Approved by   
Order of the Federal Environmental, Industrial and Nuclear Supervision Service   
No. \_\_\_ dated \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_, 20\_\_

SAFETY GUIDE   
IN THE USE OF ATOMIC ENERGY "RECOMMENDED METHODS FOR ASSESSMENT AND PREDICTION OF ACCIDENT RADIOLOGICAL CONSEQUENCES AT NUCLEAR FUEL CYCLE FACILITIES"

(PB-134-17)

I. General

1. The safety guide in the use of atomic energy "Recommended methods for assessment and prediction of accident radiological consequences of accident at nuclear fuel cycle facilities" (RB-134-17) (hereinafter referred to as the Safety Guide) has been developed in accordance with Article 6 of the Federal law No. 170-FZ dated November 21, 1995 "On atomic energy use" for the purpose of securing the compliance with the requirements of the Federal Rules and Regulations in the field of atomic energy use "General provisions for safety assurance of nuclear fuel cycle facilities" (NP-016-05), approved by the Ordinance of the Federal Environmental, Industrial and Nuclear Supervision Service No. 11 dated December 02, 2005 (registered by the Ministry of Justice of Russia on February 1, 2006, registration No. 7433) (hereinafter referred to as NP-016-05).

2. This Safety Guide is designed for use by the design, project, research and development organizations and operators on safety justification of the nuclear fuel cycle facilities (hereinafter the NFCF), as well as by the Federal Environmental, Industrial and Nuclear Supervision Service on safety justification of the NFCF.

3. The Safety Guide contains the assessment and prediction methods of radiological consequences outside the nuclear fuel cycle enterprise sites recommended by the Federal Environmental, Industrial and Nuclear Supervision Service and caused by the releases during emergencies at the following NFCF:

constructions, complexes, installations with nuclear materials (excluding commercial reactors, research nuclear installations critical and sub-critical assemblies, uranium ore mining facilities designed for production, transportation, processing of nuclear fuel and nuclear materials;

structures, complexes and installations containing radioactive substances and/or radioactive wastes, located at the nuclear installation territory and not provided for in the nuclear installation design;

on-site facilities and constructions designed for storage of nuclear materials, radioactive substances, radioactive wastes including the facilities and constructions located on the nuclear installation territory and not provided for in the nuclear installation design;

Assessment and prediction methods of the radiological consequences caused by the releases during emergencies contained in this Safety Guide may be used for other nuclear facilities.

4. The requirements of the Federal Rules and Regulations in the field of atomic energy use may be implemented through the use of methods other than those specified by this Safety Guide subject to substantiation of the selected methods.

II. General principles of assessment of the consequences of accident at the NFCF with release of radionuclides

5. Given the fact that the protective measures are divided into measures executed at the initial period of radiation accident (for the first 10 days after the accident) and measures executed for the first year after the radiation accident and subsequent years, the calculation of the effective dose outside the NFCF site at the initial period of accident (for the first 10 days after the accident), for the first year after the accident and subsequent years shall be executed.

6. The effective dose shall be calculated in the form of dependency from the distance x from the source of emergency release according to the following formulae both for the initial period of accident and for the period for the first year after the accident.

at the initial period of accident:

, (1)



for the first year after the accident:

, (2)



where:

Emax10(x) - maximum total (for radionuclides) effective exposure dose of a person located at a distance of x from the point source or from the center of the site emergency release source due to external exposure and internal exposure from inhalation at the initial period of accident, Sv;

Emax>10(x,xmax) - maximum total (for radionuclides) effective exposure dose of a person located a distance x from the point source or from the center of site source of emergency release, due to external exposure and internal exposure from inhalation, and due to exposure caused by consumption of local contaminated food products produced at a distance of xmax from the specified source for the first year after the accident, Sv;

- radionuclide r caused total effective exposure dose of a person located at a distance of x from the point source or from the center of the site emergency release source due to external exposure and internal exposure from inhalation at the initial period of accident, Sv;



- radionuclide r caused total effective exposure dose of a person located a distance x from the point source or from the center of site source of emergency release, due to external exposure and internal exposure from inhalation, and due to exposure caused by consumption of local contaminated food products produced at a distance of xmax from the specified source for the first year after the accident, Sv;



r - radionuclide;

j - grading index of atmospheric stability category (A, B, C, D, E or F); the Pasquill-Gifford parametrization is used in this Safety Guide;

x - distance from the source of emergency release, m;

- symbol denoting the summation for all the radionuclides r.



The recommended calculation procedure of the quantity xmax is given in the item 18 of this Safety Guide.

7. The following exposure pathways shall be considered for assessment at the initial period of radiation accident: external cloud shine, external exposure from the soil surface and internal exposure from inhalation. The calculation of the doses caused by the impact of individual radionuclides (including inert radionuclide gases containing radionuclides argon (Ar), xenon (Xe) and krypton (Kr) (hereinafter IRG) shall be made for this purpose according to the following formula:



, (3)



where:

- effective dose of external cloud shine caused by the radionuclide r, Sv;



- effective dose from internal exposure caused by inhalation of radionuclide r, Sv;



- effective dose from external exposure from the soil source caused by radionuclide r, Sv.



8. The exposure pathways specified in the item 7 of this Safety Guide as well as the additional exposure pathways - internal exposure from radionuclides contained in the local food products (peroral route) and from radionuclides in air during secondary wind uplift shall be considered for assessment of the radiological consequences of accident for the first year after the radiation accident and subsequent years. The calculation shall be performed for this purpose according to the formula:



, (4)



where:

- effective internal exposure dose caused by the radionuclide r contained in the consumed local food products at a distance of xmax calculated in accordance with the procedure given in the item 16 of this Safety Guide, Sv;



- effective internal exposure dose caused by inhalation of radionuclide r in air due to secondary wind uplift, Sv.



9. Effective doses , , , , shall be calculated in accordance with the items 12 - 20 of this Safety Guide. The calculations of the following parameters shall be tentatively performed for this purpose:



concentrations of radionuclides in the environmental components (in accordance with Appendix 1 of this Safety Guide);

dilution and deposition factors (in accordance with Appendix No. 2 of this Safety Guide);

elevation of emergency release (in accordance with Appendix 3 of this Safety Guide).

10. The elevation of emergency release and dilution and deposition factors shall be assessed for the following sources of formation of emergency radioactive release:

fire at the outdoor territory of NFCF (site source) (hereinafter scenario 1);

wind entrainment of radioactive substances from the contaminated areas, arranged at the open territory of NFCF due to extreme wind loads (distributed source) (hereinafter scenario 2);

release of radioactive substances through the exhaust ventilation systems to the atmosphere as part of process vents or as part of air collected from the NFCF rooms, an release of radioactive substances through leakage of the buildings including during occurrence of self-sustained chain reaction (hereinafter SSCR) (point source) (hereinafter scenario 3);

potential explosions of diverse origin at the NFCF outdoor territory (distributed source) (hereinafter scenario 4);

release to the NFCF outdoor territory on occurrence of SSCR (point source) (hereinafter scenario 5).

11. The following shall be considered as the outdoor territories specified in the item 11 of this Safety Guide:

territories outside the buildings and/or rooms on which equipment containing radioactive substances were located at the time of occurrence of accident initiator;

territories on which the building with equipment containing radioactive substances are ruined (considerable damage) following the accident.

III. Recommendations for consequence assessment

12. The effective dose of external exposure due to radioactive substances suspended in the lowest atmospheric layer, , shall be calculated in the approximation of semi-infinite cloud according to the following formula:



, (5)



where:

Cj,r(x) - radionuclide r concentration time interval in the lowest atmospheric layer at a distance x from the source of emergency release, Bq·sec/m3; calculation procedure of the quantity Cj,r(x) is given in Appendix No. 1 of this Safety Guide;

- dose transformation factor in external exposure of the public from the radioactive cloud for radionuclide r, (Sv.m3)/(Bq·sec); values for calculation are given in the table 1 of Appendix No. 2 of the safety guide "Recommended calculation methods of the parameters required for development and stipulation of the norms of maximum permissible releases of radioactive substances to the atmosphere" (RB-106-15) approved by the order of Federal Environmental, Industrial and Nuclear Supervision Service No. 458 dated November 11, 2015 (hereinafter RB-106-15).



