CLEARANCE OF MATERIALS RESULTING FROM THE USE OF RADIONUCLIDES IN MEDICINE, INDUSTRY AND RESEARCH

Rastogi, R.C.[1], Linsley, G.S.[1] and Baekelandt, L.[2]

ABSTRACT

This paper describes methods for applying radiological principles for exemption and clearance of radiation sources to derive practically applicable levels (clearance levels) for the release of gaseous, liquid and solid wastes resulting from the use of radionuclides in medicine, industry and research. The paper also provides guidance on the nature and scope of radiological impact assessments to be performed in deriving the clearance levels. A set of generic representative clearance values for some of the commonly used radionuclides has been derived as part of the work. The circumstance in which these representative clearance values may be used are discussed.

INTRODUCTION

Radioactive materials used in medicine, industry and research, although beneficial to mankind, are also potentially harmful and need to be regulated. The regulatory approach is based on the fundamental radiological protection principles of justification of the practice, optimization of protection and individual dose and risk limits through a system of notification and authorization such as that described in the Basic Safety Standards [1].

When applying the principle of optimization of protection, specially when dealing with relatively low level of unsealed radiation sources handled in the application of radionuclides in medicine, industry and research, the cost of the efforts to further reduce the individual and collective doses may be out of balance with the resulting improvement in sanitary conditions. In particular when the source of ionizing radiation presents a very low risk it may be a waste of resources to exercise control by regulatory processes. In such a situation, sources may be exempted or cleared from regulatory requirements. Sources which do not enter the regulatory control regime i.e. control is never imposed, are referred to as "exempt" while sources of radiation which are removed from the radiological control regime, are referred to as "cleared". The level of activity or activity concentration in the former case is called "exemption" level while in the latter case it is called "clearance" level.

A significant proportion of the waste arising as a result of the use of radionuclides in medicine, industry and research is either so low in activity concentration as to be of little health concern or has a relatively short half-life and may be stored to allow for decay to harmless levels. Most of such waste could be considered as candidate for clearance from regulatory control. The general principles and criteria for exemption and clearance have been detailed in the Basic Safety Standard. They have been built on the principles of exemption that were agreed upon in 1988 [2] and the 1990 recommendations of the ICRP [3]. The same radiological principles and criteria have been used in this paper in the derivation of representative clearance levels of radionuclides making use of the latest physical and radiological data and metabolic models.

NATURE OF WASTE, DISPOSAL PRACTICES, RADIATION CHARACTERISTICS AND THE ASSESSMENT OF RADIATION EXPOSURE

The use of unsealed radioisotopes in hospitals for diagnosis and treatment as well as for research in the medical field, in industrial applications and for research in the fields of agriculture, biology, physics, chemistry, etc. results in the generation of various kinds of radioactive waste. These include items which have been contaminated with radioactive materials, such as paper, plastic gloves and covers, counting tubes, glassware,

1 Division of Radiation and Waste Safety, International Atomic Energy Agency (IAEA), Vienna, Austria.

2 NIRAS/ONDRAF, Belgium.

washing liquids, organic liquids (e.g. scintillation liquids), excreta from patients who have had radioisotopes administered for treatment or diagnosis, animal carcasses etc. and contaminated equipment.

Many of the radionuclides used in hospitals and research establishments have relatively short half-lives. Where appropriate, they are disposed of following storage to allow for decay to harmless levels. Therefore, they are generally separated from longer-lived radionuclides. Airborne waste from hospitals and research establishments is generally less significant than solid or liquid waste. The potential for inhalation may, however, be significant and needs to be considered. Airborne effluents are discharged into the atmosphere either directly or through filtration systems. Aqueous effluents are discharged directly to sewer systems, or to septic tanks, or collection ponds, or to various water bodies such as rivers, lakes and the marine environment. Organic liquids (including scintillation fluids) are incinerated resulting in atmospheric releases. Solid waste such as paper, plastic and wood and glass vials, is usually disposed of with normal refuse in landfills; the combustible waste may be incinerated with normal refuse resulting in gaseous and particulate effluent and ashes, which are disposed of in landfills.

