**FEDERAL ENVIRONMENTAL, INDUSTRIAL AND
NUCLEAR SUPERVISION SERVICE**

APPROVED BY
Order No. 396 dated 28 August 2014 of the Federal Environmental, Industrial and Nuclear Supervision Service

**SAFETY GUIDE IN THE USE OF ATOMIC ENERGY
"BASIC RECOMMENDATIONS FOR DEVELOPMENT OF A PROBABILISTIC SAFETY ANALYSIS OF LEVEL 1 FOR A NUCLEAR POWER UNIT DURING INITIATING EVENTS STIPULATED BY EXTERNAL IMPACTS OF NATURAL AND MAN-INDUCED ORIGIN"**

**(RB-021-14)**

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**Safety Guide in the Use of Atomic Energy "Basic recommendations for development of a probabilistic safety analysis of level 1 for a nuclear power plant unit during initiating events stipulated by external impacts of natural and man-induced origin" (RB-021-14), the Federal Environmental, Industrial and Nuclear Supervision Service, Moscow, 2014**

Safety Guide in the Use of Atomic Energy "Basic recommendations for development of a probabilistic safety analysis of level 1 for a nuclear power plant unit during initiating events stipulated by external impacts of natural and man-induced origin" (hereinafter referred to as the Safety Guide) shall be non-regulatory and not a regulatory legal act.

The Safety Guide contains the recommendations of the Federal Environmental, Industrial and Nuclear Supervision Service (hereinafter referred to as Rostechnadzor) for performing PSA of external impacts of the designed, constructed and in operation NPP power units with different types of reactors.

The recommendations of the Safety Guide belong to the objectives, scope, composition, content, sequence of performance, quality assurance, contents of individual tasks (sections) and contents of the submitted documents on PSA of external impacts.

The Safety Guide is designed for use:

1) by the Operating organization in the safety case of NPP units,

2) by Rostechnadzor when carrying out expert review of the safety case documents of the NPP units.

Substitutes RB-021-01[[1]](#footnote-1).

**I. General provisions**

1. The Safety Guide in the Use of Atomic Energy "Basic recommendations for development of a probabilistic safety analysis of level 1 for a nuclear power plant unit during initiating events stipulated by external impacts of natural and man-induced origin" (hereinafter the Safety Guide) has been developed in compliance with the clause 6 of the Federal Law No 170-FZ dated 21 November 1995 "On the use of atomic energy" to assist in the compliance of the requirements of item 1.12.19 of the General Provision on Ensuring Safety of Nuclear Power Plants (NP-001-97) approved by decree No. 9 of the Federal Nuclear and Radiation Safety Authority of Russia dated 14 November 1997.

2. The Safety Guide contains recommendations of the Federal Environmental, Industrial and Nuclear Supervision Service (hereinafter Rostechnadzor) in the part of development of level 1 probabilistic safety analysis for nuclear power plant during initiating events caused by external impacts of natural and man-induced origin (hereinafter the PSA of external impacts). The Safety Guide shall not be applicable for seismic impacts.

The list of abbreviations used in the Safety Guide is provided in Appendix 1, terms and definitions in Appendix 2, recommended PSA report makeup of external impacts in Appendix 3 to this Safety Guide.

3. The Safety Guide contains recommendations that ensure acceptable PSA quality level of external impacts of natural and man-induced origin.

4. The Safety Guide is designed for use by the design organizations, operating organizations and Rostechnadzor during design, construction, operation of the NPP units, carrying out safety supervision of the NPP units, development and implementation of measures for enhancing safety level of the NPP units.

5. The PSA of external impacts is a constituent part of the full-scale level 1 PSA, developed for all categories of IE and for all possible operation states of the designed, constructed and operated NPP units with reactors of different types.

6. The PSA of external impacts may be performed using other recommendations than those that are available in this Safety Guide if they are substantiated for the safety case.

7. The recommendations of the Safety Guide relate to the objectives, scope, composition, content and sequence of performing individual tasks, as well as the content and scope of the reporting documentation and quality assurance when performing the PSA of external impacts.

**II. General information**

8. The basic tasks of the PSA of external impacts are:

accumulation of information specific for the NPP unit;

making of a list of external impacts;

assessment of the probabilities (frequencies) of external impacts;

personnel reliability analysis;

screening analysis of external impact scenarios;

detailed analysis of external impact scenarios;

analysis of significance, sensitivity, uncertainty of the PSA model of external impacts;

analysis of the PSA results of external impacts.

Recommended sequence and mutual relation of PSA tasks of external impacts is given in Appendix 4 to the Safety Guide.

9. The PSA of external impacts is recommended to develop based on information from the safety case reports of the NPP unit and PSA of the level 1 NPP unit for internal IE.

10. Recommendations of the Provision on basic recommendations for the development of level 1 probabilistic safety analysis for internal initiating events for all modes of operation of the nuclear power plant unit (RB-024-11), approved by the order No. 519 of the Federal Environmental, Industrial and Nuclear Supervision Service dated 9 September 2011 (hereinafter - RB-024-11) shall be applied to the implementation of the PSA for external impacts based on the recommendations of this Safety Guide.

Recommendations of the Safety Guide "Basic recommendations for development of level 1 probabilistic safety analysis of nuclear power plant unit for initiating events, stipulated by intra-site fires and flooding" (RB-076-12), approved by order No. 496 of the Federal Environmental, Industrial and Nuclear Supervision Service dated 5 September 2012, shall be applied to the implementation of the PSA for external impacts based on the recommendations of this Safety Guide.

11. The mutual influence of external impacts is recommended to be considered when performing the PSA of external impacts.

12. The PSA of external impacts is recommended to develop for the following RS:

nuclear fuel in the reactor core;

nuclear fuel in places of spent fuel storage (for example, in the spent fuel pool/refueling pool, in the drum of spent nuclear fuel assemblies).

13. It shall be recommended to substantiate the time interval in which the accident is considered, and the types of safe end states of the NPP unit when performing the PSA of external impacts.

**III. Acquisition of information specific for the NPP unit**

14. The composition and scope of information required for analysis and acquisition of information shall be made when performing this PSA task of external impacts. The following information shall be acquired:

all required meteorological data for analysis (precipitations, wind velocity and direction, temperature) at the NPP site location area and other data about the natural and man-induced external impacts taking place at the NPP site location area for the maximum possible period of observations;

data on infrastructure at the NPP site location area including motor, railway, river and maritime traffic and information about hazardous cargoes (explosive and toxic cargoes) transported over them (nomenclature, quantity, weight, volume, frequency of transportation); topographic maps of all the transport traffics specifying the minimum distances up to the NPP site;

data on the routes and frequency of civil and military aircraft flights at the NPP site location area including information on aircrafts (description, weight and other required data) and dimensions of the flight restriction zone near the NPP site;

data about the facilities (name, distance to the NPP site and other required data) at the NPP site location area containing explosive and toxic substances including information about them (name, weight, volume, storage method);

data about the facilities, damage thereof may lead to the occurrence of external impacts at the NPP unit (dam, dike failure, spill of petroleum products and other potential events);

data about NPP unit buildings and structures (design characteristics, design loads), damage thereof during external impacts may cause the occurrence of initiating events.

15. The following shall be recommended to use when performing PSA of external impacts of the NPP unit:

design documentation;

operation documentation, including:

operational technological procedure for the NPP safe operation;

operation manuals for the systems (elements) containing instructions for procedures during normal operation and anticipated operational occurrences, including pre-accident situations, as well as guidelines defining personnel actions in case of design-basis and beyond design-basis accidents;

system diagrams;

maintenance and repair manual of the NPP systems and equipment;

documents for control systems (components):

operation experience for all the units of the analysed NPP and operation experience of the prototypes including information about the external impacts of natural and man-induced origin taking place;

The NPP PSA of external impacts completed for prototype units;

Level 1 NPP PSA for internal initiating events;

description of safety-related systems of the NPP unit;

existing investigations for safety case of the NPP unit during external impacts;

3D-models of the NPP unit buildings (if any);

safety analysis reports for NPP units;

methodological recommendations corresponding to the current level of development of science, technology and production, for example contained in IAEA documents and documents of other organizations.

16. For NPP under operation and placed in operation it is recommended to perform a walkdown of the rooms of buildings, structures, NPP site and facilities location area near the NPP site containing explosive and toxic substances, malfunction thereof may influence the NPP safety. The objective of the walkdown shall be the establishment of the compliance of the current condition of the NPP unit to the design and operation documents and getting information which were not available in the documents of the analyzed NPP unit.

17. The approximate list of initial data required for performing PSA of external impacts is given in Appendix 5 to this Safety Guide.

**IV. Making a list of external impacts**

18. It is recommended to develop the preliminary and final list of external impacts. The final list of external impacts is recommended to use as input data for the screening analysis.

19. The preliminary list of external impacts is recommended to make with due regard to:

the approximate list of external impacts given in Appendix 5 to this Safety Guide;

the nomenclature of natural and man-induced processes, phenomena and factors specified in the Federal rules and regulations in the use of atomic energy "Account of natural and man-induced external impacts on nuclear facilities" (NP-064-05) approved by decree No. 16 of the Federal Environmental, Industrial and Nuclear Supervision Service dated 20 December 2005;

the list of external impacts from the PSA of external impacts for Russian and foreign NPP;

the list of potential combinations of external impacts (example of the determination matrix of potential combinations of external impacts is given in Appendix 8 to the Safety Guide);

the specific list of potential external impacts made following the walkdown of the territory adjoining the NPP site (on condition of detection of external impacts not specified in the design documents).

20. It is recommended to make the preliminary list of external impacts without considering the integration of external impacts into a category (for example category of external impacts "transport accidents" may integrate the following external impacts: aircraft crash, motor transport accidents, rail-road transport accidents, river transport accidents).

21. It is recommended to develop qualitative and quantitative exclusion criteria of external impacts from analysis for making the final list of external impacts. The recommended formation principles of exclusion criteria are given in item 1 of Appendix 6 to this Safety Guide. Examples of exclusion criteria of external impacts when making the final list of external impacts for analysis are given in item 2 of Appendix 6 to this Safety Guide.

22. The making of the final list of external impacts is recommended to perform by sequential checking of conformance/non-conformance of all the external impacts and their combinations from the preliminary list first by quality exclusion criteria and then by quantitative exclusion criteria.

23. For external impacts and their combinations remaining in the preliminary list of external impacts after exclusion based on quality exclusion criteria it is recommended:

to assess the probability (frequency) of external impact;

if required to determine the probability (frequency) dependence of external impact from external impact parameters (for example, wind speed, water level).

The obtained results are used for excluding the external impacts based on quantitative exclusion criteria and when performing screening and detailed analysis. The development requirement of specified dependencies shall be established in the process of making the final list of external impacts when performing screening and detailed analysis.

24. If the external impact or their combination shall meet any of the qualitative or quantitative exclusion criteria, then such external impact is excluded from the list of external impacts. Thereby the final list of external impacts shall be made from the preliminary list of external impacts.

If the external impact or their combination may be excluded from the preliminary list based on several adopted exclusion criteria, it is recommended to specify all the exclusion criteria which the excluded external impact shall meet.

25. It is recommended to provide the justification of the exclusion of external impacts and their combinations and/or provide exact references to the sections of documents confirming the justification of external impact exclusion from further consideration.

26. It is recommended to establish the possibility of joint impact on the NPP unit of several external impacts and establish the external impacts being the consequence of other external impacts. The results of the specified analysis shall be recommended to submit in the form of a matrix of external impact combinations. An example of the external impact combination matrix is provided in Appendix 8 to this Safety Guide.

27. The result of resolving the task for making the list of external impact shall be:

a preliminary list of external impacts;

a list of external impacts excluded from further analysis based on conformance check of the adopted exclusion criteria, including detailed information on the screening results:

applied exclusion criteria (qualitative or quantitative);

justification of the reasons for excluding external impacts from further review;

a matrix of external impact combinations;

a final list of external impacts;

**V. Assessment of the probabilities (frequencies) of external impacts**

28. The determination of the probability (frequency) of occurrence of external impacts for each of the external impacts from the final list of external impacts shall be performed under this task. It is recommended to determine the dependence of the occurrence probability (frequency) of external impact and failure probability of the system (component) from its intensity value for assessment of IE frequencies.

29. It is recommended to use statistical data about external impacts for assessment of the probability (frequency) of external impacts.

30. The probability (frequency) of external impact is recommended to determine as the quantity of external impacts of this type reduced to a year.

**VI. Reliability analysis for personnel**

31. The objective of human reliability analysis in the PSA of external impacts is aimed at determination and assessment of the impact on the personnel of different external impact factors when they perform accident management actions (enhanced stress level, reduced time to perform actions required, spurious actuation of fire detection system, loss of data at the MCR).

32. HRA when performing the PSA of external impacts shall be recommended to perform by the method similar to the method used during performance of level 1 NPP PSA for internal IE considering the external impacts.

33. The list designed under the level 1 NPP PSA for internal IE shall be adopted as the basic list of personnel erroneous actions. If additional emergency scenarios in external impacts of the PSA are found, it is recommended to identify new personnel erroneous actions and assess their probability.

34. Factors influencing the probability of human errors during accident management, considered in the level1 NPP PSA for internal IE should be used as the basic list of factors when performing the PSA of external impacts.

35. It is recommended to consider the additional factors stipulated by external impacts and influencing the probability of performance of actions for accident management by the personnel when performing the HRA. It is recommended to consider the following factors for non-performance of required actions by the personnel:

enhanced stress;

reduced time to perform actions required;

impossibility of performing actions locally due to occurrence of conditions preventing the performance of action;

decrease of information support at the MCR.

36. HEP assessments used in level 1 NPP PSA for internal IE when performing PSA of external impacts if required shall be corrected considering the impacts (stress, potential loss of information at MCR and other factors).

