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NEAR-SURFACE FACILITIES FOR DISPOSAL RADIOACTIVE WASTE FROM NON-NUCLEAR APPLICATION

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INTRODUCTION

Near-surface facilities for disposal of radwaste are widely used now. They are used for disposal of some types of radwaste both in the countries with well-developed nuclear energy, system e.g. USA, France, Sweden, Russia and so on and in the countries, which do not have their own NPPS.

This type of facilities has a number of advantages:

simple design;

simple control;

accessibility to perform repairing works.

But application of these facilities is limited, concerning various types of radwaste. IAEA proposed quality classification of the waste, appointed for near-surface disposal (Table 1).

IAEA Classification of the radwaste, appointed to near-surface disposal depending of its radiological characteristics

Table 1

Waste class	Characteristics	Removal possibility
1. Exempted waste	Activity level is equal or less, than the permitted one, which is based on annual radiation dose for population, 0,01 mSv	no radiological limitation
2. Low and intermediate level radwaste (LILW)	Activity level, exceeds the permitted one, heat generation up to 2 kW/m^3	
2.1. Short lived waste (LILW-SL)	Content of long-lived radnuclides is limited (limitation for long-lived alpha nuclides: up to 4000 Bq/g in single packages; up to 400 Bq/g in average for one package)	near-surface or deep disposal
2.2. Long-lived waste (LILW-LL)	Content of long-lived nuclides exceeds the limitation imposed	deep disposal
3.High level waste	Heat generation is more,.that 2 kW/m^3. Content of long lived nuclides exceeds the limitation imposed	deep disposal

Necessity of these limitations results from the fact that these facilities are situated in the area of active water exchange and the migration route of radnuclides into biosphere and consequently to a man is very short. Besides they are not protected from unauthorized intrusion of a man and geological phenomena affects.

That is why, practically, all the countries established the period of institutional control for near-surface facilities, as 300 years. For some facilities this period of time can be observed with limitations, which are to be established for each facility, through the Criteria of the waste adequacy. These Criteria are elaborated on the base of safety assessment, which meets the requirement of home Norms of radiation control.

To provide the near surface facility safety, one should select the proper place for this facility location.

This problem has technical, economic and social-political aspects. It is very difficult to find the optimum solution of the problem, and the technical aspects often play the secondary role.

Multi-barrier principle is the main principle for safety provision. The natural barriers have various functions in each facility. In some cases multi-barrier principle performs the main protective function in the other ones-additional function, of "emergency barrier" and in single cases, it is not taken into consideration at all.

2. DESIGNING PECULIARITIES OF THE NEAR-SURFACE FACILITIES OF "RADON"

Near-surface facilities were designed as a port of special regional enterprises, appointed for localization of low and intermediate level waste from non-nuclear application. The first projects of these facilities were designed at the end of the 1950-th (ТП-509) and then were modernized (ТП-6069, ТП-4891, ТП-416-9-9). Typical projects were designed by the Specialized Designing Institute (ГСПИ) of Minatom RF. They were controlled by territorial designing organizations.

Facilities included the vessels for solid and solidified radwaste disposal, of the volume from 400 to 900 m^3, tanks for liquid radwaste disposal, of the capacity from 100 to 200 m^3 well-type units for spent ionizing sources with the capacity, of 0,2 m^3. Besides in the unit for solid radwaste a section for biowaste disposal was built.

A unit for solid radwaste was designed as reinforced-concrete sectional trench with the wall thickness from 0,3 to 0,6 m. Outside, additional hydroinsulation from two layers of bitumen and ruberoid was designed. The brick wall forced it. The unit had an overlap from monolithic plates. To load the packages with radwaste into the unit, one or two plates were removed, and the opening was temporary closed with metallic cover. In some cases, the overlap contained one or several plates with the holes for radwaste loading these holes were dosed with metallic covers. The further modifications of the typical project provided erection of the building from quickly mounted assembled metallic parts. This building was erected to protect the unit from penetration of atmospheric precipitation (fig.1).

The radioactive waste was disposed for long-term storage, as the removal of the waste was not planned.

Radioactive waste was packed into metallic or plastic containers or sometimes into wooden boxes and containers were loaded into the sections of the unit. The containers were of various sizes and loaded in bulk. Sometimes capsules with spent ionizing sources packed in shipping containers were boarded into the units for solid radwaste.

Radnuclide composition contained long-lived isotopes Cs-137, Sr-90, Co-60. There are also H-3, C-14, P-32, S-35, Se-75, Tc-99m, I-131 and so on. As alpha-emitting nuclides, there are: Ra-226 - as the element of the previously used luminescent apparatus of permanent action and medical devices: Pu-239, Am-241 - as sources in radioisotope smoke detectors, georadiological units, and small amounts of U and Th isotopes.

Amount of the radwaste received was written in the register. Nuclide composition and activity due to the absence of the entry-control system was taken from the additional documents, validity of that is questionable.

Sanitary rules recommended filling sufficient amount of gars, present in the loaded unit, with the cement mortar. But these recommendations were fulfilled only in some cases, due to the absence of the cementation plants.

Units for the liquid radioactive waste temporary storage are constructed as reinforced concrete tanks, equipped with vessels of stainless steel (fig.2).

Liquid radwaste amount received by special combines is small, as a rule, it has small level of activity.

Units for location of the spent ionizing sources, without containers represent a reservoir made of stainless steel, with the capacity of 0,2 m^2, mounted in the concrete mass. This reservoir is built in the depth of 4,5 - 6 meters and is connected with the hopper through the spiral-loading pipe. The hopper is built in the surface (fig 3).

This unit is operated together with containers, equipped with the device for unloading through the bottom. The sources are unloaded through the hole in the bottom part of the container, mounted on the loading device in the unit.

3. ESTIMATION OF THE POSSIBLE EMERGENCY SITUATIONS AND THE SCENARIOS OF THEIR PROGRESS

Many papers on estimation of the possible emergency situations and the scenarios of their progress for near-surface repositories have been written. One can read them easily. In our report we would like to describe the most probable ones among those, which took place during operation of the real repositories to consider the technical measures on their prevention or decrease of their consequences.

Depending on the character or intensity of the natural agents the following can take place:

A) simultaneous loss of radioactive matters, that can result into contamination of both strict control area and partially sanitary protective area;

B) transfer and spreading the contaminants by the surface effluents, ground waters and atmospheric streams with the inadequate high speed.

Initial situation A can result from hardly probable events, e.g. meteorite or airplane falling explosion in the repository.

