

**FEDERAL CODES AND STANDARDS
IN THE AREA OF ATOMIC ENERGY APPLICATIONS**

**NUCLEAR POWER PLANT SITING.
MAIN CRITERIA AND SAFETY REQUIREMENTS**

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Note.

These federal codes and standards establish main criteria and requirements for safe nuclear power plant siting, taking into account the impact of processes, phenomena and factors of natural and man-induced origin and the nuclear power plant influence on the population and the environment.

These codes and standards supersede PNAE G-03-33-93 "Nuclear power plant siting. Main criteria and requirements of ensuring nuclear power plant safety".

The revised document PNAE G-03-33-93 takes into account the federal laws "On radiation safety of the public" as well as criteria and requirements of the "General nuclear power plant safety provisions", (N 50-C-S, N 50-SG-S1 (rev.1), N 50-CG-S5, N 50-SG-S7, N 50-SG-S9, N 50-SG-S11A, N 50-SG-S11B).

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MAIN TERMS AND DEFINITIONS

Active fault – tectonic fault along which relative displacement of the earth crust's adjacent blocks by 0,5 m and more took place during the last 1 bln. years (quaternary period).

Area of planned protective actions – territory around a nuclear power plant (NPP) within the boundaries whereof the radiation impact is possible in case of beyond-the-design basis accidents and the actions are planned for protecting the population stipulated by the current radiation safety codes. The conduct of actions for protecting the population is not required outside this area.

Area of planned actions for obligatory population evacuation – territory of predicted exposure in case of beyond-the-design basis accidents in the limits whereof the upper level of the dose criterion for obligatory evacuation of the critical group of the population established by the acting radiation safety codes can be reached or exceeded during the initial period of a radiation accident.

Nuclear power plant site – territory within the limits of the guarded perimeter where the main and auxiliary buildings and facilities of a nuclear power plant are located.

Maximum permissible emergency release – values of main dose-generating radionuclides release into the environment in case of beyond-the-design basis accidents under which the population exposure doses at the boundary of the area subject to planned protective actions and outside its limits with probability of 10^{-7} reactor/year should not exceed the corresponding values specified in current radiation safety codes, requiring making decisions on the population protection-related actions.

Nuclear power plant location area – territory including the nuclear power plant site on which phenomena, processes and factors of natural and man-induced origin, capable of affecting the plant safety, can possibly occur.

1. PURPOSE AND FIELD OF APPLICATION

1.1. This document establishes major criteria and requirements to newly sited nuclear power plants with all types of reactors, with account taken of the impact of processes, phenomena and factors of natural and man-induced origin and the plant influence on the population and the environment.

1.2. The requirements and criteria of this document should be fully met when developing the feasibility study (the design) for construction of a nuclear power plant.

2. FUNDAMENTALS

2.1. The site is considered suitable for a nuclear power plant location if there is a possibility of providing its safe operation, taking into account processes, phenomena and factors of natural and man-induced origin as well as the population safety and the environmental protection against radiation impacts in normal operation and in case of design accidents as well as the mitigation of these impacts under beyond-the-design basis accidents is provided.

2.2. To justify the plant site suitability, the following should be taken into account:

2.2.1. Impact of processes, phenomena and factors of natural and man-induced origin on the nuclear power plant safety.

2.2.2. Radiological impact of the plant on the population and the environment.

2.2.3. Specific characteristics of the plant location area and the plant site which can favour the migration and accumulation of radioactive products (topography, hydrogeology, air mass stratification, rivers, other water bodies and so on).

2.2.4. Implementation of necessary engineering and technical civil defence actions.

2.2.5. Dimensions of the sanitary protection area, area subject to planned protective actions and area of planned actions for obligatory evacuation of the population.

3. MAIN CRITERIA AND REQUIREMENTS TO SAFE NUCLEAR POWER PLANT SITING

3.1. It is not allowed to locate nuclear power plants:

- on the sites directly situated on active faults;
- on the sites whose seismicity is characterized by the maximum credible earthquake (MCE) intensity of more than 9 on Medvedev-Shponhoyer-Karnika seismic intensity scale (MSK-64);
- on the territory within the limits of which the location of a nuclear power plant is prohibited by the nature conservation-related legislation.

3.2. The following areas should be considered as unfavourable for siting a nuclear power plant:

- territories of active volcanos or active mud volcanism;
- territories exposed to tsunami, disastrous floods or inundations;
- territories which can be flooded by waves from water storage basin pressure front break;
- areas of mud torrent descent;
- regions the seismicity whereof is characterized by MCE intensity of more than 7 on MSK-64 scale;
- territories on which modern differential motion of the earth crust is established (vertical: with the rate of more than 10, horizontal: with the rate of more than 50 mm/year);
- zones of tectonic disturbances;

Karst (thermokarst) development areas

- territories with abandoned mine openings and other goafs;
- areas of development of active landslide and other hazardous slope processes;
- floodplain river terraces and water basin banks with the rate of shear line and abrasion bench movement of more than 1 m/year;
- flanks with slopes of 15° and more;
- sites with underground waters at a depth of less than 3 m from the ground surface planning with thickness of 10 m and more and with filtration coefficient of 10 m/day and higher;
- areas of occurrence of structurally and dynamically unstable grounds, permafrost earth as well as grounds with modulus of deformation of less than 20 MPa;
- territories within the limits of which facilities are located, including ammunition storages which, in case of fires and explosions, can release toxic substances and lead to other effects exceeding the design values.