Radiation Characteristics of the Waste

The radiation characteristics of the waste must be known in order to carry out a radiological impact assessment of the radioactive waste involved in the proposed disposal. Information is required on the quantities, characteristics and types of radionuclides in the waste to be disposed of, the mode of disposal and the disposal locations. Some basic radiological data (half-life, dose coefficients for ingestion and inhalation, external irradiation dose coefficients for point and infinite plane source) are required in order to calculate the clearance level of the relevant radionuclides. The chemical form that gives the highest dose coefficient is used.

Assessment of Radiation Exposure

An outline of the major ways in which people can be exposed to radiation is presented here. It is necessary to determine the ways in which radionuclides might transfer through the environment to people. Account needs to be taken of the possible accumulation of radionuclides in environmental media, as well as possible dilution and dispersion. Potential exposures, such as those due to accidents, also need to be taken into account with the probability of occurrence as well as the consequences being considered. The main concern is the assessment of doses to members of the critical group [4] but collective doses may also be required. Different models for assessing the radiation doses may be required depending on the different circumstances. The IAEA has published information on methods and data to assess the radiological impact of planned releases of radionuclides to atmosphere and to water bodies [5]. This methodology is intended to be a relatively simple assessment tool that enables rapid evaluation of planned discharges to establish whether a given practice is in compliance with relevant dose criteria. It is considered sufficiently robust for use in an initial assessment of clearance levels for discharges.

Airborne Releases

Airborne releases to the atmosphere are assumed to be through stacks or vents. Radionuclides released to atmosphere will be dispersed depending on the local meteorological conditions. They will give rise to exposure due to inhalation of, and external irradiation from, the passing plume. During dispersal, radionuclides may be deposited on to the ground, depending on their physical form. The main exposure pathways of concern then are external irradiation from the deposited material; internal irradiation following the transfer of radionuclides through the terrestrial food-chains; inhalation of radionuclides transferred back into the atmosphere by the action of the wind or mechanical disturbance (re suspension). The build-up of deposits in the environment needs to be considered for longer lived radionuclides.

Liquid Releases

A frequently used route for the disposal of very low level liquid waste is via the ordinary sewer system. In this case, the exposure of sewage system workers needs to be evaluated. Also, treatment of sewage may result in a contaminated sludge and a contaminated liquid, which is discharged to a water body. The sludge might be incinerated giving rise to contaminated airborne effluent and solid residue. Alternatively, the sludge might be treated and used as fertilizer, giving rise to exposures similar to those following deposition of radionuclides after atmospheric release. Yet another possibility is that the sludge is disposed of as solid waste.

The liquid effluent, or the sewage stream itself , may be discharged directly into a surface water body: a river, a lake, an estuary or the marine environment. Generally this results in considerable dilution which can be taken into account in assessing clearance levels. However, it is important to be sure that no circumstances could arise where this dilution does not occur. Following release of liquid effluent to a river, consideration has to be given to all the potential uses of the river water which might give rise to radiation exposure. The pathways of interest include: ingestion of drinking water; ingestion of fish taken from the river; and ingestion of foods derived from land irrigated with river water. In addition, some radionuclides may become attached to sediments and fall to the river bed. These sediments might then act as a source of external irradiation or give rise to intake via inhalation. Sediments are also applied to agricultural land in some cases and so may give rise to the transfer of radionuclides through the terrestrial food-chain. The possible build-up of long-lived radionuclides in sediment and subsequent exposure pathways, therefore, also has to be considered. For very short-lived radionuclides, the assessment should concentrate on the drinking water pathway. Similar considerations also apply to releases to other water bodies.

