

HUNGARY

European Study of Occupational Radiation Exposure

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General information

Population: 10.2 Million (2001);

GNP appr. 54 Milliard EUR (2000);

GNI appr. 49.7 Milliard EUR (2000);

1290 workplaces are registered where sources of ionising radiation are used and external exposures of their employees are regularly monitored (2001);

1 NPP with 4 reactor units;

15260 occupationally exposed workers are involved in monitoring programme of the Authority regarding external exposures (2001).

About 40% of electrical energy in Hungary is produced in the nuclear sector, which plays a significant role in the national economy. Persons employed in nuclear facilities form almost one third of the total number of workers monitored and can be occupationally exposed to ionizing radiation. Their annual collective effective dose is about 2.5 person • Sv (2001), amounting appr. 46 per cent of the total occupational annual collective effective dose. Roughly 58 per cent of workplaces where ionizing radiation is used are in medicine, the number of persons working with ionizing radiation in the medical field approaches 9000, their annual collective dose is approximately 2 person • Sv (2001).

There are about 250 industrial facilities where sources of ionizing radiation are used and the workers are regularly monitored - mainly for the purposes of industrial radiography and for technological controls. About 1300 persons are classified as occupationally exposed workers in general industry, their annual collective effective dose is at a level of 0.7 person • Sv. In the fields of technological development and isotope production and transportation appr. 800 workers are involved with annual collective effective dose of appr. 0.3 person • Sv (2001). Furtherly, about 2 per cent of occupationally exposed workers are employed in the areas of higher education, research, safety and inspection. Their annual collective effective dose is negligible (appr. 0.01 person • Sv).

Legislation in radiological protection

The basic legal document covering the area of radiation protection is the Atomic Energy Act, adopted by the Hungarian Parliament in 1996 [1]. The Atomic

1 Presently, the structure and powers in some of the ministries are under reorganization

Energy Act applies to all aspects of the peaceful use of atomic energy, including the protection of humans and the living and non-living environment. The Act does not apply to radioactive materials and to equipments producing ionising radiation, where these are not classified as being hazardous to health or to the environment. They are regulated by the Government Decree (Exemptions) No. 124/1997. (VII. 18.) [1a] and the Order of the Minister of Welfare No. 23/1997. (VII. 18.) (Exempted Levels) [1b]. The Atomic Energy Act lays down the general provisions for the safety of nuclear installations and for radiation protection. Details are to be covered by a number of implementation regulations in the form of decrees, decisions and guidelines issued under the act. Some of the decrees foreseen in the act have already been brought in force, e.g. the Executive Order No 87/1997. (V. 28.) and Governmental Decree No. 108/1997. (VI. 25.) regarding the duties and scope of the activities of the Hungarian Atomic Energy Authority and the Nuclear Safety Directorate of that, including the licensing and supervisory procedures for nuclear installations. Furtherly, distinctive conditions for acquisition of ownership of certain materials, equipments and facilities belonging to the applications of atomic energy are laid down by the Order of the Government No. 72/2000. (V. 19.) [2]. Some of the provisions of the Act on Atomic Energy have been assigned to the competence of the Minister of Health. The responsibility of the Minister (or his/her legal successor) extends to issue basic standards of radiological protection, i.e. to regulate protection against the harmful effects of ionizing radiation and the safety of radiation sources.

Thus, with particular regard to the radiation protection of occupationally exposed workers, related matters are regulated by special decree, the Order of the Minister of Health No. 16/2000. (VI. 8.) [3] issuing the implementation of the principles and standards of radiation protection as they are laid down in the Council Directive 29/96 EURATOM.

The Order consists of main part, supplements and appendices. The main part is built from the following Titles: Scope; Limitation of radiation exposure of workers and public, action levels and intervention levels in emergency response; Qualification of equipments and facilities regarding radiation protection; Rules of fitness of radiation workers for their activities; Structure of education and training of employees; Principal rules of the operational radiation protection and radiation hygiene; Establishment and operation of radiation

protection service; Requirements of radiation protection regarding transportation of radioactive materials; Authorization and control of: radioactive substances, non-nuclear establishments and facilities, generators of ionizing radiation and establishments to their production and operation; Clearance of supervision of the Authority; Withdrawal of authorization; Declaration of inactiveness (of establishment); Establishment and operation of the National Radiation Hygiene Stand-by Service; Medical care of persons having or suspected to have radiation injury; Closing provisions. To cover details of 30 regulatory paragraph of the main part, thirteen supplements and three appendices are attached to the corresponding Titles.

Similarly to the Council Directive 90/641/Euratom (1990), rules for operational radiation protection of outside workers are settled in the Order of the Minister of Health No. 30/2001. (X. 3.) [4].

With respect to new requirements affecting the radiation protection of occupationally exposed workers it can be said that the annual effective doses received by workers in 2001 only in two cases (industrial radiographers) exceeded the five-year-average of 20 mSv, and thus no difficulties are expected with the introduction of the new dose limits from January 2001. At the same time, effective doses actually above the investigation level of the Authority (6 mSv per monitoring period) were registered at 8 radiation workers. The National Personnel Dosimetry Service (NPDS) had taken measures to introduce $H_p(10)$ as the operational dose quantity and it has already been applied from January 2000 in the external personal dosimetry. Further efforts had been made within the scope of the implementation of the Council Directive 90/641/Euratom, on the operational protection of outside workers [4]. However, the practical control of the external exposures of Hungarian outside workers, including matters relating to dose history, and to issue the document on individual monitoring are due to the National Personnel Dosimetry Service of the Authority, which has been operating a computerised database on individual occupational exposures since 1972.

