Nuclear Safety Institute
of the Russian Academy of Sciences (IBRAE RAS)

Moscow E08S4R1e-FRD 2004

Federal Environmental, Industrial and Nuclear Supervision Service
(Rostechnadzor)

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

Approved by
Decree of the Federal
Environmental, Industrial and
Nuclear Supervision Service
of 30 December 2005
N 23

SAFETY RULES FOR STORAGE AND TRANSPORTATION OF NUCLEAR FUEL AT NUCLEAR FACILITIES

(NP – 061 – 05)

Effective since
„_1_" May2006

MOSCOW 2005

UDK 621.039

SAFETY RULES FOR STORAGE AND TRANSPORTATION OF NUCLEAR FUEL AT NUCLEAR FACILITIES NP-061-05

Federal Environmental, Industrial and Nuclear Supervision Service
Moscow, 2005

These Rules contain safety requirements for storage and transportation of nuclear fuel at nuclear power facilities.

The regulatory document has been developed taking into account federal standards and rules, IAEA documents related to nuclear safety for storage and transportation of fuel at nuclear facilities.

These Rules are issued to replace "Safety Rules for Storage and Transportation of Nuclear Fuel at Nuclear Power Facilities" PNAEG-14-029-91[1]∗.

[1]

LIST OF ABBREVIATIONS

AA	-	Additional Absorber rod
CIC	-	Cladding Integrity Control
CPS	-	Control and Protection System
FA	-	Fuel Assembly
FR	-	Fuel Rod
NF	-	Nuclear Facility (See context)
NF	-	Nuclear Fuel (See context)
NFCF	-	Nuclear Fuel Cycle Facility
NFSTS	-	Nuclear Fuel Storage and Transportation System
NM	-	Nuclear Materials
NP	-	Nuclear Plant
NPP	-	Nuclear Power Plant

OSTP	**-**	On-Site Transportation Package
SAR	-	Safety Analysis Report
SCR	-	Self-sustained fission chain reaction
SFA	-	Spent Fuel Assembly
SNF	-	Spent Nuclear Fuel
SSE	-	Safe Shutdown Earthquake

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TERMS AND DEFINITIONS

SNF cooling pond shall mean a structure, which is a part of nuclear facility or nuclear material storage facility designed for temporary storage of spent nuclear fuel in water or other liquid medium.

Safe geometry shall mean the geometric parameters of equipment for storage and transportation of NF, which exclude a possibility of SCR under normal operation and operational events, including design basis accidents.

On-site transportation package shall mean the set of engineered means used for emplacement of fresh or spent nuclear fuel as well as to ensure nuclear and radiation safety and security of NF during NFCF on-site storage and transportation of nuclear fuel.

Temporary nuclear fuel keeping shall mean the placement of NF in locations as determined in the NF design[2], outside storage facilities.

Group of packages shall mean the set of packages permitted for storage (transportation) without any restrictions on their mutual arrangement.

Hot cell shall mean the specially equipped enclosure for segmenting, cutting, studies and other remote operations with spent nuclear fuel.

NF storage (transportation) standard shall mean the amount of NF permitted for storage (transportation) considering constraints for its arrangements.

Spent nuclear fuel shall mean the fuel irradiated in the reactor core and finally removed from it.

Self-sustained chain nuclear fission reaction shall mean the chain fission reaction characterized by the effective neutron multiplication factor exceeding or equalling the unity.

Fresh nuclear fuel shall mean the new NF or unirradiated NF made of fissile materials resulted from processing of irradiated nuclear fuel.

NF storage and transportation system shall mean the combination of systems (components) intended for storage and transportation of nuclear fuel.

Dry spent nuclear fuel storage facility shall mean the storage facility intended for storage of spent nuclear fuel in a gaseous medium (air or inert gas).

Transportation of NF shall mean the movement and transportation of NF using transportation and lifting equipment in accordance with the process established in the design on-site of a nuclear facility.

Packaging shall mean the nuclear fuel package.

Stack of packages or FAs shall mean the set of packages or FAs permitted for storage, provided all restrictions imposed on mutual arrangement of packages or FAs are observed.

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[2] The definition of term “design” is established by existing regulatory documents.

Lattice spacing shall mean the distance between the axes of neighbouring FAs, shrouds and packages positioned on the sides of the regular lattice.

