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Radiological Emergency Monitoring Systems in the Nordic and Baltic Sea Countries

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Abstract

This report describes the national systems for emergency monitoring of radioactivity in the five Nordic countries, Denmark, Finland, Iceland, Norway and Sweden as well as in the six Baltic Sea countries, Estonia, Germany, Latvia, Lithuania, Poland and the Russian Federation. Similarities and differences regarding strategy and equipment are shown briefly. The main feature for early warning is the national network of automatic gamma monitoring stations. This network is supplemented by manual stations and/or survey teams, often measuring at predetermined locations. Air filter stations are used for nuclide analyses of particles and gases. Dose rate maps and fallout maps of ground deposited nuclides, e.g., cesium-137, are produced based on data from airborne measurements, monitoring stations, survey teams and environmental samples. Most countries describe programs for checking food contamination. Whole body counting and organ measurements are used to determine internal contamination. External contamination of people, vehicles, goods etc is checked with survey meters and other equipment at checkpoints or as needed. Field measurements of various kinds complete the national systems. Possible future development and planned improvement are discussed. This report is an extension and update of a previous NKS report covering the Nordic countries.

Key words

Contamination; Denmark; Early warning; Emergency plans; Environmental materials; Estonia; Fallout; Federal Republic of Germany; Finland; Iceland; International cooperation; Latvia; Lithuania; Norway; Poland; Radiation monitoring; Radiation monitors; Russian Federation; Sweden

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Radiological Emergency Monitoring Systems in the Nordic and Baltic Sea Countries

Joint report from the Reference Group for the Baltic Sea States on Emergency Monitoring Integrated Systems and Early Warning, Working Group A, and the Nordic Nuclear Safety Research (NKS), project BOK-1.5

Edited by

Lennart Devell, Swedish Radiation Protection Institute
Bent Lauritzen, Risø National Laboratory, Denmark

Preface

Within the Nordic Nuclear Safety Research (NKS) program 1990-1993, a project, BER-2, was carried out describing the methods and equipment used in the Nordic countries for measuring fallout radionuclides. The survey thus covered Denmark, Finland, Iceland, Norway and Sweden. The final project report, "Monitoring Artificial Radioactivity in the Nordic Countries", issued in 1995 (TemaNord 1995:559) included a description of methods for radiological data exchange between the Nordic countries, and methods for on-line airborne measurements.

In 1997, the Reference Group for the Baltic Sea States on Emergency Monitoring Integrated System and Early Warning (the Reference Group) decided to update and extend the survey also to include the Baltic Sea countries: Estonia, Germany, Latvia, Lithuania, Poland, and the Russian Federation. A Working Group A within the Reference Group was established for this purpose. With this report the Working Group A has fulfilled its task.

The present report takes its origin in the BER-2 report, and is a joint undertaking of the Reference Group, Working Group A, and the NKS, project BOK-1.5. The chairman of the Working Group A is B. Åke Persson, Swedish Radiation Protection Institute. BOK-1.5 is a subproject of the BOK-1 project, Nuclear Emergency Preparedness. The project leader for BOK-1 is Bent Lauritzen, Risø National Laboratory.

The aims of issuing this report are to

- account for the radiological emergency monitoring systems presently applied in the Nordic and Baltic Sea countries
- describe the methods employed in emergency monitoring and the characteristics of the monitoring equipment
- describe future developments in emergency monitoring in the countries
- facilitate cooperation on radiological emergency monitoring within the region, hereunder the exchange of radiological data between the countries
- create a common basis for harmonization and improvements

The structure of the report is similar to that of the BER-2 report, with separate sections covering each country. The information on each country has been provided by the country itself through its Working Group A member(s), but is presented in a common, edited form.

Acknowledgements

The compilation of the description of emergency monitoring systems in the Nordic and Baltic Sea countries is jointly sponsored project between Nordic Nuclear Safety Research (NKS), the Reference Group for the Baltic Sea States on Emergency Monitoring Integrated Systems and Early Warning, and the Swedish Radiation Protection Institute / International Development Cooperation Program (SSI/SIUS).

Contributions concerning emergency radiation monitoring systems from all eleven Nordic and Baltic Sea countries are presented in the report and all authors and other contributors are hereby warmly thanked for their efforts and support in preparing informative descriptions of the systems in their countries which have made this compilation possible. The document Monitoring Artificial Radioactivity in the Nordic Counties, prepared for NKS by Torkel

Bennerstedt, TeknoTelje with contributions from Hannu Rantanen, VTKK and Bjarne M. Mortensen, Infocom, constituted the first and basic source of information as well as the format of presentation. Updates and contributions from other countries have been provided by Kim Bargholtz (Denmark), Raivo Rajamäe (Estonia), Juhani Lahtinen (Finland), Matthias Zähringer (Germany), Sigurður Emil Pálsson (Iceland), Vija Bute (Latvia), Stasys Motiejunas assisted by Linas Morkeliunas, Albinas Mastauskas and Gendrutis Morkunas (Lithuania), Finn Ugletveit (Norway), Andrzej Merta (Poland), Valery Chelyukanov and Vyacheslav Shershakov (Russian Federation), and Kjell Nyholm (Sweden).

Valuable comments and suggestions from B. Åke Persson, SSI and other members of the Reference Group and the Working Group A are thankfully acknowledged, and the editors are indebted to Torkel Bennerstedt for his careful examination and criticism of the manuscript.

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1 Summary

Radiological emergency monitoring systems comprise systems intended for early warning about unexpected increases in the background radiation levels, and systems for mapping radioactivity in the environment, resulting from radiological accidents domestically or abroad. The Nordic and Baltic Sea countries all possess automatic early warning systems and most countries have established strategies, equipment and routines to map the national territory after fallout of radioactive material. National programs also exist for determining contamination levels of food, environmental samples, vehicles, goods etc., as well as any external or internal contamination of people.

The major radiological threats arise from nuclear power plant inside or outside the country in question, while nuclear research reactors, nuclear powered naval vessels, and the general use of radioactive materials constitute other radiological threats. The situation in this respect is not identical for the countries covered in the region.

The national strategies and their practical applications regarding the various types of measurements often coincide or turn out to be equivalent or very similar; however, in certain cases there are important differences. Some of these differences are easy to explain or justify, due to radiological differences (such as variation in normal background radiation levels or radon concentrations) and different nuclear threat pictures. Others, however, reflect differences in national organizations, available equipment, experience or historic development of procedures and equipment.

Automatic gamma monitoring stations form the most important part of the national early warning system. They constitute a fast, sensitive and reliable method for total gamma measurements. The stations monitor the total gamma radiation level on the ground, and may also detect a passing radioactive cloud, thus providing early warning as well as radiation data both under normal circumstances and in the acute phase and later stages of emergency situations. All countries possess automatic gamma monitoring networks. However, the number of stations varies greatly between the countries (see Table 1), with Finland, Germany and the Russian Federation having large numbers of stations. The national automatic gamma monitoring networks are described with respect to the type(s) of detector(s) used, dynamic range, polling periods, radon compensation, and alarm criteria. In some cases, semi-automatic or manual stations supplement the automatic networks.

High-resolution measurements of airborne activity using air filter stations are made in all countries. High volume sampling stations, with or without on-line detectors, can detect trace amounts of activity and allow for radionuclide specific analysis of sampled aerosols. As in the case of gamma stations the number of filter stations varies from country to country. The national programs include combinations of stationary and mobile units; low, high and ultra high volume air samplers; equipment for measuring aerosols and/or gaseous iodine, xenon, etc.

Most countries have programs or plans for survey teams and local measurements at predetermined points to get fast and detailed information on local dose rates. Several countries have a program for airborne fallout mapping. Mobile gamma monitoring stations and/or air filter stations are used or planned to supplement the stationary network.

Field measurements of the following types can be made in areas of special interest in most countries: Gamma spectrometry, total gamma measurements, gamma analysis of air filters, alpha and/or beta measurements. In addition, extensive programs exist for field and/or laboratory analysis of environmental and food samples.

External contamination checks (gamma, beta/gamma, or alpha) of people, vehicles, buildings etc. may be performed whenever needed. Ordinary survey meters are used in most instances; more sophisticated equipment, however, is available, should the need arise.

Whole body counters for making nuclide-specific measurements of internal contamination levels are available in several countries. In many countries, some hospitals and other institutions are equipped and staffed to detect and assess internal contamination by means of organ measurements or analysis of urine samples. In Table 1, the available radiometric equipment and systems in the Nordic and Baltic Sea countries are summarized.

The development of radiological emergency monitoring systems in the region has been advanced by bilateral and international cooperation. Future development to a large extent depends on continued international cooperation, especially for promoting exchange of monitoring data and the development of comprehensive decision support systems.

Table 1. *Available radiometric equipment and systems in the Nordic and Baltic Sea Countries.*

Available radiometric equipment and systems in the Nordic and Baltic Sea Countries.											
	Denmark	Estonia	Finland	Germany	Iceland	Latvia	Lithuania	Norway	Poland	Russ. Fed.	Sweden
Gamma monitoring; automatic	11	11	298	2150	1	16	14	22	20	152	37
Gamma monitoring; manual or semiautomatic	0	3	150		0 [c)]	0	74	no	36	1255	
Survey teams	yes	yes	yes	yes	yes [d)]	yes	yes	yes	yes	yes	yes
Aerosol sampling stations	1 [a)]	3	31	5 [b)]	1	3	1	7	19	40	5
Aerosol on-line monitoring	0	1	15	51	0	yes	1	0	8	0	0
Airborne measurements; mapping	yes	no	yes	yes	no	no	no	yes	yes	yes	yes
Airborne measurements; sampling	no	no	yes	yes	no	no	no	yes	yes	yes	no
Environmental sampling	yes		yes	yes	yes	yes		yes	yes	yes	yes
Food sampling	yes		yes	yes	yes	yes		yes	yes	yes	yes
Field gamma spectrometry	yes	yes	yes	yes	no	yes		yes	yes	yes	yes
Contamination checks of cars, goods	yes		yes	yes	yes	yes		yes	yes	yes	yes
Whole body counters	yes	no	yes	yes	no	no	no	yes	yes	yes	yes

a) 1 on standby
b) High-volume samplers
c) 2 stations planned
d) Organized as needed

2 Background and introduction

When a nuclear accident has occurred and radioactive fallout is expected or has already taken place, authorities both in the country of origin and in neighboring countries need fast and reliable information on the accident and its consequences. Information on the location and characteristics of the fallout is required to assess the radiological impact of the accident and to facilitate an adequate response to the accident. To this purpose, an emergency monitoring system with established strategies, equipment and routines must be in place.

The threats from nuclear accidents differ in the various countries of the region. The most serious nuclear threat with cross-border implications is the presence of nuclear reactors of various kinds. Some countries in the region, Finland, Germany, Lithuania, the Russian Federation and Sweden, have nuclear power plants, and several countries in the region possess smaller research reactors. Other nuclear threats arise from nuclear powered naval vessels or submarines, and from nuclear powered satellites. Production, transportation, use, and disposal of radioactive materials constitute potential local nuclear hazards. Finally, an intentionally harmful use of radioactive material may pose a nuclear threat to all countries.

A national system for radiological emergency monitoring should be devised to deal with all of, or at least with the more serious of such nuclear threats. However, differences are observed within the region, in part reflecting differences in conceived nuclear threats, e.g., type of nuclear hazards and distance to these, but also in emergency response organizations, available equipment, experience and historic development. Expectations to information received from other countries may also play a role when monitoring for accidents abroad. The national systems are under constant development and most countries cooperate internationally, e.g., within the European Union research programs. Several countries plan to implement the RODOS or ARGOS decision support systems.

In general, radiological emergency monitoring serves two purposes, to warn of any unexpected increase in radiation level, and to provide an overview of the radiation and contamination levels. While the first part may signal that a nuclear or radiological accident has occurred, the second part is needed to provide data or normal background levels before an accident and to assess the environmental impact after an accident. Also, long time series of radiological monitoring will provide a basis for understanding transport processes in the environment and help improve dose assessments through radioecological modeling.

Automatic gamma monitoring stations form the most important part of the national early warning systems. They provide on-line information and constitute a fast, sensitive and reliable method for total gamma measurements. Under normal circumstances the stations monitor gamma radiation levels on the ground, but may also detect a passing radioactive cloud, thus providing early warning. Generally speaking, the smaller the number of stations per unit area, the more important their location, in order to create an optimal coverage of the national territory.

Air filter stations provide another means for early warning. Air is continuously drawn through a filter for a predetermined period, after which the filter is sent to a laboratory for nuclide specific analysis of the sampled aerosols. Some filter systems are provided with on-line detectors, which can be used in the early warning system. Some filter systems are high volume sampling and are therefore very sensitive and can measure traces of enhanced activity.

As part of the nuclear emergency preparedness systems in the region, equipment and facilities exist for external contamination checks (gamma, beta/gamma, or alpha) of people, vehicles, buildings, etc., using ordinary survey meters or more sophisticated equipment. Whole body counters for making individual, nuclide specific measurements of internal contamination levels are available in several countries. In many countries, some hospitals and other institutions are equipped and staffed to detect and assess internal contamination by means of organ measurements or analysis of excretion samples.

To assess the long-term effects of radioactive contaminants, the monitoring systems include measurements of air, ground, water, and foodstuff contamination levels. There are also national programs for determining contamination levels of environmental samples, vehicles, goods etc., as well as any external or internal contamination of people. Following fallout of radioactive material airborne and car-borne gamma/ray surveys will allow for a mapping of dose rate levels and concentrations of ground deposited radionuclides, such as ^{137}Cs. The nuclide composition of the fallout can be determined from high-resolution gamma spectrometry and alpha/beta-measurements on environmental samples and air filters.

The organizations involved in radiological monitoring comprise governmental agencies, regulatory bodies, universities, research laboratories, hospitals, military and civil defense units, police and local communities.

In this report, the radiological emergency monitoring systems of the Nordic and Baltic Sea countries are described. For each country, the national background is presented, including legal basis and the organizations involved. The radiological monitoring systems are described, with an account of methods and equipment used. Future development and plans for improvement are discussed when relevant.

Radiation data and other relevant information can be exchanged fairly easily between the countries, when and as agreed by the involved parties. Within the European Union Radioactivity Data Exchange Platform (EURDEP) cooperation, monitoring data are exchanged by use of e-mail via the Joint Research Center Ispra in Italy. Under the Council of Baltic Sea States (CBSS), an agreement has been made on exchange of monitoring data, by which readings of gamma radiation levels from other countries may be accessed by the use of ftp. The CBSS agreement has not yet been ratified, however. Nordic and Baltic Sea countries participating in the two systems of data exchange are listed in Table 2.

Table 2. *National participation in regional systems for exchange of monitoring data.*

Country	**EURDEP**	**CBSS**
Denmark	x	x
Finland	x	x
Estonia		x
Germany	x	x
Iceland		x
Latvia		x
Lithuania		x
Norway	x	x
Poland	x	x
Russian Federation	x	x
Sweden	x	x

3 Denmark

3.1 National background

The Danish Emergency Management Agency (DEMA) is responsible for emergency planning and organization aiming at monitoring the radiological situation, alerting the relevant organization in the event of an emergency and taking other measures necessary to minimize doses and other risks to the population. DEMA has the operative command of the emergency preparedness organization, and acts as coordinator vis-à-vis other participating organizations.

The basic domestic nuclear threats are represented by three closed research reactors at Risø (Feb. 2001) and the waste management program. The external threats are mainly due to nuclear power reactors.

3.1.1 Organizational structure

Ministry of the Interior – Danish Emergency Management Agency (Beredskabsstyrelsen)

The Danish Emergency Management Agency is responsible for solving the tasks stated in the Danish Preparedness Act. In addition to this the Danish Emergency Management Agency solves tasks as a consequence of the Safety and Environmental Protection (Nuclear Installations etc.) Act, the Shelters Act and the regulations for the Hospital Preparedness.

Ministry of Health – National Institute of Radiation Hygiene (Statens Institut for Strålehygiejne, SIS)

The National Institute of Radiation Hygiene is the radiation protection authority in Denmark. The main tasks of the institute are control and inspection of radioactive sources and X-ray installations, dose measurements, emergency preparedness planning, education and information.

Ministry of Research and Information Technology – Risø National Laboratory

Risø National Laboratory undertakes research in the fields of natural science and technology, in order to provide Danish society with new opportunities for technological development. Risø has a special responsibility for consolidating the Danish knowledge base for consultation on nuclear matters.

3.2 Automatic gamma monitoring networks

In Denmark a nationwide automatic gamma-monitoring system for early warning was developed and installed after the Chernobyl accident. The Danish Emergency Management Agency (DEMA) is the owner of the system and Risø National Laboratory is the operator of the system. The network consists of 11 stations distributed evenly over the country (Fig. DK-1).

The stations are designed to

- firstly, measure the current dose rate
- secondly, differentiate between 'man-made' causes of increased readings on the one hand and increased radon concentrations and other natural causes of variations in the background level on the other

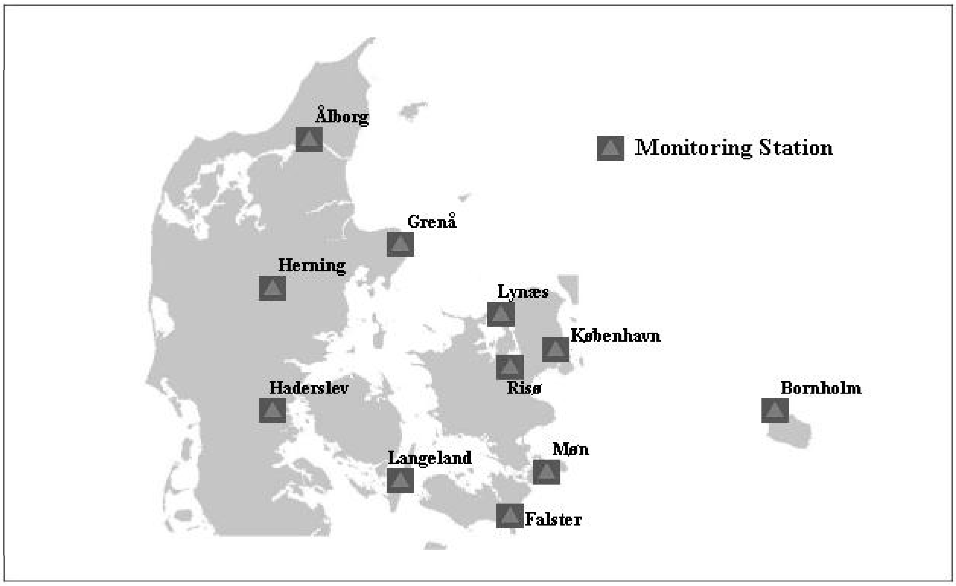


Fig. DK-1. *The 11 automatic gamma-monitoring stations in Denmark.*

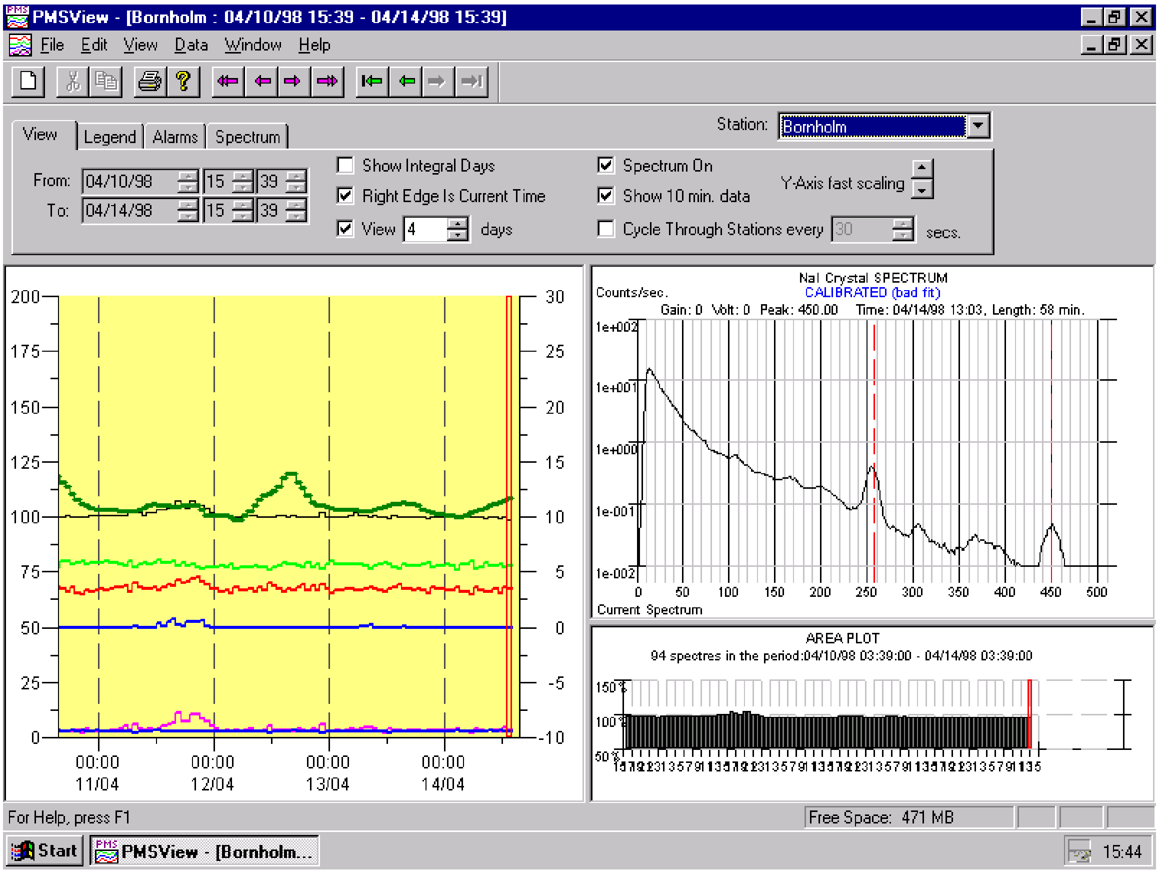


Fig. DK-2. *Viewing the data on the server.*

The specially designed microcomputer at the stations continuously stores the data until the servers at Risø or DEMA call the stations for collecting the data (a check is performed to ensure that the servers have collected the same data).

The servers (with Windows NT) collecting the data also perform the data processing. By using the least squares fit of standard gamma-ray spectra the measured gamma spectra are divided into the contribution from normal background, a contribution from radon and a contribution from the remaining, each contribution given as dose rate. The results are plotted on the screen as shown in Fig. DK-2.

At Risø and DEMA the monitoring stations are supervised around the clock by the health physicist or officer on duty. All supervising personnel have access to the measured data at all time from a portable PC, which can be connected to the servers at DEMA and Risø for viewing the data. If necessary, health physicists at SIS can be consulted.

3.2.1 System specifications

In Fig. DK-3 a sketch of the stations is seen. The system consist of a NaI(Tl) scintillation detector with spectrometer, an Reuter-Stokes ionization chamber RSS-1012 (measuring range 0.01 mSv – 0.1 Sv), and a microcomputer. In addition, a rain gauge (the rain gauge registers each 0.1 mm of precipitation) and a thermometer are placed at each station. Inside the hut containing the equipment climate control is placed.

3.2.2 Software

The central servers used to collect data from the stations are Windows NT servers. The software used on the servers is similar to the software running on the PMS (Permanent Monitoring Station) servers installed in the Baltic countries, Poland and Russia (the PMS systems in these countries are sponsored by the Danish Emergency Management Agency). A screen dump of the software used for viewing the data on the server is seen in Fig. DK-2.

On the 11 monitoring stations specially made software for the microprocessor is running.

3.2.3 Alarm levels

An alarm occurs when the system registers a dose rate higher than predefined thresholds specific for each station. Dose rate thresholds have been defined for

- Normal Background
- Radon in equilibrium
- Radon in disequilibrium
- Remaining
- Readings from the ionization chamber

3.3 Manual gamma monitoring stations

In Denmark no manual gamma monitoring stations are present.

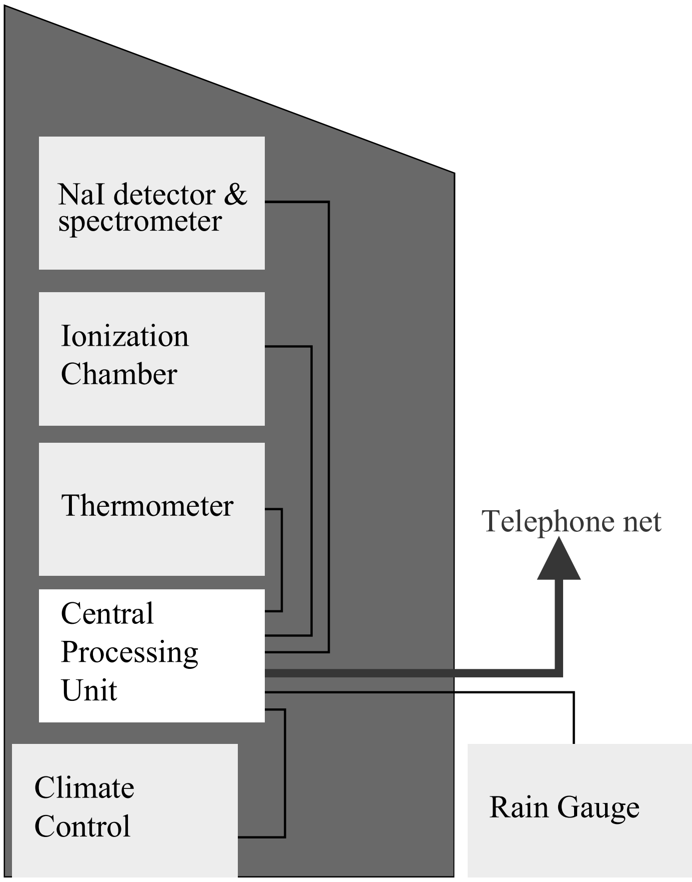


Fig. DK-3. *The Danish Monitoring Station.*

3.4 Air monitoring stations

Continuous measurements of airborne activity are performed at Risø using a high-volume sampler with a capacity of 0.3 m^3/s per m^2 filter. The filter is changed weekly under normal conditions or as often as required. The Risø station also measures gaseous iodine, noble gases and precipitation.

A similar station is situated on the island of Bornholm (the easternmost part of Denmark). In the event of an emergency or when otherwise called for, the air filter station on Bornholm can be started at short notice (within a couple of hours). The station is placed in barracks belonging to the Danish Emergency Center. The filters are brought to Risø for measurements with high-resolution detectors.

Specifications:

Filters: 6 glass fiber filters
Filter size: 56 cm × 48 cm
Flow rate: 300 m^3/h per filter
Detection limit: < 1.5 $\mu Bq/m^3$ (for Cs-137 weekly sampling)
Filter change rate: Once per week

3.5 Airborne measurements

3.5.1 Measurements around the plume

In the event of an accident at one of the Swedish nuclear power plants at Barsebäck and Ringhals, Air Force rescue helicopters can be alerted at short notice (15 minutes) to fly toward and around the nuclear power plants in search of airborne radioactive material. In the event of an accident at one of the German nuclear power plants flight schedules will be planned depending on the weather conditions (wind toward Denmark). A total of three helicopters are always available for rescue operations at sea, but in the event of a nuclear emergency radiation monitoring missions have top priority.

The helicopters are alerted when a General Alert is declared at Barsebäck or Ringhals. They are under command of the Rescue Coordination Center in Jutland, and they report currently on VHF radio to DEMA's Command Center and to their base.

3.5.2 Aerial gamma surveys

After a passage of a plume and if radioactive material has been deposited on the ground airborne gamma ray surveys are performed with the aim of mapping the total external dose rate to the population caused by the deposition. At an early stage after the passage it is most likely only possible to map the total dose rate (using large volume NaI(Tl)-detectors). In some cases a few dominant isotopes may be identified (e.g., ^{131}I). After a few days it will be possible to assess dose contributions from specific deposited nuclides on the ground.

The detection limit of the system is verified to be 2-5 kBq/m^2 Cs-137 equal to the amount of deposited Cs-137 in Denmark after the Chernobyl accident. However, if the deposition is a mixture of several gamma-emitting nuclides it is almost impossible to distinguish between the different nuclides, thus reducing the detection limit for specific nuclides.

The Danish Emergency Management Agency is the owner of two airborne gamma-ray detector systems. The detectors used are arrays of four 4 l NaI(Tl) crystals (a total of 16 l). The detectors are installed in Fennec Helicopters operated by the Danish Army. Special mounting equipment has been developed for easy mounting. A total number of 12 Fennec helicopters are available (the helicopters are identical, i.e., it is possible to mount the equipment in all helicopters). Using a survey altitude of 300 feet and a survey speed of 100-150 km/h, the sampling time is 1s.

The Danish Emergency Management Agency in cooperation with the Technical University of Denmark (Department of Automation) operates the airborne systems.

Specifications:

16 l NaI(Tl)-detector GPX-1024 (Exploranium)
Multichannel analyzer GR-820 (Exploranium)
GPS and DGPS
Navigation indicator with variable sensitivity
Radar altimeter
Standard Pentium 233 MHz PC

3.6 Foodstuffs and environmental samples

The sampling process is planned and carried out by the central emergency organization in cooperation with the National Food Agency. Measurements are made by Risø and SIS. In addition to its own facilities SIS has contracted eleven laboratories at universities, hospitals etc. to analyze environmental and food samples, using mainly germanium detectors but also NaI(Tl) detectors in the event of an emergency.

3.7 Survey teams

The six Emergency Center units (three in Jutland, two on Zealand and one on Bornholm) can at short notice (15 minutes) alert a total of 39 survey teams to monitor along selected roads. The teams are equipped with handheld gamma dose rate meters, maps showing measuring points, radio equipment and dosimeters.

The M/87 dose rate meters are Geiger Müller tubes with a detection range of 0.05 μSv/h to 10 Sv/h (gamma energy range 50 keV – 3 MeV; beta energy > 250 keV). The teams have precise instructions how to measure the dose rate in order to have comparable measurements throughout the country. The teams report to the Emergency Center units over the radio for each 3-4 measurements and the reports are relayed to DEMA's command center (EMACC) by fax or datalink.

A total of 1600 measuring points covering about 5000 km of Danish roads are marked on the maps.

In emergency situations measuring teams are available in a number of the bigger communities. They report through the nearest Emergency Center barracks, and the data are transferred to the EMACC. The teams measure at different locations depending on the accident situation. The measurements are controlled by the EMACC. The teams use the M/87 dose rate meter and other equipment.

Police stations in North Zealand (a total number of 12 stations) are equipped with gamma dose rate meters. The stations are instructed to read their instruments in the event of a Barsebäck accident. They report to the EMACC on the telephone.

SIS may deploy one or two survey teams. Their cars will be equipped with standard survey meters, including a portable plastic scintillation instrument (calibrated for dose rate measurements).

Risø can muster ten special car patrols. They measure gamma dose rates 1 m above ground (using a shield, first under and then over the detector to determine whether the plume has passed). Soil and vegetation samples are collected on demand. Air concentrations of nuclides can be roughly estimated by means of a mobile air sampler.

DEMA is the owner of a mobile gamma spectrometer system consisting of a 4 l NaI(Tl)-detector with a 512 channel analyzer. The system measures spectra with a sampling time of 1-2 seconds and uses differential GPS (DGPS) for the precise determination of the position for each measurement. The mobile unit is also equipped with a small handheld 3" Na(Tl) detector.

3.8 Contamination measurements

3.8.1 Internal contamination

The University Hospital and Risø operate whole body counters. The University Hospital uses a scanning NaI(Tl) detector, whereas Risø uses a germanium detector for chair geometry measurements. Staff and equipment for organ measurements are available at ten hospital institutions around the country.

NaI(Tl) and germanium detectors are available at SIS, Risø and ten hospitals for evaluating samples of body fluids, urine, excreta etc. In addition DEMA has equipped each of the ten hospital departments with an alpha monitor. Other types of equipment normally found at nuclear medicine and similar departments will also be used when needed.

3.8.2 External contamination

Checks for external beta and gamma emitting contamination may be performed by DEMA, SIS, defense forces and others, using most types of modern portable equipment. The ten hospital institutions capable of performing internal contamination measurements are also equipped to allow checks for external contamination, including alpha emitters.

In the event of contamination outside Danish territory, checkpoints manned by emergency monitoring teams can be established at border stations, ferry harbors etc. to measure contamination of vehicles, trains and deck cargo.

3.9 Other types of measurements

The Danish Navy Command (SOK) has at its disposal ships equipped with a gamma monitoring system. It consists of two detectors located in the open air and four inside the ship. All detectors are monitored from a central unit with a digital display, giving dose rate readings in Gy/h. The location of the ship and radiation data are continuously reported to SOK.

Water samples may be collected from the ships and sent to SIS for analysis.

3.10 Future development

An HP Portable germanium detector is planned to be included in the car-borne/airborne equipment.

4 Estonia

4.1 National background

The Estonian environmental radiation monitoring system is designed to detect releases from foreign sources. Large-scale releases from the most important potential domestic source, Paldiski nuclear waste facility, is estimated to be improbable. However, other potential domestic radiological hazards are represented by the waste depositories in Tammiku and Sillamäe, together with lost radiation sources.

Due to the small area of the Estonian territory the main strategy for establishing a national monitoring network is to install modern automatic stations in the border areas and first of all in such sites which will potentially be exposed to releases from nuclear reactors in neighbor countries. To obtain necessary radiological information for the whole country in a case of real radioactive fallout a number of automatic stations are installed in the interior parts of the country and manual permanently working network consisting of three stations has been established. These two networks have gathered a lot of information about the background level of total gamma radiation for the country.

Additionally, airborne activity is monitored in larger Estonian towns to provide valuable information for decision-makers about the concentration of radioactive gases and particles in the atmosphere. Operational surveys of surface contamination after a radioactive plume has passed is planned to be carried out by means of a mobile unit.

4.1.1 Organizational background

According to the Estonian Radiation Act, the main responsibility for organizing radioactivity monitoring and alerting other organizations in case of an radiological emergency is held by the Estonian Radiation Protection Center (ERPC), a subordinate organization in the Ministry of Environment. The Estonian Meteorological and Hydrological Institute (EMHI) is responsible for technical service of the monitoring networks and for providing meteorological information for assessment of the situation in the event of early warning alert. Responsibility for emergency planning, for decision-making of countermeasures and for providing information to the public in an emergency is held by the Estonian Rescue Board, an organization subordinate to the Ministry of the Interior.

4.1.2 Legal basis

The structure and organizational responsibility scheme are based on the following legal acts,

- Estonian Radiation Act
- Citizen Protection Act
- Extraordinary Situation Act
- Rescue Act
- Convention of Early Notification in a Nuclear Accident
- Baltic Sea States Arrangements on Regular Exchange of Radiation Monitoring Data and other Information of Radiological Significance

4.2 Automatic gamma monitoring networks

The automatic network in Estonia consists of two independent sub-networks which are serviced by their own server using specific software but the information from all stations is also processed by a central software in the main information server. All radiological information is stored in the common PMS database. Radiological data are transferred through public telephone networks, at normal monitoring once per day, to the dialing servers in the ERPC. The locations of both types of measurement stations are presented in Fig. EE-1.

The older sub-network is the area radiation monitoring system AAM-95 that includes four automatic local stations. The local stations of this system are able to measure the total environmental gamma dose rate and send the data to the server situated in the ERPC. After detecting a value above the pre-set alarm level, the stations send an alarm message to the same server.

