

## Solution of the Applied Task to Determine Total Exposure for Mechanical Engineering Workers

O V Medvedeva<sup>1</sup>, K N Orlova<sup>1</sup>, I F Borovikov<sup>2</sup>

<sup>1</sup>Yurga Technology institute, Tomsk Polytechnic University, Leningradskaya Street, 26, 652055, Yurga, Russia

<sup>2</sup>Bauman Moscow State Technical University, Baumanskay 2-ya Street, 5, 105005, Moscow, Russia

e-mail: alisasten@mail.ru

**Abstract.** In everyday life, people repeatedly exposed to ionizing radiation. Radiation sources is as natural background radiation due to the natural radioactivity of the earth, cosmic and solar radiation and artificial emitters in enterprise engineering. Therefore, the determination of the total human exposure in engineering industry will consist of a variety of factors will be strictly defined for a specific person, and undoubtedly true. Neural network technology can completely resolve this problem, follow neyroalgoritim presented in this paper.

### 1. Introduction

In today's world there are many unresolved problems [1-2], one of which is to find engineering solutions for protection against to exposure to ionizing radiation, for example, in the case of a nuclear explosion or leakage on the radiation-hazardous facility. It is known that an important spread factor of radiation is the atmosphere, in particular, cloudiness [3-5].

One of the important applications is to determine the total exposure of Machinists by mathematical modeling. Indeed, modern means of calculating possible to obtain the value of the radiation dose due to the action of one factor (finding and manipulation of sources of ionizing radiation while working at the enterprises). However, in the course of business, the employee is subjected to multivariate exposure.

To assess the exposure of workers and algorithmization engineering industry, we apply neural network.

Neural network - electrical impulses between neurons of the human brain, which a man tries to structure. The brain is the biggest "computer" for the storage and processing of information. Nervous system and the human brain consists of neurons interconnected by nerve fibers. Nerve fibers themselves are capable of transmitting electrical impulses between neurons. All transfer processes stimuli from the skin, eyes and ears to the brain, thought processes and management actions - all this is done in a living organism as the transmission of electrical impulses between neurons [6].

After the appearance of the term «neural network» is an allocation of a separate field of science - Simulation. Currently, simulation of neural activity is carried out successfully in many areas of science, such as economic processes and phenomena, algorithmization, organize data, etc. But it is not every possible application of neural networks.



Currently neural network - a kind of algorithm; mathematical model is a system of connected and interacting neurons.

Artificial neural networks are built on the principles of organization and functioning of their biological counterparts. They are able to solve a wide range problems of pattern recognition, identification, prediction, optimization and control of complex objects. Further increase the performance of computers is increasingly associated with artificial neural network, in particular, with Neurocomputers which are based on artificial neural network.

The aim of this study is to solve the problem of determining the application of the total exposure of Machinists.

In this connection were as follows:

1 Analysis of the current state of the methods of neural network technology in the activities of Machinists;

2 Analysis of the processes and phenomena that contribute to the total annual dose of gamma rays engineering industry workers;

3 Construction of an algorithm to determine the result of radiation exposure of Machinists.

According to the International Commission on Radiological Protection, in most countries, the ionizing radiation sources of natural origin provide about 50% of the average human dose irradiation [7] (Table 1).

**Table 1.** Contribution of different sources to the total human exposure

| Radiation sources                               | Natural background | Irradiation of human by decay products of radon and thoron indoors | Nuclear testing products fallout | Nuclear power | Motor vehicles using | Consumption of radio luminescent products | Usage of ionizing radiation in medicine |
|-------------------------------------------------|--------------------|--------------------------------------------------------------------|----------------------------------|---------------|----------------------|-------------------------------------------|-----------------------------------------|
| Contribution to the annual exposure of human, % | 23.0               | 42.0                                                               | 0.77                             | 0.03          | 0.1                  | 0.1                                       | 34.0                                    |

