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# Integration of Polish Monitoring Networks (ASS-500 and PMS systems)

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**Abstract** The article contains a short description of the integrated on-line radiological monitoring system, which is part of the Aerosol Sampling Stations (ASS-500) and the Permanent Monitoring Stations (PMS) network in Poland. The integrated system has been designed by the Central Laboratory for Radiological Protection and was implemented in Poland in 2000. It allows prompt detection of the presence of artificial radionuclides in the ground-level atmosphere by means of continuous monitoring of the radioactivity collected on a filter.

**Key words** aerosol sampling station • ASS-500 early warning system • PMS • radiological monitoring network

## Introduction

The Central Laboratory for Radiological Protection (CLOR) in Warszawa operates the network of ASS-500 high volume aerosol sampling stations. The network consists of 10 stations situated in Warszawa, Krakow, Wroclaw, Sanok, Katowice, Bialystok, Szczecin, Gdynia, Lublin and Swider (see Fig. 1). The ASS-500 station in its basic version is used only for sampling of the aerosols suspended in air and is not applicable for operation in an alarm mode, where it is needed to automatically detect and inform that the level of artificial radionuclides in air is exceeded. Thus, there is no possibility to determine whether artificial radionuclides are present on a filter during the collection period, and whether any increase of dose rate is the result of artificial or natural radionuclides present in air. Therefore, the CLOR developed a method and instrumentation for the Early Warning System, which permits to selectively detect and measure the radionuclides of artificial origin in the varying natural background. A spectrometer AS-01 having a NaI(Tl) as radiation detector was chosen for the system.

To estimate the population exposure due to contamination of the environment with artificial radionuclides, it is desirable that the instrumentation of the early warning system, operating in a continuous mode, should be able to detect concentrations of about 10 Bq/m$^3$.

The CLOR also supervises the network of automatic Permanent Monitoring System (PMS) stations which are able to collect and store data from various sensors (dose rate from GM-tube, gamma spectra from NaI detector looking around the measurement cabinet, precipitation, outdoor temperature etc.). The stations are located in Warszawa, Krakow, Bialystok, Gdynia, Szczecin, Lublin, Sanok, Wroclaw, Olsztyn, Zielona Gora, Koszalin (two

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new sites in Lodz and Torun are planned for the year 2001). After discussions with the representatives from the Danish Emergency Management Agency (DEMA), and its subcontractors (Prolog Development Center and Greenwood Engineering) the technical and financial possibility to integrate PMS and ASS-500 Early Warning System was found. During the period of 1999 the integrated system was designed. It was tested by the CLOR in 2000 and is implemented in Poland.

## The description of the PMS system

The PMS stations continuously monitor radioactive contamination of the environment and store the collected data on a disk in the station computer. The parameters monitored are: background gamma radiation spectra measured by a 3"×3" NaI(Tl) scintillation detector and deconvoluted into four components: natural radium, natural thorium, natural $^{40}$K and the rest (artificial); background gamma dose rate measured by a Geiger-Müller counter; precipitation in mm/h; outdoor temperature; temperature at the NaI crystal and temperature inside a cabinet of electronics [1].

Data collected by the station computer are transmitted to the central system, which is located in the Dosimetry Department of CLOR in Warszawa. The central system consists of two computers: one controlling the transmission of data and the second having the MS SQL Server 7.0 database management software for the PMS and ASS-500 systems and, also, for ARGOS_NT and NUCINFO decision support systems. The main dial-up computer manages data transmission from the stations. After the detection of a radiation level exceeding a given threshold (set approximately 10% higher than background level) the station calls the central computer and forces immediate data transmission. At the same time the information about alarm is sent (as SMS) to the mobile phone of system operator. An audible alarm is generated on the central computer. In the normal situation, the station data are averaged hourly, but in the emergency state there is the possibility to switch to 10-min averages.

