European ALARA Network

Issue 1 - July 1996

European ALARA Newsletter

Editorial

Since the publication of ICRP 22 and ICRP 26 in 1973 and 1977 respectively, the understanding and practical implementation of the concept of Optimisation of Radiation Protection has developed considerably in Europe. It is an explicit requirement of the CEC Directive laying down the Basic Safety Standards for radiological protection (EURATOM Directive), as well as of most of the national regulations.

In 1996, ALARA is an integral part of radiation protection programmes in most European nuclear plants as far as external exposure of workers is concerned. But it is far from being as well implemented with respect to internal and potential occupational exposures or, for all aspects, in the non nuclear industry sector (eg. industrial radiography, industrial accelerators…).

Therefore, as an extension of previously sponsored work on this subject the CEC considered it worthwile to create a European ALARA Network (EAN).

Its objectives are:

• to promote the wider and more uniform use of optimisation techniques in the various fields of application in Europe i.e. industry, research, and the nuclear fuel cycle,

• to provide a focus and a mechanism for the exchange and dissemination of information from practical experience, and

• to propose topical issues of interest that should be the subject of European meetings, workshops or research projects.

The network complements already existing structures and systems such as the CEC radiation protection experts group of the European LWRs (DG XI), the International System on Occupational Exposure (ISOE from NEA OECD), and the CEC training courses on the implementation of optimisation of radiation protection in nuclear facilities.

CEPN will provide a coordinating function, and a European ALARA Network Group will provide guidance on the work programme of the EAN. The EAN Group will consist of invited experts with expertise that reflects the different countries, the various fields of application, and the breadth of the research programme on ALARA.

The EAN will produce a regular ALARA Newsletter, widely distributed, to provide a link between all those concerned with ALARA, mainly the health physicists, but also the managers, the radiation protection organisations, the research bodies, the regulatory bodies, the trade unions representatives and the medical doctors.

This Newsletter intends to reflect some major aspects of the ALARA life in Europe: evolution of regulations and judicial precedents, results of research, description of existing databases, analysis of dosimetric data, authorities and utilities ALARA programmes, available ALARA tools, need for ALARA improvements, etc. Each issue will include one or two feature articles, as well as experts viewpoints and ALARA information. We therefore look forward to receiving comments, news items and suggestions for articles.

Christian LEFAURE

Contents

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MANAGING THE RADIATION RISK:

ALARA, A PRINCIPLE, AN OBLIGATION, A STATE OF MIND

Jacques LOCHARD (CEPN)
Christian LEFAURE (CEPN)

❑ The Foundations of the ALARA Principle

Although the effects of exposure to high doses of ionising radiation lead to pathologies that are now well-known (radio-dermatitis, cataracts etc.), these deterministic effects do not occur for low doses, such as those received by workers during normal operation of various industrial, medical, and nuclear facilities. Our knowledge of the risk of these low doses is still incomplete, though very intensive research has been carried out since the war. Observations, however, have showed that the predominant risk from low doses is an increase in the probability of cancer. The major uncertainty therefore concerns the relationship between cancer probability and dose.

Faced with these uncertainties, the international scientific community has adopted a cautious approach, acknowledging that there is probably no dose threshold below which the risk disappears, and, with respect to risk quantification, retaining the particularly cautious and practical assumption of a proportional relationship between the degree of exposure and the probability of the development of radio-induced cancer.

