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THE ENERGY INFLUENCE ON THE RADIATION DOSE OF THE STAFF*

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The text of this paper is concerned to the problem of dose control used the sources of gamma and X-ray radiation in the mining industry and others organization of the nondestructive testing. Distinctive features of the resources are the high energy and intensity radiation is the short time delivering testing. The research is devoted to problems of the high energies and high ionization. The influence of radiation used in the industrial purposes, in particular, in nondestructive testing was studied all time, but nowadays the type of radiation resource has other parameters. This investigation denoted to Roentgen sources of high radiation and high energy range. In this case the photo effect is playing insignificant role at this value of the energy, but others effects enter: Compton Effect and effect of annihilations, that distinguishes influence from medical X-ray, where is more a photo effect. Questions of personal dose measurement are urgent for radiation securities in the all enterprises of measuring system. The results have shown that the most considerable changes are noted to the application of modern system of radiation control allows conduct the complex monitoring system with wide range or safe security, specialty to the systems of radiating control.

***Key words*:** linear factor, linear absorption, individual control, lower energy, methods of the small dose control, high ionization, scattering radiation, doze parameters, the influence of the small dose on the people, means of the individual protection.

One of the important method of the non destructive testing in the different kinds of the industry is the Roentgen and gamma- control [1]. More than fifty years ago that methods were applied in the mining, nuclear, gas and oil industry, and also industry engineering. Despite of the high cost, the method of the gamma and roentgen control has some advantages: safety documentary R-films for a long time. It is very important for the dangerous objects on the plants and factories. Distinctive features are the high energy and intensity of used sources of the radiation are the short time of the delivering testing. In this connection the questions of the protection of the personnel from the permanent radiation are urgent. The research is devoted to problems of the high energies and high ionization. The results of supervision of the radiation consequences should be divided in the two different groups: higher isotope energy and scattering radiation of the lower energy. At the firsts it is necessary to careful study the influence of small dose of radiation during the long time influence on the personnel.

The purpose of this article is the consideration of the energy distribution and doze parameters during Roentgen and Gamma control [1, 6, 7, 8].

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The received data are devoted to the problems which connected with the used radiation resources of high energies and high ionization [5, 9] in industry. The items of information in the literature practically are absent though the small percent (interest) of the population engaged in these questions [2, 3]. The items of information widely submitted in various scientific data and monographers consider (examine) or consequence of explosion in Hiroshima, Nagasaki, or failure in Chernobyl APS and others [4, 5, 9]. The norms of radiating safety [11] were corrected by results of careful supervision over victims of explosions in Japan. Also there are researches of the influence radiation in medical diagnostic and therapeutic purposes that's spent all over the world [10, 15-17].

The influence of radiation used in the industrial purposes, in particular, in nondestructive testing was studied a few times ago. The modern devices are used Roentgen sources of high radiation of the power range, by energy $E > 200$ keV up to 1.5 MeV and above, and also nuclear isotopes of high activity. For example, the power range for isotope Ir192 makes $E = 0.488$ keV, and for isotope Co60: $E = 1.17$ keV, $E = 1.33$ meV. The photo effect plays insignificant role at this energy, other effects enter: Komptoneffect and effect of annihilations, that distinguishes influence from medical X-ray, where is more the photo effect.

In a general view the processes of interaction with material are characterized by a dualism: some properties (scattering) are described by the wave theory, others one (change of length of a wave particle) are explained by the corpuscular theory [11-13]. The implementation of high-energy sources for the control of the large thickness of the material causes in a material and body of the man all physical processes [14-16]:

1) photo-electric absorption;

2) coggerent dispersion connected (Thomson dispersion);

3) an incoherent dispersion on electrons (Compton scattering);

4) generation of pairs: at $E > 1{,}022$ MeV exists absorption gamma – quantum with generation of pair electron-positron .