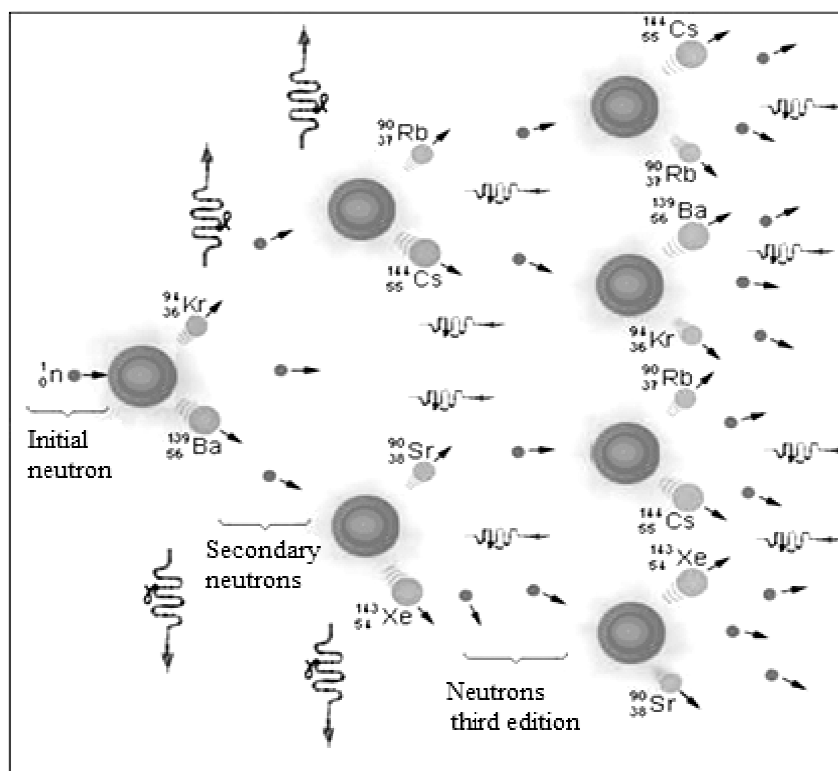
At the same time according to the research about 30% of the natural background make it cosmic particles [7].

Cosmic radiation bumps into Earth's upper atmosphere, which provides effective protection for all living creatures without missing much of the radioactive particles. Cosmic rays consist of «galactic» particles which occur outside the solar system and the "sun" particles emitted by the sun. The solar radiation is energetic charged particles, electrons, protons and nuclei injected Sun into interplanetary space Galactic radiation consist of the various chemical elements nucleus having a kinetic energy of more than a few tens of MeV/nucleon, and the electrons and positrons with  $E > 10$  MeV.

The cosmic rays comprised of high-energy atomic particles, the percentage contribution of which is as follows [9]:

- 87% protons.
- 11%  $\alpha$ -particles,
- $\approx 1\%$  heavy atoms,
- $\approx 1\%$  electrons.

In the atmosphere "solar" particles produce cascades of nuclear interactions, which give a lot of secondary particles that play an important role in the production of space radionuclides (Fig. 2).



**Figure 2.** Basic Cascades interaction of nuclear particles

Radioactive transformation is a chaotic process and often leaves the transforming nucleus in an excited state in which the protons and neutrons in the shells of the nucleus are not in the most tightly bound state possible. This excitation energy will be emitted as electromagnetic radiation as the protons and neutrons in the nucleus rearrange themselves to the desired lowest energy state. The shell model of the nucleus suggests discrete energy states for neutrons and protons; it is this difference between energy states that is emitted as a gamma photon when rearrangement takes place. Thus, the emitted gamma ray is characteristic of that particular nucleus [7].

Person is exposed to ionizing radiation from various sources throughout their lives. Irradiation may be both of synthetic and natural sources of radiation. With an increase in the technical development of the planet to the overall human exposure to artificial radiation sources is constantly growing.

Natural sources of ionizing radiation is primarily the natural background of the Earth, that is, the soil, the earth's crust and other layers of the Earth have a sufficient amount of a radionuclide that decompose emit ionizing radiation.

Dose that gets the population will vary depending on the geographic location of residence. Radiation levels in some areas of the world where lie especially radioactive rocks (the Caucasus and Altai) is considerably above the average, and in other places - is correspondingly lower.

In everyday life, people repeatedly exposed to ionizing radiation. Radiation sources is as natural background radiation due to the natural radioactivity of the earth, cosmic and solar radiation and artificial emitters (household appliances, building materials, fuel, medical equipment, power plants and nuclear power plants). Therefore, the determination of the total human exposure in everyday life will consist of a variety of factors will be strictly defined for a specific person, and undoubtedly true. Neural network technology can completely resolve this problem, follow neyroalgoritim presented in this paper.

