

**Federal Nuclear and Radiation Safety Authority of Russia
(Gosatomnadzor of Russia)**

**FEDERAL RULES AND REGULATIONS
IN THE FIELD OF NUCLEAR ENERGY USE**

Approved by the Decree of
Gosatomnadzor of Russia
No 11 of 31 December 2003

**Siting of Nuclear Fuel Cycle Facilities.
Basic Safety Criteria and Requirements
NP-050-03**

Put into effect
from 28 May 2004

Moscow 2003

UDK 621. 039

**SITING OF NUCLEAR INSTALLATIONS OF NUCLEAR FUEL CYCLE.
BASIC SAFETY CRITERIA AND REQUIREMENTS
NP-050-03**

**Gosatomnadzor of Russia
Moscow 2003**

These federal rules and regulations establish basic safety criteria and requirements for siting regions and sites of nuclear installations of nuclear fuel cycle.

The document has been developed in accordance with the Russian Federation legislation and taking account of federal rules and regulations, as well as the documents below:

50-C-S (Rev-1), Code on the safety of nuclear power plants: Siting. IAEA, Vienna, 1990,

50-SG-S1, Earthquakes and associated phenomena. Topics in relation to nuclear power plant siting. IAEA, Vienna, 1994.

This document is issued for the first time* .

The document passed legal review in the RF Ministry of Justice (a letter of Minjust of Russia No 07/665-YuD of 21.01.2004)

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ACRONYMS

DBE	Design Basis Earthquake
MSK-64	Medvedev-Sponheuer-Karnik Seismic Intensity Scale
NI NFC	Nuclear Installation of Nuclear Fuel Cycle
SSE	Safe Shutdown Earthquake

BASIC TERMS AND DEFINITIONS

Active Break – tectonic break with relative displacement of the Earth’ crust by 0.5 m and more having occurred during the recent one million years (quaternary).

Area of NI NFCF Siting – an area including the NI NFC site for which NI NFC siting conditions are determined and where there is a possibility of natural and man-induced phenomena, factors and processes to occur, which may impact safety of the NI NFC.

Geodynamic Zone – 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.

Maximum Permissible Accident Release – magnitude of radionuclide emission into environment as a result of a beyond design-basis accident, when under the worst weather conditions the population exposure dose at the border of the protective action planning zone and beyond its boundaries shall not exceed 5 mSv for the first year after the accident and 1mSv per year for the next years.

NI NFC Site – an area within the guarded perimeter, where NI NFC buildings and structures are located.

Population Evacuation Planning Zone – an area around NI NFC where a projected radiation impact on critical groups of the population in the events of beyond design basis accidents could approach or exceed dose criteria for mandatory evacuation as set forth by radiation safety standards and for which population evacuation measures are planned.

Protective Action Planning Zone – an area around NI NFC where a radiation impact in the case of beyond design-basis accident is possible in excess of dose criteria established by radiation safety standards and for which organizational, engineering, technical and medical population protection measures are planned.

Underground NI NFC – a nuclear installation located below the site surface.

1. PURPOSE AND APPLICABILITY

1.1. This regulatory document applies to nuclear installations of nuclear fuel cycle, i.e. structures, complexes, facilities for production and reprocessing of nuclear fuel and nuclear materials, including facilities for weapons-grade plutonium conversion, fabrication of plutonium-containing fuel, management of fresh and spent plutonium-containing fuel and resulted radioactive waste, excluding uranium mining facilities.

1.2. This regulatory document defines basic criteria and requirements to sites of newly sited NI NFCF.

1.3. Organizational and technical measures to eliminate or compensate for deviations from requirements of this document for NI NFCF being sited shall be determined on the case-by-case basis in accordance with the established procedure.