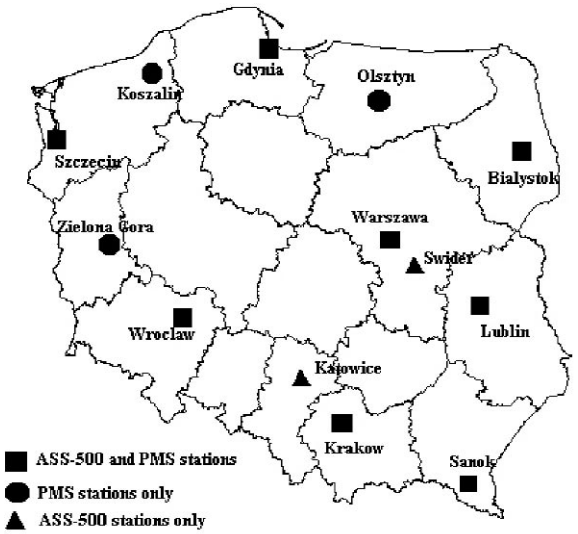


**Fig. 1.** PMS and ASS-500 stations in Poland.

## The description of an AS-01 spectrometer

At present all of the ASS-500 stations are equipped with AS-01 spectrometers. The AS-01 spectrometer consists of an NaI(Tl) detector placed over an ASS-500 station filter, spectrum memory and a microprocessor controller connected via an RS-422 interface to the station computer (currently PMS station computer).

The scintillation detector is equipped with a 2"×2" NaI(Tl) crystal. The detector contains an $^{241}$Am source pulverized directly on the crystal under its aluminum cover. The energy response of the detector for $\alpha$ particles of this isotope is above the energy range of natural and artificial $\gamma$-emitters. The position of the peak is continuously monitored and the necessary high voltage at the NaI(Tl) detector is adjusted. The resolution of the spectrometer for the energy of $^{137}$Cs photons (661.6 keV) is 8.5%.

The collected spectra are stored together with time and date of the last measurement, the optional GM-counter reading and the value of the air flow rate through the filter in the memory of the controller. The spectra and the accompanying results are transmitted to the station computer for storage, further analyses and visual presentation.

## The method of the measurement by AS-01 spectrometer

When artificial radionuclides present in air are deposited on the filter of the ASS-500 station, the shape of the measured pulse distribution changes. Some energy ranges are affected by a higher count rate. Proper selection of the range width enables the detection of artificial radionuclides in air by means of continuous measurements of the count rate and by checking the changes of the ratios between the selected seven energy ranges.

The energy ranges were chosen taking into account that the peaks of the artificial radionuclides are predominant in the range below 1.5 MeV, whereas the peaks of natural radionuclides cover the range between several keV and 3 MeV. The measurement of the count rate in particular ranges, as well as the analysis of the ratios of the count rates between the properly chosen pairs of ranges makes it possible to detect the presence of the artificial radionuclides in air [2].

The first, relatively narrow (40 to 150 keV), range is used to detect the presence of artificial radionuclides emitting photons of energies below 150 keV, e.g. $^{141}$Ce (145 keV) and $^{144}$Ce (133 keV), as well as for observation of the changes in $\gamma$ radiation intensity.

Two ranges (from 150 to 475 keV, and from 475 to 870 keV) contain the peaks for artificial radionuclides present in air after nuclear accident or nuclear explosion. The range between 150 and 475 keV is called an "iodine" range, and contains the $\gamma$ peaks of $^{131}$I (284 and 364 keV) and $^{132}$Te (228 keV). The range between 475 keV and 870 keV is called a "cesium" range. The $\gamma$ peaks of the following radionuclides are within this range: $^{137}$Cs (662 keV), $^{134}$Cs (605 keV and 796 keV), $^{103}$Ru (497 keV), $^{132}$I (668, 727 and 773 keV), and $^{133}$I (530 keV). The range between 870 and 2000 keV besides $\gamma$ peaks of natural radionuclides has the

