BNL-63999
97266

CONF-970701--6

"RADON" - The System of Soviet Designed Regional Waste Management Facilities

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ABSTRACT

The Soviet Union established a system of specialized, regional facilities to dispose of radioactive waste generated by sources other than the nuclear fuel cycle. The system had 16 facilities in Russia, 5 in Ukraine, one in each of the other CIS states, and one in each of the Baltic Republics. These facilities are still being used. The major generators of radioactive waste they process these are research and industrial organizations, medical and agricultural institutions, and other activities not related to nuclear power. Waste handled by these facilities is mainly beta- and gamma- emitting nuclides with half lives of less than 30 years. The long-lived and alpha-emitting isotopic content is insignificant. Most of the radwaste has low and medium radioactivity levels. The facilities also handle spent radiation sources, which are highly radioactive and contain 95-98 per cent of the activity of all the radwaste buried at these facilities.

INTRODUCTION

Management of radioactive waste generated by medical, industrial, agricultural, and research institutions (including universities) is an increasing problem in most countries. This radwaste does not include material generated by the nuclear fuel cycle, such as from reprocessing. It normally does not contain long lived isotopes and consist mainly of elements with relatively short half lives (the main long lived exception is radium radiation sources). This material can be disposed of and will decay to a level near background in about 300 years or less.

Approaches being followed, or proposed, are different in various nations. The United States is attempting to establish regional compacts. The technology used, and timing of implementation varies in the various countries. Regulations also differ. Disposal of this material constitutes a problem in nations with nuclear regulatory infrastructures. Many nations that use radiation sources for purposes such as medical applications do not have nuclear infrastructures to regulate or manage the disposal radwaste or spent radiation sources.

Disposal of spent radiation sources is a significant problem. There have been at least two significant threats to people and the environment from incidents involving spent radiation sources - one in Mexico resulting from improper disposal of a spent cobalt 60 source and one in Brazil resulting from improper disposal of a spent cesium 137 source. There are potential problems. In Afghanistan a leaking spent radium source is in temporary storage, with no ability for final safe disposal. Potential problem exist in other countries with many sources in temporary storage. The large quantity of this waste is a world wide problem.

Considerable attention has been focused on nuclear safety problems associated with Soviet designed nuclear facilities. Attention is also being given to problems such as contamination of the Arctic Seas, the waters in the Far East where the Soviet Pacific Fleet was based, and radioactive contamination resulting from Soviet nuclear weapons production. Problems associated with radioactive waste generated by medical, industrial, agricultural, and research institutions in the former Soviet Union has, to date, received little attention. There is a general lack of knowledge about the technology and facilities used to manage this type of radioactive waste in the former Soviet Union. There are over 30 years experience in the operation of these facilities. Others might profit by studying this experience.

*This work performed under the auspices of the U.S. Department of Energy, Contract No. DE-AC02-76CH00016.

Operations are regulated by organizations such as the State Committee for Surveillance over Nuclear Facilities, the State Committee for Sanitary and Epidemiological Surveillance, the Ministry of Ecology, and the Ministry of Internal Affairs. Research for operation of the facilities in Russia is provided by the "RADON" Research and Production Association.

The major generators of radioactive waste handled by the "RADON" facilities are various kinds of organizations, i.e. medical and agricultural institutions, as well as industrial activities not related to the nuclear power industry. The waste transported to the "RADON" facilities contains mainly beta - and gamma-radionulides with half life's of less than 30 years. Its long-lived alpha-nuclide content is insignificant. Most of the waste contains only low- and medium-activity materials.

REQUIREMENTS AND REGULATIONS

The legal requirements and regulations for radwaste management in Russia (and in most other nations of the former Soviet Union) are regulations issued by the USSR Ministry of Health. These include "The Basic Sanitary Rules for Managing Radioactive Waste and Other Ionizing Radiation Sources" (OSP-72/87) (providing the sanitary and hygienic requirements for radwaste collection, conditioning, transportation, and burial). OSP-72/87 defines prohibited and allowable actions, as well as engineering and other technical requirements. Basic principles for radwaste management are specified in another All-Union sanitary legislative document, "Sanitary Regulation on Radioactive Waste Management" (SPORO-85). SPORO-85 provides requirements for radioactive safety when collecting, storing, transporting, reprocessing and burying radioactive waste.