13. The effective dose of external exposure of the public due to radioactive substances located on the ground surface, , shall be calculated using the formula:



, (6)



, (7)



where:

Clj,r(x) - value of total fall-out of radionuclide r on the ground surface due to dry and wet deposition, Bq/m2; calculation procedure of the quantity Clj,r(x) is given in Appendix No. 1 of this Safety Guide;

- dose transformation factor in external exposure from the ground surface for radionuclide r, (Sv.m2)/(Bq.sec); values for calculation are given in the table No. 1 of Appendix No. 2 RB-106-15;



Kr - coefficient considering the time of presence (residence) at a contamined territory following release of radioactive substances, sec;

- decay constant of dose rate with time from the contaminated soil layer due to all the processes, except radioactive decay leading to removal of activity from this layer, sec-1 (shall be taken as equal to 1.27 · 10-9 sec-1);



- radioactive decay constant of radionuclide r, sec-1



tl - time of public presence in the contaminate territory, sec (at the initial period of accident shall be taken as equal to 8.64 · 105 sec, and for the first year after the accident - 3.15 · 107 sec).

14. The calculation of effective dose of internal exposure from inhalation, , shall be made according to the formula:



, (8)



where:

Cj,r(x) - radionuclide r concentration time interval in the lowest atmospheric layer of suspended atmospheric air at a distance x from the source, Bq·sec/m3; calculation procedure of the quantity Cj,r(x) is given in Appendix No. 1 of this Safety Guide;

- respiration rate for persons of the age group, which is critical for intake of radionuclide r due to inhalation in accordance with the table 8.1 SanPiN 2.6.1.2523-09 "Radiation safety standards. Sanitary Rules and Regulations", approved by the Decree of the Chief State Health Inspector of the Russian Federation dated July 7, 2009 No. 47 (registered by the Ministry of Justice of the Russian Federation registration No. 14534 dated August 14, 2009) (hereinafter NRB-99/2009), m3/sec;



- dose transformation factor in intake of radionuclide r with air, Sv/Bq; values for calculation are given in the table of Appendix No. 2 to NRB-99/2009.



15. The effective internal exposure dose due to consumption of food products, , shall be calculated according to the formula:



, (9)



where:

- cumulative (for food products n) specific activity of radionuclide r entering the human organism with food, Bq/kg; the calculation procedure of the quantity is given in Appendix No. 1 of this Safety Guide;



- annual consumption of food products n, milk l, plant of animal origin, kg, by persons of the age group which is critical in accordance with the table of Appendix 2 to NRB-99/2009 on intake of radionuclide r with the contaminated food products;



- dose transformation factor in intake of radionuclide r with food taken in accordance with the table of Appendix No. 2 to NRB-99/2009, Sv/Bq.



16. The annual consumption of food products by persons from various age groups shall be considered in the calculation according to the formula:

, (10)



where:

Er - daily energy consumption for the age group, which is critical for radionuclide r in accordance with the table of Appendix 2 to NRB-99/2009 shall be taken in accordance with the table 1 of Appendix No. 4 to this Safety Guide, kcal/day;

E6 - daily energy consumption for the age group "adults" for NRB-99/2009 shall be taken according to the table 1 of Appendix No. 4 to this Safety Guide, kcal/day;

- annual consumption of product n by a person from the age group "adults" for NRB-99/2009 kg/year.



If there are no data characteristic for the NFCF location area, the annual consumption of products by a person from the age group "adults" shall be taken in accordance with the Recommendations on rational norms of food products consumption meeting the current requirements of healthy eating approved by the order of the Ministry of Health of the Russian Federation No. 614 dated August 19, 2016 .

17. For the purposes of calculation of Emax>10(x,xmax) according to formula (2) of this Safety Guide the distance from the point source or from the center of directed source of emergency releases shall be taken as xmax, where the maximum effective dose of the internal exposure is reached due to consumption of food products . The calculation shall be made according to the following formula:



, (11)



where , , , , and - effective doses against internal exposure, caused by radionuclide r contained in the consumed local food products, in atmospheric stability categories A, B, C, D, E and F respectively, calculated using the formula (9) of this Safety Guide.



18. The xmax value obtained from the formula (11) shall be used for calculation of the value Emax>10(x,xmax) considering the following assumptions:

if the value xmax obtained from the formula (11) is reached within the sanitary protection zone (hereinafter SPZ) and no permit of the State sanitary and epidemiological supervision body is available for use of the agricultural lands and positive sanitary and epidemiological report for the produced product in accordance with the item 5.4 of SP 2.6.1.2216-07 "2.6.1. Ionizing radiation, radiation safety. Sanitary protection zones and surveillance areas of radiation facilities. Operation conditions and justification of the boundaries" approved by the Ordnance of the Chief State Public Health Officer of the Russian Federation No. 30 dated May 29, 2007 (registered by the Ministry of Justice of the Russian Federation dated June 27, 2007, registration No. 9727) (hereinafter SP SPZ and SA-07) and/or if the food products and fodder for cattle in the SPZ is not produced and/or grazing of cattle in the SPZ territory is not carried out, the value xmax shall be taken as equal to the distance from the point source or from the center of the directed source of emergency release up to the SPZ boundary;

if the value x1 obtained from the formula (11) is attained outside the SPZ or if the obtained value xmax is within the SPZ, and permit of the State sanitary and epidemiological supervision agencies is available for use of the SPZ lands for agricultural purposes and favorable hygiene certificate for the manufactured product is available in conformance with the item 5.4 of SPZ SR and SZ-07, the value xmax obtained from the formula (11) shall be used for calculation of the value Emax>10(x,xmax);

if there is no SPZ at the NFCF outside the on-site limits, and the value xmax obtained from the formula (11) is reached within the on-site limits, the value xmax shall be taken as equal to the distance from the source or from the center of the site source of accident release up to the on-site boundary.

19. Only those food products which are characteristic for the area where the NFCF is located shall be considered in assessing the effective dose of internal exposure caused by the consumption of food products, .



20. The effective internal exposure dose from inhalation due to secondary wind uplift, , shall be calculated according to the formula:



, (12)



, (13)



where:

R(t) - deflation coefficient, m-1;

T1/2 - half-life of radionuclide r, year;

A1, A2, C - constants taking the values 1.93 · 10-6, 1.71 · 10-8 and 1.00 · 10-9, m-1;

B1, B2 - constants taking the values -14.235 and -0.9125, year-1;

T0 and T - start and end of the time interval corresponding to the specific year for the period starting with the end of the first year after the accident, year.

Appendix No. 1   
to the safety guide in the use of atomic energy "Recommended assessment and prediction methods of the radiological consequences of accidents at the nuclear fuel cycle facilities" approved by the Federal Environmental, Industrial and Nuclear Supervision Service   
order No. \_\_\_\_\_\_\_ dated \_\_\_\_ \_\_\_\_\_\_\_\_\_\_ 20\_\_

RECOMMENDATIONS   
FOR CALCULATION OF RADIONUCLIDE CONCENTRATIONS IN ENVIRONMENTAL COMPONENTS

1. Calculation of the concentrations of radionuclides in atmospheric air in scenarios 1, 2, 3 and 5

1.1. Calculation of the time interval of radionuclide r concentration suspended in the lowest atmospheric air layer, Cj,r(x), for such sources of formation of radioactive accident release as fire at the NFCF outdoor area (scenario 1); wind entrainment of radioactive substances from the contaminated areas located at the NFCF outdoor area due to extreme wind loads (scenario 2); release of radioactive substances through the exhaust ventilation system to the atmosphere as part of process blowdowns or as part of air removed from the NFCF rooms, and radioactive substance release through leakiness of the buildings including on occurrence of SSCR (scenario 3); release to the NFCF outdoor area on SSCR occurrence (scenario 5) shall be made according to the following formula:

Cj,r(x) = Qr · Gj,r(x), (1)

where:

Qr - activity of radionuclide r in accident release, Bq;

Gj,r(x) - ground-level dilution factor of radionuclide r at distance x from the source of accident release, sec/m3;

The recommended calculation procedure of the quantity Cj,r(x) for scenarios 1 and 2 is set forth in the section 2 of Appendix No. 2 of this Safety Guide, and for the scenarios 3 and 5 in the section 1 of Appendix No. 2 of this Safety Guide.

