Federal Environmental, Industrial and Nuclear Supervision Service

FEDERAL STANDRADS AND RULES IN THE FIELD OF USE OF ATOMIC ENERGY

Approved by
Decree of the Federal Environmental, Industrial and Nuclear Supervision Service
No 11 of December 21, 2006

TRANSURANIC RADIOACTIVE WASTE IMMOBILIZATION FACILITIES. SAFETY REQUIREMENTS

(NP-076-06)

EFFECTIVE SINCE

June 1, 2007

Moscow 2006

UDK 621.039

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These federal standards and rules in the field of use of atomic energy "Transuranic Radioactive Waste Immobilization Facilities. Safety Requirements" establish safety principles, criteria and requirements for immobilization of radioactive waste containing transuranic elements as sources of possible radiation impact on the employees (personnel), population and environment.

The document is developed in accordance with the general safety principles, criteria and requirements for the nuclear fuel cycle facilities, on the basis of the legal acts of the Russian Federation, Joint Convention of Safe Management of Spent Fuel and Safe Management of Radioactive Waste, federal standards and rules in the field of use of atomic energy, and also IAEA recommendations.

The document is issued for the first time[1*].

[1*]The regulatory document is developed by the Scientific and Engineering Center for Nuclear and Radiation Safety (SEC NRS) jointly with the Nuclear Safety Institute of the Russian Academy of Sciences (IBRAE RAN) involving V.M.Iruishkin, A.I.Kislov, I.V.Sokolova (Federal Environmental, Industrial and Nuclear Supervision Service), I.V.Kaliberda, V.P.Slutsker, A.A.Stroganov (SEC NRS), A.A.Polishuk (IBRAE RAN), L.I.Petrova, M.O.Shvedova (Rosatom), G.B.Borisov, P.P.Poluektov, A.Ia.Chilikin (FSUE "VNIINM"), A.V.Demin (FSUE "LI "VNIPIET", Yu.V.Glagolenko (FSUE "PA "Mayak"), C.N.Philippov (JSC "Sverdniichimmash").

Comments of Rosatom, FSUE "PA "Mayak", FSUE "SCC", FSUE "VNIINM", FSUE "LI "VNIPIET", JSC "Sverdniichimmash" are reviewed and taken into account.

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List of abbreviations

FSR	- Federal Standards and Rules in the field of use of atomic energy
GRW	- Gaseous Radioactive Waste
GSP NFCF	General Safety Provisions for Nuclear Fuel Cycle Facilities
HLRW	- High-level Liquid Radioactive Waste
NFCF	- Nuclear Fuel Cycle Facility
NHFM	- Nuclear-Hazardous Fissile Material
NM	- Nuclear Material
QAP	- Quality Assurance Program for development, operation and decommissioning of the facility
QAP(C)	- local Quality Assurance Program for the facility Commissioning
QAP(D)	- local Quality Assurance Program for WPIF Design
QAP(De)	- local Quality Assurance Program for the facility Decommissioning
QAP(E/D)	- local Quality Assurance Program for Design (development) of safety important the facility Equipment
QAP(E/M)	- local Quality Assurance Program for Manufacturing of safety important WPIF Equipment
QAP(G)	- General Quality Assurance Program for work on WPIF development, commissioning and decommissioning
QAP(O)	- local Quality Assurance Program for WPIF Operation
QAP(S)	- local Quality Assurance Program for WPIF Siting
QAP(T/D)	- local Quality Assurance Program for Development of plutonium immobilization Technology
QAP(Con)	- local Quality Assurance Program for WPIF Construction – assembling and aligning of safety important WPIF equipment
RadS	- Radioactive Substances
RW	- Radioactive Waste
SAR	- Safety Analysis Report
SAR WPIF	- Safety Analysis Report of Weapons Plutonium Immobilization Facility (hereinafter WPIF)
SCR	- Self-sustained Chain nuclear Reaction
SCR EAS	- Self-sustained Chain nuclear Reaction Emergency Alarm System

Basic terms and definitions

For the purposes of this document the following definitions are used:

Embedded elements shall mean the part of an immobilized transuranic RW package of specific geometry containing the main amount of the immobilized transuranic RW and manufactured of the material which represents an inert chemical matrix (ceramic, mineral-like etc.) with a long-term stability against the radiation damages and emplaced inside the shaping container with the vitrified HLRW.

Immobilization shall mean the encasement of transuranic RW into the embedded elements (including their transfer into the inert physicochemical form with a long-term stability against radiation and thermal impact) and emplacement of the embedded elements into the glass mass which is solidified HLRW and a physical barrier isolating the transuranic RW encased into the embedded elements from the external environment and, if necessary (depending on specific immobilization objectives), forming a radiation barrier to impede an unauthorized access to the immobilized transuranic RW.

Immobilized transuranic RW package (packaging) shall mean the transuranic RW immobilization end product item representing a shaping container equipped with the embedded elements and filled with vitrified HLRW.