OSP-72/87 and SPORO-85 requirements apply to institutions, laboratories and other organizations using radioactive materials, as well as organizations transporting, processing and burying radioactive waste (irrespective of their departmental affiliation). Radwaste includes solutions, articles, materials, and biological items containing radioactive substances in amounts exceeding values specified by the standards and regulations in force (if those substances are not intended for further use at the given or any other facility or experimental research). Radwaste also includes spent ionizing-radiation sources of no further use.

The radwaste classification now in force is similar to classifications accepted and used in many other countries. Unlike the US the classification is based upon the level of radioactivity. In accordance wit rather than the origin.

SPORO-85 subdivides radwaste is into liquids and solids. Liquid radwaste includes solutions of inorganic substances, pulps of filtering materials, and organic liquids. Solid radwaste includes articles, materials, biological items, and spent radiation sources. Liquid waste is considered to be radioactive the individual radionuclides or the mixtures exceed the permissible limits of the Radioactive Safety Regulation (NRB) for water.

Liquid radwaste is low-level at activities below 370 kBq/l ($1\cdot10^{-5}$ Ci/l); medium-level waste is between 370 kBq/l and 37 GBq/l ($1\cdot10^{-5}$ to 1 Ci/l); high-level waste is 37 GBq/l and higher. Solid waste is considered to be radioactive if the specific waste activity exceeds 74 kBq/kg ($2\cdot10^{-6}$ Ci/kg) for beta-active substances, 1.10 radium equiv./kg for gamma-active substances, 7.4 kBq/kg ($2\cdot10^{-7}$ Ci/kg) for alpha emitting substances, 0.37 kBq/kg ($1\cdot10^{-8}$ Ci/kg) for transuranic radio nuclides, or if the surface contamination levels exceed 5 alpha-particles/(cm^2·min), or 50 beta particles/(cm^2·min) over an area of 100 cm^2.

Solid radioactive waste is subdivided into three groups based on the dose rate at a distance of 10 cm from the surface:

- group 1 - to 0.3 mSv/hr (20 mrem/hr);
- group 2 - 0.3 to 10 mSv/hr (30 to 1000 mrem/hr);
- group 3 - above 10 mSv/hr (1000 mrem/hr).

Radwaste is subdivided by physical and chemical properties:

liquid non-combustible waste: water solutions of acids, alkali, salts, including organic substances and suspensions. These result from releases by production/research activities, decontamination, processing low-activity water, etc.;

liquid combustible waste: oils, alcohols, kerosene, combustible organic solvents, etc. Most of this is spent oils from various machines operating with products containing radioactive material, as well as sorbents and organic solvents from extraction processes and washing of machine parts;

solid non-combustible waste: metal, glass, ceramics, construction garbage. This includes packaging for radioactive materials, junked equipment, tools, machine parts, metal furniture, dismantled metal constructions, plaster and other construction materials;

solid combustible waste: wood, plastic, rubber, PVC articles, textile, etc. This type includes wooden and plastic equipment, furniture, overalls, packing materials, paper, wiping materials, filters, clothes, wooden construction materials and structures.

This centralized system has two major stages. The first stage is gathering radwaste at a generator, transporting the radwaste to temporary storage and preparation for transfer to "RADON" facilities. The second stage is receipt of radwaste from generators, its transportation to the "RADON" facilities, reprocessing, and burial. These operations are carried out as "RADON" facilities operations.

The "RADON" facility normally provides transportation at the request of the generator. The facility is responsible for radwaste safety. The generator is responsible for radwaste sorting and preparation for transportation in accordance with regulation for radwaste collection, temporary storage, and transfer.