37. It is recommended to perform preliminary quantification (calculation) of the PSA model with assignment of HEP equal to 1.0 for all the basic events simulating human error for identifying all dependent actions of the personnel. Reassessment of the dependent actions of personnel shall be recommended to perform considering the external impacts.

38. The results of HRA shall be recommended to consider when performing screening and detailed analysis of the external impacts.

**VII. Analysis of external impact scenarios**

39. Analysis of external impact scenarios shall be recommended to perform in two stages:

screening analysis phase of external impact scenarios (hereinafter screening analysis);

detailed analysis phase of external impact scenarios (hereinafter detailed analysis).

40. Conservative probabilistic quantitative assessment of the implementation of scenarios with damage of each of the considered RS stipulated by external impacts from the final list of external impacts for identifying the most significant scenarios for which additional investigation is performed at the detailed analysis phase for specifying the obtained assessment.

41. Detailed analysis is performed for the external impact scenarios not excluded during screening analysis (major contribution to the cumulative probability of severe beyond design-basis accidents for each of the considered RS). The objective of this analysis shall be the reassessment of the cumulative probability of severe beyond design-basis accidents by reducing the level of conservatism included when performing screening analysis and getting realistic assessment of the cumulative probability of severe beyond design-basis accidents.

**VIII. Screening analysis of external impact scenarios**

42. Screening analysis shall be recommended to perform for all external impacts included in the final list of external impacts.

43. Screening analysis shall be recommended to start with the identification of the external impact scenarios (hereinafter the scenarios) during which the external impacts shall not lead to occurrence of IE. Such scenarios shall be recommended to exclude from further analysis.

44. Under this task it is recommended to identify scenarios which may be assessed as of low significance by contribution to the cumulative probability of severe beyond-design basis accidents. It is recommended to use simplified conservative assessment methods for assessment of the significance of scenarios.

45. The following conservative assumptions are recommended to use during the screening analysis of scenarios:

all the systems (components) subject to external impact with intensity exceeding the design values are damaged in such manner that the consequences of this damage are the worst from the point of view of increasing the cumulative probability of severe beyond design-basis accidents; provided that if several types of failures caused by external impact are possible, it is recommended to consider all the potential types of failures;

all possible spurious operations, caused by external impact take place; it is assumed that all the systems (components) in standby mode go into the worst state from the point of view of accident scenario development (for example, closed valve opens, and vice versa, motor does not start on origin of the requirement and starts if this start deteriorates the accident development scenario);

operating systems (elements) cease operation (for example, pumps, fans stop);

restoration of the initial state of systems (components) is impossible after spurious operation.

46. It is recommended to determine potential IE for each scenario. The occurrence of several IE is possible for one scenario. However the consideration of one IE is sufficient on the condition of justification of the worst consequences from the view point of possibility of nuclear fuel damage.

47. It is recommended to use the model of emergency sequences developed in level 1 NPP PSA for internal IE for simulation of scenarios. Consideration of specific features caused by external impact is recommended to made by imposition of specific boundary conditions. The use of ES models developed in level 1 NPP PSA for internal IE may be impossible when developing the external impact scenarios due to the requirements of considering the specifics of external impact consequences (multiple failures and spurious operations). In these cases it is recommended to develop new ES models on condition that the simulation principles and basic allowances accepted under performing level 1 NPP PSA for internal IE are saved. The structural flow chart of the process of making changes to the PSA model of NPP unit level 1 for considering the influence of external impacts is provided in Appendix 7 to this Safety Guide.

48. It is recommended to use the calculated analysis of external impact parameters executed under the safety justification of the NPP unit or prototype units when performing the screening analysis. It is recommended to justify the applicability of investigations for the analyzed unit when using the investigations made for the prototype units. If the required calculated analysis of the external impact parameters are not available it is recommended to execute them.

49. Assessment of the cumulative probability of severe beyond design-basis accidents during screening analysis is recommended to be made using software used for creating the PSA model of NPP unit level 1 for internal IE.

50. It is recommended to state the exclusion criteria of scenarios which do not require detailed analysis during the screening analysis. Examples of exclusion criteria at the screening analysis stage are given in item 3 of Appendix 6 to this Safety Guide.

51. Screening of scenarios (considering the recommendations of item 43 of this Safety Guide) for detailed analysis is recommended to perform based on the establishment of the fact of conformance/non-conformance of the scenario to the adopted exclusion criteria. If the scenario does not meet all the adopted exclusion criteria then this scenario shall be subject to consideration under detailed analysis.

52. The result of screening analysis are the following lists of scenarios:

scenarios excluded from consideration in accordance with the recommendations of item 43 of this Safety Guide;

scenarios with nuclear fuel damage, excluded in accordance with the adopted exclusion criteria of scenarios; lists of scenarios excluded from further analysis in accordance with each of the adopted exclusion criteria are made when using several exclusion criteria;

scenarios included in the assessment of cumulative probability of severe beyond design-basis accidents without performing detailed analysis;

scenarios selected for detailed analysis.

**IX. Detailed analysis of scenarios stipulated by external impacts**

53. The objective of this analysis of accident scenarios caused by external impacts is reassessment of the cumulative probability of severe beyond design-basis accidents by reducing the level of conservatism included when performing screening analysis and getting realistic assessments of the cumulative probability of severe beyond design-basis accidents.

54. The detailed analysis is made for all the scenarios selected for detailed analysis.

55. Lowering of the level of conservatism of scenarios is recommended to perform by specifying the following factors:

nomenclatures of systems (elements), failure thereof is stipulated by external impact;

loads on the systems (components) stipulated by external impacts;

performing analysis considering the possibility of operating personnel actions for control of alternative systems (elements) and considering the personnel actions for restoration of the systems (components).

56. It is recommended to be governed by item 47 of this Safety Guide for simulating the scenarios under the detailed analysis. Making changes to the logic and probabilistic model of the PSA is recommended to be made considering the specified factors related to external impact, failures of systems, human errors.

57. It is recommended to perform additional deterministic investigations for specifying the external impact scenarios.

Analysis of potential dependencies identified at the stage of performing individual tasks of external impact PSA is recommended to be made in accordance with the recommendations of items 99 - 103 of RB-024-11. It is recommended to determine the dependence of the occurrence probability (frequency) of external impact and failure probability of the system (component) from its intensity value if required.

**X. Analysis of uncertainty, sensitivity and significance**

58. Analysis of uncertainty, sensitivity and significance at the stage of performing individual tasks of external impact PSA is recommended to be made in accordance with the recommendations of items 119 - 127 of RB-024-11.

**XI. Analysis of the results of probability safety analysis of external impacts and assessment of the safety level of nuclear power plant unit**

59. Analysis of the results of PSA of external impacts and assessment of the safety level of NPP unit is recommended to be made in compliance with the recommendations of items 128 - 132 RB-024-11.

 APPENDIX No. 1

to the Safety Guide in the Use of Atomic Energy "Basic recommendations for development of a probabilistic safety analysis of level 1 for a nuclear power plant unit during initiating events stipulated by external impacts of natural and man-induced origin" approved by order No. 396 of the Federal Environmental, Industrial and Nuclear Supervision Service dated 28 August 2014.

**Abbreviations**

|  |  |
| --- | --- |
| HRA | - human reliability analysis |
| NP | - Nuclear Power Plant |
| ES | - emergency sequence |
| MCR | - main control room |
| PSA | - probabilistic safety analysis |
| FDP | - nuclear fuel (fuel element) damage probability |
| HEP | - human error probability |
| ASW | - air shock wave |
| IE | - initiating event |
| RS | - radioactive source |
| IAEA | - International Atomic Energy Agency |
| NF | - nuclear facility |
| TS | - toxic substance |
| CDF | - core damage frequency |

 APPENDIX No. 2

to the Safety Guide in the Use of Atomic Energy "Basic recommendations for development of a probabilistic safety analysis of level 1 for a nuclear power plant unit during initiating events stipulated by external impacts of natural and man-induced origin" approved by order No. 396 of the Federal Environmental, Industrial and Nuclear Supervision Service dated 28 August 2014.

**Terms and definitions**

**Probabilistic Safety Analysis of external impacts**  - probabilistic safety analysis of NPP unit level 1 performed for initiating events caused by natural and man-induced external impacts.

**Intensity of external impact** is the value of key parameter of external impact determining the force of this impact on the NPP facilities (earthquake intensity, maximum horizontal acceleration during earthquake, intensity of tornado, wind velocity, water level at the site etc.) expressed in dimensional and dimensionless quantities (points m/sec2, class, m/sec, m etc.).

**Load bearing capacity** is the property of the facility to withstand loads of various intensity of external and internal impacts.

**Repeatability of external impact of given intensity** is the quantitative characteristics of the periodicity of external impact occurrence.

**Frequency of external impact** is the ratio of the number of cases of occurrence of external impacts of the given type during a specific time interval to the specified time interval.

 APPENDIX No. 3

to the Safety Guide in the Use of Atomic Energy "Basic recommendations for development of a probabilistic safety analysis of level 1 for a nuclear power plant unit during initiating events stipulated by external impacts of natural and man-induced origin" approved by order No. 396 of the Federal Environmental, Industrial and Nuclear Supervision Service dated 28 August 2014.

**Recommended report contents of the PSA of external impacts**

**Chapter I. General information**

Information on characteristics of radioactive sources, operation states considered, tasks set, scope of surveys and tasks, performed under the PSA of external impacts are given in this chapter, and the main assumptions and limitations adopted in the analysis are stated.

The references to expert opinions confirming the quality of level 1 NPP PSA for internal IE which was used when performing the PSA of external impacts are recommended in this chapter.

1. Recommended sequence and mutual relation of PSA tasks of external impacts is given in Appendix 4 to the Safety Guide. Brief information in the deliverables about the NPP deployment site, reactor plant, monitoring and control of the unit, principal and emergency power supply systems, main equipment cooling systems and about the systems involved in the performance of safety functions is recommended to provide in the deliverables for the PSA of external impacts. References to the respective sources of more detailed information are recommended to be given.

2. It is recommended to provide brief characteristics of the procedures, manuals and software programs used for resolving all the tasks considered under the PSA of external impacts in the deliverables for the PSA of external impacts.

**Chapter II. Acquisition of information specific for the NPP unit**

3. It is recommended to provide all information about the NPP unit, which were used when performing the PSA of external impacts, in the deliverables for the PSA of external impacts. Initial data shall be provided in the scope required for assuring adequacy and completeness of the analysis.

4. It is required to provide references to the used information about NPP and performed analysis, results thereof were used when performing the PSA of external impacts when preparing initial data for the PSA of external impacts in the deliverables.

5. It is recommended to gather and use information in scope and content specified in Appendix 5 to this Safety Guide in the PSA of external impacts.

**Chapter III. Making a list of external impacts**

6. It is recommended to submit an analysis for identifying all possible external impacts and results of decision of this task namely the final list of external impacts.

7. It is recommended to provide the following lists of potential external impacts at the stage of analysis for making the list of external impacts.

basic list of external impacts (from Appendix 5 to this Safety Guide);

list of external impacts from other PSA;

list of external impacts, specific for the analysed NPP unit;

a list of external impact combinations;

a preliminary list of external impacts.

8. It is recommended to provide information about the used exclusion criteria of external events.

9. It is recommended to provide references to the sources of information, from where the sources of external impacts were taken for making the list of external impacts under the performed PSA.

10. It is recommended to provide description of the basic stages of analysis for formation of the final list of external impacts including the making of the complete list of external impacts from the considered list of external impacts, screening of external events based on qualitative and quantitative exclusion criteria, justify the use of one or another criteria for excluding external impacts and their combinations; analysis for determining the combinations of external impacts.

11. It is recommended to provide the combination matrix of external impacts, which was used when making the final list of external impacts.

12. In a separate sub-section of the chapter it is recommended to present the final list of external impacts, which shall be used during screening analysis of the scenarios of external impacts.

**Chapter IV. Assessment of the probabilities (frequencies) of external impacts**

13. It is recommended to provide detailed information about input data used for determining the probabilities (frequencies) of external impacts, including:

meteorological data in the NPP site area in the scope sufficient for justification of the frequency assessments of external impacts;

data on external impacts having taken place in the NPP site deployment area;

data on external impacts having taken place at the territories outside the NPP site, if data not available about the external events having taken place at the considered NPP site (it is recommended to justify the expediency and justification of the use of specified data).

14. It is recommended to present the assessment results of the probabilities (frequencies) of external impacts in accordance with the recommendations for the PSA task of external impacts "Assessment of probabilities (frequencies) of external impacts".

15. It is recommended to present the main stages of analysis for assessment of the frequencies of external impacts and their combinations included in the final list of external impacts.

16. It is recommended to provide references to the procedures used for statistical processing of information during assessment of the frequencies of external impacts and construction of the dependencies of probabilities (frequencies) of external impacts.

17. It is recommended to present the results of construction of the dependence of external impact probabilities (frequencies) and probabilities of system (element) failure based on their intensities.

**Chapter V. Reliability analysis for personnel**

18. It is recommended to present the results of human reliability analysis in the PSA deliverables of external impacts, including: brief description of the HRA procedure used, the list of considered human errors and their identifiers, results of the analysis for screening of human errors, results of the analysis for determination of the HEP, results of analysis for assessing the dependences of human errors.

19. It is recommended to present the basic list of human actions and the list of actions obtained following the analysis of additional scenarios related to external impacts in the PSA deliverables of external impacts.

20. It is recommended to present the results of the final HRA for the PSA of external impacts considering the influence of factors stipulated by the external impact on personnel actions.

21. It is recommended to present the assessment results of the probabilities of performing personnel actions which are used in the PSA of external impacts.

22. It is recommended to present the analysis of dependent human errors and results of their assessment.

**Chapter VI. Analysis of external impact scenarios**

23. It is recommended to present the following during the analysis of external impact scenarios:

screening analysis of external impact scenarios;

detailed analysis of external impact scenarios.

