Clearance and recycling – how can radiation protection and application of the waste hierarchy be optimised?

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Abstract

This paper describes and discusses the principles behind the current Swedish regulations for clearance of materials and for application of the waste hierarchy on radioactive waste. As a background, the applicable legislation for radiation protection and nuclear safety is briefly described as well as the environmental legislation for waste management. It is concluded that clearance of materials can play an important role in optimisation of radioactive waste management with due regard to radiation protection and sustainability. Also, different factors to be considered in the optimisation of waste management in the context of clearance and recycling are presented and discussed. Concluding remarks are made from a radiation protection regulatory perspective.

Introduction

According to international conventions and Swedish legislation [Joint Convention, SSMFS 2008:1], measures shall be taken to avoid the production of radioactive waste. Radioactive waste from regulated practices involving radioactive substances shall be managed and disposed of in a safe way, so that people and the environment are protected against negative effects from ionising radiation. In doing so, the principles for radiation protection shall be followed, which implies both that dose limits for workers and the public shall be respected and that protective measures shall be optimised, taking economic and social factors into account.

This means that every type of radioactive waste should be managed in a manner that takes due consideration of the risks for negative effects from the waste's radioactivity and provides optimised protection against those risks. In practice, this often results in a range of approaches for different types of waste, typically deep geological disposal of high level waste, near surface disposal of short-lived low (and in some countries also intermediate) level waste, surface disposal of very low level waste, and clearance of waste with a low content of radioactive substances for conventional disposal or for reuse or recycling.

Modern environmental legislation includes principles of minimising impacts on the environment and conserving natural resources. This has led to the establishment of the waste hierarchy, which among other things, gives preference to recycling or reuse of material over waste disposal [Directive 2008/98/EC].

Thus, the question arises how the principles and requirements for radiation protection should be considered in combination with the waste hierarchy when decisions are made on the management of radioactive waste. In this paper we will focus on the specific case of metallic scrap with a low content of radioactive substances; shall it be treated as radioactive waste and kept separated from people and the environment or shall it be processed for recycling or reuse in order to save natural and economic resources?

Swedish requirements on radioactive waste management

Radioactive waste that is generated at a nuclear facility is regulated according to the Act (1984:3) on Nuclear Activities, the Radiation Protection Act (1988:220) and the Environmental Code (1998:808). According to all three legislations, the responsibility for managing the waste falls on the waste producer. SSM is the regulatory and/or supervisory authority for issues relating to ionising radiation according to all three legislations.

The Environmental Code is applicable to all kinds of environmentally hazardous activities, including nuclear activities and activities involving radiation, and is applied in parallel to the more specific legislations on nuclear safety and radiation protection. According to the Environmental Code, it is a general requirement to economise with resources and energy and make use of the possibilities for recycling and reuse of materials and recovery of energy in waste.

The Act on Nuclear Activities contains the basic provisions concerning nuclear safety, which includes a requirement to prevent all circumstances that may result in a radiological accident. The purpose of the Radiation Protection Act, which applies to all practices involving radiation, including nuclear activities, is to protect people, animals and the environment from harmful effects of radiation. The legislation is based on the internationally recognised principles of justification, dose limitation and optimisation of protection (keeping both expected and potential doses as low as reasonably achievable, i.e. following the ALARA- principle). Both acts state that radioactive waste shall be managed by final disposal. However, the Government or the responsible authority (SSM) may prescribe exemptions from the acts, as long as they are not conflict with the purpose of the acts. Such exemptions may relate to a particular practice or to a particular material. Exemptions can be prescribed both by specific regulatory decisions and by regulations.

Furthermore, SSM has been authorised to issue regulations both according to the radiation protection and nuclear safety legislations. In particular, two regulations relate to the management of radioactive waste from the nuclear industry. These are the regulations concerning safety in nuclear facilities [SSMFS 2008:1] and the regulations concerning protection of human health and the environment in connection with final management of spent nuclear fuel and nuclear waste [SSMFS 2008:37]. According to SSMFS 2008:1 the amount of waste, as well as its content of radioactive substances, shall be minimised to the extent possible. To this end, the potential for materials to become contaminated or activated shall be minimised. Furthermore, the waste shall be managed without unnecessary delay. According to SSMFS 2008:37, the principles of dose limitation and optimisation shall be applied in relation to the management of nuclear waste. Thus, in addition to complying with a dose target, the waste management, including final disposal, should strive to keep doses to the public and releases to the environment as low as reasonably achievable, taking societal and economic factors into account. These are requirements that should be considered on an early stage when elaborating radioactive waste management plans according to SSMFS 2008:1.

