Radiation Protection

# ISOE

## Information System on Occupational Exposure

# 10 Years of Experience

Nuclear Energy Agency
Organisation for Economic Co-operation and Development

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The OECD Nuclear Energy Agency (NEA) was established on 1st February 1958 under the name of the OEEC European Nuclear Energy Agency. It received its present designation on 20th April 1972, when Japan became its first non-European full Member. NEA membership today consists of 27 OECD Member countries: Australia, Austria, Belgium, Canada, Czech Republic, Denmark, Finland, France, Germany, Greece, Hungary, Iceland, Ireland, Italy, Japan, Luxembourg, Mexico, the Netherlands, Norway, Portugal, Republic of Korea, Spain, Sweden, Switzerland, Turkey, the United Kingdom and the United States. The Commission of the European Communities also takes part in the work of the Agency.

The mission of the NEA is:

- to assist its Member countries in maintaining and further developing, through international co-operation, the scientific, technological and legal bases required for a safe, environmentally friendly and economical use of nuclear energy for peaceful purposes, as well as
- to provide authoritative assessments and to forge common understandings on key issues, as input to government decisions on nuclear energy policy and to broader OECD policy analyses in areas such as energy and sustainable development.

Specific areas of competence of the NEA include safety and regulation of nuclear activities, radioactive waste management, radiological protection, nuclear science, economic and technical analyses of the nuclear fuel cycle, nuclear law and liability, and public information. The NEA Data Bank provides nuclear data and computer program services for participating countries.

In these and related tasks, the NEA works in close collaboration with the International Atomic Energy Agency in Vienna, with which it has a Co-operation Agreement, as well as with other international organisations in the nuclear field.

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# 1. Introduction

During the 1980s, radiation protection experts in the nuclear industry 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 optimisation 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 optimisation 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 organised 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 connected 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) by regulatory authorities from 25 countries.

ISOE was created in 1992 to provide a forum for radiation protection experts from both utilities 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 exposure arena, such as:

- **The world's largest database on occupational exposure from nuclear power plants**. The ISOE database currently includes information on occupational exposure levels and trends at 459 reactor units (405 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 (433) 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 a utility 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 exposure management issues through ISOE workshops and symposia**. Each year, an international workshop or symposium on occupational 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 and regulatory authorities to exchange information on practical experience on occupational exposure issues in nuclear power plants.

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

During the first ten years, ISOE has gained a high level of participation and support. Active participation of a large number of utilities 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.

This report summarises the experience gained from ten years of developing ISOE. Participants were asked to comment upon their experience and some of their responses are presented throughout the report. Annexes describe the ISOE databases (A.1), the ISOE structure and organisation (A.2), ISOE publications (A.3), Contact Co-ordinates for ISOE (A.4) and Participation in ISOE (A.5).

# 2. Radiation protection professionals benefit from ISOE

## Benchmarking analysis

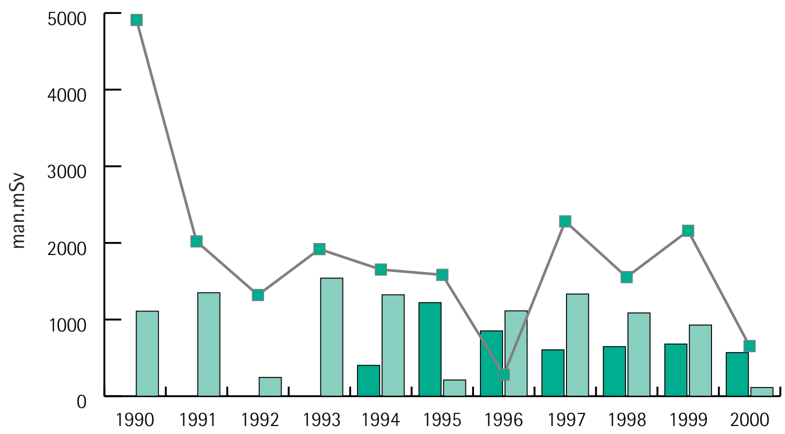
The ISOE database forms an excellent basis for studies and comparisons of occupational exposure data between nuclear power plants in various countries or even within the same country. To improve the significance and usefulness of these studies, comparative analyses of data from reactors having similar 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.

Using the ISOE software*, 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 the graphs shown on the following page.

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.