Structure

Ministerial responsibility

The Government, several ministries¹ - among them the Ministry of Health, the Ministry of Economy, the Ministry of Environment - and several other ministries or state offices have responsibilities arising from the execution of certain parts of the Atomic Energy Act. However, the central role in the implementation of the Act is assured by the Hungarian Atomic Energy Commission and its executive, the Hungarian Atomic Energy Authority (HAEA). The HAEA has the major responsibilities in the licensing and supervision of the nuclear facilities.

Ministry of Health

Matters concerning radiation protection and especially radiation protection of occupationally exposed workers, are completely under the responsibility of the Ministry of Health. Personal responsibility, under the supervision of the Minister, lies with the Chief National Public Health and Medical Officer who is directly supervising - through the Chief Medical Office of the State Public Health and Medical Officer's Service (SPHMOS) - the work of the "Fodor József" National Centre of Public Health (NCPH) and the County Institutes of the SPHMOS. It includes then the Capital's Chief Medical Office and the seven Regional Centres for Radiation Hygiene, too. The National Centre of Public Health, as one of the central organs of the SPHMOS, includes five institutions. One of them, the "Frédéric Joliot-Curie" National Research Institute for Radiobiology and Radiohygiene (NRIRR) has extensive responsibilities and areas of competencies as official duties, in the field of radiation protection in the environment and workplaces, and concerning radiation hygiene of members of the public and occupationally exposed workers. The NRIRR operates the National Personnel Dosimetry Service and maintains - for workers' radiation exposures exceeding the current registration level - the National Register of Occupationally Exposed Workers. It is charged with assuring both scientific and practical support to the governmental organisations concerned in all aspects of radiation protection and radiation hygiene.

¹ Presently, the structure and powers in some of the ministries are under reorganization

Regional authorities

As already mentioned above there are a number of regional health authorities with responsibilities in the area of public health and in some aspects of environmental protection. In addition to the Capital's Institute, there are 19 County Institutes of the State Public Health and Medical Service, which fall under the authority of the Office of the Chief National Public Health and Medical Officer and - within the corresponding County Institute - seven regional centres for radiation hygiene. The latter Institutes are declared as authorities in the counties of their own while giving assistance to others in aspects of radiation hygiene. The county Institutes, however, have become of somewhat more weight in official functions according to the Order No. 16/2000. These institutions are included in the system of supervision of the radiation facilities and control of the safety at work on the fields being under responsibility of the Minister of Health. They do not, however, have direct competencies in the monitoring of occupational exposure, but must be informed by the National Dosimetry Service in relation to all problems in keeping existing dose limits, and are involved in the investigation of overexposures. It should be mentioned that this organisational structure represents the new restructured public health system in Hungary, the radiation protection aspects of which are reflected in the Order cited before. Thus, the new order of the Minister of Health implements the Council's new Basic Safety Standards in Radiation Protection within Hungarian regulations remedying some historically based discrepancies between the organisational structure and the regulations.

Dose quantities, dose limits, dose levels

Dose quantities

The dosimetric quantities in Order No.16/2000 [3] relating to the dose limits are the effective dose, equivalent dose. The calibrating dose quantity for external (photon) exposures until 1999 was the air kerma, and the unit used in the registry was the gray (Gy). The National Dosimetry Service has taken measures earlier to introduce the application of the new recommended operational dose quantity $H_p(10)$ into the standard dosimetric practice, together with the Dosimetry Section of the National Office of Measures (NOM) in Budapest. The introduction of $H_p(10)$ in the routine monitoring has taken place in January 2000. The staff of the NPDS and registry will use and store, in the first two years following the change, both dose quantities - the air kerma and the personal dose equivalent $H_p(10)$, in order to ensure that more realistic

trend analysis can be carried out for occupational exposure. In cases of internal contamination, the routinely measured quantity is the activity, and where necessary the committed effective dose $E(\tau)$ is also calculated.

Dose limits regarding occupational exposure

The existing dose limits for occupationally exposed workers are included in Supplement 2 of Order No. 16/2000, and defined in accordance with the corresponding limits in Council Directive 96/29/Euratom. The annual dose limits for radiation workers are as follows:

- for the effective dose from external and internal sources altogether:
100 mSv accumulated for five consecutive calendar year period. The effective dose shall not be exceeded 50 mSv in any single calendar year. The accumulation of effective doses relates the same periods for all workers monitored and starts on the first day of 2001.
- for the equivalent dose to the lens of the eye: 0.15 Sv
- for the equivalent dose to the extremities and the skin: 0.5 Sv

Special regulations for students and apprentices

Persons aged under 18 are not allowed to be employed as occupationally exposed workers.

For limitation of external and internal doses of students and apprentices who have completed their 18th year and are using radiation sources in the course of their studies the limits for radiation workers shall be applied.

The annual dose limits for students and apprentices aged over 16 but below 18 years who are training for work with use of radiation sources are:

- 6 mSv for effective dose and irrespective of that,
- 50 mSv for equivalent dose to the lens of the eye and
- 150 mSv equivalent dose to the skin and the extremities.
- For those students and apprentices who have not been specified before, the dose limits for members of the public shall be applied.

pregnant women, nursing mothers and women giving mother's milk

Prohibition of employment for female workers denominated is set in a special rule. The corresponding Supplement of the Order of the Minister of Public Welfare No. 33/1998 [5] states that pregnant and nursing women and those who have born not long ago are not allowed to work as occupationally exposed workers..

