IRPA9
1996 INTERNATIONAL CONGRESS ON RADIATION PROTECTION
APRIL 14-19, 1996
VIENNA, AUSTRIA

ALARA IN PRACTICE: A REGULATORY PERSPECTIVE

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"Radiation Protection at Nuclear Facilities"
Wednesday, April 17, 1996
Vienna, Austria

ABSTRACT:

The paper will start with a presentation of how ALARA programmes fit into the operation management of nuclear power plants. This will be illustrated with the practices adopted in Swedish power plants in recent years. A particular attention will be given on how regulatory requirements related to ALARA have been formulated and implemented in a systematic way by utilities.

The paper will also address all aspects related to inspection and controls of ALARA programmes. The experience gained so far in Sweden allows for some general recommendations about the way to establish an effective framework for the implementation of ALARA programmes and a positive co-operation between regulators and utilities.

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 eighties and beginning of the nineties progress has been made and occupational doses have decreased in most countries but unfortunately this is not the situation in Sweden. We 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, the ICRP Publication 60, which recommends more stringent dose limits, further draws the attention to the exposure of workers and consequently to ways of reducing such exposure.

BACKGROUND

In 1975 the Swedish Radiation Protection Institute started the work with a new regulation on limitation of releases of radioactive substance from nuclear power stations.
Because of the limit 5 manSv/ GW installed electric effect (global collective dose) for the releases from the power station, we had to say something about the occupational collective dose.

In the above regulation we can read the following:

"In the assessment as to whether the practice is justified, the contribution made by occupational exposures must also be taken into account. This also applies when assessing the scale of the radiation protection measures which should be taken ("protection optimisation"). In order to limit the future *per caput* dose it is found to be more suitable from an administrative point of view to limit the occupational exposure by means of special rules which are not associated with the releases of radioactive substances into the environment. The rules for occupational
exposures should nevertheless include a limitation of the collective dose commitment from this exposure per unit of the practice. Until further notice it is recommended that measures be taken with the purpose of keeping the contribution from occupational exposure within the power stations below 2 mansieverts per GW installed electric effect and year."

:, one of the most important reason to give the utilities a guidance value for the collective dose from onal exposures was our knowledge about the dose situation in other countries. During the early s there was a trend to higher doses. This was a situation we tried to avoid (figures 1 and 2).

1

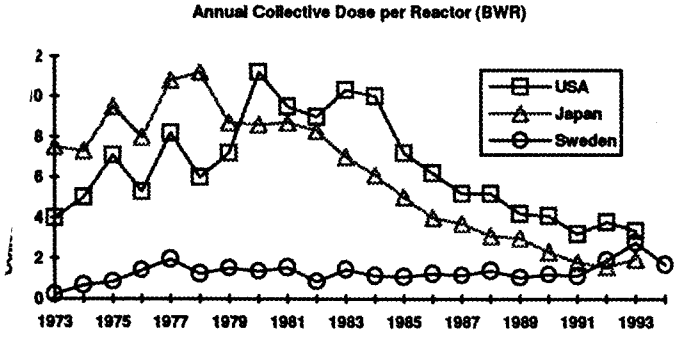
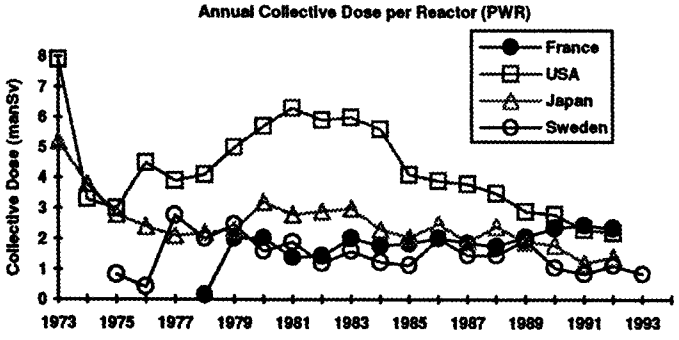
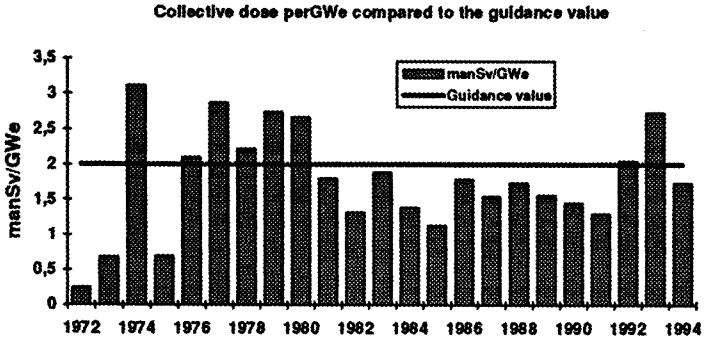


Figure 2



The decrease in doses we saw in the end of the eighties and in the beginning of the nineties (figure 3), didn't give any motivation for implementing new ideas with regard to lower the doses.