Storage of nuclear fuel shall mean the temporary keeping of the fresh or spent NF in the NF storage facility.

Nuclear fuel storage facility shall mean the nuclear material storage facility or structure, which is a part of the nuclear installation, intended for storage of fresh or spent nuclear fuel.

Class 1 storage facility shall mean the storage facility for fresh fuel to which penetration of water or any other moderator is excluded.

Class 2 storage facility shall mean the storage facility for fresh fuel, flooding of which with water or any other moderator is excluded that is ensured, beside other measures, by the engineered features.

Class 3 storage facility shall mean the storage facility for fresh fuel which is not subject to the requirements set for Class 1 and 2 storage facilities. Floating storage facilities pertain to Class 3.

Nuclear materials shall mean the material containing or capable of producing fissile (fissionable) nuclear substances.

Nuclear fuel shall mean the items in the form of FR or FA containing nuclear materials.

1. PURPOSE AND SCOPE OF APPLICATION

These Rules establish the basic technical and organisational requirements for nuclear fuel storage and transportation systems and are aimed at ensuring safety during storage and transportation of nuclear fuel at nuclear facilities. These Rules apply to nuclear power plants, including separate storage facilities in the nuclear power plant (NPP) territory, storage facilities off-site NPP, nuclear research installations, on-shore and floating nuclear fuel storage facilities of ships and other marine vessels[3*].

These Rules establish safety requirements for fresh and spent nuclear fuel storage facilities, hot cells as well as to the equipment for storage and transportation of fresh and spent nuclear fuel including:

1.1 cranes, grips, spreaders, bars;
1.2 platforms, trolleys and other transportation features;
1.3 reloading devices and machines;
1.4 storage shrouds, racks, and packages, storage tubes;
1.5 fresh and spent FA drums;
1.6 FA assembling and disassembling devices;
1.7 FA washing benches;
1.8 FA inspection benches;
1.9 on-site transportation packages;
1.10 equipment of heat removal system from the storage facility cooling medium; clean-up systems; systems for level and chemistry control of the cooling medium; ventilation systems; systems for filling and draining of the storage facility; systems for leak detection and collection; and radiation control systems;
1.11 equipment used for preparing spent NF for placing into the cooling pond;
1.12 equipment for preparing spent NF for off-shipment from a nuclear facility.

These Rules apply to nuclear facilities under design, construction and operation.

2 GENERAL SAFETY REQUIREMENTS

2.1 General provisions

2.1.1 The NF design shall provide for nuclear fuel storage and transportation system.

2.1.2 The basic safety justification document for nuclear fuel storage and transportation shall be the Safety Analysis Report of a nuclear facility (the relevant SAR sections of nuclear facilities listed in para. 1.1). As regards nuclear fuel transportation and storage, the nuclear facility SAR shall contain lists of possible operational violations, initiating events of design basis and beyond design basis accidents as well as a probability and severity categorization of beyond design basis accidents. Exemplary lists of initiating events for design basis accidents and an exemplary list of beyond design basis accidents are given in Appendix.

2.1.3 Radiation safety for NF storage and transportation is regulated by appropriate regulatory documents.

Components of the nuclear fuel storage and transportation system shall be categorized in terms of their impact to safety.

[3*] Note. The Rules can be used as the basis for design and operation of nuclear fuel storage and transportation systems at NFCF used for other purposes.

Changes to NFSTS design and designs of its safety important components, as well as NFSTS safe operation limits and conditions, cannot be made without making corresponding changes to the NF design and SAR.

To maintain and verify design characteristics, safety important NFSTS components shall be subjected to inspection and testing during manufacturing, assembling and aligning and undergo periodic in-service checks to verify their compliance with the design.

The design shall contain a list of nuclear hazardous operations during storage and transportation of nuclear fuel.

The design shall provide for engineered features for storage and transportation of damaged nuclear fuel.

The nuclear fuel storage and transportation system shall be capable of performing its functions in the scope determined in the design taking account of internal and external natural and man-induced events, as assumed in the design.

The NF design shall establish nuclear fuel storage and transportation standards confirmed by an independent conclusion on nuclear safety. A procedure to obtain this conclusion is set up by a body for state control of the use of atomic energy.

