TECHNICAL CODE OF COMMON PRACTICE

TCP 263-2010 (02300)

CONSIDERATION OF EXTERNAL EFFECTS OF NATURAL AND MAN-CAUSED ORIGIN ON NUCLEAR FACILITIES

УЛІК ВОНКАВЫХ УЗДЗЕЯННЯЎ ПРЫРОДНАГА І ТЭХНАГЕННАГА ПАХОДЖАННЯ НА АБ'ЕКТЫ ВЫКАРЫСТАННЯ АТАМНАЙ ЭНЕРГІІ

The present draft technical code is not enforceable until it is approved

The Ministry of Emergency Situations of the Republic of Belarus

Minsk

UDK MKS KP 01

Key words: external effect, facilities using nuclear energy, processes, phenomena and factors of natural and man-caused origin, classification according to hazard level, location district, location site, hydro-meteorological processes and phenomena, geological and engineered-geological processes and phenomena, man-caused factors, requirements on engineer surveys and research, principles and criteria of stability and safety assurance, requirements on engineer protection, requirements on monitoring and control

Introduction

Objectives, basic principles, provisions on state regulation and management in the field of technical rate setting and standardization are established by the Law of the Republic of Belarus “On technical rate setting and standardization”.

1 DEVELOPED by the State scientific institution “Joint Institute for Power and Nuclear research – Sosny” of NAS of Belarus

INTRODUCED by the National Academy of Science of Belarus

2 APPROVED AND BROUGHT INTO FORCE by the Decree of the Ministry of Emergency Situations of the Republic of Belarus No. 48 as of October 12, 2010.

3 INTRODUCED FOR THE FIRST TIME

Published in Russian

Content

TECHNICAL CODE OF COMMON PRACTICE

CONSIDERATION OF EXTERNAL EFFECTS OF NATURAL AND MAN-CAUSED ORIGIN ON FACILITIES USING NUCLEAR ENERGY

УЛІК ВОНКАВЫХ УЗДЗЕЯННЯЎ ПРЫРОДНАГА І ТЭХНАГЕННАГА ПАХОДЖАННЯ НА АБ'ЕКТЫ ВЫКАРЫСТАННЯ АТАМНАЙ ЭНЕРГІІ

External Natural and Human Induced Events
For The Nuclear Facilities

Date of validity

1 Scope of application

The present technical code of common practice (hereinafter – technical code) establishes requirements on consideration of effects of natural and man-caused origin during arrangement, design, construction, operation and decommissioning (including in case of long-term keeping under observation) of *nuclear facilities* (hereinafter – NF).

The present technical code establishes list of processes, phenomena and factors of natural and man-caused origin which shall be detected during surveys and research in district and NF site and considered during its justification of its stability and safety.

Requirements of the present technical code are obligatory for physical and legal entities performing activity connected with design, construction, commissioning, operation and decommissioning of NF in the whole territory of the Republic of Belarus as well as those performing surveys and research in the district and at the site of NF arrangement.

Requirements of the present technical code are not applicable to the facilities containing or using nuclear materials and radioactive substances in amounts and with activity (and (or) emitting ionizing radiation with intensity or energy) lower than the values established by regulatory legal acts including technical regulatory legal acts, for which a permission is required from the Ministry of Emergency Situations of the Republic of Belarus during performance of activity at this facilities.

NF, where in case of destruction of all protective barriers (e.g. in case of fire at the facility) potential doses of public exposure outside the facility leak-tight enclosures, on the boundary of sanitary-protective zone and outside it will not exceed limits for design accidents established by radiation safety norms, are subjected to general requirements on consideration of external effects of natural and man-caused origin applicable to facilities of industrial and civil purpose.

Requirements of the present technical code are not applied to space- and aircrafts, transport and transportable means, as well as shipment (transportation) of nuclear materials, radioactive substances and radioactive waste.

Requirements of the present technical code shall not be applied to nuclear facilities which are under jurisdiction of the Ministry of Defense of the Republic of Belarus.

Requirements of the present technical code are not applied to NF in case of external effects from intentional (terroristic, sabotage) actions as well as during exceptional period (military activity).

2 Terms and definitions

In the present technical code the following terms with the following definitions are used:

2.1 explosion of drifting clouds: explosion caused by inflammation of gases into atmospheric air formed in a form of clouds which, moving at considerable distance, can preserve concentration within the limits of flammability for long time.

2.2 explosion at facility: explosion occurred beyond the boundaries of NF by various reasons from explosion source and as the result of which may be caused external effect of man-caused origin on NF and its territory.

2.3 external effect: effect, caused by processes, phenomena and factors of natural and man-caused origin which are external in regard to NF.

2.4 effect: physical action (mechanical or impact), made on buildings, structures, systems, elements, personnel of NF, population and environmental objects.

2.5 air shock wave: shock wave, generated by pressure of compressed-expanded air mass, spreading at high speed in atmospheric air.

2.6 breaking wave: wave generated in the result of waterfront outbreak of hydraulic structures or of natural origin.

2.7 emission of explosive, inflammable, toxic fumes, gases and aerosols into atmospheric air: ingress into atmospheric air of contaminating substances in amounts and concentrations which can change composition and properties of considerable volumes of air masses and making harmful effect on human and environmental objects.

2.8 geological and engineering-geologic processes and phenomena: processes and phenomena of natural origin running in upper levels of earth's crust and constituting consequences of impact on earth's crust of energy sources located inside earth's crust (endogenous energy sources) or outside earth's crust (exogeneous energy sources), or from their combined action.

Note – exogeneous energy sources and endogenous energy sources are classified into natural and man-caused ones.

2.9 hydrometeorological processes and phenomena: processes and phenomena running in atmospheric air and surface water and characterizing by parameters of air masses, moisture circulation, thermal condition of atmospheric air hydrologic regime of rivers and other parameters.

2.10 gravitational-slope geotechnogenic processes: processes generated and activated on the slopes during deforestation, undercutting slopes with channels and filtration of water from them, during massive explosions and other man-caused effects which decrease rigidity of rocks and increasing pressure in slopes.

2.11 gravitational-slope endogenous phenomena: phenomena constituting rockfalls, landslides, rubble-block avalanches, mudslides, which occur in high seismicity regions (above 8 degrees) and active neotectonics at high rocky flanks and conduce formation of unstable slopes.

2.12 deterministic approach: design and construction approach on the basis of completely unequivocal data on parameters of effects and properties of the object knowingly to the safety margin with non-exceedance of the controlled parameters limit values established by norms with factors of margin.

2.13 ice dam: accumulation of loose ice material in river bed.

2.14 flooding: formation of free water surface in the territory in the result of floods, storm surge and rising of water level.

2.15 ice jam: accumulation of ice in river bed constraining natural river flow and causing water level rise.

2.16 personnel protection: complex of technical and organizational measures ensuring the set safety level directly taking part in operation of NF.

2.17 protective barriers: barriers constituting a complex of technical means intended for constraint of radioactive substances and ionizing radiation within the measures established by NF design.

2.18 earthquake (of any origin): earth shocks and earth surface wobbles occurring in the result of impulsive displacements and faults in earth's crust.

2.19 electromagnetic impulses: Impulses constituting powerful short-time radiation from sources of electromagnetic field.

2.20 engineering protection of NF from external effects: set of measures, protective means, space planning decisions, organizational and technical measures aimed at assurance of stability and safety of NF, protection of its buildings, structures, systems, components, personnel and prevention of accidents related to emission of radioactive substances into atmospheric air and (or) release of radioactive substances into water bodies or geosphere during external effects of natural and (or) man-caused origin, prevention or mitigation of economic and social damage of NF.

2.21 engineering protection of NF territory: set of measures and means on prevention or mitigation of negative effect of hazardous hydrometeorological, geological and engineered-geological phenomena, processes and factors in the territory of NF.

2.22 karst: the whole of phenomena connected with water (surface and ground) activity and expressed in dissolution of rock and formation in them of voids that are various in size and form, as well as in creation of a special character of circulation and ground water regime and characteristic terrain relief and hydrographic network regime.

2.23 catastrophe (natural and man-caused): catastrophe accompanied by consequences of global and regional scale causing irreparable harm to the environment with many victims, direct economic losses and expenses on elimination of consequences originating in the result of external effects of natural and man-caused origin.

2.24 corrosive liquid effluents into surface and ground water: releases constituting ingress into water bodies of contaminators constituting inflows into water bodies in amounts and concentrations which disrupt the composition and properties of water, making corrosive effect on underground utility system and underground constructions.

2.25 cryogenic-geologic (cryogenic) processes: processes characterized by frost crack formation, frost heaving, occurring in case of periodic freezing and thawing of soils.

2.26 monitoring: system of monitoring over the process (phenomenon, factor) of natural or man-caused origin, state of environment, facility, as well as assessment and prediction of their changes and development.

2.27 flooding: water flooding of area within the river valley and settlements located beyond annually flooded bottom-land occurring in the result of precipitation together with other hydrometeorological phenomena, e.g. repeated heavy rains and snow melting.

2.28 surge: water level rise caused by effect of wind on water surface.

2.29 assurance of NF safety during external effect: complex of engineering-technical and organizational measures on NF intended for prevention of exceedance of permissible limits and conditions of safe operation during external exposure.

2.30 landslides: process constituting movement of rocks (soil) along the slope driven by gravity and load (seismic, filtrational, vibrational, man-caused).

2.31 subsidence and sinks: forms of relief formed in the result of rock failure in domes above karst, thermokarst and worked out cavities, as well as during pumping of water, oil, gas, extraction of potassium salts.

2.32 residual seismic deformations: deformations of earth's crust constituting fissures, stepline subsidences, fold-thrusts, groundwater eruptions, absorbings, earthen waves, formed in the result of passage of seismic waves.

2.33 floods: short-time and fast rise of water level in river with rapid decrease and occurring irregularly.

2.34 fall of air vehicles and other flying objects: factor of man-caused origin characterized by the total of parameters of loads (mechanical, fire, temperature) on the territory of NF, buildings, structures, systems, elements of NF, occurred in the result of fall of aircraft or its wreckage on them in case of air crash, as well as flying objects (in a form of fragments of building structures, constructions and transportation vehicles), moved under effect of excessive pressure during explosion, wind, hurricane and tornado.

2.35 fire caused by external factors: fire occurred beyond NF in the result of various reasons and which can lead to external man-caused impact on NF and its territory.

2.36 seasonal flood: phase of water regime with annually repeated in the same season long-time rise of water content of the river causing smooth rise of water level.

2.37 radiation accident consequences: consequences (radiation situation), occurred in the result of radiation accident at NF.

2.38 natural effect: effect caused by external in relation to NF processes, phenomena, and factors of natural origin.

2.39 design basis: the whole of initial data on required parameters and technical characteristics of NF, its systems, elements, buildings, structures, including data on their operation, parameters of man-caused regimes and postulated external events necessary for designing NF, manufacturing its equipment, systems and devices, their installation and adjustment, construction of NF, ensuring its normal operation during the established operational period, as well as decommissioning.

2.40 system operability: property of a system to perform set functions during the established period of time prescribed in operational limits and conditions.