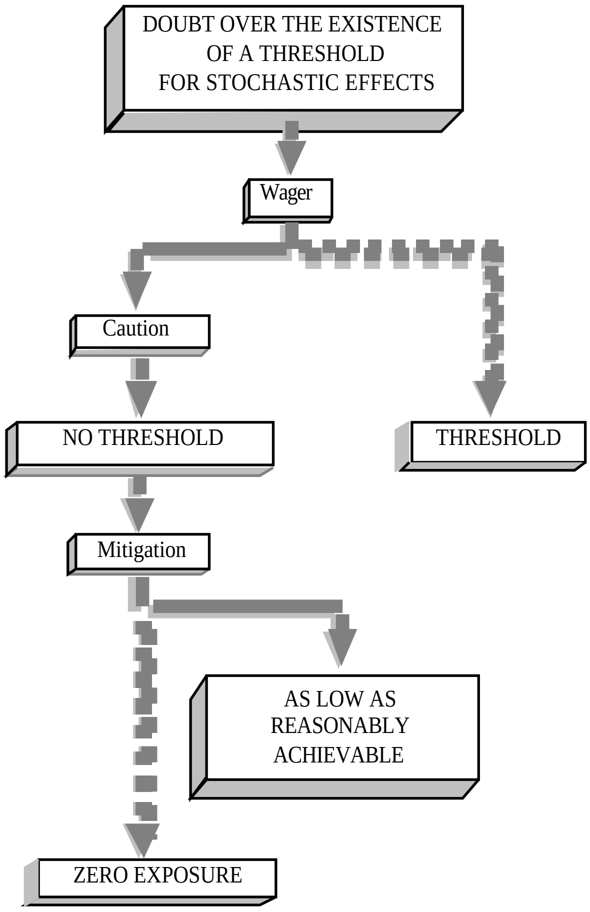

Fig 1. The Foundations of the Optimisation Principle

On the basis of these assumptions, even a very low dose could lead to harmful health effects; it seems therefore logical to attempt to reduce exposure resulting from human activities (see Fig 1). From the moment a human activity involving exposure to ionising radiation (diagnostic radiography, nuclear power production, industrial radiography, etc.) is deemed socially acceptable, that is to say if society considers that it will reap a net benefit therefrom, exposure must be reduced whenever possible. However, it is advisable to be « responsible », that is to say one must not waste resources or favour one group to the detriment of another.

The adoption of this cautious and responsible approach led to the development of the optimisation principle of radiation protection, or ALARA: « Exposure must be kept as low as reasonably achievable, taking into account economic and social factors ». The aim of such a principle, therefore, is to seek the best compromise between the « residual risk », that is to say the risk that could remain after the implementation of protective measures, and economic and social criteria.

Furthermore, since the assumption is that the risk increases proportionally with the dose, international experts have recommended that for the application of the ALARA principle, priority should be given to the reduction of the higher individual doses.

❑ ALARA: A Statutory Obligation at both European and National Levels

In theory, the ALARA principle could be applied without statutory control. However, in practice, the existence of regulations and the enforcement of them play a considerable role.

Most countries have already integrated ALARA into their national regulations, and the continued need for this is confirmed in the new EURATOM Directive on the Basic Safety Standards (Council Directive 96/29/EURATOM of 13 May 1996). Its article 6 states:

« In addition, each Member State shall ensure that: in the context of optimisation, all exposures shall be kept as low as reasonably achievable, economic and social factors being taken into account;…»

❑ The ALARA Approach

From a practical point of view, applying radiation protection optimisation should lead to a reduction in risk via the implementation of the most cost-effective protective measures. This means implementing an approach that is both *predictive* and *evolutionary.* It must be *predictive*, since, in order to « manage the risk », the doses associated with the planned work programme have to be predicted, and possible protection measures have to be devised and quantified. These measures have to be compatible with available resources as well as equitable in the framework of a process involving all the various participants. It must be *evolutionary* because it has to be flexible enough to adapt to changes in techniques, resources, and social context.

In its article 17, the EURATOM Directive, for the first time, briefly describes basic elements of the ALARA approach:

« Operational protection of exposed workers shall be based on the following principles:
***a**. prior evaluation to identify the nature and magnitude of the radiological risk to exposed workers and implementation of the optimisation of radiation protection in all working conditions;… »*

The success of this approach will be all the greater when implemented in the framework of ALARA programmes (see Fig. 2), that are characterised by:

• The determination, during the preparatory stage of the work, of optimised individual and collective doses goals;

• The installation of a data acquisition system enabling a follow-up of the evolution of these doses during the performance of the work programme in order to detect any drift and, if need be, to implement corrective actions. Statutory dosimetric systems e.g. films or badges rarely enable a follow-up since the results are only available with some delay and incorporate all the activities performed during the full period of wearing. Thus, it is generally not possible, on the basis of film badge data, to accurately and rapidly determine the causes of the drift. The use of an operational dosimetry system therefore seems essential at this stage. Ideally, this should enable computerised linking of doses to tasks.