1.2. Calculation of the integral from the radionuclide r concentration distributed by height in the vertical direction of accident release for such sources of formation of radioactive accident release as fire at the NFCF outdoor area (scenario 1); wind entrainment of radioactive substances from the contaminated areas located at the NFCF outdoor area due to extreme wind loads (scenario 2); release of radioactive substances through the exhaust ventilation systems to the atmosphere as part of process blowdowns or as part of air removed from the NFCF rooms, and radioactive substance release through leakiness of the buildings including on occurrence of SSCR (scenario 3); release to the NFCF outdoor area on SSCR occurrence (scenario 5) shall be made according to the following formula:



, (2)



where - radionuclide deposition factor in vertical direction of accident release propagation, sec/m2.



The recommended calculation procedure of the quantity for scenarios 1 and 2 is set forth in the section 2 of Appendix No. 2 of this Safety Guide, and for the scenarios 3 and 5 in the section 1 of Appendix No. 2 of this Safety Guide.



2. Calculation of radionuclide concentration in atmospheric air in scenario 4

2.1. In calculating the time integral of radionuclide r concentration suspended in the lowest atmospheric air layer at a distance x from the source of accident release, Cj,r(x), the non-uniform distribution of radionuclide r along the emergency release column height shall be considered for such source of formation of radioactive accident release as the explosions of diverse origin at the outdoor area of NFCF (scenario 4). The following formula shall be used for this purpose:

, (3)



where:

- fraction of radionuclide r from its content in the accident release in its entirety contained at a relative height Hh, calculated in accordance with the section 4 of Appendix No. 3 of this Safety Guide;



Gj,r,h(x) - values of radionuclide r dilution factor in the ground-level air atmosphere at distances x from the source of accident release located at a relative height Hh, sec/m3;

- symbol denoting the summation along all relative heights calculated in conformance with section 4 of Appendix No. 3 of this Safety Guide.



The recommended values are given in the table 2 of Appendix No. 4 of this Safety Guide.



2.2. In calculating the integral from height distributed radionuclide r concentration in the vertical direction of accident release propagation, , the non-uniform distribution of radionuclide r along the accident release column height shall be considered for such source of formation of radioactive accident release as the explosions of diverse origin at the outdoor area of NFCF (scenario 4). The following formula shall be used for this purpose:



, (4)



where - values of the radionuclide r deposition factor in the vertical direction from the source of accident release located at a relative height Hh, sec/m2.



2.3. Recommended procedure for calculation of the quantities Gj,r,h(x) and for the scenario 4 is stated in the section 2 of Appendix No. 2 of this Safety Guide.



3. Calculation of specific concentrations of radionuclides on the soil surface for scenarios 1 - 5

3.1. The cumulative fall-out of radionuclide r on the ground surface due to dry and wet deposition, Clj,r(x) shall be calculated according to the following formula:

, (5)



where:

- value of the rate of radionuclide r deposition on the ground surface, m/sec; values are presented in the table 3 of Appendix No. 4 of this Safety Guide;



- value of permanent washing of radionuclide by atmospheric precipitations, sec-1; calculation procedure of the quantity is set forth in the section 3 of Appendix No. 2 of this Safety Guide.



4. Calculation of specific concentrations of radionuclides in food products for scenarios 1 - 5

4.1. The specific activity of radionuclide r in the food products, , shall be calculated according to the following formula:



, (6)



where:

- accumulation factor standardized for productivity "fall-out from the atmosphere - content in food products" along the stem route for dairy products (m2/l), vegetable and animal origin (m2/kg); the values are presented in the table 4 of Appendix 4 of this Safety Guide;



- accumulation factor standardized for productivity "deposition on soil - content in food products" along the root path for dairy products (m2/l), vegetable and animal origin (m2/kg); the values are presented in the table 5 of Appendix 4 of this Safety Guide;



If the values of coefficients and for radionuclide r present in the accident release are not available in the tables 4 and 5 of Appendix No. 4 of this Safety Guide, the values of and shall be taken from the reference materials.



4.2. The accumulation factor standardized for productivity equal to zero shall be taken in assessment of the radiological consequences after the first year after accident (in the assumption that the exposure in this period is conditioned primarily by that part of the activity, which entered the products through the root path).



Appendix No. 2   
to the safety guide in the use of atomic energy "Recommended assessment and prediction methods of the radiological consequences of accidents at the nuclear fuel cycle facilities" approved by the Federal Environmental, Industrial and Nuclear Supervision Service order No. \_\_\_\_\_\_\_   
dated \_\_\_\_ \_\_\_\_\_\_\_\_\_\_ 20\_\_

RECOMMENDATIONS FOR CALCULATION OF DILUTION AND DEPOSITION

1. Calculation of the dilution and deposition factors by point source method of accident releases for the scenarios 3 and 5

1.1. The point source method of accident releases for calculation of the dilution and deposition factors shall be used for assessing the radiological consequences for such sources of formation of accident radioactive release as the release of radioactive substances through the ventilation systems to atmospheric air as part of process blowdowns or as part of air removed from the rooms of NFCF, and release of radioactive substance through leakages of the buildings including on SSCR occurrence (scenario 3) or release to the outdoor territory of NFCF on occurrence of SSCR (scenario 5).

1.2. The following formula shall be used for calculation of the values of the dilution factor of radionuclide r in the atmospheric boundary layer at a distance x from the point source of emergency release:

, (1)



where:

Gj,r(x) - ground-level dilution factor of radionuclide r at distance x from the source of accident release, sec/m3;

Kb - dimensionless coefficient considering the fraction of radionuclide entering the air shadow area;

Fj,r(x) - dimensionless radioactive cloud depletion function;

and - radioactive cloud dispersion coefficients in horizontal and vertical directions of radioactive cloud propagation at distance x from the point source of accident release for atmospheric stability criteria j, assessed in accordance with the section 3 of this Appendix, m;



hТ - height of pipe from where accident release to the atmosphere takes places, m;

xb - distance at which the virtual source of accideent release is located, m; calculation procedure of the quantity xb is given in the section 3 of this Appendix;

uj - wind speed at radioactive substance release height for atmospheric stability category j, m/sec; in calculation of the dilution factor for such sources of formation of accident radioactive release, as the release of radioactive substances through the exhaust ventilation systems to the atmosphere as part of the process vents or as part of air collected from the NFCF rooms, and release of radioactive substances through the leakages of buildings (scenario 3) or release to the NFCF outdoor territory on occurrence of SSCR (scenario 5), the wind velocity calculated according to the formula (5) of this Appendix shall be used;

Hj - effective height of radioactive release at atmospheric stability criteria j calculated in accordance with the sections 3 and 5 of Appendix No. 3 of this Safety Guide, m.

1.3. The recommended formula for calculation of the values of radionuclide r deposition factor in the vertical direction of propagation of accident release by method of high source of accident releases has the form:

, (2)



where - radionuclide deposition factor in vertical direction of accident release propagation, sec/m2.



1.4. The value of fraction of radionuclides Kb entering the air shadow area created by the building located in the direction of accident release propagation, depending on the dimensionless effective height of the building shall be determined according to the table 1 of Appendix No. 5 of this Safety Guide.



1.5. The effective height of the building shall be calculated according to the following formula:



, (3)



where:

- reduced height of building, m;



HIZ - height of disturbed zone, m;

Hb - height of nearest building, located in the direction of radioactive cloud propagation, m.

1.6. Calculation of the height of disturbance HIZ shall be made according to the following formula:

, (4)



where b - width of building section perpendicular to the wind direction, m

1.7. In calculating the dilution factor according to formula (1) and deposition factor according to formula (2) of this Appendix for such source of formation of accident radioactive release of radioactive substances as release through the exhaust ventilation systems to the atmosphere as part of process blowdowns or as part of the air removed from the NFCF rooms, and release of radioactive substances through the leakiness of buildings including on occurrence of SSCR (scenario 3), if no building is available shall be taken in the formulae (1) and (2) of this Appendix that Kb=0. Similarly Kb=0 shall be taken in the formulae (1) and (2) of this Appendix for the source of formation of accident radioactive release to the NFCF outdoor area on SSCR occurrence (scenario 5).