2.41 soil liquefaction: process in the result of which loss of strength and rigidity of water-saturated soils occurs during dynamic effects (earthquakes, explosions, vibrations).

2.42 stream-bank erosion, slope wash, riverbed erosion: processes of deformation from erosion, abrasion of shores of lakes, reservoirs, rivers in surf zone with formation of bench and littoral shelf as well as erosion, displacement and redeposit of rocks and soils on slopes and in beds of rivers and gullies under the effect of surface flows.

2.43 safe (considered) distance: distance from source of hazard to NF, beyond the measures of which potential external effects of natural and man-caused origin on it may be neglected.

2.44 risk: combination of possibility of damaging and severity of this damage in a form of negative consequences (destruction, damage of building, structure, system, element, violation of NF operation, accident at NF and related to them hazards of damaging life and health of human and (or) harm to the environment) during external effects of natural and man-caused origin.

2.45 seismic isolation of structure (building): complex of engineer constructions arranged, as a rule, in foundation of structures and ensuring decrease of vibrations of isolated structure in relation to seismic vibrations of basement soils, as well as elements and systems ensuring regulation (shift) of values of natural frequencies of structure vibrations into the desired field.

2.46 seiche: fluctuations of water levels of enclosed or semi-closed water body under the effect of disturbing force of atmospheric or seismic origin.

2.47 tornado: strong small-scale atmospheric vortex having great destruction power (diameter up to 1000 m), in which air rotates with a great speed (up to 100 m/s), which occurs in thunder cloud and spreading downwards often to the very land surface, in a form of dark cloudy sleeve or arm with the diameter of dozens or hundreds of meters; exists not long, moving together with a cloud; consists of fast-rotating air, particles of moisture, sand, dust and other suspended matter;

distinguished by high speed of wind in tornado funnel, decrease of atmospheric pressure in its centre and shock effects from flying objects risen by wind.

2.48 current differentiated movements of earth's crust: movements of earth's crust constituting relative displacement of crustal blocks including tectonic creep.

2.49 solifluction: slow movement of wet finely-dispersed or dusty soils (with a rate of 3 – 8 cm per year) down the slopes in the result of numerous soil expansions during freezing and subsidence during thawing, as well as gravity; each cycle "freezing – thawing" leads to displacement of upper stratum of loose soils deposits.

2.50 support to NF operation: monitoring and performance of compensating measures on assurance of stability and safety of NF during external effects.

2.51 specific soils: soils which properties and characteristics change with time in terms commensurable with the term of facility operation, they contain multiyear-frozen, subsiding, dilative, loose, saline, eluvial, artificial soils.

2.52 resistance of system (element) during external effects: ability of system (element) to maintain indexes of performance of its functions and values of parameters of system (element) during the established period in the conditions of normal operation and during external effects of natural and (or) man-caused origin (seismic resistance, vibration resistance, corrosion resistance, etc.) within the limits determined by norms and (or) technical specification on designing and operation of systems (elements).

2.53 suffosion processes: processes of softening of loose soils by ground water with carrying out of fine fractions or whole soil mass, at that, suffosion cavities are formed along with sinks and subsidence of earth surface above them.

2.54 scenario of state of facility or complicated technical system: logical sequence of interrelated states of facility or complicated technical system possible during effects of natural and (or) man-caused origin included into design basis of NF.

2.55 tectonic creep: process characterized by slow relative displacements of crustal blocks along tectonic-active faults and fissures.

2.56 thermokarst: processes of melt-out of ice formations enclosed in frozen rocks or thawing of heavily icy disperse rocks in the result of which sinks and subsidence are formed.

2.57 man-caused effect: effect caused by human activity directly or as a result of his use of equipment and technology.

2.58 lightning stroke: natural phenomenon characterized by effect on the environment of electric charge occurred between clouds or between clouds and ground surface.

2.59 hurricane: wind of destructive force (12 points and higher according to the Beaufort scale) of significant duration and speed of 35 m/s and more.

2.60 stability of NF during external effects: property of facility characterized by resistance of buildings, structures, systems and elements of NF important for safety, its protective barriers and safety of facility for personnel, population and environment during any types of external effects.

2.61 record-keeping of external effects: activity of assurance of stability and safety of NF during external effects at all stages of its service life related to its arrangement, design, operation and decommissioning with consideration of external effects at NF site, results of which are reflected in design-and-engineering decisions and organizational and technical measures.

2.62 electromagnetic radiation: process of formation of free electromagnetic field.

2.63 nuclear facilities: facilities constituting nuclear facilities, radiation sources, storage points for nuclear materials and radioactive substances, storage facilities of radioactive waste, fuel

assemblies of nuclear reactor, exposed fuel assemblies of nuclear reactor, nuclear materials, radioactive substances, radioactive waste.

3 Symbols and abbreviations

In the present technical code used are the following symbols and abbreviations:

ASW – air shock wave;

MDE – maximum design earthquake;

MPF – maximum possible flood;

MSK-64 – international scale of earthquake intensities;

RLA – regulatory legal act;

DBE – design basis earthquake;

TRLA – technical regulatory legal act;

NF– nuclear facilities.

4 General provisions

4.1 The present technical code establishes:

- list of processes, phenomena and factors of natural and man-caused origin, classification according to their level of hazard;

- requirements on engineering investigations and examination of processes, phenomena and factors of natural and man-caused origin;

- classes of NF sites according to the level of hazard of processes, phenomena and factors of natural and man-caused origin;

- principles of assurance of stability and safety of NF during external effects;

- requirements on engineering protection of NF territory;

- requirements on record-keeping of external effects during arrangement, designing, construction, operation and decommissioning of NF;

- requirements on protection of NF from external effects including protection of its systems, elements and personnel directly participating in NF management;

- requirements on control of stability of NF during external effects;

- requirements on monitoring processes, phenomena and factors of natural and man-caused origin.

4.2 Requirements of the present technical code are applied to NF at which the following is performed:

- production of radionuclide radiation sources;

- nuclear energy use for energy supply (electric and (or) thermal) or research;

- use of radioactive substances for scientific, medical and other purposes (control at customs, informing about changes of environmental state, occurrence of fire, etc.);

- storage of nuclear fuel, nuclear materials and radioactive substances;

- storage and disposal of radioactive waste.

4.3 Necessity and terms of performance of works on bringing into line with the requirements of the present technical code of NF, construction of which was started before enforcement of the

present technical code, are determined in each specific case under the established procedure. Corresponding substantiations shall be presented in the report on justification of NF safety.

5 List of processes, phenomena and factors of natural and man-caused origin

5.1 Established is the following list of processes, phenomena and factors of natural and man-caused origin which shall be studied in the district or at the NF site:

5.1.1 Hydrometeorological processes and phenomena:

- flood;
- ice phenomena in water flows (jams, dams);
- seiche;
- change of water sources: extremely low flowoff, extraordinary decrease of water level;
- tornado;
- wind, hurricane;
- precipitation;
- extreme snowfalls and snow accumulation;
- air temperature;
- glaze ice;
- lightning stroke.

5.1.2 Geological and engineering-geological processes and phenomena:

- seismotectonic fault displacements, seismic dislocations, seismotectonic raising, foundering of earth’s crust blocks;
- current differentiated movements of earth’s crust, tectonic creep;
- residual seismic deformations of earth’s crust;
- earthquake (of any genesis);
- landslides;
- rockfalls and landslide-collapse;
- mudflow;
- erosion of banks, slopes, riverbeds;
- subsidence and sinks;
- underground erosion including karst symptoms;
- cryogenic-geological (cryogenic) processes;
- deformation of specific soils (karst, thermokarst, liquefaction, solifluction, suffosion processes).

5.1.3 Factors creating external effects of man-caused origin (man-caused factors):

- fall of aircrafts and other flying objects;
- fire caused by external reasons;
- explosion at a facility;
- releases of explosive, flammable, toxic fumes, gases and aerosols into atmospheric air, explosion of drifting clouds;

- corrosive liquid effluents into surface and ground water;

- electromagnetic radiation;

- spillage of oil and oil products at littoral surfaces of rivers;

- break of natural or artificial reservoirs.

6 Classification of processes, phenomena and factors of natural and man-caused origin

6.1 Three levels of hazard of processes, phenomena and factors of natural and man-caused origin according to consequences of effect on the environment are established:

Level 1 – highly hazardous process (phenomenon, factor) characterized by maximum possible for the given process type values of parameters and characteristics within the set time period and accompanied by natural and (or) man-caused catastrophes;

Level 2 – hazardous process (phenomenon, factor) characterized by quite high (but not more than known maximum value for the given type of process) values of parameters and characteristics within the set time period and accompanied by consequences tangible for the environment;

Level 3 – non-hazardous process (phenomenon, factor) characterized by low values of parameters and characteristics within the set time period and not accompanied by consequences tangible for the environment.

6.2 Hazard of processes, phenomena and factors of natural and man-caused origin detected in the district or at NF site shall be defined on the basis of maximum calculated values of their parameters of effects (intensity and frequency) with use of limit values of parameters presented in Appendix A.

6.3 Maximum value of parameters of hydrometeorological, geological and engineer-geological processes and phenomena shall be determined for the time period equal to 10,000 years.

Design basis shall consider man-caused factors which occurrence frequency is equal to or more than 10^{-6} 1/year. During calculation of occurrence frequency of man-caused factor, values of its maximum estimated intensity and other parameters of effects, analyzed shall be data on violations of operation of facilities with sources of man-caused effects generalized for multiannual period for the examined district or NF site.

According to the results of the analysis, determined shall be parameters of potential man-caused effect occurred in case of violations of operation of facilities with sources of man-caused effects with consideration of remoteness of hazard sources from NF.

Values of maximum estimated parameters of processes, phenomena and factors of natural and man-caused origin shall be determined with confidence coefficient of non-exceedance of their average mathematic value (expected value) equal to 0.95.

6.4 For specific local conditions while defining levels of hazard of processes, phenomena and factors of natural and man-caused origin, possibility of accompanying them by other interrelated and interdependent processes (phenomena and (or) factors) shall be taken into account. Parameters of these processes, phenomena and factors shall also be determined and classified according to the level of their hazard in accordance with the requirements 6.3 and 6.3 considering data of the list of interrelated and interdependent processes of natural origin presented in Appendix B.

For processes and factors of man-caused, natural-man-caused and man-caused-natural origin scenarios of their occurrence shall be developed in order to define their interdependence and interaction.

6.5 NF sites shall be classified in accordance with the level of hazard of the processes, phenomena and factors occurring at them. Three classes of sites are established:

- class A – site at which there are no external effects of I and II levels of hazard;

- class B – site at which there are no external effects of I level of hazard;

- class C – site at which there are external effects of I, II and III levels of hazard.

6.6 Design basis of NF shall include values of maximum estimated intensities of external effects from processes, phenomena and factors of natural and man-caused origin possible at NF site, as well as values of other necessary parameters of external effects, including the observed data in a multiannual section about condition of atmospheric air (inversions, fogs, dust storms) in a district and at NF site, geohydrological characteristics of soils and data about aquifers in district and at NF site, detected in the result of investigations and examination.

