PROPOSALS ON AMB SNF MANAGEMENT

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Abstract

The first commercial AMB reactors at the Beloyarsk NPP were shutdown in 1981 (the AMB-100 reactor) and in 1989 (the AMB-200 reactor). The SNF was discharged from the reactors and is presently stored in the cooling pools at the Beloyarsk NPP and in the storage pool at PA “Mayak”. The peculiarities of the AMB SFAs are as follows: a variety of ~ 40 types of fuel compositions, big dimensions, a complicated SFA configuration. The main problems for the AMB SNF handling at the Beloyarsk NPP are an unsatisfactory state of the fuel rods, corrosion of the SFA canisters and the cooling pool lining made of carbon steel sheets. At PA “Mayak”, all AMB SFAs are stored in stainless steel canisters. A special facility for pre-reprocessing preparation of the AMB SNF is planned to be constructed at the PA “Mayak”. The problem of the AMB SNF management is being resolved in two parallel directions: (1) ensure safe storage of the AMB SNF at the Beloyarsk NPP as a top-priority urgent task, (2) develop a technology and equipment for the AMB SNF reprocessing at the RT-1 plant of PA “Mayak”. Results of the work are addressed in the paper.

1. INTRODUCTION

The first AMB power reactors at the Beloyarsk NPP (BNPP) were shutdown in 1981 (the AMB-100 reactor) and in 1989 (the AMB-200 reactor). The SNF was discharged from the reactors and is presently stored in the cooling pools at the Beloyarsk NPP and in the storage pool at PA “Mayak”. The specific features of the AMB SFAs are as follows:

— A variety of ~40 types of fuel compositions;
— Large overall dimensions (the length of a sfa is ~13 m);
— A complicated sfa configuration.

At the Beloyarsk NPP the SNF is stored in cartridges made of carbon and alloyed stainless steel. The main problems in the AMB handling are heavy damage to the fuel rods, corrosion of the SFA canisters and the cooling pool lining made of carbon steel. At PA “Mayak”, all the AMB SFAs are stored in stainless steel canisters.

The main options for the AMB SNF management are:

(1) Shipment for temporary storage with subsequent solution of the reprocessing problem;
(2) Shipment for long-term storage with subsequent disposal;
(3) Cutting and canistering at the NPP, shipment for reprocessing to the PA” Mayak”;
(4) Delivery of SFAs to PA” Mayak”, cutting and reprocessing.

The disadvantages of dry storage of the AMB SNF are:

— Lack of justification for the safe transport and storage of assemblies because of the nuclear and radiation safety problems and hydrogen accumulation during storage and transport;

— Large dimensions and high cost of the ventilated storage;
— Lack of experience and regulating documents;
— Complication of the future reprocessing due to the ongoing SNF degradation during its storage.

As a result, a decision was made to reprocess the AMB SNF at Mayak.
It is supposed that a special building will be built at Mayak for preparation of the AMB SNF for reprocessing.

The problem of the AMB SNF management is being solved in two parallel ways:

— Ensuring safe storage of the AMB SNF at the Beloyarsk NPP as a top-priority and urgent task;
— Development of the technology and equipment for the AMB SNF reprocessing at the RT-1 plant of PA "Mayak".

For the purposes of realization of the AMB SNF reprocessing, the following problems are being solved:

(1) Development of the chemical reprocessing technology for all types of the AMB SNF;
(2) Design of the building at PA "Mayak" (cutting and containerizing facility — DCF) for the pre-reprocessing preparation of the AMB SNF, including the SNF stored at Mayak and the fuel stored in cartridges in case of their delivery from the Beloyarsk NPP;
(3) Development of two technologies for the SNF transport from the Beloyarsk NPP;
(4) According to one of them, SFA cartridges will be transported from the Beloyarsk NPP to Mayak and then cut at the DCF;
(5) According to the second technology, the cartridges and SFAs will be cut directly at the Beloyarsk NPP using the Complex of Equipment for Safe Cutting (CESC).

2. CHEMICAL REPROCESSING OF AMB SNF

Investigations carried out several tens years ago by the VNIINM experts demonstrated that, in principle, the AMB SNF could be reprocessed by the classical PUREX process, but that work was not tied to the RT-1 plant technology.

