INFORMATION SYSTEM ON OCCUPATIONAL EXPOSURE – TEN YEARS OF EXPERIENCE

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1. Introduction

During the 1980s, radiation protection experts in the nuclear industry, at operating organizations and at regulatory authorities were faced with new challenges in the management of worker protection at nuclear power plants. The main issue was the growing pressure to put into practice the conceptual approach of optimization of protection, which at that time was becoming one of the cornerstones of international radiation protection standards. This almost naturally generated a feeling that worldwide progress in applying the optimization principle to the control and reduction of worker exposures could be achieved if the variety of managerial and operational approaches adopted in different nuclear power plants and different countries were pooled, exchanged and compared in an organized way.

But this would require a mechanism to exchange and review experience between health physicists. The idea was raised to create an international database and a network of contacts and assistance, with the aim of establishing a bridge between regulators and operators in areas of common interest by involving regulatory authorities in discussions on the implementation of the "as low as reasonably achievable" (ALARA) principle based on operational information. This idea proved to be successful, as is demonstrated by today's participation in ISOE (the Information System on Occupational Exposure) of regulatory authorities from 25 countries.

ISOE was created in 1992 to provide a forum for radiation protection experts from both operating organizations and national regulatory authorities to discuss, promote and co-ordinate international co-operative undertakings in the area of worker protection at nuclear power plants. The ISOE System is promoted and sponsored by the OECD Nuclear Energy Agency (NEA) and the International Atomic Energy Agency (IAEA), which provide a Joint Secretariat for the programme. The ISOE programme is managed by a Steering Group, whose chairman is selected among representatives from the participating utilities.

The ISOE programme offers a variety of products in the occupational radiation exposure arena, such as:

- The world's largest database on occupational radiation exposure from nuclear power plants. As of December 2001, the ISOE database includes information on occupational radiation exposure levels and trends at 460 reactor units (406 in operation and 54 in various phases of decommissioning), operated by 73 utilities in 29 countries. This database thus covers some 93% of the total number (438) of power reactors in commercial operation throughout the world.
- A yearly analysis of dose trends and an overview of current developments, through ISOE Annual Reports. The Annual Reports [1] summarise recent information on levels and trends of average annual collective dose at the reactors covered by the database, provide special data analyses and dose studies, outage experience reports, summaries of ISOE workshops and symposia, as well as information on principal events in ISOE participating countries.

- Detailed studies and analyses, as well as information on current issues in operational radiation protection, through ISOE Information Sheets. Dosimetric and other data from nuclear power plants provide an ideal basis for studies on dose related to certain jobs and tasks, such as refuelling, steam generator replacement, insulation work, etc. These studies are published as ISOE Information Sheets and distributed to ISOE participants.
- A system for rapid communication of radiation protection information, such as effective dose reduction approaches, effective decontamination procedures and implementation of work management principles. Anytime an operating organization wishes to share experience on good practices, radiological problems or other technical issues, the ISOE network may be used to request or send information through the Email system. This allows rapid responses and interaction between interested participants.
- A forum for discussing occupational radiation exposure management issues through ISOE workshops and symposia. Each year, an international workshop or symposium on occupational radiation exposure management at nuclear power plants is organised, in turn, in Europe and North America. The objective of these workshops and symposia is to provide a forum for radiation protection professionals from the nuclear industry, operating organizations and regulatory authorities to exchange information on practical experience on occupational radiation exposure issues in nuclear power plants.

A part of the above-mentioned components of the Programme are reserved for sole use by the participating operating organizations, which can thus dispose of a closed network for information exchange on particular operational experiences.

