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THE EFFECTS OF VARIATION IN METEOROLOGICAL AND RELEASE CONDITIONS ON DOWNWIND CONCENTRATION OF RADIONUCLIDES

A parametric study is presented of a model for calculation of the downwind concentration from short term release of radioactive isotopes to the atmosphere. A series of calculations were made to estimate the effects of variations in meteorological and release conditions on downwind concentrations. It has been assumed that the changes occur in the depth of mixing layer, deposition velocity, washout coefficient, wind speed, and height of release.

1. INTRODUCTION

This paper is a summary of research carried out by the author during his fellowship in Denmark. Detailed information on this issue has been given in the report [15]. A computational model for calculation of downwind radiation doses from the release of radioactive isotopes to the atmosphere was made in the Health Physics Department at Riso [16, 17]. The model can be used to calculate external gamma doses as well as internal doses due to inhalation of radioactive material. Based on the model, two computer programs were written for the calculation of doses to individuals GDOS8 (external gamma doses) and INDOS7 (inhalation doses).

In view of the large contribution of airborne radionuclide transport, as well as uncertainties in meteorological parameters and release conditions, a parametric study of models for calculation of the downwind concentration was performed in order to determine the effect of variations with respect to the calculated consequences. The influence of factors affecting airborne radionuclide transport was determined under different data and assumptions concerning these factors.

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2. AIR TRANSPORT MODEL

The mathematical model for computing the atmospheric transport and diffusion of radioactivity is described in [16]. In a stationary case the concentration $\varkappa$ of gas or aerosols at the distances x, y, z from the sources of continuous emission evaluated at the level H is given by the following equation:

$$\varkappa(x, y, z) = \frac{Q}{2\pi\sigma_y\sigma_z\bar{u}} \exp\left[-\frac{1}{2}\frac{y^2}{\sigma_y^2}\right]\left\{\exp\left[-\frac{1}{2}\frac{z^2}{\sigma_z^2}\right]+\exp\left[-\frac{1}{2}\frac{(z+2H)^2}{2\sigma_z^2}\right]\right\}, \tag{1}$$

assuming that:

in both horizontal and vertical plumes the plume spread has a Gaussian distribution,

σ_y and σ_z — standard deviations of horizontal and vertical plume concentration distributions, respectively (m),

$\bar{u}$ — mean wind speed affecting the plume (m/s),

Q — uniform emission of radionuclide (pCi/s),

total reflection of the plume takes place at the earth surface (i.e. there is no deposition or reaction at the surface),

radioactive decay is not taken into acount.

Equation (1) is valid when diffusion in the direction of travel x may be neglected, i.e. when no diffusion proceeds in the x direction. This condition may be assumed if the release is continuous or greater than the travel time $x/\bar{u}$ from the source to the location of interest. If the receptor is located at ground level $z = 0$, and the concentration is to be calculated along the center line of the plume $y = 0$, then

$$\varkappa(x) = \frac{Q}{\pi\sigma_y\sigma_z\bar{u}} \exp\left[-\frac{1}{2}\left(\frac{H}{\sigma_z}\right)^2\right]. \tag{2}$$

Equation (2) is the base of our calculation; the following notations are used:

$\varkappa(x)$ — the mean concentration at ground level $z = 0$ along the center line of the plume $y = 0$ at the downwind distance x(pCi/m^3),

Q — source strength (pCi/s),

$\bar{u}$ — mean wind speed (m/s),

H — height of release (m),

σ_y — standard deviation of cross wind distributions,

σ_z — statistical diffusion parameter representing the standard deviation of vertical distribution of pollutant material in the airborne effluent plume (m).

σ_z is evaluated by using the following expression [4]:

$$\log\left[\sigma_z\left(\frac{x}{1\,000}\right)\right] = a_0, +a_1 \log\left(\frac{x}{1\,000}\right)+a_2\left[\log\left(\frac{x}{1\,000}\right)\right]^2,$$

where:

a_0, a_1, a_2 are parameters associated with each stability classification; for each stability category, the values for a_0, a_1, a_2 were obtained by fitting the graphs in [14, 17] and listed in tab. 1,

x is given in m, and is usually accepted to be a Gaussian distribution for relatively short distances [14, 17], but for a long-travel distance a stable layer above the unstable one restricts the vertical diffusion.

Table 1

The values for a_0, a_1 and a_2 for each stability category
Wartości a_0, a_1, i a_2 dla każdej kategorii stabilności

Stability conditions	a_0	a_1	a_2
A	2.611617	2.021631	0.548155
B	2.044409	1.057002	0.0303405
C	1.786247	0.918815	−0.00397974
D	1.484478	0.733034	−0.745961
E	1.329482	0.680872	−0.105925
F	1.137662	0.655019	−0.121964

When one-tenth of the center line concentration extends to the mixing layer the plume becomes affected by it. This takes place at the distance x_L determined by

$$\sigma_z(x_L) = \frac{L-H}{\sqrt{2\ln(10)}} = 0.466(L-H). \tag{3}$$

At this distance the concentrations are calculated from the following formula [16]:

$$\varkappa(x) = \frac{Q}{\pi\sigma_y\sigma_z\bar{u}}\exp\left[-\frac{1}{2}\left(\frac{H}{\sigma_z}\right)^2\right] + \frac{Q}{2\pi\sigma_y\sigma_z\bar{u}}\left\{\sum_{i=1}^{4}\exp\left(-\frac{1}{2}\left[\frac{2iL-2H}{\sigma_z}\right]^2\right)\right.$$
$$\left. + \exp\left(-\frac{1}{2}\left[\frac{2iL+2H}{\sigma_z}\right]^2\right) + 2\exp\left[-\frac{1}{2}\left(\frac{2iL}{\sigma_z}\right)^2\right]\right\}, \tag{4}$$

where:

x, Q, σ_y, σ_z, $\bar{u}$, H as in (2),

L — height of mixing layer (m).

