The Implication of ICRP Publication 60 for Nuclear Power Plants

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Abstract

The potential consequences of ICRP Publication 60 for the design and operation of nuclear power plants were investigated. Collective doses for plant personnel and maximum doses for members of the public are already so low particularly in plants of recent design that the increase in risk factors will not require additional protective measures according to the ALARA principle. The new limit for the individual occupational dose accumulated during 5 calendar years may require additional surveillance with respect to a few persons. The evaluation of the design of protection of the public against accidental exposures according to the new criteria needs further discussion.

ICRP Publication 60 contains a large number of basic changes in comparison to Publication 26. The most important change in principle is the requirement to include "probabilistic" exposures in the evalution according to the three principles: justification, optimization and individual limits.

With respect to justification, this would require a new evaluation in which radiological hazards from planned operation and from potential accidents are both taken into account. By contras, the optimization of protection against accidents and the not yet defined limits for the individual risk caused by potential accidents could be evaluated separately.

An upper bound for the occupational risk caused by accidental exposures can be estimated from operating experience. With respect to critical groups outside the plant (next neighbours) such data cannot be obtained from past experience. The existing methodologies used for probalistic safety assessments have to be developed further to obtain such data. These can then specifically be used for the optimization of protective devices against accidents under the constraints of individual risk limits.

Whereas the extension of the radiation protection principles to include probalistic exposures needs further methodological work the other changes contained in ICRP 60 brought can be applied immediately. The major ones of this category are the new risk factors and new individual limits with respect to normal plant operation.

If safety measures would be designed exactly to the optimum, increased risk factors would require additional measures according to the ALARA principle. Fortunately this is not the case. Older designs have been investigated many years ago and shown to be ALARA /1 -4/. These analyses were based on much higher collective exposures than applicable today.

The trend of collective occupational exposure in nuclear power plants designed by SIEMENS is shown in Fig.1. Two conclusions can be drawn: Firstly, more recent designs feature much lower collective exposures and, secondly, at plants of older design - with generally higher collective exposures- exposures could be reduced by additional control and added protective devices. Any decrease in radiation exposure reduces the need for protection if the optimization criterion is applied. Therefore, a high degree of overprotection exists.

The influence of design improvements is shown even more clearly in Fig.2, where plants of the same size are compared on the basis of their service lives.

It is evident that these improvements are much larger than the increase in risk factors from ICRP 26 to ICRP 60: We can conclude that despite the new risk factors we are still well on the safe side of the optimum. At this low level of exposure additional protective measures will have such a low return in terms of reduction of exposure that it is unlikely that even increased risk factors would balance out the cost.

The same is true with respect to collective exposures of the public. A measure for this exposure is the release of radioactive substances to the environment. As an example the radioactive liquid effluents (other than tritium) and the release of aerosols and gaseous iodine compounds are shown in Fig.3. The curves represent the overall tendency for the average of all plants built by SIEMENS. Individual plants sometimes deviate from that averaged long-term curves. In order to evaluate the safety margin with respect to the limits we calculated the hypothetical exposure of an individual assumed to stay permanently as a self-supplier at the most unfavourable location outside the plant boundary. A water flow rate which is typical for fairly small rivers at which some nuclear power stations are situated in Germany has been chosen for this evaluation. It turns out that the resulting exposure is below the new ICRP limits by several orders of magnitude. Additionally one has to keep in mind that the exposure of an average member of a critical group would be much lower than the exposure of the hypothetical person assumed for these calculations.

We have also evaluated the distribution of individual exposures of plant staff as a function of plant design and years of operation. An example of these evaluations is given in Fig.4 for a third generation BWR. Whereas the peak exposure has been one half of the limit for a single year in 1986 it decreased to only one fifth in 1990.

A more critical point is the new limit for five calendar years. Although this limit is not to be applied retrospectively a retrospective evaluation may show to what degree additional measures may be necessary in the future.

Figs.5 and 6 give examples of such evaluations: There is a limited number of people who may exceed the new limit in plants of older design, if no additional measures are taken. It is evident that the necessary reduction in peak individual dose is so low that it can be obtained by administrative means only. Job rotation will probably not even be necessary for the most exposed persons.

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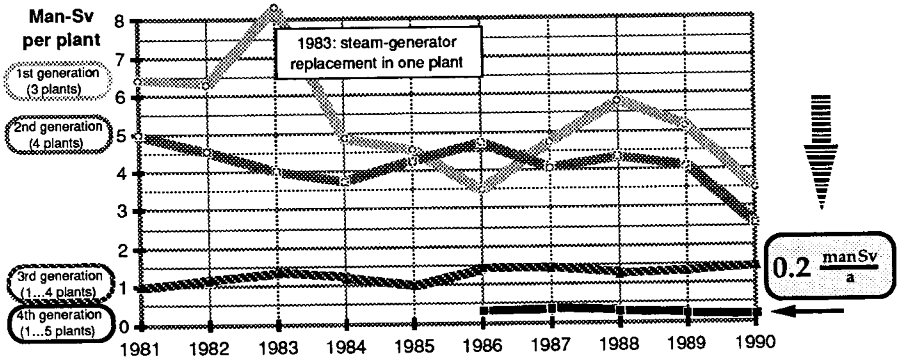

Fig.1 Influence of Design on Collective Dose (Siemens-built PWRs)