Melter shall mean the device (furnace) to produce a liquid (melted) glass mass from glass frit mass, HLRW and (if necessary) vitrifying additives.

Radiation barrier shall mean the gamma-radiation field with a high (not less then the established value) dose rate, which is formed around an immobilized transuranic RW package by long-lived radioactive isotopes contained in the package glass mass and impedes an unauthorized access to the package and retrieval of the embedded elements from the package.

Radiation source sky-shine (photon or neutron) shall mean the effect of reflection of photons or neutrons of a radiation source located on or near the earth’s surface from the near-surface atmospheric layer, which leads to generation of dispersed radiation fields at significant (hundreds of meters) distances from the source.

Shaping container shall mean the part of the immobilized transuranic RW package representing an envelope of specific geometry and intended for emplacement of the embedded elements inside it with a subsequent filling with vitrified HLRW and encapsulation.

Transuranic RW (for the purposes of this document) shall mean RW containing transuranic elements.

1. Purpose and scope

1.1. The federal standards and rules "Transuranic Radioactive Waste Immobilization Facilities. Safety Requirements" develop further and specify GSP NFCF requirements as regards specifics in ensuring safety of the transuranic RW immobilization facilities implementing (completely or partially) a generic scheme of the transuranic RW immobilization presented in Appendix 1 (reference).

1.2. This document applies to the transuranic RW immobilization facilities under siting, design, construction, operation and decommissioning (hereinafter referred to as the "facilities"), which use the process schemes aiming at transferring high-level transuranic RW into the immobilization end product which meets the established requirements to its quality.

2. Safety principles and criteria (general provisions)

2.1. The facility meets safety requirements if in normal operation and operational events including design basis accidents, its radiation impact to the employees (personnel), population and environment does not exceed the established exposure dose limits for the employees (personnel) and population as well as standards for releases and discharges of RadS, RadS contents in the environment, as well as if these impacts are limited in case of beyond design basis accidents.

2.2. The facility safety shall be ensured through consistent implementation of the safety-in-depth concept, which is based on application of a system of physical barriers preventing propagation of ionizing radiation, NM and RadS into the environment.

2.3. During normal operation of the facility all physical barriers shall be workable and their protection system shall be available. When any of the physical barriers is found out of order or measures to protect it are not in place, the measures shall be taken to prevent a possible propagation of ionizing radiation, NM and RadS and to bring appropriate systems of the facility to the safe state.

3. Main safety requirements

3.1. Facility siting

3.1.1. When siting the facility, the compliance with NFCF siting criteria and requirements established in FSR shall be ensured.

3.1.2. All phenomena, processes and factors of natural and man-induced origin revealed within the location region and on the site and other site characteristics which may affect the facility safety and its possible radiation impact on the population and environment during the facility operation and decommissioning shall be taken into account in the design, during the facility operation and decommissioning.

3.1.3. The facility shall be located only within the site which hosts (jointly with other NFCF) HLRW storage facilities with characteristics corresponding to the applied immobilization technology and which is capable of supplying the facility with all relevant process media during its all design service life in sufficient amounts.

3.1.4. The facility location on such site shall not cause the necessity to change the set boundaries of the controlled are and surveillance zone.

3.2. Facility design

3.2.1. Requirements to the end product characteristics and transuranic RW immobilization technology

3.2.1.1. The following requirements to the transuranic RW immobilization end products (immobilized transuranic RW packages) shall be met:

- mean content of the immobilized transuranic RW in ceramic or mineral-like matrices of the embedded elements shall be regulated by resistance of the matrix material against the radiation degradation and by nuclear safety requirements for manufacturing of embedded elements and packages, long-term storage of packages taking into account initiating events, and shall be determined in the facility design;
- physical and chemical properties of the matrix material of the ceramic or mineral-like matrices that host transuranic elements shall so as to impede recovery of transuranic elements from the matrices;
- radiation stability, thermal stability, leaching stability of the glass matrix, maximum content of transuranic elements in the hosting glass mass shall be in compliance with requirements of FSR “Collection, Processing, Storage and Conditioning of Liquid Radioactive Waste. Safety Requirements” for HLRW solidification by the vitrification method;
- geometry and sizes of the packages shall be such as to ensure reliable cooling of the packages along with maintaining the maximum temperature of the glass mass and embedded elements below maximum permissible limits during the long-term storage taking into account initiating events of design basis accidents;
- mechanical and strength properties of packages shall be such as to exclude mechanical damage of the packages during their handling at the facility, including the long-term storage of the packages taking into account initiating events of design basis accidents;
- the immobilized RW packages (the immobilization end product) shall be suitable for long-term (many dozens of years or up to the final removal of the packages from the human environment as provided for in the design) storage without essential radiation and thermal degradation of the mechanical properties of the packages and their capability to hold radionuclides contained in the glass mass and transuranic elements contained in the embedded elements included in the glass mass.