In adverse regions and areas characterized with the occurrence of hazardous processes, phenomena and factors of natural and man-induced origin, a nuclear power plant is allowed to be located provided that technical and organizational actions for safety assurance are implemented.

3.3. The boundaries of the sanitary protection area, area covered by planned protective actions and area of planned actions for obligatory evacuation of the population should be justified in the design, provided that the following conditions are fulfilled.

3.3.1. The boundary of the plant sanitary protection area should be established in compliance with nuclear power plants-related sanitary codes and standards so that:

- during nuclear power plant normal operation, failures in normal operation (except for accidents) and decommissioning, the population (critical group) exposure outside the plant sanitary protection area would not exceed the quota (portion) of the main dose limit;
- in case of design accidents the predicted population exposure doses at the boundary of the sanitary protection area and outside its limits should not exceed values requiring making decisions on the population protection measures in case of a radiation accident involving radioactive contamination of the territory.

3.3.2. The boundary of the area of planned protective actions should be so that, in case of beyond-the-design basis accidents involving maximum permissible emergency radioactive product release in the environment, the predicted population exposure doses at the boundary of the area of planned protective actions and outside its limits should not exceed the values established by the current radiation safety codes requiring making decisions on measures for protecting the population in case of a radiation accident involving radioactive contamination of the territory.

3.3.3. The boundary of the area covered by planned actions for obligatory evacuation of the population should be so that, in case of beyond-the-design basis accidents involving maximum permissible emergency radioactive product release in the environment within its limits, the upper level of the dose criterion for obligatory evacuation of the critical population group established by current radiation safety codes may be reached or exceeded in the initial period of a radiation accident.

4. REQUIREMENTS TO TAKING INTO ACCOUNT PROCESSES, PHENOMENA AND FACTORS OF NATURAL AND MAN-INDUCED ORIGIN

4.1. Processes, phenomena and factors of natural origin

4.1.1. Engineering survey and investigations of processes, phenomena and factors of natural origin capable of affecting the nuclear power plant safety should be performed in the plant location area and on the plant site.

4.1.2. The tectonic activity characteristics should be determined:

- schemes of faults, fractures, possible earthquake sources relatively to the plant site, with indicating the orientation and boundaries of potentially hazardous discontinuous breaks;
- amplitude, rate and gradients of newest and current earth's crust movements and possible shift parameters;
- characteristics of active fault zones (geometry, shift amplitude and direction by faults, time of last activation).

4.1.3. Within the plant limits it should be necessary to determine:

- characteristics of initial ground vibrations under earthquakes of MCE intensity at surface planning elevations;

- risk of slope landslide movements with account taken of ground conditions and seismic vibrations with intensity of up to the MCE inclusively as well as taking into account the impact of underground waters, tectonic disturbances and modern geodynamic processes;
- possible development of karst (thermocarst), suffosion and karst-suffosion processes and their impacts on the plant safety;
- occurrence of specific (biogenic, subsided, shrink, swelling, saulted, permafrost, eluvial, man-induced) grounds, their thickness and physical-mechanical properties (modulus of deformation, strength characteristics and others) and assessment of their impact on uneven settlement of the plant facilities, reactor department heeling under earthquakes with intensity of up to the MCE inclusively;
- zones of water-saturated loose grounds capable of liquefaction under seismic impacts with intensity of the MCE inclusively;
- impact on the plant safety exerted by increase in ground water level and site underflooding in case of spread of the underground water backup from water basins, filtration of irrigated grounds, water leakages, atmospheric precipitations and snow melting;
- intensity of tornados, maximum values of tornado wall rate of rotation and translational motion, pressure differential between tornado swirl periphery and centre.

4.1.4. For the plant site should be determined: maximum water level and duration of possible flooding in case of precipitations, intense snow melting, high water level in a water body, riverbed blockage by a jam, avalanche and landslide. For a coastal plant site it should be necessary to determine characteristics of possible maximum flooding in case of tsunami or combination of high tide and wind onset.

4.1.5. The safety implications of other processes, phenomena and factors of natural origin (storm, extreme precipitations, air and water temperature, rime, thunderstorms, dust and sand storms, river and water body bank transformation) should be determined for a nuclear power plant site.

4.1.6. For a nuclear power plant site situated on the sea and water body shore it should be necessary to determine probability of occurrence of tsunami (seiche) and maximum tsunami (seiche) wave height, taking into account seismotectonic conditions, shore configuration, landslides and landslips into water bodies.

4.2. Man-induced factors

4.2.1. The survey should be conducted in the plant location area and on the plant site in order to identify sources of potential man-induced risk. The analysis and assessment of the impact exerted on the plant safety by man-induced risk sources should be performed with account taken of their remoteness from the plant. It is allowed not to take into account man-induced risk sources the probability of accidents whereof is lower than 10^{-6} per year.

