PREOPERATIONAL STUDIES BY THE ENVIRONMENTAL MONITORING SYSTEM OF THE PAKS NUCLEAR POWER STATION

I. Fehér, A. Andrási, S. Deme, I. Németh, P. Zombori, L. Koblinger, E. Láng, E. Germán*, L. Kemenes*
Central Research Institute for Physics, Budapest, Hungary.
* Paks Nuclear Power Station, Paks, Hungary.

Details are given of the preoperational investigations carried out by the continuous on line environmental monitoring system and mobile laboratory developed and installed for the Paks Nuclear Power Station.

Introduction

The telemetric stations of the continuous monitoring system have been developed for measuring gamma dose rates and the time integrals of ^{131}I concentration. In addition to the telemetric units, high volume aerosol and ^{131}I samplers are operated at the telemetric stations. The mobile laboratory is equipped with gamma-spectrometers and GM counters similar to those at the telemetric stations [1-5]

The minimum detectable dose rates and time integrals of the iodine activity concentration in air were calculated by different methods and compared with the authorized dose limit.

Measurements

Continuous background gamma dose rate measurements were carried out by the GM counters of the telemetric stations.

The temporal variations in background count rates at the different telemetric stations are in very good cross-correlation [6]. Both types of temporal variations /hourly and daily/ can be related to changes in weather parameters: i.e. to hourly changes in the temperature gradient and to daily changes in air pressure and precipitation.

The early morning positive temperature gradient increases the near-surface concentration of radon and its daughters.

The inversion effect, generally preceding precipitation, causes the same type of increase in the daily mean count rates on rainy days. Additionally, the decrease in air pressure enhances the intensity of the other component of background radiation, i.e. secondary cosmic rays.

The good cross-correlation in the temporal changes observed at the different telemetric stations enables the use of a correction method [6] for a more accurate determination of the actual background count rate at the downwind station. On applying this method the coefficient of variation for the actual background count rates can be reduced to 1.2-1.3 %, compared with that of 2.8-3.0 % for the measured values.

Results obtained by evaluating data of the continuous telemetric ^{131}I monitors can be summarized as follows:

- the temporal variations of count rates show only a weak correlation with changes in the level of radon and those of its daughters';
- the standard deviation of count rates is 3.5 % which hardly exceeds the statistical error.

The minimum detectable values derived from the data of one--year's operation are:

GM counter	3	nGy/h
GM counter /with Pb+Sn filter/	3.4	nGy/h
^{131}I monitor	1	Bqh/m^3
High volume ^{131}I sampler	0.03	mBq/m^3

As a part of the preoperational survey programme, in situ measurements were performed by a mobile laboratory equipped with a NaI/Tl/ spectrometer and a pair of GM counters. Since the first unit of the nuclear power station was put into operation the measurements have been continued, and the spectrometric method has been improved by the application of a Ge/Li/ detector [7].

We determined the dose rate contributions and the radioactive concentrations of the natural radioisotopes in the soil. The presence of ^{137}Cs originating from global fallout was detected in a few cases.

The mean, minimum and maximum values of the total terrestrial gamma dose rates are: 49.6 nGy/h, 31.8 nGy/h and 82.0 nGy/h, respectively. The overall uncertainty of the dose rates is about 15 %.

We found good agreement between the total average dose rate values measured by different methods. The differences do not exceed 25 % and arise from the uncertainties of the calculational model and the calibration used. A good correlation was also found between the dose rates obtained by the GM counter of the mobile laboratory and those of the telemetric stations.

The minimum detectable dose rates /nGy/h/ achievable by in situ measurement for several characteristic source distributions are as follows:

Detector	Natural emitters in the soil			^{137}Cs in the soil	^{131}I on the ground surface	^{133}Xe in plume
	^{40}K	^{232}Th series	^{238}U series			
GM counter	4.0	4.1	3.7	10.2	11.0	6.5
GM counter with filter/	5.1	6.1	5.7	14.0	17.5	715
NaI/Tl/	0.4	0.9	2.2	1.6	0.6	2
Ge/Li/	0.2	0.5	1.1	0.07	0.05	-

Conclusions

Hungarian regulations [8] require that the effective dose equivalent to members of the public living in the vicinity of the nuclear power station should not exceed 1/3 of the 5 mSv recommended by the ICRP. The radiation exposure due to activity released to the atmosphere per 1000 MW/e/ must not exceed 1/10 of the value above, namely 170 μSv/year [9].