TRANSPORTATION

Radwaste is gathered at the generator and separated from ordinary waste. It is characterized and subdivided according to its physical condition, the half-life of the radio nuclides it contains, explosion and fire hazards, and their nature (organic, inorganic, biological). To gather and transport within one organization, different types of packages must be used:

for solid waste: collection containers, as well as plastic-compound or paper bags, as primary or separate packages;

for liquid waste: collection containers or special cisterns.

The dimensions and design of the collection containers are determined by the type and quantity of radioactive waste, kind of radiation, and radio nuclide activity. Special requirements for collection containers are defined in SPORO-85.

The most significant requirements with respect to radiation safety are the dose rate 1 meter from the collection container, which must not exceed 100 μSv/hr (10 mrem/hr). The outer surface must not exceeds the levels specified by regulations.

Temporary storage of radwaste at a generator is regulated by SPORO-85. Solid radioactive waste at a generator must be sorted before removal and divided into the following categories:

> combustion waste: corpses of experimental animals; bedding for animals, food remnants; overalls and other protective clothing, cloth, rags, pads, paper, cardboard, wood waste, ventilation filters, etc.;
>
> compressible waste: small equipment, various packages, laboratory utensils, other metal, ceramic, glass articles, as well as any other waste whose size can be reduced by compaction;
>
> not-to-be-reprocessed waste: small equipment, etc., not subject to compaction; large equipment (larger than 900 x 1,200 x 3,000 mm); spent sources of ionizing radiation, solid high-level waste.

Combustible and non-combustible liquid radioactive waste must be collected separately.

Preparation and loading of containers and other packages with radwaste must be performed by the organization transferring the waste. They must convert any dangerous explosive and self-inflammable waste to a safe state. A certificate for every portion of radwaste must be provided to the receiving facility. Before transportation of radwaste receiving facility must monitor it no less than one day before shipment. This inspection includes:

- gamma dose rate of packages and total shipment;
- the contamination on outer surfaces

In addition, the strength and air-tightness of the packages is checked, as well as their marking, correctness of the certificate, and the invoice for the radwaste portion. For liquid waste, the pH must also be measured. Package inspection also includes the package weight, overall size, markings, mechanical strength, the availability of the label (or other documents containing the required additional information about the package), and the radioactive waste composition.

Liquid and solid radwaste containing nuclides with a half-life greater than 15 days must be transported to "RADON" facilities. Radwaste must be transported by specially equipped vehicles and intended for regular transportation. Relevant procedures (in Russia) must be approved by state sanitary surveillance authorities and the Ministry of Internal Affairs of the Russian Federation. Radwaste transportation is regulated by "Rules for Radioactive Waste Transportation Safety" (PBTRZ-73). The required sanitary certificate must be granted by the state sanitary surveillance for every vehicle transporting radwaste.

Metal, concrete or plastic containers (one-time and reusable containers alike) are used for shipping. Radwaste is transported mainly by trucks. Special trucks are use that are built on the chassis ZIL-130 trucks. The truck, called OT-20, is the basic truck for transporting solid radwaste and is equipped with a leak proof metal body with a volume of 3 cubic meters and load capacity of about two tons. OZh-10 trucks equipped with a 2.7-m^3 tanks are used to carry liquid radwaste. These trucks are equipped for radiation monitoring and radio communications.

FEATURES

The regional radwaste management facilities were constructed using a standard design developed by GSPI (this design has been updated several times). Depending on the amount and kind of the waste produced in the region under consideration, local natural and climatic, geological and hydro geological conditions, as well as operational characteristics, a number of modifications to the standard design have been made in all of the facilities.

The Moscow "RADON" Research and Production Association and Leningrad used individual, site specific designs.

Each facility has its own region to serve. This zoning, based on consideration of allowances for the design capacities of the various regional radwaste management facilities, solved the problem of management and disposition to disposal locations of all of the radwaste produced.

