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REPUBLICA ARGENTINA
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# ENVIRONMENTAL ASSESSMENTS RELATED TO THE MANAGEMENT OF RADIOACTIVE WASTES ARISING FROM NUCLEAR EMERGENCIES ON LAND AND SEAS

Panel on Management of Radioactive Wastes Arising from Emergencies on Land and Sea, International Atomic Energy Agency, Athens (Greece), 1-7 December 1973.

Ing. González
Comité de Licenciamiento y Normas

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RESUMEN

En el trabajo se discute la filosofía básica de la gestión de desechos radiactivos producidos en situaciones de emergencia nuclear. Se considera la interrelación de la ubicación y de las consecuencias eventuales del escape de dichos materiales, sugiriéndose el uso de los criterios del IOEA para las evaluaciones de seguridad del emplazamiento de las instalaciones. Se discuten escapes planificados y no-planificados provenientes de esas emergencias y en particular, aquellas situaciones en las que se producen: a) residuos similares a los provenientes de la operación normal y b) residuos de características diferentes a las de estos últimos. Se concluye que las evaluaciones relacionadas con la gestión pueden ser llevadas a cabo usando las filosofías básicas desarrolladas por la CIPR aunque teniendo en cuenta que en muchos casos razones de índole práctica pueden requerir la adopción de aproximaciones más simples aunque ellas resulten menos coherentes.

ABSTRACT

Basic philosophy for managment of radwaste materials arising from nuclear emergencies situations are discussed. The interelation of siting and eventual consequences of releases are considered and, the use of IAEA criteria for the safety assessment of the site of facilities are suggested. Planned and unplanned releases of radwastes arising from those emergencies are discussed; in particular two situations of planned releases are analyzed: a) those with similar wastes to the ones arising from normal operation and, b) those generating wastes of different characteristics than ones in normal operation. Finally, it is concluded that assessments related with this managment can be taylored using the basec philosophies as developed by ICRP; nevertheless, it must be borne in mind that in many cases practical reasons may force the adoption of a more practicable even if less coherent approach.

## 1. INTRODUCTION.

Nuclear emergency situations can be divided in two groups:

a. Situations where the radioactive material arising from accident is retained within the instalation and where therefore waste management is possible at least in principle, and

b. Situations where a substantial amount of radioactive materials are released without control into the environment.

It is therefore convenient to categorize in two different ways the release into the environment of radioactive materials arising from nuclear emergencies: planned and unplanned releases.

During normal operations planned releases of radioactive substances are subject to limitations so that the consecuent dose comply with appropriate predeterminate standards. On the other hand, in emergency conditions planned releases are only limited by authority decisions taking into account the particular circumstances on a case by case bases. Unplanned releases may in some cases be subject to limitation by natural processes or by engineering safeguards, but are clearly outside of limitations by authority decisions.

In both planned and unplanned releases, the time scale may be chronic or acute, either taking the form of a single short release or being the result of a series of short duration events. However, from the radioprotection point of view there is no substantial difference between both time scales if the relevant parameter for risk assessment is the resulting dose commitment.

The dose commitment resulting from a release is the integral over an infinite period of time of the average dose rate in the population group under consideration. (1)

It can be shown that the release of an amount of radioactive material (Q) will produce a dose commitment equal to the annual dose which would be reached after equilibrium in the case of a continuous release at a rate of Q per year. (2).

## 2. CONSIDERATIONS ON THE INTERELATION OF SITING AND THE EVENTUAL CONSECUENCES OF RELEASES.

The waste disposal management is now such that only in exceptional circumstances will planned releases of radioactive waste have a decisive influence on the choice of site. However, the potentiality for accidental releases of large amounts of radioactive materials in a serious nuclear accident is still an importa[nt] factor in the final choice of site.

If the safety assessment of the site of the facility has been carried out in accordance with the criterias recommended by the Agency, (3) the public will not be considerably affected, even if "representative accidents" occur in the installation. The term "representative accident" defines an hypothetical accident which is specifically appropriate to the type of installation and is severe enough to test the safety provisions.

The safety assessments should show that even in the eventuality of representative accidents the dose to the "critical group" will remain below some preestablished "reference doses for safety evaluation". The term "critical group" is used here to describe the population group representative of those individuals expected to receive the highest dose from the release arising from the accidents under consideration. The reference doses for safety evaluation will be prescribed by the Licensing Authority for use in evaluating the safety of the facility.

Operational radiological protection limits are clearly not applicable in these evaluations because these limits are intended to apply only to those conditions where the source of exposure is under control and they are meaningless in accidental situations with unpredicted overexposures. (4),(5).

## 3. NUCLEAR EMERGENCIES INVOLVING PLANNED RELEASE OF WASTES.

### 3.1. Situations with wastes similar to those arising in normal operation.

When the radioactive materials arising from a nuclear emergency remain contained in the facility and their physicochemical characteristics and amounts are similary to those wastes arising from normal operations, it is possible to plan the management with the existent installations. The waste management primary decision is whether to contain or to discharge the waste or part of it into the environment.

In both cases it is possible to manage the wastes in their original state or to make some previous treatment mainly intended to reduce the operational cost.

In rutinary operations the annual amount of release radioactivity must be less than the discharge limit given by the authorities for the facility taken into account the stipulated radiological capacity to the environment (6). Nevertheless, in emergency situations, these regulatory concepts loose their validity.

