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INTERPRETING RADIOLOGICAL PROTECTION PRINCIPLES AND CRITERIA FOR GEOLOGICAL DISPOSAL

Summary of a topical session held at the 43rd meeting of the RWMC, 24 March 2010

The work of the RWMC Regulators' Forum (www.nea.fr/rwm/regulator-forum.html) on regulation and safety criteria for geological disposal of radioactive wastes, which culminated in the Tokyo workshop of January 2009, has identified a number of issues concerning the application of the currently-available international guidance. It was thus felt important that the dialogue initiated in Tokyo should continue between the waste management practitioners and the radiation protection profession. A topical session was held at the RWMC meeting of March 2010. To better elicit and understand the various viewpoints, all speakers were asked to address four pre-identified questions. The discussion greatly benefitted from the participation in the topical session of Jacques Lochard, the Chair of ICRP Committee 4. The present summary captures the main points made by each speaker, the main points that emerged in the discussion, and includes the summary note provided by Jean-Paul Minon, who acted as the rapporteur of the topical session.

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13. INTERPRETING RADIOLOGICAL PROTECTION PRINCIPLES & CRITERIA FOR GEOLOGICAL DISPOSAL

Chair: Catherine Haney

Ms. Haney opened the Topical Session by recapitulating the key features in this context from previous ICRP documents: ICRP-60, ICRP-77, ICRP-81, ICRP-101 ad ICRP-103. She then invited all speakers to address the following questions:

First question:

- Meaning of "dose"
- Connection to health detriment; does it matter that it is "potential dose"?
- Potential effective dose is a risk indicator. Do regulators make this distinction?

Second question:

- What defines the level of protection (redundancy and diversity, surveillance, controls, …) achievable for the current generation?
- Is the "same level of protection" for future generations an (unattainable) principle or a fact?

Third question:

- Optimization – what does the concept mean for the long term

Fourth question:

- Are criteria needed as part of the protection approach? Value of defining dose limits (or risk limits)?

a. The position of the RF

Georg Arens

Mr. Arens described a questionnaire that had been distributed to Regulators Forum members, based on a discussion that had taken place at the Tokyo Workshop. The responses to the questionnaire revealed that while there is general agreement on some of the fundamental issues (see below), there was a considerable range of differences in application.

There was general agreement that calculated doses are effective doses, which are, in the long term, a measure only of potential effects under assumed conditions and therefore not a direct indicator of health effects. Some regulators do treat calculated doses as a fairly direct measure of future health risk, whereas others consider that in the long term they provide only a context, or an indicator that needs to be supplemented by other indicators.

There was also general agreement with the general principle of equal protection for future generations. However, in some countries this was treated as demonstrating that current criteria will be met in the long term, whereas in others it was considered that this is unattainable in the far future, and that we must rely on optimisation as a requirement. There were also diverging opinions on the role of institutional controls.

Optimisation was interpreted in a variety of ways, ranging from optimisation of

radiological protection (against exposure) to balancing calculated exposures against other measures of acceptability. There was also variation in the approach to numerical criteria in the long term ('hard' acceptance criteria vs. indicators used to inform the optimisation process; no change with time vs. time cut-offs after which numerical compliance is no longer required). There were differing views on how a dose or risk 'constraint' in the long term should be interpreted, given that no 'control' of exposure can be assumed in that timeframe.

Several questions were identified for dialogue with the ICRP:

- Are calculated consequences (effective dose/risk) relevant indicators of health detriment for the long term? Yes/No
- Does "potential dose" mean the same thing as "potential exposure" for ICRP?
- Is potential dose only a system performance indicator? Does potential exposure have the same meaning for long and short term?
- Is it appropriate to assign different weight to dose estimates for the long term as compared to the short term (e.g., hard ⇨ soft criteria)? If so, why?
- Should dose/risk criteria be combined with additional indicators expressing the reliability of the calculated consequences? Do dose constraints for the very long term have the same meaning as for current situations for planning a nuclear facility?
- How does optimisation relate to compliance with the dose/risk criteria? What is optimisation of protection against "future doses"? Increase of system reliability as optimisation goal?
- Is there a relationship (and if so, what is it?) between the timescale for optimisation of long-term safety and the period of time where reliable assessment can be performed?

b. The position of the IGSC
Hiroyuki Umeki

Mr. Umeki gave a presentation on responses to the four questions from some members of the IGSC.