A partial reconstruction/modification of these facilities was completed by the middle of the 1970's. This was to upgrade their capacities and improve their material and engineering base.

PROCESS OVERVIEW

The flow and processes for radwaste reprocessing at these facilities are determined by the amount and characteristics of the waste to be reprocessed. The wide variety of radwaste types and forms requires use of several processes. The "RADON" Research and Production Association used various technologies for radwaste reprocessing. This center's tasks include studies to improve radwaste collection, transportation, reprocessing and ultimate burial (disposal), as well as radiation safety. This center develops and introduces new processes and equipment for radwaste disposal and related scientific assistance.

Compaction and incineration are used to process solid radioactive waste. Compaction is used for waste from laboratory equipment, glass and ceramic laboratory utensils, miniature apparatus and equipment, remnants of construction materials, plastic protective overalls, etc.

Compaction is performed in a horizontal hydraulic press in both multi layer paper packages and metal drums. The maximum pressure is 4.9 MPa. Compactor equipment handles up to 3 cubic meters of waste per hour. Volume reduction varies from 2 to 10. Compacted waste is forwarded to a storage facility for solid radwaste where cementing is performed.

To reprocess liquid radwaste, bituminization, cementation and vitrification technologies are used. Bituminization and cementation are already at the industrial stage.

COMBUSTION

Beginning in 1983 a two-compartment ceramic furnace "FAKEL" has been used for materials with a specific activity of up to 1 mCi/kg. The furnace's yield is 30 kg of solid waste and 65 kg of liquid waste per hour. The temperature in the combustion zone varies from 800 to 1000 °C. Waste volume reduction factors are 50 to 60. A multiple-stage gas-purification dry-type system whose principal element is a metal-cloth filter is used. The gas phase purification coefficient is about 1.5 x 10^4.

The ultimate combustion product of ash residue containing alpha-, beta-, and gamma-emitting radio nuclides is a dispersed dusty material easily leachable and unsuitable for burial. The most widespread technique for cementing the ash residue causes, besides an extra material expenditure, an increase in the weight and volume of the product, but does not provide high chemical stability. A method was developed for high-temperature reprocessing of ash residue in an induction melter with a cold crucible. This forms of a melted product with high stability. The quantitative composition (in per cent) of the product (2-5 Na_2C; 3-7 K_2O; 10-20 CaO; 3-8 MgO; 5-10 Fe_2O_3; 13-22 P_2O_5; 20-30 SiO_2) enables its reprocessing with a minimum amount of fluxing additions.

The rate of solid radwaste combustion is limited by the time required for complete burn up of carbon residues. When operating compartment-type combustion furnaces, problems arise when glass and other non-combustible materials, as well as fluxing components (salts), penetrate the waste being reprocessed. These materials may cause slagging of grates and failures of the ash removing system. Therefore, all known combustion facilities require careful sorting of waste.

Despite the design's simplicity compartment-type furnaces have a number of drawbacks. These include considerable entrainment of radio nuclides, low specific productivity, non-uniformity of gas and aerosol loads upon the gas purification system, necessity of careful preliminary sorting of waste. Ash requires additional treatment before the ultimate burial.

A technology that eliminates many of the drawbacks, and provides a number of significant advantages over the process of burning in an air-excess layer, is the high-temperature method of solid radwaste reprocessing in shaft-type furnaces with liquid slag removal at an operating temperature of 1,400 to 1,600 ° C. Waste is loaded in the top of a shaft and flows by gravity, to meet the exhaust flow, undergoing the stages of drying, gasification, pyrolysis, and melting.

Both combustible and non-combustible solid radioactive waste are subjected to thermal reprocessing. A test stand using a shaft-type furnace with plasma heating sources was developed in 1987. The furnace was 3 meters high, the hearth part area was 0.12 m^3, and the furnace's total volume was 8 m^3. The inner refractory lining was made of heat- and slag-resistant refractory materials with an operating temperatures of up to 1,650 ° C. The final product is slag that is dumped into collecting containers. Both plasma and fuel-plasma heating sources are used. Research was conducted on burning simulated solid radwaste. Chemical stability of the slag product was evaluated. The average specific activity of the waste was up to 10^5 Bq/kg. The composition was: wood - 75-80%, metal - up to 10%, glass - up to 2-5%, concrete - up to 10%. The facility processes 60 kg/hr.