1.8. The wind velocity at radioactive substance release height for atmospheric stability category j according to the formulae (1) and (2) of this Appendix for such sources of formation of accident radioactive release, as the release of radioactive substances through the exhaust ventilation systems to the atmosphere as part of the process vents or as part of air collected from the NFCF rooms, and release of radioactive substances through the leakages of buildings (scenario 3) or release to the NFCF outdoor area on occurrence of SSCR (scenario 5) shall calculated according to the following formula:

, (5)



where:

z - height of weather cock (recommended to take as equal to 10 m);

uz - wind velocity at weather cock height, m/sec;

hT - geometric height of pipe from its base to the orifice, m; half the building height shall be taken as the quantity hT, and Kb = 1 in calculating the wind velocity for radioactive substance release through the leakiness of buildings;

- dimensionless coefficient, depending on stability category j; recommended values are given in the table 2 of Appendix No. 5 of this Safety Guide.



z0 - mesoscale roughness coefficient of the underlying surface, cm; recommended values of z0 are given in the table 3 of Appendix No. 5 of this Safety Guide.

1.9. The wind velocity at the weather cock height (uz) shall be taken for atmospheric stability categories B,C, D, E equal to 2 m/sec, and for A, F -1 m/sec for getting a conservative assessment of wind velocity at the accident release rise height.

2. Calculation of the dilution and deposition factors by distributed source method of accident releases for the scenarios 1, 2 and 4

2.1. The distributed source of emergency releases for calculation of the dilution and deposition factors shall be used for assessment of the radiological consequences for such sources of formation of accident radioactive releases as fire at the NFCF outdoor area (scenario 1), wind entrainment of radioactive substances from the contaminated areas located at the NFCF outdoor area due to extreme wind loads (scenario 2) or possible explosions of diverse origin at the NFCF outdoor area (scenario 4).

2.2. The following formula shall be used for calculation of the values of the dilution factor of radionuclide r in the atmospheric boundary layer at a distance x from the distributed source of accident release as fire at the NFCF outdoor area (scenario 1):

, (6)



where:

uj - wind velocity at the radioactive substance release height for atmospheric stability category j, m/sec;

Hj - effective release height which shall be calculated in accordance with the section 1 of Appendix No. 3 of this Safety Guide, m;

dy and dz - coefficients responsible for formation of the virtual source of accident release in the horizontal and vertical directions of accident release propagation at a distance x, m;

and - shall be calculated according to the formulae (19) and (20) of this Appendix.



2.3. The following formula shall be used for calculation of the values of the deposition factor of radionuclide r from such distributed source of accident release as fire at the NFCF outdoor area (scenario 1):

. (7)



2.4. The wind velocity (uj) for the effective height of accident release for the atmospheric stability category j according to the formulae (6) and (7) of this Appendix shall be calculated according to the following formula:

, (8)



where:

z - height of weather cock (shall be taken as equal to 10 m);

uz - wind velocity at the weather cock height, m; recommended values of uz for various categories of atmospheric stability are given in the item 2.5 of Appendix No.2 of this Safety Guide;

pj - dimensionless exponential factor; recommended values pj are given in the table 4 of Appendix No 5 of this Safety Guide.

2.5. The wind velocity at the weather cock height (uz) shall be taken for atmospheric stability categories B,C, D, E equal to 2 m/sec, and for A, F -1 m/sec for getting a conservative assessment of wind velocity at the accident release rise height.

2.6. The coefficients dz and dy shall be calculated according to the following formulae:

; (9)



, (10)



where:

R - equivalent surface radius at the NFCF outdoor territory where fire broke out (scenario1) or explosion took place (scenario 4), m;

, , , - dimensionless coefficients of diffusion for atmospheric stability category j.



The recommended values of the diffusivity, , , for the calculation and are given in the table 5 of Appendix No. 5 of this Safety Guide.



2.7. For the calculation of radionuclide concentrations in the atmospheric air Cj,r(x) and for such distributed source as potential explosions of diverse origin at the NFCF outdoor territory (scenario 4), the effective height of radioactive release at atmospheric stability category j(Hj) the values Hh obtained according to formula (14) of section 4 of Appendix No. 3 of this Safety Guide shall be used and for each Hh the following quantities shall be calculated in accordance with this Appendix:



Gj,r,h(x) and in the formulae (3) and (4) pf Appendix No. 1 of this Safety Guide according to the formulae (6) and (7) of this Appendix;



uj in the formulae (6) and (7) of this Appendix according to the formula (8) of this Appendix;

Fj,r(x) in the formulae (6) and (7) of this Appendix according to the formulae (18) of this Appendix;

dy и dz in the formulae (6) and (7) of this Appendix according to the formulae (9) and (10) of this Appendix.

2.8. The following approximations shall be used for calculation of the values of radionuclide r dilution in the atmospheric boundary layer at a distance of x according to the formula (11) and radionuclide r deposition factor in the vertical direction of accident release propagation according to the formula (13) of this Appendix from such directed source of accident release, as wind entrainment of radioactive substances from contaminated areas located at the NFCF outdoor territory due to extreme wind loads (scenario 2).

distributed source has square form with side 2a;

distributed source is centered and each side is perpendicular to the radioactive cloud propagation direction;

formulae used for calculation of the values of radionuclide r dilution factor in the atmospheric boundary layer at distance x and deposition factor in the vertical direction of accident release propagation are applicable for calculation at distances from a to 50 km.

2.9. The values of the radionuclide r dilution factor in the atmospheric boundary layer at distance of x from such source of emergency release such as wind entrainment of radioactive substances from the contaminated areas located at the outdoor territory of NFCF due to extreme wind loads (scenario 2) shall be calculated according to the following formula:

, (11)



where:

- vertical dispersion factor;



a - half the side length of the directed source of release, m;

- integration variable, m;



z - variable characterizing the height above the ground surface (shall be taken as equal to 1 m);

erf - error function;

uj - wind speed at roughness height for stability category of atmosphere j for extreme wind loads (scenario 2), which shall be taken in accordance with the extreme wind loads characteristic for the NFCF location area, m/sec.

2.10. The value of vertical dispersion factor shall be calculated according to the following formula:

, (12)



where:

n - summation variable;

Hmix - height of mixing layer, m (shall be taken as equal to 100 m);

Hj - effective release height which shall be calculated in accordance with the section 2 of Appendix No. 3 of this Safety Guide, m.

2.11. The values of the radionuclide r deposition factors in the vertical direction of accident release propagation from such distributed source of emergency release such as wind entrainment of radioactive substances from the contaminated areas located at the outdoor territory of NFCF due to extreme wind loads (scenario 2) shall be calculated according to the following formula

. (13)



3. The calculation of parameters required for calculation of dilution and deposition factors for the scenarios 1 - 5

3.1. The calculation of the release cloud depletion function due to radioactive decay shall be performed according to the following formula:

, (14)



where:

- dimensionless release cloud depletion function due to radioactive decay of radionuclide r;



- radioactive decay constant of radionuclide r, sec-1.



3.2. The cloud depletion function due to radioactive decay shall be taken as equal to 1 for the radionuclides with half-life more than 10 days.

3.3. The calculation of the radioactive cloud depletion function due to dry deposition shall be performed according to the following formula:

. (15)



3.4. When calculating and the radioactive cloud depletion function due to removal processes by atmospheric precipitations in the formula (18) of this Appendix shall be calculated according to the following formula.



, (16)



where - permanent washout quantity of radionuclide r by atmospheric precipitations, sec-1.



3.5. When calculating and the function of radioactive cloud depletion due to washout processes by atmospheric precipitation shall be taken as equal to 1 in the formula (18) of this Appendix.



3.6. The calculation of the values of permanenet removal by atmospheric precipitations shall be made according to the following formula:

, (17)



where:

K0 - dimensionless quantity of relative washout capacity of the precipitations of other types; recommended value K0 is given in table 6 of Appendix No. 5 of this Safety Guide;

I - intensity of atmospheric precipitations, which is recommended to take as the maximum recorded for the time period equal to the scheduled period of further operation of NFCF, mm/h;

Kr - standard value of washout capability, h/mm·sec) (for IRG shall be taken as equal to 0, for other radionuclides equal to 10-5 h/(mm·sec).

