Radiation Protection

OCCUPATIONAL EXPOSURES

AT NUCLEAR POWER PLANTS

Eighth Annual Report

Of the ISOE Programme, 1998

ORGANISATION FOR ECONOMIC CO-OPERATION AND DEVELOPMENT

Pursuant to Article 1 of the Convention signed in Paris on 14th December 1960, and which came into force on 30th September 1961, the Organisation for Economic Co-operation and Development (OECD) shall promote policies designed:

- to achieve the highest sustainable economic growth and employment and a rising standard of living in Member countries, while maintaining financial stability, and thus to contribute to the development of the world economy;
- to contribute to sound economic expansion in Member as well as non-member countries in the process of economic development; and
- to contribute to the expansion of world trade on a multilateral, non-discriminatory basis in accordance with international obligations.

The original Member countries of the OECD are Austria, Belgium, Canada, Denmark, France, Germany, Greece, Iceland, Ireland, Italy, Luxembourg, the Netherlands, Norway, Portugal, Spain, Sweden, Switzerland, Turkey, the United Kingdom and the United States. The following countries became Members subsequently through accession at the dates indicated hereafter; Japan (28th April 1964), Finland (28th January 1969), Australia (7th June 1971), New Zealand (29th May 1973), Mexico (18th May 1994), the Czech Republic (21st December 1995), Hungary (7th May 1996), Poland (22nd November 1996) and the Republic of Korea (12th December 1996). The Commission of the European Communities takes part in the work of the OECD (Article 13 of the OECD Convention).

NUCLEAR ENERGY AGENCY

The OECD Nuclear Energy Agency (NEA) was established on 1st February 1958 under the name of 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 all OECD Member countries, except New Zealand and Poland. The Commission of the European Communities takes part in the work of the Agency.

The primary objective of the NEA is to promote co-operation among the governments of its participating countries in furthering the development of nuclear power as a safe, environmentally acceptable and economic energy source.

This is achieved by:

- *encouraging harmonization of national regulatory policies and practices, with particular reference to the safety of nuclear installations, protection of man against ionising radiation and preservation of the environment, radioactive waste management, and nuclear third party liability and insurance;*
- *assessing the contribution of nuclear power to the overall energy supply by keeping under review the technical and economic aspects of nuclear power growth and forecasting demand and supply for the different phases of the nuclear fuel cycle;*
- *developing exchanges of scientific and technical information particularly through participation in common services;*
- *setting up international research and development programmes and joint undertakings.*

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

FOREWORD

Throughout the world, occupational exposures at nuclear power plants have been steadily decreasing over the past decade. Regulatory pressures, particularly after the issuance of ICRP Publication 60 in 1990, technological advances, improved plant designs, and improved water chemistry and plant operational procedures have contributed to this decreasing trend. However, with the ageing of the world's nuclear power plants the task of maintaining occupational exposures at low levels has become increasingly difficult. In addition, economic pressures have led plant operation managers to streamline refuelling and maintenance operations as much as possible, thus adding scheduling and budgetary pressure to the task of reducing operational exposures.

In response to these pressures, radiation protection personnel have found that occupational exposures will be reduced by properly planning, preparing, implementing, and reviewing jobs, such that they become "as low as reasonably achievable (ALARA)". To facilitate this global approach to work, sometimes referred to as "work management", through the exchange of techniques and experiences in occupational exposure reduction, the Nuclear Energy Agency (NEA) of the Organisation for Economic Co-operation and Development (OECD) launched the Information System on Occupational Exposure (ISOE) on 1 January 1992 after a two year pilot programme. Participation in ISOE includes representatives from both utilities (public and private) and from national regulatory authorities. In 1993, the International Atomic Energy Agency (IAEA) agreed to co-sponsor the ISOE Programme, thus allowing the participation of utilities and authorities from non-NEA member countries. More recently, in 1997, the ISOE Steering Group agreed that a Joint Secretariat should be formed between the NEA and the IAEA to most efficiently take advantage of the strengths of both organisations for the benefit of the ISOE Programme.

The ISOE Programme includes two parts. First, occupational exposure data and experience are collected periodically from all participants to form the ISOE Databases. Due to the varied nature of the data collected, four distinct but linked databases are used for data storage, retrieval and analysis. Second, in creating the network necessary for data collection, close contacts have been established among utilities and authorities from all over the world, thus creating an ISOE Network for the direct exchange of operational experience. This two-tier system of databases and communications network joins utilities and regulatory agencies throughout the world, providing occupational exposure data for trending, cost-benefit analyses, technique comparison, and other ALARA analyses.

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EXECUTIVE SUMMARY

The ISOE Programme Eighth Annual Report 1998, as it is given here, represents the state of the ISOE Programme at the end of December 1998.

As of the end of 1998, occupational exposure data from a total of 422 reactors (383 operating and 39 in cold-shutdown or some stage of decommissioning) from 26 countries representing 77 utilities are included in the ISOE 1 database. In addition, regulatory authorities from 21 countries participate in the ISOE Programme. During 1998, two non-NEA countries, Armenia and Ukraine, joined the ISOE Programme with in total 17 reactors and one regulatory authority (from Armenia). The participation of 383 operating commercial nuclear reactors in the ISOE programme represents 88% of the World's operating commercial nuclear reactors (total of 434).

In 1998, the occupational exposure, in general, followed the downward trend already observed in the last eleven years from 1986 to 1997. In most of ISOE participating countries, 1998 saw a reduction of the average collective dose per unit. The average collective dose per unit for PWRs decreased from 1.20 man·Sv in 1997 to 0.95 man·Sv in 1998, for BWRs from 2.05 man·Sv in 1997 to 1.80 man·Sv in 1998, for CANDU from 0.58 man·Sv in 1997 to 0.59 man·Sv in 1998 and for GCR from 0.23 man·Sv in 1997 to 0.21 in 1998. In 1998, the average collective dose per reactor for LWGRs (RBMK), represented in the database only by the two units in Lithuania, decreased from 9.25 man·Sv in 1997 to 7.53 man·Sv in 1998, a value higher than for all other types of reactors.

Part of the observed reduction in PWRs is due to the implementation of work management principles and the reduction in outage duration. The only PWR in the United Kingdom participating in the ISOE programme, Sizewell B, had no outage in 1998 resulting in a very low dose of 0.04 man·Sv.

The observed reductions in BWRs are in part due to both the positive effect of major plant modification works performed in previous years (e.g. in Sweden), and the result of extensive ALARA and work management programmes (e.g. in Germany, Spain and Switzerland). The Laguna Verde nuclear power plant in Mexico experienced in 1998 an increase of the average annual dose after a major reduction from 1996 to 1997.

The average collective dose per reactor for shutdown reactors saw a reduction over the years 1988 to 1998. However, the reactors represented in these figures are of different type and size, and are, in general, at different phases of their decommissioning programmes. For these reasons, and because these figures are based on a limited number of shutdown reactors, it is impossible to draw definitive conclusions.

A study has been performed on the evolution of exposures to insulation workers in some European PWRs, based on ISOE 1 data. The study analyses the evolution of insulation jobs' exposures, comparing results from different countries as well as comparing results for different sister-unit groups. This study confirms the global trend of decreasing collective doses for insulation jobs in nearly all plants, however, it also indicates that major differences still exist between the countries and/or the type and the design of units. It should also be noted that this trend is closely related to the decrease of total collective doses which can be observed in the majority of the countries due to the implementation of good practices and the communication of these among plants. The study lists the main actions collected through a request within the ISOE network in 1997 undertaken to reduce insulators' exposures. The complete study will be published during 1999 as an ISOE Information Sheet.

The ISOE 1 database has also been used to extract data on doses during refuelling for PWRs and BWRs, investigating the trends as a function of reactor type and generation. The study shows that, since 1990, refuelling in both PWRs and BWRs has been relatively stable in terms of the doses, but also in terms of number of workers involved and job duration. It is also clear that reporting of these data depends on how "refuelling" is defined. Although tendencies in dose, number of workers and job duration are stable, there are considerable numerical differences among the reporting countries. Finally, it can be seen that national practices seem to have a larger influence on refuelling doses than sister-unit practices. This tends to suggest that shared national experience (using the same language) seems to be more valuable to plants than experience from sister-unit in other countries. These preliminary conclusions point toward additional, more in depth studies, which can be performed.

Another study analysed, in great depth, occupational exposures from in-service inspections (ISI) in North American nuclear power plants as well as some less detailed data from other countries in the ISOE programme. In-service inspections are routinely performed at nuclear power plants to determine the wear, fatigue, or stress corrosion cracking that welds and piping encounter during the operational life of piping systems. Although observed ISI doses in North America nuclear power plants have been fairly stable over the past ten years, the accrued dose at American units tended to be higher than that in units of other countries. This may be due to differences in regulatory approaches towards weld inspections, snubber inspections and the like. An effort has been undertaken to evaluate 20 years of nuclear power plant piping in-service inspection experience using the benefits of probabilistic fracture mechanics. One goal of this study is the objective determination of what to inspect and how often inspections should occur.

The first EC/ISOE Workshop on Occupational Exposure at Nuclear Power Plants took place in September 1998 in Malmö, Sweden. The objective of the workshop was to communicate experience in ALARA implementation and occupational exposure issues, and to share lessons learned. A total of 150 participants from 21 countries attended the meeting.

Finally, the ISOE Programme made significant progress during 1998, particularly in terms of data analysis and output, and organisational structure. Details of this progress as well as the programme of work for 1999 are provided in Chapter 3.

SYNTHÈSE DU RAPPORT

Le huitième rapport annuel du programme ISOE, le rapport 1998, présente la situation du programme ISOE à la fin décembre 1998.

Fin 1998, la base de données ISOE 1 regroupe les données sur les expositions professionnelles de 422 réacteurs (383 en exploitation et 39 en arrêt à froid ou en phase de démantèlement). Ces données proviennent de 77 exploitants de 26 pays. Par ailleurs, les Autorités de 21 pays participent au programme ISOE. Au cours de l'année 1998, deux pays non membres de l'AEN, l'Arménie et l'Ukraine, ont rejoint le programme ISOE (17 réacteurs et une autorité en Arménie). Les 383 réacteurs en fonctionnement participant au programme ISOE représentent 88% des réacteurs en fonctionnement dans le monde (434 réacteurs).

En 1998, les expositions professionnelles ont, d'une façon générale, poursuivi la tendance à la baisse déjà observée ces onze dernières années de 1986 à 1997. Dans la plupart des pays participant à ISOE, 1998 a vu une réduction de la dose collective moyenne par réacteur. La dose collective moyenne par réacteur est passée pour les REP de 1,20 homme·Sv en 1997 à 0,95 homme·Sv en 1998, pour les REB de 2,05 homme·Sv en 1997 à 1,80 homme·Sv en 1998, pour les CANDU de 0,58 homme·Sv en 1997 à 0,59 homme·Sv en 1998 et pour les UNGG de 0,23 homme·Sv en 1997 à 0,21 en 1998. En 1998, la dose collective moyenne par réacteur pour les RBMK, représentés uniquement dans la base de données par les deux réacteurs de Lithuanie, est passée de 9,25 homme·Sv en 1997 à 7,53 homme·Sv en 1998, ce qui représente une dose collective plus élevée que celles des autres types de réacteurs.

La réduction des expositions observée pour les REP est en partie due à l'application du principe de gestion ALARA du travail et à la réduction de la durée des arrêts. Le seul REP au Royaume-Uni participant au programme ISOE, Sizewell B, n'ayant eu aucun arrêt pour rechargement en 1998 a eu une dose très faible de 0,04 homme·Sv.

Les réductions observées pour les REB sont en partie dues à l'effet positif des importants travaux de modification des centrales effectués ces dernières années (par exemple en Suède), et à la mise en œuvre d'importants programmes ALARA et de gestion du travail (par exemple en Allemagne, en Espagne et en Suisse). La centrale nucléaire de Laguna Verde au Mexique a connu en 1998 une augmentation de la dose collective annuelle moyenne, après une réduction importante de 1996 à 1997.

La dose collective moyenne par réacteur pour des réacteurs définitivement arrêtés a diminué au cours des années 1988 à 1998. Cependant, il convient de noter que ces réacteurs sont de types et de tailles différents, et sont, en général, à différentes phases de leurs programmes de démantèlement. Pour ces raisons, et compte tenu du faible nombre de réacteurs arrêtés dans la base de données, il est impossible de tirer des conclusions des résultats observés.

Une étude s'appuyant sur les données ISOE 1 a été réalisée sur l'évolution des expositions des calorifugeurs dans un certain nombre de REP européens. L'étude analyse l'évolution des expositions des travaux de calorifugeage, en comparant les résultats de différents pays ainsi que les résultats pour différents groupes de réacteurs de conception similaires « sister unit ». Cette étude confirme la tendance globale à la baisse des doses collectives pour les travaux de calorifugeage dans pratiquement toutes les centrales, cependant, elle indique également que des différences importantes existent toujours entre les pays et/ou les types et les générations de réacteurs. Il convient également de noter que cette tendance est étroitement liée à la diminution des doses collectives totales qui peuvent être observées dans la majorité des pays suite à la mise en place de bonnes pratiques et à la diffusion de ces dernières dans les centrales. L'étude énumère les principales actions entreprises pour réduire les expositions des calorifugeurs. Ces données sont le résultat d'une requête effectuée au sein du réseau ISOE en 1997. L'étude complète sera publiée au cours de l'année 1999 sous la forme d'une feuille d'information ISOE.

La base de données ISOE 1 a été également utilisée pour étudier les évolutions des doses liées au rechargement du combustible dans les REP et les REB, en fonction du type et de la génération des réacteurs. L'étude montre que, depuis 1990, le rechargement du combustible dans les REP et les REB a été relativement stable en termes de doses, mais également en termes de nombre de personnes impliquées et du volume de travail. Il est également clair que le contenu de ces données dépend de la façon dont le « rechargement du combustible » est défini. Bien que les doses, le nombre de personnes et le volume de travail soient stables, il y a des différences numériques considérables d'un pays à l'autre. En conclusion, on peut remarquer que l'homogénéité des pratiques dans un pays semblent avoir une plus grande influence sur les doses liées au rechargement du combustible que la conception des réacteurs « sister unit ». Ceci tend à suggérer qu'une expérience nationale partagée (utilisant le même langage) semble être plus profitable aux centrales nucléaires que l'expérience des réacteurs de conception similaires « sister unit » dans d'autres pays.

Une autre étude a analysé les expositions professionnelles des contrôles non-destructifs dans les centrales nucléaires d'Amérique du Nord aussi bien que quelques données moins détaillées dans d'autres pays participants au programme ISOE. Ces contrôles sont habituellement effectués dans les centrales nucléaires pour déterminer l'usure, la résistance, ou la corrosion sous contrainte, des soudures et des tuyauteries. Bien que les doses correspondantes aux contrôles non-destructifs observées dans les centrales nucléaires d'Amérique du Nord aient été assez stables au cours des dix dernières années, la dose des réacteurs américains tend à être plus élevée que celles observées dans les réacteurs dans les autres pays. Ceci peut être dû aux différences dans les approches réglementaires concernant les inspections des soudures, les inspections des amortisseurs et similaires. Un effort a été entrepris pour analyser 20 ans de retour d'expérience sur les contrôles non-destructifs dans les centrales nucléaires en utilisant les avantages de la mécanique de rupture probabiliste. Un des objectifs de cette étude est la détermination objective de ce qu'il faut examiner (inspecter) et de combien de fois les contôles doivent être faits.

Le premier Séminaire EC/ISOE sur la gestion des expositions professionnelles dans les centrales nucléaires s'est tenu à Malmö, en Suède en septembre 1998. L'objectif du Séminaire était la présentation du retour d'expérience dans le domaine de la radioprotection (mise en place d'ALARA, gestion des expositions professionnelles …),et la diffusion de bonnes pratiques. Cent cinquante participants de 21 pays ont assisté à ce Séminaire.

En conclusion, le programme ISOE a fait des progrès significatifs au cours de l'année 1998, en particulier en termes d'organisation du système, et d'analyse de données et de production de documents. Les détails de ces progrès ainsi que le programme de travail pour 1999 sont donnés dans le chapitre 3.

正文摘要

ISOE计划第8个年度报告（1998年），正如这里所提供的是1998年12月底ISOE计划的状况。

截至1998年年底，ISOE 1数据库内包括来自26个国家并代表77个电力公司的总计422座反应堆（383座正在运行和39座正处于冷停堆或某个退役阶段）的职业性照射量数据。此外，来自21个国家的监管当局参加了ISOE计划。1998年期间，两个非核能机构国家（亚美尼亚和乌克兰）加入ISOE计划，包括全部17座反应堆以及1个监管部门（来自亚美尼亚）。383座运行商用核反应堆参加ISOE计划，占全世界运行商用核反应堆（总数为434）的88%。

1998年，总的来说职业性照射量继续循着过去1986至1997年这11年间已经观察到的下降趋势下降。在大部分参加ISOE国家中，1998年显示每个机组平均集体剂量有所减少。就PWR来说，每个机组平均集体剂量从1997年的1.20人·希沃特降到1998年的**0.95**人·希沃特，就BWR来说，从1997年的2.05人·希沃特降到1998年的**1.80**人·希沃特，就CANDU来说，从1997年的0.58人·希沃特降到1998年的**0.59**人·希沃特，以及就GCR来说，从1997年的0.23人·希沃特降到1998年的**0.21**人·希沃特。1998年，就LWGR（RBMK）而言（在该数据库内仅以立陶宛的两个机组为代表），每个堆的平均集体剂量，从1997年的9.25人·希沃特降到1998年的7.53人·希沃特，这是一个高于所有其他类型反应堆的数值。

在PWR上所看到的减少部分是由于实施了工作管理原则以及减少停机持续时间的结果。参加ISOE计划的唯一联合王国的PWR（Sizewell B）在1998年没有停机，结果剂量很低仅为0.04人·希沃特。

在BWR上看到的减少部分地是由于以下两个原因，即前几年进行的主要设备修改工作（例如在瑞典）取得了积极的效果以及扩大ALARA和工作管理计划（例如在德国、西班牙和瑞士）取得的结果。墨西哥Laguna Verde核动力厂在1998年发现经过1996年至1997年明显减少后平均年剂量有所增加。

就已停运反应堆而言，每座反应堆平均集体剂量在1988至1998年期间出现减少。然而，反映在这些数字中的反应堆有不同类型和大小不等，而且一般说来都处于其退役计划的不同阶段。由于这些原因，还由于这些数字是以数量有限的停运反应堆为依据，因此，不可能得出肯定的结论。

根据ISOE 1数据，开展了一项关于某些欧洲压水堆绝缘工人所受照射量演变的研究。这项研究对绝缘工作受照量的演变作了分析，并比较了来自不同国家的结果，还比较了不同姊妹机组小组的结果。这项研究证实了在几乎所有核动力厂绝缘工作的集体剂量呈现下降这一全球性趋势，然而，它也指出各国之间和/或机组类型和设计之间仍然存在重大差别。还应指出的是，这种趋势与从大多数国家可以看到的由于实行良好实践和各厂之间互相沟通致使总的集体剂量下降密切相关。该研究列举了为减少绝缘体受照量而采取的并通过1997年ISOE网内的要求所收集的主要措施。完成的报告将在1999年间出版作为ISOE的资料文件。

ISOE 1数据库也被用来摘录有关PWR和BWR换料期间剂量方面的数据，研究这种趋势与反应堆类型和世代之间的关系。研究显示，自1990年以来，PWR和BWR两种堆的换料在剂量方面相对来说是稳定的，而且在所涉工人数量和工作持续时间方面也比较稳定。以下这一点也很明显，即这些数据的报告与如何界定“换料”有关。虽然剂量、工人数量和工作持续时间方面的趋势是稳定的，但在报告国家之间存在相当大的数量差异。最后，可以看出各国的实践对换料剂量的影响似乎要比姊妹机组的实践造成的影响更大。这有助于表明共享国家经验（利用同一种语言）比分享来自其他国家的姊妹机组的经验对工厂更有价值。这些初步结论表明可以开展更深入的进一步研究。

另一项研究非常深入地分析了北美核动力厂在役检查（ISI）中引起的职业性照射以及参与ISOE计划有其他国家提供的某些不太详细的数据。对核动力厂通常要进行在役检查，以便测定焊接点和管道在管道系统运行寿期内发生的磨损、疲劳或应力腐蚀破裂。虽然在北美核动力厂看到的ISI剂量在过去10年里相当稳定，但在美国机组上获得的剂量往往高于在其他国家机组上的剂量。这可能是由于对焊接检查、缓冲器检查等等的监管方式不同所致。已经开展工作以借助概率断裂力学来评价20年核动力厂管道在役检查的经验。这项研究的一个目标是要客观地确定检查什么和应该多长时间进行一次检查。

1998年9月在瑞典马尔摩举行了EC/ISOE关于核动力厂职业性照射的第一次讲习班。这次讲习班的目的是交流在ALARA实施和职业性照射问题方面的经验，并共同吸取经验教训。来自21个国家的总共150名代表出席了这次会议。

最后，IOSE计划在1998年取得了重要进展，尤其是在数据分析和输出以及组织结构方面。第3章详细介绍有关这一进展的细节以及1999年的工作计划。

ZUSAMMENFASSENDE ÜBERSICHT

Der vorliegende ISOE Jahresbericht 1998 gibt den Stand des ISOE Programms Ende Dezember 1998 wieder.