Burning waste in shaft-type furnaces is characterized by more uniform gas releases than initial burning in excess air furnaces. In addition to gaseous combustible components, exhaust gases include complex hydrocarbons, resins, and solid particles. The resin concentration in the exhaust gases is 3 to 4 times higher than that in the solid phase. A high-efficiency burning chamber is used to burn resins and solid particles. A cyclone chamber with a plasma heater has the best performance characteristics. The aerosol concentration is reduced by a factor of 20-30.

Experimental studies demonstrated that high-temperature reprocessing of solid radioactive waste in the shaft-type furnaces avoided solid phase removal to the gas purification system. Filtration mechanisms in high-temperature and low-temperature regions are different. The most significant advantage of the shaft-type furnace is the possibility of obtaining liquid slag.

Depending on its composition, slag can be a glass-like or crystalline product. Slag dumping at the test furnace starts at a temperature 1,400 to 1,500 °C (with fluxing components). When reprocessing the waste containing a considerable amount of ferrous metals (8-10%), unoxidized iron may accumulate in the hearth part of the furnace under the slag layer. Therefore, the temperature in the hearth must be 1,500 to 1,580 °C.

The rate of slag sample leaching for Cs-137 is 10^{-4}-10^{-6} g/cm^2·days. The mechanical compressive strength of the slag is more than 1 GPa. The slag product features high water resistance and mechanical strength. The slag volume is approximately 100 times less than the initial solid radwaste.

The specific power consumption per 1 kg of reprocessed waste is 1.5 kW, of which the share of the electric power from the plasma power source is 0.6 to 1.0 kW. The results of the tests made it possible to start developing a deployable facility.

Research performed on technologies for purifying hot flue gases formed when burning radwaste enabled developing a relatively efficient gas purification scheme. Gases formed as a result of the burning process with temperature of about 900 °C are cooled sequentially in gas and dispersing heat exchangers down to 400 °C and enter a high-temperature filter where they pass through a wire-cloth-weaved membrane that removes a major part of soot and aerosols. Exhaust gases that are already free of aggressive components are purified to comply with established standards by an absolute filter.

CEMENTATION

Combined burial of liquid and solid radwaste is used. After reprocessing, solid radwaste is placed in near surface storage facilities. The voids between the waste fragments are then filled with cement prepared using liquid radwaste. A cementing plant is used, which includes a 25 m^3 hopper equipped with a jigger, a worm feeder, a mixer with an agitator, a pipeline, and a pump for liquid waste. The plant is equipped with remote control. For cementing, liquid radwaste with a specific activity up to 10 μCi/l and a salt content no greater than 130 g/l is used. The productivity of the plant is 4 m^3 of liquid waste per hour. The strength of the cemented product obtained is 150 to 180 kg/cm^2. The Cs-137 leaching rate is $2 \cdot 10^{-3}$ to $4 \cdot 10^{-4}$ g/cm^2·day.

A high-productivity mobile cementing plant on the chassis of a KrAZ-250 truck is also used. The plant is uses a hydro vacuum agitator to produce an 20 m^3 of liquid waste per hour.

In 1989-1990 an experimental mixer using turbulent layer apparatus was developed which enables performance of cementation both in continuous and periodical modes with fine adjustment of the output was developed, fabricated and tested. The mixer includes a system for feeding liquid waste and a binder, a dividing grate, a mixing area, and a cement mixture dump area. Ferromagnetic bodies are placed inside the mixer case. The bodies start to rotate and move under the action of the electromagnetic field produced by windings of the inductor of the turbulent apparatus. When moving, the bodies collide and form the turbulent layer proper. Liquid waste and cement supplied to the mixing area interact with moving ferromagnetic particles and are mixed. Homogeneous cement slurry passes through the dividing grate and is poured out into a cement tank.