Figure 3

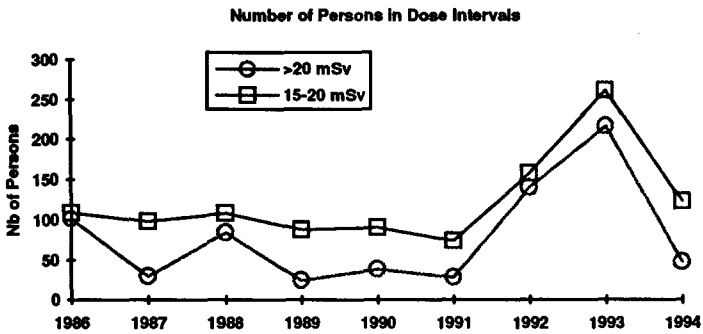


As can be seen from Figure 1, the collective doses in Swedish BWRs have been low, but started to increase in 1992 and continued to do so also in 1993. In 1993 the total collective dose (PWRs included) reached the level

of about 28 manSv, i.e. 2.8 manSv per installed GWe, which in fact exceeds the planning level of 2 manSv per GWe.

Also, the annual individual doses have increased during the same years but are still well below the dose limits (50 mSv for any one single year and 100 mSv as a total for five consecutive years). Moreover, the annual average 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 was in 1993 about 200 but the number decreased to less than 50 for 1994 (figure 4).

Figure 4



REASONS FOR INCREASING DOSES

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

ACTION TO TURN THE TREND

The changed situation with high collective doses has called for the establishment of more fundamental ALARA-programs (ALARA an acronym for As Low As Reasonably Achievable) especially for the BWRs. Using the 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 as well as to give advice on actions to reduce occupational doses Ref. (2). The purpose with the program (DORIS=Dosreduction in Swedish BWRs), was to serve as a basis for the utility ALARA-programs.

The base 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.

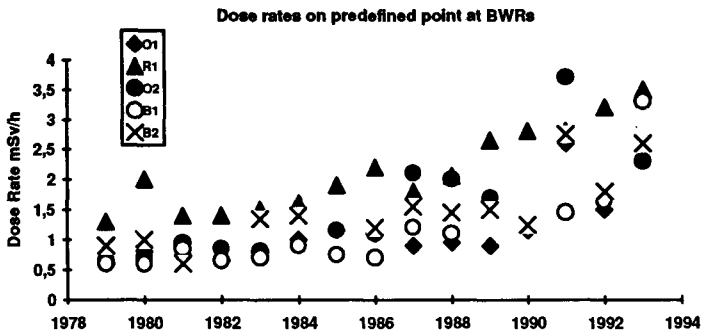
Dose rates

To get a measure of the evolution of the dose rates in the reactor systems, the nuclear industry is measuring continuously the dose rates at a number of places at the reactors. One such series of measurements is shown in Figure 4, from which it is evident that the radiation levels at that particular place on the recirculation loops are increasing with time.

The dose rates are in general higher the closer to the reactor and its primary systems you are. The five oldest BWR-reactors are here of particular interest in that their recirculation loops require significant inspection and

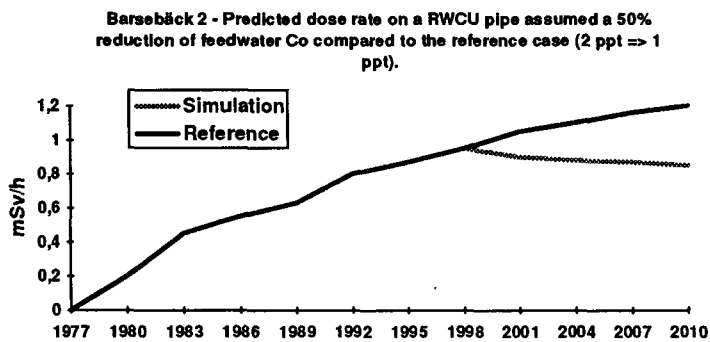
test activities causing important doses to the personnel. In PWR similar problems exist as far as their steam generators are concerned.

