SAFE AND ENVIRONMENTALLY SOUND MANAGEMENT OF RADIOACTIVE WASTE

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Contents

1. Approaches to Radioactive Waste Classification

1.1. Purpose of Classification

Classification is an approach which is used, mainly when the quantity of elements considered (objects or ideas) is large, to ease management of the elements by reducing their number. Classification is realised by selecting the main features (criteria) and by structuring these criteria.

Classification may be more or less precise depending on the number of classes and the criteria considered. The degree of differentiation depends on the purpose of the classification. It is essential, however, that:

- the definition of the classes and the derivation of the corresponding levels are clear and easily understood and developed on a sound technical basis;
- the restrictions of the applicability of the classification system are clearly known; and
- the number of classes is balanced between the desired differentiation and the ease of handling of the classification system.

Classification systems for radioactive waste may be derived from different points of view, such as safety related aspects, process engineering demands or regulatory issues. In this publication, emphasis is given to the safety related aspects, since these are in most cases of highest importance. This does not preclude consideration of other aspects.

Classification of radioactive waste may be helpful at any stage between the arising of the raw waste and its conditioning, interim storage, transportation and disposal. Therefore, classification of radioactive waste will serve many purposes. It will help:

- at the conceptual level:
  - in devising waste management strategies;
  - in planning and designing waste management facilities;
  - in designating radioactive waste to a particular conditioning technique or disposal facility;

- at the operational level:
  - by defining operational activities and in organising the work with waste;
  - by giving a broad indication of the potential hazards involved with the various types of radioactive waste;
  - by facilitating record keeping;

- for communication:
  - by providing words or acronyms universally understood which improve communication among experts from different countries, and between experts, generators and managers of radioactive waste, regulators and the public.

To satisfy these purposes, an ideal radioactive waste classification system should meet a number of objectives, including the following:

- cover the full range of radioactive waste types;
- address all stages of radioactive waste management;
- relate radioactive waste classes to the associated potential hazard;

- be flexible to serve specific needs;
- change already accepted terminology as little as possible;
- be simple and easy to understand; and
- be as universally applicable as possible.

It should be clear from this list that an ideal classification system does not exist. For instance, a classification system cannot at the same time be universally applicable and still reflect the finer details of all the stages of radioactive waste management. Compromise is needed, and because a primary purpose of an international document is to facilitate communication, the compromise should be sought in the direction of simplicity and flexibility.

1.2. Methods of Classification

Depending on the purpose of a radioactive waste classification system, there are different approaches to its derivation. One basic method of classification is a qualitative description of the individual classes. In this case, mostly general characteristics of the radioactive waste are used as criteria for the classification. Nonetheless, numerical values to characterise broad bands or orders of magnitude may also be helpful for classification by this approach: the other method is a quantitative approach, i.e. numerical values are given for the definition of most classes.

The methods described in the following sections have been derived mainly from the safety aspects of radioactive waste disposal, but can be developed into the other stages of radioactive waste management. It is reasonable to start classification from the point of disposal to keep consistency among the different stages of radioactive waste management.

A clear distinction has to be made between a classification system and a set of regulatory limits. The purpose of classification is to simplify language and to help planning, while the purpose of regulatory limits is to ensure safety. Therefore, the effort in developing precise limits has to be applied within the regulatory framework of licensing or authorising specific radioactive waste management activities. Actual quantity or concentration limits for the classification of radioactive waste are to be established by the regulatory body of a Member State. While a radioactive waste classification system may be useful for generic safety considerations, it is not a substitute for specific safety assessments performed for an actual facility involving well-characterised types of radioactive waste.

1.2.1 Qualitative classification

There are already ”natural” classification systems, e.g. grouping the radioactive wastes in terms of their origin. Moreover, even within a given type of radioactive waste, the characteristics related to safety may vary widely and necessitate different treatment of subtypes.

Another “natural” classification system is the differentiation of radioactive wastes according to the physical state, i.e. solid, liquid, gaseous. This system stems from the

process engineering needs for the treatment of the different radioactive waste streams and is often refined corresponding to individual radioactive waste treatment systems. A classification system of this type is mostly specific to individual facilities and follows their technical needs and possibilities. It may, however, incorporate safety considerations such as the radiation protection necessary for radioactive waste classes with higher radioactivity content.

