminated metal to industry, packages metal with residual contamination for disposal and documents the process to meet Federal regulatory requirements. This meets the requirements of "Main sanitary rules of radioactive safety" (OSPORB-99) [1] and "Sanitary rules for radioactive waste management" (SPORO-2002) [2].

Metal ingots for recycle, generated from RMW processing, must meet the sanitary and epidemiological rules and regulations. The Russian consumer supervision authority (Rospotrebnadzor) allows recycling for a lot of scrap metal based of the radiation level, the specific activity of the samples, the equivalent radiation exposure and concentration of alpha-beta-particles and radiation surveys of the transport vehicle.

The quantity of the secondary radioactive waste, resulting from RMW processing (slag, refractory-lined materials, dust, etc.), averages 5-7% mass. (maximal value is up to 10% mass) of the initial mass of the waste delivered for processing. The secondary RAW corresponds to the category of low-activity SRW. Secondary SRW are shipped for the long-term storage (burial) or returned to the RMW contractor depending on contract conditions.

Using the method of metal melting for RMW management developed by JSC "ECOMET-S" provides the following:

- reducing the costs for RMW management (service cost of RMW processing is lower, than service cost of receipt, conditioning and long-term storage);
- reducing the costs for new storage capacities for SRW produced;
- reducing the costs for conditioning of the secondary RAW;
- reducing the SRW volume, directed for burial (long-term storage);
- reducing the consumption of the storage capacity for SRW;
- transformation of the secondary RAW into a safe and convenient shape for conditioning and storing;
- return of metals to industry for unlimited use (ingots are environment safe);

- avoidance of RMW ingress to metallurgic production as the scrap metal;
- avoidance of mining and smelting for new metal production;
- increasing of the level of ecological safety in all phases of RMW, secondary SRW, recycled metal management for unlimited use in industrial purposes.

Ecological and economical justification for using melting as a method of RMW management is confirmed by foreign specialized enterprises use, much of which started performing industrial melting of contaminated metals at the end of the 1980-s. Among such enterprises Siempelcamp (Germany), Studsvik (Sweden), BNFL (Great Britain) and EnergySolutions (USA) shall be noted.

### **JSC “ECOMET-S” Production Facilities**

The JSC “ECOMET-S” has its own production capacities for processing of the low-activity RMW at a facility, located at the Leningrad special industrial complex “Radon” and commissioned in 2002. The RMW processing and disposal facility has a capacity of 5 thousand tons annually.

The JSC “ECOMET” complex is equipped with up-to-date high-technological equipment. The environmental and processing control is performed by quality laboratories, accredited by the Federal Agency of technical regulation and metrology. Existing licenses and technological equipment at the enterprise allow operations with RMW and low-activity SRW with beta-, gamma-emitters and alpha-emitters of low toxicity.

An external view of the complex is shown in Fig. 1. The complex is intended for decontamination of the metal waste (non-corrosive nickel-chrome and carbon steel, copper and its alloys, as well as of aluminum alloys) with levels of radioactive contamination corresponding to low-activity solid radioactive waste.



Fig. 1. Industrial complex for RMW processing and utilization.

The RMW facility consists of an acceptance and fragmentation department, deactivation department, remelting department, the area of input, intermediate and output radiation control, radiochemical laboratory, physical-chemical laboratory, the off gas purification system, air supply and other technological and auxiliary systems.

At the acceptance area the waste is unloaded from the motor vehicle and initial (input) radiation surveys are conducted. At the fragmentation area, waste is sorted and cut to the size to allow loading into abrasive decontamination devices and melting furnace.

The deactivation department includes the abrasive (bead-blasting) decontamination cleaners, thermal processing and the container decontamination areas. The bead-blasting facility is shown in Fig. 2. Metal waste, having radiometric survey is delivered to the melting department.



Fig. 2. Bead-blasting facility.