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

Annual dose benchmarking for Tricastin 1 between 1990 and 2000

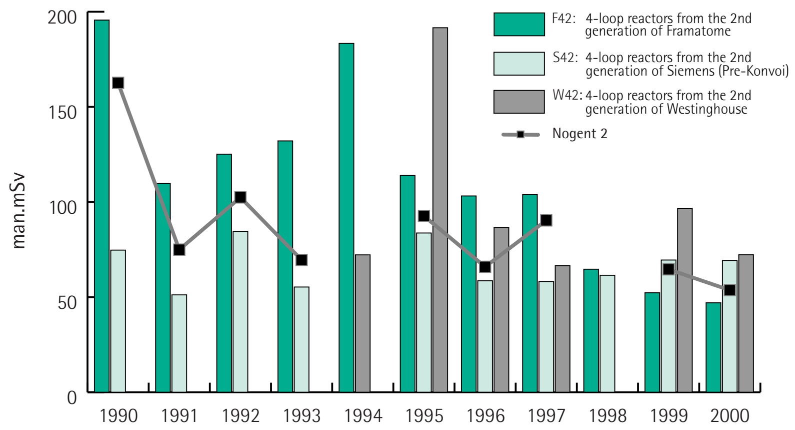



| | 1990 | 1991 | 1992 | 1993 | 1994 | 1995 | 1996 | 1997 | 1998 | 1999 | 2000 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Daya Bay 1 | | | | | 402 | 1221 | 852 | 605 | 647 | 680 | 569 |
| Koeberg 2 | 1109 | 1350 | 245 | 1540 | 1323 | 211 | 1114 | 1333 | 1086 | 928 | 113 |
| Tricastin 1 | 4990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

*"What we have found to be of particular interest is the ability to compare our nuclear power plant with its sister plants. This makes the comparison useful as we are comparing stations with similar designs, capacity, etc."*

*Koeberg nuclear power station, South Africa*

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 |

## 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 Email 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).

> *"We made a survey through the ISOE network on experience and practices with the decontamination of reactor building pools in other nuclear power plants in the world. We received many answers that have allowed us to discover new ways of implementing decontamination. Then we established direct contacts with some of the contact persons, allowing us to receive more detailed and precise data and to modify our procedures during a pilot decontamination."*
>
> *Nogent-sur-Seine nuclear power plant, France*

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 exposure. The report[5] 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 presenting the evolution of occupational 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) – see Annex A.3;
- 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 utilities and regulatory bodies who, besides deliberating on ISOE management issues, review current developments and national trends in the operation and regulation of the nuclear industry, from a radiation protection expert's perspective.

## 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 financial help for participants from countries participating in ISOE through the IAEA and also for participants from target countries of two IAEA Technical Co-operation 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 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.

*"As result of information received in a workshop on optimisation of radiation protection, we implemented in our plant from the very beginning the recommendations from the reference document on ALARA, which had a positive impact on the operator's commitment to ALARA."*

*Cernavoda nuclear power plant, Romania*

*"The ISOE symposia and workshops have made it possible for us to exchange information with other radiation protection professionals as Koeberg is isolated from the rest of the nuclear industry in terms of geographic location. The contacts that have been established during such workshops have been used to solve some of our operational problems."*

*Koeberg nuclear power plant, South Africa*

*"We see a very important use of the ISOE System in the exchange of information and experiences through the participation in international ALARA symposia and workshops on occupational exposure management."*

*Consejo de Seguridad Nuclear (CSN), Spain*

*"Conclusions from the symposium in Anaheim in the year 2001 were:*

- *There is not a lot of space left to optimise or reduce exposures in operating nuclear power plants. Additional tools like self-assessment can help achieve even better results.*
- *Personal dosimetry at appropriate quality level is important not only as information about daily exposures but also as the source of legal data about personal risk.*
- *Understanding radioactive source behaviour is necessary in case of unexpected levels of contamination which may occur.*
- *Human resources management should assure proper functioning of radiation protection at nuclear power plants in the future."*

*ISOE Chairman*

## 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 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.

*"The NEA Work Management report supports ALARA recommendations submitted to the plant manager. If the concept or site improvement was referenced in the NEA report, approval of the site ALARA recommendation was very likely to be approved and funded."*

*Laguna Verde nuclear power plant, Mexico*

*"The NEA expert group report on Work Management is so important to the plant operator, work planners and senior management that 50 additional copies were ordered and distributed to plant managers."*

*D.C. Cook nuclear power plant, Michigan, USA*

A letter from a site Vice-President-Nuclear (BWR-USA) was sent to the Chairman of the US Nuclear Regulatory Commission (NRC), acknowledging and stressing the value of the global exchange of radiological work management practices. This initiative was seen as particularly important, because an understanding by US senior management of the benefits from applying optimisation of protection at European nuclear power plants, especially in the area of refuelling outage work management, could be critical to the success of US nuclear power plants in a deregulated utility environment.

