Industrial Exploitation of Testing Ground for Treatment of Radioactive Waste of Alkaline Coolants under Decommissioning of Fast Research Reactors

K. Butov[1], V. Smykov[1], M. Kononyuk[1], A. Zhurin[1]

[1]State Scientific Centre of the Russian Federation – Institute for Physics and Power Engineering named after A.I. Leypunsky (SSC RF – IPPE), Obninsk, Russia

E-mail contact of main author: bets@ippe.ru, butik-k@mail.ru

Abstract. Since 2002 at site of Research Reactor BR-10 (Obninsk) implemented actions in transition period between final shutdowns and decommissioning. For this at site of reactor was arranged Industrial Ground for treatment of total volume of spent alkaline coolants and contaminated their individual equipments of reactor. For processing of total amount of coolants organized Conditioning Site. Currently, is carrying out work on conditioning of secondary sodium. For removed non-drainable sodium residues from internal surfaces of individual equipments organized Neutralization Site. Currently, is carrying out work on neutralization of following cold trap oxides from primary circuit.

Key words: decommissioning fast reactor, spent sodium and sodium-potassium alloy coolants, non-drainable sodium residues.

1. Introduction

Since 2002 Research Reactor BR-10 (BR-10) has a status of decommissioning. Now, BR-10 is implemented in transition period between final shutdown and decommissioning. These works are connecting with bringing of BR-10 in nuclear-safety and radiation-safety condition.

In accordance with Decommissioning Project of BR-10, before dismantling of major equipments and systems of reactor, works must contain the remove nuclear materials (last batch submitted for processing in 2016) and liquid radioactive waste, which also include spent alkaline coolants. As a coolants at BR-10 were used a sodium and sodium-potassium alloy. Thus, after 46 years of operation, has accumulated about 18 m^3 of radioactive waste of alkaline coolants, including sodium from 16 cold traps oxides (CTO) from primary circuit with radioactivity above 10^8 Bq/kg [1].

For implementation of activities in transition period at BR-10 was established Industrial Ground for treatment of total volume and non-drainable residual of radioactive waste of alkaline coolants, which are contaminated in individual equipments of reactor and in storage tanks.

2. Industrial Ground

Industrial Ground is located in placements of BR-10, which were used during operation of reactor. Main equipment is located in adjacent rooms to reactor hall for accesses to boxes with contaminated equipment and to storage tanks with spent coolants.

Composition of Industrial Ground includes Testing Ground for treatment of spent coolants, which consists of three units. The first unit is Magma for conditioning of total amount of sodium and sodium-potassium alloy, the second – unit Luisa-RW for neutralization of non-drainable sodium residues in separate equipment, the third – unit Getter for cleaning sodium-potassium alloy from impurities of mercury [2].

The principles of operation of Testing Ground are founded on technologies which have experimental and estimated studies sufficiently for events during Decommissioning Project of BR-10, as well as some major technologies, which are used for treatment, has protected by patents of Russian Federation [3].

In accordance with Decommissioning Plan treatment of total amount of spent coolants must to begin of secondary sodium (about 4,5 m^3), after which – primary sodium (about 4,5 m^3). The final step is conditioning of sodium-potassium alloy (about 9 m^3), purified from impurities of mercury. Work on neutralization of non-drainable sodium residues form individual equipments carried out in parallel with conditioning.

2.1 Conditioning Site

For treatment of total volume of spent coolants organized Conditioning Site. Conditioning Site consists of placement for preparation of reaction vessel (RV) and placement for processing.

Ongoing Site activities include: preparation, transporting of oxidant and alkaline coolant at placement for processing; reaching stationary operating parameters of equipments and systems; portion holding of spent coolant; cooling and transporting of product of conditioning for temporary storage.

At placement for preparation of RV *(see FIG.1.)* are carrying out following activities: a) to fitting-out RV of branch pipes, b) to load oxidant in RV, c) sealing of RV, d) heat processing of oxidant in RV, e) to load of RV in protective container, f) sending RV to placement for processing.

FIG. 1. Placement for preparation of RV.

For prepare of RV for conditioning it is necessary to fitting-out internal elements (branch pipes and cover for thermocouples) and load oxidant (granulated slag from copper smelting industry). Then, RV is sealed and installed into furnace for heat processing of oxidant. To withstand specified temperature conditions, RV is unloaded from furnace and moved at placement for processing in protective container *(see FIG.2.)*.

FIG. 2. Protective container with RV.

RV in protective container enters at placement for processing with temperature of oxidant required for conditioning at that time, as coolant is delivered by use of separate pipe from storage tank to metering tank of unit Magma.

Prepared RV loaded into shaft-furnace and connected with systems of unit Magma. After pressurization of systems is carried out process of coolant conditioning which includes reaching to stationary operating parameters and portions processing of coolant [4]. All operations are carried out remotely from control room *(see FIG.3.)*

FIG. 3. Conditioning Sites control room.

After cooling in shaft-furnace RV with product of conditioning is disconnected from systems of unit Magma, discharged from shaft-furnace and placed in protective container. RV moving in protective container to temporary storage site where it is unloaded and protective container is returned to load of new RV.

The firsts RV with product of conditioning of secondary sodium has been investigated with purpose of optimizing ongoing high-temperature processes and modernization design of RV in terms of performance and safety requirements *(see FIG.4.)*.

FIG. 4. Modernized RV with final product (70 liters of secondary sodium).

Currently, at Conditioning Site is carry out of work on conditioning of secondary sodium, processed more than 1 m^3 of secondary sodium.

2.2. Neutralization Site

For removal of non-drainable sodium residuals from inside surfaces of individual equipments was organized Neutralization Site [3]. The main goal for operation of Neutralization Site is treatment of spent CTO which are using in primary circuit.

