Radiation Protection Culture in Waste Management

Workshop

From August 31st to September 1st the German-Swiss *Fachverband für Strahlenschutz* (**FS**) in cooperation with the *International Radiation Protection Association* (**IRPA**) called for a Workshop on the topic **«Radiation Protection Culture in Waste Management»**

Participants

Some 26 Experts from several European countries attended the meeting. This paper is a summary of the main conclusions of this workshop. It was divided into four groups:

A) *Dose reduction versus waste minimization;*
B) *Interim storage versus (final) disposal;*
C) *How to deal with safety culture deficiencies?*
D) *A common dose concept for clearance and release.*

Need for a solution

Radioactive Waste is mainly produced in Nuclear Power Plants (NPP), but – to a smaller amount – also in Medicine, Industries and Research (MIR). The producer of the waste – indirectly as consumers everybody of us – is responsible for its long term safe handling, disposal and storage. This has to be done in such a way and for a sufficiently long time, in order to avoid that radioactive material enters in contact with the biosphere and threatens humans and environment. The time schedule is in probably of the order of 10^5 year, at least until it has decreased to the radioactivity level of natural uranium ore. Nuclear reprocessing would reduce storage time by a factor of roughly 25, transmutation – provided that this will one day be technically possible –- would reduce storage time by a factor of 1000 and the volume of waste by a factor of 100. Actually several countries have renounced on nuclear reprocessing; in these countries the used fuel elements will be deposited without retreatment, after an intermediate storage time of some 20 to 30 years and after an adequate conditioning - i.e. in storage containers, which are suitable for this purpose - in a disposal facility.

The **decision** to build and operate such a disposal facility, the choice of a suitable site and the evaluation of the best suited host rock, as well as the way of conditioning is the responsibility of the national nuclear authority of each state. This body or its superior authority will also deliver the building **permit** and the operating **licence** and has in addition the responsibility to assure the necessary **financing** and the long-term **monitoring** and **quality assurance** of the disposal facility in terms of protection of man and environment.

In some countries like Switzerland, the relevant parliamentary decision will probably be followed by a public vote. So the task of the scientists and authorities in charge with the radioactive waste storage is to **convince the population** of the **need** of such a project and that the solution put forward by them is **optimized** from the point of view of **safety**, technology and in particular **protection of man and environment**. Although individual countries will renounce in the near future from nuclear energy they already have radioactive waste that needs to be disposed of. A long term surface storage as called for by certain people is, however, not a suitable long term solution as its security cannot be ensured over such a long time period.

Open questions

Three fundamental questions need to be addressed in this regard:

1) First, an **ethical** one: We charge future generation with a kind of mortgage, i.e. the responsibility for our waste disposal facilities, without their consent. They will be in charge of something they haven't caused and have to bear the expenses and the responsibility of long term safety and also the surveillance of these disposal facilities.
2) Secondly, we have to store the waste in a geological formation, which appears to us optimal from today's perspective *(probably in deep geological layers)* but without knowing the **long term changes** that will occur in geology of the earth and in regard to the evolution of human civilizations. Although 100 percent security is not possible, every effort should be made to keep it on the highest possible level and this for a time interval beyond human imagination.
3) And third, we can do it only based on **scientific and technological knowledge of today**. That means we cannot anticipate future developments of reuse or for new methods of treatment or conditioning of radioactive waste. In this regard, the question arises, how long should the stored waste remain accessible (retrievability) and how long should the site be monitored, and who will be responsible for it in the distant future?

Dosimetry considerations

The **radiation doses** for **population** from artificial radiation sources – as recommended by ICRP and laid down in most of the national radiation protection legislation – are limited to 1 milli-Sievert per year. For Switzerland, a protection target for people living near a nuclear power plant has been fixed to 0.3 milli-Sievert per year and for those living near a deep geological disposal facility for radioactive waste to 0.1 milli-Sievert per year.