Solid Waste

Combustible solids, as well as organic liquids and animal carcasses, may be incinerated giving rise to airborne discharges. Non-combustible solids, including ash from incinerators, might be disposed of to some form of municipal landfill. These facilities can vary considerably, both in their design and in the degree to which operations are controlled. At one extreme, such disposal might consist of little more than loose tipping on to a ground surface with final cover only being applied after considerable delay, if ever. At the other extreme, operations may be carefully controlled, with prompt covering of disposed material, preventing any human contact with the waste except by those workers directly concerned with the disposal operation. For such workers, exposure due to direct irradiation from the waste and as a result of the inhalation of re suspended radionuclides will be the main exposure pathways. In the first case, however, consideration should be given to the possibility of scavenging as an exposure scenario.

Once in the ground, radionuclides could find their way back to people by a number of mechanisms. Leaching by infiltrating groundwater is likely to be one of the most important mechanisms. Contaminated leachate may find its way to a surface water body but there may be considerable delay in the ground before this occurs. Solubility of the radionuclides and the potential for sorption in the ground are important factors; both are element specific and vary from site to site according to the nature of the ground materials. The ground water flow system is also important. Again, this is site specific, and a full analysis must take account of factors such as rainfall and infiltration, level of the water table relative to the buried material, and the engineered features of the facility designed to minimize leaching and/or to control leachate movement.

CLEARANCE PRINCIPLES AND THEIR APPLICATIONS

The System of Control

Sources and practices involving the exposure of people to ionizing radiation are normally controlled by a system of notification and authorization as exemplified in the BSS [1]. In general, prior to the use of radioactive materials, the operator is required to notify the Regulatory Authority of his intentions and to apply for an authorization in the form of a registration or a license. Such authorizations may include discharge limits and provisions to control the discharges, such that doses to members of the public are kept as low as reasonably achievable and below the appropriate dose limits and constraints. However, specific sources and practices may be exempted from the system of control, if, based on an analysis of the health hazards involved, the Regulatory Authority considers the inclusion of the respective sources or practices in this system to be unnecessary. Similarly, sources and practices already under regulatory control may be cleared from regulatory requirements if the Regulatory Authority considers that this is warranted. The implementation of the clearance principles in the context of discharges to the environment is described in Ref. [4].

Clearance Criteria

From a radiation protection standpoint, the basic principles for determining, whether or not radioactive material is no longer subject to regulatory control [1] are as follows:

- individual and collective risks must be sufficiently low as not to warrant regulatory concern; and
- the practices and sources must be inherently safe.

These principles have been quantified as follows: a practice or source within a practice may be cleared without further consideration provided that the following criteria are met in all feasible situations:

(i) the effective dose[3] expected to be incurred by any member of the public due to the practice or source is of the order of 10 micro sievert or less in a year, and

(ii) either the collective effective dose committed by one year of the performance of the practice is no more than about 1 man.Sv or an assessment for the optimization of protection shows that clearance is the optimum option.

The Need for Derived Quantities

The guiding radiological criteria for clearance are expressed in terms of dose and cannot be used directly for establishing clearance levels. It is therefore necessary to convert them into practical quantities derived in terms of mass activity concentration (Bq g^{-1}), surface contamination (Bq cm^{-2}), total activity per unit time (Bq a^{-1}) or total mass per unit time (t a^{-1}). The derivation of these quantities requires a thorough examination of the reasonably possible routes by which humans may be exposed to radiation from the proposed cleared radioactive materials. The radiation doses associated with each route of exposure and for each radionuclide considered must be evaluated. On the basis of these evaluations it is possible to calculate a quantity, either in Bq g^{-1}, Bq cm^{-2}, Bq a^{-1}, t a^{-1}, or some combination of them, which will satisfy the clearance criteria.

Regulatory Considerations

In general, the control of radioactive waste disposal is exercised through regulation of the activities of the operator of the facility that generates the waste. In IAEA Safety Series No. 89 [3], the possibility is left open that control could also be exercised at the disposal facility which might receive waste from several operators. Although possible in principle, this approach presents difficulties in practice; for example, it is difficult to control by means of monitoring or any other checks, the nature of the waste arriving at a disposal site from a number of different facilities. It is, therefore, more appropriate for control to be exercised by regulation of the operator of the facility where the material originated.