Therefore, reprocessing of spent AMB fuel at RT-1 is feasible, but there are a number of problems that need to be addressed at the stage of the scientific research. One of such problems is its transportation and cutting into fragments. The compositions of the AMB SNF vary to a great extent. The fuel composition may contain from 1% to 20% of ^{235}U and may consist of uranium oxide, metallic uranium, magnesium, calcium and molybdenum. For each fuel type, safe conditions of dissolution must be carefully chosen to prevent formation of explosive hydrogen concentrations.

A significant portion of spent AMB fuel also contains from 3– 9% of metallic molybdenum, dissolution of which may cause precipitation of both molybdenum and zirconium molybdate, which can entrap plutonium and cesium.

Problems may also occur during the evaporation and vitrification operations, which are part of the liquid radwaste processing. The spent AMB fuel reprocessing technology must be well built into the existing RT-1 processes. At present, the development of the chemical part of the

process is nearing completion and there is an absolute certainty in its implementation at Mayak.

3. AMB FA CHARACTERISTICS

Design of the AMB SFA is shown in Figure 1.

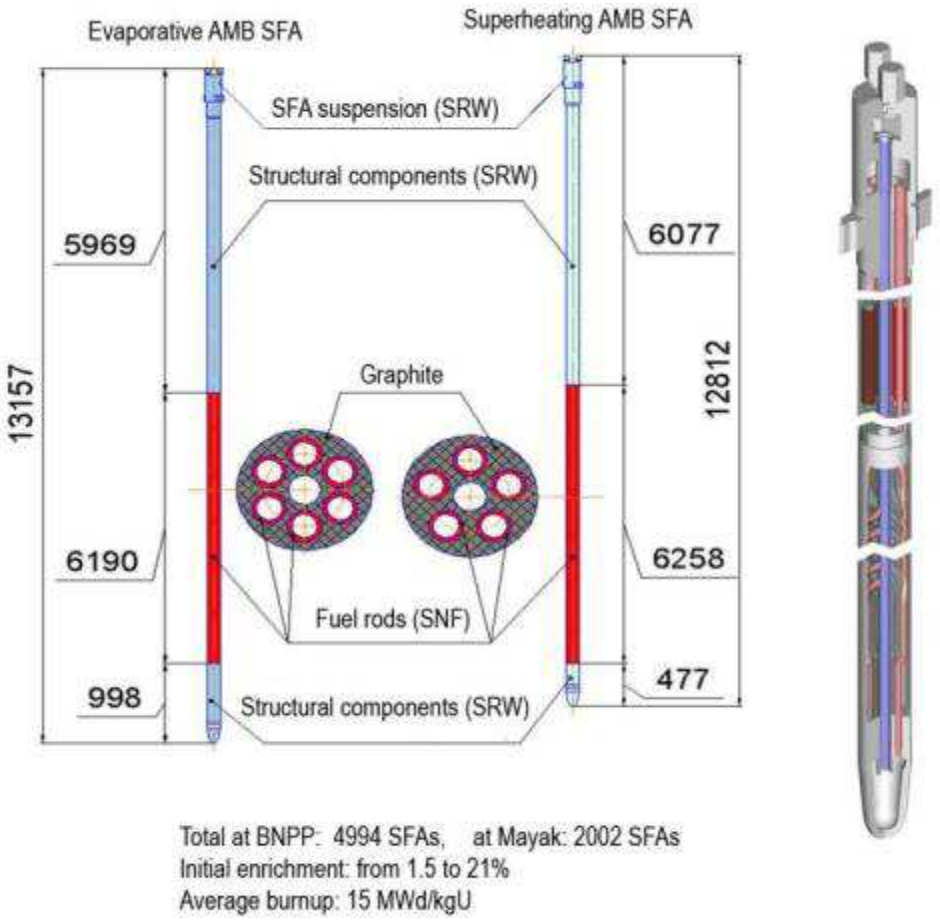

FIG. 1. Design of the AMB fuel assembly.

The SFAs are stored in tubes in 17- and 35-seat cartridges (bundles) K-35 and K-17, respectively. All 95 cartridges of K-35 and 6 cartridges of K-17 are made of stainless steel; 139 cartridges of K-17u are made of carbon steel. At present all carbon steel cartridges are loaded into the thin-walled stainless steel canisters.

4. PREPARATION OF SPENT FUEL FOR SHIPMENT TO MAYAK

The main principles of the proposed technology for spent AMB fuel management.