Die ISOE 1 Datenbank umfaßte Ende 1998 Daten der beruflichen Strahlenexposition von insgesamt 422 Kernkraftwerken (383 in Betrieb und 39 in der Phase der Stillegung oder des Rückbaus) von 77 Energieversorgungsunternehmen aus 26 Ländern. Außerdem nehmen am ISOE Programm Genehmigungsbehörden aus 21 Ländern teil. Im Jahre 1998 haben sich zwei Nichtmitgliedstaaten der NEA, die Armenische Republik und Ukraine, mit insgesamt 17 Kernkraftwerken und einer Genehmigungsbehörde (aus der Armenischen Republik) dem ISOE Programm angeschlossen. Die damit auf 383 angewachsene Zahl von teilnehmenden Kernkraftwerken stellt 88% der insgesamt 434 weltweit in Betrieb befindlichen kommerziellen Kernkraftwerke dar.

Die mittlere jährliche Kollektivdosis folgte auch im Jahre 1998 im allgemeinen dem bereits in den elf vorangegangenen Jahren von 1986 bis 1997 beobachteten Abwärtstrend. In den meisten ISOE Teilnehmerländern konnte auch im Jahre 1998 eine Reduktion der mittleren jährlichen Kollektivdosis pro Anlage beobachtet werden. Für Druckwasserreaktoren (DWR) fiel die mittlere jährliche Kollektivdosis pro Reaktor von 1.20 man·Sv im Jahre 1997 auf 0.95 man·Sv im Jahre 1996, für Siedewasserreaktoren (SWR) von 2.05 man·Sv (1997) auf 1.80 man·Sv (1998), für CANDU Reaktoren von 0.58 man·Sv (1997) auf 0.59 man·Sv (1998) und für gasgekühlte Reaktoren (GCR) von 0.23 man·Sv (1997) auf 0.21 man·Sv (1998). Die jährliche Kollektivdosis pro LWGR (RBMK Reaktoren), derzeit nur durch die beiden Blöcke in Litauen in der Datenbank vertreten, fiel von 9.25 man·Sv im Jahre 1997 auf 7.53 man·Sv im Jahre 1998, einen Wert, der über den Werten aller anderen Reaktortypen liegt.

Ein Teil der beobachteten Abnahme der Kollektivdosis bei DWR kann auf die Einführung von verbesserten Arbeitsmanagements sowie auf die Verkürzung der Revisionsdauer zurückgeführt werden. Sizewell B, der einzige an dem ISOE Programm teilnehmende DWR aus Großbritannien, hatte im Jahre 1998 keine Revision was zu einer sehr geringen Dosis von 0.04 man·Sv führte.

Die beobachtete Abnahme der Kollektivdosis bei SWR kann zum Teil auf die positiven Auswirkungen der umfangreichen Modernisierungen, die in den letzten Jahren (z. B. in Schweden) durchgeführt wurden, zurückgeführt werden, oder ist das Ergebnis ausgedehnter ALARA – und Arbeitsmanagementprogrammen (wie z. B. in Deutschland, Spanien und der Schweiz). Das Kernkraftwerk Laguna Verde in Mexiko erfuhr im Jahre 1998 einen Anstieg der mittleren jährlichen Kollektivdosis nach einer deutlichen Reduzierung im Jahre 1997.

Bei den stillgelegten Reaktoren nahm die mittlere jährliche Kollektivdosis pro endgültig außer Betrieb genommenen Reaktor in den Jahren 1988 bis 1998 ab. Die hier betrachteten Reaktoren unterscheiden sich jedoch sehr stark in Typ und Leistung und befinden sich zudem in unterschiedlichen Phasen ihrer Stillegungs- oder Rückbauprogramme. Da die Datenbank zudem nur eine geringe Zahl von endgültig abgeschalteten Reaktoren umfaßt, sind Schlußfolgerungen derzeit nicht möglich.

Auf der Basis von ISOE 1 Daten wurde eine Untersuchung zur Entwicklung der Strahlenexposition von Arbeiten an Isolierungen in Europäischen Druckwasserreaktoren durchgeführt. Die Studie analysiert die Entwicklung der Strahlenexposition während Arbeiten an der Isolierung, indem sie die Ergebnisse aus verschiedenen Ländern sowie für verschiedene Reaktorlinien vergleicht. Diese Studie bestätigt den allgemeinen Trend abnehmender Kollektivdosen für Arbeiten an der Isolierung in nahezu allen Kernkraftwerken, weist jedoch auch darauf hin, daß immer noch größere Unterschiede zwischen den Ländern und zwischen Typen und Auslegungen der Reaktoren existieren. Es ist anzumerken, daß dieser Trend eng mit der Abnahme der Kollektivdosis korreliert ist, die in den meisten Ländern aufgrund der Einführung von „fortgeschrittenen Arbeitsmethoden“ und verbesserten Erfahrungsaustausch zwischen den Kernkraftwerken zu beobachten ist. Die im Jahre 1997 im Rahmen von ISOE gesammelten Maßnahmen zur Reduzierung der Strahlenexposition bei Arbeiten an der Isolierung sind in dieser Studie zusammengefaßt. Die komplette Studie wird im Jahre 1999 als „ISOE Information Sheet“ veröffentlicht.

Auf der Basis der ISOE 1 Dosisdaten zum Brennelementwechsel bei DWR und bei SWR wurden die Trends in Abhängigkeit von Reaktortyp und -generation untersucht. Dabei zeigt sich, daß seit 1990 sowohl die Strahlenexposition als auch die Anzahl der involvierten Arbeiter und die Arbeitsdauer beim Wechsel der Brennelemente in DWR und SWR relativ stabil blieben. Diese Daten hängen jedoch stark davon ab, wie die Tätigkeit „Brennelementwechsel“ definiert wird. Obwohl die Strahlenexposition, Anzahl der Arbeiter und Arbeitsdauer relativ konstant blieben, sind deutliche zahlenmäßige Unterschiede zwischen den berichtenden Ländern festzustellen. Schließlich wird deutlich, daß nationale Eigenheiten einen stärkeren Einfluß auf die Dosis beim Brennelementwechsel haben als die Tatsache einer Baugleichheit von Reaktoren aus unterschiedlichen Ländern. Dies deutet darauf hin, daß gemeinsame nationale Erfahrung – in der gleichen Landessprache kommuniziert –mehr Wert für Anlagenbetreiber darstellt als Erfahrungen von baugleichen Reaktoren in anderen Ländern. Diese vorläufigen Schlußfolgerungen sollten durch zusätzliche tiefergehende Untersuchungen bestätigt und erweitert werden.

Eine weitere Untersuchung im Rahmen von ISOE analysierte detailliert die berufliche Strahlenexposition während wiederkehrender Prüfungen (WKP) bei nordamerikanischen Kernkraftwerken und – weniger detailliert – bei Reaktoren aus anderen Ländern des ISOE Programms. Regelmäßig wiederkehrende Prüfungen werden in Kernkraftwerken durchgeführt, um Verschleiß, Ermüdung sowie Spannungs- und Korrosionsrisse, die bei Schweißnähten und Rohrleitungen während ihrer Einsatzzeit auftreten können, frühzeitig zu erkennen. Obwohl die bei WKP beobachteten Dosen in nordamerikanischen Kernkraftwerken in den letzten zehn Jahren nahezu stabil blieben, ist die Dosis bei amerikanischen Reaktoren deutlich höher als bei Reaktoren in anderen Länden. Dies mag seine Ursache in unterschiedlichen Einstellungen der Genehmigungsbehörde gegenüber Umfang und Frequenz der WKP, z. B an Schweißnähten, Aufhängungen von Rohrleitungen etc. haben. Deshalb wurde der Versuch unternommen, objektiv festzustellen, was zu prüfen ist und wie häufig die WKP durchzuführen sind, indem man versucht, 20 Jahre Erfahrung mit WKP der Rohrleitungen von Kernkraftwerken mit Hilfe der probabilistischen Bruchmechanik auszuwerten.

Der erste EC/ISOE Workshop über das „Management von Beruflicher Strahlenexposition in Kernkraftwerken“ fand im September 1998 in Malmö, Schweden, statt. Ziel dieses Workshops war es, Erfahrungen mit der Einführung von ALARA und anderen Themen der beruflichen Strahlenexposition auszutauschen. Das Treffen wurde von insgesamt 150 Teilnehmer aus 21 Ländern besucht.

Die im Jahre 1998 erzielten deutliche Fortschritte im ISOE Arbeitsprogramm, insbesondere in den Bereichen Datenanalyse, Datendarstellung und Organisationsstruktur, sowie das ISOE Arbeitsprogramm für 1999 sind in Kapitel 3 zusammengefaßt.

要　約

この第８年次総括報告書は、1998年12月末におけるISOEプログラムの状況をまとめたものである。

1998年12月末現在、ISOE１データベースには26ヶ国から77の電気事業者の合計422基の原子力発電所（内383基が運転中、39基が永久冷温停止または廃止措置段階にある）に関する職業被ばくデータが含まれている。また、21ヶ国の規制当局がISOEプログラムに参加している。1998年には、NEA非加盟のアルメニアとウクライナの２ヶ国がISOEプログラムに参加し、原子力発電所17基と１ヶ国の規制当局（アルメニア）が加わった。ISOEプラグラムに含まれる運転中商用炉383基は、全世界の運転中商用炉（総計434基）の88％を占める。

1998年における職業被ばくは、全般的には1986年から1997年までの過去11年間に渡り見られる減少傾向を継続している。大半のISOE参加国において、1998年は１基当たり平均線量当量の減少が見られた。各炉型に対する原子力発電所１基当たり平均線量当量は前年から減少しており、それぞれ、PWRでは1.20人·Svから0.95人·Sv、BWRでは2.05人·Svから1.80·Sv、CANDU炉では0.58人·Svから0.59人·Sv、そしてGCRでは0.23人·Svから0.21人·Svであった。また、ISOEデータベースではリトアニアの２基のみが登録されている軽水冷却黒鉛炉(RBMK)は、9.25人·Svから7.53人·Svに減少しているものの、他の炉型の原子力発電所よりも高い値を示している。

PWRにおいて見られる線量低減の一部は、作業管理の原則の適用と運転停止期間の短縮によるものである。英国からISOEプログラムへ参加しているただ１基のPWR　Sizewell Bについては、1998年には運転停止がなかったため、0.04人·Svという非常に低い線量となっている。

BWRにおいて見られる線量低減の一部は、前年度に主要なプラント改造作業が実施されたこと（スウェーデン）、そしてALARA及び作業管理プログラムが強化されたこと（ドイツ、スペイン、スイス）の両方の効果によるものである。メキシコのLaguna Verde原子力発電所は年間平均線量が前年大きく減少したが1998年には増加した。

永久停止した原子力発電所に対する１基当たり平均線量当量は、1988年から1998年に渡って減少している。しかし、これらの原子力発電所は炉型または容量が異なっており、全般的には廃止措置計画の異なった段階にある。これらの理由により、また、これらのデータが限られた基数に基づくものであるため、はっきりした結論を引き出せない。

ISOE１データベースを用いて、欧州数カ国のPWRにおける保温材作業員に対する被ばく状況について調査が実施された。保温材作業の被ばく状況について国及び類似設計ユニットグループに関する比較分析が行われた。調査により、大半の発電所において保温材作業に関する線量当量は全般的に減少傾向であることが確認された。しかしまた、依然として大きな差異が国及び/またはユニットの炉型及び設計において存在することを示している。この傾向はまた、大半の国において見られる良好事例の実施やこれらの発電所間でのコミュニケーションによる総線量当量の減少に強く関係していることに注意すべきである。また、

1997年にISOEネットワーク内の質問調査により収集された、保温材作業員の被ばく低減のために実施された主要な事例を挙げている。全ての調査検討結果は1999年にISOE情報シートとして発行される予定である。

ISOE 1データベースは、また、PWRとBWRの燃料交換作業線量データを抽出して炉型と発電電力量に対する傾向を調査するために使用された。この調査は1990年以来、PWRとBWRの両方における燃料交換が線量の観点、また、関係する作業員数と作業期間の観点からは概ね一定していることを示している。また、これらデータの報告は「燃料交換作業」がどのように定義されているかということに左右されることも明らかである。線量、作業員数そして作業期間における傾向は一定しているが、報告している国の間ではかなり多くの相異点がある。最後に、燃料交換作業線量に関しては類似設計グループよりその国における作業方法（習慣）の方がより大きな影響があることが見られる。これらの傾向は国で共有される経験（同じ言語を使う）は、他国の類似設計ユニットからの経験よりも発電所にとってはより価値があると見なされることを示唆している。これらの予備的な結論から、今後行うべき詳細な調査が提示される。

その他、調査としては、北米の原子力発電所における詳細な共用期間中検査(ISI)の職業被ばくについて、ISOEプログラムに含まれる他国からのいくつかのデータを加えて分析を行った。ISIは配管システムの運転寿命中に溶接と配管に生じる摩擦や疲労、あるいは応力腐食割れを特定するために、原子力発電所で定例的に実施されている。北米の原子力発電所におけるISI線量は過去10年に渡りかなり安定しているが、他国の原子力発電所における線量よりも高い傾向がある。これは溶接検査、スナバー検査等に対する規制の差異によるものかもしれない。確率論的破壊力学を使用して20年間の原子力発電所配管のISIに関する経験の評価が行われている。この研究の一つの目標は何をどの頻度で検査すべきかを客観的に決定することである。

原子力発電所における職業被ばくに関する第１回EC/ISOEワークショップが1998年にスウェーデンのマルメにて開催された。このワークショップの目的はALARAの実施における経験と職業被ばく事例について情報交換し、また、学んだ教訓を共有することであった。21ヶ国から150人がこの会合に出席した。

最後になるが、ISOEプログラムは1998年に、特にデータ分析、発行物及び組織構成に関して大きく進歩した。この進歩と1999年の作業プログラムの詳細については第３章で述べられている。

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RESUMEN EJECUTIVO

Este octavo informe del programmea ISOE de 1998 representa el estado del programmea ISOE a finales de Diciembre de 1998.

En estas fechas, la base de datos ISOE 1 contenía datos de exposiciones ocupacionales de un total de 422 reactores (383 en operación y 39 en parada fría o en alguna fase de desmantelamiento) correspondientes a 26 países y que representaban 77 empresas eléctricas. Adicionalmente los organismos reguladores de 21 países estabán participando en el programmea ISOE. A lo largo de 1998 dos países no integrados en la NEA: Armenia y Ucrania se sumaron al programmea ISOE, con un total de 17 reactores y la participación de un organismo regulador (Armenia). La participación de 383 reactores nucleares comerciales en operación en el programmea ISOE representa el 88% del parque mundial de reactores comerciales en operación (total de 434).

En 1998 las exposiciones ocupacionales han mantenido su tendencia decreciente que se venía observando en los últimos once años, desde 1986 hasta 1997. En la mayoría de los países participantes en ISOE, se ha registrado una reducción de la dosis colectiva por reactor. La dosis media por unidad para reactores PWR se redujo de 1,20 Sv·persona en 1997 a 0,95 Sv·persona en 1998; para reactores centrales tipo BWR la reducción fue de 2,05 Sv·persona en 1997 a 1,80 Sv·persona para 1998; para reactores CANDU se paso de 0,58 Sv·persona en 1997 a 0,59 Sv·persona en 1998; y en los reactores GCR se obtuvieron 0,23 Sv·persona en 1997 y 0,21 Sv·persona en 1998. En 1998, la dosis colectiva media por reactor para centrales LWGR (RBMK), representadas en la base de datos solamente por las dos unidades de Lituana, descendió de 9,25 Sv·persona en 1997 a 7,53 Sv·persona en 1998, valores superiores a los de otro tipos de reactores.

Una parte de la reducción observada en los reactores PWR ha sido debida a la implantación de los principios de gestión de trabajos y a la reducción de la duración de las paradas. El único reactor PWR del Reino unido participante en le programmea ISOE, Sizewell B, que no tuvo parada en 1998 consiguió un resultado de dosis colectiva tan bajo como 0,04 Sv·persona.

Las reducciones observadas en los reactores centrales tipo BWR son en parte causadas por las importantes modificaciones realizadas en años anteriores (por ejemplo en Suecia) y el resultado de los programmeas ALARA y de gestión de trabajos (por ejemplo en Alemania, Suiza y España). La central nuclear de Laguna Verde obtuvo un ligero repunte de las dosis colectivas en 1998, después de una significativa reducción de 1996 a 1997.

Las dosis colectivas por reactor de centrales en parada también se han reducido en los últimos diez años, desde 1988 a 1998. No obstante, los reactores incluidos en estos datos son de diferente tipo y tamaño, y en general se encuentran en distintas fases de su desmantelamiento. Por estas razones, y debido a que los valores presentados se basan en un número reducido de reactores en parada, es difícil obtener conclusiones definitivas.

Se ha realizado un estudio sobre la evolución de las exposiciones debidas a trabajos en calorifugados, basándose en los datos de centrales PWR europeas recogidos en ISOE 1. Este estudio analiza la evolución de las exposiciones de trabajos relacionados con aislamientos térmicos, comparando resultados de distintos países y distintos grupos de centrales gemelas. Este estudio confirma la tendencia general descendiente de las dosis colectivas asociadas a estos trabajos en prácticamente todas las centrales, poniendo sin embargo de manifiesto que existen diferencias significativas entre países y tipos y diseños de centrales. También es destacable la relación entre las tendencias decrecientes de las dosis de estos trabajos y las de las dosis colectivas totales. Así mismo, este estudio incluye una relación de las principales acciones llevadas a cabo para la reducción de las exposiciones en estos trabajos recopiladas mediante un cuestionario especifico remitido a lo largo de 1997. El estudio completo será publicado en 1999 como una ISOE Information Sheet.

La base de datos ISOE 1 también se ha utilizado para extraer datos de dosis durante paradas para recarga en reactores tipo PWR y centrales tipo BWR, investigándose las tendencias por tipo de reactor y generación. Este estudio concluye que desde 1990 se mantienen prácticamente constantes tanto las dosis colectivas como el número de trabajadores involucrados y la duración de los trabajos, si bien la definición y alcance de las tareas de "recarga de combustible" presenta algunas heterogeneidades. En efecto, si bien las tendencias de las dosis, numero de trabajadores y duración de los trabajos es estable, hay importantes diferencias entre distintos países. Finalmente, puede observarse que las prácticas nacionales tienen mayor influencia que las practicas entre centrales gemelas. Esto parece indicar que el compartir experiencia a nivel nacional tiene mayor relevancia que el compartir experiencias a nivel de tipo de central entre países. Estas conclusiones preliminares apuntan sobre la posibilidad de realizar estudios mas profundos sobre el tema.