Specially authorized exposures

The Chief Medical Office of the SPHMOS can issue, excluding emergency situations, permission for volunteers identified by the licensee special exposures where excess of the annual dose limits cannot be avoided. Specially authorized exposures shall not exceed the annual effective dose of 50 mSv. Such exposures can be permitted temporarily at the following conditions: only for workers categorized as A; for five years at most; they cannot be repeated for the same workers; they shall be justified in advance by the employee or licensee and the employee involved shall be informed; permission of special exposures shall be reported to the competent County Institute of the SPHMOS, to the competent Service of Occupational Hygiene and to the NPDS; the employer shall provide for precautionary actions with respect to operations leading to special exposures and is obliged to inform the workers on the risk involved; for monitoring of specially authorized exposures separate dosimeter may be applied. Further provisions are: such exposures shall not be permitted for female workers of reproductive age and for students and apprentices; for the reason of having received specially authorized exposure, workers shall not be excluded from their usual work and moved to another job.

Emergency exposures

In radiological emergency, radiation exposure of person undertaking an intervention shall not exceed the effective dose of 50 mSv. Among the persons involved in emergency exposure situations, those individuals are excepted who intend to avert considerable exposure of the public or carry out life saving actions; in such cases efforts shall be made to keep doses to individuals not exceeding an effective dose of 100 mSv, except for persons undertaking life saving actions, who shall not be exposed to effective dose in excess of 250 mSv.

The employer shall provide for precautionary actions with respect to remedial operations.

Women of reproductive capacity and students, apprentices are not allowed to participate in remedial activities involved in intervention.

Workers' exposures to radon

If employees are exposed of necessity to radon owing to work activities, to limitation of their exposure the occupational dose limits shall be applied and account shall be taken of the dose proportion due to radon.

In circumstances different from those specified previously, exposures to natural radiation sources due to work activities shall be regarded as chronic exposure situations in which the requirements of intervention are operative. In these cases the action level for radon in workplaces is a yearly average concentration of 1000 Bq•m⁻³ in air.

Dose constraints for workers

The Article II of the Supplement 2 in the Order No. 16/2000 decrees: for the sake of ensuring that radiation exposures from given activities or controlled sources to the workers and the public should not considerably exceed the lowest level which is reasonably achievable, for the sources dose constraints shall be applied. The range of values for workers and the upper bound for the critical group shall be remained within the effective dose limits and decided, regarding the source, occupational field and critical group and with attention to the status of radiation hygiene, by the Chief Medical Office of the SPHMOS.

(reference) levels applied in monitoring programme

The minimum detectable level (MDL) for routinely used film dosimeters is 0.1 mSv for ⁶⁰Co with 95 % confidence level of 0.028 mSv. The general recording and reporting levels from January 2000 are at a level of the MDL, i.e. 0.1mSv. Doses which lie below the recording level are officially regarded as zero values in the preparation of national statistics.

Recording levels (RL), however, are not specified or quantified neither for external exposure nor for internal contamination in the relevant Appendices of the Order in question. The official investigation levels of the Authority applied in the course of practical completion of monitoring external exposures by the NPDS are 6 mSv per monitoring period and 20 mSv effective dose accumulated during the given calendar year. If such values are observed in dosimeter responses, by the report and initiative of the NPDS, measures will be taken by the competent County Institute. However, in the corresponding rule (Appendix 2 of the Order No. 16/2000) the obligation of the official investigation at 6 mSv is linked with one month increment in the effective dose of an individual which has been registered. This manner of prescription appears to make some confusion between the real and false exposures because they will only be decided after the investigation. According to the practice which has been followed by the National Dosimetry Service since 1987, another, directly operating level called "investigation level for the employer/workplace" was officially put into force by the new Order of regulation, mainly for the use by the management, which lies between 2 and 6 mSv. The investigation should be performed on the workplace involved and is initiated by the NPDS on the base

of suspected unreasonable or irregular dosimeter responses. In the latter case the personal responsibility will also be cleared up. The results will be registered in the on-line registry either as effective dose or as dosimeter response completed with remark. ^{125}I and ^{131}I is 5 kBq. The reporting level is set at the same value. The NRIRR's competent laboratory performing activity measurements applies an internal investigation level of 10 kBq.

Monitoring of occupational individual exposure

shall be monitored?

- as the general rules of monitoring of occupational individual radiation exposures in the Article IV of the Supplement 2 attached to the Order No. 16/2000. A summation of these is given in the followings:

- The undertaking who is engaged in application of atomic energy is obliged to control occupational exposures by sources, working conditions and regulations.
- In respect of monitoring radiation exposure, the workers shall be ranged into two classes. Those workers belong to category *A* whose annual effective dose possibly exceed 6 mSv or three tenth of the limits authorized for equivalent dose. All other workers shall be classified as *B*.
- The licensee shall perform the categorization of radiation workers.
- Individual monitoring of external exposures for the workers in category *A* is obligatory and it shall be fulfilled the rules of the 2nd Appendix of the Supplement to the Order No. 16/2000.
- Internal radiation exposures of workers involved in possible or suspected radioactive contamination shall be controlled. The liability of monitoring is decided by the competent County Institute of the SPHMOS. The way and frequency of reporting and registration of results shall be ascribed in the local Rules of Workplace for Radiological Protection of the establishment involved and the method of monitoring as well as the results obtained shall be reported to the NPDS.
- In those workplace in which, owing to its settlement or attribute, is suspected that the presence of natural radiation sources leads to enhanced exposure of workers, the employer shall have the activity concentration of radon and the ambient dose equivalent rate for external sources determined. Such types of workplaces and activities especially involved in this matter are listed in Appendix 2 of the Supplement 2 (for example: spas, caves, underground workplaces, specified aboveground workplaces and intercontinental jets).