2. GENERAL PROVISIONS

2.1. Design, survey and research work on definition and evaluation of siting conditions shall be performed for the NI NFC region and site, including:

- 1) identification of natural and man-induced processes, phenomena, and risk factors and assessment of external NI NFC impact parameters of the region and site;

2) accounting of economic, social and cultural facts of significance or other activities in the NI NFC siting region considering its prospective development, including the Mineral Resources Register;

3) identification of the regional population in the NI NFC siting region considering its demographic growth and distribution among sectors, including largest NI NFC release and discharge direction areas and remoteness from NI NFC of the most populated settlement within the evacuation measures planning zone and mandatory population evacuation planning zone;

4) characterization of the environment regarding radioactive substance transport and accumulation, including hydrological and hydrogeological conditions;

5) taking account the present within the NI NFC siting region and on its site other nuclear facilities at the operation or design or construction stage, buildings related to the category of fire and explosion hazardous objects, objects that host toxic and corrosive substances as well as transportation routes accidents wherein could affect NI NFC;

6) identification of routes and conditions for nuclear material, nuclear fuel, irradiated nuclear fuel, radioactive substances and radwaste transport and population safe evacuation routes;

2.2. Design and survey activities in the NI NFC region and at the site shall be performed in compliance with Quality Assurance Programs.

2.3. Methods and techniques to assess frequencies (recurrence) and severity and other parameters of external events of natural and man-induced origin revealed in the NI NFC siting region and site, and also those for transport of radioactive substances shall be in compliance with the achieved level of science and technology. Pertinent software shall be certified in accordance with the established procedure.

2.4. At the stage of construction investment justification of NI NFC, a preliminary assessment of whether the site complies with requirements of this document shall be carried out as relates to:

- 1) safe NI NFC operation, accounting for identified extreme natural and man-induced processes, phenomena, and risk factors, including their unfavorable combinations;
- 2) safety of the population and protection of the environment from radiation impacts of NI NFC in normal operation and design basis accidents;
- 3) mitigation of radiation impact to the population and environment in beyond design basis accidents;
- 4) physical protection of NI NFCs and nuclear materials handled at this facility;
- 5) compliance with health and fire safety requirements of regulations on design and construction of special-purpose buildings and codes of development of engineering and technical measures of civil defense.

2.5. Compliance of the site with safety criteria established herein shall be confirmed in the course of the NI NFC project feasibility study development, considering developed organizational and engineering measures. It shall be also made on the basis of:

- 1) limitation of safety impact of natural and man-induced processes, factors and phenomena revealed on the site and its siting region on safety of newly sited NI NFC, including their unfavorable combinations;
- 2) limitations of man-induced impacts on NI NFC from nuclear installations already existing in the NI NFC site and siting region;
- 3) limitation of a radiation impact of NI NFCF on the population within the protective measure planning zone and the environment considering a contribution of existing nuclear facilities located in the NI NFC site and siting region ;
- 4) consideration of environmental characteristics facilitating radioactive substance transport or accumulation;
- 5) ensurance of safe transportation of nuclear materials, nuclear fuel, irradiated nuclear fuel, radioactive substances, and radioactive waste;
- 6) identification of sizes of the protective action planning zone and mandatory population evacuation zone, considering medical, biological, demographic, and other regional factors;
- 7) provisions of conditions for population evacuation within time when dose criteria for mandatory evacuation are not exceeded as per the existing standards of radiation safety;
- 8) justification of a possibility to eliminate consequences of design basis and beyond design basis accidents as well as undertake prompt measures to prevent unauthorized actions regarding NI NFC.

2.6. Nomenclature, severity, and frequencies of natural and man-induced processes, phenomena and factors shall be identified in accordance with to safety requirements of Federal standards and regulations and safety guidelines for the use of atomic energy.

2.7. Site characteristics shall be monitored during NI NFC operation and decommissioning.

Environmental monitoring shall be carried out 6 to 12 months prior to the beginning of construction and during construction, operation, and decommissioning of NI NFC.