Situation B is more probable and can occur due to violation of the integrity of engineering constructions and result from ignition of burnable materials. Engineering constructions and natural materials in the vicinity of the repository can degrade due to irregular settling of the individual parts of engineering constructions, seal failure of the construction both due to aging and degradation of hydroinsulator, thermal degradation of the concrete, degradation of the structures due to tectonic and creeping processes, unsealing of the envelopes due to water-wind erosion, flooding the repository with the surface and ground waters.

Situation A will be followed by situation B, while situation B can occur by itself.

During realization of the safety analysis we consider typical versions of the scenarios of the population radiation, resulted from external and internal radiation due to intake and through food chains.

The real estimation of the emergency situations demonstrated that the most probable one is infiltration of water into the repository, followed by radnuclides leaching and their transfer with the effluents.

These can be atmospheric fallout or underground waters. The fall-out can penetrate through unsealed surfaces of the structure or the joints of the plates in overlapping. The places, where units of plates join to the walls of the repository are the most vulnerable.

The second version of possible fall-out penetration can be it accumulation during infiltration in the slots of the reservoir with the further penetration through the walls or the bottom. This process is the consequence of quality requirement violation during performance of constructive works.

The conclusions about origination of the water in the repository can be done on the basis of the technological monitoring system organization. This monitoring system includes a number of observation holes, designed, and technological drivings inside the repository, which allow judging about presence of the water in it and dynamical change of its level. To determine the character of water infiltration we should perform observation of its level in the repository.

To perform safety estimation we should use:

information about ground water level and its dynamical change;

information about level of ground water in the repository;

dynamical change of the water level in the repository;

interaction between changing the level of water in the repository and the volume of fall-out;

analysis of seasonal changes in the level of water in the repositories.

In some cases we can use telesystems and other technical means to find the points of leakage.

Infiltration of the ground water in the repositories is less probable, because initial depth of the ground water occurrence on the site should be substantially lower than its bottom (according to the previous normative documents not more, than 2,5 m). That is why large growth of the water level can be induced by the substantial change of hydrodynamic conditions in water level horizon. These changes can be resulted from erection of hydrotechnical constructions, introduction of irrigation, mass constructive works in the vicinity of the enterprise. Such changes take much time that is why long-term observations for ground water changes are very important. Hence, dynamical changes of the water level in the repository should be good correlated with the dynamical changing the ground water level. Leakage from the repository can be determined from analyses of artificial radnuclides content in the under ground waters. One should take into consideration that many soils have high sorbtion properties, that, as if, mask the process. That is why H-3, tritium, which is not practically retained in mineral part of the soil and can be a good marker is very informative.

4. POSSIBLE SAFETY ENHANCING DURING OPERATION OF NEAR-SURFACE FACILITIES

One should take into consideration that the question of application of those or these facilities for storage or disposal of some types of radwaste should be regulated by the state normative acts, resulted from both: national policy in the field of nuclear energy and radioisotope devices application and also technical and economic possibilities of the state and its national concern. In relation with essential changes of the requirements and approaches in this field, occurred lately, one should consider two situations. They are concern about so called, "Historical facilities", and newly developed ones.

4.1. "Historical" Facilities

In the previous sections we tried characterize the "Historical" facilities, to analyze their advantages and disadvantages and possible emergency situations. It is clear, that one could perform further operational activities according to investigations results and results of the activities for complete estimation safety, performed. One should take into account, that while planning any measures, the basic principles of the organized activities for radwaste management should be observed:

provision of the adequate level of radiation protection, to protect the human heath from radwaste dangerous affect, according to the principles of optimization, normative requirement and validity of this activities;

provision of the adequate level of environment protection from radwaste dangerous affect;

exemption, if possible, of the excessive burden imposition on future generations;

account of possible transition of radwaste through the boundaries, and this consequent affect on human health and environment;

predictions of consequences for future generation should not exceed the adequate levels of consequences which are suitable now;

radwaste generation should be kept at the level, as low, as can be obtained, and radwaste characteristics should meet the norms and rules in the field of nuclear energy application and radwaste management;

account of interaction between the stage of radwaste generation and radwaste management;

reliability and safety of the systems for and radwaste management should be properly provided within their lifetime and after shutting down;

understanding that the final responsibility for provision of safety during and radwaste management is imposed on the state, which should perform governing and regulation in this field.

That is why, two versions, concerning the, so called, "historical" facilities should be considered:

unloading the facility;

planning and performing the works on upgrading of the facility safety.

It is clear that the first version requires complicated designing work, development of the set of special technical means and system of radwaste management.

Hence we should study the second version in details.

4.1.1. Reconstruction and Upgrading of the Monitoring System

The radiation monitoring system is based on the principles of unexceeding the normative values on the areas, controlled, (content of radnuclides into various objects, exposure dose rate.

Now, due to application of the principle for dose rate limitation, the radiation monitoring system undergoes some changes. This also results from the fact, that the present safety estimation schemes require a number of parameters to be introduced in estimated models, that allows to characterize situation in the repository and in the vicinity more unambiguous.

It is expedient to add the controlled parameters of radiation monitoring with the measuring of the radnuclide content in the agricultural products, produced in the supervision area, observation for their content in the near-surface ponds, used for domestic-drinking water supply, measuring of the radnuclide content in the atmospheric air, measuring of equivalent dose values around the site with repository, at various distances from the repository. It serves for the most complete characterization of the repository real affect for population and helps to overcome the problems, resulted from negative attitude of the population to the facility. The most useful measures for overcoming this problem is performing of individual selective dosimetric control for definite groups of population from the nearest places. The most expedient is to draw the authoritative people: doctors, teachers, and so on.

To take calculations for safety justifying, one should get data, characterizing the surface flow and underground flow. Some of information may be obtained from the data of meteorobservation made by the nearest meteostation, e.g.:

fall out amount;

prevailing speed and direction of wing;

average value of the surface flow module;

evaporation value.

One can also estimate the value of the surface flow from the site by the direct measuring during observation for the amount of the daily discharge from the control ponds.

One should provide observation for the water level at the first water line on the system of watching wells.

And it is also expedient to organize the system of technological monitoring. The object of this monitoring is control of engineering barrier condition and observation of the processes, which occur in the repository and in the vicinity of it.

It is necessary to control:

chemical compositions of gases;

radnuclide content in gases;

humidity of gases;

water presence;

dynamical changes of water amount;

chemical composition of water;

radnuclide composition of water inside the repository.

Analysis of these materials allows judging about the character and intensity of the processes, occurring in the repository. Monitoring inside the repository can be performed through the technologic all grooves.

Stationary wells are drilled in the grounds, surrounding the repository, to supervise their water regime, and chemical and radnuclide composition of the ground water. The results of the supervision allow to estimate the tightness of engineering barriers and to predict the corrosion resistance of construction materials. In the whole monitoring system must be target oriented and serve for observing the processes, which can result into emergency situation occurrence.