Otro estudio realizado analiza, con gran profundidad, dosis ocupacionales debido a Inspecciones en Servicio (ISI) en centrales nucleares norteamericanas, y de otros países participantes en el programmea ISOE, con menor detalle. Este tipo de inspecciones se realizan habitualmente en las centrales nucleares para determinar desgastes, fatigas o corrosiones en tuberías y soldaduras a lo largo de la vida operacional de la planta. Del estudio se observa que las dosis debidas a ISI en las centrales nucleares norteamericanas se mantienen bastante estables en los últimos diez años, pero son mayores que en centrales nucleares equivalentes del resto de los países. Esto puede ser debido a las diferencias de los aspectos reguladores relativas a este tipo de inspecciones. Un esfuerzo se ha realizado para evaluar la experiencia de los últimos 20 años de inspecciones en servicio de tuberías utilizando los benéficos de la mecánica probabilistica de fracturas. El objetivo de este estudio es la determinación objetiva de que es lo que hay que inspeccionar y con que frecuencia debe hacerse.

El primer Seminario Internacional sobre Exposiciones Ocupacionales en Centrales Nucleares tuvo lugar en Septiembre de 1998 en Malmö, Suecia. El objetivo del Seminario fue comunicar y compartir experiencias de la implantación de actividades ALARA. Un total de 150 participantes de 21 países estuvieron presentes en el Seminario.

Finalmente, el programmea ISOE ha realizado un significativo progreso durante 1998, particularmente en términos de análisis de datos y estructura organizativa. Detalles de estos avances así como el programmea de trabajo para 1999 se incluyen en el capítulo 3.

1. STATUS OF PARTICIPATION IN THE INFORMATION SYSTEM ON OCCUPATIONAL EXPOSURE ISOE

Since the inception of the ISOE Programme in 1992, the number of actively participating commercial nuclear power plants has continued to increase. At the same time, the depth to which participating units supply the various occupational exposure details to the database has also grown. The result of this growth is that the ISOE database system is the most complete commercial nuclear power plant occupational exposure database in the world.

As of the end of 1998, occupational exposure data from a total of 383 operating commercial nuclear reactors and 39 commercial nuclear reactors in cold-shutdown or some stage of decommissioning are included in the ISOE 1 database. These units represent 77 utilities from 26 countries. In addition, regulatory authorities from 21 countries participate in the ISOE Programme. Annex 2 provides a complete list of the units, utilities and authorities participating in the programme and included in the database. Table 1 below summarises participation by country, type of reactor and reactor status.

The participation of 383 operating commercial nuclear reactors in the ISOE programme represents 88% of the World's operating commercial nuclear reactors (total of 434). These numbers are illustrated in a pie chart on this page.

During 1998, two non-NEA countries, Armenia and Ukraine, joined the ISOE Programme with in total 17 reactors. Armenia participates with one PWR (Armenia 2) as well as with the Armenian Nuclear Regulatory Authority (ANRA). Ukraine adds 3 LWGR (Chernobyl 1, 2 and 3) and 13 PWR (Khmelnitski 1, Rovno 1, 2, 3, South Ukraine 1, 2, 3, and Zaporozhe 1, 2, 3, 4, 5, 6) to the programme. In addition, the German research reactor AVR Jülich, a 13 MWe High Temperature Reactor shut down in 1988, joined the ISOE Programme.

Operating Nuclear Power Plants

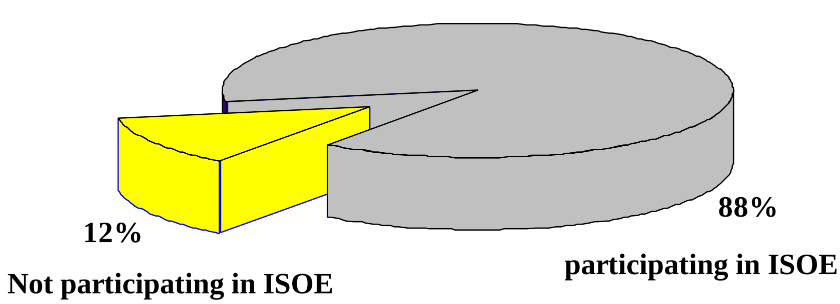


Table 1

Participation summary

Operating reactors participating in ISOE						
Country	**PWR**	**BWR**	**HWR**	**GCR**	**LWGR**	**Total**
Armenia	1	–	–	–	–	1
Belgium	7	–	–	–	–	7
Brazil	1	–	–	–	–	1
Canada	–	–	21	–	–	21
China	3	–	–	–	–	3
Czech Republic	4	–	–	–	–	4
Finland	2	2	–	–	–	4
France	57	–	–	–	–	57
Germany	14	6	–	–	–	20
Hungary	4	–	–	–	–	4
Japan	23	28	1	–	–	52
Korea	10	–	2	–	–	12
Lithuania	–	–	–	–	2	2
Mexico	–	2	–	–	–	2
Netherlands	1	–	–	–	–	1
Romania	–	–	1	–	–	1
Slovakia	4	–	–	–	–	4
Slovenia	1	–	–	–	–	1
South Africa	2	–	–	–	–	2
Spain	7	2	–	–	–	9
Sweden	3	9	–	–	–	12
Switzerland	3	2	–	–	–	5
Ukraine	13	–	–	–	3	16
United Kingdom	1	–	–	–	–	1
United States	26	15	–	–	–	41
Total	**187**	**66**	**25**	**–**	**5**	**283**

Operating reactors not participating in ISOE, but included in the ISOE database						
Country	**PWR**	**BWR**	**HWR**	**GCR**	**LWGR**	**Total**
United Kingdom	–	–	–	34	–	34
United States	45	21	–	–	–	66
Total	**45**	**21**	**–**	**34**	**–**	**100**

Total number of operating reactors included in the ISOE database						
	PWR	**BWR**	**HWR**	**GCR**	**LWGR**	**Total**
Total	**232**	**87**	**25**	**34**	**5**	**383**

Table 1 (continued)

Definitively shutdown reactors participating in ISOE					
Country	**PWR**	**BWR**	**HWR**	**GCR**	**Total**
France	1	–	–	6	7
Italy	1	2	–	1	4
Japan	–	–	–	1	1
Germany	–	1	–	1	2
Netherlands	–	1	–	–	1
Spain	–	–	–	1	1
United States	2	3	–	1	6
Total	**4**	**7**	**–**	**11**	**22**

Definitively shutdown reactors not participating in ISOE but included in the ISOE database					
Country	**PWR**	**BWR**	**HWR**	**GCR**	**Total**
Canada	–	–	2	–	2
Germany	–	2	–	–	2
United Kingdom	–	–	–	6	6
United States	4	2	–	1	7
Total	**4**	**4**	**2**	**7**	**17**

Total number of definitively shutdown reactors included in the ISOE database					
	PWR	**BWR**	**HWR**	**GCR**	**Total**
Total	**8**	**11**	**2**	**18**	**39**

Number of Utilities Officially Participating:77
Number of Countries Officially Participating:26
Number of Authorities Officially Participating:21

2. THE EVOLUTION OF COLLECTIVE DOSE IN ISOE MEMBER COUNTRIES

One of the most important aspects of the ISOE Programme is the tracking of annual occupational exposure trends. Using the ISOE 1 database, which contains annual occupational exposure data supplied by all Participating Utilities, various exposure trends can be displayed by country, by reactor type, or by other criteria such as sister-unit grouping.

2.1 Occupational exposure trends in operating reactors

In most ISOE participating countries, 1998 saw a reduction in the average dose per unit, for PWRs. As can be seen in section 2.6, part of this reduction is due to the implementation of work management principles and the reduction in outage durations. The only PWR in the United Kingdom participating in the ISOE programme, Sizewell B, had no outage in 1998 resulting in a very low dose of 0.04 man·Sv.

In 1998, the average annual doses for BWRs saw a reduction for most of the countries. These reductions are in part due to the positive effect of major plant modification works performed in previous years (e.g. in Sweden), and the result of extensive ALARA and work management programmes (e.g. in Germany, Spain and Switzerland). The Laguna Verde nuclear power plant in Mexico experienced in 1998 an increase of the average annual dose after a major reduction from 1996 to 1997.

Table 2 summarises the average annual exposure trends for individual units over the past three years. Figures 1 to 4 show this tabular data in a bar-chart format, for 1998 only, ranked from highest to lowest average dose. Figures 5 and 6 show the trends in average collective dose per reactor for the years 1988 to 1998 by reactor type.

Table 2. Evolution of average annual dose per unit, by country and reactor type, from 1996-1998(man·Sv)

	PWR			**BWR**			**CANDU**		
	1996	**1997**	**1998**	**1996**	**1997**	**1998**	**1996**	**1997**	**1998**
Armenia	3.46	3.41	1.51						
Belgium	0.92	0.39	0.70						
Brazil	1.34	2.61	1.26						
Canada							0.53	0.59	0.52
China	0.74	0.67	0.71						
Czech Republic	0.36	0.38	0.34						
Finland	1.32	0.57	1.04	0.84	0.83	1.03			
France	1.59	1.42	1.20						
Germany	1.66	1.43	1.01	1.43	1.33	1.56			
Hungary	0.63	0.49	0.59						
Japan	1.04	1.01	0.96	1.60	2.05	1.78			
Korea	0.88	0.88	1.04				2.99	0.62	1.00
Mexico				8.08	2.25	4.77			
Netherlands	1.11	2.83	0.68	0.99					
Romania								0.25	0.26
Slovakia	0.68	0.77	0.98						
Slovenia	2.01	0.99	1.25						
South Africa	1.11	1.24	0.65						
Spain	1.47	1.35	0.55	3.36	2.39	0.53			
Sweden	0.66	0.64	0.59	2.33	2.82	1.55			
Switzerland	0.71	0.48	0.46	1.68	1.45	1.19			
United Kingdom	0.53	0.50	0.04						
United States	1.30	1.32	0.90	2.52	2.05	1.90			

		GCR			**LWGR**	
	1996	**1997**	**1998**	**1996**	**1997**	**1998**
Japan	0.39	0.24				
Lithuania				7.55	9.25	7.53
United Kingdom	0.25	0.23	0.21			

