Acta Physica Academiae Scientiarum Hungaricae, 52 (3—4), pp. 373—379 (1982)

ENVIRONMENTAL MONITORING SYSTEM AT THE PAKS NUCLEAR POWER STATION

I. FEHÉR, S. DEME and A. ANDRÁSI

HEALTH PHYSICS DEPARTMENT, CENTRAL RESEARCH INSTITUTE FOR PHYSICS
1525 BUDAPEST, HUNGARY

The environmental monitoring system of the Paks Nuclear Power Station (Hungary) has been designed with a dual aim:

in normal operation: to check that the population's burden does not exceed the prescribed dose limit;

under accidental conditions: to provide rapid information on the expected radiation burden of the population so that necessary steps can be taken.

For assessing environmental doses the following parts of the monitoring system are used

— telemetric stations to determine the time integral of ^{131}I concentration in air and the gamma dose rate;
— sampling stations and devices for sample measurement;
— mobile laboratories;
— a meteorological tower.

The main principles and structure of the environmental monitoring system are discussed.

Introduction

In the next future nuclear power is due to contribute in a substantial measure to the supply of electrical energy in Hungary; the first 440 MW_e block of the Paks Nuclear Power Station is near completion, three others are to follow. Environmental monitoring is one of the prerequisites of the safe operation of a nuclear power plant. The Central Research Institute for Physics has been commissioned to develop and to implement the environmental monitoring system of the Paks Nuclear Power Station. The conception and main elements of the monitoring system will be reviewed in the following.

Aim and basic methods of environmental monitoring

The environmental monitoring system of the Paks Nuclear Power Station has been designed with a twofold aim:

in the case of normal operation to keep the radiation burden of the population due to the power station below the dose limit prescribed by the competent authority;

under accidental conditions to provide rapid information on the expected radiation burden of the population in order that the competent authority should be able to take the necessary measures.

To achieve this dual aim two parallel basic methods are used:

— the external radiation burden and the radioactive contamination are computed by use of a normal operation diffusion model utilizing measured values of radioisotope release and local meteorological data,

— the external radiation dose and the radioactive contamination of the environment are evaluated partly from telemetric data, partly by the laboratory analysis of environmental samples.

The first method is suitable for the determination of the environmental burden due to activity release during normal operation when the expected value of the field dose and of the environmental contamination is near or below the detection limit of direct measurements. The results of measurements by the second method either directly confirm the correctness of the values measured by the first method, or they furnish direct data on the population burden to be expected in the case of any accident.

The second method is of special importance in the case of accidental activity release when the activity of the radioisotopes released into the environment cannot be measured. In this case the accidental diffusion model has to be fitted to the data of telemetric environmental measurements in order to determine the expected radiation burden of the population in the concerned area. Under accidental conditions quick results are obtained from sample measurements by mobile laboratories.

The environmental monitoring system is schematically shown in Fig 1.

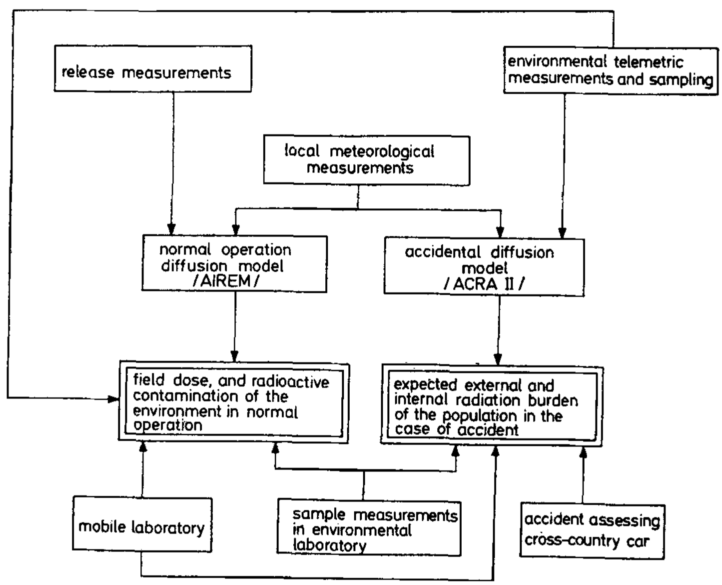

Fig. 1. Scheme of the environmental monitoring system.

Main modules of the environmental monitoring system

Measurements of activity release

In the case of normal operation as well as under accidental conditions activity from the Paks Nuclear Power Station can be released practically only into the atmosphere. For this reason primarily the environmental atmosphere is covered by activity release measurements. The release of radioactive noble gas, radioiodine, radioaerosols including ^{89}Sr, ^{90}Sr is continuously measured by the use of the Soviet KALINA apparatus which is completed by the high sensitivity noble gas concentration meter (Budapest Technical University product) and by the continuous ^{131}I monitor (Central Research Institute for Physics product).

