Implementation of ALARA culture in German NPPs

Peter Jung, EnBW Kraftwerke AG, Kernkraftwerk Philippsburg,
Wolfgang Pfeffer and Jörg Kaulard, GRS

Experience has shown that occupational exposure in nuclear power plants basically is driven by two main factors: one important factor is the detailed design of the plant which defines the general basic radiological conditions in the plant. These form the basis for the conditions in the working areas and even more the basis from which radiation protection planning starts to optimize the working conditions and reduce exposure to be as low as reasonably achievable (ALARA).
The second factor is the degree and quality of implementation of radiological protection planning and measures during operation and outages of the plants (operational radiation protection). This influences and controls the exposure (under the given radiological conditions) related to the tasks and the work load prevailing and will be the operational part of ALARA implementation.

Regarding the first factor addressed, on the basis of experience feedback from the early time of the operation of NPPs in Germany, the design of the plants was significantly improved with time in joint co-operation efforts of operators, designer, authorities and technical consultant organizations. Special guidance was developed and published in Germany not only to assure safety of the NPPs but also to foster good design in radiation protection. Important issues addressed in this field (and laid down in the guideline IWRS I) were dedicated material selection (to avoid material producing long-lived gamma-emitting activation products as e.g. cobalt), recommending working conditions and equipment supporting shortening of working times in high-radiation areas, separation of systems and components to reduce background radiation from adjacent systems, and installation of fixed and temporary shielding to reduce the radiation levels in workplaces and in corridors and waiting areas. As an outcome, the most recent NPPs can be operated with extremely low collective doses.
As a selected example the basic radiological conditions at the primary circuit of the cold leg of the main coolant loops of German PWR are presented in Fig. 1.

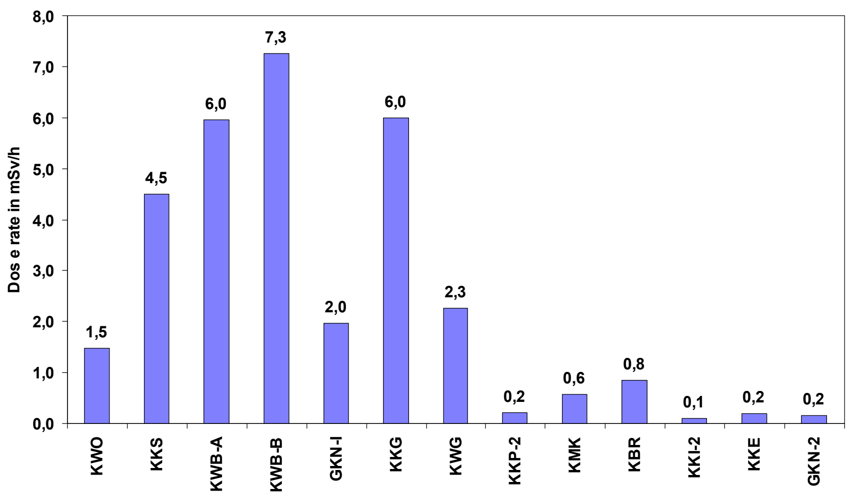

Fig. 1 Mean value of dose rate at the cold leg of main coolant loop in mSv/h. Data are averaged in time and over all available measured values for each PWR

Fig. 1 documents the significant reduction of dose rate in the recent plants, which was provoked by experience feedback and supported in the IWRS-I guideline resulting in significant improvements of the basic radiological conditions as an effect of the reduction of cobalt during construction. The influence of replacing cobalt and antimony in the early years of the operation of an older plant on the dose rate can be identified from the dose rate data of GKN-I;

regarding ALARA, it has to be considered in this case that replacement work certainly will cause some exposure and radioactive waste. As a general outcome of the experience feedback in the construction of NPPs it can be concluded that the different situations regarding dose rates in the individual plants will make a big difference between radiation protection planning and measures to be implemented to reduce exposure to ALARA.

Regarding operational radiation protection, the reduction of exposure could be improved dramatically due to experiences in the early years, starting from quite high collective and individual doses. The trend of collective exposures is presented in Fig. 2 to Fig. 4 for three examples.