Figure 5



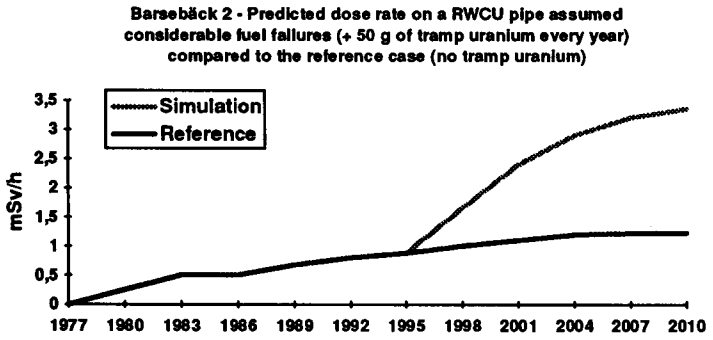
Erosion and corrosion of base material in the reactor systems mean that large amounts of corrosion products are fed into the reactor. An important part of them are deposited onto the fuel, activated and thereafter spread in the reactor systems. Activated corrosion products and in particular Cobalt-60 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 per cent in the hard facing alloy Stellite, common in valves. The following figure shows the predicted dose rates assuming various levels of inflow of Cobalt to the reactor.

Figure 6



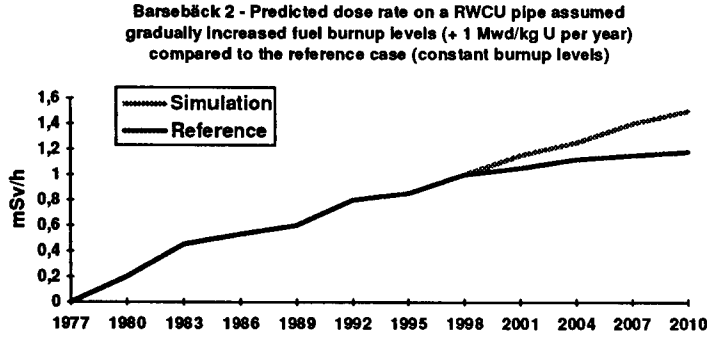
Also, fuel failures are causing an increased spread of cobalt-60 from the fuel to the reactor systems. This phenomenon is presently studied in more detail, but it is already now evident that increased attention to fuel failures are needed also from the occupational exposure point of view as in shown in the figure below.

Figure 7



As shown in the following figure, increased burnup 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 with the new fuel with higher burnup level. The present burnup level is around 40 MWd/kg U.

Figure 8



With the results from project DORIS in fresh memory, we asked ABB, on our behalf, to do a feasibility study on ultrasonic decontamination of nuclear fuel.

The objectives of this study was:

- To determine the possibilities of decontaminating nuclear fuel using ultrasonics
- To outline how an ultrasonic decontamination could be performed and examine technical limitations due to fuel
  and fuel handling
- To determine the long-term aspects of radiation protection and compare the benefits in exposure reductions with the costs

The reasons for performing a fuel decontamination:

- Removal of Co 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

The study shows us as one of the results that, if two year 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 of the collective dose from approximately 2 to 1-1,2 manSv per year.

NEW REGULATIONS

In our new regulations (SSI FS 1994:2) on occupational exposure, new requirements were included. First of all we decided to introduce a new individual dose limit, 100 mSv in 5 consecutive year in addition to the annual individual dose limit which is 50 mSv.

We have also 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. We believe that this program will increase the understanding and motivation of the personnel to more heavily engagement in dose reduction.

Additionally, we believe 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.

We also require 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 analysing 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.

WORK MANAGEMENT AND ALARA-PROGRAM

The SSI supervises through inspections and reporting the radiation protection situation at the Swedish nuclear power plants and monitored thereby early on the negative trend described above. One action taken by the SSI was to alert the plant managements on the situation and to explain the concerns of the SSI as regards this development. The SSI pointed out the importance of taking powerful measures to strengthen the radiation protection at the plants. To get doses to the ALARA level, it is, according to the SSI, 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 Ref (3).

Management approach

The opinion of the SSI is that the management approach adopted 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 works 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 up and all the personnel is informed about the importance management attaches to the achievement of those goals.

Policy defined by management is not enough, however, continuous support is needed; a support that has to penetrate 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. Many countries have realised this and several of them have defined ALARA programs and some more are in the progress of doing it.

In Sweden, the above mentioned regulatory requirement to prepare an ALARA program by each utility is part of such a management approach. 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 analysing 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.

Industry response

The Swedish nuclear industry has responded positively to the initiatives of the SSI. All the 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 emphasis 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. Such component comprise actions that 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 most likely will 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 automations and robotisation will be important. However, a systematic approach will be needed including a review of

- working conditions (protections, working environment, etc.)
- worker characteristics (qualification, experience, information about the work, etc.)
- work organisation (scheduling, preparation, co-ordination, etc.).

The modification of one or several of the above factors will have a direct impact on the productivity of workers and then influence directly 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 a 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, mechanisms 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.

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