Figure 1

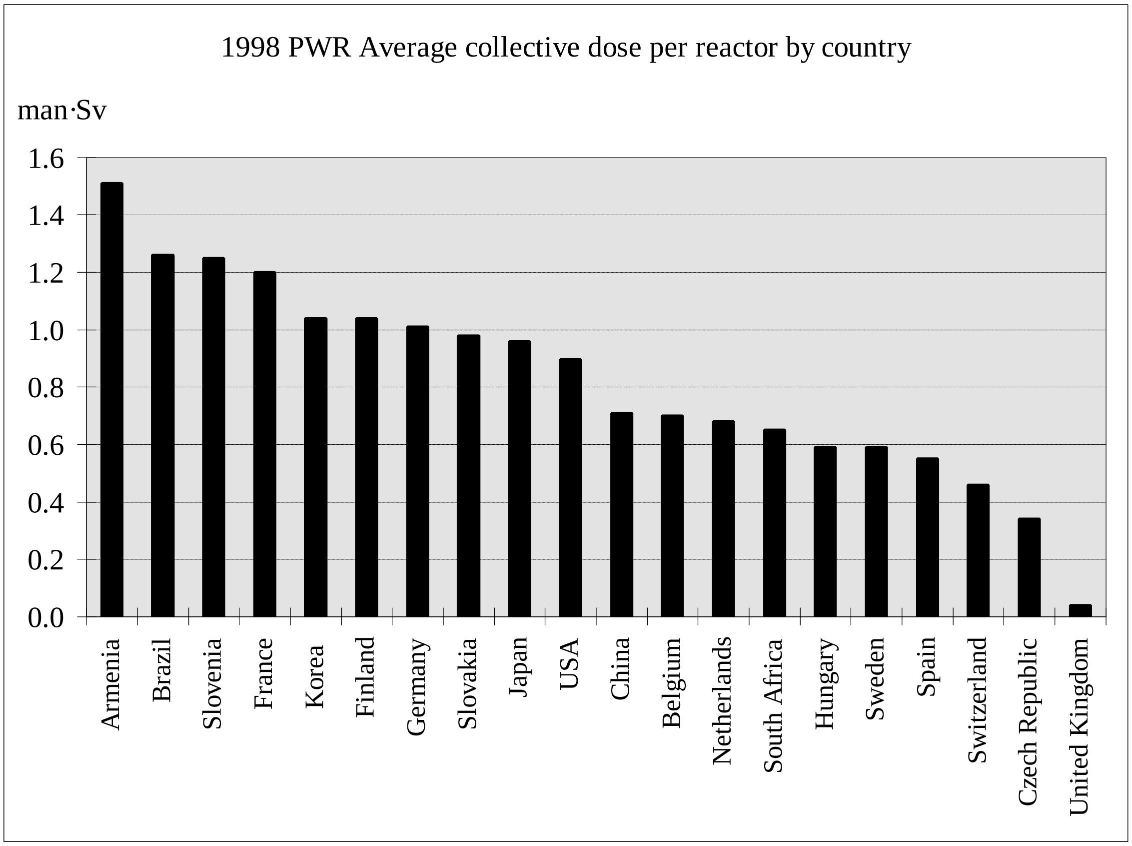


Figure 2

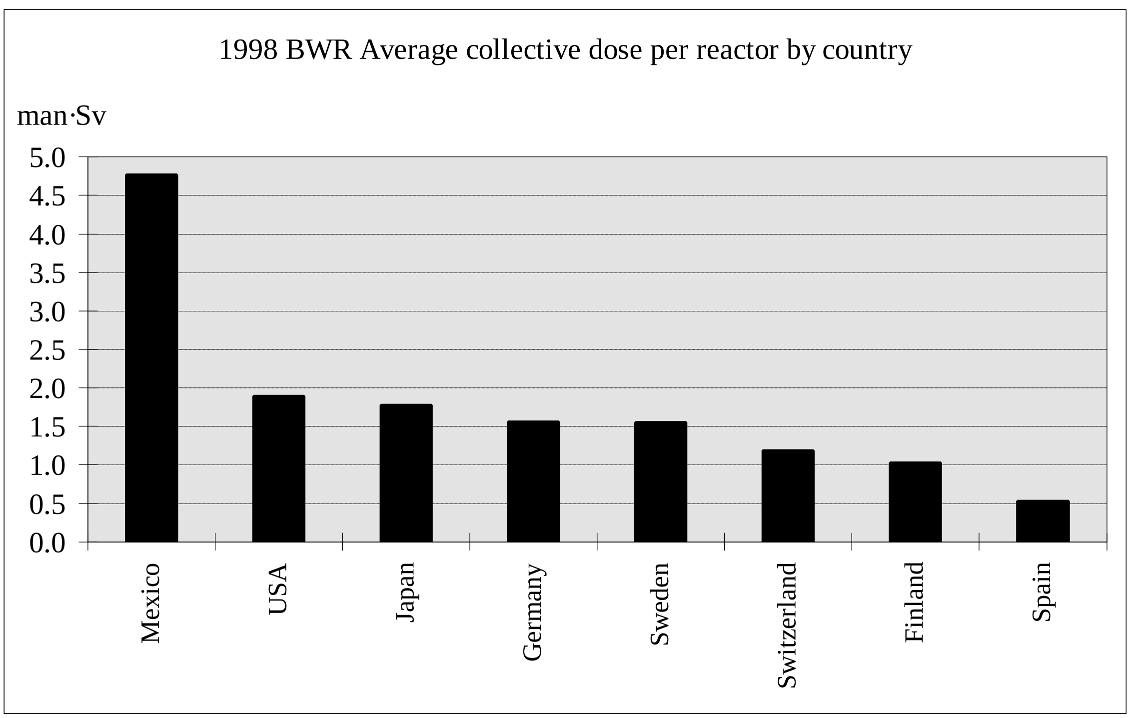


Figure 3

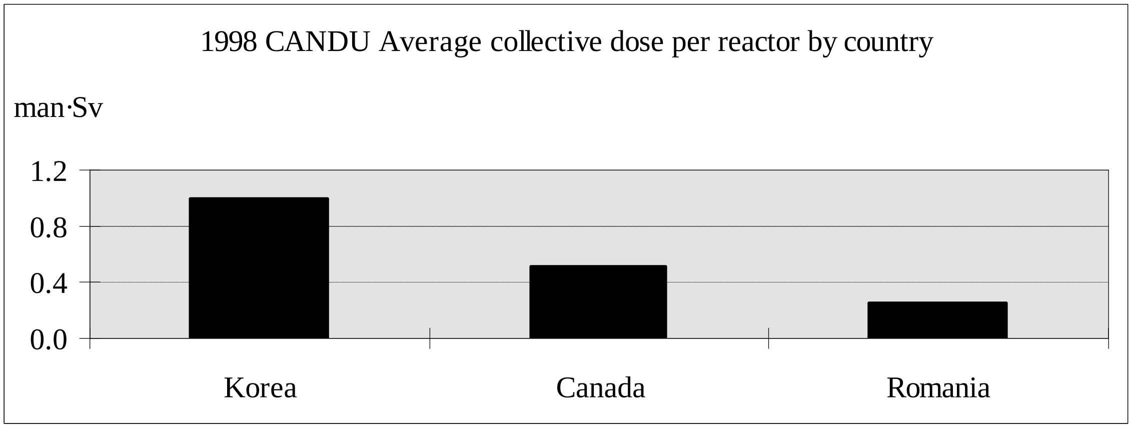


Figure 4

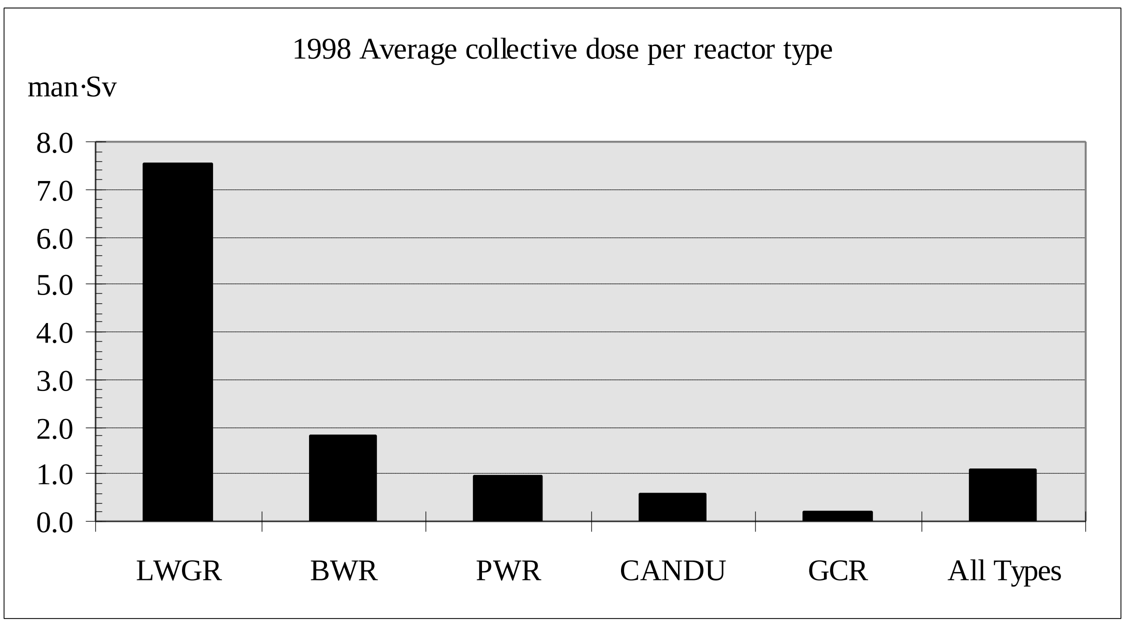


Figure 5

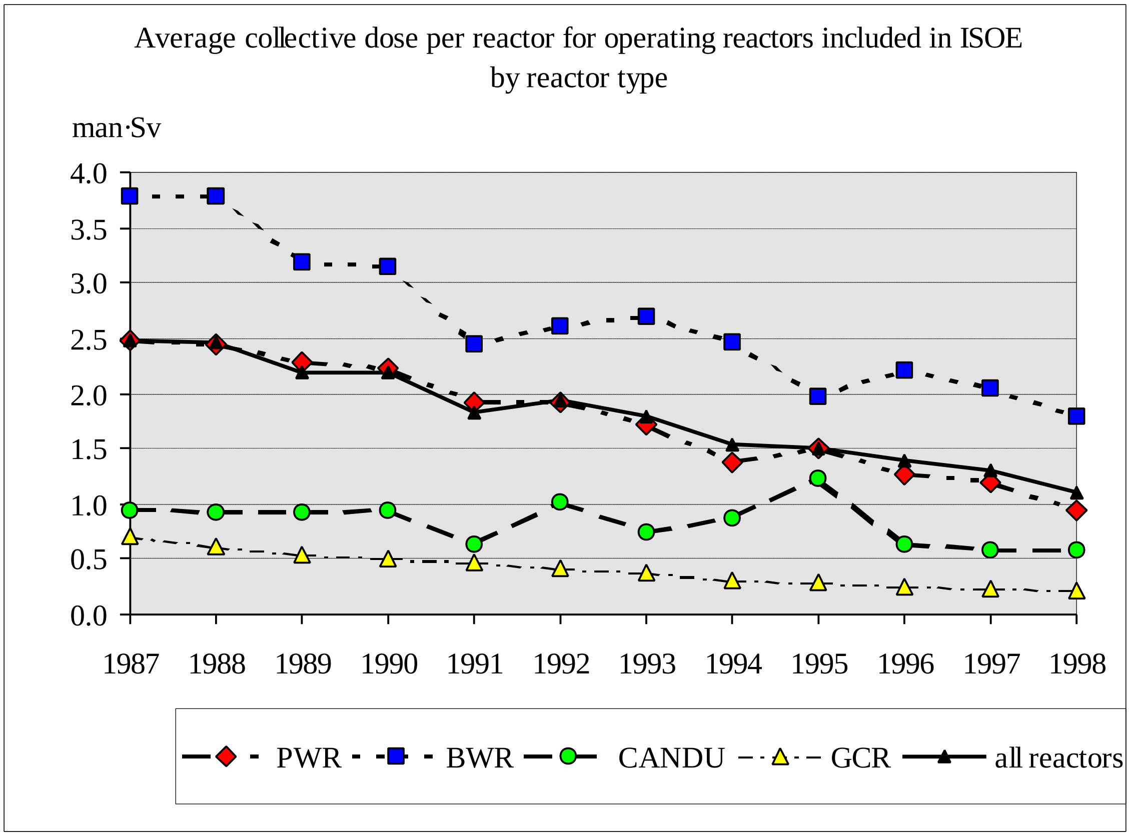
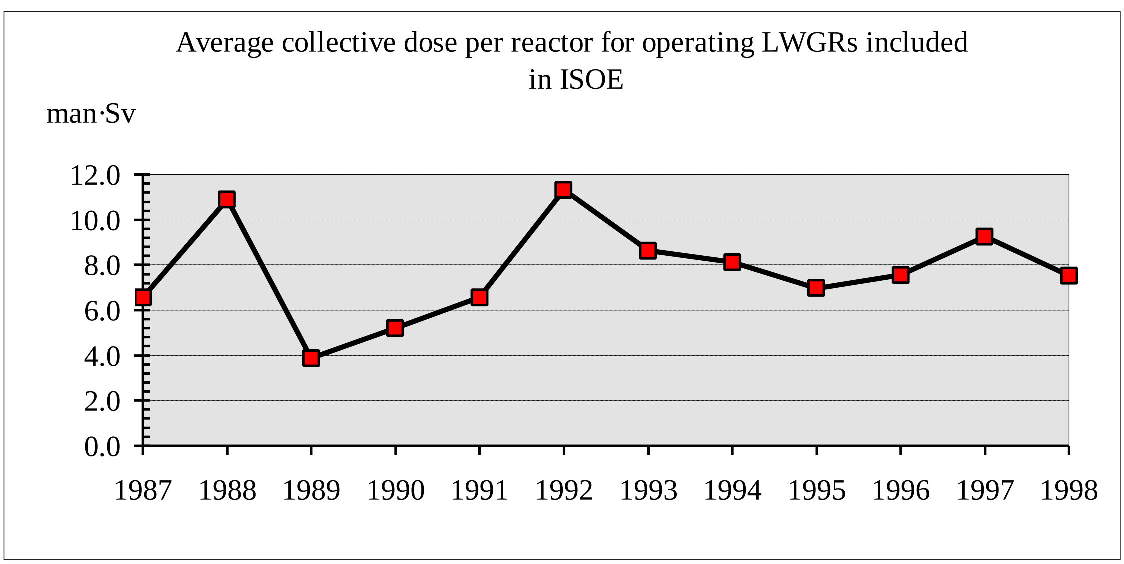


Figure 6



2.2 Occupational exposure trends in reactors in cold shutdown or in decommissioning

The average collective dose per reactor for shutdown reactors saw a reduction over the years 1988 to 1998. However, the reactors represented in these figures are of different type and size, and are, in general, at different phases of their decommissioning programmes. For these reasons, and because these figures are based on a limited number of shutdown reactors, it is impossible to draw definitive conclusions.

Table 3 shows the average annual dose per unit by country and type of reactor for the years 1996 to 1998. Figures 7 to 10 summarise the average collective dose per reactor for shutdown reactors and the number of shutdown reactors for the years 1988 to 1998 for PWRs, BWRs, GCRs and for all types.

Table 3

Average annual dose per unit by country and reactor type for the year 1998

	PWR					
	1996		**1997**		**1998**	
	No.	man·mSv	No.	man·mSv	No.	man·mSv
France	1	230	1	112	1	120
Germany					6	96
Italy	1	2	1	1	1	1
United States					6	520
	BWR					
Germany			1	461	4	386
Italy	2	34	2	50	2	56
Netherlands			1	168	1	158
United States					3	357
	GCR					
France	6	22	6	49	6	81
Germany					1	44
Italy	1	11	1	43	1	43
Japan					1	130
United Kingdom	4	122	6	77	6	78

Figure 7

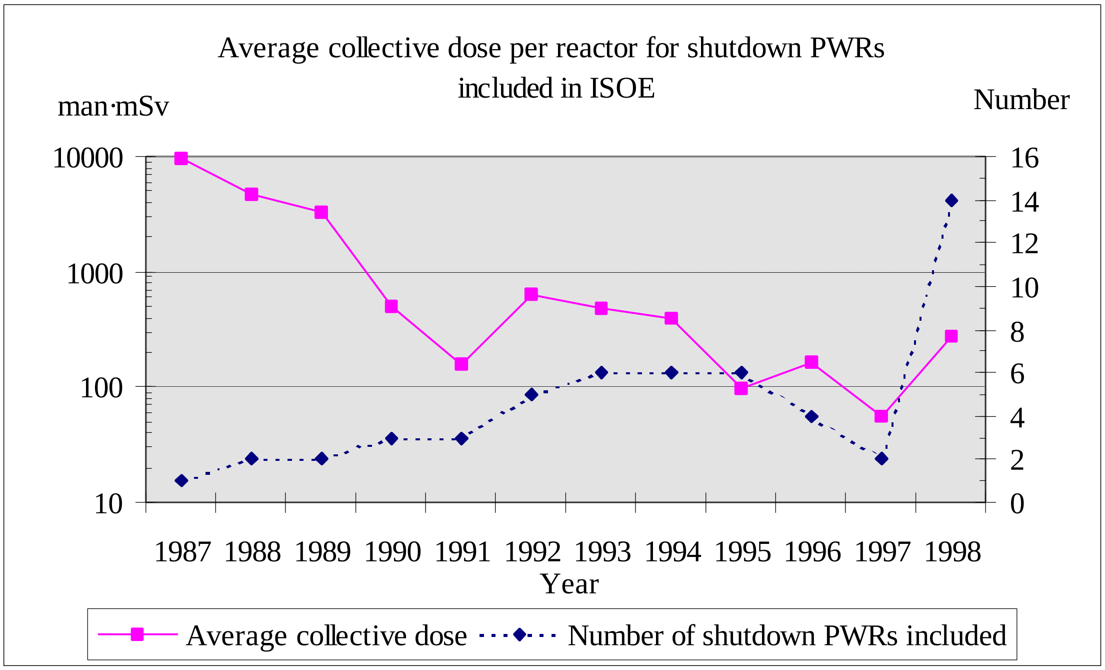


Figure 8

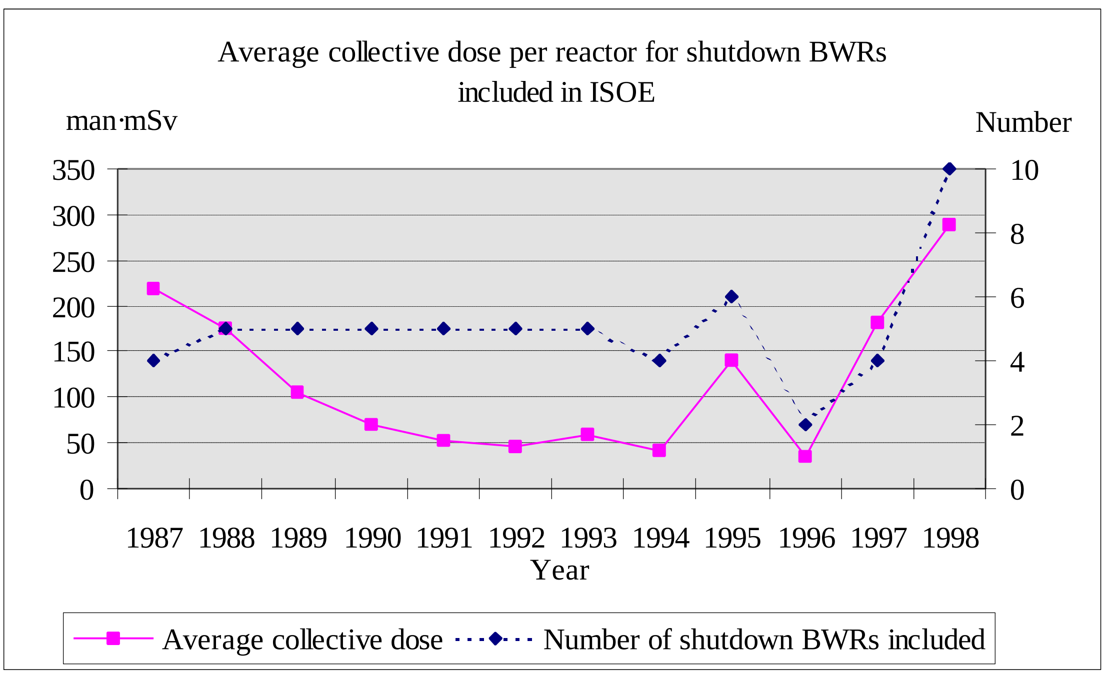


Figure 9

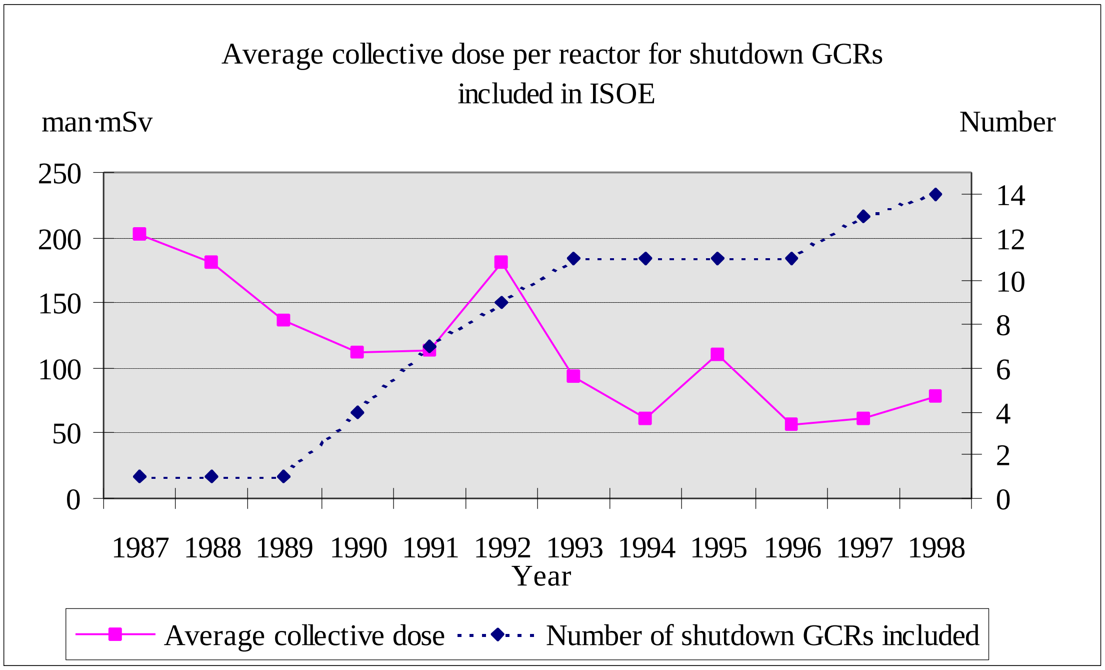
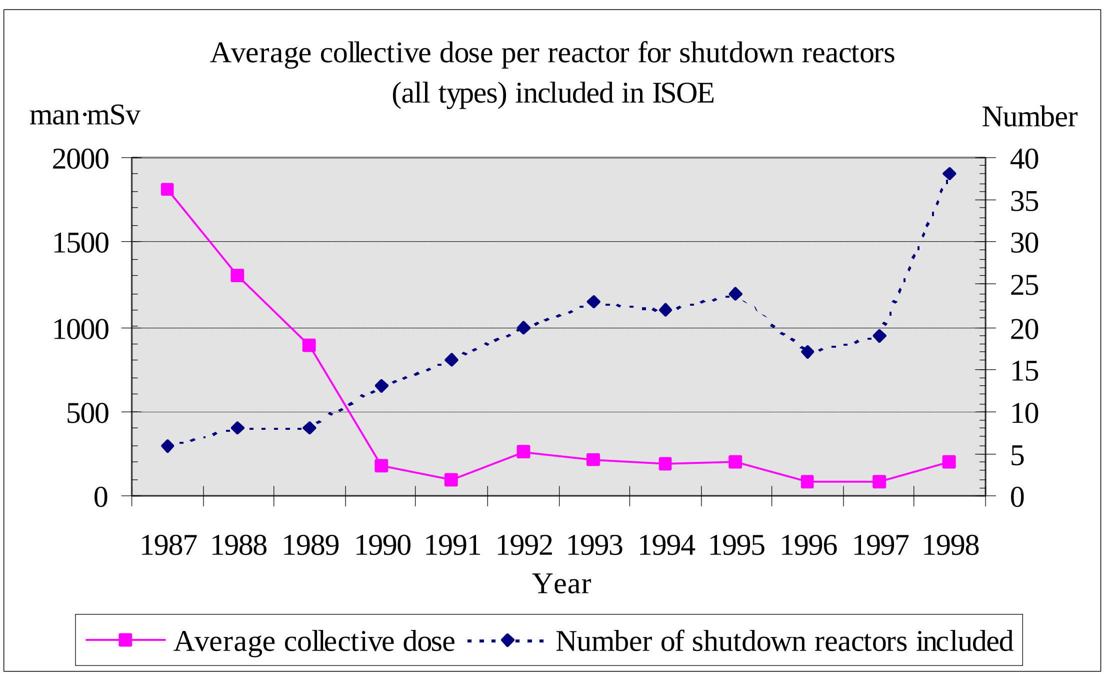


Figure 10



2.3 Insulation trends

Analysis of the evolution of collective doses related to insulation jobs in some European PWRs

Within the framework of the ISOE Working Group on Data Analysis, a study has been performed by the European Technical Centre on the evolution of insulator's doses in some European PWRs, based on ISOE 1 data. The complete study will be published as an ISOE Information Sheet during 1999. The extraction was made on a period of 8 years: from 1990 to 1997. The 84 units selected were those providing more than 3 years of data for insulation job doses (the number of units considered in each country is indicated in Figure 11). The calculations have been made on a three years rolling average for each unit. The mean per country, or per sister-unit group, has then be calculated using the three years average dose of each unit belonging to the group under consideration.

Analysis of the evolution of insulation jobs' exposures per country

In all these countries, the collective dose due to insulation jobs represents between 5% and 7% of the annual collective dose. This percentage is relatively stable over the period under consideration.

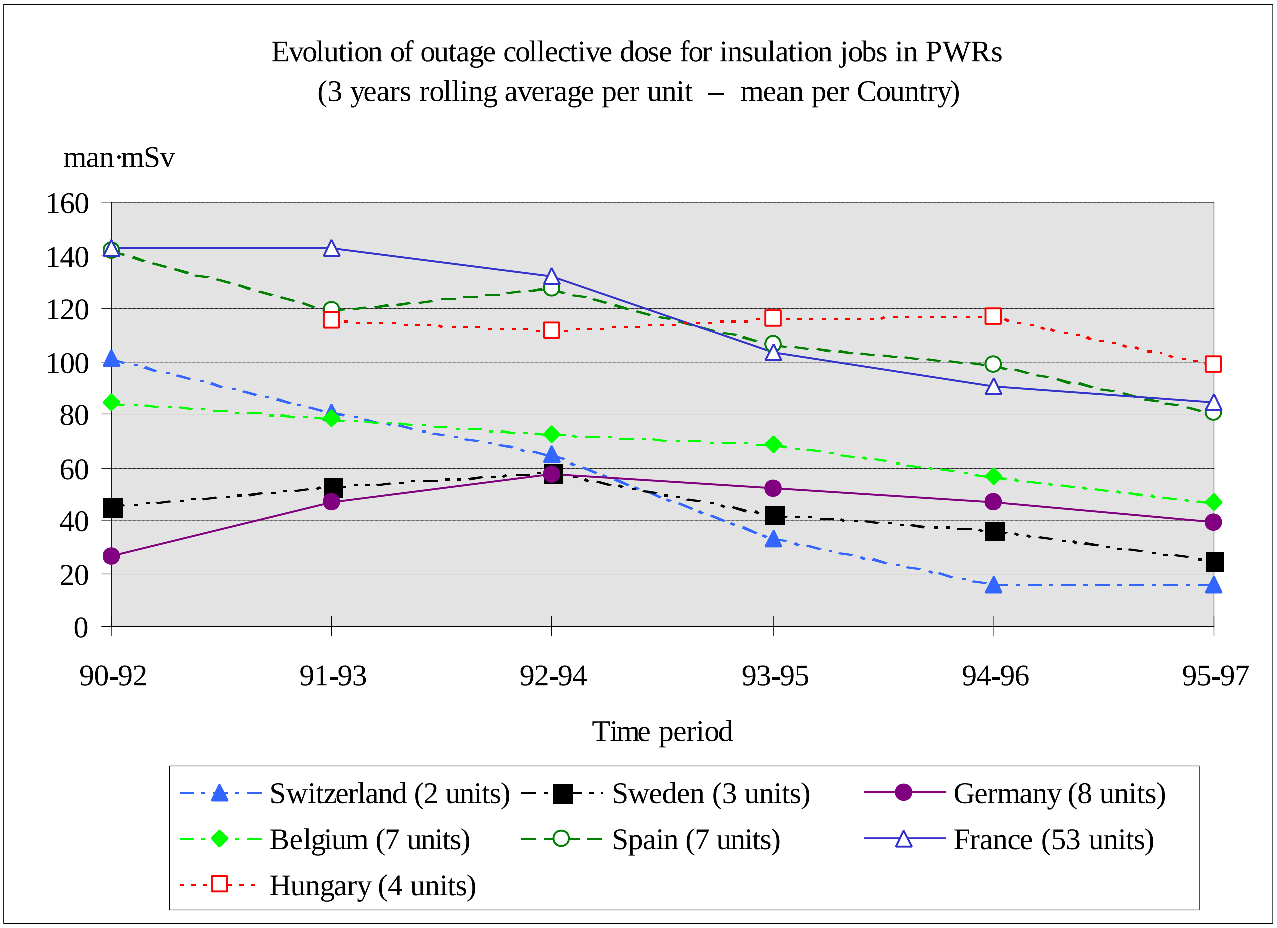
When looking at the quantitative values of the 3 years rolling average of the collective dose due to insulation jobs, it appears that they are decreasing in nearly all countries. Two main groups of countries can be identified (see Figure 11).