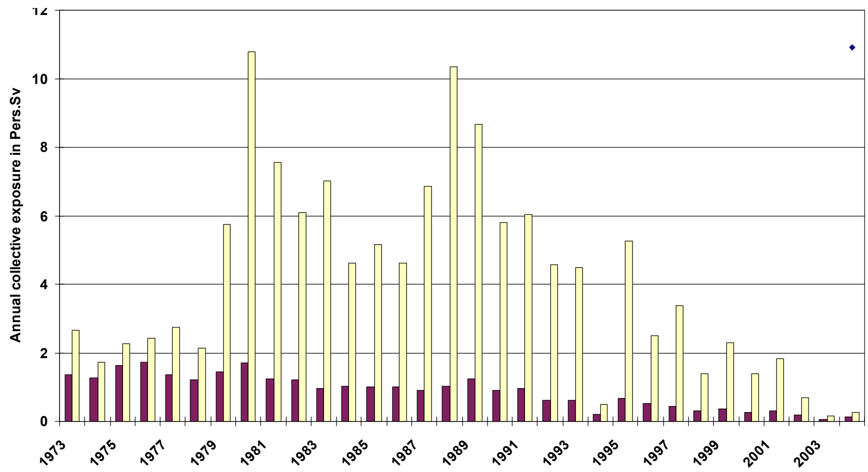

Fig. 2 Collective exposure of staff in KKS (PWR-type), KKS contributed significantly to the evaluation of the increase of collective exposure in the early years of operation

Dark bars: utility
Light bars: contracted personnel

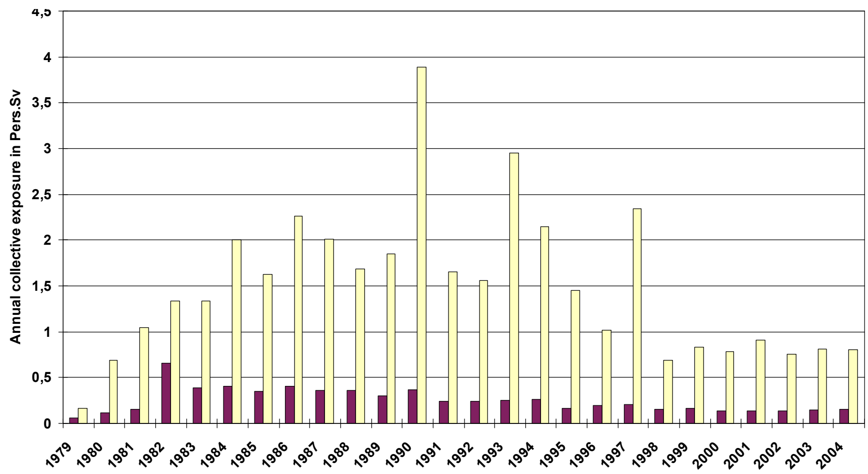

Fig. 3 Collective exposure of staff in KKP-1 (BWR-type)

Dark bars: utility
Light bars: contracted personnel

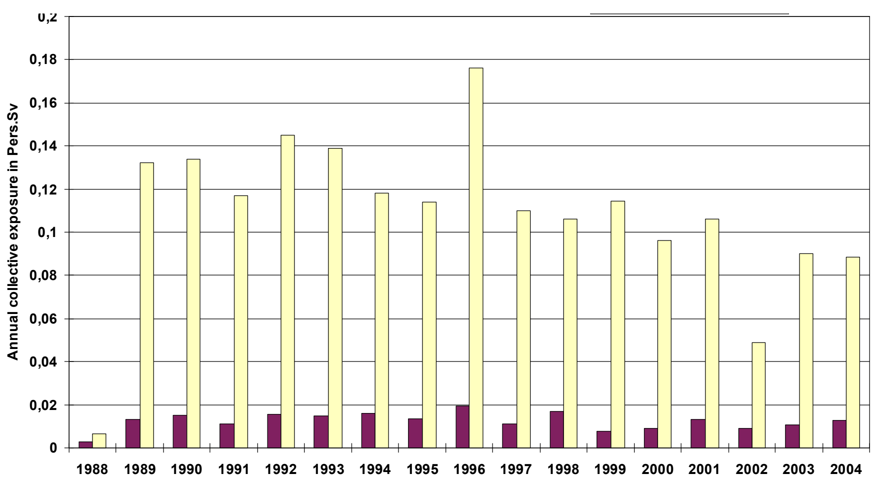

Fig. 4 Collective exposure of staff in KKE, this plant is one of the most recent German NPP (PWR-type) with the lowest collective exposure in Germany. Even in this plant the reduction of collective exposure with time is obvious.