**Chapter VII. Screening analysis of scenarios stipulated by external impacts**

24. It is recommended to submit the description of the basic stages of screening analysis of external impacts in the PSA deliverables of external impacts, as well as its results in accordance with the recommendations for performing the PSA task "Screening analysis of external impacts".

25. It is recommended to submit the results of screening analysis made for all external impacts included in the final list of external impacts.

26. It is recommended to submit information about the adopted exclusion criteria for performing screening analysis.

27. It is recommended to submit justification of external impacts exclusion specifying the criteria in accordance thereof the external impacts were excluded.

28. It is recommended to submit the following results of screening analysis:

scenarios that do not lead to occurrence of IE;

scenarios with nuclear fuel damage, excluded from further analysis in accordance with the adopted exclusion criteria of scenarios; lists of scenarios excluded from further analysis in accordance with each of the adopted exclusion criteria are presented when using several exclusion criteria; core damage frequency stipulated by the excluded scenarios is included in the general assessment of CDF.

scenarios included in the assessment of cumulative probability of severe beyond design-basis accidents without performing detailed analysis;

scenarios selected for detailed analysis.

29. It is required to provide substantiation of the external impact exclusion based on qualitative and quantitative exclusion criteria and/or references to the documents confirming the justification of external impacts exclusion from further consideration.

**Chapter VIII Detailed analysis of scenarios stipulated by external impacts**

30. It is recommended to submit all investigations made under the detailed analysis of external impacts and its results in the deliverables for PSA of external impacts.

31. It is recommended to submit the logical models and results of probabilistic analysis of accident scenarios for IE developed at the detailed analysis stage caused by external impacts.

32. It is required to provide the changes made to the PSA model of level 1 for internal IE stipulated by an external impact:

specific peculiarities of scenarios development;

change of equipment failure probabilities;

change of human error probabilities;

additional accident scenarios, NPP equipment failures and human error.

33. It is recommended to submit the brief results of calculation and other investigations from different sources of information used in the detailed analysis and results of investigations made under the detailed analysis in the deliverables for the PSA of external impacts.

**Chapter IX. Analysis of uncertainty, sensitivity and significance**

34. It is recommended to provide the results of analysis of uncertainty, sensitivity and significance in the deliverable for the PSA of external impacts.

**Chapter X. Analysis of the results of probability safety analysis of external impacts and assessment of the safety level of nuclear power plant unit**

35. It is recommended to provide recommendations for improving the safety level of NPP unit developed based on PSA of external impacts and probabilistic assessments of their efficiency, including engineering and organizational measures in the deliverables for the PSA of external impacts.

APPENDIX No. 4
to the Safety Guide in the Use of Atomic Energy "Basic recommendations for development of a probabilistic safety analysis of level 1 for a nuclear power plant unit during initiating events stipulated by external impacts of natural and man-induced origin" approved by order No. 396 of the Federal Environmental, Industrial and Nuclear Supervision Service dated 28 August 2014.

**Recommended sequence and mutual relation of the PSA tasks of external impacts**

|  |
| --- |
| Accumulation of information specific for the NPP unit |
|  |
| Making a list of external impacts |
| Development of the preliminary list of external impacts |
|  |
| Development of exclusion criteria of external impacts from the preliminary list |
|  |
| Development of the final list of external impacts |
|  |
| Assessment of the external impact frequencies and construction of the dependencies of external impact probabilities (frequencies) on their intensity |
|  |
| Screening analysis of external impacts |
| Development of exclusion criteria of external impacts from the detailed analysis |
|  |
| Screening analysis of external impact scenarios |
|  |
| Detailed analysis of external impact scenarios |
|  |
| Analysis of uncertainty, significance and sensitivity.Analysis and submission of the PSA results of external impacts |

 APPENDIX No. 5

to the Safety Guide in the Use of Atomic Energy "Basic recommendations for development of a probabilistic safety analysis of level 1 for a nuclear power plant unit during initiating events stipulated by external impacts of natural and man-induced origin" approved by order No 396 of the Federal Environmental, Industrial and Nuclear Supervision Service
dated 28 August 2014.

