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IMPLICATIONS OF THE 1990 RECOMMENDATIONS OF THE ICRP

by

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I. Introduction

The International Commission on Radiological Protection (ICRP) was established 1928, with the name of International X-ray and Radium Protection Committee, to draw on guidances for protection of human beings against harmful effects of ionizing radiation. The present name was given in 1950 after the organization was restructured to cope with the increased uses of radiation.

In 1959, the Commission issued its first report in the current series, subsequently numbered Publication 1, containing the recommendations of the Commission, which was referred to as ICRP 1. Subsequent general recommendations have been issued as Publication 6 of 1964, Publication 9 of 1966, Publication 26 of 1977, and Publications 60 and 61 of 1991. The last two publications are referred to as the 1990 Recommendations of the ICRP because the recommendations were approved by the Commission in November 1990. The ICRP 61 is a supplement to the ICRP 60 and contains data for use in the assessment of the internal exposure incurred by intaking radionuclides. The publications whose numbers are not mentioned above are related

to specialized topics other than the fundamental principles of radiation protection.

The general recommendations of the Commission prescribes the fundamentals of radiation protection, which include the philosophy of radiation protection, basic quantities, a system of radiation protection, and guides for the implementation of the recommendations. In the 1990 Recommendations, significant changes were made to the conceptual framework of radiation protection. Some minor changes may be adopted without any difficulties, but it is expected that considerable efforts and costs will be required to implement the major changes.

In the next section, the changes in the 1990 Recommendations from the former, i.e. ICRP 26, will be reviewed briefly in the order of the text of the ICRP 60. The impact and implications of some major changes will be discussed in the section follows.

II. Changes in the 1990 Recommendations

The very fundamental dosimetric quantity in radiological protection, the absorbed dose, was re-defined as the *average* value over a tissue or organ. This is a modification of the original definition of the quantity given by the International Commission on Radiation Units and Measurements (ICRU). The name dose equivalent reverted to *equivalent dose* reflecting the changes from absorbed dose to average absorbed dose and from the quality factor to the *radiation weighting factor*. With significant

changes in the *tissue weighting factors*, the effective dose equivalent got a short new name *effective dose*. The biological aspects of radiological protection are much more elaborated in the ICRP 60 than in the ICRP 26. The concept of detriment is limited to health detriment and the non-fatal detriment is included to represent the effects on the quality of life. The term *risk* is restricted to represent potential detriment or probability but is to be used only descriptively. The term non-stochastic effect is replaced by *deterministic effect*. In the risk projection for the stochastic effects other than leukaemia, the multiplicative model is selected. Mental retardation resulting from prenatal exposure is regarded as a deterministic effect with coefficient of approximately 30 IQ points per Sv. As many as seven organs or tissues are added to the list of tissues at risk, so the tissue weighting factors are largely modified.

The Commission has established two contrasting concepts in the system of radiation protection; practice and intervention. Practice causes exposures to radiation while intervention latter decreases exposures. The system of radiological protection for proposed and continuing practices is based on the three general principles; justification of a practice, optimization of protection, and individual dose and risk limits. In the course of optimization, the number of people exposed and the likelihood of incurring exposure as well as the

magnitude of individual doses are subjected to the principle of As Low As Reasonably Achievable(ALARA). The risk limits are imposed on the potential exposures. Similar principles are to be applied to intervention except for dose limits.

Nevertheless, the most significant changes recommended are the reduction of dose limits and the introduction of the concept of constraints for proposed and continuing practices. In the ICRP 60, the Commission recommended a limit on effective dose of 20 mSv per year for the occupational exposure *averaged over 5 years*, with the further provision that the effective dose should not exceed 50 mSv in any single year. For protection against the deterministic effects of tissue having no or very low tissue weighting factors, additional limits on equivalent dose are prescribed as 150 mSv per year for the lens of the eye, and 500 mSv per year for the skin, hands and feet. For the exposure of the general public, the limit of 1 mSv per year remains valid but the condition, "averaged over 5 years", has been deleted. The most significant fact is that the effective dose limit has been reduced to 40 % of the previous limit of 50 mSv per year although a provision is provided for having a higher exposure on occasion and offsetting the higher exposure with a lower exposure in succeeding years.