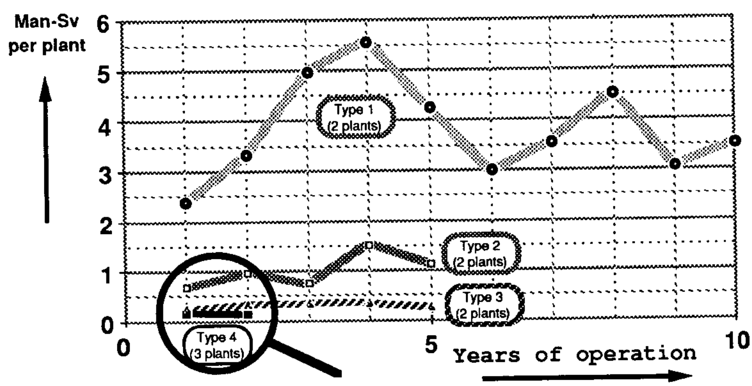

Fig.2 Influence of Plant Age on Collective Dose (1300 MWe PWR plants)

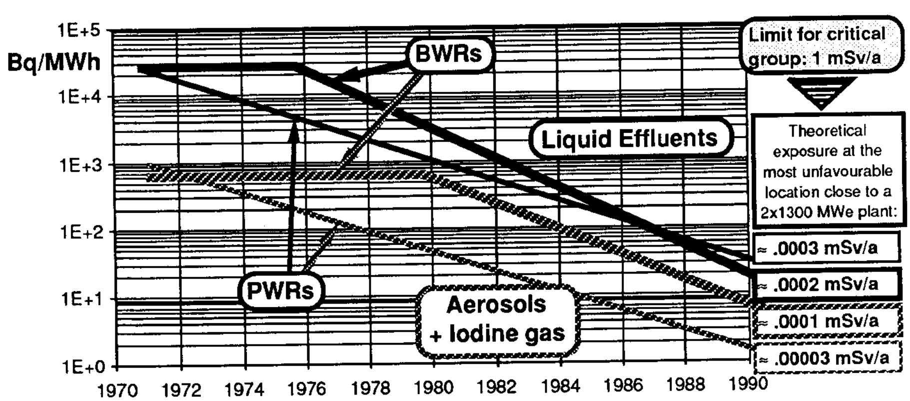

Fig.3 Release of Radioactive Substances to the Environment (Siemens-built plants)

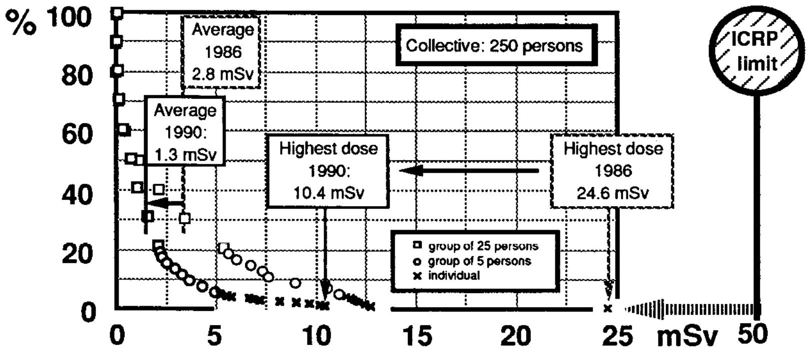

Fig.4 Distribution of Individual Doses in One Calendar Year (3rd Generation BWR)

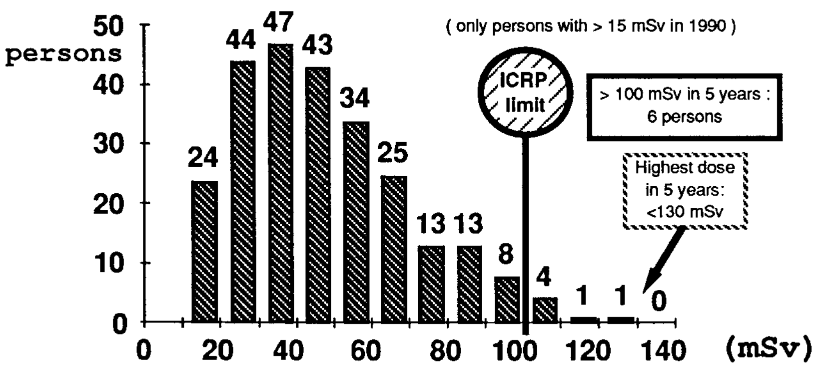

Fig.5 Individual Doses within five Calendar Years of a Collective operating a number of PWRs

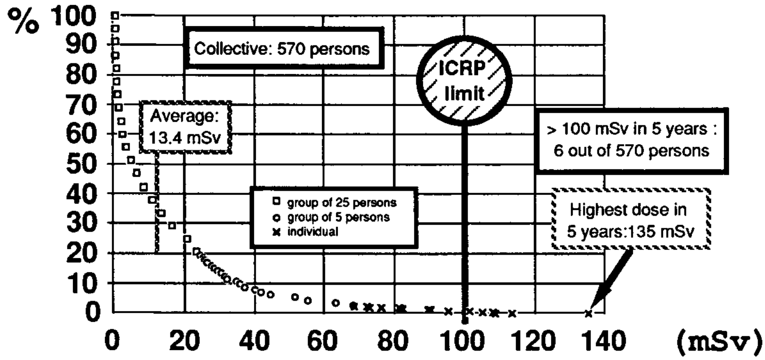

Fig.6 Individual Doses within five Years (Siemens-built 2nd Generation PWR)