- For activities and workplaces where increased radiation exposures from natural sources are present, inasmuch as being reasonable by the radiation level, the regular monitoring of occupational exposure and its manner are decreed by the Chief Medical Office of the SPHMOS.
- In such establishments where workers may be exposed to beta- and neutron-radiation, the obligation of regular monitoring of exposures from these sources is decided by the competent County Institute of the SPHMOS.

Until now the NPDS is officially unaware of the existence both of laboratories under approval, except that of the NRIRR and NPP Paks, and workplaces for which such kinds of measurements would be prescribed. Therefore, no official reports have been received to the NPDS and its central registry neither on internal, nor on beta and neutron exposures. The same relates to exposures from natural sources.

the competent laboratory of the NRIRR, Division of Public and Environmental Radiohygiene, fulfills the requirements to determine internal contamination and, in the same time, calculates equivalent doses to some human organs. Periodical controls have been performed for members of distinguished or selected occupational groups. Efforts in the area of the estimation of doses due to exposure to radon have been made in the same Division of the NRIRR.

The regulations require that the length of the monitoring interval for external exposures be established between 1 and 6 months by the NPDS, depending on the level of stochastic risk due to occupational exposure and the method applied. In this respect, the employer may also ask for 1 month period in workplaces where this is reasonable. In practice, the monitoring interval for the majority of occupationally exposed persons is two months. Only workers employed in maintenance work at the nuclear power plant and in the radioactive waste repository are monitored over a one-month period.

Dosimetry services

Approval

The regulation for the monitoring of occupational exposure and exposure to members of the public fall under the responsibility of the Minister of Health, more directly under that of the Chief Medical Office of the SPHMOS. Paragraphs in the main part of the Order No. 16/2000 prescribe the obligation both of controlling the occupational exposure and estimating exposure to the reference group of the public with a frequency given by the Chief Medical Office of the

SPHMOS. The standards for monitoring the former type of exposure have been detailed in the previous section. It means that, within the general prescriptions, the occupational exposures due to external photon radiation sources are subjected to regular and *central personal dosimetric control* of the Authority which shall be organized and performed by the NRIRR of the National Centre of Public Health of the SPHMOS. Requirements and the manner of monitoring exposures from all other (beta or neutron) sources are regulated or directed in the corresponding paragraphs of the Order or its Supplements or Appendices as mentioned before.

To establish dosimetry laboratories or services other than those of the NRIRR or within the network of the SPHMOS for external and internal exposures are not excluded by the Order in question, although such institutes are not denominated or appointed. However, independently of the maintenance of these laboratories/services or type of radiation to be measured, for functioning and acceptance they shall have an approval of the National Board of Accreditation, from the 1st of January, 2003.

The requirements affecting the work of dosimetry services and the basic rules for the workplaces involved in monitoring programme of the Authority are laid down in the 2nd Appendix of the 2nd Supplement of the Order No. 16/2000. The methods applied in dose estimation require, however, the issuing of approval. The technical performance of dosimetry service is controlled, through calibrating irradiations and internationally accepted performance tests, by the National Office of Measures (NOM) which has a Dosimetry Section being entitled to such activities. Basic regulations concerning the verification and accuracy of the equipments and methods used are included in Act No. XLV 1991, and in Government Decree No. 127/1991. Official approval is issued - through the NCPH - by the Chief Medical Office of the SPHMOS. At present film dosimetry has been approved for the performance of individual external dosimetry on the basis of Kodak type 2 film.

External dosimetry

The National Personnel Dosimetry Service operated by the National Research Institute for Radiobiology and Radiohygiene of the NCPH is the only dosimetry laboratory which has been approved to offer legal services in regular monitoring of individual external exposure to other institutions [3]. There are, nevertheless, several dosimetry units in certain facilities which control occupational doses received by their own staff and the exposures during certain operations, for the purposes of improving radiation protection. In most cases they use electronic or TL doseimeters. The most significant dosimetry service for

operational dosimetry is the one at the Paks NPP, which monitors more than 1000 persons who work in the controlled area.

Presently the NPDS is monitoring approximately 15300 persons at about 1290 workplaces. The method used is film dosimetry for γ and x-ray fields. The film dosimeters consist of Kodak type 2 film and AERE/RPS (Harwell) badge. To estimate effective doses, dosimeters are calibrated in personal dose equivalent [$H_p(10)$] for radiation quality of medium-filtered x-rays, ^{137}Cs and ^{60}Co beams, at the angle of incidence of 30° , in the range 0.02-1.25 MeV, by the Dosimetry Section of the NOM.

Monitoring for internal contamination is not centrally organised as that in the case for external exposure. The necessity of individual monitoring for internal contamination shall be decided by the County Institutes with the assistance of the competent regional centres of radiation hygiene within the SPHMOS in establishments where unsealed sources are used. These authorities prescribe the monitoring method and monitoring interval with respect to the working conditions and the type of work. The licensee shall provide for the proper measurements of internal contamination according to the approved local Rules of Workplace for Radiological Protection. Laboratories involved in performing such measurements shall be approved by the National Board of Accreditation. Reporting to the NPDS is obligatory for these workplaces.

In practice, larger quantities of unsealed radioactive materials are used in the preparation of radio-pharmaceutical products at the NRIRR and in the Institute of Isotopes Co. Ltd. Internal contamination is regularly monitored also at the Paks NPP and occasionally in the KFKI Atomic Energy Research Institute. Both of them operate their own laboratories for internal dosimetry.