The re-melting department includes the induction furnace, the system of exhaust ventilation and gas purification, the area for fluxes preparation, metal loading into furnace and metal casting into molds. Besides, the control of contamination of the ingots lot by means of selection and measurement of the melt sample at Metal waste melting is performed under the layer of refining fluxes. Upon completion of the melting the slag is removed, metal samples are selected and metal casting into molds is performed. Metal casting in the remelting department is represented in Fig. 3. From re-melting, secondary radioactive waste in the form of slag, dust, worked off refractory-lined materials, are delivered to burial (long-term storage) together with the waste from the decontamination area. After re-melting metal samples and ingots are delivered to the radiation control.



Fig. 3. Metal casting in the remelting department.

Output control of the metals includes measurement of the ingot dose rate and surface contamination levels in accordance with developed methods. Besides, the control of contamination of the ingots lots by means of selection and measurement of the metal samples by gamma-spectrometer prior to metal casting into molds is provided. Residual contamination of the ingot metals is regulated by ГOCT P 51713-2001 “Ingots of ferrous and non-ferrous metals. Permissible levels of gamma-emitting radionuclides. Method of radiation control” [3].

SRW (slag, dust, non-metal enclosures, etc.), from RMW processing from all three departments of the complex is collected and packed into standard metal containers and delivered to the Leningrad NPP for processing. Secondary SRW is packed into 200-liter metal drums and delivered to the contractor or to long-term storage. Liquid RAW drain waters from decontamination rooms is collected into receiving tanks at the decontamination department, and discharged to a tank for liquid RAW at the Leningrad NPP via special sewage pipes. Gaseous radioactive waste from the fragmentation, decontamination and remelting departments is passed to the common ventilation system and discharged to atmosphere through the 20-24 m tall stacks.

More detailed characteristic and main results of the complex operation for processing and disposal of RMW for the period of 2002-2003 are represented in works [4, 5].

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Five years of experience show this technical solution provides safe operation and allows work on different RMW management independent of the type of material (non-ferrous and carbon steels, non-ferrous metals and alloys), structural peculiarities and dimensions (pipelines, armature, large-size thick-walled equipment, etc.), radionuclides and level of radioactive contamination. The equipment in the complex and applied technology produce metal ingots suitable for unlimited use for industrial purposes in accordance with the requirements of the effective SanPiN.

### **Results of Operation upon RMW Processing and Disposal of the Leningrad NPP**

Practical experience of the JSC "ECOMET-S" for RMW management was first acquired as a result of RMW processing from the Leningrad NPP. Prior to commissioning of the industrial complex, RMW processing from the Leningrad NPP was performed at the experimental industrial facility, located at the site of the Leningrad special industry complex "Radon". In this period (1996-2001) 3360 tons of RMW was processed, most of which was waste from the low-pressure condenser (LPC) tubing composed of copper-nickel alloys.

The main portion of the processed RMW was disassembled technological equipment, pipe lines, shut-off and control valves, heat exchanger tubing, metal structures, details of the attachments, etc., from units 1-4 of the Leningrad NPP.

Besides this waste with surface contamination, the upper and lower tail parts of channels were processed. The aim of this processing is volume reduction and the ingots were directed to the temporary storage at the Leningrad NPP.

The JSC "ECOMET-S" also possesses experience in processing large-sized equipment in the form of parts and tanks (bowls) of the main circulation pump (HCP). The HCP provides circulation through the active zone of RBMK-1000 reactor to the heat exchanger. The pump is centrifugal, vertical, single-stage with shaft sealing. The following component parts of the pump were subjected to processing:

- tank (bowl) with the axial feeding and radial pressure tubes;
- parts, including shaft, impeller, hydrostatic bearing, shaft sealing;
- cover with the neck and HCP base.

The weight of the parts without the electric motor was about 30 tons. Parts of HCP were stored at the RMW station temporary storage and dismantled area. In all 25 units of disassembled equipment was processed. Delivery to the complex and processing of the HCP tanks represented a complicated technical task due to their mass and size.