The Commission placed a new condition called *constraint* in the system of radiological protection as an integral part of optimization. The dose constraints will be applied to the source-related exposures, and the risk constraints to potential

exposures. The concept of constraint was introduced to limit the inequity between one individual and another in the process of optimization.

For the existing source of exposure, particularly to the public, an intervention should be introduced based upon justification that it would do more good than harm, and upon optimization that the form, scale, and duration of the intervention have been chosen so as to optimize the protection. Two long-term problems, radon in dwellings as well as radioactive residues from previous events and emergencies resulting from accidents, are highlighted as situations calling for intervention.

Departing from the previous recommendations, the Commission stressed the implementation of the Commission's recommendations in ICRP 60. Implementation emphasizes the importance of the operational level of radiological protection and shows how the level should be developed from the requirements of regulatory agencies and the recommendations of the Commission. A logical sequence of stages for implementation is established. The stages are allocation of responsibility, basic recommendations of the Commission, requirements of regulatory agencies, management requirements, and finally validation of performance.

The definition and placement of responsibility, the authority needed to meet the responsibility, and the accountability are clearly stated. Emphasis is placed on the necessity of providing adequate resources for the education and

training of future professional and technical staff in radiological protection.

Classification of working conditions is no longer recommended because the crude classification is not linked to the original intention to help in the choice of workers to be subjected to individual monitoring and special medical surveillance. Classification of work places into two designated areas, i.e., controlled area and supervised area, will remain but the boarder line between the two areas is not specified and is left to the management judgement.

Special attentions were paid to the assessment of doses because it is vital to the practice of radiation protection. The Commission recommends that all individuals exposed occupationally be monitored their external exposures unless it is clear that their doses will be consistently low, or it is clear that the circumstances prevent the doses from exceeding an identified value. Individual monitoring for intakes of radioactive material should be performed only for workers who are employed in areas that are designated as controlled areas specifically in relation to the control of contamination and in which there are grounds for expecting significant intakes. This policy comes from the differences in the complexity of the measurement and interpretation procedures comprising monitoring programs.

Regarding to the intervention levels to be applied in an emergency, the Commission recommends that the derived

intervention levels for radioactivities in foodstuffs be applied in a different way than previously to avoid unnecessary restrictions in international trade. The Commission suggests that the intervention level could indicate a line of demarcation between freely permitted exports or imports and those that should be subject to special decisions. This implies that trade in materials above an intervention level should not automatically be prohibited, but such materials might be subject to temporary controls.

Finally, there are discussions on the needs for exclusion and exemption from regulatory control for saving regulatory efforts and costs. The conceptual conditions for exemption are that a source gives rise to small individual doses and a small collective dose in both normal and accident conditions, and that no reasonable control measures can achieve significant reductions in individual and collective doses. Some unresolved problems, however, remain in this area, which may be attributable to the fact that exemption is necessarily a source-related process, while a small dose is primarily individual-related.

III. Implications of the New Recommendations

In this section, I would like to discuss the expected impacts of some major changes incorporated in the new recommendations and the pros-and-cons associated with the

changes. Although the recommendations given in the ICRP 26 of 1977 have been accepted by many countries, they were adopted only recently in some countries and some countries have still not been introduced to the regulations. Note that the changes included in the ICRP 26 were as significant as the changes in its successor. Considering the wide range of practices in different countries, we can easily assume that the impact of the changes in the ICRP 60 will differ from country to country. Since consideration of all situations arising in all countries in the world is not practicable, discussions will be made only in general terms given the transition from the ICRP 9 to the ICRP 26 has been settled in the system of radiological protection.