In this case complete linear absorption coefficient μ is:

$$\mu = \tau + \delta_1 + \delta_2 + \chi, \tag{1}$$

where τ – linear absorption coefficient caused by photo absorption; δ_1 – linear absorption coefficient of the noncoggeren dispersion; δ_2 – linear absorption coefficient of the coggeren dispersion accordingly; χ – linear absorption coefficient caused by process of annihilation of pairs [11].

Mass factor of linear absorption at the coggeren dispersion does not depend on length of wave primary photons and from absorbing material

$$(\delta_2)_m = \frac{\delta_2}{\rho} = 0{,}2. \tag{2}$$

For any kind of radiation the parameters describing interaction of radiation with substance are:

1. Linear factor of absorption μ – relation of share $\partial N/N$ photons of the given energy, interacting at passage of an elementary way ∂l in environment to length of this way:

$$\mu = \frac{1}{N}\frac{\partial N}{l}. \tag{3}$$

2. Linear factor of transfer of energy μ_1 – relation of a share of falling energy radiation, which transforms to kinetic energy in an elementary way to length of this way:

$$\mu_1 = \frac{1}{\omega}\frac{\partial \varpi}{\partial l}. \tag{4}$$

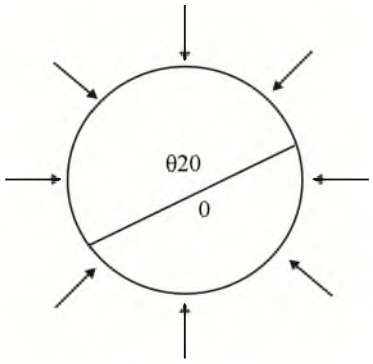


Fig.1. Principe of the ambient equivalent dose for sphere fantom: oxygen – 76,2 %, carbon – 11,1 %, hydrogen –2,65 %, nitrogen – 2,65 %, and density – 1 g/sm

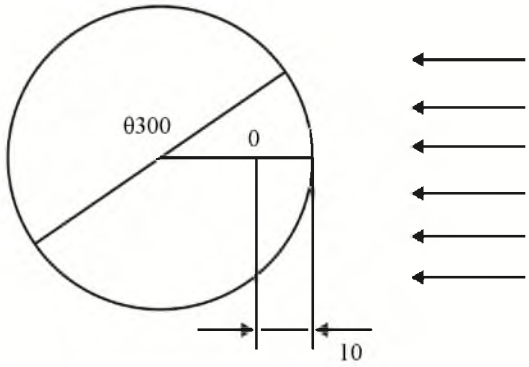


Fig.2. Principe of the ambient equivalent dose sphere phantom on the deepness of 20 mm in the center of sphere

3. Linear factor of absorption of energy μ_2 – difference between linear factor of transfer of energy and product of this factor on a share secondary electrons, passing in roentgen radiation in the given substance:

$$\mu_2 = \mu_1(1-g), \tag{5}$$

where g – factor of the share secondary electrons.

The size opposite to factor of absorption μ, is called as average length of free pass $l = 1/\mu$.

The ambient equivalent dose at the data point H(10) is the equivalent dose, that made on the size of 10 mm inside the sphere by the directive and homogenous field (fig.1) [8, 15,17].

This parameter is summered the common parameter of the dose control for the different energy. In any case the difference may be account by the field ambient dose of the radiation in the center of sphere by the radius of 10 mm (fig.2).

Nevertheless the list of the radiation data above does not is full. But it is the common test which repeated by probe radioactive resources and had been dating commonly.

There is the dependence of the equivalent dose factor M/X (sZv/P) from energy radiation resource $E\gamma$ (MeV) on the fig.3.

The main measurement of the decreasing personal radiation dose during working on the open square: restriction the working time, increasing the distances from operate to isotope, minimization the energy of radioactive source (fig.3) and using the different defense instruments. As result of investigation was the good preparation of the radioactive control procedure before allows conducting the radioactive control with the higher quality and small influence on the personnel.