4.1.2. Stabilizing the Containers with Radioactive Waste Disposed in the Repositories with Filling Materials

During loading the containers in the cells of the repository, particularly, loading in bulk, the unfilled spaces occur, the volume of these unfilled spaces (gaps) can amounts 40 – 50 %. According to the world practice this gaps are filled with stabilizing materials to enhance the safety of the process of radioactive waste disposal. Stabilizing material is used to prevent the containers with radioactive waste from the contact with water in case of leakage and to upgrade the mechanical strength of the repository structure.

For this purpose various materials are used: crushed rock (stone), sand and clay mixtures, concrete, mortars, clays. They are used both as dry materials and as suspensions with various water content.

Their composition and way of filling is chosen in relation with concrete situation and natural-climatic conditions on the site, where the repository is located. The matters based on cement, often with sorbents and modifying additives are very movable, that provides their intrusion into very thin spaces and slots, filling them. After hardening these matters form very durable material. These matters are spread widely and simple in preparing and delivery to the repository, this resulted in their wide application for the purposes, mentioned. If the process was inefficient, additional pumping the high permeable solutions through the wells is possible. This process is widely used in hydrotechnical construction. The disadvantages of cement materials are their cracking and possible chemical degradation under the contact with aggression waters. Intensity of these processes increases with the time that leads to deterioration of their protective properties.

Application of the fillers on the base of cement materials can be justified only if the decision to give the storage a status of repository is made.

Other properties the clay and clay containing fillers, have. They can be fed as suspension or dry materials. In comparison with the matters on the base of cement they have lower mobility and water separation is possible. At the same time the material, obtained has plasticity and is able to remedy the cracks by itself, to sorb radnuclides from the solutions. Besides during the dry mixture application, various clay materials can swell, while interring with the water. High swelling pressure causes tamponing various defects in the repository structure and restoration of its functions.

This filler can be removed easily if the decision about retrieval is made. One should notice that the filler, made on the base of clay, properties are practically permanent during the whole period of the repository operation, and on their chemical compositions are in good agreement with the materials of the main packing units.

4.1.3. Development of the Complicated Conservation Coverings

We perform a number of works on conservation to bring the constructions where the radioactive waste is disposed into conditions providing:

isolation of radioactive waste from environment with maintenance of the required operational qualities of the constructions within the stated period, depending on their status or within the whole period of institutional control;

possible fulfillment of the activities on radiation monitoring planned;

possible fulfillment of the repairing works, required, during predicted unfavorable conditions.

Modern conservation coverings of the constructions, where the containers with radioactive waste are located consist of several levels, each has its functional purpose:

soil;

lump materials;

clays;

geomembranes;

sand;

monolithic concrete.

The mentioned materials, duly arranged provides:

protection from infiltration of the water from atmospheric precipitation;

protection erosion;

protection from the room system advance;

prevention the water permeable layers from drying and cracking;

prevention of the small animals activities;

protection from cyclic frosting - melting;

resistance of the covering to creep of some layers;

drainage of raining and melting waters.

The covering is conjugate with shielding side the wall's sides. The wall's side shields include sand, clay and lump materials.

The main conservation activities concern to a unit the construction (section, module, site) they are performed during operation, and after shutting down, they are terminated with transforming this unit into the phase of institutional control.

4.1.4. Development of Plants for Liquid Radioactive Waste Purification

As long-term experience demonstrated near-surface facilities periodically produce liquid radioactive wastes. These wastes arise from:

liquid radioactive waste, delivered into facility;

liquid radioactive waste, resulted from decontamination of vehicles, equipment and production areas;

liquid radioactive waste from penetration of the water into repository;

surface waters, polluted with radioactive matters, resulted from the accident.

In general the streams of these wastes are delivered irregularly, their volumes are not large as a rule. The solutions have simple chemical composition, liquid minerals and specific activity.

For management with such type of liquid radioactive waste it is advantageous to develop simple module plants with low capability. They can be both stationary and mobile.

"Radon" has practical experience in use of mobile module plants for liquid radioactive waste purification. From 1996 to 1999 these plants treated more then 2000 m^3 in Lvosky, Rizhsky, Saratovsky, Volgogradsky and Nizhegorogsky special combines.

Principal technological scheme of the plant for such type of liquid radioactive waste purification, which "Radon" uses now, includes two water purifying modules: filtration module and ultrafiltration one and filter-container with sorbent. Sorbent composition can be charged according to the concrete liquid waste radioactive composition.

The plant capacity is up to 0,3 m^3/hr (fig 1).

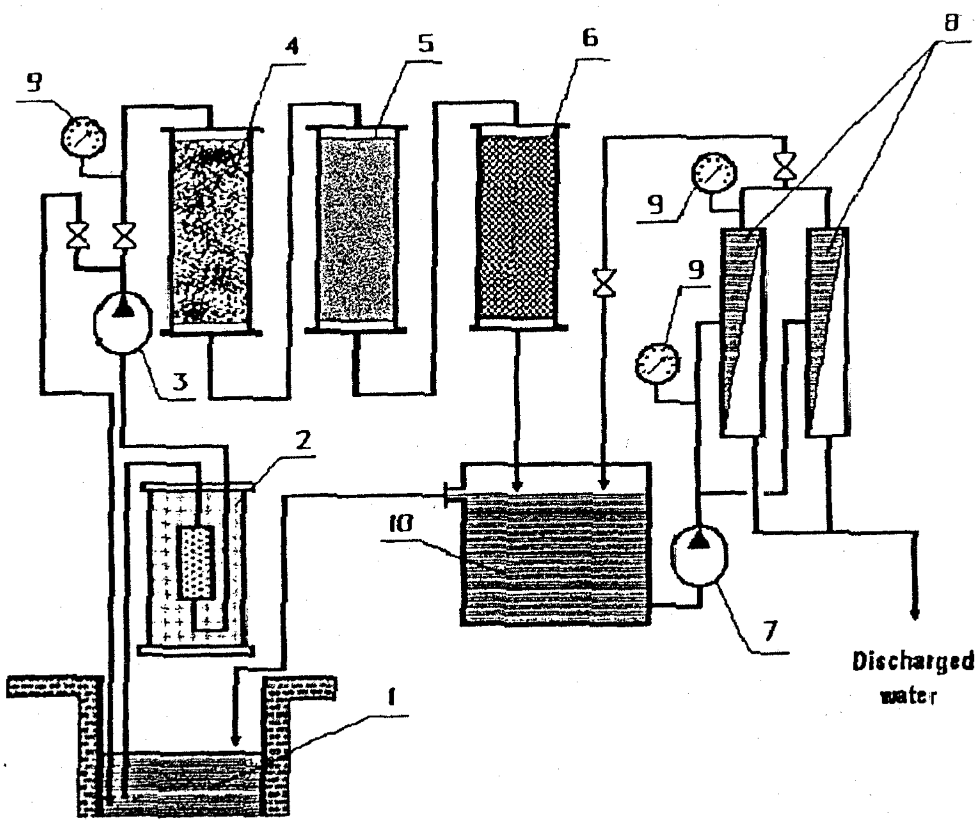


Fig.1. Principal technological scheme of the module mobile plant "Aqua-Express"

1 - initial vessel of LRW, 2 - Filter-container with synthetic sorbent of ferrocyanide type "Fenix A", 3 - peristaltic pump, 4 - 6 bulk filters, 7 - centrifugal pump, 8 - rolled ultrafiltration units, 9 - manometers, 10 - intermediate vessel.