[3] Unless otherwise stated, the term 'dose' refers to the sum of the effective dose from external exposure in a given period and the committed effective dose from radionuclides taken into the body in the same period.

In the context of this paper, the process of disposal begins when the operator relinquishes control of the waste. In most situations, this will be when the waste leaves the premises of the operator, unless, for some reason, the operator retains control of the waste after that time. For example, disposal of solid waste could begin when a dustbin or waste container passes into the control of other persons, or the operator's employee delivers it to a disposal facility. For liquid waste, disposal could be considered to begin when the waste is poured down the sink or drain on the operator's premises. For airborne waste, disposal could be considered to begin at the fumehood. The radiological impact assessment should take into account doses to all persons exposed after the disposal process begins.

The control of radioactive waste disposal is normally exercised through the granting of permits, licenses, or authorizations by a competent authority to the operator. Such authorizations usually stipulate disposal routes for various waste forms and the limits in terms of specific and/or total activity, as conditions that the operator must comply with.

Clearance authorizations covering a variety of situations may be granted. They may be unconditional, in which case there is no restriction on the further use of the material. Alternatively they may be conditional, in which case the end use is controlled, for example by limiting the disposal route. It should, however, be ensured that the dose to members of the general public from the practice under consideration and any other cleared practice does not exceed a few tens of micro sieverts per year. Clearance should be justified and supported by a radiological impact assessment. The assessment should cover all the likely pathways of exposure situations that could arise from a practice being considered for clearance. In some circumstances the assessment may simply be a review to determine that the conditions of a reference evaluation, such as presented in this document, remain valid and that therefore the representative clearance levels can be applied. In general, the assessment should provide estimates of doses to workers and to members of the public who may be exposed after the point of disposal. Both normal and accidental exposure circumstances should be covered. The competent authorities should exercise judgment in considering exposure situations with a low probability of occurrence, such as the possible misuse of waste from the cleared practice which could have consequences serious enough to preclude clearance.

DERIVATION OF CLEARANCE QUANTITIES

In this Section a set of representative clearance levels is presented for use as an indication of possible clearance levels. Details of the derivation of these values are given in IAEA-TECDOC-1000 [6].

Representative Clearance Levels for Release to Atmosphere

Representative clearance levels for releases to the atmosphere are presented in Table I for a selected number of radionuclides. They were derived based on a number of assumptions that were intended to give a cautious estimate of the clearance levels. These clearance values take account of the ingestion of crops produced 100 m from the release point and animal products produced 800 m from the release point; it was assumed that the food intake rates were typical of critical groups. The models and data used were developed for application in temperate European and North American conditions. The clearance values may therefore need to be reviewed for countries with significantly different types of diet, agriculture and style of living. Table I indicates which exposure pathways are most important in determining the clearance levels for releases to atmosphere.