This formula is applied to the distances ranging from x_L to x_c determined by

$$\sigma_z(x_c) = \sqrt{2/\pi}\, L = 0.798\, L. \tag{5}$$

At the distance x_c it is assumed that the plume is uniformly distributed between the earth surface and the mixing layer, i.e. the concentration does not vary with height. Thus, the concentration can be calculated from the following equation [16]:

$$\varkappa(x) = Q\,\frac{1}{\pi\sigma_y\sqrt{2/\pi}L}, \tag{6}$$

where

$\varkappa(x)$, Q, σ_y, L as in (4).

As a release cloud travels downwind, the material is progressively removed by deposition of radionuclides on the ground and by radioactive decay. In this report radioactive decay is not taken into account. Deposition is caused by numerous and often not well understood mechanisms, such as gravitational settling (not considered in this study), precipitation scavenging (wet depletion), surface impaction, electrostatic attraction, adsorption (dry depletion), etc.

2.1. DEPLETION OF CLOUD BY WET DEPOSITION

The depletion of a cloud by wet deposition (washout) is an exponential decay process obeying the equation

$$\varkappa_w(x) = \varkappa(x) \exp\left(-\Lambda \frac{x}{\bar{u}}\right), \tag{7}$$

where:

$\varkappa_w(x)$ — the mean concentration at ground level $z = 0$ along the center line of the plume $y = 0$ at the downwind distance x during wet weather (pCi/m^3),

Λ — washout coefficient (s^{-1}),

x, u — as in expression (2),

$\varkappa(x)$ — as in expression (2).

For

$$0 < x < x_L$$

$$\varkappa_w(x) = \frac{Q}{\pi\sigma_y\sigma_z\bar{u}} \exp\left(-\frac{1}{2}\left(\frac{H}{\sigma_z}\right)^2\right) \exp\left(-\Lambda \frac{x}{\bar{u}}\right). \tag{8}$$

For

$$x_L \leqslant x \leqslant x_c$$

$$\varkappa_w(x) = \left\{\frac{Q}{\pi\sigma_y\sigma_z\bar{u}} \exp\left[-\frac{1}{2}\left(\frac{H}{\sigma_z}\right)^2\right] + \frac{Q}{2\pi\sigma_y\sigma_z\bar{u}}\left(\sum_{i=1}^{4} \exp\left[-\frac{1}{2}\left(\frac{2iL-2H}{\sigma_z}\right)^2\right]\right.\right.$$
$$\left.\left. + \exp\left[-\frac{1}{2}\left(\frac{2iL+2H}{\sigma_z}\right)^2\right] + 2\exp\left[-\frac{1}{2}\left(\frac{2iL}{\sigma_z}\right)^2\right]\right)\right\} \exp\left(-\Lambda \frac{x}{\bar{u}}\right). \tag{9}$$

For $x > xc$

$$\varkappa_w(x) = \frac{Q}{\pi\sigma_y\sqrt{2/\pi}L} \exp\left(-\Lambda \frac{x}{\bar{u}}\right). \tag{10}$$

2.2. DEPLETION OF CLOUD BY DRY DEPOSITION

Depletion of the cloud resulting from a dry deposition process is obtained from substitution of Q^1 (a reduced release rate $Q \cdot D$, whree D is the correction for the amount of radionuclide deposited by the plume from the point of release to the point of consideration [14]) for Q (the release rate in equation (2)). The depletion of radioactive substances in the plume, due to a dry deposition process during downwind travel, is derived from the relationship given by Van der HOVEN [14] as expressed by the following expression:

$$\frac{Q^1}{Q} = \exp\left\{-\left(\frac{2}{\pi}\right)^{1/2} \frac{V_g}{\bar{u}} \int_0^x \frac{1}{\sigma_z} \exp\left[-\frac{H^2}{2\sigma_z^2}\right] dx\right\}. \tag{11}$$

Replacing Q in (2) by (11), we get the following expression:

$$\varkappa d(x) = \frac{Q}{\pi\sigma_y\sigma_z\bar{u}} \exp\left[-\frac{1}{2}\left(\frac{H}{\sigma_z}\right)^2\right] \exp\left\{-\left(\frac{2}{\pi}\right)^{1/2} \frac{V_g}{\bar{u}} \int_0^x \frac{1}{\sigma_z} \exp\left[\left(-\frac{H^2}{2\sigma_z^2}\right)\right] dx\right\}, \tag{12}$$

where:

$\varkappa d(x)$ — the mean concentration at ground level $z = 0$ along the center line of the plume $y = 0$ at the downwind distance x during dry weather (pCi/m^3),

σ_y, σ_z, $\bar{u}$, Q, x, H — as in (2),

V_g — deposition velocity (m/s).

This expression can be applied only to the distance x_L. For $x \geqslant x_L$ we have no equations for the calculation of downwind concentrations during dry weather.

3. SENSITIVITY STUDIES. EFFECTS OF PARAMETER VARIATION

Parametric variations were made and analysed in order to better understand the mechanisms in the model of the calculation of airborne radionuclide transport, as well as to assess the effect of uncertainties in input data. In a general study it is virtually impossible to take into account all possible variations; nevertheless sensitivity studies were performed to evaluate the effects of uncertainties in the parameters believed to be most significant as far as their influence on the downwind concentration of radionuclides is concerned. A series of calculations were made to estimate the effects of variations in meteorological and release conditions. The changes involved mixing layer depth, deposition velocity, washout coefficient, wind speed, and height of release.