3.7. The complete function of radioactive cloud depletion shall be calculated using the following formula:

, (18)



3.8. The calculation of the dispersion coefficients and for the scenarios 1 -5 shall be made according to the following formulae:



; (19)



. (20)



3.9. In the formulae (1) and (2) of Appendix No. 2 of this Safety Guide the parameter xb characterizing the distance at which the virtual source of emergency release is located shall be determined as the root of the following equation:

, (21)



where Sb - area of the building section located perpendicular to the direction of propagation of the emergency release, m2.

Appendix No. 3   
to the safety guide in the use of atomic energy "Recommended assessment and prediction methods of the radiological consequences of accidents at the nuclear fuel cycle facilities" approved by the Federal Environmental, Industrial and Nuclear Supervision Service   
order No. \_\_\_\_\_\_\_ dated \_\_\_\_ \_\_\_\_\_\_\_\_\_\_ 20\_\_

RECOMMENDATIONS   
FOR CALCULATION OF EMERGENCY RELEASE RISE CHARACTERISTICS

1. Calculation of rise of emergency release at scenario 1

1.1. The equation (1) of this Appendix shall be resolved with respect Hj by placing in it the right side of equation (8) instead of u(Hj) of this Safety Guide for determining the radioactive cloud rise.

, (1)



where:

Hj is the radioactive cloud rise height formed following fire, m;

F - radioactive cloud buoyancy flow formed following fire, m4/sec3;

X - distance from the source of fire to the point of reaching the rise by the radioactive cloud, m;

u(Hj) - wind velocity at the height Hj for atmosphere stability category j, m/sec;

S - proportionality ratio, m/(sec2·°K).

1.2. The value of radioactive cloud buoyancy value shall be calculated according to the following formula:

, (2)



where:

Q - release rate of amount of heat, J/sec;

Ta - temperature of atmospheric air at the time of accident, °K;

0.003 - proportionality ratio, (m4·°K)/(sec2·J).

1.3. The maximum temperature of atmospheric air characteristic for the region in which the NFCF is located shall be used for getting conservative assessments of the emergency release rise.

1.4. The value calculation of the rate of thermal release shall be made according to the following formula:

, (3)



where:

V - volume of burned fuel, m3;

tr - fuel burning time of scope V, sec;

2.86 · 107 - proportionality ratio, J/m3.

1.5. The distance from the source of emission to the point of radioactive cloud reaching the rise shall be calculated according to the following formula:

. (4)



1.6. The calculation of the proportionality ratio of the emergency release rise shall be made according to the following formula:

. (5)



5. Calculation of rise of emergency release at scenario 2

2.1. The value of effective release height Hj is equal to height of surface roughness, the value thereof is recommended to take in accordance with the table 3 of Appendix No. 5 to this Safety Guide shall be taken for such source of formation of emergency radioactive release as wind entrainment of radioactive substances from the contaminated areas located at the outdoor area of NFCF due to extreme wind loads (scenario 2).

3. Calculation of rise of emergency release at scenario 3

3.1. For calculation of the radioactive cloud rise height from the pipe the following formula shall be used:

, (6)



where:

hТ - geometric height of pipe from its base to the opening neck, m;

- dynamic (velocity) and thermal rise of radioactive cloud above the pipe opening neck, m;



Cj - correction for skewness of radioactive cloud trajector during weak wind from impact of air shadow of the pipe itself, m.

3.2. The correction for skewness of radioactive cloud trajectory at gentle breeze from the impact of air shadow shall be calculated according to the following formula:

, (7)



where:

w0 - outflow rate of discharged gases, m/sec;

d - diameter of pipe neck, m

3.3. The dynamic (velocity) and thermal rise of radioactive cloud above the opening neck of the source for all weather conditions shall be calculated for modified Netterville formulae:

for category D (indifferent stratification of atmosphere):

; (8)



for categories A, B and C (instability conditions):

; (9)



for categories E and F (stable conditions):

, (10)



where:

f - characteristic frequency of turbulence spectrum during neutral atmosphere, c-1 (recommended to be taken as equal to 0.7 · 10-2 sec-1);

M0 - value proportional to the kinetic energy flow of exiting stream of emergency release, m4/sec2;

tj = x / uj - cloud movement time by wind up to a distance x;

- initial radius of emergency release jet with Hanna correction, m;



- dimensionless transfer constant; recommended values are given in the table 7 of Appendix No. 5 of this Safety Guide;



s - stability parameter of atmosphere, sec-1; recommended values of s are given in the table No. 7 of Appendix No. 5 of this Safety Guide.

3.4. The value of radioactive cloud buoyancy value shall be calculated according to the following formula:

, (11)



where - difference of temperatures of discharged T and atmospheric Ta of air, °C.



3.5. The maximum temperature of atmospheric air for the region in which NFCF is located shall be used for getting conservative assessments of the emergency release rise of radioactive substances on discharge of radioactive substances as part of process blowdown or as part of air drawn from the NFCF rooms through the exhaust ventilation systems to the atmosphere, as well as during discharge of radioactive substances through crackages (scenario 3).

3.6. The value proportional to flow of kinetic energy of exiting emergency release jet from the pipe shall be calculated according to the following formula:

. (12)



3.7. The calculation of initial jet radius with Hanna correction shall be made according to the following formula:

. (13)



4. Calculation of rise of emergency release at scenario 4

4.1. The following formula shall be used for calculation of relative rise of emergency release:

, (14)



where:

Hh - relative height of radioactive substances release column to the atmosphere, m;

hобл - height at the maximum point of the release, m;

- dimensionless coefficient, characterizing the vertical distribution of radionuclide in the release column; recommended values are given in the table 2 of Appendix No. 4 of this Safety Guide.



4.2. Calculation of height at the highest release point shall be made according to the following formula:

hобл = 123 · w0.25, (15)

where w - explosion yield measured in TNT equivalent, kg

5. Calculation of rise of emergency release at scenario 5

5.1. The value of effective release height Hij is equal to height of surface roughness, the value thereof is recommended to take in accordance with the table 3 of Appendix No. 5 to this Safety Guide shall be taken for the source of formation of emergency radioactive release to the outdoor territory of NFCF on occurrence of SSCR (scenarion 5).

Appendix No. 4   
to the safety guide in the use of atomic energy "Recommended assessment and prediction methods of the radiological consequences of accidents at the nuclear fuel cycle facilities" approved by the Federal Environmental, Industrial and Nuclear Supervision Service   
order No. \_\_\_\_\_\_\_ dated \_\_\_\_ \_\_\_\_\_\_\_\_\_\_ 20\_\_

RECOMMENDED VALUES OF THE   
PARAMETERS USED DURING CALCULATION OF HUMAN EXPOSURE DOSE AND CONCENTRATION OF RADIONUCLIDES ENTERING THE ENVIRONMENT FOLLOWING ACCIDENT AND SPREADING ON FOOD PRODUCTS

Table 1

Recommended values of daily energy for persons from different age groups, kcal/day <\*>

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| Age group (g) | 2 | 3 | 4 | 5 | 6 |
| Age | 1 - 2 years | 2 - 7 years | 7 - 12 years | 12 - 17 years | > 17 |
| Energy, kcal/day | 1400 | 2000 | 2600 | 3100 | 2900 |

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<\*> Energy values are taken in accordance with the safety guide "Recommended methods of calculation of the parameters required for development an establishment of the maximum permissible releases of radioactive substances to the atmosphere" (RB-106-15) approved by order of Federal Environmental, Industrial and Nuclear Supervision Service dated November 11, 2015 No. 458.

Table 2

Recommended values of dimensionless parameters and for assessment of the radionuclide r concentration <\*>



|  |  |  |
| --- | --- | --- |
| Item |  |  |
| 1 | 0.8 | 0.20 |
| 2 | 0.6 | 0.35 |
| 3 | 0.4 | 0.25 |
| 4 | 0.2 | 0.16 |
| 5 | 0 | 0.04 |

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<\*> Values of coefficients are taken in accordance with the document HotSpot Health Physics Code. Version 3.0. User's Guide. Lawrence Livermore National Laboratory, 2013 (User guide of HotSpot software, designed for assessment of radiation impact).