7 Requirements for engineering investigations and examination of processes, phenomena and factors of man-caused origin

7.1 For detection and identification of processes, phenomena and factors of natural and man-caused origin, investigations and examinations shall be performed on the basis of complete and accurate information including data from sources list of which is presented n Appendix C.

7.2 Program of engineering investigations and examinations in district and at NF site shall be developed with consideration of specific features of NF. These specific features include among others level of potential radiation hazard of the facility for personnel, population and the environment, planning and conditions of NF arrangement, period of its operational lifetime, possibility of storage of spent nuclear fuel, nuclear materials and radioactive substances, storage and disposal of radioactive waste at NF site.

7.3 NF site and district shall be studied for detection at NF site of hazardous processes, phenomena and factors of natural and man-caused origin from a number of those specified in the list (section 6), assessments of possibility of their interrelation, prediction of evolution and determination of values of maximum estimated parameters.

Examinations shall be performed for the types of processes, phenomena and factors of natural and man-caused origin in the territory around NF sites with radiuses determined in accordance with the requirements of RLA, including TRLA.

List of basic parameters for description of processes, phenomena and factors of natural and man-caused origin shall be sufficient for consideration of their possible effect on NF and its territory. Recommended list of basic parameters for description of processes, phenomena and factors of natural and man-caused origin is presented in Appendix D.

7.4 Sources of man-caused hazard shall be determined at NF site district with consideration of specific conditions of the existing as well as potential development of territory adjacent to the site.

7.5 Results of consideration and determination of hazard of processes, phenomena and factors of man-caused origin detected in a district or at NF site shall be presented in a report on justification of NF safety.

7.6 Methods of engineering investigations and examinations of processes, phenomena and factors of natural and man-caused origin shall be reliable for detection of interrelation of processes and mechanisms of effect on the environment and NF (their systems and elements), as well as obtainment of complete and accurate information for determination of maximum estimated values of parameters of external effects.

8 Principles and criteria for assurance of stability and safety of nuclear facilities during external effects

8.1 For assurance of NF safety, its stability during external effects shall be guaranteed. NF shall be arranged, designed, constructed, operated and decommissioned with consideration of external

effects possible at its site. Systems and elements of NF important for safety shall be resistant to external effects from processes, phenomena and factors of natural and man-caused origin which may characterize NF site.

8.2 During external effects on NF, the following shall be done:

- prevent inadmissible in terms of performance of safety functions failures of violations of systems and elements, buildings and structures important for safety;

- exclude influence of external effects on rise of values of occurrence frequencies of design basis accidents and severity of their consequences estimated from initial events of internal origin;

- preserve envisaged protective barriers, preventing emissions and releases of radioactive substances in the environment or limiting their amounts and (or) their activity during long time after an accident within the limits admissible in RLA including TRLA.

8.3 NF safety during external effects is reached also by:

- selection of place for NF arrangement complying with the criteria and requirements of safety established in RLA including TRLA;

- designing of NF resistant to external effects possible at their site;

- maintenance of NF operation (organization of observations of evolution of hazardous processes and reaction of important-to-safety systems on them, performance of compensating measures; assurance of possibility of safe shutdown at NF in case of exceedance of the established in design basis maximum level of intensity of external effects or other lower level established in design; performance of technical measures on protection of personnel directly participating in NF management against negative consequences of external effects);

- provision of conditions for realization of plans of emergency preparedness including evacuation of workers and population from the area of accident if it is caused by external effects.

9 Requirements on engineering protection of nuclear facilities

9.1 Prior to beginning of NF construction or in the process of its reconstruction at NF site classified of category B or C, engineering protection of NF territory shall be performed for prevention or minimization of negative consequences on NF site from processes, phenomena and factors of natural and man-caused origin with consideration of scenarios of processes evolution, their interrelation and interdependence.

9.2 Engineering protection of NF territory shall be performed in accordance with the requirements of RLA including TRLA. In case of absence of norms and rules on engineering protection of territory, the proposed definite technical decisions shall be justified and established by the developer upon agreement with the bodies of state regulation of safety under the established procedure.

9.3 Compatibility and efficiency of mutual functioning of protective means envisaged for engineer protection of NF territory from various external effects shall be ensured. List of recommended technical measures according to engineer protection of NF territory from external effects is presented in Appendix E.

9.4 If NF is arranged at site of B and C class, evacuation ways of workers and population shall be analyzed and protected (if necessary) in order to exclude occurrence of temporal obstacles (landslides, avalanches, floods, faults, etc.).

9.5 During selection of NF site to exclude necessity of performing measures on protection of territories as well as in purposes of risks reduction of negative consequences from external effects, preference shall be given to the site with lower level of intensity of external effects (sites of class A or B).

10 Requirements on consideration of external effects during arrangement, designing, operation and decommissioning of nuclear facilities

10.1 During NF arrangement, adequacy of its site shall be evaluated considering class of the site in accordance with 6.5 and results of analyses of NF safety performed at the stage during external effects.

10.2 NF designing shall be performed with consideration of external effects which are accepted in design basis.

For each type of external effect accepted in design basis, a list of buildings, structures, systems, elements of NF subject to analysis of resistance to this external effect shall be established.

During establishment of lists of buildings, structures, systems, elements, analysis of scenarios of realization of external effects and their consequences for NF shall be performed with use of logical scheme of NF safety analysis against external effects presented in Appendix F.

List shall contain buildings, structures, systems, elements which can be influenced by the given external effect out from the number of buildings, structures, systems, elements of NF important to safety as well as others which do not relate to safety-important, but their destruction, damage or failures during external effects may influence NF safety.

During determination of lists of buildings, structures, systems, elements subject to analysis of resistance to the external effects accepted in design basis, all probable interrelated and interdependent events shall be considered as initial events (e.g. earthquake) and secondary effects of external effects impact on NF (e.g. landsliding, break of dam, soil subsidence, building tilt and yield of building foundation, floor collapse, pipe break, flying streams, flying items, fire, etc.).

10.3 Assessments of stability of buildings, structures, systems, elements of NF included in lists and subject to analysis of resistance to external effects, shall be performed in relation to each type of external effects accepted in design basis.

For each building, structure, system, element, determined shall be design criteria of resistance during loads from external effects, including loads from secondary effects selected in design bases considering norms and criteria (strength, vibrating strength, seismic resistance and stability), established in RLA, including TRLA, or obtained in the result of experimental justifications, as well as specific features of construction and planning decisions, operation experience.

10.4 During resistance analysis of building, structure, system, element of NF, non-exceedance of design resistance criteria shall be ensured according to the following parameters:

- deformations, displacements and deflections;
- tilt and yield of foundation of buildings and structures;
- reliability of fastening joints, equipment and elements;
- thermal and corrosive resistance of materials;
- strength and durability;
- tightness and impermeability (gas- and и fume tightness) of internal cavities of objects;
- operability of structures, systems and elements;
- limits of fire-resistance of building structures.

10.5 Design of NF with consideration of external effects shall be performed on the basis of deterministic approach. For assessments of resistance of buildings, structures, systems, elements during external effects, applied shall be deterministic values of parameters of maximum estimate effects from processes, phenomena and factors of natural and man-caused origin and deterministic

values of parameters of the objects themselves (properties and characteristics of foundation soils, materials of building structures, equipment, systems, elements, bearing elements).

10.6 For assessment of strength, resistance and stability during external effects accepted in design bases, for each building, structure, system, element of NF, the basic and potential specific combinations of loads shall be established. The basic combination of loads shall consist of loads of normal operation (permanent, temporal). Specific combinations of loads shall consist of basic combination of loads and one of the loads from external effects (long acting or short-term). Number of combinations shall be determined being equal to the number of types of external effects accepted in design basis of analyzed building, structure, system, element of NF.

Loads from violations of normal operation, as well as from design basis accidents with loads from specific external effects are not acceptable to combine for buildings, structures, systems and elements of NF not related to nuclear facilities.

10.7 For assessment of resistance to external effects, accepted in design basis, of buildings, structures, systems, elements of NF, applied shall be methods of analysis, methods of estimation, initial data and software tools, accuracy of which is justified.

10.8 At low levels of maximum possible parameters of intensity of external effects (hazard level 3), accepted in design basis for each newly designed NF, potential hazard of which during accident may lead to man-caused catastrophe of global or regional scale, the following shall be ensured:

- seismic resistance during acceleration at a mark of free-form surface not less than 0.1 from the acceleration rate of free fall;

- resistance to ASW loads with pressure in a front being not less than 10 kPa, time of compression phase up to 1 s;

- fire-resistance of important-to-safety buildings and structures constructions to fires caused by external reasons of not less than 1.5 h of standard fire;

- resistance of protective constructions of localizing systems to localized impact load from fall of aircrafts and other flying objects, equal in contact zone to impact load not less than one occurred during fall of light airplane (5.7 t);

- spatial physical separation of safety systems and their channels.

10.9 Protection from potential impact on NF of objects constituting potential hazard (radiation, from ASW impact, fire hazard, hazard from electromagnetic radiation, from corrosive emissions and releases, emissions of toxic gases and aerosols, etc.) is ensured at the stage of arrangement by moving NF away from these objects and observance of safe distances. Safe distances are determined on the basis of the performed safety analyses in accordance with RLA provisions, including TRLA. Technical substantiation of refusal from offset distancing of objects which constitute potential hazard for NF, and proposed technical decisions on protection from their impact are agreed by developer with state bodies on safety regulation under the established procedure.

10.10 Failure to perform measures on exclusion of damages from external effects to important-to-safety buildings and structures of operated NF shall be substantiated by justification that:

- inadmissible failures and damages of important-to-safety systems and elements are excluded;

- values of frequency of design basis accidents and severity of their consequences estimated in the result of probabilistic safety analyses of NF from external effects do not change significantly compared to the results of probabilistic safety analyses of NF from initial events of internal origin leading to design basis accidents; they are acceptable;

- frequency of beyond-design basis accidents caused by external effects of natural and man-caused origin is quite small (less than 10^{-6} 1/year) or value of frequency of maximum accident

release (emission) into the environment during beyond-design basis accidents caused by external effects of natural and man-caused origin, less than 10^{-7} 1/year.

10.11 Selection of measures on engineering protection of NF shall be substantiated from the point of view of reliability, efficiency and sufficiency via one or two methods:

- calculation;

- previous experience of operation of protective measures prototypes;

- testing of buildings, structures, systems, elements or their models adequately reflecting specifics of actual construction and its characteristics;

- compliance with recommendations of safety guidelines;

- science and technology achievements.

The list of recommended measures on engineering protection of NF from external effects is presented in Appendix E.

10.12 Envisaged in NF design measures on protection against external effects of systems and elements important to safety shall be sufficient for safety assurance at the stages of operation and decommissioning of NF as well as long-term decay storage under supervision.

10.13 For safety assurance at the stage of NF commissioning, dynamic characteristics shall be studied (attenuation and natural frequencies) for systems and elements (except for buildings and structures) important to safety, via the method of experimental investigations or their dynamic tests in accordance with the procedure, methodology, scope of investigation established in the project.

For operated NF, dynamic characteristics of safety-important systems and elements shall be determined by calculation, and then approved by investigation of examination during operation at the NF which are shut down and brought into safe condition (e.g. within the period of scheduled shutdown of NF).