- A first group with Switzerland, Sweden, Germany and Belgium where the level of the 3 years rolling average per country for insulation jobs is situated between 20 and 100 man·mSv during the first period (90-92), and between 20 and 45 man·mSv during the last period (95-97). The best results were obtained in Switzerland, with a decrease of nearly 80%: from 100 man·mSv per year during the period 90-92 to 18 man·mSv during the last period 95-97. In Sweden and Germany, after an increase between 90-92 and 92-94, the mean collective dose of insulation jobs has decreased. But in Germany, the level of the period 95-97 (around 40 man·mSv) is still about that of the period 90-92 (around 25 man·mSv). In Sweden, the level of the last period (25 man·mSv) correspond to a decrease of 45% since the first period (45 man·mSv).

- A second group composed of Spain, France and Hungary, where the level of collective doses due to insulation jobs is greater than in the first group: between 120 and 140 man·mSv during the first period, and between 80 and 125 man·mSv during the last period. An important decrease can be observed in France and Spain, where the mean collective dose has decreased by nearly a factor 2: from 140 man·mSv in 90-92 to 80 man·mSv in 95-97. In Hungary, the collective dose due to insulation jobs was quite stable from 91-93 to 94-96 (around 118 man·mSv per year). A decrease can however be observed on the last period, where the collective dose of insulation jobs is below 100 man·mSv.[1]

[1] In Hungary, the collective dose of insulation jobs can be higher than the mentioned 5-7% of the annual collective dose. Due to the 6-loop design of the Paks nuclear power plant, the authority requires more inspection work on insulation. The collective dose of insulation jobs during a long outage could therefore be 3-4 times higher than the above mentioned 5-7% of the annual collective dose.

Figure 11



Analysis of the evolution of insulation jobs' exposures per sister-unit group

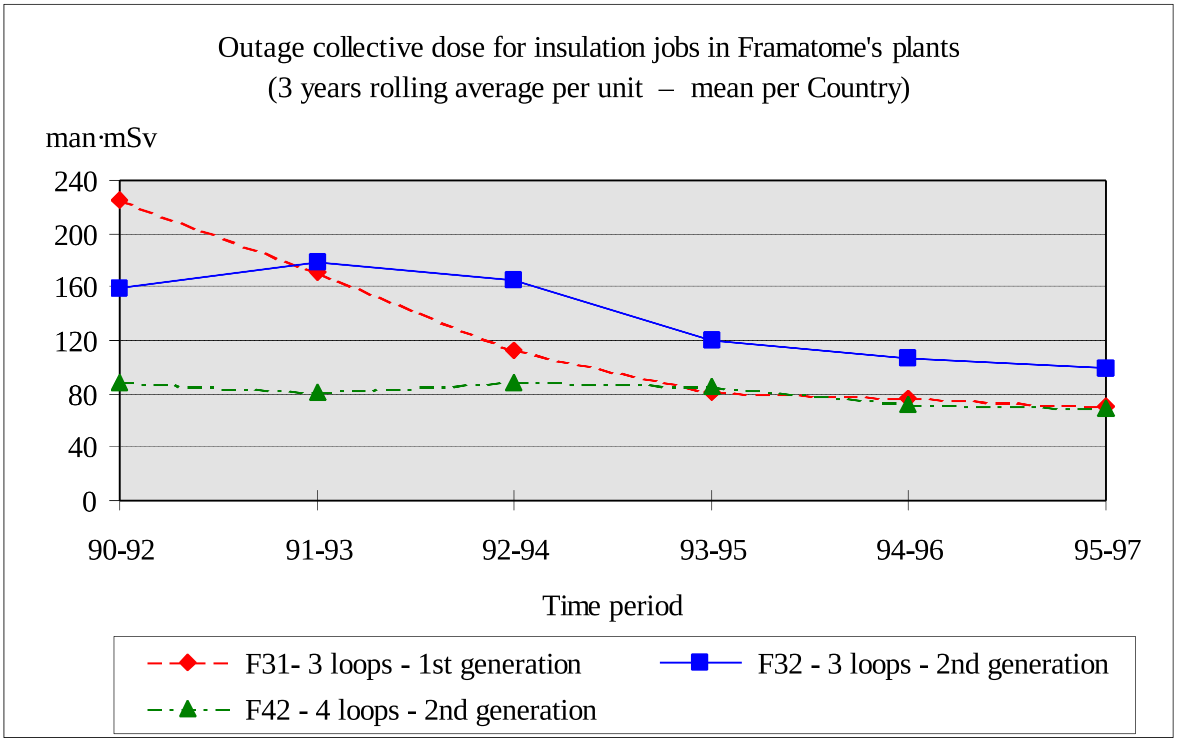
In order to take better into account the differences in terms of design between the various plants, the analysis of the collective dose due to insulation jobs has been performed for the different sister-unit groups, as defined in ISOE.

It is then interesting to look for example at the evolution of the collective dose within sister-unit groups from the same designer, with the evolution of generations. Figures 12 and 13 present the Framatome plants three/four loops generations 1 to 3, and the Siemens plants of two/three/four loops, generations 1 to 3, respectively.

- Within the three Framatome's generations, the level of collective dose due to insulation jobs of the first generation with three loops has now reached the level of the 2nd generation with four loops, around 70 man·mSv. Despite a major reduction, the three loops of the second generation are still slightly above the others, with a level of 100 man·mSv.
- The four types of Siemens plants show stronger differences. The level of collective dose in the pre-Konvoi and Konvoi plants is around 10 man·mSv, about a factor of 14 lower that the

corresponding number for the first two loops generation (around 140 man·mSv in 95-97). For this first two loops generation, the dose of insulation jobs has in fact increased between 90-92 and 92-94, reaching levels up to 160 man·mSv. However, it seems that the tendency is now slightly falling. The level of the collective dose for the three loops second generation has also decreased, and is now closed to 50 man·mSv.

Figure 12



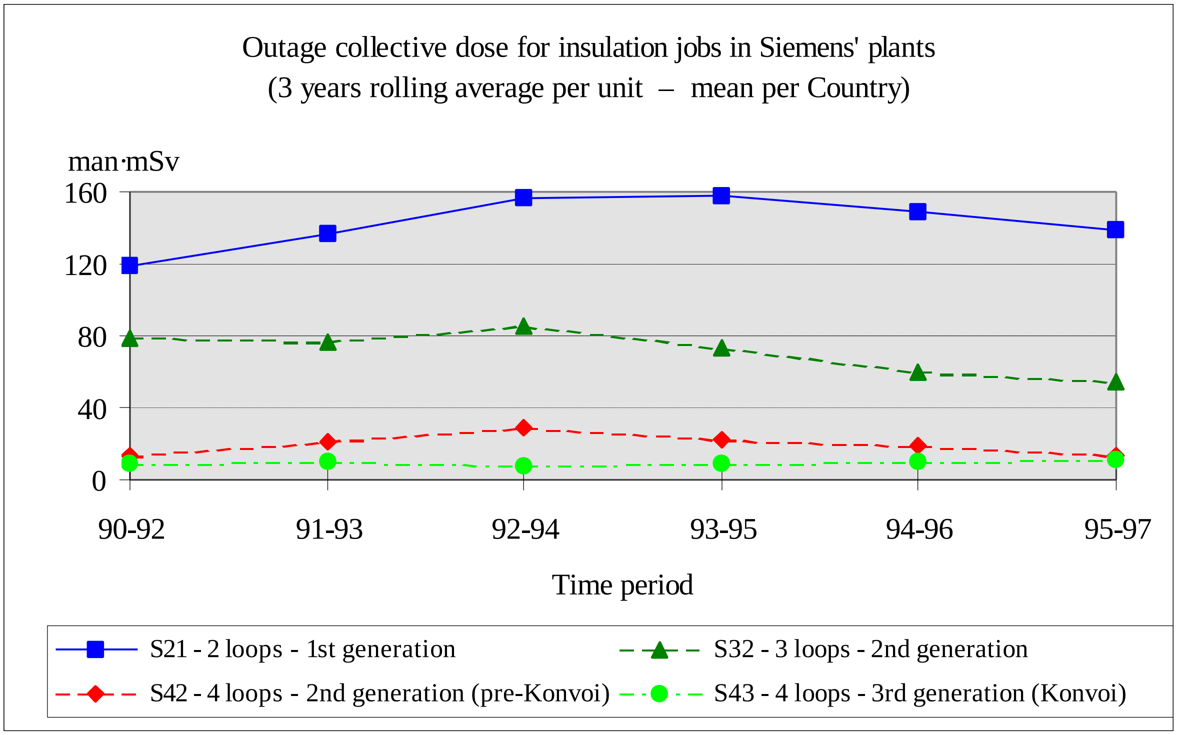
Conclusion

Even if some major differences are still existing between the countries or the type and the design of units, this study confirmed the global trend of decreasing collective doses for insulation jobs in nearly all plants. This trend has to be linked to the decrease in terms of total collective doses which can be observed in the majority of the countries, and to the implementation and sharing of good practices between plants. The main actions undertaken to reduce insulators exposures collected through a request within the ISOE network in 1997 are the following:

- Replacement of normal insulation by "cassette insulation" (easy to remove and replace – divide by a factor 2 to 3, at a minimum, the exposure time).
- Improvement of scaffoldings (use of quick assembly scaffoldings).
- Reduction of the amount of insulation to be removed.
- Selection of the best work time period in the outage schedule (ex: insulation works planned when the piping is full of water whenever possible).
- Specific radiation work permit.
- Improvement of insulation marking just before removal to facilitate the replacement.

- Improvement of storage to prevent damage.
- Team management.
- Specific training on mock-up.

Figure 13



2.4 Refuelling trends

The Secretariat is currently performing a study on refuelling doses, investigating the trends as a function of reactor type and generation.

The ISOE 1 database has been used to extract data on doses during refuelling for PWRs and BWRs. Figure 14 presents as an example the collective dose for refuelling in BWRs in different countries. Figure 15 shows the collective dose for refuelling in PWRs by country.

A first conclusion which can be drawn is that, since 1990, refuelling in both PWRs and BWRs has been relatively stable in terms of the doses and also – which is not shown here – in terms of number of workers involved, and job duration. It is also clear that reporting of these data is not uniform in terms of how "refuelling" is defined. Although tendencies in dose, number of workers and job duration are stable, there are considerable numerical differences.

Concerning average collective doses by country or by sister-unit group, for BWRs doses tend to be between 50 man·mSv and 100 man·mSv. In PWRs, the average seems to be somewhat higher, being between 50 man·mSv and 150 man·mSv. Figures 14 and 15 show these tendencies.

Figure 14

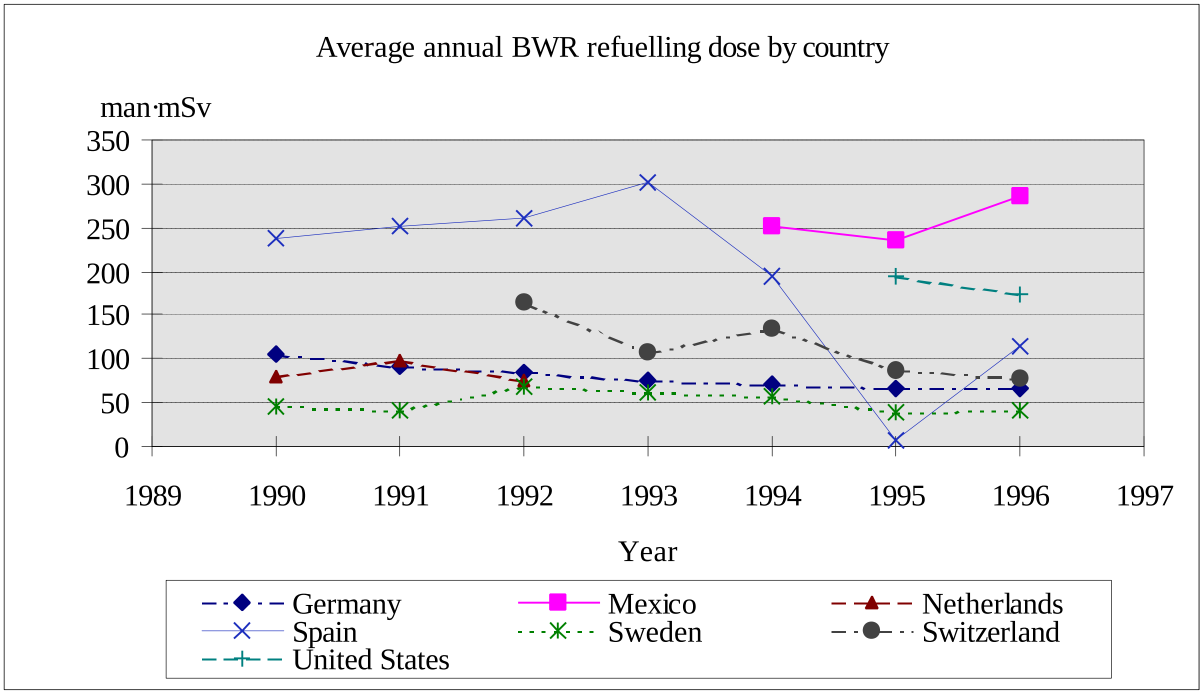
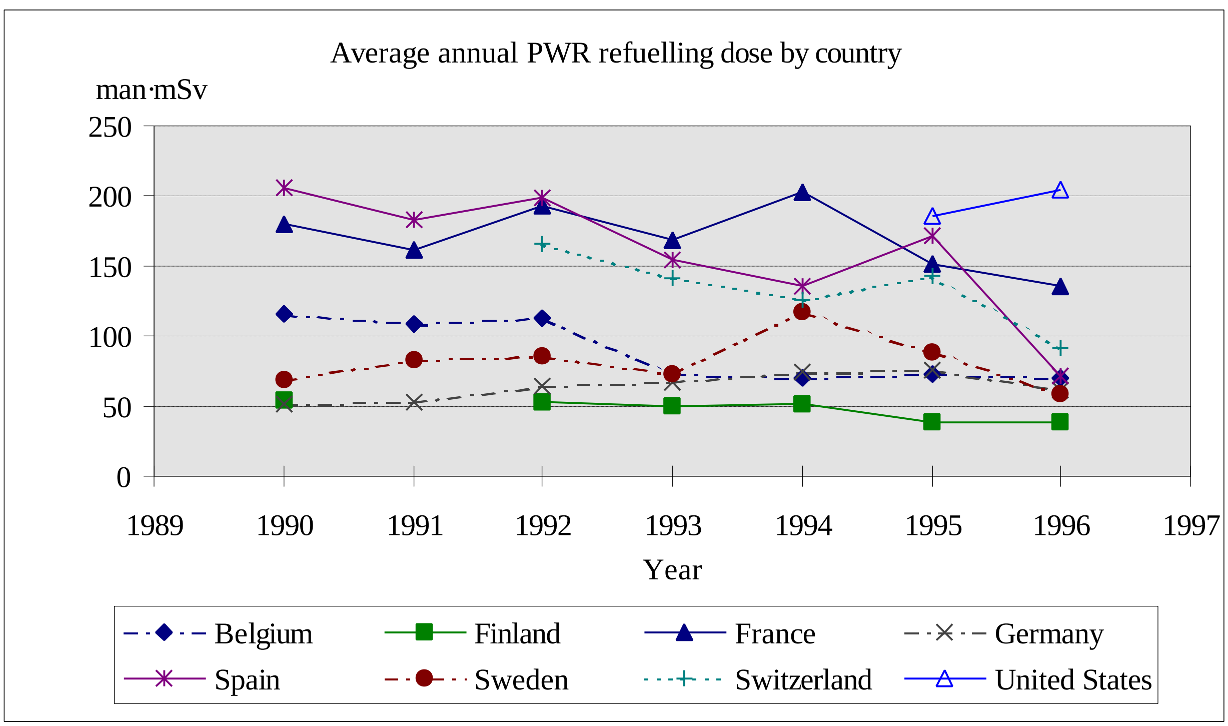


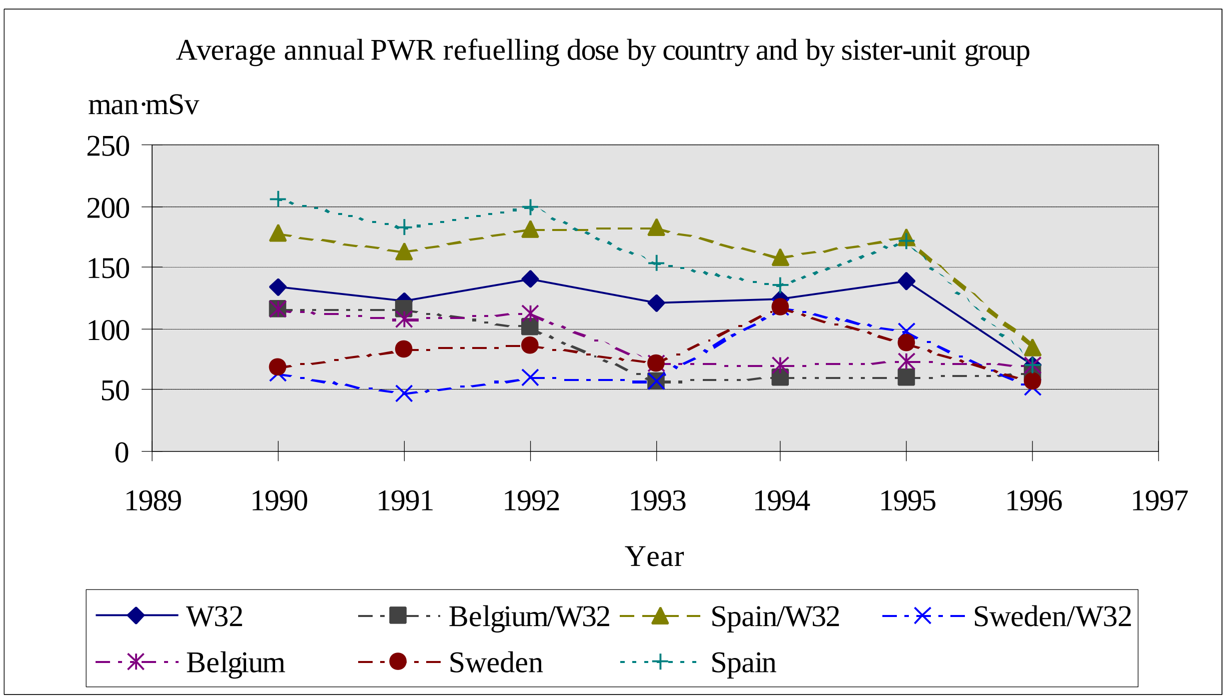
Figure 15



Finally, it can be seen that national practices seem to have a larger influence on refuelling doses than sister unit practices. Figure 16 shows the average refuelling dose per unit for a particular sister-unit group. The average for the sister-unit group (for reactors found in all countries) is shown, as well as the average for the sister-unit group in one particular country. The average refuelling dose for the W32 sister-unit found in Belgium, for example, does not track particularly well with the average for all W32 units around the world. However, the average refuelling dose for W32 units in Belgium tracks well with the average for all plants in Belgium. The same tendencies are seen for W32 units in Sweden and Spain, as well as for W21 plants in Belgium and Switzerland. This tends to suggest that shared national experience (using the same language) seems to be more valuable to plants than experience from sister-unit in other countries.

These preliminary conclusions point toward additional, more in depth studies, which can be performed. The objective of such studies is to provide some useful information to ISOE Participants, but also to demonstrate the types of information, which can be found in the database.