The design shall contain lists of methodologies and computer codes used for safety justification of nuclear fuel storage and transportation, and define the fields of their application. The computer codes applied shall be verified and certified in accordance with the established procedures.

2.2 Storage of nuclear fuel

Nuclear fuel storage facilities shall be equipped with fire alarms, ventilation, regular and emergency lighting. The design shall indicate whether it is reasonable to equip the nuclear fuel storage facility with a CCTV system.

Nuclear fuel storage facilities shall be equipped with automated and portable fire extinguishing devices. It is prohibited to use for fire extinguishing the media which when used can increase the effective neutron multiplication factor.

The permissible term of nuclear fuel storage at NF shall be indicated in the design.

It is prohibited to keep in the storage facility the flammables or toxic agents or explosives which are not a part of packagings.

It is prohibited in nuclear fuel storage facilities to lay cables which are not directly relate to power supply of equipment for storage and transportation of nuclear fuel, and to lay pipelines containing flammable and explosive liquids and explosive gases.

The storage facility design shall provide for automatic trip of ventilation in the event of fire.

The possibility of using OSTP for storage of specific type of nuclear fuel shall be justified in the design.

It is allowed to store in nuclear fuel storage facilities the reactor core components which do not contain fissile material. In this case the component types and their locations shall be regulated by the design.

Layout of the storage facility shall provide for unimpeded personnel evacuation from the premises in the event of an accident.

2.3 Transportation of nuclear fuel

On-site transportation of nuclear fuel shall be carried out in OSTP on special vehicles intended for these purposes. Requirements for special vehicles intended for transportation of nuclear fuel shall be established in the design.

The design shall establish whether in the on-site transportation of nuclear fuel it is permitted to use vehicles intended for transportation of other goods provided they are additionally furnished with special equipment and shall set uprequirements for additional equipment of such vehicles.

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The possibility of transporting in OSTP the nuclear fuel which is not envisioned in the design, including new NF types, shall be additionally justified in the design.

During transportation the packages shall be reliably fixed on a vehicle to avoid spontaneous movement and tilting at turning, bumps, braking, roll movements.

In case of natural and man-induced events specific for the NF location site a possibility for NF falling out of OSTP or violation of NF mutual arrangements inside OSTP shall be excluded.

During the package movements the lifting height shall be possibly minimal. The maximum permissible height for lifting the packages shall be justified in the design.

It is allowed to lift a package at a height exceeding that defined in the design provided one of the following requirements is met:

- graded lifting is provided, for which technical measures exclude exceeding the value defined in the design for each step;
- lifting is performed above a shock-absorber or using a damping device that reduce loads to the package in case of drop down to the loads that arise from a drop from the design height;
- availability of an independent (of the main) back-up lifting (lowering) system that ensures lifting (lowering) of a fully loaded package.

2.3.1 It is prohibited to lay routes and transport loads, if such loads are not elements of lifting or reloading devices, and nuclear fuel packages through the places where nuclear fuel is stored or is temporary placed (in case the nuclear fuel is present in these places). If this requirement is not feasible for existing storage facilities, the nuclear fuel in storage shall be protected from damages associating with drop of nuclear fuel loads and packages. Should this be the case, the capabilities of protective structures to withstand static and dynamic loads, which can arise from a drop of nuclear fuel load or package, shall be justified in the design.

2.3.2 Speed of on-site movement of vehicles with nuclear fuel packages or shrouds shall be justified in the design.

2.3.3 Movement of a vehicle transporting nuclear fuel shall be immediately terminated if a malfunction of driving gear, coupling or package fixing on the vehicle is detected.

2.3.4 An NF shall provide for special sections and equipment for preparing transport packages and vehicles for off-site transportation.

2.4 Equipment for nuclear fuel storage and transportation

2.4.1 While designing the safety important equipment of the nuclear fuel storage and transportation system the possibility shall be provided for its testing, maintenance and repair.

The transportation and process equipment for nuclear fuel transfers shall ensure the speed and acceleration of nuclear fuel movement which do not exceed values established in technical specifications or other technical documentation of the nuclear fuel manufacturer.

Nuclear fuel storage and transportation equipment shall have no sharp edges that may damage nuclear fuel.