TABLE I: DERIVED REPRESENTATIVE CLEARANCE LEVELS FOR AIRBORNE RELEASES

Radionuclide	Annual Release Rate (Bq a^{-1})	Main Exposure Pathways and limiting age group
H-3	1 10^{11}	Ingestion
C-14	1 10^{10}	Ingestion
Na-22	1 10^{6}	External from deposit (Adults and Infants)
Na-24	1 10^{9}	External from deposit (Adults and Infants)
P-32	1 10^{8}	Ingestion (Infants)
S-35	1 10^{8}	Ingestion (Infants)
Cl-36	1 10^{7}	Ingestion (Infants)
K-42	1 10^{10}	External from deposit (Adults and Infants)
Ca-45	1 10^{8}	Ingestion (Infants)
Ca-47	1 10^{9}	External from deposit and Ingestion (Adults and
Cr-51	1 10^{9}	External from deposit (Infants)
Co-57	1 10^{9}	Ingestion (Infants)
Co-58	1 10^{9}	Ingestion (Infants)
Fe-59	1 10^{8}	External from deposit (Adults and Infants)
Ga-67	1 10^{10}	External from deposit (Adults and Infants)
Se-75	1 10^{8}	External from deposit (Adults and Infants)
Sr-85	1 10^{8}	External from deposit (Adults and Infants
Sr-89	1 10^{8}	Ingestion (infants)
Y-90	1 10^{10}	Inhalation and Ingestion (Infants)
Mo-99	1 10^{9}	External from deposit (Adults and Infants)
Tc-99	1 10^{7}	Ingestion (Infants)
Tc-99m	1 10^{11}	External from deposit (Adults and Infants)
In-111	1 10^{9}	External from deposit (Adults and Infants)
I-123	1 10^{10}	External from deposit (Adults and Infants)
I-125	1 10^{8}	Ingestion (Infants)
I-131	1 10^{8}	Ingestion (Infants)
Xe-127	1 10^{11}	External from cloud (Adults and Infants)
Xe-133	1 10^{12}	External from cloud (Adults and Infants)
Pm-149	1 10^{10}	Inhalation (Adults and Infants)
Er-169	1 10^{10}	Inhalation and Ingestion (Infants)
Au-198	1 10^{9}	External from deposit (Adults and Infants)
Hg-197	1 10^{10}	External from deposit (Adults and Infants)
Hg-203	1 10^{8}	External from deposit and Ingestion (Infants)
Tl-201	1 10^{10}	External from deposit (Adults and Infants)
Ra-226	1 10^{6}	Inhalation and Ingestion (Adults and Infants)
Th-232	1 10^{5}	Inhalation (Adults)

Notes

1. The calculations on which these values are based assume releases from a building vent or window. The closest individual is located 20 m from the release point and gets his food, 100 and 800 m from the release point. Doses are evaluated via inhalation, ingestion and external exposure routes.

2. Significant differences in these values are possible for different source to receptor distances.
3. Monthly/weekly/daily release rates may be derived directly from the values presented here. In deriving clearance levels for atmospheric and liquid discharges, annual averages have been used for some parameters. Therefore, they are not appropriate for short term releases.

Representative Clearance Levels for Aquatic Releases

Representative clearance values for liquid releases to sewers or freshwater bodies are given in Table II for a selected number of radionuclides. For discharge to sewers two extreme possible scenarios were considered: assuming that no radioactive material is retained in sewage sludge but it is all discharged to the water body in liquid form; and assuming that all of the radioactive material discharged is retained in the sewage sludge at the sewage treatment works. Radiation doses were calculated for both cases and the most restrictive screening level used to give the representative values in Table II. If the waste is discharged directly to a river and the sewage scenario is the most restrictive, then the doses will be over estimated. The release is assumed to occur into a relatively small river with a low flow rate and a receptor location 1 km downstream of the release point. Changes in these assumptions, particularly changing the river size and flow rate can have a significant effect on the resultant doses. Releases to an estuary or to the marine environment will result in lower doses. However, releases in a lake may result in higher doses and need to be considered separately.

For radionuclides in sewage sludge, two exposure pathways were considered: external irradiation and inhalation of re suspended material. For releases to a river, the pathways considered were: ingestion of drinking water; ingestion of fish; and external irradiation from contaminated sediments. For these calculations, the transfer of radionuclides to the terrestrial food-chains due to irrigation or treatment with sewage sludge has not been considered. In particular circumstances, some pathways may be important and should be considered. Table II indicates which exposure pathways are most important in determining the clearance levels for aquatic releases.