Figure 16



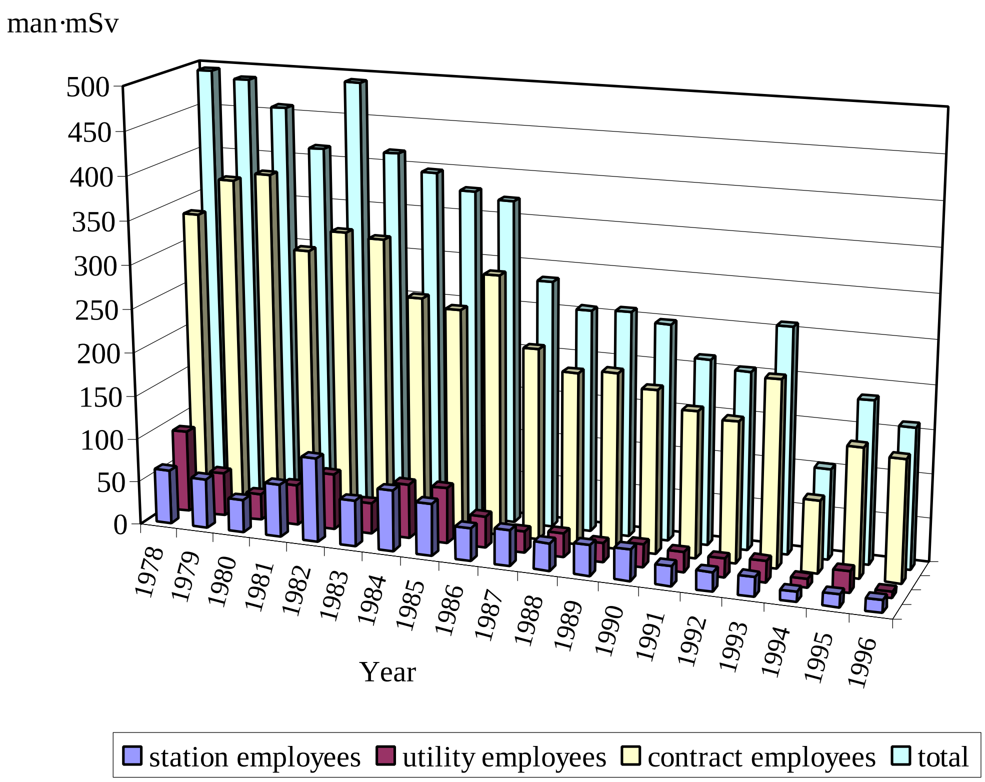
2.5 In-service inspection (ISI)

In-service inspections (ISI) are routinely performed at nuclear power plants to determine the wear, fatigue, or stress corrosion cracking that welds and piping encounter during the operational life of piping systems. Non-destructive methods used to analyse the welds and pipes evaluate system integrity and may be performed to keep occupational exposure to a minimum. ISI is considered a "good engineering practice".

In the 1980s, doses due to PWR in-service inspections in the United States remained fairly constant, with peaks occurring in 1982 and 1986. During this period, extensive work activities in radiological areas occurred at U.S. nuclear power plants to implement Three Mile Island related investigations. Contributors to the steady dose trend in later years were steam generator evaluations and eddy current testing. Dose from ISI to the U.S. PWR fleet remains in the range of about 12 man·Sv per year, with the dose per reactor in the range of about 0.17 man·Sv per year (see figure 7).

Figure 17

Normalised in-service inspection data from U.S. PWR for 1978-1996
(dose per reactor)

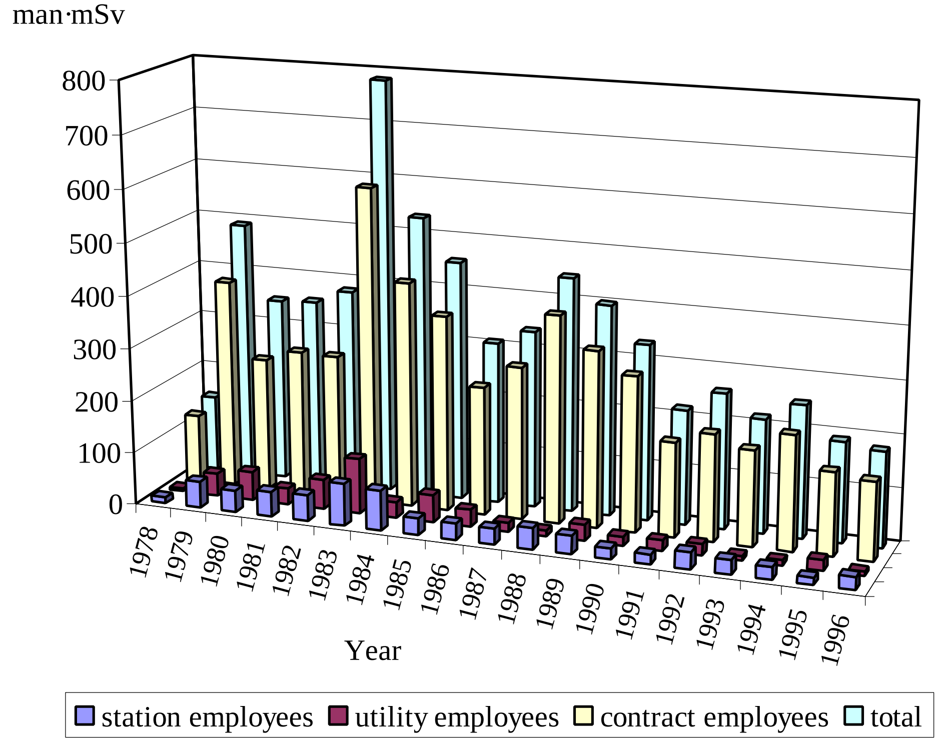


The occupational dose from in-service inspection activities in U.S. BWRs peaked in 1983. Dose received from ISI remains in the range of about 7.5 man·Sv for the U.S. BWR fleet, with the dose per reactor in the range of about 0.18 man·Sv per year (see figure 18).

For the year 1996, whereas dose for ISI at U.S. units averaged in the range of about 0.15-0.20 man·Sv, reported data from other countries was in the range of 0.01-0.28 man·Sv. The accrued dose at U.S. units tended to be higher than that in units of other countries. This may be due to differences in regulatory approaches towards weld inspections, snubber inspections and the like.

Figure 18

Normalised in-service inspection data from U.S. BWR for 1978-1996
(dose per reactor)



The American Society of Mechanical Engineers (ASME) has prepared several code cases evaluating 20 years of nuclear power plant piping in-service inspections, using the benefits of probabilistic fracture mechanics. One goal of this study is the objective determination of what to inspect and how often inspections should occur. ASME studies at PWRs indicate that up to 60% of the primary piping weld inspection programmes at nuclear power plants may not be necessary from a nuclear safety standpoint. The studies further suggest that water and steam leaks should be more commonly used as the first indicator of weld failure on nuclear plant primary piping.

This effort should be seen in the context of an overall move toward risk informed regulation, to ensure objective and efficient means of maintaining adequate protection of public and worker health and safety. The U.S. NRC and the American nuclear industry, via organisations such as the Nuclear Energy Institute, are developing approaches to greater use of probabilistic assessments and other risk assessment means in development of changes to regulations and regulatory guidance and to plant operational practices.

2.6 Principal events of 1998 in ISOE participating countries

As with any “raw data”, the information presented in section 2.1 and 2.2 above is only a graphical presentation of average numerical results from the year 1998. Such information serves to identify broad trends and to help to highlight specific areas where further study might reveal interesting detailed experiences or lessons. To help to enhance this numerical data, this section provides a short list of important events which took place during 1998 and which may have influenced the occupational exposure trends. These are presented by country.

Armenia

During 1998, from the end of September to the beginning of November, one shutdown of Unit-2 was performed at the Armenian nuclear power plant in order to carry out planned preventive maintenance and the usual refuelling. Dose estimates for the following work were agreed upon with the regulatory body:

- Transport-technological operations on the reactor, reactor revision and maintenance.
- Steam Generators revision and maintenance.
- Maintenance and revision of the main circulation circuit equipment.
- Maintenance and revision of the pressuriser.
- Maintenance and revision of the Special Water Purification-1 (SWP) system.
- Decontamination works.
- Works on metal control.
- General works.
- Miscellaneous works.

Due to a lack of qualified operating personnel at the nuclear power plant, and software, operational problems during the mounting and dismounting of equipment, some individual effective doses exceeded planned doses, and it is natural that implementation of the ALARA system is not always achievable in such cases.

During 1998, there were no cases of personnel over-exposure.

Programmes on reduction of personnel exposure doses are continuously developed, including organisational and technical issues of the following type:

- Programmes on performance of work which is dangerous from the point of view of radiation.
- Materials and methodical instructions according to ALARA approaches for the implementation of optimisation.
- Maps of marked instruments, dismantled equipment and controlled areas for maintenance buildings.
- Technical arrangements, such as use of mobile ventilation facilities, which provide local removal of radioactive aerosols during the operations connected with cutting, welding and decontamination in the nuclear power plant controlled zone.
- Introduction of water investigation system of cladding with the aid of under-water cameras.
- The work on the installation and fixing of cameras in the reactor hall of the nuclear power plant for visual control of crane remote control.

In 1998, there were no replacements of any components or systems at the Armenian nuclear power plant.

In 1999, a number of technical and regulatory issues should be resolved. Installation of a new TLD system and procedures and the organisation of service personnel training will be finalised. Implementation of new training software for the mounting and dismounting of reactor facilities is planned for the maintenance personnel.

The construction of new nuclear power plant is not yet planned in Armenia. The issue concerning decommissioning or further reconstruction of the shut down Unit-1 of the Armenian nuclear power plant has not been resolved as yet.

As for regulating tasks, these basically refer to the development of new regulatory documents in the field of Radiation Safety, which will be based on the ICRP and International Basic Safety Standards recommendations. In Armenia, the development of new legislative documents has already begun. Their implementation will require that the licensee limit occupational exposure in accordance with ICRP recommendations (20mSv per year). This will require implementation of additional protective measures.

Belgium

In 1998, the Belgian Nuclear Power Plants continued to carry on their efforts to minimise the radiation exposure. In 1998, there was a replacement of the steam generators of Unit III of the Tihange Nuclear Power Plant with a collective dose for the operation itself of 625 mSv. The steam generators of Unit II will be replaced in the year 2000. The pressure vessel head of Tihange I is due to be changed in 1999, and the results will be introduced in the ISOE 3 database.

Brazil

For 1998:

Summary of national dosimetric trends

Angra Nuclear Power Site has one unit in operation, Angra 1 nuclear power plant, and one unit in construction, Angra 2 nuclear power plant.

Events influencing dosimetric trends

Angra 1 nuclear power plant had its 8th Outage from 17 October to 15 December 1998 involving 1014 workers into controlled areas and a collective dose of 1.04 man·Sv. The annual collective dose for 1998 was 1.26 man·Sv.

Radiological Important Tasks:

- All 121 fuel elements were changed, a few of them with failure, to new fuel elements from Westinghouse.
- A total of 26 reactor vessel thermocouples were changed.

Major Evolutions

All 12 heat exchangers of the secondary side were changed from copper and nickel alloy to stainless steel material, in order to protect both steam generators from the pitting and intergranular stress corrosion process.

For 1999:

Angra 2 nuclear power plant is expected to start running at end of 1999.

Canada

Pt. Lepreau Generating Station was in outage for most of January and February, with Primary Heat Transport Feeder Inspections being the main job. A planned outage ran from about May 24 to July 15, with a Single Fuel Channel Replacement being the main job. An incomplete cut in the tube resulted in a portion of it being stuck in the exposed position. About 40-50 mSv was expended in recovering from this.

For Gentilly-2, the total dose was 1.75 man·Sv (85% external) which is slightly lower than in 1997 for which the dose was 1.98 man·Sv. The average dose per worker in 1998 was 3.92 mSv. Most of the 1998 dose (88%) was received during the annual shutdown of the station (March 15 to June 20). The doses for the annual shutdown were mainly recorded during fuel channel inspection, fuelling machine works, feeders related jobs and environmental qualification activities in the reactor building.

During the year, a more current benchmark was calculated for the reactors operated by Ontario Hydro Nuclear (OHN). It is a top decile value of the 3-year rolling average dose/unit for world-wide PWR/BWR/CANDU reactors in 1995-1997. The value takes into account reactor size and age. The benchmark was revised to 0.68 Sv/unit/year from 0.81.

For 1998, OHN is considered to have 19 units for purposes of dose/unit. Bruce A-2 is considered as permanently shutdown at this time. Between the end of 1997 and early 1998, the remaining Bruce-A units were also shutdown, and de-fuelled. Low-level maintenance and inspection work will continue on these laid-up units, to ensure that they are available for start-up approximately 2005 should that be decided.

The four Pickering-A units were shutdown all throughout 1998, although they remain fuelled and some work continues on these units. Plans at the end of 1998 projected a significant degree of maintenance work to be performed on these units in 1999 through 2001, in order to re-start these units between mid 2000 and late 2001.

In 1998, Darlington's dose was 172 mSv/unit. The dose target was revised from 330 mSv/unit to 250 as a result of an outage being postponed to December (extending into 1999). On-going efforts in internal dose control have produced good results. Since 1995, internal dose has been decreasing steadily at a rate of approx. 30 mSv per year from 300 mSv in 1995 to 180 mSv in 1998.

Bruce A dose was 258 mSv/unit, below target of 420 despite the additional scope of work (Pressure tube inspections and a pressure-tube removal). Dose was primarily expended on the lay-up of units 1, 3 and 4.

Bruce B dose was 991 mSv/unit, above target of 800 for the year. This was due to a greatly increased scope of work on Units 7 and 8 that included full boiler and preheater inspections.

Pickering dose was 353 mSv/unit, well under revised target of 550 mSv/unit, although it must be noted that only 4 units were actually operating in 1998.

Czech Republic

The Czech Republic introduced new radiation protection legislation, changed the organisational structure of the State Office for Nuclear Safety (SONS), their supervision of radiation protection issues, the inspection system and licensing procedures. In the next five years all utilities in the Czech Republic must be licensed according to the new legislation.

In 1998, in the Czech Republic all four units (PWR, VVER 213) of the Dukovany nuclear power plant were in operation. The total annual collective dose at this plant has been 0.34 man·Sv, the lowest value in the past five years. The standard maintenance outages in all units were performed with very low doses well within planned collective dose values. The highest individual dose was well below 10 mSv.

In 1998, there has been only one event involving the internal contamination of a contractor leading to a total effective dose of that worker of 1.85 mSv.

France

In 1998, in France 57 Nuclear Power Stations were in operation, 34 3-loop reactors of 900 MWe, 20 4-loop reactors of 1 300 MWe, and 3 reactors of the new N4 type of 1 400 MWe.

In 1998, there were 27 regular outages, 11 short outages and 6 ten year outages (with major maintenance work). Nine 4-loop reactors were in operation without outage due to the introduction of an eighteen month cycle.

At the new Civaux plant, which began commercial operation in July 1998, an 18 cm crack in its RHR piping has forced the plant, as well as the other two N4 generation units, Chooz B1 and B2, to close so that the system piping can be re-engineered. It is expected that all three plants will restart in the beginning of 1999.

The Objectives for 1999 are to:

- solve the problems with the contamination of transport containers,
- solve the problems with the contamination of clothes and
- improve the training of workers on radiation protection.

In addition, the status of operational dosimetry in France will change. Up to now, the only licensed dosimeter is the film badge. However, there is an attempt to license electronic dosimeter in the near future. A new French order, published 24 December 1998, was the first step, giving an official status to the operational dosimetry.

Germany

PWR

For the PWRs operated in Germany, 1998 was a very good and effective year. Most of the PWRs had routine outages with standard recurrent testing and maintenance. This easily can be derived from the outage duration. Six of the 14 PWR had outage durations less than 20 days with shortest durations of 14 to 15 days, two had durations of 22 and 23 days respectively, two (KWB A and KMK) had no outage and only 4 had longer outage durations of 33 days and up to 59 days. Comparing the outage duration of these 4 plants to that in 1997, three of them had short outages in 1997, showing to a certain extent the trend to concentrate work in one year and to reduce the outage duration in the next year.

For the 4 units with longer outages, special work beyond routine maintenance and recurrent testing had to be carried out, e.g.:

- For KWB B, non-destructive testing was performed on the welds of the primary circuit (the pressure vessel, steam generators and main coolant pumps), eddy current testing took place on the steam generators and hangers were changed in the plant.
- For KKU, all 4 main coolant pumps were revised, maintenance and repair was carried out on the pressuriser and pressure relief system, and non-destructive testing by mechanical ultra sonic testing was performed on the surge line.
- In KKG, maintenance, inspection and tests of the pressure vessel internals, of the residual core cooling and safety injection system and of the pressuriser and pressure relief system was carried out, and additionally, eddy current testing on the steam generators took place.
- In KBR, inspection and tests were performed on the steam generators (primary side), the residual core cooling and safety injection system and the primary circuit; for the primary circuit, non destructive tests were carried out on the pressure vessel, pressure vessel head and on the pressuriser.

A new practice worth mention was carried out in GKN-2. Opposite to the trend of prolonging the time between outages, GKN-2 had two short outages of 7 days each in 1998, performing a change of fuel in both outages to allow for a more effective fuel operation and to optimise the burn up of fuel. Sharing the work to be performed in the outage, GKN-2 succeeded in having only 14 days of planned outage as a total in 1998, which is the shortest time of all units in 1998. Saving money due to fuel optimisation, this practice may perhaps be adopted by other plants, but will, however, necessitate consideration in the ISOE-system, as the data base is not yet well adapted to take the data of both outages.

BWR

For boiling water reactors in Germany, the picture looks a little bit different compared to the PWRs. Regarding cycle length, due to the prolonged outage philosophy applied at that site, the two units of KRB did not have a refuelling outage in 1998.

For the other units, except of KKP 1 with 20 days, quite long outages are documented due to special work to be carried out. In this case the following important actions should be mentioned:

- For KKB, feed water and steam pipes (including the casing of the steam isolation valves) were replaced, ultra sonic tests of the pressure vessel were performed, and the supports of the emergency core cooling lines were improved.

- For KKI-1, the feed water lines were changed, ultra sonic tests of the pressure vessel were performed, and inspections of the steam supply system and of the control rod drives were carried out.
- In KKK, the outage lasted for 186 days covering a leak test for all fuel elements in the core, recurrent tests on the pressure vessel, recurrent tests on three control rod drives, modification of the internal circulation pumps, recurrent tests on the condensation chamber, exchange of piping in the feed water system and non-destructive tests on welds in the feed water system in the scope of the special tests programme "stretching induced crack corrosion".

Hungary

In 1998, as in previous years, the outages of the units had a major impact on the collective and individual doses. More than 90 % of the collective doses are related to the activities carried out during outages. Unit 1,2 and 3 had short outages (21-36 days), while on unit 4 a long outage (57 days) was completed in 1998.

As in the past 5 years the maximum individual dose did not reach the 20 mSv/year effective dose, thus providing a substantial margin in complying with the 50 mSv/year dose limit. There was no internal radiation exposure reaching or exceeding the 0.15 mSv committed effective dose.

In 1998, the collective effective dose for unit 1 – 4 was 2343 man·mSv determined by legal dosimetry control (using film badges) including plant staff and contractors. This figure is much lower than the collective dose measured by operational dosimetry because of the conservative approach used. Based on the result of legal dosimetry control, the average collective effective dose per unit was 0.59 man·Sv at Paks NPP.

The safety enhancement programme was continued at Paks NPP in 1998. Some activities performed in connection with this programme had a considerable influence on the collective dose:

- Primary loops and steam generators of all units had been upgraded within the frame of earthquake protection projects.
- Following units 1,2 and 3, the primary circuit emergency gas removal system has been installed at unit 4 this year.
- During reactor protection system reconstruction, installation of cables in the unit 1 containment has been completed.

Japan

The Tokai power station, which was the first commercial nuclear power plant and the only gas-cooled reactor in Japan, ended its 32-year commercial operation in March 1998. The withdrawal of all spent nuclear fuel will take three and a half years.

Kashiwazaki-Kariwa Number 6, the first ABWR, carried out its first annual inspection outage from November 1997 through January 1998. Outage duration was 61 days.