There is the comprehensive energy range of radiation with compare to the interaction with material:

1) at the energy range 10-100 keV, in this case it`s photoeffect - the single practically type of the interaction with material on this energy level;

2) at the energy range 100-250 keV there are exists the photoeffect and slowly apiaries Compton scattering;

3) at the energy range 250-1022 keV is the type of the interaction with material mainly Compton scattering;

4) at the energy range 1022 keV and above the common type of the interaction with material is Compton scattering (less) and effect of appear pairs;

5) at the energy range about 9000 keV and above the type of the interaction with material is the effect of appear pairs mainly. So, in this case the common scattering radiation has the minimum level.

Those there are the basic physical characteristics radiation influencing in the material. Evidence If the characteristic spectrum for an isotope Co60 has two components $E = 1.17$ MeV and

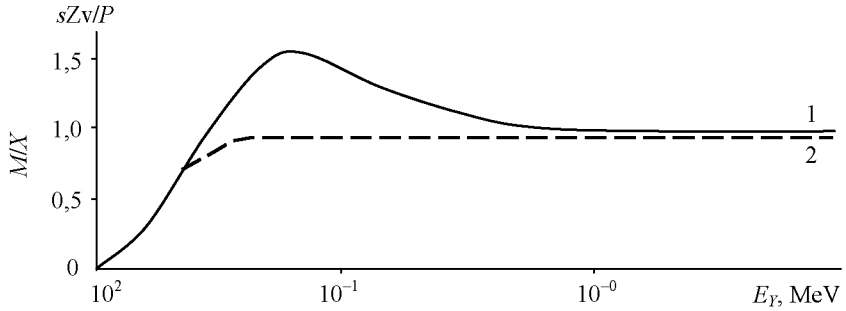


Fig.3. The dependence between ambient equivalent dozes (1) and field ambient equivalent dozes (2) from resource energy

E = 1.33 MeV, that the effect of annihilation of pair will here prevail. Hence, the character of influence will be probably differ from x-ray radiation used in medicine, where E < 150 KeV. The results of supervision on consequences of influence of radiation on the man can be divided (shared) into three groups therefore:

• the persons among the population which have undergone to external influence of radiation and an internal irradiation as a result of explosion of nuclear bombs and at various failures on Atomic Power Station;

• the patients and personnel receiving radiation dose as a result of medical diagnostic by x-ray radiation and isotope therapy;

• the professional personnel in industries admitted to contact with radiation, received the normalized dose radiation and frequently, irradiated above the dose norm as a result of emergencies (failures), which are sometimes not fixed, but have nevertheless place.

Such dividing is truth, so in the first case the injures receive medical aid and are under medical supervision. These results are data in various articles. In the second case a radiation doze planned, limited by a recommended norm of a doze, they have the medical supervision. In the third case the personnel probably may be exposed:

1. To the two above described influences.

2. The radiating norms in 10 times are more than for the population.

3. The total doze for personnel in one year is permitted by the instruction (NRB-99/2009) is 20 mZv (milliZivert). It is concerned for the doze arising during job only, and all common radiation dose is not taken into account absolutely.

The annual medical control does not allow looking after changing of health in time: because they are forbidden to have such job with even small problem of health. Only the absolutely healthy people permitted to a job with sources of radiation otherwise.

It is interest to careful study the influence of small dose of radiation during long time on the personnel. Nevertheless long-term «experience» of deal the man with radiation allows to conclude some results from data written in the literature and to reveal the certain common laws of biological action of radiation. The stochastic and determined effect is present at all. The stochastic effects – harmful biological influences which are not having doze limit (threshold). The probability of their occurrence is proportional to a doze, and the weight does not depend on a doze. Determined effects mean existence of a limit (threshold) above which weight of effect depends on a doze. For small dozes (less than 0,5 Zv, Zivert) the individual risk of occurrence of stochastic effects is defined (determined) accordingly:

$$r = pr_E E, \tag{5}$$

where r – individual risk; E – individual effective dozes; p – probability of events creating doze E; r_E – factor of risk from a fatal cancer, serious illnesses and not fatal cancer; $r_E = 5.6 \cdot 10^{-1}$ 1/man-Zv for professional personnel $r_E = 7.3 \cdot 10^{-2}$ 1/man-Zv for the population.