A modular plant for reprocessing both solid and liquid radwaste by the cementation technique has been developed. This plant includes the following modules - cementing and mixing, a module for preparation of a liquid waste pulp, a sorbent module, metering pumps, mobile cement storage, and an automated gripper for primary packages. The plant is intended for preparing a cement mixture based on liquid radwaste or water with various admixtures and bagging into primary packages prefilled with solid waste. The output for cement slurry is up to 4 m^3 per hour when Portland cement is used as a binder, and bentonite and natural zeolite as sorbents. The water-to-cement ratio is 0.4 to 0.8 and that of cement to admixtures is 10:1. The specific activity of the waste is up to 1 mCi/l. The maximum height of the plant is 6.5 m. The plant is controlled automatically and visual control of the operating units is provided by a TV camera. Modular design allows it to be mounted on a truck.

With cement slurry treatment in the turbulent mixer, the strength of solidified samples is above 100 kg/cm^2. At the same time the rate of cement composition solidification rises, which reduces the time required for storing containers with the cement mixture before transportation to the storage facility. The rate of radionuclide leaching from cement compositions is $2 \cdot 10^{-3}$ to $4 \cdot 10^{-4}$ g/cm^2-day.

BITUMINIZATION

Unlike cementing, bituminization yields water-resistant compounds without an increase in the waste volume. Bituminization of liquid radwaste is performed at a URB-8 facility. The productivity is 450 to 600 liters of liquid waste per hour. The basic element of the facility is an industrial film type evaporator with a heat exchange surface area of about 8 m^2 and an operating temperature of 130 to 140 °C. Bituminized liquid radwaste has a salt content of 300 to 500 g/l. The resulting bituminized salt compound contains 40 to 50 mass per cent of salt. The leaching rate is 10^{-4} to 10^{-5} g/cm^2-day.

VITRIFICATION

Vitrification of medium- and low-activity waste is a newer and promising approach that provides reduction in the waste volume and allows formation of the most resistant products. Experimental vitrification of radioactive waste started in the early 1970s. Borosilicate glass was chosen as the matrix material. For vitrification, a ceramic melter with direct Joule heating was used.

When reprocessing liquid waste containing 200 g/l of salts, the productivity of the plant reaches 50 kg/hr. The specific productivity for glass is 40 to 50 kg/m^2-hr and the specific power consumption is 3.2 to 3.4 kW·hr/kg. The electric power of the plant is 150 kW, the temperature in the melter is 1,250 °C. The waste volume reduction factor (after vitrification) is 4.2-4.5. The rate of Cs-137 leaching from the ultimate product is $1.4 \cdot 10^{-5}$ to $4.4 \cdot 10^{-6}$ g/cm-day. More than 10 tons of glass have been produced in the ceramic melter. This research indicated a number of shortcomings of such a melter and afterwards an induction melter was employed.

Featuring fast action and good corrosion resistance, induction melters of the "cold crucible" type seem to be promising devices from the viewpoint of low- and medium-activity waste vitrification. An experimental stand has been assembled and a high productivity vitrification plant based on high-frequency inductors is under development. In this facility liquid waste goes through a concentration stage. The product, in the form of a suspension with 22 to 25 weight per cent moisture mixed with glass forming admixtures is supplied into the melter. The experimental stand is equipped with: a lamp oscillator with a vibrational power of 60 kW and an operating frequency of 1.76 MHZ; a melter of the "cold crucible" type with an operating surface area of 5.63 dm^2; a vertical rotor evaporator; dispensing devices; some auxiliary equipment. The stand productivity for glass is 7 to 10 kg/hr at a specific productivity 120 to 180 kg/m^2-hr. The specific power consumption per 1 kg of glass is 4.5-6.0 kW·hr. Solid phase removal from the melter is 1.0-1.2 per cent. At the stand, some research with simulators and real radioactive waste from nuclear power plants has been carried out. The rate of leaching from the glass bricks obtained is (1.4 x 10-4 g/cm^2-day.