First of all, the introduction of the concept of constraint calls for attention. The Commission describes it in many different ways : a maximum individual dose or risk from a single source, a fraction of limits, upper bound on optimization, regulatory tool, and so on.

It is recommended that the constraints should be set up on the national or local level. Implementation of the concept of constraint, however, will not be easy in reality. Since constraints are fundamentally source-related matters and since varieties of practices are not bounded by nature, it will require a considerable amount of efforts and resources to implement the concept of constraint in the regulatory procedures. Although it need not be based on the result of

optimizations, a good deal of experiences are required to figure out appropriate values of constraint for a given group of practices or sources of exposure. If we choose broad groups, the corresponding constraints would approach the upper-bound, dose limits. This is not consistent with the objective of selecting the constraints. On the other hand, if we want to divide practices into many specific groups, we have to elaborate more and will need a system of analysis to establish the proper constraints.

Another problem is the enforcement of the constraint: constraint is a relatively broad term and will not be appropriate to be defined in laws or regulations. Laws and regulations should define the minimum norm and should be applied equally to all practices. Since the constraints imposed on each practice could be different from practice to practice, it is not proper to prescribe them in a simple fashion in the regulations. Therefore, it is expected that constraints will be issued as regulatory guides, which are more flexible than laws or regulations. They can be applied at the licencing stage of a proposed practice together with the optimization process.

When the concept of constraint comes into the frame of regulation, it may save a considerable amount of exposures. Particularly, a significant reduction in medical exposures of patients is anticipated if the constraints are set carefully for the group of medical practices.

It should be pointed out that a considerable amount of costs and resources will be required for implementing the new recommendations. The most dominant portion of the resources would be needed in the education program for all the individuals involved in radiation protection. As the system of radiation protection becomes complicated more and more, a highly qualified staff of experts will be required for successful implementation. The need for the specialists leads to the necessity of maintaining well organized and prepared training programs. Many things should be taught. A very intensive program should be developed and implemented for training dosimetry personnel and health physicists.

Education of the general public on the underlying concept of the new system of radiological protection is also important to prevent any unfavorable disturbance on the public acceptance. It should not be overlooked that the social cost of nuclear energy, which is related either directly or indirectly to public acceptance, has rapidly increased over past two decades.

The importance of training calls for active involvement of the competent authorities in the training program. Nevertheless, it will take time for us to get ready to implement all the new concepts and guidelines prescribed in the recommendations. For moderation of the impact of the proposed changes, a period of time is needed for preparation before beginning implementation. During this period, we should

concentrate on the training of personnel while drafting revisions to the regulations. Training courses organized by appropriate international bodies such as the International Atomic Energy Agency will be helpful for enhancing the infrastructure for radiation protection in developing countries and eventually promote international harmonization of the protection standards.

The most significant change would be the reduction of dose limits for occupational exposures. It should be noted that the dose limits have been periodically lowered from the time the limits were first introduced: from 1.5 R per week in 1928, 0.2 R per day in 1934, 0.3 R per week in 1950, 5 rem per year in 1958, and to 20 mSv per year averaged over 5 years in 1990. The reduction until 1950 could be attributed to the insufficient knowledge of human beings on the biological effects of ionizing radiation. According to the explanation of the Commission, this further reduction in 1990 was also partly based on the result of studies performed recently : DS86[1)] and analysis of the revised epidemiology data base. To this end, one can deduce that another reduction of limits could also come in the future and consequently can accuse that our knowledge about the harmful effects of radiation could not be located at any point on the line of the fact with a definite confidence interval.

Ability of human beings is far below that of mighty God. Never could they understand the alpha-to-omega of the nature.

Are they, however, so ignorant that they could not protect themselves from the mysterious invisible light which they discovered a century ago? What I believe is we already understand radiation enough to protect ourselves from its harmful effects. My understanding is that most of the knowledge needed for adequate protection has been acquired by virtue of the intensive researches done in the past half a century as conceptually illustrated in Fig. 1, where the shape of the knowledge distribution is intuitively assumed to be Maxwellian. Complete knowledge, however, will likely never be achieved. The deficiency can be compensated for by introducing an intentional margin to the system of radiation protection, which in fact has been included in the present system.