Typical values of these parameters are given below:

deposition velocity — 10^{-2} m/s [1–3,6],

washout coefficient — 10^{-4} s^{-1} [1–3,6],

wind speed for stability categories: A — 1m/s, B — 2m/s, C — 5 m/s, D — 5 m/s, E — 3 m/s, F — 2 m/s [14, 17],

mixing layer for stability categories: A — 1 500 m, B — 1 500 m, C — 1 000 m, D — 500 m, E — 200 m, F — 200 m [13],

height of release: 0 m, 50 m, and 100 m.

Variations in parameters included 6 stability categories: A, B, C, D, E, F; 3 release heights: 0 m, 50 m, and 100 m; and 3 cases of dispersion, namely: depletion of cloud by dry deposition ($V_g = 0$ m/s) and wet deposition ($\Lambda = 0$ s^{-1}) are neglected, depletion of cloud by wet deposition is taken into consideration.

3.1. DEPOSITION VELOCITY V_g (m/s)

The deposition velocity may take different values depending upon the size, shape and density of the particle, and its chemical properties. It also varies with wind velocity and turbulence, as well as with the nature of the surface involved, although the deposition velocites have been measured none of them was completely satisfactory. Field experiments called controlled environmental radioiodine tests [10] were conducted at Idaho to trace radioiodine through the air–vegetation–cow–milk–human chain.

Further important measurements of the deposition of radioactive vapours and aerosols were conducted by CHAMBERLAIN [4] at Harwell. He was concerned with the products of fission occurring in reactors or resulting from nuclear detonations. One of the more important fission products studied was the isotope ^{131}I. Similar results in the deposition of ^{131}I were obtained by CONVAIR [9] from the Fission Products Field Release Test I held in Idaho (NRTS) and Test II held in Utah.

CHAMBERLAIN [5] has found that the average velocity of ^{131}I deposition on grass for the Windscale accident was 4×10^{-3} m/s, and according to ISLITZER [12] the deposition velocity on segebrush for SLI accident in the winter of 1962 amounted to 2×10^{-3} m/s.

The Convair reports [9] covered the release and downwind measurements of various radioactive isotopes from irradiated metallic reactor fuel elements including isotopes of iodine, caesium, ruthenium, zirconium, cerium, niobium, and tellurium for which deposition velocities have been calculated.

Form these results presented there it may be concluded that the dry deposition velocity ranges over two orders of magnitude, i.e. from 10^{-3} m/s to 10^{-1} m/s, and depends to a large extent upon the characteristics of the vegetation and ground surfaces and on the kind of particles. From the available field test data on the deposition of vapours and submicron particles two conclusions seem apparent, i.e. that chemically active materials such as ^{131} I are more rapidly deposited than inactive materials such as ^{137}Cs, and that on surfaces covered with vegetation such as grass and bushes the removal rates are higher than on the bare surfaces. At present, however, it is not clear whether or how wind speed, thermal stability or atmospheric turbulence affect the deposition velocities. For the present calculations it seems reasonable to assume the following values for deposition velocities: 0 m/s, 10^{-3} m/s, 5×10^{-3} m/s, 10^{-2} m/s (typical value), 5×10^{-2} m/s,

and 10^{-1} m/s. The example of calculation results of relative downwind concentrations for these 6 values of deposition velocities 1 during cat. F are presented in fig. 1 ($H = 50$ m). Complete results of calculations are given in [15].

