POSITION PAPER

Implementation of reasonable optimisation in the Radiological Protection System

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Optimisation is one of the leading principles of radiation protection since decades and it has resulted in significant reductions of both collective and invididual radiation doses in the nuclear installations. However, there is a need for complementary guidance which should focus on the current challenges in the nuclear industry:

- *How to promote reasonable optimisation while avoiding undue minimisation in the low dose and low dose rate situations.*
- *How to implement optimisation in various practical planned exposure situations.*

Introduction

The ICRP has started the process of preparing a review of the ICRP system of radiation protection. The intended aim is to approve, by 2029, a new set of fundamental recommendations on radiological protection.

ENISS member organisations represent some of the “end users” of the radiation protection (RP) system, i.e. those who apply the RP system into practice within the operation of their nuclear facilities. Regarding optimisation of radiation exposure, the nuclear industry typically faces the questions, how to apply the principle of “As Low As Reasonably Achievable” (ALARA) in practice and how to ensure that the RP is optimised. These questions are posed by the authorities, by the operators (license holders), by the workers, and by the public. This paper is focused on the occupational radiation exposure at, and the radioactive releases from, nuclear facilities during their lifecycle in planned exposure situations.

The RP system developed by the ICRP has been deployed globally and has been very successful over the past decades in substantially reducing occupational and public exposures worldwide. Since its introduction, the optimisation principle has been central in achieving the ambition to lower the exposures. However, the question raised now by many RP practitioners is whether it has been “too” successful and, whether there are limits in the application of the optimisation principle.

Optimisation versus minimisation

Reducing radiation exposure has been a central element in the RP system from very early times. Regarding optimisation in radiation protection, a central milestone was the ICRP publication 26 [1], issued in 1977, in which the ALARA principle was introduced, and the cost-benefit analysis was promoted as a quantitative decision-aiding technique to achieve the optimum. In spite of the challenges, e.g. in defining the applicable monetary value of dose, the concept of optimisation was relatively straightforward. The optimum is searched for between various options, whose harm or cost (including radiation doses expressed using the monetary value of the collective dose) is balanced with the benefit achieved from the operations causing radiation exposure. It is to be borne in mind that in the 1970’s, the occupational radiation exposure at nuclear facilities was significantly higher than nowadays. The trends in annual values are shown in Figure 1 [2].