Almost universally, the term "dose" today implies "effective dose" or "committed effective dose". It seems now widely recognised that "dose" in the context of post-closure safety assessment for geological disposal does not refer to real radiological effects, but is a quantitative indicator of safety of the system either in the absolute within an agreed assessment process, or as a quantity to use for identifying the more robust solutions. Only if monitoring of pathways and receptors is in operation can dose be considered a direct indicator of health detriment. Thereafter, dose is not directly connected to health detriment and would better be referred to by another phrase. However, in safety assessment, "dose" and "effective dose" are the normal terms. This distinction has also not been made (or required) by regulators.

With respect to the level of protection achievable in the near term, while the repository is still in operation or for some time after closure, there will be benefits from additional protection measures that will not apply to later generations: surveillance, controls, monitoring, records keeping, safeguards, etc. However, these protection measures do not necessarily imply higher safety.

The principle of equal protection is one by which the current generation can specify safety requirements on long-term system performance, i.e. it is the ethical basis for a safety goal. This principle will most likely be fulfilled during the period of predictability of the repository; it may or may not be attained thereafter. For future generations, safety criteria may be best considered attributes for an optimisation process, rather than quantitative criteria against which compliance must be demonstrated.

The term optimization should be used for holistic optimized system design, recognising the need for trade-offs or balancing between conflicting requirements (e.g. long-term and operational safety, practicality, socioeconomic and environmental impacts, etc.) In this regard, optimization involves a much wider perspective than radiation protection alone and, indeed, may run against reduction of doses according to the ALARA principle, which is mostly applicable for contemporaneous facilities.

Criteria are needed to define safety goals agreed by society. These criteria need to take into account the different levels of system predictability in time. The criteria would be used during system optimisation, e.g., through internal provision of safety margins.

c. Current position in ICRP
Jacques Lochard

Mr. Lochard gave a presentation of the ICRP viewpoint on interpreting radiological protection principles and criteria for geological disposal. Radiation protection is based on a combination of science, values and experience. Detriment is an indicator of risk, whereas effective dose is an indicator of exposure. The construction of both indicators requires the application of inferences, judgments and values. These have been developed for current conditions and values, and can be expected to change over time.

The key evolution from ICRP-60 to ICRP-103 has been the abandonment of the distinction between practices and interventions, which has been replaced by recognition of three types of exposure situations: planned, emergency and existing. The basic principles of justification, optimization and limitation of exposure apply to all three situations, but with different suggested criteria.

It is impossible to define a priori how the detriment (which involves knowledge of the effects of radiation and the average health status of the population), the values (precaution, equity and tolerability), and the source term (the technical system and its environment) will evolve in the long term. The only feasible approach in applying the current system of radiation protection is to assume that control will be maintained, regularly re-evaluated and adapted as necessary, and then refer to the present principles and criteria. Optimization of protection for future exposure is based on the present dosimetric criteria (individual and collective) to ensure intergenerational equity. In case of loss of control in the future, the situation would fall into the "existing exposure" category, and the objective will be to optimize the protection with a reference level between 1 and 20 mSv.

An ICRP Task Group has been formed to prepare a new ICRP publication that will describe how the recommendations of ICRP 103 apply to the geological disposal of long-lived solid radioactive waste. This publication will update and replace ICRP-77 and ICRP-81.

d. A Country Example: The UK perspective
Robert Smith, UKEA

Mr. Smith described the perspective of the UK regulatory agency to the use of dose and risk in post-closure safety assessments. He pointed out that the fact that a dose is not certain to be received matters a great deal to the UK regulators. The regulators expect to receive environmental safety cases that include risk assessments that take into account: the magnitude of the potential effective dose, the probability of that dose being received and the probability that, if the dose is received, it will lead to harm.

With respect to the level of protection that should be provided, it is expected that the use of Best Available Techniques will lead to the provision of measures such as redundancy, diversity, surveillance, controls, etc., which will normally lead to effective doses that are substantially less than the applicable national and international standards. However, the UK regulators consider that a requirement to provide the same level of protection for future and present generations is unrealistic. We know what level of dose is being delivered to the present generation because we can monitor it. We cannot know with certainty what level of dose will be delivered to future generations because the future is intrinsically uncertain; all we can do is perform assessments. This point of view is reflected in ICRP-103: "*In case of exposures taking place far in the future, additional uncertainties are involved. Thus dose estimates should not be regarded as measures of health detriment beyond times of around several hundreds of years into the future. Rather they represent indicators of the protection afforded by the disposal system*."