The newer part of the countrywide network consists of seven PMS stations. These are fully automatic stations of a new generation, which measure the total gamma dose rate as well as gamma spectra. The latter feature makes it possible to discriminate between an increase in the dose rate caused by natural activity and by contamination by artificial radionuclides. The stations analyze the dose rates from five different sets of isotopes for which independent alarm levels are preset, providing early warning even in the case of very low levels of atmospheric contamination. Like the AAM-95 system, the PMS stations are able to generate an alarm message at increased dose rate level and send it to ERPC.

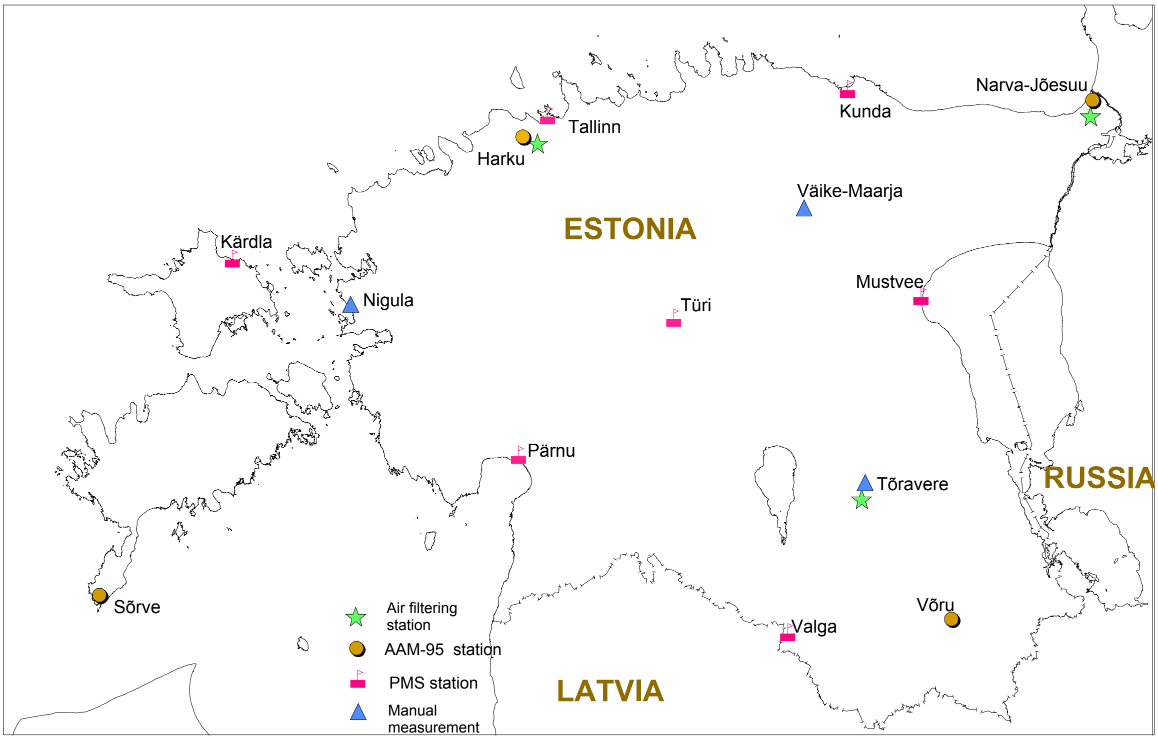


Fig. EE-1. *Locations of gamma dose rate measurement stations and air filtering stations in Estonia.*

The alarm messages are stored in the main dialing server and will be distributed through the Internet service to GSM phones and local area computer networks to call for duty specialists around the clock. Measurement integration time and interval lengths for data sampling are separately adjustable for each station from the ERPC. The real radiological data measured are used for modeling and prognoses of dispersion of the radioactive plume using special ARGOS software.

4.2.1 Automatic gamma monitoring network AAM-95

General description

The system is designed for general area radiation monitoring purposes containing local automatic stations, which are connected to the main server via the public telephone network. The local automatic station consists of a RADOS type GM tube detector, portable radiometer type RD-02 and a connection box with modem (Fig. EE-2). Due to security problems all stations are installed in meteorological monitoring stations and detectors are arranged on the roofs about 3-6 meters above the ground. All data measured are displayed on the RD-02 and the latest 864 dose rate values are stored in the device memory. The local station automatically sends an alarm message. The system software installed in the main server sends questions to the stations, stores original measurement data for one year, enables graphical presentation of data and calculates accumulated doses.

Alarm settings

Though it is possible to set eight different dose rate alarm levels in routine monitoring in normal situations only one level is set. It has the value 0.3 µSv/h for all stations, which is about three times higher than the mean natural background level. This relatively high value is set to prevent fault alarms due to abrupt changes of radon concentration in the lower atmosphere.

Another alarm criterion is defined for the difference in the gamma dose accumulated during the last 24 hours and the previous day. The alarm value is set to 1 µSv for all stations.

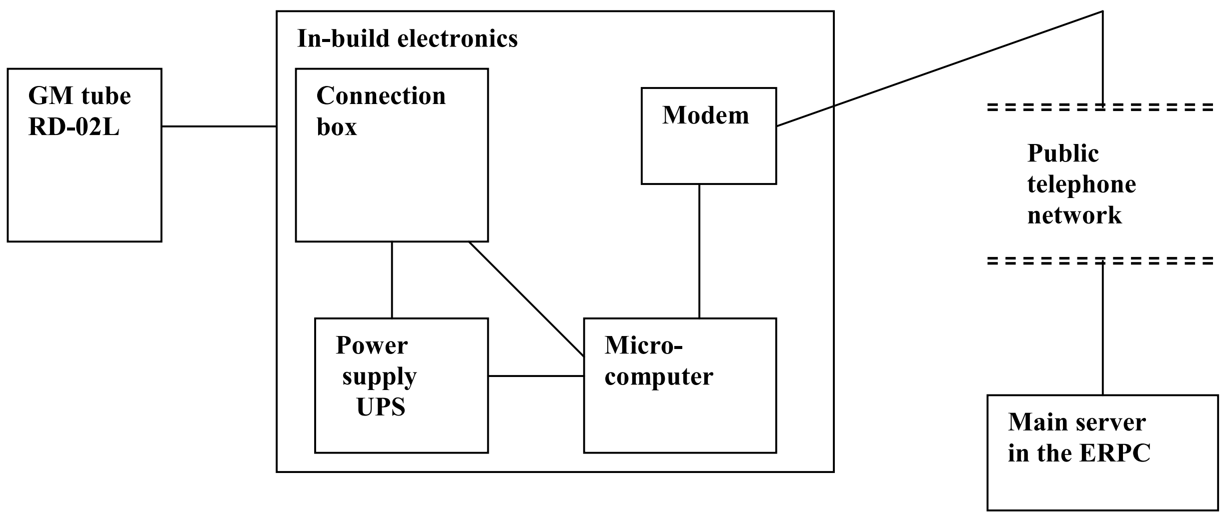


Fig. EE-2. *Block diagram of automatic area monitoring system AAM-95.*

Communication mode

In the AAM-95 system the minimum measuring integration time is set to 5 minutes and the measuring interval to 15 minutes. This means that the station gives 96 measured values per day. In normal routine monitoring the station polling interval is 24 hours and, when needed, the dialing interval can be changed separately for each station from the server.

4.2.2 Automatic gamma monitoring network PMS

General description

The system consists of automatic measuring stations and a dialing server that gathers data and transmits them to the main information server where all data are stored (Fig. EE-3). In all local stations detector boxes are installed on the ground (in Tallinn about 2 m above ground). Each station has two detectors of different type. For general information about radiation background it is equipped with the RD-02L type GM tube. The second detector is a 3" NaI(Tl) scintillator unit connected to a 256 channel analyzer. Thus, it is possible to monitor specific radiation levels caused by different natural and artificial isotopes. As information about temperature and rain at the site is very important in the analysis of radiological data, each station is equipped with gauges to measure these parameters as well.

The local station contains a powerful PC allowing all data to be stored and spectrum analysis to be performed to check the dose rate levels in the specific windows and give an alarm when the pre-set level is exceeded. The radiation information is temporally well differentiated, as the total dose rate is measured every minute and gamma spectrum every 10 minutes.

Alarm levels

The system software allows alarm levels to be set for the total gamma dose rate and separately for dose components caused by natural radionuclides such as radon (in equilibrium and dis-equilibrium with daughter isotopes) and normal background (calculated from the spectra), and by artificial sources. The alarm values are as follows:

- Total gamma dose rate 200 nSv/h
- Dose rate from radon (equilibrium) 200 nSv/h
- Dose rate from radon (dis-equilibrium) 200 nSv/h
- Dose rate from normal background 200 nSv/h
- Dose rate from artificial sources 95 nSv/h

Communication mode

In routine monitoring the dialing server picks data once per day and transfers them to the main data base in which data will be stored for at least one year.

If a station detects a dose rate value above the pre-set alarm level, the station immediately calls the server and the message will be distributed via Internet or through a computer network to the corresponding specialists on duty.

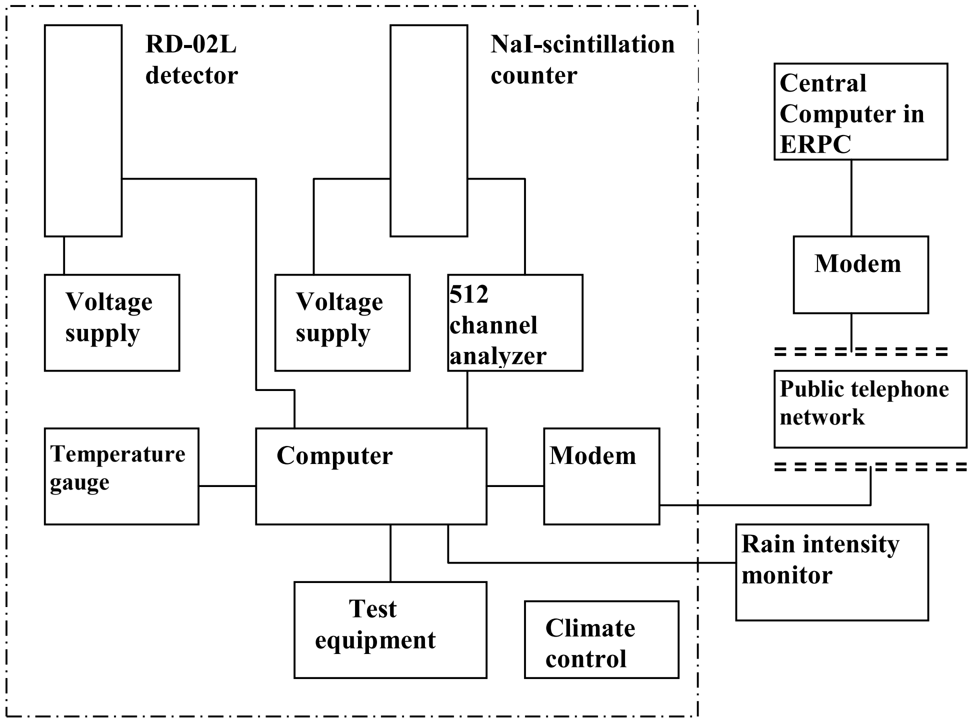


Fig. EE-3. *Block diagram of PMS gamma monitoring station.*

4.3 Manual gamma monitoring network

In addition to the automatic stations manual measurements of gamma dose rate are organized in nine sites, mainly in the inner parts of the country (Fig. EE-1). In normal situations, the dose rate is measured eight times per day by means of radiometers with distance detectors and data obtained are input into daily database and transferred via computer connection to the information server in the ERPC. In the event of abnormally high dose rate values, the person performing the measurement in the station will call the responsible officer in the ERPC and the measurement intervals will be shortened as required by the situation.

4.3.1 Manual gamma monitoring stations

In the stations for manual measurement RDA-31 radiometers with GMP-31 detector are used. In a normal radiological situation a reading is made every three hours at the height of about 1 m above the ground.

The alarm level is the same as for automatic stations of the AAM-95 system: 0.3 µSv/h. If a reading exceeds that level, the person on duty will inform the ERPC in Tallinn.

4.4 Air monitoring network

4.4.1 General description of the network

In Estonia three air filtering stations are installed (Fig. EE-1) which are placed in the meteorological stations in the vicinity of the larger cities. The oldest filter station located near Tallinn at the Harku site was designed and constructed in 1994 in a local small technological bureau. Its design is very simple, it does not have a gauge for permanently measuring the air flow and calculating the air volume filtered. The filtering capability was determined once during the initial installation and its value was estimated at about 1500 m^3/h. It was designed to sample only air particles using the Petryanof type filtering material which has insufficient adsorption ability for small aerosol particles. Because this disadvantage the isotope data measured on filters from this site are used with caution.

In late 1996 the modern air filter station *Snow White JL 900* was installed for detecting, as early as possible, air contamination in the event of a nuclear accident at the Leningrad Nuclear Power Plant. Gamma spectra of glass fiber and activated charcoal filters from this station are analyzed by a large volume HPGe detector. In 1997 a smaller air filter station *The Hunter Jl 150* was installed in Tõravere, in the southeastern part of Estonia.

4.4.2 Alarm level and filter change rate

The filter station *Snow White* has a GM type detector placed just above the filter frame enabling it to check the radiation level in the surrounding air. The gamma detector belongs to the radiation monitoring station of the AAM-95 system described above. As radioactive isotopes bound to air particles are concentrated on the filter, the reading from the detector increases. Still, these data are valuable for very early detection of the radionuclide concentration increase in the atmosphere. For this purpose, the alarm level for the station is set to 0.3 μSv/h, above which the radiation monitoring station calls up the AAM-95 server in ERPC.

In all filter stations the filters for air particles are sampled for one week and impregnated charcoal filters (sampling organic iodides) for one month. Radiometrical measurements of filters are performed in the analytical laboratory of ERPC in Tallinn. In the event of radiological threat, indicated by the concentration of artificial isotopes above 10 $\mu Bq/m^3$ in the air, the filter change frequency will be increased depending on the situation.

4.5 Airborne gamma measurements

At the moment Estonia does not have an aircraft equipped with a spectrometer with a larger volume NaI(Tl) detector to perform gamma mapping of contaminated areas.

4.6 Foodstuffs and environmental samples

The sampling program of environmental samples is planned and carried out by the ERPC. The responsibility for food sampling is laid on the Veterinary and Food Inspection reporting to the ministry of agriculture. All analytical work is done in the radiometric laboratory of the ERPC.

4.7 Survey teams

For mapping of contaminated areas the ERPC has at its disposal a mobile laboratory equipped with a large volume (4 l) NaI detector, a spectrometric unit, a mobile ARGOS workstation and a GPS system as well as portable gamma spectrometers for manual measurements outside the laboratory vehicle.

5 Finland

5.1 National background

In states of emergency, the Finnish Ministry of the Interior (Sisäasiainministeriö, SM) directs civil defense operations. If necessary, an emergency radiation-monitoring organization is set up. The monitoring of external radiation is then led from sheltered command centers, and special sheltered laboratories are brought into use. Decisions on measures concerning civil protection, rescue services and emergency management are the responsibility of the Ministry of the Interior.

The Radiation and Nuclear Safety Authority (Säteilyturvakeskus, STUK) collects all information concerning the accident situation and environmental monitoring results. STUK is also the international contact point in Finland, receiving and sending notifications in the event of radiological or nuclear accidents, in accordance with the IAEA convention and bilateral agreements with the Nordic countries, Russia, Germany, Estonia and Ukraine.

STUK assesses the importance of the situation to the radiation safety of the population, environment and the society, and makes a prediction of the development of the situation. STUK gives responsible authorities recommendations for necessary protective measures. In addition, STUK shall advise, e.g., the industry, trade, transport and customs authorities regarding the mitigation of harmful effects. STUK disseminates information about the situation, radiation levels and radiological consequences to domestic and foreign counterparts and to the media.

STUK is the central authority and research institute of the national radiological monitoring organization. It carries out a wide range of environmental radiation measurements, sampling and laboratory analyses. The reporting level of STUK is defined as any unusual observation of environmental radioactivity.

Other important radiation monitoring organizations include the Defense Forces (Puolustusvoimat, PV) and the Finnish Meteorological Institute (Ilmatieteen laitos, FMI). The Defense Forces is a cooperation authority, which gives assistance on request to the other authorities. FMI has the meteorological expertise and also performs some radiation monitoring. In addition, the Seismological Institute of the University of Helsinki (Helsingin yliopiston Seismologian laitos) takes part in the national radiation monitoring system by reporting to other authorities possible nuclear explosions and earthquakes near nuclear facilities.

The types of measurements carried out before and after a fallout and the organizations responsible for these measurements are summarized in Table FI-1. The Finnish countrywide monitoring system is presented schematically in Fig. FI-1.

The Finnish monitoring system is designed to detect releases originating from foreign and domestic sources. Among the latter, the following possible sources are the most important:

- Two nuclear power plants (Loviisa and Olkiluoto), each with two reactor units
- One research reactor (Espoo)

The external dose-rate (gamma) monitoring system in Finland is extensive, consisting currently of STUK’s automatic network of some 290 automatic stations, FMI’s eight stations and about 150 manual monitoring stations operated by local authorities and the Defense Forces. The number of manual stations is continuously decreasing, partly because of upgrades to the system and partly because radiation measurement activities at some monitoring sites have been completely terminated.

In addition to the gamma-monitoring stations in the Finnish territory, there are monitoring stations in Kola and Sosnovyy Bor, Russia, which are also connected to the Finnish monitoring system. On the Kola Peninsula there are six stations which at present are not operating. However, there is an on-going project for establishing 17 new monitoring stations around the Kola nuclear power plant.

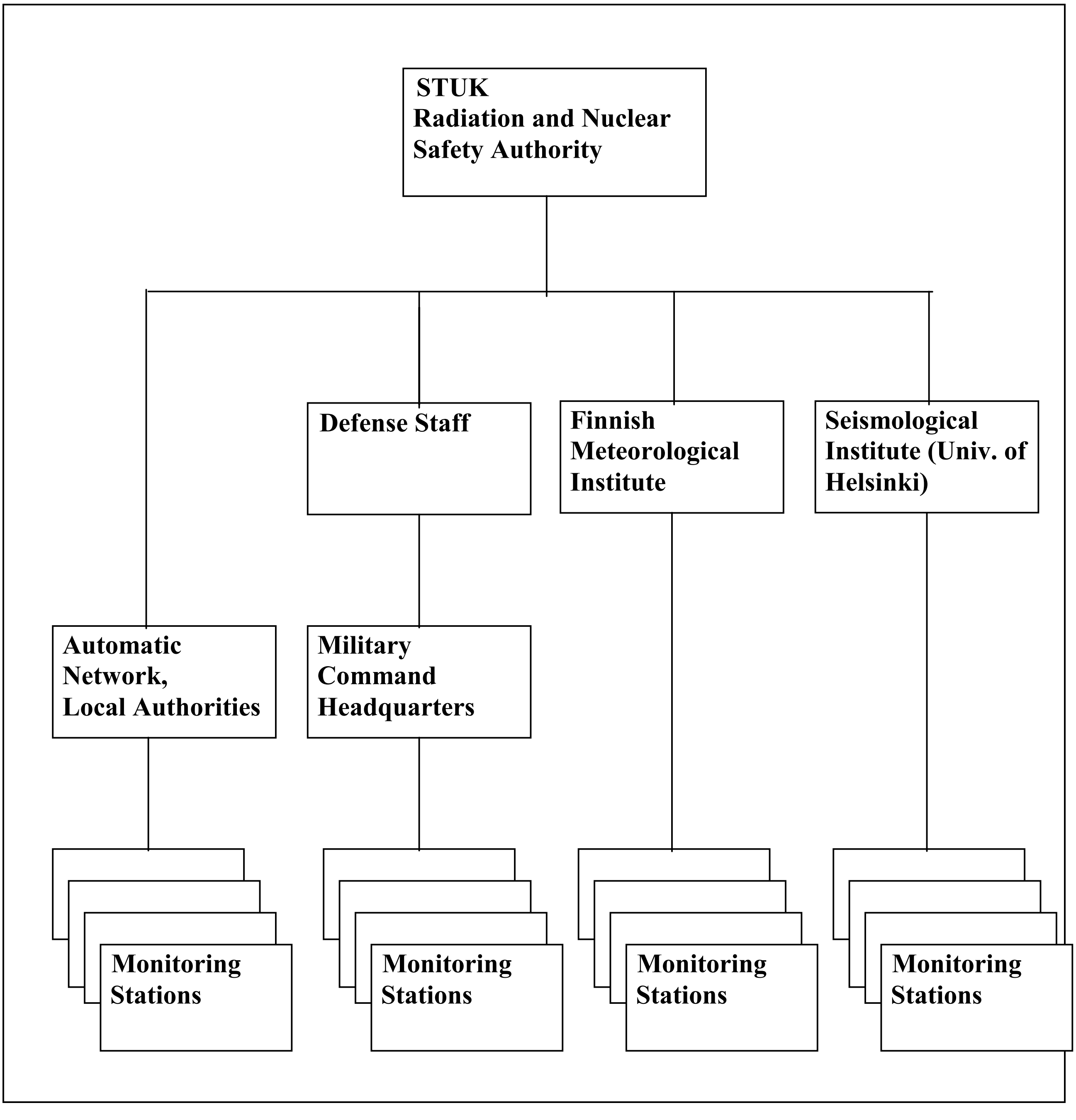


Fig. FI-1. *Schematic presentation of the structure of the countrywide monitoring system. The task of the Seismological Institute of the University of Helsinki is to inform other radiation monitoring authorities of all observed nuclear detonations and seismic events.*

__Table FI-1.__ Measurement services in Finland.

Organization/ Type of measurements	STUK	SM	PV	FMI	GTK	HYRL	Lab	NPP
Automatic gamma monitoring stations	x		x	x				x
Stations monitoring airborne activity								
- gamma	x		x					x
- beta				x				
Airborne measurements								
- external gamma			x		x			
- air filters			x					
Field measurements								
- gamma analysis	x			x				
- total gamma	x	x	x	x				x
- air filter gamma analysis	x		x					x
- beta	x		x	x				x
- alpha	x		x					x
Laboratory sample analysis								
- gamma	x		x	x		x	x	x
- beta (Sr)	x					x		
- alpha (Pu)	x					x		
Whole body counting	x					x		
External contamination	x	x	x	x				x

STUK Radiation and Nuclear Safety Authority
SM Ministry of the Interior (including provincial state offices and organizations)
PV Defense Forces
FMI Finnish Meteorological Institute
GTK Geological Survey of Finland
HYRL Radiochemical Laboratory, University of Helsinki
Lab Local laboratories
NPP Finnish nuclear power plants

In the surroundings of the Leningrad Nuclear Power Plant there are currently 24 automatic stations (one of them mobile), established in cooperation with Danish authorities.

An important part of the Finnish radiation monitoring system is USVA, the national radiation monitoring information system (Fig. FI-2). It controls the automatic dose-rate monitoring network, includes a data base for all radiation-related measurement results and serves as a tool for creating, maintaining and presenting an overall view of the current radiation situation.

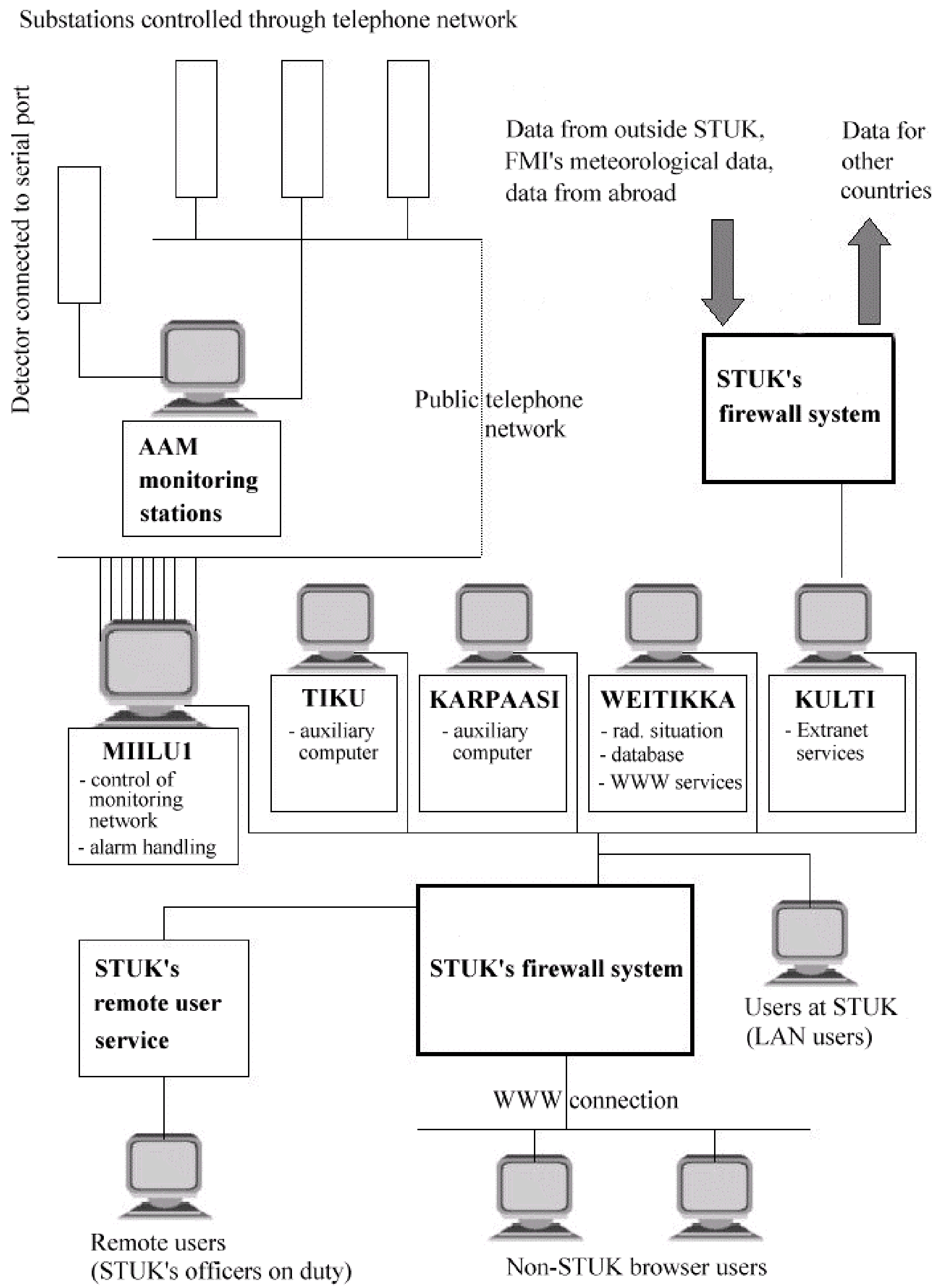


Fig. FI-2. *Schematic presentation of the Finnish radiation monitoring information system (USVA). The central equipment is located in the facilities of STUK.*

5.2 Automatic and manual external dose rate monitoring stations

5.2.1 STUK

A map showing the locations of the automatic external dose-rate (gamma) monitoring stations, based on Geiger-Müller (GM) tubes and operated by STUK in cooperation with local authorities, is given in Fig. FI-3. The strategy and major goals related to the automatic network are established and revised in annual agreements between STUK and SM. SM also allocates resources to STUK for managing the network.

The network consists of some 70 AAM central stations and about 220 substations, each of which is connected to one of the central stations. Fig. FI-4 shows the structure of the monitoring system. The stations are usually placed at local rescue and fire stations. The alarm level is set at 400 nSv/h.

5.2.2 Ministry of Interior

Under the administrative command of SM and local authorities there are currently a few tens of manual dose-rate monitoring stations with GM type measuring equipment. Manual monitoring is carried out mainly by municipal fire brigades and civil aviation authorities at the airports. The alarm level in manual measurements is currently 700 nSv/h.

5.2.3 Defense Forces

The Defense Forces operate an external radiation-monitoring network of 94 continuously operating manual stations, based on GM counters of the type used by the Ministry of Interior. Alarms are transmitted manually via the telephone network, the alarm level being 700 nSv/h (ambient dose equivalent rate). Part of the network (some 30 stations) will be automated by the end of 2001.

5.2.4 Finnish Meteorological Institute

FMI operates eight automatic gamma dose-rate monitoring stations (Fig. FI-5), which also record rainfall intensity. Five of the stations are based on a pair of NaI(Tl) scintillation detectors, arranged to allow for the separation of gamma emitters deposited on the ground and those suspended in the air. Three of the stations are equipped with a single NaI(Tl) detector and a pulse height analyzer. The detection limit for the increase (of non-natural origin) in external radiation levels is about 10 nSv/h in the case of wet deposition. Precipitation data are reported from about 350 weather observation stations.

5.2.5 Routines for reporting data and transmitting alarms

The routines for reporting measurement data and transmitting alarms from the dose-rate monitoring networks described above are summarized in Table FI-2.

Fig. FI-3. *Automatic external dose-rate monitoring network in Finland (the network operated by STUK).*

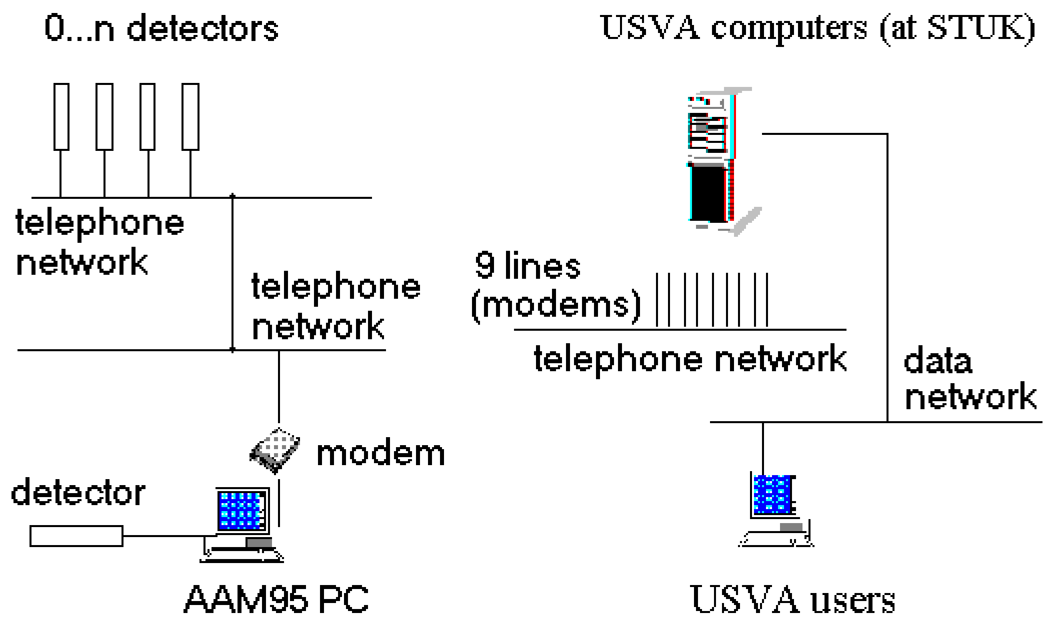


Fig. FI-4. Structural components of automatic external dose-rate monitoring system.

Table FI-2*. Routines for regular reporting of measurement data and for transmitting alarms from the automatic and manual external dose-rate monitoring station networks operated by STUK, the Ministry of the Interior (SM) and the Finnish Meteorological Institute (FMI). In addition, the Defense Forces inform STUK about all abnormal observations detected within the military dose rate monitoring network.*

Data sent to	Reporting party	What?	When?	How?
STUK	Automatic monitoring stations	24-hour data	Once a day	Telephone polling
		Alarms	When occur	Telephone (automatic)
	Manual stations and/or local authorities	Alarms	When occur	Telephone
		Measuring results	When adequate	Fax, telephone
FMI	Automatic monitoring stations	24-hour data	Once a day	Telephone polling
		Alarms	When occur	Telephone (automatic)
SM and/or provincial State offices	STUK	Alarms	When occur	Telephone
Regional alarm centers	Automatic substations	24-hour data	AAM-specific set intervals	Telephone polling
(automatic AAM central stations)		Alarms	When occur	Telephone (automatic)
Provincial state office/ Rescue department	Manual stations (measuring continuously or as requested)	Measuring results during an emergency	When asked	Fax, telephone

5.2.6 Systems operated by nuclear power plants

The two Finnish power plants have installed automatic external dose-rate monitoring networks of their own. However, these networks are also integrated into the national monitoring system. The stations around the power plants are situated in two rings, the radii of which are approximately 1 and 5 kilometers. In Loviisa the number of detectors in the first ring is 4, and 11 in the second ring. In Olkiluoto the corresponding numbers are 5 (these five monitoring stations are not directly connected to the national automatic network) and 10, respectively. All detectors are GM counters of the type used in the nation-wide network operated by STUK.

5.3 Monitoring of airborne radioactive substances

In Finland the monitoring of airborne radioactive substances is carried out by STUK, FMI and the Defense Forces. There are two principal types of stations used for measuring airborne activity:

- Continuously measuring aerosol monitoring stations with alarm capability.
- Aerosol sampling stations with filter type or activated charcoal cartridges to be analyzed in the laboratory.

The detection limits for the various types of stations are summarized in Table FI-3.

5.3.1 STUK

STUK has eight air sampling stations (Fig. FI-6). Air samples are used to determine the concentrations of radioactive substances in air close to the ground. Airborne particles are collected in a glass fiber filter and the filter is analyzed in the laboratories located in Helsinki and Rovaniemi. The typical minimum detectable concentration is of the order of 0.1 – 10 $\mu Bq/m^3$ for several important fission products.

There are three types of samplers:

- The sampler located in Helsinki is fully automated: it filters radioactive substances from the air, monitors the filter in real-time, changes the filter, prepares the filter for on-site high-resolution gamma-ray analysis, analyses the gamma-ray spectra and reports the results on STUK's Intranet pages. The sampling period is one day and the filter is measured after a delay of one day using a one day counting time. The flow rate is 550 m^3/h.
- The flow rate of the high volume samplers in Kotka, Kajaani and Rovaniemi is 900 m^3/h. The sampling period is one week.
- The flow rate of the Imatra, Jyväskylä, Sodankylä and Ivalo samplers is 150 m^3/h. Filters are changed twice a week. Two samples are combined as a week sample in the laboratory.

All samplers except the one located in Helsinki are equipped with a charcoal cartridge in order to collect gaseous radioactive substances. Charcoal cartridges are analyzed monthly in the laboratory.

All samples are subjected to an immediate gamma measurement as soon as they arrive in the laboratory. If no artificial substances are detected, a final analysis of the samples will be conducted within a couple of days.

