

Federal Environmental, Industrial and Nuclear Supervision Service

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

Approved by the Order of
Federal Environmental,
Industrial and Nuclear
Supervision Service
31 August 2005
No. 3

**SITING OF NUCLEAR MATERIAL AND RADIOACTIVE SUBSTANCE STORAGE
FACILITIES. BASIC SAFETY CRITERIA AND REQUIREMENTS**

NP-060-05

Effective
since 01 January 2006

Moscow 2005

UDK 621. 039

SITING OF NUCLEAR MATERIAL AND RADIOACTIVE SUBSTANCE STORAGE FACILITIES. BASIC SAFETY CRITERIA AND REQUIREMENTS
NP-060-05

Federal Environmental, Industrial and Nuclear Supervision Service of Russia
Moscow 2005

This regulatory document establishes basic safety criteria and requirements for siting, as well as for safety assessments of aboveground and underground storage facilities for nuclear materials and radioactive substances of nuclear fuel cycle facilities, including storage facilities for fresh and irradiated uranium and MOX-fuel and excluding natural uranium mining facilities.

This regulatory document has been developed taking into account the federal norms and rules and IAEA documents that regulate selection of sites for nuclear power plants.

This document is issued for the first time¹.

The regulatory document has passed a legal review by the Ministry of Justice of the Russian Federation (MOJ letter # 01/7289-E3 of 15.09.2005).

¹ This document has been developed in the SEC NRS jointly with IBRAE RAS with participation of E.G. Bugaev, I.V. Kaliberda, I.M. Lavrov, L.M. Fikhieva (SEC NRS); A.A. Polishuk, the Development Leader (IBRAE RAS); V.M. Iryushkin, A.I. Kislov, (Federal Environmental, Industrial and Nuclear Supervision Service); V.N.Morozov, V.N. Tatarinov (GC RAS).

The document has been developed taking into account the comments and proposals of MOE of Russia, Rosatom, JSC TVEL.

TABLE OF CONTENTS

LIST OF ACRONYMS	4
BASIC TERMS AND DEFINITIONS	5
1. PURPOSE AND SCOPE	6
2. GENERAL PROVISIONS	6
3. BASIC SITING CRITERIA OF NUCLEAR MATERIAL AND RADIOACTIVE SUBSTANCE STORAGE FACILITIES AND REQUIREMENTS FOR THEIR SITING	7
4. REQUIREMENTS FOR ASSESSMENT OF PARAMETERS OF NATURAL AND MAN-INDUCED PROCESSES, PHENOMENA, AND FACTORS	8
4.1. NATURAL PROCESSES, PHENOMENA AND FACTORS	8
4.2. MAN-INDUCED FACTORS	10
5. ENVIRONMENTAL AND POPULATION IMPACT ASSESSMENT OF NUCLEAR MATERIAL AND RADIOACTIVE SUBSTANCE STORAGE FACILITIES	10

LIST OF ACRONYMS

DBE	Design Basis Earthquake
MEE	Maximum Estimated Earthquake
MSK-64	Seismic Intensity Scale by Medvedev-Sponheuer-Karnik
NM and RadS SF	Nuclear Material and (or) Radioactive Substance Storage Facilities

Basic Terms and Definitions

The following terms and definitions are used for the purposes of this document.

Active Break shall mean the tectonic break with relative displacement of the Earth' crust by 0.5 m and more as having occurred during the last 1 million years (quaternary).

Geodynamic Zone shall mean the linear or annular part of the Earth' crust, in the boundaries of which the velocity gradient of quaternary movements is equal to 10^{-9} a year or more.

Nuclear material and (or) radioactive substance storage facility shall mean stationary facilities and structures intended for storage of nuclear materials and (or) radioactive substances.

Nuclear material and (or) radioactive substance storage facility site shall mean the area within the guarded perimeter where NM and (or) RadS SF main and auxiliary buildings and structures are located.