At the NRIRR, internal dosimetry is carried out by the Division of Public and Environmental Radiohygiene [6]. The division monitors the staff of the Department of Applied Isotopes (approx. 50 persons) of this institute and additionally workers from other facilities, the main group being workers from the Paks NPP, occasionally. The most frequently measured isotopes are ^{125}I , ^{131}I , ^{137}Cs , and ^{40}K . Usually whole-body activity is measured, and where work with iodine is involved, the thyroid activity, too. The AGEDOS algorithm is applied for the estimation of E_{50} if this seems to be necessary. The laboratory has the proper certificate on accreditation as required by the related Order.

Practically, however, workers who might be exposed should undergo whole-body counting at least once a year.

Quality assurance and control

The present regulations for the area of radiation protection do not contain explicitly formulated requirements regarding the quality of dose assessment. In general, the Order No. 16/2000 requires the status of accreditation for all laboratories involved in dosimetric control.

However, the existing general law on measurements, i.e. Act XLV /1991 and the supporting Governmental Decree No. 127/1991 contain general provisions concerning the calibration, accuracy of measurements and devices used. There are National Standards concerning the procedures for the control of the accuracy of measurements, generally, but there are only a few actual provisions which are applicable today for the specific area of the assessment of personal doses due to exposures to ionising radiation. The staff of the NPDS are intended during their work to keep to all conditions provided in the above-mentioned regulations and follows the recommendations of the international organisations like ISO, IEC and IAEA. Especially helpful in the external dosimetry practice are the Technical Recommendations of the EC (EUR 14582) and the IAEA Safety Guide No. RS-G-1.3.

The activities of the NPDS are operatively controlled by the executive of the NRIRR and, at a higher level, by that of the National Centre of Public Health which is operated as a partially budgetary organ of the SPHMOS and the Office of the Chief National Public Health and Medical Officer, respectively.

The accuracy of dose assessment depends on the proper initial calibration, and periodical re-calibration of the dosimeters for which the standard irradiations are performed by the Dosimetry Section of the National Office of Measures. The staff both of the NPDS and the Dosimetry Section at the NOM have invested a lot of efforts into the calibration of personal dosimeters. The parameters of basic calibration is checked regularly at one-yearly intervals. The NPDS takes part in different intercomparisons in the field of personal dosimetry in photon fields, e.g in the IAEA Coordinated Research Programme (type testing, 1997-98). Furtherly, in addition to the certificate on accreditation, the NPDS' method has been subjected to the procedure of performance testing according to the requirements laid down in the Recommendations cited before. The certificate on the results of performance testing is issued by the Dosimetric Section of the NOM. It has been proved that the NPDS' system well meets the conditions required by the relevant international organizations.

Reporting of dose information, flow of the dose data

The National Personnel Dosimetry Service sends the information on received individual doses after every evaluation of the dosimeters - usually every two months - to the radiation protection officer at the workplace. The printout contains the name and the ID of the workplace and the individual records. The officially issued documents on results are filled in according to the particular rules of the standards of accreditation. Each personal record includes the name of the worker, the number of the dosimeter worn, the date of the evaluation, the dose value, and a field for remarks. By official report of the employer or the local radiation protection officer, when accident or overexposure(s) are suspected, the NPDS is ready for exceptional evaluation of the immediately transmitted dosimeter(s).

The NPDS reports include, additionally, the beginning and the end of the monitoring interval. The results of dose estimation are transferred automatically to the on-line register after each evaluation of the dosimeters, and are processed further in the central registry. Each dosimeter reading is automatically compared with the existing official and internal investigation levels (see section Dose levels). If the investigation level for workplace appears to be exceeded by dosimeter readings, the NPDS sends letter(s) to the radiation protection officer with a recommendation to carry out an investigation of circumstances within the workplace in order to avoid further unnecessary exposures or to omit untrue exposures from the individual record/registry. In cases when the official investigation level has been exceeded, the NPDS has to inform immediately, by special formal letter, both the employer and the competent authorities (County Institute of the SPHMOS and the Regional Centre for Radiation Hygiene). They then have to carry out an investigation of the circumstances. The results from the authority's investigation or from that of the facility's management are to be transmitted in written form to the NPDS.

Long-term storage of the data

The regulation prescribes the duration of keeping of data on individual exposure as thirty years after ceasing of employees' radiation work. The radiation protection officer responsible at the facility is obliged to keep records of all data on occupational exposure, and on the number of dosimeters used. The Central Registry of the NPDS keeps computer records of dosimetric data for a period prescribed. In practice all data exceeding the MDL or completed with remarks are stored in on-line system, and the earlier annual dose records are being archived in other system which is capable of processing data for long term

analysis and surveying the status of occupational exposure. Alongside this, the NPDS has been keeping all processed films since 1966.