Filter container

Capacity on initial liquid radioactive waste, l/hr	not more, than 500.
Salt content in initial liquid radioactive waste, g/ l	unlimited.
pH of initial LRW	1-10.
Volume of filter-container, l	200.
Volume of sorbent, l	30.
Grade of sorbent	" Fenix A".
Maximum head, MPa	not more, than 0,7.
Initial hydraulic resistance of the filter, MPa	not more, than 0,1.
Dimensions of filter-container, (dia × height), m	not more, than 0,6 × 0,85
Mass of filter-container, kg	not more, than 400

Filtration module

Capacity on initial LRW, l/hr	not less, than 300.
Full volume of one bulk filter, m^3	0,12.
Working volume of one bulk filter, m^3	0,1.
Inner diameter of the filter, m	0,3.
Capacity of the pump, m^3/hr	not less, than 1.
Maximum head of the pump, m of water column	not more, than 45.
Full volume of the bottom, m^3	not less, than 1.
Dimensions of sorbtion unit (l×w ×h)	not more, than 0,8 ×1×1,5
Mass of the sorbtion unit (unloaded and without water), kg	not more, than 300.

Ultrafiltration module

Dimensions of the rolled unit (l × dia), m	not more, than 1,3 × 1,15.
Pump capacity, m^3/h	not more, than 2.
Maximum head, m of water column	not more, than 30.
Volume of the buffer vessel, l	80.
Capacity of the Thermal energy carrie, kW	not more, than 1.
Dimensions (l ×w ×h), m	not more, than 0,6×0,6×1,5.
Mass (without water), kg	not more, than 200.

Amount of secondary waste from LRW purification is not more, than 5 %.

4.2. New-Developed Facilities

4.2.1. Criteria of Waste Adequacy for Location in the Repository

4.2.1.1. Elaboration and establishment of Principles for the control exemption

The basic standards and recommendations on radiological protection, published by various international organizations constitute the basis for normative-legislative regulation of activities with application of spent ionizing sources. Regulation control is based on the system of notification registration and licensing that gives the regulating organs the opportunity to state the necessary safety requirements. But in some cases control of the regulating organs of high level is not required that is why the system of exemption and withdrawal of control is established.

One should take into consideration the application of radioactive materials and power production by NPPs result into generation of large amount of radioactive waste both in the process of NPPs operation and after shutting-down.

Many types of radioactive waste are of very low activity and they can be isolated as traditional industrial waste. For this purpose one should determine conditions for exemption of control for low-level waste.

Lately this important problem initiated the regulating organs and expert teams from various countries and international organizations to formulate the principles of control exemption, to have an opportunity to determine quality data on radioactive waste activity, which allow to make a decision about the control exemption, and after this to use traditional methods of disposal.

The discussions, held, resulted into publishing the Guide on IAEA safety N 85 "Principles of exemption of regulation control for the ionizing sources and activities".

The main item of this Guide is application of three basic principles of radiation protection:

validity;

dear profit for society;

upgrading – dose rate is so low as it is possible to reach, taking into consideration social-economic expediency;

limitation – unexeeding the stated individual dose limits.

Criteria of control exemption, expressed in the individual or accumulated doses have not direct or indirect adequacy, when the decisions about radioactive waste disposal are taken. It is evident that one must use values of total and specific activity, providing the possibility of direct estimations or measurements. Definite methods of calculations, which allow making quantity characterization of radnuclide migration into environment and the doses, obtained, are used:

definition of activity;

definition of the way of removal;

radnuclide content analysis;

definition of the scenario and the ways of radiation.

4.2.1.2. Radioactive waste segregation. Principles of radioactive waste characterization and classification

The main items in the structure of the radioactive waste management system are characterization, segregation and minimizing the radioactive waste, treatment and conditioning, storing and/or disposal.

Waste characterization means definition of it physical, chemical and radiological properties, to find the proper technologies for it treatment, conditioning, determine the conditions of it storing and disposal.

Radioactive waste segregation and minimizing is very important, because it results into reduction both the further steps of treatment cost and average annual doses.

Characterization is very important for segregation and classification doses. It governs the required procedure of management with radioactive waste, including the estimation of measures during treatment and storing.

Typical scheme of radioactive waste segregation includes:

• separation of nonradioactive materials from radioactive ones;

• separation of radioactive waste into categories according to the following factors:

source of waste (waste producer enterprise),

aggregate condition (liquid, solid, spent ionizing sources),

determination of radiochemical composition (activity, long-lived and shot-lived radionuclide amount, type of emission),

presence of the other dangerous materials (chemical and biological properties, flammability, explosiveness).

National and state requirements on organization of activities with the waste, concern as a rule, it transportation and the system of storage/disposal identification. In many countries the requirements on provision safety of radwaste transportation are based on the "Safety Regulations of Radwaste transportation", adopted by IAEA "Requirements" N ST-1. Safety requirements for management and location of radioactive waste for storing/disposal are governed by it classifying on the level of radiological danger.

In case when (according to the exemption canceling approach) the radioactive waste must be isolated from the environment the document, regulating the Criteria of waste adequacy, where all the requirements of the enterprise dealing with location of radwaste in special constructions should be identified, is being elaborated.

Content of long-lived nuclides is the most important radiological parameter. Classification proposed by IAEA is given in Table 1.

Classifying system, affecting the operations at previous steps of the system of management with radioactive waste is regulated by the National normative documents "Sanitary Rules" and "Radiation Safety Norms".

4.2.2. Upgrading of the Technological Schemes for Treatment and Conditioning of Radioactive Waste

The status of Moscow SIA "Radon" is regional enterprise for treatment and disposal of the conditioned forms of waste for the purpose of it storage and radiological protection of population and environment of the region, served. For this purpose, the enterprise solves the problems of radwaste treatment and conditioning to realize its disposal for long-term storage. "Radon" considers the method of disposal the radwaste for long term-storage as the one allowing further removal of the waste and it transportation to the other place, while observing the requirements of radioactive substances safe transportation.

