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(GOSATOMNADZOR of RUSSIA)

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Collection, Treatment, Storage and Conditioning of Liquid Radioactive Waste. Safety Requirements
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GATHERING, REPROCESSING, STORAGE AND CONDITIONING OF LIQUID RADIOACTIVE WASTE. SAFETY REQUIREMENTS
NP-019-2000

Gosatomnadzor of Russia
Moscow 2000

Federal norms and rules "GATHERING, REPROCESSING, STORAGE AND CONDITIONING OF LIQUID RADIOACTIVE WASTE. SAFETY REQUIREMENTS" establish safety requirements for gathering, reprocessing, storage and conditioning liquid radioactive waste at nuclear installations, radiation sources, nuclear materials and radioactive substances storage facilities, and radioactive waste storages.

This regulation has been issued for the first time.
The regulation was developed by the Scientific and Engineering Center of Gosatomandzor of Russia (SEC NRS) with participation of Ms.Zakharova K.P., Ms. Masanova O.l. (The Bochvar Institute of Non-Organic Materials / VNIINM), Mr.Kiselev V.V. (Ministry of Health of Russia), Ms. Nepeypivo and Mr.Charafoutdinof (SEC NRS).

In the process of the development of the regulation comments were reviewed and taken into account provided by such institutions and agencies as Ministry of Health, State Committee for Ecology of Russia / Goscomecology, Minatom of Russia, VNIINM, the Moscow " RADON" facility, VNIIPIET, the R&D Center " Biophysics Institute", the Mining-Chemical Combine, Siberian chemical combine, the " Mayak" facility, Concern "Rosenergoatom" , Leningrad NPP, etc.

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LIST OF ABBREVIATIONS

LRW – liquid radioactive waste

RAW – radioactive waste

EAS – emergency alarm system

SSFCR – self-sustained fission chain reaction

LWS – liquid radioactive waste storage

1. MAIN TERMS AND DEFINITIONS

1. LRW bituminization – inclusion of waste into bitumen matrix.
2. Water-resistance- ability of compound to maintain its properties and retain its radionuclides in contact with water.
3. LWR exposure – LRW storage to make lower radioactivity and heat release due to short-lived radionuclides decay.
4. The state-of – the art technology- complex of scientific and technical knowledge, process and architect project & design developments in a certain area of science and engineering, validated by R&D and practical experience, and reflected in science and engineering materials.
5. Compound - matrix with RAW included.
6. LRW conditioning – manufacturing of waste packages suitable for safe storage, and/or transportation and/or disposal. The conditioning may include LRW transformation into a stable form or LWR encapsulation .
7. Casks for RAW - a tank designed for gathering and/ or transportation, and /or storage, and/or disposal of RAW.
8. Corrective measures – actions to eliminate non-compliance and prevent its occurrence once again.
9. Matrix material – non-radioactive material for LRW immobilization in a monolith. Note**:** Bitumen, cement, glass-like materials are examples of a matrix material.
10. LRW management – all types of activities in conjunction with gathering, transportation, reprocessing, conditioning, storage and/or disposal of LRW.
11. RAW management quality assurance – planned and implemented on a systematic basis activity ensuring that all RAW management actions, effecting nuclear and radiation safety, are carried out in compliance with federal rules and regulations for atomic energy use and with other regulatory documents, and that results of such actions meet corresponding requirements.
12. LRW vitrification - RAW transformation into a glass-like state.
13. LRW solidification – LWR transformation into solid state to lower the possibility of radionuclide migration into the environment.
14. Liquid radioactive waste – RAW in the form of liquid substances (aqueous or organic) which contain dissolved or suspended radionuclides.
15. Organic liquid radioactive waste – LRW in the form of oils, oil water emulsion , detergent solutions, extractants, etc
16. Radioactive waste – not subject to further use substances in any state of aggregation, materials, products, devices, equipment, biological objects containing radionuclides in the amount exceeding the levels prescribed by federal rules and regulations for atomic energy use. Such substances, materials, products, devices, equipment and objects are defined as belonging to radioactive waste by an operating organization with appropriate justification included in a nuclear facility , storage or radiation source design.
17. LRW reprocessing – process operation to decrease the volume, change the state of aggregation, and/or physical or chemical properties of LRW.
18. Quality assurance program – documented complex of organizational, technical and other measures to assure quality, which provide to the management of an operating organization and/or organization implementing works and rendering services, assurance that all activities effecting nuclear and radiation safety are carried out in compliance with federal rules and regulations for atomic energy use and other regulatory documents.
19. Gathering of LRW – placing LRW into instrumented tanks.
20. RAW package – package (cask) containing RAW ready for transportation, and/or storage and/or disposal.
21. LRW cementing – LRW including in matrix material.