By the first option all the SNF canisters are delivered to Mayak for reprocessing. There, at the DCF, the assemblies are cut into fragments and the fuel part is loaded into the thin-walled leak-tight canisters in which it is sent for reprocessing.

By the second option the following operations are performed:

(1) Separation of the fuel component from solid radioactive waste at the Special Cutting Facility (SCF) in the appropriate cooling pool;
(2) Loading of spent fuel into canisters meeting the Mayak requirements;
(3) Use of the TK-6 casks for transport of canisters from Beloyarsk NPP to Mayak;
(4) Reprocessing of canisters containing the SNF at Mayak after loading the canisters directly through the cooling pool (without the use of the DCF);
(5) Loading of solid radwaste into containers and solving the problem of its handling.

Maybe a decision will be made to use both options of the AMB SNF transport to Mayak.

The design concept:

— Meet the requirements of the NPP and nuclear fuel cycle (SNF) standards simultaneously;
— Adaptation of new production into the existing building at the Beloyarsk NPP of the first stage of construction;
— Own infrastructure to prevent the additional loading on the existing NPP systems for the basic production process.

In accordance with the concept all the work is subdivided into the following tasks:

(1) Development and implementation at Mayak of the chemical technology for the AMB SNF reprocessing;
(2) Investigations in support of the design solutions and safety analysis of the work;
(3) Design of tools, equipment and supporting systems;
(4) Manufacturing of the equipment and tools mockup;
(5) Final study of the technical decisions on the equipment and tools using the mockups. Personnel training;
(6) Preparation of the necessary technical, organizational and licensing documents;
(7) Fabrication of the basic equipment and tools;
(8) Mounting and commissioning work at the Beloyarsk NPP in accordance with the layout (Fig. 2);
(9) Practical work;
(10) Decommissioning of the equipment involved in the practical work.

5. RESULTS OF INVESTIGATIONS IN SUPPORT OF THE FIRE AND EXPLOSION SAFETY OF THE LEAK-TIGHT CANISTERS CONTAINING CUT AMB SNF FROM THE BELOYARSK NPP

Based on the analysis of the experimental data, the volume fraction of hydrogen accumulated for 5 years in the canister with cut and dried AMB fuel at the Beloyarsk NPP (OM9 in magnesium matrix) is estimated at less than 0.15% that confirms the fire and explosion safety of the package. The hydrogen accumulation rate for fragmented fuel under the water layer is 2–3 orders of magnitude higher than that for the dried SNF. Therefore, the explosive hydrogen concentration (4%) in the canister with the wet leaky SNF is formed in a day after its storage!