UK regulators define dose limits to protect the present generation. "Because the future is intrinsically uncertain, we think that applying risk limits to protect future generations is meaningless". Compliance with any limits that might be applied to an assessment of future risk (or dose) is only as rigorous as the assumptions made in the assessment. For this reason, a Risk Guidance Level has been put forward against which risk assessments can be judged to determine whether future generations are adequately protected.

e. Panel-led discussion
Catherine Haney

The ensuing discussion was mostly a dialogue between committee members and Mr. J. Lochard on each of the four questions taken one by one.

On the first question: Mr. Lochard observed that (a) effective dose is an operational concept for an average situation for an average person. This gives operators a yardstick. Considerations of risk and health are only indirect. (b) The ICRP system of protection is meant for contemporaneous situations ("for the time being"): three generations living together. If you make the assumption that everything stays the same then you can use still use it for the future, but it is full speculation. The science base would be lost. (c) In ICRP-103, potential dose is only 2 paragraphs. It was introduced many years ago to introduce the dimension of probability. ICRP should look at this concept and decide what to do with it, because it is difficult to manage and put to use. It may have meaning in that we enter into the realm of probability and it may be useful for design, not for protecting people. (d) For more clarity about protecting people, other quantities than dose could be used, e.g., Becquerels. [on points (c) and (d) it was observed by the audience that indeed we cannot use dose in the absolute for a design but only in a comparative fashion and that in Finland

the regulator does resort to other concepts such as radionuclide concentrations and fluxes].

In the ensuing discussion, Mr. Lochard observed that the fundamental question is perhaps "is the RP system good for disposal?" Unfortunately the RP system cannot answer the question of what would be acceptable in the future. RP is about NOW, and in order to apply it integrally we have to assume that the present continues as it is. On the other hand: what else would one use?

It was observed by others that even if the current approach is imperfect, is it not much better than nothing? Also, a numerical argument is always needed as a reference, including by the general public. For safety purposes we must anyway show that we understand the system: good models to simulate the future. Dose could then be used in many ways, as other calculated values. Dose has the advantage of being an integrated value.

On the second question: Concerning the question of "the same level of protection" in the future, Mr. Lochard started by observing that (a) If you are planning to keep control you have 1 mSv; (b) If there will be a loss of control in the future then you may have 1 to 10 mSv/yr; (c) for emergency situations you should look at doses less than 100 mSv. However, it was replied by others that, for disposal, the planned situation in the long term is no control, and planning for loss of control might be seen rather as a situation of unrestricted release. Mr. Lochard observed then that "Because you are planning the situation, the source is under control. So you can use the control approach of the ICRP." It may sound as a special definition of control, but "this is the understanding". He then concluded that the significance of "control" should be perhaps the subject of the round table discussion next year. "In any event, even if you decide to walk away from a repository it is not unrestricted release, but an existing situation."

On the third question (optimization): It was suggested that one should distinguish between optimising for safety and optimising for radiation protection. Mr. Lochard was non-committal on this point. He observed that, for optimisation, many types of technical and managerial aspects are required that will reduce exposures. So robustness is a good test of technical options. He also emphasises the "matrix approach" to collective dose.

There was insufficient time to discuss additional issues. Mr. Lochard thanked for the opportunity of dialogue and testing the ICRP system, and hoped that the dialogue would continue. The new ICRP Task Group will report to the RWMC; he would also report to the ICRP Committee 4 on the present meeting.

Ms. Haney concluded that two new questions should be added to those identified by the RF (Mr. Arens' presentation). These are:

1. How you define control?
2. For post closure stages, what else would be used if not dosimetric criteria?

f. Recap of views by rapporteur
Jean-Paul Minon

Mr. Minon began by reviewing the long-term safety functions for geological disposal: isolation, containment and retardation. These functions are assured not by active control measures at the time of the exposure, but by measures implemented in the design

to ensure the effectiveness, redundancy and robustness of both engineered and geological barriers. The demonstration of system performance is performed using calculations of impacts, notably radiological impacts, of postulated scenarios.