3.2.1.2. The design may set forth the following additional requirements to the packages as conditioned by specific objectives of the transuranic RW immobilization and specifics of the concrete technology for the packages handing at NFCF:

- requirements to the form and mass value of immobilized transuranic RW packages;
- requirements to minimal values of dose rates of external gamma-radiation from the packages (without shielding) during their storage at NFCF.

3.2.1.3. The technology to encase transuranic RW into ceramic or mineral-like matrices, a method to manufacture embedded elements of the matrix material containing transuranic RW and method of grouting of embedded elements in the hosting glass mass jointly with HLRW shall be determined in the facility design and justified in SAR for the facility.

3.2.1.4. The technology to encase embedded elements into the hosting glass mass shall provide for their fixing to ensure that the embedded elements are emplaced inside the shaping container as provided in the design.

3.2.1.5. Relative content of short-lived radionuclides – fission products not intended for setting a long-term radiation barrier to reduce the radiation and thermal load on the hosting glass mass – shall be limited in HLRW, delivered to the facility for the vitrification. A total residual energy release caused by short-lived radionuclides shall not exceed 10 % of the total energy release.

3.2.1.6. The vitrification technology and parameters (HLRW chemical composition and additives in use) shall provide for production of the homogeneous glass-like material.

3.2.2. Requirements to facility design

3.2.2.1. The facility design shall ensure radiation safety by using a system of physical barriers between the RadS and (or) NM containing initial materials, process media etc. and the employers (personnel) and environment, i.e isolating RadS and (or) NM and protecting RadS and (or) NM against neutron- and gamma-radiation.

As isolating physical barriers of the facility, leaktight enclosures (walls of the equipment and (or) glove boxes) and the exhaust or combined extract and input ventilation equipped with the gas clean-up system shall be used during all process operations involving the transuranic RW subjected to the immobilization, HLRW and secondary RW when ingress of radionuclide aerosols from the equipment into the environment of the working premises is possible.

During the handling of the finished conditioned embedded elements (their intermediate storage, encasement into the shaping container and (or) its transportation to the vitrification bay) or finished packages, the ceramic or mineral-like matrix of the embedded elements including immobilized transuranic RW, and also solid matrix for vitrified HLRW encased into the shaping container, which hosts the embedded elements with the immobilized transuranic RW, may be considered as one of the isolating physical barriers.

The fixed (including walls of the equipment and structures) and temporary radiation shields (shielded transportation container) may be used as physical barriers at the facility.

3.2.2.2. The facility design shall provide for at least three physical barriers between process media containing RadS and (or) NM and the environment and at least two physical barriers between these process media and employees (personnel).

If the less number of the physical barriers is used, compensatory measures shall be provided for. The sufficiency of this number shall be justified in the design. This justification shall be presented in the SAR for the facility.

In case of the initial event of the design basis accident, there shall be at least two physical barriers between the process media containing RadS and (or) NM and the environment and at least one physical barrier between the process media and employees (personnel).

3.2.2.2.1. As regards the process sections for handling the process media containing transuranic RW, the isolating (shielding) physical barriers shall be:

- the first barrier – walls of the process equipment (vessels, vitrification installation, melter), pipelines, containers hosting the process media, RadS, NM, HLRW and secondary RW in combination with the process exhaust ventilation equipped with the gas clean-up system;
- the second barrier – walls of the leaktight working premises (canyons, hot cells etc.) where the process equipment, pipelines, containers are located, in combination with the local (repair, emergency) exhaust ventilation equipped with the gas clean-up system;
- the third barrier – the engineering structures of the buildings in combination with the general extract and input ventilation.

3.2.2.2.2. The facility design shall provide for the location of each process section intended for manufacturing of the embedded elements (the section for pre-treatment and blending of transuranic RW with ceramic- and mineral-producing agents, the section for manufacturing of the embedded elements, the section for quality control of the embedded elements), and also the section for encasement of the embedded elements into the shaping containers inside the glove boxes, and, if necessary, to protect the personnel against the neutron- and gamma-radiation caused by transuranic RW – inside cells equipped with appropriate shielding. Glove boxes and cells shall be leaktight and provided with local exhaust ventilation with the gas clean-up system.

3.2.2.2.3. As regards the process sections for handling the finished embedded elements (storage, loading into the shaping containers), transportation of the shaping containers loaded with the embedded elements to the HLRW vitrification section, transportation to the storage facility there shall be the following physical barriers:

- the first barrier – physical and chemical form of the inert matrix material of the embedded elements and (or) solidified glass mass holding the transuranic RW and radionuclides contained in the vitrified HLRW in combination with the package shell (walls of the shaping container);
- the second barrier – walls of leaktight process premises (transport corridors, etc.), walls of the transport containers (if their use is required to protect the employees (personnel) against the external exposure) in combination with the local (repair, emergency) exhaust ventilation equipped with the gas clean-up system;
- the third barrier – the engineering structures of the buildings in combination with the general extract and input ventilation equipped with the gas clean-up system.