22. LRW storage – provisional LRW storage in tanks (storage facilities) which ensures protection from radiation or LRW isolation with the intention of further retrieval.

2. Purpose and Scope of Application

2.1.The present regulation establishes requirements to ensuring safety during gathering, reprocessing, storage and conditioning of LRW at nuclear installations, radiation sources, nuclear materials and radioactive substances storage facilities and RAW storage facilities (hereinafter referred to as storage facilities).

2.2. The present document covers designing, construction, operation and decommissioning stages of nuclear installations, radiation sources and storage facilities involved in LRW gathering, reprocessing, storage and conditioning.

2.3. The present document does not cover:

- Management of LRW resulting from mining and enrichment of radioactive ores and other minerals.
- Management of LWR generated in surface waters at nuclear fuel cycle facilities.

3. General requirements to ensuring safety during gathering, reprocessing, conditioning and storage of liquid radioactive waste

3.1. Technical means and organizational measures on ensuring radiation safety during LRW gathering, reprocessing, storage and conditioning at nuclear installations, radiation sources and storage facilities shall be defined based on the highest acceptable LRW activity at the said installations and facilities and confine the workers (personnel), population and environmental radiation exposure to limits prescribed by Radiation safety regulations (NRB-99) and other federal rules and regulations pertinent to atomic energy use and normative documents.

3.2. The design of a nuclear installation, radiation source and storage facility shall envisage concrete technical solutions for safe LRW gathering, reprocessing, conditioning and storage, developed in compliance with the requirements prescribed by this regulation and other federal rules and regulations pertinent to atomic energy use and normative documents.

When appropriate normative documents are not available such proposed technical solutions are produced and justified in the design of a nuclear installation, radiation source and storage facility in accordance with the state-of-the-art science and technique.

3.3. Requirements to designing, manufacturing and installation of equipment designed for LR W gathering, reprocessing, conditioning and storage and to project design of appropriate systems (elements) of nuclear installations, radiation sources and storage facilities as well as classification of systems (elements) and equipment designed for LRW gathering, reprocessing, conditioning and storage in terms of their purpose, effect on safety and nature of their safety functions , seismic and fire- or explosion hazardous categories are prescribed by federal rules and regulations pertinent to atomic energy use which regulate safety of nuclear installations, radiation sources and storage facilities , and by the present regulation.

3.4. Project design and reliability of systems (elements) of a nuclear installation, radiation source and storage facility as well as documentation and works on LRW gathering, reprocessing, conditioning and storage shall be the responsibility of the operating organization and /or organizations providing to the operating organization works or services in compliance with the quality assurance program, belonging to the operating organization , and federal rules and regulations pertinent to atomic energy use and other normative documents.

3.4.1. The quality assurance program shall be aimed at:

- Organization of an efficient system of workers (personnel) training, refreshment training, skills improvement and qualification.
- Making as low as possible the LRW activity, mass and volume.
- Quality control of equipment, its components and materials to be procured;
- Obtaining reliable and complete information as regards LRW quantitative and qualitative content in the areas of waste generation, gathering, reprocessing, storage and conditioning;
- Quality control of process operations during LRW gathering, reprocessing, storage and conditioning;
- Establishing the quality criteria system for LWR to meet following its gathering, reprocessing, storage and conditioning;
- Application of metrologically certified techniques for LRW quality control and conditioned waste package tests.
- Quality control of LRW and conditioned waste packages.
- Organization of an efficient system of documentation recording and storage during LRW gathering, reprocessing, storage and conditioning, including identification labeling of conditioned waste packages.

3.4.2. Depending on the stage of LRW management , for establishing LRW quality criteria consideration shall be given to basic characteristics of LRW, cask and package.

3.4.2.1. LRW characteristics:
- Chemistry and phase status;
- Total activity;
- Radionuclide content, specific alpha- and beta-activity;

3.4.2.2. Solidified LRW characteristics:

3.4.2.2.1. Bitumen compound:
- Radionuclide content, specific alpha- and beta-activity, equivalent dose capacity;
- Unbound water content in a compound;
- Water resistance;
- Thermal resistance;
- Radiation resistance;
- Biological stability.