Regarding the first question, on the meaning of dose and its connection to health detriment, the calculated doses in design assessments are based on stylized models of transport and uptake of radionuclides, which in turn are based on potential scenarios of system evolution. Effective doses calculated in this way are useful as comparative criteria, but do not represent measures of actual health effects or of actual risks. The health status and lifestyles of future generations are unknown, and both knowledge about radiation and the values of society will also change with time. The risk as evaluated by a future generation will thus be different from the risk evaluated today, even for the same scenario. Therefore the effective doses calculated during design assessment do not give a direct measure of future health detriment, nor can they be considered to be quantitative measures of safety. This suggests that in addition to effective doses, other safety criteria more directly related to the physico-chemical evolution of the repository, such as radionuclide fluxes, should also be used.

Regarding the second question on the level of protection achieved for future generations, we begin by noting that the link between health detriment and dose constraints is indirect. Detriment is an indicator of risk to a population, whereas dose is a measure of individual exposure. Today's dose constraints have been derived for today's conditions and values and will not necessarily be applicable in the distant future. In this sense, the application of today's criteria does not guarantee the same level of protection in the future. In ICRP-103, the concept of existing exposure situations recognizes that each situation of radiological risk must be evaluated in the context of knowledge and values at the time the exposure is incurred. The level of protection as evaluated using today's models and criteria will not necessarily be the same as the level of protection as evaluated by future generations.

The only practicable approach is to use current principles and criteria on the assumption that control will be maintained and regularly re-evaluated and adapted as necessary. If control is lost, the situation becomes one of existing exposure, in which case the recommended protection level according to ICRP-103 is in the range of 1-20 mSv.

The third question related to optimization. Optimization is a process of system improvement through successive iterations. It applies to all aspects of system performance, not only to radiation protection performance. Optimization seeks to improve system performance and robustness, whereas the application of protection criteria represents a limitation of damage. Such a limitation may represent a constraint on the optimization process (e.g. an upper boundary on calculated consequences).

Optimization is carried out based on an assumption of control. The notion of passive safety, i.e. of system evolution constrained by the design features rather than by active control, is an essential part of the concept of repository safety and of optimization of the design. If the system evolved in such a way as to exceed the design constraints, future generations would be placed in a situation of existing exposure in which they were faced with the necessity of re-establishing control.

Regarding criteria, the use of criteria as limiting values is an essential part of the active control process to ensure safety of current operational activities and also to ensure

confidence in safety. These limiting values are well-defined, and the conditions of their application to current activities are clear. However, in the long term, when active control is progressively replaced by the provision of safety through passive design features, the notion of criteria and the way they are applied becomes less clear. Calculations of future consequences are essentially probabilistic in nature, and the results of these calculations cannot be considered as certain in the same sense as current operational exposures, and instead of being limiting values, the criteria may more appropriately be viewed as reference or guidance values.

Some questions still need to be addressed. One is the meaning of control: does control require feedback and active control, or is there such a thing as "control by design"? How does this relate to the planned vs. existing exposure situations in ICRP-103? Once a repository is closed and there is no longer a means of active control, are the applicable reference values in the 1-20 mSv/year range appropriate to an existing exposure situation, or the 0.3 mSv/year reference value for planned exposure situations?

g. Closing of the Topical Session
Catherine Haney

Catherine Haney closed the session by thanking all speakers. The way forward would be covered under Item 14.

14. WAY FORWARD ON IDENTIFIED ISSUES

Carmen Ruíz

Ms. Ruiz reviewed the historical background, including the long term safety criteria studies that have been performed by the Regulators Forum and that led up to the Topical Session. She noted that there is confusion or imprecision in terminology for fundamental concepts and proposed a roadmap for future work, as follows:

1. The report of this topical session should be finished in time to be distributed at the next ICRP task group meeting in April (NEA Secretariat)
2. The RF ought to refine its position based on the materials now gathered (RF Core Group)
3. The RWMC Bureau meeting would review the RF position document
4. An imporoved draft of the position document would be presented to the ICRP Task Group in the Autumn.
5. Continue dialogue with the ICRP at the 44th RWMC plenary meeting (March 2011), and establish contact and dialogue with EURATOM and the IAEA.

Decision by the Committee: This was an especially interesting topical session and dialogue, that took benefit of the participation of Jacques Lochard, the Chair of the ICRP Committee 4. The validity of the questions that were sent to the ICRP, with new questions also arising, namely on the meaning of "control", has been confirmed. As a way forward: 1. The record of the topical session will be provided to the ICRP task Group; 2. The RF Core Group will consider how to progress with work with its constituency; 3. A new dialogue opportunity will be organised at the next meeting of the RWMC, with the ICRP and the CRPPH plus IAEA and EC, the latter two in their roles as additional providers of international guidance.