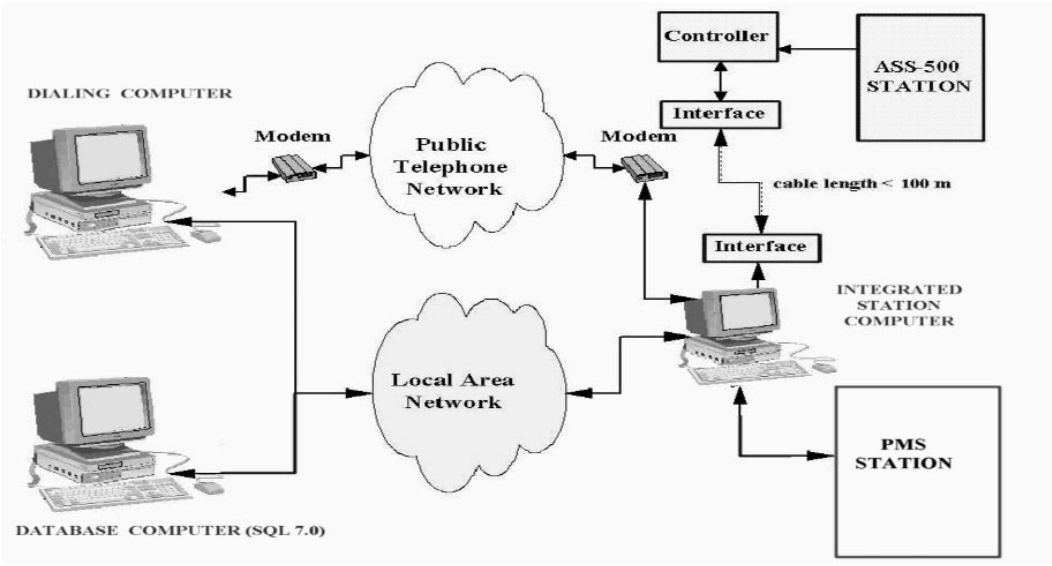


**Fig. 2.** PMS/ASS-500 System block diagram.

peaks of $^{60}$Co, $^{132}$I, $^{136}$Cs and $^{140}$La. The fifth energy range (2000–2700 keV) contains peaks of natural radionuclides, mainly those of $^{208}$Tl. This range does not contain important radionuclides of artificial origin. The changes in the ratios in the count rate in "iodine" and "cesium" ranges with this range, which, due to the fluctuations of natural radioisotope concentrations in air are small. This range was chosen to be the reference range.

The calibration of the AS-01 spectrometer for the artificial radionuclides collected on the ASS-500 station filter, was performed using flat surface sources of $^{133}$Ba (gamma peak close to $^{131}$I) and of $^{137}$Cs with activities of 3000 Bq and 1000 Bq, respectively. The reference solution was prepared by the Physikalisch-Technische Bundesanstalt (PTB) in Braunschweig (Germany) [3]. The area of the sources was equal to the area of the filter used in the ASS-500 station. The analysis of the changes in the count rate in "iodine" and "cesium" ranges, as well as the ratios of the count rates in these ranges to the reference range, enables the detection of 220 Bq of $^{133}$Ba and of 395 Bq of $^{137}$Cs, at the confidence level of 0.95. This corresponds to the lower limit of detection of 0.4 Bq/m$^3$ for $^{133}$Ba and 0.79 Bq/m$^3$ for $^{137}$Cs, for 500 m$^3$ air filtered during one hour. The tests were made for non-exposed filters, thus the real LLD should be somewhat higher than the given above. Some experiments to determine the real LLD are to be made in the year 2001 in PTB.

## Software developed for the Early Warning System

For most locations, the ASS-500 stations are situated next to the PMS stations. The exceptions are the stations in Katowice and Swider (aerosol sampling stations only). Originally, the AS-01 spectrometer was controlled by the separate PC running Windows 95 and the separate modem line was used to transmit the collected data to the dedicated database server located at the CLOR. The idea was to take advantage of one free serial port of the PMS station and the PMS Station computer to transmit data collected by the AS-01 spectrometer. This would save one PC, modem and phone line, and make available the transmission of the results for both systems at once. The flowchart of the integrated system is shown in Fig. 2.