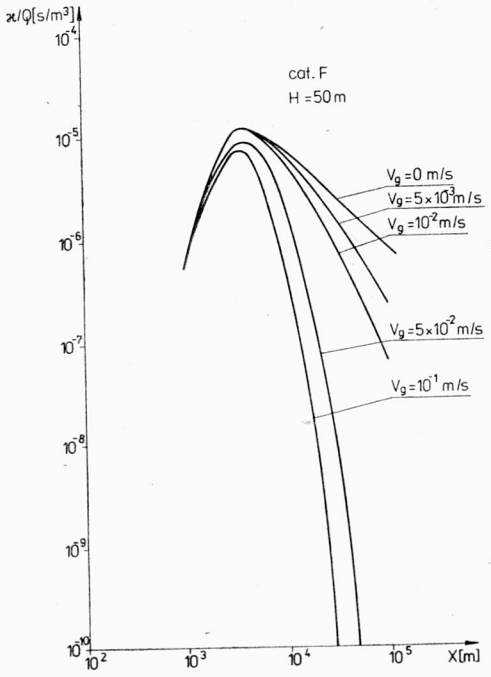

Fig. 1. Variations of deposition velocities

Rys. 1. Zmiany w prędkościach osadzania

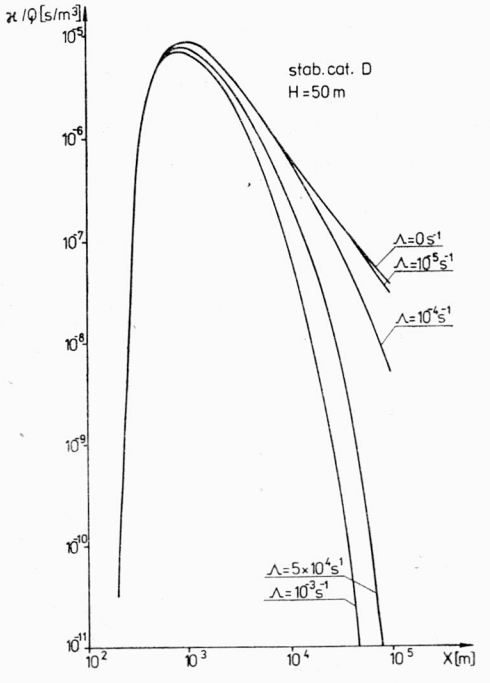

Fig. 2. Variations of washout coefficients

Rys. 2. Zmiany we współczynnikach spłukiwania

3.2. WASHOUT COEFFICIENTS Λ(s-1)

In the recent years extensive research has been carried out in this field, but the results obtained are not conclusive. The predicted values of washout coefficients for iodine and bromine gas range from 10^{-5} to 10^{-4} s^{-1} at the rainfall rates of 0.1 to 3 mm/h, at the rate of about 0.5 mm/h this value is approximate 3×10^{-5} s^{-1} [7]. The two measured values for bromine gas were within a factor 2 of this, whereas the three measurements for iodine gas gave the values ranging from 3×10^{-6} s^{-1} to 2×10^{-7} s^{-1}. This large difference is attributed to differences in their respective reactions with water [7]. Theoretical values have been predicted by CHAMBERLAIN [4] and ENGELMANN [7, 8] who also carried out measurements which were to determine the order of magnitude of washout for prediction of hazard in reactor analysis. The possible values of washout coefficient cover the broad range of 10^{-7} to 10^{-3} s^{-1} approx., the highest values being stated for the effluent gas with a high water content, and atmospheric conditions are conducive for condensation. Such a broad range of washout coefficient value is caused by several factors. In the case

of vapour or gas the value of Λ dependes upon the chemical reactivity or solubility of the material or upon the particle size in the case of solids. In all the cases it depends upon the precipitation rate. A suitable choice of the value of Λ among the available experimental or theoretical data is at least as difficult as in the case of V_g for dry deposition. For the present estimation it seems reasonable to assume the following values of the washout coefficients: $10^{-5}s^{-1}$, $10^{-4}s^{-1}$ (typical value), $5 \times 10^{-4}s^{-1}$, $10^{-3}s^{-1}$.

The example of calculation results of relative downwind concentrations for these five values of washout coefficient during cat. F are presented in fig. 2. Complete results are given in [15].

3.3. WIND-SPEED u (m/s)

The wind speed ranges and typical values of wind speed for various stability classes [14, 17] are given in tab. 2.

Table 2

Typical wind speed ranges for the various stability categories

Typowe zakresy prędkości wiatru dla różnych kategorii stabilności

Stability category	Wind speed range m/s
A	1–2.5 (1)*
B	1.5–5 (2)*
C	2–6 (5)*
D	2–10(5)*
E	2–5 (3)*
F	2–3 (2)*

*The typical value of wind speed for particular stability categories is given in the brackets.

For our calculation it seems reasonable to assume the following values of the wind speed:

for A — 0.5 m/s and 3 m/s,
for B — 1 m/s and 5 m/s,
for C — 2 m/s and 7 m/s,
for D — 2 m/s and 10 m/s,
for E — 2 m/s and 5 m/s,
for F — 2 m/s and 5 m/s.

The example of calculation results of relative downwind concentrations for cat. F and H = 50 m are presented in figs. 3 (without deposition), 4 (wet weather), and 5 (dry weather). Complete results are given in [15].

3.4. MIXING LAYER L(m)

The mixing layer is defined as the height above the surface within which vertical mixing is relatively vigorous. It ranges from 1 000 m to perhaps 10 000 m [11]. For our calculations it seems reasonable to assume the following values of mixing layer:

a. L — no mixing layer.

b. For West Germany the values of mixing layer height according to KLUG [13] are: A — 1 500 m, B — 1 500 m, C — 1 000 m, D — 500 m, E — 200 m, F — 200 m (typical case).

c. In the third case it is assumed that for particular stability conditions, i.e. for A — 5 000 m, B — 5 000 m, C — 1 500 m, the values of L are 1.5 to about 3 times higher than in the second case.

d. In the fourth case it is assumed that the values of L are 2 to 3 times lower than in a second case, i.e. A — 500 m, B — 500 m, C — 300 m, D — 200 m, E — 110 m, and F — 110 m.

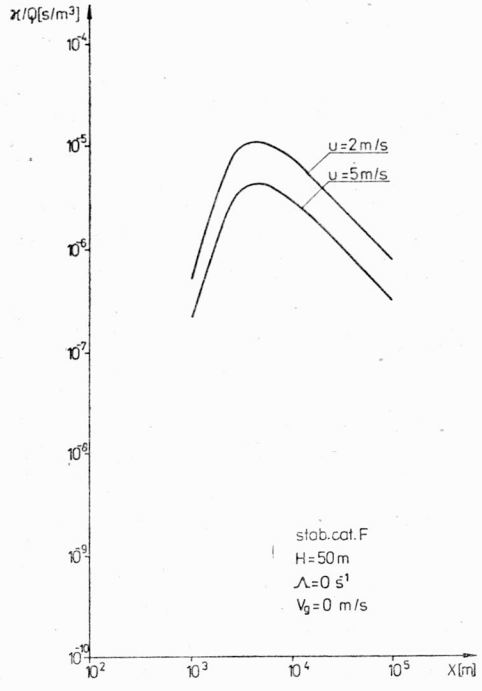

Fig. 3. Variations of wind speeds

Rys. 3. Zmiany w prędkościach wiatru

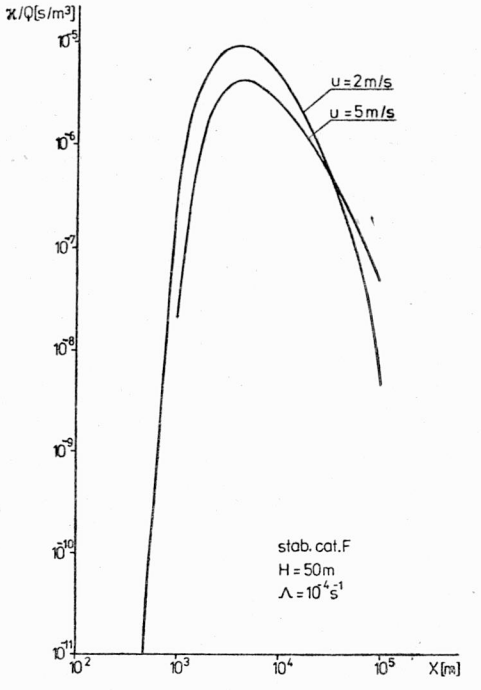

Fig. 4. Variations of wind speeds (wet weather)