**Suggested list of input data required for performing the PSA of external impacts**

| **External impact and impact damage effects** | **Required information** | **Characteristics under review** | **Source of information and nomenclature of considered facilities** |
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| **Impact facilities** | **Information for performing the screening analysis** | **Information for performing the detailed analysis** |  |  |
| **External impacts of man-induced origin** |
| Aircraft crash or other missiles:shock impact;fuel spillage;entry of fuel inside containment;accompanying fires and explosions;soil vibration | The NPP buildings and structures.NPP operating personnel.OSG | Distance from NPP to airport, air routes, military facilities and ranges.Shock impact parameters:physical characteristics ofcolliding bodies; body weight;impact velocity; angle of the impact with the structure;impact direction;impact area; application point.Fuel weight.Design basis of NPP protection against aircraft crash | Probability of fall of object in to the building or structure containing equipment important for safety.Probabilistic characteristics of impact caused by fall of object in to the NPP building or structure.Probabilistic analysis of the stability of NPP buildings and structures.Probability of preventing the propagation of consequences related to the aircraft crash (fire, flooding, smoke formation, gas contamination).The NPP PSA model for internal IE | Cumulative probability of severe beyond design-basis accidents due to destruction of individual NPP buildings and structuresNote:Core damage is assumed on impossibility to prevent mass distribution of the consequences  | Information of location of airports and air corridors, intersection of air routes in the NPP deployment area, at a radius of 50 km from the power unit site.Information on air traffic types, types and characteristics of aircraft, frequency of flights.Schemes of aircraft take-off, landing and parking.Information on the presence within the NP exposure zone of military objects or bombing grounds in use.Information on the types of any potential missiles, their characteristics and hazard occurrence probability (frequency).Archive data on airplane crashes |
| Explosion at the facility: air shock wave, missiles, smoke, gas, dust, accompanying fires, ground motion | The NPP buildings and structures.NPP operating personnel.OSG | Distance from the sources of potential explosions to the NPP buildings and structures.Volumes, weights of toxic substances.Rated concentration of explosion hazardous gas near the impact facility.Gauge pressure in the air shock wave front.Trinitrotoluene-equivalent.Ignition source power.Design characteristics of the stability of NPP buildings and structures | Probabilistic characteristics of pressure in ASW front.Probability of explosive cloud drift in the direction towards NPP siteProbabilistic characteristics of rated concentration of explosive materials.Probability of cloud ignition. Probabilistic characteristics of stability of NPP buildings and structures.The NPP PSA model for internal IE | Damage probability of NPP buildings and structures.Cumulative probability of severe beyond design-basis accidents | Information on presence of any potential stationary and mobile explosion sources in the nuclear facility deployment site and at the nuclear facility site:warehouses and storage facilities for explosive substances within the radius of 10 km;any enterprises where hazardous technologies are applied, process-related explosions are possible and also any pressurized vessels or high-pressure plants with gases, vapors and other liquids are installed within the radius of 5 km;motorways and railways, water communications, including the roads used at the NPP site with indication of transported explosive substances and transportation vehicles within the radius of 5 km;oil and gas main pipelines, product pipelines, process equipment or pipelines for flammable gases or highly flammable liquids that can become a source of leakage resulting in formation of clouds of explosion- and fire-hazardous mixtures within the radius of 7 km;military facilities within the radius of 30 km.Information on reserves of explosives. Archived and statistical data on any explosions near the nuclear facility siteGeological conditions in the NPP area and deployment site.Meteorological conditions.Hydrological conditions.Map of external sources of explosions in relation to the NPP site.Diagram of external (in relation to the nuclear reactor, fuel pool etc.) sources of explosions at the NPP deployment site |
| Discharge of explosive, flammable and toxic vapors, gases and aerosols into the atmosphere, drifting cloud explosion: air shockwave; missiles;fume, gas, dust; related fires;soil vibration | The NPP buildings and structures.NPP operating personnel.OSG | Distances from the sources of potential discharges.Volumes, weights of discharged substances.Initial concentration at the place of discharge.Dispersion of discharges in the atmosphere.Concentration from primary sources and secondary effects of injury as a function of time considering standard intake and release of airDischarge duration.Design characteristics of the stability of NPP buildings and structures | Probability of explosive cloud drift in the direction towards NPP siteProbabilistic characteristics of the design concentration of explosive, inflammable vapors, gases and aerosols at the power unit site.The NPP PSA model for internal IE | Damage probability of NPP buildings and structures.Cumulative probability of severe beyond design-basis accidents | Information on availability of sources of potential explosive inflammable vapor, gas and aerosol discharges in a 7 km radius and at the NPP location site.Transportation diagrams of potential sources of emission of explosive, inflammable vapors, gases and aerosols.Information on potential scopes of discharge of explosive, inflammable vapors, gases and aerosols.Archived and statistical data on discharges of explosive, inflammable vapors, gases and aerosols in the NPP location area.Meteorological conditions at the NPP location area |
| Discharges of toxic vapors, gases and aerosols into the atmosphere.Increase of concentration of toxic gases and aerosols | NPP operating personnel | Distances from the sources of potential discharges of toxic substances to the air intake chambers of MCR.Volumes, weights of toxic substances.Design-basis of NPP protection against toxic substances.Critical concentration of toxic substances for NPP personnel | Probability of toxic cloud drift in the direction towards NPP site.Probabilistic characteristics of design concentration of toxic substances at the power unit site.Probabilistic characteristics of toxic substance concentration at MCR.Accounting model of the factors influencing the personnel behavior related to appearance of toxic substances at MCR.The NPP PSA model for internal IE | Cumulative probability of severe beyond design-basis accidents due to toxic substances impact on NPP personnel | Information on availability of stationary and mobile sources of potential toxic substances discharges within a 7 km radius and at the NPP location site:storages, repositories, vehicles;enterprises where hazardous technologies are used and damage of vessels containing toxic substances are possible;motor and rail roads, water transport specifying information about the transported toxic substances;military facilities.Toxic substances transportation diagrams.Information on reserves of toxic substances at the NPP territory.Historical and static data about discharges of toxic substances at the NPP location area.Meteorological conditions at the NPP location area |
| Corrosive and toxic liquid discharges into surface and ground waters.Corrosive precipitation fallout on the facility.Entry of corrosive liquid into the water cooling subsystem from the places of water intake; entry of corrosive medium into the air intake assemblies of the NPP | The NPP equipment.NPP operating personnel | The distance to the NPP.Power of the source of corrosive and toxic substances.Availability of flows and possibility of entry of corrosive and toxic substances into the water pools vital for the NPP safety assurance.Initial concentrationConcentration of corrosive media interacting with the NPP systems as a function of time and distance.Duration of exposure.Critical concentration of corrosive and toxic substances for the NPP equipment and personnel | Probability of entering of corrosive and toxic substance to the water pools assuring safety and functional capability of the NPP.Probabilistic characteristics of the rated concentration of corrosive and toxic substances.Probabilistic characteristics of the concentration of corrosive and toxic substances in the water pools ensuring the NPP safety.The NPP PSA model for internal IE | Cumulative probability of severe beyond design-basis accidents due to impact of corrosive and toxic substances on the NPP equipment | Information on the presence in the nuclear facility area and deployment site of industrial enterprises using chlorine, hydrogen sulfide, ammonia, sulfur dioxide and other chemically active substances, and places of chemically active discharges from these production facilities.Relocation diagrams of mobile corrosive and toxic hazard sources.Information on reserves of chemical and polluting substance around the NPP territory.Information on reserves of chemical and polluting substances at the NPP territory.Information on possible volumes of effluents (discharges).History and statistical data on discharges.Hydrological conditions.Meteorological conditions.Data on relief, availability of flows, hydrological features |
| Spill of oil and oil products on the coastal surfaces of the rivers, seas and oceans:contamination of equipment heat exchange surfaces;secondary fires and fires;corrosion exposure | The NPP equipment.NPP buildings and structures | Spill area and film thickness.Chemical composition.The distance to the NPP.Distance to the NPP water intake point.Heat flux in the source of fire and nature of its change in the direction to the NPP.Concentration of oils and petroleum at the NPP water intake point | Probability of entering of oils and petroleum products to the water pools assuring safety and functional capability of the NPP.Probabilistic characteristics of the rated concentration of oils and petroleum products.Probabilistic characteristics of the concentration of oils and petroleum products in the water pools ensuring the NPP safety.Occurrence probability of secondary firesThe NPP PSA model for internal IE | Cumulative probability of severe beyond design-basis accidents due to impact of oils and petroleum products, secondary fires on the NPP equipment | Information on the presence in the NPP facilities location area on the banks of rivers, seas and oceans, which may contain petroleum products and oils, on the passage of routes of ships, motor roads and rail roads.Information on possible volumes of spillage of oils and petroleum products.Sizes of the potential stains of contamination of coastal surfaces of rivers, seas and oceans (archival data and statistics).Meteorological conditions.Hydrological dispersion of impurities on the near shore surfaces of rivers, seas and oceans |
| Fire due to external reasons:high temperature;smoke;toxic products (pollutants);combustion of pyrolytic decomposition;reduced oxygen concentration | The NPP buildings and structures.The NPP equipment.NPP operating personnel | Equivalent surface area affected by the fire.Heat flux in the source of fire and its changes towards the NPP power unit.Distance from the NPP power unit, its buildings and structures.Wind velocity and direction.Design-basis of the NPP safeguard against external fires | Probability of a fire breakout.Probability and speed of fire propagation in the direction of the NPP.Probability of fire damage of the NPP buildings and structures, overhead transmission lines and the NPP equipment.The probability model of performing actions by the NPP personnel for preventing consequences of IE.The NPP PSA model for internal IE | Cumulative probability of severe beyond design-basis accidents due to damage of buildings, structures, overhead transmission lines caused by fire. | Information on presence of any external fire hazard sources in the NPP location site and on the site within the radius of 2 km:forestation;warehouses for explosive materials (solid, liquid and gaseous);product pipelines and oil and gas manifold pipelines;railroads and motor roads, navigable rivers and sea routes;aerodromes, air communication and transportation lines;residential areas;industrial enterprises (with specification of the category of buildings and outdoor process installations, sites in terms of fire and explosion hazard);coal and turf production; sites and areas of turfaries;surface of water areas with indicated film of oil and other oil products.Archived and statistical data on fires and their causes in the NPP area and at the NPP location site for at least 5 recent years.Information on reserves of combustible materialsMeteorological conditions.Hydrological conditions |
| Breaking of natural and man-made water reservoirs:flooding of NPP equipment;damage of shore facilities;flooding of the area;washing of the watercourses bed;dynamic impact | NPP systems (components), buildings and structuresBank reinforcement | Elevations of NPP buildings, structures and bank reinforcements.Data on location of reservoirs.Breakthrough wave height and speed in the nuclear facility deployment area.Absolute elevation of level and duration of flooding of the territory at a combination of unfavorable factors including extreme levels of spring tide or rainfall flood in the watercourse within the NPP location area with due regard for the reservoir breakage wave heightDesign safeguard basis of buildings and structures against flooding on breaching of reservoirs.Design characteristics of wave caused by damage of reservoirs in high water level conditions in high water | Probabilistic characteristics of water level change in high water periods on damage of dams.Probabilistic characteristics of the stability of reservoir enclosing structures.Probabilistic characteristics of reliability of hydraulic engineering structures under external impacts of natural and human-induced origin.The NPP PSA model for internal IE | The cumulative probability of severe beyond design-basis accidents due to flooded equipment failure  | Atlas of deployment of water reservoirs and NPP.Topographic maps and plans, bathymetric and climate maps.Data on seismicity of the region.Surface water resources.Hydrological annual books. Archived data.Results of hydrological monitoring.Historical data in breakthroughs of water reservoirs.Statistical data obtained through processing of hydro- meteorological information for a long-term period (not less than 50 years), which contains sets of annual parameter values and peaking data.Data collected within, at least, one year in the area surrounding the NPP site. The sizes of such areas shall be sufficient to take account of all regional features and factors affecting climatic conditions of the given region.Observation data obtained through standard hydro-meteorological survey programs, which provide for hourly measurements performed on hydrological stations and posts in immediate proximity to the NPP deployment site.Data on annual water level measurement in the upstream reach.Statistical estimates of the maximum water storage in the upstream reach |
| Destruction of the separation dam:loss of heat removal in process water pool | EquipmentNP | Design characteristics of NPP safeguard on damage of separating dike dam | Probabilistic characteristics of the stability of reservoir boundariesProbability model of performing actions by the NPP personnel for preventing consequences of dike dam damage.The NPP PSA model for internal IE | Cumulative probability of severe beyond design-basis accidents due to loss of heat removal in the process water pool | Measurement results of temperature differential for different elevations of the process water pool.Data on condition of hydraulic structures.Geometric, drainage and heat removal characteristics of process water pool |
| Destruction of the levee:loss of process water pool | The NPP equipment | Minimum level and volume in the process water pool providing the possibility of safe unit shutdown.Design basis of NPP safeguard on reduction of level in the storages of water.Design basis for assuring integrity of damming up | Probabilistic characteristics of the stability of levee boundaries.Probability model of performing actions by the NPP personnel for preventing consequences of dike dam damage.The NPP PSA model for internal IE | Cumulative probability of severe beyond design-basis accidents due to loss of process water pool | Data on condition of hydraulic structures.Geometric, drainage and heat removal characteristics of process water pool |
| Electromagnetic impulses and emissions:electromagnetic disturbances; interruptions;spurious operation | The NPP equipment | Intensity of electrical and magnetic fields.Design characteristics of NPP equipment and personnel protection against electromagnetic impulses and radiation | Probabilistic characteristics of the intensity of atmospheric electric field (lightning energy).Probability of damage of control, monitoring and measuring systems due to electromagnetic impulses.The NPP PSA model for internal IE | Cumulative probability of severe beyond design-basis accidents due to the NPP equipment failure caused by lightning strikes. | Information about the presence of enterprises, military and other facilities characterized by electromagnetic radiation and associated with the production and use of electromagnetic fields in the NPP deployment area.Special information on power of sources.Information system content |
| Diffusion of emissions from  industrial enterprise in the NPP site atmosphere:smoke;toxic substances | Service personnel | Repeatability of wind directions and windless conditions and average wind speeds in 16 rhumbs at the height of 100 and 200 m.Average values of the mixed layer height at different categories of atmospheric stability (based on observation data.Roughness parameter of underlying surface and terrain that surrounds the NPP.Joint recurrence of wind velocities and directions in 16 rhumbs at heights 100 and 200 m at different categories of atmospheric stability | Probabilistic characteristics of the atmospheric emissions of industrial enterprises.The NPP PSA model for internal IE | - | Information on availability of enterprises being the sources of atmospheric emissions at the NPP deployment area |
| Interaction between the systems:missiles;explosions;fires | The NPP equipment | Design characteristics of NPP equipment protection against intersystem interactions | Probability of damagPe of moving (rotating) pressurized mechanisms and vessels.Probability of system equipment damage by hard missiles and high pressure fluid jets.The NPP PSA model for internal IE | Cumulative probability of severe beyond design-basis accidents due to NPP equipment failure caused by hard missiles and jets | NPP P&ID.Routing of NPP pipelines.Data on mutual deployment of NPP equipment |
| **Impact caused by hydro-meteorological processes and phenomena** |
| Lightning strikes:Impact of electromagnetic field;Impact of electrical discharge;inflammation | Buildings, constructions, networks, equipment | Average and highest number of stormy days.Specific density of lightning strikes for 1 km2 Earth surface at the facility deployment area.Frequency of strong lightning discharges at the NPP area.Design characteristics of lightning arresters of the NPP buildings, structures and equipment | Probabilistic characteristics of the intensity of atmospheric electric field (maximum lightning energy).Probability of loss of power caused by lightning strikes.Probability of damage of control, monitoring and measuring systems due to electromagnetic impulses.The NPP PSA model for internal IE | Cumulative probability of severe beyond design-basis accidents due to equipment failure caused by lightning strikes. | Topographic and climatic maps.Historical data. Surface water resources. Hydrological year-books.Witness reports. Archived data. Hydrological monitoring.Statistical data obtained through processing of hydro- meteorological information for a long-term period (not less than 50 years), which contains sets of annual parameter values and peaking data.Systematic data collected within, at least, one year in the area surrounding the site. The sizes of such areas shall be sufficient to take account of all regional features and factors affecting climatic conditions of the given region.Measurement data obtained through standard hydro- meteorological survey programs, which provide for hourly measurements performed directly at the proposed site.Climate reference books. Climate monthly and yearly books.Aerial and meteorological monitoring |
| Flood or water logging at the site:NPP site submergence;equipment flooding;hydrochemical impact;dynamic impact | NPP buildings and constructions | Maximum flow rates and water levels of watercourses in the area of location of the facility for different probability levels, including 0.01%.Hydrographs of rain floods and spring flood of watercourses in the area of the facility.Absolute elevation of the site over-flooding (underflooding) level.Water flow speed.The assessment of water level rise at the site should be estimated for such phenomena as extreme high water or rain floods, extreme precipitations, ice jams and congestion on watercourses, .the possibility of flooding shall be substantiated based on the calculation of the water level during flood and (or) rise of the groundwater level;results of impact assessments of high water level, peak water flow due to precipitation, ice jams, breakthrough of water reservoirs.Elevations of NPP buildings, structures and bank reinforcements.Design basis for safeguard of NPP buildings and structures against flooding | Probabilistic characteristics of water level change during periods of floods or water logging.The NPP PSA model for internal IE | The cumulative probability of severe beyond design-basis accidents due to flooded equipment failure  | Topographic and climatic maps.Historical data on floodings.Statistical data obtained through processing of hydro- meteorological information for a long time period (not less than 50 years), which contains sets of annual parameter values and peaking data.Systematic data collected within, at least, one year in the area surrounding the NPP site. The sizes of such areas shall be sufficient to take account of all regional features and factors affecting climatic conditions of the given region.Measurement data obtained through standard hydro-meteorological observation programs with hourly measurements directly at the NPP site.Climate reference books. Climate monthly and yearly books.Aerial and meteorological monitoring |