Doses received by the **nuclear workers** can amount up to a few milli-Sievert per year and are well below the dose limit for this category of persons, fixed in the legislation to 20 milli-Sievert per year. Real **doses to the public** from nuclear installations including scoping calculations for disposal facilities for radioactive waste are or will be significantly lower, typically in the range of a few micro-Sievert per year. So, there is a safety interval of 3 orders of magnitude between the protection target and the real radiation exposure.

Comprehensive approach

An optimized waste management concept should **consider the whole process** from the production of waste to its final disposal and not just individual steps thereof. All driving forces should be included in the search of the optimal solution, not only from the technical site but also to meet the requirements from politics, population, media and environmental organisations. Of particular importance are general aspects for communication to stakeholders in order to increase public understanding and acceptance, what is essential.

Decision process and information of the stakeholders

A **communication strategy** promoting confidence and trust in the scientific arguments should be established. The entire decision process should be transparent and comprehensible for the concerned population. A structured engagement of stakeholders in the discussions and information sessions about waste management should be put in place taking into

consideration the national culture. In particular, the communication of the periodic reviews', results and safety status of the facilities should be tackled in an appropriate form (target-oriented).

Licensing process

A licensing process for geological disposal may **last for several years**. This represents a challenge: A rigid licensing process for geological disposal, i.e. requiring permanent decisions too early in the process, may hinder the consideration of further requirements emerging from the advancements in the state of the art in science and technology. On the other hand, keeping too many decisions open, following the development of the state of the art in science and technology, may be disruptive in the late phases of a project and end up with taking no decision at all. In general the change with time of standards and social values needs to be better managed.

Evolution of safety culture

Safety culture is not a constant standard existing in the same way at the beginning of nuclear technology as today. How to deal with legacies with radioactive waste, which we classify today as legacy but in former times they were in compliance with state of the art or due to a lack of adequate legislation? How can we avoid a general demonization of the waste management of nuclear waste today by the legacies of waste from yesterday? Obviously concept of **safety culture will evolve** as changes of standards and social values may occur on a long time range.

Additionally, security considerations of long-term safety of disposals for radioactive waste are often ambiguous and misinterpreted by media and public. Decisions should therefore be kept **open for any future evolution**, technical as well as societal and cultural, and, therefore, should have a maximum of flexibility. A systematic approach is necessary to find legacies especially from industrial site, as they need radiation protection assessments. Radioactive waste from remediation of legacies needs options for disposal. Recommendations for radioactive waste management have to be increased in a structured way with blame-free conditions in view of a long term quality assurance: periodic review, appropriate communication, qualified radiation protection personnel, periodic training, confidence and trust. Radiation protection experts should explain better, what risks for future generations arise if disposal facility projects are failing?

Periodic safety review

Periodic reviews of the safety case of waste disposal facilities (for example as suggested by WENRA) should be implemented.

Public acceptance

To increase public understanding and acceptance of a waste storage concepts **education** (school, universities) and **communication** (information transfer, experience from the past) need to be improved and **stakeholders should be involved** in the opinion-finding process from the beginning although the final decision will be taken by political authorities.

Communication

Communication of the process and of the results of the safety case, especially with regard to the **long-term perspective**, is somehow lacking. The promise of long-term safety is ambiguous and often misinterpreted by the media and the public. In relation with communication, but also with providing the correct background information to decision-makers, there exists the wrong perception that avoiding a decision and/or not approving a final

disposal strategy (including site selection) is a solution. Instead, the discussion needs always to start from the consideration that waste is already existing and mostly stored in temporary facilities, for which there is no long-term safety case. Saying no to any final disposal means automatically saying yes to existing temporary facilities with all the associated risks for man and environment.

Surface storage is not a long-term solution

It is emphasized that, radioprotection professionals should explain and better inform stakeholders about the fact that the **rejection of disposal options** means necessarily the acceptance of existing situations and temporary surface storage facilities, that for a long term storage is not an acceptable solution and presents significantly more important risks for men and environment than a final underground storage. The public should be made aware that, however, the predicted long-term governmental control remains questionable.