3.4.2.2.2. Cement compound;
- Radionuclide content, specific alpha- and beta-activity, equivalent dose capacity;
- Water resistance;
- Mechanical strength;

- Radiation resistance;
- Thermal resistance.

3.4.2.2.3. Glass-like materials;
- Radionuclide content, specific alpha- and beta-activity, equivalent dose capacity;
- Phosphate material content;
- Homogeneity of solidified material;
- Heat emission;
- Water resistance;
- Thermal resistance;
- Radiation resistance;
- Mechanical strength;
- Thermal physics constants (thermal conductivity, thermal expansion factor).

3.4.2.3. LRW cask characteristics
- Corrosion resistance, radiation resistance, configuration (dimensions) – as for a metal cask;
- Density, porosity, water and gas permeability, frost resistance, radiation resistance, resistance to micro-organisms, mould and fungus, fire resistance, configuration (dimensions) – as for reinforced concrete container;
- Other characteristics indicating isolation capabilities of a cask;

3.4.2.4. LRW package characteristics
- Radionuclide content, specific alpha- and beta-activity, equivalent dose capacity;
- Total activity;
- Homogeneity
- Mechanical strength (static, dynamic and impact load)s;
- Resistance to thermal loads and temperature cycles;
- Radiation resistance.

3.4.3. The LWR and conditioned waste quality control system shall check:
- LRW gathering process;
- LRW to be reprocessed;
- LRW reprocessing:
- Matrix materials;
- LRW solidification process;
- Solidified LRW;
- Conditioned waste packages.

The scope of quality control is defined in the design of a nuclear installation, radiation source or storage facility and shall provide for availability of reliable data as regards characteristics, of LRW, matrix materials, solidified LRW and conditioned waste packages.

3.4.4. The quality assurance program shall prescribe practice and procedures of recording quality criteria non-compliance for LRW and conditioned waste packages as well as for the process of non-compliance data acquisition, reprocessing and cause analysis.

Based on cause analysis results corrective measures are to be developed and implemented to prevent non-compliance occurrence in future.

3.4.5. The operating organization shall monitor the quality assurance program efficiency implemented at a nuclear installation, radiation source or storage facility by means of checks (inspections), which consist of:

- Verification of compliance of process operations on LRW gathering, reprocessing, conditioning and storage with design parameters in accordance with requirements of federal rules and regulations pertinent to atomic energy use and license conditions issued by a state body regulating safety in the field of atomic energy use.
- Check of operability of process operations control systems and their monitoring;
- Check of LRW and conditioned waste quality for compliance with quality criteria.

For all revealed non-compliance corrective measures shall be implemented.

3.5. During LRW gathering, reprocessing, storage and conditioning the following shall be ensured:

- Maintaining the required safety level in managing LRW as ionizing radiation sources;
- Avoiding cases of unjustified workers (personnel) exposure;
- As low as reasonable possible exposure of workers (personnel) and population taking into account sanitary and hygienic rules and regulations as well as economic and social factors;
- Prevention of possible accidents with radiological consequences and mitigation of these consequences if they emerge;
- LRW volume reduction;
- LRW preparation for storage and disposal following waste conditioning.

3.6. In the design of a nuclear installation, radiation source or storage facility classification shall be established for premises intended for LRW gathering, reprocessing, storage and conditioning in terms of explosion and fire safety in compliance with federal rules and regulations pertinent to atomic energy use.

Concrete technical solutions and organizational measures aimed at ensuring explosion and fire protection during LRW gathering, reprocessing, storage and conditioning shall be specified and justified in the design of a nuclear installation, radiation source or storage facility.

3.7. Premises designed for LRW gathering, reprocessing, storage and conditioning shall be equipped with venting systems preventing release of radioactive substances in air of the premises and environment and maintaining climatic conditions needed for normal operation of equipment. Contaminated air removed from the premises as well as gases taken away from equipment shall be decontaminated before being released to atmosphere.

3.8. During LRW gathering, reprocessing, storage and conditioning the following shall be implemented:

- Technical means and organizational measures to ensure LRW physical protection:
- Technical means and organizational measures to prevent LRW leakage or other processes that would lead to release of radionuclides to environment in amounts exceeding limits prescribed by sanitary and hygienic rules and regulations as well as by federal rules and regulations pertinent to atomic energy use.

- Radiation monitoring, including the monitoring of premises surface, equipment and pipeline contamination and of equivalent dose capacity, specific activity and LRW radionuclide content.

Radiation monitoring means and scope are established in the design of a nuclear installation, radiation source or storage facility in compliance with sanitary and hygienic rules and regulations as well as with federal rules and regulations pertinent to atomic energy use.