Table 3

Recommended values of radionuclide r precipitation rate on the ground surface <\*>



|  |  |
| --- | --- |
| Groups of radionuclides | , m/sec |
| Molecular iodine | 0.020 |
| Organic iodine | 0.001 |
| Aerosols | 0.008 |
| Gases (IRG) | 0 |

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<\*> Values of the coefficients are taken in accordance with the document "Methodical instructions on assessment of radiation situation in the environment and of the expected radiation in case of short emissions of radioactive substances into the atmosphere" - Moscow, Minatom of Russia, 1998.

Table 4

The recommended values of storage coefficient standardized for productivity "precipitation from atmosphere - content in food products" for the cauline contamination path, <\*>, m2/l (m2/kg)



|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| Nuclide | Meat | MIlk | Wheat | Cucumbers | Cabbage | Potatoes |
| 22Na | 6.2 · 10-1 | 8.2 · 10-1 | 8.2 · 10-1 | 2.6 · 10-2 | 3.5 · 10-2 | 8.7 · 10-3 |
| 51Cr | 3.1 · 10-4 | 3.2 · 10-4 | 1.1 · 10-2 | 2.4 · 10-2 | 3.8 · 10-3 | 9.6 · 10-4 |
| 54Mn | 1.2 · 10-2 | 3.2 · 10-3 | 5.6 · 10-1 | 2.6 · 10-2 | 2.7 · 10-2 | 6.8 · 10-3 |
| 56Mn | <\*\*> | 2.3 · 10-8 | <\*\*> | 2.0 · 10-7 | 5.9 · 10-10 | 1.5 · 10-10 |
| 55Fe | 2.6 · 10-1 | 6.4 · 10-3 | 8.3 · 10-1 | 2.6 · 10-2 | 3.5 · 10-2 | 8.8 · 10-3 |
| 59Fe | 1.0 · 10-2 | 3.0 · 10-4 | 4.3 · 10-2 | 2.5 · 10-2 | 6.5 · 10-3 | 1.6 · 10-3 |
| 58Co | 8.4 · 10-2 | 5.7 · 10-3 | 1.1 · 10-1 | 2.5 · 10-2 | 1.0 · 10-2 | 2.6 · 10-3 |
| 60Co | 3.0 · 10-1 | 1.7 · 10-2 | 9.1 · 10-1 | 2.7 · 10-2 | 3.7 · 10-2 | 9.4 · 10-3 |
| 63Ni | .5.3 · 10-2 | .5.3 · 10-2 | 9.9 · 10-1 | 2.7 · 10-2 | 4.0 · 10-2 | 1.0 · 10-2 |
| 65Zn | 8.2 · 10-2 | 8.8 · 10-2 | 4.8 · 10-1 | 2.6 · 10-2 | 2.4 · 10-2 | 6.1 · 10-3 |
| 89Sr | 1.8 · 10-5 | 7.4 · 10-5 | 5.6 · 10-2 | 2.5 · 10-2 | 7.4 · 10-3 | 1.8 · 10-3 |
| 90Sr | 5.6 · 10-4 | 1.8 · 10-3 | 9.8 · 10-1 | 2.7 · 10-2 | 4.0 · 10-2 | 9.9 · 10-3 |
| 90Y | 1.7 · 10-8 | 1.2 · 10-9 | 1.4 · 10-13 | 8.6 · 10-3 | 1.2 · 10-4 | 3.0 · 10-5 |
| 91Y | 1.1 · 10-4 | 2.3 · 10-7 | 7.7 · 10-2 | 2.5 · 10-2 | 8.6 · 10-3 | 2.1 · 10-3 |
| 95Zr | 2.6 · 10-2 | 3.7 · 10-6 | 9.2 · 10-2 | 2.5 · 10-2 | 9.4 · 10-3 | 2.3 · 10-3 |
| 97Zr | 1.6 · 10-11 | 1.5 · 10-9 | <\*\*> | 1.2 · 10-3 | 5.7 · 10-6 | 1.4 · 10-6 |
| 95Nb | 4.6 · 10-2 | 4.3 · 10-4 | 2.2 · 10-2 | 2.4 · 10-2 | 5.0 · 10-3 | 1.2 · 10-3 |
| 99Mo | 6.1 · 10-6 | 1.5 · 10-4 | 9.6 · 10-13 | 9.2 · 10-3 | 1.4 · 10-4 | 3.5 · 10-5 |
| 99Tc | 9.2 · 10-1 | 3.7 · 10-1 | 1 | 2.7 · 10-2 | 4.0 · 10-2 | 1.0 · 10-2 |
| 103Ru | 5.8 · 10-2 | 7.4 · 10-6 | 3.1 · 10-2 | 2.4 · 10-2 | 5.6 · 10-3 | 1.4 · 10-3 |
| 106Ru | 9.2 · 10-1 | 5.9 · 10-5 | 6.1 · 10-1 | 2.6 · 10-2 | 2.9 · 10-2 | 7.2 · 10-3 |
| 105Rh | 2.4 · 10-7 | 5.9 · 10-4 | 8.5 · 10-6 | 9.9 · 10-3 | 3.8 · 10-5 | 9.4 · 10-6 |
| 110mAg | 2.2 · 10-1 | 5.3 · 10-1 | 4.9 · 10-1 | 2.6 · 10-2 | 2.5 · 10-2 | 6.2 · 10-3 |
| 125mTe | 3.2 · 10-2 | 3.9 · 10-3 | 7.5 · 10-2 | 2.5 · 10-2 | 8.5 · 10-3 | 2.1 · 10-3 |
| 127mTe | 6.2 · 10-2 | 7.0 · 10-3 | 2.2 · 10-1 | 2.6 · 10-2 | 1.5 · 10-2 | 3.8 · 10-3 |
| 129mTe | 1.6 · 10-2 | 2.2 · 10-3 | 2.0 · 10-2 | 2.4 · 10-2 | 4.7 · 10-3 | 1.2 · 10-3 |
| 131mTe | 7.6 · 10-8 | 1.7 · 10-5 | 1.9 · 10-6 | 3.5 · 10-3 | 2.0 · 10-5 | 6.4 · 10-6 |
| 132Te | 5.0 · 10-5 | 9.8 · 10-5 | 4.1 · 10-11 | 1.1 · 10-2 | 1.9 · 10-4 | 4.8 · 10-5 |
| 129I | 1.8 · 10-1 | 3.7 · 10-1 | 1 | 2.7 · 10-2 | 4.0 · 10-2 | 1.0 · 10-2 |
| 131I | 7.1 · 10-4 | 4.6 · 10-3 | 1.1 · 10-5 | 1.8 · 10-2 | 8.1 · 10-4 | 2.0 · 10-4 |
| 133I | 6.5 · 10-10 | 8.2 · 10-5 | <\*\*> | 1.8 · 10-3 | 7.4 · 10-6 | 2.5 · 10-6 |
| 134Cs | 9.2 · 10-2 | 2.2 · 10-1 | 7.8 · 10-1 | 2.6 · 10-2 | 3.4 · 10-2 | 8.4 · 10-3 |
| 137Cs | 1.1 · 10-1 | 2.6 · 10-1 | 9.8 · 10-1 | 2.7 · 10-2 | 4.0 · 10-2 | 9.9 · 10-3 |
| 140Ba | 1.4 · 10-5 | 4.5 · 10-6 | 3.4 · 10-4 | 2.1 · 10-2 | 1.5 · 10-3 | 3.8 · 10-4 |
| 140La | 1.3 · 10-9 | 7.8 · 10-9 | <\*\*> | 5,3 · 10-3 | 5.0 · 10-5 | .1.2 · 10-5 |
| 141Ce | 2,3 · 10-4 | 2.0 · 10-6 | 1.8 · 10-2 | 2.4 · 10-2 | 4.6 · 10-3 | 1,1 · 10-3 |
| 143Ce | <\*\*> | <\*\*> | <\*\*> | <\*\*> | 3.2 · 10-5 | 1.1 · 10-5 |
| 144Ce | 5.6 · 10-3 | 3.9 · 10-5 | 5.3 · 10-1 | 2.6 · 10-2 | 2.6 · 10-2 | 6.5 · 10-3 |
| 143Pr | 1.2 · 10-4 | 2.1 · 10-7 | 5.4 · 10-4 | 2.1 · 10-2 | 1.7 · 10-3 | 4.2 · 10-4 |
| 147Nd | 6.6 · 10-5 | 1.7 · 10-7 | 1.3 · 10-4 | 0.020 | 1.2 · 10-3 | 3.1 · 10-4 |
| 153Sm | 6.9 · 10-8 | 7.9 · 10-9 | <\*\*> | 6.4 · 10-3 | 6.8 · 10-5 | 1.7 · 10-5 |
| 181W | 7.9 · 10-2 | 2.5 · 10-3 | 2.5 · 10-1 | 2.6 · 10-2 | 1.6 · 10-2 | 4.1 · 10-3 |
| 239Np | 6.6 · 10-11 | 1.9 · 10-10 | <\*\*> | 7.9 · 10-3 | 1.0 · 10-4 | 2.6 · 10-5 |
| U <\*\*\*> | 1.8 · 10-3 | 9.0 · 10-3 | 1 | 2.7 · 10-2 | 4.0 · 10-2 | 1.0 · 10-2 |
| Pu <\*\*\*> | 1.1 · 10-5 | 2.1 · 10-7 | 1 | 2.7 · 10-2 | 4.0 · 10-2 | 1.0 · 10-2 |