Nuclear material and (or) radioactive substance storage facility site region shall mean the territory where natural and man-induced phenomena, factors and processes are possible that are capable of affecting NM and RadS SF and determining conditions of their siting, and which includes the NM and RadS SF site.

Nuclear Material and Radioactive Substance Storage Facilities shall mean the stationary facilities and structures designed to store nuclear materials and radioactive substances including the facilities and structures which are located on-site of a nuclear facility and are not the constituents of the nuclear facility design.

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

Population Evacuation Planning Zone shall mean the shall mean the territory within which the likely radiation impact in the case of an accident can reach or exceed Level B of criteria established by the Radiation Safety Standards for evacuation of the critical group of the population.

Protective Action Planning Zone shall mean the territory within which the likely radiation impact in the case of an accident can reach or exceed Level A of criteria for making urgent decisions at an initial stage of the accident, as established by the Radiation Safety Standards.

1. PURPOSE AND SCOPE

- 1.1. This regulatory document establishes basic safety criteria and requirements for siting of newly constructed aboveground and underground NM and RadS SF of nuclear fuel cycle facilities, including storage facilities for fresh and irradiated uranium fuel and MOX-fuel.
- 1.2. Terms and scope of measures to bring NM and RadS SF in compliance with requirements of these Rules are established on the case-by-case basis by the operating organization and reviewed by the state competent safety regulatory authority.
- 1.3. This regulatory document does not cover the natural uranium mining facilities.

2. GENERAL PROVISIONS

- 2.1. The project and survey work to determine and evaluate siting conditions shall be performed on the NM and RadS SF site and in the site location region, including the determining of:
 - 1) a possibility of natural and man-induced processes, phenomena, and factors to occur on the NM and RadS SF site and their parameters;
 - 2) characteristics (including hydrological and hydrogeological) of the environment that are capable of affecting radioactive substance migration and accumulation;
 - 3) parameters of impacts to the environment and NM and RadS SF produced by existing, being designed or constructed chemical and (or) nuclear and radiation hazardous facilities on the NM and RadS SF site;
 - 4) a possibility to ensure conditions for and routes of evacuation of the population, transportation of nuclear materials, radioactive substances and radioactive waste in the event of occurrence of hazardous natural and man-induced processes, phenomena and factors on the NM and RadS SF site and in the site location region.
- 2.2. The methods of surveys and studies, methods and methodologies of evaluation of parameters of external natural and man-induced processes, phenomena and factors, as well as transfer of radioactive substances from the radiation release and (or) discharge source shall be those recommended by regulatory documents or proven by their application experience and ensuring credibility.
- 2.3. The computer codes which help to implement methods of assessing parameters of external impacts and methodologies for determining characteristics of radioactive substance migration shall be duly qualified (certified).
- 2.4. The assessment of siting conditions for NM and RadS SF shall be carried out considering the possibility to reach safety criteria, principles and requirements formulated in the NM and RadS SF design, including ensurance of:

- 1) safety of NM and RadS SF operation taking into account identified extreme natural and man-induced processes, phenomena, and factors, including their unfavorable combinations;
- 2) safety of the population and environmental protection against NM and RadS SF during normal operation and operational events including accidents (design basis and beyond design basis accidents);
- 3) physical protection of NM and RadS SF, nuclear materials and radioactive substances;
- 4) compliance with sanitary and fire safety standards for design and construction of buildings and design standards for technical and engineered measures of the civil defense;
- 5) stability (retaining) of properties of rock mass hosting underground NM and RadS SF in the event of design basis and beyond design basis accidents.

2.5. The applicant, in the feasibility study (project), shall determine the scope and content of monitoring of natural and man-induced processes, phenomena, and factors in the NM and RadS SF location region and on site and start operating a monitoring system not less than 6 to 12 months prior to the beginning of construction of the NM and RadS SF.

