SIMULATION OF RADIATION CONDITIONS IN CONTAMINATED ROOMS

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(Received March 19, 2007)

Method for beta and gamma radiation exposure rate calculations inside the radioactively contaminated buildings is presented. Method is based on the realistic model accounting for removable and irremovable components of the surface contamination. Exposure rate calculations for areas with considerable level of surface contamination are presented and discussed.

PACS: 28.41Te

1. INTRODUCTION

Work activities inside radioactively polluted facilities require radiation environment assessment. Two factors contribute to the resulting radiation fields: local radiation sources and surface contamination. The first are usually removed during the preliminary deactivation activities together with the part of surface contamination. Thus in the absence of local radiation sources surface contamination solely determines interior radiation environment. The remaining surface contamination is constituted by removable and irremovable components. Existing experimental methods allow efficient removable component evaluation. At the same time assessment of the irremovable contamination is a rather complicated procedure. So usually only removable contamination is measured. At the same time contribution of the irremovable contamination to the total exposure rate could be rather significant. In this paper we present the method of total (and irremovable) surface contamination reconstruction based on data on removable contamination. Assessment of radiation environment for the "Shelter object" (SO) of Chernobyl NPP using this method is also presented and discussed.

2. REMOVABLE AND IRREMOVABLE CONTAMINATION ANALYSIS

Irremovable contamination is formed mainly by radioactive sediments diffusion into construction material surface layer. Another possibility is surface deposition of the high-temperature radioactive aerosol. The last likely took place during the accident on the Chernobyl NPP in 1986. Surface contamination amount depends on a variety of factors. The most significant are radioactive aerosol initial amount and composition, surface adhesion, interior aerodynamic conditions. Usually building inner space is divided into isolated ares such as rooms, airshafts, lift shafts, etc. Surface contamination formation conditions are specific to each area. We can assume removable and irremovable contamination ratio be characteristic constant for every isolated area.

The starting point of our analysis was statistical analysis of removable contamination and exposure rate ratio. As an example we considered data for SO room 7001. For this area exposure rate and removable surface contamination are known for 10 surface locations. Statistical analysis of removable contamination and exposure rate ratio gives average value $\beta_r = 655 \pm 83\,(particles/(cm^2 \cdot min))/(mR/h)$ with 0.95 reliability level. This value was used for further analysis.

SO room 4000 is situated near room 7001 and seems to have similar contamination formation conditions. Detailed data on surface contamination and exposure rate are available and were used for verification purposes. Calculated removable surface contamination levels fall within the $4.5 \cdot 10^3 - 59 \cdot 10^3\,(particles/(cm^2 \cdot min)$ interval. This is in good agreement with experimental values of $5 \cdot 10^3 - 80 \cdot 10^3\,(particles/(cm^2 \cdot min)$.

Observable exposure rate for contaminated area is governed by total surface contamination. So we have developed calculation scheme for exposure rate calculations. It implemented point-source kernel method with buildup factor. Analytical expression for buildup factor was taken from handbook [1]. The final value of $\beta_t = 10^5\,particles/(cm^2 \cdot min)/(mR/h)$ for the total surface contamination and exposure rate ratio was obtained. Analytical expressions used for calculations are linear on surface contamination value. Thus total surface contamination could be easily recalculated using β_t factor.

Factors β_t and β_r for the selected area allow total and removable surface contamination ra-

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tio calculation. For the SO room 7001 this ratio is $\alpha = \beta_t/\beta_r \approx 150$. Using α for the observed values of removable contamination total contamination level of $4 \cdot 10^7\, particles/(cm^2 \cdot min)$ for the most polluted region near the vent was obtained. Corresponding calculations for the room 4004 having similar conditions gave maximum level of above $5 \cdot 10^6\, particles/(cm^2 \cdot min)$ for total surface contamination.

3. RESULTS OF CALCULATIONS AND DISCUSSION

Some work activities inside SO required personnel presence inside the vent header. Radiation environment inside the vent header was unknown. Assessment of the exposure rate required assumption on the surface contamination inside the vent header. For the calculations we have assumed surface contamination at upper and lower ends of the vent header to be the same as that at adjacent areas of rooms 7001 and 4004 correspondingly. Contamination Height distribution of the surface contamination was assumed to satisfy parabolic law.

Surface contamination for adjacent areas was fount using the method discussed in the previous section. Fitting this values we obtained parameters of the parabolic height distribution. So total contamination value for every surface point could be easily calculated. This allowed to use point-source kernel method to calculate exposure rate spatial distribution inside the vent header. Doze distribution along the horizontal section of vent header is shown on Fig.1.