For an underground NI NFC the mountain monitoring system shall be provided 6 to 12 months prior construction, as well as during construction, operation, and decommissioning of NI NFC.

The underground NI NFC depth shall be justified considering parameters of external natural and man-induced impacts on NI NFC and its potential impacts on the population and environment.

3. BASIC SAFE SITING CRITERIA AND REQUIREMENTS FOR NUCLEAR INSTALLATIONS OF NUCLEAR FUEL CYCLE

3.1. A site is considered to be suitable for siting a NI NFC if the following conditions are concurrently met:

- 1) compliance of the NI NFC site with environmental legislation, health rules and regulations and special civil defense requirements, fire safety requirements for special purpose buildings and terrorist protection requirements;
- 2) siting within the boundaries of a tectonic block, that is not affected by active faults and geodynamic areas;
- 3) an intensity of SSE on the site is less than 6 points (MSK-64 scale);
- 4) long-term stability of properties in rock mass which hosts the underground NI NFC as relates to transfer and migration of radioactive substances after an accident;
- 5) absence of a flooding possibility.

3.2 The following conditions are unfavorable for NI NFC siting:

- 1) areas with operating artesian wells and there is extensive exchange between the ground and surface water;
- 2) areas featuring tornado and strong wind hazard;
- 3) areas featuring strong winds of an average speed of 12 m/s;
- 4) areas of known deposits of commercial minerals or their mining;
- 5) areas susceptible to tsunamis, disastrous floods, and inundations
- 6) areas which can be flooded by rush of water from the pressure front of a water reservoir
- 7) areas where NI NFC are located on the windward side for wind prevailing direction with respect to existing facilities and apartment blocks;
- 8) sites, where SSE intensity is 6, 7, 8 points as per MSK-64 scale;
- 9) linear geodynamic zones with differential tectonic movements of the Earth's crust during quaternary with the deformation rate exceeding 10^{-9} a year (without active faults);
- 10) areas of tectonic fissuring;
- 11) areas featuring development of active mudflow and other disastrous hillside processes;
- 12) flood valleys of rivers and water pond banks, with the rate of movement of the edge line and scarp exceeding 1 meter a year;
- 13) slopes with incline equal to or more than 15°
- 14) areas of structurally or dynamically unstable soils, permafrost, and soils with deformation modulus less than 20 MPa;
- 15) sites featuring 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 for the surface NI NFC;
- 16) areas of high lightning activity for the surface NI NFC where heavy lightning probability is significantly higher than in the neighboring territories;
- 17) areas with abandoned mining and other excavations excluding those that can be used for underground NI NFC;
- 18) areas that host facilities including military ones where emission of flammable, toxic and corrosive substances and other impacts, such as shock wave and missiles generated by a fire or explosion are possible;
- 19) areas where external fires jeopardizing NI NFC are possible;
- 20) for underground NI NFC – rock masses where horizontal stress exceeds vertical stress by 2.5 times or higher;
- 21) territories within the mandatory evacuation planning zone with an average population density of higher than 100 people per square kilometer and intended for the entire period of NI NFC operation and decommissioning.

3.3 Siting NI NFC shall be prohibited in the following locations:

- 1) areas which is unusable for NI NFC as per the environmental legislation and special radiation safety requirements for the population, civil defense requirements and fire safety requirements for special purpose buildings;
- 2) in the site where, for the entire period of NI NFC operation and decommissioning, the protective actions planning zone covers institutions which tenants' evacuation (relocation) is difficult or impossible (penitentiary institutions, special hospitals etc.);
- 3) sites which are located directly on active faults;
- 4) sites where seismic activity at SSE exceeds 8 point as per MSK-64 scale;

- 5) in regions featuring development of karst (thermokarst), suffusion and karst-suffusion processes;
- 6) sites susceptible to tsunami, active volcanoes or active mud volcanism;
- 7) sites within mudflow and avalanche affected areas;
- 8) mountain tunnels where stability cannot be provided for the entire period of the underground NI NFC operation and decommissioning;
- 9) in rock masses if long-term stability of rock properties which prevent radionuclide releases to the work premises cannot be ensured in the event of an accident at the underground NI NFC.