| High water level in water poolsNPP site submergence;equipment flooding;hydrodynamic impact | NPP buildings and structures | Elevations of revetments.Design basis of revetments safeguard | The probability model of performing actions by the NPP personnel for preventing consequences of IE.Probabilistic characteristics of the damage of revetments depending on the water level in the water pool.The NPP PSA model for internal IE | Cumulative probability of severe beyond design-basis accidents due to equipment failure caused by loss of process storages of water | Topographic and climatic maps.Historical data on floodings.Statistical data obtained through processing of hydro- meteorological information for a long time period (not less than 50 years), which contains sets of annual parameter values and peaking data.Systematic data collected within, at least, one year in the area surrounding the NPP site. The sizes of such areas shall be sufficient to take account of all regional features and factors affecting climatic conditions of the given region.Measurement data obtained through standard hydro-meteorological observation programs with hourly measurements directly at the NPP site.Climate reference books. Climate monthly and yearly books.Aerial and meteorological monitoring |
| Tides:flooding of buildings and constructions;loss of cooling water |  | Extreme amplitude of tide and ebb fluctuations.Absolute elevation of area overflooding level.Absolute elevation of coastal area dereliction level.Elevations of NPP buildings, structures and bank reinforcements.Design characteristics for safeguard of NPP buildings and structures against flooding | Probabilistic characteristics of tide level change.The NPP PSA model for internal IE | Cumulative probability of severe beyond design-basis accidents due to flooded equipment failure or loss of cooling water | Topographic and climatic maps.Historical data. Surface water resources. Hydrological year-books.Witness reports. Archived data. Hydrological monitoring.Statistical data obtained through processing of hydro- meteorological information for a long-term period (not less than 50 years), which contains sets of annual parameter values and peaking data.Systematic data collected within, at least, one year in the area surrounding the site. The sizes of such areas shall be sufficient to take account of all regional features and factors affecting climatic conditions of the given region.Measurement data obtained through standard hydro- meteorological survey programs, which provide for hourly measurements performed directly at the proposed site.Climate reference books. Climate monthly and yearly books.Aerial and meteorological monitoring |
| Near shore zone mode of seas (set down, pile ups, storm waves, change of shore line, submergence of the NPP site):submergence of the NPP deployment site; dynamic impact on hydraulic engineering structures;flowing around obstacles and through structures | NPP buildings, structures and revetments | Rated maximum characteristics of storm wave (height, length, wave period, level of wave top at the point of downfall, the depth of the wave downfall, maximum height of wave run-up after the downfall) of different probabilities including 0.01%.Absolute elevation of the area over-flooding level at run-up of storm waves onto the shore.Absolute elevation of shoreline dereliction at recession of storm waves.Flooding area.Dynamic impact of flooding from storm | Probabilistic characteristics of the change of coastal zone regime.The NPP PSA model for internal IE | Cumulative probability of severe beyond design-basis accidents due to equipment failure  | Topographic and climatic maps.Historical data. Surface water resources. Hydrological year-books.Witness reports. Archived data. Hydrological monitoring.Statistical data obtained through processing of hydro- meteorological information for a long-term period (not less than 50 years), which contains sets of annual parameter values and peaking data.Systematic data collected within, at least, one year in the area surrounding the site. The sizes of such areas shall be sufficient to take account of all regional features and factors affecting climatic conditions of the given region.Measurement data obtained through standard hydro- meteorological survey programs, which provide for hourly measurements performed directly at the proposed site.Climate reference books. Climate monthly and yearly books.Aerial and meteorological monitoring |
| Near shore zone mode of the seas when combined with unfavorable factors (inflows and outflows, set down, pile up, storm waves, seiches, tsunami):equipment flooding;dynamic damages of buildings and structures, revetments | NPP buildings, structures and revetments | Absolute elevation of area flooding level at combination of unfavorable factors (tides, onsets, storm waves, seiches, tsunamis, etc.)Absolute elevation of coastal strip dereliction level at combination of unfavorable factors (ebbs, offsets, storm waves, seiches, tsunamis)For such phenomena as offset and onset of water, storm waves in the coastal zone, tsunamis, seiches, tides and ebbs, it is required to use the assessment results of the rise or fall of the water level at the site. calculation results of high water level of different probability, including 0.01%, following seiches, tsunami, waves, inflows, breakthroughs of water reservoirs and other phenomena;calculation results of water level decrease of different probability, including 99.99% following seiches, tsunami, waves, negative setups, ebb tides and other phenomena.Elevations of NPP buildings, structures and bank reinforcements.Design basis for safeguard of NPP buildings and structures against flooding | Probabilistic characteristics of water level change.The NPP PSA model for internal IE | The cumulative probability of severe beyond design-basis accidents due to flooded equipment failure  | Topographic and climatic maps.Historical data. Surface water resources. Hydrological year-books.Witness reports. Archived data. Hydrological monitoring.Statistical data obtained through processing of hydro- meteorological information for a long-term period (not less than 50 years), which contains sets of annual parameter values and peaking data.Systematic data collected within, at least, one year in the area surrounding the site. The sizes of such areas shall be sufficient to take account of all regional features and factors affecting climatic conditions of the given region.Measurement data obtained through standard hydro- meteorological survey programs, which provide for hourly measurements performed directly at the proposed site.Climate reference books. Climate monthly and yearly books.Aerial and meteorological monitoring |
| Seiches:Deployment site flooding | NPP buildings and structures | Parameters of wind load leading to occurrence of critical seiche.Maximum amplitude of fluctuations in the water level of the water reservoir at seiches.Absolute elevation of area overflooding level.Elevations of NPP buildings, structures and bank reinforcements.Design basis for safeguard of NPP buildings and structures against flooding | The NPP PSA model for internal IE | The cumulative probability of severe beyond design-basis accidents due to flooded equipment failure  | Topographic and climatic maps.Historical data. Surface water resources. Hydrological year-books.Witness reports. Archived data. Hydrological monitoring.Statistical data obtained through processing of hydro- meteorological information for a long-term period (not less than 50 years), which contains sets of annual parameter values and peaking data.Systematic data collected within, at least, one year in the area surrounding the site. The sizes of such areas shall be sufficient to take account of all regional features and factors affecting climatic conditions of the given region.Measurement data obtained through standard hydro- meteorological survey programs, which provide for hourly measurements performed directly at the proposed site.Climate reference books. Climate monthly and yearly books.Aerial and meteorological monitoring |
| Tsunami:temporary rise of water level in the coastal area;NPP site submergence;wave dynamic impact;temporary decrease of the water level in the coastal area | NPP buildings and constructions | Tsunami wave height.Maximum positive amplitude of tsunami wave.Maximum negative amplitude of tsunami wave.Elevations of water rise and lowering height (uprush of tsunami to the shore and drying of shore strip during back draft of tsunami wave) of different probability of recurrence, including once in 10000 years.Dynamic impact parameters of tsunami wave.Design basis for safeguard of NPP buildings and structures against flooding | The NPP PSA model for internal IE | The cumulative probability of severe beyond design-basis accidents due to flooded equipment failure  | Topographic and climatic maps.Historical data. Surface water resources. Hydrological year-books.Witness reports. Archived data. Hydrological monitoring.Statistical data obtained through processing of hydro- meteorological information for a long-term period (not less than 50 years), which contains sets of annual parameter values and peaking data.Systematic data collected within, at least, one year in the area surrounding the site. The sizes of such areas shall be sufficient to take account of all regional features and factors affecting climatic conditions of the given region.Measurement data obtained through standard hydro- meteorological survey programs, which provide for hourly measurements performed directly at the proposed site.Climate reference books. Climate monthly and yearly books.Aerial and meteorological monitoring |
| Watercourse icing (ice jams, ice gorges):NPP site submergence;equipment flooding;loss of water sources;dynamic impact during occurrence of a breakthrough wave | NPP buildings and constructions | Absolute elevation of area overflooding level.Dynamic impact of flooding caused by ice jams and gorges.Ice thickness.Dimensions of individual ice blocks.Speed of ice blocks.Angle of approach of ice blocks to the shore.Width and extension of ice jams and gorges.Probability of formation of ice jams and gorges.Dates of onset of ice phases.Minimum level and volume in the process storages of water providing the possibility of safe unit shutdown.Cushion of time before the onset of critical ice level in the process reservoirs.Design basis for safeguard of NPP on ice layer formation in the reservoirs. | Probability model of performing actions by NPP personnel for preventing consequences of impact.The NPP PSA model for internal IE | Cumulative probability of severe beyond design-basis accidents due to equipment failure caused by loss of process storages of water | Topographic and climatic maps.Historical data. Surface water resources. Hydrological year-books.Witness reports. Archived data. Hydrological monitoring.Statistical data obtained through processing of hydro- meteorological information for a long-term period (not less than 50 years), which contains sets of annual parameter values and peaking data.Data collected within, at least, one year in the area surrounding the NPP site. The sizes of such areas shall be sufficient to take account of all regional features and factors affecting climatic conditions of the given region.Measurement data obtained through standard hydro- meteorological survey programs, which provide for hourly measurements performed directly at the proposed site.Climate reference books. Climate monthly and yearly books.Aerial and meteorological monitoring.Instructions for the NPP personnel actions in conditions of ice phenomena |
| Tornado:extreme wind load;loads from the pressure drop between the periphery and the center of the whirl;water carryover from cooling process water pools; equipment flooding | NPP buildings and constructions | Rated intensity class of tornado is per Fujita scale.Length/width of movement path (route)Maximum horizontal speed of tornado wall rotational movement.Tornado travel speed.Pressure difference between the periphery and the funnel rotation center.Pressure drop rate.Rate of water removal from process cooling pond.Tornado occurrence frequency.Characteristics caused by tornado of fragments of buildings and structures, hard missiles etc.Values of coefficients of pressure pattern and distribution on flat surfaces and round structures of the type of containment.Combination of loads at the most unfavorable impact of tornado on the structure.Design-basis of NPP protection against tornadoes. Design characteristics of the stability of NPP buildings and structures for wind loads | Probabilistic stability characteristics of NPP buildings and structures as function of wind load.Probabilistic characteristics of wind loads on NPP buildings and structures. Probabilistic characteristics of load from air pressure drop. Probabilistic characteristics of load from hard missiles. Probability of water removal from process cooling water pools. Probability of wave occurrence caused by tornado leading to flooding of NPP safety-related buildings and structuresThe NPP PSA model for internal IE | Damage probability of individual NPP buildings and structures.Cumulative probability of severe beyond design-basis accidents due to equipment failure, caused by damage of NPP buildings and structures.Cumulative probability of severe beyond design-basis accidents due to equipment failure caused by water loss in process storages of water | Topographic and climatic maps.Historical data. Surface water resources. Hydrological year-books.Witness reports. Archived data. Hydrological monitoring.Statistical data obtained through processing of hydro- meteorological information for a long-term period (not less than 50 years), which contains sets of annual parameter values and peaking data.Systematic data collected within, at least, one year in the area surrounding the site. The sizes of such areas shall be sufficient to take account of all regional features and factors affecting climatic conditions of the given region.Measurement data obtained through standard hydro- meteorological survey programs, which provide for hourly measurements performed directly at the proposed site.Climate reference books. Climate monthly and yearly books.Aerial and meteorological monitoring |
| Wind, hurricane:wind pressure;missiles | Buildings and structures | Maximum observed wind speed.Rated maximum wind speeds of various occurrence including 0.01% (repeatability once in 10000 years).Estimated maximum wind speeds by altitude from 10 m to the effective height of the rise of emission into the atmosphere, the recurrence intervals of the maximum wind speed and gust coefficients.Wind loads,wind loads, structural vibration form coefficients, distribution of wind pressure along the height of structures (in this case, methods are described for converting wind speed into effective pressure on the wind-facing surfaces of structures).Recurrence of wind directions (wind rose) for a height of 10 m above the ground.Design-basis of NPP protection against strong wind.Design stability characteristics of NPP buildings and structures for potential wind loads | Probabilistic characteristics of wind loads on NPP buildings and structures. Probabilistic characteristics of load from missilesProbabilistic stability characteristics of NPP buildings and structures as function of wind load.Damage probability of individual NPP buildings and structures. The NPP PSA model for internal IE | Cumulative probability of severe beyond design-basis accidents due to equipment failure, caused by damage of NPP buildings and structures | Topographic and climatic maps.Historical data. Surface water resources. Hydrological year-books.Witness reports. Archived data. Hydrological monitoring.Statistical data obtained through processing of hydro- meteorological information for a long-term period (not less than 50 years), which contains sets of annual parameter values and peaking data.Systematic data collected within, at least, one year in the area surrounding the site. The sizes of such areas shall be sufficient to take account of all regional features and factors affecting climatic conditions of the given region.Measurement data obtained through standard hydro- meteorological survey programs, which provide for hourly measurements performed directly at the proposed site.Climate reference books. Climate monthly and yearly books.Aerial and meteorological monitoring |
| Snow storms:choking of air intake chambers;Loss of cooling in the NPP rooms | NPP air intake chambers.The NPP personnel | Design-basis of NPP protection against snow storms | Probability of clogging of air intake devices. Probability of loss of cooling of NPP rooms on choking of air intake chambers. The probability model of performing actions by the NPP personnel for preventing consequences of IE. The NPP PSA model for internal IE | Cumulative probability of severe beyond design-basis accidents due to NPP equipment failure caused by ES | Topographic and climatic maps.Historical data. Surface water resources. Hydrological year-books.Witness reports. Archived data. Hydrological monitoring. Statistical data obtained through processing of hydro- meteorological information for a long-term period (not less than 50 years), which contains sets of annual parameter values and peaking data. Systematic data collected within, at least, one year in the area surrounding the site. The sizes of such areas shall be sufficient to take account of all regional features and factors affecting climatic conditions of the given region. Measurement data obtained through standard hydro- meteorological survey programs, which provide for hourly measurements performed directly at the proposed site.Climate reference books. Climate monthly and yearly books.Aerial and meteorological monitoring |
| Sand storms:choking of air intake chambers;Loss of cooling in the NPP rooms | NPP air intake chambers.The NPP personnel | Volume of sand mass near NPP.The distance to the NPP.Design-basis of NPP protection against sand storms | Probability of clogging of air intake devices.Probability of loss of cooling of the NPP rooms on choking of air intake chambers.The probability model of performing actions by the NPP personnel for preventing consequences of IE.The NPP PSA model for internal IE | Cumulative probability of severe beyond design-basis accidents due to equipment failure caused by ES | Topographic and climatic maps.Statistical data obtained by processing of long-term hydrometeorological information.Systematic data collected within, at least, one year in the area surrounding the NPP site. The sizes of such areas shall be sufficient to take account of all regional features and factors affecting climatic conditions of the given region.Historical data on atmospheric phenomena |
| Tropical cyclone (typhoon):wind pressure on buildings and structures;shower precipitation | NPP buildings and structures | Maximum observed wind speed.Daily observed precipitation maximum | Probabilistic characteristics of wind loads on NPP buildings and structures. Probabilistic characteristics of load from hard missiles. Probabilistic stability characteristics of NPP buildings and structures as function of wind load. Damage probability of individual NPP buildings and structures. The NPP PSA model for internal IE | Cumulative probability of severe beyond design-basis accidents due to equipment failure, caused by damage of NPP buildings and structures | Topographic and climatic maps.Historical data. Surface water resources. Hydrological year-books.Witness reports. Archived data. Hydrological monitoring. Statistical data obtained through processing of hydro- meteorological information for a long-term period (not less than 50 years), which contains sets of annual parameter values and peaking data. Systematic data collected within, at least, one year in the area surrounding the site. The sizes of such areas shall be sufficient to take account of all regional features and factors affecting climatic conditions of the given region. Measurement data obtained through standard hydro- meteorological survey programs, which provide for hourly measurements performed directly at the proposed site.Climate reference books. Climate monthly and yearly books. Aerial and meteorological monitoring |
| Extreme snowfalls and snowpacks:roof collapse;collapse of buildings and constructions;equipment failures;Snow drifts of driveways | NPP buildings and structures | Observed maximum height of snow cover on a level surface.Estimated maximum snow loads (weight of snow cover per 1 m2 of horizontal surface of ground) of different probability values, including 0.01% (repeatability is once per 10000 years).Snow load distribution diagrams.Factors of snow blanket mass conversion into snow load on the surface.Design analysis of the NPP safeguard against snow loads (considering potential ice formation | Probability of formation of critical snow mass on the roofs of NPP buildings and structures. Probability of damage of NPP buildings and structures.Probability mode of human actions performance for preventing consequences of IE.The NPP PSA model for internal IE | Cumulative probability of severe beyond design-basis accidents due to destruction of NPP buildings and structures | Topographic and climatic maps.Historical data. Surface water resources. Hydrological year-books.Witness reports. Archived data. Hydrological monitoring.Statistical data obtained through processing of hydro- meteorological information for a long-term period (not less than 50 years), which contains sets of annual parameter values and peaking data.Systematic data collected within, at least, one year in the area surrounding the site. The sizes of such areas shall be sufficient to take account of all regional features and factors affecting climatic conditions of the given region.Measurement data obtained through standard hydro- meteorological survey programs, which provide for hourly measurements performed directly at the proposed site.Climate reference books. Climate monthly and yearly books.Aerial and meteorological monitoring.Instructions for personnel actions |