In normal operation conditions the design of nuclear fuel storage and transportation equipment shall exclude shocks or any other impacts that may cause damage or change of geometry of FAs or FRs.

Designs of shrouds, OSTP, racks in nuclear fuel storage facilities shall ensure their stability to internal and external natural and man-induced events characteristic of the NF location site.

For NF handling it is permitted to use only operable equipment, as stipulated in the design, which underwent recurrent inspections, tests and visual checks before the NF operations are performed.

While designing the equipment for storage and transportation of nuclear fuel it is required to consider all loads arising during normal operation, operational violations, including design basis accidents.

OSTP design shall provide for applying seals to all outer detachable joints.

NFSTS design (for example, shrouds, OSTPs, fresh and spent fuel assembly drums, etc.) shall ensure nuclear safety, generally, through arranging nuclear fuel with certain lattice spacing.

The equipment (for example, racks and shrouds), which structural materials contain neutron absorbing nuclides to ensure nuclear safety, shall be designed and manufactured to exclude unallowable decrease of absorption ability under mechanical, chemical or radiological impact in normal operation, operational events, including design basis accidents. The equipment structural elements' absorbing properties, as designed, shall be confirmed before the equipment installation and in service.

There shall be foreseen engineered means to exclude uncontrolled and spontaneous movements of nuclear fuel storage and transportation equipment, nuclear fuel drops, including in the events of loss of power and when power supply is resumed.

NUCLEAR SAFETY DURING NUCLEAR FUEL STORAGE AND TRANSPORTATION

3.1 Nuclear safety of fresh and spent nuclear fuel storage and transportation shall be ensured, beside other measures, by means of:

- limitations imposed on the arrangement of nuclear fuel in shrouds, racks, stacks, fresh and spent FA drums, OSTPs;
- limitations imposed on the number of FAs and FRs in shrouds, racks, stacks, fresh and spent FA drums, OSTPs;
- limitations imposed on the number of packages and shrouds in a group, number of packages in a stack;
- limitations imposed on the arrangement of the groups of shrouds, racks, stacks, fresh and spent FA drums, OSTPs ;
- use of heterogeneous or homogeneous absorbers;
- monitoring of the arrangement of FRs and FAs, heterogeneous absorbers, packages, shrouds, racks, stacks;
- monitoring of presence and/or absence of moderators in fresh nuclear fuel storage facilities;

2.1.4 monitoring of presence, condition and composition of the cooling water and presence of a moderator in SNF dry storage facilities;

2.1.5 observing process parameters of the nuclear fuel storage and transportation system.

3.2 The spacing of FAs arrangement in shrouds, racks, and packages, as well as mutual arrangement of shrouds, racks, stacks and tubes, shall be chosen so that during nuclear fuel storage and transportation the effective neutron multiplication factor would not exceed 0.95 in normal operation and operational events, including design basis accidents. At this, such number, distribution and density of a moderator (water, in particular) shall be considered which lead to the maximum neutron multiplication factor in case of design basis accident initiating events during storage and transportation.

3.3 The nuclear safety analysis shall consider a possibility of the neutron multiplicity factor increase due to fissile nuclide accumulation in case of nuclear fuel burnup. Spent nuclear fuel shall be considered as fresh if the neutron multiplicity factor in case of burnup decreases, except for the cases where burnup value is used as a nuclear safety parameter. The analysis of initiating events shall consider the following possibilities:

re-grouping of FAs inside shrouds, fresh and spent FA drums, racks and packages resulting in an increase of the effective neutron multiplication factor;
change of geometry of FR and FA, as well as spacing between FR and FA, resulting in an increase of the effective neutron multiplication factor;
boiling of water, formation of steam-water mixture, and resulting increase of the effective neutron multiplication factor and thinning of the water protection layer;
loss of efficiency of heterogeneous and homogeneous neutron absorbers;
penetration of water or steam-water mixture into a package, shroud, fresh or spent FA drum, a dry storage facility for spent nuclear fuel.

3.4 If irretrievable heterogeneous absorbers are used in rack and shroud structural components, the nuclear fuel spacing is selected on the basis of their absorbing capacity. It is not permitted to use retrievable heterogeneous in racks and shrouds.