3.9. During LRW gathering, reprocessing, storage and conditioning the following shall be avoided:

- Unauthorized change of LRW aggregate state, including formation of precipitation and sludge;
- Unauthorized exothermic reactions;
- Unauthorized formation of corrosion aggressive agents.

3.10. During gathering, reprocessing, storage and conditioning of LRW containing nuclear hazardous fission materials the possibility of SSFCR shall be excluded.

The design and dimensions of equipment intended for gathering, reprocessing, storage and conditioning of LRW containing nuclear hazardous fission materials, as well as operational procedures shall not result in SSFCR.

The amount of nuclear hazardous fission materials in conditioned LRW and geometry of waste packages shall exclude the possibility of SSFCR.

Premises locating equipment designed for gathering, reprocessing, storage and conditioning of LRW containing nuclear hazardous fission materials shall be equipped with on-line emergency alarm system to detect SSFCR.

Assurance of criticality safety during gathering, reprocessing, storage and conditioning of LRW containing nuclear hazardous fission materials is regulated by federal rules and regulations pertinent to atomic energy use which specify criticality safety requirements.

3.11. During LRW gathering, reprocessing, storage and conditioning the possibility of equipment, pipeline, cask and premises decontamination shall be envisaged. Equipment, pipelines and surface of premises intended for LRW conditioning shall be resistant to corrosion aggressive environment , have low radioactive substance absorbing capacity and be easily decontaminated.

3.12. LRW gathering, reprocessing, storage and conditioning together with non-radioactive waste is not acceptable.

3.13. LRW gathering, reprocessing, storage and conditioning shall be documented as required by quality assurance program. Every LRW batch (package) should be accompanied by relevant documentation at all management stages . such documentation shall specify its main characteristics, such as:

3.13.1. LRW gathering:

- Source ;
- Amount;
- Chemistry and phase status;
- Total activity;

- Radionuclide content, specific alpha- and beta-activity, date of their measurement.
- Cask type (for a LRW package)
- Date of packaging (for a LRW package)
- Equivalent dose capacity (for a LRW package)
- Cask surface contamination (for a LRW package)
- Package identification symbol (for a LRW package);
- Place of storage ;
- Compliance with quality criteria.

3.13.2. LRW reprocessing

- Source;
- Reprocessing techniques;
- Amount;
- Chemistry and phase status;
- Total activity;
- Radionuclide content, specific alpha- and beta-activity, date of their measurement;
- Cask type (for a LRW package)
- Data package (for a LRW package);
- Equivalent dose capacity (for a LRW package);
- Cask surface contamination (for a LRW package);
- Package identification symbol (for a LRW package);
- Place of storage.

3.13.3. LRW solidification:

- Source ;
- Reprocessing techniques;
- Amount;
- Total activity;
- Radionuclide content, specific alpha- and beta-activity, date of their measurement;
- Cask type;
- Date of packaging;
- Equivalent dose capacity (for a LRW package);
- Cask surface contamination;
- Package identification symbol;
- Place of storage .

3.3.4. LRW conditioning:

- Source ;
- Amount;
- Reprocessing techniques;
- Conditioning techniques;
- Total activity;
- Radionuclide content, specific alpha- and beta-activity, date of their measurement.
- Cask type and number;
- Date of packaging;
- Cask surface contamination, equivalent dose capacity for a package and date of their measurement;
- Package identification symbol;

- Place of storage.

4. Requirements to ensuring safety during LRW gathering

4.1. LRW gathering shall be an obligatory stage of waste preparation for reprocessing, storage and conditioning and ensure no releases to environment in quantities exceeding limits prescribed by sanitary and hygienic rules and regulations as well as by federal rules and regulations pertinent to atomic energy use by way of LRW localizing in special equipment.

4.2. LRW gathering shall be implemented separately taking into account:
- Radionuclide half-life (less than 15 days, more than 15 days);
- Specific activity value;
- Concentration of alpha –active radionuclides;
- Chemistry;
- Phase status;
- Reprocessing technique supposed to be used.

4.3. Organic and explosion or fire hazardous LRW shall be gathered separately from other types of LRW.

4.4. For organic LRW, the type of waste shall be gathered separately:
- Low salt-containing aqueous solutions (with salt concentration less than 1g/l);
- High salt-containing aqueous solutions (with salt concentration more than 1g/l);
- Alkaline metals acting as coolant;
- High active oxidizers;
- Corrosion-active agents;
- Chemically unstable agents;
- Ion exchanger resins;
- Pearlite, vermiculite ;
- Titanium sorbents;
- Sludge.