The considering data given for two types of population allows to reveal some attributes of a deviation in health of professional personal, who is connected with a sources of roentgen or gamma radiation (the personnel A [9]).

The strong pollution of territories of Average Ural in Russia by [2, 3, 5] radioactive substances, as a result of failures (on the plant «Majak», 1959), where the population receives a chronic (permanent) radiation in small doses, influences on the health of men and is submitted in the literature. There is aterosclerous [2], suffer, first of all, brain and heart, arises hypoxia, edema, dyspnea, an excessive weight that results to sugar diabetic and obesity (fatness). The stimulation blood supply gives temporary simplification, forecast adverse. Thus, at study of consequences of influence of radiation on the professional personnel A the classical radial illness can not be observed at all. In this case can take place another symptoms: superfluous weight, obesity, diabetic, hormonal infringement. The damages of small vessels lead to raising (increasing) frequency of pulmonary diseases, pulmonary cancer, so as pulmonary material consists of smallest vessels [2].

Besides À.Petco [3] had studied the influence of small dose of radiation on membranes. He had found – the destructive doze in thousand times is less. The influence on the membranes is more than less doze, since than less concentration of toxic radicals, the more strongly they are drawn by an electrical field of a membrane. Probably there are special cells sensitive to low intensity radiation, the failure occurs instantly, immediately.

In the case if some regions were subjected to the scattering radiation there has been probably different exchanging: erased alveolus figure, the connecting tissue was defined (determined), rough collagen tissue becomes almost without cell, with changed blood vessels. The defeat occurred for two types [2]:

1) teleangiectasia of small blood vessels;

2) fibrosis of large vessels, from hardly appreciable till complete replacement of a wall of vessels by a connecting tissue without preservation among it untreated muscles cells [6].

The changed vessels negatively influence on blood supply, is observed full blood of a capillary network, plethora, cottage, connecting replacements inside of vessels. Nevertheless it is possible to take some measures to prevent the development of this exchanging further. The changes of vessels can be partially exchange with serviceability of the next regions. So it is necessary to improvement of an exchange of substances, to stimulate the next region (vessels) that is disposing near destroyed vessels. In this connection the questions of care on health get the special meaning (importance) for the personnel [2]: the improved feed (meal), physical loadings with the purpose of improvement blood supple of all parts of a body, water procedures in pool and sauna [7], and also other improving measures. A correct feed (meal) essentially raises resistance body to the various negative factors. Also this is concerning all population in every country who have medicine radiation, for example, after visiting odontology doctor, dental hospital, roentgen cabinet, etr. The vitamin diet, balsams without alcohol [5] is recommended. Thus there is a decrease (reduction) of risk on unit of a doze at having a place or after radiation.

In the review [3-6] allocate the following biological active additives removing consequences of influence of radiation: macro and microelements, including calcium, selen, ftor; vitamins and pro-Vitamins; the food additives as sea (luminary – sea cabbage) and other of seaweed.

For a taking out incorporated isotope and the decrease (reduction) of accumulation in critical bodies are effective products containing vegetative fibbers: pectin of substance, mineral substances: calcium, ftor, iron [9].

Difficulties of diagnostics of consequences of a chronic irradiation body of the man, impossibility precisely to put the diagnosis with which by the factors this or that deviation (rejection) of health is called show increased requirements to the professional personnel [9-10]:

1) careful fulfill the radiation requirements, instruction;

2) observance of (keep) hygienic norms of a healthy life;

3) development and perfection of inexpensive means of individual protection and dozes instruments. The main conclusions to serve the healthy body concerning the all people who take the medicine roentgen also.

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REFERENCES

1. *Bystrov Yu.A., Ivanov S.A.* Uskoritel'naja tehnika i rentgenovskie pribory (*Accelerating technology and roentgen apparatures*). Moscow: Vysshaya shkola, 1983, p.288.