Employment of outside workers, radiation passports

The operational protection of outside workers is regulated by the Order No. 30/2001 of the Minister of Health [4] which is declared to be consistent with the Council Directive No. 90/641/Euratom. The Order consists of the following sections and paragraphs, respectively: frame of force and definitions (par. 1,2); engagements of the licensee (par. 3-5); obligations of the outside worker (par. 6); Dosimetric control (par. 7-8); Control of the Authority (par. 9-10). The paragraphs are subdivided into heads, of which the followings can be stressed:

- the power of the Order extends to those employees who are to work as outside workers within controlled area, furthermore, to their employers and to the licensees of controlled area;
- the licensee is obliged to report to the competent Authority of Radiation Health if outside workers are contracted to work in controlled area;
- the licensee shall be responsible regarding the properness of outside workers' activities and the conditions of radiological protection, including dosimetric supply;
- prior to beginning with work, the outside undertaking shall get the proper authorization from the competent Authority of Radiation Health;
- outside worker is allowed to work abroad if holding certification on individual monitoring of exposure (i.e. radiation passport);
- outside worker is obliged to report dosimetric data of the outside activities for the home Central Registry;
- the pass on data of monitoring exposure shall be issued by the NPDS;
- the pass shall contain the followings: number of the document, personal data, place and date of birth, permanent address, date and result of the last periodic health surveillance, identification and accessibility of the outside undertaking, dosimetric data of the past five years, denomination of the issuing organization with date and signature;
- the pass of dosimetric data should contain individual doses regarding each monitoring period, (i.e. commission) as follows: $H_p(10)$, $H_p(3)$, $H_p(0.07)$, $E(\tau)$ and assessment for incorporation of radionuclides (nuclides, activities);
- the individual doses and the document shall be recorded and signed, respectively, by the licensee;
- results of monitoring obtained during each commission shall be forwarded to the NPDS by the outside workers;

- foreign citizen as outside worker shall obtain the pass from the competent Authority of his/her own country;

implementation of this Order shall be inspected regularly by the Authority of Radiation Health.

It follows from the prescriptions of the Order that the proper dosimetric control of outsider workers employed within the country does fall amongst the licensee's obligations but getting the so called dosimetric pass in cases of outside workers transferred within the country does not; possession of pass is compulsory for employees going to have jobs, as outside workers, abroad.

However, this category of workers does already exist in Hungary, and the main group of outside workers have activities in the Paks NPP. Due to the fact that there is only one official dosimetry service in the country and to the effective operation of the Central Dose Register, the monitoring and control of received doses and, therefore, issuing radiation pass is ensured, presuming that the contractors have been announced to the NPDS. The only missing information is the previous dose history for foreign workers, because their numeric data are usually not available for the NPDS.

mainly two categories of outside workers in Hungary:

- individual contractors who are self-employed
- employees of undertakings which have contracts with nuclear facilities for the performance of certain operations.

In the first case the persons are to be registered for the monitoring of individual exposures by the facility operator. In the second case two versions may be experienced in the present practice: a) the actual employer assures monitoring of its own employees; b) in some cases, the outside undertaking gets an agreement with the facility operator on the monitoring of outside workers within the framework of the dosimetry programme of the facility. In all cases, the NPDS has exact information if the monitored workers at the NPP belong to the staff of the plant or are contractors (outside workers). This information is included in the NPP sector of the Central Dose Registry by special occupational code. The data on individual exposures and radiation pass(es) are sent generally to the actual employer, but in case b) to the outside undertaking.

During the first half of the year 2002, the NPDS has issued 30 sheets of "Document on individual monitoring of radiation worker", i.e. radiation passports.

Regular monitoring of individual doses due to occupational exposure to ionising radiation was enforced in Hungary in 1965 through Order No 4/1965 of the Minister of Health. The National Research Institute for Radiobiology and

Radiohygiene was charged with the organisation of individual monitoring for all radiation workers in Hungary in relation to external exposure to γ and x-rays. The prescription of monitoring of exposure to β -rays and neutrons and that from internal sources falls under the responsibility of the County Institutes of the SPHMOS, while the implementation is due to the facility involved. The results from dose estimation should be transmitted to the Central Dose Registry. Since 1966 film detectors and dose data - on protocols or in printed form - have been stored in the archives of the NPDS. Computerisation of the archive began in 1972 on the basis of the ICL computer [7], and both software and hardware underwent several changes as a result of rapid development in computer equipments. An interface between the densitometer and the personal computer was realised in 1984 [8]. The process of modification and modernisation of the record keeping system was accompanied at all times by implementation of measures to assure safe storage and continued access to older information. The present Central Register on Occupational Exposure in Hungary was last updated in terms of the applied hard- and software in 1994. With regard to datasets, dosimetric quantities and some other parameters, the software has been completed in 1999/2000. The structure of the registry will be presented below.

Contents of the Central Register

The registry at the NPDS is subdivided into two parts: the on-line operated database and the archive register. The general feature of the central registration is that radiation workers who had ever received exposure - from external sources - equal to or greater than the RL shall be identified and registered by the NPDS. However, the criterion of RL was replaced with the MDL from January 2000.

The on-line operated database of the register

The on-line database contains the detailed results from the evaluation of dosimeters during each monitoring period in each year, and information about workers, employers and their activities:

Personal data: names, mother's name, date of birth, gender.

Employer data: name, address, name of RPO, number of monitored workers, code of the regional supervisory authority, several other codes for the classification of the employer's main activity and the workplace activity, register number for the workplace and identification number in the accreditation registry

Exposure data: codes for the type of radiation, beginning and end of the monitoring interval, serial No of the film, all dosimeter readings for the current year, remarks on cases of irregular irradiation, results from the authority's or management's investigations in cases exceeded the specified dose levels, indication for evaluation in exceptional or suspected accidental cases. Mainly for comparative studies, dosimeter readings obtained for each worker (above the MDL) in the years 2000 and 2001 were evaluated and registered both in air kerma [mGy] and $H_p(10)$, mSv. Obviously, in these years two calibration procedures were performed, too.

Dosimetry data: calibration parameters, sensitivity curves, correction factors, etc.