To dispose the radioactive waste for long-term storage it should be packed (fig. 6) into containers, the fillers should be added and multi-purpose conservation coverings should be developed. For radioactive waste for long-term storage the packages with proper mechanical and diffusion characteristics, guaranteed for some decades, are used.

The Moscow SIA "Radon" uses the multi-barrier system, which includes several barriers, meeting definite operational standards. They are structural elements of the repository, packages, matrix materials, stabilizing materials (fillers).

The safety level required, is provided by the following: variety of the radioactive waste, delivered, for treatment and disposal is limited by the Criteria of receipt application - estimation of the quality and quantity characteristics of waste should be done by the regulating organ.

The Moscow SIA "Radon" fulfills the total set of activities, related to it main functional object. They are (fig. 7):

establishment of the rules for the waste transference;

transportation organizing and realizing;

receipt control;

treatment, conditioning;

location of waste in special constructions (facilities);

radiological monitoring;

conservation works.

The basic technological methods of radwaste treatment and conditioning include:

thermal methods (combustion, vitrifying, hot compaction, metallized fuels application;

treatment of suspension and silts (fig. 8, 9, 10);

compaction (fig. 11),

cementation (fig. 12),

purification of the liquid waste with membrane,

technologies, selective sorbents, ion exchange;

waste segregation according to radiological danger categories (Table 1),

fragmentation.

Glass, ceramic, mortar, metallic alloys are used as matrix materials.

"Radon" uses 200-liter barrels and reinforced concrete containers as packing sets for radwaste isolation and location in the facility.

The conditioned forms of waste should meet the following requirements:

monolithic matrix material in the package;

specified fire-resistance, compressive strength, leachability of nuclides from matrix materials;

absence of biological origin materials, subject to chemical decomposition, followed by gas release and swelling of the package;

specified properties of the package material (strength characteristics, permeability parameters on H-3, Cs-137).

4.2.3. Upgrading of the Facility Structure

The project of the new facility, elaborated by the Moscow SIA "Radon" differs sufficiently from the projects, used traditionally in Russia and projects, used in Europe.

First it was planned to create the facility, similar to El Cabril (Spain) or Soulaines (France) with mobile topping and crane. But taking in consideration Russian climate, it was decided to design the facility, similar to sectional bunker, with the overlap previously designed.

The project provides that the waste will be stores in removable from for 50 years. During this period the reinforced-concrete plates and hydroinsulating material will be used as overlap. When this period expires, the conservation covering, with the layers of soil, lump material, clay geomembrane, silt, sand, monolithic concrete is erected.

The facility is provided with inspection drainage galleries for control and withdrawal of the leakage both during operation and in the period of post conservation control. For withdrawal of surface effluent a peripheral channel is built.

Status of the new facility is identified as a storage, which can be transformed into repository (fig 14). Adequate decision should be taken within the next 50 years. Then two scenarios of the further activities are possible:

all the content of the facility (containers with conditioned radwaste) are transported into the other place;

part of waste is transported into the other place and the other part is conserved.

The project provides the facility ventilation during its loading with containers, filled with radwaste. The system of filling the gaps between containers with mortar or sorbing material in case of giving the facility the status of "repository" is also provided. Capacity of the facility is 100000 m^3 of conditioned radwaste (in containers). The facility will be filled for 20 years.

Institutional control durability is 300 years.

Containers with radwaste should be loaded with fork loading crane through the side holes, provided with temporary light metal shield.

It is supposed that only conditioned forms of radwaste should be stored in the facility (radwaste + matrix).

In the project the draining galleries are proposed and designed, which allow the packages of radwaste inspection. The process of the facility settling is estimated in details and recommendations on technical means for soil properties upgrading are given. So far, conservation covering has no analogies in Russia.

5. Management with Spent Ionizing Sources

The spent ionizing sources delivered to and accumulated in special combines account for the main part of the radnuclide activity.

To dispose powerful spent ionizing sources (with activity more, than 1 Ci) the wells are used. For Russian special combines averaged radionuclide composition of spent ionizing sources amounts Cs-137 (40 %), Co-60 (25 %), Sr-90 (22 %), Ir-192 (8 %), Tm-170 (4 %).

Construction for containless disposal of spent ionizing sources represents metallic vessel of stainless steel, located at the depth from 3,5 m to 6 m. The volume of this vessel amounts from 0,1 to 1 m^3. It is connected to the surface with spiral-like tube, which is ended with the cap and hopper.

According to the spent ionizing sources disposal technology, they are discharged into the reservoir of repository.

Long-term operation of such repositories resulted into finding a number of drawbacks. The spent ionizing sources, discharged, accumulates in the bottom part of reservoir that leads to the local thermal and radiation loadings on the structural elements of the repository.

Sometimes water flowed into the repository both due to its uptightness and water accumulation resulted from condensation. Degradation of water, resulted from radiolysis can lead to the hydrogen and corrosive components accumulation, that may break the tightness of the spent ionizing sources envelopes and reservoir of repository.

To exclude these phenomena the Moscow SIA "Radon" developed the technology of embedding the spent ionizing sources into lead matrix. This technology includes methods of the repository examination, which allow determining the following parameters:

activity of the spent sources disposed;

amount of the spent ionizing sources in the repository;

degree of the repository filling;

dose rate on the cap of the repository and in the bottom of reservoir;

temperature in the reservoir;

presence and level of water in the reservoir;

nuclide content in the water;

contamination of the receiver;

presence of hydrogen in the annual phase;

main dimensions of the reservoir.

To realize this technology we developed the mobile system, which allows to fulfill all the operation on inclusion the spent ionizing sources into metallic matrix. This system conditioned the spent ionizing sources in the Moscow SIA "Radon", at Volgogradsky, Nizhne-Novgorodsky, Ekatherinenburgsky and Ufimsky special combines. Total activity of these sources amounts more then 1 million Ci. Detailed analysis of the safe storing the spent ionizing sources was performed in 1998-1999 by the experts of "Radon", GNTS VNIINM and BFRAN, as an example the conditions of radioactive waste storing in the Moscow SIA "Radon" were taken.

The analysis showed that only inclusion of the spent sources in the additional material (lead matrix) gives safe isolation of radnuclides from the environment for the total term of storing, up to 1000 years. In case of the most pessimistic scenario the dose equivalent does not exceed (5,5 - 7,5) D^{-5} Sv/per year.

English experts performed safety assessment for this repository on the program MASCOT, the value of dose equivalent was estimated as 10^{-8} Sv/year.

