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CURRENT STATE OF WWER SNF STORAGE IN RUSSIA AND THE PERSPECTIVES

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Introduction

30 nuclear power units of 20.8 GW total installed capacity are being operated now in the Russian Federation. They produce about 16% of electric power of the country. 6 WWER-440, 8 WWER-1000 power units are in operation. Yearly spent fuel discharge from WWER reactors is ~87 t (~ 700 SFA) of WWER-440, ~220 t (~ 435 SFA) of WWER-1000 reactors, respectively.

WWER-440 SNF is reprocessed at RT-1 plant near Cheliabinsk. WWER-1000 SNF is supposed to be reprocessed at RT-2 plant which will be built about 2020.

In all the cases the interim “wet” storage of WWER spent nuclear fuel is an obligatory stage of the nuclear fuel cycle. WWER SNF is cooled in at-reactor cooling pools for no less than three years. At the NV NPP an independent storage facility for WWER SNF has been built in which SFA may be additionally cooled for no less than 10 years.

The information on the capacity and fill up level of the at-reactor pools at NPP with WWER reactors considering its modification up to May 2005 is given in Table 1.

As it can be seen from Table 1, in case of no dispatch, the capacity of the existing at-reactor WWER-1000 SNF storage facilities may be exhausted in the nearest years.

Table 1 - Cooling pool and SFSF capacity at the NPP up to 23.05.2005

NPP	Number of SFA		Capacity after modification	Number of free places
	WWER-440	WWER-1000		
Balakovo	-	856	1767	911
Volgodon	-	151	594	443
Kalinin	-	540	848	0
Kola	799	-	2577	1778
Novovoronezh	416 -	- 97	1330 259+ 812 (SFSF)	914 162+ 574 (SFSF)

The requirements to SNF "wet" storage facilities

The wet technique of WWER reactor SNF storage is a prevailing one and will remain as such within the nearest years. SNF of WWER-440 reactors is stored in at-reactor cooling pools and in the wet storage at RT-1 plant. WWER-1000 reactor SNF is stored in at-reactor cooling pools and in a central wet storage at RT-2 plant. The information about WWER SNF management techniques, requirements to the wet and dry storage conditions was presented at the Third international seminar on WWER reactor fuel characteristics, modeling and experimental support, Pamporovo, Bulgaria, October 1999.

In agreement with the regulatory safety documents which are in force in the Russian Federation, the following requirements are set forth to all SNF "wet" storage facilities:

- fuel location in the pool should provide nuclear safety in storage and shipment considering all possible departures from normal operation;
- in agreement with the Federal norms and rules for NPP, radiation safety of the personnel in the storage operation should be provided;
- fuel condition during storage should be checked;
- fuel integrity in the storage should be guaranteed;
- SNF decay heat removal should be provided;
- water should be cleaned from radioactive substances entering the water with surface contaminations and from damaged fuel rods, as well as from corrosion products;
- water leak into the environment should be prevented by the storage facility design excluding water ingress into the ground;
- radioactive substances release into the atmosphere in higher than permissible levels should be excluded;
- possibility of SFA with defective FE isolated storage should be provided.

To meet these requirements in at-reactor independent SNF storage facilities at NPP and SNF reprocessing plants, the following principle design and engineering solutions were taken:

- placing of fuel assemblies in the pool in a way that the water level above them and the pool wall thickness met the radiation safety requirements;
- cooling pool fitting with the systems of water cooling and purification, water make up to maintain the required level, water pool filling and emptying, ventilation of the above-water space, engineering and radiation control equipment;
- stainless steel lining of the pool surfaces;
- leaks control from under the pool lining and their accumulation to prevent entering into the neighboring rooms or the ground;
- storage of fuel assemblies with damaged fuel rods in tight canisters.

Provision of radiation safety and the environmental protection are also achieved by a complex of measures in spent fuel storage, in particular:

- location of the storage in the sanitary protection zone;
- zonal lay-out of the building rooms with the provision of the sanitary lock;
- collection and removal of liquid and solid radwastes;
- timely decontamination of transport and handling equipment and vehicles;
- radiation monitoring both inside and outside the storage building.

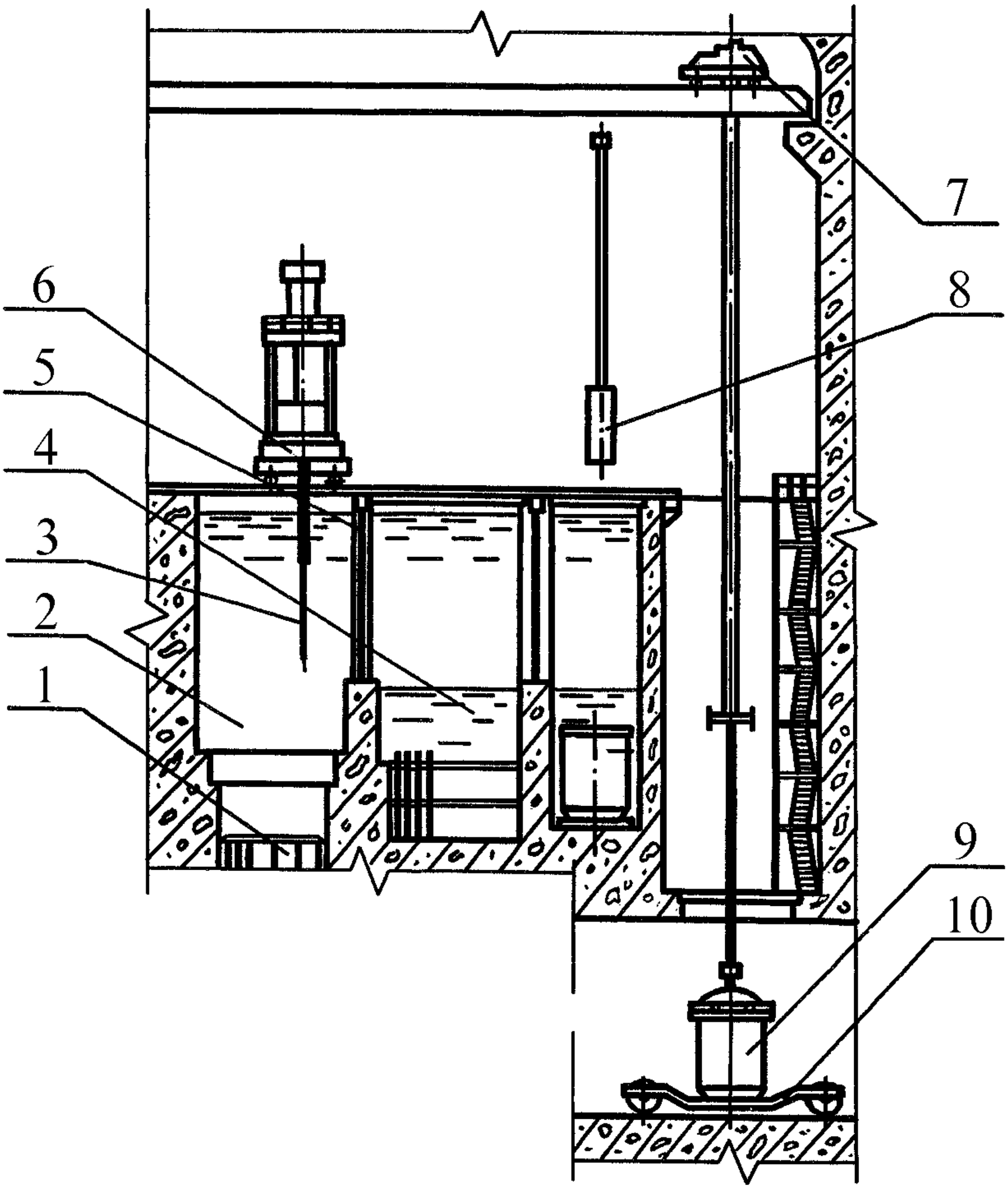
The storage facility is designed with due account to all external impacts characteristic of this region, initial events which may cause a radiation accident, failure of equipment and personnel errors.