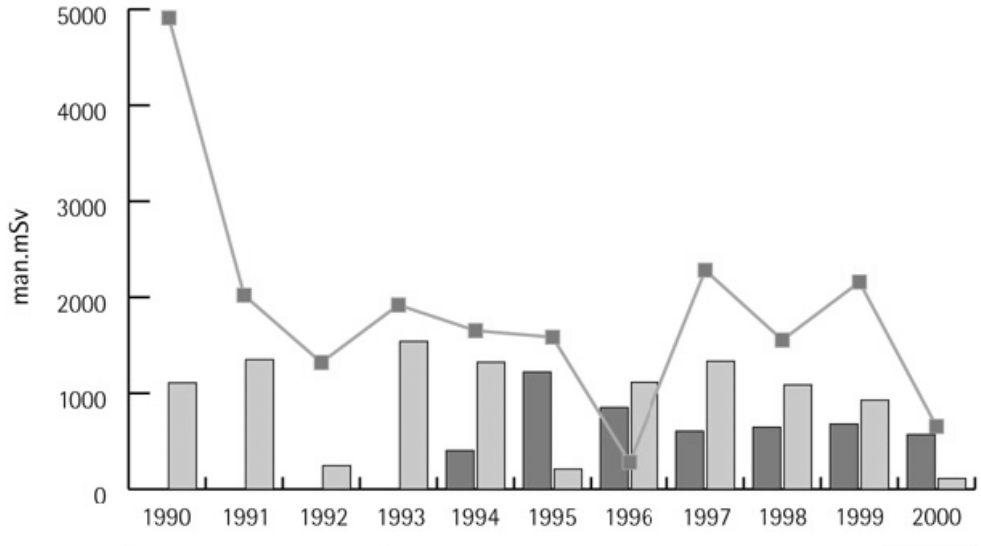
This paper is based on a report [2], published in 2002, summarizing the experience gained from ten years of developing ISOE. The full report contains, in addition to further details, comments from participants on their experience with the system.

2. Radiation protection professionals benefit from ISOE

2.1 Benchmarking analysis

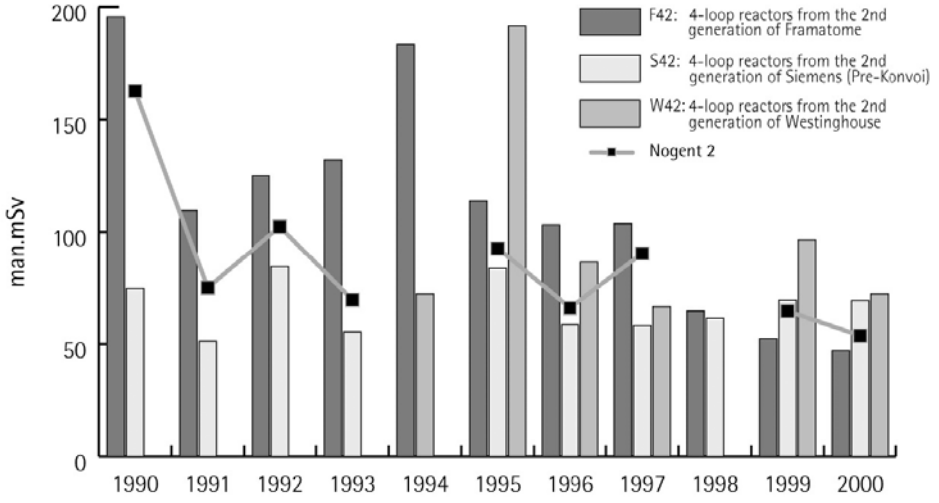
The ISOE database forms an excellent basis for studies and comparisons of occupational radiation exposure data between nuclear power plants in various countries or even within the same country. To improve the significance and usefulness of these studies, comparative analyses of data from reactors having similar characteristics can be made. For this purpose, “sister unit groups” have been defined within the ISOE database, each containing reactor units of comparable type and design. Except for gas cooled reactors, each reactor included in the ISOE database has been assigned to a sister unit group.

Annual dose benchmarking for Tricastin 1 between 1990 and 2000



	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000
Daya Bay 1					402	1221	852	605	647	680	569
Koeberg 2	1109	1350	245	1540	1323	211	1114	1333	1086	928	113
Tricastin 1	4990	2020	1320	1919	1652	1584	281	2281	1554	2158	654

Annual dose benchmarking on the job "refuelling" for Nogent 2 between 1990 and 2000



	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000
F42	196	110	125	132	183	114	103	104	65	52	47
S42	75	51	85	55	72	84	59	58	61	69	69
W42						192	86	67		97	72
Nogent 2	163	75	102	70		93	66	90		65	54

Using the ISOE software,[1] participants are able to generate pre-defined benchmarking tables and graphs. They can create their own comparisons with other units, within the relevant sister unit group and/or in other sister unit groups. The benchmarking analysis is available at various levels, such as annual collective dose and dose per job (e.g. refuelling, steam generator primary side, etc.). Examples are given in Figures 1 and 2.

For a more detailed understanding of the results, participants can directly contact the responsible counterparts in other nuclear power plants by using the contact information available within the ISOE database.