The detection limit for the different units of the measuring stations are as follows:

	short term release / 1 h/	continuous release
GM counters	3 nGy_{air}/h	26 μGy_{air}/year
^{131}I monitors	3 $\mu Gy^{inhal.}_{thyr.}$/case	104 $\mu Gy^{inhal.}_{thyr.}$/year
High volume ^{131}I samplers	0.02 $\mu Gy^{inhal.}_{thyr.}$/case	1 $\mu Gy^{inhal.}_{thyr.}$/year

For continuous releases a detection limit of about 18 μSv/year was obtained when the effective dose equivalent was calculated by assuming a shielding factor of 0.7 for external radiation, and the weighting factor of 0.03 is applied for ^{131}I thyroid exposure /inhalation/. If the ^{131}I dose contribution by milk consumption is also taken into account a resultant /external + inhalation + ingestion/ effective dose equivalent detection limit of 26 μSv/year is obtained. /Here a 500 times higher effective dose equivalent is assumed due to ingestion than from inhalation for the same airborne ^{131}I concentration/

Dose calculations were carried out by the AIREM diffusion program [10]. Data actually measured at the meteorological tower during the first year of operation were used as input to the program. The results of the calculations led to the conclusion that the maximum dose occurring anywhere in the vicinity of the nuclear power station does not exceed by more than 5 % the highest dose measured at the telemetric stations. Approximately 70 % of the maximum value is expectable at the boundary of the 3 km radius safety zone whereas only 55 % of the maximum is expectable for the mostly exposed settlement.

Measurements made by the mobile laboratory complement those made by the telemetric system, especially in the case of the sensitive and specific determination of the fallout.

It is evident from the preoperational investigations that the environmental monitoring system of the Paks Nuclear Power Station is a suitable means of establishing that the exposure of the population does not exceed 1/5 of the value prescribed for the atmospheric release of a 1000 MW/e/ power unit.

References

[1] I. Fehér, S. Deme, A. Andrási: Environmental monitoring system at the Paks Nuclear Power Station. Acta Phys. Hung. 52, 3-4, p 373, 1982.

[2] S. Deme, I. Fehér, M. Rövid: Telemetric and data acquisition system for environmental monitoring system at the Paks Nuclear Power Station. Acta Phys. Hung. 52, 3-4, p 381, 1982.

[3] A. Andrási, P. Zombori: Gamma spectrometric measuring system for environmental sample analysis. Acta Phys. Hung. 52, 3-4, p 389, 1982.

[4] L. Koblinger, L. Németh, P. Zombori, A. Andrási: Comparison of field dose rate measurements and Monte Carlo calculations. Acta Phys. Hung. 52, 3-4, p 397, 1982.

[5] I. Fehér, S. Deme, A. Andrási: Application of the new limitation system in the radiation protection monitoring program of the nuclear power plant in Hungary. IAEA-SM-258/59, 1982.

[6] S. Deme, I. Fehér, E. Láng, J. Rónaky: GM-counters for continuous environmental monitoring at the Paks Nuclear Power Station. Proc. XIth. Regional Congress of IRPA, Vienna, 20-24 Sept. 1983.

[7] I. Németh, P. Zombori, L. Koblinger, A. Andrási, E. Germán, L. Kemenes: Investigation on the preoperational level of radiation field in the vicinity of the Paks Nuclear Power Station. Proc. XIth Regional Congress of IRPA, Vienna, 20-24 Sept. 1983.

[8] Regulation on health aspects of nuclear power plants No. 4. /1979. V. 29./ EüM, Magyar Közlöny 32 /1979/ 490 /in Hungarian/.

[9] Regulation on radionuclide atmospheric release limits for nuclear power plants No.1. /1980. II. 6./ OKTH, Magyar Közlöny 8 /1980/ 114 /in Hungarian/.

[10] Martin J.A. et al.: A computer code for calculating doses, population doses and ground depositions due to atmospheric emissions of radionuclides. Rep. EPA-520 /1974/.