Ongoing Site activities include: transporting CTO from storage protective box; draining of coolant from CTO; neutralization of residues inside of amount of CTO; washing and decontamination of internal surfaces; transporting CTO at site for treatment of solid radioactive waste.

At Neutralization Site are carrying out following activities: a) setting CTO in protective box, b) connection with draining sodium system, c) draining of sodium from CTO, d) disconnection from draining sodium system, e) connection with system and equipment of unit Luisa-RW, f) neutralization of non-drainable sodium residues into CTO *(see FIG.5.)*, g) cleaning and decontamination of internal surfaces of CTO, h) disconnection CTO from unit Luisa-RW, i) transport CTO to reprocessing as a solid radioactive waste.

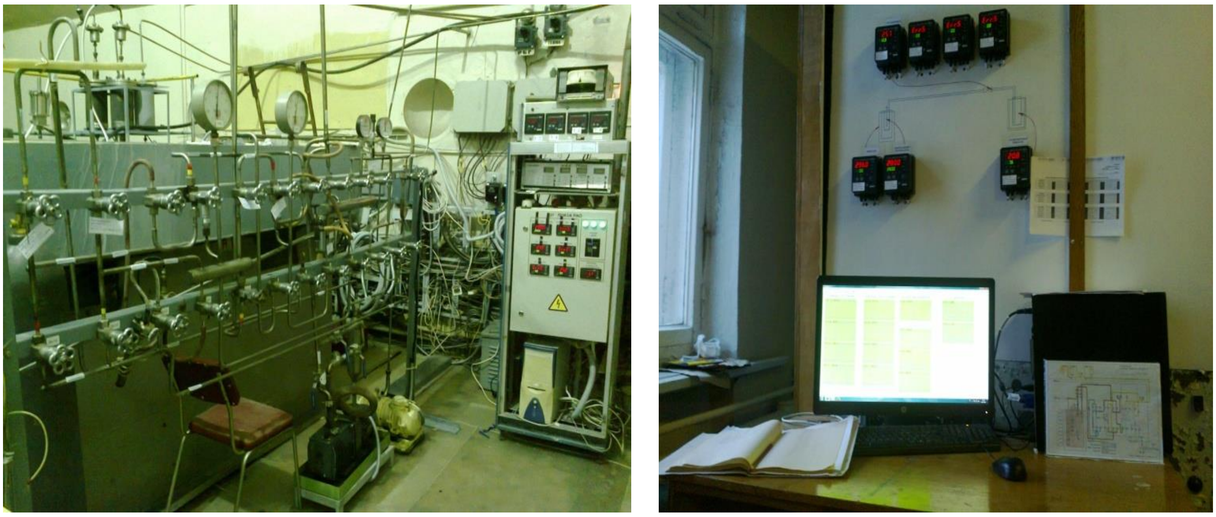

FIG. 5. Neutralization Sites control rooms.

CTO comes out on Neutralization Site from storage box, sets in protective box and connects to draining sodium system. Drainage is carried out sequentially from two cavities of CTO. After draining of maximum possible amount of sodium CTO is disconnected from draining sodium system and connects to system and equipment of unit Luisa-RW.

Then, on unit Luisa-RW, is carry out neutralization of non-draining sodium residues at expense of portion filing and circulation of mixture of inert and oxidizing gases into internal volume of CTO [4].

During controlling of neutralization process by material composition of exhaust gases, neutralization process finish and proceed to washing and decontamination CTO with water solutions. After drying CTO is disconnected from unit Luisa-RW and extracted from protective box. Washed and dry CTO is transporting to reprocessing as a solid radioactive waste.

Currently, there is neutralization of following CTO from primary circuit, drained amount of sodium is sent to Conditioning Site. Two CTO from secondary circuit and one CTO from primary circuit already were subjected on Neutralization Site.

3. Conclusion

Thus, organized Industrial Ground for treatment of total volume of spent coolants and contaminated them individual equipments can meet needs of BR-10 Decommissioning Project. Recently, is revealing the reserves at existing Testing Ground to increase conditioning portion of coolant, thereby to improve performance.

Together with secondary sodium conditioning is preparation for treatment of primary sodium. By this time was developed number of measures to prevent possible contamination of internal surfaces of equipments and pipelines for provision of radiation safety requirements.

After execution of activities of conditioning of spent coolants from BR-10, it will be possible to condition spent alkaline coolants delivered from other fast research reactors during their decommissioning.

References

[1] INTERNATIONAL ATOMIC ENERGY AGENCY, Treatment of Residual Sodium and Sodium Potassium from Fast Reactors, Review of Recent Accomplishments, Challenges and Technologies, IAEA-TECDOC-1769, IAEA, Vienna, Austria (2015).

[2] SMYKOV, V.B., BUTOV, K.A., ZHURIN, A.V., KOMAROV, E.A., Research Reactor BR-10 – Testing Ground for Conditioning of Radioactive Waste of Alkaline Liquid-metal Coolants under Decommissioning Project, (Proc. Int. Conf. IAEA–CN–238, Madrid, Spain, 2016).

[3] KANUKHINA, S.V., KONONYUK, M.H., BUTOV, K.A., SMYKOV, V.B., The Estimated and Experimental Issue of Technology of Solid-phase Oxidation of Alkaline Metal by Slag from Copper Smelting Industry, Atomic Energy, T. 120, Vol. 6, Moscow (2016).

[4] SMYKOV, V.B., et al., Treatment of radioactive waste alkaline liquid metal coolants of research reactor BR-10, Nuclear and Environmental Safety (international journal), N. 3 (2011), p. 105.