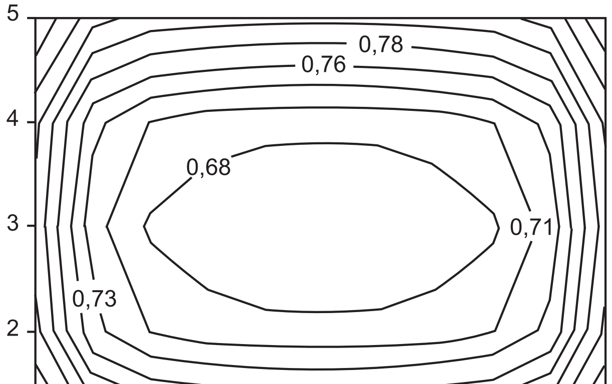

Fig.1. *Doze rate inside the airshaft (mZv/h)*

High levels of surface contamination in SO room 7001 have set up problem of shielding optimization according to ALARA principle. During the optimization procedure Room 7001 was divided into square areas $(2 \times 2)\, m^2$ in accordance with the experimental scheme of exposure rate measurements. Total surface contamination for each square was calculated using using method developed in section 2.

On the next step two shielding configurations of the most contaminated areas near the vent header were considered. Shield was constituted by $10\, mm$ thick lead plates with total square of $48\, m^2$ and $64\, m^2$. Using data on surface contamination we calculated exposure rate spatial distribution at work area. Obtained values showed shielding to be ineffective. Attenuation factor for work area was only $3.5 - 3.7$ for both configurations while personnel irradiation during shielding mounting had increased significantly. So using ALARA principle shielding was rejected.

Estimations of the total surface contamination were also used for personnel β-irradiation hazard analysis inside SO room 4004. For conservative reasons the highest total surface contamination value $7.5 \cdot 10^6\, particles/(cm^2 \cdot min)$ was taken for calculations. ^{90}Sr and ^{90}Y activities were taken according to the averaged fuel radionuclide composition.

Calculations of the β-radiation exposure rate (see Fig.2) showed surface eye lens exposure doze have reached limiting value $(150\, mZv)$ in less then an hour. Skin exposure doze have reaches its limit $(500\, mZv)$ in less then 3 hours.

As it follows from our calculations (see Fig.2) near the contaminated surface eye lens exposure doze reaches limiting value $(150\, mZv)$ [2] in less then an hour and open skin exposure doze reaches its limit $(500\, mZv)$ [2] in less then 3 hours. From Fig.2 it also follows that exposure rate at 3 m away from the surface decreases only by a factor of 10. Such radiation environment requires obligatory usage of personnel protective equipment.

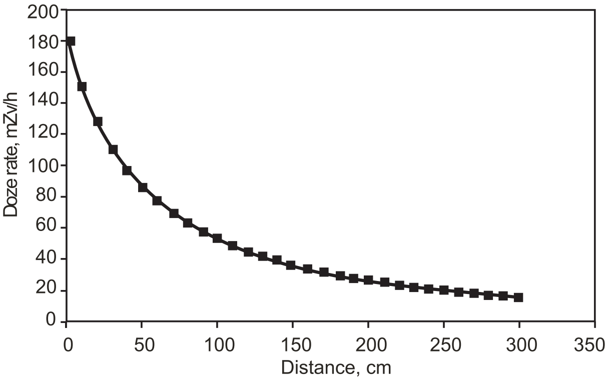

Fig.2. *β-radiation exposure rate attenuation in air*

Calculations for the same radiation conditions with plexiglass shielding of 1, 2 and $3\, mm$ thickness showed crucial improvement of the working conditions. For example, even the $1\, mm$ plexiglass shielding increases permissible work time from 1 to 500 hours. In this case β-radiation no longer is the limiting factor as γ-radiation doze limit is reached in 250 hours.

The presented calculations for real-life radiation environment ("Shelter" object) have proved method effectiveness for various problems concerning radiation hazard in polluted facilities. This method could be successfully used for various practical tasks concerning nuclear energetics.

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МОДЕЛИРОВАНИЕ РАДИАЦИОННОЙ ОБСТАНОВКИ В ЗАГРЯЗНЕННЫХ ПОМЕЩЕНИЯХ

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Представлен метод расчета мощности дозы бета- и гамма-излучений внутри загрязненных помещений. Разработанный метод основан на реалистичной модели с учетом снимаемой и неснимаемой составляющих поверхностного загрязнения. Приведены результаты расчетов для сильно загрязненных помещений объекта "Укрытие".

МОДЕЛЮВАННЯ РАДІАЦІЙНОЇ ОБСТАНОВКИ У ЗАБРУДНЕНИХ ПРИМІЩЕННЯХ

В.Г. Батій, Д.В. Федорченко

Представлено метод розрахунку потужності дози бета- та гамма-випромінювань всередині забруднених приміщень. Створений метод оснований на реалістичній моделі, який враховує поверхневе забруднення, що знімається та таке, що не знімається. Наведено результати розрахунків для сильно забруднених приміщень об'єкту "Укриття".