| Extreme air temperature:equipment failures;temperature loads on buildings, structures, networks etc. | NPP buildings and contructions.The NPP personnel | Maximum and minimum observed temperatures.Rated maximum and minimum air temperatures of various probability including 0.01% (repeatability once in 10000 years).Change in average temperature and temperature differential over time in warm and cold seasons.Average daily outdoor air temperatures in warm and cold seasons.Initial temperature in warm and cold season.Temperature increment.Design basis of the NPP safeguard at extreme ambient temperature | Probabilistic characteristics of stable extreme ambient temperature.Failure probability of systems assuring normal operation conditions of the NPP equipment.Probability of damage of control, monitoring and measuring systems due to extreme temperature in the NPP rooms.Probability of fluid freezing in the pipelines and vessels.The probability model of performing actions by the NPP personnel for preventing consequences of IE.The NPP PSA model for internal IE | Cumulative probability of severe beyond design-basis accidents due to equipment failure caused by extreme temperature | Topographic and climatic maps.Historical data. Surface water resources. Hydrological year-books.Witness reports. Archived data. Hydrological monitoring. Statistical data obtained through processing of hydro- meteorological information for a long-term period (not less than 50 years), which contains sets of annual parameter values and peaking data.Systematic data collected within, at least, one year in the area surrounding the site. The sizes of such areas shall be sufficient to take account of all regional features and factors affecting climatic conditions of the given region.Measurement data obtained through standard hydro- meteorological survey programs, which provide for hourly measurements performed directly at the proposed site.Climate reference books. Climate monthly and yearly books.Aerial and meteorological monitoring.Data on the NPP ventilation and air-conditioning systems.Data on configuration of NPP unit, distinctive features in the part of resistance to impact of extreme temperatures.Instructions for NPP personnel actions in conditions of extreme temperatures |
| Snow-slide:dynamic impact;static impact;shock impact;roof collapse;overpressure in the ASW front | NPP buildings and structures | Avalanche volume and speed. Density and thickness of avalanche deposition.Static and dynamic pressure of sliding snow on the snow-retaining structures.Avalanche impact strength per 1m2 of a fixed stiff obstacle surface located perpendicular to the avalanche movement direction.Avalanche load on the damping obstacle on its flow-around by avalanche.Pressure at a diagonal avalanche impact.Load on the roof of structures.Avalanche pressure on the concave surface.Overpressure at the ASW front.Design-basis of NPP safeguard against avalanche hazard | Probability of avalanche front reaching the NPP territory.Probabilistic characteristics of avalanche pressure on the structure (dynamic, static).Damage probability of anti-avalanche barriers.The probability model of performing actions by the NPP personnel for preventing consequences of IE.The NPP PSA model for internal IE | Cumulative probability of severe beyond design-basis accidents due to destruction of NPP buildings and structures affected by avalanche | Topographic and climatic maps.Historical data.Geodetic, aerospace, engineering-geological and geophysical monitoring. Engineering survey (geodetic, hydro-meteorological) documents for construction in development areas of hazardous geological processes.Documents of engineering protection from hazardous geological processes.For avalanche-hazardous mountain slopes:location scheme for avalanche faults, their morphology, avalanche routes;height, steepness, surface form, degree of weathering;speed-up path length along the slope, the section (channel) depth and shape, location of benches in the channel;material of the sliding surface (rock, soil, snow);In order to assess average avalanche hazard at the site or along the route:number of sources per 1 km2 of the NPP site or per 1 km of the valley bottom length;share of avalanche-hazardous area in the total one;ratio between the avalanche-affected valley bottom length and the total length at this section;share of channel avalanche sources in the total area of avalanche-hazardous slopes |
| Glaze-ice:increased load on round section components;increased load on roofs;damage of communication and power supply line supports;failure of communications, power supply systems | The NPP buildings and structures.Transmission lines | Glaze thicknessRated linear glaze load on round cross-section components.Rated surface glaze load on other components.Design analysis of NPP safeguard during ice layer formation on the roof and overhead transmission lines | Not required.Considered during the analysis of the IE "Snow load" | Not required | Topographic and climatic maps.Historical data. Surface water resources. Hydrological year-books.Witness reports. Archived data. Hydrological monitoring. Statistical data obtained through processing of hydro- meteorological information for a long-term period (not less than 50 years), which contains sets of annual parameter values and peaking data.Systematic data collected within, at least, one year in the area surrounding the site. The sizes of such areas shall be sufficient to take account of all regional features and factors affecting climatic conditions of the given region.Measurement data obtained through standard hydro- meteorological survey programs, which provide for hourly measurements performed directly at the proposed site.Climate reference books. Climate monthly and yearly books.Aerial and meteorological monitoring.Instructions for the NPP personnel actions in ice formation conditions |
| Hail:dynamic impact;related flooding | Transmission lines.Outdoor NPP equipment.Equipment in NPP buildings and facilities without hail protection | Frequency of hail phenomena near the NPP.Design stability characteristics of NPP buildings and structures for potential hail loads | Probability of loss of power caused by hail.Probability of hail penetration inside NPP building and equipment damage caused by thawing of hail mass.The NPP PSA model for internal IE | Cumulative probability of severe beyond design-basis accidents due to equipment failure caused by hail | Topographic and climatic maps.Historical data. Surface water resources. Hydrological year-books.Witness reports. Archived data. Hydrological monitoring. Statistical data obtained through processing of hydro- meteorological information for a long-term period (not less than 50 years), which contains sets of annual parameter values and peaking data.Systematic data collected within, at least, one year in the area surrounding the site. The sizes of such areas shall be sufficient to take account of all regional features and factors affecting climatic conditions of the given region.Measurement data obtained through standard hydro- meteorological survey programs, which provide for hourly measurements performed directly at the proposed site.Climate reference books. Climate monthly and yearly books.Aerial and meteorological monitoring.Instructions for NPP personnel actions in conditions of hail impact |
| Drought:loss of cooling for the NPP equipment;ventilation system failure;Operation disturbance for NPP operating personnel | NPP process water pools | IE occurrence frequency.Cushion of time before the onset of critical water level in the process water pools.Minimum level and volume in the process water pool providing the possibility of safe unit shutdown.Design analysis of NPP safeguard on reduction of level in the process water pools. | Probability mode of human actions performance for preventing consequences of IE.The NPP PSA model for internal IE | Cumulative probability of severe beyond design-basis accidents due to equipment failure related to loss of process water pools | Topographic and climatic maps.Historical data. Surface water resources. Hydrological year-books.Witness reports. Archived data. Hydrological monitoring. Statistical data obtained through processing of hydro- meteorological information for a long-term period (not less than 50 years), which contains sets of annual parameter values and peaking data.Systematic data collected within, at least, one year in the area surrounding the site. The sizes of such areas shall be sufficient to take account of all regional features and factors affecting climatic conditions of the given region.Measurement data obtained through standard hydro- meteorological survey programs, which provide for hourly measurements performed directly at the proposed site.Climate reference books. Climate monthly and yearly books. Aerial and meteorological monitoring.Instructions for NPP personnel actions during drought |
| Precipitations (storm):damage of NPP buildings and structures due to flooding of roofs | NPP buildings and structures | Design analysis of NPP safeguard against storm precipitations | Probability of flooding of roofs of NPP buildings and structures.Damage probability of NPP buildings and structures.The probability model of performing actions by the NPP personnel for preventing consequences of IE.The NPP PSA model for internal IE | Cumulative probability of severe beyond design-basis accidents due to destruction of NPP buildings and structures | Topographic and climatic maps.Historical data. Surface water resources. Hydrological year-books.Witness reports. Archived data. Hydrological monitoring.Statistical data obtained through processing of hydro- meteorological information for a long-term period (not less than 50 years), which contains sets of annual parameter values and peaking data.Systematic data collected within, at least, one year in the area surrounding the site. The sizes of such areas shall be sufficient to take account of all regional features and factors affecting climatic conditions of the given region.Measurement data obtained through standard hydro- meteorological survey programs, which provide for hourly measurements performed directly at the proposed site.Climate reference books. Climate monthly and yearly books.Aerial and meteorological monitoring.Instructions for NPP personnel actions in conditions of storm precipitations |
| Local precipitations (storm):Flooding of NPP equipment due to presence of local water passages into NPP rooms | The NPP equipment | Results of the analysis of local water passages to the NPP buildings and structures containing equipment important for safety | Probabilistic characteristics of storm drainage system.Probability mode of human actions performance for preventing consequences of IE.The NPP PSA model for internal IE | Cumulative probability of severe beyond design-basis accidents due to NPP equipment flooding | Topographic and climatic maps.Historical data. Surface water resources. Hydrological year-books.Witness reports. Archived data. Hydrological monitoring.Statistical data obtained through processing of hydro- meteorological information for a long-term period (not less than 50 years), which contains sets of annual parameter values and peaking data.Systematic data collected within, at least, one year in the area surrounding the site. The sizes of such areas shall be sufficient to take account of all regional features and factors affecting climatic conditions of the given region.Measurement data obtained through standard hydro- meteorological survey programs, which provide for hourly measurements performed directly at the proposed site.Climate reference books. Climate monthly and yearly books.Aerial and meteorological monitoring.Relief of NPP site.Instructions for NPP personnel actions in conditions of local precipitations |
| **Impacts of geological and engineering-geological processes and phenomena** |
| Non-seismic ground movements:damage of NPP buildings and structures; damage of the boundaries of process water pools | The NPP buildings and structures.Process water sources | Design basis of NPP safeguard against seismic ground movements | Probabilistic characteristics of non-seismic ground movements.Probabilistic characteristics of the damage of buildings and structures.Probability mode of human actions performance for preventing consequences of IE.The PSA model for internal IE | Cumulative probability of severe beyond design-basis accidents due to non-seismic ground movements. | Literature and archives on structural geology, geomorphology, Quaternary tectonics, geophysics, deep-seated structure and modern crust movements. Space and air photo. Geophysics, geochemistry and geodetic surveys of fissure geodynamics including high-accuracy recurrent leveling and instrumental monitoring of modern fissure geodynamics including high-accuracy recurrent leveling and instrumental monitoring of micro-earthquakes. Results of comprehensive geological and geophysical survey.Data acquired in the course of boring, sinking exploration shafts and gutters, electric survey profiling, well logging.Geodetic, aerospace, engineering-geological and geophysical monitoring. Engineering survey (geodetic, hydro-meteorological) documents for construction in development areas of hazardous geological processes.Documents of engineering protection from hazardous geological processes |
| Fissure seismotectonic displacements, seismic dislocations, seismic and tectonic upheavals and settling of crustal blocks.Fast dump, shift and other crust ruptures accompanied with strong vibrations | NPP buildings and structures | On the territory with high seismicity (more than or equal to 8 points) in the radius of 150-300 km from the NPP:location of the seismogenic subsurface fault, type of the fault (downthrow, displacement and etc.);length of the fault;amplitude of displacement along the fault (vertical and (or) horizontal);shares of creep and seismogenic motions in the displacement amplitude;rocks of the fault banks (sides) and in the fissure zone;location, length and width of the seismically active fault zone including motion parameters (velocities and amplitudes of vertical and horizontal displacement, inclinations) on the sides and in the fault zone before and after a severe earthquake; parameters of soil disturbance of the "tear-off" type, soil loosening, stone ejection;thickness of the seismogenic layer.The same parameters as for tectonic creep and geological seismicity criteria are used for predictable seismotectonic fissure displacements. | Probabilistic characteristics of seismotectonic troubles, seismic dislocations, seismotectonic upheavals, down warping of crustal blocks.Probabilistic characteristics of the damage of buildings and structures.Probability mode of human actions performance for preventing consequences of IE.The NPP PSA model for internal IE | Cumulative probability of severe beyond design-basis accidents due to equipment failure, destruction of NPP buildings and structures | Literature and archives on structural geology, geomorphology, Quaternary tectonics, seismic tectonics, geophysics, seismology, deep-seated structure and modern crust movements, seismicity, quaternary seismic dislocations. Space and air survey images. Geophysics, geochemistry and geodetic surveys of fissure geodynamics including high-accuracy recurrent leveling and instrumental monitoring of modern fissure geodynamics including high-accuracy recurrent leveling and instrumental monitoring of micro-earthquakes. Results of comprehensive geological and geophysical survey.Data acquired in the course of boring, sinking, electric and seismic survey profiling, well logging. |
| Neotectonic, quaternary, modern differentiated crustal motions, tectonic creep:roll, bends, folds, tension, compression of foundation soils | NPP buildings and structures | Location of tectonically **-** active faults, regional and other fissures including buried fissures.Length and width of these fault and fissure zones.Structure of tectonically **-** active faults, their disruptive zones and sub-zones.Rising and sinking rate for tectonic blocks and wedges.Tectonic creep velocity in various motion modes (stable, variable, before and after an earthquake).Displacement (rising and sinking, shift, inclination) of tectonic blocks and wedges. Creep over geological time and other time intervals.Irregular motion gradient - the ratio between the displacement amplitude and the deformation zone width and a unit of time.Age and displacement amplitude in the youngest tectonic creep and nature of their manifestation in the terrain.Background values of the velocity gradient vector of current-day vertical Earth crust motions on the site, its magnitude and direction | Probabilistic characteristics of neotectonic, quaternary, modern differentiated Earth crust, tectonic creep movements.Probabilistic characteristics of the damage of buildings and structures.Probability mode of human actions performance for preventing consequences of IE.The NPP PSA model for internal IE | Cumulative probability of severe beyond design-basis accidents due to equipment failure, destruction of NPP buildings and structures | Literature and archives on structural geology, geomorphology, Quaternary tectonics, seismic tectonics, geophysics, seismology, deep-seated structure and modern crust movements, seismicity, quaternary seismic dislocations. Space and air survey images.Geophysics, geochemistry and geodetic surveys of fissure geodynamics including high-accuracy recurrent leveling and instrumental monitoring of modern fissure geodynamics including high-accuracy recurrent leveling and instrumental monitoring of micro-earthquakes. Results of comprehensive geological and geophysical survey.Data acquired in the course of boring, sinking, electric and seismic survey profiling, well logging. |
| Earth crust residual seismic deformations:deformations; foundation cracks; depressions;deformation of foundations;irregular depressions due to the heterogeneity of the rocks at the base of structures crossing the zone | NPP buildings and structures | Location of tectonically - active faults, regional and other fissures including buried fissures.Length and width of these fault and fissure zones.Structure of tectonically - active faults, their disruptive zones and sub-zones.Rising and sinking rate for tectonic blocks and wedges.Tectonic creep velocity in various motion modes (stable, variable, before and after an earthquake).Displacement (rising and sinking, shift, inclination) of tectonic blocks and wedges.Creep over geological time and other time intervals.Irregular motion gradient - the ratio between the displacement amplitude and the deformation zone width and a unit of time.Age and displacement amplitude in the youngest tectonic creep and nature of their manifestation in the terrain.Background values of the velocity gradient vector of current-day vertical Earth crust motions on the site, its magnitude and direction | Probabilistic characteristics of residual seismic deformations of earth crust.Probabilistic characteristics of the damage of buildings and structures.Probability mode of human actions performance for preventing consequences of IE.The NPP PSA model for internal IE | Cumulative probability of severe beyond design-basis accidents due to equipment failure, destruction of NPP buildings and structures | Literature and archives on structural geology, geomorphology, Quaternary tectonics, seismic tectonics, geophysics, seismology, deep-seated structure and modern crust movements, seismicity, quaternary seismic dislocations. Space and air survey images. Geophysics, geochemistry and geodetic surveys of fissure geodynamics including high-accuracy recurrent leveling and instrumental monitoring of modern fissure geodynamics including high-accuracy recurrent leveling and instrumental monitoring of micro-earthquakes. Results of comprehensive geological and geophysical survey.Data acquired in the course of boring, sinking, electric and seismic survey profiling, well logging. |
| Earthquakes (of any genesis):structural oscillations;deformation of foundations;subsidences;changes of groundwater hydrologic regime | NPP buildings and structures, NPP equipment | For each zone of potential earthquake sources within the earth radius from the NPP:maximum magnitude;effective depth of focus;seismicity in the epicenter (in points according to MSK-64 scale); seismic dislocation, seismic gravitational processes and phenomena, breakthrough of water fronts; seismicity and consequences of hazardous geological and hydro-geological phenomena in the nuclear facility deployment area; ground motion parameters on the surface and at the foundation bed level of the structures (rated or analog accelerograms and consolidated response spectra, frequency characteristics of soils, dynamic factors, maximum acceleration amplitudes, velocities and displacements of horizontal and vertical vibration components, the corresponding periods and number of cycles) | Probabilistic characteristics of earthquakes.Probabilistic characteristics of the damage of buildings and structures.Probability mode of human actions performance for preventing consequences of IE.The NPP PSA model for internal IE | Cumulative probability of severe beyond design-basis accidents due to equipment failure, destruction of NPP buildings and structures | Literature and archives on structural geology, geomorphology, Quaternary tectonics, seismic tectonics, geophysics, seismology, deep-seated structure and modern crust movements, seismicity, quaternary seismic dislocations. Space and air survey images. Geophysics, geochemistry and geodetic surveys of fissure geodynamics including high-accuracy recurrent leveling and instrumental monitoring of modern fissure geodynamics including high-accuracy recurrent leveling and instrumental monitoring of micro-earthquakes. Results of comprehensive geological and geophysical survey.Data acquired in the course of boring, sinking, electric and seismic survey profiling, well logging. |