2.2 Experience exchange

The communication network available to participants, using modern technology for real-time information exchange, is one of the most useful features of ISOE. ISOE participants can use their respective Technical Centre to obtain information and advice on specific radiological problems, radiation protection techniques, procedures of work, and more. Each ISOE Technical Centre investigates questions raised by a participant, by contacting other ISOE participants directly or through the other ISOE Technical Centres. The resulting information is passed on to the questioner. In cases of general interest, a summary is published as an ISOE Information Sheet.

For the above purpose, an E-mail system has been installed at the NEA Secretariat. This system also allows ISOE participants to exchange reports, questions and other information electronically with all other ISOE participants (utilities or authorities only, or both).

ISOE expert groups can be established to conduct specific studies based on the needs of the participants. For example, an expert group was created to quantify the impact of work management on occupational radiation exposure. The report [3] generated by this group was widely distributed and translated into several languages.

As already noted, several types of documents are made available to ISOE participants. These include the following:

- ISOE Annual Reports [1] presenting the evolution of occupational radiation exposure in nuclear power plants, as well as information on principal relevant events in the ISOE participating countries;
- ISOE Information Sheets (with “general distribution” to all participants or “limited circulation” to utilities only);
- reports issued by expert groups.

Additional exchanges of experience take place during the annual Steering Group meetings. The ISOE Steering Group consists of representatives from operating organizations and regulatory bodies who, besides deliberating on ISOE management issues, review current developments and national trends in the operation and regulations of the nuclear industry, from a radiation protection expert’s perspective.

2.3 Symposia and workshops

Since 1997, ISOE has developed a programme of annual workshops and symposia for radiation protection professionals from all types of nuclear power plants. Attendees also include contractors and regulatory staff. The workshops and symposia are held alternatively in North America and in Europe. The European workshops are co-organised by the European Technical Centre and the European Commission, which provides a substantial financial contribution. The IAEA supports the workshops and symposia by providing

[1] ISOE provides participants with software packages, including the ISOE database and the input module (ISOEDAT) and the interface programme containing pre-defined analyses (MADRAS).

financial help for participants from countries participating in ISOE through the IAEA and also for participants from target countries of two IAEA Technical Cooperation Projects aimed at enhancing occupational radiation protection in nuclear power plants.

The objectives of these meetings include the following:

- To provide a large forum to exchange information and experience on occupational radiation exposure issues at nuclear power plants.
- To allow vendors to present their recent experiences and current technology in the radiation protection area.

These workshops and symposia have given hundreds of professionals an opportunity to listen to oral presentations (about 30 in each workshop), exchange information, share ideas and learn from others. The workshops' concept, with contributions from and for the radiation protection professionals, has proven to be very effective. The discussions on selected topics in small groups in Europe and the practical ALARA training sessions in North America have contributed to the success of the programme.

Further information exchange is accomplished by having the three best papers from each workshop presented at an alternate workshop. These papers and additional information are available on the European Technical Centre website (http://isoe.cepn.asso.fr/) and the North American Technical Centre website (http://hps.ne.uiuc.edu). Non-participating individuals and institutions have access to these websites.

2.4 Expert group on work management

The ISOE Steering Group published an expert group report on Work Management in the Nuclear Power Industry in 1997. This was one of the first ISOE products that documented good radiological work management practices aimed at reducing occupational doses.

The preparation of the report [3] started in 1995 with the creation of an ISOE expert group of radiation protection managers from eight countries, including Canada, Finland, France, Germany, Sweden, Switzerland, the United Kingdom and the United States. The expert group was chaired by the United States.

The contents of the report cover work planning, including scheduling and training, implementation and feedback.

Feedback from ISOE participating utilities on the report has been exceptionally positive. For example, reported applications of this document by US participating utilities include:

- use of the report's outline and text as an ALARA assessment format;
- use of the report's basic concepts to develop a Site ALARA Enhancement Action Plan.

The beneficial effects of the improved work management approach induced by ISOE can also be seen in the continuous decrease of refuelling duration times. For example, US average refuelling duration was reduced from 55 days in 1990 to 32 days in 2000.

The importance of providing applied information in the native languages of the nuclear power plant personnel of different participating countries was recognised by the ISOE Steering Group. This report was therefore translated into several languages, including Chinese, German, Russian and Spanish, in addition to its standard version in English.

2.5 Monetary value of collective dose

During 1997, a survey was performed within the ISOE network to better understand the usefulness of the monetary value of collective dose in the practical application of protection optimization. This value is commonly referred to as the “alpha value”.