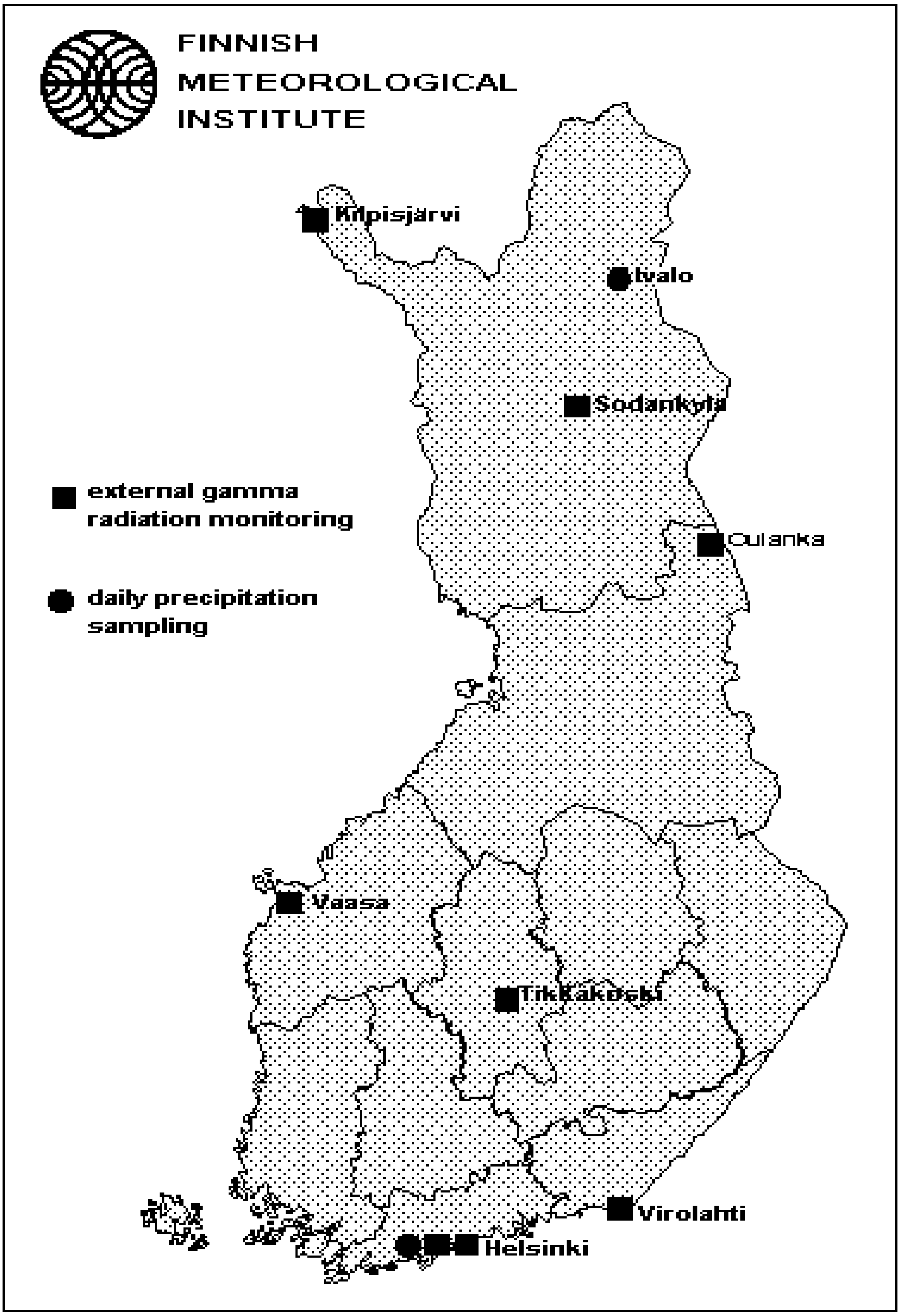


Fig. FI-5. *FMI's network of external dose-rate monitoring and precipitation sampling.*

5.3.2 Finnish Meteorological Institute

FMI operates 14 aerosol beta-activity monitoring stations (Fig. FI-7). The filters are changed weekly. All 14 stations have an alarm system for early warning, based on beta counting GM tubes placed above the filter. The system will trigger an alarm in response to an increase in artificial beta activity of the order of 2 Bq/m^3 (after a delay of some four hours). This value corresponds to a dose rate of about two orders of magnitude smaller than that required to activate the external gamma dose-rate monitoring networks discussed above.

The filters from the aerosol monitoring stations and additional filters from four daily sampling stations are measured in a laboratory for alpha and beta activity. The detection limit for artificial activity after a delay of some five days is about 200 $\mu Bq/m^3$. Daily aerosol samples from two stations are also assayed with gamma spectrometry about one week after the sampling. Also as a routine, X-ray films are exposed to daily aerosol samples of two stations to reveal possible hot particles.

5.3.3 Systems operated by nuclear power plants

The activity of ground-level air around the Finnish power plants is monitored on a routine basis with four high-volume air samplers situated in the vicinity of both power plants (Fig. FI-6). Air is drawn through combined glass fiber and activated charcoal filters. These filter pairs are changed twice a month and analyzed at STUK.

When a reactor is undergoing refueling and maintenance, a supplementary air sampler is placed near the plant in question. The collection period in this case is usually one week.

5.3.4 Defense Forces

The Defense Forces have one air sampler (of the model used by STUK) in Tampere (see Fig. FI-6). The analysis procedure is identical to that used in STUK.

Table FI-3. *Detection limits for Finnish air monitoring stations.*

Type of station	Minimum detectable activity	Remarks
STUK (Helsinki, Kotka, Rovaniemi)	0.1 - 0.3 $\mu Bq/m^3$	Most important gamma emitters (^{131}I, ^{137}Cs etc.)
STUK transportable model (other stations)	0.4 - 0.8 $\mu Bq/m^3$	Most important gamma emitters (^{131}I, ^{137}Cs etc.)
STUK nuclear power plant	2 $\mu Bq/m^3$	Most important gamma emitters (^{131}I, ^{137}Cs etc.)
FMI on-line aerosol measuring stations	Alarm level about 2 Bq/m^3	Total beta activity
FMI sampling stations	200 $\mu Bq/m^3$	Total beta activity with 5-day delay
Defense Forces	0.4 - 1 $\mu Bq/m^3$	Most important gamma emitters (^{131}I, ^{137}Cs etc.)

5.4 Airborne measurements

When called upon, the units of the Air Force collect samples from the radioactive cloud in the upper atmosphere. The Air Force also has a system with an efficient high-purity germanium detector and portable spectroscopy equipment, which can be installed on a helicopter or an airplane. The system is used for mapping ground deposition and for searching for radioactive debris after passage of a radioactive cloud.

The Geological Survey of Finland (Geologian tutkimuskeskus, GTK) has two airborne gamma-ray spectrometers equipped with NaI(Tl) detectors into total volumes of 41 l and 20 l. These systems are normally used for geophysical surveys but are also ready for mapping areas after a fallout or searching for debris after a satellite crash, for example.

5.5 Monitoring of deposited radioactive substances

5.5.1 STUK

STUK has 9 stations collecting continuously wet and dry deposition in Finland (Fig. FI-8). Samples are usually analyzed on a monthly basis, but sampling periods will be shortened if some indications of fresh fallout exist. Samples are usually collected at a height of one meter above the ground. Sampling areas of the collectors are 0.05 or 0.07 m^2. In addition, there is a possibility to enhance the use of a few stations sampled for a long-term study on the resuspension of deposited radionuclides.

In Helsinki there is also a sampler which collects wet and dry deposition separately. Its sampling area is 0.5 m^2 for both wet and dry deposition. All the samples are analyzed for gamma-emitting radionuclides and radiostrontium. When necessary, samples can also be analyzed for alpha-emitting transuranics (Pu or Am). Detection limits for gamma-emitting radionuclides depend, among other things, on the counting time and are typically 0.5 Bq/m^2.

In Rovaniemi and Helsinki there are separate samplers collecting precipitation for ^3H determinations, which are also usually analyzed monthly. The detection limit is 1 Bq/l.

5.5.2 Finnish Meteorological Institute

FMI collects daily precipitation samples from two stations (Helsinki and Ivalo) with 1 m^2 samplers (Fig. FI-5). The detection limit for artificial beta activity is about 2 Bq/l (delay 3-5 days).

5.5.3 Nuclear power plants

Deposited radioactive substances are also analyzed in the environments of the nuclear power plants in Loviisa and Olkiluoto (Fig. FI-8). Four deposition collectors (wet plus dry) are located in the vicinity of both power plants. The sampling area of one collector is 1 m^2 and that of the others is 0.07 m^2. Samples from the large sampler are analyzed at STUK monthly, while those from the others are combined into three-month samples. All the samples are analyzed for gamma-emitting radionuclides. Samples of three months are normally also analyzed for radiostrontium. If necessary, sampling periods can be shortened. At two stations around each power plant there are additional samplers for ^3H determinations.

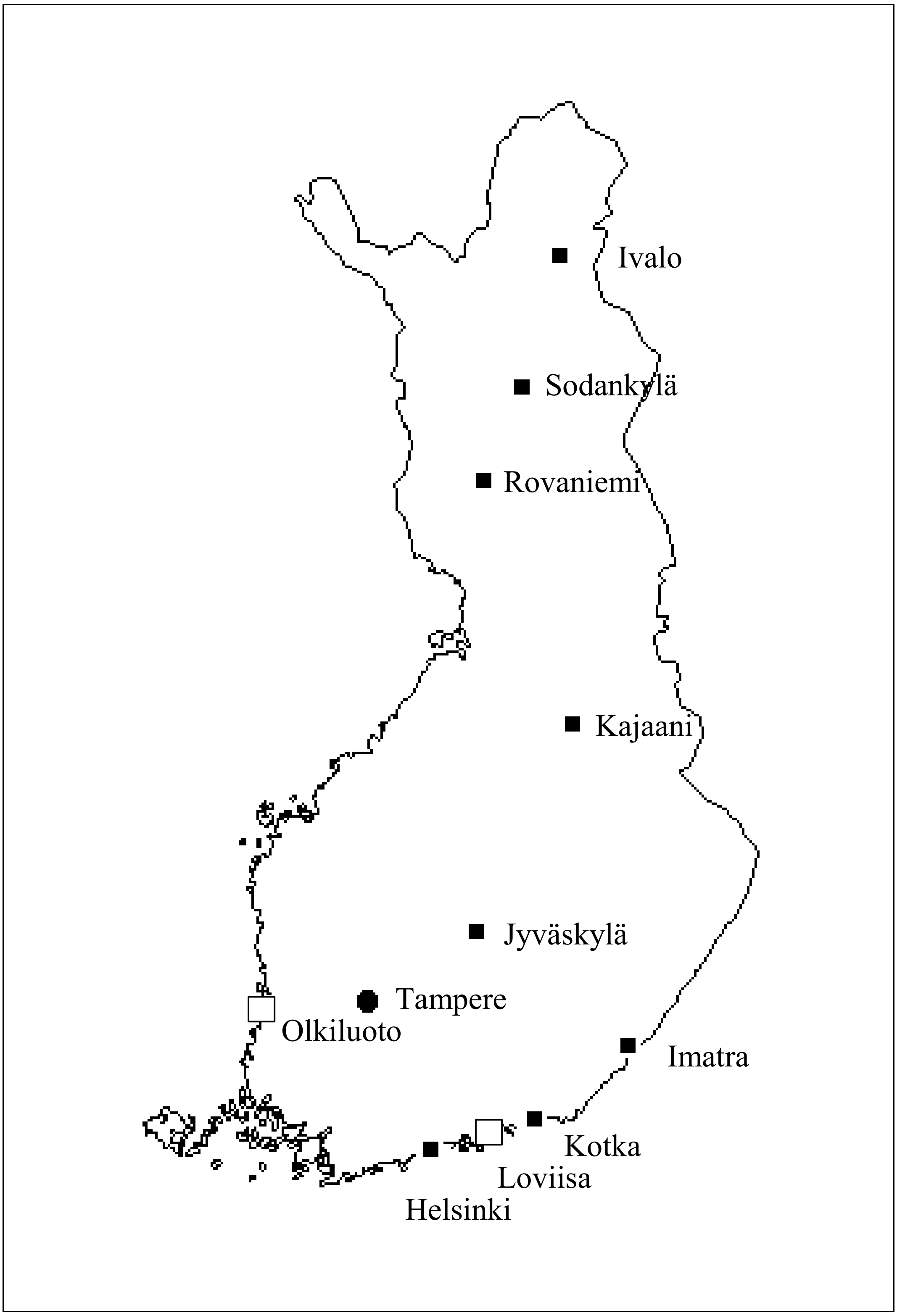


Fig. FI-6. *Air sampler stations operated by STUK (filled squares), Defense Forces (filled circle) and nuclear power plants (open squares).*

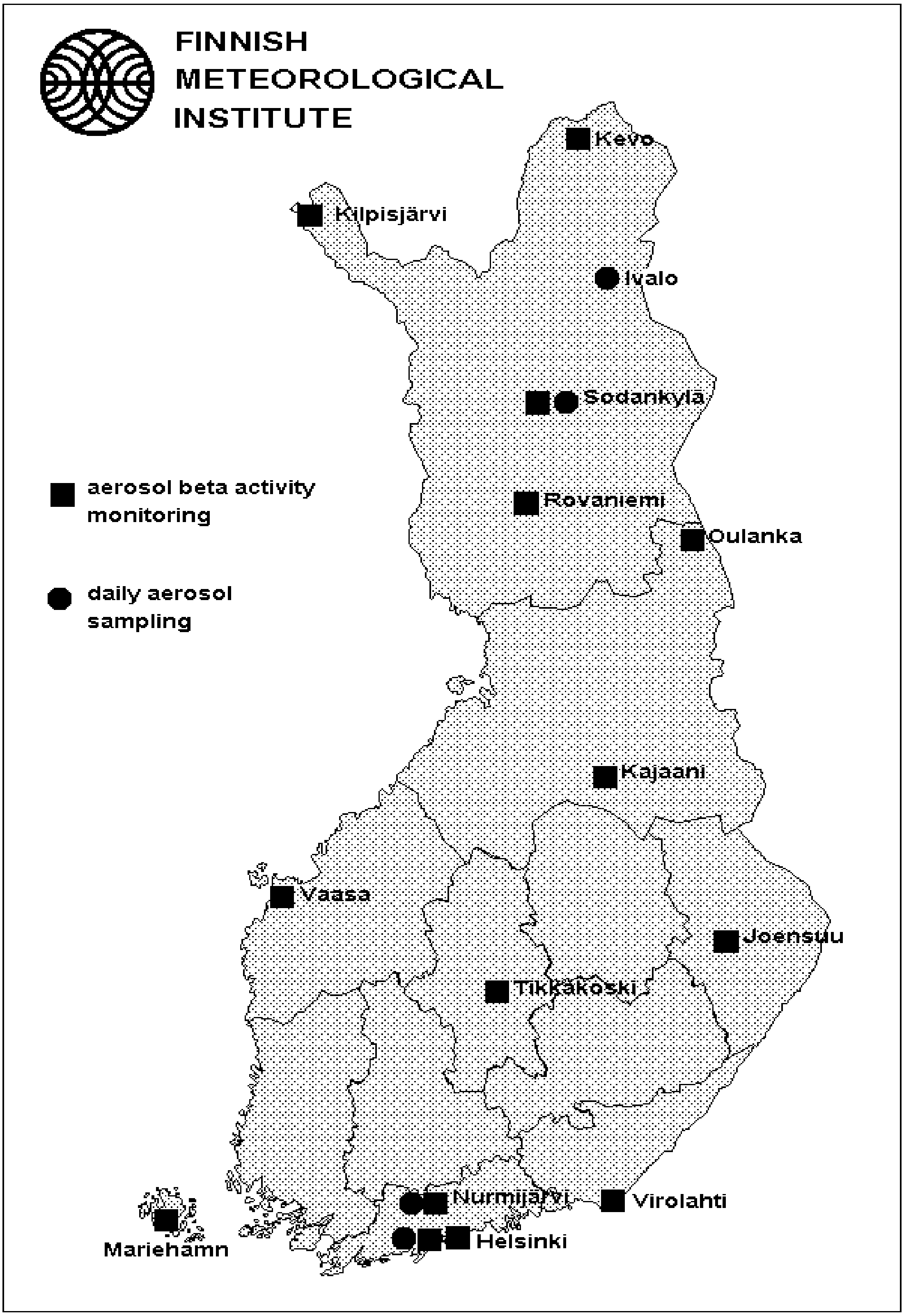


Fig. FI-7. *Aerosol monitoring stations operated by FMI.*

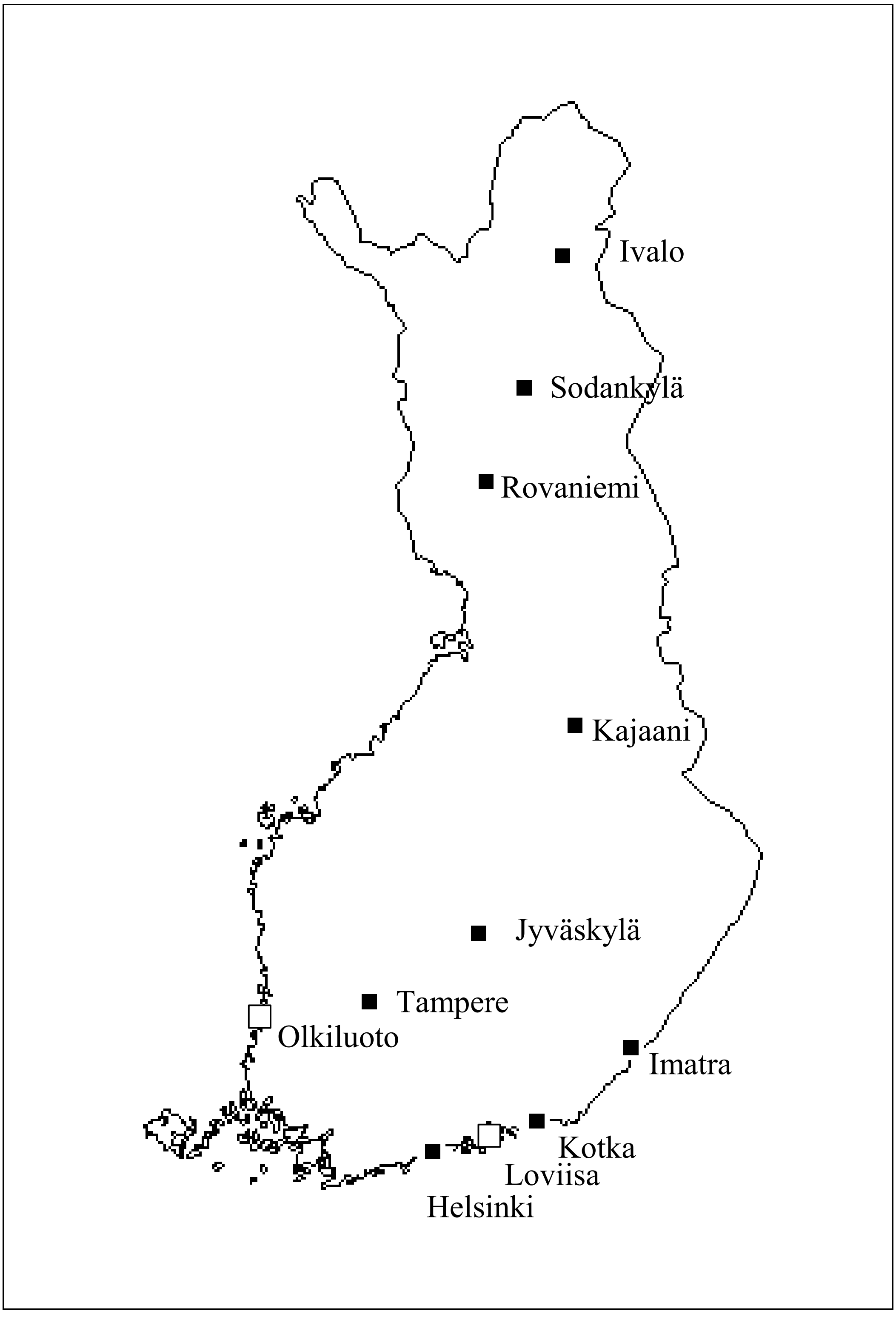


Fig. FI-8. *Sampling stations for precipitation and deposition operated by STUK (filled squares) and power plants (open squares).*

5.6 Foodstuff and environmental samples

The Department of Research and Environmental Surveillance at STUK has advanced laboratories in Helsinki and in Rovaniemi for both direct instrumental and radiochemical determination of radionuclides in environmental and foodstuff samples. They are equipped with the necessary devices for alpha, beta and gamma spectrometric measurements.

The regular food and environmental surveillance program includes milk, whole diet, drinking and surface water. Milk samples are taken from four dairies. Gamma-emitting radionuclides are analyzed monthly and ^{90}Sr quarterly. The whole diet and drinking water samples are collected twice a year in three sites. The samples represent bigger population centers and institutional kitchens. The samples are analyzed for gamma-emitting radionuclides and ^{90}Sr, drinking water is also analyzed for ^{3}H. Water samples from three large rivers are taken four times per year and analyzed for gamma-emitting radionuclides and ^{90}Sr.

In addition, STUK has a large nation-wide program of environmental and foodchain research. Soil, vegetation, water, milk, beef, pork, reindeer meat, fish, game, wild mushrooms and berries, as well as grains, field and greenhouse vegetables and fruits are sampled and analyzed regularly.

In a large-scale, long-term radiation situation STUK establishes three regional laboratories when necessary. One of these laboratories is permanently situated in Rovaniemi. In addition, there are 49 local food laboratories operated by municipal health and food authorities. These local laboratories monitor gamma-emitting nuclides in food by using NaI(Tl) detectors. The radioanalytical and sampling programs for emergency situations are under the guidance of STUK.

The laboratories in major towns have supplemented their equipment with gamma spectrometers using germanium detectors.

5.7 Survey teams

In radiation emergency situations STUK can initiate assessment of environmental dose rates and fallout levels by using a special mobile laboratory and other mobile survey teams. The equipment of the laboratory vehicle includes:

- a sensitive GM counter
- a high-pressure ionization chamber
- a semiconductor detector (germanium) and a portable spectroscopy system
- air samplers
- a GPS system and a cellular phone for transmitting data to the headquarters in real time (also while the car is moving)

Other mobile teams may have, depending on the case, GM tubes, portable air samplers, thermoluminescent dosimeters (TLD) to be placed in the accident area and cellular phones for transmitting information to STUK. Furthermore, STUK (both the headquarters in Helsinki and the branch office in Rovaniemi) and the rescue centers in Kotka and Vantaa have special packages consisting of a PC with dedicated software, a GM detector, a GPS receiver and a cellular phone. Dose rate levels can be seen continuously on the map and transmitted forward in real time.

In the event of an accident at a domestic power plant, mobile survey teams are also dispatched by local emergency organizations (fire brigades, rescue services, the Defense Forces, civil defense organizations, emergency organization of the power plant). The equipment is based mainly on GM detectors, but the teams from the power plant also use air samplers and TLD dosimeters.

Both Finnish nuclear power plants have predetermined special survey routes in their surroundings where measurements will be performed under accident conditions. All municipalities have similar plans.

5.8 Contamination

5.8.1 Internal contamination

Internal contamination of radionuclides in man can be determined using whole body counting or organ measurement techniques. Internal contamination can also be estimated indirectly by measuring radionuclides in excreta, body fluids, inhaled air or in foodstuffs consumed.

The total number of whole body counters in Finland is four. Two are operated by STUK and two by the Radiochemical Laboratory of the University of Helsinki (Helsingin yliopiston Radiokemian laboratorio, HYRL). One of the whole body counters of STUK is installed in an iron room. The system uses the scanning bed technique and has four NaI(Tl) detectors and two high purity germanium detectors. The NaI(Tl) detectors are installed on a circular frame around the bed and the semiconductor detectors are located one above and one below the bed. The measurement method also permits the profile distribution of radionuclides in the body to be determined. The measuring time is typically 30 minutes and the minimum detectable activity for ^{134}Cs and ^{137}Cs is about 50 Bq.

The second whole body counter operated by STUK is installed in a truck. This mobile whole body counter is provided for self sustained field measurements and is therefore also suitable for field measurements needed in emergency situations. The background shield is made of lead and is of a shadow shield type. The measuring geometry is a modified chair geometry. A high purity germanium detector is used for measurements of gamma spectra. The minimum detectable activity for ^{134}Cs and ^{137}Cs is typically about 100 Bq with a measurement time of 1000 seconds.

One of the whole body counters operated by HYRL is installed in an iron room and the other in a container. The system installed in a container can be transported by a truck. The measuring geometry in both the systems is a chair geometry with a single NaI(Tl) detector. The background shield is of the shadow shield type and made of lead. The minimum detectable activity for ^{137}Cs is typically about 50 Bq with a measurement time of 1000 seconds.

At the Finnish nuclear power stations there are body monitors for the determination of the contamination level in the workers. The detection level for a one-minute measurement is several thousands of becquerels, and the monitors are not nuclide specific.

In Finland there are about 30 hospitals which have gamma cameras. This kind of equipment is suitable for the determination of gamma emitting radionuclides in organs, e.g., ^{131}I in the thyroid. In addition to the whole body counters, STUK also has a monitor for determining ^{131}I in the thyroid. The system consists of a NaI(Tl) detector with a lead collimator. The minimum detectable activity is about 500 Bq ^{131}I.

In addition to STUK and HYRL there are some institutes in Finland, which can perform measurements of alpha and beta emitting radionuclides in samples of excreta, urine or body fluids.

5.8.2 External contamination

Surveys of external gamma and beta contamination can be carried out by STUK, the Ministry of the Interior, the Defense Forces and other authorities and organizations, using most types of modern portable equipment.

5.9 Future development

During the next few years, the following changes in the monitoring systems and procedures are foreseen:

- The number of manual gamma monitoring stations will decrease while that of automatic stations will increase, primarily because part of the stations operated by the Defense Forces will be made automatic. The total number of external dose-rate monitoring sites in Finland will, however, remain (approximately) at the current level.
- An automatic data exchange procedure between the automatic dose-rate monitoring networks of STUK and the Defense Forces will be established.
- The international cooperation within the European Union will improve and also have an impact on national radiation monitoring strategies.
- New technical means for data transfer (e.g., wireless communication) will be introduced in monitoring networks

6 Germany

6.1 National background

Protection of the public against ionizing radiation in Germany is organized and maintained at local, state and federal level.. Nuclear facilities are licensed by the states and both the license holder and the state (“Land”) are responsible for site-specific monitoring (KFÜ). Urgent countermeasures following a major accident in a nuclear installation with a release into the environment are implemented by the disaster control organization of the state. The legal basis for site-specific surveillance is given by the federal Radiation Protection Ordinance (Strahlenschutzverordnung, StrlSchV) and its regulation for monitoring releases from nuclear installations (Richtlinie zur Emissions- und Immisionsüberwachung kerntechnischer Anlagen, REI). However, implementation of the federal recommendations is the responsibility of the state, and differences in monitoring strategies exist in different states.

On the other hand, the Federal Government operates a nation-wide monitoring and information system (IMIS). The system provides competent authorities with timely information on any changes in radiation levels and enables them to take appropriate precautionary protective measures and to inform the public. The system mainly consists of an on-line network part, operated by organizations of the federal government, and a laboratory part, conducted by the states. The legal basis is the ‘Act on the Precautionary Protection of the Population Against Radiation Exposure’ (Strahlenschutzvorsorgegesetz, StrVG).

Both KFÜ and IMIS were planned for different purposes and implemented by different authorities. Hence, differences in strategy and instrumentation were inevitable. Efforts are now being made to harmonize strategies and to make measurement results comparable.

The measurement strategy of German radioactivity monitoring networks is mainly based on on-line monitoring at fixed sites. Thus, the site-specific background and characteristics are well known and the systems allow for early warning. Mobile units, which go into an affected area upon alert, play a minor role.

The basic domestic nuclear threats are represented by 19 nuclear power reactors, 6 research reactors and 6 other nuclear facilities. There exist also 8 foreign nuclear facilities at a distance of less than 25km from the national border. The monitoring system also complies with the needs for monitoring large-scale contamination originating from a far-field source.

6.1.1 The German nation-wide monitoring system IMIS

The German “Integrated Measurement and Information System” (IMIS) is part of the federal government’s national response plan for dealing with the consequences of large-scale radioactive contamination of the environment. It consists of

- Five nationwide ground-based networks with fixed stations
- About 25 mobile units (land vehicles for *in-situ* gamma spectrometry, helicopter equipment for airborne gamma spectrometry, equipment for plume tracking by air planes and by ships)
- 43 specialized laboratories for measurements of food and of environmental samples
- A data processing system of some 70 computers connected by a wide area network (IMIS-IT)
- Computer models for airborne radionuclide transport and dose predictions.

IMIS has two modes of operation. During routine operation, the on-line networks report once a day to the accountable authority, the Federal Ministry for Environment, Nature Conservation and Nuclear Safety (BMU). During emergency operation, reporting of the on-line systems is scheduled every 2 hours. Off-line systems report as soon as possible (asap), i.e., several times per day.

Tables DE-1 and DE-2 give an overview on the number of stations and frequency of measurements of different networks in the emergency operation mode.

Table DE-1. *Type of measurement and frequency of reporting of dose rate and air monitoring networks in emergency operation mode of IMIS.*

Institution operating the sub-network	Federal Office for Radiation Protection (BfS)	Federal Office for Radiation Protection (BfS)	German Weather Service (DWD)
Number of stations	2150	12	39
Type of data	dose rate	air monitoring	dose rate and air monitoring
Gamma dose rate	2 h		BfS/IAR probes co-located
***In-situ* gamma-ray spectrometry of ground contamination**	asap*		asap
Aerosols, specific concentration in air			
Gross beta		2 h	2 h
Gross alpha		2 h	2 h
Gamma spectrum			2 h
^{131}I (gaseous)		2 h	4 h **
$^{89/90}$Sr			asap
Alpha spectrum			asap
Spec. conc. in precipitation			
Gamma spectrum			asap
Alpha spectrum			asap
$^{89/90}$Sr			asap
^{3}H			asap
Gross beta			asap
Precipitation rate			asap

asap = as soon as possible

* Six mobile units measure at the sites of dose rate probes

** Manual sampling at 20 sites and gamma spectrometric measurement of all iodine isotopes

Table DE-2. *Type of data and frequency of reporting of surface water monitoring networks in emergency operation mode of IMIS.*

	"Federal waterways" (Rivers)	**North Sea and Baltic Sea**
Institution operating the sub-network	Federal Institute for Hydrology, (BfG)	Federal Maritime and Hydrographic Agency (BSH)
Number of stations	40	12
Type of Data		
Spec. Cont. of Surface water (Bq/l)		
Gross beta	2 h	
Gross gamma	2 h	2 h
Gross alpha	asap	
^{3}H	asap	asap
$^{89/90}$Sr	asap	asap
Gamma spectrum	asap	asap
Alpha spectrum	asap	asap
Suspended matter (Bq/kg)		
Gamma spectrum	asap	asap
Spec. Cont. of Sediment (Bq/kg)		
Gamma spectrum	asap	asap

6.2 Automatic gamma monitoring networks

A network of 2150 dose rate probes equipped with Geiger-Müller counters is run by the Federal Office for Radiation Protection (BfS) (cf. Fig. DE-1). The probes are installed at a height of 1 m above grassland. Network planning seeks to minimize obstructions in the vicinity of the probes in order to facilitate a certain level of representativeness and comparability. All probes are connected to the public telephone network via modem. Data are polled every 48 hours in routine operation and every 2 hours during an emergency by computers located at six different sites of BfS. Computers communicate data via ISDN and TCP/IP. Data are checked for plausibility and consistency with data of the air monitoring networks at the Institute for Atmospheric Radioactivity (IAR) of BfS at Freiburg. Quality checked data are transmitted to the Federal Ministry for Environment, Nature Conservation and Reactor Safety (BMU).

If, for a certain probe, three subsequent one-minute average values exceed a site-specific limit (approx. 5 standard deviations above the median), a spontaneous message is sent to the data center. If two such messages come from neighboring probes at a distance of less than 30 km and within a time interval of 1 hour, an officer on duty at the IAR data center at Freiburg is notified to check the data.

Information on precipitation is crucial for the interpretation of dose rate data in the early phase of an increase. The German Weather Service monitors precipitation with weather radar. Data are updated every 30 minutes.

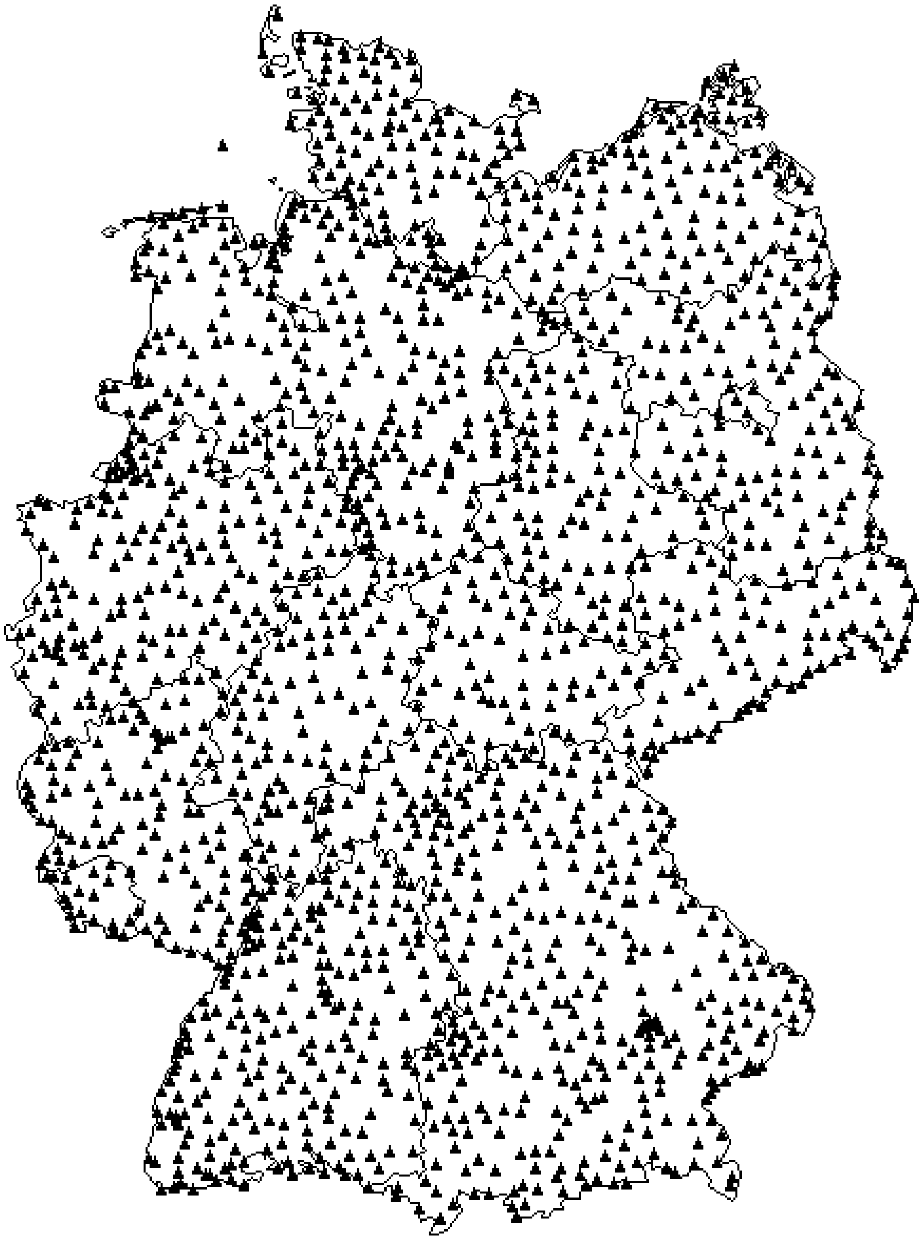


Fig. DE-1. *Location of dose rate monitoring probes of the German IMIS network.*

6.2.1 *In-situ* gamma spectrometry

At each of the 6 BfS sites that service the dose rate network, nuclide specific systems on vehicles are co-located. These mobile units are optimized for fast measurements at pre-selected representative sites of dose rate probes using high-resolution *in-situ* gamma spectrometers. In addition, one mobile *in-situ* spectrometry system is allocated to each state. Another 39 portable systems are deployed in emergency situations at DWD sites. These are operated as fixed on-line stations and supplement the station instrumentation in order to obtain a complete understanding of the situation around the station. Measurements can also be carried out during the passage of radioactive air masses in order to assess not only deposited activity but also air concentration of xenon isotopes. The equipment of these units is identical to that of the mobile systems.