3.2.2.2.4. If necessary, during the transportation operations involving the embedded elements and packages, the system of physical barriers between the employees (personnel) and the environment and RadS and NM contained in the intermediate (embedded elements) or end (package with HLRW) product of the transuranic RW immobilization shall be supplemented with the radiation shielding (protective barrier) to protect employees (personnel) carrying out transportation and (or) being present near the transportation route against the external radiation.

3.2.2.2.5. If the facility design proves that an RadS and NM ingress from the embedded elements into the air inside the transport corridor is excluded under the normal mode of transportation of the shaping containers loaded with the embedded elements and during design basis accidents, it is allowed not to use the exhaust ventilation system equipped with the gas clean-up system inside the transport corridor.

3.2.2.2.6. The transportation corridor for HLRW transport to the melter working premises incorporated into the facility complex shall be provided with, over its all run from HLRW storage to the process units and systems of the facility, at least 2 physical barriers between transported (in HLRW) RadS and the environment and employees (personnel). Pallets and sumps under the transportation corridor shall be arranged for to confine and collect possible radioactive leaks.

3.2.2.2.7. The HLRW transport along the transportation routes shall be mainly implemented using static pressure of the liquid or vacuum or using special leaktight pumps.

3.2.2.2.8. If necessary, an required gamma-radiation shielding shall be arranged for along the transportation routes for HLRW or immobilized transuranic RW packages. At that, the radiation source sky-shine effect produced by the transported HLRW or immobilized transuranic RW packages shall be considered.

3.2.2.2.9. If necessary, the design shall provide for additional organizational measures to limit personnel access to the facility site where increased radiation levels may be present during transportation of the HLRW or immobilized transuranic RW packages.

3.2.2.3. The radiation shielding of the employees (personnel) from the external exposure shall be designed on the basis of conservative assumptions concerning the radiation source geometry (process media) and considering:

- neutron radiation due to spontaneous fission of even-even nuclei of transuranic element isotopes and due to the reaction (alpha-neutron) involving nuclei of light elements being a part of composition of the process media in use;
- possible reflection (albedo) of neutrons from structural elements (and low energy photons – from structural elements and air of the work premises).

While designing the shielding of employees (personnel) from external radiation, neutron- and gamma-radiation from unfixed and fixed (non-removable) surface contamination by transuranic elements of the inner surface of glove boxes shall be considered, and in all cases it shall be taken into account when assessing an anticipated exposure of the repair workers (personnel).

3.2.2.4. The facility design shall provide for spatial isolation (separation by main walls or hosting by separate buildings) of all process premises indented for processing of the process media and (or) products containing NM (including plutonium) and RadS, their storage and transportation and premises attended by the facility personnel who are not directly involved in main process, and also auxiliary facility premises intended for storage and pre-treatment of the process media not containing RadS and NM.

3.2.2.5. The facility design shall provide for spatial isolation of the facility complex part (process premises) intended for manufacturing of the embedded elements from the facility complex part (process premises) intended for HLRW vitrification in packages loaded with the embedded elements in such a way that the safe operation conditions in a complex’s part would not be violated during any possible design basis accidents at any other complex’s parts.

3.2.2.6. The facility design shall provide for the HLRW supply to the receiver tank of the melter directly from the on-site stationary HLRW storage facilities. It is not allowed to accumulate the HLRW in the facility section intended for HLRW vitrification in amounts exceeding the HLRW amounts required by the vitrification technology in the receiver tank. In case of the facility shutdown for repairs or accident, the HLRW shall be removed from the HLRW pipeline over its all run from the stationary HLRW storage facility to the facility. The capacity of the receiver tank of the melter shall be sufficient to provide for complete HLRW draining from the pipeline into the receiver tank in case of a design basis accident.

3.2.2.7. The facility design shall provide for a possibility to vitrify spent conditioned decontamination liquids jointly with HLRW in the main process at the facility.

3.2.2.8. To provide for the development and implementation of the radiation protection program during the facility operation, the design shall provide for a possibility to carry out instrumental control of each liquid radioactive waste generation source at the facility.

3.2.2.9. When designing the facility a factor analysis shall be done regarding a possibility of SCR at all stages of the facility process cycle during normal operation, operational events, design basis accidents, initiating events and external events of maximum intensity with consideration of:

- composition, physical and chemical form and amounts of NHFM involved in different process operations at the facility;
- mutual arrangement of the equipment containing such materials;
- location of structural elements;
- location of auxiliary equipment containing media which are moderators and/or reflectors of neutrons;
- in case of accidents, possible ingress of NHFM to the confining sumps, pallets, other tanks.

SCR initiation shall be prevented both under the normal conditions and operational events (in case of a single failure).