4.2.2. The facilities characterized by possible accidents involving explosions and fires, releases of dangerously explosive, flammable, toxic and corrosion-active products should be assigned to facilities of man-induced hazard.

4.2.3. The plant safety implications of all possible stationary and mobile sources of emergency explosions including industrial facilities for production, processing, storage and transportation of chemical and explosive materials located at a distance of up to 5 km and for ammunition storages - of up to 10 km from the plant site boundary should be analyzed.

The parameters of the most hazardous emergency explosion impact should be analyzed, and the plant safety should be justified taking into account shock wave and secondary effects of the expected explosion in terms of ground shaking, projectiles and local conditions for gas cloud migration.

4.2.4. The nuclear power plant safety implications of all possible stationary and mobile sources of emergency releases of chemically active products at a distance of up to 5 km from the plant site boundary should be analyzed including those industrial facilities where processing, use, storage and transportation of toxic and corrosion-active products are carried out.

4.2.5. The plant safety implication parameters should be determined as well as the probability of their reaching in case of events caused by:

- explosions and fires, releases of dangerously explosive, flammable, toxic and corrosion-active gases and products at industrial facilities, land and water transport;
- aircraft (planes, helicopters) crashes;
- inundations with a pressure front break of water bodies situated upstream from the nuclear power plant site;
- accidents at water transport and in shore port areas involving explosions and fires, chemically hazardous releases if the nuclear power plant is situated on the sea coast;
- electromagnetic fields;
- external fires (burning of forests, peats, combustible liquids);
- field development of mineral deposits and mines (tunnels, mines, pits);
- water level oscillations in the plant water source.

5. REQUIREMENTS TO TAKING INTO ACCOUNT NUCLEAR POWER PLANT IMPACT ON THE POPULATION AND THE ENVIRONMENT

5.1. In the area of planned protective actions, it should be necessary to investigate aerological, hydrometeorological, hydrogeological and geochemical conditions for radionuclide dispersal, migration and buildup as well as natural radiation background and to predict changes in these conditions for the whole plant operation period.

5.2. The atmospheric dispersion should be assessed taking into account gentle breeze, calm, air temperature, ground and raised inversions, atmospheric stability, precipitations and fog in the plant location area.

5.3. The characteristics of radionuclide migration in surface and underground waters and of radionuclide buildup at the water body bottom should be determined taking into account:

- possible radioactive contamination of drainage and ground waters;
- physical-chemical radionuclide properties;
- kinetics of geochemical reactions and likely change in rock specific mineralogical features;
- lithologic composition and thickness of water-containing and waterproof layers, aeration zone grounds and soils;
- sorptive capacity of rocks, grounds and soils with regard to radionuclides and hazardous chemical substances;
- directions and rate of motion of contaminated flows to discharge areas (water courses, water basins, water intake wells, etc.);

- characteristics and stratification of water-bearing horizons and strata;
- hydraulic connections between underground and surface waters;
- characteristics of water basins, hydraulic facilities, data on water use, water levels and flow rates, river flow velocity and possible mechanism for radionuclide transfer and deposition.

5.4. The radiation situation justification for nuclear power plant normal operation, design and beyond-the-design basis accidents and the development of technical and organizational actions providing the population safety should be performed in the phase of the feasibility study (of the design).

The radiation situation assessment for normal operation of a nuclear power plant should be performed using probabilistic distribution of atmospheric dispersion parameters, characteristic for the plant location area.

The radiation situation assessment for nuclear power plant design and beyond-the-design basis accidents should be performed for the least favourable meteorological conditions characteristic for the nuclear power plant location area.

5.5. The design should justify prevention of radioactive contamination of water body areas, having national economic significance, during normal operation, failures in normal operation and decommissioning of a nuclear power plant, and the measures for protection of the mentioned object against contamination in case of accidents should be provided for.

5.6. The possible radiological impacts of emergency radioactive releases and discharges from nuclear power plants on the population and the environment should be determined taking into account:

- radiation situation assessment results;
- characteristics of water in-take facilities in the observation area;
- characteristics of water bodies intended for fishery, reproduction of fish resources and other biological resources in the observation area;
- data on existing and planned population distribution in the plant location area and on population sites remoteness from the nuclear power plant.

5.7. The boundary of the area of planned protective actions for nuclear power plants and nuclear energotechnological stations should not be moved away by farther than 25 km and for nuclear heating plants - by 5 km from the site boundary.

5.8. In the area of planned protective actions for the whole plant operation period, the institutions should not be located the evacuation (resettlement) of the contingent whereof is difficult or impossible (penitentiary institutions, specialized hospitals and so on).

5.9. Outside the area covered by planned protective actions in case of a beyond-the-design basis accident, temporary restrictions for consumption of particular local agricultural products may be placed.

5.10. In the area of planned actions for obligatory evacuation of the population, the average population density, estimated for the whole plant operation period, should not exceed 100 men/km².

5.11. In the area covered by planned actions for obligatory evacuation of the population, transport communications should be provided for, making it possible to evacuate the population over the period of time meeting the criteria established by the acting radiation safety codes.

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