3.5 When analyzing nuclear safety of nuclear fuel storage facilities one is required to assume that:

the nuclear fuel storage facility is full at maximum design degree;
when nuclear fuel of different enrichment is present in the storage facility, all fuel has the maximum enrichment;
when nuclear fuel with different nuclide composition is present in the storage facility, all fuel has the composition corresponding to the maximum effective neutron multiplication factor;
for normal operation in SNF storage facilities with homogeneous absorbers (for example, borated water) and for nuclear fuel containing removable burnable absorbers, the absorber is absent;
a reflector is present in the storage facility.

3.6. Calculation methodology errors, errors in determining enrichment of fissile nuclides and nuclear fuel nuclide composition and nuclear fuel fabrication allowances shall be considered in calculations used for justification of NF nuclear safety as regards nuclear fuel storage and transportation.

3.7. The use of burnup as a nuclear safety parameter shall be justified in the design. At this, the design shall provide for burnup monitoring installations.

4 SAFETY MEASURES FOR FRESH AND SPENT NUCLEAR FUEL STORAGE AND TRANSPORTATION

4.1 Storage of fresh nuclear fuel

Class 1 storage facility shall meet the following requirements:

arrangement of the storage facility above the flood-free elevation;
absence of adjacent premises, from which water or other moderator may penetrate to the storage facility;
absence of pipelines with water or other moderators in the storage facility.

Class 2 storage facility shall meet the following requirements:
arrangement of the storage facility above the flood-free elevation;
absence of pipelines with water or other moderators in the storage facility;
availability of water detectors and drainage systems or emergency water pumps connected with water detectors.

4.1.3 The packages or FAs placed in a stack shall be fixed by means of special racks and nests. The mutual arrangement of packages in a group shall be provided for by their design.

4.1.4 The design shall stipulate the allowed number of fuel rods and FAs in benches, visual inspection tables, FA disassembly and assembly tables, geometry verification tables.

4.1.5 In nuclear fuel storage facility the locations of groups of packages or shrouds with nuclear fuel shall be shown with marking. Should transportation vehicles (trucks, battery-powered trucks) be used in the storage facilities, the routes of their movement shall be shown with marking. Various limiters and restrictors (fences and the like) are recommended to exclude the possibility of collision of a vehicle with racks, packages, etc.

4.1.6 It is not permitted to store materials, which are effective neutron moderators, between shrouds, racks and groups of packages or inside their materials.

4.1.7 Safety of combined storage of nuclear fuel with different isotopics and enrichment shall be justified in the design.

4.1.8 The placing of mixed uranium-plutonium fuel in storage facility originally designed for storage of uranium fuel shall be justified. In this case corresponding changes shall be done to the design and operating documentation.

4.1.9 Fresh nuclear fuel storage facilities shall be equipped with SCR emergency alarm system. A waiver to install this system in the fresh nuclear fuel storage facility shall be justified in the design.

4.1.10 Fresh nuclear fuel storage facility design shall provide for systems maintaining temperature and humidity.

4.1.11 Class 3 storage facilities shall be equipped with emergency water pumps actuated at signals from water detectors. The pumps' capacity shall ensure pumping-out of water without its accumulation, when water comes in with maximum anticipated flow rate.

4.1.12 The diameter of drainage pipelines in storage facilities shall be chosen so that the pipelines ensure water removal without its accumulation, when water comes in with maximum anticipated flow rate. The possibility of flooding of the storage facility by reverse water coming through drainage shall be excluded by engineered features.

4.1.13 The designing, construction and operation of new Class 3 storage facilities are permitted only in case of floating storage facilities.

4.2 Storage of spent nuclear fuel

4.2.1 For at-reactor storage of spent nuclear fuel the storage capacity shall so that it is possible to hold-up nuclear fuel for the time sufficient for reduction of radioactivity and heat release down to levels allowing for SNF off-site shipment.

4.2.2 For SNF storage and transportation the measures or devices shall be provided for to exclude a possibility of fuel clad temperature increase during storage and transportation in excess of the values established for normal operation and operational violations including design basis accidents.