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<\*> The values of coefficients are taken in accordance with the document "Safety in nuclear power generaton. Volume 1. Part 1. General safety provisions of NPP. Methods for calculation of propagation of radioactive substances from NPP and radiation exposure of neighboring public. - Moscow, Energoatomizdat, 1984.

<\*\*> Negligibly small

<\*\*\*> Given values are same for all the isotopes of element.

Table 5

The recommended values of storage coefficient standardized for productivity "precipitation on soil - content in food products" for the root path, <\*>, m2/l (m2/kg)



|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| Nuclide | Meat | MIlk | Wheat | Cucumbers | Cabbage | Potatoes |
| 22Na | 2.1 · 10-4 | 2.8 · 10-4 | 8.2 · 10-4 | 4.0 · 10-5 | 1.5 · 10-4 | 1.5 · 10-4 |
| 51Cr | <\*\*> | <\*\*> | 1.7 · 10-9 | 54 · 10-9 | 2.6 · 10-9 | 2.6 · 10-9 |
| 54Mn | 5.3 · 10-7 | 1.4 · 10-7 | 3.4 · 10-4 | 2.4 · 10-5 | 7.2 · 10-5 | 7.2 · 10-5 |
| 56Mn | <\*\*> | <\*\*> | <\*\*> | <\*\*> | <\*\*> | <\*\*> |
| 55Fe | 1.2 · 10-6 | 2.9 · 10-8 | 8.4 · 10-4 | 4.0 · 10-5 | 1.5 · 10-4 | 1.5 · 10-4 |
| 59Fe | 1.7 · 10-11 | 5.1 · 10-13 | 2.2 · 10-7 | 1.9 · 10-7 | 1.5 · 10-7 | 1.5 · 10-7 |
| 58Co | 2.2 · 10-8 | 1.4 · 10-9 | 4.4 · 10-6 | 1.5 · 10-6 | 1.8 · 10-6 | 1.8 · 10-6 |
| 60Co | 3.9 · 10-5 | 2.3 · 10-6 | 9.7 · 10-4 | 4.2 · 10-5 | 1.7 · 10-4 | 1.7 · 10-4 |
| 63Ni | 8.8 · 10-5 | 8.8 · 10-5 | 3.6 · 10-4 | 1.4 · 10-5 | 6.2 · 10-5 | 6.2 · 10-5 |
| 65Zn | 3.0 · 10-5 | 3.2 · 10-5 | 2.4 · 10-4 | 1.9 · 10-5 | 5.2 · 10-5 | 5.2 · 10-5 |
| 89Sr | 5.7 · 10-12 | 2.3 · 10-1 | 5.3 · 10-7 | 3.5 · 10-7 | 3.0 · 10-7 | 3.0 · 10-7 |
| 90Sr | 1.8 · 10-6 | 5.8 · 10-6 | 7.4 · 10-4 | 3.0 · 10-5 | 1.3 · 10-4 | 1.3 · 10-4 |
| 90Y | <\*\*> | <\*\*> | <\*\*> | <\*\*> | <\*\*> | <\*\*> |
| 91Y | 3.2 · 10-12 | <\*\*> | 1.4 · 10-6 | 7.0 · 10-7 | 6.9 · 10-7 | 6.9 · 10-7 |
| 95Zr | 7.6 · 10-11 | <\*\*> | 2.5 · 10-6 | 1.0 · 10-6 | 1.1 · 10-6 | 1.1 · 10-6 |
| 97Zr | <\*\*> | <\*\*> | <\*\*> | <\*\*> | <\*\*> | <\*\*> |
| 95Nb | 1.8 · 10-10 | 1.7 · 10-12 | 2.3 · 10-8 | 3.7 · 10-8 | 2.2 · 10-8 | 2.2 · 10-8 |
| 99Mo | <\*\*> | <\*\*> | <\*\*> | <\*\*> | <\*\*> | <\*\*> |
| 99Tc | 2.7 · 10-2 | 1.1 · 10-2 | 2.3 · 10-7 | 9.0 · 10-9 | 3.9 · 10-8 | 3.9 · 10-8 |
| 103Ru | 3.0 · 10-9 | 3.8 · 10-13 | 7.0 · 10-8 | 8.3 · 10-8 | 5.6 · 10-8 | 5.6 · 10-8 |
| 106Ru | 5.3 · 10-5 | 54 · 10-9 | 4.2 · 10-4 | 2.7 · 10-5 | 8.5 · 10-5 | 8.5 · 10-5 |
| 105Rh | <\*\*> | <\*\*> | <\*\*> | <\*\*> | <\*\*> | <\*\*> |
| 110mAg | 3.2 · 10-5 | 7.5 · 10-5 | 2.5 · 10-4 | 2.0 · 10-5 | 5.4 · 10-5 | 5.4 · 10-5 |
| 125mTe | 4.4 · 10-7 | 5.5 · 10-8 | 1.4 · 10-6 | 6.7 · 10-7 | 6.6 · 10-7 | 6.6 · 10-7 |
| 127mTe | 1.0 · 10-5 | 1.2 · 10-6 | 3.0 · 10-5 | 5.3 · 10-6 | 8.9 · 10-6 | 8.9 · 10-6 |
| 129mTe | 6.2 · 10-9 | 8.5 · 10-10 | 1.5 · 10-8 | 2.7 · 10-8 | 1.5 · 10-8 | 1.5 · 10-8 |
| 131mTe | <\*\*> | <\*\*> | <\*\*> | <\*\*> | <\*\*> | <\*\*> |
| 132Te | <\*\*> | <\*\*> | <\*\*> | <\*\*> | <\*\*> | <\*\*> |
| 129I | 1.8 · 10-3 | 3.5 · 10-3 | 3.1 · 10-9 | 1.2 · 10-10 | 5.4 · 10-10 | 5.4 · 10-10 |
| 131I | <\*\*> | <\*\*> | <\*\*> | <\*\*> | <\*\*> | <\*\*> |
| 133I | <\*\*> | <\*\*> | <\*\*> | <\*\*> | <\*\*> | <\*\*> |
| 134Cs | 1.4 · 10-5 | 3.2 · 10-5 | 7.4 · 10-4 | 3.7 · 10-5 | 1.4 · 10-4 | 1.4 · 10-4 |
| 137Cs | 1.8 · 10-4 | 4.1 · 10-4 | 7.2 · 10-4 | 2.9 · 10-5 | 1.2 · 10-4 | 1.2 · 10-4 |
| 140Ba | <\*\*> | <\*\*> | <\*\*> | <\*\*> | <\*\*> | <\*\*> |
| 140La | <\*\*> | <\*\*> | <\*\*> | <\*\*> | <\*\*> | <\*\*> |
| |  | | --- | | Consultant Plus: note.  There is probably a misprint in the official document test: we mean footnote <\*\*>, and not asterisk <\*> | | | | | | | |
| 141Ce | 1.3 · 10-13 | <\*> | 1.1 · 10-8 | 2.1 · 10-8 | .1.2 · 10-8 | .1.2 · 10-8 |
| 143Ce | <\*\*> | <\*\*> | <\*\*> | <\*\*> | <\*\*> | <\*\*> |
| 144Ce | 1.7 · 10-8 | 1.1 · 10-10 | 3.0 · 10-4 | 2.2 · 10-5 | 6.4 · 10-5 | 6.4 · 10-5 |
| 143Pr | <\*\*> | <\*\*> | <\*\*> | 5.3 · 10-13 | 1.2 · 10-13 | 1.2 · 10-13 |
| 147Nd | <\*\*> | <\*\*> | <\*\*> | <\*\*> | <\*\*> | <\*\*> |
| 153Sm | <\*\*> | <\*\*> | <\*\*> | <\*\*> | <\*\*> | <\*\*> |
| 181W | 2.5 · 10-7 | 8.0 · 10-9 | 4.3 · 10-5 | 6.6 · 10-6 | .1.2 · 10-5 | .1.2 · 10-5 |
| 239Np | <\*\*> | <\*\*> | <\*\*> | <\*\*> | <\*\*> | <\*\*> |
| U <\*\*\*> | 5.3 · 10-7 | 2.7 · 10-6 | 7.1 · 10-11 | 2.8 · 10-12 | .1,2 · 10-11 | .1,2 · 10-11 |
| Pu <\*\*\*> | 3.2 · 10-10 | 6.4 · 10-12 | 2.0 · 10-6 | 8.0 · 10-8 | 3.5 · 10-7 | 3.5 · 10-7 |