A widely used qualitative classification system separates radioactive waste into three classes:

- low level waste (LLW),
- intermediate level waste (ILW) and
- high level waste (HLW).

A further distinction is made between short-lived and long-lived waste. These classes address activity content, radiotoxicity and thermal power. The differentiation between the long- and short-lived radionuclide content is made to assist in the choice of the appropriate type of repository. This system mainly serves the purpose of facilitating international communication.

1.2.2 Derivation of quantitative criteria

The proposals originated from qualitative considerations of practical aspects related to processing and transportation of radioactive waste. Thus they are not based on quantitative assessments and justifications.

Classification of radioactive waste in many cases is related to safety aspects of their management. In this context it provides a link between the waste characteristics and safety objectives that have been set up by a regulatory body or the operator of a waste management facility. Since safety objectives are formulated in general in terms of numerical values, a quantitative approach to classification is necessary for this purpose. To derive a quantitative classification system, a common procedure should be used which is outlined in the following paragraphs.

The first step is a definition of the purpose of the classification system, since any classification system can only address a particular aspect of radioactive waste management. This implies decision on such aspects as:

- the type of radioactive waste to be covered;
- the activity or installation considered;
- the corresponding level of application (planning, operation, post-operation), and
- the safety objectives to be met.

The next step requires the definition of the areas that are addressed by the system, for example:

- exposure of personnel;
- exposure of members of the public;

- contamination of the environment;
- safety from criticality;
- normal operation, incidents or accidental conditions;
- heat generation of radioactive waste, and
- process engineering aspects.

Communication is another important issue to be addressed.

For some of these areas regulatory or technical constraints may exist that have to be taken into account. These may be, for example:

- the radioactive waste itself, characterised by the annual arising, the spectrum of radionuclides and their concentrations;
- limits and requirements set by the authorities;
- pathways or scenarios prescribed for safety assessments;
- operational limits;
- site specific conditions (e.g. for radioactive waste disposal, geological, hydrogeological and climatic characteristics may restrict the choice of disposal site or of the type of radioactive waste that can be disposed of at the site);
- social or political aspects, and
- legal definitions and requirements.

These factors may restrict the degree of freedom for the choice and the development of a classification system and therefore have to be evaluated before the classification system can be derived.

Once the framework for classification has been set, the parameters to be used for classifying may be chosen in a third step. Starting from the radioactive waste itself, there are a number of properties that may be taken into account. Table 1 lists the more important ones that are used in one or the other case.

Origin	
Criticality	
Radiological properties	• half-life • heat generation • intensity of penetrating radiation • activity and concentration of radionuclides • surface contamination • dose factors of relevant radionuclides
Other physical properties	• physical state (solid, liquid or gaseous) • size and weight • compactability • dispersibility • volatility • solubility, miscibility
Chemical properties	• potential chemical hazard • corrosion resistance/corrosiveness

	• organic content • combustibility • reactivity • gas generation • sorption of radionuclides
Biological properties	• potential biological hazards

Table 1. Important properties of radioactive wasted used as criteria for classification

The possible scenarios, design options and site specific options have then to be evaluated in a fourth step to assess their suitability as classification parameters. Factors to be considered regarding disposal of radioactive waste in a repository are:

- interim storage for decay of radionuclides;
- selection of techniques for conditioning radioactive waste;
- engineering for handling of radioactive waste in the repository;
- administrative measures to be taken during handling of radioactive waste;
- engineered barriers to contain the radioactivity during handling and after emplacement (ventilation systems, backfill, dams, seals, covers);
- duration of institutional control as a factor in the design of a near surface disposal facility;
- improvements of some characteristics of the disposal site, and
- assignment of radioactive waste to a repository.

Interim storage may result in the subsequent attribution of a radioactive waste to a lower class and allow time to develop and implement a disposal strategy.

If a set of classification parameters has been chosen, intervals for numerical values or, as an alternative, qualitative characteristics are defined as limits for different classes. Assigning the considered types of radioactive waste to these classes will show whether or not a meaningful system has been established.