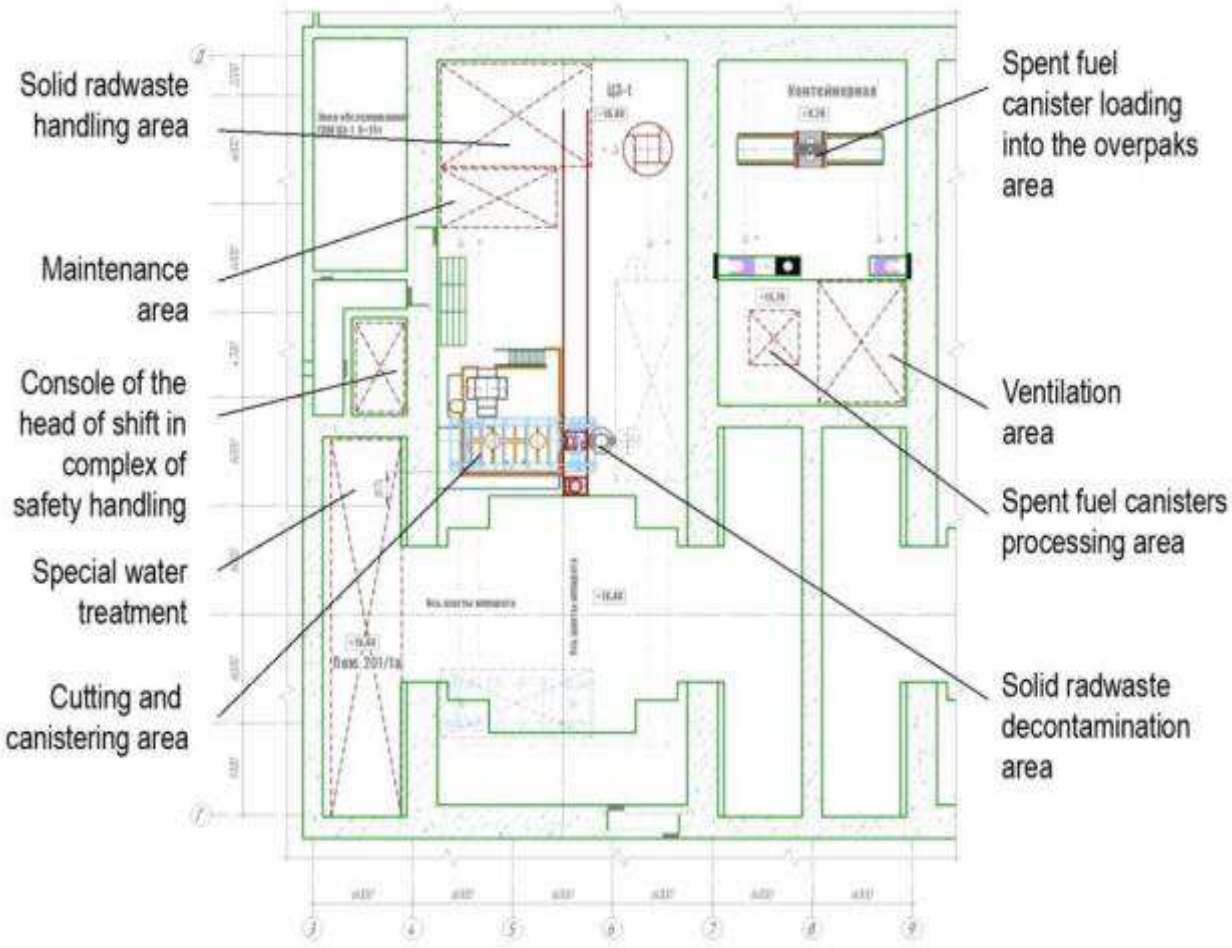

FIG. 2. Layout of the equipment at the Beloyarsk NPP.

It is assumed that the SFAs at the Beloyarsk NPP will be cut in water using the equipment located in the NPP hall (Fig. 3).

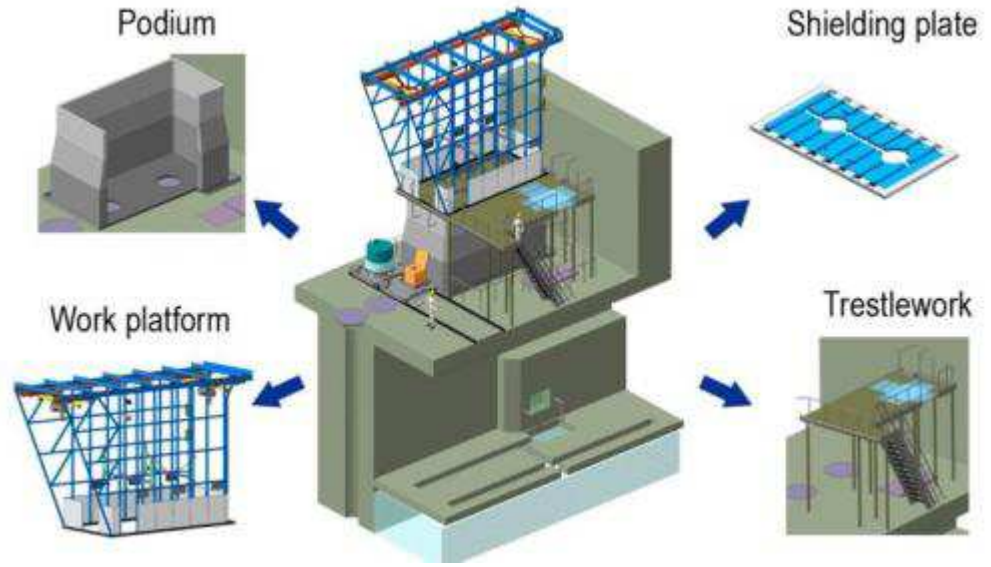

FIG. 3. View of the facility for cutting the cartridges and loading the SNF into canisters.