Data on clarified dynamic characteristics of components (systems, elements) of NF shall be used during performance of analyses of NF safety, and also be reflected in corresponding safety substantiation reports.

10.14 Personnel directly involved in operation of NF arranged in area characterized by site high seismicity (at MDE of 7 points and more) or other processes, phenomena and factors related to the hazard level 1 and determined by dynamic impacts of mechanical character (explosion, fall of flying objects) shall have protection excluding negative impact of external effects. Necessity of protection of personnel directly involved in NF operation, which excludes negative effect on personnel of external effects, shall be established on the basis of analysis of potential final consequences of external effects on these personnel and various values of possible loads. Protection of personnel directly involved in NF operation is required in cases, when it is defined that loads on personnel can exceed values of safe loads levels. The recommended levels of safe loads on personnel are presented in Appendix G.

Sufficiency and reliability of protection of personnel directly involved in NF management, from external effects shall be substantiated in the project.

The list of recommended means of collective and (or) individual protection of personnel from external effects (and their consequences) is presented in Appendix I.

10.15 Probabilistic analyses of NF safety during external effects intended for obtainment of risk assessments of accidents at NF shall be performed. Risk assessments of negative consequences of accidents at NF during external effects shall be considered during assurance of NF stability and safety at the stage of designing and operation.

10.16 During development of emergency preparedness plans, the results of risk assessments of accidents at NF during external effects shall be considered.

10.17 Operational documentation shall regulate behavior of operator of nuclear facility, as well as actions of other NF personnel directly involved in NF operation during external effects in case of occurrence of hazard of external effects.

10.18 For NF in a form of nuclear facilities, considering their high potential nuclear and radiation hazard, in design basis of which external effects of natural and man-caused origin of stage 1 of hazard are accepted with dynamic character of their realization, complementary systems of automated registration of these external effects and automated shutdown of nuclear facilities shall be envisaged in projects.

Systems of automated shutdown of nuclear facilities shall perform their set functions in cases if exceeded are reference levels of external effects intensities for setting levels of detectors (indicators) of external effects recording.

10.19 NF shall be shut down automatically or in manual mode after external effect of natural or man-caused origin with dynamic character of realization (earthquake, external explosion and fall of aircraft) occurred at the site in cases, when reference levels of external effects intensities established in design set with sufficient conservatism are exceeded. Quantitative parameters values accepted as reference levels shall be substantiated in the project and presented in reports on NF safety substantiation.

10.20 It is necessary to perform investigations and analysis of conditions of buildings, structures, systems, elements of NF for assessment of possibility of its further safe operation if at the site of NF operation a process, phenomenon or factor of natural or man-caused origin with dynamic character and intensity of hazard level 1 and 2 occurred.

10.21 During operation and at the stage of decommissioning of NF (as well as in case of long-term decay storage under supervision), monitoring over NF stability during external effects shall be performed by:

- observation of state of soil basements of buildings and structures important to safety;

- assessment, analysis and prediction of technical state of buildings, constructions, assemblies of building structures important to safety, including assessments, analyses and predictions of tilts and yield of foundations of these buildings;

- analysis of condition of protective barriers and prediction of their reliability according to the results of inspection and technical certification;

- periodic inspections of state and testing of protective means (seismic isolation, damping devices, etc.), fire protection system, bunding of NF territory;

- control over operability of measuring, registering and transferring apparatus used in systems of warning and protection from external effects;

- control of presence and adequacy of individual and collective protection equipment of NF personnel.

10.22 At NF, databases on parameters of processes, phenomena and factors of natural and man-caused origin at NF site and district shall be created.

The recommended forms of maintenance of data bases on processes, phenomena and factors of natural and man-caused origin are presented n the Appendix K.

10.23 If in the result of observation during NF operation changes in design parameters of external effects accepted in design basis are detected, then consequences of impact of these changes on NF stability and safety shall be assessed. When necessary, additional measures on engineer protection of NF and (or) its territory shall be performed.

10.24 Protection from external effects of important-to-safety buildings, structures, systems, elements shall be ensured up until then nuclear material and radioactive waste are present at NF and while NF is a source of radiation hazard.

10.25 During long-term decay storage under supervision of NF containing nuclear materials, radioactive substances and radioactive waste, the resistance of important-to-safety structures shall be assured, including their long-term strength with consideration of external effects accepted in design basis during the whole supervision period established in the design.

10.26 Project on NF decommissioning shall envisage measures on assurance of stability of building structures during external effects at the stages of performing decommissioning works.

11 Requirements on monitoring of parameters of processes and phenomena of natural origin and periodic control of parameters of factors of man-caused origin

11.1 In NF district and at the site, monitoring of parameters of processes and phenomena of natural origin included in design basis shall be provided, as well as periodic control of parameters of factors of man- caused origin included in design basis at all stages of life cycle of NF.

11.2 If at NF site processes and phenomena of natural origin of I and II hazard levels are possible, monitoring systems for assessment of their parameters shall be realized and function until NF commissioning.

11.3 Monitoring systems shall perform their functions in accordance with requirements of the project at all stages of NF life cycle.

11.4 Technical means for monitoring and periodic control of parameters of processes and factors shall be inspected. Frequency of inspections shall be established in design documentation of monitoring and periodic control systems and be sufficient for assurance of their failure-free operation during the period between inspections.

11.5 Systems of monitoring parameters of processes and phenomena of natural origin shall be integrated into unified national systems of monitoring available in the territory of the Republic of Belarus in district of NF site.

Appendix A
(compulsory)

Hazard levels according to consequences of environmental effects of natural and man-caused processes, phenomena and factors

Table A.1

Process, phenomena and factor	Possible effects on a site of nuclear and radiation hazardous facility	Limits of parameters according to which hazard levels are classified	Hazard level according to environmental effect consequences
1	2	3	4
1. Hydrometeorological processes and phenomena			
Flooding	Flooding of NF site. Hydrochemical and dynamic effects on buildings, constructions and networks	Flood level ≥ 1 m, water flow rate ≥ 0.7 m/s	I
		Flood level < 1 m but > 0.2 m; water flow rate < 0.7 m/s	II
	Underflooding of NF site	Flood level ≤ 0.2 м	III
Ice phenomena on water flows (jams, dams)	Flooding of NF site. dynamic effects in case of break wave	Territory flooding ≥ 1 m. Dynamic effects parameters estimated by calculation	I
	Flooding of NF site, dynamic effects in case of break wave, (plugging of water inlet devices and water pipelines NF by means of sludge surge – ice chips)	Flood level < 1 m but > 0.2 m. Dynamic effects parameters estimated by calculation	II
		Territory flooding ≤ 0.2 м	III
Seiches	Flooding of NF site.	Territory flooding to the depth of ≥ 1 m	I
		Flood depth < 1 m but < 0.2 m.	II
		Flood depth ≤ 0.2 m	III
Change of water resources: extremely low flowoff, anomalistic drawdown	Drawdown in surface technical water supply sources of NF	Dewatering depth > 0.2 m	II
		Dewatering depth ≤ 0.2 m	III
Tornado	Wind pressure to buildings and constructions. Loads due to pressure difference between periphery and funnel rotation centre. Loads due to flying objects caught by tornado. Outflow of water from process cooling ponds	Maximum horizontal rate of rotational motion of tornado wall: ≥ 50 m/s; pressure difference ≥ 3 kPa, tornado intensity class F2 and higher; track length ≥ 15 km, track width ≥ 50 m. Dynamic loads from flying objects and water ponds dewatering depth estimated by calculation	I
		Maximum horizontal rate of rotational motion of tornado wall < 50 m/s but > 7 m/s; pressure difference < 3 kPa, tornado intensity class F1, track length <15 km but > 1.6 km, track width < 50 m but > 16 m. Dynamic loads from flying objects and water ponds dewatering depth estimated by calculation	II
		Maximum horizontal rate of rotational motion of tornado wall ≤ 7 m/s; pressure difference < 1 kPa, tornado intensity class F0 and less, track length ≤ 1,6 km, track width ≤ 16 m.	III

1	2	3	4
		Dynamic loads from flying objects and water ponds dewatering depth estimated by calculation	
Wind, hurricane	Wind pressure. Flying objects	Wind speed ≥ 35 m/s. Dynamic loads due to flying objects estimated by calculation.	I
		Wind speed < 35 m/s but ≥ 7 m/s. Dynamic loads due to flying objects estimated by calculation.	II
		Wind speed < 7 m/s	III
Precipitation	Flooding of arrangement site	Precipitation depth ≥ 50 mm during 12 h (in mudflow dangerous districts – 30 mm and more during 12 h and less)	I
		Precipitation depth < 50 mm but > 30 mm during 12 h and less)	II
		Precipitation depth < 30 mm during 12 h and less	III
Extreme snowfalls	Accumulation of snow of access roads, sites, communication lines etc	Precipitation depth ≥ 20 mm /y during 12 h and less	II
Extreme snow storages	Snow loads on roof of buildings and constructions	Layer depth estimated by calculation	II
Air temperature	Temperature loads on buildings, constructions, networks etc.	Maximum values of positive and negative temperatures, their differences and temperature gradients estimated by calculation	II
Glaze ice	Destruction of towers of communication lines and power supply, communication and power supply systems failure due to their covering with ice, rime	Glaze ice wall thickness > 25 mm	I
	Heaving of building constructions as a result of their covering with ice, rime	Glaze ice wall thickness > 3 mm	II
		Glaze ice wall thickness ≤ 3 mm	III
Lightning strike	Effect of electric discharge on building, construction, network, equipment	Estimated by calculation with consideration of thunderous hazard of a district and field intensity	II
2. Geological and engineering-geological processes and phenomena			
Seismotectonic fault displacement, seismic dislocation, seismotectonic highs, lowering of crustal blocks	Fast faults and other breaks of Earth's crust, accompanied with intense motions (magnitude 8 according to MSK-64)	Fault pulse displacement with the amplitude of ≥ 0.3 m	I
Current differential ground motions, tectonic creep	Slow fault and infolding shifts accompanied with rock deformation and shifts along the faults	Shifts along the fault ≥ 0.3 m. Geodynamic zones with quaternary movements velocity gradient ≥ 10^{-6} m/y	I
		Shifts along the fault < 0.3 m. Geodynamic zones with quaternary movements velocity gradient from 10^{-9} to 10^{-6} m/y	II
		Territories with quaternary movements velocity gradient < 10^{-9} m/y	III
Residual seismic deformations of Earth's crust:			
In zones of tectonic violations with width >10 m, in case of 7-9 point earthquakes	Deformations. Fissures in foundations	Displacements with the amplitude ≥ 0.3m	I