The design of the mobile units is robust in order to cope with the needs of in-field measurements. All systems are identically calibrated for freshly deposited activity on the ground. Pre-existing contamination, mainly from Chernobyl fallout, is assessed by routine background measurements at pre-defined sites. It will be subtracted in an emergency from measured data giving correctly the net value of fresh soil surface contamination

6.3 Systems for site-specific monitoring of nuclear facilities

The German systems and regulations for site-specific monitoring include both on-line systems (KFÜ) for the permanent surveillance of in-plant and stack parameters and of the radiological situation in the environment as well as sampling and measurement programs (REI) in the vicinity of a plant. Details of a typical parameter set of a KFÜ system are given in Table DE-3. Data are updated every 10 minutes.

Most of the KFÜ systems integrate environmental on-line gamma dose rate networks which are typically operated up to distances of 10 kilometers from the plant. The basic criteria for site selection are equal coverage (one station per 30° sector) and the distribution of the population. In addition to the site-specific monitoring systems, the density of the nation-wide gamma dose rate network of IMIS (cf. Section 6.2) has been increased in the vicinity of these German nuclear power plants up to a distance of 25 kilometers. Therefore, data from about 20 to 40 on-line stations for gamma dose rate are available in the area up to 25 km distance from a nuclear power plant. Fig. DE-2 shows a typical distribution of gamma probes in the vicinity of a German nuclear power plant.

Each KFÜ system operates an atmospheric model for the diagnosis of the atmospheric transport in real time. At present, the legal requirement is a Gaussian plume model. In addition, Gauss puff models or Lagrangian models are operated.

The sampling and measurement programs of the REI regulations are comprised of gamma and – if required at a particular installation - neutron dose rate measurements as well as sampling and nuclide specific measurement of air, precipitation, soil, vegetation, ground water, surface water, sediment, drinking water, foodstuff and animal feed. The programs are specified for different types of nuclear installations and distinguish between routine and emergency operation. In an emergency, the license holder is responsible for monitoring and sampling in the central zone (up to 2 km radius) and the most contaminated 90° sector of the middle zone (10 km radius). The competent authorities concentrate their monitoring/sampling activities in neighboring sectors of the middle zone and in the outer zone (10 to 25 km).

6.3.1 Survey teams

In Germany, mobile survey teams consist of measuring teams and radiation detection teams. According to federal basic recommendations for disaster control in the environment of nuclear installations, the measuring teams primarily measure the gamma dose rate and take air samples to measure the specific activity concentration of radionuclides in air. *In-situ* gamma-ray spectrometers are used for measuring the soil contamination after a plume passage. The specialized Nuclear Emergency Service (KHG) located at Karlsruhe supports the measuring teams of the operator of a nuclear facility. Fire brigades and other disaster control organizations provide radiation detection teams equipped with simple and robust detectors. They support the measuring teams and take environmental samples.

Table DE-3*. Parameters of on-line monitoring of the German KFÜ systems; various parameters, which characterize the status of the plant, are also available on-line. A parenthesis indicates that the measurement is not mandatory.*

Type	Parameter	License holder	Competent authority
Release rate	noble gases (stack)	X	X
	gamma dose rate (stack)	X	X
	I-131 activity concentration (stack)	X	X
	activity concentration (aerosols, stack)	X	X
	air flow	X	(X)
	temperature	X	(X)
	activity concentration (liquid effluent)	X	(X)
	water flow	X	
	activity concentration (cooling water)	X	(X)
	water flow (cooling water)	X	
Site-specific meteorology	wind direction	X	(X)
	wind velocity	X	(X)
	air temperature	X	(X)
	precipitation	X	(X)
	radiation balance	X	(X)
	standard deviation of wind direction	X	(X)
	relative humidity	X	(X)
	atmospheric pressure	X	(X)
Environment-al situation	gamma dose rate		X
	activity concentration of air (aerosol and iodine)		(X)

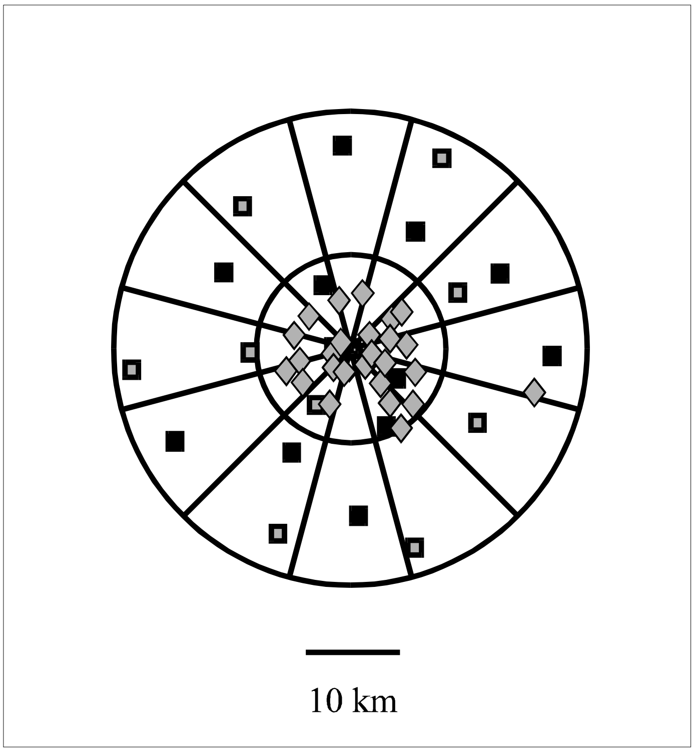


Fig. DE-2. *Location of dose rate monitoring probes within a 25 km distance of a German nuclear power plant. The gray squares denote regular IMIS probes, the black squares denote the 12 additional probes which increase the network density around the power plant. The location of the KFÜ probes for the same power plant is indicated with rhombuses*.

6.4 Air monitoring stations

Taking into account the number and the position of the nuclear power plants in Europe, the population density in Germany, and the potential of diagnostic weather codes to interpolate between individual stations, a total number of about 50 monitoring stations is considered to be required on the territory of Germany (cf. Fig. DE-3). At 39 stations, the German Weather Service (DWD) operates automatic on-line systems. Filter tape systems furnished with high resolution gamma spectrometers (10 m^3/h) and filter tape systems furnished with gross alpha and beta counters (ABPD, 40 m^3/h) measure aerosols. The minimum detectable concentration for ^{137}Cs is 15 mBq/m^3 on a daily average. Iodine samples are taken manually at 20 stations and measured nuclide specifically. The detection limit is about 50 mBq/m^3 for a 4-hour sample. Reporting time is daily in routine operation and every 2 hours in emergency operation. At each station, a probe of the dose-rate monitoring network is co-located. In addition, stations are equipped with fixed *in-situ* gamma detectors (cf. section 6.2.1).

This network is completed by additional 12 on-line stations of BfS furnished with a combined alpha/beta-aerosol and iodine monitor.

Fig. DE-3. *Location of IMIS air monitoring stations in Germany, run by the Federal Office for Radiation Protection (BfS) and the German Weather Service (DWD).*

6.4.1 Trace analysis program

High volume samplers (300-800 m^3/h) are operated for measuring nuclide specific airborne activity at 5 sites. The minimum detectable concentration for ^{137}Cs is less than 1 µBq/m^3 for weekly samples. Xenon and Krypton samples are taken at 7 sites and analyzed at the BfS noble gas laboratory at Freiburg. Data from these stations are considered necessary to inform the competent authorities and the public about detectable man-made radioactivity at a level far below any hazard.

6.4.2 Modeling

The information system of IMIS includes models for the diagnosis and prognosis of atmospheric dispersion (trajectories, Lagrangian models with grid space of 55–60 km and of 7 km respectively) as well as for the dose and the contamination of food and environmental samples (PARK). The operation of the automatic module of the PARK system is optimized to process the input of data from the automatic networks of IMIS, with an update every two hours in emergency operation mode.

6.5 Airborne systems

Five mobile measuring systems, equipped with NaI-detectors and high-resolution gamma spectrometry systems, exist at BfS sites for installation in helicopters of the Federal Border Police (BGS). These systems assess ground contamination in cases when a detailed contamination profile of an affected area is needed. They will also be used for searching for lost sources, debris of nuclear powered satellites etc. In addition, an aircraft is available to take samples in the upper air. The system consists of an aerosol filter sampling unit and a high-resolution gamma spectrometer for analysis of the samples on board.

6.6 Foodstuffs and environmental samples

The 43 specialized laboratories are operated to measure foodstuff, drinking water and animal feed, but also environmental samples. The laboratory data are mostly based on analyses with high-resolution gamma spectrometers. Sample collection and measurement are based on predefined standardized programs and techniques. The samples are collected at the production sites. The laboratories have to participate in regular quality assurance programs carried out by specialized agencies (Leitstellen). The overall capacity of the laboratories is capable of increasing the sampling and measurement frequency by about two orders of magnitude when switching from routine to emergency operation mode. For example, the number of milk samples (about 1000) routinely analyzed in Germany per year can be analyzed, if necessary, per day.

6.7 Data quality checks in IMIS

There are three levels of data checking. Firstly, each institution operating the sites is responsible for checking its own data at a technical level. This typically comprises the check for status data. On a second level, data from each measuring method are checked for internal consistency and representativeness. On a third level, data from different detection methods are inter-compared and checked for plausibility. The level 2 and level 3 quality checks are performed by specialized agencies where data are also evaluated with respect to representativeness. Data having passed these three levels of quality control provide a consistent and representative picture of the contamination situation and are appropriate for subsequent evaluation.

6.8 Contamination measurements

6.8.1 Internal contamination

No attempt is made at internal screening of a large number of affected persons in a nuclear emergency. Only a crosscheck is planned in emergency care centers assessing the radioiodine content of the thyroid. A thyroid surface dose rate of 10 µSv/h corresponds to a thyroid dose of 150 mSv for adults and to 1200 mSv for children.

For smaller incidents or representative measurements, there are about 45 whole body counters operated by hospitals, nuclear power plants, research institutes etc. Routine monitoring of occupational exposure is the main purpose of these instruments. Hospitals and research institutes are certified by a specialized agency (Leitstelle Inkorporationsüberwachung). Instrumentation is mainly NaI detectors with additional high-resolution germanium detectors for nuclide identification. Excretion analysis can be performed at some of these sites but also at other independent laboratories certified by the Leitstelle.

6.8.2 External contamination

In the event of a severe nuclear accident, emergency care centers will be set up upon request by local authorities. Fire brigades and paramedics under the responsibility of the local community operate the centers. Screening measurements are made with simple dose rate meters. If necessary, additional measurements with contamination monitors allow for higher precision.

6.9 Future development

In the near future, improvements and developments in the following areas are planned:

- Implementation of the recommendations of the EU Commission on the application of article 36 of the Euratom Treaty (Dense/sparse network)
- Harmonization of site-specific monitoring programs (REI) and nation wide monitoring (IMIS)
- Improving and enhancing national and international exchange of on-line monitoring data and radiological information (e.g. EURDEP).
- Installation of the RODOS decision support system at the BfS in Bonn for use by the federal government and the states in the event of a nuclear accident

7 Iceland

7.1 National background

The Icelandic Radiation Protection Institute (IRPI, "Geislavarnir ríkisins") is the competent authority and research institute for monitoring radiation and radioactivity in foodstuffs and in the environment. IRPI has a leading role in planning and coordinating nuclear emergency preparedness in Iceland and in providing assessments and information to the relevant authorities and the public.

In a radiological emergency involving an acute threat to the population the Icelandic Civil Defense (Almannavarnir ríkisins) becomes the responsible authority, with IRPI taking on an important advisory role.

IRPI is also the international contact point in Iceland, receiving and sending notifications in the case of radiological or nuclear accidents, in accordance with the IAEA convention and bilateral agreements.

The general background level of the country (gamma dose rate) is fairly well known. It is rather low due to the low concentration of natural radionuclides in the basaltic bedrock of Iceland.

The main nuclear threats are of two types:

1. Health risks due to accidents involving mobile radioactive sources, including reactors, which could cause serious contamination in a limited area.
2. Economic and societal risks due to accidents in nuclear facilities relatively far away, but which could cause a measurable contamination of the environment.

Iceland does not have a nuclear power program and no research reactors; there is basically no domestic nuclear threat to the population or the environment. Nuclear facilities in other countries are also relatively far away (900 km the closest, generally much further away). Mobile reactors (submarines, other types of naval vessels, icebreakers, satellites) represent the most important threat with possible adverse health effects. Other threats are nuclear weapons and the transport of radioactive sources. Mobile reactors are neither in use in Iceland nor controlled by Icelandic authorities even when close to Icelandic territory. Emergency response planning for accidents involving these types of sources is therefore of general nature and not focussed on a specific location or scenario.

Nuclear accidents far away with limited health risks can however have serious economic consequences, due to a measurable contamination of the environment. More emphasis has therefore in recent years been put on fast exchange of information with other countries and the ability to evaluate the radiological situation in Iceland and neighboring regions.

7.2 Automatic gamma monitoring station

At present, there is but one gamma monitoring station in Iceland, located in Reykjavík, (Fig. IS-1). The station has an ionization chamber detector of the same type as used in Sweden.

The gamma station is connected to a computer at IRPI. The reading of the gamma station can be polled at any time from IRPI. This is done automatically a few times per day. Records of the variations in radiation level are kept at IRPI. A block diagram of the gamma monitoring system is shown in Fig. IS-2. This system is currently (late 2000) being integrated with a system of radiation detectors installed in air monitoring stations (described in next section). An example of the output from the gamma station is shown in Fig. IS-3. It shows the typically low and rather stable levels of 50 - 60 nSv/h, reflecting the low concentration of natural radionuclides (e.g., from the uranium and thorium series) in the Icelandic rocks and soils. The fairly low and stable radiation level makes it easier to detect abnormal increases in these levels.

When an alarm is triggered, a signal is sent directly to IRPI. The alarm level is currently set as in Sweden (i.e., at a 300 nSv increase during the last 24 hours). During normal office hours the alarm will be handled routinely by the staff. After office hours an alarm will be sent to the Emergency Notification Department of the Icelandic Coast Guard and they will contact an expert from IRPI to assess the situation. If needed, the Icelandic Civil Defense will be alerted.

7.3 Air monitoring stations

Two high-volume air samplers will be in operation in Iceland in 2001.

1. One is a 550 m^3/h sampler for monitoring low level background values. The collection period for each filter can be up to a month. The filter is made of synthetic fibres. After sampling the filter is pressed into a solid pellet and after waiting for short lived radionuclides to decay, the filter is measured in a HPGe gamma spectrometric system.

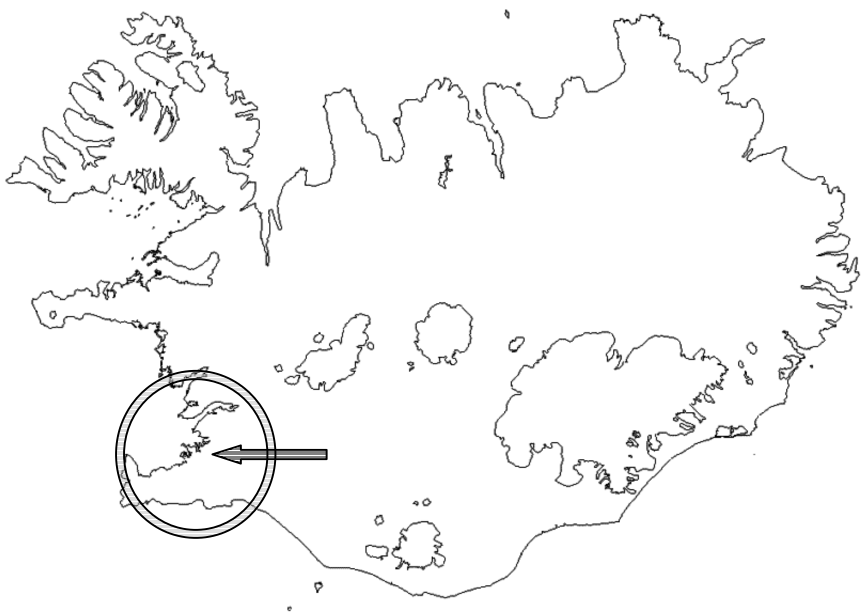


Fig. IS-1. *Location of the automatic gamma monitoring station and the air monitoring stations in Reykjavik (64°05'08"N, 21°50'35"W).*

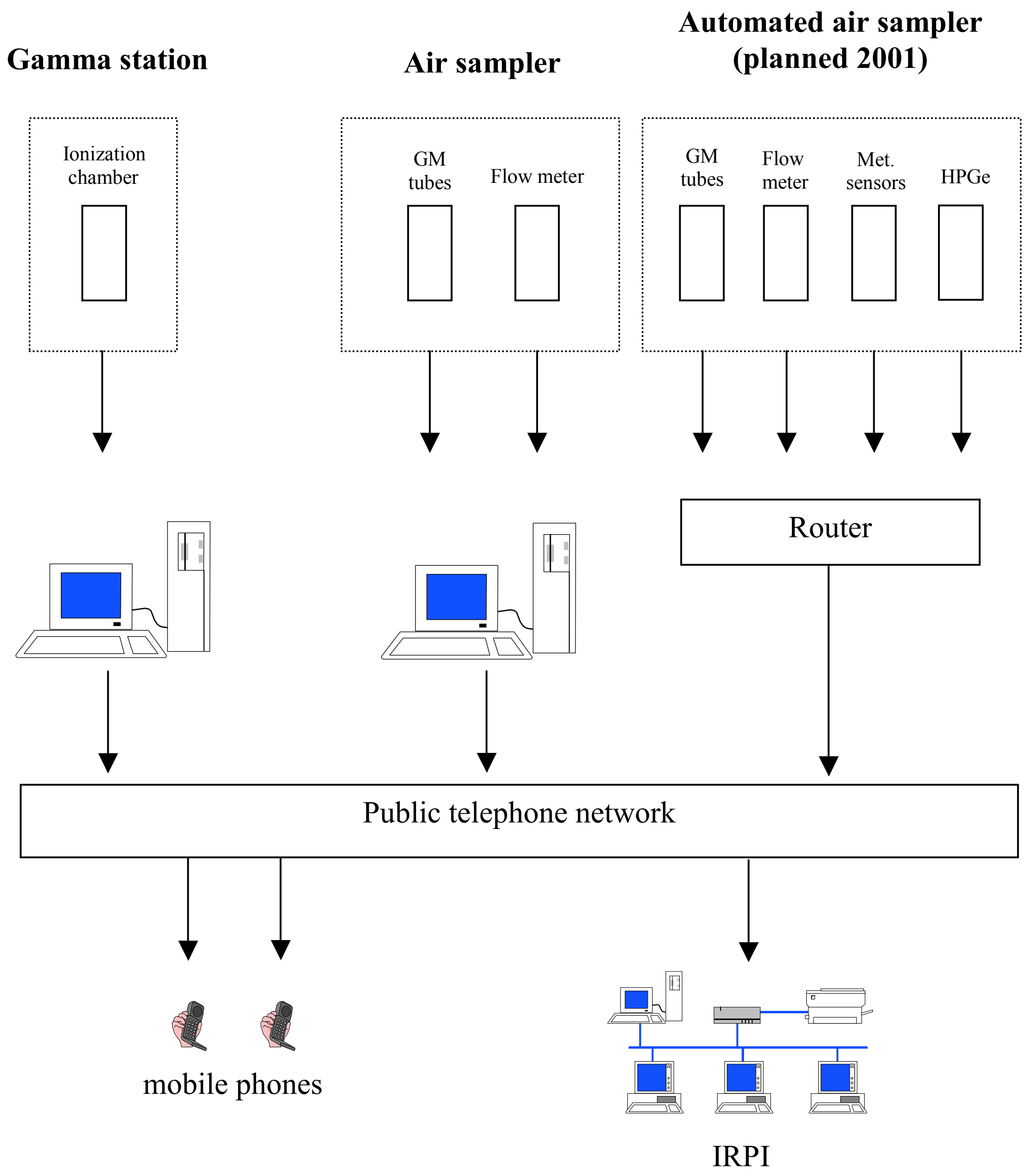


Fig. IS-2. Block diagram of the Icelandic gamma monitoring system.

2. An automatic system with similar flow rate will be installed in 2001. The filter will be changed once per day. This station is a part of the global network of stations of the Comprehensive Nuclear-Test-Ban Treaty Organization (CTBTO). The operating cycle of the automated air sampling station will be 24 hour sampling, 24 hour decay time and 24 hour counting using an HPGe detector. Results can thus be available 48 hours after end of sampling. If required, preliminary results can be obtained earlier, while the counting is still ongoing.

Both samplers have the capability to have detectors monitoring radionuclides on the filter surface during sampling. This option has already been used in the existing system to provide a very sensitive indicator of increased radionuclide concentration in air. If abnormally high levels were reached, then notifications were sent to pagers and by fax. It is also planned to install radiation detectors beneath the filter in the new sampler for continuous monitoring of the radiation level from the filter.

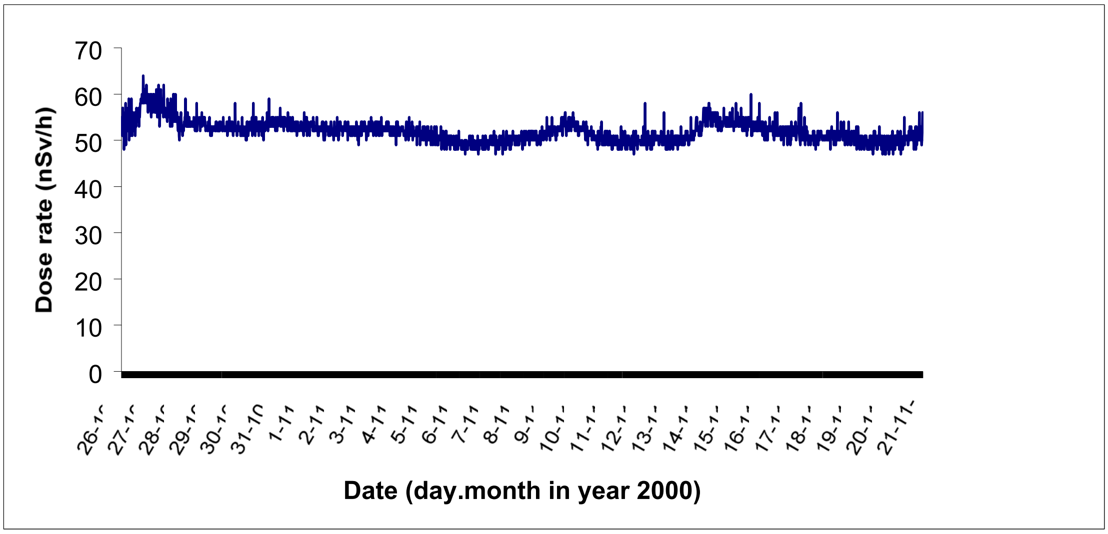


Fig. IS-3. *Typical gamma dose rate background measured in Reykjavik*

This alarm system is now being updated and integrated with the gamma monitoring network. Station information and meteorological information will be included as well. The staff of IRPI can access this information via the Internet. The staff can also access the same information using wireless mobile terminals via the Mobile Internet.

IRPI acts as the Icelandic National Data Center (NDC) receiving data products from the CTBTO International Monitoring System network and as the operator of the station, IRPI will have direct access to the data it produces. This includes data from radionuclide air sampling stations spread over the globe. The data can be available 48 hours after sampling and IRPI will have the ability to analyze the raw data from any of these stations.

Nationally and internationally produced data are thus collected and evaluated at IRPI, and made available to staff using a secure (SSL) Web site when appropriate, accessible using the ordinary Internet or the Mobile Internet via a wireless terminal. This synthesis of information will greatly improve the early warning system and the ability to evaluate possible threats.

7.4 Airborne measurements

In case of an emergency, available mobile equipment could be used for plume tracking.

Iceland has no equipment specially designed for airborne measurements of ground deposition. If needed, such equipment would have to be obtained from other countries.

7.5 Foodstuffs and environmental samples

IRPI continuously carries out measurements of food, water and vegetation samples. At its disposal is the following equipment for spectrometric measurements and beta analysis,

- a radiochemical laboratory
- two HPGe detectors
- one system of 5 low-level beta detectors

When necessary, the facilities at the University of Iceland in Reykjavík and University of Akureyri as well as of the National University Hospital could be used for sample measurements. What this means in terms of equipment and staff can vary from time to time.

The following types of samples are collected on a routine basis and analyzed for gamma emitting radionuclides using HPGe detectors,

Foodstuffs:

- Milk from the largest dairies is monitored every month
- Dry milk from the two national producers
- Lamb meat during the slaughtering season in autumn
- Fish and fish products (being the backbone of the national economy)

Other types of samples:

- Sea water
- Fucus
- Rainwater
- Soil
- Vegetation

Other types of foodstuffs and environmental samples are measured less frequently, but are included as needed.

7.6 Survey teams and local measurements

Civil defense forces and fire brigades do not carry out any type of measurements of ionizing radiation on a routine basis but can be called on to perform gamma dose rate measurements.

7.7 Contamination

7.7.1 Internal contamination

Iceland has no specific systems for whole body counting, but hospitals have detectors that can be used for this purpose. Icelandic hospitals can also perform direct organ scans, and samples of excreta, urine and body fluids can be analyzed for radionuclides. If needed, persons who might have been contaminated internally might be sent abroad for monitoring.

IRPI has hand held monitors which have been calibrated for estimating the concentration of I-131 in the thyroid. Similar monitors are also available at the National University Hospital and have been used during treatment of patients with thyroid cancer.

7.7.2 External contamination

Checks for external beta and gamma emitting contamination may be performed by IRPI and university and hospital staff, using most types of modern portable equipment. Instruments for alpha contamination checks are also available at IRPI.

7.8 Other types of measurements

IRPI has a number of portable instruments for field measurements of total gamma dose rates.

In case of an emergency, some of the instruments may be turned into mobile automatic gamma monitoring stations. This is achieved by affixing the detector on a tripod and linking it to a data logger, a local computer and a modem. Measured data will be forwarded to IRPI over a telephone network or Internet. These stations can also be programmed to send alarms when called for.

7.9 Future development

- Iceland may install a few more stationary gamma stations. An automated air monitoring station will be installed in 2001.
- Mobile gamma monitoring stations are currently (late 2000) being considered. These units could be transported quickly to any location. This would be very important when having to respond to some nuclear threat far away or to threats from mobile sources near or in Icelandic territory.

8 Latvia

8.1 National background

According to the national legislation the regulatory bodies shall be the ministries with their subordinate institutions as executive and technical support organizations. The ministries may issue requirements to their subordinate institutions and also have the right to initiate new legislative acts. The three relevant ministries are:

- Ministry of Environmental Protection and Regional Development
- Ministry of Interior
- Ministry of Welfare

Subordinate institutions to the ministries have executive power in supervising and they also participate in the licensing process.

There have been recent changes in the nuclear legislation and the Parliament has approved a new law on Radiation Safety and Nuclear Safety. According to this law the new regulatory body, the Radiation Safety Center (RDC), will be established in 2001.

Latvia has one research reactor, which was decommissioned in 1998. The major radiological threats are considered to be nuclear accidents outside of Latvia, from legal and illegal transport of radioactive materials.

8.1.1 Organizational structure

The scheme of nuclear regulatory bodies is as follows.

Ministry of Environmental Protection and Regional Development

The Ministry is responsible for coordination of international cooperation, drafting legal documents, development of national strategies etc. Subordinate organizations of Ministry:

- Department of Environmental Protection (DEP), the main duties of the Department include drafting a national environmental protection policy and monitoring its implementation and observance. DEP is responsible for radiation protection and nuclear safety in Latvia.
- Radiation and Nuclear Safety Control Division (RNSCD), which is part of State Environmental Inspectorate (SEI), is the main regulatory body. RNSCD is responsible for nuclear safeguard and supervision of nuclear facilities (except medical).
- RNSCD will work until Radiation Safety Center will be established and then experts from this unit will be transferred to new regulatory body.
- Radiation Safety Center will have full responsibility for state supervisory system and also to manage radiation incidents and to consult Fire and Rescue Service in case of nuclear accidents.
- Latvian Environmental Agency (LEA) is responsible for computer and program support of all institutions under the Ministry as well as maintenance of the Early Warning Monitoring System of Latvia. The Latvian Environmental Agency (LEA) is the owner of the Automatic Gamma monitoring system and the Laboratory Department is the operator of the system. The network consists of 16 stations distributed evenly over the country.

- Latvian Hydrometeorological Board (LHMB) implements state policy in the field of hydrometeorology, carries out hydrometeorological and environmental quality observations, provides weather forecasts and similar information. Environmental pollution observation network stations carries out pollution observations in inland waters, ambient air, snow cover.
- The LHB has responsibility to consult state institution regarding predictions of metrology condition and will participate in case of nuclear emergency as consultants.
- The state enterprise "Radon" was the responsible organization for the national radioactive waste management and the operation of the emergency decontamination unit.
- The new radioactive waste management agency (RAPA) will be established in 2001. This Agency will be composed by former state enterprises "Radons" and "Reaktors, Ltd". RAPA will be responsible for national system of radioactive waste management, safe enclosure of research reactor, decommissioning of the reactor and emergency decontamination activities.
- Regional Environmental Boards (REB) have responsibility for local inspections in small facilities and assistance to SEI.

Ministry of Welfare

- Environmental Health Center (EHC) and Radiological Center (RC) are regulatory bodies in the field of nuclear energy applications in medicine. EHC deals with all medical applications.
- The Radiological Center deals with X-ray applications and operates the national radiation exposure register.
- Both above mentioned institutions of the Ministry of Welfare will change their activities - the experts from them with competence in radiation safety will be transferred to the Radiation Safety Center, e.g., all supervision and control of the users. Also national TLD dosimetry services will be transferred to the Radiation Safety Center.
- Latvian Food Center has responsibility for police development and implementation regarding control of food contamination.

Ministry of Interior

The Ministry of the Interior and the Ministry of Economy must also be mentioned here. These two ministries are responsible for the border control system; certain activities are undertaken by the Ministry of Welfare, namely the Sanitary Inspectorate. The Ministry of the Interior is responsible for the assessment of physical protection and also manages the emergency preparedness system.

- The State Firefighting and Rescue Service has responsibility for emergency preparedness, maintenance of the Alarm Center in case of an emergency and national planning within these areas.
- The border guards are responsible for preventing illicit trafficking of radioactive and nuclear materials.

8.1.2 Legal basis

Laws and the Cabinet of Ministers regulations

The Law on Radiation Safety and Nuclear Safety (01.12.1994, amendment 24.04.1997); new law is in force since 21 November 2000

The Cabinet Regulations on Protection against Ionizing Radiation (12.08.1997, amendments in 1997, 1998)

The Cabinet Regulations on State Accounting and Control System of Nuclear Materials (14.04.1998)

The Cabinet Regulations on Committee of Strategic Export and Import (22.01.1997), they replaced several previous regulations about the implementation of NSG regime in Latvia

The Cabinet Regulations on Issuance of Licenses and Permits for Activities with Radioactive Substances and other Sources of ionizing Radiation (20.06.1996; amendments in 1997 and 1998)

The Cabinet Regulations on Medical Contraindications (17.03.1998)

The Cabinet Regulations on Control of Radioactive Contamination in Food Products (26.05.1998)

The Cabinet regulation on Safe Transportation of Radioactive Materials (28.07.1998)

8.2 Automatic gamma monitoring networks

There are two different automatic gamma-monitoring networks in operation in Latvia. The first system, the Automatic Area Radiation Monitoring system AAM-95, is designed for monitoring releases from foreign and domestic sources. At present the AAM-95 system consists of eight local stations.

The second system, PMS, consists of GM detectors and gamma spectrometers, which are located at seven different places.

The central AAM-95 system is integrated in the PMS server and alerts the staff if the alarm criteria are exceeded. The staff at LEA will then alert the staff at RNSCD, the Department of the Environmental Protection (DEP) and the State Firefighting and Rescue Service (SFRC) by phone, by mobile phone by short e-mail messages, fax and e-mail for decision making and for involving other state offices.

If an alarm occurs in the PMS network, staff from LEA, RNSCD, (SFRC) and Daugavpils Environmental Board can start forecasting the spreading of radioactive material and initiate other actions. LEA has presently not staff on 24-hour duty, but it will be organized as needed. The Radiological Center (RC) has an advisory role and organizes iodine prophylaxis if needed and provides personal dosimetry for persons, who will take part in the rescue work.

The Latvian countrywide monitoring system is presented in Fig. LV-1 and in Tables LV-1, LV-2.