The waste hierarchy

The European Waste Framework Directive [Directive 2008/98/EC] provides an overarching legislative framework for the management of waste in the European Union (excluding radioactive waste). The directive establishes the so-called waste hierarchy as a priority order for waste management policy and legislation. The hierarchy contains the following levels:

Priority 1. The production of waste should be avoided.
Priority 2. Reuse of products that have become waste.
Priority 3. Recycling of the materials contained in the waste.
Priority 4. Energy recovery, for example by incineration to utilize the energy content of the waste.
Priority 5. Disposal (in the context of the directive, disposal means a method that is not recycling or reuse).

According to the directive, this priority order should be followed as long as it is environmentally sound and economically feasible. According to article 10 in the directive, the member states shall take the measures that are necessary for the recycling of waste.

The directive was fully implemented in Swedish legislation in 2011, in chapter 15 of the Environmental Code (SFS 1988:808) and in the waste ordinance (SFS 2011:927). It is stated in the directive that it is not applicable to radioactive waste, but as described above, in the Swedish legislation the waste hierarchy to some extent also applies to radioactive waste (priorities 1, 2 and 3). Concerning priority 4 and 5, there are some specific requirements concerning the treatment and disposal of non-radioactive waste from which disposal facilities for radioactive waste are excluded.

The application of the waste hierarchy on radioactive waste is however not straightforward, since there are many cases when it would not be environmentally sound simply to follow the priority order. The priorities 2, 3 and 4 may not even be acceptable from a radiation protection or nuclear safety point of view.

Clearance of materials

Optimisation of radiation protection implies that there may be situations when it might not be reasonable to require any radiation protection measures. This is the case when it comes to exemption of practices from regulation, as well as for clearance of materials from regulated practices. Clearance means release from regulatory control, i.e. a regulatory decision that an object that is subject to regulatory control can be managed without further control from a radiation protection point of view. Criteria for clearance of materials have been established in international standards and European legislation [IAEA BSS, EU BSS]. There are also a number of international and national recommendations and standards governing clearance values and clearance procedures. The main condition for clearance of materials is that expected or reasonably possible radiation doses are sufficiently low as to be of no regulatory concern. For authorised practices this is further specified as an effective dose of the order of 10 microsievert or less per year[1] to any member of the public, in all feasible circumstances [EU BSS].

[1] A common misunderstanding is that “of the order of ten” means “some tens of”. However, by studying the principal document Safety Series No 89, Principles for the Exemption of Radiation Sources and Practices from

By analysing exposure situations in different possible scenarios for the use of material after clearance, general clearance levels for specific radionuclides have been derived, and recently also established in international standards and European legislation [IAEA BSS, EU BSS]. In the standards and legislation it is also acknowledged that specific clearance values may be applied in specific cases, for example clearance for recycling of metals and disposal as conventional waste [EU BSS, article 30]. In such cases, higher clearance levels can often be applied, since there are circumstances that reduce the possibilities for exposure of members of the public[2].

The SSM has judged that, for material and waste containing radioactive substances below certain specified levels, a rational and sustainable materials management according to the waste hierarchy should not be restricted by radiation protection requirements. SSM has therefore issued general regulations on clearance of materials from practices involving ionising radiation [SSMFS 2011:2, IRPA 2010], as well as in specific cases issued permissions for clearance of materials or waste for specific purposes. The main examples of such specific cases are the re-melting of metals in a conventional facility or the disposal of waste in a conventional disposal facility.

By applying the regulations, materials and waste from licensed practices are being released from further regulatory control and thereby also from further responsibilities of the licence holder. An important prerequisite for this is that the licence holder makes adequate and quality controlled measurements on each batch of material to show compliance with the clearance levels. The measurements must be governed by a written control program. In line with the principle of segregation of waste categories, the regulations prohibit the dilution of radioactive waste with the purpose of achieving clearance of the waste.

A common misunderstanding is that the principle of optimisation of radiation protection should not be valid for materials that can be cleared. However, the principle applies throughout the practice and it might be reasonable to apply rudimentary protective measures before clearance, in order to reduce potential doses after clearance. Therefore, SSM has also issued advice on the removal of contamination [SSMFS 2011:2]. A typical example is the removal of low levels of loose contamination to avoid unnecessary internal exposure from cleared materials. (The prohibition of dilution can also be seen as a measure to avoid unnecessary exposure.)

Thus, clearance opens a possibility to apply the waste hierarchy also on radioactive waste. By recycling of materials, natural resources can be saved and the amounts of radioactive waste that require disposal can be reduced, which in the end could lead to an optimised use of available disposal options.