Not long before the new recommendation came to the light, the Commission had taken the position that it would not intend to lower the dose limits in spite of the revised risk estimations. What made the Commission alter its position so abruptly? There was no apparent sign of failure in the previous system of dose limitation as long as the system was respected. Will the benefit derived from reduced limits justify the cost of implementing them? Many questions may arise.

It has been recognized that most radiation workers received doses far less than the previous limit, 50 mSv a year. An example is given in Fig. 2 which shows the distribution of doses to the workers at the nine nuclear power units in Korea in 1991. After rejection of 3,545 workers who received less

than 0.1 mSv the average dose per Korean nuclear power plant workers was 2.84 mSv. This average is far less than 1/10 of the current limit. Only 0.2 percent of the monitored workers received more than 20 mSv. The general distribution of doses among workers are known to have a log-normal shape as illustrated in Fig. 3. If we reduce the limit from 50 mSv to 20 mSv, the tail part at high dose will be pushed downward. Therefore, a simple reduction of dose limits will only eliminate the small number of workers who get a dose higher than a few tens of mSv a year, but will result in only a small saving in collective dose.

In normal conditions where stochastic effects are of main concern, the collective dose is the correct quantity to be used in the risk assessment. In this respect, reduction of dose limits may not contribute to upgrading the level of radiation protection under the multi-stage control system comprising dose limits, constraints, authorized limits, investigation levels, and design targets. Particularly, imposition of the ALARA principles and constraints will tightly restrict the exposure levels. Under this circumstance, the possibility of getting rid of the concept of dose limit could be considered. However, it doesn't seem that it is the right time for the limits to fade away.

Since constraints are source-related and flexible as pointed out earlier, dose limits are worthy of being retained to provide a mechanism of legislation for which transparent, clear

and enforceable concept is necessary. Because the limits are stringent, they can provide a minimum but tolerable protection level even under a poor infrastructure for radiation protection.

To justify the new limits, the Commission provided very detailed biological background and risk estimates. With that information of the revised risk estimates, the Commission may have been uneasy in doing nothing because of public concern about radiation risk. Decisions of the ICRP are determined by not only scientific information but also socio-political considerations. This would be quite natural if the fact that radiation causes not only biological effects but also socio-political impacts is taken into account. Furthermore, as the most prominent, authoritative and influential organization, the Commission should maintain continuity and consistency in its recommendations. In this regard, it should have sufferred hot internal debates to give birth to the new dose limits. Lowering the limits is good if we admit that "no radiation is safe" as they say. It is as easy as passing a fishing hook through silk, but we should not forget that the retrieving might be extremely difficult. The fundamental question is if the public feels safe with the lowered limits. Unfortunately, the further we reduce the limits, the more the public concern about radiation.

For developing countries, the recommendations of the Commission may not be considered as either refutable or

negligible ones simply because they cannot repeat the same kinds of risk estimates to establish their own limits due to lack of resources and capabilities. It seems to be a mandatory process for regulatory bodies of developing countries being aware of public concern to reflect the Commission's recommendations in their radiation protection legislation system. They have to rely on the recommendation of the Commission with little choice and pay a formidable cost, even though their society may not be ready to accept.

Consideration of protection cost leads to necessity of evaluation of monetary value of radiation dose averted, which is a fundamental element to be quantified for optimization processes. The monetary value should be determined by reflecting the socio-economical environment where practices exist or are planned. It varies very widely from country to country and from one to another who evaluates it. All the same, it is low in the developing countries and high in the developed countries which implies, if translated, that people in poor countries are forced to or willing to tolerate higher risk. It could be a common sense but hardly be admitted by the public in developing countries.

