

Differences in regulatory criteria for the long-term safety of radioactive waste disposal

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Internationally, underground disposal of certain long-lived radioactive wastes such as spent nuclear fuel and high-level radioactive waste is the most widely accepted approach to ensure confidence about the long-term protection of future societies. Regulatory acceptance criteria, and in particular radiological protection criteria for humans and the environment over long timescales, are a prerequisite to the realisation of any underground repository for these long-lived wastes. A number of countries have established such regulatory criteria, while others are now discussing what constitutes a proper regulatory test and suitable time frame for ensuring the safety of long-term disposal.

Current regulatory criteria are meant to ensure protection and safety for periods of time that are exceptionally long. Because of differences in attitudes towards safety and the methods by which protection is established and ensured in different societies, it is not surprising that national differences exist among these criteria. On the other hand, it has been recognised for many years now that national differences in criteria may make it difficult to establish the necessary levels of acceptance of national repository proposals. It is thus important that the differences can be understood and explained.

Under the auspices of the NEA Radioactive Waste Management Committee (RWMC), two initiatives were undertaken to study and compare the ways in which a suitable level of confidence is attained in different countries. One of these is the Timescales initiative of the Integration Group on the Safety Case (IGSC), which focuses on the technical arguments by which safety is demonstrated over the long timescales involved. The other is the RWMC Regulators Forum's Long-term Safety Criteria (LTSC) initiative, which looks at the bases of current long-term safety regulation and their applicability. Although these two initiatives deal with different aspects of the demonstration of safety, there is considerable overlap and convergence of the results achieved to date.

When the RWMC Regulators Forum was formed in 1999, one of its first tasks was to review the arrangements in member countries for regulating radioactive waste management. This work resulted in a comparative study of regulatory structures in member countries¹. Part of the work leading to this comparative study was a review of the long-term radiological protection criteria for disposal of long-lived waste, and an examination of their consistency across countries. After this initial comparison, which revealed a broad range of differing criteria and practices, a follow-up initiative on Long-term Safety Criteria was undertaken. The objective of this ongoing initiative is neither to set nor to judge existing standards, but rather to study the criteria used by various member countries and to provide a forum for discussion. Ultimately, it is hoped that this will help provide guidance and information to those programmes still developing

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criteria, and assist national programmes in communicating the context and meaning of regulatory standards for long-term disposal.

How regulatory criteria differ

Although regulatory criteria for long-term safety normally address several aspects related to safety and protection, the focus of the group's work was initially on radiological (dose and/or risk) criteria. The group found significant numerical differences among the criteria, ranging over roughly two orders of magnitude. The differences are due, in some part, to concrete differences in technical factors such as geology and engineering approaches to both design and performance assessment. These technical differences appear to be greatly overshadowed, however, by differences of a more cultural nature, namely differing attitudes towards the questions of establishing and interpreting safety-related targets, criteria and margins of safety. These cultural differences are reflected in differences in the choice of appropriate indicators for protection in the long term, differences in the ways numerical criteria are applied, and different expectations regarding the desired level of confidence in the calculations. Regardless of these differences, the criteria used in all countries are well below levels at which actual effects of radiological exposure could be observed either directly or statistically.

The LTSC group found that the fundamental bases for long-term radiological protection criteria vary among member countries, with at least three differing approaches observed. Of these approaches, two are based on radiological dose criteria, with one approach using criteria derived from the dose limits and constraints that are used for current practices, and the other approach using criteria derived from arguments related to naturally-occurring levels of background radiation. The third approach rests directly upon the concept of acceptable levels of risk, without direct reference to radiological dose criteria. Of course, these three fundamental approaches are interrelated, and combinations of them are often used.

In addition to differences at the level of fundamental bases for the criteria, the group also observed the existence of several other factors that lead to differences in numerical criteria among countries. For example, in some cases current dose-constraint criteria are adopted directly, whereas in others the criteria are reduced by an additional factor which may reflect either the possibility of the existence of multiple sources of exposure as time elapses or increasing uncertainties in the calculations at more distant times. Criteria based on background-dose rates may either rest on direct comparisons to

existing, natural dose rates, or on comparisons to the observed variability in those dose rates. When risk criteria are used, the calculations are used to produce an aggregated risk number in some cases while, in others cases, the probabilities and consequences are left disaggregated.

It is generally recognised that the outcomes of calculations of radiological doses received by future populations are best regarded not as predictions of actual impacts, but rather as somewhat stylised performance indicators. However, when used as the basis for regulatory decision making, in some cases the regulatory criteria are used as limits in much the same way as they are used for current practices. In other cases, the regulatory criteria are used as targets rather than as firm limits.