TABLE II: DERIVED REPRESENTATIVE CLEARANCE LEVELS FOR LIQUID RELEASES

Radionuclide	Annual Release Rate (Bq a^{-1})	Main Exposure Pathways
H-3	$1\ 10^{12}$	River - Ingestion
C-14	$1\ 10^{10}$	River - Ingestion
Na-22	$1\ 10^{5}$	Sewage - External
Na-24	$1\ 10^{8}$	Sewage - External
P-32	$1\ 10^{6}$	River - Ingestion fish
S-35	$1\ 10^{9}$	River - Ingestion fish
Cl-36	$1\ 10^{10}$	River - Ingestion fish and water
K-42	$1\ 10^{9}$	Sewage - External
Ca-45	$1\ 10^{10}$	River - Ingestion fish and water
Ca-47	$1\ 10^{8}$	Sewage - External
Cr-51	$1\ 10^{8}$	Sewage - External
Co-57	$1\ 10^{9}$	Sewage - External
Co-58	$1\ 10^{8}$	Sewage - External
Fe-59	$1\ 10^{6}$	Sewage - External
Ga-67	$1\ 10^{8}$	Sewage - External
Se-75	$1\ 10^{6}$	Sewage - External
Sr-85	$1\ 10^{6}$	Sewage - External
Sr-89	$1\ 10^{9}$	River - Ingestion fish and water
Y-90	$1\ 10^{10}$	River - Ingestion fish and water
Mo-99	$1\ 10^{8}$	Sewage - External
Tc-99	$1\ 10^{10}$	River - Ingestion fish and water
Tc-99m	$1\ 10^{9}$	Sewage - External
In-111	$1\ 10^{8}$	Sewage - External
I-123	$1\ 10^{9}$	Sewage - External
I-125	$1\ 10^{8}$	Sewage - External
I-131	$1\ 10^{7}$	Sewage - External
Xe-127	Not applicable	
Xe-133	Not applicable	
Pm-149	$1\ 10^{10}$	Sewage - External and River - Ingestion
Er-169	$1\ 10^{10}$	River - Ingestion fish and water
Au-198	$1\ 10^{8}$	Sewage - External
Hg-197	$1\ 10^{9}$	Sewage - External
Hg-203	$1\ 10^{7}$	Sewage - External
Tl-206	$1\ 10^{8}$	Sewage - External
Ra-226	$1\ 10^{6}$	Sewage - External
Th-232	$1\ 10^{6}$	Sewage - External

Notes

1. The values are the most restrictive of those calculated following discharge to a river or discharge to a sewer
2. Monthly/weekly/daily release rates may be derived directly from the values presented here.

Representative Clearance Levels for Solid Waste

The Basic Safety Standards [1] give exemption criteria for a wide range of radionuclides. Sources can be automatically exempted from the requirements of the Basic Safety Standards if they comply with these exemption criteria. Those were derived using a conservative model for a series of limiting use and disposal scenarios. The values of activity concentration represent the lowest values calculated in any scenario. The calculated values apply to practices involving small-scale usage of activity where the waste quantities involved are at most of the order of a tonne.

In 1996, the IAEA published an interim report on clearance levels for radionuclides in solid materials [7]. Its aim is to provide a set of nuclide specific clearance levels which can apply to solid materials irrespective of the use to which they are put or of their destination after radiological control has been relinquished. These values are generally applicable to large amounts of materials. They were derived independently of the BSS exemption levels, but it has been observed that there is a fairly good agreement between these clearance levels and one tenth of the BSS exemption levels[8].

In the interest of promoting consistency and uniformity in recommended international values for exemption and clearance, the generic clearance levels for solid wastes are numerically equal to the BSS exemption values. However, they should be adjusted using the modifying factor of 1/10 when the amounts for clearance become large. Generic clearance levels for some of the frequently used radionuclides for moderate quantity of solid waste (generally less than 3 tonnes per year per facility) based on Ref. [6] is presented in Table III.

TABLE III. GENERIC CLEARANCE LEVELS FOR SOLID WASTE (Bq/g)