WWER-440 SNF management

By this time are realized nearly all phases of the accepted closed fuel cycle concept for WWER-440 SNF interim storage, transportation to RT-1 plant, reprocessing and production of UO_2 and Pu, except for construction of a disposal facility for conditioned high-level wastes from radiochemical reprocessing and organization of mixed uranium-plutonium fuel (MOX) production for fast reactors.

WWER-440 nuclear fuel after its discharge from the reactor is stored in at-reactor cooling pools (Fig. 1). They are designed for 3-year fuel storage. The at-reactor storage facilities are equipped with a full complex of process and lifting and conveying machines to fulfill spent fuel reception, storage and issuing operations.

The water quality in the cooling pool is determined by the specified norms. pH value at 25 ºC should be higher than 4.3, chlorine– and fluorine-ion concentration should not exceed 0.15 mg/kg, the boric acid concentration – no less than 12 g/kg. The two-stage water purification system maintains water transparency at the level of no less than 90 %.



1 – reactor; 2 – reactor well; 3 – FA; 4 – cooling pool; 5 – lock;
6 – reloading machine; 7 – crane; 8 – basket; 9 – cask for SFA; 10 – truck.

Fig. 1 - **AR cooling pool for WWER-440 spent fuel**

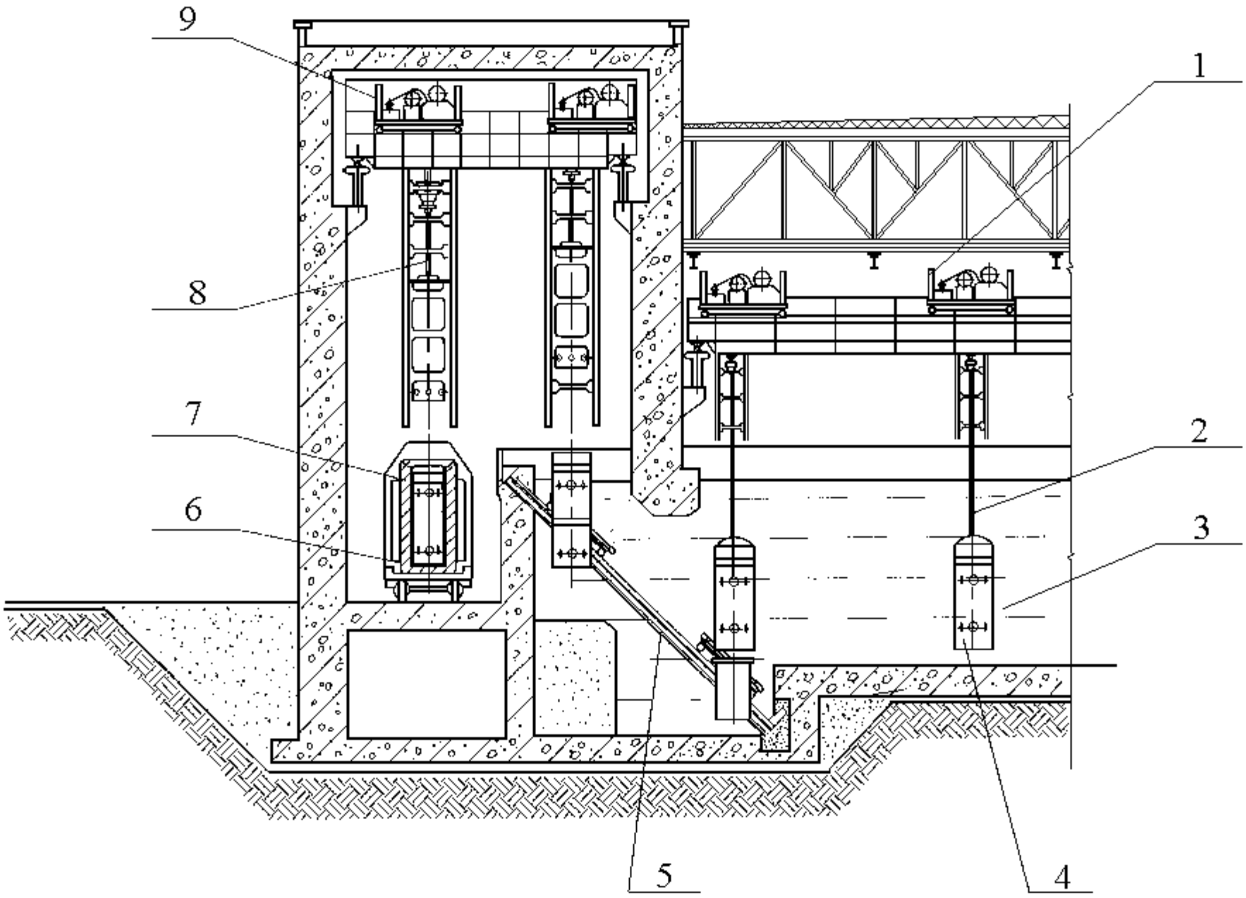
To check the assembly condition during storage, industrial TV sets are used. The indirect control is achieved by means of periodic analysis of radiochemical composition of water. The cooling pools are equipped with systems providing safe management of spent fuel assemblies. When discharged from the reactor, each SFA should go through the fuel rod cladding tightness control stand. For this, SFA is placed in a special canister from which after its tightening water and gas samples are taken by a special technique. The probable tightness loss of the assembly is determined by the isotopic gas composition and fissile product content in the water sample. The detected untight FAs are loaded into tight canisters for further storage. The canisters are placed in the cooling pool.

Spent fuel having achieved the specified 3-year cooling is sent to RT-1 plant for reprocessing. SNF is shipped in TK-6 cask-wagons.