• The analysis of results (i.e. the dose rates at the workstations, the work exposure times, and individual doses by task) and the explanation of any discrepancies in relation to those predicted, are indispensable for the proper analysis of feedback, that in turn permits the prediction and optimisation of doses for subsequent work programmes.

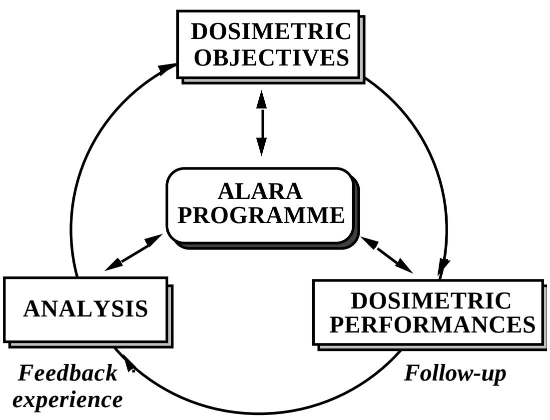

Fig 2. The ALARA Approach

As in any management procedure, there must be an audit, that will check that the whole ALARA programme is working correctly, that it is suited to the situation and permits optimal solutions to be retained. Such an audit system can either be internal to the organisation, or external to the organisation, calling upon institutions recognised for their expertise.

In most cases, implementing ALARA is just common sense, and one must therefore rely on each person's awareness in seeking the reduction of individual and collective exposures. In some cases it is worthwhile devoting more time and effort to reach an ALARA solution through a formalised procedure.

Feedback experience shows that three major components are necessary to ensure the efficiency of ALARA programmes:

- The commitment of all individuals involved in radiological protection
- The existence of adapted structures
- The use of appropriate tools

❑ A Shared Risk Philosophy

The effective implementation of the ALARA approach implies that all the persons involved in radiation protection are aware of, and accept the assumptions upon which the principle of radiation protection optimisation is based: that is to say the lack of any certainty as to the existence of carcinogenic effects at low doses, and the adoption of a cautious and responsible attitude towards the management of a residual radiation risk at low doses. This acceptance of the notion of residual risk is at the very foundation of each person's awareness of his responsibility and motivation in seeking the reduction of individual and collective risks.

The application of the ALARA principle can be compared to the implementation of a standard of behaviour, both intellectual and material. This standard must be seen not as an obligation to meet a numeric regulatory standard (which is the case in the respect of limits), but as obligatory means to urge optimal vigilance on those concerned by radiation protection.

The ALARA approach is supported, above all, by an awareness of this residual risk and corresponds essentially to **a state of mind**, that must be shared by the authorities and all those concerned by radiation protection in design, operation, maintenance, and dismantling of facilities using ionising radiation.

« RADIOR »
an Introductory Computer Aided Training Package on Radiation Protection Optimisation

Prodidact-France has developed this tool, with the scientific collaboration of CEPN and the financial support of the European Commission (DG XI). It allows self-discovery of the ALARA approach, the application of the optimisation principle and to self-test the knowledge after 2-3 hours usage. The software has 5 languages options : English, French, German, Spanish, Swedish. There is no prerequisite such as knowledge of PCs to use the software.

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DOSE DISTRIBUTIONS IN GERMANY AND THE UK

John CROFT (NRPB),
Annemarie SCHMITT-HANNIG (BfS)

For occupationally exposed workers, personal monitoring data provides an important element in the management of radiation exposure and feedback to the planning phase: all of which is highly relevant to the principle of ALARA.

❑ New Central Dose Register in Germany

In Germany, the BfS (Bundesamt für Strahlenschutz) is currently compiling a new Radiation Protection Register of dose data for occupationally exposed individuals. This will include assessments of both external and internal exposure together with registration of radiation passbooks for persons working at more than one site.

There are some 350,000 persons under official dose control. Data has to date been kept at a State level and it will take some time to produce coherent national distributions of individual dose. However, coherent data is available on collective dose and the percentage of exposed persons who have annual doses equal to or greater than 0.1 mSv.

Whilst the bulk of the collective dose comes from the nuclear power sector, the sector with the highest percentage of persons receiving doses above 15 mSv is industrial radiography (see second column in Table 1 for 1994 data). This points out that special attention has to be paid to this sector.