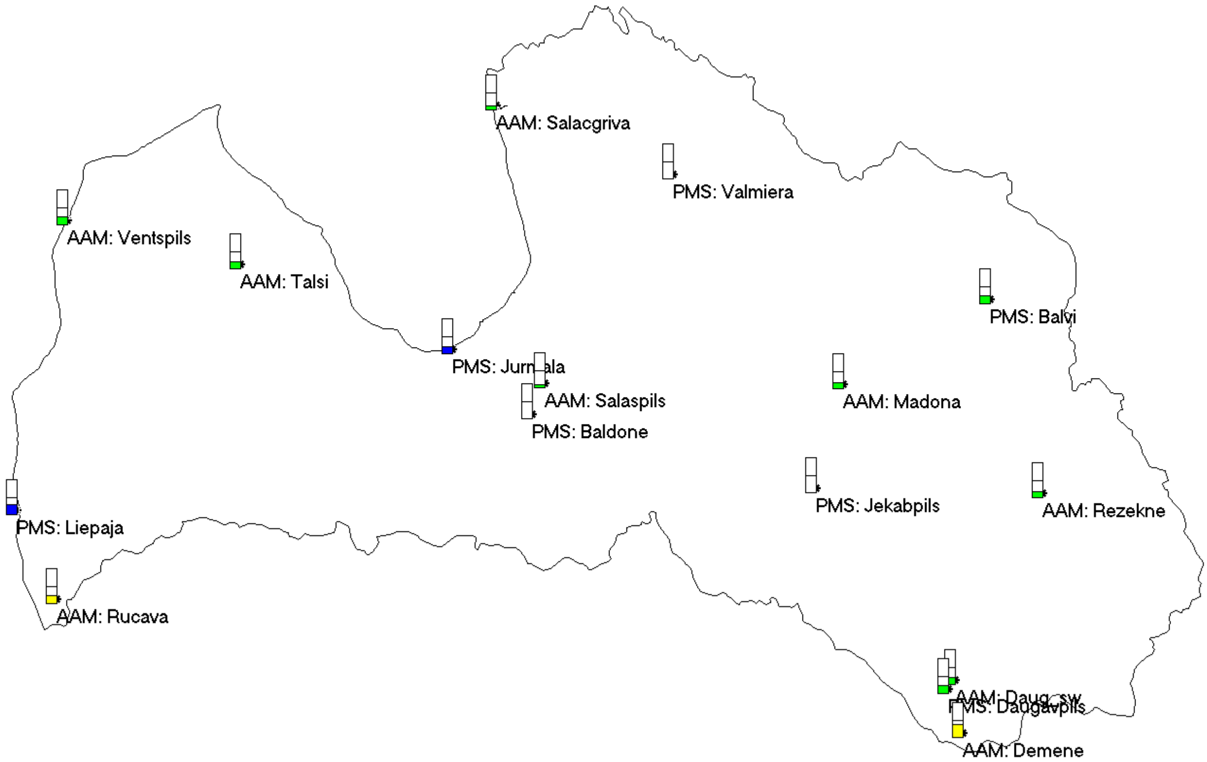


__Fig. LV-1.__ Automatic gamma monitoring networks in Latvia.

__Table LV-1.__ Available radiometric service in Latvia.

Type of measurement		**Organization**
Stationary automatic gamma monitoring stations	15 + 1*	LEA
Manual stations	no	
Air filter stations	3	LEA, RAPA Ltd.
Precipitation's	no	
Subway measuring on sites	yes	RNSCD, LEA, EHC
Total gamma analysis	yes	LEA, EHC, REB
SR90, H3, C14 determination	with liquid scintillation method	LEA
Gamma spectrometry with PGE, GeLi detector	yes	LEA, VDC, EHC, RMC
Alpha spectrometry, determination of transuranium elements	yes	LEA, RMC, VDC
Total alpha	no	
Environmental sampling(soil, vegetation, sediments, water)	yes	LEA
Sources of radioactivity with unknown origin	yes	LEA, RMC
Foodstuff control	yes	EHC,

* GM tube over air filter in JL-900

Table LV-2. *Latvian network of gamma monitoring stations.*

Location	Type of network	ID number	Type of detector	Remarks
Baldone	PMS	PMS 47	RD-02L; Oxford TD3X3	GM tube; NaI(Tl)
Balvi	PMS	PMS 33	RD-02L; Oxford TD3X3	GM tube; NaI(Tl)
Daugavpils	PMS	PMS32	RD-02L; Oxford TD3X3	GM tube; NaI(Tl)
Daugavpils	AAM-95; JL-900	ID 19	RD-02L; Air filtering	GM tube
Demene	AAM-95	ID 11	RD-02L	GM tube
Jekabpils	PMS	PMS 46	RD-02L; Oxford TD3X3	GM tube; NaI(Tl)
Jurmala	PMS	PMS 30	RD-02L; Oxford TD3X3	GM tube; NaI(Tl)
Rucava	AAM-95	ID 18	RD-02L	GM tube
Liepaja	PMS	PMS31	RD-02L; Oxford TD3X3	GM tube; NaI(Tl)
Madona	AAM-95	ID 15	RD-02L	GM tube
Rezekne	AAM-94	ID 16	RD-02L	GM tube
Salacgriva	AAM-95	ID 14	RD-02L	GM tube
Salaspils	AAM-95	ID 13	RD-02L	GM tube
Talsi	AAM-95	ID 17	RD-02L	GM tube
Valmiera	PMS	PMS 48	RD-02L; Oxford TD3X3	GM tube; NaI(Tl)
Ventspils	AAM-95	ID 12	RD-02L	GM tube

8.2.1 Automatic gamma monitoring network AAM-95

General

AAM-95 is a general-purpose area radiation monitoring system, designed for use in a network with eight local stations. The local station measures current gamma dose rate by use of two Rados GM-tubes, RD-02L, placed at a height of 1.5 to 6 m above ground level. The local station sends alarms and fault reports and store raw data from 864 individual measurements. Dose rate data from the detector are displayed locally too. A block diagram of the AAM-95 system is given in Fig. LV-2.

Detector specification

Detector: Two halogen-quenched energy compensated GM tubes
Measurement range: 0.01 µSv/h - 10 Sv/h
Radiation detected: Gamma and x-rays
Energy response: 50keV-3 MeV
Operational temperature range: -40°C to +70°C
Calibration accuracy: ± 5% of Cs137 exposure at 20°C
Measurement accuracy: ± 15% from 0.1 µSv/h to 10 Sv/h

The measurement interval is 15 minutes.

AAM-95 software

All AAM-95 local stations are polled automatically once a day by the central computer at LEA in Jurmala. Under emergency conditions there is a possibility to change the dose rate query interval and transmit results at request. The central computer is used for storing data and calculating gamma radiation doses, altering probe parameters as needed, storing raw data for two weeks and mean values from measurements for one year.

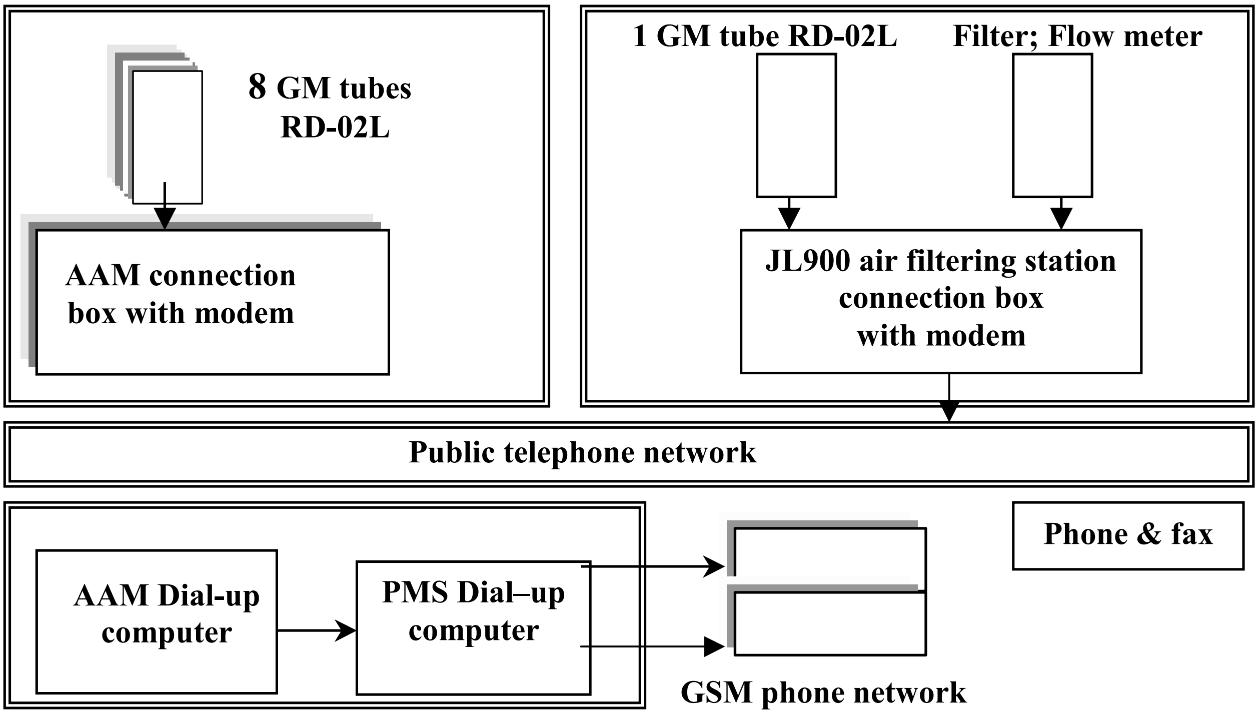


Fig. LV-2. *Block diagram of AAM 95 gamma monitoring system.*

Alarm and malfunction settings

The lower alarm setting corresponds to 500 nSv/h, which is five times higher than the average normal background level of 100 nSv/h. The program calculates doses and gives alarm if the dose exceeds 500 nSv (it is used as default for the alarm threshold by AAM-95 software). If the dose of the last 24 hours exceeds the dose of the previous 24 hours by the alarm threshold value, an alarm will occur.

When a detector or system develops a fault, the program displays a malfunction alarm message with error code. There are eleven fault codes. Malfunctions can be ruled out by repeated polling automatically or manually. Summation of data, trends and tables are prepared automatically.

8.2.2 Automatic gamma monitoring network PMS

General

The PMS system consists of seven local stations and a central monitoring server and is a surveillance tool for gamma monitoring in the environment, especially relating to nuclear emergency situations. The system is designed to be in operation at all times. The unmanned local stations measure various radiological data, weather and other environmental conditions. The results are stored locally. If the radiation reaches threshold levels, this will be reported when the local station is checked by the server. This check is done every 10 minutes. All measurement data remain stored on the local PMS Station for 3 days in a directory accessible from the PMS Server, and in another directory in a compressed format for up to one month.

A block diagram of the PMS system is given in Fig. LV-3.

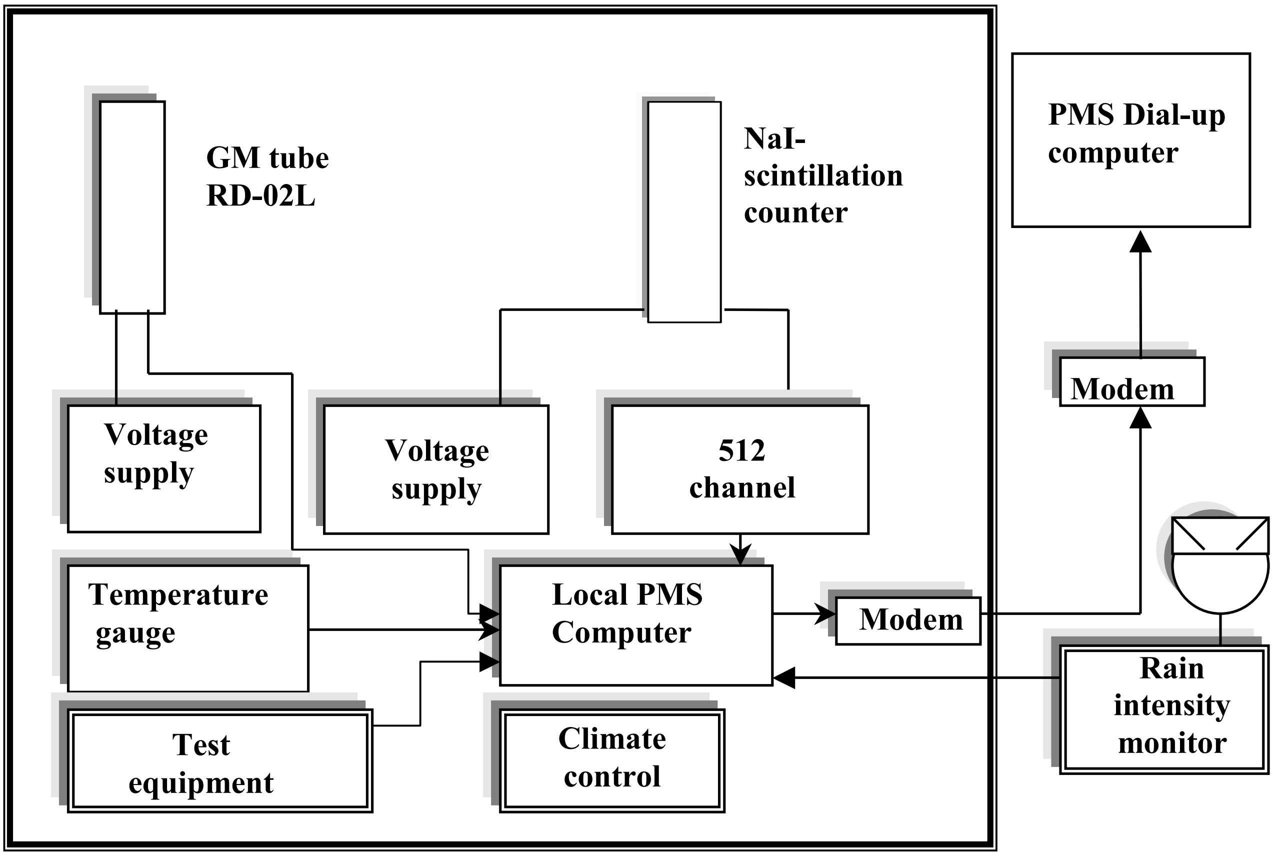


Fig. LV-3. *Block diagram of PMS gamma monitoring station.*

Specifications

For measuring gamma dose rate the GM detector Rados RD-02L is used. The dynamic range is 10 nSv/h - 10 Sv/h and the GM data are collected each minute. An Oxford TD 3x3 inch. NaI(Tl) detector together with a 512 channel analyzer for gamma spectrometry is also used.

The spectrometer energy setting is adjusted for giving the number of counts per second for each of a number of pre-set energy windows, representing radon gas as radon daughters, K-40 and some man-made radionuclides, such as Cs-137. The GM reading interval is every 1 minute, and the NaI reading every 10 minutes. Ten-minute spectra are written as a file. This file is automatically transmitted from server. At each site there is also a rain intensity gauge that gives an impulse for every 0.1 mm of precipitation and furthermore the temperature at the station is recorded. With fixed intervals of six hours the PMS server calls each local station and transfer measurement data.

PMS software

The PMS server handles most communications and analyses. It is connected to the local stations by public phone lines or MEPRD computer network. The PMS software is designed to run around the clock to regularly monitor the present situation on the attached PMS local stations. The PMS software consists of several programs: PMS Dialer, PMS Database, PMS Data Insertion, PMS Alarm monitoring, which should be running at all times.

Alarm levels

The system software allows to set alarm levels separately for the total gamma dose rate and for dose components caused by natural radioactivity as radon, K-40, thorium and by artificial ones belonging to the group "remaining". When one or more of calculated radiation dose levels exceed the following settings an alarm is triggered:

- gamma dose rate level from the GM-tube exceeds 200 nSv/h
- dose rate from K-40 exceeds 200 nSv/h
- dose rate from thorium exceeds 200 nSv/h
- dose rate from radon exceeds 200 nSv/h
- dose rate from remaining exceeds 30 nSv/h

If an alarm occurs and Alarm Dial Up is enabled, the local PMS station calls the server. The program can also send and display malfunction messages.

8.3 Manual gamma monitoring station

In Latvia there is no manual gamma-monitoring network at present.

8.4 Air monitoring stations

8.4.1 General

LEA operates two stations: one stationary high-volume air monitoring station JL-900 for aerosols and gaseous iodine in Daugavpils and one mobile air filter station JL-150. Under normal conditions the filters will be sent to LEA in Jurmala weekly for gamma spectrometric analysis. The mobile air filtering station JL-150 is used for on-site field measurements.

An environmental air filter station is located near the decommissioned Nuclear Research Center (NRC) (now: State Enterprise RAPA) in Salaspils and Radioactive Waste Disposal (RWD) site in Baldone. This station is equipped with a Typhon type air-filtering device. Spectrometric analyses are carried out by RAPA and LEA. Sampling of precipitation and subsequent radiometric analysis, which earlier was performed by Latvian Hydrometerological Board, is now interrupted.

8.4.2 Specifications

	SnowWiteJL900	**Hunter JL150**	**Typhon**
Air flow rate: filter	900 m3/h	150 m3/h	1000 m3/h
carbon	12 m3/h	12 m3/h	-
Filter type:	Whatman GF/A	Whatman GF/A	Petrianoff
	Activated carbon	Activated carbon	-
Filter size:	570x460 mm	530x285 mm	550x550 mm
Detection limit of	2 µBq/m3	10 µBq/ m3	not found
	(for Cs-137 weekly sampling)		

8.4.3 Alarm levels and filter change rate

Station JL900 has the alarm for early warning based on counting data of a GM-tube, placed above the filter. The device will trigger an alarm in response to an increase of the gamma dose rate to more than 500 nSv/h. The GM-tube is included into the AAM-95 monitoring network as the ninth local detector. Alarms are transmitted automatically by use of the public phone line.

The filters are changed once a week and once in two weeks during summer time. When necessary, the filters will be changed and analyzed more often.

8.5 Survey teams

In case of a nuclear accident, mobile survey team can initiate and carry out assessment of environmental dose rates and fallout with cars equipped with

- 16 L NaI(Tl)-detector GPX-1024 (Exploranium)
- Multichannel analyzer GR-820 (Exploranium)
- GPS and DGPS
- Navigation indicator with variable sensitivity
- Radar altimeter
- Standard 486 PC with
- GM counter
- NaI(Tl) scintillation detector and gamma spectrometer
- Mobile air sampling unit Hunter JL150 for aerosol and iodine measurements
- Personal dosimeters
- Mobile ARGOS Workstation for implementation data from mobile radiation monitoring equipment into ARGOS NT code and conversion of detailed for use in ARGOS NT
- Surface contamination meters

There is a plan to increase the capacity of survey teams by technical upgrades in 2001 and 2002, the Fire and Rescue Services by portable devices, which will be used for investigations in contaminated areas, and to control emergency working conditions.

8.6 Foodstuffs and environmental samples

The analysis of radioactivity in foodstuffs is handled by the Environmental Health Center (EHC). The EHC organization includes laboratories in the ERB equipped with radiometers for checking total beta contamination.

In case of a nuclear emergency, food and environmental samples will be measured, if required, in LEA, EHC, State Enterprise RAPA and Veterinary Diagnostics Center (VDC) with high-resolution gamma spectrometry.

LEA has four high-resolution gamma spectrometers, manufactured by Ortec and Canberra. One of them is portable and mobile for *in-situ* measurements. A Canberra Packard low background liquid scintillation radiometer TRICARB and Wallac liquid scintillation radiometer GUARDIAN is available at LEA for strontium 90 analysis and in addition an Oxford alfa spectrometer is used for determination of transuranium elements.

8.7 Future developments

- From July 2001 supervision and control in radiation safety and nuclear safety field will independently be carried out by the state regulatory authority, the Radiation Safety Center (RSC), being supervised by the Ministry of Environmental Protection and Regional Development.
- The new Radioactive Waste Management Agency (RAPA) will be established in 2001. This Agency will be composed by former state enterprises "Radons" and "Reaktors" Ltd. RAPA will be responsible for national system of radioactive waste management, safe enclosure of research reactor, decommissioning of the reactor and emergency decontamination activities.
- Both above mentioned institutions of the Ministry of Welfare Environmental Health Center (EHC) and Radiological Center (RC) will change their activities - the experts from them with competence in radiation safety will be transferred to the Radiation Safety Center. Also national TLD dosimetry services will be transferred to the Radiation Safety Center.
- There is a plan to increase the capacity of survey teams by technical upgrades in 2001 and 2002 the State Firefighting and Rescue Services by portable devices, which will be used for investigations in contaminated areas and to control emergency working conditions.

9 Lithuania

9.1 National background

Ignalina Nuclear Power Plant represents the most important domestic nuclear threat. Other potential nuclear threats are represented by radioactive waste disposals, industrial facilities where radiation sources are used and medical applications of radiation sources for diagnostics and treatment. Loss of control over radiation sources may lead to dramatic impact on the region.

9.1.1 Legal basis

- Law No. VIII-1019 On Radiation Protection, adopted on 12 January 1999
- Law No. VIII-529 On Environmental Monitoring, adopted on 20 November 1997
- National Environmental Monitoring Program, adopted by Government on 01 July 1998, Government Protocol No. 27
- Governmental Decision "General provisions on dosimetric control in the case of radiation accident", No. 578, 1998
- Draft agreement on exchange of information of radiological significance between Denmark, Estonia, Finland, Germany, Iceland, Latvia, Lithuania, Norway, Poland, Russia, Sweden and the European Commission.

A number of hygiene norms adopted by the Minister of Health Care determines general requirements for monitoring for exposure and radioactive contamination, permissible levels of radioactive contamination of different items, and sampling techniques,

- **HN 24:1998 "Drinking water. Quality requirements and monitoring"**
- **HN 54:1998 "Raw materials and foodstuffs. Maximum permitted levels of chemical contaminants and radionuclides"**
- HN 72:1997 "Sampling methods of foodstuffs, feedingstuffs, soil and water for determination of specific and volumetric activity of radionuclides"
- HN 73:1997 "Basic standards of radiation protection"
- HN 84:1998 ”Maximum permitted levels of radioactive contamination of foodstuffs and feedingstuffs following a nuclear of radiological emergency"
- HN 85:1998 "Natural exposure. Standards of radiation protection"

9.1.2 Organizational structure

Ministry of the Environment, Joint Research Center (JRC). The Ministry of Environment is responsible for organization and coordination of monitoring of releases and the monitoring of environment.

The Radiation Protection Center is responsible for monitoring of drinking water, foodstuff and its raw materials, building materials and all items, which may cause human exposure.

Two levels of radioactivity monitoring are provided for: National environmental monitoring and Monitoring of industrial sites.

The Ministry of Environment elaborated a National Environmental Monitoring Program. The program was approved by the Government in 1998. The Program includes the monitoring of air, water and soil radioactivity. The monitoring network covers the entire country. Samples of water, soil and aerosols are taken regularly and measured in laboratories. Monitoring for radioactivity in the Baltic Sea is performed in accordance with the Recommendations of the Helsinki Commission. Measured data are transmitted to the database of the Helsinki Commission. A network of automatic permanent gamma measuring stations is one of the most important components of the national monitoring system. Special attention is focused on the Ignalina Nuclear Power Plant region. The measured data is transferred to the data base computer with the Joint Research Center (JRC) of the Ministry of Environment via the telephone lines. If the gamma dose rate exceeds a threshold the computer is to generate an alarm signal.

Industrial sites shall perform the Monitoring of Industrial Sites in accordance with permits for the use of natural resources issued by the Ministry of Environment. Ignalina Nuclear Power Plant performs the monitoring of radioactive effluents into air and water. Also, the nuclear power plant controls the contamination of the nearest environment. Data on releases of radionuclides into the environment and contamination of the environment are stored in the database of the Ministry of Environment.

9.2 Automatic and semi-automatic gamma monitoring networks

There are two different automatic gamma radiation-monitoring networks in Lithuania. The AAM-95 network has five stations (two of them will be put into operation very soon) and the PMS network has nine stations, see Fig. LT-1. The central AAM-95 computer and the PMS server at the JRC alert the staff if the alarm criteria are exceeded. The staff at JRC will then alert the staff in the Civil Defense Department by phone, fax, or e-mail for decision making and for involving other state organizations. The Civil Defense department has the staff on 24-hour duty. The information also will be transferred to VATESI, the central nuclear safety authority.

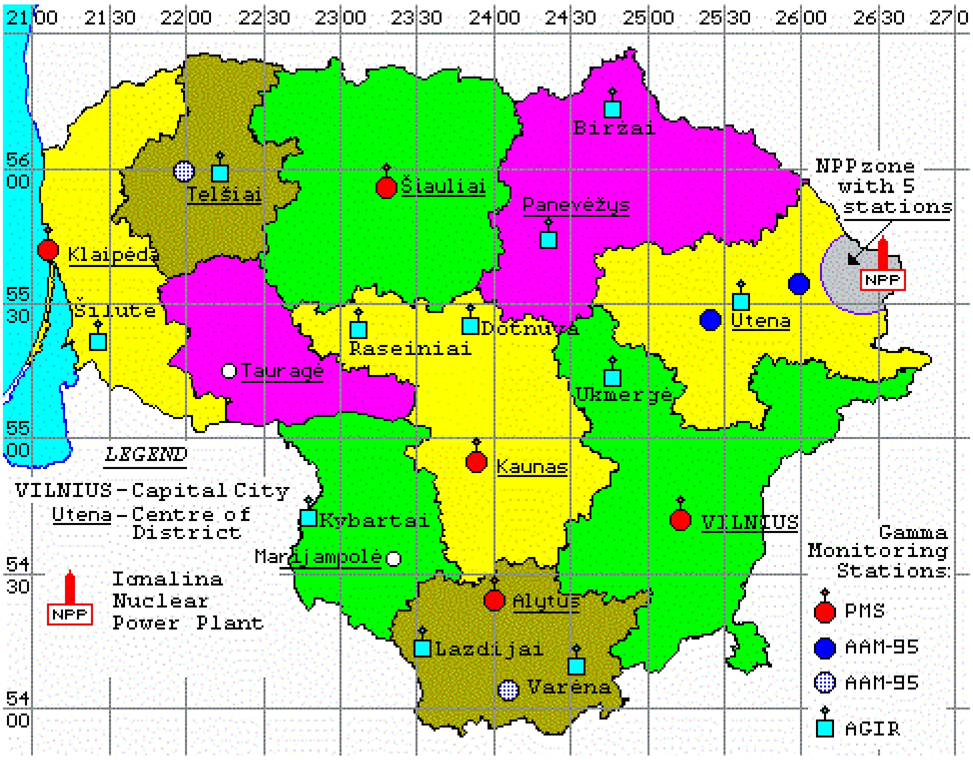
9.2.1 Automatic gamma monitoring network PMS

General

The PMS system consists of nine local stations and a central monitoring server and is a surveillance tool for gamma monitoring in the environment. The system is designed to be in operation at all times. It is a fully automatic system, which measures various radiological data, weather and environmental conditions. If the radiation reaches threshold levels, this will be automatically reported to the main server at the JRC. Under normal conditions the PMS server transfers the data from each station every three hours. The data from each station are stored in compressed format on the PMS server. The structure of the PMS system is shown in Fig. LT-2.

Equipment

All PMS stations have GM RADOS RD-02L detectors, which measure the gamma dose rate. The dynamic range is 10 nSv/h – 10 Sv/h (the data are collected each minute). An Oxford TD 3×3-inch NaI (T1) detector together with a 512-channel analyzer for gamma spectrometry is also used. The spectrometer energy setting is adjusted for giving the number of counts per second for each of the pre-set energy windows. The measurement interval is set up to 10 minutes. There is also a rain gauge at each station, which measures rain intensity. Three thermometers are also used at each station (at the NaI crystal, in enclosure and outdoors).



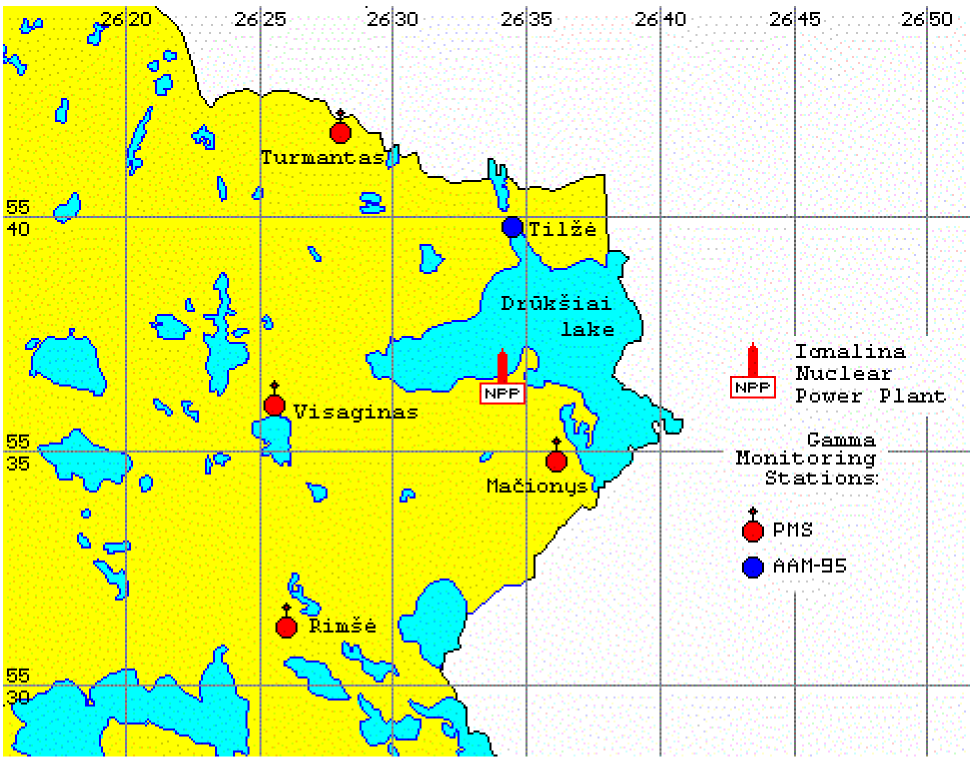


Fig. LT-1. Automatic gamma monitoring networks in Lithuania.

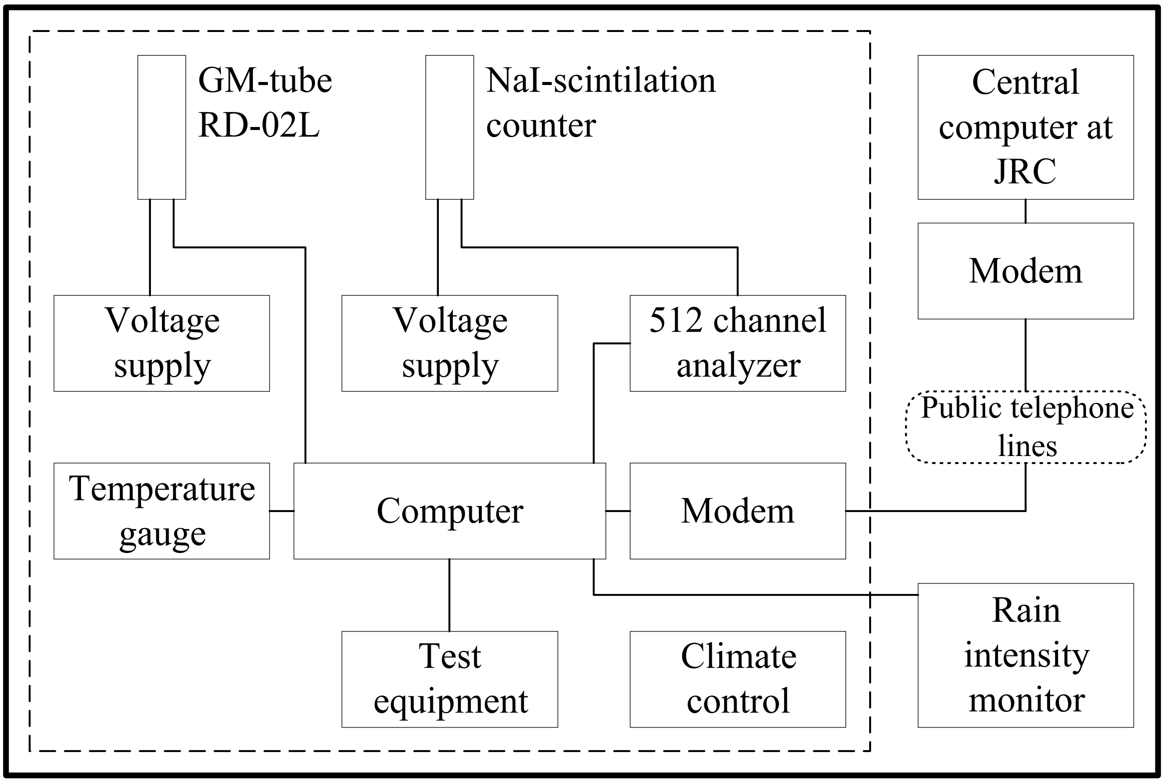


Fig. LT-2. *Block diagram of the PMS gamma monitoring network.*

PMS software

The PMS server handles most communications and analysis. It is connected to the local stations by public phone lines. At fixed intervals of three hours the PMS server calls each station and transfers local measurement data. The program can also send and display malfunction messages.

Alarm levels

An alarm is triggered when gamma radiation dose rate exceeds the following alarm thresholds:

- Gamma dose rate from GM tube – 200nSv/h;
- Dose rate from radon daughters– 200nSv/h;
- Dose rate from remaining energy windows – 50nSv/h.

9.2.2 Automatic gamma monitoring network AAM-95

General

The AAM-95 system consists of five local stations and a central computer at JRC. One of them is combined with air sampling equipment. It is a fully automatic system, which is designed to be in operation at all times. If the radiation reaches threshold levels, this will be automatically reported to the main computer at JRC. In normal conditions the station sends the radiological data to the main computer every six hours. The structure of the AAM-95 system is shown in Fig. LT-3.

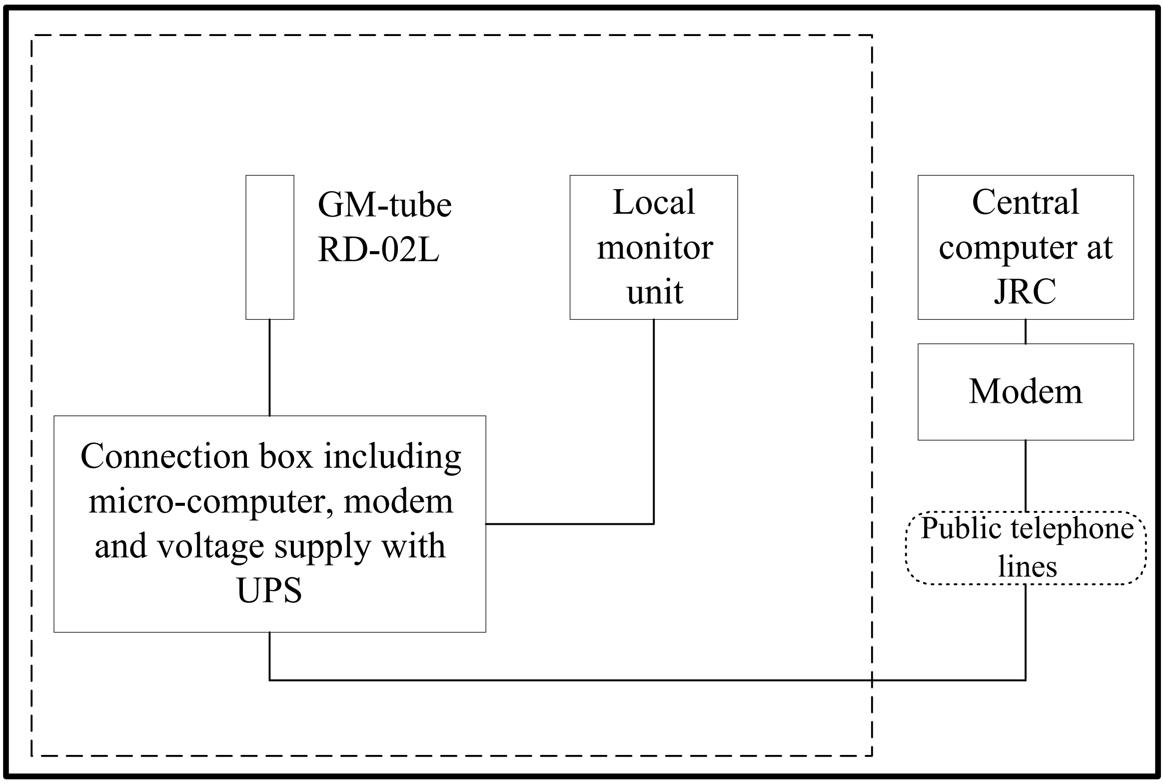


Fig. LT-3. *Block diagram of the AAM-95 gamma-monitoring network.*

Equipment

The local stations measures the current gamma dose rate by means of the GM tube RD-02L placed at a height of 4-10 meters above the ground. The local stations send alarms and fault reports and store raw data from 864 measurements. All the data from the detector are also displayed locally too.

AAM-95 software

Under emergency conditions there is a possibility to change the dose rate query interval and transfer the data on request. The main computer is used for storing and calculating gamma radiation dose rates, altering probe parameters as needed, storing raw data for two weeks and mean values from measurements for one year.

When a detector or system develops a fault, the program displays a malfunction alarm message and an error code. Malfunctions can be examined automatically or manually by calling the station from the main computer.

Alarm settings

The alarm threshold is set to 200nSv/h. The program also calculates dose rates and gives an alarm if the dose of the last 24 hours period exceeds 0.05 µSv. If the dose of the last 24 hours exceeds the dose of the previous 24 hours by the alarm threshold level, an alarm will occur.

9.2.3 Semi-automatic gamma monitoring network AGIR

General

The AGIR semi-automatic gamma-monitoring network was designed by the Lithuanian Institute of Physics and is placed countrywide in Lithuania. The system consists of 11 local stations, which are placed in meteorological stations, and 9 stations placed in public health centers and their branches. The AGIR network is called "semi-automatic", because local operators should read the data and input them manually into a local computer. Presently, it is not possible to do this automatically. The structure of the AGIR system is shown in Fig. LT-4, and in Fig. LT-1 and LT-5, the placement of semi-automatic gamma monitoring stations is shown.