3.2.2.10. If the results of nuclear safety analysis done do not prove that SCR is in principle impossible in the facility process cycle, the nuclear safety requirements established by the existing FSR shall be met in the course of the facility and its systems (elements) design and development of the facility equipment, as well as the monitoring means and procedure shall be developed regarding:

- values of nuclear safety parameters that characterize the equipment and processes;
- content of NHFM in process media;
- compliance with standards for loading the equipment with NHFM;
- NHFM accumulation in the process equipment including in the gas clean-up equipment.

If the results of nuclear safety analysis done prove that SCR is in principle impossible in the facility process cycle, it shall be justified in the facility SAR and confirmed in the nuclear safety statement.

3.2.2.11. Nuclear safety of the facility shall be ensured by:

- layout of the process premises of the facility, which shall exclude a possibility of uncontrolled NHFM transfers and changes to characteristics of the process environment of the facility equipment that may cause SCR under the normal operation, operational events, and design basis accidents;

- locations of the process piping (water supply, etc.) that completely exclude violations of the nuclear safety conditions during operational events, design basis accidents, initiating events and external events of maximum intensity;
- compliance of the design with the established FSR requirements.

Adequacy of the applied design solutions shall be justified in the design and reflected in the facility SAR, and also confirmed in the nuclear safety statement.

3.2.2.12. The facility design shall provide for the radiation monitoring inside the facility premises, on its site, inside the controlled area and surveillance area. The scope of the radiation monitoring shall be set forth in the design in accordance with the FSR requirements.

The design shall provide for the availability of permanent and periodic monitoring systems for the RadS content in the air inside the facility premises, facility releases and discharges.

3.2.2.13. In accordance with the type, scope and conditions of the required radiometric and dosimetry monitoring under the normal operation, operational events, design basis accidents, as set in the facility design, the design shall define:

- the nature and range of changes of monitored (measured) parameters;
- locations of fixed instrumentation and points of continuous and periodic monitoring;
- the technical environs of the instrumental means of radiometric and dosimetry monitoring (temperature, air humidity, presence of corrosive media, etc.);
- reliability requirements (minimum time before the first failure) for the instrumental means of radiometric and dosimetry monitoring;
- values of actuation settings of the warning and(or) emergency alarms on changes in the radiation situation (for radiation situation monitoring means in attended and unattended rooms), and if necessary, engineered means of displaying signals indicating actuation of alarms at the facility central and local control rooms (boards);
- list of types and number of required radiometric and dosimetry instruments and auxiliary equipment;
- methodologies for processing of radiometric and dosimetry monitoring results;
- methods and technical means of calibration of the radiometric and dosimetry monitoring instrumentation;
- composition and characteristics of the facility premises required for the purposes of radiation monitoring;
- required staff and permanently maintained and periodically checked competence of the personnel who carry out radiation monitoring.

3.2.2.14. Facility layout solutions shall be such as to provide for a possibility for the prompt evacuation of the employees (personnel) from working places in the event of an accident.

3.2.2.15. The processes provided for in the facility design shall be mechanized and automated (with a possibility for a remote control by the operator).

3.2.2.16. The facility design shall provide for:

- facility and NM, RadS and RW physical protection system;
- NM, RadS and RW accounting and control system.

3.2.2.17. The facility design shall provide for methods and means of the premises and equipment decontamination, elimination of the emergency contaminations of premises and equipment with RadS.

3.2.2.18. The facility design shall provide for technical solutions ensuring safe management of the secondary RW generated at the facility in the course of the transuranic RW immobilization.

3.2.2.19. The facility design shall provide for the systems (elements) intended to:

- prevent violations of the normal operation limits;
- prevent violations of safe operation limits and conditions;
- prevent design basis accidents and mitigate their consequences.

The design shall provide for engineered means and (or) organizational measures to limit possible consequences of beyond design basis accidents.

3.2.2.20. The facility design shall provide for monitoring of:

- content (concentrations) of radiolytic hydrogen (in all elements of the process equipment containing HLRW) and organic vapors (ethylene glycol) and carbon oxide – inside the melter casing;
- content (concentrations) of the said gases and vapors as well as radionuclides (in the gaseous and (or) aerosol form) released from the furnace during the HLRW vitrification;
- cooling water flow rate in the cooling system serving the casing, drains, plunger pistons and in other heat exchanging equipment;
- process parameters of operation to obtain the embedded elements with immobilized transuranic RW;
- arranging of the embedded elements inside the shaping containers;
- process parameters of glass mass "cooking";
- arranging of the shaping container with the embedded elements exactly under the melter drain at the glass pouring section;
- level of pouring of the glass mass into the shaping containers filled with embedded elements.

3.2.2.21. To prevent the glass mass spill while filling the shaping container or its transporting, the design shall provide for:

- a device to exclude a glass mass overflow during its pouring into the shaping container;
- a device to exclude the spill during the transportation of the shaping container filled with the glass mass from the pouring section to the place of its hold-up.

3.2.2.22. The facility design shall utilize technical solutions that provide for safety of the employees (personnel) during repairs at the facilities parts specified in para 3.2.2.2.2 of this document when RadS- and NM-containing process media are present in individual items of the equipment in quantities corresponding to the processes in use.