Table 1. Dose Data in Germany (1994)

Categories of facilities	% of Persons exposed to doses > 15 mSv	Collective Dose (man.Sv)
Medical Practices	0.04	7.25
Dental Practices	0.02	0.11
Hospital, clinics or sanatoriums	0.02	14.70
Other medical facilities	0.04	0.69
Research, science	0.02	0.63
Industrial radiography	3.43	7.80
Reactor operation (excluding contract personnel)	1.34	23.70
Operation of installations of the nuclear fuel cycle	0.11	0.54
Technical control, governmental supervision, experts working in the field	0.46	0.98
Other facilities (including contract personnel for NPP)	1.94	45.30

❑ United Kingdom Dose Trends

In the UK all dose recording-keeping Approved Dosimetry Services (ADS) are required to send annual summaries of doses reported for classified workers (category A) to the UK's Central Index of Dose Information (CIDI). This is run by NRPB (National Radiological Protection Board) under contract to the enforcing authority, the Health and Safety Executive (HSE). There are currently some 29 work categories in the database. One of the key reasons for HSE establishing CIDI was to provide a mechanism to provide data on trends in worker exposure as an aid to developing policy and targeting inspection and enforcement priorities. Annual summaries of statistics are published, as are occasional reports on trends.

It is impossible to provide one simple set of figures that adequately expresses all facets of dose trends, however Table 2 gives an overview of the major trends in doses in the UK for the nine year period 1986 to 1994. The legislation introduced in 1985 to replace older legislation and to implement the last BSS Directive, was a watershed in changing the focus from compliance with dose limits to an ALARA approach. This change in emphasis is clearly reflected in the reduction over the last nine years in both collective doses and the profile of individual doses, especially those greater than 15 mSv in a year. The key elements have been the development of a radiation protection safety culture involving commitments from managements and workers alike; and the influences of the qualified experts (Radiation Protection Advisers) and the regulators.

Whilst the nuclear industry still accounts for just over half the collective dose, there has been a dramatic change in the distribution of the higher individual doses. The nuclear industry are to be congratulated for a massive 300 fold reduction in the individuals exceeding 15 mSv in a year. This has not been an easy task, but the sector has the benefit of having a relatively small number of organisations and therefore corporate decisions or commitments to ALARA can have a wide impact. This now leaves the non-nuclear sector as the major source of high occupational exposures. Industrial Radiography and Mining Underground stand out as the sectors where there are perhaps the most problems to be solved.

The Mining Underground category stands out as the one with the largest number of doses in excess of 15 mSv in a year. These doses arise from exposure to radon and its daughter products. This route of occupational exposure has only started to come into prominence in recent years and there would seem to be scope to pursue ALARA. The other category of work with high individual doses is that of industrial radiography. The problems in this area are long standing and well known. There has been some improvement but the industry is made up of many companies, often small in size, where commitment to ALARA struggles for attention against commercial competitiveness/survival. In 1992 an industrial radiographer died of acute myeloid leukaemia associated with a 10 Gy dose from chronic exposure.
This triggered a campaign by the HSE and NRPB to improve standards, which has met with some success, but requires ongoing attention. One element of this is to raise the awareness of clients requesting radiography, to the hazards involved and the safety standard they should expect

(and insist upon) from industrial radiographers working on their premises. Clearly the non-nuclear sector provides some ALARA challenges for the future.

Table 2. Selected UK Occupational Dose Data for 1986 and 1994

Occupational Category	Collective Dose (man.Sv)		Number of Individual Doses > 15 mSv	
	1986	**1994**	**1986**	**1994**
Nuclear Industry	77.2	27.8	1243	4
Industrial Radiography	7.5	2.7	57	29
General Industry	15.8	7.1	169	1
Mining Underground	6.6	4.3	224	140
Other	19.9	9.5	218	9
Total (man.Sv)	**127**	**51**	**1911**	**183**

ALARA IN PRACTICE:
A REGULATORY PERSPECTIVE
FROM SWEDEN

Thommy GODÅS,
Swedish Radiation Protection Institute (SSI)

❑ Introduction

Occupational dose reduction is important not only for the health and safety of the workforce but also because the associated requirement for a good management system enhances safety, quality and reliability of the installation and thus the economy of the plant. Indeed, during the 80's and beginning of the 90's progress had been made and occupational doses had decreased in most countries but unfortunately in recent years this has not been the situation in Sweden. The SSI have learned that there is no time for complacency because as plants become older there is a general tendency of increased maintenance and repair requirements. Moreover, ICRP Publication 60, which recommends more stringent dose limits, further draws the attention to the optimisation of the radiological protection of workers and consequently to ways of reducing their exposures.