National or international solutions for waste storage

Most of the countries have so far decided that waste has to be stored in the country where it is produced in order to avoid any «waste tourism». Nevertheless, in a long term perspective and in caring for an **optimal solution** this question should be discussed again. Therefore **multinational solutions** should be taken into account especially for countries with small amounts of radioactive waste or for those who have no nuclear power or plan to shut down their existing nuclear power stations in the near future. Long term surface storage of spent nuclear fuel is only an alternative, if spent fuel is considered as resource for reprocessing. Finally experience from operating and shut down of disposal facilities should be preserved.

Optimization programmes by international cooperation

The waste management concepts should be **optimized by comparing the programs of different countries** in order to benefit from their experiences. Despite the decision taken by many countries, that waste should be treated and stored in the country where it is produced, the question of sharing disposal facilities between several countries should be evaluated as an option. For optimizing security of waste disposal facilities and certainly also to increase public acceptance a comparison of the concepts established by different countries would be recommendable. Such a comparison should be based on the following information.

Information for comparing concepts of different countries

- **amount** and **nature** of radioactive waste to be stored;
- nuclear waste after or without **retreatment**;
- waste **containers** and **conditioning** technique;
- **one or two** storage facilities (LMW and/or HAW);
- **intermediate** surface or **final** underground storage or a combination of both;
- **host rock**: Crystalline, salt dome, sedimentary rock like Opalinus Clay, others;
- **time schedule** and licencing procedure: licencing authority, start of licencing procedure, start of construction, start of operation, operation time, sealing, monitoring period;
- **monitoring** programme: Monitoring authority, long term funding for monitoring,
- option of **retrievability** and for how long,
- **financing**: Estimation of the cost and who is responsible for funding and for the long term financing,

- long term **security and safety** concept,
- **risk analyses** and **quality assurance** programme,
- **geological studies** and research performed,
- **dose concept**,
- **information concept**,
- **participation concept** for the final decision.

Waste minimization to reduce the overall risk

To what extent is waste minimization necessary to reduce the overall risk? Would it make more sense to set the priority on risk reduction then on dose reduction and on optimization instead of minimisation? Many countries have a law about waste minimization in force. This underruns the imperative of dose reduction, as waste minimization causes further work in controlled areas and additional irradiation doses to the involved workers. A holistic optimization process might be the right solution to get out of this **dilemma, considering both the dose reduction and the waste minimization**. In some cases a modification of the national legislation would therefore be necessary. Switzerland has explicit regulations for waste minimization, as Germany is still trusting in the market. So the question needs to be addressed, which level of dose is acceptable and to what extent waste minimization is necessary to lower the overall risk?

Advantage of waste minimization

Waste minimization has the advantage of a better use of the of available disposal facility space. Such a more environmental friendly approach might to some extend increase public acceptance. The doses workers are taking by waste minimization are real, calculated doses of the nearby population are, however, hypothetical and conservative. On the base of accepted concepts an **optimized waste management** system should take into account costs, volume minimization of waste for different kind and activity level of the waste, technical low dose waste minimization methods and realization of final disposals. Such an optimized waste management system is based on a proper radiation protection balance, low risks and an optimal safety culture.

Common dose concept for clearance and release

Clearance is defined as the removal of radioactive materials or radioactive objects within authorized practices from any further regulatory control by the regulatory body. The clearance system is based on the so called 10 µSv-dose concept. A dose for members of the public caused by clearance of materials should below some ten µSv per year. Individual radiation dose is likely to be regarded as trivial, if it is of the order of some ten µSv/year. This level of dose corresponds to a few percent of the annual dose limit for members of the public and is much smaller than any upper bound set by competent authorities for practices subject to regulatory control. This level corresponds to a few percent of the radiation of the natural background.