> *"The most prominent example of improvement is the new approach for dose reduction and dose control that has been introduced in Angra 1 and Angra 2, guided by information from the ISOE System, especially from the report on Work Management in the Nuclear Power Industry, from experience exchange at ISOE workshops, from benchmarking exercises using the ISOE database and, finally, analyses presented through ISOE information sheets."*
>
> *Angra nuclear power plant, Brazil*

## 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 optimisation. 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 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 utilities represented in ISOE had set up their own alpha-value system. Some use a single alpha value, the average of which is about US$ 1300 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.

*"We increased significantly the monetary value of a man·Sv based on an ISOE report on monetary value of man·Sv for the purpose of optimisation of radiation protection in various nuclear power plants."*

*Cernavoda nuclear power plant, Romania*

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 |

## Annual outages in European reactors

Annual outage duration and collective doses in European reactors have been analysed based on three-year rolling averages in the time period 1993-1999. A summary of the results is shown in the following table.

For PWRs, the average outage dose showed a clear decreasing trend from 1993 to 1999 (a decrease of 30% over that period). During the same period, the average outage duration was rather stable, fluctuating around 53 days. As a consequence, the decrease of total outage doses does not appear to be linked to the duration of outages, but rather to the levels of outage dose per day (-30% over the time period considered). This finding might be explained by the application of work management approaches, which resulted in a reduction of number of workers and of workload in high dose areas. Improvements in the direction of a decrease of dose rates may also have contributed to this favourable trend.

Three-year rolling average of total outage dose, outage duration and outage dose per day in European reactors

| | Years | BWR | PWR | VVER |
|---|---|---|---|---|
| Average outage dose (man·mSv) | 1993-95 | 1449.70 | 1600.19 | 472.91 |
| | 1994-96 | 1385.40 | 1444.23 | 495.44 |
| | 1995-97 | 1515.95 | 1347.92 | 510.23 |
| | 1996-98 | 1539.03 | 1206.02 | 608.07 |
| | 1997-99 | 1302.89 | 1096.92 | 548.73 |
| Average outage duration (No. of days) | 1993-95 | 43.75 | 54.96 | 44.74 |
| | 1994-96 | 42.76 | 50.94 | 44.78 |
| | 1995-97 | 44.47 | 51.56 | 47.15 |
| | 1996-98 | 48.45 | 50.79 | 51.52 |
| | 1997-99 | 46.19 | 53.45 | 49.36 |
| Average outage dose per day (man·mSv/day) | 1993-95 | 33.13 | 29.12 | 10.57 |
| | 1994-96 | 32.40 | 28.35 | 11.07 |
| | 1995-97 | 34.09 | 26.14 | 10.82 |
| | 1996-98 | 31.77 | 23.75 | 11.80 |
| | 1997-99 | 28.21 | 20.52 | 11.12 |
| Total number of outages | 1993-95 | 57 | 230 | 38 |
| | 1994-96 | 59 | 234 | 40 |
| | 1995-97 | 58 | 237 | 41 |
| | 1996-98 | 60 | 229 | 42 |
| | 1997-99 | 57 | 230 | 42 |

On the other hand, no clear trend can be observed for BWRs. After a slight decrease, the average outage dose increased by 11% from 1994 to 1998, followed by a 15% decrease in the last year of the period. A parallel evolution is observed for the outage duration, suggesting that, in this case, the outage dose is influenced by the duration.

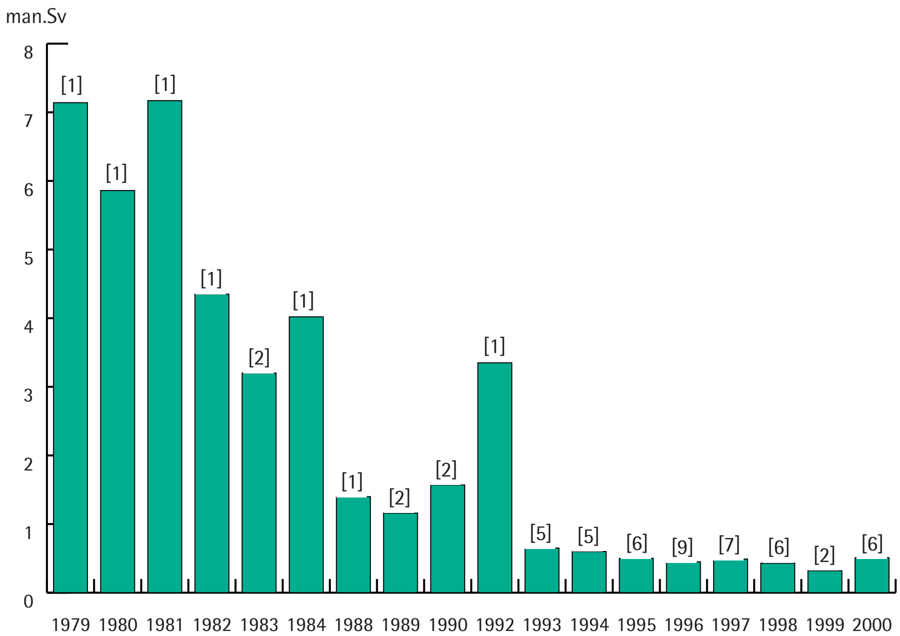
For VVERs, an increase in average outage dose was observed until 1998, followed by a slight decrease. During the period, the outage dose per day remained quite stable.