Validity of exclusion and exemption from regulatory control should have been emphasized more clearly. As the public awareness of radiation exposure and radioactive waste grows seriously, most of the licensees and regulatory bodies faced deep dilemma of decision-making about handling substances

contaminated to extremely low levels. The United States Nuclear Regulatory Commission staff had proposed a rule on Below Regulatory Concern, but it was put on hold by the commission which is influenced by the strong opposition to the below regulatory concern concept. If we have to classify all garbage as radioactive merely because it contains man-made nuclides or technically concentrated natural radioactive isotopes, no matter how low their levels of contamination are, it is obvious that we cannot afford all the cost incurred to satisfy the general public. Potential increases of a few tens microsieverts a year are acceptable compared to the real exposure of thousands microsieverts caused by the natural radiation. An international consensus on possible exemption is badly needed to untie this Gordian knot when it is not expected to be cut by another Alexander the Great. The Commission should take the leading role by recommending more active and specific guidelines.

One final aspect we should observe is that the arguments made by some scientists such as Drs. J. W. Gofman and T. Mancuso would be in the spot light after decades of being neglected, although there are still considerable gaps between their assessment and the current position of the Commission. Their preferred model of risk projection, the relative risk model, is now applied to the risk projection for most of the cancers other than leukaemia. Dr. K. Z. Morgan strongly suggested that the limit on occupational exposures should be

lowered by a factor of at least two in one of his articles published in 1982[2)]. Could it be an exaggeration saying that they were like Galileo Galilei or Nicolaus Copernicus of this uncertain nuclear age? Indeed, the implication of the new recommendations casts many things to be speculated.

IV. Concluding Remarks

Conservatism is good in general and even better for safety. It could be a different matter, however, when we have to pay for the conservatism especially when we are forced to pay undue costs. When we say *Safety First*, it means a reasonable safety. Safety or benefits cannot be separated from costs. If radiation is however the sole risk to which we are imposed, that risk should be eliminated at any cost. Radiation risk occupies very small fraction of the total risks that we are facing in the industrialized society. Moreover most of the doses received by the human beings are due to the radiation environment created by God. The small increases in radiation exposure caused by human activity and even the trivial increases in risk we are facing shall not be exaggerated. As Dan Beninson, chairman of the ICRP, stated "radiation should be treated with care rather than fear." The prime principle always lies in balancing and harmonization.

V. Notes

1) Reassessment of Atomic Bomb Radiation Dosimetry in Hiroshima and Nagasaki, Radiation Effects Research Foundation, Hiroshima(1986).

2) Karl Z. Morgan, "Underestimating the Risks", in Nuclear Power: Both Side, M. Kaku and J. Trainer, edits., W.W. Norton and Company, New York(1982).