At RT-1 plant spent fuel is being stored now in the storage facility of building 101A which has 4 bays for different reactors types SFA storage. One of the bays is intended to store 210 baskets with WWER-440 SNF (Fig. 2).

At RT-1 plant it was planned and done earlier reprocessing of WWER-440 SNF of foreign NPP built from the designs and with the assistance of the former USSR. By some reasons foreign SNF is not arriving for reprocessing now. The reprocessing volume has decreased for to-day to 100 t per year with the design capacity of 400 t per year.

Due to this and considering that RT-1 plant service life in case of the equipment modification may be rather large, now the version of gradual reorientation of the plant for reprocessing of WWER-1000 SNF is being studied. As the first phase of such RT-1 plant modification, construction of a regional “wet” storage facility is considered, which will be designed to receive as well 1600 t of WWER-1000 reactor SNF.

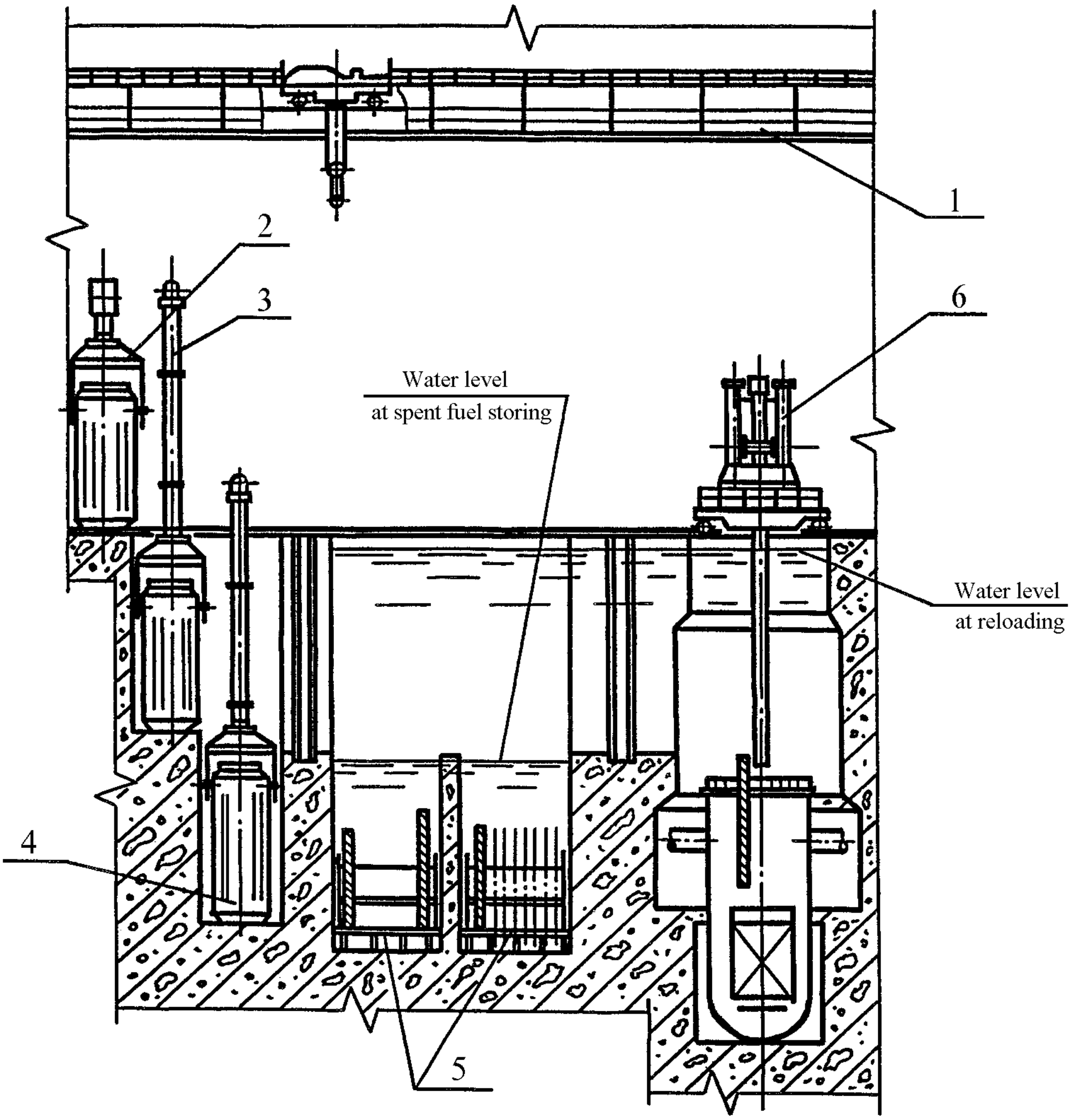


1 - Crane; 2 - Grip; 3 - Cooling pool; 4 - Storage basket; 5 - Trolley;
6 - Cask wagon; 7 - Cask; 8 - Rod for the cask; 9 - Crane