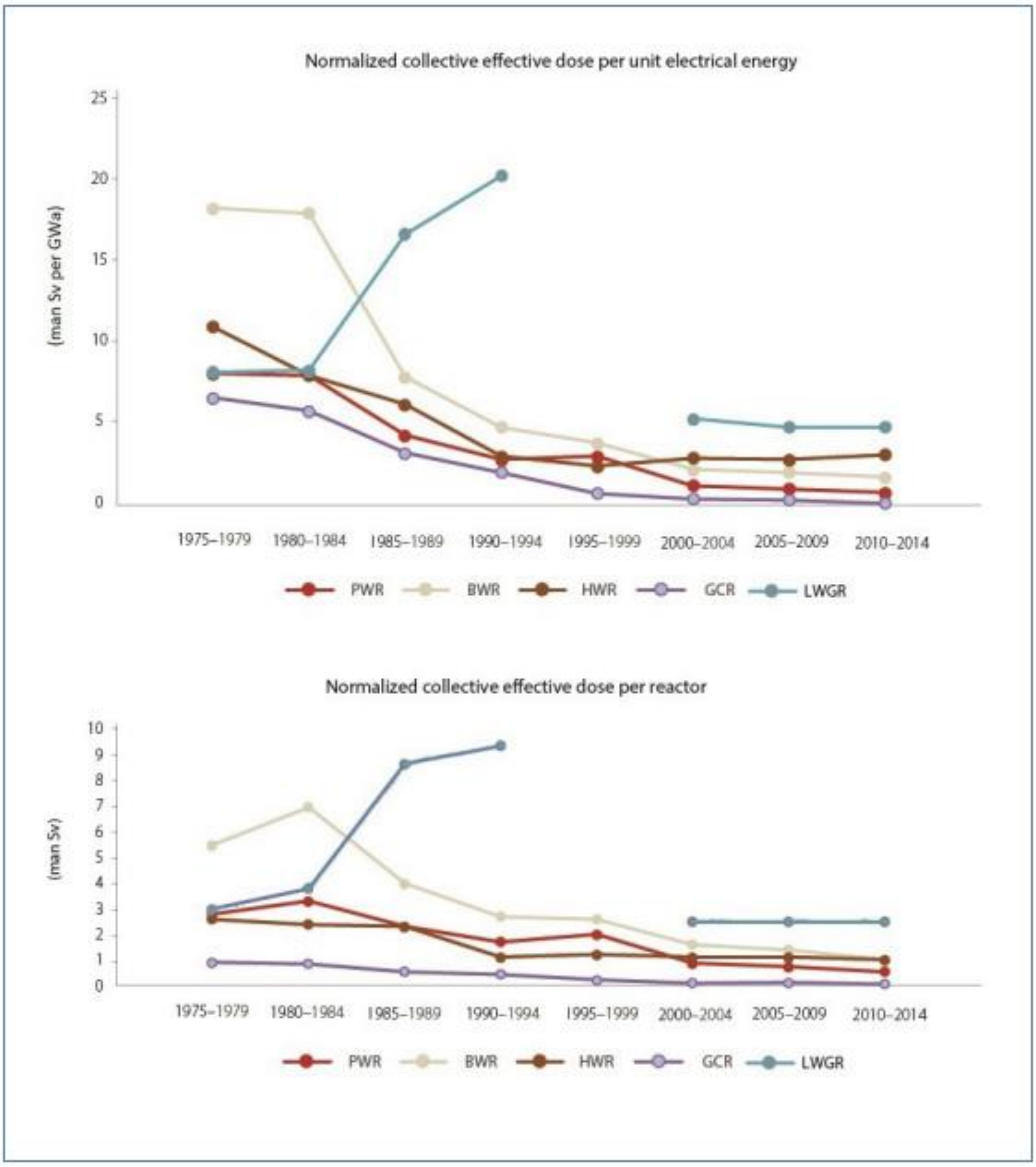

Figure 1. Worldwide trends in average annual collective effective dose due to reactor operation, and in normalized average annual collective effective dose per unit electrical energy and per reactor [2]. *PWR: Pressurized water reactor; BWR: Boiling water reactors; HWR: Heavy water reactor; GCR: Gas-cooled reactors; LWGR: Light-water-cooled, graphite-moderated reactor.*

Nowadays, the doses in planned exposure situations are in general very low. In the nuclear fuel cycle the average annual individual effective dose to monitored workers is around 0.6 mSv (2014) [2]. Still, laypeople are anxious about radiation, especially in the field of nuclear energy, which has negative consequences for both the industry and the society. The desire among regulators in a non-negligible number of countries to further reduce already very low doses (in comparison with natural background) by requesting continuous optimisation has implications, on the industry and also on risk communication and perception. The pressure on operational RP management is then to reduce exposures far below natural background values in some areas, with no significant net benefit for human health, safety or allocation of resources. This tendency towards an approach of minimisation of exposure in many situations has also been discussed by others, e.g. IRPA [3].

One of the objectives for future recommendations [4] should be to provide clear and well-defined guidance for ending unreasonable minimisation in the name of optimisation in some planned exposure situations.

Implementation of optimisation

One of the objectives for future recommendations [4] should also be to focus more on categories of workers in planned exposure situations for which doses are the highest to reinforce the equity value associated to the optimisation process. In the nuclear industry, the average occupational individual dose for planned exposure situations is generally very low [5] [6] [2], as mentioned previously, but some deviation among worker doses still remain. For example, some categories of workers, especially those with specific skills, are more likely to receive higher doses than others. For nuclear power plants (NPP), this is especially the case for workers involved in maintenance tasks linked to for instance automation and electrical systems; insulation; pipes; non-destructive controls; logistics; mechanics; valves; cleaning; RP. These special works often represent a large fraction of the total collective dose of an NPP. For example, in France 2021, the average individual effective dose in the nuclear sector ranged from 3.6 mSv for mobile radiographic measurement operators, 3.5 mSv for plumbers, 3.1 mSv for scaffolders, 2.2 mSv for pipefitters, 2 mSv for welders to 0.6 mSv for decontamination operators [7].