Dark bars: utility
Light bars: contracted personnel

The figures show different levels of collective exposure (please refer to the different scales of the graphs) and the different development of the increase of the exposure levels in the first years due to the increase of the activation products in the early plants. Certainly, due to differing work loads for an individual NPP the trend in the collective exposure presented is not definite proof of the improvement of radiological working conditions with time, as outages and back fitting activities in different years may increase the collective dose of the staff significantly. As an additional indicator, the mean task-related dose rate may be applied, which to some extent can be used as a measure of the overall mean radiological working conditions in the plant. In this case the collective exposure is normalized by the working time invested into the workload.

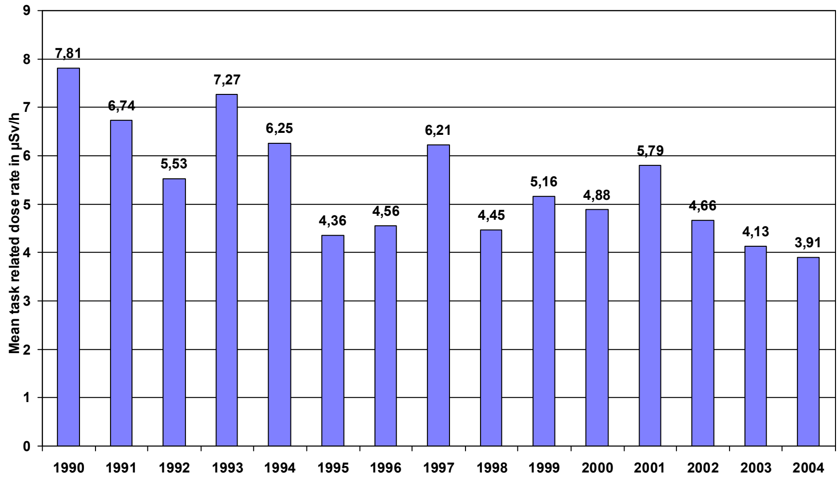

Fig. 5 Mean task-related dose rate in KKP-1; in spite of fluctuations, the decreasing trend of the data is obvious.

The example in Fig. 5 shows that the overall radiological working conditions in general could be improved with time. Issues as e.g. improved radiation protection commitment, feedback including task-related personnel dosimetry, and improved planning and implementation of optimized protective measures such as shielding contributed in this field to dose reductions with ongoing efforts without bigger changes in the radiation levels.

For many of the issues addressed it is not easy or even possible to present the connection between the measure implemented and the outcome, but one special measure implemented in some early German NPPs to reduce the dose rate and as a consequence the exposure of the staff is presented in Fig. 6. The positive effect of zinc injection to reduce the cobalt deposits on the surfaces of the components and systems containing primary coolant can be taken from Fig. 6 which presents the averaged measured dose rates at the main coolant loops.

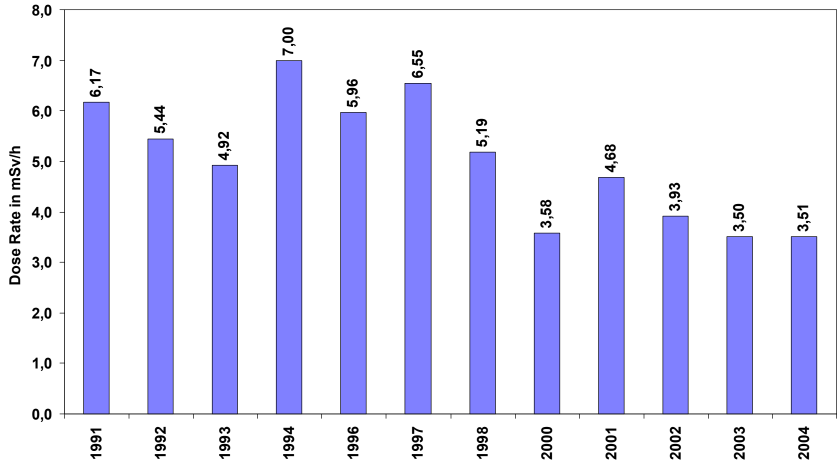

Fig. 6 Mean dose rate in mSv/h at main coolant loops (cold and hot leg) of KWB-B as a function of time. KWB-B has been injecting depleted zinc in the last years

In practice, issues that were later considered to be a part of work management already contributed to reduce exposure in the early years of operation of NPPs in Germany. Early guidelines such as the IWRS II significantly supported RP, as this guideline - which was published already in 1978 - introduced the need of qualified radiation protection planning for dose-intensive tasks with collective doses higher than 50 Pers.mSv or individual exposures exceeding 10 mSv. Moreover, it was requested that independent experts review the implementation and results of radiation protection planning on behalf of the authorities. In addition, a status of implementation has to be performed by the utility and be reported to the competent authorities to allow feedback of experiences from the tasks performed.