## 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 figure). 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.

Evolution of the average collective dose per steam generator replaced

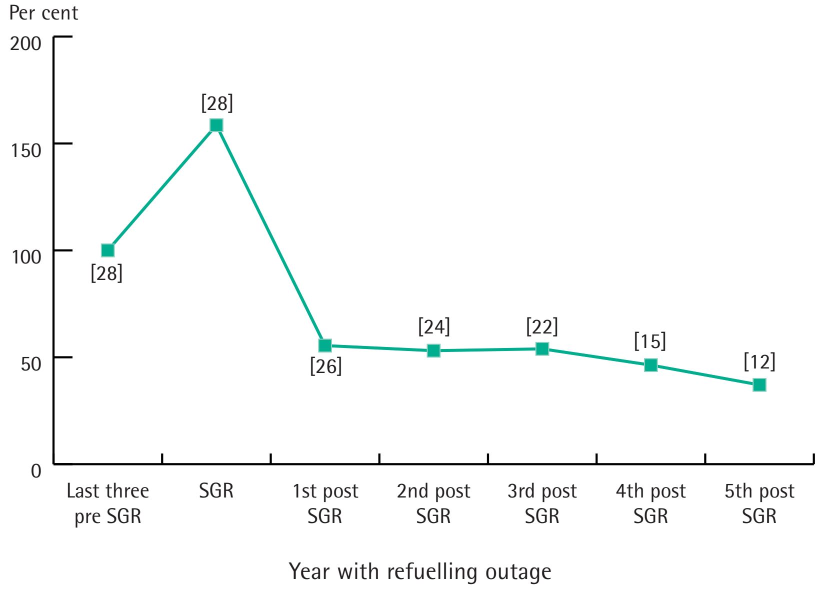
[number of steam generator replacements considered]




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 next page).

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.

Average impact of a SGR on the evolution of the reactor annual collective dose
[number of data considered for the average calculation]




*"In the bidding documentation for the steam generator replacement (SGR) we have specified an acceptable range of collective dose based on the available benchmarking data from ISOE.*

*Krsko nuclear power plant, Slovenia*

## In-service inspections in North America

### *Analysis of in-service inspections*

In the 1980s, doses due to in-service inspections (ISI) in North American PWRs remained fairly constant, with peaks occurring in 1982 and 1986. During that period, extensive work activities in radiation areas were carried out at nuclear power plants to implement Three Mile Island-related investigations. The steady dose trend in later years was essentially due to steam generator evaluations and eddy current testing. The contribution of ISI to the total collective dose across the US PWR fleet remains in the range of about 12 man·Sv per year, with the average dose per reactor in the range of about 0.17 man·Sv per year.

The occupational dose from in-service inspection activities at BWRs peaked in 1983. ISI contributes by about 7.5 man·Sv to the total annual collective dose for the whole of North American BWRs, with the average dose per reactor in the range of about 0.18 man·Sv per year.

A comparative review of collective doses due to in-service inspection at various nuclear power plants, based on a sample of data reported by utilities from the USA and from a number of other countries, for 1996, revealed that this kind of dose tends to be higher at the US reactors than in other countries. In fact, the average ISI collective doses were reported to be ranging between about 0.15 and 0.20 man·Sv per year and per reactor in the USA, whilst a wider, but generally lower, range of doses, between 0.01 and 0.28 man·Sv per year and per reactor, was reported by the other countries. A possible explanation for this difference may be found in differences of national regulatory approaches toward weld inspections, snubber inspections and the like.

### *Initiatives for risk-informed, in-service inspections*

The effectiveness of applying in-service inspections to nuclear plant piping during the past 20 years was evaluated by the American Society of Mechanical Engineers (ASME) using a number of code cases based on probabilistic fracture mechanics. A goal of these studies is to achieve a more objective determination of the target pieces of plant equipment and the needed frequencies of these inspections. For example, some of the ASME analyses applied to PWRs indicate that up to 60% of the primary piping weld inspection programmes at nuclear power plants may not be necessary. These studies further suggest that water and steam leaks are more commonly used as the first indicator of weld failure on nuclear plant primary piping. ASME studies also show that in-service inspection may be more effectively applied to secondary piping (e.g. service water piping) to detect corrosion or erosion problems.