3.2.2.23. The facility design shall provide for engineered means to cool the packages during their storage at the facility and transportation.

3.2.2.24. For the equipment that directly houses radioactive process media or HLRW the design shall provide for sumps or pallets to confine and collect possible radioactive leaks and spills.

3.2.2.25. The facility design shall determine safe operation limits and conditions for the systems (elements) important for safety and also measures to be implemented if these limits and conditions are violated. The facility design shall justify reliability of the physical barriers.

3.2.2.26. When designing the facility the fire and explosion safety requirements for the facility established by the regulatory documents shall be met.

3.2.2.27. The facility design shall provide for methods and means of control over processes to meet the GSP SAR requirements, as well as the means to prevent single errors of the employees (personnel) or the ones to mitigate their consequences including during maintenance of the facility equipment.

3.2.2.28. The facility shall include independent means to provide for recording and storing of the information necessary for accident investigations. The said means shall be protected against an unauthorized access and retain operability under design basis and beyond design basis accident conditions. The scope of information to be recorded and stored shall be determined in the design and justified in the facility SAR.

3.2.2.29. The facility design shall establish the facility service life; the service life management measures for the equipment, systems (elements) and structures shall be provided for.

3.2.2.30. Under the normal operation, operational events, design basis accidents, and also when the glass mass is ultimately removed from the melter prior to its replacement or facility decommissioning, the melter's design shall exclude an ingress of radioactivity along with gases generated in the "cooking" bath to the glass mass pouring unit where the glass mass is put into the shaping containers, and to the shroud loading chamber.

3.2.2.31. For the cases of failures of water-cooled heaters (electrodes in ceramic direct heating melters), water-cooled drains or plunger pistons or water-cooled melter's walls the melter design shall exclude a possibility of forming the solid non-removable highly active glass mass. The possibility of complete drain of glass mass from all sections (elements) of the ceramic melter shall be provided for (due to redundancy and relevant design of drains and plunger pistons). The service life of the melter's metal casing shall be sufficient to allow for complete drain of glass mass even when the water cooling of the casing is lost.

3.2.2.32. The design shall provide for timely diagnostics of failures of working heaters and/or cooling systems, etc.

3.2.2.33. The facility design shall provide for:

- dilution down to the safe concentrations by inert gas or nitrogen of gaseous explosion and fire hazardous mixtures, which may result from chemical reactions and radiolysis decomposition of process media;
- continuous or periodic removal (process blowout) of these gaseous explosion and fire hazardous mixtures being generated in the process equipment;
- gas clean-up systems for the gaseous explosion and fire hazardous mixtures removed from the process equipment to prevent a release of RadS and NM from the process equipment of the facility.

3.2.2.34. When designing the facility, materials that are corrosion resistant in case of their contact with the melted glass shall be used.

3.2.2.35. Seamless pipes shall be primarily used for transporting the process media containing transuranic radionuclides in the facility. In all possible cases the welded joints shall be used; the number of welded joints shall be minimized.

Detachable joints are permitted only when necessary to provide access to visually examine and repair the equipment; such joints shall be located only inside glove boxes.

3.2.2.36. The facility design shall establish the values of maximum permissible corrosion rate of walls of the equipment and process lines, permissible values of welded joints break frequency, as well as welding quality assessment criteria.

3.2.2.37. The design shall determine procedures to inspect conditions of the walls of equipment, process lines and welded joints.

3.2.2.38. The facility equipment layout shall provide for:

- a capability of full collection of leaks and spills in pallets under separate equipment items without their release beyond the closest physical barrier, at that the SCR initiation due to leaks and spills shall be excluded;
- minimum possible length of pipelines;
- minimum possible number of stop valves and detachable joints;
- the lack of non-drainable stagnant zones;
- convenience for the employees (personnel) during operation, maintenance, repair, inspection and decontamination of the equipment.

3.2.2.39. The facility design shall include and justify lists of the monitored parameters of the systems (elements), equipment.

Under normal operation, operational events, design basis accidents, including the total loss of power supply, the control systems shall be provided with power supply in the scope justified in the design of the facility.

3.2.2.40. The facility design shall provide acceptance control systems for the transuranic RW and HLRW being delivered for immobilization and a quality control system for the immobilization end product, as well as shall define specific quality control methods for the glass mass and embedded elements.

3.2.2.41. The facility design shall establish requirements to the sequence and scope of the pre-startup and alignment operations including the requirements for testing of the physical protection system and radiation monitoring system, as well as the acceptance criteria as for individual equipment pieces as for the systems (complexes) of the facility equipment being commissioned.

3.3. Safety in commissioning and operation of the facility

3.3.1. Prior to the facility commissioning, the operating organization shall develop and implement the pre-startup and alignment operation program.