The radioactive contamination of cooling water is due to be prevented by a multiple safety system. To ensure the quality of the water of the Danube, a water monitor system is being built. The system is composed of a continuous gross-gamma concentration meter, a continuous water sampler and of remote controlled automatic water sampler units. Cold water, hot water and sewage are monitored by the system.

Meteorological tower

The most important local meteorological data for diffusion calculation are obtained from wind direction, wind speed and thermometer probes on the 20, 50 and 120 meter levels of the 120 m high meteorological tower as well as on the 2 m high field station. At the field station complementing meteorological data are furnished by radiation equilibrium, atmospheric humidity measuring instruments and a precipitation meter. The meteorological station is incorporated in the national network of wireless and telex communication.

Diffusion models

For the normal operation diffusion model the AIREM [1] while for the accidental diffusion model the ACRA II [2] computer codes have been adapted. The external effective dose-equivalent is calculated by use of the POKER-CAMP program [3] developed at our Institute.

Measuring and sampling stations

The so-called "A"-type stations are built on a circle of 1.5 km radius around the nuclear power plant in the direction of settlements. The gamma dose rate and time integral of ^{131}I concentration are continuously measured by the

7 "A" stations, which are connected by cable to the radiation protection control room of the nuclear power plant. The telemetric and data acquisition system installed in the control room is connected to the "A" stations, the release meters and to the sensors of relevant meteorological data. The telemetric and data acquisition system is described in more detail in another paper of this issue [4].

Continuous aerosol, large volume aerosol and radioiodine samplers are operating on the "A" stations and on a "B"-type station mounted at 26 km distance from the nuclear plant. Fall-out, tacky cloth sampling and thermoluminescent gamma dose measurements are also carried out.

The 14 "C"-type sampling stations built in the environment of the nuclear plant within a circle of a radius of about 30 km, are suitable for fall-out tacky-cloth sampling and thermoluminescence gamma dose measurements.

Soil and plant (grass) samples are taken in the environment of the "A",

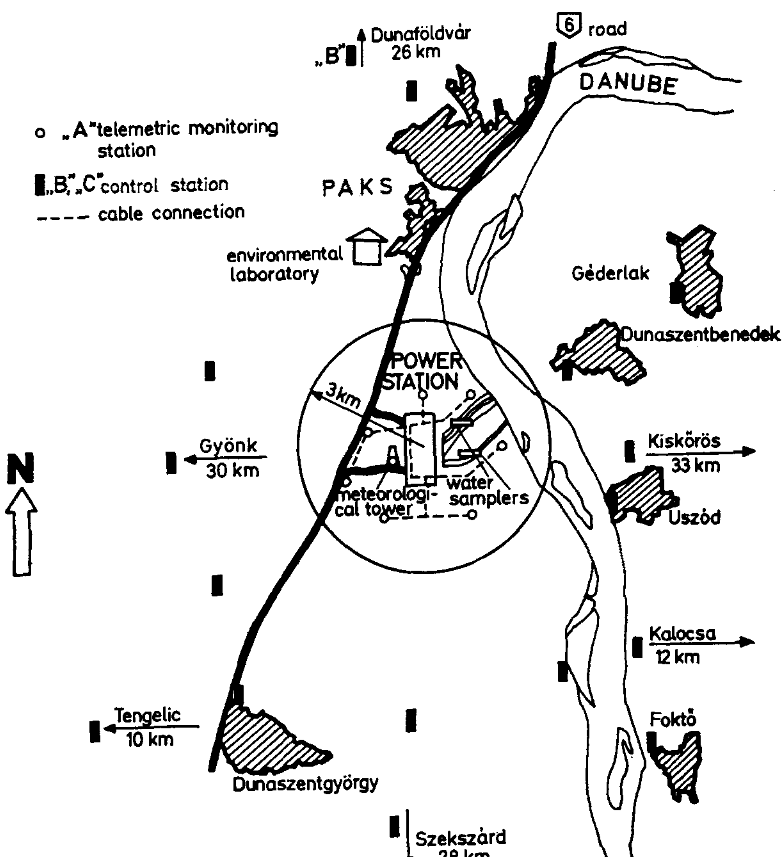

Fig. 2. Location of the environmental monitoring stations around the nuclear power plant.

and "B"-type stations. Milk samples are taken from dairy-farms which pasture cattle in fields near the "C" stations within the 30 km radius circle.

Radioactive contamination of ground water is measured on samples taken from wells intended for this purpose. Periodically mud and fish samples are taken from the Danube for the detection of possible radioactive contamination.