4.3 Storage of spent nuclear fuel in water or other liquid medium

4.3.1 Cooling ponds of spent nuclear fuel shall be equipped, at minimum, with the following systems necessary for safety ensurance:

4.4.2.1 heat removal from the cooling medium (except for the cases, for which it is proved that the design temperature values of the cooling medium are not exceeded when the cooling medium heat removal system is unavailable);
4.4.2.2 monitoring of specific activity of the cooling medium;
4.4.2.3 cooling medium clean-up system;
4.4.2.4 process control systems (over content of homogeneous absorbers in the cooling medium or heterogeneous absorbers in racks, should such systems be foreseen in the design; over temperature, cooling medium level, water chemistry; hydrogen content in the air, as necessary);
4.4.2.5 radiation monitoring;
4.4.2.6 ventilation;
4.4.2.7 filling and draining of the cooling pond;
4.4.2.8 leak monitoring, collection and return;
4.4.2.9 make-up;
4.4.2.10 emergency make-up.

The heat removal system shall be designed so that the cooling medium temperature in the cooling ponds does not exceed design values in normal operation, operational violations including design basis accidents. In the design of the heat removal system passive devices should be preferably used.

For at-reactor storage facilities free storage capacity shall be foreseen to ensure complete unloading of the core at any time of operation.

Should the ponds of the storage facilities have several separate compartments or should there be several separate ponds, the possibility of independent heat removal from spent FAs in each compartment and/or pond shall be provided for.

In the SNF storage facility a free capacity shall be foreseen for SNF unloading from one compartment of the cooling pond in case of repair or accident.

All pipelines in the cooling pond shall be set in the upper part in order to maintain the necessary level of water above nuclear fuel, should the pipelines break and water flow from the pond through these pipes. Dumping of the cooling ponds shall be performed using immersion pumps and down to the level justified in the design.

The possibility of dumping the ponds due to the siphon drain effect shall be excluded. Pipelines for the cooling medium supply or removal shall be made so that in case of an air-block or a break (leakage) the water level does not fall below the level ensuring safe storage of nuclear fuel.

If there is a flood gate between compartments of the cooling ponds, it shall be designed to withstand water pressure from any side with no water from the other one.

SNF cooling ponds shall be equipped with devices which exclude the ponds overflow with the cooling medium.

Requirements for the cooling medium quality of SNF storage facilities shall be justified in the design.

When a separate cooling medium clean-up system is used it is required that the clean-up system flow capacity be less than that of the make-up system.

The storage facility design shall exclude spills and/or leaks of the cooling medium in excess of the make-up and/or emergency make-up amount during normal operation, operational violations including design basis accidents.

Structural materials used for lining of cooling ponds, racks, shrouds, packages, reloading equipment shall be corrosion resistant.

The cooling pond lining shall be made as an accident confining component. The lining shall ensure the design degree of leak-tightness and stability to stresses, as envisioned in the design. The lining shall remain intact when a SFA, shroud, tube with SFA, other equipment and tool falls from the maximum height possible during transport and process operations. Structural materials shall not be sources of contamination of SFAs with alien substances that may affect SFAs integrity during their design storage period, and shall not be sources of contamination of the cooling medium of the storage facility.

The cooling pond shall be equipped with devices for detecting the cooling medium leaks, identifying their locations; the CP design shall allow for their elimination. Systems for radioactive water collection into monitored water collectors shall be envisaged for cooling ponds.

The storage facility design shall provide for:

- technology for faulty SNF handling
- faulty SNF criteria which, if achieved, require specific tubes and other equipment and measures to exclude spread of the fission products in the cooling medium exceeding the permissible values;
- safety justification for faulty SNF handling, and limits and conditions of SNF safe storage.

The storage tube design shall provide for devices which allow to remove highly radioactive medium from storage tubes without its mixing with the cooling pond medium.

In the design the possibility of lighting of the internal cooling pond volume shall be provided. Materials of the equipment used in these lighting fixtures shall not corrodeinside the storage facility environs and cause its deterioration.

The filtering equipment of the ventilation system shall be designed and operated so as to limit a potential release of radionuclides as well as radioactive aerosols.

The ventilation system shall provide for dilution and safe evacuation of hydrogen resulting from water radiolysis.

In case of a drop of SFAs, tubes, shrouds on the cooling pond bottom all routine transportation operations shall be terminated until they are removed.

The design shall provide for removal of dropped SFAs, tubes or shrouds without draining the cooling ponds and full unloading of SFAs.