Rys. 4. Zmiany w prędkościach wiatru (pogoda deszczowa)

The examples of calculation results of relative downwind concentrations for category A and H = 50 m are presented in figs. 6 (without deposition) and 7 (wet weather). Complete results are given in [15].

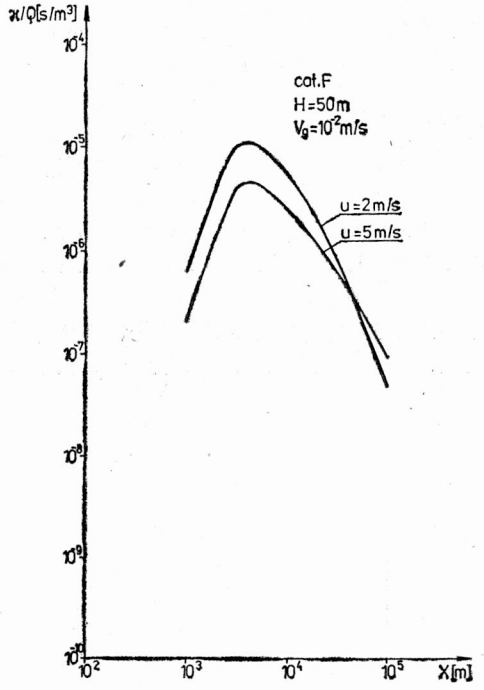

Fig. 5. Variations of wind speeds (dry weather)
Rys. 5. Zmiany w prędkościach wiatru (pogoda bezdeszczowa)

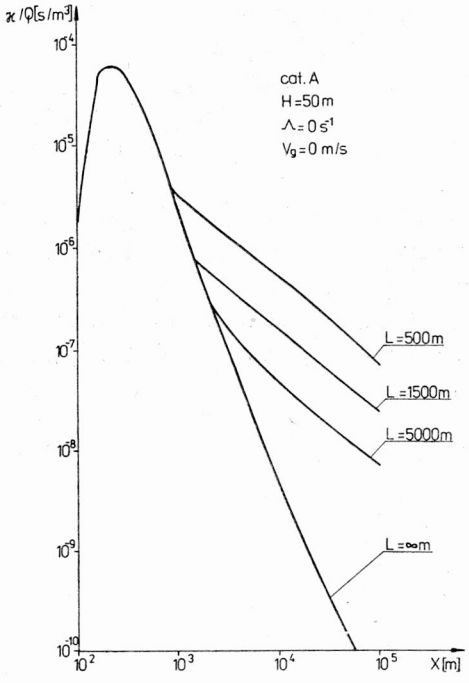

Fig. 6. Variations of mixing layers
Rys. 6. Zmiany w warstwach mieszania

3.5. HEIGHT OF RELEASE

For the present calculations the following values of release height were assumed: 0 m, 50 m, 100 m. The example of calculation results of relative downwind concentrations for categories A and F are presented in figs. 8–13. Complete results are given in [15].

4. RESULTS AND DISCUSSION

The effects of variations in deposition velocity on relative downwind ground level concentrations of radionuclides during 6 meteorogical categories are presented graphically in fig. 1. It is shown that an increase in the value of deposition velocity always causes a decrease in the relative ground level concentration of the radionuclide along all

the distances from the release point. The decrease in relative concentration becomes more pronounced at distances far away from the release point, this fact being in good conformity with the expression (12).

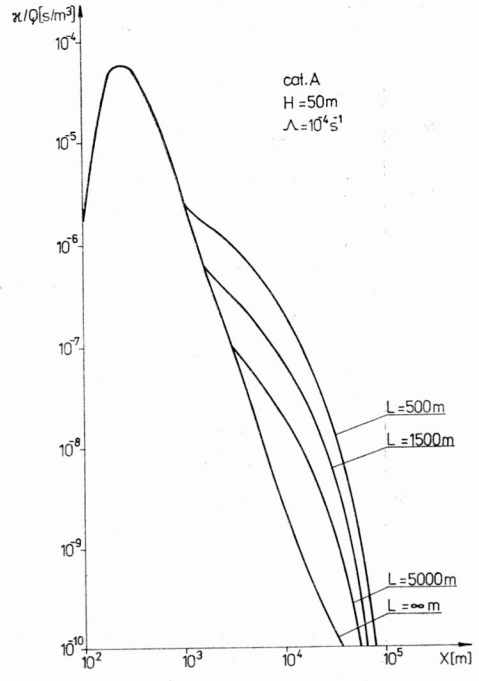

Fig. 7. Variations of mixing layers (wet weather)

Rys. 7. Zmiany w warstwach mieszania (pogoda deszczowa)