Equipment

Each AGIR station is equipped with a NaI-scintillation counter with a local monitor, which displays the data of the station, a printer and a local computer with an Internet connection.

AGIR software

Data from 11 AGIR stations, presented in picture LT-1, are handled by local operators on 24-hour duty. Data readings are carried out every three hours. After that the data are entered into a local computer. The main computer at the JRC transmits the data by an Internet connection using ftp.

Data from 9 AGIR stations, placed in public health centers and their branches, are transferred to the Radiation Protection Center once per month. In case of dose rates higher than alarm threshold, the data shall be transferred immediately.

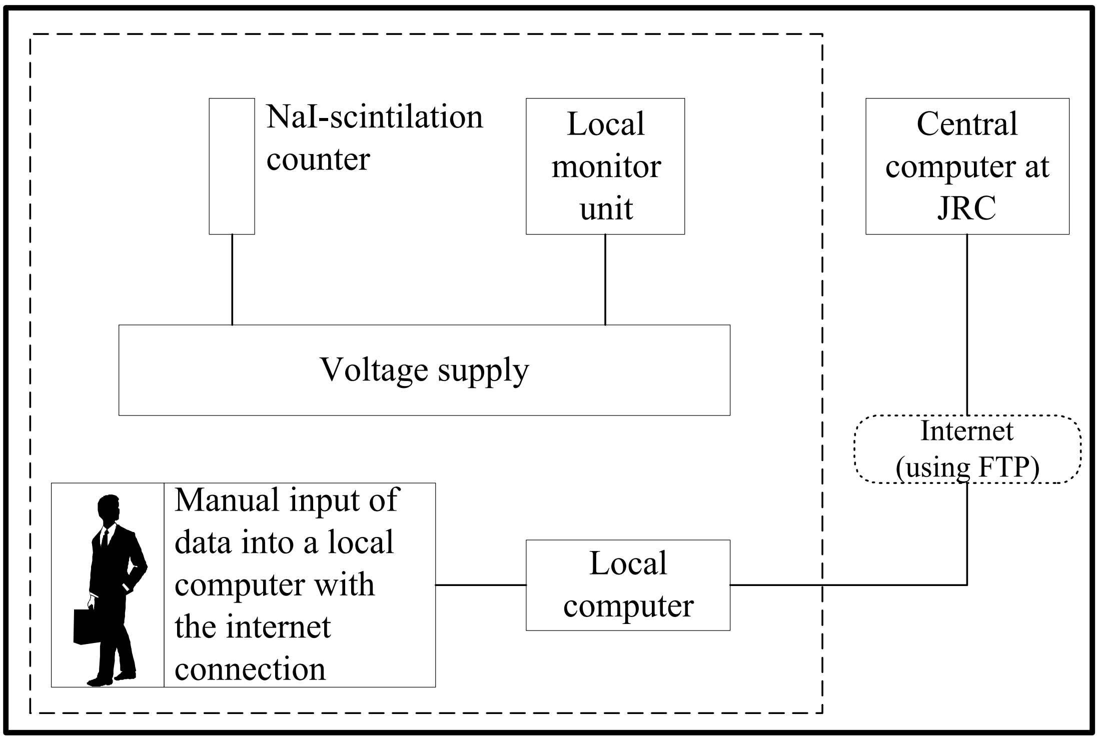


Fig. LT-4. *Block diagram of AGIR gamma monitoring network (local computer and Internet connection is not available in 9 AGIR stations, operating in public health centers and their branches).*

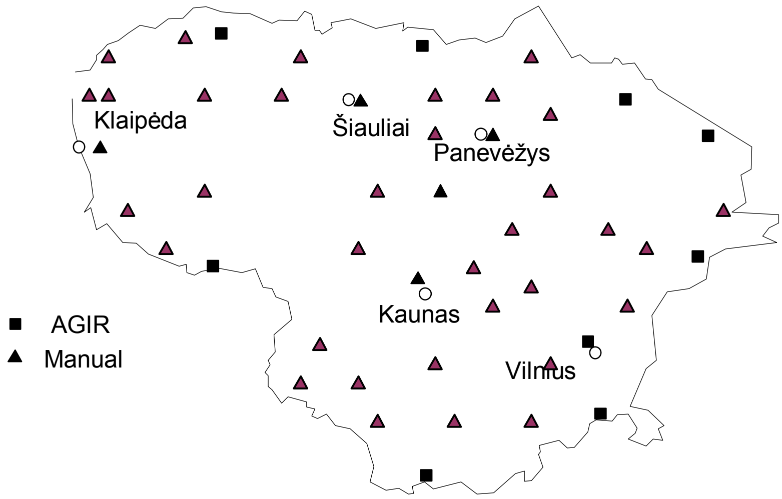


Fig. LT-5. *Manual and semi-automatic gamma monitoring networks in Lithuania.*

Alarm settings

The alarm threshold level is set to 200nSv/h.

9.3 Manual gamma monitoring networks

Manual gamma monitoring is performed inn Kaunas, Klaipeda, Siauliai and Panevezys departments of the Radiation Protection Center, in public health centers and their branches (54 points) all around Lithuania, cf. Fig. LT-5. Radiometers SRP88, calibrated for dose rate measurements, and NaI(Tl) detectors of dimensions 40×40 mm^2 are used. Measurements are performed once per day and data are transferred to the Radiation Protection Center once per month. This system enables an increase in the frequency of monitoring if necessary.

9.4 Air Monitoring Network

9.4.1 General description of the network

In 1997 the modern air filter station *Snow White JL 900* was installed in Utena city for detecting air contamination. Glass fiber and activated charcoal filters from this station are analyzed by gamma spectrometer. The glass fiber is changed twice a week and charcoal filters every month.

9.4.2 Alarm level

The filter station *Snow White* has a GM type detector placed just above the filter frame which enables it to check the radiation level in the surrounding air. The gamma-detector belongs to the radiation monitoring station of the AAM-95 system described above. As radioactive particles are concentrated on the filter, the reading from this detector increases. These data are valuable for very early detection of the activity concentration increase in the atmosphere. For this purpose, the alarm level for the station is set to 0.3 μSv/h.

9.5 Measurements of fallout radioactivity

Atmospheric fallout is continuously collected at 5 stations (Vilnius, Kaunas, Klaipeda, Utena and Dukstas). The total beta activity of ashed samples is measured. Every quarter, gamma spectrum analyses of integrated samples is performed.

In addition precipitation is permanently collected in Vilnius. Sampler area is 0,25 m^2. Samples are analyzed once per month and total beta activity is determined. This activity is normalized for 1 m^2 and 24 hours. Besides, samples of 3 months are used for determination of Sr-90 and Cs-137 concentrations. Radiochemical separation is used during analysis.

9.6 Airborne gamma measurements

At the moment Lithuania does not have an aircraft equipped with a spectrometer to perform gamma mapping of contaminated areas.

9.7 Survey teams

For mapping of contaminated areas the JPC has at its disposal a mobile laboratory equipped with large volume (4 l) NaI detector, spectrometer and GPS system as well as portable gamma spectrometers.

9.8 Foodstuffs and environmental samples

Food analysis is based on determination of activity of radionuclides in individual food items rather than in mixed diet samples because this kind of analysis can indicate which countermeasures should be taken in order to reduce doses. Selection of foodstuff to be sampled is based on food consumption statistics. Concentrations of two long-lived radionuclides Cs-137 and Sr-90 are routinely monitored.

Samples of drinking water are controlled for naturally occurring radionuclides as well. The first step of analysis is determination of gross alpha and beta activity in drinking water. In case gross alpha activity exceeds 0.1 Bq/l or gross beta activity exceeds 1 Bq/l, more detailed analysis of content of radionuclides is performed.

Long lived radionuclides (Sr-90, Cs-137) in foodstuff, drinking water and soil in Ignalina Nuclear Power Plant region are monitored. For comparison, measurements of these radionuclides are also performed in five different geographical areas at different distances from Ignalina. The samples are taken up to four times per year in different seasons and gives information on migration of radionuclides. The frequency of sampling at 9 monitoring points is 105 samples of food and 144 samples of drinking water. Meat is sampled twice, milk four times, fish twice, vegetables (potatoes and cabbages) once in the end of summer, cereals once per year, soil (from the cultivated fields in which the vegetables are growing) once per year, and drinking water four times. It is possible to perform more frequent sampling after an accident.

Sampling techniques are used following the Hygiene standard 72:1997 “Sampling methods of foodstuffs, water, feedingstuffs and soil for determination of specific and volumetric activity of radionuclides”. Analysis of activities of radionuclides is performed taking into account an influence of food preparation activities such as washing, cleaning, etc.

Measurements of activity of Sr-90 are performed by Liquid Scintillation Analyzer Tri-Carb 2770 manufactured by company Packard. The procedure of determination of Sr-90 is based on measurements of activity of Y-90 after extraction of yttrium by di(2-etyl-hexyl)phosphoric acid. Cerenkov radiation is registered in a Liquid Scintillation Counter. It is applicable for all kind of samples.

In order to increase sensitivity of measurements registration of activity of Cs-137 and Cs-134 is performed by low level radiometer after chemical separation in order to assure higher sensitivity and lower limits of detection.

Gross alpha and beta activity in drinking water is determined by liquid scintillation counting of water sample evaporated 10 times, and by counting of ash after evaporating water to dryness (monitoring gross beta together with K-40). Gamma spectrometry is performed by Oxford spectrometer with Ge detector (diameter 55.5 mm, length 55.3 mm) and Elektronika spectrometer with a NaI(Tl) detector (diameter 63 mm, length 63 mm).

In Fig. LT-6, a map of sampling locations is shown.

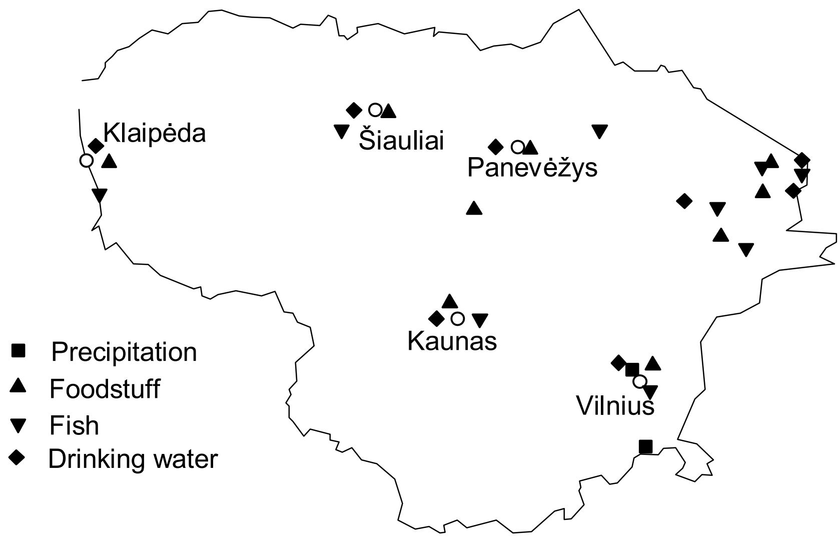


Fig. LT-6. *Locations of sampling of precipitation, foodstuff and drinking water.*

9.9 Contamination measurements

9. 9.1 Internal contamination

Whole body counting and measurements of content of radionuclides in biological samples determine activities of internally deposited radionuclides. Whole body and thyroid counters are available at Ignalina Nuclear Power Plant. The whole body counter (with a Ge(Li) detector) is used for determination of internal contamination of human lungs and body with gamma radionuclides. The counter allows detecting radionuclides with gamma energies in the range of 50 keV to 3 MeV. The range of measurable activities is 1.2 10^4 to1.1 10^7 Bq for Cs-137 in whole body, and 1.6 10^2 to 3.7 10^6 Bq for Co-60 in lungs. The range of measurable activities of I-131 by thyroid counter (with NaI(Tl) detector) is 3.7 10^3 to1.9 10^6 Bq.

There are two hospitals in Lithuania with gamma cameras. These cameras may be used under accidental conditions. Bioassay measurements started in the Radiation Protection Center. Urine samples are analyzed by means of gamma spectrometry, liquid scintillation counting and measurements of gross beta activity.

9.9.2 External contamination

Surveys of external contamination are carried by the Radiation Protection Center using contamination monitors.

9.10 Measurements of doses to members of public

Measurements of external exposure to public were started in 1992. The doses to members of public in the Kupiskis region are compared with doses received by inhabitants of Utena, Ignalina, Zarasai regions. Dosimetry measurements are performed every 6 months for groups of persons (80 to 100) by means of TLD. LiF detectors are used. The errors of measurements in dose range of 10^{-4} to 10^{-2} Gy are 30%, in range of 10^{-2} to 10 Gy – not more than 15%.

9.11 Future developments

It is necessary to install a whole body counter since now available is rather old. Besides, problems of calibration of whole body counter shall be resolved.
Another direction is creation of system of routine bioassay measurements for determination of internal exposure.

10 Norway

10.1 National background

The Crisis Committee (Kriseutvalget), a committee with representatives from 5 central authorities on the sub-ministerial level, has been given the responsibility for planning an early phase response to nuclear and radiological accidents. In the later phase of an accident, the committee is acting as an advisory body for the responsible ministries.

The Norwegian Radiation Protection Authority, NRPA, (Statens Strålevern) has the leadership and secretariat for this committee. In the event of an emergency, the Crisis Committee will convene in the facilities of NRPA. Measurements of various kinds form an integral and important part of this organization.

The radiological monitoring program comprises a number of different systems and techniques involving a number of organizations. Various types of measurements are carried out before and after a fallout situation, and the organizations responsible for these measurements, are summarized in Table NO-1.

The Norwegian monitoring system has been established to detect releases emanating from any source, foreign or domestic. The research reactor in Halden and the isotope-producing reactor at Kjeller represent the most important domestic nuclear threat. Nuclear powered and nuclear-armed vessels also constitute a major radiological threat. The national waste management program is a less significant contribution to the total risk.

10.2 Automatic gamma monitoring stations

Norway has an automatic network of 28 gamma-monitoring sites (with a total of 29 detectors) (Fig. NO-1), including one station in Verhnetulomski on the Kola peninsula. The network is used for early warning as well as for a rough mapping of the fallout following an accident. There is a higher concentration of stations in the northernmost regions of the country. The monitoring sites and some technical data are summarized in Table NO-2.

10.2.1 Ionization chamber detectors

There are eleven sites with stationary ionization chamber detectors (Reuter-Stokes), placed approximately 3 m above the ground. These are operated by the Norwegian Institute for Air Research (Norsk Institutt for Luftforskning, NILU) on behalf of NRPA.

Every ten seconds the local microcomputer obtains a reading from the detector. From these readings, 1-hour average exposure rates (expressed in µR/h) are computed and stored. All stations are polled by a central computer at NILU at 1-hour intervals. A block diagram of an ionization chamber station is shown in Fig. NO-2A. All data are displayed locally.

Radon compensation is not possible with these stations, since no spectrometric data are available from them. The central computer at NILU gives an alarm when the total gamma radiation level has increased by 40 nSv/h as compared to the mean value for the last 10 days; or 400 nSv per 24 hours. The latter is computed as the difference in dose between two moving 24-hour windows, covering the last 48 hours.

Table NO-1. *Measurement services in Norway.*

Type of measurements	Organizations								
	NILU	**HI**	**NRPA**	**LORAKON**	**Civ. Def.**	**NGU**	**IFE**	**NLH**	**FFI**	**Armed forces**
Automatic gamma monitoring stations	X						X			
Air monitoring stations: gamma analysis			X				X		X	
Airborne measurements:										
- external gamma						X				X
- air filters										
Field measurements:										
- gamma analysis	X		X	X		X	X		X	
- total gamma	X		X	X	X	X	X	X		X
- air filter gamma analysis			X				X			
- beta			X		X		X			
- alpha			X				X			
Laboratory sample analysis										
- gamma	X	X	X	X			X	X	X	
- beta (Sr)			X				X	X		
- alpha (Pu, Am)			X				X	X		
Whole body counting			X				X			
External contamination			X	X	X		X	X		

NILU Norwegian Institute for Air Research
HI Institute of Marine Research
NRPA Norwegian Radiation Protection Authority
LORAKON Measurement organization of the Norwegian Food Control Authority
Civ. Def. Directorate of Civil Defense and Emergency Planning
NLH Agriculture University of Norway

NGU Geological Survey of Norway
IFE Norwegian Institute for Energy Technology
FFI Norwegian Defense Research Establishment

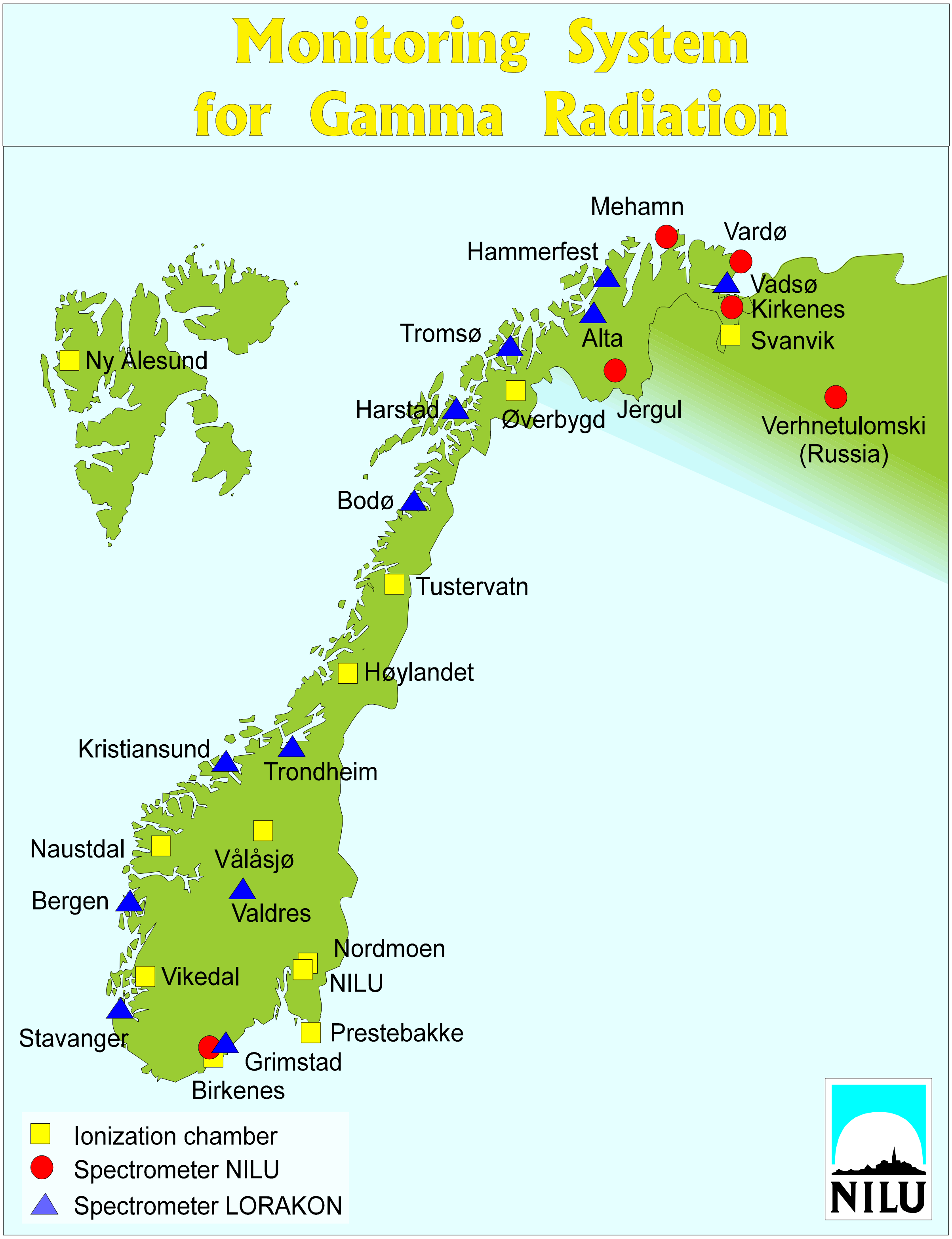


Fig. NO-1. *Norwegian gamma monitoring stations.*

Table NO-2. *Norwegian gamma monitoring stations.*

Location	Type of detector	Central alarm
Ny-Ålesund	Ion ch RSS 121	Yes
Mehamn	Scint S10 Plus	Yes
Hammerfest	Scint S10 Plus	Yes
Vardø	Scint S10 Plus	Yes
Vadsø	Scint S10 Plus	Yes
Alta	Scint S10 Plus	Yes
Kirkenes	Scint Inspector	Yes
Tromsø	Scint S10 Plus	Yes
Svanvik	Ion ch RSS 1012	Yes
Algevarre	Scint S10 Plus	Yes
Øverbygd	Ion ch RSS 1012	Yes
Harstad	Scint S10 Plus	Yes
Bodø	Scint S10 Plus	Yes
Tustervatn	Ion ch RSS 121	Yes
Høylandet	Ion ch RSS 1012	Yes
Trondheim	Scint S10 Plus	Yes
Kristiansund	Scint S10 Plus	Yes
Vålåsjø	Ion ch RSS 121	Yes
Naustdal	Ion ch RSS 1012	Yes
Bergen	Scint S10 Plus	Yes
Valdres	Scint S10 Plus	Yes
Nordmoen	Ion ch RSS 1012	Yes
NILU	Scint S10 Plus	Yes
Vikedal	Ion ch RSS 1012	Yes
Prestebakke	Ion ch RSS 1012	Yes
Stavanger	Scint S10 Plus	Yes
Grimstad	Scint S10 Plus	Yes
Birkenes 1	Ion ch RSS 1012	Yes
Birkenes 2	Scint S10 Plus	Yes
Verhnetulomski (Kola)	Scint S10 Plus	Yes

Ion ch = ionization chamber detector (Reuter-Stokes)

Scint = NaI(Tl) scintillation detectors with multichannel analyzers

Only ionization chamber stations have a separate local logger.

"Central alarms" are issued by the central computer as appropriate during the automatic polling of the stations. These alarms could be delayed due to the one-hour time period between polls.

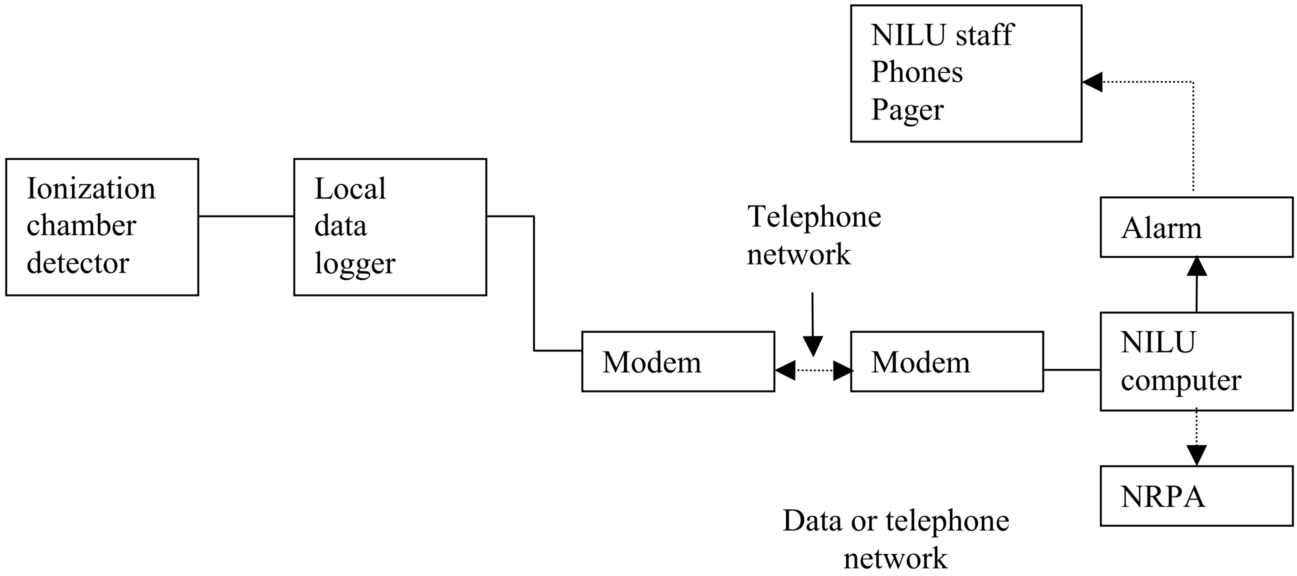


Fig. NO-2A. *Block diagram of the Norwegian ionisation chamber gamma monitoring stations and alarm response.*

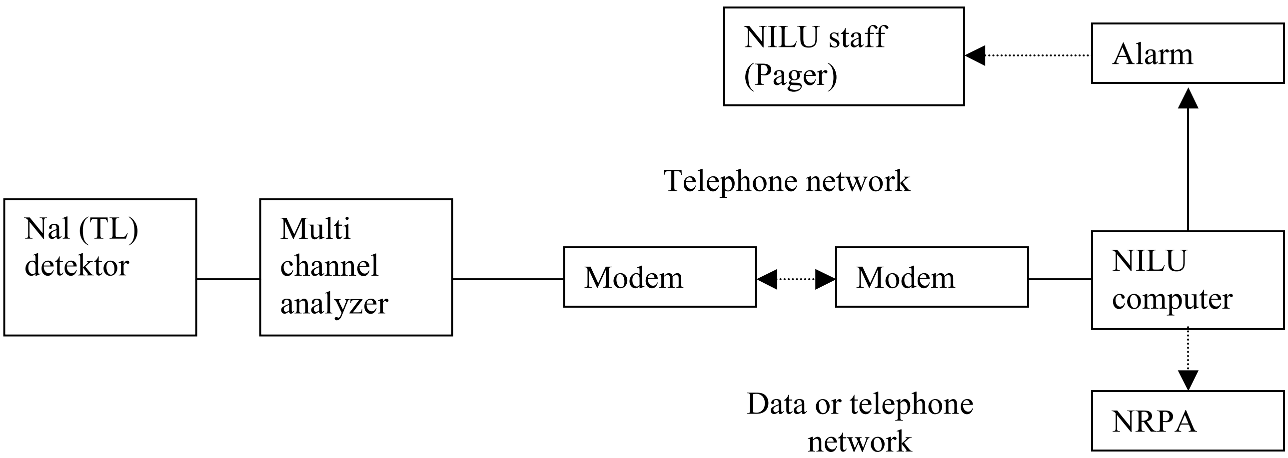


Fig. NO-2B*. Block diagram of the Norwegian NaI(Tl) gamma spectrometric stations and alarm response.*

10.2.2 Scintillation detectors

There are 18 sites with NaI(Tl) scintillation detectors for total gamma and spectrometric measurements (19, including the station in Verhnetulomski, Kola). The spectrometer consists of the detector and a multichannel analyzer; but there is no separate data logger. Introduction of procedures for compensation for variations in radon concentrations makes this a very sensitive system. Very small variations in the normal background radiation level may be detected. A block diagram of the scintillation detector stations is shown in Fig. NO-2B.

Seven of the nineteen stations are operated by NILU. The remaining twelve detectors belong to the LORAKON network and are primarily used for food analysis (see the section on Foodstuffs and Environmental Samples below). During their fairly long down time, they are put in a laboratory window and used by NILU for background surveillance.

The scintillation detector stations are not equipped with local data loggers and may not trigger an alarm themselves. These stations are automatically polled every hour by the central computer at NILU. If during the polling any of the alarm criteria below should be exceeded, an alarm is sent by the NILU computer.

The following alarm criteria are applied for the scintillation detector stations:

• Increase in total gamma dose rate above the mean value for the last 10 days	> 40 nSv/h
• Increase in total gamma dose	> 400 nSv for last 24 hrs
• Increase in the Cs-137 window	> 4 cps (counts per second)
• Increase in the Cs-134 window	> 4 cps
• Increase in the I-131 window	> 4 cps
• Dead time	> 2 %

10.2.3 Data transmission and alarm response

All these stations in Norway are connected to the public telephone network via modems. The main computer at NILU calls each station once per hour to collect the data for storage in a central database, and alerts NILU staff in case one or more of the alarm criteria are exceeded. The station can be called from NILU and recorded data may be transmitted to NILU at any time, regardless of the automatic polling periods. Transmitted data are stored in NILU's main computer for possible future evaluation.

When an alarm level has been exceeded, NILU staff is alerted from the central computer. This is possible on a 24-hour basis thanks to a nationwide pager system operated by the telephone company. A display on the pager gives information on where, when and why the alarm was triggered. If malfunction can be ruled out directly by NILU staff, NRPA is alerted immediately.

10.3 Air monitoring stations

NRPA, operates 5 high-volume air monitoring stations for aerosols, three of which also capable of monitoring gaseous iodine. Under normal circumstances, weekly filters are analyzed by gamma spectrometry. With an air flow rate of 750-900 m^3/h, the aerosol detection limit is typically 0.1-1 µBq/m^3 for weekly samples; for quick tests it is on the order of 1-10 µBq/m^3. For gaseous iodine, the air capacity is 12-20 m^3/h, and the detection limit about 10 µBq/m^3. In addition, NRPA operates two mobile air monitoring stations with a capacity of 140 m^3/h for aerosols and 10 m^3/h for gaseous iodine.

As part of the global monitoring network established under the Comprehensive Test Ban Treaty (CTBT), a monitoring station for aerosols and noble gases is planned to be established at Longyearbyen, Spitsbergen during 2001. Norwegian authorities will have access to the data from this station.

The Norwegian Institute for Energy Technology (Institutt for Energiteknikk, IFE), operates on behalf of the Norwegian Defense Research Establishment (Forsvarets Forskningsinstitut, FFI), four stationary air monitoring stations with an air flow rate of about 20 m^3/h.

The locations of the stationary Norwegian air monitoring stations are shown in Fig. NO-3.

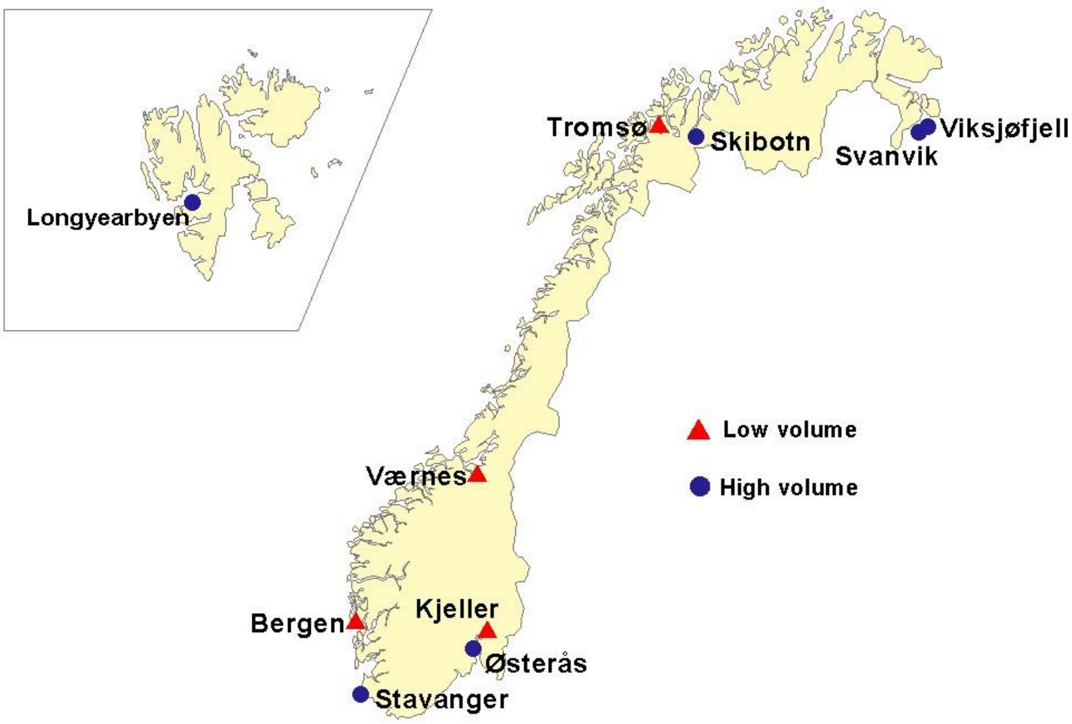


Fig. NO-3. *Norwegian air sampling filter stations.*

In addition, NILU operates approximately 100 stationary general air quality monitoring stations with a flow rate of approximately 1 m^3/h, and six mobile stations of about the same capacity. These stations may be used for radiometric purposes if so recommended by the Crisis Committee.

10.4 Airborne measurements

The resources in Norway for airborne monitoring are under restructuring in an effort to improve the capability and minimize the costs.

The following measurement equipment is available:

Geological Survey of Norway	1 20 l NaI detector
Norwegian Institute for Air Research	1 16 l NaI detector
Norwegian Armed Forces	2 16 l NaI detectors

The Geological Survey of Norway (Norges Geologiske Undersøkelse, NGU) is doing airborne measurements as part of their regular work and has instrumentation and procedures for airborne mapping of radioactive fallout and search for radioactive sources. These measurements performed from rented helicopters.

The Norwegian armed forces have one set of equipment installed in a military aircraft. The other set of equipment is presently not in use.

NILU has one set of equipment, which is presently not in operation. There are however plans to put it into operation again.

The aim of the organization is to establish 4 complete sets of equipment that could be used for monitoring from fixed wing aircraft, helicopters or cars depending on the nature of the assignment and to produce results of high quality in a timely manner for assessments and basis for decisions to be taken.

10.5 Foodstuffs and environmental samples

The analysis of radioactivity in foodstuffs is the responsibility of the Norwegian Food Control Authority (Statens Næringsmiddeltilsyn, SNT). For this purpose they have established 59 LORAKON- laboratories, equipped with NaI(Tl) detectors and multichannel analyzers.

In the event of a nuclear emergency where high-resolution gamma spectrometry is required, food and environmental samples will be measured using germanium detector systems at NRPA, IFE and a number of other organizations.

Strontium-90 analyses of milk and other agricultural products can be performed at NRPA, IFE and Agricultural University of Norway (Norges Landbrukshøyskole, NLH), using liquid scintillation detectors or low background beta detectors.

Surface barrier detectors and appropriate procedures for nuclide specific analysis of food and environmental samples containing transuranic elements are available at NRPA, IFE and the NLH. The procedures require radiochemical facilities. Most common combinations of trans-uranic nuclides and materials can be analyzed.

10.6 Survey teams and local measurements

The Norwegian civil defense organization is equipped with approximately 160 survey meters for external gamma dose and dose rate measurements. The instruments have been distributed to local civil defense patrols for use in emergency situations. The northern part of the country has been given priority. A system of predetermined survey points, time intervals and measurement procedures is in operation in order to establish normal background levels. The instruments will also be used for determining radiation levels following an accident. People, objects, vehicles, soil etc. can be checked for external contamination by applying special probes. Data are transmitted to the Directorate of Civil Defense and Emergency Planning (Direktoratet for Sivilt Beredskap, DSB) and the Crisis Committee.

Norwegian defense forces are equipped with about 200 instruments, basically of the same type as those used by the civil defense. In addition to this, other authorities, organizations and companies throughout the country have all together about 200 survey meters.