4.5. LRW gathering shall be implemented in compliance with the requirements given in items 4.1.-4.4. following the sequence that ensures the lowest workers (personnel) exposure. Sequence of LRW gathering operations is to be established by the design of a nuclear installation, radiation source or storage facility.

4.6. Receptacles (tanks, casks, etc) shall be located as close as possible to the place of waste generation.

4.7. LRW containing 15-day half-life radionuclides only shall be gathered separately and are subject to a hold on period in LRW provisional storage places to decrease waste specific and total activity down to values under which activity radioactive substances are released from regulation by NRB-99.

4.8. Special sewer system shall be installed for LRW gathering. If the amount of LRW does not exceed 200l/day, casks could be used for waste gathering. Requirements to casks (receptacles) are prescribed by regulations.

4.9. LRW discharge to municipal fecal sewer system , industrial-cumulonimbus sewer system , surface waters, absorbing cavities, wells, drills, sewage farms, filtration farms and ground surface is prohibited.

5. Requirements to ensuring safety during LRW reprocessing

5.1. LRW reprocessing shall ensure LRW liquid phase cleaning and radionuclide concentration in a less volume.

It is not allowed to completely dehydrate high salt LRW aqueous solutions in case of possible exothermic interaction between LRW dry residual components.

Concrete techniques and means of LRW reprocessing shall be established and justified in the design of a nuclear installation, radiation source and storage facility.

5.2. Measures shall be taken to prevent formation of sludge in pipelines and equipment when LRW salt concentrates (evaporated residue) are transferred (transported).

5.3. Resulting from LRW reprocessing salt concentrates, spent sorbents, sludge, precipitants shall be conditioned in compliance with the requirements addressed in this regulation.

5.4. If concentration of radionuclides and dangerous substances in decontaminated water , resulting from LRW reprocessing , does not exceed acceptable limits prescribed by sanitary and hygienic rules and regulations, as well as by federal rules and regulations pertinent to atomic energy use , then this water can be used in the reverse water supply system of a nuclear installation, radiation source or storage facility or can be discharged to open hydro-network through an intermediate check tank.

6. Requirements to ensuring safety during LRW storage

6.1. During LRW storage the following shall be excluded:

- unjustified workers (personnel)exposure;
- population exposure exceeding prescribed limits;
- release of radionuclides to environment exceeding limits prescribed by federal rules and regulations pertinent to atomic energy use and by other normative documents.

6.2. The design of a nuclear installation, radiation source and storage facility shall envisage technical means and organizational measures for LRW safe storage as well as establish and justify acceptable LRW amount, their radionuclide composition, activity and term of LRW storage.

6.3. Storage of a high quantity of LWR shall be implemented in specially equipped storage facilities with the system of protection barriers preventing release of radionuclides to environment above the limits, prescribed by federal rules and regulations pertinent to atomic energy use and by other normative documents. Technical barriers are established and justified in the design of a nuclear installation, radiation source or storage facility in compliance with the requirements of the present regulation and other federal rules and regulations pertinent to atomic energy use.

6.3.1. Structures and structural materials of LRW storage shall:

- Prevent release of radionuclides to environment above the limits the limits, prescribed by federal rules and regulations pertinent to atomic energy use .
- Provide for LRW storage service life not less than that of a nuclear installation, radiation source or storage facility at which this storage is located.

LRW storage tank capacity shall ensure the required technological hold on period for LRW prior to their reprocessing and/or decay of short-lived radionuclides.

6.3.2. LRW storage tanks shall be equipped with:

- Pipelines and valves for LRW receiving, then sending them for conditioning and complete draining;
- Process parameters control means (temperature, pressure, level in tanks), including alarm system , indicating exceeded upper level in a tank and system of LRW leakage detection.
- Radiation monitoring;
- Sampling device which allows to take samples all over a tank;
- Precipitation thickness (height) meters;
- Devices for dispersion and removal of sludge (precipitation) and deposition;
- Equipment and pipelines for transferring from one tank to the other of solutions, sludge, sorbents and resins.
- Overflow pipeline connected to an auxiliary tank having the diameter more than that of a receiving pipeline.
- Process blow-off under depressurization**,** connected to the process blow off system and preventing excessive pressure in a tank free space;
- Hydrogen detection means, preventive and emergency alarm, automated means of fire detection and fire extinguishing, if necessary;
- Devices which prevent tank damage caused by increased pressure in tanks or their vacuumization.