2.6. The applicant, in the feasibility study (project), shall determine the scope and content of rock monitoring. The applicant shall start operating a monitoring system not less than 6 to 12 months prior to the beginning of construction of the NM and RadS SF and monitor stability characteristics of geologic formations, stability of tunnels and civil engineering structures during the entire period of construction, operation and decommissioning of NM and RadS SF.

3. BASIC SITING CRITERIA OF NUCLEAR MATERIAL AND RADIOACTIVE SUBSTANCE STORAGE FACILITIES AND REQUIREMENTS FOR THEIR SITING

3.1. It is not permitted to site NM and RadS SF:

1. in the territories where siting of nuclear and radiation hazardous facilities is prohibited by the environmental protection legislation and civil defense requirements;
2. on sites located directly at active faults or in active geodynamic zones;
3. on sites which seismic activity is characterized by magnitude 8 of the maximum estimated earthquake as per MSK-64 scale;
4. in regions of karst development (thermokarst) processes;
5. in territories susceptible to tsunami, catastrophic water raises or floods;
6. in territories susceptible to active volcanoes and in the territory featuring manifestations of active mud volcanism;
7. in territories which can be flooded by rush of water from the pressure front of water reservoirs in the event of the dam break located upstream the NM and RadS SF;
8. in zones of mudflows, snow avalanches and in the regions where landslides and other disastrous hillside processes occur;

9. on slopes with inclination equal to or more than 15° ;
10. in flood valleys of rivers and water pond banks, with the rate of movement of the edge line and scarp exceeding 1 meter a year;
11. in areas of structurally or dynamically unstable soils, permafrost, and soils with deformation modulus less than 20 MPa;
12. in mining tunnels which stability cannot be ensured throughout the whole operating life and decommissioning of underground NM and RadS SF;
13. in rock mass, if in the event of an accident at underground NM and RadS SF stability of the rock mass properties cannot be ensured.

3.2 The following conditions shall be termed unfavorable for NM and RadS SF siting:

1. Areas with operating artesian wells and zones of extensive exchange between the ground and surface water.
2. Areas with tornado and strong wind hazard.
3. Areas with large-scale mineral deposits which have been explored or are being developed.
4. Areas where NM and RadS SF would be located windward, for prevailing wind directions, with regard to enterprises and residential areas.
5. Sites, where seismic activity is characterized by the intensity of a MEE of magnitude 6–8 as per MSK-64 scale.
6. Sites within which quaternary differentiated tectonic movements were revealed but which are not located on active tectonic faults.
7. Areas of tectonic fissuring.
8. For the aboveground NM and RadS SF: the sites with ground water located less than 3 m deep from the surface in the soil of 10 m or greater thickness and permeability of 10 m/day or greater.
9. For the aboveground NM and RadS SF: the sites with thunderstorms – the regions within which a probability of intensive thunderstorms is significantly higher than in the surrounding territory.
10. Areas with abandoned mining and other tunnels, excluding those which can be used for underground NM and RadS SF.
11. Areas where facilities (including military) are located where releases of toxic substances and other impacts, such as air-shock wave and missiles, as well as secondary fire factors, may occur in case of fire and explosion.
12. Areas where a probability of fires due to external causes is high, which are dangerous for NM and RadS SF.
13. For underground NM and RadS SF - rocks where horizontal stress exceeds vertical stress by 2.5 times or higher.
14. Territories characterized by average anticipated population density of up to 100 persons/km² for the period of NM and RadS SF operation and decommissioning within the population evacuation planning zone.
15. Regions which host institutions which evacuation (resettlement) is difficult or impossible (correction institutions, special clinics and the like).
16. Regions featuring unstable geopolitical, socio-economic situation and criminal rate.
17. Other specific criteria, which may be identified during the site survey process.