3.3.2. The pre-startup and alignment operation program shall meet the requirements for the sequence and scope of operations defined in the design and include integrated tests of the facility, manufacturing of the packages with dummies of embedded elements, which do not contain NM, encased in the hosting non-radioactive glass mass, and also check whether the packages quality complies with requirements for the packages established in the design as regards uniformity of filling of the shaping containers and homogeneity of the glass mass.

When it is necessary to verify compliance of radiation protection, radiation monitoring systems and EAS SCR with the acceptance criteria it is permitted to use sealed isotopic sources of neutrons and gamma-quantum (provided the radiation safety requirements for operations with such sources are met).

3.3.3. Results of pre-startup and alignment operations and integrated system testing and verification that individual equipment items and equipment systems (complexes) meet the established acceptance criteria shall be documented in the corresponding records in accordance with the established procedure.

3.3.4. Pilot and industrial operation can be commenced only after pre-startup and alignment operations and integrated tests have been completed on the basis of the facility commissioning program including first RadS and NM loading.

3.3.5. The documents regulating the second stage of commissioning shall contain a list of works involving RadS and NM (including vitrified HLRW and secondary RW generated during the facility operation), list of works involving NHFM with which SCR is possible, and also list of accident prevention measures and limitation of accident consequences.

3.3.6. Test programs and techniques shall include measures to ensure safety of these tests, be concurred by the designers and developers of the equipment and processes and approved by the operating organization.

3.3.7. In the design and prior to the pilot industrial operation, action plans for the employees (personnel) and population protection in case of an accident at the facility shall be developed and ready for implementation in accordance with the FSR requirements. Main and alternative communications with organizations specially authorized in the field of the protection of the population and territories against the emergencies shall be involved in accordance with the plans for employees (personnel) and population protection and prior to the pilot industrial operation.

3.3.8. The facility acceptance for industrial-scale operation shall take place according to the established procedure after the pilot industrial operation.

3.3.9. In accordance with the facility design the operability of the systems (elements), conditions of the metal and welding joints of the facility systems (elements) and equipment shall be inspected prior to and during the facility commissioning.

3.3.10. To maintain operability of the facility systems (elements) and equipment, and also to prevent systems and equipment failures, the facility maintenance, repair, tests and inspections shall be conducted periodically in the course of operation.

Periodicity and scope of the periodic inspections shall be determined in the design.

3.4. Decommissioning of the facility

3.4.1. The facility decommissioning concept shall be justified in the design and presented in the facility SAR.

3.4.2. The design shall provide for one of the following options as an ultimate facility state after its decommissioning:

- complete dismantling of the equipment and main building and complete or partial dismantling of the auxiliary buildings (for storage and production of the agents and non-radioactive process media);
- conversion of the main building of the facility and (or) auxiliary buildings to be used for accommodation of new radiation- and (or) nuclear-hazardous productions and (or) auxiliary structures of other NFCF located on the same site where the facility is located, in particular, to host the HLRW vitrification facilities.

In the latter case, the facility design shall provide for:

- the design service life of the engineering structures of the main building or auxiliary buildings subject to the conversion of the facility to be not less that the sum of the design operating time of the facility and the design operating time of new productions to be located in the main and (or) auxiliary buildings of the facility according to the conversion plan;

- characteristics of the engineering structures of the facility buildings subject to conversion which meet the safety requirements established by the existing regulatory documents for these new productions during the whole design service life.

3.4.3. The facility decommissioning program shall, as far as possible, exclude long-term intervals between the end of the facility operation, decontamination of the premises and dismantling of the facility equipment, dismantling (conversion) of the facility buildings and rehabilitation of the territory adjacent to the facility.

4. Quality assurance

4.1. The operating organization shall provide for development and implementation of a quality assurance program in accordance with the FSR requirements.

4.2. As regards the different activities related to the facility safety and implemented at the stages of the facility siting and design, technology development, design and manufacturing of the facility equipment, construction, commissioning and operation of the facility, its decommissioning, local quality assurance programs shall be developed and include areas of quality assurance activities specified in Appendix 2 (mandatory).

4.3. When developing each type of the quality assurance program, requirements established by FSR, other regulatory documents on quality assurance for appropriate types of the activity in the field of use of atomic energy shall be met.

4.4. Equipment and products including imported ones utilized by the facility and related to safety shall have quality certificates produced in accordance with the established procedure.

4.5. As regards equipment or products subject to certification, the quality assurance program shall include a complete list of regulatory and other documents (state and industry-internal standards, technical conditions, technical requirements, other documents), compliance with which shall be confirmed by certificates of equipment and products. Regarding equipment or products subject to certification against separate requirements of the said documents, appropriate sections or paragraphs addressing the quality requirements, compliance with which shall be confirmed by the certificates of conformance, shall be specified.

4.6. Computer codes and calculation techniques used to justify parameters of the processes and separate operations related to the facility safety during its design and development of its equipment shall be qualified in accordance with the established procedure.