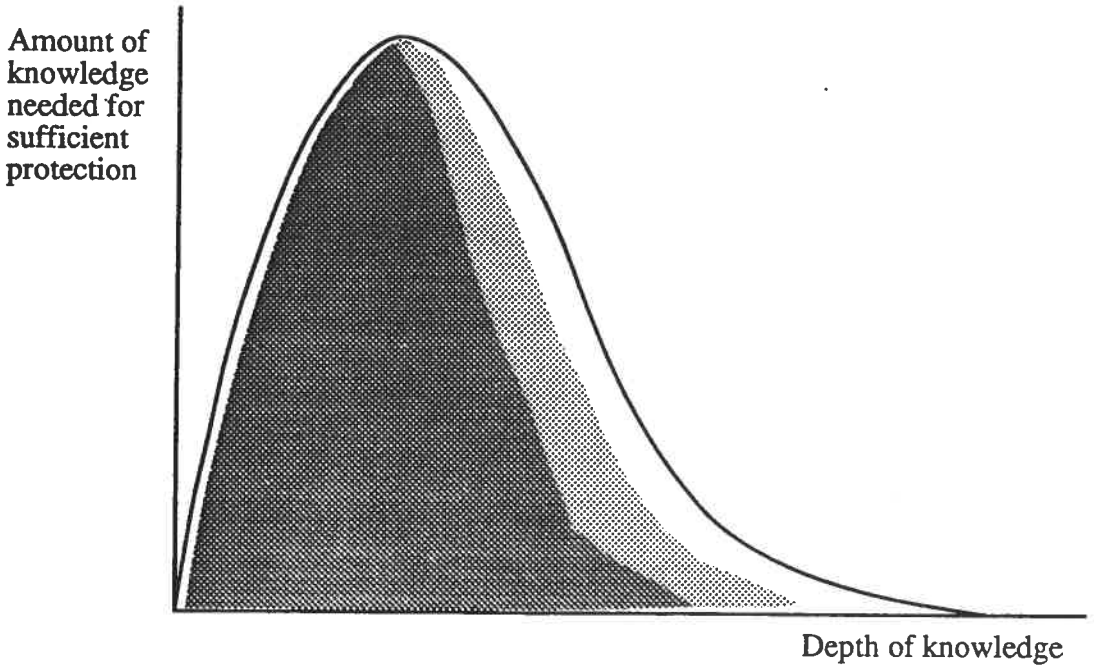

Fig. 1 An illustration of the spectrum of knowledge needed for sufficient protection from radiation. The dark shaded part of the figure represents knowledge already acquired. The light shaded part represents partial knowledge. The white area represents the unknown knowledge.

