RESULTS OF IRRADIATION IN THE MINING ACTIVITY, POSSIBLE RISK SOURCES

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Abstract: In this paper is studied the problem of radiation exposing in mining industry (especially in the coal mines). The radiation sources from the mine's atmosphere, where the radon is disintegrated appearing its solid disintegration products, named also descending products, presents a risk degree both for the personnel trained directly in work and for the personnel not exposed professional, and for the rest of the population. The radiation exposing should be known by each miner, in every work zone of the mine and the time spent by the miners in every work zone.

I.GENERALITIES

In the mining industry, where the labor is done with radioactive sources (nuclear raw materials, nuclear materials, radioactive waste, artificial radio-nuclides, etc) or in its presence, appear a lot of specific noxious radioactive factors called radioactive noxe, induced by the property that the radioactive elements have to spontaneously disintegrate with emission of corpuscular alpha and beta radiations accompanied or not by gamma electromagnetic radiations.

The basic standards of radiatios security, are regarded at art.22 that "the limit of the effective doze for the personnel professional exposed is 20mSv (milisievert) per year", and art.25 say that "the limit effective doze for the population is 1mSv per year".

II. THE RADON GAS

Radon gas and its daughter products are commonly found in mines of radioactive minerals. Their concentrations should not be allowed to exceed 3700 S^{-1} m^{-3} (10^{-1} μC per cubic metre) for prolonged exposure. Radon is a naturally occuring radioactive gas. It is chimically inert and can not be detected by any of the human senses. It is easy soluble in water and is rapidly released after contact with air. The radon is formed as a result of the radioactive desintegration of U^{238} and Th^{232}, which are present in coal-bearing strata. The U^{238} decays into Rn^{222} and Th^{232} decays in Rn^{220}, ussually known as Thoron. Thoron has a relatively

short half-life, (the necessary time for radioactivity to be reduce to half), of 52 seconds, the radiological risk being considerable smaller then Rn^{222}.

The establishments from the last years, as those from some other countries with a developed mining industry, confirms the existence of a professional exposition risk to the radioactive natural gases , and for other category of miners, beside those from the mines with radioactive ore, fact that caused the passing to the systematic research of all the mines.

After this time, the closed system is balanced because the descendents are disintegrated as soon as they are produced. In the mine, there where the Radon penetrates constantly into the galleries, the ventilation dilutes the gas and remove it outside the mine, reducing the chances of producing the descendents in the mine"s atmosphere.

Therefore, the radon gas does never realize all his potential of descendents. In this way the concentration of the descendents of radon from underground gets to the theoretical maximum of a closed system. Beside, the descendents of radon can attach to the solid surfaces of the underground, in this way reducing the radiological risks. The concentrations of the radon gas and radon`s descendents in the mine`s atmosphere are connected through the balance factor (FE). For a ventilated typical gallery FE=0,2. This mean that the radon gas realize only 20 percentage from the hole potential of descendents. In a closed system the balance could be realized in approximately 3,5 hours when FE=1.

It can be concluded that the ventilation does not allow the radon to remain to long in the mine"s atmosphere and in this way the balance is hard to realize, bringing the contribution also the fact that after the descendents are formed they attach to particles in suspension (vapors, powders and on the walls of the galleries).

III. DISTRIBUTION OF RADIOACTIVE ELEMENTS IN COAL AND COAL ASH

All the coal types contain very small quantities of Uranium and Thorium, and also their descendents from the radioactive disintegration series. The uranium is present in the coal as an organic complex of uranium or of a organic compound of uranium. Coal contains U^{238}, U^{235}, U^{232} , Thorium and their radioactive daughter products in secular equilibrium (a stable situation in witch the forming rate of the radioactive descendents is equal with their desintegration rate).

During the combustion process, the gaseous products are eliminated, but the solid ones, containing uranium, thorium and derivations, go through a process of concentrating in ash. For example the Indian coal has a high content of ash (30%-40%) and finally a huge quantity of ash, about 60 tpa, and is generated as a secondary product of termoelectric centrales.

Chart I. The uranium concentration (ppm) in coal and ash

INDIA		**USA**		**GREECE**	
Coal	Ashes	Coal	Ashes	Coal	Ashes
34,3 – 49,6	63,6 - 79,2	0,7 - 2,4	30 - 50	24,1 – 35,1	40,1 – 70,1

Chart II. Radioactive elements, forms and risks for health

Radionuclides	**Halfing period (years)**	**Form**	**Organ (critical)**	**The most probable way for exposing**
U – 238	$4,5x10^9$	Insoluble	Lung	Inhalation
U – 235	$7x10^8$	Insoluble	Lung	Inhalation
U – 233	$1,6 \times 10^5$	Insoluble	Lung	Inhalation
Th –232	$14*10^9$	Insoluble	Lung	Inhalation
Rn – 222	4 days	Insoluble	Lung	Inhalation
Cs – 134	2	Soluble	Hole body	Food absorption
Cs – 137	3	soluble	Hole body	Food absorption

IV. POSSIBLE RISK SOURCES

The possible radiations sources in the mining industry are the natural radionuclides:

- radionuclides from the series U- 238;
- radionuclides from the series U- 235;
- radionuclides from the series Th-232;
-radioactive isotope of potassium .

Artificial radionuclizi:

-standard radioactive sources or irradiated tests;
-nuclear apparatus and installations used;
-nuclear techniques used.