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

4.1. Accounting of Natural Processes, Phenomena and Factors

4.1.1. When performing engineering surveys and research, the following environment characteristics which may affect NI NFC safety shall be determined:

- 1) characteristics of volcano activities;
- 2) the NI NFC location in regard to potential earthquake focuses, active faults, geodynamic zones, and tectonic abnormalities;
- 3) amplitudes, rates, and velocity gradients of tectonic movement of Earth's crust, along active faults and geodynamics zones;
- 4) characteristics of active fault zones (geometry, amplitudes and directions of fracture shifting, period of recent activity);
- 5) the seismic parameters during DBE and SSE at the NI NFC zero level and foundation depth;
- 6) risk of hillside landslides taking into account tectonic abnormalities, current geodynamic processes, soil conditions, ground water, and seismic oscillations with intensity of up to SSE, inclusive;
- 7) characteristics of maximum possible flooding for a frequency of 10^{-4} a year in the event of river floods considering tide and wind surge, as well as maximum height of tsunami or seiche waves for the site located on the coast of a sea, lake or reservoir;
- 8) presence and possibility of development of karst (thermokarst), suffusion, and karst-suffusion processes;
- 9) presence of specific soils (biogenic, sagging, shrinking, swelling, saline soils, permafrost, eluvial, and man-made); their thickness and physical and mechanical properties (deformation modulus, strength characteristics, etc.); their susceptibility to uneven settling;
- 10) areas with water-saturated non-cohesive soils that may liquefy in case of seismic impacts of up to SSE, inclusive;
- 11) parameters determining ground water levels, possibility of site underflooding in case of propagation of ground water hydrostatic lift from water reservoirs, irrigated soil filtration, water leaks, and their dependence from precipitation, and snow melting;
- 12) tornado intensity, maximum values of the rotation speed and tornado forward speed, pressure differential between tornado periphery and whirlpool center, missiles generated by tornado.

4.1.2. Presence and parameters of other natural processes, phenomena and factors (tornadoes, hurricanes, extreme precipitation, water and air temperature, sleet, thunderstorms, dust and sandstorms, long term erosion of river and pond shorelines), as well as impact of their hazardous combinations shall be additionally studied for the surface NI NFC.

4.1.3. The following characteristics of tunnel stability shall be additionally studied and determined for an underground NI NFC for the entire period of its operation and decommissioning:

- 1) physical and mechanical properties of rock mass, including limiting stresses that can initiate fissuring and degrading of natural isolation properties of the rock mass;
- 2) distribution of the natural stress fields in the rock mass;
- 3) hydro-geological mode of the rock mass;
- 4) characteristics of tectonic disruptions crossing mountain tunnels;
- 5) processes, including geo-mechanical ones, that determine stability of underground structures;
- 6) thermal and physical properties of the rock mass;
- 7) sorption properties of the rock mass;
- 8) dependence of thermal impact and (or) other impact of the NI NFC sited in the tunnel on properties of the hosting rock mass.

4.2. Accounting of Man-Induced Factors

4.2.1. Facilities (including military ones) where hazardous explosions and fires, emissions of explosive, flammable, toxic, and corrosive gases and substances dangerous for NI NFC, as per state standards are possible in the course of normal operation and (or) accidents, as well as nuclear installations in operation in this region shall be considered sources of man-induced hazard.

4.2.2. Presence and NI NFC safety importance of potential fixed and mobile sources of explosions and fires, including industrial facilities for fabrication, reprocessing, storage, and transportation of flammable and explosive substances located at the NI NFCF site or region shall be analyzed.

It is allowable to determine and take account of in the design bases parameters of the most hazardous accident explosion and fire.