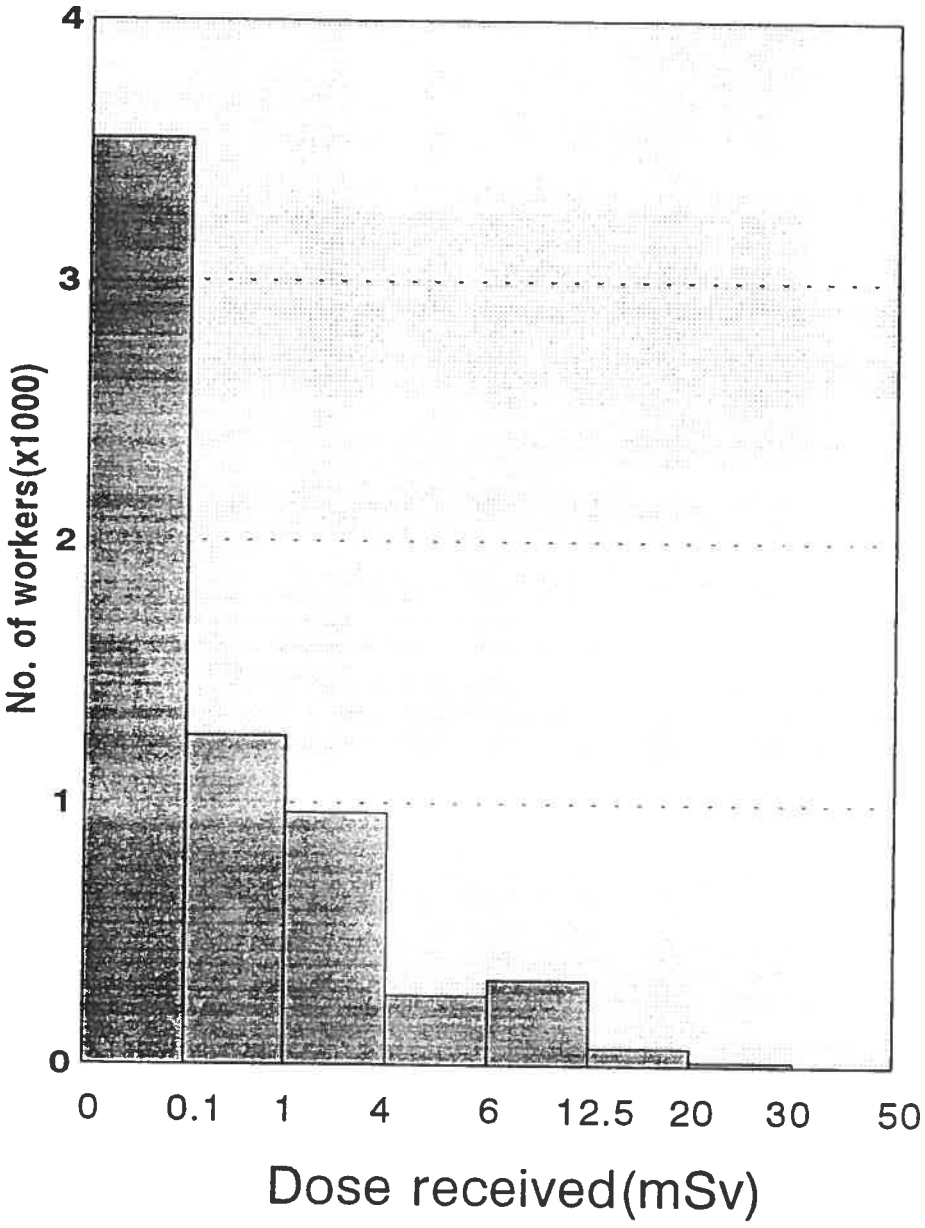

Fig. 2 Distribution of doses among workers at the nine nuclear power units in Korea in 1991.

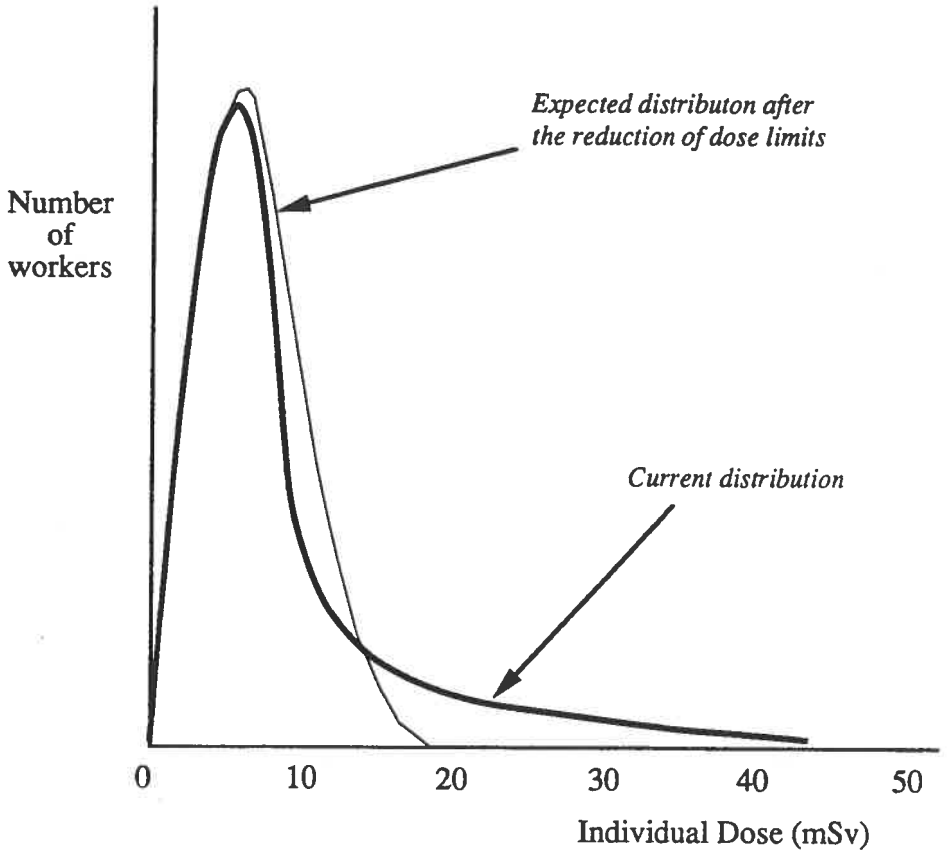

Fig. 3 Effect of reduction of dose limits on distribution of occupational doses. A significant reduction of collective dose is hardly expected.