One of the important applications is to determine the total exposure of Machinists by mathematical modeling. Indeed, modern means of calculating possible to obtain the value of the radiation dose due to the action of one factor (finding and manipulation of sources of ionizing radiation while working at

the enterprises). However, in the course of business, the employee is subjected to multivariate exposure.

To assess the exposure of workers and algorithmization engineering industry, we apply neural network.

Also, throughout all history of existence of Earth different types of ionizing radiation fall on Earth surface from the Sun from space and a galaxy, despite the protective layers of Earth formed by the atmosphere. The size of galactic and solar radiation depends on existence of atmospheric overcast (the high overcast, moderate weather or clear).

It is worth carrying a problem of radonic pollution to natural sources of radiation also. More exact than migration and accumulation of radionuclide of radium which as a result of disintegration forms radon, and it in turn toron and other affiliated products of disintegration including gripping gamma radiation. And poor such radionuclides as potassium, calcium, sodium, phosphorus, size of migration of radionuclides considerably grows in soils. In a life this problem is aggravated with existence of plastic windows, insignificant frequency of ventilation of rooms, sealing of walls, existence of full-fledged outlets at basements, etc. If the person works in machine-building branch, his body is exposed to additional serious radiation [8]. There is a number of separate types of radiation of workers of mechanical engineering on a workplace, it is possible to carry to them: radiation by the working laser, radioactive materials, air pollution by harmful volatiles, etc. Besides, in mechanical engineering sources of intensive radiation by electromagnetic waves of an infrared range are: heated surfaces of walls, furnaces and their open apertures, and also trenches, the final trays, rolled metal of a stream of the melted metal, heated processed details and preparations, different types of welding and plasma processing, etc. All this significantly influences efficiency of the person, his health and health. For definition of result of radiation of workers of mechanical engineering it is necessary to process the following factors (Fig. 3):

1 Space radiation: 1.1 Galactic radiation (1.1.1 Cloudy weather, 1.1.2 Sunny weather, 1.1.3 Moderate weather); 1.2 Solar radiation (1.2.1 Cloudy weather, 1.2.2 Sunny weather, 1.2.3 Moderate weather);

2 Using air transport: 2.1 Yes, 1-2 times a year; 2.2 Yes, 6 and more times a year; 2.3 Isn't present;

3 Ionizing radiation use in medicine: 3.1 didn't pass in a year; 3.2 passed 1 time in a year; 3.3 passed several times in a year;

4 Radio engineering: 4.1 TV; 4.2 Personal computer (laptop, tablet);

5 Global loss of products of nuclear tests;

6 Radiation by disintegration products toron and radon: 6.1 Frequency of airing of the room (6.1.1 2 times a day, 6.1.2 Once a day, 6.1.3 Not daily are more often); 6.2 Sealing of walls (6.2.1 Existence of repair with isolation of walls, 6.2.2 Isn't present repair with isolation of walls); 6.3 Accommodation on first floors of buildings (6.3.1 Ventilation of basements, 6.3.2 Lack of fragrances); 6.4 Top floors;

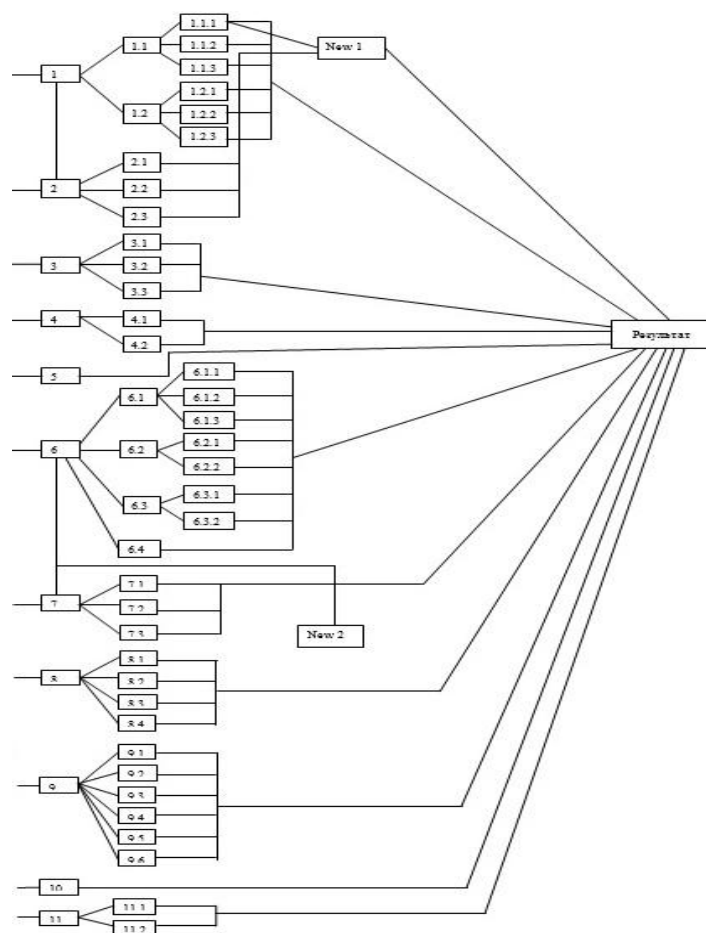
7 Natural radiation background: 7.1 Accommodation in places of the raised radiation background; 7.2 Accommodation in places of a moderate radiation background; 7.3 Accommodation in places of a usual radiation background;