The geographical positions of the measuring and sample stations are mapped in Fig. 2.

Environmental laboratory

In Paks Town at about 5 km from the nuclear plant an environmental laboratory has been built for the measurement of environmental samples. The laboratory comprises three main units:

Sample preparation unit, where the physical processing of samples, e.g. evaporation of water samples, comminution and drying of soil and plant samples, takes place.

Radiochemistry unit, where the samples are chemically and physicochemically enriched. Procedures of this type are the concentration of fall-out and milk by ion exchange, elimination of radon from iodine adsorbents. Laborious radiochemical procedures are used only in the above specified cases. External institutes will be commissioned by the nuclear plant to perform long-lived radioisotope concentration measurements and tritium determination by high sensitivity isotopic enrichment procedure on environmental samples.

Radiometry unit equipped with

— low background beta counters,
— low background scintillation and Ge(Li) gamma-spectrometers, and
— a thermoluminescence reader.

The gamma spectrometer is dealt with in more detail in another paper of this issue [5]. The program of environmental sample measurements is specified in Table I.

Mobile laboratory

The mobile laboratory is equipped with a gamma spectrometer and with a G—M counter dose rate meter similar to that mounted in the "A" stations. The mobile laboratories have their own power supply and a wireless connection to the environmental laboratory.

Preoperational measurements by the mobile laboratory have already been in progress for two years at the sites of the "A", "B" and "C"-type stations. After the start of the nuclear power plant's operation systematical monitoring is to take place at the "A" and "B" stations and in the environment of the expected maximum radioactive deposition.

Table I

The program of environmental sample measurements

Media	Measured samples	Sampling station	Sampling number	Sampling duration (days)	Sampling frequency (sample/year)	Measured components
Air	TLD	A + B + C	22	30	4	gamma doses
	aerosols	A + B	8	3.5	104	gross-beta conc.
			8	4×7	12	gross-gamma conc. + individual nuclides in certain samples
	radioiodine	A + B	8	7	52	^{131}I conc.
	fall-out	A + B	8	7	52	gross-gamma conc. + individual nuclides
	tacky cloth coll.	A + B + C	22	30	12	gross-gamma conc. + individual nuclides
Milk			5		12	^{131}I conc.
Plants	grass	A + B	8		2	individual nuclides conc.
Soil		A + B	8		1	individual nuclides conc.
Monitor well	ground water		5		12	gross-beta, tritium, individual nuclides in certain samples
Danube	water		1	1	365	gross-beta, tritium
	mud		4		2	individual nuclides
	fish		4		2	individual nuclides

In another paper a comparison of the results of in situ field dose rate measurements in the environment of the Paks Nuclear Power Station with values computed by use of the POKER-CAMP program is reported [6].

Accident assessing cross-country car

The cross-country car which can take samples will be equipped with recording gamma dose rate and beta surface contamination measuring instruments operated from a battery and with a "Pille"-type [7] small thermoluminescence reader operated from the car battery. The Pille-type reader will permit the thermoluminescent dosimeters on the spot to be rapidly evaluated without the contribution from the transport dose. Similarly to the mobile laboratory, the cross-country car has a wireless connection to the low background laboratory.

A substantial part of the environmental monitoring system installed at Paks Nuclear Power Station is already in operation and performs systematical preoperational measurements. The mounting of the telemetric and data acquisition system is still in progress.

REFERENCES

1. J. A. Martin, C. B. Nelson and P. A. Cuny, A Computer Code for Calculating Doses, Population Doses, and Ground Depositions due to Atmospheric Emissions of Radionuclides. Environmental Protection Agency Report EPA-520, 1974.

2. F. W. STALLMANN and F. B. K. KAM, ACRA—A Computer Program for the Estimation of Radiation Doses Caused by a Hypothetical Reactor Accident, Report, Oak Ridge National Laboratory, ORNL-TM-4082, 1973.
3. L. KOBLINGER, POKER-CAMP: A Program for Calculating Detector Responses and Phantom Organ Doses in Environmental Gamma Fields, Report, Central Research Institute for Physics, Budapest, KFKI-1981-79, 1981.
4. S. DEME, I. FEHÉR and M. RÖVID, Acta Phys. Hung., this issue, p. 381.
5. A. ANDRÁSI and P. ZOMBORI, Acta Phys. Hung., this issue, p. 389.
6. L. KOBLINGER, I. NÉMETH and P. ZOMBORI, Acta Phys. Hung., this issue, p. 397.
7. I. FEHÉR, S. DEME, B. SZABÓ, J. VÁGVÖLGYI, P. P. SZABÓ, A. CSŐKE and M. RÁNKY, Adv. Space Res., **1**, 61, 1981.