1	2	3	4
watered soils	Fissures Subsidence Deformation of foundations	Displacements with the amplitude ≥ 0.1m	I
in zones of tectonic violations with suspended tectonic movements	Uneven rainfall because of heterogeneity of rocks in foundations of constructions transversing the zone	Ledges in foundations < 0.3 m but > 0,1 м. Displacements with the amplitude < 0.3 m but ≥ 0.1 m.	II
on gradient slopes and changed sections in case of 7-9 point earthquakes	Fissures Subsidence Deformation of foundations	Displacements with the amplitude < 0.3 m but ≥ 0,1 m	II
In zones of tectonic violations, on slopes and low sites in thawed soil in case of concussions of 4-6 points from powerful explosions and earthquakes	Deformation of foundations	Displacements with the amplitude < 0.3 m but > 0.1 m	II
	Fissures Subsidence Deformation of foundations	Displacements with the amplitude < 0.3 m but ≥ 0,1 м	III
Earthquakes (of any genesis)	Vibrations of structures. Deformation of foundations. Subsidence. Change of ground water hydrological regimes	Intensity of MDE level according to MSK-64 scale > 8 баллов	I
		Intensity of MDE level according to MSK-64 scale = 5-8 баллам	II
		Intensity of MDE level according to MSK-64 scale 64 < 5 баллов	III
The landslides, rockfalls and landslides-rockfalls which are moving and suspended			
with covering depth > 5m	Displacement of foundation soils	Displacing mass area ≥ 10000 m^2	I
with covering depth < 5m		Displacing mass area < 10000 m^2	II
Erosion of coasts, slopes, courses	On NF site: damages and fissures, subsidence, sinks of foundations	Movements of line of a cut and abrasion ledge crest ≥ 1 m/y	I
		Movements of line of a cut and abrasion ledge crest < 1 but ≥ 0.1 m/y	II
		Movements of line of a cut and abrasion ledge crest < 0.1 m/y	III
Territory subsidences, sinks, subsoil washaway, including karst symptoms	On NF site: subsidences, sinks	1 sink or more in the area less or equal to 10 km^2	I
		1 sink or more in the area of 100 km^2	II
Cryogenic-geological (cryogenic) processes	Deformation of foundations	For design bases, the maximum possible values are accepted, determined by calculation for specific site conditions	II
Deformations of specific	Deformation of foundations	For design bases, the maximum possible values are accepted, determined by calculation for	II

1	2	3	4
soils (thermokarst, liquefaction, solifluction, suffosion processes)		specific site conditions	
3. The factors creating external effects of man-caused origin (man-caused factors)			
Falling of the aircraft and other flying objects	Blow, spill of fuel, fuel ignition, fire	Possible aircraft weight > 20 t	I
		Possible aircraft weight ≥ 5 t but ≤ 20 t	II
		Possible aircraft weight < 5 t	III
Fire because of external reasons	Dangerous factors of fire (smoke, ambient temperature increase, toxic products, burning of thermal decomposition, lowered concentration of oxygen)	Equivalent surface area engulfed in fire ≥ 10 km^2, inventories of combustible materials provides NF burning and effect on NF > 2 h	I
		Equivalent surface area engulfed in fire ≥ 10 km^2, inventories of combustible materials provides burning and effect on NF ≤ 2 h	II
Explosion at the facility	ASW, flying objects, smoke, gas, dust, accompanying fires	Pressure in ASW front ≥ 30 kPa	I
		Pressure in ASW front < 30 kPa but ≥ 1 kPa	II
		Pressure in ASW front < 1 kPa	III
Emissions of explosive, flammable gases and aerosols, explosion of drifting clouds	ASW, flying objects, smoke, gas, dust, accompanying fires, ground motions	Pressure in ASW front ≥ 30 kPa	I
		Pressure in ASW front < 30 kPa but ≥ 1 kPa	II
		Pressure in ASW front < 1 kPa	III
Emissions of toxic vapors, gases and aerosols	Increased concentrations of toxic gases and aerosols in atmospheric air	Estimated parameters exceeding permissible values	II
		Estimated parameters lower than limit permissible values	III
Corrosion liquid releases in surface and ground waters	Corrosion fallout onto the facility, inflow of corrosion liquid to the assemblies of water cooling system from water intake points. Leak of the corrosion environment to the air intake assemblies, etc.	Estimated parameters exceeding permissible values	II
		Estimated parameters not exceeding permissible values	III
Electromagnetic impulses and radiation	Effect of electromagnetic field on networks, equipment, personnel	Parameters estimated for certain conditions by calculation	II
Spill of oils and oil products on coastal river surfaces	Effect of heat stream, corrosive effects, etc.	Parameters estimated for certain conditions by calculation	II
Break of natural or artificial reservoirs	Flooding of the territory. Erosion of water currents bed. Dynamic effects	Wave height ≥ 1 m, water flow rate ≥ 0.7 m/s	I
		Wave height < 1 m but > 0.2 m water flow rate < 0.7 m/s	II
		Wave height < 0.2 m	III

Note – The table A.1 contains options which specify the following for processes, phenomena and factors:

- limit values of maximum parameters specified for I, II and III hazard levels;

- limit values of maximum parameters specified only for the I hazard level;

- limit values of maximum parameters specified for II and III hazard levels;

- limit values of maximum parameters specified for the II hazard level.

Examples of options of Appendix A data use

Option a): a phenomenon, process or factor can be of I, II or III hazard levels. After definition of estimated values of maximum parameters, they are used for implementation of requirements relevant to TCP for ensuring stability and safety of NF in case of external effects.

Option b): a phenomenon, process or factor, depending on effect intensity or according to its determination, can belong only to specifically hazardous (the I hazard level); the fact of its occurrence at NF site indicates the necessity of making decision on other site selection (replacement) due to presence of specifically hazardous phenomenon, process or factor at the given site. The possibility of the facility safety provision and its economic efficiency are estimated.

Option c): a phenomenon, process or a factor is not the factor restricting placement. They have to be considered in design bases. Estimated values of parameters can be equal or above the numerical values determining the II hazard level. If a phenomenon, process or factor has the III hazard level, then it is acceptable not to consider them in the project (because of insignificant consequences of their effect on the environment).

Option d): for some types of phenomena, processes and factors, numerical values for I, II and III hazard levels are not established. But these processes, phenomena and factors characterized only by the II hazard level cannot be excluded from design bases. Irrespective of their intensity, the maximum design value determined for site specific conditions is accepted in design bases (for example, a lightning strike).

Appendix B
(reference)

The list of the interconnected and interdependent processes of natural origin

Table B.1

Typical association of geological processes	Form of interactions
Earthquakes, landslides, rockfalls	Activation of landslides and rockfalls as a result of a strong earthquake
Landslides, rockfalls, mudflows, flooding, river or gully erosion	Blocking by displacing landslide or rockfall masses of valleys of rivers and ravines which break leads to formation of mudflows, strengthening of erosion and flooding territory
Karst, suffosion, rockfalls	Activation of karst process which is followed by suffosion and sliding of soils in resultant karst funnels
Re-engineering of reservoirs banks, rockfalls, landslides, karst	Re-engineering of reservoirs banks which is caused by activation of rockfalls, landslides and karst processes
Weathering, deep creep, landslides, rockfalls	The intensive weathering of rocks, strengthening creep processes transferring to landslides and rockfalls
River and gully erosion, landslides, rockfalls	The intensive erosion causing activation of landslides or rockfalls
Landslides and rockfalls	Transformation of landslide process to rockfall (landslides-rockfalls) or rockfall to landslide (rockfalls-landslides)
Dewatering of territory, subsidence of ground surface, aeolian processes	Dewatering of territory causing subsidence of ground surface and activation the aeolian processes
Underflooding, bogging, karst, suffosion, pollution of soils and underground water	Underflooding of territory followed by bogging, karstic suffosion processes and pollution of soils and underground water
Earthquakes, geodynamic and tectonic activity	Activation of seismic activity as a result of activation of geodynamic and tectonic activity
Earthquakes, change of geotechnical properties of soil in time	Change of site seismicity as a result of change of soil geotechnical properties
Change of geotechnical properties of soil, karstic-suffosian processes and human engineering activity	Change of soil geotechnical properties as a result of a karst-suffosion processes, underflooding or site dewatering, compaction of soil under the influence of construction mass, etc.
Earthquakes, human engineering activity (pumping out of oil, gas, mining including coal, rock salt, pumping of industrial waste and flooding of reservoirs, filling of reservoirs, prompt discharge of water in reservoirs)	Induced seismicity, deformation of soil surface

Appendix C
(reference)

Sources of required information for detection and identification of processes, phenomena and factors of natural and man-caused origin

Table C.1

Hazardous processes, phenomena, factors	Information sources
1	2
I. Hydrometeorological processes and phenomena	
Flood; the ice phenomena on waterways (jams, dams); seiches; change of water resources: extremely low drain, abnormal decrease in water level; tornado; wind, hurricane; precipitation; extreme snowfalls and snow accumulation; air temperature; glaze ice; lightning strike	Topographic and climatic maps; Historical data. Surface water resources. Hydrological year-books; Eyewitness reports. File materials. Hydrological monitoring. The statistical data obtained by processing of hydrometeorological information in long-term period (not less than 50 years) containing numbers of annual parameter values as well as data on prominent maxima; The systematic data collected within, at least, one year near around the site which dimensions are sufficient to consider all features of the territory and factors influencing climate of this area. Measurement data on standard programs of hydrometeorological observations with hourly frequency of measurements directly on the assumed site; Reference books on climate. Climatic monthly journals and year-books. Aerometeorological monitoring
II. Geological and engineering-geological processes and phenomena	
Seismotectonic fault dispacement, seismodislocations, seismotectonic highs, lowerings of blocks crust; the modern differentiated earth movements, tectonic creep; residual seismic deformations of crust; earthquake (of any genesis);	Literary and library materials on structural geology, geomorphology, quarternary tectonics, seismic tectonics, geophysics, seismology, deep structure and modern earth movements, seismicity, paleo seismic dislocation. Space and aerial photographs. Geophysical, geochemical and geodetic supervision over modern geodynamics of faults, including high-precision re-leveling and instrumental observations over modern geodynamics of faults, including high-precision re-leveling and instrumental observations over microearthquakes. Results of comprehensive geology-geophysical survey. These drills, passes of pits and ditches, electro-and seismic shooting profiling, well logging
Rockfalls and landslides rockfalls; erosion of banks, slopes, courses; failures and territory subsidence; underground erosion including karst symptoms; cryogenic-geological (cryogenic) processes; deformations of specific soil (thermokarst, liquefaction, solifluction, suffosion processes)	Geodetic, space, engineering-geological and geophysical monitoring. Materials of engineering researches (geodetic, hydrometeorological) for construction in areas of hazardous geological processes development (including in seismic regions). Materials on engineering protection against hazardous geological processes
III. Factors inducing external effects of man-caused origin (man-caused factors)	
Falling of the aircraft and other flying objects	Maps containing data on availability of airports, arrangement of air corridors, crossing of air routes in NF area. Data on types of air traffic, types of aircrafts and their characteristics, frequency of flights. Schemes of take-off, landing and parking of aircraft. Information on existence in a zone of influence on NF of military facilities, operating bombing grounds. Data on types of possible flying objects, their characteristics, hazard actualization frequency. Archival data on plane crashes
Externally caused fire	Maps containing data on presence in NF area and on their site of all possible land-based sources of external fire hazard: - forests; - explosive storages (solid, liquid and gaseous); - product pipelines and main pipelines of oil and gas; - railways, vehicle ways, river and maritime routes; - airfields, lines of air routes and flights; - residential zones; - the industrial enterprises (with indication of category of rooms, buildings and open technological installations, sites on explosion-fire and fire hazard);