This effort should be seen in the context of an overall move towards risk-informed regulation, meant to ensure objective and efficient means of maintaining adequate protection of public health and safety. The US NRC and the industry, via organisations such as the Nuclear Energy Institute, are developing approaches to a greater use of probabilistic risk assessments and other risk assessment means to assist regulatory programmes and improve plant operational practices.

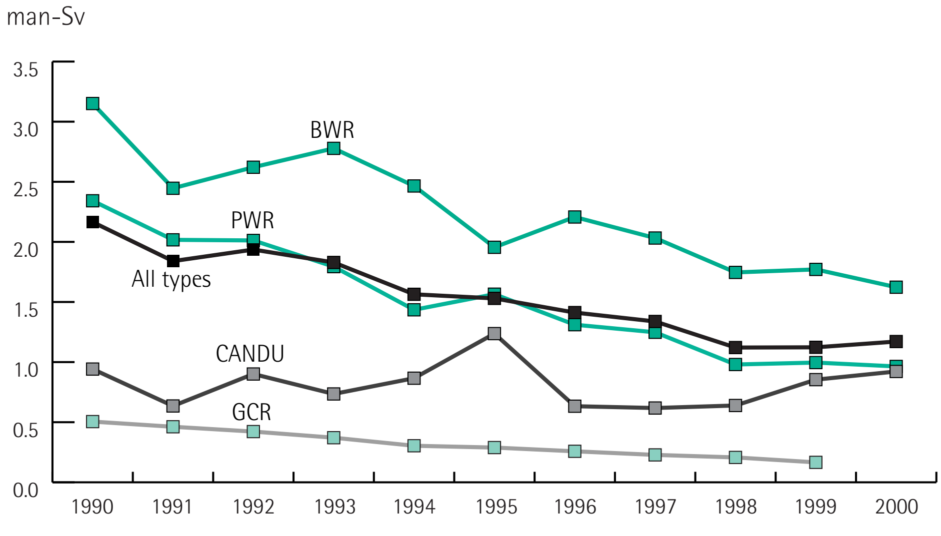
Pilot studies performed at some PWRs, such as Millstone 3 and Surry NPPs, show that increased safety and significant reductions in inspection number and cost, as well as in collective dose, may result from the application of "risk-informed, in-service inspection". For example, Millstone 3 experienced a 84% reduction in inspections while still reducing the risk due to pipe failure by half. The overall effect of the inspection reduction is reflected in a 0.15 man·Sv outage dose reduction. At the Surry plant, a 65% reduction in inspections was realised, the risk due to pipe failure was cut in half, and a saving of 0.10 man·Sv per outage was achieved.

Based on the PWR pilot studies and techniques, risk-informed, in-service inspection procedures and codes are also in development for BWRs. As a first step, ASME is developing ground rules at the Browns Ferry NPP regarding risk-based inspection.

# 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 the figure below 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.

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



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.

The yearly fluctuations that can be seen in the above figure 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, as shown on page 19, major work, such as the replacement of steam generators, leads to a significantly higher dose in the year of the replacement.

*"We use the ISOE Annual Reports as evidence for the comparison of our plant's performance in managing occupational exposure versus the performance of other power plants in the world, especially when discussing with authority review missions or inspectors. It is important that the occupational exposure data contained in ISOE are authorised through ISOE and can therefore be used officially."*

*Bohunice nuclear power plant, Slovakia*

# 4. The future of ISOE

## 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 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 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.

## 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 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 organisations, such as the World Association of Nuclear Operators (WANO), to further improve the support of ISOE from nuclear power plant managers. Occupational exposure in other areas of the nuclear fuel cycle – research reactors, fuel production, waste treatment – could be considered for future inclusion into ISOE.

# *Annexes*

## *A.1 ISOE databases*

All information included in the ISOE databases is supplied by participating utilities, who have full access to all such data. Participating authorities only have access to a reduced database, which includes, however, data from utilities in their own country.

The databases include:

ISOE 1

Dosimetric information from commercial nuclear power plants in operation or in some stage of decommissioning, including for each participating unit, e.g.:

- annual collective dose for normal operation;
- maintenance/refuelling outage doses;
- collective dose for unplanned outage periods;
- annual collective dose for certain tasks and worker categories.

ISOE 2

Plant-specific information pertinent to dose reduction, such as materials, water chemistry, start-up/shutdown procedures, cobalt reduction programme, etc.