Another important point regarding optimisation of low, and especially, very low doses, is to keep the optimisation process proportionate to the level of doses or risks (graded approach). As the reduction potential of very low doses is low in essence, a formal optimisation procedure may often be inherently non optimal. This issue is referred to by the ICRP in publication 101b [8] as follows: “The optimisation process should be as elaborate as necessary to address a given situation. A graded approach is needed to take into account both the level of exposure and the complexity involved.” Also, e. g. IRPA has paid attention to the same issue [3].

Dose constraints and dose reference levels are often misused as “limits” and therefore further clarifications on the use of those concepts would be welcome, in order to avoid inconsistency or misunderstanding in the interpretation and implementation of the concepts. An illustrative example for which further guidance should be elaborated is the use of the optimisation principle and dose constraints in the control of routine discharges to air and water from nuclear installations, since the resulting doses are most often too low to be included as a criterion in an optimisation process.

Nowadays, the discussion about tolerability and reasonableness seems to a great extent to be focused on individual doses. Also, the dose constraints are almost exclusively set for individual doses, following the model of tolerability of risk (see annex). However, the optimisation, at least in its original form, was to a greater extent based on the collective doses [1] [8] [9] [10], which, due to the linearity of the LNT hypothesis, was considered to measure the risk as a consequence of radiation exposure. Individual doses or their distributions have been included in optimisation models e.g. with beta terms describing an aversion to high individual doses, thus resulting in an individual-dose-dependent “cost” for exposure. The implementation of such a model is, however, not always very practical in the operational RP and not always applied in the way described in ICRP 101b [8]. Therefore, guidance on how to optimise with regard to individual doses would be needed, and also how to take both the individual doses and collective doses into account. For example, quantitative decision-aiding techniques – such as cost-benefit analyses – are according to the ICRP Publication 103 [11] still essential, but the cost due to radiation exposure has typically been expressed as a monetary value of the collective dose only.

Another objective for future recommendations should be a more comprehensive approach concerning implementation of optimisation in the different stages of a facility life cycle, since the means, possibilities and goals of optimisation are different in various stages, especially between on the one hand design and on the other hand operation and decommissioning. For example, in the design and construction phase, some prerequisites for the radiation protection are created, which are difficult to be modified during the operation of a facility. The permanent shielding (such as wall thickness, labyrinth structures, remote-controlled operations) as well as the ventilation, control and measurement systems and layout of the equipment are to a great extent fixed in the design phase and thus, there could already be “optimisation by design”, which is an important feature. During the operation, including planned outages, the optimisation is focused on particular work tasks and procedures, which are carried out under the prerequisites created in the design. The last phase of the lifecycle of a nuclear facility is decommissioning, and the previous phases (design and operation) should not unduly hamper the optimisation in radiation protection during the decommissioning.

Communication and stakeholder involvement

There is a long communication and information chain from the scientific research on the effects of radiation on health, via the ICRP recommendations to the practical implementation of RP at nuclear facilities, and to the perception of RP in the society. The experience has shown that the message does not always go through this chain without distortions. Even though the ICRP does not promote minimisation, the term “minimisation” occurs frequently in both professional and public communication.

Wordings and formulations like “minimisation” or “as low as possible” at any stage of the communication adds to the misrepresentation, and therefore they should be avoided and replaced by “optimisation”, “as low as reasonably practicable”, “considering the factors…” or equivalent.

Due to the long and sometimes distorted communication chain mentioned above, we appreciate the initiative from the ICRP to involve stakeholders (e.g. regulators, safety authorities and operators) during the process of elaborating the new recommendations. We believe that the ICRP needs to take into account the specifics (e.g. RP concerns and factual situation) that the nuclear sector has in comparison to some other sectors. For example, as the optimisation in general terms within the nuclear sector is already on a rather advanced level, the focus should be on justification of changes to the current system and analysis of their consequences.

Conclusion

Optimisation is one of the leading principles of radiation protection since decades and it has resulted in significant reductions of both collective and individual radiation doses in the nuclear installations. However, at the same time, the continuous strive to further decrease radiation doses, sometimes included in the legislative system, poses a risk of going beyond the optimum and requiring undue resources without significant improvement to the protection of workers and public. Furthermore, it challenges the communication to both the authorities and the public, in particular when, for a justified reason, the radiation doses may deviate from the decreasing trend. Therefore, it is important to emphasize the message that optimisation is not minimisation, as well as to have practical guidance to implement optimisation in the context of low doses.

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Annex - The model of tolerability of risk [9].