Appendix 1
(reference)

Basic scheme of transuranic RW immobilization

1. Encasement of specific amounts of the immobilized transuranic elements (concrete amounts shall be defined in the facility design) attributed to RW into the embedded elements; at that their physical and chemical form represents an inert chemical matrix (ceramic, mineral-like etc.) with a long-term stability against the radiation damages, and geometry and sizes shall be determined by capabilities of the package manufacturing technology and subsequent process operations.

2. Emplacement of the embedded elements inside the shaping container (the shaping container loading) using or not using additional assembly parts to be followed by encasement of the embedded elements into the hosting glass mass produced by the vitrification of the long-lived HLRW of the required chemical and radionuclide composition (which, probably, contains also transuranic elements in small amounts).

3. Loading of the embedded elements into the blocks bounded by the shaping container and made from vitrified long-lived HLRW of special form and mass to produce radiation- and thermal-stable packages of the immobilized transuranic RW suitable for long-term (many dozens of years) storage without essential radiation and thermal degradation of the mechanical properties of the packages and their capability to hold radionuclides and transuranic elements up to the final removal of the packages from the human environment and, if necessary (depending from the specific immobilization objectives), capable of producing gamma-radiation fields with a high dose rate in its immediate environs during the long time period (a radiation barrier impeding an unauthorized access to the immobilized transuranic RW which may contain, in particular, plutonium).

4. Loading of the immobilized transuranic RW packages into the transport shielding container, their transportation to the immobilized transuranic RW storage facility, their removal form the shielding container and emplacement in the storage facility.

Appendix 2
(mandatory)

Areas of quality assurance activities addressed in different QAP

N	**Areas of quality assurance activities**	**Life cycle stages of a facility**								
		Siting	Design	Development of technology	Development of equipment	Manufacturing of equipment	Construction	Commissioning	Operation	Decommissioning
1.	Quality assurance organizational activity	+	+	+	+	+	+	+	+	+
2.	Preparation and implementation of quality assurance programs	QAP(G), QAP(S)	QAP(G), QAP(D)	QAP(G), QAP(T/D)	QAP(G), QAP(E/D)	QAP(G), QAP (E/M)	QAP(G), QAP(Con)	QAP(G), QAP(C))	QAP(G), QAP(O)	QAP(G), QAP(Dc)
3.	Personnel training and qualifications	+	+	+	+	+	+	+	+	+
4.	Procedures, methodologies, drawings	+	+	+	+	+	+	+	+	+
5.	Document management	+	+	+	+	+	+	+	+	+
6.	Inspections and tests	+	-	-	-	+	+	+	+	+
7.	Control over design (development) of a facility (technologies, equipment)	-	+	+	+	-	-	+	+	+
8.	Quality assurance of software, calculation methodologies and calculations	+	+	+	+	+	+	+	+	+
9.	Control over documents for delivery of products and rendering of services	+	+	+	+	+	+	-	+	-
10.	Management of purchasing of equipment, instruments, complete parts and materials as well as services rendered	+	-	+	-	+	+	+	+	+
11.	Identification of the equipment, instruments, complete parts and materials as well as services rendered	+	-	+	+	+	+	+	+	+
12.	Process monitoring	-	+	+	+	+	+	+	+	+
13.	Inspection of instrumentation and controls and test equipment	+	-	-	-	-	+	+	+	+
14.	Equipment handling, storage and transportation	-	-	-	-	+	+	+	+	+
15.	Reliability of safety important equipment, products and systems	-	+	+	+	+	+	+	+	+
16.	Inspection, tests and operational state of equipment	-	-	-	-	-	-	+	+	+
17.	Control of non-compliance (deviations) with quality requirements and corrective measures	+	+	+	+	+	+	+	+	+

18.	Quality assurance documentation (records)	+	+	+	+	+	+	+	+	+
19.	Inspections	+	+	+	+	+	+	+	+	+

Note

+ - section shall be presented in QAP (G) or local QAP.

- - it's not mandatory to present the section in QAP (G) or local QAP

Applied abbreviations

QAP - Quality Assurance Program for development, operation and decommissioning of a facility

QAP(C) - local Quality Assurance Program for decontamination and dismantling of the facility equipment during facility Commissioning

QAP(D) - local Quality Assurance Program for Design (and siting) of a facility

QAP(De) - local Quality Assurance Program for facility Decommissioning

QAP(E/D) - local Quality Assurance Program for Design (development) of safety important facility Equipment

QAP(E/M) - local Quality Assurance Program for Manufacturing of safety important facility Equipment

QAP(G) - General Quality Assurance Program for work on facility development, commissioning and decommissioning

QAP(O) - local Quality Assurance Program for facility Operation

QAP(S) - local Quality Assurance Program for works implemented during facility Siting (site investigation)

QAP(T/D) - local Quality Assurance Program for Development of transuranic RW immobilization Technology

QAP(Con) - local Quality Assurance Program for facility Construction – assembling and aligning of safety important facility equipment