Radionuclide	**Clearance level for moderate quantities (a)**	**Radionuclide**	**Clearance level for moderate quantities (a)**
H-3	$1\ 10^{6}$	Sr-89	$1\ 10^{3}$
C-14	$1\ 10^{4}$	Y-90	$1\ 10^{3}$
Na-22	$1\ 10^{1}$	Mo-99	$1\ 10^{2}$
Na-24	$1\ 10^{1}$	Tc-99	$1\ 10^{4}$
P-32	$1\ 10^{3}$	Tc-99m	$1\ 10^{2}$
S-35	$1\ 10^{5}$	In-111	$1\ 10^{2}$
Cl-36	$1\ 10^{4}$	I-123	$1\ 10^{2}$
K-42	$1\ 10^{2}$	I-125	$1\ 10^{3}$
Ca-45	$1\ 10^{4}$	I-131	$1\ 10^{2}$
Ca-47	$1\ 10^{1}$	Pm-147	$1\ 10^{4}$
Cr-51	$1\ 10^{3}$	Er-169	$1\ 10^{4}$
Fe-59	$1\ 10^{1}$	Au-198	$1\ 10^{2}$
Co-57	$1\ 10^{2}$	Hg-197	$1\ 10^{2}$
Co-58	$1\ 10^{1}$	Hg-203	$1\ 10^{2}$
Ga-67	$1\ 10^{2}$	Tl-201	$1\ 10^{2}$
Se-75	$1\ 10^{2}$	Ra-226	$1\ 10^{1}$
Sr-85	$1\ 10^{2}$	Th-232	$1\ 10^{0}$

(a) Moderate quantity means less than 3 tonnes per year and per facility. For larger quantities the clearance level is one tenth of the levels given in this Table.

Note: The clearance levels for moderate quantities are identical to the BSS [1] exemption levels.

Applicability of the Representative Clearance Values

The representative clearance values presented here have been derived generically using conservative assumptions. The values in Tables I, II and III are to be considered as order of magnitude, reflecting a level of uncertainty associated with this type of generic assessment. In deriving clearance levels for atmospheric and liquid discharges, annual averages have been used for some parameters. Therefore, they are not appropriate for short-term releases. The values in these Tables were derived with the intention of assuring that if complied with, annual doses to individual members of the public arising from any single cleared practice will not exceed 10 μ Sv. A cautious approach has, therefore, been adopted throughout in the assumptions and in the choice of scenarios and model data.

Ideally, clearance quantities should be derived using assumptions and model parameters that are appropriate to the particular local situation of interest. This would increase the degree of confidence associated with the use of such quantities compared to those derived based on generic assumptions. Without appropriate site specific information the uncertainty associated with the dose estimate is likely to be higher and conservative assumptions have to be made to compensate for this uncertainty.

They may be useful for an initial assessment of whether a proposed disposal could be cleared from regulatory control. However, they do not preclude the use of other clearance values derived using more appropriate local or regional information. For a particular source, it may be appropriate to use site specific information and more realistic assumptions. However, if clearance levels are intended for general application to a large number of similar facilities within a particular country or region, then a site specific approach is not applicable and a generic, cautious approach of the type outlined here is appropriate.

The scenarios, models and data used in the derivation of the representative values are all derived from experience in Europe and North America. The cautious nature of the assessment procedure will be expected to compensate for some differences between countries, for example in food-chain transfer and food-consumption habits. However, there may be circumstances or exposure pathways that are outside the range of possibilities covered in this analysis. For example, it has been assumed that waste actually reaches the disposal facility. If it did not, then a range of possibilities exist for early exposure. However, this has been taken care of to some extent in the derivation of the clearance levels for solid waste. A judgement should be made by the competent authority as to whether the methodology outlined in this report is suited to local conditions. If it is felt that a potentially important scenario or exposure pathway has been omitted then a specific analysis should be undertaken.

Collective Doses

An important principle for exemption and clearance is that the radiation protection be optimized, which involves consideration of the collective dose associated with a practice. If it can be shown that the collective dose commitment is less than about 1 man.Sv per year of practice, then no further action is required but otherwise a more thorough optimization exercise may be needed. The evaluation of collective dose requires information on the disposal practice as well as site specific data on the population at risk, exposure routes etc.. However, it is possible to explore, in a general way, the likely order of magnitudes of collective doses which could result from disposal of radioactive waste. Generic estimates of collective dose for unit discharge of a number of radionuclides to atmosphere and to water bodies have been made by the IAEA [5]. These are orders of magnitude estimates intended for screening purposes. They could be used to determine if the collective doses corresponding to the clearance levels for airborne or liquid discharges meet the 1 man.Sv criterion. The representative clearance values presented in the above tables meet, in all cases, this criterion.

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