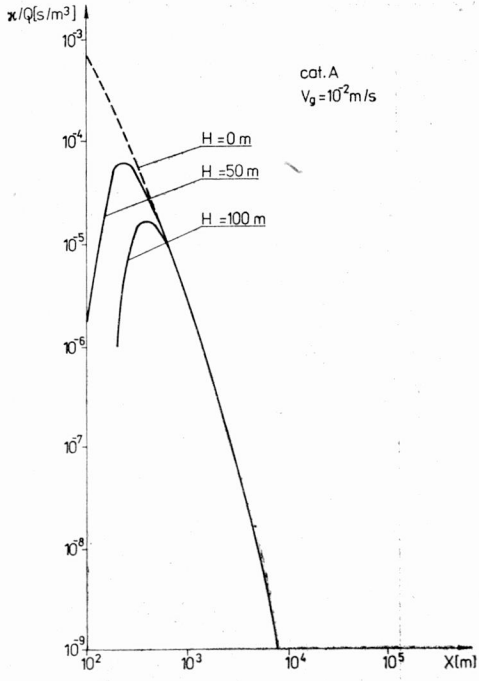

Fig. 8. Variations of height releases (dry weather) — cat. A

Rys. 8. Zmiany w wysokości uwalniania (pogoda bezdeszczowa) — kat. A

The effects of variations in washout coefficients on downwind relative ground level concentrations of radionuclides during 6 meteorological categories are presented graphically in fig. 2 as a function of downwind distance. Variations in washout coefficient affect downwind relative concentration in the same way as variation in deposition velocity.

The effects of variation in wind speed on the ground level relative concentration of radionuclides during 6 stability categories for 3 cases of atmospheric dispersion are presented as a function of downwind distance in figs. 3–5. It may be seen that when the deposition of the radionuclides ($V_g = 0$ and $\Lambda = 0$, fig. 3) is disregarded, then the increase in the wind speed always decreases the relative concentration of the radionuclides at any distance from the release point. However, when the depletion of the radionuclides from the cloud is taken into account ($V_g = 10^{-2}$ m/s for fig. 5 and $\Lambda = 10^{-4}$ for fig. 4), it becomes evident that an increase in the wind speed not only fails to decrease the relative concentration of radionuclides in the environment, but — on the contrary — at a certain

distance from the release point the relative concentration of radionuclide resulting from its release during an increased wind speed becomes larger than that released during a lower wind speed. This effect may be explained in the following manner. During low wind speed a large amount of radionuclides dispersed into the atmosphere is deposited clo-

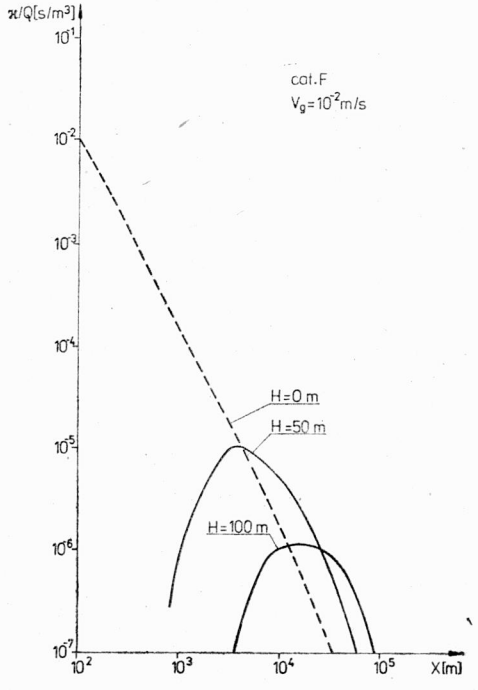

Fig. 9. Variations of height releases (dry weather) — cat. F

Rys. 9. Zmiany w wysokości uwalniania (pogoda bezdeszczowa) — kat. F

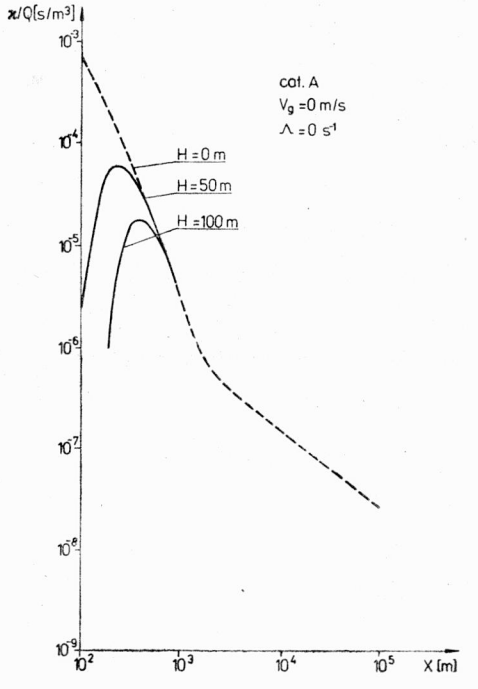

Fig. 10. Variations of height releases — cat. A

Rys. 10. Zmiany w wysokości uwalniania — kat. A

sely to the release point and only a small portion remains dispersed. That is why the concentrations at the distances from the release point are relatively small. When, however, the radionuclide is dispersed into the atmosphere during high wind speed, only a small amount of the material will be deposited nearby. Thus, a relatively large amount of the radionuclide is further dispersed, causing relatively high concentrations at a distance. The effects of variations in the mixing layer height on ground level relative concentrations of radionuclides during 6 stability categories for 2 cases af atmospheric dispersion are presented graphically as a function of downwind distance in figs. 6–7. It is shown that an increase in the value of the mixing layer height always causes a decrease in the ground level relative concentrations of the radionuclide at all distances greater than the release point. The decrease in relative concentration becomes more pronounced when depletion of the cloud by wet deposition is not taken into account, because a wet depletion process

diminishes the influence of the mixing layer height on downwind concentrations. The effects of variations in the release height on ground level relative concentrations of radionuclide during 6 stability categories for 3 cases of atmospheric dispersion are presented graphically as a function of downwind distance in figs. 8–13. Disregarding the deposition