Fig. 2 **- SF reception and storage compartment at PO "Mayak"**

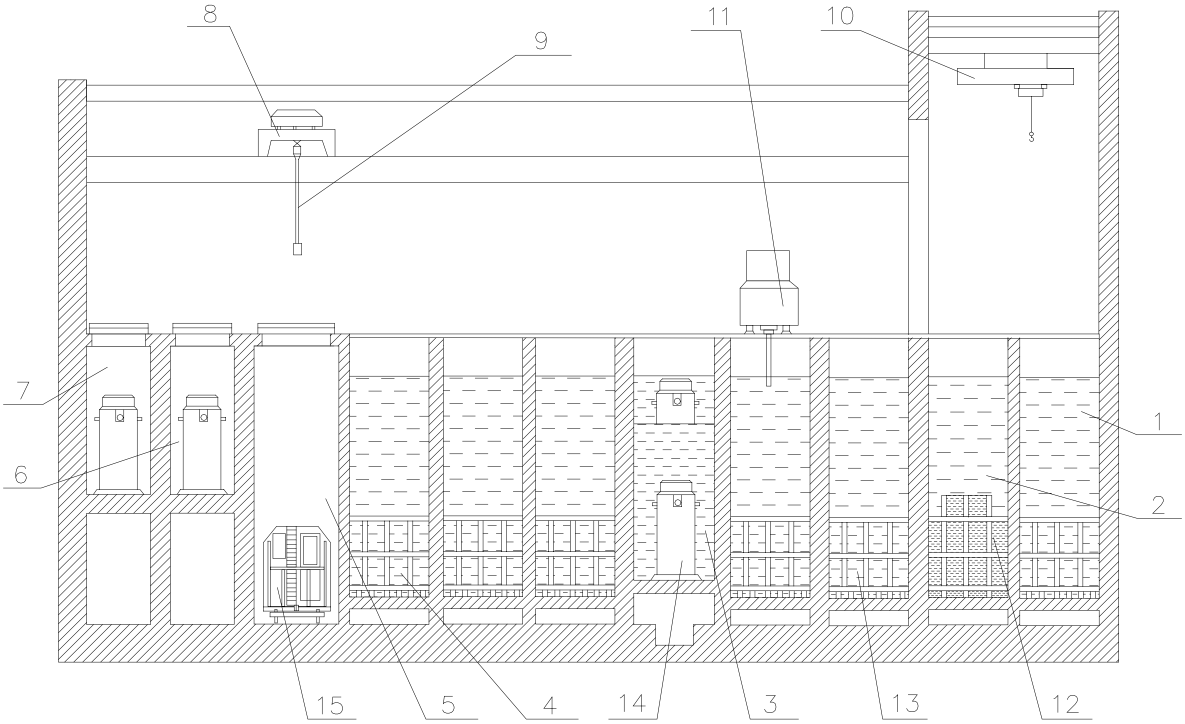
WWER-1000 SNF management

At all NPP with WWER-1000 reactors SNF being discharged from the reactor arrives for storage to at-reactor cooling pools (Fig. 3). Cooled in the at- reactor pools, SNF of the serial WWER-1000 reactors goes to interim storage of RT-2 plant at MCC which is a central WWER-1000 SNF storage. Irradiated SFAs of unit five of the Novovoronezh NPP are sent for storage from the at-reactor storage facility to an independent spent fuel storage facility (SFSF) located in the territory of the NV NPP near the power unit (Fig. 4).



1 – circular electric crane, 320+160/2+70 lifting capacity; 2 – cross-bar for spent fuel cask; 3 – rod for a cask; 4 – shipping cask; 5 – cooling pool racks; 6 – reloading machine.

Fig. 3 - **At-reactor cooling pool for WWER-1000 spent fuel**



1-storage compartment for BAR; 2-storage compartment for spent cassettes; 3-intake compartment; 4-standby compartment; 5-transport corridor; 6-decontamination well; 7-decontamination test bench; 8-crane, 1/c 160/32 t; 9-cross bar; 10-crane-beam of 1/c 10 t; 11-handling machine; 12-spent FA; 13-rack; 14-cask (TK-13); 15-vehicle.

Fig. 4 - **Interim bay for SNF of WWER-1000 reactors**

WWER-1000 SNF storage facilities are steel concrete structures lined with steel sheets. Steel sheet connection is by welding. WWER-1000 SFA are stored on racks placed on the pool bottom.

SNF is reloaded into the at-reactor cooling pool at the shut-down reactor through a special reloading bay which functions only at the reactor shut-down. Before beginning of the planned reloading the bay is filled with borated water and is connected with the storage pool and the reactor. At NPP with WWER-1000 a “wet” reloading method is accepted with the use of the refueling machine which under protective water layer withdraws fuel assemblies from the reactor core and transfers them into the storage facility located nearby.

Spent fuel is reloaded once a year with change of 1/3 of the core, i.e., annually 54 – 55 SFAs are discharged from the reactor. The at-reactor cooling pool for WWER-1000 spent nuclear fuel of 1100 m^3 total volume is divided into 3 bays. The first bay and a half of the second one are occupied by the main rack for SFA. Besides, in the second bay a rack for fresh fuel assemblies is placed, where they are located before loading into the reactor. The third bay contains a stand-by rack for emergency unloading of fuel from the core.

For design purpose the total cooling pool capacity is assumed based on the possibility to locate in it 2.5 reactor cores simultaneously (three annual reloadings plus an emergency unloading of the core) ~165 tU. Spent tight FA are installed in the rack cells of the cooling pool. There are cells in the racks to locate tight canisters with defective (untight) FA. The space between the cells is 400 mm on equilateral triangle.

The requirements to the pool water quality are as follows:

- transparency, %, no less than 90
- pH, no higher than 4.3
- chloride and fluoride concentration (in sum), mcg/kg 100
- boron acid concentration, g/l 12

Water chemistry in the cooling pools is maintained by introduction of necessary chemical reagents and water cleaning by a special water purification system. The need to introduce chemical reagents and actuation of the special water purification systems are determined by the chemical analysis results. For water purification a two-stage diagram is used. On stage one water is purified from suspended corrosion products, on stage two – from dissolved salts, on both stages purification from radioactive contaminations is done simultaneously.

To inspect fuel assembly condition during storage, industrial TV sets are used. The indirect control is achieved by measurement of the specific radioactivity and analysis of radiochemical composition of water. To remove heat from SFA, there is a cooling system in the at-reactor storage facility which is periodically actuated keeping water temperature in the pool at about 30 ºC.

The interim storage facility at the Novovoronezh NPP is designed to store spent FA of WWER-1000 reactors of the fifth power unit of the NPP.

The storage facility capacity is determined based on the storage condition of SFA arriving for no less than 10 years and equals 770 SFA (~ 330 t of uranium).

SFA, AR CPS and burnable absorber rods are stored under the layer of water on the racks with a pitch 400 mm in triangular lattice.

The storage bays for spent fuel are located in one row on both sides of the bay for container with spent FA reception.

Besides, the storage facility includes: decontamination bay, radiation monitoring bay and process support compartment. The decontamination bay includes a pit and decontamination and coating stands. The bay for SFA container receipt is stepped with two seats for containers. In placing the container on the upper seat the lid is disengaged, on the lower seat the container unloading (loading) is done. The storage bays are connected between themselves by apertures closed by waterlocks. To store AR CPS and BAR, there is a bay similar to the SFA bay.

There are 8 bays in the storage facility, 5 of which are for SFA storage, 1 – for cask reception, 1 – for absorber storage and 1 – stand-by.

The bays are reinforced concrete rectangular structures with a double lining and controlled system for leakage accumulation from the interlining space. The bay dimensions are: 6200 x 4400 x 16400 mm.

SFA are delivered to the storage facility either in TK-10 (6 SFA) or in WWER-1000 Castor casks (for 12 SFA).

WWER-1000 spent fuel storage facility at RT-2 plant, MCC, was put in operation in 1985 (Fig. 5). SNF is stored in baskets for SFA. A basket capacity is 12 SFA. The design capacity of the storage facility: 1100 baskets or 13200 SFA, which is about 6000 tU. At present, works are being carried out to increase the capacity due to the use of baskets with 16 SFA. The storage facility capacity after its modification will be 17600 SFA or 9000 tU. Now in the central storage facility of RT-2 plant spent fuel of Russian, Ukrainian and Bulgarian NPPs with WWER reactors is stored. The amount of stored fuel is about 3500 t WWER-1000 SNF.

The storage facility comprises: reception bay, storage bay, general transport hall and a process support compartment.

In the reception bay there are areas for cask-wagons unloading, container cooling down, emptied container washing, container preparation to dispatch. In the reception bay two container-wagons may be located at the same time.

The areas are located in separate rooms and communicate with the transport hall through the openings.