Eight regulatory authorities in charge of radiological protection (Canada, Czech Republic, Finland, Netherlands, Sweden, Switzerland, the United Kingdom and the United States) responded that they explicitly refer to the concept of monetary value of collective dose as a baseline reference for their regulatory decisions, and have defined one value or a set of values for this quantity. They also considered the implementation of the ALARA principle within the nuclear industry to be mainly an industry concern, and that, in this context, the monetary value of collective dose is essentially a managerial tool.

In most countries, alpha values are used when making decisions related to budget and impact on the operation and safety of a plant. About 60% of these uses are associated with significant modifications, large and expensive repairs, or chemistry of the plant.

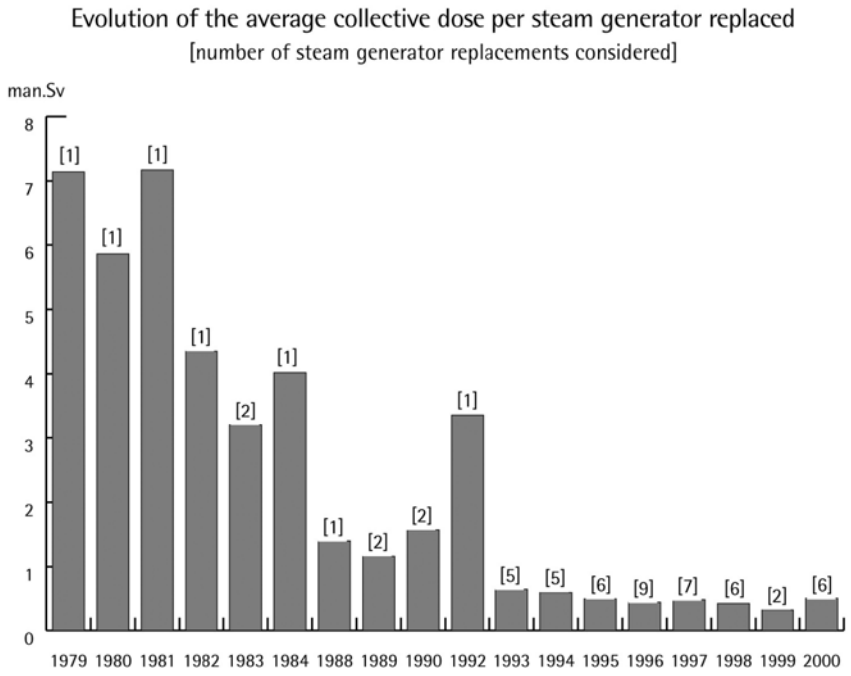
As of 1997, nearly three quarters of the operating organizations represented in ISOE had set up their own alpha-value system. Some use a single alpha value, the average of which is about US$ 1 300 per man·mSv for North American utilities in the year 2000 and US$ 600 per man·mSv for utilities in non-OECD countries. European utilities have established sets of monetary values which increase commensurate with increased risk. Mean values within this group, of about US$ 1000 per man·mSv, do not differ drastically from those observed in the other groups.

Table 1. **Alpha values used by utilities**

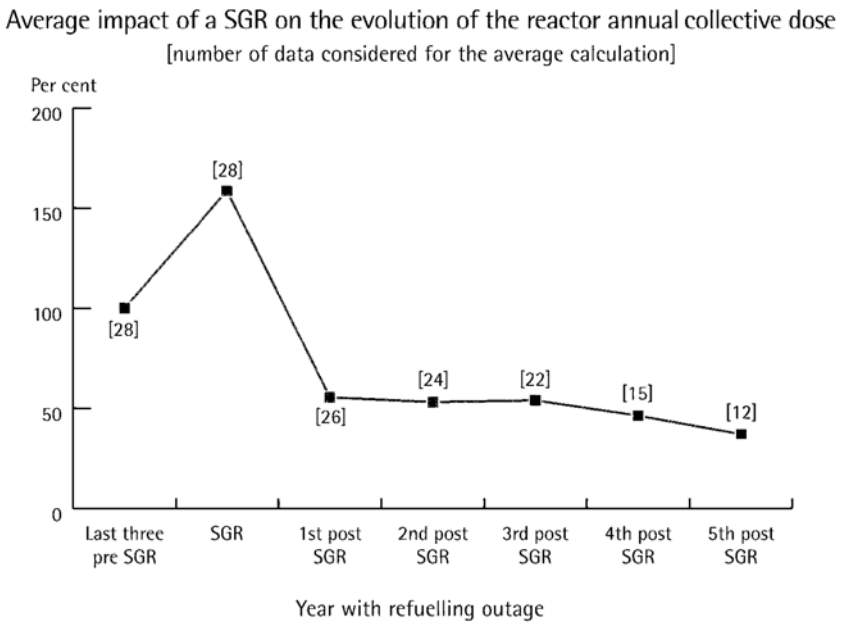
	Alpha values US$/[man·mSv]			
	Type	Minimum	Average	Maximum
North America (2000)	Single value	500	1300	3300
Europe (1997)	Set of values	17	1000	5300
Non-OECD (1997)	Single value	4	600	1000