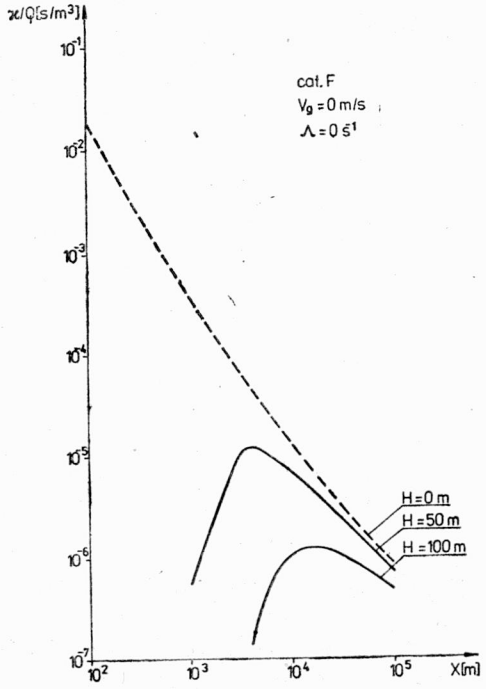

Fig. 11. Variations of height releases — cat. F

Rys. 11. Zmiany w wysokości uwalniania — kat. F

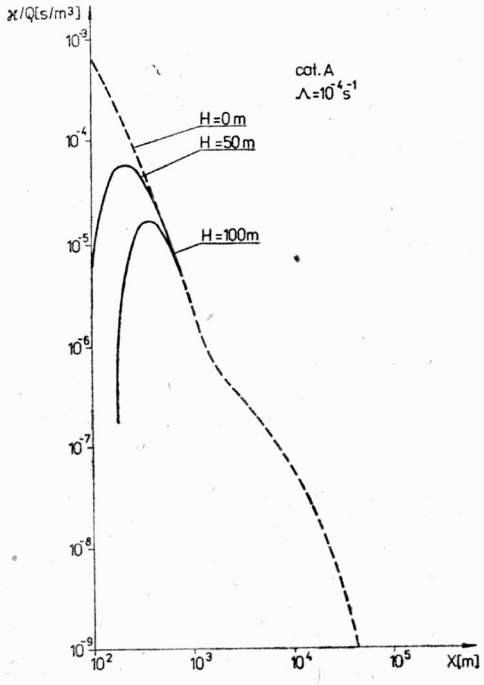

Fig. 12. Variations of height releases (wet weather) — cat. A

Rys. 12. Zmiany w wysokości uwalniania (pogoda deszczowa) — kat. A

velocity of the radionuclide ($V_g = 0$ m/s), (figs. 10–13), an increase of the release height always decreases the relative concentration of radionuclides at any distance from the release point. The decrease in relative concentration becomes less pronounced at distances far from the release point. However, when the dry deposition of the radionuclide is taken into consideration, specifically $V_g = 10^{-2}$ m/s (figs. 8–9), an increase not only fails to decrease the relative concentration through the environment, but, on the contrary, at a certain distance from the release point the relative concentration resulting from a release of pollutant at an increased height becomes larger than that at a lower height. The adverse effect of the increase in release height on the relative concentration is most accentuated during moderately stable conditions F (fig. 9). The relative increase in the relative concentration at distant regions following a release of radionuclide at greater heights compared to the release at lower heights may be explained as follows.

When radionuclides are released at a relatively low height, a large part of the material is deposited nearby. Thus, only a small amount of the radionuclides is left to disperse further, and the relative concentrations at a distance are relatively small. When, however, the pollutant is released at a relatively great height, only a small amount of the ra-

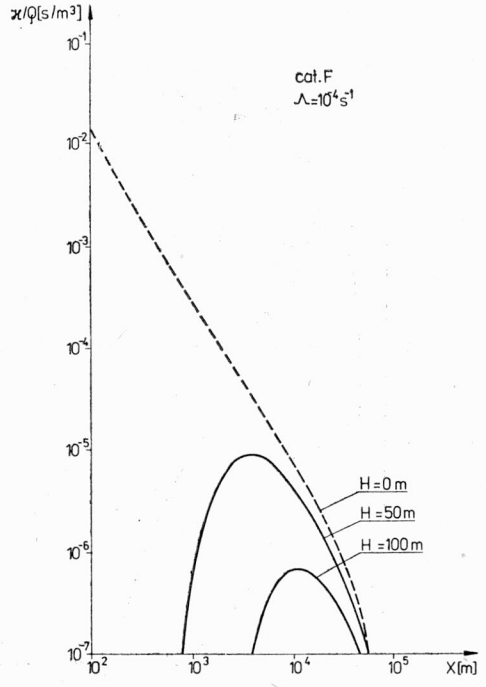

Fig. 13. Variations of height releases (wet weather) — cat. F

Rys. 13. Zmiany w wysokości uwalniania (pogoda deszczowa) — kat. F

dionuclide will be deposited nearby. Thus, a relatively large amount of the radionuclides remains to disperse further causing high relative concentrations at a distance. It is shown that when dry depletion of the cloud is taken into account, an increase in the height of release within certain limits may cause an increase in the ground level relative concentrations of the radionuclides in air at a certain distance from the release point. This effect is especially important when highly populated centres are located at the distance where an increase in the relative concentration of the radionuclide occurs due to the increase of its release height. In this case it is necessary to find the optimum height of release in order to obtain the required decrease of radionuclide relative concentration in the close vincinity of the release point, and yet not to increase significantly the relative concentration at distances of dense population. An optimization study of the radionuclide release height should include the following factors:

the velocity of deposition of the radionuclides,

the critical distance from the source of release, i.e. the distance at which the population would be most affected by the radionuclides,

the detailed analysis of the population density as a function of distance from the source of release,

the prevailing wind directions.