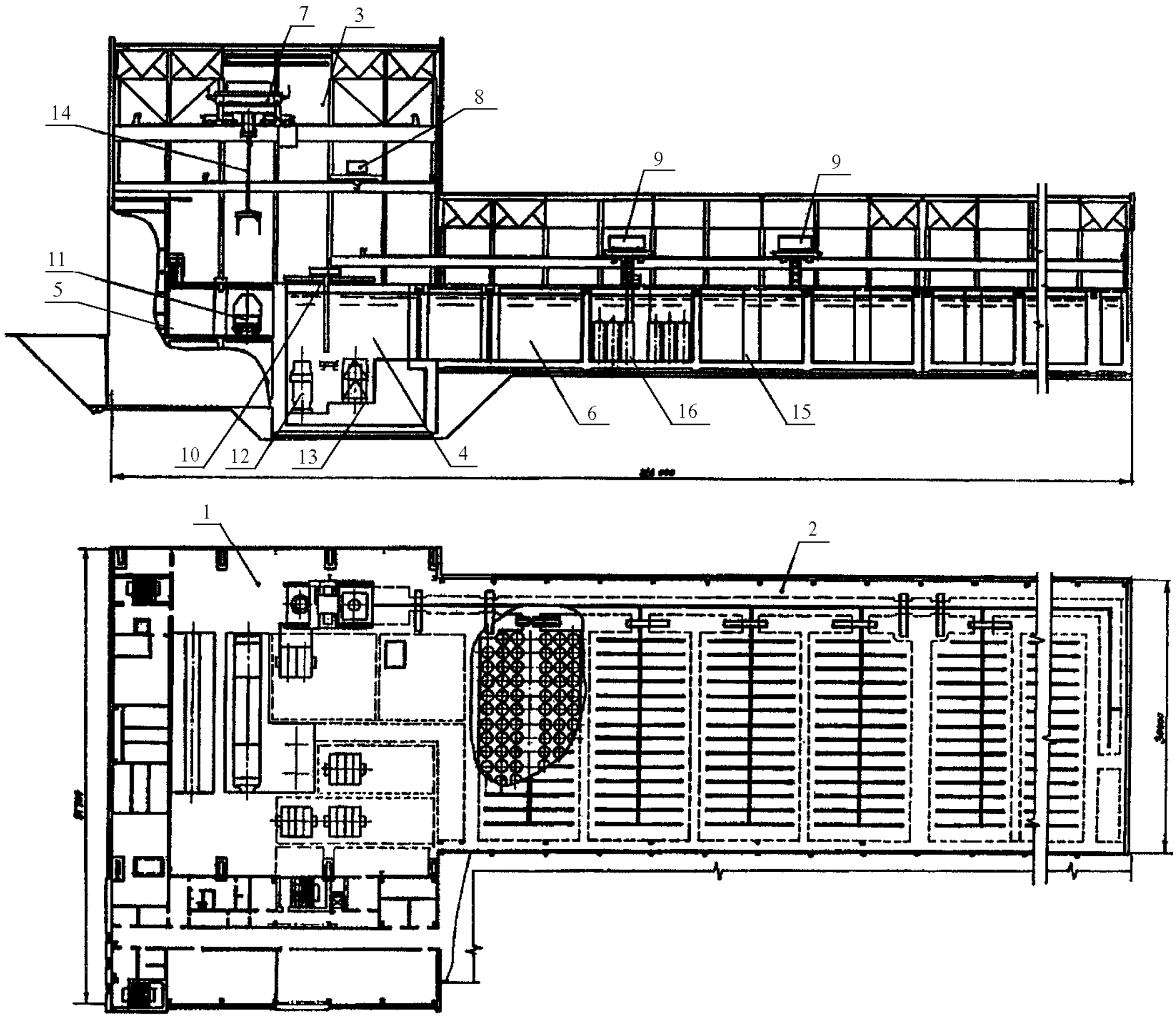
The storage area consists of a bay for SFA reloading from TUK into storage baskets and 15 storage bays connected with each other by a transport corridor. The bays are steel concrete rectangular structures lined with stainless steel. The size of the storage bays is: 23.45 x 11.30 m – 13 bays, and 23.45 x 9.05 m – two bays. The bay volumes are ~ 2200 m^3 and ~ 1800 m^3, respectively. The transport corridor and storage bays have a slotted flooring with flaps for basket carrying over the pool.

The baskets with SFA are installed on the bay bottom. The pitch of the basket placing is 1600 x 1600 mm. A bay receives 69 or 84 baskets. Each bay may be separated from the transport corridor by a water lock and emptied separately for preventive and repair works.

In the technical service bay there are heat-exchangers for water cooling to the needed temperature, filters for purification of suspended matters and soluble salts, ventilators for airsol removal and hydrogen from the above-the-surface space of the pool.

The following norms for storage water are specified:

- pH value .... 5.5÷8.0
- chloride-ion, mcg/l, no more than 100
- specific heat conductivity mcSm/cm, no more than............3
- oil products, mcg/l, no more than...................................100
- suspended matters, mg/l, no more than 1.5
- radionuclides, Bq/m^3, no more than.......................... $3.7 \cdot 10^6$



1 – intake section;
2 – storage section;
3 – transfer corridor;
4 – reloading bay;
5 – container-wagon reception bay;
6 – storage bay;
7 - crane of 160 t 1/c;
8 – cable trolley;
9 – crane of 16 t 1/c;
10 – floor machine for SFA reloading;
11 – container wagon;
12 – cask;
13 – enclosing structure;
14 – cross-bar;
15 – hydraulic gate;
16 –canister for SFA.

Fig. 5 - **Centralized storage facilities at the Mining and Chemical Combine**

The maximum permissible temperature of the cooling pool water is 50 ºC, and no exceeding of this level is supposed for the time of the storage facility operation. For water purification precoated pearlite filters (dissolved corrosion products and suspended particles) and ion-exchange filters (dissolved corrosion products and salts) were used. Hydrogen formed due to water radiolysis is removed by the above-water purge using ventilators.

WWER-1000 SNF is shipped in TK-10 and TK-13 container-wagons using TUK-10B and TUK-10B-1, TUK-13B and TUK-13/1B transport packagings.

Dry storage of WWER-1000 SNF

Because of the delay with WWER-1000 SNF reprocessing plant construction, vault-type dry storage facility construction designed for storage of RBMK-1000 and WWER-1000 reactors SNF has begun.

"Dry" storage of SNF has some advantages over the "wet" one. There is no cooling water in the dry storage, which excludes leaks of radioactive water; storage conditions are improved (as water is a more aggressive storage medium as compared to air or inert gases); so, SFA integrity is achieved due to natural convection, as no pumps are required and the share of electric equipment is reduced. Dry storage decreases the volume of secondary radioactive wastes as compared to the wet one. Dry technology makes easier to realize the modular principle of putting in operation, the construction time and operation expenses are decreased, the decommissioning procedure is simplified.