There are more possible irradiation sources in the mining industry, but I want to focus over one, over the resulted ashes from the coal burning and bituminous shale, where as radionuclides are: the uranium, the radium, the radon and the products of their affiliation. The radioactive elements from the coals (0,001- 0,4 % U) are concentrated (with a concentration factor of 2-3 comparing with the initial concentration) by burning in the ashes and are stored with them, and one part goes in the atmosphere during the burning process.

V. THE LIMITS OF THE DOSES

For the radon and the toron"s descendents are used the following conventional conversion factors in a effective dose per exposition to the alpha potential energy (Sv/ Jpm-3):

-radon in homes: 1,1

-radon at working place: 1,4

-toron at working place :0,5

The alpha potential energy (of the descendents of radon and and toron) represents the total alpha energy sent forth by the desintegration of the descendents of radon and toron from the specific desintegration chain, up to, but not including ^{210}Pb for the descendents ^{222}Rn and up to the isotope ^{208}Pb for the ^{220}Rn descendents.

The effective dose employed per incorporation unity by ingestion (SvBq-1) for the population is given in chart III.

Chart III

Nucleus	**Halfing time**	**Age G<1a**		**f_1 for g>1a**	**Age 1-2a**	**Age 2-7a**	**Age 7-12a**	**Age 12-17a**	**Age >17a**
		f_1	**g(h)**		**h(g)**	**h(g)**	**h(g)**	**h(g)**	**h(g)**
Radium									
Ra-223	11,4d	0,600	5,3E-0,6	0,200	1,1E-0,6	5,7E-07	4,5E-07	3,7E-07	1,0E-07
Ra-224	3,66d	0,600	2,7E-06	0,200	6,6E-07	3,5E-07	2,6E-07	2,0E-07	6,5E-08
Ra-225	14,8d	0,600	7,1E-06	0,200	1,2E-06	6,1E-07	5,0E-07	4,4E-0,7	9,9E-08
Ra-226	1,60E+03a	0.600	4,7E-06	0,200	9,6E-07	6,2E-0,7	8,0E-07	105E-06	2,8E-07
Ra-227	0,703h	0,600	1,1E-09	0,200	4,3E-10	2,5E-10	1,7E-10	1,3E-10	8,1E-11
Ra-228	5,7a	0,600	3,0E-05	0,200	5,7E-06	3,4E-06	3,9E-06	5,3E-06	6,9E-07

Note: the values of f1 for the age group from 1year to 15years , for radium is 0,3

Effective dose coefficients (Sv Bq-1)

Chart IV

Nucleus	**Halfing time**	**Inhalation**				**Ingestion**	
		Time	**f_1**	**h(g)1um**	**h(g)5um**	**f_1**	**h(g)**
Radium							
Ra-223	11,4d	M	0,200	6,9E-06	5,7E-06	0,200	1,0E-07

Ra-224	3,66 d	M	0,200	2,9E-06	2,4E-06	0,200	6,5E-08
Ra-225	14,8d	M	0,200	5,8E-06	4,8E-06	0,200	9,5E-08
Ra-226	1,60E+03a	M	0,200	3,2E-06	2,2E-06	0,200	2,8E-07
Ra-227	0,703h	M	0,200	2,8E-10	2,1E-10	0,200	8,4E-11
Ra-228	5,75a	M	0,200	2,6E-06	1,7E-06	0,200	6,7E-07

Note: the column "time" contains the description of the absorption speed into the longs, and the letter "M" means the moderated absorption speed.

The compounds and the values for the factors f1 that were used in counting the dose coefficients for ingestion:

Element	**f_1**	**Compound**
Radium	0,200	All compounds

VI. THE RADIATION'S CONTROL

The main method to control the concentration of radon and descendents in the mines is the ventilation. This is essential in order to maintain the low concentration of radon by diluting it with clean air and reducing the time that radon stays in (10-15 minutes), in this way only 10%-20% of descendents are produced in the mine"s atmosphere.

When is projected a ventilation system for a mine that has ventilation problems, must be considered the following factors:

a. the primary system of ventilation must be directed, when is possible, by sterile or in some cases through some ores of inferior quality;
b. the exploded ore must be evacuated as soon as possible, in order to avoid the forming of the descendents of radon;
c. when is possible, the transportation must be limited in evacuation galleries, to reduce the dust level and the diesel spread in the working area, improving the ventilation requires;
d. the holes ore, the transportation was and the crushing stations must be ventilated in a such a way that the evacuated air to be quickly directed towards the vitiated air;
e. the repairs garages must be correctly ventilated by controlling the flow volume of air;
f. the water that drain into the mine must be stopped, or pumped as soon as possible.
g.

Chart V. The requires regarding the flow volume of air in different mining areas

Mining areas	Flow volume of air	Characteristics
Exploitation with drilling machines	0,091	Six or seven separated working places to one zone
Exploitation with long shooting holes	0,104	Big working , reduced speed of air , great quantity of broken ore at every shooting
Exploitation with *"pilieri"*	0,156	Big working, slow air speed, long time of air "resistance" requires big flow volume of air

CONCLUSIONS

The control of the cumulative exposing of the miners to the radiation, by limiting their staying time in the area with high risk and by their rotation to the areas with a lower risk, it can be utile practice.

For this reason, the cumulative exposing to the radiations should be known by each miner, and should be available alternative working places. The big mining exploitations can supply alternative working places without a great difficulty. For the estimation of cumulative exposing of the miners to the descendents of radon, should be known, from the mine's records, the medium concentration of the descendents of radon in every working area of the mine.

For the radioprotection of the environment is necessary the establishment and the applications of some efficient and scientific founded measures to know the radioactive pollution level of the environment by a permanent watching of the natural factors.

BIOGRAPHY

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