Analysis of activity on management with spent ionizing demonstrated that the present system could solve the main tasks, concerning the conditions for environmental safety providing.

Very important is the problem of long-term storing the radnuclide sources containing long-lived radnuclides (e.g. Pu-239, Ra-226 and so on). These radnuclide sources, immobilized in matrix material, for a long period of time can be safety stored at regional combines "Radon". Later such radnuclide sources (with long-lived nuclide) will be disposed into deep geological formations. The mobile module plants for radnuclide sources immobilization of the type developed at the Moscow SIA "Radon", can be applied not only for the standard well-like repositories but also for solidification of the radnuclide sources in containers.

Development of the proper shielding container at the earliest possible date is very important.

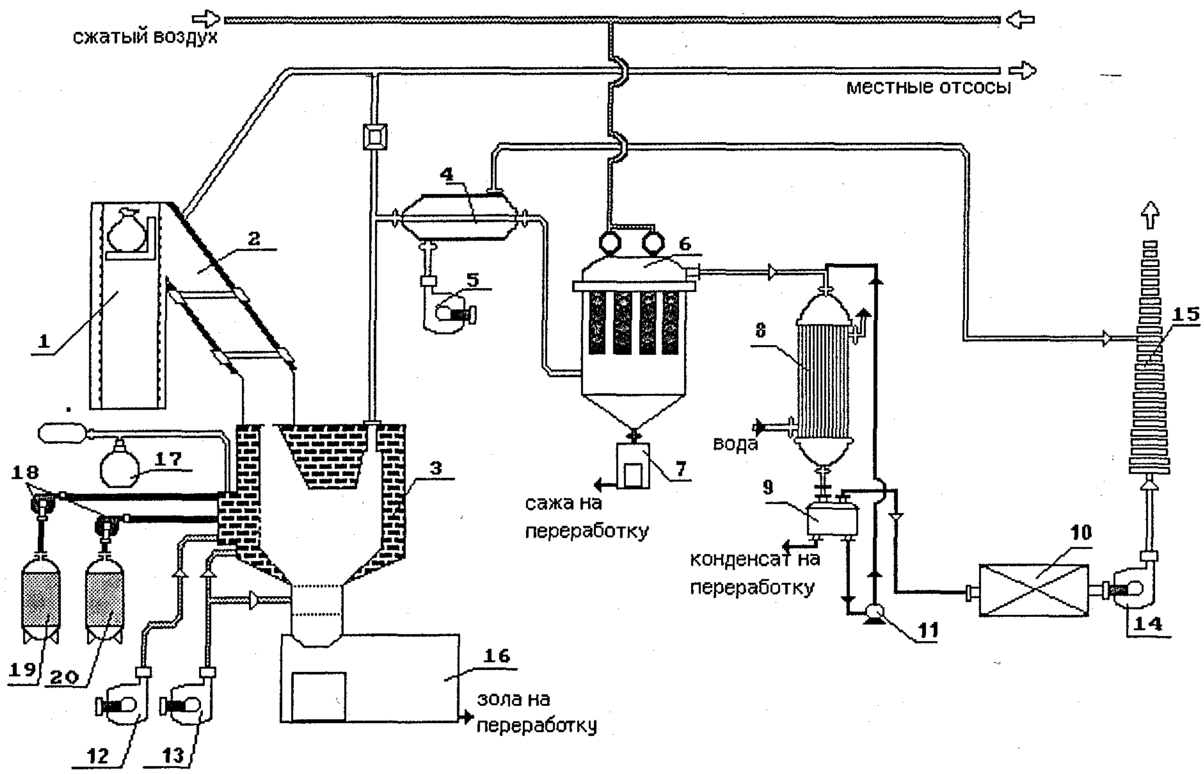
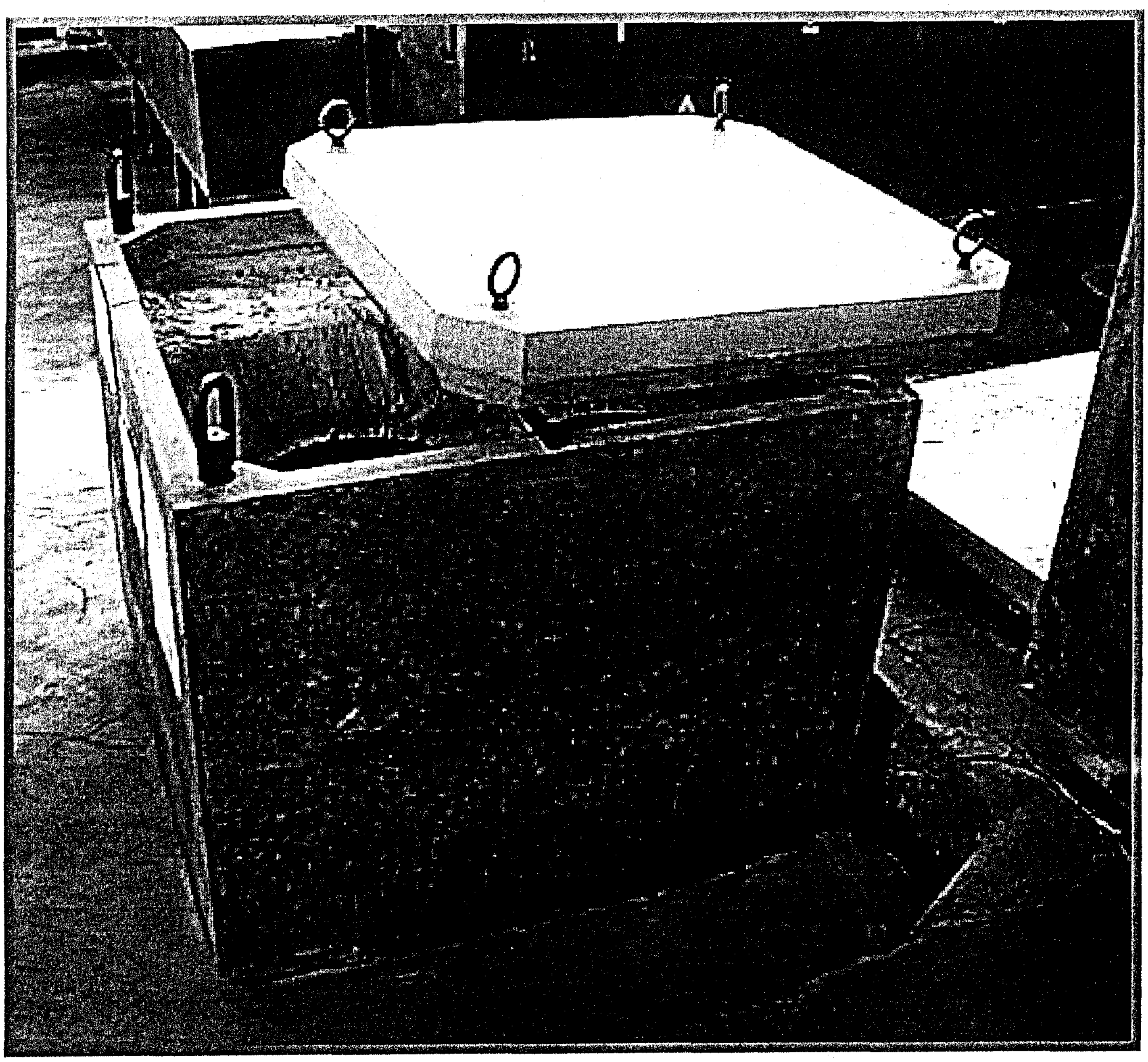