NRPA and IFE have emergency vehicles with transportable laboratory equipment for measurements and analysis. They can be made operational at short notice. Examples of available equipment:

- germanium detector systems for *in-situ* and laboratory gamma measurements
- NaI(Tl) detector systems
- pressurized ionization chambers in vehicles
- high volume air samplers
- survey meters

10.7 Contamination

10.7.1 Internal contamination

There are stationary whole body counters with NaI(Tl) detectors at NRPA and IFE (Kjeller and Halden). One system is of the scanning type (at NRPA); the rest (NRPA, IFE) apply chair geometry for measurements.

Most NaI(Tl) detectors, e.g., at the LORAKON stations, and portable germanium detectors may be used for whole body counting in an emergency situation. Also, some hospitals have equipment that can be used for whole body counting.

Survey meters owned by Norwegian armed forces and civil defense forces may be applied for organ measurements (e.g., the thyroid).

NaI(Tl) and germanium detectors are available at NRPA, IFE and certain hospitals for evaluating samples of body fluids, urine, excreta etc.

10.7.2 External contamination

Checks for external beta and gamma emitting contamination may be performed by NRPA, IFE, civil defense forces, a number of hospitals and others, using different types of modern portable equipment.

10.8 Future development

A working group established by the Crisis Committee has been reconsidering strategies and need of resources for monitoring purposes. It has been recognized that measurements should not be considered alone but need to be considered together with all the other tools being used for assessments and decisions.

To improve the performance of the nuclear emergency response organization, the following topics have been identified as the most cost-effective measures at present:

improved international exchange of information

improved communication systems

improved assessment procedures

improved decision support systems

improved modeling capabilities,

rather than increasing the number of monitoring equipment. The number of instruments is therefore not expected to be significantly increased in the near future. There is however areas identified where new instruments and procedures would result in an improved national ability to respond to nuclear or radiological accidents, and the introduction of new instrumentation and procedures are currently considered.

It has however been recognized that some equipment need to be replaced due to aging and the fact that spare parts are no longer available. For some types of measurements, this might result in upgrading the instruments to the next generation of equipment.

11 Poland

11.1 National background

Poland, which does not itself have nuclear power plants, has 10 nuclear power plants with 25 units in operation within 300 km of its borders. Some of these plants have been constructed according to older safety standards. The basic domestic nuclear threats are represented by

- research reactor Maria (30 MW th of power)
- spent fuel interim storage facility containing about 5000 spent fuel elements
- radioisotope production center and the radioactive waste facilities and installations,

all located in nuclear research center in Swierk, 20 km from Warsaw.

11.1.1 Legal bases

Existing regulations:

- Decree of the Organization and scope of Activity of the Service for Measurements of Radioactive Contamination, 1964
- Atomic Law, Act of Parliament, 1986,
- Decree of the Cabinet on Scope of Activity of the National Atomic Energy Agency (NAEA) and of the NAEA President, 1987
- Agreements on cooperation between the President of NAEA and other Ministries

Convention and bilateral agreements:

- Convention on Early Notification of a Nuclear Accident, 1986
- Convention on Assistance in the Event of a Nuclear Accident or Radiological Emergency, 1986
- Bilateral Agreements with Denmark, Norway, Austria, Ukraina, Bielorussia, Russia, Lithuania and Slovak Republic in the field of Nuclear Safety and Radiation Protection

Regulation under preparation:

- Nation-wide Emergency Preparedness, Act of Parliament
- Atomic Law (new regulation), Act of Parliament

11.1.2 Organizational structure

The National Atomic Energy Agency (NAEA) is the competent government competent authority for all matters related to radiation protection and nuclear safety. According to national legislation the President of NAEA is responsible for tasks such as

- organizing the radioactive contamination measurements
- evaluating the radiation situation in the country
- communication and information exchange with internal and national organizations
- public information

under both normal and as emergency conditions.

The most important bodies, from the radiation monitoring point of view, are

- the National Radiation Emergency Center (NREC) at the NAEA

- the Center for Radioactive Contamination Measurements (CRCM) and the Local Emergency Center (LEC) at the Central Laboratory for Radiological Protection (CLRP) – supervised by the NAEA

The main tasks of NREC are

- collecting, analyzing and verifying data and information received from other services and institutions
- developing and administering databases and other computer systems needed for assessment of the radiation situation
- computer analysis and prognoses using data from meteorological services for decision making in the case of radiation emergency
- implementing projects to inform the public and media about the radiation situation in the country in normal and emergency conditions

The main tasks of the CRCM are

- collecting and verifying the data and measuring results received from measuring stations of the radiation monitoring system
- elaboration of unified measurement methods for stations
- transmitting appropriate radiological data to the NREC
- implementing the quality assurance program of the radiation measuring station (organizing intercalibration and training courses)

The organizational structure of the radiation monitoring system is presented in Fig. PL-1.

11.2 Automatic gamma monitoring networks

The automatic gamma radiation monitoring system, Fig. PL-1, is presently under reconstruction. At present there are four gamma-monitoring networks in operation,

- network of PMS
- network of meteorological stations (IMWM, Institute of Meteorology and Water Management)
- network of military stations (Ministry of National Defense)
- network of civil defense stations (Ministry of Interior).

The first two networks form early warning system; radiological data are transmitted automatically by public telephone lines to the central computer in the CRCM (located at the CLRP) connected with the computer system of the Center for Radiation Emergencies "CEZAR" in NAEA. The locations of the early warning systems are shown in Fig. PL-2.

The data from the two latter networks are reported by telex to the CRCM or to Center "CEZAR" at the request of NAEA.

RADIATION MONITORING AND EARLY WARNING SYSTEM IN POLAND

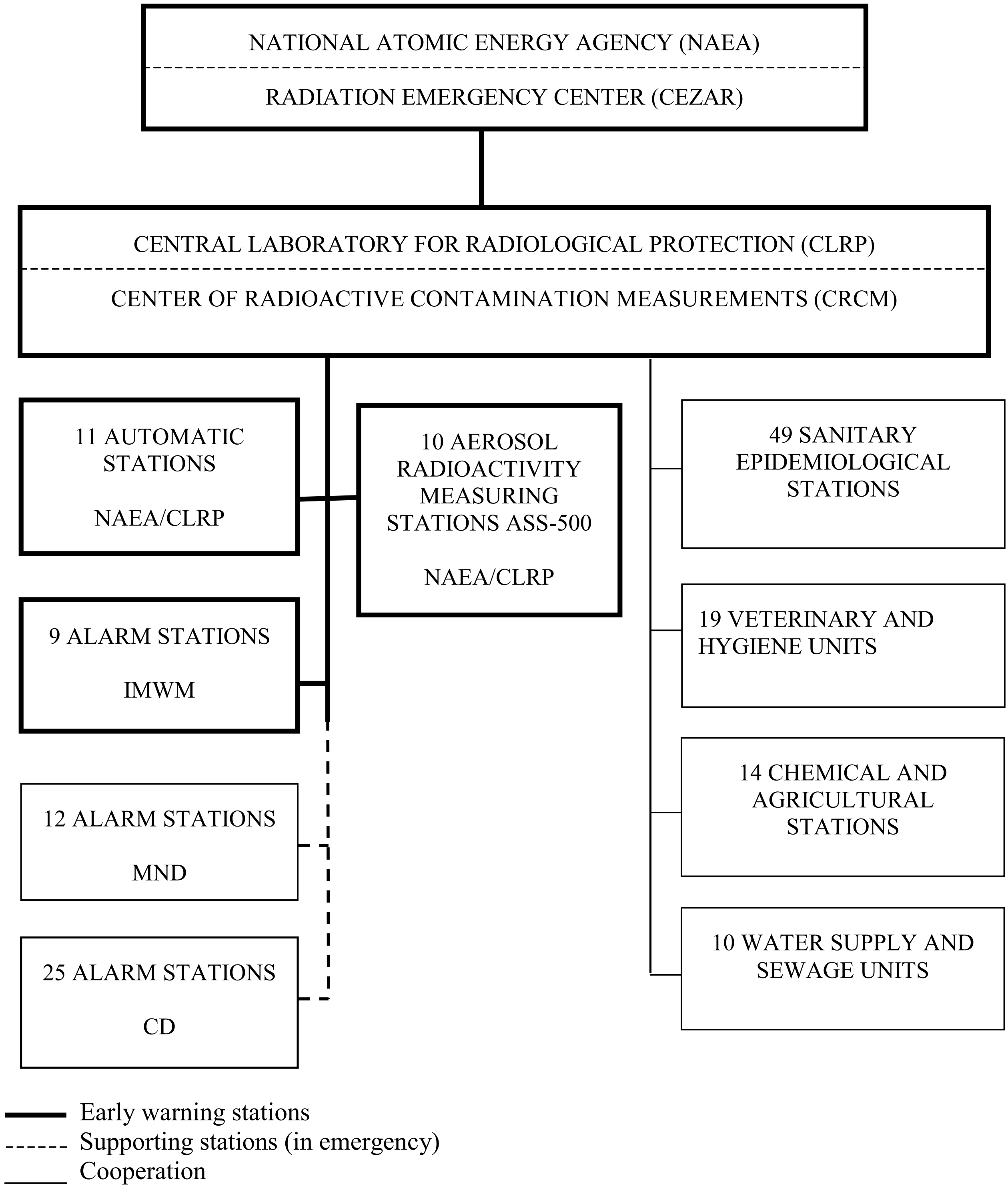


Fig. PL-1. *Organizational structure of radiation monitoring.*

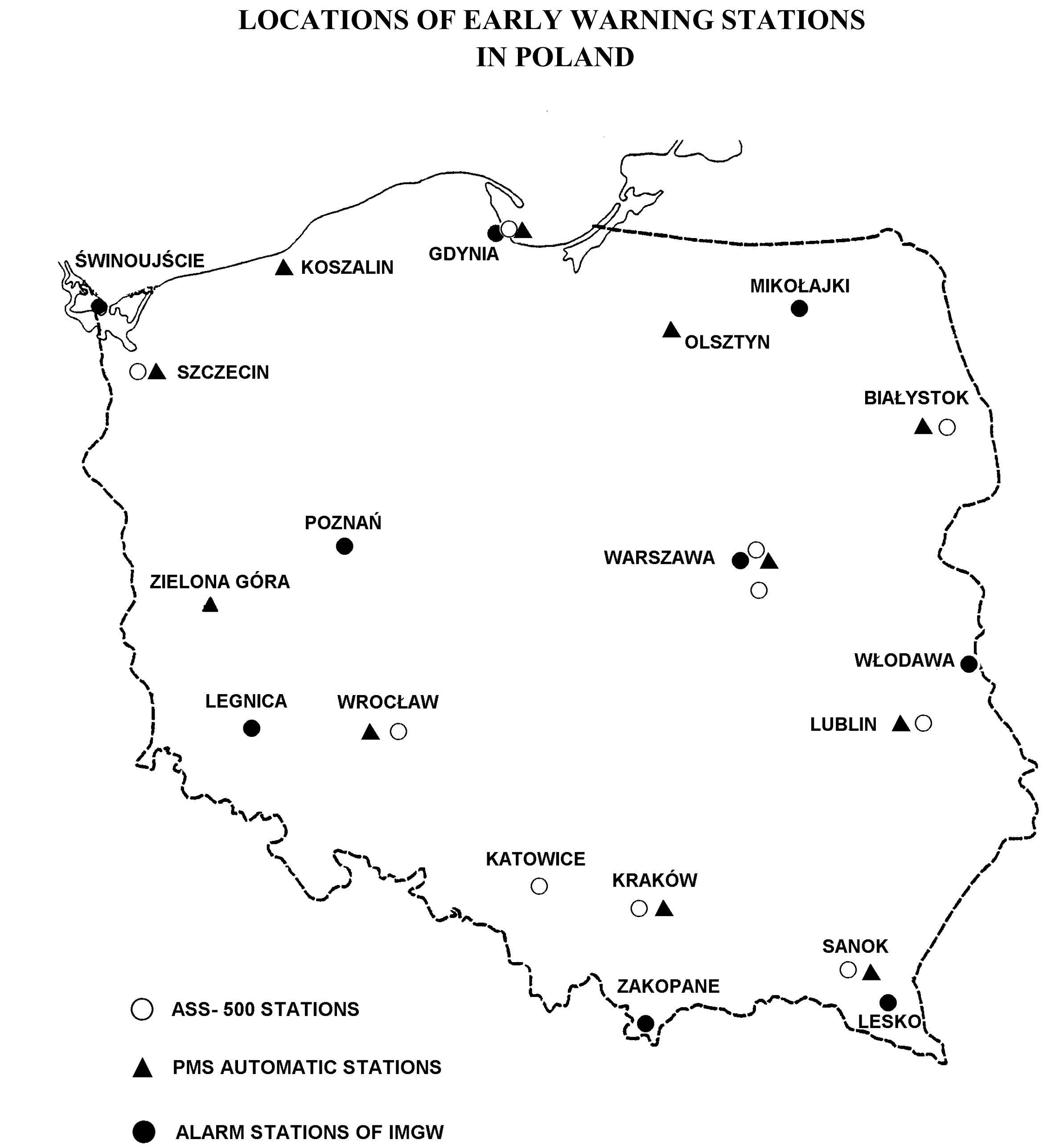


Fig. PL-2. *Early warning systems in Poland.*

11.2.1 PMS gamma monitoring network

General

This network consists of 11 field stations placed at regular distances close to the borders of the country and the central station with the central computer server located at the CLRP in Warsaw.

The PMS system (Fig. PL-3) is designed to current measurements of:

- ambient gamma dose rate
- gamma spectrum in the air, that enables to distinguish the increase of dose rate caused by natural and artificial radionuclides.

Moreover, each field station is equipped with gauges to measure the temperature and intensity of rain. The specially designed micro-computer at the station continuously stores the radiological and meteorological data until the server at CRCM calls the stations for collecting the data. These data are used for the evaluation and presentation in real time of the radiation situation using special ARGOS software.

Specifications

Each station has two detectors of different type:

- a GM tube type RD-022 for measuring ambient gamma dose rate in the range of 10 nSv/h – 10 Sv/h. The data are collected each minute
- a scintillation NaI(Tl) detector (3x3") coupled to a 256 channel analyzer for measuring gamma radiation spectrum

The spectrometer is adjusted to give the number of counts per second for each of a number of pre-set radiation energy windows representing radon gas as radon daughters; K-40 and some artificial radionuclides, such as Cs-137; the data measurement interval is set up to 10 minutes.

The rain gauge registers each 0.1 mm of precipitation.

Software

The PMS server in CRCM handles most communications and analysis of data. It is connected to the field stations by ordinary public telephone (with modem) lines. At fixed intervals of 12 hours the PMS server calls each field station and transfers measurement data to the Center for Radiation Emergencies "CEZAR" in NAEA.

Rain intensity and temperature at the stations are recorded automatically by micro-computer.

Alarm levels

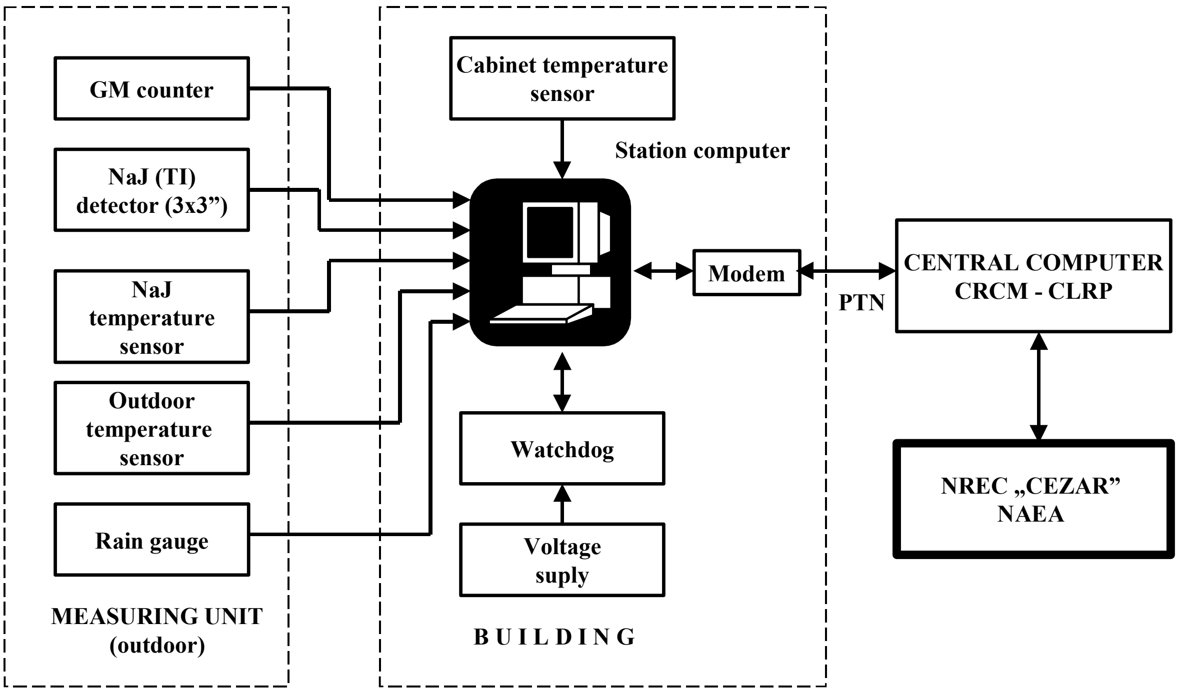
An alarm occurs when the system registers:

- the total gamma dose rate (GM tube) exceeds 200 nSv/h
- more than 25 cps in the residual spectrum, i.e., more than 25 cps in the spectrum after subtraction of the contribution from K-40 and radon daughters

Values of 25 cps in the residual spectrum are equivalent to about 15 % of the normal background.

Fig. 3

BLOCK DIAGRAM OF PMS NETWORK IN POLAND



PTN - PUBLIC TELEPHONE NETWORK

Fig. PL-3. *The PMS early warning system.*

11.2.2 IMWM gamma monitoring network

General

This network is operated by the Institute of Meteorology and Water Management and consists of 9 field stations distributed all over the country (Fig. PL-2).

All stations are connected via a meteorological communication line to the main computer in IMWM. All data are transmitted daily via a dedicated telephone line to the computer unit in CRCM.

These stations carry out

- continuous measurements of the gamma dose rate
- total beta activity of 24-hour samples of air aerosols and fallout

Specifications

The standard equipment of a station is the Polish measuring device type "SAPOS-90M" consisting of

- an external probe resistant to weather conditions with a set of G-M tubes placed about 2 m above the ground

- an electronic device with microcomputer and printer with input for series data transmission (RS-232 interface)

Alarm level

The microcomputer of SAPOS–90M is equipped with an alarm function. The alarm is activated if the gamma dose rate increases to 1.5 times of the average value of dose rate in the previous 24-hour period.

11.2.3 Military and civil defense gamma monitoring networks

The military network consists of 11 field stations (Fig. PL-2), with the central station placed in military Center of Contamination of Army Forces.

The civil defense network consists of 25 stations (located in towns) with the central station at the State Rescue Coordination Center in the Ministry of Interior.

All networks mentioned above are operated by military or civil defense services respectively.

All stations are equipped with SAPOS-90 M devices. The results of gamma dose rate are transmitted to respective centers. In normal situations these data are reported weekly - by telex – in the term of written reports to the CRCM in CLRP. In an radiation emergency these centers can transmit data to the CRCM every 1-2 hours.

11.2.4 Other types of gamma monitoring systems

In Poland no manual gamma monitoring systems are present but 82 stations belonging to the Ministry of Health and Ministry of Agriculture, cf. Section 11.6, are equipped with portable or pocket rate meters type EKO based on GM counters. These instruments make it possible to measure gamma dose rate from 10nSv/h to about 100 mSv/h in the gamma energy range from 100 KeV up to 2 MeV.

11.3 Stationary gamma monitoring points

Distribution of the average annual gamma dose rate due to natural and artificial radionuclides in the area of Poland territory are determined using thermoluminescens dosimetry. The measurements are carried out at about 260-fixed points (Fig. PL-4); three thermoluminescent detector sets are placed 1 m above the earth surface. The detectors are exposed in two six-month periods and the average annual gamma dose rate is evaluated.

11.4 Air monitoring system

The air monitoring (Fig. PL-2) system consists of two networks

- 9 alarm stations operated by IMWM
- 10 stations, called aerosol stations, operated by different institutions under the supervision of CRCM at the CLRP

Fig. PL-4. *Position of TL-detectors for gamma monitoring in Poland.*

11.4.1 The network of alarm stations

The air aerosols of 24 hour-day samples (air volume 200-300 m^3) are collected on a filter placed 2 m above the ground. Total beta activity measurements of aerosol samples are performed twice

- immediately after collection (T_o)
- one hour after collection (T_1)

The ratio of the results of these two measurements gives information on radioactive contamination of air. In normal situations the ratio $T_1 : T_0$ is less than 0.8. Results of measurements are coded and transmitted daily by the meteorological network METPAK as a written report to the CRCM in CLRP. A specially designed computer program decodes all data and gives daily reports of total beta contamination of the air.
It has been assumed to be an emergency situation if the total beta activity of aerosols measured immediately after sampling exceeds 3 Bq/m^3 and during 1 hour decreases less than

20 percent. In such a situation the measurements are performed every two hours and the results are transmitted immediately to the CRCM.

In addition, all alarm stations are carrying out the measurements of total beta activity of fallout in daily samples.

11.4.2 The network of aerosol stations

In recent years a new system of high volume air stations of the ASS-500 type are being used and developed for the routine environmental air monitoring. All stations are able to perform

- continuous sampling of airborne aerosols
- identification and determination of particular gamma emitting isotopes in aerosol samples

The aerosols are collected on the chlorinated PVC Petrianov filter type FPP-15-1,5. The collection efficiency of the filter (for aerosols with diameters between 0.3 – 1.25 µm, at linear air velocities through the filter varying from 0.25 to 4 m/s) is 96-99 percent.

The range of the air flow rate, adjusted with a special valve, is from 100 m^3/h to 800 m^3/h (average 400 m^3/h). In a normal radiation situation the stations work on a weekly basis, with replacement of the filter taking place each Monday at noon (12:00). The concentration of particular natural and artificial radionuclides are calculated for the end of the sampling period.

A gamma spectrometric method with germanium detectors is applied; the detection limit is from 0.5 to tens of µBq/m^3 for particular radionuclides and for a 7-day sampling period.

From all stations written weekly reports are transmitted by fax to the CRCM. In the event of a radiation emergency data will be transmitted every 1-2 hours.

The ASS-500 station in its basic version is not applicable for "on-line" detection of the aerosols activity deposited on the filter. For this purpose, existing stations are equipped with a specially designed spectrometer and NaI(Tl) detector (placed over the filter). The detection limit for 400-500 m^3 air filtered during 1 hour is from about 0.4 Bq/m^3 for I-131 and 0.8 Bq/m^3 for Cs-137.

At present, eight stations are equipped with these devices. The spectrometers are connected to the station computer for collection and processing of the measurement data. The results of on-line measurements are transmitted via the public telephone network to the central server in CRCM.

11.5 Airborne measurements

11.5.1 High altitude air sampling

The objective of these measurements is to provide the data on activity levels in the troposphere and lower stratosphere, between ground level and from 1, 3, 6, 9, 12, and 15 km altitude. The sampling is now being carried out one or three times a year.

The samplers with the Petrianov filter FPP-15-1,5 are placed inside the fuel tanks of a MIG-21 airplane. A special computer program is used for calculations of air passing through the filter for various levels and plane speeds. The volume of air samples ranged from about 100 m^3 at 15 km to about 3700 m^3 at 1 km altitude.

The samples are analyzed by γ-spectrometry method using a HPGe detector and a Canberra 90 analyzer or by radiochemical methods (for Sr-90, Pb-210 and Ra-226).

11.5.2 Aerial surveys

In an emergency Armed Forces rescue helicopter Mi-2rs with the specially designated measuring unit RL-75 can be used for mapping contaminated areas. The flying altitude is in the range of 25-500 m. The measuring unit consists of a dose rate meter and associated electronics which allow the dose rate to be measured at 1 m above ground in the range of 2-100 000 mSv/h.

11.6 Foodstuffs and environmental samples

The monitoring of radioactive contamination of the environment and foodstuffs is carried out by 82 stations (Fig. PL-5) and units belonging to the Ministry of Health and Ministry of Agriculture.

The sampling program and measuring methods for these stations are established by the CRCM in cooperation with Radiation and Nuclear Safety Department in NAEA.

For determination of contamination of food, meat, milk, drinking water, grass, vegetables, cereals etc. total beta counting, gamma spectroscopy and radiochemical analyses are used. The frequency of sampling is in the range of four times per year for milk, to once per year for vegetables, cereals, and grass.

The results of measurements are collected by CRCM. All stations have the standard measuring system “SAPOS-90” equipped with

- scintillation probe with NaI(Tl) crystal (45 x 50 mm)
- scintillation probe with plastic detector
- protective lead castle
- probe with a set of GM-counters for continuous dose rate measurements
- probe with GM window counter for beta and alpha radiation measurements

In addition 38 sanitary-epidemiological stations (Fig. PL-6) have at their disposal a scintillation spectrometer with multichannel analyzer “TRISTAN-1024”; six stations are equipped with a germanium detector. Besides, all stations are equipped with portable radiometers and laboratory facilities for radiochemical analysis of the samples. When necessary, the specialized measuring techniques at the CRCM and research institutions can be used for sample measurements.

Fig. PL-5. *Locations of stations for measurement of radioactive contamination in environmental and foodstuffs samples in Poland.*

Fig. PL-6. *Gamma spectrometers for measurement of radioactive contamination in environmental and foodstuffs samples in Poland.*

11.7 Survey teams

In a radiation emergency situation NAEA can initiate mapping of dose rates and contaminated areas by using a special moving laboratory operated by CLRP. The main equipment of this laboratory includes

- a portable 256 channel gamma-ray spectrometer with a NaI detector
- a spectrometric unit with a large volume (4l) NaI detector type GPX-256
- a GR-660 software system with computer
- GPS navigation system

Another mobile laboratory is at the disposal of the Military Institute of Chemistry and Radiometry, equipped with

- a semiconductor detector (germanium) and a portable spectroscopy system (type INSPECTOR)
- a multichannel analyzer SNIP 204G with a NaI detector
- portable monitors type FH-40G and CONTAMAT FHT 111M.

In an emergency all institutes supervised by NAEA can perform (by the local survey teams) gamma dose-rate measurements using portable GM or scintillation monitors.

11.8 Contamination

11.8.1 Internal contamination

The measurements of internal contamination in man are carried out by two institutions belonging to the NAEA: Institute of Atomic Energy (IAE) and CLRP.

The monitoring equipment consists of

- one whole body counter (operated by IAE) with a high purity germanium detector and a NaI(Tl) crystal installed in a special iron room. The system uses scanning bed and chair geometry techniques. The measuring time (for chair geometry) is typically 20 minutes; the minimum detectable activity (MDA) for Cs-134 and Cs-137 of standard men is about 40 Bq.
- two stationary units (operated by IAEA and CLRP) for monitoring radioiodine in the thyroid. Each system consist of two NaI(Tl) detectors (for I-125 and I-131) placed in led collimators. The MDA for I-125 and I-131 is about 20 Bq for a measuring time of 15 minutes
- one mobile unit (operated by CLRP) for *in-situ* measurements to be used for fast screening of population in radiological emergency and for monitoring occupationally exposed people. The MDA for I-125 and I-131 is about 30 and 60 Bq respectively

In addition, IAE and CLRP can perform measurements of alpha and beta emitting radionuclides in samples of urine.

11.8.2 External contamination

Surveys of external gamma and beta contamination can be carried out by CLRP, IAE, defense forces, nuclear medicine departments and others using portable monitors.

11.9 Monitoring of radioactive material at borders

Beginning in 1991, at a few border checkpoints stationary monitors for permanent measurements of gamma radiation levels were installed. At the end of 1999 126 such monitors were deployed (57 at road checkpoints, 35 at railway checkpoints, 24 at airports and 10 at the harbors of the Baltic Sea) All monitors are operated by the Border Guards. The monitors are deployed at the entrance gates and consist of

- a detection device with a NaI(Tl) detector in a lead collimator
- a computerized control and signal device

A unit can detect a Cs-137 source of about 4.6 MBq within a distance of 5 m from the detection device, when a vehicle is moving at a speed of 30 km/h. An alarm is activated when the gamma radiation exceeds twice the local background level.

11.10 Other types of measurements

11.10.1 Monitoring of radioactive contamination of rivers and lakes

Systematic measurements of concentrations of radionuclides in the two main rivers and 6 lakes in different districts are carried out by the CLRP. The concentrations of Cs-137 and Ra-226 are determined separately in filtrated water, suspended matter and bottom sediments. The sampling frequency is twice a year for Vistula and Odra rivers and once a year for all others.

11.10.2 Monitoring of radioactive contamination of the Baltic

The CLRP in cooperation with the Institute of Meteorology and Water Management are carrying out the monitoring program of the Baltic Sea, coordinated by the Helsinki Commission. The concentration of cesium and plutonium is determined in samples of water, bottom sediments, and fish. The sampling frequency is once or twice a year.

11.11 Future development

It is being considered to equip the mobile laboratory with additional devices for radiological measurements, such as

- a high volume air sampler
- a portable spectrometer with an external germanium detector and a lead castle
- a portable PMS station

It is planned to install three additional PMS stations localized in the middle part of the country in order to optimize the evaluation of the radiological situation using the ARGOS system.

The efforts continue to

- combine readings from the ASS-500 and PMS measurement devices in the integrated computer system
- improve the ARGOS system and instructions, making them more user-friendly for operators who only work with the system occasionally
- establish routine data exchange between the Nordic countries on-line radiation measurement systems and the Polish on-line monitoring system

12 Russian Federation

12.1 National background

The radiological monitoring network in the Russian Federation (RF) is being developed within the Federal program on setting up the common state system of radiological monitoring in the territory of Russia (EGASKRO).

According to the concept of development of EGASKRO a monitoring system is being built as a distributed system providing for information support for decision making at different levels: federal, regional (subjects of Russian Federation) and local. In compliance with the given concept the structure of EGASKRO consists of:

- a basic territorial subsystem for radiation monitoring (BTSRM) providing integration of monitoring data from subsystems of EGASKRO for information support for decision making at federal level;
- territorial subsystems for radiation monitoring operating in the territory of a subject of RF (republic, region, etc.) and providing information support for decision making to the executive authority of the subject;
- departmental subsystems of radiation monitoring around nuclear facilities (NF) (as a rule - in the 30-km zone) being operated as a part of ministries and departments.

A territorial subsystem may include forces and means for the radiation monitoring of basic territorial subsystems and departmental subsystems functioning in the territory of a subject of RF.

From 2001, EGASKRO will be developed within the common Federal program, with a special purpose, «Nuclear and Radiation Safety of Russia».

12.1.1 Organizational structure

Ministry of Russian Federation of Civil Defense and Emergency Situations

Responsibility includes: management and coordination of all forces and means, forming parts of the state emergency system, in accordance with the Federal plan of actions aimed at the prevention and mitigation of emergencies (including nuclear emergencies).

Health Ministry of Russia

Provides monitoring of population irradiation levels and radioactive contamination of the environment.

Russian Federal Service of Hydrometeorology and Environmental Monitoring (Roshydromet)

Roshydromet is responsible for monitoring the radioactive contamination of the environment in the entire territory of Russian Federation by means of common-state monitoring and laboratory control (testing) network. Carries out general management.

Ministry of Atomic Energy of Russia

Carries out monitoring of the radiation situation on the territory of nuclear facilities, which are in operation, and sanitary zones. Provides monitoring of radioactive exposure of personnel.

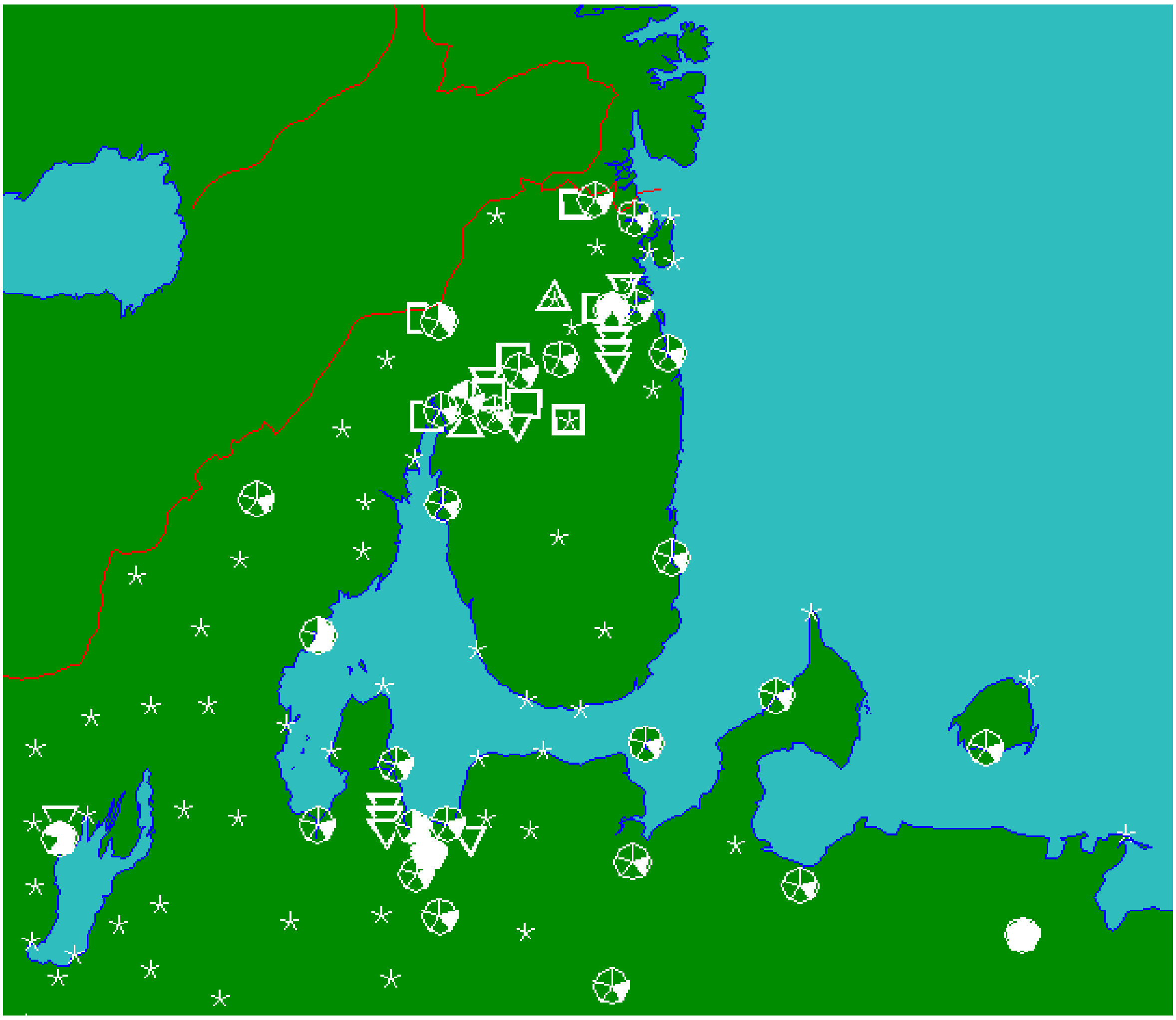
12.2 Basic territorial subsystem of radiation monitoring of EGASKRO

At present BTSRM is being developed on the basis of common-state monitoring and laboratory control (testing) network. The monitoring and laboratory control (testing) network, under the authority of the Ministry of Emergency Situations of Russia, operates on the entire territory of the country. If an emergency occurs subdivisions responsible for of monitoring of radiation situation of the Health Ministry of Russia, Roshydromet, Agriculture Ministry and some other ministries and departments (Ministry of Natural Resources, Forestry Ministry and others) are included in the network. On the whole it integrates more than 40 specialized science and research institutions and about 1000 local-level laboratories forming part of different departments. Information originating from this network is used by authorities of Ministry of Emergency Situations for decision making in the event of an emergency.