NPP-part: names, mother's name, internal registration number at NPP, register and identification number of the workplace, code for job, code for workplace, code for employment status (internal/outside worker), code for monitoring interval (one/two months).

or, if necessary, protocols.

The archive part of the registry

The archives contain several kinds of data:

- annual archive files on the basis of the above described on-line register
- annual archive files for the NPP section of the on-line operated database (since 1982)
- database containing individual annual dose data since 1972 which can be considered as a central 'life-time' dose register; the structure for the personal and employer data is similar to that described above in relation to the on-line register, the exposure data are compiled in the form of the annual dose
- a separate data section for cases of exceeded investigation levels: additionally to the data in the on-line registry this contains information on the competent regional authority, the code for the classification of the individual case, and the results from the investigation
- in addition to the personal registry, annual files are available since 1979 on workplaces which have been involved in the NPDS' monitoring programme. Also these files are supplied with the same code system as those of exposed workers
- individual annual doses of 2000 and 2001 have been archived in both of the dosimetric quantities used (K_a [mGy], $H_p(10)$ [mSv]), as parallel files.

The archive database contains roughly one hundred twenty nine thousand records on results and data of workers and workplaces, resp.; each consists of

6 - 8 fields, in addition to the suitable codes for identification. Within this size of the database, the individual annual section counts about eighty nine thousand, the registry of radiation workplaces extends over about thirty eight thousand and the proportion of investigated cases includes appr. one thousand six hundred records.

Hardware and software

The hardware component of the on-line register includes five work stations arranged in a Novell NetWare net. A self-designed data management system is used, the programs are written in Turbo C. The archive part of the register is run on a personal computer under DOS, the database management system is DBASE, and the programme language is Clipper. Processes of dosimetric data for special purposes are performed by applying MS Access or Excel procedures.

Classification of workers and facilities in the central register

The NPDS uses the following sophisticated system in the central registry for the classification of:

- main activity (6 classes: hygiene, industry and technology, education, research, agriculture and breeding, others)
- details of the occupational activity (11 classes, e.g. medical service, medical research, public health inspection, basic research, industrial research, etc.)
- type of facility (24 classes, e.g. radiology in polyclinic, radiology in hospital, veterinary, isotope production, maintenance of medical devices and x-ray machines, etc.)
- sub-department of the facility or workplace (18 classes, e.g. brachytherapy, teletherapy, nuclear medicine, dentistry, industrial radiography, pediatric x-ray diagnostics, etc.)
- type of radiation (8 classes: x-ray, x-ray + β , x + γ , γ (+ β), β , neutrons, γ + neutrons, electron microscopy).

The complex classification system is practically realised through a common classification code composed of 6 characters. The classification code for each worker is set by the staff of the register on the basis of information supplied by the radiation protection officer at the workplace.

There is a separate system for classification of the workers at the Paks nuclear power plant. It includes 33 classes for classification of work facility /workplace (e.g. reactor maintenance and repair, primary circuit operation, coolant pump maintenance and repair, radiography, quality control, waste handling, decontamination, general operation, secondary circuit operation, reactor block operation, etc.). There exists an additional code for the status of worker, i.e. internal staff or contractor.

Access to the data, national statistics

The data on occupational exposure are stored in accordance with the requirements of Act XLVII /1997 on data protection. On the other hand, it is prescribed in the Appendix 2 of the Order No. 16/2000 that the employer shall have the employees' declaration of agreement on registration and handling of their dosimetric data, according to the conditions specified in distinct rule, at the NPDS. Only authorised persons among the staff of the NPDS and the Director of the NRIRR have access to the database. Information about individual doses in the form of a certificate can be provided only to following persons/organisations:

- the radiation workers themselves
- the radiation protection officers at the workplaces or the employers
- the supervisory central and/or regional authorities
- the offices of occupational hygiene, the state social assurance organisation
- the Court of Justice or Industrial Tribunal, the Institute of Forensic Medicine
- domestic or international organizations carrying out epidemiological studies: only in the form of processed data, with the permission of the Director of the NRIRR.

There are no restrictions concerning the use of the data in aggregated form for statistical purposes, if otherwise the purpose and activity of the user organization meet the prescriptions of the Act XLVII/1997 (on protection and handling of personal data). The staff of the NPDS and the central dose registry have many years of experience in the preparation of national statistics on occupational exposure in Hungary and always provide support to international organisations such as UNSCEAR, the OECD, IAEA, or WHO in the form of information in this field. It is worth pointing out that the central registry in Hungary holds comprehensive and detailed data on individual occupational exposures covering a long period of about 30 years. On the basis of the available information it is possible to compile historical overviews, and to follow up trends in the development of individual and collective dose patterns, and in doses accumulated during the individuals' working life time [9, 10, 11, 12].

Medical surveillance

Medical examinations are obligatory for all workers in Hungary and this matter is regulated in Order No 33/1998 of the Minister of Welfare. The system of health surveillance includes pre-employment examinations and periodical check-up of health. The frequency for the carrying out of medical examinations is at least once a year for both workers in nuclear facilities and those at

workplaces where radiation sources are used. The medical review includes an examination by an internist, laboratory tests (blood, urine, etc.); additionally, examinations by an ophthalmologist, gynaecologist, dermatologist, psychiatrist or other specialists might be prescribed depending on the kind of work [13].