For several decades, clearance has been a well-established part of the waste management system in Sweden. Waste is being cleared both for disposal as conventional waste and for materials recycling or reuse. Metallic waste (scrap) is being cleared either directly from the nuclear facility or after treatment and melting at the Studsvik melting facility. In both cases, each batch of material is measured, typically by gamma spectroscopic measurements on the whole batch or on a

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Regulatory Control, issued by IAEA in 1988 and the studies behind the clearance levels, it can be seen that “of the order of ten” means “approximately ten”.

[2] It should be noted that workers on conventional disposal sites are regarded as members of the public if there is no license for managing radioactive waste on the disposal site.

representative sample from the batch. The decision for clearance of the individual batch is thereafter taken by the licence holder himself.

Optimisation of waste management with regard to radiation protection and sustainability

The regulations on clearance give an option for license holders to use conventional waste management options for some of their radioactive waste. For example, contaminated metallic waste that can be cleared may be recycled or reused in the same way as conventional metallic waste from other practices. From an environmental and sustainability perspective, this option should be used in order to follow the waste hierarchy and recycle or reuse materials to the extent possible. From a radiation protection regulatory perspective, the option is acceptable and reasonable, but care should still be taken as to not unnecessarily release radioactive substances into the public domain. To summarise: as much material as possible should be recycled with as little radioactivity as possible. (The best option would obviously be to separate the radioactive substances from the bulk material, but this can often not be fully achieved.) An important boundary condition of this equation is that it has to be shown by measurements and with adequate degree of confidence that the activity content (which may be actual or only suspected) in the material is below the clearance levels. Another important condition is that it is not allowed to dilute radioactive material with other materials in order to facilitate clearance. It should be acknowledged that in practice these legal requirements put constraints on the possibility to optimise the waste management.

As stated above, radioactive waste management shall be optimised from a radiation protection point of view, keeping doses to workers and the public as low as reasonably achievable, in accordance with the ALARA principle. This is one of the principles that have formed the current system for radioactive waste management in Sweden, which involves several disposal options for different types of waste. For example, contaminated metallic waste can be recycled/re-used, disposed of in shallow land burials, in different parts of the existing repository for short-lived waste (SFR) or in the planned geological repository for long-lived waste (SFL) [RD&D-programme 2013]. For each type of waste, the appropriate disposal option shall be selected according to the ALARA principle. In this context, the protective capabilities of available repositories should be utilised as much as possible and the potential need for extension of disposal capacities should be considered. Although economic aspects should be taken into account when selecting an appropriate disposal option, the cheapest option might not necessarily be the optimised choice, when considering environmental aspects and radiation protection of workers and the public. For any given option, there are also legal criteria that must be complied with (such as waste acceptance criteria or clearance levels).

Optimisation of radiation protection should play an integral role in radioactive waste management planning. In order to be able to select an optimised waste management solution, different possible alternatives should be identified at an early, pre-planning stage and carefully evaluated. However, SSM believes that it would be very difficult to achieve an “ideal, fully optimised system” taking all factors and potential scenarios into account. For example, it is difficult to compare the additional dose a worker might receive during waste management with an expected or potential reduction of doses to the general public today or in a distant future. Instead, in the case of final disposal of radioactive waste, SSM has given the advice that the licence holder describes to what extent the measures taken for radiation protection of workers may affect the long term performance of the repository (see the general advice to SSMFS 2008:37). Similarly, SSM suggests that the licence holder

should investigate how radiation protection measures for workers may affect the amounts and activity content of materials for clearance.

Factors to be considered in the optimisation of waste management in the context of clearance and recycling

As stated above, clearance for recycling or reuse, as well as clearance for conventional waste disposal, are acknowledged as options for an optimised management of radioactive waste. In practice, the possibility to use the clearance option for radioactive waste management depends on a number of factors, which should be considered in the pre-planning stage for waste management. Some examples are given below.

Knowledge of the source of contamination and the history of contamination or activation of the material

In order to make adequate clearance measurements, the possible contaminants in the waste must be known. This puts requirements on knowledge of the source of contamination and on the processes by which the material may have been contaminated or activated in the practice. The process of contamination may include steps of decontamination, which also need to be known.

Availability of adequate methods for clearance measurements

As mentioned above, it must be possible to show compliance with the clearance levels. This might not be possible if the material has complex geometries or if the contamination is unevenly distributed or mainly consists of hard-to-measure nuclides. Background radiation may cause problems in showing that the clearance levels are being met. This could especially be a problem for materials contaminated with naturally occurring radionuclides or artificial radionuclides that form part of the radiation background (such as Cs-137 and Sr-90).