1	2
	- production facilities of coal and peat mining; - areas with indication of peat bogs bedding; - areas of water surfaces with indication of spots of oils and other oil products. Archival and statistic data on fires, causes of their occurrence in the area and on NF site for not less than last 5 years. Data on stocks of combustible materials. Weather conditions. Hydrological conditions
Explosion at the facility	Maps containing data on existence in the area and on NF site of stationary and mobile possible explosion sources: - explosives warehouses and storages; - enterprises operating hazardous technologies where technological explosions are possible and which housing vessels operating under pressure and high pressure installations with gases, vapors and other liquids; - automobile and railroads, water transport with indication of data on transported explosives, vehicles; - main pipelines of oil and gas, product pipelines, processing equipment or pipelines of combustible gases, flammable liquids which can become a source of leak as a result of which clouds of explosive and fire-hazardous mixtures are formed; - military facilities. Data on reserves of explosives. Archival and statistical records about explosions near the NF site. Geological conditions in the area and on NF site. Weather conditions. Hydrological conditions. Map of external sources (in relation to radioactive source), explosions on NF site.
Emissions of explosive, flammable, toxic vapors, gases and aerosols in atmospheric air, explosion of the drifting clouds	Maps containing data on existence in the area and on NF site of sources of toxic emissions from chemical enterprises; fire sources. Schemes of transportations of mobile toxic hazard sources. Dispersion of impurity in the atmosphere. Data on possible scopes of toxic substances. Weather conditions, including data on inversion, fogs
Corrosion liquid releases into surface and ground water	Maps containing data on presence in NF area and on NF site of the industrial enterprises using chlorine, hydrogen sulfide, ammonia, dioxide of sulfur and other chemically active agents and places of chemically active discharges from these manufactures. Schemes of movement of mobile corrosion hazard sources. Dispersion of impurities in surface and ground water. Data on possible scopes of a release (emission) Archival and statistical records on releases. Hydrological conditions
Electromagnetic impulses and rays	Maps containing data on existence in NF area of enterprises, military and other facilities characterized by electromagnetic radiation and connected with receiving and use of electromagnetic fields. Special information on the power of sources
Spill of oils and oil products on coastal surfaces of the rivers	Maps containing data on existence in the area and on NF site of objects on banks of rivers and lakes which can be polluted with oil products and oils; about passing of routes of ships, vehicle ways and railway tracks. Data on possible scopes of oils and oil products spilling. Sizes of possible pollution spots of side surfaces of rivers and lakes (archival data and statistical data). Weather conditions. Hydrological dispersion of impurities on side surfaces of rivers and lakes.
Break of natural or artificial reservoirs	Atlas on reservoirs and NF location. Topographic and climatic maps. Seismicity of area. Resources of surface water. Hydrological year-books. Library materials. Hydrological monitoring. Probabilistic characteristics of reliability of hydraulic engineering constructions in case of external effects of natural and man-caused origin. Statistical data obtained by processing of the hydrometeorological information in a long-term section (not less than in 50 years) containing ranks of annual parameter values, and also data on prominent maxima. Data of annual measurements of upstream water level. Statistical estimates of maximum water-supplies in the top byef. Measurement data according to standard programs of hydrometeorological observations with the hourly frequency of measurements directly on surface of water adjoining NF site.

Appendix D
(reference)

Basic parameters describing processes, phenomena and factors of natural and man-caused origin

Table D.1

Processes, phenomena and factors	Parameters included to design bases
1	2
I. Hydrometeorological processes and phenomena	
Flooding	Maximum consumption and water levels. Indices of hydrographers of rainfall floods and spring floods
Ice phenomena on water courses (jams and dams)	Ice thickness. Sizes of separate ice floes. Rate of ice floe movement. Angle of ice floes approach to the bank. Width and extent of jams and dams. Frequency of jams and dams formation. Terms of ice phases occurrence
Seiches	Maximum elevation of a reservoir water level fluctuations
Change of water resources: extremely low drain, abnormal decrease in water level	Minimum water drain. Minimum water level
Tornado	Estimated class of tornado intensity according to Fujita scale. Length (width) of movement track (route). Maximum horizontal rate of tornado wall rotation. Travelling speed of tornado movement. Pressure difference between center and periphery of rotation funnel. Rate of pressure drop. Speed of water carryover from process reservoir cooler. Tornado occurrence frequency
Wind, hurricane	Maximum wind speed
Precipitation	Precipitation depth
Extreme snowfalls and snow accumulations	Snow cover thickness. Duration of snow cover period
Air temperature	Maximum and minimum temperatures
Glaze ice	Ice wall thickness
Lightning strike	Average and maximum amount of stormy days. Intensity of atmospheric electric field / maximum lightning intensity
II. Geological and engineering-geological processes and phenomena, rockfalls, landslides and mudslides	
Seismotectonic fault displacements, seismic dislocations, seismotectonic highs, lowering of crustal blocks	In the territory with high seismicity (more or equal to 8 points) in a radius of 150 - 300 km from NF: - location of a seismogenic near-surface break, break type (dumping, displacement, etc.); - break length; - displacement amplitude along the break (vertical and (or) horizontal); - shares of creep and seismogenic movements in displacement amplitude; - rocks of banks (wings) of a break and in the break zone; - location, length and width of a zone of seismically active fault including movement parameters (rate and amplitude of vertical and horizontal displacements, slopes) on banks and in a fault zone before and after a strong earthquake; - parameters of violation of soil like "separation", soil loosening, ejection of stones; - seismogenic layer capacity. For the predicted seismotectonic fault displacement, the same parameters as for a tectonic creep are used as well as seismicity geological criteria
The modern differentiated earth crust movements, tectonic creep	Location of tectonically active faults, regional and other breaks including buried. Length and width of zones of these faults and breaks. Structure of tectonically active faults, their blasting zones and subbands. Rate of raising and lowering of tectonic blocks and wedges. Rate of tectonic creep in different movement mode (stable, changeable, before and after an earthquake). Displacement (raising and lowering, displacement, inclination) of tectonic blocks, wedges. Creep during geological time and other time periods. A gradient of irregular movements – ratio of displacement amplitude to width of deformation
Residual seismic deformations of earth crust	

1	2
	zone and time unit. Age and amplitude of displacement at the youngest tectonic creep and character of their symptoms in relief
Earthquake (of any genesis)	For each zone of the possible earthquake centers in a terrestrial radius from NF: - maximum magnitude; - effective center depth; - seismicity in epicenter (in points according to MSK-64 scale); - seismic dislocations, seismic gravitational processes and phenomena, break of pressure waterfronts; - seismicity and consequences of hazardous geological and hydrological phenomena around NF area; - parameters of ground motion on a surface and at the level of construction footing (estimated or analog accelerograms and generalized reactions ranges, frequency characteristics of soil and coefficients of dynamism, maximum amplitudes of acceleration, rate and displacement of horizontal and vertical components of fluctuations, periods and number of cycles corresponding to them)
Erosion of stream banks, slopes, water courses	For wave abrasion of a shore: - erosion volume during a year per shoreline length unit; - length of active erosion zone; - movement of shore horizon and bench crest during a year. For an erosion of slopes and courses - increase in degree of an erosive dissection, length and volume of gullies, movements of river courses etc. during a year or other time
Territory subsidence and sinks	Categories of territory stability in relation to faults of any genesis (karst, thermokarst, suffosion, geotechnogenic mine openings and pumping out of water, oil, gas) are established according to sink formation intensity (on amount of sinks in a year per a unit of area) and according to average diameters of sinks or average width of the extended sinks. Negative forms of relief (crust, ponor, funnels, hollows, barren uplands, valleys, subsidence troughs), their outlines and sizes in the plan (area, length, width). For separate typical forms - average and maximum depths and rates of ground surface lowering
Underground erosion including underground karst symptoms	For territories with underground erosion symptoms on ground surface (karst, suffosion, leaching): - conditions of occurrence of rocks vulnerable to erosion by underground water; - hydrogeological conditions of erosion; - borders of sites of various extent of underground erosion. On the site underground erosion map the following shall be reflected: - zones of decompression and destruction; - fissures expanded with dissolution, suffosion, leaching of cavern; - channels, galleries, caves, other cavities, their sizes; - violations of rocks bedding as a result of their movement and falling over the cavities destroyed and loosened zones; - degree and composition of cavities filler; - tectonically weakened zones; - other symptoms of underground erosion. Activity of a karst is characterized by the relation of volume of soluble breeds to volume of the estimated element or all massif as a percentage for 1000. Speed of a suffosion is characterized by the volume of the masses which is taken out by a suffosion during a year
Cryogenic-geological (cryogenic) processes	Depth, thickness, lithological composition, filtration properties, temperature, thermal capacity and heat conductivity of frozen and thawed massif. Thickness of active layer. Amount of heat evolved by a construction to the massif. Cryogenic processes and educations (solifluction, frost mounds, frost fracture formation, thermokarst, aufeis), forms and sizes of cryogenic formations (diameter and height of mounds, depth, length, width and area of thermokarst faults and subsidence, depth of thermokarst development, area, volume, thickness

1	2
	of aufeis, sizes of frost fractures). Rates of cryogenic processes (heaving rate, accumulation of aufeis, movements of solifluction, deepening of faults and subsidence).
Deformations of specific soil (thermokarst, liquefaction, solifluction, suffosion processes)	Key parameters of subsiding soil: - deformation module, specific cohesion and angle of internal friction with natural humidity and in water-saturated state, degree of their variability in plan and according to depth; - type of soil conditions according to subsidence, thickness of subsidence thickness of its strata, their change; - relative subsidence; - initial subsidence pressure.
Rockfalls, landslides – rockfalls and mudslides	For rockfalls of dangerous slopes: - arrangement scheme of existing and expected rockfalls for more than 10 m^3; - height and steepness of rockfall slopes; - slope surface form; - degree of slope rocks weathering, presence of weakened zones, - layers of plastic or suffosion-unstable rocks, tectonic dislocations; - resistance to displacement, volumetric weight, humidity and deformation module of rocks in weakened zones and interlayers, in fissures filler; - sizes and volume of predicted rockfall; - symptoms of rockfall or landslide rockfall preparation: inrushes and falling of separate blocks, expansion of existing fissures and emergence of new, narrowing of displacement rents, periodically repeating crash, small motions of rock blocks
Mudflows	By mechanism of formation, erosive, breaking, rockfall-landslide, landslide mudflows are distinguished. According to occurrence conditions, rain (most widespread), snow, seismogenic (in areas with 8 points and more seismicity), limnogenic (breaking), technogenic, anthropogenic mudflows are distinguished; according to material composition – mud, mud-stone, water stone; according to motion character – viscous, fluid. In the territory mudflow hazard map, in a radius of up to 50 km from NF: - boundaries of mudflow basins; - hydrographic network with characteristic of bed slopes, zones of formation, motion and accumulation of mudflow streams; - lakes and reservoirs hydraulic structures, mudflow protection structures, other objects (including NF). On the map of mudflow basin: - mudflow centers and volume of material in them; - erosional feature of water catchment relief and topsoil stratum; - mudflow channels and places of possible jams, volume and activity of rockfalls, slides, landslides in mudflow channel zone; - volume, area, depth, length, width of mudflow deposits in mudflows accumulation zone. On the mudflow possible motion scheme: - maximum speed, depth, width and discharge; - mudflow flood zones (with catastrophic destructions, with mudflow deposits accumulation); - mud stream effect zones; - zones of possible violation of slopes stability when undermining; - safe zones, evacuation pathways; - contours of the designed and existing constructions Reflected in the report: - genesis, occurrence conditions, formation mechanism, types and frequency of mud flows; - maximum volumes of synchronously accumulated mudflow masses and dynamic parameters of mudflows; - physical and mechanical properties of soil in mudflow centers and in