8 Construction material of the house: 8.1 Tree; 8.2 Brick; 8.3 Slag stone (including bulk); 8.4 Panel;

9 Radiation on production: 9.1 Laser; 9.2 Heated surfaces of walls, furnaces and their open apertures; 9.3 Welding and plasma processing; 9.4 Rolled metal of a stream of the melted metal, heated processed details and preparations; 9.5 Volatiles in air; 9.6 the radioactive materials participating in production;

10 Number of the people living together in one room;

11 Wireless communication indoors: 11.1 Cell phones; 11.2 Wi-Fi zone.



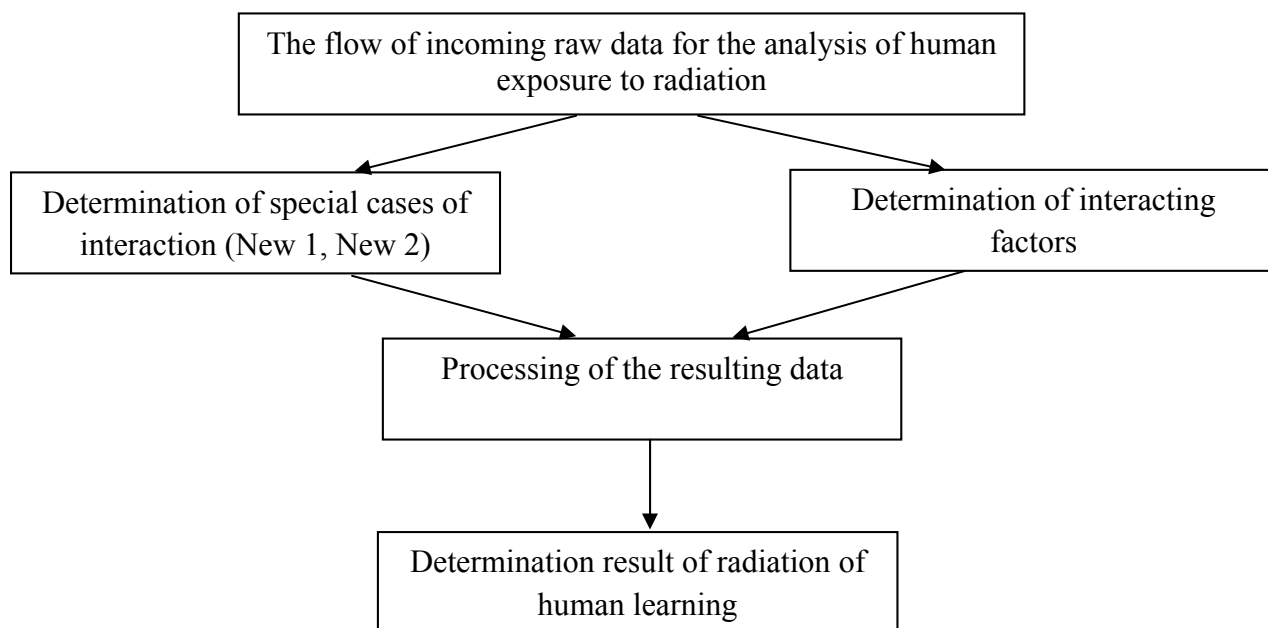
**Figure 3.** Diagram of a neural network of natural processes related to everyday human life

Thus, the radiation exposure is subject to any citizen of the world, especially if he carries out his professional activities with sources of ionizing radiation.