6.3.3. Tanks designed for high level LRW shall be provided with additional technical means and techniques to prevent:

- LRW heating and evaporation;
- Accumulation of explosion hazardous gaseous substances.

6.3.4. The LRW storage tank design shall allow for detection of leakage and its repair.

6.3.5. Transfer of LRW from one tank to another shall be done using static pressure of either liquid or gas. (without using pumps).

6.3.6. Premises intended for placing LRW storage tanks shall have a not less than a three-layer hydro-insulation and stainless-steel plating. The plated premises shall accommodate all LRW included in storage tanks.

6.3.7. In the vicinity of premises with LRW storage tanks surveillance bore-holes shall be made for ground water sampling. The number and location of such bore-holes are prescribed by regulatory documents.

6.3.8. Premises where LRW storage tanks are placed shall be equipped with:

- Leakage alarm;
- Leakage gathering and return system;
- Ventilation;
- Radiation monitoring;
- Decontamination means.

6.3.9. The LRW storage tank chemistry shall exclude intensive corrosion.

6.3.10. Premises where organic LRW storage tanks are located , shall be equipped with fire alarm and fire extinguishing means. It is not allowed to store organic LRW together with oxidizer – containing media.

6.3.11. The design of a nuclear installation, radiation source and storage facility shall provide for redundant tanks intended for storage of LRW resulting from accident. A minimal redundant tank capacity shall be justified in the design. Redundant LRW storage tanks and premises are covered by the same requirements as for primary LRW storage tanks.

6.4. Small amounts of LRW shall be stored in specially equipped premises . The location of such premises, their equipment and conditions of storage shall be in compliance the "Main Sanitary Rules on Radiation Safety (OSPORB-99). "

7. Liquid radioactive waste solidification safety requirements

7.1. The LRW solidification process shall ensure resulting products with quality indicators established in the present regulation. Specific techniques and means of LRW solidification shall be defined and justified in the design of a nuclear installation, radiation source and storage facility.

7.2. LRW solidification shall be implemented using cementing**,** bituminization and vitrification techniques.

To chose a proper technique of LRW solidification the following shall be taken into account:

- LRW physical and chemical characteristics;
- Matrix material properties;
- Supposed technique of conditioned waste storage and/or disposal.

It is allowed to use other state-of the-art LRW solidification techniques.

7.3. The LRW solidification process shall be fire- and explosion - safe and shall not yield great amounts of secondary RAW.

7.4. When LRW are solidified by cementing the following basic requirements shall be met:

7.4.1. A cementing facility shall be located in separate premises equipped with a ventilation system;

7.4.2. Non-organic binders (cement, portlandcement, slagportlandcement**,** etc**)** shall ensure the quality of a cement matrix which meets the requirements prescribed by the present document.

7.4.3. LRW containing agents, which reaction with cement results in generation of toxic substances (such as ammonium salts), shall not be included in a cement matrix.

7.4.4. In order to avoid spill of cement compound over premises while its packaging in containers the following shall be envisaged:

- Check of placing a cement compound container beneath an outlet nozzle;
- Check of filling a container by cement compound;

- Device which shall exclude the possibility of spilling during transportation of a cement compound container from the place of it filling in to the area where it will be held for solidification.

7.4.5. LRW cement viscous mass stirring devices shall ensure obtaining a homogeneous cement compound with uniform distribution of radionuclides over its volume.

7.4.6. While cementing, process parameters shall be controlled and monitored, so that to obtain a cement compound with the main quality indicators as follows:

Quality indicator	Acceptable values
Compound specific activity:	
Beta-activity	$< 3{,}7 \cdot 10^{10}$ Bq/kg ($1 \cdot 10^{-3}$ Ci/g)
Alphaactivity	$< 3{,}7 \cdot 10^{7}$ Bq/kg ($1 \cdot 10^{-6}$ Ci/g)
Water-resistance (Cs-137 and Sr90 radionuclides ……. rate)	$< 1 \cdot 10^{-3}$ g/sm^{2}day
Mechanical strength (compression ultimate strength)	$\geq$ 50 kgf/sm^2
Radiation resistance	Post 10^6 Gr (10^8 rad) irradiation mechanical property not less tan 50 kg/ cm
Thermal cycle resistance	Mechanical property not less tan 50 kg/cm following 30 freezing and de-freezing cycles (-40 … +40°C)
Water resistance	Mechanical property not less tan 50 kgf/cm^2 following a 90-day immersion in water

Cement compound quality requirements are established in normative documents.