1	2
	deposition zone.
III. Factors forming external effects of man-caused origin (man-caused factors)	
Aircraft or other flying objects falling	Probabilities of falling of aircrafts or other flying objects of various classes on this area during NF operation: - stiffness properties of colliding objects; - weight of objects; - weight of fuel; - shock velocity; - construction impact angle; - direction of effect; - impact area; - point of application.
Externally caused fire	Probability of fire occurrence. Probability and rate of fire propagation to NF direction. Equivalent area of surface affected by fire. Heat flux in fire source and its change towards NF. Distance from NF. Speed and direction of wind
Explosion at the facility	Excessive pressure in ASW front. TNT equivalent. Distance to NF. Estimated concentration, toxicity of gas near NF. Probability of explosive cloud drift towards NF, probability of cloud ignition. Ignition source intensity
Emissions of explosive, flammable, toxic vapors, gases and aerosols in the atmosphere, explosion of drifting clouds	Initial concentration at the emission point. Dispersion of emissions in the atmosphere. Concentration from primary sources and secondary affect effects as function of time with consideration of air standard intake and egress. Effect duration.
Corrosion liquid releases into surface and ground water	Initial concentration. Concentration of corrosion mediums interacting with NF systems as function of time and distance. Effect duration. Damageability of system during a year of operation and for operation period. Distance from emission source, from emission point to NF
Electromagnetic impulses and rays	Electric and magnetic fields intensity
Spill of oils and oil products on shore surfaces of rivers, seas and oceans	Area of a spot, layer thickness. Chemical composition. Distance to NF. Distance to the NF water intake point. Thermal flux in fire source and its change towards NF. Concentration of oils and oil products in water intake point of NF
Break of natural and artificial reservoirs	Height and speed of wave, time of territory flooding

Appendix E

(recommended)

List of recommended measures for engineering protection of NF and NF territory against external effects

E.1 List of measures on engineering protection of NF territory

1 Level regulation of surface and ground water.

2 Construction of the protective structures protecting flanks and slopes from erosion, effect of landslide, rockfall and other processes.

3 Arrangement of supporting walls, buttresses, pile curtains and other holding constructions preventing earth masses displacement.

4 Development of channel hydraulic, mudflow-protective and mudflow-offtake constructions.

5 Ground water drain.

6 Strengthening of soil under constructions bases.

7 Lightning strike protection device.

8 Arrangement of protective constructions against flying objects in case of tornado.

9 Arrangement of barriers on the way of ASW propagation.

10 Bunding or arrangement of ditches around the territory of NF site, arrangement of fire-prevention gaps and barriers to exclude propagation of externally caused fire.

E.2 List of measures on engineering protection of NF against external effects

E.2.1 The approximate list of technical measures for engineering protection of NF against external effects includes:

- designing of stable footings;

- assurance of resistance of constructions to extreme dynamic loads (from hurricanes, earthquakes etc);

- decrease in level of dynamic loads transferred by the “soil-base-construction” system to the reactor, process and electrotechnical equipment and other NF elements important for safety;

- assurance of protection of systems and elements against dynamic effects.

E.2.2 As standard seismic, impact and vibration protection measures, the following is recommended:

- stiffness increase for structural elements of building constructions, equipment, attachment points as well as use of equipment unfreezing devices, constructions, pipelines;

- decrease in dynamic inertial loads effecting on object elements in a way of seismic isolation of structures, equipment, pipelines, engineering communications, separate rooms and constructions;

- restriction of mutual relative displacements and deformations of elements of equipment, structures, pipelines with the aim to exclude inadmissible deformations and collisions applying special limiters, compensators of deformations, seismic isolators and dampers.

The listed measures can be held selectively or in a complex.

Use of seismic isolators or dampers has to be proved in the project by:

- efficiency estimation of their use;

- experimental check of proposed devices or data on their analogs tests.

The seismic isolators experimentally tested and approbated shall be used. The devices providing independent three-component seismic isolation and noncritical to amplitude-frequency effect characteristics shall be preferred.

E.2.3 Facility resistance to loads of falling aircrafts and other flying objects shall be provided by means of:

- increase of sectional area of elements of protective constructions, their reinforcing percentage, use of shockproof materials etc;

- the improved facility configuration, redundancy of systems important for safety, their division from each other by safe distances etc.;

- applications of high-frequency vibration absorbers installed on systems of normal operation and systems important for safety;

- provision of reliable fire extinguishing equipment;

- implementation of technical and organizational measures for protection against secondary effect in case of flying objects impact (arrangement of protective barriers, etc.).

E.2.4 Protection of NF against the hazard of emergency external explosions can be solved by removal or shielding of an explosion source or strengthening of structures, buildings, constructions of NF (increase of stiffness and inertial characteristics of sections).

E.2.5 For effective increase of fire safety with the aim to protect against the externally caused fires, the project shall envisage the following:

- redundancy of systems (elements) important for safety allowing them to perform its functions in case of a fire;

- additional protective barriers;

- spatial and physical division of safety systems, their channels and safety control systems; protection of the reactor facility shutdown and cooling systems against dangerous factors of a fire and assurance of performance of design functions by these systems during and after a fire;

- rational space arrangement of a facility, laying of processing equipment, cable lines, pipelines and air shafts and air ducts in separate shaft and boxes detached by fire-prevention barriers (barriers) or located at safe distance from each other for exclusion of simultaneous effect of fire on main and standby equipment;

- application of building constructions with the required fire resistance limit;

- space-planning and constructive solutions of buildings ensuring fire safety;

- fire extinguishing systems, including systems of internal and external fire-water supply;

- regulation of places and amounts of flammable explosion and fire hazardous mixtures and substances located on the NF site;

- application of automatic fire extinguishing installations, systems of warning and response involvement of fire brigades, (systems) of fire alarm system, notification of workers about a fire.

Systems of ventilation shall be designed with consideration of postulated external fire.

E.2.6 Protection of systems against corrosion liquid releases can be assured by means of:

- application of corrosion-resistant materials, protective coatings;

- increase in thickness of pipelines and equipment walls;

- application of protective tight cases for electronic equipment and instruments;

- application of corrosion gas detectors regulating locking valves operation;

- control of a chemical composition of cooling water etc.

E.2.7 To prevent hazard of toxic substances emissions, the following means are applied:

- toxicity detection;

- decrease in volume and concentration in atmospheric air of emissions of toxic substances (ventilation, flux geometrical division);

- personal protection.

E.2.8 To protect against lightning strikes, electromagnetic impulses and rays, the following is applied:

- shields, optimum spatial placement of lightning protection systems;

- lightning rods, lightning arresters, grounding of separate parts of NF systems;

- devices preventing extra voltage at the most responsible places;

- protection of inputs to a construction which can provide penetration of the induced currents and voltages.

E.2.9 To protect NF against intrusion of oils and oil products in water supply systems, the following is carried out:

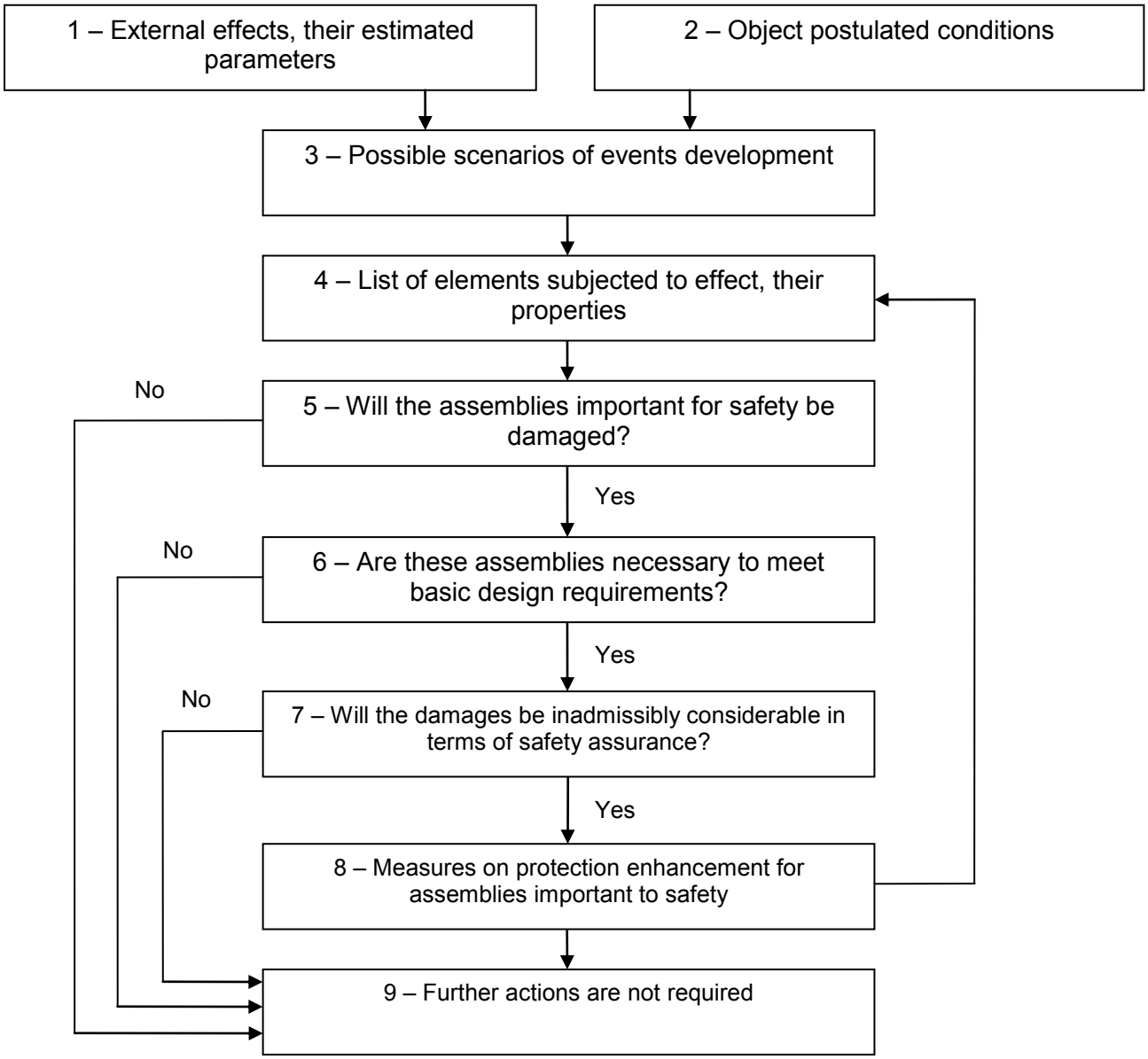
- equipment of water intakes with detectors of oils and oil products;

- arrangement of water receiving nozzles under water surface.