Important factors of radiation exposure in engineering is the time taken to complete the work in the enterprise, while overtime hours.

The value of annual dose also depends on the lifestyle of people. So if a person often uses air (especially more than 4-6 times in a year), the total dose received will be much higher.

Studying the interaction data in the neural network of natural processes, it was found that there is an important influence on the outcome of the process, based on the interacting factors in the direction of strengthening, weakening or compensation exposure. Was built by the algorithm of the neural network to analyze the data (Fig.4).



**Figure 4.** Algorithm to determine the result of radiation exposure of human

Based on this, the first paragraph of the algorithm is to find the particular cases and to determine the relationship factors. After the data is determined by the result - the annual exposure dose of gamma rays.

Mathematical modeling was solved important problems of the process of total human exposure in the company, allowing to calculate the radiation dose caused by multiple factors.

## 2. Results and Discussion

Detector dosimeter is used to convert the phenomena caused by ionizing radiation into an electrical or other easily accessible to measurements signal. The detector of the dosimeter is the ionization counter, by type of Geiger counter with a sensitivity of 20,000 pulses/ $\mu$ Sv. The gamma radiation dosimeter has two measurement channels: to measure ambient dose equivalent rate of gamma radiation and to measure the dose with independent reset these values. The measurement carried out continuously with the constant refinement of the result, at what the statistical error displayed on the screen. So we can get a result with the necessary statistical accuracy. The measurements were carried out with not more than 5% statistical error.

## Conclusions

The following conclusions can be made on the basis of the study:

- 1) based on neural network technology algorithmization allow to resolve the issue of private to determine the total exposure of the worker in the field of engineering activities;
- 2) radiation exposure in engineering is going from the set of interdependent natural phenomena and factors in the classification and algorithmization which revealed the dependence of such a neural;
- 3) based on neural network technology built algorithm resolves the issue of search and compute the total radiation dose of Machinists in the course of their professional activities.

## References

- [1] Portola, V.A. Indirect Negative Influence of Coal Mine Motor Vehicles on the Environment [Electronic resource] / V. A. Portola, E. S. Torosyan, A. S. Kuznetsova // Applied Mechanics and Materials : Scientific Journal. – 2015. – Vol. 770 : Urgent Problems of Up-to-Date Mechanical Engineering. – [P. 690-694].
- [2] Torosyan, V.F. Updating of sewage - purification facilities of electroplating enterprises with counterflow

- ion-exchange filters [Electronic resource] / V. F. Torosyan [et al.] // IOP Conference Series: Materials Science and Engineering. – 2015. – Vol. 91: VI International Scientific Practical Conference on Innovative Technologies and Economics in Engineering, Yurga, Russia, 21-23 May 2015. – [012077, 8 p.].
- [3] Andersen, P.A. Environmental variables associated with vacationers' sun protection at warm weather resorts in North America/ P.A. Andersen [et.al] // Environmental Research. – 2016. – V. 146. – [P. 200-206].
- [4] Tesfaye, M. Simulation of bulk aerosol direct radiative effects and its climatic feedbacks in South Africa using RegCM4 / M. Tesfaye [et.al] //Journal of Atmospheric and Solar-Terrestrial Physics. – 2016. – V. 142. – [P. 1-19].
- [5] Allen, R.J., Sherwood, S.C. Aerosol-cloud semi-direct effect and land-sea temperature contrast in a GCM// Geophysical Research Letters. – 2010. – V. 37 (7), art. no. L07702.
- [6] Kashirina I.L. Neural network technology. Teaching aid for higher education. - Publishing House of the Voronezh State University, 2008 – [72p.]
- [7] Kostenko O.V., Orlova K.N. Building neyroalgoritim to determine the total human exposure // Scientific and Technical Gazette of the Volga region. - 2013. № 2. – [pp 142-145]
- [8] James E.Martin. Physics for radiation protection, WILEY-VCH Verlag GmbH & Co. KGaA, Weinheim. – 2006. – [844 p.]