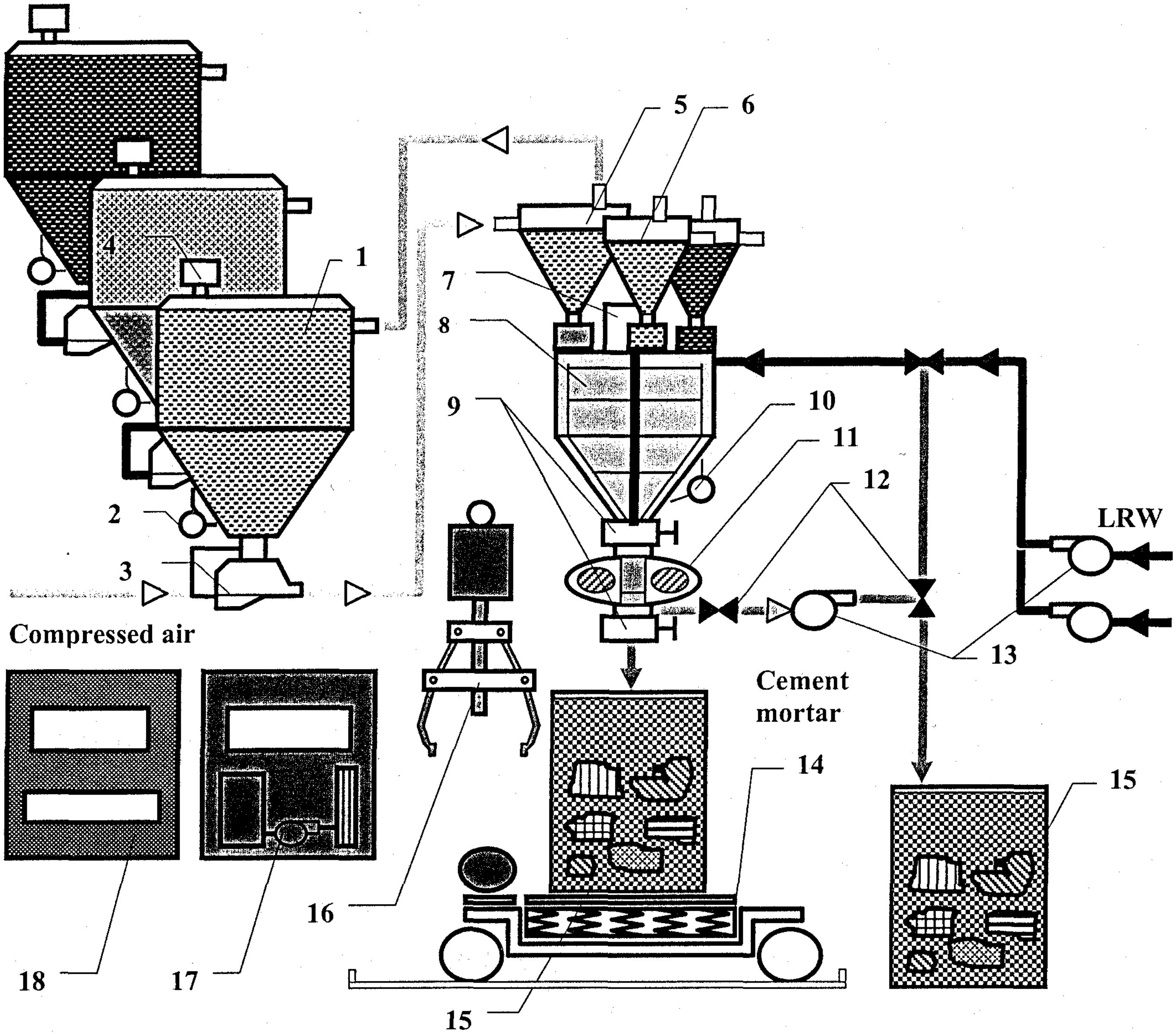
Рис. 2. Установка сжигания ТГРО и ЖГРО "Факел":

1	–	Лифт
2	–	Узел загрузки ТГРО
3	–	Печь
4, 8	–	Теплообменник
5, 12, 13, 14	–	Вентиляторы
6	–	Фильтр грубой очистки
7	–	Сажесборник
9	–	Конденсатосборник
10	–	Фильтр тонкой очистки
11, 18	–	Насосы
15	–	Труба
16	–	Бокс выгрузки золы
17	–	Система зажигания факела
19	–	Топливная емкость
20	–	Емкость ЖГРО

Контейнер для длительного хранения радиоактивных отходов



КОМПАКТНЫЙ КОМПЛЕКС ЦЕМЕНТИРОВАНИЯ РАДИОАКТИВНЫХ ОТХОДОВ



1-bunker for storage of dry materials;
2-vibrator;
3-jet pump;
4-воздушный клапан;
5-рассходный бункер цемента с дозатором;
6-расходные бункера добавок с дозаторомн;
7-привод мешалки;
8-емкость с мешалкой;
9-шланговые затворы;
10-вибратор;
11-вихревой смеситель;
12-электромагнитные задвижки;
13-насосы-дозаторы;
14- самодвижущая тележка с виброплощадкой;
15-контейнер с ТРО;
16-кран-захват;
17-блок обслуживания вихревого смесителя;
18-пульт управления.