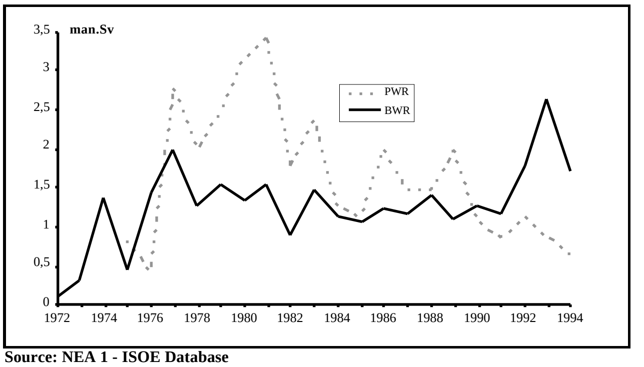
❑ Background

A 1977 regulation issued by the SSI recommands that *« until further notice […] measures [must] be taken with the purpose of keeping the contribution from occupational exposure within the power stations below 2 man.Sv per installed GWe and year »*.

In my opinion, this guidance value led to the achievement of very low collective doses (compared to many other countries) in Swedish nuclear power plants during the 80's and in the beginning of the 90's. In 1992 the doses started to increase and continued to do so also in 1993, especially in BWRs (Boiling Water Reactors). In 1993 the total collective dose, PWRs (Pressurised Water Reactors) included, reached the level of about 28 man.Sv, i.e. 2.8 man.Sv per GWe, which in fact exceeds the planning level of 2.0 man.Sv per GWe.

Also, the annual individual doses increased during this time but are still well below the new dose limits (50 mSv for any one single year and 100 mSv as a total for five consecutive years). Moreover, the annual average dose for all the work force are below the ambition level of the SSI of 5 mSv per year. However, for some groups the average individual doses have exceeded that level. The number of persons with annual doses of more than 20 mSv in 1993, was about 200 but the number decreased to less than 50 in 1994.

Graph 1. Average Collective Dose per reactor in Sweden (1972-1994)



Source: NEA 1 - ISOE Database

❑ Reasons for Increasing Doses

Due to significant volumes of work, the doses increased considerably during 1992 and 1993. This can be partly explained by the fact that some of the reactors are ageing thus requiring significant maintenance and repair work. Increasing safety requirements resulting in extended inspection programs are also contributing to this. In particular, a significant safety related event happened in 1992, when some insulation material was inadvertently fed into the inlets of the safety injection systems causing risk of clogging. This event led to repair and modification work at all the BWRs of similar design leading to collective doses of about 7 man.Sv for the five reactors concerned.

❑ Action to Turn the Trend

The changed situation with higher collective doses has called for the establishment of more fundamental ALARA programs especially for the BWRs. Using research funds, the SSI started in April 1993 a significant development program in the field of dose reduction.

The Swedish « reactor maker » ABB-Atom was asked to examine the reasons for the increasing dose levels, to assess the expected dose situation during the years to come and to give advice on actions to reduce occupational doses. The purpose of the program (DORIS = DOse Reduction In Swedish BWRs), was to serve as a basis for the utility ALARA-programs. The core of the investigation was a comprehensive analysis of exposure and radiation data from the ABB Atom BWRs. Extensive computer simulations were performed to find the factors responsible for this radiation build-up.

Dose Rates

Dose rates data from continuous measurements in the reactor systems, have confirmed that the radiation levels are increasing with time. As might be expected, the dose rates are in general higher the closer to the reactor and its primary systems you are. The five oldest BWRs are here of particular interest in that their recirculation loops require significant inspection and test activities causing important doses to the personnel.