| Volcanic eruption:displacement of foundations;shock impacts;high-temperature impacts;toxic emissions | NPP buildings and structures | Activity of volcano (active, dormant, extinct).Characteristics of dangerous phenomena accompanying eruption of an active volcano (lava stream, mud streams, floods, hot cloud, toxic gases).Height and inclination of the volcanic neckType of the volcano according to eruption nature.Design-basis of the NPP safeguard against volcanic activity | Probabilistic characteristics of volcanic eruptions.Probabilistic characteristics of the damage of buildings and structures.Probability mode of human actions performance for preventing consequences of IE.The NPP PSA model for internal IE | Cumulative probability of severe beyond design basis accidents due to failures of systems (elements) related to volcanic activity | Literature and archives on structural geology, geomorphology, Quaternary tectonics, seismic tectonics, geophysics, seismology, deep-seated structure and modern crust movements, seismicity, quaternary seismic dislocations. Space and air survey images. Geophysics, geochemistry and geodetic surveys of fissure geodynamics including high-accuracy recurrent leveling and instrumental monitoring of modern fissure geodynamics including high-accuracy recurrent leveling and instrumental monitoring of micro-earthquakes. Results of comprehensive geological and geophysical survey.Data acquired in the course of boring, sinking, electric and seismic survey profiling, well logging. |
| Mud volcanismmud flooding;gas contamination;thermal impacts;deformations of foundations | NPP buildings and contructions.The NPP personnel | Mud flooding rate.Flooded area increase for one year.Mud level rise rate.Mud flooding area at the specified mud level.Mud temperature in the flooded area and at the blowout point.Parameters of air contamination with gases | Probabilistic characteristics of mud volcanism.Probabilistic characteristics of the damage of buildings and structures.Probability mode of human actions performance for preventing consequences of IE.The NPP PSA model for internal IE | Cumulative probability of severe beyond design basis accidents due to failures of systems (elements) related to mud volcanism | Literature and archives on structural geology, geomorphology, Quaternary tectonics, seismic tectonics, geophysics, seismology, deep-seated structure and modern crust movements, seismicity, quaternary seismic dislocations. Space and air survey images. Geophysics, geochemistry and geodetic surveys of fissure geodynamics including high-accuracy recurrent leveling and instrumental monitoring of modern fissure geodynamics including high-accuracy recurrent leveling and instrumental monitoring of micro-earthquakes. Results of comprehensive geological and geophysical survey.Data acquired in the course of boring, sinking, electric and seismic survey profiling, well logging. |
| Soil slips:displacement of base soils | NPP buildings and structures | For active landslides including potentially seismic-gravitational ones:location scheme and contours;slope length and area;form of slope terrain (configuration, height, steepness); development history, genesis and age of slope;mode of occurrence of weakness zones and surfaces (including displacement surfaces) in the slope block and physical and mechanical properties of rocks (particularly, shear strength) in these surfaces and zones;tectonic disturbance of slope rocks with the impact assessment of the landslide activity; assessment of the impact of modern tectonic movements and seismicity on landslide displacements;level and pressure regime of the aquifers and conditions for their discharge at the slope with assessment of impact of underground water on the landslide activity;degrees of weathering, erosion, scouring of the slope, erosion of banks with assessment of impact on landslide development;displacement mechanism: sliding, out-squeezing, floating, flowing, sudden liquefaction; slope capture depth;character of movement: continuous, regular with long-term and geological time intervals (in new forms);rate of movement along the slope in various motion modes (stable, variable, before and after an earthquake); | Probabilistic characteristics of soil slips.Probabilistic characteristics of the damage of buildings and structures.Probability mode of human actions performance for preventing consequences of IE.The NPP PSA model for internal IE | Cumulative probability of severe beyond design basis accidents due to failures of systems (elements) related to soil slips | Geodetic, aerospace, engineering-geological and geophysical monitoring. Documents generated in the course of engineering surveys (geodetic and hydro-meteorological) carried out for the purposes of constructing in the regions featuring hazardous geological processes (including seismic regions).Documents of engineering protection from hazardous geological processes |
|  |  | displacements along the slope in various time intervals;type, humidity and volume of the landslide rocks |  |  |  |
| Earth falls and earth slip-falls:displacement of base soils | NPP buildings and structures | For collapses of hazardous slopes:location scheme for the existing and expected rockfalls with the volume exceeding 10 m3;height and steepness of rockfall-hazardous slopes;slope surface form;weathering degree for the slope rocks, presence of any weakened zones, layers of plastic or suffosion-unstable rocks, tectonic faults;resistance to displacement, volume weight, humidity and rock stiffness modulus in weakened zones and interlayers, in the interlock filler; sizes and volume of projected landslide;preconditioning signs of a rockfall or an earth slip-fall:breakout and falling of separate boulders, expansion of the existing fissures and appearance of new ones, narrowing of displacement rents, periodical crackling, small-scale movements of rock blocks | Probabilistic characteristics of landslides and soil-slips.Probabilistic characteristics of the damage of buildings and structures.Probability mode of human actions performance for preventing consequences of IE.The NPP PSA model for internal IE | Cumulative probability of severe beyond design basis accidents due to failures of systems related to earth falls and earth slip falls | Geodetic, aerospace, engineering-geological and geophysical monitoring. Documents generated in the course of engineering surveys (geodetic and hydro-meteorological) carried out for the purposes of constructing in the regions featuring hazardous geological processes (including seismic regions).Documents of engineering protection from hazardous geological processes |
| Mudflows:shock impact;hydrodynamic impact | NPP buildings and structures | Mudflow type:erosional, discontinuous, landslide-soil slip, soil slip;rain, snow, glacial, volcanic, seismogenic (in areas with seismicity 8 points and more), limnogenic (discontinuous), technogenic, anthropogenic; mudflow, mud-rock, water-rock; cohesive, non-cohesive.Parameters of mudflow hazard map of the territory within the radius of up to 50 km from the NPP:mudflow basin boundaries;hydrographic network with characteristics of the bed inclinations, zones of mudflow formation, movement and accumulation;glaciers, moraines, lakes, water reservoirs, hydroengineering structures, mudflow protection facilities and other objects (including NPP).Parameters of mudflow basin map:mudflow sources and volume of material in them;erosional features of the catchment basin terrain and soil and vegetation cover;mudflow beds and places of potential bottle-necks, scope and activity of slides, caving-ins, landslides in area of dry wash; volume, area, depth, length, width of mudflow deposits in the area of mudflow accumulations.Diagram of potential mudflow movement: maximum velocity, depth, width and flow rate; areas of mudflow flooding (with catastrophic damages, drifting of mudflow deposits);mudflow impact areas; area of probable disturbance of slope stability during washing away;safe areas, escape routes; outlines of being designed and existing constructions.Origin, conditions of occurrence, formation mechanisms, types and frequency of mud flows.Maximum volumes of non-recurrent mudflow mass transport and dynamic parameters of mud flows.Physical and mechanical properties of soils in the mudflow sources and deposit areas.Design analysis of the NPP safeguard against mudflows | Probability of mudflow front reaching the NPP territory.Probabilistic characteristics of flow pressure on NPP buildings and structures (dynamic, static).Damage probability of anti-mudflow barriers.The probability model of performing actions by the NPP personnel for preventing consequences of IE.The NPP PSA model for internal IE | Cumulative probability of severe beyond design-basis accidents due to destruction of NPP buildings and structures affected by mudflows | Geodetic, aerospace, engineering-geological and geophysical monitoring. Documents generated in the course of engineering surveys (geodetic and hydro-meteorological) carried out for the purposes of constructing in the regions featuring hazardous geological processes (including seismic regions).Documents of engineering protection from hazardous geological processes |
| Snow-rock and debris-boulder avalanches:shock impact; hydrodynamic impact | NPP buildings and structures | For avalanche-hazardous mountain slopes: location scheme for avalanche faults, their morphology, avalanche routes;elevation, steepness, surface shape, degree of weathering; length along the speedup route slope, depth and the section shape (bed), bench deployment in the bed;material of the sliding surface (rock, soil, snow);maximum distance of throw and volume of the avalanche, maximum travelling velocity, height and width of the avalanche front in the nuclear facility deployment site; effective density of avalanche material;maximum avalanche pressure (dynamic, static).In order to assess average avalanche hazard at the location site or along the route:number of sources per 1 km2 of the location site or per 1 km of the valley bottom length; share of avalanche-hazardous area in the total one;ratio between the avalanche-affected valley bottom length and the total length at this section;share of channel avalanche sources in the total area of avalanche-hazardous slopes;average width of the channel avalanche discharge area.Design-basis of NPP safeguard against avalanche hazard | Probability of avalanche front reaching the NPP territory.Probabilistic characteristics of avalanche pressure on the structure (dynamic, static).Damage probability of anti-avalanche barriers.The probability model of performing actions by the NPP personnel for preventing consequences of IE.The NPP PSA model for internal IE | Cumulative probability of severe beyond design-basis accidents due to destruction of NPP buildings and structures affected by avalanche | Geodetic, aerospace, engineering-geological and geophysical monitoring. Documents generated in the course of engineering surveys (geodetic and hydro-meteorological) carried out for the purposes of constructing in the regions featuring hazardous geological processes (including seismic regions).Documents of engineering protection from hazardous geological processes |
| Subsidence and cave-ins of territory:subsidences;cave-ins | NPP buildings and structures | Categories of stability of the territory with regard to crevasses of any origin (karst, thermokarst, suffosion, man-made geological workings and pumping of water, oil and gas) are established based on intensity of crevasse formation (by number of crevasses per year at a unit of area) and average diameter of crevasses or average width of longitudinal crevasses.Negative landforms (weathering crust, sink holes, craters, hollows, karstic depressions, valleys, subsidence troughs), their contours and plan dimensions (area, length, width).Average and maximum depths and the earth surface subsidence rates - for individual typical forms | Probabilistic characteristics of subsidences and cave-in of territory.Probabilistic characteristics of the damage of buildings and structures.Probability mode of human actions performance for preventing consequences of IE.The NPP PSA model for internal IE | Cumulative probability of severe beyond design basis accidents due to failures of systems related to subsidences and cave-ins of territory | Geodetic, aerospace, engineering-geological and geophysical monitoring. Documents generated in the course of engineering surveys (geodetic and hydro-meteorological) carried out for the purposes of constructing in the regions featuring hazardous geological processes (including seismic regions).Documents of engineering protection from hazardous geological processes |
| Underground erosion including underground karst formation:subsidences; cave-ins | NPP buildings and structures | For territories with any underground erosion (karst, suffosion, leaching) manifestation on the earth surface:mode of occurrence of the rocks prone to scouring with underground water;hydro-geological wash-out conditions; boundaries of sections with different degree of underground wash-out. Map of site underground erosion: decompaction and destruction zones;fissures expanded by dissolution, suffosion, cavity leaching;channels, galleries, caves and other cavities, their size; disturbance of rock deposits as a result of their movements and collapse over cavities, over destroyed and loosened areas; degree and composition of cavity filling material; tectonically weakened areas; other manifestations of underground washout.Karst activity shall be characterized by the ratio between the volume of dissoluble rocks and the volume of the assessed element or the entire block in percent per 1000 years.Suffosion rate shall be characterized by the bulk volume carried away through suffosion per year | Probabilistic characteristics of underground erosions.Probabilistic characteristics of the damage of buildings and structures.Probability mode of human actions performance for preventing consequences of IE.The NPP PSA model for internal IE | Cumulative probability of severe beyond design basis accidents due to failures of systems (elements) related to underground erosions. | Geodetic, aerospace, engineering-geological and geophysical monitoring. Documents generated in the course of engineering surveys (geodetic and hydro-meteorological) carried out for the purposes of constructing in the regions featuring hazardous geological processes (including seismic regions).Documents of engineering protection from hazardous geological processes |
| Erosion by water of shores, slopes and streams:damage and cracks; subsidence; foundation cave-ins | NPP buildings and structures | For wave abrasion of banks:annual amount of processing per a unit of the shore length;length of active erosion zone; displacement of encroachment line and bench edge per year.For erosion of slopes and stream beds - increase of erosive roughness, length and volume of creeks, displacement of the river bed per a year etc. or any other period of time.Design basis of NPP resistance to stream bank, slope, river bed erosions | Probabilistic characteristics of underground erosions of banks, slopes, river beds.Probabilistic characteristics of the damage of buildings and structures.Probability mode of human actions performance for preventing consequences of IE.The NPP PSA model for internal IE | Cumulative probability of severe beyond design basis accidents due to failures of systems (elements) related to erosion of banks, slopes, river beds | Geodetic, aerospace, engineering-geological and geophysical monitoring. Documents generated in the course of engineering surveys (geodetic and hydro-meteorological) carried out for the purposes of constructing in the regions featuring hazardous geological processes (including seismic regions).Documents of engineering protection from hazardous geological processes |
| Permafrost-geological (cryogenic) processes:deformations of foundations | NPP buildings and structures | Depth, thickness, lithological composition, filtration properties, temperature, heat capacity and heat conductivity of frozen and unfrozen block.Active layer thickness.Amount of heat emitted by the facility to the block.Cryogenic processes and formations (solifluction, moulds, heaves, ice-break crack formations, thermokarst, ice blisters), shapes and dimensions of cryogenic formations (diameter and height of moulds, depth, length, width and area of thermokarst crevasses and depressions, thermokarst development depth, area, volume and thickness of ice blisters, sizes of ice-break cracks).Rate of cryogenic processes (rate of heaving, accumulation of ice blisters, solifluction movement, deepening of crevasses and depressions) | Probable characteristics of permafrost-geological (cryogen) processes.Probabilistic characteristics of the damage of buildings and structures.Probability mode of human actions performance for preventing consequences of IE.The NPP PSA model for internal IE | Cumulative probability of severe beyond design basis accidents due to failures of systems (components) related to permafrost-geological (cryogen) processes | Literature and archives on structural geology, geomorphology, Quaternary tectonics, geophysics, deep-seated structure and modern crust movements.Space and air photo.Geophysics, geochemistry and geodetic surveys of fissure geodynamics including high-accuracy recurrent leveling and instrumental monitoring of modern fissure geodynamics including high-accuracy recurrent leveling and instrumental monitoring of micro-earthquakes.Results of a integrated geological and physical survey.Data acquired in the course of boring, sinking exploration shafts and gutters, electric survey profiling, well logging. |
| Deformations of specific soils due to the development of natural and human-induced processes (thermokast, liquefaction, solifluction and suffosion processes):- deformation of foundation | NPP buildings and structures | Key parameters of collapsible soil: stress-and-strain modulus, specific cohesion and angle of internal friction under natural humidity and in water-saturated state, degree of their variation in plan view and in depth; type of soil conditions by subsidence, subsidence thickness and its layers and their change;relative subsidence;initial subsidence pressure | Probabilistic characteristics of deformation of specific soils.Probabilistic characteristics of the damage of buildings and structures.Probability mode of human actions performance for preventing consequences of IE.The NPP PSA model for internal IE | Cumulative probability of severe beyond design basis accidents due to failures of systems (components) related to deformation of specific soils | Geodetic, aerospace, engineering-geological and geophysical monitoring. Documents generated in the course of engineering surveys (geodetic and hydro-meteorological) carried out for the purposes of constructing in the regions featuring hazardous geological processes (including seismic regions). Documents of engineering protection from hazardous geological processes |
| Anomalous decrease of the water level in closed pools (without a connection to temperature phenomena):loss of cooling for the NPP equipment;ventilation system failure;Operation disturbance for NPP operating personnel | Process water sources | Critical water level in process storages of waterWater level in the rivers providing replenishment of process storages of water.Design protection characteristics of NPP on reduction of level in the storages of water.Minimum level and volume in the process storages of water providing the possibility of safe unit shutdown | Failure probability of makeup system of storages of water.The probability model of performing actions by the NPP personnel for preventing consequences of IE.The NPP PSA model for internal IE | Cumulative probability ofsevere beyond design-basis accidents due to equipment failure caused by loss of process storages of water | Topographic and climatic maps.Historical data.Statistical data obtained through processing of hydro- meteorological information for a long time period, which contains sets of annual parameter values and peaking data.Data collected within, at least, one year in the area surrounding the NPP site. The sizes of such areas shall be sufficient to take account of all regional features and factors affecting climatic conditions of the given region. |
| **External impacts caused by biological phenomena** |
| Biological phenomena:damage of power and control cables and wires;clogging of filters of process water intake systems;loss of cooling capacity of heat exchanging equipment | Power and control cables and wires.Filters of systems for process water intake.Heat exchange equipment | Design characteristics of the NPP equipment protection against biological phenomena | Probability of occurrence of critical biological mass (animal population).Probability of damage of the NPP vital equipment.The probability model of performing actions by the NPP personnel for preventing consequences of IE. | Cumulative probability of severe beyond design-basis accidents due to destruction of NPP buildings and structures | NPP data on monitoring over the assurance of lack of vital capacity of NPP rooms for rodents and other animals.Measurement data on microbiota and fish population of NPP storages of water |
|  |  |  | The PSA model for internal IE |  |  |
| **External impacts caused by aerial reasons** |
| Aerial impacts (meteoric stones, satellite crash):damage of buildings and structures;damage of overhead lines, secondary fires | The NPP buildings and structures.Transmission lines | Design-basis of NPP protection against aerial impacts | Probability of fall of meteorite stones or other aerial objects at the NPP site for the facility's service life | Not required | Observation data on fall of aerial objects near the NPP |
| **Local events** |
| Indoor flooding | Not included in the scope of this Safety Guide |
| Indoor fires | Not included in the scope of this Safety Guide |