The system of monitoring and laboratory control (testing) of Roshydromet monitors levels of radioactive contamination of the environment - soil, air, surface waters. The system incorporates a stationary network, consisting of 1252 hydrometeorological stations and monitoring posts (Fig. RU-1) equipped with devices for measuring the gamma radiation dose rate (GDR), 452 posts collecting samples to measure the total beta activity of atmospheric depositions and concentrations of radioactive aerosols in the lowest atmospheric layer and 107 posts collecting samples of precipitation and samples of water from main water bodies, cf. Figs. RU-5, RU-6.

About 50 laboratories carrying out analyses of gamma and beta activity and specialized subdivisions providing operative (fast) investigation of contaminated territories in the event of an accident at a nuclear facility are in operation. Measurements of gamma radiation dose rate carried out at regular intervals at hydrometeorological stations and monitoring posts allow problems of early warning (notification) in the event of a nuclear accident as well as problems of prognosis of propagation of radioactive contamination in the environment to be resolved using meteorological data collected at these stations.

At the Health Ministry, monitoring of radiation safety of the population is implemented by about 230 radiological subdivisions of territorial centers of the State Sanitary and Epidemiological Service. These subdivisions are equipped with devices to carry out radiometric, dosimetric and spectrometric investigations. Every year several hundred thousands of such investigations are performed. The content of radionuclides in foodstuff, drinking water and human environment is checked. The execution of safe keeping and the safe use of sources of ionizing radiation is supervised as well as random monitoring of radiation dose taken by personnel of nuclear facilities and population. At especially hazardous nuclear facilities and adjacent territories the monitoring of radiation exposure is carried out by the forces of a special medical and sanitary Service which is under the authority of the Federal Board of Medical-biological and Extreme Problems (Health Ministry of Russia). About 100 medico-sanitary posts and sanitary-epidemiological stations monitoring the radiation exposure of population in the vicinity of nuclear facilities form parts of the Service.



- gamma-dose rate measurements
- aerosol samples are collected with filters
- aerosol samples are collected on horizontal collectors
- aerosol samples are collected with vertical collectors
- samples of precipitation and freshwater are collected to measure tritium
- samples of sea water and freshwater are collected to measure strontium-90
- Finnish stations
- Norwegian stations (installed)
- Norwegian stations (planned to be installed)

Fig. RU-1. *Part of radiation monitoring and laboratory control (testing) network the north-west region of Russia.*

The Radiological Monitoring Service of Agriculture Ministry of Russia includes the State Agricultural Chemistry and Veterinary Services. The former service carries out radiation monitoring of arable soils, plants for food and fertilizers by forces of radiological departments (over 100 centers and stations of Agricultural Chemistry Service and 7 centers of Agricultural Chemistry and Radiology Service). The latter consolidates over 80 radiological departments of veterinary laboratories of subjects of Russian Federation, 1200 regional and interregional laboratories, 1500 laboratories of veterinary and sanitary expertise at market places and production veterinary laboratories at enterprises of processing industry and supervises the observance of veterinary and sanitary rules in the manufacture, processing, storing and transportation of animal produce and when farm produce is in the market. For years systematic radiometric measurements have been carried out at more than 1700 standard sites and 400 standard points located on the territory of Russia. Over one million radiometric, spectrometric and radiochemical investigations and over four million measurements of the gamma radiation background are carried out annually.

12.2.1 Example of an automatic gamma-monitoring system

At the present time the systems of automatic gamma dose rate monitoring are incorporated into the structure of BTSRM for operative monitoring of radiation situation. The ASIGAM system (automated gamma dose rate monitoring system) installed around Obninsk, Kaluga region, may serve as an example. The system is shown if Figs. RU-2, RU-3.

The ASIGAM system is designed for continuous automatic monitoring around nuclear facilities of the absorbed gamma dose rate in air. The network of monitoring posts of the system can be set up both in populated area and in the field.

The radiotelemetric system of automated gamma-monitoring ASIGAM consists of

- 7 autonomous monitoring posts (Fig. RU-2)
- the central station of receiving and processing of information

The autonomous monitoring post is equipped with

- a container
- a system unit (controller)
- a unit of gamma radiation meters
- a radio station with antenna
- a storage battery

The central station is equipped with

- a radio station with antenna
- a radio modem
- a line-operated power supply unit
- a personal computer IBM PC

The main technical features of ASIGAM system

- energy range (gamma radiation): 50 keV - 3 MeV
- measurement range (air absorbed gamma dose rate): 10 nGy/h - 2,0 Gy/h
- accuracy (confidence coefficient is 0.95): 30 %
- frequency (reception-transmission): 165,05 MHz

- time of continuous operation
  of monitoring posts in autonomous mode: at least 3 months
- range of radio communication: at least 30 km

Fig. RU-2. *Monitoring post.*

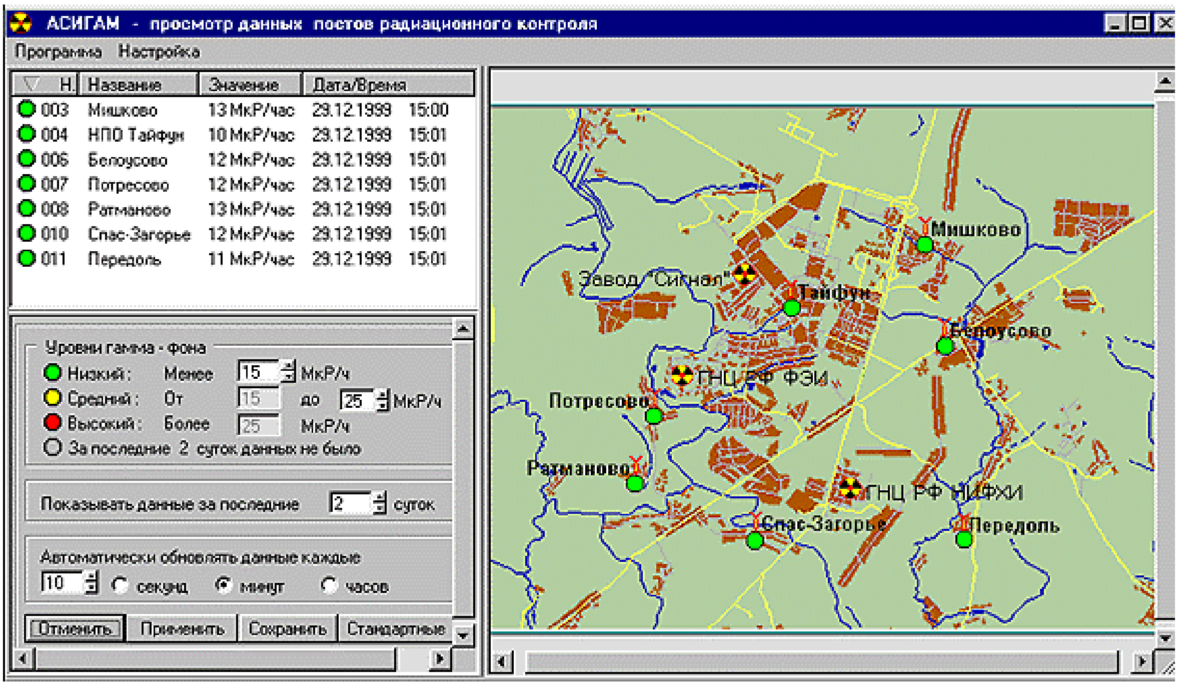


Fig. RU-3. *ASIGAM: viewing of data collected at monitoring posts.*

12.3 Territorial subsystems of EGASKRO

Territorial subsystems of EGASKRO are developed within the general technical specifications of EGASKRO. Therefore they may differ from each other in some parts but meet the main specifications of design.

12.4 Nuclear facility subsystems of EGASKRO

At the Ministry of Atomic Energy of Russia radiation monitoring is implemented by departmental monitoring systems operating at all nuclear facilities of the nuclear industry. The main tasks of these systems are

- the detection of possible leakage of radioactive materials during the technological process
- monitoring of radiation dose levels in the production area
- information support for activities aimed at the compliance with radiation safety standards
- monitoring of releases of radioactive materials into the environment

Local outdoor dosimetry services carry out regular monitoring of levels of radioactive contamination of the environment within sanitary zones and zones around nuclear facilities. A number of facilities are equipped with automated systems operating continuously to monitor the radiation dose rate; work is proceeding on the improvement of these systems (Fig. RU-4).

At present within the TACIS Nuclear Safety Program NSP/REA 001/95 work is in progress on the introduction of the SkyLINK system as an early warning system at all Russian nuclear power plants.

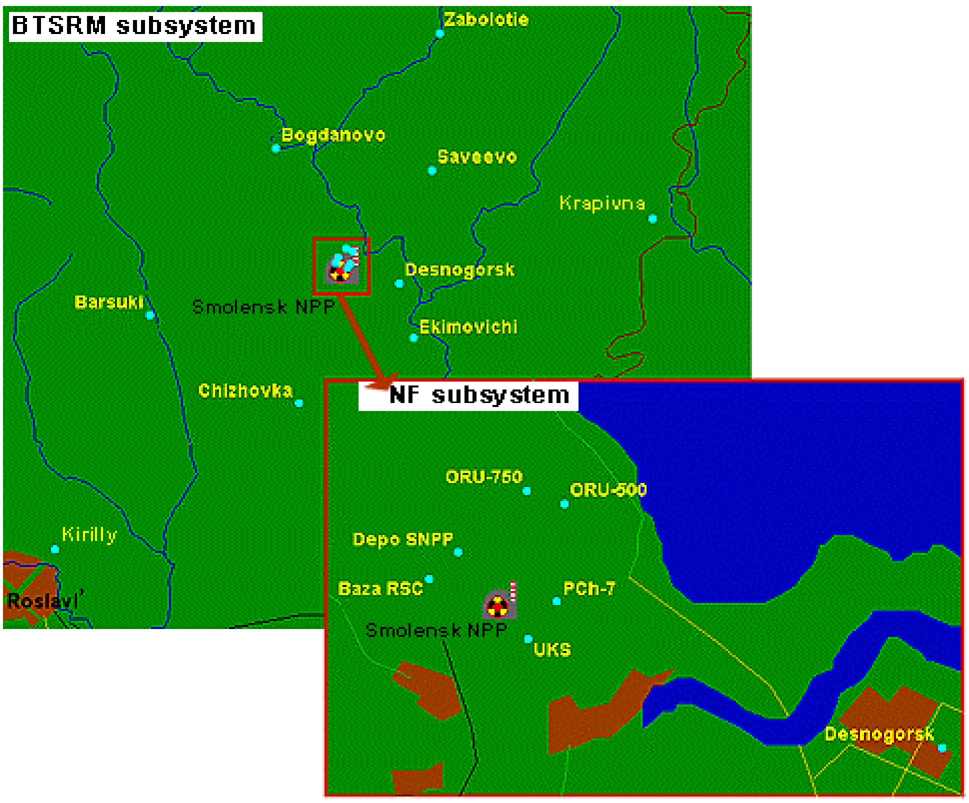


Fig. RU-4. Gamma radiation monitoring system around Smolensk Nuclear Power Plant.

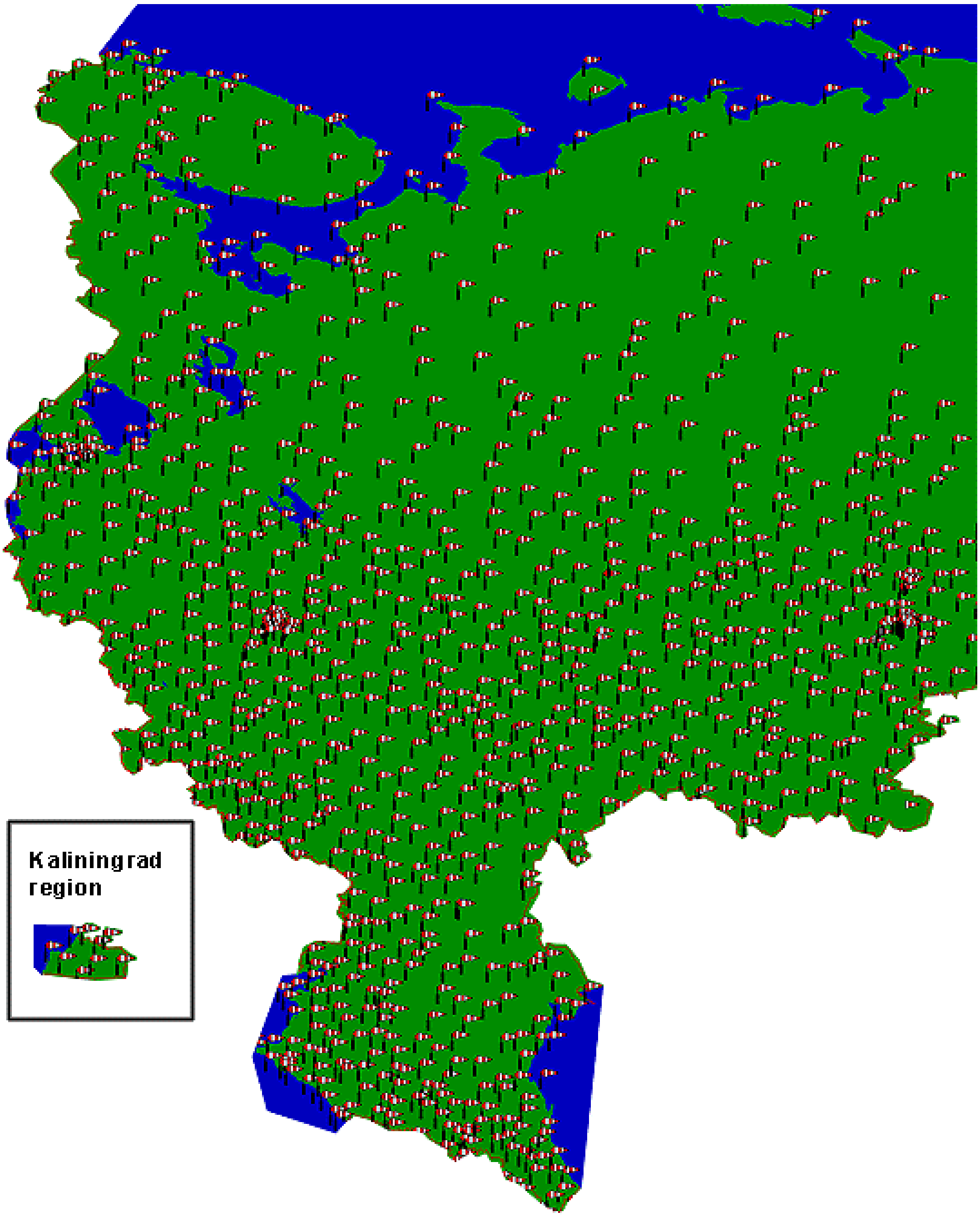


Fig. RU-5. *Monitoring posts at the European part of Russia.*

Fig. RU-6. *Aerosol sampling stations at the European part of Russia.*

12.5 Future development of monitoring network

In the near future the main direction of the development of the radiological monitoring network in Russia will consist of modernization and equipment with automatic gamma dose rate and spectrometric measuring devices. This will be provided within the Federal program on setting up the common state system of radiological monitoring in the territory of Russia (EGASKRO). Under this program it is planned to install devices for automatic measuring gamma dose rate at all meteorological stations engaged in the radiological monitoring network in the 100 km zone around nuclear facilities.

The work performed has proven that the data exchange between radiation monitoring systems of different agencies can be achieved within a common information environment. The system of data collection and exchange should be built as a distributed system of databases which will permit reducing the volumes of data of routine measurements (no-accident case) to be transmitted between different levels (centers) of the system in real time. Using the "client-server" technology in building the system, one can receive data, if necessary, from any database within the distributed system. The organization of databases by common rules is the foundation for their use as an information base for a decision-making support system at any level of the distributed system.

13 Sweden

13.1 National background

The Swedish Radiation Protection Institute (Statens Strålskyddsinstitut, SSI) is a government authority with the task of protecting people and the environment from the harmful effects of radiation.

SSI is responsible for coordinating activities in Sweden should an accident occur involving radiation. Its resources can be called upon at any time of the day or night. In the event of a nuclear accident, a special emergency preparedness organization comes into operation. Early notification of emergencies is obtained from automatic alarm monitoring stations in Sweden and abroad and through international and bilateral agreements on early notification and exchange of information.

The basic domestic nuclear threats are the 12 nuclear power reactors at 4 sites, one of which is permanently shut down. There is also a small research reactor. A large number of shipments of radioactive materials take place every year, such as spent nuclear fuel from the power plants and radioactive substances for medical use. External threats are nuclear power reactors abroad and ships powered by nuclear reactors.

13.1.1 Legal basis

In the Government bill 1980/81:90, issued after the Three Mile Island accident, the emergency preparedness issues received much attention. The Parliament decided that emergency planning shall consider all types of accidents, from those with very small environmental consequences to the most serious accidents. Furthermore, there must be a systematic training of decision-makers, organization of personnel on duty and verified telecommunication between the responsible organizations.

The Rescue Services Ordinance (SFS 1986:1107) states that within the Inner Emergency Planning Zone (12-15 km from the Swedish nuclear power plants) and the Radiation Monitoring zone (extending to 50 km), it is the responsibility of the County Administration to establish a radiological emergency plan.

SSI is responsible for giving expert advice to other central authorities, according to the Radiation Protection Ordinance (SFS 1988:293), on questions concerning radiation protection as well as clean-up after a release of activity, and to inform the general public and media.

The Swedish Nuclear Power Inspectorate (Statens Kärnkraftinspektion, SKI) is responsible according to the Nuclear Activities Ordinance (SFS 1988:294) for giving technical advice to other authorities responsible for the protection of the public in the event of an accident involving nuclear activities.

13.1.2 Organizational structure

The 21 County Administrative Boards in Sweden are responsible for leading emergency relief and rescue operations in connection with nuclear accidents. They are also responsible for clean-up operations after accidents involving radioactive material.

SSI leads and coordinates measurements of radiation on the national level and advises both county administrations and pertinent central authorities such as the National Food

Administration, the Swedish Board of Agriculture and the National Board of Health and Welfare concerning measures to minimize the radiation dose received by the population.

Many other authorities are included in the emergency preparedness organization. SKI analyzes accident causes and estimates the source term of a possible radioactive release. The Swedish Rescue Services Agency (SRV) supervises regional planning for rescue services and clean-up, but has no operative responsibilities.

SSI has several ways of conducting measurements and some measurements are carried out by other organizations according to agreements with SSI. SSI operates 37 automatic gamma-monitoring stations. Also the National Defense Research Establishment (Totalförsvarets Forskningsinstitut, FOI) has 5 air-sampling stations. Several universities have contracts for making nuclide specific measurements in the event of a radiological emergency.

In addition each of the 289 communities in Sweden has a handheld gamma-monitoring instrument. There are at least 2 to 4 predefined points within each community at which measurements can be carried out.

SSI is responsible for the operation of the national emergency preparedness organization. Measurements of various kinds form an integral and important part of this organization. The radiological monitoring program comprises a number of different systems and techniques. The Swedish Rescue Services Agency, having no operative responsibilities, does not receive any radiation data from the monitoring systems.

The types of measurements carried out before and after a fallout and the organizations responsible for these measurements are summarized in Table SE-1.

The Swedish monitoring system is designed to detect releases emanating from foreign and domestic sources. Sweden has twelve nuclear power reactors (one of which is permanently shut down), one research reactor, one nuclear fuel fabrication plant and a large waste handling program, including several repositories and a vessel for transporting radioactive waste.

The general background radiation levels (total gamma) are well known, thanks to early geophysical measurements and background mapping as well as post Chernobyl measurements.

13.2 Automatic gamma monitoring stations

Sweden has an automatic network of 37 stationary gamma-monitoring stations throughout the country (Fig. SE-1). The main purpose of the network is twofold,

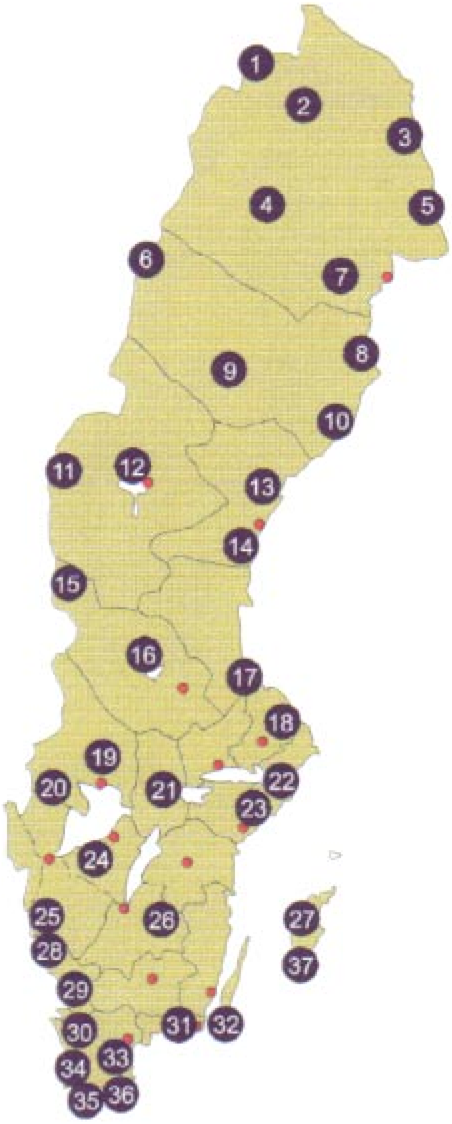
- to give an alarm if there is a significant increase above the natural background gamma radiation level
- to give an instant overall picture of the radiation situation in Sweden

The distance between the gamma monitoring stations has been chosen to make sure that a radioactive release abroad will be detected by at least one station as it passes over Swedish territory.

Table SE-1. *Measurement services in Sweden.*

Type of measurement	Organization						
	SSI	**FOI**	**SGU**	**NPP**	**County**	**Local**	**Others**
Automatic gamma monitoring stations	*			*			
Air monitoring stations gamma analysis		1)			*		
Airborne measurements							
– external gamma	*		2)				
Field measurements							
– gamma analysis	*	*		*			*
– total gamma	*	*	*	*	*	*	*
– air filter gamma analysis	*	*		*	*		*
– beta	*	*		*			*
– alpha	*	*					
Laboratory sample							
analysis	*	*		*			*
– gamma	*	*		*			*
– beta (Sr)	*	*					*
– alpha (Pu)							
Whole body counting	*	*		*			*

SSI	Swedish radiation protection institute
FOI	Natinal Defense Research Establishment
SGU	Geological surway of Sweden
NPP	Swedish nuclear power plants
County	Government of NPP Counties
Local	Community organizations
Others	Universities, Radiation physics dep., Studsvik etc.
1)	Analysis performed by FOI under contract from SSI
2)	Measurements performed by SGU under contract from SSI



1. Katterjåkk
2. Kiruna
3. Pajala
4. Tjåmotis
5. Övertorneå
6. Hemavan
7. Älvsbyn
8. Skellefteå
9. Ulvoberg
10. Umeå
11. Storlien
12. Täng
13. Bredbyn
14. Njurunda
15. Idre
16. Mora
17. Gävle
18. Alunda
19. Gustavsfors
20. Blomskog
21. Örebro
22. SSI Stockholm
23. Åda
24. Skara
25. Landvetter
26. Eksjö
27. Visby
28. Ringhals
29. Halmstad
30. Ljungbyhed
31. Ronneby
32. Ölands s. udde
33. Everöd
34. Malmö
35. Smygehamn
36. Sandhammaren
37. Hoburgen

Fig. SE-1. *Swedish gamma monitoring stations operated by SSI.*

The measuring device consists of a pressurized ionization chamber with associated electronics. The 4 l chamber is filled with argon at a pressure of 600 kPa and placed 2.5 m above the ground in a housing designed to withstand the conditions of the environment. The measuring range is 1 – 6,000,000 nSv/h ambient dose equivalent rate. The average normal background level in Sweden is 100 nSv/h.

The detector at each station is constantly logged by a local microcomputer, and the results are stored locally. The reading of the individual station is presented on a display as a dose rate together with the integrated dose during a preset time. It is also possible to show the integrated dose for the last 24 hours and the corresponding integrated dose for the preceding 24-hour period.

A modem is connected to the microcomputer. The main computer (a personal computer) at SSI in Stockholm calls each gamma station over the public network a preset number of times every day (presently three times per day). The incoming data are stored in the database of the institute. Evaluation and presentation of registered data can be performed automatically at any time..

The microcomputer at each station is equipped with an alarm function. It is triggered whenever the integrated dose for the last 24-hour period exceeds that of the previous 24-hour period by more than a pre-set level, presently 300 nSv. The method of two moving consecutive 24-hour windows has been chosen to avoid false alarms from sudden changes in weather and moisture conditions. Radon related temporary dose rate increases by 20-40 % of the natural background level are not infrequent, and must not be allowed to affect the alarm function of the station.

The pre-set alarm criterion of 300 nSv per 24 hours may be changed individually for each station. This setting may be lowered when enough statistical material on unwarranted alarms has been collected from the stations.

In the event of an alarm, the station calls a personal pager, displaying the individual code of the station as well as the latest registered dose rate. The radiation protection officer on duty can then call the station and obtain more readings.

After each polling of the stations, the main computer at SSI calculates present trends and gives an alarm via the personal pager whenever needed.

13.3 Air monitoring stations

The National Defense Research Establishment (FOI) operates a national air monitoring network of five stations to detect very low levels of particulate radionuclides in the air. (Map in Fig. SE-2.) In the event of a large increase of radioactive particles, the system will be used to assess the time-integrated air concentration in order to predict inhalation doses and ground deposition. Contrary to the gamma monitoring stations, priority is given to sensitivity rather than rapidity.

The objective is to sample and measure ground level air. All stations collect airborne dust on fiberglass filters manufactured by FOI. Air is drawn through the filter by a high capacity centrifugal pump at a rate of at least 1000 m^3/h. The filters are sent by mail to FOI's Stockholm laboratory, where they are analyzed by high resolution gamma spectrometry in a low-background shielded chamber. The detection limit is of the order of 0.1-1 $\mu Bq/m^3$.

Under normal conditions it takes 5-10 days after the filter is removed until it has been completely analyzed. A quick check of the filters is always performed right after arrival by screening them for 15 minutes in a primary measurement chamber to detect any artificial nuclides, with a detection limit of 1 mBq/m^3. SSI is notified, should this limit be exceeded.

Some of the air monitoring stations are also equipped with units for sampling

- precipitation
- gaseous iodine
- xenon

Fig. SE-2 shows the locations of these stations.

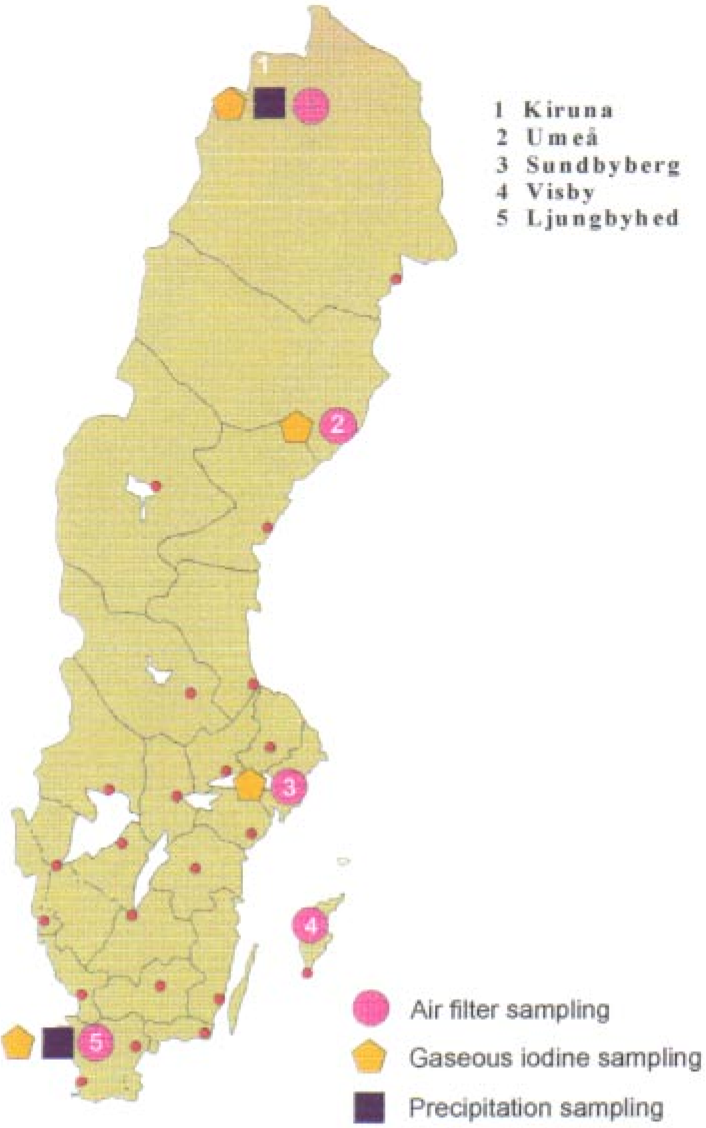


Fig. SE-2. *Air sampling stations operated by FOI under contract from SSI.*

13.4 Airborne measurements

13.4.1 High altitude air sampling (not in operation presently)

The system for air monitoring includes high altitude air samplers mounted under the wings of an Air Force aircraft. This type of aircraft is no longer in operation and it is not possible to attach the sampler to another type of aircraft.

13.4.2 Aerial surveys

Airborne spectrometric surveys are of vital importance in finding regions with high deposition while at the same time covering vast areas within a reasonable time span.

In order to avoid contamination of the aircraft, instrumentation and crew, measurements are planned to start well after the release has ceased. The aircraft can be airborne within 48 hours after an alert.

The Swedish Geological Survey (Sveriges Geologiska Undersökning, SGU) has been contracted to carry out the surveys. The flying altitude is of the order of 50-100 m. In order to get an overview of the deposition pattern, primary flight lines can be chosen with a separation of 50-100 km. A second mapping with more densely spaced flight lines may be performed if desired.

13.5 Foodstuffs and environmental samples

The National Food Administration (Statens Livsmedelsverk, SLV) is responsible for sampling and analyzing foodstuffs in Sweden. SSI is responsible for giving advice on sampling and measurements, as well as for checking the quality of the measurements.

Gamma spectrometric measurements authorized by SSI are performed at two government institutes, six university laboratories, Studsvik and at the nuclear power plants. Strontium analyses are performed at SSI. Alpha spectrometric measurements are performed mainly at a university institution, Studsvik and SSI.

Milk is considered the most important foodstuff to check continuously. Leafy vegetables, meat, fish, game, berries etc. are checked whenever needed.

Soil, water and vegetation samples can be measured at, e.g., SSI and a number of university institutions.

A large number of NaI(Tl) and germanium detectors are available throughout the country for gamma spectrometric analysis of food and environmental samples.

13.6 Survey teams and local measurements

13.6.1 Stationary gamma monitoring points

Each of the 289 local Environmental Health Protection Departments (Miljö- och hälsoskyddsförvaltningar) has a survey meter for making gamma dose rate measurements at predefined reference points every seven months. All in all there are some 900 reference points all over Sweden. These regular measurements are intended as an exercise as well as a collection of reference data to be used in a possible future fallout situation. In an emergency, measurements will be made at the same reference points and the data reported to the applicable county government. The 21 county governments, in turn, will report the data to SSI. Also, each county government has two survey meters for making their own measurements, as appropriate. Within approximately 24 hours after a deposition SSI has a fairly good picture of the fallout situation in Sweden thanks to these local measurements.

In the event of an off-site alert or general emergency alarm following an accident at one of the four Swedish nuclear power stations, survey teams from the local fire brigades are automatically dispatched to predefined monitoring points to measure dose rates. Measurements will be made even during the passage of the plume, in order to determine its direction and to establish what areas are not affected by the release (where measures like sheltering can be ruled out directly). Special precautions will be taken to avoid contamination of the equipment.

13.6.2 Mobile air filter stations

The stationary ultra high-volume air sampling stations are supplemented by a set of mobile stations that can be transported quickly to regions where additional sampling capacity is needed. There are presently about 30 mobile air filter stations of different kinds available, operated by

- the county government in each of the four counties with nuclear power stations (low volume)
- the nuclear power stations (low volume)
- FOI (high volume)
- SSI (low volume)

13.7 Contamination

13.7.1 Internal contamination

A total of about 20 whole body counting units are available in the country, one of them mobile. They are operated by SSI, Westinghouse ATOM, Studsvik, FOI, nuclear power plants and a number of hospitals, universities and other organizations. Most units apply the chair geometry, some with NaI(Tl) detectors, others with germanium detectors. The few scanning units are equipped with NaI(Tl) detectors.

At least 60 gamma cameras at some 30 hospitals are available for checking internal contamination in the event of an emergency. NaI(Tl) and germanium detectors are available at hospitals and other organizations for evaluating samples of body fluids, urine, excreta etc.

13.7.2 External contamination

Checks for external beta and gamma emitting contamination may be performed by SSI, FOI, local communities, nuclear power plants and others, using most types of modern portable equipment.

13.8 Other types of measurements

Spectrometric measurements must be applied in order to detect non-natural radiation levels smaller than background variations. This can be accomplished by *in-situ* measurements, the most rapid spectrometric technique, since no special sample preparation is needed. Levels down to approximately 1/1000 of the natural background can be detected by *in-situ* measurements with high-resolution germanium spectrometers.

The radionuclides may be deposited on the ground or still airborne. In the latter case, a helicopter can be used to make measurements in the cloud.

Emergency preparedness resources for *in-situ* high-resolution spectrometry are available at SSI, three universities, Studsvik and FOI

13.9 Future development

- SSI is considering establishing a number of mobile automatic gamma monitoring stations, to be used in emergencies.
- SSI has decided to buy four mobile NaI(Tl) spectrometers with GPS navigation systems for use in road vehicles and aircraft to determine ground deposition in the event of an emergency.
- Three of the Swedish nuclear power plants are testing a stationary network of gamma monitoring stations around the plant.

14 Participants of Working Group A / BOK-1.5

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Abstract	This report describes the national systems for emergency monitoring of radioactivity in the five Nordic countries, Denmark, Finland, Iceland, Norway and Sweden as well as in the six Baltic Sea countries, Estonia, Germany, Latvia, Lithuania, Poland and the Russian Federation. Similarities and differences regarding strategy and equipment are shown briefly. The main feature for early warning is the national network of automatic gamma monitoring stations. This network is supplemented by manual stations and/or survey teams, often measuring at predetermined locations. Air filter stations are used for nuclide analyses of particles and gases. Dose rate maps and fallout maps of ground deposited nuclides, e.g., cesium-137, are produced based on data from airborne measurements, monitoring stations, survey teams and environmental samples. Most countries describe programs for checking food contamination. Whole body counting and organ measurements are used to determine internal contamination. External contamination of people, vehicles, goods etc is checked with survey meters and other equipment at checkpoints or as needed. Field measurements of various kinds complete the national systems. Possible future development and planned improvement are discussed. This report is an extension and update of a previous NKS report covering the Nordic countries.
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