In spent nuclear fuel storage in dry storage facilities safety problems are of major importance. In "dry" storage, the same as in "wet" ones, fuel cladding integrity should be assured just up to the end of the storage time. To prevent radioactivity release, tightening of defective fuel rods is required. Dry storage facility design should foresee measures to prevent the personnel exposure and the environment contamination.

The most important characteristics of the dry storage facilities are:

- the accepted heat removal technique (forced or natural cooling);
- personnel protection method;
- location relative to the ground level (on the ground, near-surface, and completely below the ground level);
- mobility;
- the independence level of individual storage vaults;
- modularity, or possibility to increase storage capacity by means of module building on.

The requirements to the dry storage facility are the same as abroad. Besides, specific conditions of dry storage facilities are considered which should provide:

- SNF safe keeping for no less than 50 years;
- temperature conditions of fuel storage;
- possibility to retrieve SNF canisters from the storage for their inspection, from the viewpoint of the IAEA safeguard system inclusive;
- possibility, if necessary, to dispatch SNF outside the storage site at any moment;
- durability of the storage building structures for no less than 100 years;
- passive method of heat rejection from the fuel under storage;
- possibility of cleaning of heat rejection surfaces during the storage operation;
- resistance of the storage facility to external impacts (aircrash, air shock wave, missiles, earthquake, hurricane, tornado);
- possibility of simple and fast identification of radioactive contamination source;
- minimum expenses for the storage facility construction.

In selection of the central dry storage facility concept, several methods of SNF dry storage were studied. The international experience was also taken into account. At present, different types of dry storage facilities for NPP SNF are being designed and operated in foreign countries. They include vault-and-shaft (hole)-type storage facilities, dry storage systems of MACSTOR, NUHOMS type, different kinds of container stores. As a rule, the existing dry storage facilities are located on NPP sites and are intended for SNF of this NPP storage. Due to this, the capacity of the storage is limited. Central cask-type dry storages are available in Germany, in Gorleben and Ahaus.

Of the concepts studied (Fig. 6 – 8) (cask-type, shaft-type, steel concrete massif-type (SCM), vault-type storage facility) the most promising from the viewpoints of economy, safety provision and workability are the vault-type and steel concrete massif-type storage facilities.

SNF storage in the steel concrete massif-type storage (Fig. 6) is supposed to be done in special nests-shafts where the tight canisters with SNF are located in two tiers (by two canisters in each nest; each canister contains 30 RBMK-1000 fuel rod bundles or 3 WWER-1000 SFA). Heat rejection from the steel concrete massif is achieved by means of heat removal tubes with natural circulation of the cooling air. The radiation protection is provided by the steel concrete massif. The storage nests in the massif are closed with steel concrete plugs and are connected with the suction collector of the system for maintaining rarification in the storage nests and canister tightness control connected at the discharge to the ventilation system.

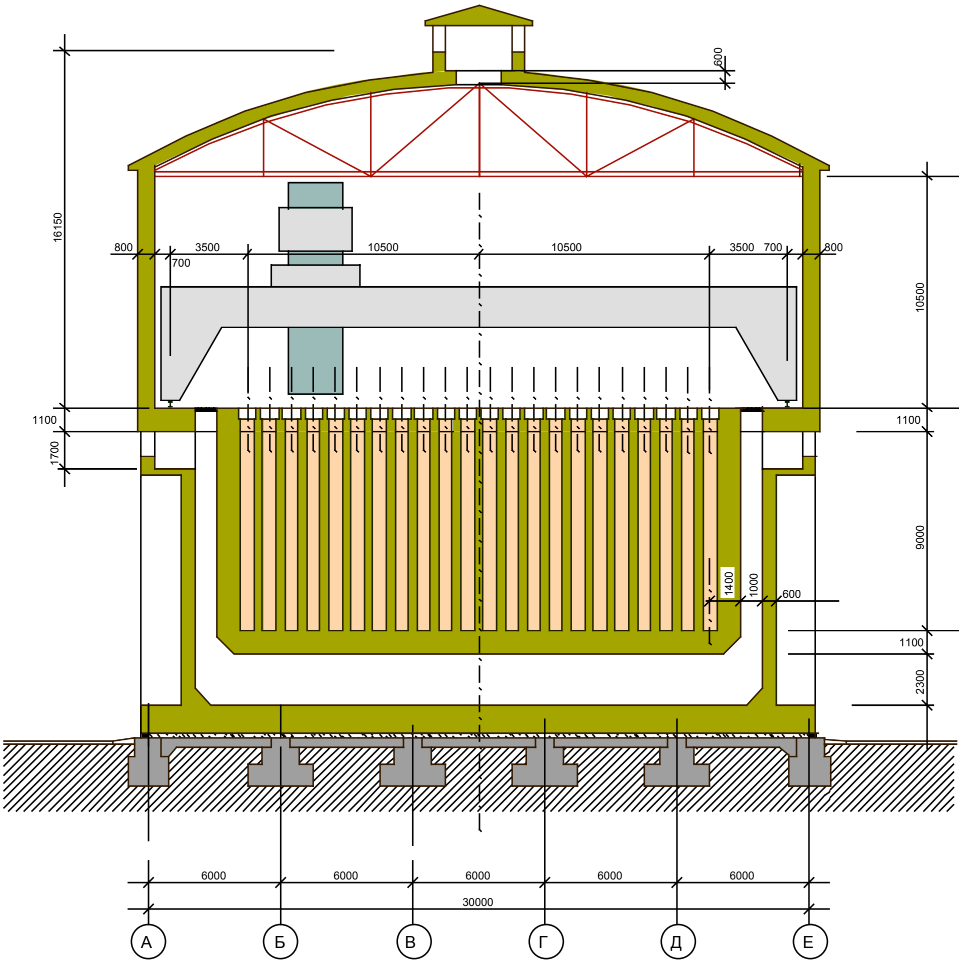


Fig. 6 - **SCM-Type Storage**

The concept of SCM dry storage facility provides for a multibarrier system of the environmental protection, durability, prevention of natural and engineering factors impact upon the stored SNF, safety and convenience for the personnel operation. The advantage of this dry storage concept is high density of fuel disposition, 3.4 t/m^2.

In the vault-type storage facility a passive method of heat removal from SNF by air is also used; SNF is supposed to be located in the storage nests (tubes), and the storage nests – in steel concrete vaults (Fig. 7). Some technical solutions are taken from the dry storage facility design of SCM type. First of all, it is the storage nest design in which the same as in the SCM – type storage the tight canisters with SNF are located in two tiers (by two canisters in each nest; each canister contains 30 fuel bundles RBMK-1000 or 3 SFA WWER-1000). Use of these nests allowed to increase significantly the storage density – up to 3.4 t/m^2.