Possibilities of waste segregation and separation at the source of the waste stream

In order to define a batch of material that is candidate for clearance by a selected clearance measurement procedure, it must be possible to segregate the very low level waste from waste with higher activity content or from waste with different nuclide distributions. This puts requirements on pre-characterisation of components and structures before dismantling, as well as thorough procedures for separation of different waste categories as they arise.

The possibilities for waste segregation may depend on a number of considerations or limitations, for example worker health protection issues, such as external exposure, risk for internal contamination or conventional hazards such as asbestos.

Possibilities of decontamination

If the contamination levels are too high to enable clearance, clearance may still be an option if it is possible to use some kind of decontamination method to reduce the contamination. In this case, care must be taken that the decontamination process may alter the nuclide distribution.

Availability and acceptability of routes for recycling or disposal

The foreseen conventional recycling or waste management option must be available and broadly accepted. The acceptance of cleared materials should be based on a good understanding of the underlying radiation protection considerations, regulatory requirements and procedures for clearance. Therefore it is important that stakeholders are well informed about these issues.

Costs, environmental and material value

The cost for waste segregation, decontamination and clearance measurements should be reasonable, taking into account the benefit of recycling of materials and of reducing the amount of waste for disposal as radioactive waste. In this context, the costs for clearance should be compared with environmental values and the value of the material itself.

Summary and concluding remarks

The generation of radioactive waste shall be minimised as far as possible. To this end, the potential for materials to become contaminated or activated shall be minimised. Radioactive waste that cannot be avoided shall be managed safely with due regard to optimisation of radiation protection of workers and the public.

Optimisation of radiation protection implies that there may be situations when it might not be reasonable to require any radiation protection measures. The SSM has judged that, for material and waste containing radioactive substances below certain specified levels, a rational and sustainable materials management according to the waste hierarchy should not be restricted by radiation protection requirements. SSM has therefore issued general regulations on clearance of materials from practices involving ionising radiation, as well as in specific cases issued permissions for clearance of materials or waste for specific purposes. Clearance has been a well-established part of the waste management system in Sweden for several decades.

In any project there may be certain waste streams where clearance and subsequent reuse or recycling may offer potential benefits. However, care should always be taken as to not unnecessarily release radioactive substances into the public domain. Therefore, it is not allowed to dilute radioactive waste with the purpose of achieving clearance of the waste. Also, decontamination should be considered and contamination should be removed before clearance, especially if it can be easily done. The licence holder must also show by measurements and with adequate degree of confidence that the activity content in the material is below the legal clearance levels.

Thus, metallic scrap with a low content of radioactive substances does not necessarily need to be treated as radioactive waste and kept separated from people and the environment. Instead, it can be recycled or reused, if it can be shown that it meets the legal clearance criteria and as long as it is accepted as a route for radioactive waste management.

In the end, the possibility to use the clearance option for radioactive waste management depends on a number of factors, which should be carefully considered by the licence holder when comparing different waste management options at the pre-planning stage for radioactive waste management. Since this task is complex and multifaceted, it may be useful for the practitioners to develop a shared vision and common approaches towards good practices for the optimisation of waste management, including clearance, reuse and recycling.

References

Directive 2008/98/EC	Directive 2008/98/EC of the European Parliament and of the Council of 19 November 2008 on waste and repealing certain directives.
EU BSS	Council Directive 2013/59/Euratom of 5 December 2013 laying down basic safety standards for protection against the dangers arising from exposure to ionising radiation, and repealing certain directives.
IAEA BSS	Radiation Protection and Safety of Radiation Sources: International Basic Safety Standards - Interim Edition, General Safety Requirements Part 3, IAEA, 2011.
IRPA 2010	New Swedish Regulations for Clearance of Materials, Rooms, Buildings and Land, Henrik Efraimsson, Swedish Radiation Safety Authority, Paper presented at the third European IRPA Congress 2010, Helsinki, Finland, 2010.
Joint Convention	Joint Convention on the Safety of Spent Fuel Management and on the Safety of Radioactive Waste Management, adopted on 5 September 1997.
RD&D-programme 2013	Programme for research, development and demonstration of methods for the management and disposal of nuclear waste, SKB TR-13-18, Swedish Nuclear Fuel and Waste Management Co, 2013.
SSMFS 2008:1	The Swedish Radiation Safety Authority's regulations concerning safety in nuclear facilities, SSMFS 2008:1, 2011.
SSMFS 2008:37	The Swedish Radiation Safety Authority's regulations concerning the protection of human health and the environment in connection with the final management of spent nuclear fuel and nuclear waste, SSMFS 2008:37, 2008.
SSMFS 2011:2	The Swedish Radiation Safety Authority's regulations and general advice concerning clearance of materials, rooms, buildings and land in practices involving ionising radiation, SSMFS 2011:2, 2011.