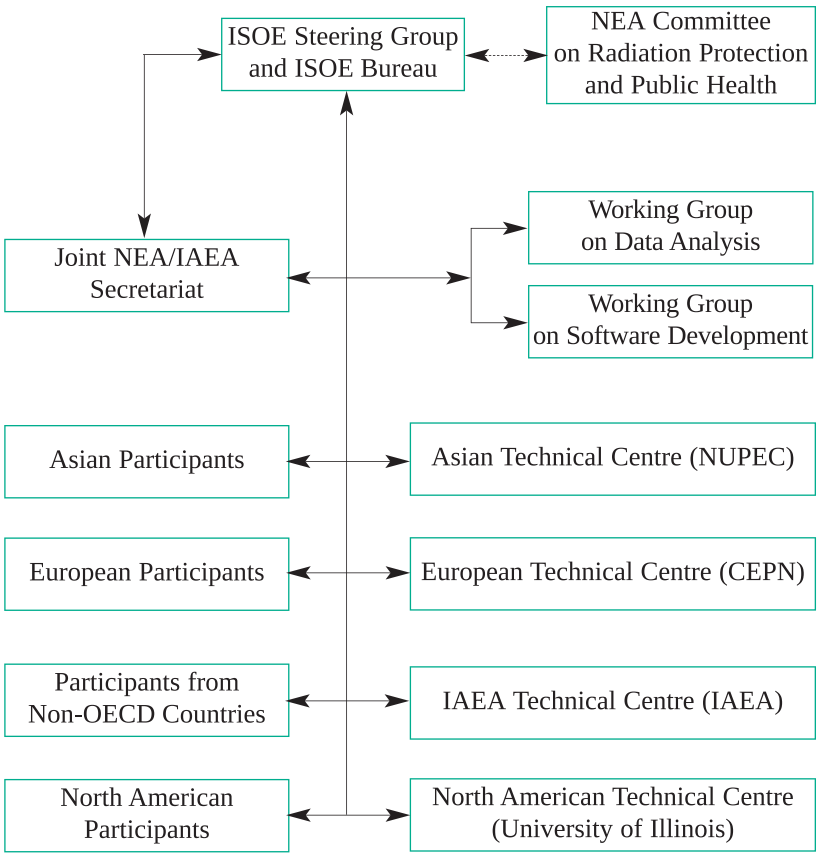
ISOE 3

Radiation protection information for specific operations, jobs, procedures, equipment or tasks:

- effective dose reduction;
- effective decontamination;
- implementation of work management principles.

The European Technical Centre is responsible for the maintenance of the ISOE databases.

## *A.2 ISOE structure and organisation*



## *A.3 ISOE publications*


1. ISOE (2001), *Occupational Exposures at Nuclear Power Plants: Tenth Annual Report of the ISOE Programme, 2000*, OECD, Paris.

2. ISOE (2000), *Occupational Exposures at Nuclear Power Plants: Ninth Annual Report of the ISOE Programme, 1999*, OECD, Paris.

3. ISOE (1999), *Occupational Exposures at Nuclear Power Plants: Eighth Annual Report of the ISOE Programme, 1998*, OECD, Paris.

4. ISOE (1999), *Occupational Exposures at Nuclear Power Plants: Seventh Annual Report of the ISOE Programme, 1997*, OECD, Paris.

5. ISOE (1997), *Work Management in the Nuclear Power Industry*, OECD, Paris (also available in Chinese, German, Russian and Spanish).