The Radiation Council of Japan submitted its opinions on the implementation of the ICRP-60 Recommendations (from 1990) to the regulatory agencies in June 1998. The agencies are supposed to prepare draft amendments of their relevant regulations and refer them to the Radiation Council. The regulations acknowledged by the Council shall be promulgated:

Occupational dose limits

Effective dose limits should be "100 mSv per 5 years and 50 mSv in any fiscal year".

Occupational dose limits for women

Effective dose limit for female workers should be 5 mSv per 3 months.

Designation of work areas

Areas likely to exceed 1.3 mSv per 3 months should be designated "controlled areas".

Emergency exposure

Current regulatory effective dose equivalent limit of 100 mSv for emergency exposure shall not be changed. Dose limits of 300 mSv for lens of the eye and 1 Sv for the skin shall be added.

Lithuania

The principal events which have affected the collective dose during 1998 at Ignalina nuclear power plant are:

At Unit 1:

- Preparation for the inspection of the Primary System Pipes d=300 mm, (1.111 man·Sv).
- Inspection of the Primary System Pipes d=300 mm, (0.224 man·Sv).
- Repair of the Primary System Pipes d=300 mm, (1.277 man·Sv).
- Insulation works, (0.395 man·Sv).
- Valve works, (0.15 man·Sv).
- Surveillance of the Drum-Separator, (0.281 man·Sv).
- Replacement of the Reactor Fuel Channels, (1.06 man·Sv).
- Replacement of the cooling channels of the Control and Protection System Circuit, (0.086 man·Sv).
- Temporary shielding, (0.048 man·Sv).
- Decontamination, (0.055 man·Sv).
- Repair of the air cooling equipment of the Filtered Vent Systems, (0.125man·Sv).
- Repair of the illumination, (0.11 man·Sv).
- Repair of the Reactor Water Clean-up System, (0.115 man·Sv).
- Installation of system of the Additional Emergency Reactor Protection, (0.125 man·Sv).
- Repair of the Emergency Core Cooling System, (0.372 man·Sv).
- Routine inspections of the Primary System, (0.11 man·Sv).

The overall dose after implementation of these works during maintenance period of unit 1 is 5.644 man·Sv, that means 62.8% of the total dose during outage of unit 1 in 1998 and 37.5% of the annual dose of the Ignalina nuclear power plant's personnel including contractors.

At Ignalina Unit 2 the overall dose after implementation of the eleven major works during the maintenance period was 1.02 man·Sv, that means 67.3% of the total dose during outage of unit 2 in 1998 and 6.8% of the annual dose of the Ignalina nuclear power plant's personnel including contractors.

Mexico

After having, in 1996, very high collective dose at the two Mexican Boiling Water Reactors, the annual collective dose in 1997 was reduced considerably to 1.95 man·Sv for Unit 1 and 2.51 man·Sv at Unit 2. The refuelling outage at Unit 2 accounted for 1.89 man·Sv, and took just 33 days.

In 1998, most of the Laguna Verde dose reduction programme actions for both units were started up; such actions include:

- Installation of particulate filters downstream of the main condenser.
- Depleted zinc injection.
- Chemical decontamination.
- Stellite-free spare part replacement policy.
- Semi-permanent shielding.

With the exception of chemical decontamination, however, these actions are not expected to produce short-term results. It has been estimated that the maximum results will be obtained by the year 2003. The goal of the dose reduction programme is to place LVNPP on the long term, into the world BWRs best quartile regarding collective dose. So far, the presence of Co-60 inside systems remains the strongest radiological challenge.

Collective doses in 1998 were 5.95 man·Sv for Unit 1, and 3.58 man·Sv for Unit 2. The total average dose per unit was 4.76 man·Sv.

There were in 1998 refuelling outages in both units whose most remarkable activities were ISIs and the substitution of the recirculation System discharge valves. These 2.7-ton valves are located inside the drywell, constitute high radiation components, and there were not previous experience on their replacement in a GE BWR. For this activity in Unit 1, 7 166 man-hour and 3 595 interventions were necessary with a radiological cost of 0.673 man·Sv. The collective dose initially estimated was of about 5.44 man·Sv; a saving of 4.76 man·Sv was possible for Unit 1 and a similar figure for Unit 2. Significant dose savings were obtained due to the conjunction of chemical decontamination, mock-ups, strong supervision and the control of times and movements.

Netherlands

In the Netherlands, there are two reactors, the Borssele Nuclear Power Station and the Dodewaard plant. In 1997, Dodewaard was definitely closed after 30 years of operation. The Plant will be decommissioned "to the green field" after remaining 40 years in Safe Store. The Borssele Nuclear Power Station has been in operation for 25 years, and could be operated another 15 years. However, there are ongoing political discussions of early closure by the year 2004.

In 1997, an extensive backfitting programme was performed at the Borssele Plant. A programme for shortening the outage duration, by doing more work during the normal operation period, was begun and resulted in a 24 day outage during 1998 (0.53 man·Sv) and is planned to result in an 18 days outage in 1999. It has been discovered that there is significant fuel damage, which is thought to have been the indirect result of the major maintenance work performed during the 1997 outage.

Romania

Cernavoda nuclear power plant Unit 1 is the only reactor in operation within the country. The year of 1998 is the second full year of operation. The total collective dose was 257.6 man·mSv. The main contribution, i.e. approximately 65%, was from maintenance outages.

The total number of exposed workers, i.e. those who received doses above reporting levels is 337. Individual doses were below 10 mSv for all exposed workers. Moreover, 97% of individual doses were below 5 mSv.

The activities with significant impact on station collective dose were performed during the planned outage:

- Upgrading of supporting elements for Local Air Coolers (10.1 man·mSv).
- Maintenance work on fuel handling machine (15 man·mSv).
- Upgrading of supporting elements in feeder cabinets (13.8 man·mSv).
- 25% of NDE programme (24.2 man·mSv).

(N.B.: The above dose data are based on electronic dosimetry.)

Compared to previous year, the trends were similar with respect to both collective and individual doses and number of exposed workers. At this point should be mentioned the increasing contribution of tritium which represents approximately 20% of station collective dose. This contribution is increasing compared to previous year, but still within the usual percentage for CANDUs. The main contribution for this increase is the build up of tritium in the heavy water.

For the coming year the major work with radiological impact is represented by Fuel Channel Inspection programme, planned for the fall of 1999.

Regarding occupational exposure, the regulatory body intends for 1999:

- To approve a review of the utility's reference document on ALARA stating a new monetary value of man·Sv (the alpha value will significantly increase).
- To impose a more detailed planning of doses during maintenance activities (the detail of planned doses shall address the level of each individual operation).

Slovakia

Principal events of the year 1998: The main events that contributed to the collective dose in Bohunice nuclear power plant were the planned outages and especially the reconstruction works at Unit 1 and 2 (nuclear power plant V1).

Unit 1 had a 110 days standard maintenance outage with refuelling prolonged due to the reconstruction.

Total collective dose: 827.56 man·mSv
Staff: 468.50 man·mSv
Contractors: 359.06 man·mSv
The main contribution to the dose, 35%, came from reconstruction works on I&C pipelines.

Unit 2 had a 175 days standard maintenance outage with refuelling prolonged due to the reconstruction.

Total collective dose: 2 727.51 man·mSv
Staff: 657.20 man·mSv
Contractors: 2 070.31 man·mSv
The main contribution to the collective dose, 41%, came from reconstruction works on ECCS & spray system.

Plans for 1999
Unit 1 – 43 days standard maintenance outage with refuelling
Unit 2 – 87 days major maintenance outage with refuelling
Unit 3 – 78 days major maintenance outage with refuelling
Unit 4 – 46 days standard maintenance outage with refuelling

Radiation protection technical improvements – two major changes are expected at both power stations V1 and V2 (all four units):

- Installation of the new personal contamination monitors at the exit out of radiation controlled area.
- Installation of the new electronic personal dosimetry system for all four units: renewing of the whole body counter.

Calculation of the dose to the surroundings caused by radioactive releases – the approval of the new model (with ICRP 60 recommendation) by the regulatory body is expected.

In Slovakia, there have been individual dose limits of 50 mSv per year and 100 mSv per 5 years since 1996. The radiation protection authority ordered the licensee to keep doses below 20 mSv per year. Any individual dose in excess of this level has to be considered and permitted by the person responsible for the radiation protection in the facility, and the licensee has to inform the authority without delay.

The collective dose in nuclear facilities has been growing during the last three years. The main contribution to the total collective dose in nuclear facilities of Slovakia is caused by the safety improvement reconstruction of Bohunice nuclear power plant V1 and by the decommissioning of nuclear power plant A1. However, the collective annual doses during operation and also during standard outages of nuclear power plants V1 and V2 (Bohunice Units 3 and 4) were relatively low. The normalised annual collective dose in V2 (man·Sv/tWh) was the lowest of all nuclear power plants with VVER 213 reactor type now in operation.

There were only two workers in Bohunice nuclear power plant exposed in excess of 20 mSv in the last 8 years. Despite the V1 reconstruction, the percentage of the monitored workers with an annual dose over 10 mSv was only 3.7%. In nuclear power plant A1, there was one worker with an effective dose in excess of 20 mSv and 27 workers with annual dose over 10 mSv in 1998. The outside workers collective dose percentage (of the total collective dose) has been growing in the last years.

There was no accident and no overexposure in nuclear facilities in Slovakia in 1998.

Slovenia

Radiological performance indicators of Krsko nuclear power plant for the year 1998 were:

Collective radiation exposure was 1.25 man·Sv (0.25 man·mSv/GWh per electrical output). Maximum individual dose was 11.60 mSv and average individual dose 1.46 mSv.

Planned outage (24.4.98-29.5.98), 35 days:

During the refuelling outage there was also maintenance work in steam generators. Inside the tubes, 135 weldless sleeves have been installed and 166 plugs. Total outage collective dose was 0.99 man·Sv. Doses for main outage jobs performed were: refuelling 0.158 man·Sv, steam generator maintenance and ECT 0.307 man·Sv.

Major evolution:

The project of modernisation of Krsko nuclear power plant started in year 1998. It includes steam generators replacement and reactor power uprate in year 2000, steam generator storage and decontamination building, power plant simulator training centre. There are licensing activities for modernisation performed in 1999 and 2000. It is expected that the authority will approve the power uprate for 6.3% (from 1876 to 1994 MWth).

In the process of modernisation of the legislation performed by the authority all provisions of the IAEA Basic Safety Standards, EU Basic Safety Standards and other EU Directives and Regulations concerning the radiation protection of workers will be included in the new legislation by year 2002.

Spain

In 1998, 5 of the 9 Spanish units had outages during the year, and total nuclear power output increased by 7%. In general, following the steam generator replacements done during the past years in Spain, the average outage doses have been very low, from about 0.5 to 0.8 man·Sv per unit. A rather long, unplanned outage occurred at the Trillo Power Plant due to problems with the generator stator. The outage lasted 90 days, but the total collective dose was only 0.07 man·Sv.

In Spain, there are a few important topics in discussion:

- Deregulation and the necessary optimisation to achieve economic savings.
- Introduction of the new Basic Safety Directive of the EU.
- Dose restrictions.
- Introduction of a Radiation Passport.
- Homologation of training for external workers.
- Appliance of clearance levels.
- Eight ongoing joint utility/authority research and development projects (e.g. compare TLD's with electronic dosimeter, hot particles, ICRP 66 respiratory tract model, neutron dosimetry ...).

In a metal melting company in Spain, a Cs-137 source was melted accidentally and resulted in a gaseous emission of a considerable amount of Cs-137.

Sweden

In Sweden, exposures in 1997 were very high due to an exceptional maintenance programme. For 1998, however, doses were more back to normal, with Ringhals having its best year since 1976, with a site dose of 3.7 man·Sv. Forsmark and Barsebäck also had a good year, with site doses of approximately 2.7 man·Sv (Forsmark) and 3.3 man·Sv (Barsebäck). At Oskarshamn 1, the vessel internals were changed, as was the vessel water-level indicator. However, due to economic restructuring currently underway, the pace of plant upgrading will most likely slow down in the future.

Finally, no final decision has been taken regarding the closure of the Barsebäck plant.

Switzerland

In the first half of the year 1998, all refuelling and standard maintenance outages were performed with low doses well within planned and approved collective dose values. The highest individual dose was well below 15 mSv.

During the second part of 1998, however, radiation protection specialists from Swiss authorities and nuclear installations have had to concentrate on the problem of contaminated transport containers. Despite the extremely small risk of radionuclide incorporation, whole body measurements of hundreds of railway personnel had to be performed. It was decided that there will be no transport of irradiated fuel in Switzerland in 1998, but it is hoped to resume transportation operations in January or February 1999.

Recently, the Leibstadt Nuclear Power Plant had received the permit for a 15% increase in power. Before the increase, an extended data sampling and review had to be performed in order to be able to compare data before and after the increase in power. The steam generator of unit II of Beznau Nuclear Power Plant will be replaced in 1999. Starting with Beznau Nuclear Power Plant, the Swiss plants will enter into a two-year operation cycle.

United Kingdom

The 4-loop reactor at Sizewell B started operation in January 1995. The first refuelling outage was performed for 485 man·mSv (highest individual dose of 6.02 mSv) and the second, in 1997, for 468 man·mSv (highest individual dose of 6.22 mSv). From 1997 on, Sizewell B will operate on an 18-month cycle.

An overview of the UK dose statistics for all radiation workers for the period 1986 to 1996 from the Health Safety Executives Central Index of Dose Information (CIDI) has now been published.

In 1998, a loss of power at the Dounreay site prompted a regulatory inspection into the management of safety at the site. This inspection resulted in 143 recommendations being made for improvements to safety management at the site. The Dounreay site includes two shut-down Na-cooled fast reactors and fast reactor and research reactor fuel reprocessing facilities.

United States

Several PWRs in the United States had been experiencing an "Axial Offset Anomaly", or flux density irregularities which may occur at high burn-up. These have led to the build-up, on the fuel, of crud, which is then released during the crud-burst which normally occurs during shutdown. This additional crud leads to higher refuelling dose rates on the refuelling bridge and also to generally higher outage doses. Water chemistry solutions are being investigated to correct this problem.

In 1998, an incident occurred, where a diver, wearing a brass helmet, accidentally hit his head, causing the helmet to leak and fill with water. The diver lost consciousness, and it took 10 minutes to bring him to the surface because of the tight working space where the accident occurred. The diver survived the event, however the question of preparations for contaminated, injured workers was raised in general. In this case, the hospital that received the victim was well prepared due to preparation work done with plant personnel.

In terms of feedback, the American plants particularly like the quartile bench marking, which the NATC produces on EXCEL spreadsheets. Sites are ranked by dose per unit and per site, outage duration, outage dose, and by normal operation dose. As an example, one plant learned that it performed well overall, but not so well in terms of normal operation dose, and was thus able to better focus its efforts. Regarding the Work Management report, the document had been very well received, and participants were interested in more case studies to illustrate work management principles. Also, some European utilities had expressed interest in the American success at reducing the use of respiratory protection by convincing workers that their effective dose would be reduced (more internal but less external).

2.7 International EC/ISOE Workshop on occupational exposure in nuclear power plants

The first EC/ISOE international symposium that took place in Malmö Sweden in September 1998 was mainly devoted to feedback experience from the plants and lessons learned on ALARA implementation and occupational exposure issues.

A topical session concerned the evolution of dosimetry systems; as well it has been one of the major topics of discussion within the groups. During the past three years NRPB in the UK has used an electronic dosimeter, the EPD, as a legal dosimeter with the agreement of the regulatory body, HSE. Since then BNFL Magnox Generation has made a request to HSE to do the same for all Magnox nuclear power plants and is in the process of receiving the agreement. The presentation of BNFL Magnox Generation has been particularly appreciated for its scientific and practical aspects. Therefore it was selected as one of the three best papers at the symposium. It is the first time in Europe that an electronic dosimeter is able to provide legal dosimetry instead of film badges (Belgium, Hungary, France …) or TLDs (Finland, Germany, Spain, Sweden, …). In most countries redundancy is required when electronic dosimeters are used for operational dosimetry. There was a clear request from many participants that their own regulatory bodies consider following the example of the UK.

Another particularly appreciated session was devoted to the reduction of dose rates through decontamination (in The Netherlands, Japan and Sweden), purification and hot spots eradication (two papers from France) and a synthesis concerning zinc and noble metal injection experiences in the U.S. A French paper on hot spot eradication was also selected as one of the three best papers at the symposium. It covered the whole subject from the design phase during which the origins of such contamination are raised, to the search for both preventive and curative solutions, the costing of such solutions and, finally, the political decision, taking all the different optimisation components into account with regards with the man-sievert monetary value.

Most of the other papers dealt with the management of radiological protection. The need for a strong commitment from the managers has been stressed several times, both in group discussions and within a French plant manager presentation: "we must never forget the importance of both an overall strategic ALARA approach and a close relationship with workers that includes personal commitment". It may be pointed out here that the participation of several top-level managers in the workshop gave a very positive sign to the radiation protection staff members.

Within all the papers devoted to ALARA management a paper from Cofrentes nuclear power plant in Spain on ALARA implementation for valve replacement has been selected as one of the three best papers at the symposium for its very pedagogical presentation. It is a good example of the room that still exists for many jobs for improvement through better planning, work preparation, workers and job responsible involvement and motivation … it also illustrates that often reduction of duration, cost, and dose as well as quality improvements are not only compatible but synergistic.

Many other issues were addressed during the work in small groups such as:

- Difficulties for the regulatory bodies to check ALARA implementation.
- Need for researchers to develop simple systems for neutron dosimetry.
- Difficulties to elaborate realistic and precise dose targets per job.
- Important impact of reworks on doses.
- Need for ISOE to perform analysis on links between outage doses and outage lengths or adequate dose rates.
- Need of dialogues between all stake holders.

All papers from the Workshop are now available at ETC as well as the three awarded papers can be downloaded from the ETC web site (http://isoe.cepn.asso.fr/).

2.8 Present and future issues in operational radiation protection

In addition to being a focal point for data collection and analysis, the ISOE Programme is also a broad and powerful network for direct communications between radiation protection experts at utilities and regulatory authorities alike. Discussions of ongoing issues of concern, as well as the identification and discussion of issues which may affect operational radiation protection in the near and/or mid-term future, are central parts of the ISOE Programme. Some of the issues, which were of concern during 1998, are listed here:

- The development of a shielding installation and good practice manual.
- Source term reduction techniques.
- Radiological Engineering good practice.
- Primary water chemistry interfaces and influences on radiation protection.
- Outage management.
- On-line maintenance.
- Official Dosimetry: Electronic vs. TLD.
- Optimisation of Training.
- Contractor Responsibility in Training.

- Outage Time Reduction vs. Total Annual Dose.
- Dose Constraints: What, How, When?
- Optimisation in Regulation: International Experience.
- VVER steam generator Replacement Study.
- Deregulation and Optimisation.
- Dose Optimisation: Internal vs. External and the use of personal protective equipment.

3. ISOE PROGRAMME OF WORK

3.1 Achievements of the ISOE Programme in 1998

Status of participation and of the ISOE databases

As of the end of 1998, occupational exposure data from a total of 384 operating commercial nuclear reactors and 38 commercial nuclear reactors in cold-shutdown or some stage of decommissioning are included in the ISOE 1 database. These units represent 77 utilities from 26 countries. In addition, regulatory authorities from 21 countries participate in the ISOE Programme. During 1998, two Non-NEA Countries, Armenia and Ukraine, joined the ISOE Programme with in total 17 reactors.

Data analysis and output

One of the most important aspects of the ISOE Programme is the data analysis, such as the tracking of annual occupational exposure trends. Using the ISOE 1 database, which contains annual occupational exposure data supplied by all Participating Utilities, various exposure trends can be displayed by country, by reactor type, or by other criteria such as sister-unit grouping.

Each Technical Centre performs various types of data analysis and publishes the results in form of ISOE Information Sheets. During 1998, some Information Sheets have been produced, such as:

- PWR collective dose per job 1994-1995-1996 data.
- Occupational Exposure and Steam Generator Replacements (update).
- Use of the man-sievert monetary value in 1997.
- ISOE 3 database – New ISOE 3 Questionnaires received.