A comparable procedure is in principle to be used in safety analyses for radioactive waste management facilities, especially for a repository. However, classification parameters, intervals for numerical values and resulting limits cannot be chosen as desired. They are derived from regulatory or legal requirements, e.g. by safety analyses, and will have to be mandatory with limits generally expressed as allowable values for the activity of individual radionuclides and for other properties of waste packages. At such an advanced level, an integrated, detailed classification system for radioactive waste can be established; it should cover all radioactive waste management steps from the generation of radioactive waste to its disposal. Furthermore, there must be assurance that all corresponding parameters are set up in such a way that they are amenable to being controlled or checked in individual waste packages.

2. Proposal for a Radioactive Waste Classification System

A classification system has previously been proposed by the IAEA placing radioactive waste into one of three classes:

- high level waste (HLW),
- intermediate level waste (ILW), or
- low level waste (LLW)

High level waste

- The highly radioactive liquid, containing mainly fission products, as well as some actinides, which is separated during chemical reprocessing of irradiated fuel (aqueous waste from the first solvent extraction cycle and those waste streams combined with it),
- Any other waste with radioactivity levels intense enough to generate significant quantities of heat by the radioactive decay process,
- Spent reactor fuel, if it is declared waste.

Intermediate level waste (medium level waste)

Waste which, because of its radionuclide content requires shielding but needs little or no provision for heat dissipation during its handling and transportation.

Low level waste

Waste which, because of its low radionuclide content, does not require shielding during normal handling and transportation.

Within the ILW and LLW classification, the IAEA also differentiated between short and long-lived waste, as well as alpha bearing waste. Here the term short-lived waste refers to radioactive waste which will decay to an activity level which is considered to be acceptably low from a radiological viewpoint, within a time period during which administrative controls can be expected to last. (Such waste can be determined by radiological performance assessment of the storage or disposal system chosen.) Long-lived waste is radioactive waste that will not decay to an acceptable activity level during the time which administrative controls can be expected to last. Alpha bearing waste is radioactive waste containing one or more alpha emitting radionuclides, usually actinides, in quantities above acceptable limits established by the national regulatory body.

This classification system has proved to be useful for general purposes, although there are limitations. First, the classification system lacks a completely clear linkage to safety aspects in radioactive waste management, especially disposal. In addition, many countries use different definitions of radioactive waste consistent with their national programmes or mandates. Some countries classify radioactive waste according to the facilities in which this waste is generated, or by the processes that generate such waste. In addition, the current classification system lacks quantitative boundaries between classes and recognition of a class of waste that contains so little radioactive material that it cannot be considered as 'radioactive' and consequently may be exempted from control as radioactive waste. Finally, it lacks recognition of wastes such as those from mining and milling uranium ore, that contain small quantities of natural radionuclides dispersed

through very large volumes of material.

2.1. System Overview

Three major classes of waste were identified and used as the basis for the system:

- Waste containing such a low concentration of radionuclides that it can be exempted from nuclear regulatory control in accordance with clearance levels, as the associated radiological hazards are negligible.
- Waste that contains such an amount of radioactive material that it requires actions to ensure the protection of workers and the public either for short or for long periods of time. This class covers a very wide range of radioactive wastes, ranging from radioactive waste just above exempt levels, e.g. not requiring shielding or particular confinement, to radioactive waste that contains such high levels of radioactivity that shielding and possibly cooling may be required. A range of disposal methods may be postulated for such waste.
- Waste that contains such high levels of radioactive material that a high degree of isolation, normally geological isolation, from the biosphere is required over long time periods. Such waste normally requires both shielding and cooling.

Although the principles of the existing classification system are retained, the revised classification system is organised to take into account matters considered of prime importance for disposal safety. Sufficient experience has been gained so that general quantitative boundaries between classes can be drawn. More detailed quantitative boundaries may be developed in accordance with national programmes and requirements.

The boundary levels addressed in this chapter are primarily applicable to solid radioactive waste, which is either generated as such or results from treatment and conditioning applied to liquid or gaseous radioactive waste, with a view to their further transportation, storage or disposal.

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K.H. Schaller. Commission of the European Communities, Rue de la Loi 200, B—1049 Brussels, 1989.