It appears that the increase in height of the stacks for the release of radionuclides may not be a straight-forward solution to the decrease of the concentration of the radionuclides throughout the environment. This will be the case if e.g. a highly dense large population centre is located in the prevailing wind direction and in the region of maximum concentration for a relatively high stack. If the region close to the release point (stack) has a low population density, it may be preferable to reduce the height of the stack and thereby to reduce the concentration in the densely population region.

REFERENCES

[1] BEATTIE J. R., BRYANT P. M., *Assessment of Environmental Hazards from Reactor Fission Product Releases*, AHSB(S) R 135, May 1970.

[2] BULTYNCK et al., *Atmospheric Dilution Factors and Calculation of Dose in the Environment of SCK/CEN Mol for Short and Long Duration Stack Discharges*, BLG446, 1971.

[3] CATTON I. et al., *Public Health Risks of Thermal Power Plants (Appendix II — Pollutant Pathways)*, UCLA–ENG–7242, May 1972.

[4] CHAMBERLAIN A. C., *Aspects of the deposition of radioactive and other gases and particles*, Intern. J. Air Pollution, No. 3 (1960), pp. 63–68.

[5] CHAMBERLAIN A. C., *Deposition of iodine-131 in northern England in October 1957*, Quarterly J. Roy. Meteorol. Soc., No. 85 (1959), pp. 350–361.

[6] CLARKE R. H., *Physical aspects of the effects of nuclear reactors in working and public environments*, Ph. D. thesis, January 1973.

[7] ENGELMANN R. Y., *Wash-out Coefficients for Selected Gases and Particulates*, BNWL–SA–G57, 1966.

[8] ENGELMANN R. J., *Calculation of precipitation scavenging of particulates and gases from the atmosphere*, Nuclear Safety, Vol. 7 (1966), No. 3, p. 354.

[9] FIELDS R. E., *Deposition Velocities of Airborne Fission Products*, Convair Report FZM 1985, 1960.

[10] HAWLEY C. A. et al., *Controlled Environmental Radioiodine Tests at the National Reactor Testing Station*, IDO–12035, 1964.

[11] HOLZWORTH G. C., *Estimates of mean maximum mixing depth in the contiguous United States*, Mon. Weather Rev., No. 92 (1964), pp. 235.

[12] ISLITZER N. F., *The Role of Meteorology Following the Nuclear Accident in Southwest Idaho*, IDO-19310, 1962.

[13] KLUG W., *Ein Verfahren zur Bestimmung der Ausbreitungsbedingungen aus Synoptischen Beobachtungen*, Staub J 29; 143, 1969.

[14] *Meteorology and Atomic Energy*, TLD — 24190, Jiuly 1968.

[15] NOWICKI K., *A Parametric Study of a Model for Calculation of Downwind Concentration*, Riso-M-1821, September 1975.

[16] THYKIER-NIELSEN S., *Models for Calculations of External Gamma Doses and Inhalation Doses from Releases of Radioactive Isotopes to the Atmosphere*, Riso-M-1725, July 1974.

[17] THYKIER-NIELSEN S., private information, June 1975.

WPŁYW ZMIENNOŚCI WARUNKÓW METEOROLOGICZNYCH I EMISJI NA STĘŻENIA RADIONUKLIDÓW W STRUMIENIU POWIETRZA

Przedstawiono badania parametryczne modelu obliczenia radionuklidów w strumieniu powietrza z krótkotrwałego uwalniania radioaktywnych izotopów do atmosfery. Wykonano serie obliczeń dla oceny wpływu zmienności warunków meteorologicznych i emisji na stężenia radionuklidów w strumieniu powietrza. Przyjęto, że zmiany zachodzą w głębokości warstwy mieszania, w szybkości osadzania, we współczynniku wymywania, w szybkości wiatru i w wysokości emisji.

DER EINFLUSS VON METEOROLOGISCHEN VERHÄLTNISSEN UND DER EMISSION AUF DIE KONZENTRATION VON RADIONUKLIDEN IM LUFTSTROM

Dargestellt werden parametrische Untersuchungen und Modellrechnungen der im Luftstrom vorkommenden Radionuklide bei Kurzemissionen von radioaktiven Isotopen in die Atmosphäre. Zur Bewertung des Einflußes der Abänderungen der meteorologischen Verhältnissen und der Emission auf die Konzentration der Radionuklide, wurden entsprechende Berechnungsserien durchgeführt. Es wurde angesetzt, daß Änderungen in der Tiefe der Mischzone, in der Absetzgeschwindigkeit, im Koeffizient der Auswaschung, in der Windgeschwindigkeit und in der Emissionsgröße vorkommen.

ВЛИЯНИЕ ИЗМЕНЧИВОСТИ МЕТЕОРОЛОГИЧЕСКИХ УСЛОВИЙ И ЭМИССИИ НА КОНЦЕНТРАЦИЮ РАДИОНУКЛИДОВ В ПОТОКЕ ВОЗДУХА

Описаны параметрические исследования модели расчёта радионуклидов в потоке воздуха по кратковременному освобождению радиоактивных изотопов в атмосферу. Осуществены серии расчётов для оценки влияния изменчивости метеорологических условий и эмиссии на концентрации радионуклидов в потоке воздуха. Принято, что изменения происходят на глубине слоя смешивания, в скорости осаждения, в коэффициенте вымывания, в скорости ветра и в высоте эмиссии.