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<\*> The values of coefficients are taken in accordance with the document "Safety in nuclear power generaton. Volume 1. Part 1. General safety provisions of NPP. Methods for calculation of propagation of radioactive substances from NPP and radiation exposure of neighboring public. - Moscow, Energoatomizdat, 1984.

<\*\*> Negligibly small

<\*\*\*> Given values are same for all the isotopes of element.

Appendix No. 5   
to the safety guide in the use of atomic energy "Recommended assessment and prediction methods of the radiological consequences of accidents at the nuclear fuel cycle facilities" approved by the Federal Environmental, Industrial and Nuclear Supervision Service   
order No. \_\_\_\_\_\_\_ dated \_\_\_\_ \_\_\_\_\_\_\_\_\_\_ 20\_\_

RECOMMENDED VALUES OF   
PARAMETERS USED FOR CALCULATION OF DILUTION AND PRECIPITATION FACTORS, AND HEIGHTS OF EMERGENCY RELEASES

Table 1

Recommended values of impurities fraction Kb falling in the air shadow area behind the building during low release depending on the dimensionless effective height of the building <\*>



|  |  |
| --- | --- |
| , m | Kb |
| 0 | 1 |
| 0.05 | 0.984 |
| 0.1 | 0.960 |
| 0.2 | 0.906 |
| 0.3 | 0.808 |
| 0.4 | 0.662 |
| 0.5 | 0.500 |
| 0.6 | 0.338 |
| 0.7 | 0.192 |
| 0.8 | 0.094 |
| 0.9 | 0.040 |
| 0.95 | 0.014 |
| 1 | 0 |

Note. The intermediate values are determined by the method of linear interpolation.

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<\*> Values of the coefficients are taken in accordance with the document "Methodical instructions on assessment of radiation situation in the environment and of the expected radiation in case of short emissions of radioactive substances into the atmosphere" - Moscow, Minatom of Russia, 1998.

Table 2

Recommended values of the parameter used for calculation of the change wind speed from height <\*>



|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Stability category | z0 = 0.05 m | z0 = 0.1 m | z0 = 1 m | z0 = 3 m |
| A | 0.05 | 0.08 | 0.16 | 0.27 |
| B | 0.06 | 0.09 | 0.17 | 0.28 |
| C | 0.06 | 0.11 | 0.20 | 0.31 |
| D | 0.12 | 0.16 | 0.27 | 0.37 |
| E | 0.34 | 0.32 | 0.38 | 0.47 |
| F | 0.53 | 0.54 | 0.61 | 0.69 |

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<\*> Values of the coefficients are taken in accordance with the document "Methodical instructions on assessment of radiation situation in the environment and of the expected radiation in case of short emissions of radioactive substances into the atmosphere" - Moscow, Minatom of Russia, 1998.

Table 3

Recommended values of the mesoscale roughness coefficient of geological substrate z0 <\*>

|  |  |
| --- | --- |
| Type of underlying surface | z0, m |
| Grazing land/hayfield/soil | 0.05 |
| Agricultural areas | 0.1 |
| Forest/fruit trees | 1 |
| City | 3 |

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<\*> The values of coefficients are taken in accordance with the document Model Description of the Terrestrial Food Chain and Dose Module FDMT in RODOS PV4.0. Rodos Report Decision Support for Nuclear Emergencies, 1999 (Отчет: Model description of Rodos software designed for assessment of radiation impact caused by consumption of contaminated food products).

Table 4

Recommended values of dimensionless exponential factor pj <\*>

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| Stability category | | | | | |
| A | B | C | D | E | F |
| 0.07 | 0.07 | 0.10 | 0.15 | 0.35 | 0.55 |

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<\*> Values of coefficients are take in accordance with the document HotSpot Health Physics Code. Version 3.0. User's Guide. Lawrence Livermore National Laboratory, 2013 (User guide of HotSpot software, designed for assessment of radiation impact).

Table 5

Recommended values of dimensionless parameters py, pz, qy, qz, used during the calculations and <\*>



|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| Release height, m | Category of atmospheric stability | Diffusion coefficients | | | |
|  |  |  |  |
|  | A | 1.503 | 0.833 | 0.151 | 1.219 |
| B | 0.876 | 0.823 | 0.127 | 1.108 |
| C | 0.659 | 0.807 | 0.165 | 0.996 |
| D | 0.640 | 0.784 | 0.215 | 0.885 |
| E | 0.801 | 0.754 | 0.264 | 0.774 |
| F | 1.294 | 0.718 | 0.241 | 0.662 |
|  | A | 0.179 | 1.296 | 0.051 | 1.317 |
| B | 0.324 | 1.025 | 0.070 | 1.151 |
| C | 0.466 | 0.866 | 0.137 | 0.985 |
| D | 0.504 | 0.818 | 0.265 | 0.818 |
| E | 0.411 | 0.822 | 0.487 | 0.652 |
| F | 0.253 | 1.057 | 0.717 | 0.486 |
|  | A | 0.671 | 0.903 | 0.025 | 1.500 |
| B | 0.415 | 0.903 | 0.033 | 1.320 |
| C | 0.232 | 0.903 | 0.104 | 0.997 |
| D | 0.208 | 0.903 | 0.307 | 0.734 |
| E | 0.345 | 0.903 | 0.546 | 0.557 |
| F | 0.671 | 0.903 | 0.484 | 0.500 |

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<\*> The values of coefficients are taken in accordance with the document Description of the atmospheric dispersion module RIMPUFF, 1999 (document: Description of the atmospheric dispersion module RIMPUFF).

Table 6

Recommended values of non-dimensional coefficient of relative washout capability of different type of precipitations K0 <\*>

|  |  |
| --- | --- |
| Precipitation type | K0 |
| Fog | 5.0 |

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<\*> Values of the coefficients are taken in accordance with the document "Methodical instructions on assessment of radiation situation in the environment and of the expected radiation in case of short emissions of radioactive substances into the atmosphere" - Moscow, Minatom of Russia, 1998.

Table 7

Recommended values of stability parameter s and dimensionless transfer constant <\*>



|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| Category of atmospheric stability | A | B | C | D | E | F |
| s, c-1 | 0.02 | 0.017 | 0.015 | 0.00 | 0.023 | 0.033 |
|  | 0.25 | 0.35 | 0.45 | 0.45 | 0.25 | 0.25 |

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<\*> Values of the coefficients are taken in accordance with the document "Methodical instructions on assessment of radiation situation in the environment and of the expected radiation in case of short emissions of radioactive substances into the atmosphere" - Moscow, Minatom of Russia, 1998.