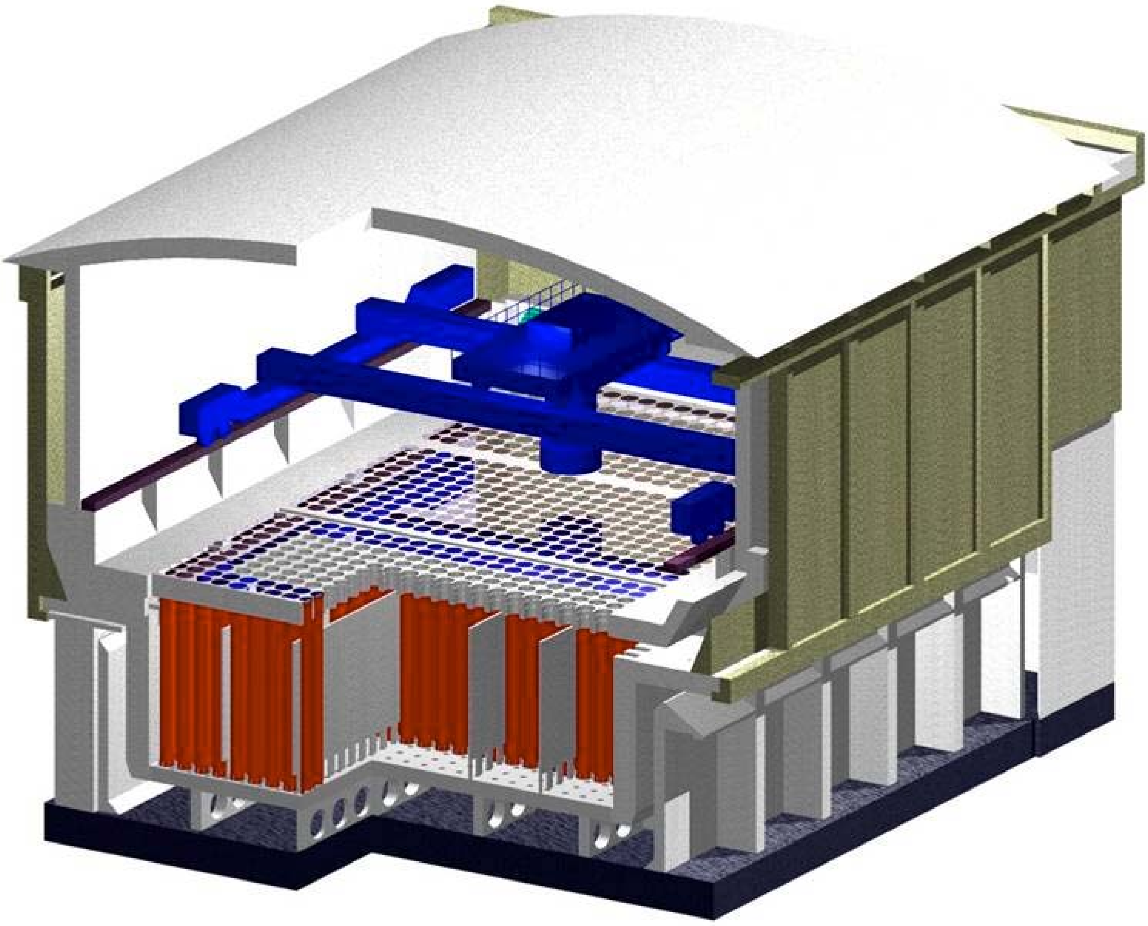


Fig. 7 - **Section of the dry storage vault**

Use of two additional tightness barriers: a tight canister (the canister tightness is achieved by welding in the storage vault SFS-2) and a tight storage nest (storage nest tightness is provided by welding on the nest location place in the storage vault) allows to realize in practice the defense in depth principle for SNF protection, which advantageously distinguishes the design of vault-type SFS-2 which is under development from the vault-type dry storage facilities operating abroad.

The pitch of the storage nests in the storage vault allows to assure non-exceeding of the maximum permissible temperature of fuel rod cladding (300 ºC for RBMK-1000 SNF and 350 ºC for WWER-1000 SNF) during the whole storage time under normal operation conditions and at initial events for design-basis accidents even in case of nitrogen use as the storage medium.

When comparing two concepts of dry storage facilities: vault-type and SCM-type, vault-type storage concept was preferred because of its cost effectiveness and possibility to locate on the existing sites of MCC.

The design capacity of the vault-type dry storage facility for WWER-1000 reactor SNF is 9Kt (20930 irradiated fuel assemblies (SFA). The period of the storage operation is 50 years.

WWER-1000 SNF arrives for dry storage directly from the “wet” storage at MCC after its cooling in water for no less than 20 years. Residual heat from the storage nests is removed by natural air flow.

The required safety level in the vault-type dry storage facility design is assured by the defense-in-depth principle. The principle is based on the “use of the physical barriers system on the way of ionizing radiation, nuclear materials, radioactive matters spread into the environment and the system of engineering and organizational measures to protect physical barriers and to keep their efficiency, as well as the personnel, public and the environmental protection”. For power reactor tight SFA, the physical barriers not depending on the dry storage concept are fuel matrix and fuel rod cladding.

Additional physical barriers foreseen by the design are:

- tight canister filled with the nitrogen and helium mixture in which 3 WWER-1000 SFAs are placed;
- tight storage well in which two canisters with SNF are placed.

Besides, the storage facility safety is provided by steel concrete structures of the facility as well as by the zonal principle of the territory (industrial site zone, sanitary-protection zone, supervision zone) and storage rooms (controlled entry zone, free access zone).

The requirements to the canister and storage nest design, material selection and tightening system are determined based on conditions of nuclear and radiation safety observation in the storage facility operation. Nuclear safety is achieved due to the canister and storage nest design, and also by storage nest location in a square lattice with a pitch of 1000 x 1000 mm. Radiation safety is provided by the choice of the canister and storage nest structural materials (stainless steel, steel 10ХСНД), as well as by the canister and storage nest tightening system – tightening is achieved by welding with provision of the third tightness class. The system of storage nest and canister check up is provided which assures serviceability of physical barriers during the storage operation.

WWER-1000 SNF storage facility is located in an independent building directly adjoining the existing “wet” storage facility for SNF. The storage facility comprises the compartment for receipt and SNF preparation to storage and a storage compartment. The compartment of spent fuel reception and preparation to storage includes: transfer corridor, canister completing chamber (CCC), SFA preliminary drying chamber, a chamber for canister with SNF discharge and some auxiliary rooms.

WWER-1000 SFA is transferred directly from the wet storage in the storage canisters through the water filled transfer corridor on a transfer platform into the preliminary drying chamber. After drying SFAs are withdrawn from the preliminary drying chamber and after burnup inspection are installed into canisters of the dry storage. After loading of three SFA into a canister a lid is placed on the canister, which is welded to the canister body. The welded canister is transferred into the nest of the tightness control unit.