2.6 Steam generator replacements

Between 1979 and 2000, 58 steam generator replacements (SGR) were performed, mainly in North America and in Europe. Collective doses decreased regularly from more than 6 man·Sv per steam generator replaced in the late 1970s-early 1980s to an average of about 0.5 man·Sv during the last six years (see Fig. 3). However, that average masks quite large discrepancies and the best results correspond to three SGR performed in 1996 and 1998 in Belgium and France with only 0.21 man·Sv per steam generator replaced.



In order to evaluate the impact of a steam generator replacement on the evolution of the total annual collective dose for a reactor, the last three years with refuelling outages before each steam generator replacement were selected as a reference period. The average annual collective dose for each reactor considered over this reference period was normalised to 100. Collective doses for the steam generator replacement year and for the years with refuelling outages following the steam generator replacement were normalised accordingly (see Figure 4). The study showed that, on average, the collective dose during the year of steam generator replacement was 60% higher than the average collective dose during the three prior years with refuelling outages. The annual collective dose in the years following the SGR decreased to 40-60% of the pre-replacement three-year average collective dose.

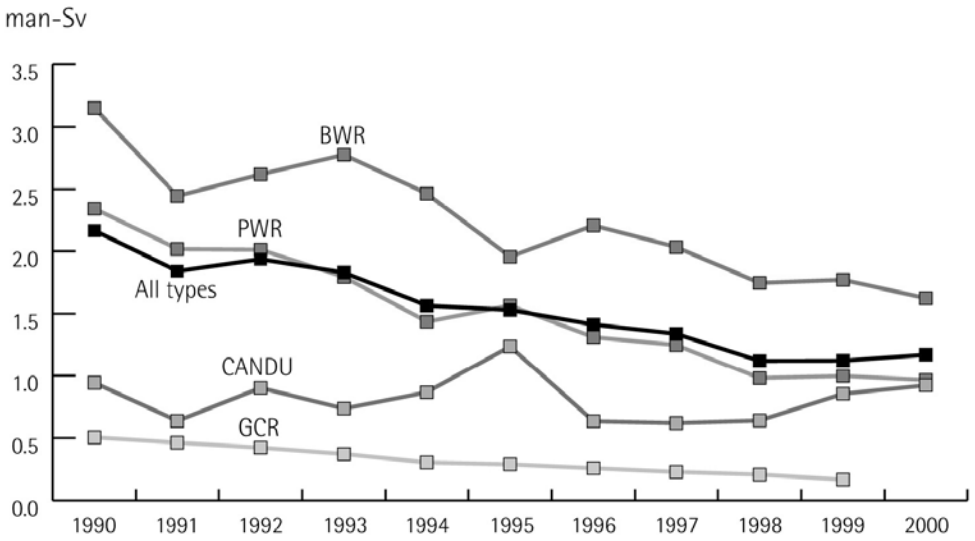


3. ISOE reveals downward dose trends

The annual average doses per reactor began to show a downward trend during the early years of nuclear power. Since the beginning of the ISOE Programme, this trend has been confirmed and consolidated, as can be seen in Fig. 5 showing data for the decade 1990-2000. Contributing to this trend are the improved communication and experience exchange between radiation protection managers of nuclear power plants worldwide, provided by the ISOE network, as well as the growing use of improved work management procedures developed and published through ISOE.

Although the data show some annual fluctuations, the average annual dose has been clearly decreasing for pressurised water reactors (PWR), from more than 2 man·Sv in the year 1990 to less than 1 man·Sv in 2000. For boiling water reactors (BWR), the dose came down from more than 3 man·Sv in 1990 to slightly over 1.5 man·Sv in 2000. The average annual dose for CANDUs in 1990 was already at a fairly low value of 1 man·Sv and has shown only some modest variations in the last decade. For gas-cooled reactors (GCR), the average annual collective dose, which was already lower than for other types of reactors, has continued to show a decreasing trend, from 0.5 man·Sv in 1990 to about 0.2 man Sv in 1999.