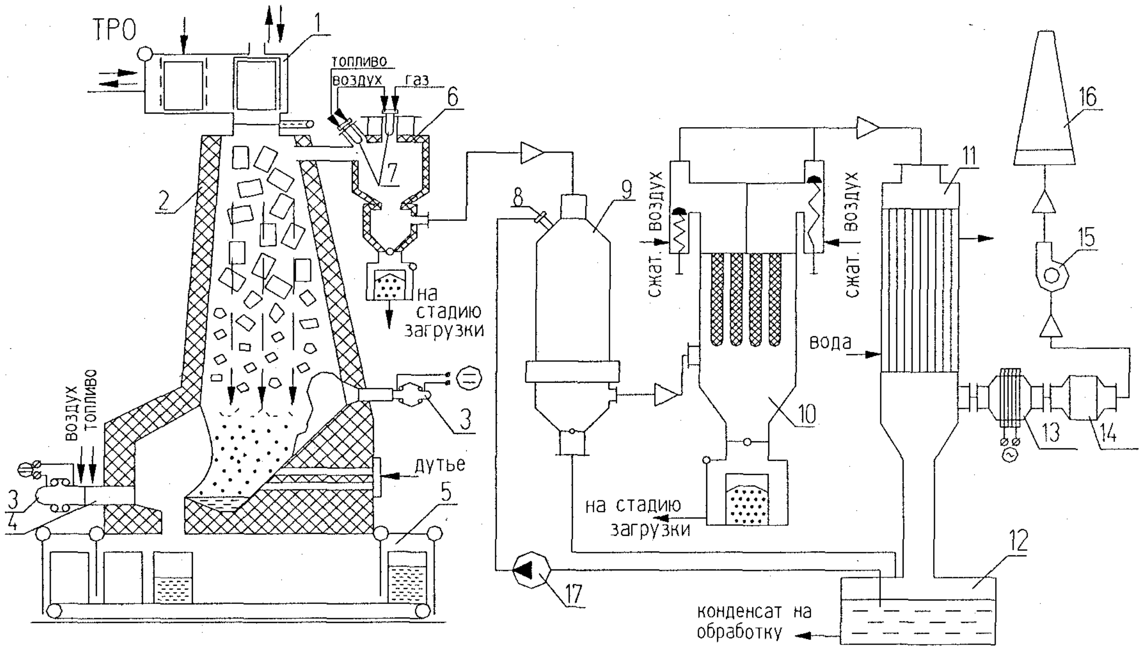
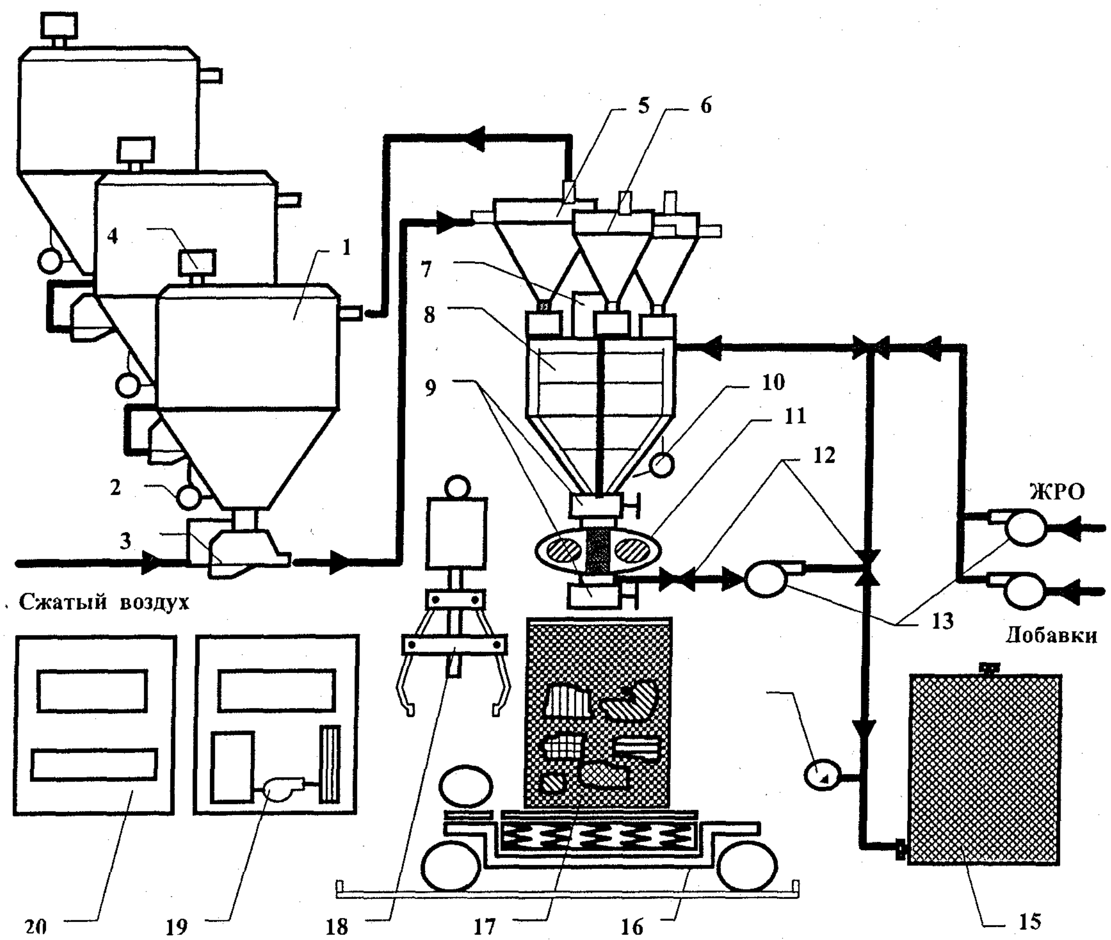


Рис. 5. Технологическая схема опытной установки переработки ТРО.

1 – Узел загрузки,
2 – шахтная печь,
3 – плазмотрон,
4 – топливно-плазменный источник нагрева,
5 – узел шлакоудаление,
6 – камера дожигания,
7 – горелка,
8 – распылительное устройство,
9 – испарительный теплообменник,
10 – металлорукавный фильтр,
11 – теплообменник,
12 – сборник конденсата,
13 – подогреватель отходящих газов,
14 – фильтр тонкой очистки,
15 – вытяжной вентилятор,
16 – дымовая труба,
17 – насос.



1-бункера хранения сыпучих материалов;
2-вибратор;
3-струйный насос;
4-воздушный клапан;
5-рассходный бункер цемента с дозатором;
6-расходные бункера добавок с дозаторомн;
7-привод мешалки;
8-емкость с мешалкой;
9-шланговые затворы;
10-вибратор;

11-вихревой смеситель;
12-электромагнитные задвижки;
13-насосы-дозаторы;
14-манометр;
15- контейнер с гранулированным сорбентом;
16- самодвижущая тележка с виброплощадкой;
17-контейнер с ТРО;
18-кран-захват;
19-блок обслуживания вихревого смесителя;
20-пульт управления.

Рис. 8. Компактный комплекс цементирования радиоактивных отходов