The plant is equipped with a module including three independent melters of the "cold crucible" type. Each melter is placed in a separate box and suppled from its own oscillator. One of the melters is equipped with an extra unit for mechanical mixing to obtain glass composite materials in the melter. An annealing furnace provides adjustable cooling of glass bricks and is made on the basis of a tunnel furnace with four zones of controlled heating/cooling.

Aerosol removal is done in two stages. In the first stage (rough purification filter), bulk filters made of the material capable of incorporating in the glass melt after its life-time is over are used. At the second stage (fine purification filter) filters made of ultrahigh glass fibers (that are also capable of incorporating in the melt easily) are used.

To remove nitrogen oxides, packed columns operating in the "film" mode are used. The ultimate purification is provided by catalytic reduction of nitrogen oxides. The catalytic material, a mixture of aluminum and vanadium oxides, is incorporated in the glass bricks after the useful life time is over.

PURIFICATION OF LIQUID RADWASTE

Stationary and mobile facilities are used to purify radioactive slurries. In a stationary facility, when purifying water solutions, a system is used which includes a mechanical purification unit based on claydite and sypron filtering elements, an electrodialysis unit, and a unit for ion-exchange purification with cationic filters. When purifying liquid waste with a specific activity 0.05 to 0.4 μCi/l and a salt content 0.6 to 3 g/l, the productivity of this a system is about 2.5 m^3 per hour. Purified water is supplied to systems for decontamination of transport vehicles, equipment and rooms. The amount of the formed waste requiring further conditioning and burial is 0.3-2.5 volume per cent of the water purified by the system.

Low salt, low-activity liquid waste formed or accumulated in small amounts by various generators is purified by a mobile electrodialysis installation. This has three modules (ultrafiltration, electrodialysis and filtration) and is mounted on a trailer. The throughput is 12 m^3 per 24 hours at a dissolved salt content in the initial solution salt content is no greater than 2 g/L. The purified water's salt content is no greater than 0.2 g/L. The purification coefficient is 20 to 600 for Cs-137, 20 to 40 for Sr-90. The installation is equipped with electrodialysis and ultrafiltration apparatus of the "filter press" type. The specific electric power consumption is no greater than 20 $kW \cdot hr/m^3$.

In a facility called "EKO" (Figure 1) a pump supplies liquid radioactive waste to a mechanical filter filled with quartz sand where water is purified from oil products and suspensions. The filtrate (Figure 2) then enters a settling tank, in the conical bottom of which coagulated suspensions and colloidal particles accumulate. This slime is removed in regular intervals. From the central part of settling tank, liquid radwaste flows to the ultrafiltration apparatus, after which the concentrate returns to a settling tank. The filtrate is collected in an intermediate tank and then pumped through sodium-cationic filters with KU-2-8 resin in Na-form (to soften water prior to electrodialysis) with further collection in the dialysis tank of the electrodialyzer.

The electrodialysis apparatus operates in the flow mode with partial dialyzate recirculation and purifies liquid radioactive waste in the continuous mode. To achieve water decontamination to the level required by the relevant standards, a part of this dialyzate flow is directed through a filter filled with KU-2-8 cationic resin in the H-form and then leaves the facility. To provide stable operation of the electrodialysis unit, the salt content and concentrate activity in the electrodialyzer are kept at a constant level by means of a electrodialyzer/concentrator placed in the by-pass loop of the concentrate channel. The brine formed in non-flow compartments of the electrodialyzer/concentrator due to electro-osmotic water transfer through ion-exchange membranes is a solution with a salt content no less than 40 g/l.