The Working Group on ISOE 2 Indicators reviewed the ISOE 2 database and proposed a new tabular format, which is compatible with the ISOE 1 database and with Microsoft ACCESS. On the basis of these recommendations it was agreed to develop a procedure in order to implement the new ISOE 2 questionnaire into the ISOE 1 database.

To enhance experience and data exchange, this last year saw the inauguration of regional topical workshops.

International ISOE Workshop on occupational exposure in nuclear power plants

The European Technical Centre co-organised with the European Commission the First EC/ISOE Workshop on Occupational Exposure at Nuclear Power Plants in September 1998, in Malmö, Sweden. 150 participants from 21 countries, mainly European but also from the United States and Japan, attended the meeting. The IAEA supported participants from central and eastern European countries as well as from Brazil and South Africa. Two thirds of the participants were senior health physicists from nuclear power plants, the last third was equally composed of representatives of national regulatory bodies and contractors. This workshop allowed 28 oral presentations and 15 posters presentations to be provided, as well 10 vendors presented their products in booths. One of the most appreciated items, by all participants, was the half-day spent in small groups' discussions. Finally, three presentations were selected as "best paper", and were invited to make their presentation in 1999 at the ISOE international ALARA symposium in the United States of America. The success of this Workshop is largely due to the significant organisational support from the Barsebäck nuclear power plant. The translation from French, German and Spanish to English, which has been financially supported by EDF and Framatome (the French Utility and Vendor), has allowed a wide participation from radiological protection professionals from the plants.

Software development

In order to improve the structure and the transparency of the ISOE 1 database, a new version of the database was developed in 1998. The quality assurance procedure on this database was improved and further formalised. After the completion of this quality assurance programme, this new version of the ISOE 1 database will be distributed in June 1999. In addition to the update of the database, the MADRAS interface programme, providing push-button access to useful graphs and tables, was updated.

It was agreed that all the ISOE databases should be transferred to a Microsoft ACCESS environment, thus maximising the efficiency and user-friendliness of database use. The ISOE 1 questionnaire will be transferred to Microsoft ACCESS, and all the capabilities of the current electronic questionnaire, called ASPIC, should be retained. This development was started in 1998 and will be finalised by the end of 1999, hopefully in time for the collection of 1999 data.

Organisational structure

A complete review of the structure and objectives of the ISOE Programme resulted in a series of structural changes, as well as a refocusing of the Programme on the development of more "value-added" products.

First, it was agreed to form a Joint NEA/IAEA Secretariat. After approval of the proposed structure and functioning by the ISOE Steering Group Bureau in early 1998, the Joint Secretariat is now in place.

In order to reflect better the participation of the IAEA in the ISOE programme, a revision of the Terms and Conditions was agreed to by the Steering Group. In addition, participating utilities agreed that authorities could have some direct access to the ISOE 1 database, and the Terms and Conditions were appropriately modified to reflect this.

Second, in order to improve the efficiency of the ISOE working groups, the Expert Group on Data Analysis and Technical Guidance, was replaced by three Working Groups addressing Data Analysis, Software Development, and the use of the ISOE 2 Database. This allows the more appropriate selection of experts to perform the work, as well as the definition of Terms of Reference for each Working Group, which are more specific, task-oriented, and short-term.

The Working Group on ISOE 2 indicators completed the tasks identified in its term of reference and presented a complete list of ISOE 2 indicators, as mentioned above. This working group has been disbanded.

3.2 Proposed future programme of work for 1999

The Information System on Occupational Exposure will continue working along the above lines, that is, the ongoing tasks are as follows:

Status of participation and of the ISOE databases

- Increase the number of Utilities and Authorities participating in the ISOE Programme.

Data analysis and output

- Collection of ISOE 1 and ISOE 2 data.
- Merging of the ISOE 1 Database and the ISOE 2 Database into one database, taking due account of the recommendations from the Working Group on ISOE 2 Indicators.
- Further Promotion of the ISOE 3 database, by developing a summary report of the data currently contained in the ISOE 3 database. Aim for the integration of the ISOE 3 database into ACCESS during the year 2000.
- Publication of ISOE technical publications, such as trends and analyses, and identification of areas for in-depth study.

International ISOE Workshop on occupational exposure in nuclear power plants

- Organisation of ISOE ALARA Symposiums, scheduled for Europe in 2000.

Software development

- Completion of the quality assurance procedure on the new version of the ISOE 1 database, and distribution of these software products to the Participants.
- Development of a new combined ISOE 1 and ISOE 2 data questionnaire in a Microsoft ACCESS environment.

Organisational structure

- Organisation and co-ordination of ISOE Web information at the Joint Secretariat and at the four ISOE Technical Centres.

Annex 1

List of ISOE Publications

Reports

1. *ISOE – Nuclear Power Plant Occupational Exposures in OECD Countries: 1969-1991*, OECD, 1993.

2. *ISOE – Nuclear Power Plant Occupational Exposures in OECD Countries: 1969-1992*, OECD, 1994.

3. ISOE – *Third Annual Report: Occupational Exposures at Nuclear Power Plants: 1969-1993*, OECD, 1995.

4. *ISOE – Fourth Annual Report: Occupational Exposures at Nuclear Power Plants: 1969-1994*, OECD, 1996.

5. *ISOE – Fifth Annual Report: Occupational Exposures at Nuclear Power Plants: 1969-1995*, OECD, 1997.

6. *ISOE – Sixth Annual Report: Occupational Exposures at Nuclear Power Plants: 1969-1996*, OECD, 1998.

7. *Work Management in the Nuclear Power Industry*, OECD, 1997.

8. *ISOE – Seventh Annual Report of the ISOE Programme: Occupational Exposures at Nuclear Power Plants: 1997*, OECD, 1999.

ISOE Information Sheets

Asian Technical Centre

No. 1, October 1995	Japanese Dosimetric Results: FY 1994 data
No. 2, October 1995	Japanese Occupational Exposure during Periodical Inspection at LWRs ended in FY 1994
No. 3, July 1996	Japanese Dosimetric Results: FY 1995 data
No. 4, July 1996	Japanese Occupational Exposure during Periodical Inspection at LWRs ended in FY 1995
No. 5, September 1997	Japanese Dosimetric Results: FY 1996 data
No. 6, September 1997	Japanese Occupational Exposure during Periodical Inspection at LWRs ended in FY 1996
No. 7, October 1998	Japanese Dosimetric Results: FY 1997 data
No. 8, October 1998	Japanese Occupational Exposure During Periodical Inspection at LWRs Ended in FY 1997
No. 9, End of August 1999	Japanese ABWR's Dosimetric Results
No. 10, End of August 1999	Shroud Replacement at BWR

European Technical Centre

No. 1, April 1994	Occupational Exposure and Steam Generator Replacement
No. 2, May 1994	The influence of reactor age and installed power on collective dose: 1992 data
No. 3, June 1994	First European Dosimetric Results: 1993 data
No. 4, June 1995	Preliminary European Dosimetric Results for 1994
No. 6, April 1996	Overview of the first three Full System Decontamination
No. 7, June 1996	Preliminary European Dosimetric Results for 1995
No. 9, December 1996	Reactor Vessel Closure Head Replacement
No. 10, June 1997	Preliminary European Dosimetric Results for 1996
No. 11, September 1997	Annual individual doses distributions: data available and statistical biases
No. 12, September 1997	Occupational exposure and reactor vessel annealing
No. 14, July 1998	PWR collective dose per job 1994-1995-1996 data (restricted distribution)
No. 15, September 1998	PWR collective dose per job 1994-1995-1996 data (general distribution)
No. 16, July 1998	Preliminary European Dosimetric Results for 1997 (general distribution)
No. 17, December 1998	Occupational Exposure and Steam Generator

Replacements, update (general distribution)

ISOE Information Sheets (contd.)

European Technical Centre (contd.)

No. 18, September 1998	The Use of the man-Sievert monetary value in 1997 (general distribution)
No. 19, October 1998	ISOE 3 data base – New ISOE 3 Questionnaires received (since September 1998) (restricted distribution)
No. 20, April 1999	Preliminary European Dosimetric Results 1998
During 1999	European Annual Outage Doses
During 1999	Radiological protection actions for insulators in nuclear power plants (restricted distribution)

IAEA Technical Centre

No. 1, October 1995	ISOE Expert meeting
No. 2, April 1999	IAEA Publications on occupational radiation protection
No. 3, April 1999	IAEA technical co-operation projects on improving occupational radiation protection in nuclear power plants
No. 4, April 1999	IAEA Workshop on implementation and management of the ALARA principle in nuclear power plant operations, Vienna 22-23 April 1998

North American Technical Centre

No. 1, July 1996	Swedish Approaches to Radiation Protection at Nuclear Power Plants: NATC site visit report by Peter Knapp

ISOE Topical Session Reports

First ISOE Topical Session: December 1994	• Fuel Failure • Steam Generator Replacement
Second ISOE Topical Session: November 1995	• Electronic Dosimetry • Chemical Decontamination
Third ISOE Topical Session: November 1996	• Primary Water Chemistry and its Affect on Dosimetry • ALARA Training and Tools

ISOE International Workshop Proceedings

North American Technical Centre	
March 1997, Orlando, Florida, USA	First International ALARA Symposium
European Technical Centre	
September 1998, Malmo, Sweden	First EC/ISOE Workshop on Occupational Exposure Management at Nuclear Power Plants

Annex 2

ISOE Participation as of December 1998

Participants in the Information System on Occupational Exposure, as of December 1998

Operating Reactors

Country	**Utility**	**Plant Name**
Armenia	Armenian (Medzamor) NPP	Armenia 2
Belgium	Electrabel	Doel 1, 2, 3, 4 Tihange 1, 2, 3
Brazil	Electronuclear A/S	Angra 1
Canada	Ontario Hydro	Bruce A1, A2, A3, A4, Bruce B5, B6, B7, B8 Pickering A1, A2, A3, A4 Pickering B1, B2, B3, B4 Darlington 1, 2, 3, 4
	Hydro Quebec	Gentilly 2
	New Brunswick Electric Power Company	Point Lepreau
China	Guangdong Nuclear Power Joint Venture Co., Ltd	Guangdong 1, 2
	Qin Shan Nuclear Power Co	Qin Shan 1
Czech Republic	CEZ	Dukovany 1, 2, 3, 4
Finland	Imatran Voima Oy	Loviisa 1, 2
	Teollisuuden Voima Oy	Olkiluoto 1, 2
France	Électricité de France	Belleville 1, 2 Blayais 1, 2, 3, 4 Bugey 2, 3, 4, 5 Cattenom 1, 2, 3, 4 Chinon B1, B2, B3, B4 Chooz B1, B2 Civaux 1 Cruas 1, 2, 3, 4 Dampierre 1, 2, 3, 4 Fessenheim 1, 2 Flamanville 1, 2 Golfech 1, 2 Gravelines 1, 2, 3, 4, 5, 6 Nogent 1, 2 Paluel 1, 2, 3, 4 Penly 1, 2 Saint-Alban 1, 2

		Saint Laurent B1, B2 Tricastin 1, 2, 3, 4

Country	**Utility**	**Plant Name**
Germany	Energie-Versorgung Schwaben AG (EVS)	Obrigheim
	Badenwerk AG (BW)/EVS	Philippsburg 1, 2
	Bayernwerk AG (BAG)	Grafenrheinfeld
	BAG/Isar-Amperwerk AG (IAW)	Isar 1
	Ostbayrische Energieversorgungs-AG Stadtwerke München (BAG/IAW/OBAG/SWM)	Isar 2
	PreussenElektra AG (PE)	Unterweser Brokdorf Stade
	Neckarwerke AG, TWS Stuttgart	Gemeinschschafts – Kernkraftwerk Neckar, Neckarwestheim (GKN) 1, 2
	Hamburgische Elektrizitäts-Werke AG (HEW)	Brunsbüttel
	HEW and PE	Krümmel
	RWE Energie AG	Biblis A, B Mülheim-Kärlich
	Kernkraftwerke Gundremmingen Betriebsgesellschaft mbH (KGB)	Gundremmingen B, C
	Vereinigte Elektrizitätswerke Westfalen AG (VEW)	Emsland
	Gemeinschaftskernkraftwerk Grohnde GMBH	Grohnde
Hungary	Magyar Vilamos Muvek Rt	Paks 1, 2, 3, 4
Japan	Hokkaido Electric Power Co.	Tomari 1, 2
	Touhoku Electric Power Co.	Onagawa 1, 2
	Tokyo Electric Power Co.	Fukushima Daiichi 1,2,3,4, 5,6 Fukushima Daini 1,2,3,4 Kashiwazaki Kariwa 1,2,3,4,5,6,7
	Chubu Electric Power Co.	Hamaoka 1, 2, 3, 4
	Hokuriku Electric Power Co.	Shika
	Kansai Electric Power Co.	Mihama 1, 2, 3 Takahama 1, 2, 3, 4 Ohi 1, 2, 3, 4
	Chugoku Electric Power Co.	Shimane 1, 2
	Shikoku Electric Power Co.	Ikata 1, 2, 3
	Kyushu Electric Power Co.	Genkai 1, 2, 3, 4

		Sendai 1, 2
Country	**Utility**	**Plant Name**
Japan (cont.)	Japan Atomic Power Co.	Tokai 2 Tsuruga 1, 2
	Japan Nuclear Cycle Development Institute (JNC)	Fugen ATR
Korea	Korean Electric Power Corp.	Wolsong 1, 2 Kori 1, 2, 3, 4 Uljin 1, 2 Yonggwang 1, 2, 3, 4
Lithuania	Ignalina State Nuclear Power Plant	Ignalina 1, 2
Mexico	Comisiòn Federal de Electricidad	Laguna Verde 1, 2
Netherlands	N.V. EPZ	Borssele
Romania	National Electricity Company	Cernavoda 1
Slovakia	Jaslovské Bohunice NPP	Bohunice 1, 2, 3, 4
Slovenia	Krsko Nuclear Power Plant	Krsko 1
South Africa	ESKOM	Koeberg 1, 2
Spain	UNESA	Almaraz 1, 2 Asco 1, 2 Cofrentes Santa Maria de Garona Trillo Vandellos 2 Jose Cabrera
Sweden	Barsebäck Kraft AB	Barsebäck 1, 2
	Forsmarks Kraftgrupp AB	Forsmark 1, 2, 3
	OKG AB	Oskarshamn 1, 2, 3
	Vattenfall AB	Ringhals 1, 2, 3, 4
Switzerland	Kernkraftwerk Leibstadt AG (KKL)	Leibstadt
	Forces Motrices Bernoises (FMB)	Muhleberg
	Nordostschweizerische Kraftwerke AG (NOK)	Beznau 1, 2
	Kernkraftwerk Gosgen-Daniken (KGD)	Gosgen

Country	Utility	Plant Name
Ukraine	Department of Nuclear Energy of the Ministry of Energy	Chernobyl 1,2,3 Khmelnitski 1 Rovno1,2,3 South Ukraine 1,2,3 Zaporozhe 1,2,3,4,5,6
United Kingdom	Nuclear Electric	Sizewell B
United States	Arizona Public Service Co	Palo Verde 1, 2, 3
	Baltimore Gas & Electric	Calvert Cliffs 1, 2
	Boston Edison Company	Pilgrim 1
	Carolina Power and Light	H. B. Robinson 2
	Commonwealth Edison Co.	Braidwood 1, 2 Byron 1, 2 Dresden 2, 3 LaSalle County 1, 2 Quad Cities 1, 2 Zion 1, 2
	Consumers Energy Company	Palisades 1
	General Public Utilities	TMI 1 Oyster Creek 1
	Illinois Power Co.	Clinton 1
	Indiana and Michigan Power Company	D.C. Cook 1, 2
	New York Power Authority	Indian Point 3
	Pacific Gas and Electric Company	Diablo Canyon 1, 2
	Pennsylvania Power & Light	Susquehanna 1, 2
	PECo Energy	Limerick 1, 2 Peach Bottom 2, 3
	South Carolina Electric & Gas	Virgil C. Summer 1
	Southern California Edison	San Onofre 2, 3
	Texas Utilities	Comanche Peak 1, 2
	Wisconson Electric Power Co	Point Beach 1, 2

PARTICIPATING UTILITIES

Definitively Shutdown Reactors

Country	Utility	Plant Name
France	Électricité de France	Bugey 1 Chinon A1, A2, A3 Chooz A St. Laurent A1, A2
Germany	PreussenElektra AG (PE) Arbeitsgemeinschaft Versuchsreaktor AVR	Würgassen Jülich
Italy	Ente Nazionale per l'Energia Elettrica	Caorso Garigliano Latina (GCR) Trino
Japan	Japan Atomic Power Co.	Tokai 1
Netherlands	NCGKN	Dodewaard
Spain	UNESA	Vandellos 1
United States	Southern California Edison General Public Utilities Commonwealth Edison Co. Pacific Gas and Electric Company PECo Energy Consumers Power Company	San Onofre 1 TMI 2 Dresden 1 Humboldt Bay 1 Peach Bottom 1 Big Rock Point 1

PARTICIPATING REGULATORY AUTHORITIES

Country	Authority
Armenia	Armenian Nuclear Regulatory Authority (ANRA)
Belgium	Service de la sécurité technique des installations nucléaires
Canada	Atomic Energy Control Board (AECB)
China	China National Nuclear Corporation (CNNC)
Czech Republic	State Office for Nuclear Safety
Finland	Säteilyturvakeskus (STUK)
France	Ministère du travail, et des affaires sociales, Represented by the Office de Protection contre les Rayonnements Ionisants (OPRI)
Germany	Bundesministerium für Umwelt, Naturschutz und Reaktorsicherheit
Italy	Agenzia Nazionale per la Protezione dell'Ambiente (ANPA)
Japan	Science and Technology Agency (STA), and Agency of Natural Resources and Energy of the Ministry of International Trade and Industry (MITI)
Korea	Ministry of Science and Technology (MOST) Korea Institute of Nuclear Safety (KINS)
Mexico	Commision Nacional de Seguridad Nuclear y Salvguardras
Netherlands	Ministerie van Sociale Zaken en Werkgelegenheld
Romania	National Commission for Nuclear Activities Control
Slovakia	State Health Institute
Slovenia	Slovenian Nuclear Safety Administration (SNSA)
Spain	Consejo de Seguridad Nuclear
Sweden	Statens strålskyddsinstitut (SSI)
Switzerland	Office Fédéral de l'Énergie, Division principale de la Sécurité des Installations Nucléaires, DSN
United Kingdom	Nuclear Installations Inspectorate
United States	Nuclear Regulatory Commission (NRC)

ISOE TECHNICAL CENTRES

European Region (ETC)	Centre d'étude sur l'évaluation de la protection dans le domaine nucléaire (CEPN), Fontenay-aux-Roses, France
Asian Region (ATC)	Nuclear Power Engineering Corporation (NUPEC), Tokyo, Japan
IAEA Region (IAEATC)	International Atomic Energy Agency (IAEA), Vienna, Austria Agence Internationale de l'Energie Atomique (AIEA), Vienne, Autriche
North American Region(NATC)	University of Illinois, Champagne-Urbanna, Illinois, U.S.A.

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Armenia	IAEATC
Belgium	ETC
Brazil	IAEATC
Canada	NATC
China	IAEATC
Czech Republic	ETC
Finland	ETC
France	ETC
Germany	ETC
Hungary	ETC
Italy	ETC
Japan	ATC
Korea	ATC
Lithuania	IAEATC
Mexico	NATC
Netherlands	ETC
Romania	IAEATC
Slovak Republic	IAEATC
Slovenia	IAEATC
South Africa	IAEATC
Spain	ETC
Sweden	ETC
Switzerland	ETC
Ukraine	IAEATC
United Kingdom	ETC
United States	NATC

INTERNATIONAL COOPERATION

- European Commission (EC)
- World Association of Nuclear Operators, Paris Centre (WANO PC)

Annex 3

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Mr. Christian Lefaure	France
Ms. Caroline Schieber	France
Ms Teresa Labarta	Spain
Mr. Mats Hjelm	Sweden
Mr. Ingolf Briesen	Germany
Mr. David Miller	United States
Mr. Jiang	China
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