For the release of a site, it should be ensured by means of the optimization of protection that the effective dose to a member of a critical group is kept below the dose constraint of 300 µSv in a year. This system of clearance of materials and release of sites is very important for a national waste management programme. Clearance/release is one of the most important tools to ensure that radioactive waste generated is kept to a minimum practicable (IAEA: GSR-3 3.131). Minor modifications to the clearance/release system can

influence the generation of radioactive waste in a very strong way (e.g. in Germany up to 97% of the materials from decommissioning a NPP could be cleared. If this is changed for example to 88% by modification of a clearance condition, the amount of radioactive waste is increasing by a factor of 4 from 3% to 12% and can cause a necessity for an additional disposal facility). On the other hand a dose concept of up to 300 µSv per year for release of a site should fit to other dose concepts for licensing, discharge of effluents, and exemption. In addition, it should be considered that a release of a site should not create a new legacy in the future.

During the workshop the possibility of a common dose concept for the release of sites and clearance of materials from regulatory control was checked. Actually, the description of **two different concepts** in two guides has a strong overlap for example for materials resulting from the release of a site on the one hand and clearance of parts of buildings or excavated soil on the other hand. Is it possible or necessary, to merge the existing two concepts together in one concept (e.g. in a single or two separate guides) or to provide more detailed guidance on the application of the two concepts for the overlapping issues?

The results were the following points:
IAEA recommends a dose concept for clearance of materials 10 µSv/y and for release of sites (buildings plus areas) up to 300 µSv/y. There is an overlap in case of release of building debris or excavated material. This is a source for inconsistencies in the system and does not support a common understanding of the system. These inconsistencies can also reduce the necessary radiation protection culture. **A common dose concept would be an ideal solution to repair the dose system, but includes the risk of loss of flexibility, if solutions are necessary for sites with higher contamination.**

In any case different dose concepts are also existent in case of NORM and release of effluents compared to the dose concept of clearance. A detailed definition for the application of all these dose concepts and their overlaps in one guide would be very helpful and increase the acceptance of the recommended dose concepts.

Intermediate storage facilities

Existing radioactive waste in **intermediate storage facilities**: although such radioactive waste is not currently perceived as legacy by the society and/or the public, because of the time-limited safety case (e.g. with regards to the design life time of casks) or due to a change in regulations, the waste can in future become a legacy.

Interim storage and final disposal

The commissioning of a disposal facility is often **postponed** due to many different reasons. Due to these delays the duration of the interim storage last much longer than planned. Often additional work has to be done to keep the interim storage safe causing additional dose for the workers. Do we need a speed up of the process for a disposal facility? Interim storage and final disposal is the strategy for most of the countries that have to dispose of the radioactive waste. Unlimited (surface) storage (as discussed in US) in order to improving public perception is a discussion topic among some critical groups. By joining their forces IRPA and IAEA could work in order to **eliminate such contradictions and to provide better information of the population**, in particular between retrievability and final disposal or between immediate conditioning and dose reduction.