Erosion and corrosion of base material in the reactor systems mean that large amounts of corrosion products are fed into the reactor. A significant fraction is deposited onto the fuel, activated and thereafter spread in the reactor systems. Activated corrosion products, in particular Cobalt 60, are the main source of the radiation fields in the nuclear power plants and thus to the resulting radiation doses. Cobalt is one element in stainless steel and amounts up to 60 % in the hard facing alloy stellite, common in valves.

Also, fuel failures are causing an increased spread of Co-60 from the fuel to the reactor systems. This phenomenon is presently being studied in more detail, but it is already evident that increased attention to fuel failures is needed from the occupational exposure point of view.
The increased burn-up level of more recent BWR fuel is also a factor responsible for the increasing radiation levels in Swedish BWRs. The effect is delayed, which means that the increasing radiation levels turn up after 5 years of operation or more of using the new fuel with a higher burnup level. The present burnup level is around 40 MWd/kg U.
With the results from project DORIS fresh in its memory, the SSI asked ABB to do a feasibility study on ultrasonic decontamination of nuclear fuel. The reasons for performing a fuel decontamination are:

- Removal of Co-58 and Co-60 from the cladding surface reduces radiation exposure
- Removal of loosely adherent crud may give a significant decrease of particle transients during reactor shut-down
- Removal of tramp uranium deposited on the core following fuel failures or minor core accidents mitigates the negative effects of these incidents

One result of the study shows that, if two years old fuel elements are decontaminated each year there is a potential for dose reduction with up to 40-50 %.

For a typical BWR it corresponds to a reduction in collective dose from 2.0 man.Sv to 1.0-1.2 man.Sv per year.

❑ Work Management and ALARA Program

Through its inspection and monitoring program SSI was able to identify, at an early stage, the adverse trends described above. One action taken by the SSI was to alert the plant management to the situation and to explain its concerns regarding this development. The SSI pointed out the importance of taking forceful measures to strengthen the radiation protection at the plants. To get doses ALARA, SSI believes it is necessary to review *all* the components that make up the doses, one by one, and judge their dose reduction potential in relation to their respective costs.

The SSI Requirements

The opinion of the SSI is that the approach adopted by management towards radiation work can have a major influence on the degree of radiation exposure in the workplace. Experience has also shown that effective dose reduction needs firm management involvement and support, as well as appropriate dosimetric systems and other tools.

In other words, the organisation, control and follow up of radiation work to ensure that doses are ALARA is a management issue and must not be left to the radiation protection department alone.

Also, the involvement of top management seems to be a very important measure to improve the attitude and awareness for effective radiation protection of all personnel. This is further enhanced if specific radiation protection goals are set and all personnel are informed about the importance management attaches to the achievement of these goals.

Policy defined by management is not enough on its own; continuous support is needed, and this must penetrate to and be made known at all levels in the organisation. A key to successfully pursuing ALARA seems to be commitment; a commitment that has to exist at all levels of management, not just at the top level. In many countries, utilities have realised this and several of them have defined ALARA programs.

In Sweden, there is a regulatory requirement for each utility to prepare an ALARA program as part of such a management approach. In the new regulations on occupational exposure, new requirements were included.

ALARA REQUIREMENTS
IN THE NEW SWEDISH REGULATIONS
(SSI FS **1994**:2)

The SSI have required an extended education and training program in radiation protection, addressed especially to foremen and team-leaders, working for the utilities as well as for contractors. The SSI believes that this program will increase the understanding and motivation of the personnel to become more heavily involved in dose reduction.

Additionally, the SSI believes in an ALARA or work management approach, i.e. where the utilities systematically review their strategy towards radiation protection and develop goals in the area of occupational exposure.

The SSI has required that each utility have to prepare an ALARA program. These programs shall contain objectives and dose targets for the short and longer terms, discussions on the basic considerations behind the choice of such objectives and targets, dose reduction plans (source and exposure time reductions to be considered) and ways to monitor, follow up and analyse experience. Finally, the plans shall contain programs for education and training of the workforce as well as the organisational aspects related to all the above.

The SSI has also decided to introduce a new individual dose limit: 100 mSv in 5 consecutive years (in addition to the annual individual dose limit which is 50 mSv).