Fig. 4 schematically shows movements of cartridges containing the SFAs, their fragments as well as solid and liquid radioactive waste.

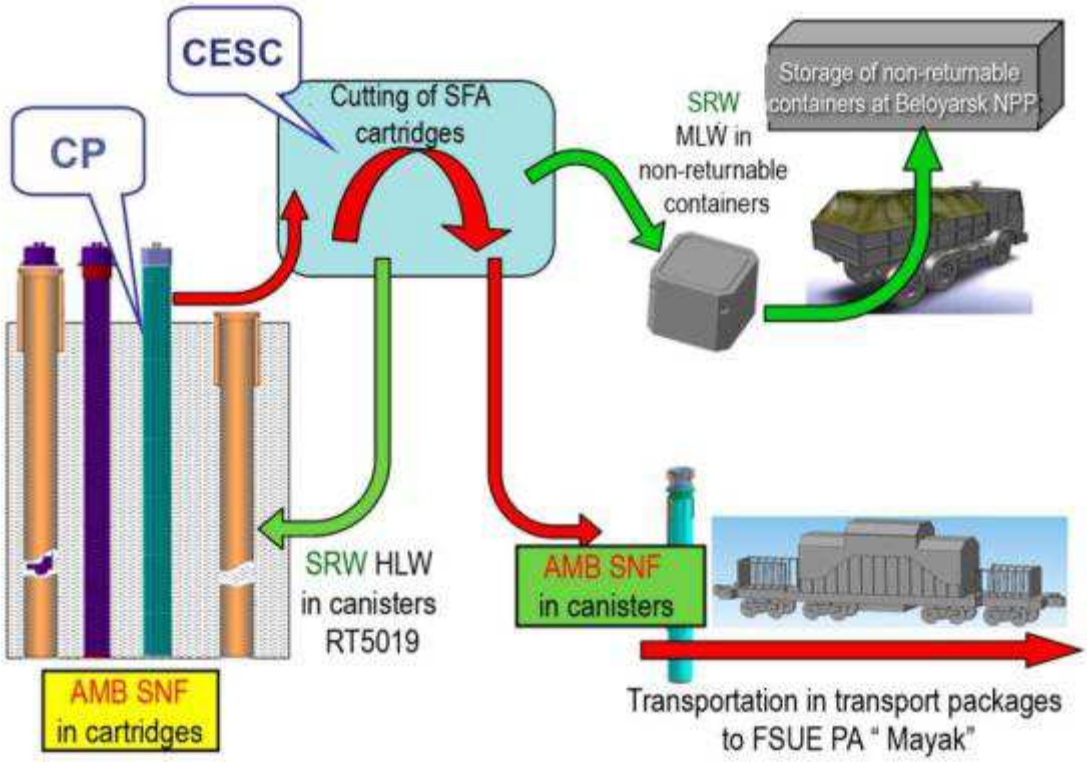

FIG. 4. Handling of the AMB SNF at the Beloyarsk NPP.

The DCF design principles (Figs 5 and 6):

1. Cutting the SNF using the water technology similar to that used at the BNPP;
2. If possible, tools, equipment and supporting systems are designed similar to their analogues in the "BNPP" work project;
3. Provision is made to prepare the AMB SNF located both at Mayak and BNPP for reprocessing at the DCF.