Operations at the Leningrad NPP site on the HCP tanks were performed within the period of September-November, 2004. HCP tanks were stored at one of the sites of the station with muffled internal hollows and technological apertures. Internal hollow of the HCP tanks after removal of the portable part was isolated from external environment by a metal sheet, welded upon the tank perimeter on. The HCP tanks are mainly carbon steel. Internal surface of the tanks is plated by non-corrosive steel of the thickness of ~8 mm thick. The gamma-emitting dose at the tanks surface did not exceed 0.3  $\mu\text{Sv/h}$ , at the area of the technological apertures the gamma-emitting dose was up to 2.0  $\mu\text{Sv/h}$ . Separate areas of the external surfaces of the HCP tanks were sealed by plates in order to reduce the gamma-emitting dose. In all 15 HCP tanks, 10 of them represented by 62 K mark of the weight of 33.3 tons each, and 5 of them represented by 62 K mark of 26 tons each, were situated at the site. HCP tanks dimensions are 2900 mm in diameter, 2500mm in height.

Transportation of the HCP tanks was performed by means of trailer with the special stand. For performing loading and unloading operations were performed by a mobile crane with a lifting capacity of 50 tons was used.

Preliminary fragmentation of the HCP tanks by means of gas cutting at the specially equipped site was performed prior to transport to the JSC "ECOMET-S" building. HCP tank perimeter was cut into two parts, which were loaded on the trailer and transported to the acceptance and fragmentation department of the complex, where radiation surveys were conducted and further cutting was performed. The gamma-

emitting dose from the separate areas of the internal working surface of the tanks was  $3.0 \mu\text{Sv/h}$ . The main radionuclide content of contamination was  $\text{Co}^{60}$ ,  $\text{Cs}^{137}$ .

Tanks cutting was performed at the flux-oxygen cutting facility. Thickness of the metal cut was 150-250 mm, maximal thickness if 300 mm. External view of the HCP tank of the partial cutting is represented in Fig.4. In all each HCP tank was cut into 130-135 fragments of the weight of 200-250 kg each. As a result of one HCP tank cutting 1.5 tons of waste in a form of scale and slag was produced on the average.



Fig. 4. External view of the HCP tank after partial cutting.

Cut fragments were placed into technological containers and were directed to the decontamination department. HCP tank fragments decontamination was performed by means of bead-blasting facility within 20 min (mass of RMW nonrecurring loading is  $\sim 1$  ton). Processed metal fragments were unloaded into containers and directed to radiation control. The internal working surface of the tanks had local areas of radioactive contamination with gamma-emitting dose rates up to  $0.4 \mu\text{Sv/h}$  remained. The gamma-emitting dose on the exterior surface of the ingots formed after melting should not exceed 0.01 to  $0.02 \mu\text{Sv/h}$ .

From the decontamination department the HCP tank fragments were delivered to the remelting department. After melting slag was removed and liquid metal samples obtained. Melted metal was poured into to the molds, after cooling-down the ingots were pulled out of the molds and directed to the radiation control. The radiation characteristics of ingot samples must correspond with criterion of unlimited usage. Processing 15 HCP tanks which weighted 463 tons resulted in 843 ingots that weighted 430 tons total. These ingots (a lot is of 30-40 pcs) met sanitary and epidemiological limits were directed to the metallurgical industry for unlimited usage.

The slag, used refractory-lined materials, worked-off fraction, dust as well as scale and slag from fragmentation department were placed into  $2 \text{ m}^3$  containers for solid radioactive waste and directed to the RAW processing complex at the Leningrad NPP. On average one bowl of HCP processing depending on the type, resulted in 2 to 2.5 tons ( $1$  to  $1.25 \text{ m}^3$ ) of the secondary radioactive waste. A total of 35 tons ( $17 \text{ m}^3$ ) of the secondary radioactive waste was generated from processing the HCP tanks.

Thus, the "ECOMET-S" complex efficiently processed and disposed of large contaminated equipment from the Leningrad NPP. This acquired experience can be used for processing and disposal of the large contaminated equipment for another NPP.