Considering governmental input to radiation protection and ALARA considerations, dose limits to some extent contributed to the trend of reduction of personnel exposure. In this case the driving force was not really the fixed individual annual limit, but rather more the discussion and implementation of the lifetime dose of 400 mSv in Germany in the late eighties, which supported the introduction of some mean dose levels as a kind of constraint, followed by the broad discussion of the new 20 mSv limit of the EU Basic Safety Standards and discussion and implementation of this new limit in the German Radiation Protection Ordinance.

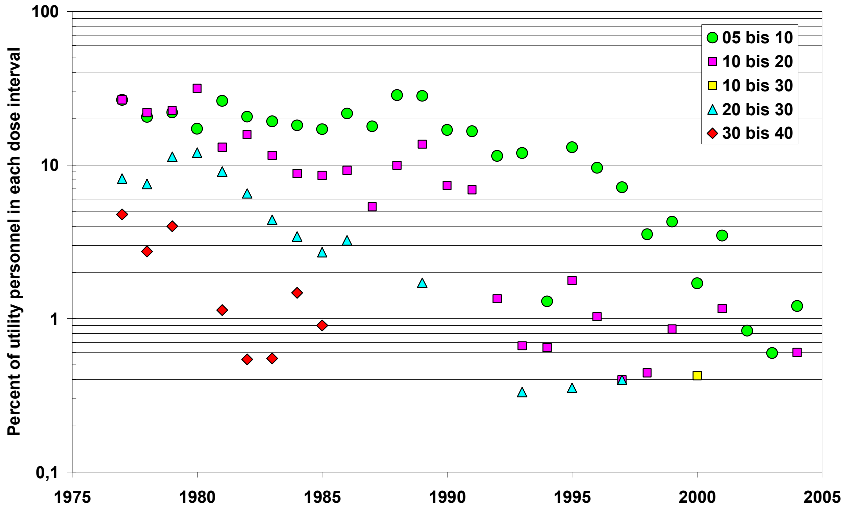

Fig. 7 Distribution of individual doses of utility personnel in KKS. (Doses below 5 mSv not shown)

The individual doses decreasing with time can be taken from Fig. 7 for the utility personnel of the plant selected: high doses close to limits have very low occupancies of the interval, which means that only individual persons are affected. Dose distributions for contracted personnel show similar trends.

Summary

With time, improved planning, re-evaluation as well as exchange of experiences and the stimulus of national and international discussion of ALARA implementation and work management further reduced exposure levels in German NPPs, making RP planning more and more an integral part of work planning. The re-issue of IWRS II laid down reduced dose limits and fostered an early integration of RP specialists (SSB) into work planning.

This investigation is supported by the German Federal Ministry for the Environment, Nature Conservation and Nuclear Safety under contract StSch 4487

“IWRS I“: Richtlinie für den Strahlenschutz des Personals bei der Durchführung von Instandhaltungsarbeiten in Kernkraftwerken mit Leichtwasserreaktor:
Teil I : Die während der Planung der Anlage zu treffende Vorsorge - IWRS I vom 10.7.1978 (GMBl 1978, S. 418), under review

„IWRS II (old): Richtlinie für den Strahlenschutz des Personals bei der Durchführung von Instandhaltungsarbeiten in Kernkraftwerken mit Leichtwasserreaktor -
Teil 2: Die Strahlenschutzmaßnahmen während der Inbetriebsetzung und des Betriebs der Anlage vom 23. Juni 1981 (GMBl 1981, Nr. 26 S. 363)

„IWRS II“: Richtlinie für den Strahlenschutz des Personals bei Tätigkeiten der Instandhaltung, Änderung, Entsorgung und des Abbaus in kerntechnischen Anlagen und Einrichtungen:
Teil 2: Die Strahlenschutzmaßnahmen während des Betriebs und der Stilllegung einer Anlage oder Einrichtung - IWRS II vom 17. Januar 2005 (GMBl 2005, Nr. 13)