Average collective dose per reactor for operating reactors included in ISOE by reactor type for the years 1990-2000



The yearly fluctuations that can be seen in Figure 5 for all types of reactors are due to variations in outage scheduling, changes in cycle length and amount of maintenance work in the plants. For example, major work, such as the replacement of steam generators, leads to a significantly higher dose in the year of the replacement.

4. The future of ISOE

4.1 Improving the current system

During the last ten years, the ISOE Programme has gained a high level of participation and support. The major challenges the Programme still faces, in order to improve its current performance and effectiveness, are the need to complete the ISOE database as well as to further promote information exchange on actual examples, best practices and lessons learned in the field of occupational radiation exposure management.

As the ISOE database is the backbone of the Programme, it is essential for its success that the database is as comprehensive and updated as possible, containing detailed, up-to-date dose information for a variety of situations, jobs and tasks from all nuclear power plants worldwide. This completeness can be achieved only if and when all participants are motivated to input data that is as detailed as possible and to update their contributions regularly.

Information about experiences, lessons learned and best practices in occupational radiation exposure management for a large spectrum of situations should be shared amongst all participants as soon as the analysis of an interesting task is reasonably finalised. In order to facilitate this exchange of information and experience, important technical means have been developed to input relevant reports into the current database and, at the same time, to distribute the information through electronic media to all ISOE participants. Efforts have been made to achieve a system which is easy to use and not time-consuming. However, in the end, it is the commitment of participants to report on new experiences and to share them with other radiation protection experts that determines the usefulness and success of the system.

Another important challenge here is the need to make sure that the two-tier information exchange scheme established by the Programme's Terms and Conditions can operate in a consistent and fair way. Careful management of the system is, in fact, necessary to ensure that the regulatory participants benefit from a fair share of information without, however, affecting the established right of the utility participants to preserve their own confidential channels for the direct exchange of detailed operational information.

4.2 Addressing new challenges

ISOE is also beginning to face new challenges where adjustments and expansion of the system may be required. These will have to address the increased importance of the decommissioning and dismantling of nuclear power reactors, as well as the discussion on future nuclear power plant generations. Plant life extension of currently licensed facilities will also be part of future concerns within ISOE. In all these areas ISOE can provide valuable information and a well- established community to discuss occupational exposure management issues.

As decommissioning and dismantling of nuclear power plants become more widespread, ISOE can play an important role in managing occupational radiation exposure during these activities. Information exchange on this growing issue and the use of analytical tools developed within ISOE will help achieve a higher level of protection for the workers involved in these activities. Information and experience contained within the ISOE system could also provide assistance in the design of new reactors, to ensure that an appropriate level of occupational dose management is built into their conception.

Another important concern for the future of ISOE is the establishment of liaisons with international organizations, such as the World Association of Nuclear Operators (WANO), to further improve the support of ISOE from nuclear power plant managers. Occupational radiation exposure in other areas of the nuclear fuel cycle – research reactors, fuel production, waste treatment – could be considered for future inclusion into ISOE.

5. Conclusions

During the first ten years, ISOE has gained a high level of participation, recognition and support. However, establishment of further interaction with international organizations, such as WANO, is needed with a view to further improving the support of ISOE from nuclear power plants. Active participation of a large number of operating organizations in this programme has contributed to a reduction in occupational exposure at nuclear power plants worldwide. In order to maintain or even further reduce the already low levels of occupational exposure, the ISOE system needs to be regularly used and further promoted and supported by its participants, both the utilities and the regulatory authorities. ISOE can also play an important role in achieving a high level of protection for the workers involved in decommissioning and dismantling of nuclear power plants.

References

[1] OECD Nuclear Energy Agency, Occupational Exposure at Nuclear Power Plants, ISOE Annual Report, OECD, Paris (2001).

[2] OECD Nuclear Energy Agency, ISOE – Information system on Occupational Exposure – Ten Years of Experience, OECD, Paris, (2002).

[3] OECD Nuclear Energy Agency, Work Management in the Nuclear Power Industry: A Manual prepared for the NEA Committee on Radiation Protection and Public Health by the Information System on Occupational Exposure (ISOE) Expert Group on the Impact of Work Management on Occupational Exposure, OECD, Paris, (1997).