4.2.3. Presence and NI NFC safety importance of potential fixed and mobile sources of toxic substance releases and corrosive discharges, including industrial facilities which process, use, store, and transport toxic and corrosive substances shall be analyzed.

4.2.4. Parameters of external impacts on surface and underground NI NFC shall be analyzed including frequency (recurrence) and intensity as regards sources of below events revealed on the site and siting region:

- 1) explosions and releases of explosive, flammable, toxic and corrosive gases and substances;
- 2) aircraft and other airborne objects crashes;
- 3) floods, including those associated with breaks of hydraulic structures, atmospheric precipitation, avalanches, high waters;
- 4) electromagnetic fields, thunderstorms;

- 5) external fires (forest fires, peat bog fires, flammable liquid fires);
- 6) rock deformations, subsidence of rock and other factors initiated by mining of minerals and mining operations, including construction of tunnels, operation of mines and open-pit mines, as well as due to processes of intense deformation in upper overlying beds and destruction of mining tunnels.

5. REQUIREMENTS FOR ACCOUNTING OF IMPACT OF NUCLEAR INSTALLATION OF NUCLEAR FUEL CYCLE ON THE POPULATION AND ENVIRONMENT

5.1. Natural radiation background, upper-level, hydro-meteorological, hydro-geological and geo-chemical conditions of NI NFC that determine dispersion, migration and accumulation of radionuclides in the protective action planning zone shall be studied; forecasts of changes in these conditions shall be produced; distribution of population and land use data shall be generated to cover the entire period of NI NFC operation and decommissioning.

5.2. Atmospheric accumulation and migration of radionuclides (radionuclide dispersion) shall be assessed for the NI NFC siting region taking into account light wind, calm, air temperature, ground and elevated inversions, stability of atmosphere, precipitation, and fogs.

5.3. Conditions of radionuclide migration in surface and ground water, as well as radionuclide accumulation on the bottom of 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 rock mineralogy;
- 4) lithological composition and thickness of water-bearing layers and retainers, aeration zones and soils;
- 5) sorption properties of the rock and soils as regards radionuclides and hazardous chemical substances;
- 6) direction and speed of contaminated streams toward the discharge locations (water passages, reservoirs, water wells, etc.);
- 7) characteristics and stratification of water-bearing layers and systems;
- 8) hydraulic connection between ground and surface water;
- 9) properties of water reservoirs, hydraulic structures, data on water use, water levels and flow rates, river current speed, potential mechanism of radionuclide transfer and deposition.

5.4. Justifications of the radiation conditions for NI NFC normal operation, design basis accidents and beyond design basis accidents, as well as development of technical and organizational measures to ensure safety of the population, shall be completed during the feasibility study (of the design).

A radiation conditions assessment for NI NFC normal operation shall be performed applying probabilistic distribution of atmospheric dispersion parameters typical of the NI NFC location.

A radiation conditions assessment for design basis accidents and beyond design basis accidents at NI NFC shall be based on the least favorable meteorological conditions typical of the NI NFC location.

5.5. A radiation conditions assessment for design basis accidents and beyond design basis accidents at the underground NI NFC shall be performed taking account of conservative values of rock filtration coefficients and rates of radionuclide migration in ground water.

5.6. The design shall justify the proposed preventive actions against contamination of water area which is of importance for the national economy and located near NI NFC; these shall be justified for NI NFC normal operation, operational events and decommissioning.

5.7. Consequences of a potential radiation impact to the population and environment by accident-induced radioactive releases and discharges within the protective actions planning zone during NI NFC normal operation and decommissioning shall be determined considering:

- 1) results of the radiation conditions assessment;
- 2) properties of water intake structures in the surveillance zone;
- 3) properties of water reservoirs as regards fishing, reproduction of fish and other biological resources in the surveillance zone;
- 4) data on the current and planned population distribution;
- 5) assessment of quantities of radionuclides getting into farm products.