2. *Val'kovich A.I.* Sostojanie krovenosnyh sosudov posle rentgenovskogo terapevticheskogo obluchenija raka bronhov (*State of blood vessels after the X-ray therapeutic irradiation of cancer of the bronchi*). Radiation medicine. Moscow: Izd-vo «Meditsina», 1972, p.295-297.

3. *Grab R.* Effekt Petko: vlijanie malyh doz radiacii na ljudej, zhivotnyh i derev'ja (*Petko effect: the influence of small dose radiation on the people, enamels and trees*) Moscow: Izd-vo megdunarodnogo dvigeniya «Nevada-Semipalatinsk», 1994, p.263.

4. *Karpenko P.A.* Pishhevaritel'naja profilaktika ot neblagoprijatnogo vozdejstvija na organizm radiacii (*Digestive preventive maintenance from the unfavorable action on the organism of the radiation*). Problemy bezopasnosti pri chrezvychaynykh situatsiyakh (Safety problems in the extraordinary situation). Moscow: Izd-vo «VINITI RAN». 2001, p.87-93.

5. *Kortez J.I., Potapov A.I., Morokina G.S.* Nerazrushajushhij kontrol' i diagnostika okruzhajushhej sredy, materialov i promyshlennyh izdelij (*Nondestructive testing and control of environment, material and industrial goods*). St Petersburg, Izd-vo Severo-Zapadnogo Technicheskogo Universiteta, 2001. N 2, p.137-143.

6. *Koshelev V.Ye.* Metody i tehnicheskie sredstva tamozhennogo dosmotra i poiska (*Methods and technical equipment in the custom control and search*). Moscow: Izd-vo RIO RTA, 2000, p.15-124.

7. *Morokina G.S.* The Problema kontrolja malyh doz obluchenija dlja professional'nyh rabotnikov v mashinostroenii (*Problem of the Small Dose Control of the Radiation for the Professional Personnel in the Industry Engineering*). Internet Journal of Industrial Engineering. 2014. Vol.2. N 4, p.62-66.

8. *Morokina G.S.* Fizicheskie faktory v rentgenstomatologii (*Physical factors in the Roentgen stomatology*). St Petersburg, Izd-vo Medicinskaia academia poslediplomnogo obrazovaniia, 2003, p.22.

9. Normy radiacionnoj bezopasnosti (The norms of the radiation safety). Moscow: Ministerstvo zdravookhraneniya Rossii. 2009, p.87.

10. Osnovy tamozhennogo kontrolja deljashhihsja i radioaktivnyh materialov (*The basis of the custom control for the nuclear and radioactive materials*). Moscow: Izd-vo GTK Rossii, 2001. p.325.

11. Osnovnye sanitarnye pravila obespechenija radiacionnoj bezopasnosti (*The main sanitary rules guarantee radiation security*). Moscow: Minzdrav Rossii.1999, p.100.

12. *Fedotov A.I., Lisin S.K., Morokina G.S.* Teorija izmerenij (*The theory of measurements*). St Petersburg, Izd-vo Politekhn. un-ta, 2013, p.324.

13. *Morokina G.S.* Vlijanie rassejannogo izluchenija na dozu pri gamma-kontrole v mashinostroenii (*Scattering Radiation on the control dose in the industry engineering*). Internet Journal of Industrial Engineering. 2015. Vol.3. N 2, p.65-68.

14. Bravo for the Marshallese: Regaining Control in a Post-Nuclear. Post-Colonial World. By Holly M.Barker. Wadsworth, 2004.

15. *Constantinou Chris, Attix F.H., Bhudatt R. Paliwal.* A solid water phantom material for radiotherapy x-ray and γ-ray beam calibrations. Med. Phys. 1982. N 9, p.436.

16. *Ernesto Cortez, German Ardul Muñoz Hernandez, José Italo Cortez, Liliana Cortez.* Methodology for the MDL Model Implementation of the Dinorwig Hydroelectric Plant. Journal of Engineering Research and Applications. Vol.3. Is.6, 2013, p.71-74.

17. Killing Our Own: The disaster of America's experience with atomic radiation. By Harvey Wasserman, Delacorte Press, 1992.