Appendix F

(recommended)

The logic diagram of NF safety analysis in case of external effects



The short description of procedure of NF safety analysis in case of external effects of natural and man-caused origin:

1 Types of the external effects considered in design bases (the unit 1 from the given units 1 - 9 in the Appendix F), and their input parameters defined.

2 Postulated NF conditions (unit 2) identified.

3 Basing on consideration of possible events evolution scenarios (unit 3), the elements subjected to effect listed, their characteristics and reliability limits (unit 4) set.

4 Responses of buildings, structures, systems and elements of NF to external effects of the considered types defined on the basis of deterministic approach; their damageability as well as

damageability of assemblies important for safety defined deterministically applying (or with no application) of the probabilistic analysis elements (unit 5).

5 Safety analysis, which aim is the risk assessment (units 6 and 7), is carried out. Compliance of assemblies for implementation of basic design requirements estimated deterministically for the newly designed facilities. If assemblies are necessary, then measures for their protection are provided. For the operated facilities, it is permitted to estimate need in these assemblies for safety functions performance. In case of obtaining unacceptable risk characteristics because of these assemblies failure, their protection against external effects of the considered type is performed.

6 After engineering protection taking measures, the analysis shall be repeated beginning from units 4 - 7, for confirmation of sufficiency of these protection means. Compatibility of means of assemblies protection from various effect types has to be analyzed.

Note – Those events can be excluded from detailed consideration for which it can be demonstrated that the loads caused by them are "overlapped" by loads from other considered events (for example, in most cases there is no need to consider equipment vibrations arising from external explosions if it is designed with consideration of the loads occurring in case of earthquake and (or) falling of an aircraft). The analysis is allowed to be limited to comparison of amplitude-frequency characteristics of external effects, preparation of the conclusion on "relative insensitivity" of equipment to other effects in comparison with the basic ones from which protection is provided.

Appendix G

(recommended)

The recommended safe levels of loads on personnel

1 Acceleration levels on personnel are equal to 0.9 g (seated, in the upright position) according to all coordinate axes (the vector sum of accelerations).

2 When hitting a head against a barrier, the permissible velocity of impact shall be not more than 2.3 m/s.

3 When hitting a head against secondary objects weighing 1, 2, 3, 4, 5 kg, the permissible speed of impact shall be not more than: 5; 3.7; 3; 2.5; 2.2 m/s respectively.

4 The excess pressure allowed value of ASW on a person shall be less than 35 kPa.

5 Permissible levels for toxic and radioactive gases, aerosols, fumes, fire dangerous factors, thermal flux and air temperature indoors shall be accepted according to the existing standards.

Appendix H
(recommended)

The recommended means for collective and (or) personal protection of personnel

Table H.1

Affecting factor	Recommended means	
	collective protection	personal protection
ASW	Protective shields, safety boxes	Fixing devices in passages (walkways) (guardrails, handrails, handles), fixing devices – belts in the workplace
Kinematic parameters of motion of constructions: bases, slabs	Seismic and vibration protection devices	Special chairs, helmets, fixing devices (guardrails, handrails, handles), carpets
Local shock loads	Local seismic and vibration protection	Special chairs, helmets, fixing devices
Flying objects	Protective shields, grids, impact protection structures (for objects weighing from 5 kg to 5 t	Protective helmets (miner's helmet)
Falling in the result of stability loss	Seismic and vibration protection devices	Fixing devices
Acrid toxic and radioactive gases aerosols, fume	—	Respirators, breathing apparatuses
Fire dangerous factors including increased temperature, thermal radiation	Fire evacuation areas in which personnel safety is ensured for the whole time of effect of fire dangerous factors	Self-rescuers, respiratory devices with compressed air, oxygen breathing apparatuses (respirators)

Appendix I

(recommended)

Input information for maintenance of data base on processes, phenomena and factors of natural and man-caused origin

The purpose of database maintaining is the presentation of conditions of NF arrangement during all life cycle and contents of the most important information on processes, phenomena and factors of a natural and man-caused origin effecting on NF.

I.1 General background

I.1.1 NF name.

I.1.2 Years of NF commissioning and decommissioning.

I.1.3 NF arrangement (region of the Republic of Belarus, district, closest city, distance from the closest city to NF site, azimuth). If NF site is in a border zone (25 km and less from border), neighboring country (countries) shall be indicated.

I.1.4 Geographical coordinates of NF site (latitude, longitude).

I.1.5 Site absolute elevations according to the Baltic Elevation System (BS) (natural: the highest, average, the lowest; layouts).

I.1.6 Landscape in a radius of 20 - 30 km. Short description (plain, hilly district, position in a valley, arrangement of rivers, shoreline of lake, etc.).

I.1.7 Distribution of population. The closest administrative center (village, town): name, distance, population. The closest city (50 thousand people): name, distance, population.

I.2 Meteorological conditions

I.2.1 Tornado hazard zone on a zoning map.

I.2.2 Tornado intensity class according to Fujita's scale.

I.2.3 Maximum horizontal rate of tornado wall rotary motion.

I.2.4 Length tornado track.

I.2.5 Width of tornado track.

I.2.6 Pressure difference between periphery and center of tornado funnel.

I.2.7 Probability of tornado within NF site.

I.2.8 Probability of hurricanes (typhoons).

I.2.9 Estimated characteristics of probable maximum hurricane (typhoon).

I.2.10 Estimated maximum wind speeds of various probability including 1, 0.1 and 0.01%.

I.3 Hydrological conditions

I.3.1 Type of water object effecting NF safety (river, lake, reservoir).

I.3.2 Factors of formation of maximum possible flood entered into the project. For rivers – spring flood, rain floods, breaks of dams and dikes, blockages, rockfalls, landslides, mudflows, dams and jams caused by the ice regime, seismic and wind activity etc. For reservoirs – wind surge, storm wave, maximum wave setups on a shore, seiches, etc.

I.3.3 The highest observed (historical) water level of a water body.

I.3.4 Parameters of maximum possible flood with estimated values of formation factors. Maximum levels measured relatively to zero mark corresponding to BS of various probability

including 1, 0.1 and 0.01%. The maximum height of various probability waves, including 1, 0.1 and 0.01%.

For rivers – the maximum consumption of water of various probability, including 1, 0.1 and 0.01%.

For reservoirs:

- level of maximum possible flood with consideration of a limit elevation of shore flooding with combination of estimated contributions of formation factors (seiches, wind surge, storm wave);

- maximum height of water level with seiche oscillation;

- estimated values of storm surges with maximum wind speeds of various probability, including 1, 0.1 and 0.01%;

- maximum height of waves in deep water with maximum wind speeds of various probability, including 1, 0.1 and 0.01%.

I.4 Geohydrological, geological and engineering-geological conditions

I.4.1 Characteristic of aquifer next to the surface:

- unconfined (confined);

- area of distribution;

- elevation of lower (upper) aquiclude;

- elevations of ground water level (maximum, average, minimum);

- lithological characteristics;

- permeability coefficient;

- act. Porosity;

- existing water intake;

- elevations of groundwater level on NF (maximum, average, minimum).

I.4.2 Characteristic of aquifer, the second from surface:

- area of distribution;

- elevation of lower (upper) aquiclude;

- elevations of ground water level (maximum, average, minimum);

- lithological characteristics;

- permeability coefficient;

- act. Porosity;

- existing water intake;

- elevations of groundwater level on NF (maximum, average, minimum)

I.4.3 Characteristic of aquicludes:

- area of distribution;

- elevation of lower (upper) aquiclude;

- lithological characteristics;

- permeability coefficient;

- presence of hydrogeological windows.

I.4.4 Characteristic of engineering-geological conditions:

- development of specific soils (loose with the deformation module less than 20 MPa - liquefiable, subsiding, dilative, saline, permafrost);

- hazardous modern geological processes and phenomena;

- presence of karst, suffosion and karst-suffosion processes.

I.5 Seismicity

I.5.1 Seismotectonic model of a region.

I.5.2 Scheme of detailed seismic zoning.

I.5.3 Scheme of structural and tectonic conditions.

I.5.4 Scheme of seismic microzonation of NF site for natural and man-caused changed conditions.

I.5.5 Characteristics of spectral composition and duration of vibrations for various types of earthquakes: remote, intermediate, local (regional).

I.5.6 MDE and DBE parameters from the closest seismogenic zones: magnitude, center depth h, distance to a seismogenic zone r, seismicity J according to MSK-64 scale on reference soil of NF site.

Seismogenic zone number	Magnitude		h, km		r, km		J, point	
	MDE	DBE	MDE	DBE	MDE	DBE	MDE	DBE

I.5.7 Seismicity of NF site in case of MDE (DBE).

I.5.8 Maximum amplitudes of horizontal vibrations on free surface of NF site in case of MDE (DBE): accelerations, rates.

I.5.9 Maximum amplitudes of horizontal vibrations of a roof of massive rocks in case of MDE (DBE): accelerations, rates.

I.5.10 The periods of maximum amplitude of acceleration (rate) at the level of grading in case of MDE.

I.5.11 Ratio of vertical acceleration to horizontal one.

I.6 Aircraft falling

I.6.1 Minimum removal NF site from flights routs, landing route, of any airport.

I.6.2 Distance to a major airport.

I.6.3 Frequency of aircraft falling on NF site.

Aircraft category	Frequency of falling onto NF site, 1/y		
	according to the falling statistics	prediction for 10 years	prediction for 50 years

I.7 Explosion at the facility (emergency explosion) outside NF site

I.7.1 Potential emergency explosions sources in a zone with a radius of 5 - 10 km:

- components of chemical, oil refining complexes;

- storages of coal, oil, gas, etc, explosives;

- transport – land, water;

- oil and gas pipelines;

- objects of defense industry.

I.7.2 Land-based transport potential sources of emergency explosions. Routs, ports, ship canals, railway stations, characteristics of freight traffics.

Appendix. Site layout plan (scale of 1:25000).

I.8 Externally caused fire (fires outside NF site)

Potential fire sources in radius of 2 km: wood, peat bog, gas, oil, product pipeline, complex (warehouse, storage) of flammable materials, ship canal.

Statistical data on fires.

Appendix. Topographic-landscape map of a district with indication of fire sources.

I.9 Toxic and corrosion emissions and releases into the environment

Sources of emissions outside NF site of toxic vapors (gases, aerosols), corrosion liquid releases.

Appendix. Scheme emission sources arrangement.

The Director General
SSI “JIPNR–Sosny” of NAS of Belarus
Doctor of Physical and Mathematical Sciences, Professor V.I. Kuvshynov

Responsible Executor
Candidate of Technical Sciences A.P. Malykhin

The present technical code was developed with participation of:
From SSI “JIPNR–Sosny” of NAS of Belarus:
A.P. Malykhin, the Candidate of Technical Sciences
T.Yu. Pronkevych
M.A. Kozel