6. ISOE (1998), *Occupational Exposures at Nuclear Power Plants: Sixth Annual Report, 1986-1996*, OECD, Paris.

7. ISOE (1997), *Fifth Annual Report: Occupational Exposures at Nuclear Power Plants, 1969-1995*, OECD, Paris.

8. ISOE (1996), *Fourth Annual Report: Occupational Exposures at Nuclear Power Plants, 1969-1994*, OECD, Paris.

9. ISOE (1995), *Third Annual Report: Occupational Exposures at Nuclear Power Plants, 1969-1993*, OECD, Paris.

10. ISOE (1994), *Nuclear Power Plant Occupational Exposures in OECD Countries: 1969-1992*, OECD, Paris.

11. ISOE (1993), *Nuclear Power Plant Occupational Exposures in OECD Countries: 1969-1991*, OECD, Paris.

## ISOE Information Sheets

| No. | (year) | Asian Technical Centre |
| --- | --- | --- |
| 1 | (1995) | Japanese Dosimetric Results: FY 1994 Data |
| 2 | (1995) | Japanese Occupational Exposure During Periodical Inspection at LWRs Ended in FY 1994 |
| 3 | (1996) | Japanese Dosimetric Results: FY 1995 Data |
| 4 | (1996) | Japanese Occupational Exposure During Periodical Inspection at LWRs Ended in FY 1995 |
| 5 | (1997) | Japanese Dosimetric Results: FY 1996 Data |
| 6 | (1997) | Japanese Occupational Exposure During Periodical Inspection at LWRs Ended in FY 1996 |
| 7 | (1998) | Japanese Dosimetric Results: FY 1997 Data |
| 8 | (1998) | Japanese Occupational Exposure During Periodical Inspection at LWRs Ended in FY 1997 |
| 9 | (1999) | Replacement of Reactor Internals and Full System Decontamination at a Japanese BWR |
| 10 | (1999) | Experience of 1st Annual Inspection Outage in an ABWR |
| 11 | (1999) | Japanese Dosimetric Results: FY 1998 Data and Trends |
| 12 | (1999) | Japanese Occupational Exposure During Periodical Inspection at LWRs Ended in FY 1998 |
| 13 | (2000) | Japanese Dosimetric Results: FY 1999 Data and Trends |
| 14 | (2000) | Japanese Occupational Exposure During Periodical Inspection at LWRs Ended in FY 1999 |
| 15 | (2001) | Japanese Dosimetric Results: FY 2000 Data and Trends |
| 16 | (2001) | Japanese Occupational Exposure During Periodical Inspection at PWRs and BWRs Ended in FY 2000 |
| **No.** | **(year)** | **European Technical Centre** |
| 1 | (1994) | Occupational Exposure and Steam Generator Replacement |
| 2 | (1994) | The Influence of Reactor Age and Installed Power on Collective Dose: 1992 Data |
| 3 | (1994) | First European Dosimetric Results: 1993 Data |
| 4 | (1995) | Preliminary European Dosimetric Results for 1994 |
| 6 | (1996) | Overview of the First Three Full System Decontamination |
| 7 | (1996) | Preliminary European Dosimetric Results for 1995 |

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| 9 | (1996) | Reactor Vessel Closure Head Replacement |
| 10 | (1997) | Preliminary European Dosimetric Results for 1996 |
| 11 | (1997) | Annual Individual Doses Distributions: Data Available and Statistical Biases |
| 12 | (1997) | Occupational Exposure and Reactor Vessel Annealing |
| 14 | (1998) | PWR Collective Dose Per Job 1994-95-96 Data (restricted distribution) |
| 15 | (1998) | PWR Collective Dose Per Job 1994-1995-1996 Data (general distribution) |
| 16 | (1998) | Preliminary European Dosimetric Results for 1997 |
| 17 | (1998) | Occupational Exposure and Steam Generator Replacements, Update |
| 18 | (1998) | The Use of the Man-Sievert Monetary Value in 1997 |
| 19 | (1998) | ISOE 3 Data Base – New ISOE 3 Questionnaires Received (Since September 1998) (restricted distribution) |
| 20 | (1999) | Preliminary European Dosimetric Results 1998 |
| 21 | (2000) | Investigation on Access and Dosimetric Follow-up Rules in NPPs for Foreign Workers |
| 22 | (2000) | Analysis of the Evolution of Collective Dose Related to Insulation Jobs in Some European PWRs |
| 23 | (2000) | Preliminary European Dosimetric Results 1999 |
| 24 | (2000) | List of BWR and CANDU Sister Unit Groups |
| 25 | (2000) | Conclusions and Recommendations from the 2nd EC/ISOE Workshop on Occupational Exposure Management at Nuclear Power Plants |
| 26 | (2001) | Preliminary European Dosimetric Results for the Year 2000 |
| 27 | (2001) | Annual Outage Duration and Doses in European Reactors |
| 28 | (2001) | Trends in Collective Doses Per Job from 1995 to 2000 |
| 29 | (2001) | Implementation of Basic Safety Standards in the Regulations of European Countries |
| **No.** | **(year)** | **IAEA Technical Centre** |
| 1 | (1995) | ISOE expert meeting |
| 2 | (1999) | IAEA publications on occupational radiation protection |
| 3 | (1999) | IAEA technical co-operation projects on improving occupational radiation protection in nuclear power plants |

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|---|---|---|
| 4 | (1999) | IAEA workshop on implementation and management of the ALARA principle in nuclear power plant operations, Vienna 22-23 April 1998 |
| 5 | (2000) | Preliminary dosimetric results for 1999 |
| 6 | (2001) | Preliminary dosimetric results for 2000 |
| **No.** | **(year)** | **North American Technical Centre** |
| 1 | (1996) | Swedish Approaches to Radiation Protection at Nuclear Power Plants: NATC Site Visit Report by Peter Knapp |
| 2 | (1998) | Monetary Value of Person-REM Avoided 1997 |
| 3 | (2001) | 3-year Rolling Average Annual Dose Comparisons US PWR, 1998-2000 |
| 4 | (2001) | 3-year Rolling Average Annual Dose Comparisons US BWR, 1998-2000 |
| 5 | (2001) | 3-year Rolling Average Annual Dose Comparisons CANDU, 1998-2000 |
| 6 | (2001) | U.S. PWR 2000 Occupational Dose Benchmarking Charts |
| 7 | (2001) | U.S. BWR 2000 Occupational Dose Benchmarking Charts |
| 8 | (2001) | Monetary Value of Person-REM Avoided: 2000 |