### General Results of the Practical Activity

Over its life the enterprise has processed more than 9 thousand tons of low-activity metal waste from NPPs. Most of RMW (more than 8.000 t.) was delivered form the Leningrad NPP. RMW equipment was

sent to temporary storage for disassembly. Recently sending RMW to temporary storage was fully discontinued. Now RMW is sent directly from the station in 10 m<sup>3</sup> containers (YKTH-10000) or in station owned 2 m<sup>3</sup> containers for SRW. Use of the JSC “ECOMET-S” has practically eliminated RMW accumulation in temporary storage. This recovered a storage capacity for SMW of at least of 10000 m<sup>3</sup>. RMW processing from the Leningrad NPP has resulted in more than 6 thousand tons of metal ingots directed to metallurgic industry for unlimited use.

Based on the results of “ECOMET-S” operation at the Leningrad NPP, “Rosenergoatom” (of which all NPPs of the Russian Federation are related) has determined that using the production capacities of “ECOMET-S” for processing low-activity metal waste from other nuclear plants to be reasonable. In 2004 the first lot of the RMW from the Kurskaya NPP, and in 2006 – from Smolenskaya NPP, was processed. Summary data on the results of RMW processing from the nuclear plants of the “Rosenergoatom” concern (for July, 1<sup>st</sup>, 2008) is represented in the Table I.

Table I. Results of Activity of the JSC “ECOMET-S” upon Processing of the Metal Waste, Contaminated by Radioactive Substances, from the Nuclear Power Plants of the Russian Federation

Characteristic denomination	Nuclear Power Plant		
	Leningrad NPP	Kursk NPP	Smolensk NPP
Q-ty of processed RMW, including:	8031 t	686 t	466 t
-for the purpose of volume reducing (compaction)			
-in a form of large-sized equipment (of the HCP bowl);	1469 t	-	-
-from carbon steels;	463 t	-	-
-from stainless and alloyed steels;	~50 %	>90 %	>90 %
-from non-ferrous metals and alloys	~25 %	<10 %	<10 %
	~25 %	-	-
Processed RMW volume	~15000 m <sup>3</sup>	813 m <sup>3</sup>	1026 m <sup>3</sup>
Metal quantity (charge ingots), directed for unrestricted use	6035 t	621 t	431 t
Secondary SRW volume	371 m <sup>3</sup>	36 m <sup>3</sup>	29 m <sup>3</sup>
Summary activity of the secondary SRW	3.9 Cu	0.9 Cu	0.7 Cu

The processed RMW from Kursk and Smolensk NPP came from disassembled technological equipment, pipe, armature, and metal structures, generated from operation of the plants. The nature of the radioactive contamination of the waste is surface contamination. Radionuclide compound of contaminations is determined in general by radionuclides Co<sup>60</sup> (~60 %), Cs<sup>137</sup>. The external gamma-emitting dose rate is 0.2 to 200 μSv/h.

Besides nuclear power plants, the JSC “ECOMET-S” renders services in the area of RMW processing for a range of enterprises of the Fuel Element Corporation, FSE RSC “Kurchatovskiy Institute”, FSUE “SevRAO”, etc. In addition, “ECOMET-S” renders services for processing and disposal of the metal production waste with increased natural radioactive content from the oil-and-gas complex of OJSC “Rosneft” Oil Company. In all JSC “ECOMET-S” has processed more than 5 thousand tons of RMW from different enterprises and organizations, not related to the NPP.

### **SRW Transportation**

For RMW and other kinds of SRW transportation the JSC “ECOMET-S” has its own fleet of metal transport containers, developed for transportation and temporary storing of SRW. The existing container fleet provides temporary storage and transportation of up to 800 tons of RMW or other types of SRW.

RMW transportation to the enterprise from other NPPs is performed by railway transport:

-in the metal transport containers КТБН-3000 (lifting capacity is of about 3 tons, the capacity is 2.0 m<sup>3</sup>), certified in the prescribed manner as a type “A” package for low-activity SRW transportation by motor-vehicle or rail modes of transport;

-in the universal large-capacity transport containers for low-activity SRW of YKTH-24000 type (lifting capacity is up to 20 tons, the capacity is 32 m<sup>3</sup>), developed based on ICC 20 containers as an industrial packing for transportation of the low-activity SRW. External YKTH-24000 container view is represented in Fig.5. More detailed information referring to universal large-capacity transport container YKTH-24000 and the JSC “ECOMET-S” experience upon carriage of the low-activity RMW is represented in the work [6].