4. REQUIREMENTS FOR ASSESSMENT OF PARAMETERS OF NATURAL AND MAN-INDUCED PROCESSES, PHENOMENA, AND FACTORS

4.1. Natural Processes, Phenomena and Factors

4.1.1 Parameters of all possible natural processes, phenomena and factors capable of adversely affecting NM and RadS SF, as well as factors which characterize NM and RadS SF siting conditions shall be determined for the NM and RadS SF location and site areas, to include:

1. Characteristics of volcano activities.
2. The NM and RadS SF location with regard to potential earthquake focuses, active faults, geodynamic areas, and tectonic abnormalities.
3. Amplitudes, rates, and rate gradients of tectonic movement of Earth's crust, in active faults and geodynamics areas.
4. Characteristics of active fault, geodynamic zones of tectonic faults (geometry, amplitudes and directions, period of recent activity).
5. Seismic impact parameters during DBE and MEE at the NM and RadS SF site surface and foundation depth.
6. Characteristics of the surface relief and internal boundaries of the geologic divide.
7. Values of landslide movements taking into account tectonic abnormalities, current geodynamic processes, soil conditions, ground water, and seismic oscillations with intensity up to and including MEE.
8. Characteristics of maximum possible flooding for a frequency of 10^{-4} a year in a combination of tide and wind surge, as well as maximum height of tsunami or seiche waves should be determined for the site located alongshore of a large water area.
9. Availability and possibility of development of karst (thermokarst) and karst suffusion processes.
10. Soil filtration characteristics (their permeability).
11. Presence of specific soils (biogenic, sagging, shrinking, swelling, saline soils, permafrost, eluvial, and man-made) and assessment of their characteristics including their thickness and physical and mechanical properties, deformation modulus, strength characteristics, and also possible uneven soil settlement and other parameters.
12. Presence of areas with water-saturated non-cohesive soils that may liquefy in case of seismic impacts up to and including MEE
13. Parameters defining the ground water level, site underflooding in case of propagation of ground water hydrostatic lift from water reservoirs, irrigated soil filtration, water leaks; parameters' dependence from precipitation, and snow melting.
14. Probabilistic distributions of atmospheric dispersion parameters characteristic of the NM and RadS SF location region.
15. Values of tornado intensity, maximum values of the rotation speed and tornado forward speed, pressure drop between tornado periphery and whirlpool center, missiles generated (objects caused to become airborne).
16. Characteristics of Arctic (cold) storms, dust and sand storms, strong winds.

17. Parameters of hurricane, extreme atmospheric precipitation, ambient air and water temperatures, icing, thunderstorm, erosion of banks of rivers and water reservoirs.

4.1.2 For underground NM and RadS SF, besides the above mentioned factors, characteristics of excavation stability shall be studied and determined for the entire period of NM and RadS SF operation and decommissioning including:

1. Physical and mechanical properties of the rock including limiting stress values which result in initiation of fissuring and disruption of natural isolating properties of the rock mass.
2. Distribution of the natural stress fields in the rock mass.
3. Hydrogeologic regimes of the rock mass.
4. Characteristics of tectonic disruptions crossing mining tunnels.
5. Processes including geomechanical processes defining stability of underground constructions.
6. Thermal and physical properties of the rock.
7. Sorption properties of the rock.
8. Characteristics of the rock chemical stability.
9. Thermal impact and (or) other impact of underground NM and RadS SF on properties of the hosting rock mass.

4.2. Man-Induced Factors

4.2.1. Parameters shall be determined of external impacts from facilities (including military ones) located on the NM and RadS SF site and its location region where hazardous man-induced factors of explosions and fires, releases of explosive, combustible, toxic and corrosive substances, break of hydrostructures, aircraft or their fragments crash or other bodies and other impacts can occur during normal operation or accidents.

Parameters of external impacts from all sources of man-made hazards revealed on the site of NM and RadS SF and in its location region where accidents are possible with frequency 10^{-6} per year and higher shall be determined.

4.2.2 The impact on NM and RadS SF safety from explosions and fires shall be analyzed.

If there are several sources of an explosion or fire it is permitted to determine and consider in the design bases the parameters of the most hazardous explosion and fire under the most unfavorable accident sequence.