From the point of view of implementing those criteria and decision making, differences also exist at a less explicit and, therefore, less obvious level. Thus, even when similar computational models are used, the assumptions and data that are used in these models may vary depending on whether the calculations are viewed – by choice or regulatory demand – as “best-estimate” calculations of future impacts, as “conservative” safety analyses for licensing, or as attempts to provide an upper bound on the possible consequences. These differences in the expected or intended role of the analyses are often accompanied by differences in the treatment of uncertainties in data, models and numerical techniques.

For all of these reasons, a simple numerical comparison of criteria listed in a table can be highly misleading, if not meaningless, in order to compare required levels of safety. In its ongoing work, the LTSC group has therefore focused on some of the more fundamental reasons behind the differences among national criteria for long-term safety of radioactive waste, rather than on the numerical criteria themselves.

Some deeper reasons for the apparent discrepancy

While considering the underlying reasons for the current differences in criteria, the LTSC group's investigations identified a number of important contributing factors, among them the complexity and non-uniformity of the regulatory decision-making process, a lack of consensus on how to characterise and measure protection in the distant future, and fundamental ethical issues related to the nature of current society's obligations to the future. Discussion of these factors led to consideration of such matters as the role of the regulator, the meaning of safety and protection, building confidence in decision making,

and ethical issues related to the means by which fairness to future generations should be provided.

The disposal of long-lived radioactive waste differs in significant ways from most practices involving radioactive materials in that by design the impacts are unlikely to become apparent until far into the future, if at all. Therefore, regulatory follow-up after granting a disposal licence, in order to see that the desired long-term effects are being achieved, is effectively impossible over the full design life of the disposal system. This means that an important conventional component for ensuring continued safety is unavailable to regulatory bodies, at least over the majority of the design life of the facility, namely the ability to monitor for non-compliance and take corrective action. Hence an important difference between countries is a result of different views on the meaning of safety in the absence of monitoring and direct control. Safety, as understood technically, is the absence of (or reduced potential for) physical harm resulting from the existence and operation of the system over a given period of time. Harm, in turn, is an impact that is judged, within a social and temporal context, to be unacceptable. Criteria for defining acceptability normally involve value judgments and can change with the context. This judgment may vary from one country to another, and also change with time within a given country. This poses problems for those who are charged with defining criteria to be applied to a repository whose design lifetime is expected to considerably exceed the duration of recorded human history and where contexts may vary greatly.

Any consideration of long-term safety criteria for disposal of radioactive waste inevitably raises questions of intergenerational equity – waste is generated today, beneficiaries are today's consumers of energy, but the waste can potentially impact future generations for a very long time. Initially, the most widely-adopted approach to the ethical question of intergenerational equity was based on the principle, simply stated, that the impacts of actions carried out in the present on future generations should not exceed the levels of impact that are considered acceptable today. More recently, however, thinking with respect to intergenerational equity recognises that as the time frame becomes longer, our ability to guarantee that current limits will be met to an acceptable level of confidence diminishes because of uncertainties not only in the physical and engineering models, but also and more significantly in our ability to predict and influence the behaviour, needs and aspirations of future populations many generations removed from us. In addition, and

especially taking current trends towards reversibility and stepwise decision making into account, it is increasingly recognised that the impacts of the present generation's actions on the distant future are likely to be modified by the actions of our more immediate successors.

Current thinking about these ethical obligations is evolving, and such ethical considerations are another factor contributing to differences in national criteria for long-term protection. This is particularly evident when comparing the approaches in different countries to the question of time limits or cut-offs to the application of regulatory criteria, and/or to the use of criteria which depend on the timescale.

Conclusions

Since the granting of a licence for definitive disposal of long-lived waste and closure of a repository involves the ultimate absence of the element of active control, the design objective is passive safety without the requirement for further intervention. This represents a fundamental difference between the regulation of present-day activities and the regulation of disposal. This fundamental difference is reflected to a greater or lesser extent in the regulatory processes and criteria adopted in each country.

The LTSC working group is continuing its investigations on this subject and, at the time of writing, was preparing to hold a workshop at the end of November in Paris. In addition to making the work done to date more widely and better known, it is hoped that points of agreement and points for further discussion will be identified during this workshop, so that a road map for future work may be proposed in support of regulators and policy makers who are currently charged with developing regulatory acceptance criteria for proposed repositories. ■

Note

1. See www.nea.fr/html/rwm/reports/2005/nea6041-regulatory-function.pdf.