4.4 Storage of spent nuclear fuel in dry storage facilities

4.4.1 Dry storage facilities

4.4.1.1 For dry storage of spent nuclear fuel the design shall identify a method of cooling (forced circulation and/or natural convection), which excludes a possibility of fuel cladding temperature increase in excess of values established in the design in normal operation and operational events including design basis accidents.

4.4.1.2 Requirements for leaktightness of dry storage facilities shall be established in the design. The means of monitoring of gaseous cooling medium leaks and filters shall be provided for in the design that allow to keep a release of radioactive substances within permissible limits established by radiation safety standards in case of possible loss of integrity due to an initiating event.

4.4.1.3 Requirements for leaktightness of a storage facility are not established if nuclear fuel is stored in OSTPs, which exclude loss of integrity in initiating events anticipated in the design.

4.4.1.4 The design shall define the scope of activities related to maintenance and monitoring of OSTPs, including monitoring by instruments pertaining to the confining system, and temperature of OSTP surface.

4.4.1.5 The design shall envisage special rooms and equipment for opening of OSTPs with SNF.

4.4.1.6 The storage facility shall be equipped with devices and tools which use will allow to resume normal operation of the storage facility and storage and transportation of damaged SFA OSTPs after design basis accidents.

4.4.1.7 Where forced heat removal from OSTP is used, redundant systems for heat removal from OSTPs shall be provided for.

4.4.1.8 For dry storage facilities it is required to anticipate measures for monitoring and limitation of radioactive substance accumulation, moderator detection, and temperature monitoring.

4.4.1.9 In the design it shall be justified whether it is possible to use OSTP and open-air pads for dry storage.

4.4.2 Requirements for OSTPs used for dry storage

4.4.2.11 In the designing (developing) OSTPs for dry storage all possible external and internal impacts characteristic of the storage in normal operation and operational events, including design basis accidents, shall be taken into account.

The design of the OSTP confining system shall be calculated with the account for maximum pressure in the OSTP inner space, data on radiation, physical and chemical characteristics of SNF, temperature of the OSTP gaseous medium, and temperature of the environment in normal operation and operational events including during design basis accidents.

Any detachable joint of OSTP shall have not less than two confining barriers, where each confining barrier shall ensure design leaktightness parameters.

The OSTP design shall ensure the possibility of control over the confining system. The leaktightness inspection methods and frequency of SNF OSTP leaktightness shall be defined and justified in the design.

Safe operation limits as regards radionuclide releases from SNF OSTPs shall be defined and justified in the design.

The OSTP design shall ensure the possibility of dumping of its inner space. Duration of SNF storage in OSTP and requirements for gas composition and allowed humidity level in OSTP shall be justified in the design.

The OSTP design shall provide for decontamination; it shall ensure that there are no stagnant zones of possible accumulation of liquid (water, including atmospheric precipitation, working media and decontamination solutions) and locations which are difficult to access for maintenance.

4.4.2.8 Structural materials of OSTP components shall not cause electromechanical interaction with each other and the package content; shall be resistant to decontamination solutions; withstand the impact of ionising radiation corresponding to characteristics of SNF; and the impact of temperature that may arise in normal operation and operational events including design basis accidents.

4.4.2.9 The OSTP design shall consider:

chemical and physical and chemical interactions;
changes in material properties due to cyclic alterations of temperature in the environment;

conditions of operation (irradiation, residual heat, internal pressure, humidity, presence of fission products and the environmental conditions).

4.4.2.10 Valves through which a leak of radioactive content is possible shall be equipped with technical devices protecting from unauthorised manipulation and leak confining devices.

4.5 Hot cells

4.5.1 During spent FA disassembling provided for in the design loss of integrity of FR cladding shall be excluded. FR studies shall be done in accordance to the technology envisaged in the design.

4.5.2 FRs and SFAs cut in hot cells shall be stored in special equipment (safe geometry storage tubes, etc.).

4.5.3 The engineered features for collection and storage of spilled nuclear material shall be envisaged.

4.5.4 Spills shall be put into specially provided containers with safe geometry (volume, diameter and layer thickness). Should vacuum cleaners be used to collect spills, their collectors shall have safe geometry.