7.5. When RAW is solidified by bituminization technique the following basic requirements shall be met:

7.5.1. A bituminization installation shall be placed in a separate room equipped with ventilation, fire alarm and fire extinguishing devices.

7.5.2. The bitumen which serves as a matrix material shall meet the following requirements:

- Flash temperature not less than 200°C
- Ignition temperature not less than 250°C
- Self-ignition temperature not less than 400°C

7.5.3. The bitumen matrix shall not include RAW that could chemically resulting in:

- Exothermic effect;
- Generation of toxic or explosion-hazardous substances;
- Deterioration of a compound quality.

7.5.4. Salt concentrates intended for bituminization shall meet the requirements as follows:

- Strong oxidant concentration (tri-valency metal nitrates, manganese oxide potassium, etc) in LRW shall not exceed 5% of the dry residue;

- Content of ammonia nitrate in LRW shall not exceed 12% of the dry bottoms mass;
- LRW pH shall be kept within a 6,5-11,5 range;
- LRW specific activity shall not exceed $3,7 \cdot 10^{10}$ Bq/dm (1 Ci/dm^3)

7.5.5. LRW shall not include organic substances that could produce under the bituminization conditions easily volatile compounds in amounts that might result in explosion –hazardous concentration in the gas phase. The concentration of such compounds in emitted gases shall be monitored.

7.5.6. In order to prevent the possibility of bitumen compound spill in premises during its packaging the following shall be implemented:

- Check on location of a bitumen compound cask under a discharge nozzle;
- Check on filling the cask with bitumen compound
- Device that prevents the possibility of compound spilling out while transporting the cask from the filling- in location to the place where it will be stored for cooling down.

7.5.7. Bituminization process parameters shall ensure the production of a homogeneous bitumen compound with uniform distribution of radionuclides in it.

7.5.8. Bituminization process parameters shall be monitored and controlled to ensure the production of bitumen compound with the following properties:

Quality Indicators	Acceptable values
Compound specific activity	
Beta-activity	< $3,7 \cdot 10^{10}$ Bq/kg ($1 \cdot 10^{-3}$ Ki/g)
Alpha - activity	< $3,7 \cdot 10^{7}$ Bq/kg ($1 \cdot 10^{-6}$ Ki/g)
Water-resistance (Cs-137 and Sr90 radionuclides ……. rate)	< $1 \cdot 10^{-3}$ g/cm·day
Compound unbound humidity	< 3%
Thermal resistance	• Flash temperature t° 200°C • Ignition temperature t° 250°C • Self-ignition temperature t° 400°C
Radiation resistance	Post-10^6 Gr (10^8 rad) irradiation 10% volume increase
Biological resistance	No fungus observed

Bitumen compound quality requirements are established in normative documents.

7.6. When LRW are solidified by a vitrification technique the following requirements shall be met:

7.6.1. A vitrification installation shall be placed in a room equipped with ventilation.

7.6.2. In order to prevent the possibility of the glass-like material spill during its packaging the following shall be implemented:

- Check on location of a glass-like material containing cask under a discharge nozzle;
- Check on filling the cask with the glass-like material;
- Device that prevents the possibility of a glass-like material spilling out while transporting the cask from the filling- in location to the place where it will be stored for cooling down.

7.6.3. The plutonium concentration im LRW shall not be more than 0.03 g/dm^3

7.6. 4. During the vitrification process the concentration of radionuclides as well as concentration of H_2, CO and other gases released from furnace shall be monitored.
7.6.5 During the vitrification , materials used and process parameters shall be controlled to ensure the production of a homogeneous glass-like material with uniform distribution of radionuclides in it.

7.6.6.The vitrification process parameters shall be monitored and controlled to ensure the production of glass-like material with the following properties:

Quality Indicators	Acceptable values
Solidified LRW composition	< 24-27% mass Na_2O and single-valent nuclide oxides; < 20-24% mas. Al_2O_3. And multi-valent nuclides, including < 0,2 % mas. Of transuranium elements; < 50-52% mas.P_2O_5
Homogeneity	Uniformity of the block composition in terms of macro-elements within the range of $\pm$10%; no segregation of the disperse phase is observed, specifically for alpha-emitters**.** Number of alpha-emitters < 0.2 % mas.
Heat-release	< 5 kW/m^3
Water-resistance (Cs-137, Sr-90, Pu leaching rate)	$10^{-5} – 10^{-6}$ g/sm^2 · day Cs^{137} 10^{-6} g/sm^2 · day Sr^{90} 10^{-7} g/sm^2 · day Pu
Thermal resistance	No changes in structure and water resistance in the result of storage at 450°C
Radiation resistance	No changes in structure and water resistance at: a) dosage ~ 10^8 Gr (10^{10} rad) (in terms of β, γ-radiation), b) $10^{18} – 10^{19}$ α-decays/cm^3
Mechanical strength Compression strength Bending strength	 (0,9 – 1,3) kgf/mm^2 (0,9 – 1,3) · 10^7 N/m^2
Young module	(4,1 – 4,7) kgf/mm^2 (4,1 – 4,7) · 10^7 N/m^2 > 5400 kgf/mm^2 (> 5,4 · 10^{10} N/m^2)
Thermal physics constants: Thermal expansion factor	(8 – 15) · 10^{-6} 1/°C
Heat conductivity factor	Variation within 0,7-1,6 W/mK under 20-500°C
Gas emission	Not acceptable

7.6.6. Glass mass quality control requirements are established in normative documents.

8. Liquid radioactive waste safety requirements

8.1. LRW conditioning shall ensure LRW transformation into forms fit for further transportation and/or storage and/or disposal.

8.2. Depending on LRW characteristics and techniques of further handling conditioned LRW ., including their transportation, and /or reprocessing, and/or storage, and/or disposal , the LRW conditioning shall include one of the following operations or a set of such operations:

- LRW placing in casks;
- LRW solidification and their placing in casks;
- LRW package placing in an additional cask.

8.3. The design of a nuclear installation, radiation source, and storage facility shall envisage adequately justified techniques and means of LRW conditioning in compliance with requirements of the present document and other federal rules and regulations pertinent to atomic energy use.

8.4. To define techniques and means of LRW conditioning the following shall be taken into account:

- characteristics of LRW subject to conditioning;
- techniques of further handling of conditioned LRW, including their reprocessing, and/or transportation, and/or storage, and/or disposal;
- LRW quality criteria established for further LRW handling.

8.5. Radionuclide composition, radionuclide specific activity. RAW package total activity, cask surface equivalent dose, cask outer surface contamination shall be comply with LRW quality criteria for the next stage of their management. The Raw package shall prevent radionuclide propagation in the environment.

8.6. The conditioned RAW package shall not contain:

- Strong oxidizers and chemically unstable substances;
- Corrosion-aggressive substances;
- Toxic, pathogenic and infectious materials;
- Biologically active materials;
- Substances capable of detonation or explosive decay;
- Substances interacting with water exothermally, resulting in explosion;
- Substances which contain or can generate toxic gases, steam or sublimation products.
- Easily inflammable and explosion- and fire-hazardous substances;

Liquid content in RAW package shall not exceed 3%.

8.7. The choice of cask design and structural materials is based on:

- RAW physical and chemical characteristics;
- Techniques of further management of RAW cask;
- Quality criteria established for further management of RAW.

8.8. Cask design and its structural materials shall provide for maintaining its integrity and operability, including its strength properties during further RAW management;

8,9, Cask structural materials and its surface cladding materials shall ensure protection from atmospheric impact and provide for decontamination.

8.10. If the RAW package contains corrosion-resistant substances, its inner surfaces shall be clad with corrosion – resistant material.

8.11. If the design of a nuclear installation, radiation source and storage facility does not prescribe the technique, place and specific term of conditioned LRW disposal , in this case a cask shall maintain integrity during the expected storage time period till disposal and prevent unacceptable propagation of radionuclides from the RAW package.

The cask shall ensure the possibility of:

- RAW package retrieval from storage facility an the end of storage time period;
- Placing RAW package in additional cask, if necessary;
- Radwaste package transport for disposal;
- RAW package handling during disposal.

8.12. If the RAW package does not meet established RAW quality criteria for transportation, and/or storage and/or disposal, in this case an additional cask shall be used to cope with this in-compliance.

8.13. RAW casks and packages designed for long-term storage and/or disposal are subject to mandatory certification.

8.14. Conditioned LRW shall be stored in specially equipped storage facilities having a system of barriers preventing release of radionuclides in environment beyond the levels, prescribed by federal rules and regulations pertinent to atomic energy use. Technical characteristics of such barriers, conditioned LRW storage term and amount of LRW are established and justified in the design of a nuclear facility, radiation source and storage facility in compliance with the requirements of the present regulation and other federal rules and regulations pertinent to atomic energy use.