BALANCING NUCLEAR SAFETY AND WORKER PROTECTION REQUIREMENTS: A NEW CHALLENGE IN THE APPLICATION OF RADIOLOGICAL PROTECTION PRINCIPLES

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Introduction

In recent years, accelerated efforts in nuclear safety to minimise the potential frequency and consequences of accidents that could impact on the public have resulted in additional requirements affecting the design and operation of nuclear installations. These included in-service inspection, increased preventive maintenance on sensitive equipment, revised safety specifications necessitating equipment modification and backfit, and unscheduled special maintenance programmes. These requirements, formulated by designers and operators or imposed by regulatory authorities, involve exposing personnel to radiation doses which are additional to those originally expected to be associated with the normal running of the plants.

The trade-off to this is represented by a decrease of the potential exposure of the public, and possibly the workers, due to the possible decrease of the probabilities of accidents and/or the projected doses associated with these accidents. It is to be noted, however, that this decrease applies to an exposure of the public which is virtual rather than real.

There is a growing feeling among experts that this situation seems to show an imbalance, not only in the actual level of risk attributed to two different groups of people (workers and population), but also in the response to two different requirements (safety of plants and protection of workers) which both have a regulatory value. The result could be, in some cases, a deterioration, rather than an improvement, of the overall level of radiological protection associated with nuclear facilities.

One of the contributing factors to this imbalance may be the fact that many safety requirements appear to be established in isolation from the global context mentioned above, and do not seem to be based on an explicit analysis of the justification for the increase of radiation detriment to workers generated by the safety-related requirements in connection with their safety-related benefits, which may be expressed in terms of lower risk to the public and, under some circonstances, to the workers.

There is, therefore, a need for a rational approach which allows the finding of the optimum balance between the requirements of nuclear safety and those of radiological protection. In order to achieve such a result, there is a need to establish a dialogue between radiological protection experts and nuclear safety engineers for the purpose of developing a common language and methodological approach to the optimisation of safety.

For this purpose, the Committee on Radiation Protection and Public Health of the NEA set up, in 1982, a Group of Experts entrusted with the task of reviewing available data on occupational exposure in the nuclear industry, identifying those aspects which involve problems of balancing nuclear safety and radiological protection requirements, and discussing possible approaches and methodologies for the determination of an optimum balance. The work of the Expert Group is far from complete, and its concepts are still in the course of development. However, some preliminary considerations can be made on this work.

Occupational Exposure Implications

Undoubtedly, there appears to be a lack of published data on worker doses associated specifically with nuclear safety-related operations and on expected doses resulting from plant backfitting. It is, therefore, difficult to analyse these safety-related actions with respect to their dosimetric implications. Nevertheless, the few data available, almost entirely referred to nuclear power plants, seem to suggest that there are cases in which an imbalance is produced between the implementation of nuclear safety requirements and the corresponding levels of protection of workers. There is, therefore, scope for improvements in this area.

Such an improvement, however, should be sought through the search for an optimisation of the overall level of protection of the whole community represented by the workers and the public.

This provides an incentive to establish a generic methodology to define whether the nuclear safety-related dose expenditures are optimised, in the ICRP ALARA sense, and whether the increase in public safety, or other benefits thus achieved, warrant the resulting increase in occupational risk. The answer has specific implications for the required extent and methods of in-service inspection and maintenance, and the degree to which additional design efforts may be needed in catering for this facet of nuclear safety.

Also, although the ICRP system of dose limitation, of which optimisation is a part, has been initially applied explicitly only to the case of sources under control (normal conditions of operation), there are increasing indications that the protection of people should be optimised in all the aspects of the performance of a given practice, including those involving events of a stochastic nature, such as the accidents.

Conceptual Approach to an Optimised Balance

The Expert Group is studying a tentative conceptual approach to this optimisation, which is similar to the cost-benefit analysis approach suggested by the ICRP for the application of the principle of optimisation of protection.

The relevant parameters for the definition of the suggested balance approach are financial costs required for the implementation of safety measures, potential financial losses associated with nuclear accidents, collective doses to workers due to safety-

related activities, potential collective doses to workers and the public saved through the decrease of accident probability and/or mitigation of their consequence due to the implementation of safety measures.

However, the application of this balance involves two orders of problems. One is the question of the balance between workers and population detriment in the application of the optimisation process. The other, more complex problem is the fact that to evaluate detriments in the case of probabilistic events it is necessary to consider not only the magnitude and distribution of doses that may arise from these events, but also their probabilities of occurrence.

The question of balance between workers and population detriment in the optimisation procedure can be dealt with, for example, in the framework of the methodology suggested in ICRP Publication 37. In particular, with reference to the equation of the cost of detriment given in that publication (ICRP Pub. 37, paragraph 87), the same value of α could be applied to the collective doses to workers and the public, ignoring possible minor differences in the objective health detriment per unit collective dose between workers and the public. On the contrary, both the value of β and the form of the function $f_j(H_j)$ in the "β term" of the equation can be expected to be different for the two groups of people. This is due to the different degress of voluntariness in the acceptation of risk and the different levels and types of risk perception in the two groups.

As far as the other question of the treatment of probabilistic events in optimisation is concerned, the only possible solution seems to be the shift from the concepts of dose and detriment to the concept of risk, defined here as the probability of a health-effect for an individual. It is to be recognised that the risk associated with a given event is, in fact, a combination of the probability of this event and that of its potential consequences. This can be expressed as the product of the probability of people receiving a given dose and the probability of detrimental health effects associated with that dose.

The use of the concept of risk in an optimisation process taking into account the whole spectrum of accidents potentially associated with a nuclear plant, requires the assessment and the costing of the total collective risk associated with this spectrum of accidents. A combination of probabilities and consequences for this purpose, based purely on the product of these quantities, would give an "expectation value" of the objective collective risk. This may be a too simplistic view of the total collective detriment, when a large spectrum of probabilities and consequences is involved. The response of people and decision makers to accidents having different consequences is, in fact, different and not necessarily linearly related to their probabilities. It would be necessary, therefore, to introduce in the calculation of the total collective risk appropriate subjective factors giving a variable weight to different consequences in relation to their probabilities of occurrence. Only then would it be possible to assign a cost to the total collective risk and balance it against the costs of protection and prevention.

In the specific case which is the object of the present study, the various issues mentioned above are complicated by the fact that a part of the risk - that to the workers - is associated with a real dose and is therefore represented by a "risk of the first order" of stochasticity, namely the risk of health effects due to the dose actually received. On the other hand, the part of risk which concerns the public in connection with the accidents is only associated with a potential dose, that is it corresponds to a "risk of the second order" of stochasticity.

Conclusions

The degree of quantification of the parameters involved is far from being satisfactory at present. In order to overcome this difficulty, an organised data base correlating measured occupational doses with specific nuclear safety-related measures and activities and their monetary costs should be set up. Moreover, objective calculations of the occupational and public risk variations resulting from the past or present introduction of safety-related measures and procedures should be carried out.

An additional difficulty of a less technical nature, which can complicate or delay the already technically difficult solution of this issue, is the concern expressed by the nuclear operators, designers and safety specialists about the methodological complications associated with the introduction of a further constraint, represented by the requirement of optimisation, into their decision-making process.

The task assigned to the NEA Expert Group is obviously very difficult and the state of scientific and technical development, as well as that of doctrine and policy are probably not mature yet for the solution of this complex issue. However, the debate among nuclear safety and radiological protection experts is now actively engaged, and this represents in itself a successful achievement. The future will tell us which will be the outcome of these efforts.