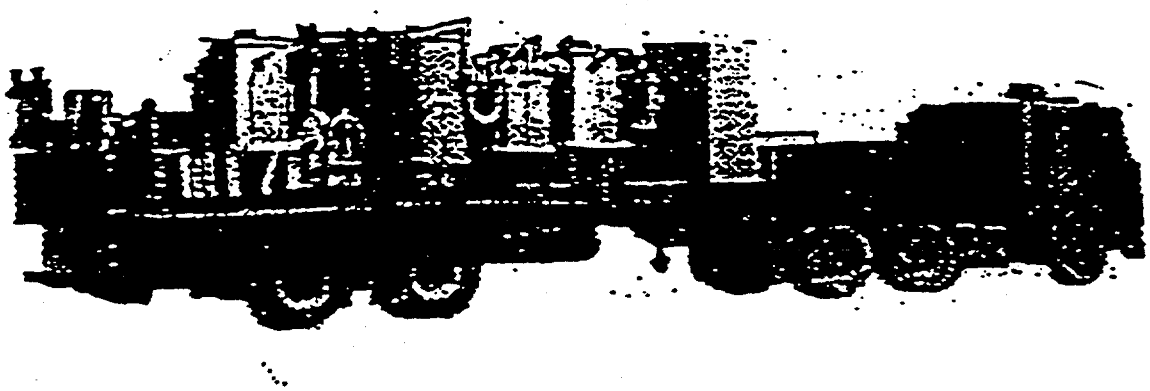

Figure 1 The "EKO" Mobile facility

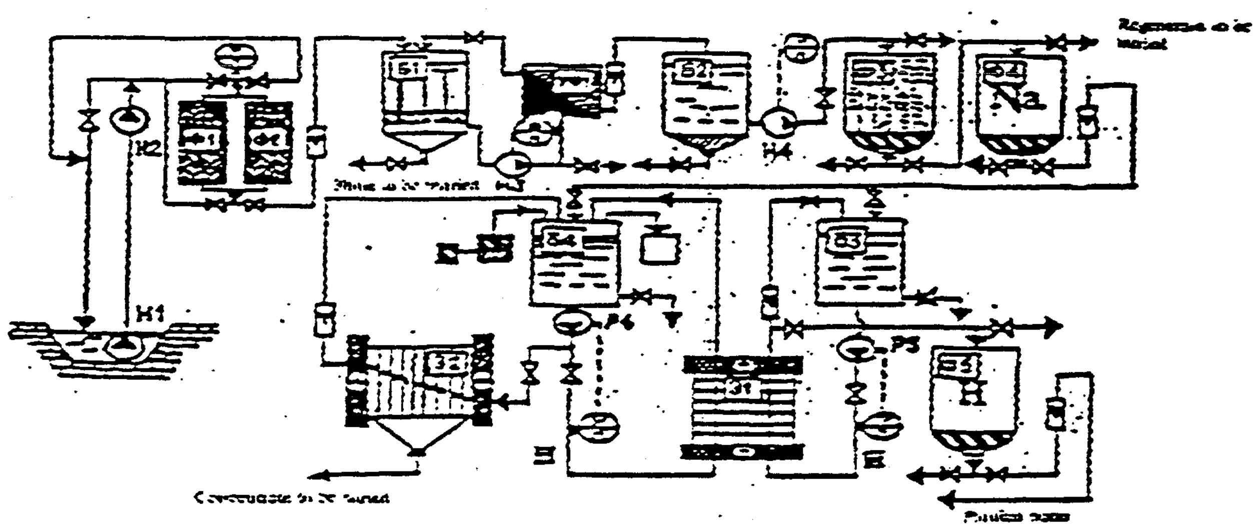

Figure 2 Flow diagram of the mobile facility

First stage 1,2 Mechanical filter; 3,4 Na+ cationic filters; 5 H+ cationic filter;
Second Stage 1 desalinization electrodialyzer; 2 Electrodialyzer concentrator;
Third stage Ultra filtration unit tank; 2 intermediate tank; 3 dialyzate tank; 4 concentrator tank
fourth stage 1-6 pumps; Ultrafiltration apparatus