## *A.4 Contact co-ordinates for ISOE*

### ISOE Joint Secretariat

***http://www.nea.fr/html/jointproj/isoe.html***

*Nuclear Energy Agency (NEA)*

| | |
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*International Atomic Energy Agency (IAEA)*

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|---|---|
| Dr. Monica Gustafsson<br>International Atomic Energy Agency<br>Division of Radiation and Waste Safety<br>P.O. Box 100<br>A-1400 Wien | Tel.: +43 1 2600 22725<br>Fax: +43 1 2600 7<br>e-mail: M.Gustafsson@iaea.org |


### Technical Centres

| | |
|---|---|
| *Asian Technical Centre* | *http://www.nupec.or.jp/isoe/* |
| Naoyuki MURATA<br>Plant Operation Evaluation Div.<br>Safety Information Research Center<br>Fujitakanko-Toranomon Bldg. 8th Fl.<br>3-17-1 Toranomon, Minato-ku<br>TOKYO 105-0001 | Tel.: +81 (3) 45 12 28 65<br>Fax: +81 (3) 45 12 28 89<br>e-mail: isoe-atc@nupec.or.jp |
| *European Technical Centre* | *http://isoe.cepn.asso.fr* |
| Dr. Christian Lefaure<br>European Technical Centre (ETC)<br>CEPN<br>B.P. 48<br>F-92263 Fontenay-aux-Roses Cedex | Tel.: +33 1 46 54 79 08<br>Fax: +33 1 40 84 90 34<br>e-mail: lefaure@cepn.asso.fr |

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Fax: (217) 333 2906
e-mail: dwmphd@aol.com

## *A5. Participation in ISOE*

| Country | Operating reactors | Shut-down reactors | Regulator authority |
|---|---|---|---|
| Armenia | 1 | – | Armenian Nuclear Regulatory Authority |
| Belgium | 7 | – | Service de la sécurité technique des installations nucléaires |
| Brazil | 1 | – | – |
| Bulgaria | 6 | – | Committee on the Use of Atomic Energy for Peaceful Purposes |
| Canada | 21 | 2 | Canadian Nuclear Safety Commission |
| China | 3 | – | China National Nuclear Corporation |
| Czech Republic | 4 | – | State Office for Nuclear Safety |
| Finland | 4 | – | Säteilyturvakeskus (STUK) |
| France | 57 | 7 | Ministère du travail, et des affaires sociales, Represented by the Office de Protection contre les Rayonnements Ionisants (OPRI) |
| Germany | 20 | 11 | Bundesministerium für Umwelt, Naturschutz und Reaktorsicherheit |
| Hungary | 4 | – | – |
| Italy | – | 4 | Agenzia Nazionale per la Protezione dell'Ambiente |
| Japan | 52 | 1 | Ministry of Economy, Trade and Industry |
| Korea | 16 | – | Ministry of Science and Technology (MOST), Korea Institute of Nuclear Safety (KINS) |

| Country | Operating reactors | Shut-down reactors | Regulator authority |
|---|---|---|---|
| Lithuania | 2 | – | Radiation Protection Centre |
| Mexico | 2 | – | Commision Nacional de Seguridad Nuclear y Salvguardras |
| Netherlands | 1 | 1 | Ministerie van Sociale Zaken en Werkgelegenheld |
| Pakistan | 1* | – | Pakistan Atomic Energy Commission |
| Romania | 1 | – | National Commission for Nuclear Activities Control |
| Russian Federation | 14 | 4 | – |
| Slovakia | 6 | – | State Health Institute of the Slovak Republic |
| Slovenia | 1 | – | Slovenian Nuclear Safety Administration (SNSA) |
| South Africa | 2 | – | Council for Nuclear Safety |
| Spain | 9 | 1 | Consejo de Seguridad Nuclear |
| Sweden | 11 | 1 | Statens strålskyddsinstitut (SSI) |
| Switzerland | 5 | – | Office Fédéral de l'Énergie, Division principale de la Sécurité des Installations Nucléaires, DSN |
| Ukraine | 14 | – | – |
| United Kingdom | 1 (+34*) | 6 | Nuclear Installations Inspectorate |
| United States | 43 (+62*) | 16 | U.S. Nuclear Regulatory Commission |
| **29 countries** | **405** | **54** | **Authorities in 25 countries** |

*Operating reactors not participating in ISOE, but included in the ISOE database.

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