4.5.5 The hot cell design shall provide for special locations for temporary storage of SFAs spills.

4.5.6 Drainages where decontamination solutions are poured down shall be equipped with filtering sumps of safe geometry. There shall be also foreseen sedimentation tanks of safe geometry to rest small nuclear material particles from decontamination solutions that have passed through the filtering sumps with the deposits being sent for reprocessing.

4.5.7 Filters of the ventilation system shall have the safe geometry. The ventilation systems shall have no unmonitored stagnant zone where nuclear materials can accumulate.

4.6 SNF storage and transportation equipment

4.6.1 The equipment for storage and transportation of SNF shall be designed (developed) so that a possibility of excessive mechanical loads to FRs and FAs are reduced to minimum during FR and SFA storage and transportation. In designing (developing) the equipment for SNF storage and transportation it is required to consider changes in geometry of FRs and SFAs and equipment components, which occur during operation. Mechanical damages to outer surfaces of FRs and SFAs resulted from their insertion and withdrawal from the SFA storage and transportation equipment shall be excluded.

4.6.2 In designing (developing) the equipment for SNF storage and transportation it is required to ensure easiness of its disassembly or retrieval for repair and maintenance.

4.6.3 The SNF storage and transportation equipment in the cooling pond shall have interlocks, which exclude lifting of SNF above the corresponding water layer that is defined from the point of radiation safety.

4.6.4 Equipment and tools used for underwater process operations shall be manufactured so that hollows in these tools are filled with water during submerging to maintain water protection layer and be emptied when the tools are taken out of the pond.

4.6.5 In designing (developing) the storage facility and its equipment it is necessary to consider:

- load arising from maximum number of SFAs, CPS rods,additional absorbers, dummies, and other devices foreseen in the design;
- loads during seismic impacts;
- hydrostatic pressure of water;
- loads arising from thermal effects;
- loads arising during full OSTP loading;
- dynamic loads during tossing of floating storage facilities.

4.6.6 The reloading machine for nuclear fuel reloading under water shall have interlocks excluding:

movements of the reloading machine when SFAs are inserted in (withdrawn from) the reactor and the cooling pond and shroud rack cells;

collision of the reloading machine bar carrying SFAs with structures of the refueling pond;

SFA withdrawal from the reactor or cooling pond racks when the force to the reloading machine bar exceeds the value established in the technical documentation.

4.6.7 For computer-controlled reloading machines there shall be automatic record-taking of all bar and SFA movements and interlock actuations, as well as the means to verify interlock availability and performance.

4.6.8 The nuclear fuel storage and transportation equipment shall include devices that exclude overheating of FRs in SFAs by residual heat in excess of permissible temperature values established by the design, and which ensure protection of the personnel from overexposure.

4.6.9 The design shall provide for necessary tests to verify performance of the storage and transportation equipment, in particular, the storage facility load-bearing structures (racks, brackets), and the storage facility lining leaktightness tests.

5 CONTROL OF COMPLIANCE

5.1 The operating organization shall control the compliance with requirements of these Rules.

5.2 The operating organization shall arrange for recurrent (not less than once in two years) inspections of how these Rules are complied with at the NF and submit the results of these inspections to the state nuclear and radiation safety regulatory authority.

APPENDIX

Exemplary list of initiating event of design basis accidents

1. Internal and external natural and man-induced events characteristic of the NF site location.
2. NF total blackout.
3. Fire in the nuclear fuel storage facility and/or vehicles transporting nuclear fuel.
4. Drop of objects that may change the FAs and FRs spacing and affect integrity of FAs or FR cladding.
5. Drop of individual FAs, OSTPs, storage tubes and shrouds with spent FAs during transport and process operations.
6. Possible leaks from the cooling pond.
7. Effects from projectiles resulted from accidents (e.g. as the result of collapse of pressurised systems).
8. Ventilation failures leading to formation of explosive mixtures in the spent nuclear fuel storage facility.
9. Disruption of heat removal during storage and transportation of nuclear fuel.
10. Failures of package fixing during nuclear fuel transportation.

Exemplary list of beyond design basis accidents

1.
2.
3.
4.
5. SCR initiation as regards NF storage and handling systems.
6. Complete de-watering of SNF storage facility.
7. Falling of the process equipment and structures onto the ceiling of the storage compartments or stored NF.
8. Flooding of Class 1 storage facilities.