APPENDIX No. 6

to the Safety Guide in the Use of Atomic Energy "Basic recommendations for development of a probabilistic safety analysis of level 1 for a nuclear power plant unit during initiating events stipulated by external impacts of natural and man-induced origin" approved by order No 396 of the Federal Environmental, Industrial and Nuclear Supervision Service
dated 28 August 2014.

**1. The recommended formation principles of the criteria for excluding external impacts**

It is recommended to form the criteria for excluding external impacts at the development stage of the list of external impacts and at the stage of selective analysis for restricting the scope of analysis and concentration of efforts only on those external impact scenarios which are potentially significant from risk point of view for the NPP.

It is recommended to consider the following factors when forming the criteria for excluding external impacts:

distance (feasibility) - source of external event is located quite far from the NPP site to have an impact on it;

inclusion (grouping) - event was already considered or planned for consideration as part of another event or when executing another stage of the PSA;

time - development duration of impact against external event in time allows perform preventive and protective measures, which prevents development of emergency sequences and potential consequences influencing safety of the NPP unit;

protection against event of this intensity is stipulated by the design - design measures stipulated for events of considered intensity, confirmed by the calculations (tests) assure low level of conditional probability of failure at the given impact intensity;

low event frequency - external event of this intensity has low frequency; it is assumed that the contribution to the frequency of core damage (or other considered sources of radioactivity) from such event shall be negligible.

**2. Examples of exclusion criteria of external impacts for formation of the final list of external impacts**

External impacts may be excluded from the further consideration if at least one of the qualitative or quantitative criteria specified in Table 1 is met.

**Table 1 Exclusion criteria for making the final list of external impacts**

| **Criterion code** | **Description** | **Note** | **Principles** |
| --- | --- | --- | --- |
| A | External impact capable of rendering impact on the NPP unit may not take place near the NPP deployment site for the unit operation lifecycle | Example. The considered source of explosion hazard is located at a safe distance from the site that is confirmed by the design documentation. For example, volcanic event may be excluded as the site location is located far away from the regions of volcanic activity and these events are not characteristic for it | Distance (feasibility) |
| V | External impact capable of rendering impact on the NPP unit is included in the determination of another event | Example.Event "Flooding with repeatability once in 10000 years" has been included in the determination of complex event "Flooding and breaching of reservoir" | Inclusion (grouping) |
| С | External impact differs by slow nature of development and has sufficient time either for elimination of the source of hazard, or for carry out adequate protective measures preventing the formation of conditions influencing the safety of NPP unit | NPP personnel, representative of competent organizations (Emergencies Ministry, Ministry of Internal Affairs) etc. may take part in eliminating the source of hazard and performing protective measures. For example: gradual increase or reduction of outside air temperature, extinguishing external fires, clearing of snow on the roofs | Time |
| D | External impact of this type has substantially smaller average occurrence frequency than for other events of the same type with the consequence of it for the NPP unit similar or less than the consequence from this other event. The average frequencies of these events have been determined by methods equal by integrity  | Example.The event with loss of external power supply of NPP from external natural events of repeatability once in 10000 years shall be considered. The loss of power frequency of given duration in PSA level 1 for internal event was determined considering the external natural impacts on the power system, however, since other factors were considered it frequency is considerably more. | Inclusion (grouping) |
| E | External impact of the considered intensity from external event is characterized by similar or less disturbing potential than the action for which the NPP safeguard is provided by the design.External impact of the considered intensity has occurrence frequency below 10-6 1/year | Use of criterion for external impact of the considered intensity from external event requires study of the design basis of the unit for stability assessment of the systems (elements) for impact | Protection against event of given intensity is stipulated by the design.Low event frequency |

**3. Examples of external impacts exclusion criteria that does not require detailed analysis**

External impact may be excluded from the further consideration at the selective analysis stage if at least one of the criteria specified in Table 2 is met.

**Table 2. Scenario exclusion criteria not requiring detailed analysis**

|  |  |  |
| --- | --- | --- |
| **Criterion code** | **Description** | **Note** |
| СR 1 | External impact cannot lead to core damage (or damage of the considered sources of radioactivity) | - |
| CR 2 | External impact has average occurrence frequency below 10-4 1/year and average value of conditional core damage frequency, conditioned by external impact below 10-2 1/year | Criterion requires determination of core damage frequency provided that the external event took place (certain event, probability equal to 1) |
| CR 3 | Core damage frequency stipulated by external impact and determined by conservative methods has average frequency below 10-6 1/year | - |

APPENDIX No. 7
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**Scheme of making change to PSA model for consideration of external impacts**

APPENDIX No. 8

to the Safety Guide in the Use of Atomic Energy "Basic recommendations for development of a probabilistic safety analysis of level 1 for a nuclear power plant unit during initiating events stipulated by external impacts of natural and man-induced origin" approved by order No 396 of the Federal Environmental, Industrial and Nuclear Supervision Service
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**Example of determination matrix of potential combinations of external impacts**

Example of the matrix (from the document of Michael Knochenhauer Pekka Loukо.) is provided in Table 1. Guidance for External Events Analysis. SKI Report 02:27. Stockholm, 2003"), determining potential combinations of external impacts. Open fields in Table 1 imply the lack of requirement of accounting the condition of external impact (cumulative influence of factors of external impacts has scant differentiation on the NPP safety as compared to mono-factor influence). The sign "X" or text in the cell field of Table 1 implies that the joint influence of two factors of external impacts significantly from the mono-factor influence on the NPP safety.

**Table 1 Determination matrix of potential combinations of external impacts**

|  |  |  |  |
| --- | --- | --- | --- |
|  | **Atmospheric impact** | **Hydrosphere impact** | **Soil impact** |
| **Air velocity** | **Air temperature** | **Air pressure** | **Atmospheric precipitation** | **Humidity** | **Air pollution** | **Electromagnetic impact** | **Direct impact of hard missiles** | **Water velocity** | **Water level** | **Water temperature** | **Influence of water on soil** | **Ice impact** | **Solid particles** | **Water contamination** | **Direct influence of water** | **Ground velocity (movement)** | **Organic impact of soil** | **Direct impact of soil** | **Fire** |
| **Atmospheric impact** | Air velocity |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| Air temperature | Low T during storm |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| Air pressure | Low P during storm |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| Atmospheric precipitation | Precipitations during storm | Precipitation type | Precipitations during storm |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| Humidity |  | Drought |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| Air pollution | Salt storm |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| Electromagnetic impact |  |  | Lightning strikes | Lightning strikes during rain |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| Direct impact of hard missiles | Fragments transportation by wind |  |  |  |  | Explosion of released chemical substances |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| **Hydrosphere impact** | Water velocity | Influence onstreams |  |  | For NPP located near rivers |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| Water level | Wind-induced surge of level |  | Pressure impact on the level | For NPP located near rivers |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| Water temperature |  | **X** |  |  | Fog or frost |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| Influence of water on soil |  |  |  |  |  |  |  |  | Underwater landslide | Coast erosion / landslide |  |  |  |  |  |  |  |  |  |  |
| Ice impact | Creation of ice barriers | **X** |  |  |  |  |  |  | Creation of ice barriers |  | **X** | Ice impact on soil |  |  |  |  |  |  |  |  |
| Solid particles | Accumulation of organic particles |  |  |  |  | Air to water transfer |  |  | Accumulation of particles |  | Accumulation of organic particles | Soil in water |  |  |  |  |  |  |  |  |
| Water contamination |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| Direct influence of water | Navigation accidents |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| **Soil impact** | Ground velocity (movement) |  |  |  |  |  |  |  |  |  | Tsunami following earthquake |  |  |  |  |  |  |  |  |  |  |
| Organic impact of soil |  | Freezing of soil |  |  |  |  |  |  |  |  |  |  | Freezing of soil |  |  |  |  |  |  |  |
| Direct impact of soil |  |  | Explosions | Landslides |  |  |  |  |  |  |  |  |  |  |  |  | Landslide after earthquake |  |  |  |
| Fire |  | Dry conditions at high temperature |  |  |  | Combustion of released chemical substances | Fire due to lightning strike | Fire after impact of hard missiles |  |  |  |  |  |  | Combustion of released chemical substances |  | Fire after earthquake |  | Combustion after direct impact |  |

1. Developed by the team of authors comprising of G.I. Samokhin, D.E. Noskov, T.V. Berg, V.A. Bredova, M.A. Nazhitkov (FBU NTTs YaRB) [↑](#footnote-ref-1)