Special prescriptions are included in the Order No. 16/2000, according to which those workers who have suspectedly or actually received effective dose exceeding 250 mSv, shall be subjected to medical examination, and if necessary, to medical treatment. In cases of suspected or actual contamination of unsealed radioactive materials, the proper procedures shall be carried out as determined in so called Letter of Methodology prepared, in co-operation with the Professional Board concerned, by the NRIRR in this subject. Medical provision for such workers shall be given in 12 hospitals or medical clinics assigned for this task. Carrying out of further particular procedures are related, with co-operation of the NRIRR, to duties of the National Institute of Oncology and the National Institute of Haematology and Immunology. XLVII/1997 on data protection.

The data are recorded on the employees' Document of Individual Registry which is stored at the offices for occupational health performed medical examinations at the first degree. These physicians are usually the competent occupational hygienists. There are certain rules which ensure continuation of medical surveillance in cases where workers change to other employers. The employer receives only a statement concluding fit/unfit or restrictedly fit for work with ionising radiation, and does not the results of the examinations. The worker obtains the results and data of his/her examination. The employer must not be informed about the reason of unfitness. In cases where health problems arise the workers are sent to different specialized clinics. All cases of cancer diseases (not only occupational) must be reported to the Cancer Registry at the National Institute of Oncology.

Training in radiation protection, approval of qualified experts

Qualified experts

The general rules have appeared in the Government Decree No. 24/1971 and, especially on the field of hygiene, in Orders No. 14/1972 and No. 10/1984 of the Minister of Health. Several parts of them have been upgraded in the Act No. CLIV of 1997 on Health including radiation hygiene, too. No executive orders, followed yet, in this respect, the Act and most fields other than hygiene have no

explicit regulations at all relating the requirements of qualification for experts in radiation protection.

Matters concerning qualification and training of specialists working in the field of radiation protection of human aspects fall under the responsibility of the Ministry of Health. The procedure for nominating qualified experts is, in this respect, regulated in an administrative order of the Minister of Health. The Ministry of Health keeps a list (register) of qualified experts in the field of radiation hygiene in the country. The responsibility in other occupational fields, regarding technical or any other expert activities, are divided among the corresponding supervisory authorities.

The Law on Higher Education (No. LXXX. of 1993) was adopted by the Hungarian parliament which established the National Board of Accreditation which has to be taken into account by the approbation of qualified institutions or (University-) faculties, rather than individual experts, in Hungary. The general regulation of application of experts for qualification in various fields is being under discussion among the Ministries involved [13]. The National Research Institute for Radiobiology and Radiohygiene is the principal organisation which will be involved in the assessment and testing of the professional qualification of the applicants. According to the Minister's Order, the qualification of experts in certain, specified areas of radiation protection is foreseen for a maximum period of 5 years. After the elapse of this period the person must apply for renewal of his/her certification of expertness. However, education and the post-graduate study in the field of radiology, radiobiology, epidemiology, radiation protection, etc. are considered to be significant assets in the process of certification as a qualified expert in radiation protection.

Training of persons involved in work with ionising radiation

The regulations in the area of radiation protection require adequate training for all persons involved in work with ionising radiation. In the main part of the Order No. 16/2000 the general rules are laid down while the Supplement 4 is dealing with details of the requirements. Appropriate training and five yearly refresher course with the related examination is explicitly prescribed for the allowance of performing all kinds of activities connected with the use of atomic energy. Subjects and requirements of examinations of trainings and refresher courses in radiation protection shall be approved: at basic level, by the competent County Institute of the SPHMS; at advanced and comprehensive levels, by the CMO. The licensee is obliged to provide for the employees' taking part on training or refresher courses. The 4th Supplement of the Order includes a list of jobs or activities in facilities where sources of ionising radiation

are used, and various degrees of trainings in radiation protection are prescribed. As mentioned before, there are three levels of training or refresher courses in radiation protection:

- basic level - training for workers employed in certain jobs but who are not involved in handling or operation of radiation sources/generators;
- advanced level - training for unaided operators and supervisors whose work is related to different sealed and unsealed sources; furtherly, occasional users of ionizing radiation on medical field;
- high level - comprehensive training providing broad coverage of radiation protection, and including the application of different sources and devices, the development of measures for reducing exposure to workers and environment. Persons who have successfully completed such high-level training may be employed as radiation protection officers, inspectors, experts, designers of workplaces where ionizing radiation is applied or trainers in radiation protection at basic and intermediate levels.

Training activity can be performed by those persons for whom it has been permitted by the competent Authority as described before. The examination procedure is completed by the trainer and it needs the presence of the representative of the CMO.

Education in radiation protection can be acquired on graduate faculties of establishments of higher education if having the necessary permission of the Authority at least for giving trainings of advanced level.

The obligatory minimal time-table for various courses are as follows:

- basic level: 8 hours, including radiation physics, fundamentals of radiological protection, consultation;
- advanced level: 20 hours, covering fundamentals of: radiation physics and dosimetry, radiobiology, radiation protection; dose limitation; national organization of radiation protection and system of the Health Authority; emergency planning for remedial actions at nuclear accident; exercises; consultation.
- comprehensive course: 40 hours, giving knowledge in: radiation physics; radiobiology; radiological protection, system of dose limitation; radiation protection system of the Health Authority; radiological accidents; management of radiation-injured individuals; emergency planning for remedial actions at nuclear accidents; exercises; consultation.

CMO Chief Medical Office

CNPHMO Chief National Public Health and Medical Officer

HAEA Hungarian Atomic Energy Authority

MDL	Minimum Detectable Level
NCPH	National Centre of Public Health
NOM	National Office of Measures
NPDS	National Personnel Dosimetry Service
NRIRR	National Research Institute for Radiobiology and Radiohygiene
RL	Recording Level
SPHMOS	State Public Health and Medical Officer's Service