	An operating disposal facility would be the ideal situation, however, the reality is different and most of the counties have actually no available disposal facility. In these cases only interim storage facilities are available, but they will be only an interim and not a long term solution. Today the affected countries did not yet come to a common solution, i.e. to proper balance between an intermediate storage period (as this is necessary for used fuel elements so that they can cool down), time of conditioning and time of disposal. Such evaluations are depending on chemical form of the waste, if with or without nuclear reprocessing, external storage conditions, availability of waste acceptance criteria and storage capacity as well as funding.
Definition of a legacy	Pragmatically a legacy is considered to be an existing radioprotection situation which results mainly from a change in public perception and/or change of regulations according to new scientific knowledge. There exist legacy sites with genuine radioactive waste (e.g. drums dropped into the Atlantic Ocean), but many legacy sites with radioactive materials of former non-nuclear industries or (non-uranium) mining are not a-priori radioactive waste. All these legacy sites require nonetheless a **radiation protection assessment**. During the remediation of legacies, radioactive waste could be generated, which then needs appropriate disposal options.
approach for radioactive legacies	A systematic approach, also taking into account the different legislative situations and involved authorities in each country, is missing.
Assessment of existing exposure situations	The exposure situations resulting from legacies are evaluated and assessed in an inconsistent manner as to the necessary radiation protection measures. Radioactive materials from former nuclear activities are perceived to pose much a higher risk than existing exposure situations from former non-nuclear industries and mining, which can result in a non-optimized remediation strategy.
Education and training of staff	**Qualified staff in radiation protection** is needed in all steps of waste management. Therefore adequate plans to acquire and further educate such personnel should be offered and this should also be assured over the whole time of storage. Periodic training in safety awareness should be part of integrated safety training. In order to learn from operating experience, a blame-free reporting of events should be promoted. Experiences from disposal facilities for non radioactive waste should be included. The responsibility for the promotion of safety culture should be clearly defined and present at all staff levels. The education and development of young scientists in the field of radiation protection needs to be addressed with more attention. A dialog is necessary in order to transfer the safety culture to next generation(s).
Long term surveillance	**Monitoring programs** in the licensing and information process as they ensure the population of the long-term safety of the repository. Monitoring will be different in the different time periods.

- Pre-operational monitoring,
- monitoring during operation, i.e. during conditioning and storage of radioactive waste,
- Emergency monitoring,
- Live-time monitoring after sealing the repository site.

Perspective

The results of the workshop (s. following recommendations) are a good basis and very general for the future work to improve the safety culture in radioactive waste management. All members in the working groups are in agreement that more detailed work is necessary. The Fachverband will keep in touch with this topic and organizing a follow up meeting in 2016/2017.

Recommendations	- A waste management concept should consider the **whole process** from the production of waste to its final disposal and not just individual steps thereof. - The decision process should be **transparent** and include all potential **stakeholders**. - The licensing process should take into account **changes of standards** and social values that may occur in a long time range. A dynamic adaption of the process is necessary. - The decision process should be kept **open for any future evolution**, technical as well as societal and cultural. - A **periodic review** of the safety case of waste disposal facilities should be implemented. - To increase public understanding and acceptance concepts of **education** and **communication** should be developed. This should in particular include the fact that waste already exists and actually in most countries stored in temporary facilities, for which there is no long-term safety case. So, rejection of disposal options means necessarily the acceptance of the existing situation. - **Education and training**: Periodic training in safety awareness should be part of integrated safety training. In order to learn from operating experience, a blame-free reporting of events should be promoted. - Despite the decision of most countries to store their waste in the country itself **multinational solutions** should be taken into account. - The waste management concept should be optimized by **comparing the programs of different countries** in order to benefit from their experiences. - We need a concept for the **dilemma waste minimization vs. dose reduction** (for the in the process involved workers). - Common dose **concept for clearance and release**: A detailed definition for the application of all these dose concepts and their overlaps in one guide would be very helpful and increase the acceptance of the recommended dose concepts. In any case different dose concepts are also existent in case of NORM and release of effluents compared to the dose concept of clearance. A detailed definition for the application of all these dose concepts and their overlaps in one guide would be very

	helpful and increase the acceptance of the recommended dose concepts. - **Unlimited surface storage** in order to improve public perception: IRPA and IAEA should join their forces in order to eliminate such contradictions and to provide better information of the population, in particular between retrievability and final disposal or between immediate conditioning and dose reduction. - **Radioactive legacies**: A systematic approach, also taking into account the different legislative situations and involved authorities in each country, is missing. Radioactive materials from former nuclear activities are perceived to pose much a higher risk than existing exposure situations from former non-nuclear industries and mining, which can result in a non-optimized remediation strategy. All these legacy sites require nonetheless a radiation protection assessment. During the remediation of legacies, radioactive waste could be generated, which then needs appropriate disposal options. A systematic approach, also taking into account the different legislative situations and involved authorities in each country, is missing - A concept for a **long-term surveillance** should be developed and periodically adapted.
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