In the tightness control unit the canisters and SNF are dried in vacuum to the residual moisture level of $25 g/m^3$ and filled up with nitrogen with helium addition. The canister is finally tightened by welding of the branch pipe used for drying and filling with inert gas. The canister is tested for tightness.

The tight canisters with SNF by the reloading machine are loaded into vault-type nests (by two canisters in each storage nest); the nest is tightened by welding and the storage nest tightness is checked.

In the process of long-term storage of the canisters with WWER-1000 SNF the nests and the canisters stored in them are periodically tested for tightness using a special movable device.

In case non-tight canisters are found in the nest, the latter is opened, the canisters are withdrawn and by the reloading machine are transferred into the chamber of canister completing.

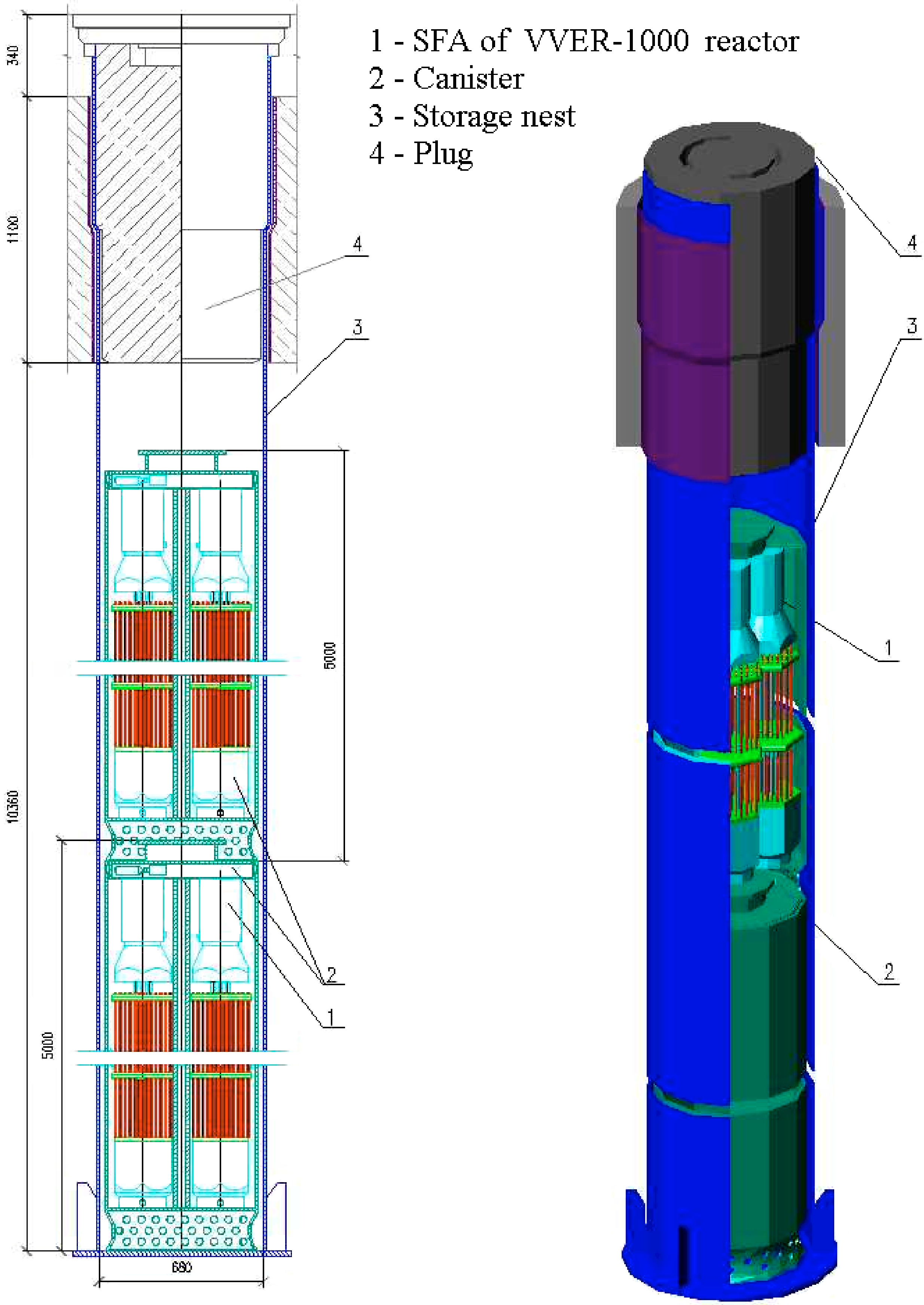
In the canister completing chamber the canisters are examined to find the reason and the place of tightness loss (cracks, pits, weld defects, etc.). If the reason is in the weld defect, additional facing (strengthening) of the weld and tightness check are made.

If it is not possible to achieve the canister tightness, it is opened (the weld is cut off) and the SFA is reloaded into another canister, which after welding and tightness check is returned into the storage well. While SFA reloading from one canister into another SFA check may be done.

The storage nest (Fig. 8) consists of the body, penetration for the nest in the storage wall flooring, shielding plug and nest movement limiter.

The main technical characteristics of the nest:

- nest head diameter, mm... 840
- the body outer diameter, mm...................................... 720
- the body wall thickness, mm 7
- the nest length, mm.. 12100
- total mass of the nest, t 2.55
- nest capacity .... 2 canisters with SFA
- SNF residual heat in a nest, kW, no more than 3.66
- material – steel 10ХСНД, the upper part of the nest body and of the shielding plug is steel 12X18H10T



1-WWER-1000 SFAs (6); 2-2 Cans for 3 WWER-1000 SFAs; 3- Storage Nest; 4-Plug

Fig. 8 – **A nest with SFA canisters of WWER-1000 reactor**

The canister for WWER-1000 SFA designed to receive 3 SFA for long-term storage in the vault-type facility consists of the body and the lid.

Main technical characteristics of the canister:

- the body outer diameter, mm... 630
- he body wall thickness, mm 7
- the canister height, mm... 5000
- mass of the canister, t 0.95
- the canister capacity .... 3 SFA
- residual heat release of SNF in the canister, kW, no more than............. 1.83
- material – steel 10ХСНД; the upper part of the body and a part of the lid is steel 12Х18Н10Т

In the conclusion it should be noted than neither Russia, nor any other country have the experience of construction of vault-type "dry" storage facilities of such a capacity to store WWER-1000 SNF (9000 tU). In the design of the facility, design solutions approved earlier in creation of other dangerous facilities were used. The calculations were based on conservative assumptions allowing with a large assurance to guarantee meeting of the requirements to provide nuclear and radiation safety, the environment protection. Studies are required to delete excessive conservatism of the taken decisions, which would significantly simplify SNF management technology and may decrease the cost of the storage facility.

At present, a program is developed for scientific-technical support of the dry storage facility design and operation, aimed at the studies whose results will allow to optimize the taken technical decisions, simplify SNF management technology and, possibly, to reduce the cost of the storage facility itself.

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