The Industry response

The Swedish nuclear industry has responded positively to the initiatives of the SSI. All nuclear power plant managements have taken actions in a very constructive way, administratively as well as technically. They have clarified the responsibilities for radiation protection by delegated it to the line management. The industry has initiated a number of development projects aiming at dose reduction and is in the process of developing the ALARA programs referred to above, including explicit goals and targets for radiation protection for all the reactors. Finally, one has to emphasise that a number of technical actions have been taken, or are in the process of being taken, at each individual power plant, e.g. finding replacement material for stellite, optimisation of water chemistry, decontamination of components and systems and development of improved strategies for fuel burnup and handling of fuel failures.

❑ The Future

SSI thinks that is it necessary to go through and review *all* the components that make up the doses, one by one, and judge their dose reduction potential in relation to their respective costs. These will contribute to reducing the dose rates in the plants, and in particular to radically decrease the inflow of cobalt into the reactor core. Here the stellite reduction efforts will be crucial. Other actions that are most likely to be important are chemical decontamination, permanent shields, prevention against fuel failures and the limitation of fuel burnup by a skilled operation strategy. When it comes to the other components that make up the collective doses, namely time and number of persons involved, planning, education and training as well as automation and robotics will be important. However, a systematic approach will be needed including a review of:

- working conditions
  (protections, working environment…)
- worker characteristics
  (qualification, experience,…)
- work organisation
  (scheduling, preparation, co-ordination…)

The modification of one or several of the above factors will have a direct impact on the productivity of workers and which will directly influence the exposed time and usually the costs of carrying out the work.

In addition to the above actions the SSI has emphasised to the nuclear industry the importance of having the management of the plants engaging themselves in radiation protection issues. Also, the SSI sees the importance of maintaining an open dialogue with all the work force including the outside workers that participate in the maintenance of the plants, particularly during the outage periods. Finally, the importance of education and training as well as setting up systems allowing analysis and feed back of experience has been pointed out by the SSI.

❑ Conclusions

The nuclear industry has come to a point where greater emphasis on systematic dose reduction is needed. This is not only for the health and safety of the personnel, but also for maintaining the safety and economic viability of the plants and for public acceptance purposes. In Sweden the doses have increased significantly during the last couple of years and great efforts are needed to turn the trend. To succeed in this, the plant management has to adopt a structured approach to radiation risks and tackle all the factors influencing exposure. The ALARA principle applied through, and by, all levels of management and in all important works seems to be a useful instrument in this respect. Management should deal with doses as they deal with money, i.e. establish systems containing targets, means to follow the results and to take corrective actions when deviations so require. In this respect it should be pointed out that the dose targets should be challenging but possible to achieve, expressed in measurable terms and accepted by those who are responsible for the results at the company.

ALARA NEWS

« ALARA Course »
Saclay (Paris), 15th-17th October 1996

A 3-days ALARA training course will be held at the Nuclear Sciences and Techniques National Institute (INSTN). This course - in French - will present both theoretical and practical examples with the participation of representatives of the French utilities and research centres.

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Standing Conference on:
« Health and Safety in the Nuclear Age »
Luxembourg, 26th-27th November 1996

The objective of this conference is to inform those involved in the process of transmitting information to the public on the recent European radiation protection standards. The most recent recommendations of ICRP (ICRP 60) made it necessary for the European Commission to perform a major revision and expansion of its directives. This revision will influence to a great extent future regulatory actions taken at national levels to protect workers and public against ionising radiation.

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UK Accident Database (IRID)

The NRPB and two regulatory authorities, the Health and Safety Executive (HSE) and the Environment Agency (EA) have jointly established an Ionising Radiations Database (IRID). This will be focused on radiological rather than nuclear accidents. It consists of 23 fields that categorise the incident together with a description in a text file. The specifications have just been published and future publications describing incidents are planned.

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New Basic Safety Standards

The Official Journal of the European Communities have published the new Council Directive, laying down the « basic safety standards for the protection of the health of workers and the general public against the dangers from ionizing radiation », (COUNCIL DIRECTIVE 96/29/EURATOM of 13 May 1996)

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4th ISOE Annual Report
on Occupational Exposures
at Nuclear Power Plants

In order to facilitate the exchange of techniques and experiences in occupational exposure reduction, the Nuclear Energy Agency (NEA) of the OECD launched the Information System on Occupational Exposure (ISOE). Its Fourth Annual Report is now available; it covers the period from 1969 up to the end of 1994.

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