The integration took place with the substantial help of the Danish Emergency Management Agency (DEMA) and Prolog Development Center (PDC).

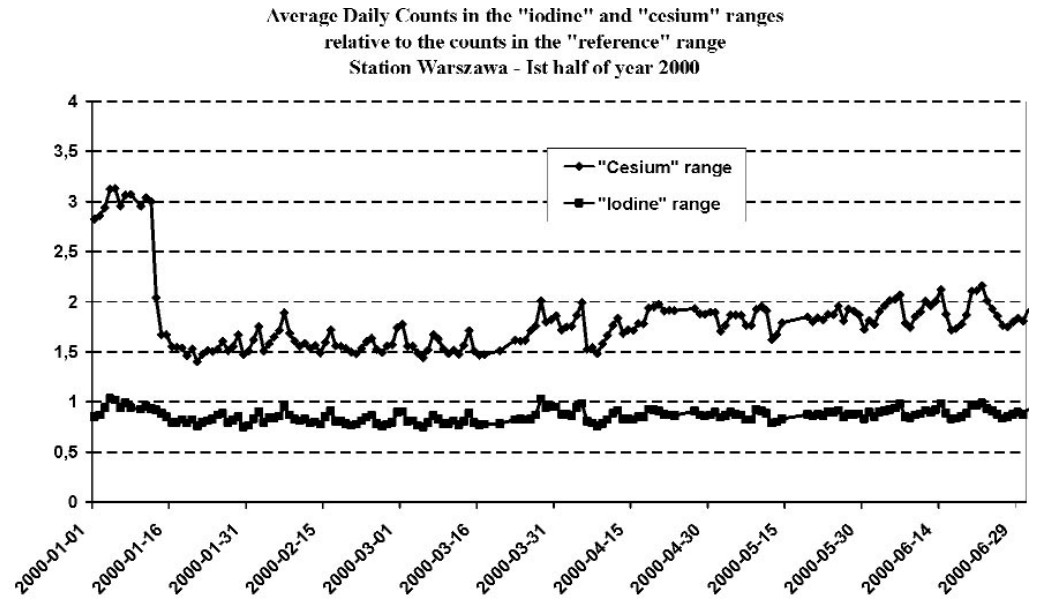


**Fig. 3.** Sample data from ASS-500 on-line system for station Warszawa (Ist half of 2000).

The problems solved are:
- recompilation of the old ASS-500 station software running originally under Windows 95 for Windows NT 3.51/4.0 operational systems;
- change of the format of the files for ASS-500 system to the format understandable by the PMS server software;
- integration of the server software for PMS and ASS-500 systems for obtaining common graphical user interface;
- design of the AIRPMS database at the CLOR for ASS-500 data.

By September 2000 the integration took place on the stations in Warszawa, Krakow, Lublin, Bialystok, Wroclaw, Gdynia, Szczecin and Sanok. The rest of the stations would be included in the system by the end of 2000.

## Conclusions

Before the integration the PMS and ASS-500 systems worked separately, which generated costs, and the data form both systems were not coherent. The integration of both systems unified the storage of the collected data, upgraded the ASS-500 network into the Early Warning System and allowed to observe the ratios between the various data (e.g. precipitation *vs.* dose rate, etc.).

The results obtained (sample data from the station in Warszawa are shown in Fig. 3) have proven that the installation of the AS-01 spectrometer in the ASS-500 station does not limit its collecting efficiency. No alarm situation was detected during the period of operation. After the collection period, the filters routinely undergo quantitative analyses for the concentration of natural and artificial radionuclides by means of HPGe detectors (lower limit of detection is below 1 $\mu Bq/m^3$ for weekly collected samples).

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