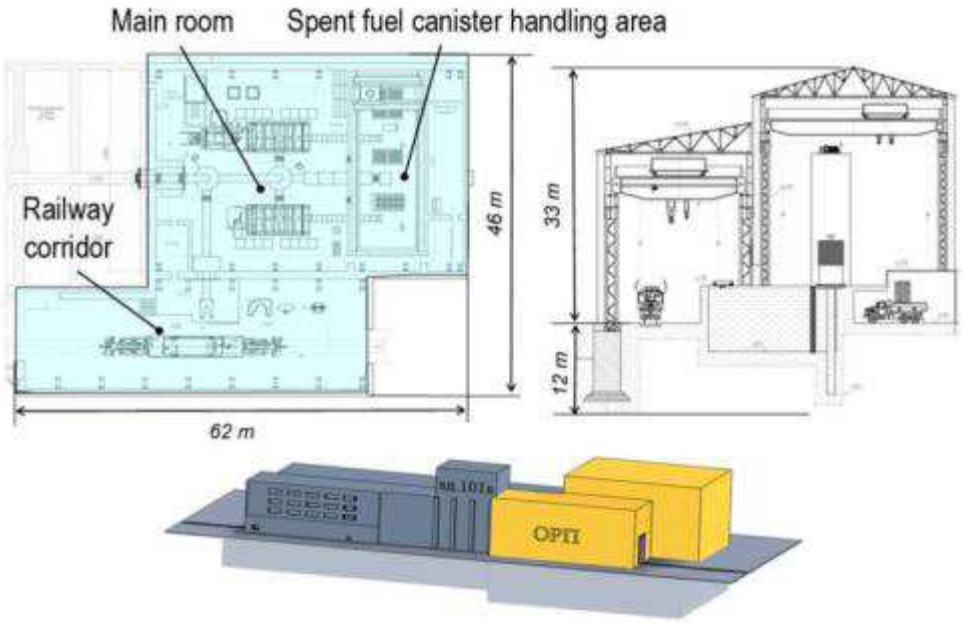

FIG. 5. Layout and configuration of the DCF building at FSUE PA "Mayak".

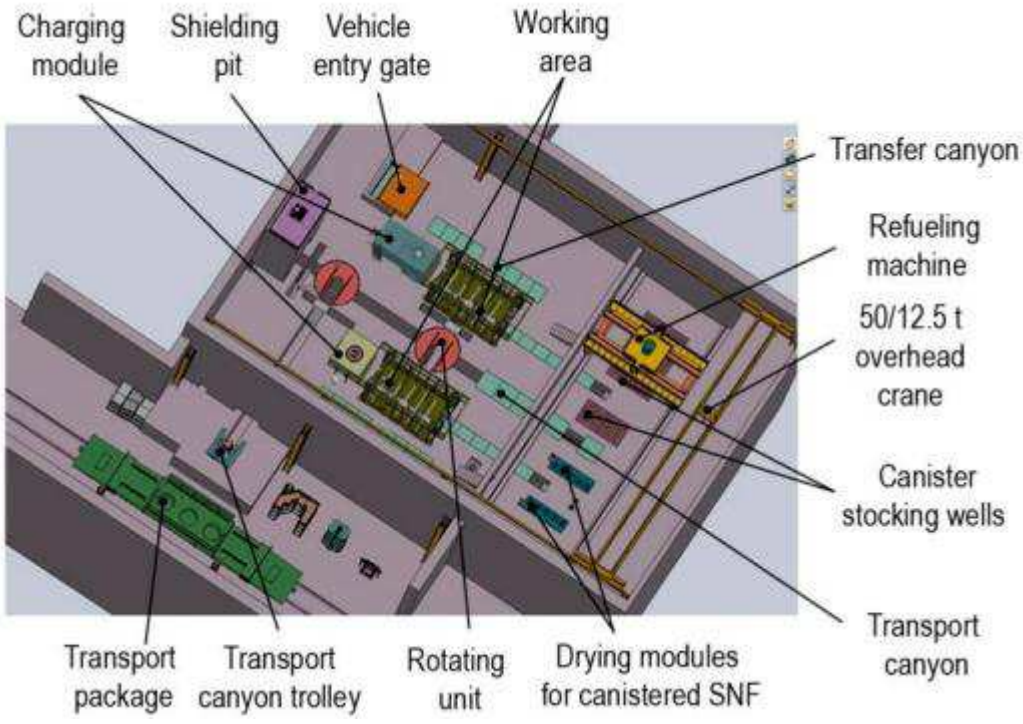

FIG. 6. Arrangement of the basic equipment in the DCF building.

6. CONCLUSIONS

The paper provides the decision on the AMB SNF handling, which consists in the following:

(1) Development of the chemical reprocessing technology for all types of the AMB fuel;
(2) Construction of the facility for cutting the AMB SNF cartridges (DCF) at Mayak and loading of the fuel composition into the tight canisters with the subsequent reprocessing at Mayak site;
(3) Development of the equipment for cutting the cartridges containing failed SNF into fragments, loading of fragments with the fuel composition into canisters and their delivery to PA “Mayak” for reprocessing;
(4) Delivery of the assemblies containing undamaged fuel assemblies from the Beloyarsk NPP to Mayak (DCF), their cutting into fragments, loading into canisters and reprocessing;
(5) The DCF will be used for handling the AMB SNF cartridges located at Mayak.