4.2.3 The impact on NM and RadS SF safety from sources of accident toxic releases and corrosive discharges in the NM and RadS SF location region and site.

4.2.4 Impacts from the following events to NM and RadS SF safety shall be analyzed:

1. Aircraft and other airborne object crashes.
2. Floods including those involving break of hydrostructures, atmospheric precipitation, snow avalanches, high water.

3. Electromagnetic fields, thunderstorms.
4. Rock deformations, subsidence of rock, and other factors related to large-scale draining of commercial wells and excavation of mineral deposits, mining works, including construction of tunnels, mines, open-pit mines, as well as those induced by processes of intense deformation in upper overlying beds and collapse of mining tunnels, soil oscillations due to man-induced earthquakes.

5. ENVIRONMENTAL AND POPULATION IMPACT ASSESSMENT OF NUCLEAR MATERIAL AND RADIOACTIVE SUBSTANCE STORAGE FACILITIES

- 5.1. Natural radiation background, aerological and meteorological, hydrologic and hydrogeological, geologic and engineering-geologic, geo-chemical and biological conditions which define dispersion, migration and accumulation of radionuclides in the protective action planning zone shall be studied; data on distribution of population and land use shall be generated for the entire period of NM and RadS SF operation and decommissioning.
- 5.2. Conditions of radionuclide accumulation and transfer in the atmosphere - atmospheric dispersion in the area of NM and RadS SF location - shall be determined taking into account specific (characteristic) wind directions and speeds, ground and elevated inversions, air humidity, pressure and temperature, stability of atmosphere, precipitation and fogs.
- 5.3. Characteristics of radionuclide migration in surface and ground water and their accumulation on the beds of water reservoirs shall be defined considering:
 1. Potential radioactive contamination of ground water.
 2. Physical and chemical properties of radionuclides.
 3. Kinetics of geo-chemical reactions and potential changes in the rock mineralogy.
 4. Lithology of sedimenting rock and strength of the water-bearing and water-proof layers, aeration zone soils.
 5. Sorption properties of the rock, ground and soils with regard to radionuclides and corrosive chemicals.
 6. The direction and speed of contaminated flow migrations toward the discharging locations (such as water passages, reservoirs, water wells, etc.).
 7. Properties and stratification of water-bearing strata and systems.
 8. Hydraulic connection between ground and surface water.
 9. Properties of water reservoirs, hydrostructures; data on water use, water levels and discharge rates, river flow speeds, potential mechanism of radionuclide transfer and deposition.
- 5.4. A justifications of the radiation situation at the NM and RadS SF site and location region for NM and RadS SF normal operation, operational events, including technical and organizational measures to ensure safety of the population shall be completed during the NM and RadS SF feasibility study (project) stage.

The radiation situation regarding NM and RadS SF normal operation shall be assessed using the probabilistic distribution of atmosphere dispersion parameters typical of the NM and RadS SF location region. If the representative statistical data is unavailable it is

permitted to do calculations using the “envelope curve” method which provides for a conservative assessment of the radiation situation.

The radiation situation regarding design basis and beyond design basis accidents at NM and RadS SF shall be assessed for the least favorable meteorological conditions typical of the NM and RadS SF location region.

- 5.5. The radiation situation regarding design basis and beyond design basis accidents at the underground NM and RadS SF site and location region shall be assessed on the basis of conservative (the highest) rock filtration coefficients and rates of radionuclide migration in ground water.
- 5.6. Measures shall be envisaged to prevent radioactive contamination of the environmental objects located in the NM and RadS SF region that ensure meeting the radiation safety requirements.
- 5.7. The protective measures planning zone’s boundary shall be so that in the event of beyond design basis accidents associated with the limiting permissible release of radioactive substances into the environment the projected population exposure doses at the boundary of the protective measures planning zones and beyond do not exceed values established by the existing radiation safety standards.