Fig. 5. Universal large-capacity transport container YKTH-24000.

### Intended Performance

At the present time, the contract for works execution for removal of radioactive metal waste from NPPs of the concern “Rosenergoatom” is at the stage of realization between FSUE concern “Rosenergoatom” and JSC “ECOMET-S”. Metal waste, relating to the category of the low-activity solid radioactive waste in accordance with requirements of sanitary rules SP AS-03 [7] and representing the following are subjected to removal:

- waste of ferrous and non-ferrous metals, non-corrosive steel, located at the sites of the temporary storage of the nuclear plants of the Contractor, and anew forming ones in a process of their operation and repair;
- pipelines, check valves, elements of building and assembly structures, as well as large-sized equipment (heat exchangers, steam generators).

RMW is transferred to the JSC “ECOMET-S” at the industry site of the NPP by lots in a quantity of ~50 tons by means of its shipment into transport containers, certified for carriage of the low-activity SRW by railway. Necessary quantity of the empty transport containers is assigned to the JSC “ECOMET-S”. Loading works are performed by NPP representatives. Upon results of RMW acceptance two-sided Delivery-Acceptance Certificate is signed, in which the quantity of RMW shipped, date of shipping, radiation characters of RMW (radionuclide content, specific activity) are noted.

Responsibility for transportation of RMW from the industrial site territory of the NPP to its own industry site is borne by the JSC “ECOMET-S”.



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According to the present contract besides deliveries of RMW from the Leningrad NPP to the end of 2008 for processing, RMW delivery from Kursk, Smolensk and Novovoronezh NPPs in a quantity of up to 900 tons is expected. RMW delivery for processing from Beloyarsk and Kalininsk NPPs is planned.

One of directions of the JSC "ECOMET-S" activity in the area of SRW management is establishing a service for radioactive thermal insulation. Thermal insulation waste processing based on mineral filament (glass fiber, basaltic fiber) shall be performed by means of melting at the electroslag remelting facility. The SRW volume, directed for burial, can be reduced by 20-30 times. The annual capacity of the electroslag remelting facility for radioactive thermal insulation is 2000 m<sup>3</sup>. By the end of 2008 the phase connected with project documentation for the facility development shall be completed. The facility shall be assembled and commissioned on the territory of the Leningrad specialized industrial complex "Radon".

Production capacities of the facility shall be used first for thermal insulation waste processing, accumulated at the Leningrad NPP.

### **CONCLUSION**

The JSC "ECOMET-S" has developed an efficient RMW management system with practical results. The results show that the JSC "ECOMET-S" is capable of handling the RMW removed from the NPP sites of "Rosenergoatom". Today the JSC "ECOMET-S" is an exclusive contractor of services for RMW processing, accumulated and generated at the nuclear power plants of the Russian Federation.

In all, the acquired experience, compliance with the existing regulatory and legal framework, production capacities and container fleet for SRW transportation, existing scientific and technical personnel allow the JSC "ECOMET-S" to take the lead in radioactive metal waste from the operation of the nuclear power plants and other objects of the nuclear-fuel and oil-and-gas complex in Russia.

At the present time the JSC "ECOMET-S" represents a single specialized enterprise in the Russian Federation for RMW management. For performing of this activity, "ECOMET-S" has a status of a sole source enterprise for having the required licenses and corresponding resolution documents from supervisory and controlling authorities. After the audit in May, 2008, the enterprise was issued an ecological certificate of conformity to the requirements of the international standard ISO 14001:2004.

The JSC "ECOMET-S" enterprise is considering to be a reliable partner for solving the problem of low activity RMW from nuclear power plants and other industries in a safe and environmentally acceptable manner.

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