On the other hand, the limiting radiological capacity concept(6) which is also inapplicable in its strict sense can still be used in emergency situations, but only to assess the levels of discharge that would result in doses which are of little significance.

It should be remembered that the limiting radiological capacity is a concept related with the Dose Limits and these Limits, while considered to be appropriated to repeat year-by-year exposures, is restrictive for direct application in the emergency.

In consequence, if the waste activity is less than the limiting radiological capacity, it appears advisable the release into the environment. In the cases where the waste activity has similar order of magnitude than the limiting radiological capacity for several years of normal operations, it would be advisable to compare the activity with the previous established action levels.

The actions envisaged should cover the amounts to be released, the amounts to be contained and the eventual previous treatment.

The assessment of the collective dose commitment due to both, the released and the contained fraction of the waste is important for the establishment of action levels. The collective dose commitments (S) will measure the total exposure of the whole body or a specified organ of a population of people. If the number of people receiving doses between H and H + dH is N(H) dH. The collective dose is given by

$$S = \int_0^\infty HN(H)dH \qquad \text{(I)}$$

where the integration is carried out over the total dose distribution over the population.(7) The calculation requires knowledge of individual doses. It can be shown that the dose commitment for individuals, arising from a released activity ($A_j$) is given by

$$H_j = A_j \sum_i Fi \quad Ei \quad Fd,i. \qquad \text{(II)}$$

Where:

$A_j$ = is the activity of radionuclide j

Fi = The transfer coefficient relating the discharge to the integral of the concentration in the basic disposal medium (air, water, etc.)

Ei = The factor relating the basic disposal medium to the compartment i to which the public is exposed to.

Fdi = The dosimetric parameter used for converting the activity integral due to compartment i into a tissue dose.

Knowing the isotopic composition of the mixture it is possible to obtain by sumation of doses to same organs the dose commitments due to the release.

The collective dose commitment then is obtained by summation of integration of the individual doses over the appropriate population. The Agency has published considerable information about parameters used in the assessment for discharges into the sea (8), (9), (10), into fresh water (11) including lakes and estuaries (12)and on the ground (13), and a bibliographycal series about these topics (14). There are also publications relating to parameters of atmospheric dispersion (15), (16).

In principle, the release of the waste should imply a larger collective dose commitment than the containment, because of the large number of people involved. However, the containment procedures may be complicated and may produce high individual exposures in the involved personnel. In this case the collective dose commitment might be higher than that resulting from the release. It is convenient, at least in principle, to release a fraction of the waste and contain the rest, choosing the fraction so as to minimize the collective dose commitment from the total operation. In all cases it must be assured that the individual exposures are less than the preselected action levels for abnormal situations.

In catastrophic accidents involving radioactive wastes of activity an order of magnitude higher than the limiting radiological capacity, contention is clearly the prefered management method. In this case the waste volume defines the eventual need of some treatment before containment. If the volume is small and the activity concentration is high the treatment is usually unadvisable . On the other hand, if the activity is diluted in high volumes, it is generally convenient to treat the waste to reduce the volume and to lower the contention cost. In a few cases, safety can be increased, treating high levelwaste with the purpose of changing its physico-chemical characteristics. The Agency has published several documents on contention methods (17), treatment methods (18),(19),(20),(21),(22),(23),(24), and economical aspects of management (25).

3.2. Situations generating wastes of different characteristics than those in normal operations.

The existing waste management facility can not be used in accidental situations where the waste arising from the nuclear emergency has different characteristic than those in the normal operation waste. In this case the waste management problem might be quite serious from the radiation protection or economic points of view. This eventuallity must be considered when planning the installation in order to minimize the probability of these hazardous situations.

However, if in spite of the precautions, the case under consideration occurs, it might be necessary to spend considerably for the management. The assessment of the cost which appears to be reasonable can be done using a criterium of differential cost-benefit analysis similar to that used in defining "as low as readily achievable...". (7) It must be pointed out that the procedure, which is outlined below, refers to normal operations and its suggested use for the accidental case is an extension, which might not be completely justified.

In normal operations involving exposure to ionizing radiations it is possible to assess the net benefit from the operations as follows: from the operation gross value would be deducted the basic productions cost, the installation cost including social cost of achieving a selected level of safety, and the total detriment valued in the same unit of the costs represented by the production use and disposal of the operation product. The detriment here is "the mathematical concept "expectation" of the harm incurred from a radiation dose, taking into account not only the probability of each type of deleterious effect but the severity of the effects as well.

Thus if pi is the probability of suffering the effect i, the severity of which is expressed by weighing factor gi, thenthe detriment G in a group composed of P persons is (7)

$$G = P \sum_{i} pi \; gi \text{ "} \qquad \text{(III)}$$

The detriment can be valued taking into account the appropriate cost by the society to the potential risk. There are several references about this detriment cost (26), (27), (28), (29), (30), (31). In particular, ICRP made suggestions relating to the estimated cost of exposures to ionizing radiation. (7)

As shown in reference (7), the optimization implied in the concept "as low as readily achievable..." corresponds to a Dose for which

$$\frac{dC}{dE} = - \frac{dG}{dE} \qquad \text{(IV)}$$

where C is the "total cost", G "the detriment" and E is a variable reflecting the exposure possible in man-rems.

As it was mentioned before, it is suggested to extend this concept to the accidental case in relation to the cost of remedial actions The calculation must necessarily be made on a case by case bases and the solution will assess the reasonable investment for the additional waste management installation. In any case, after the remedial actions, radiation levels in the installation should be compatible with its further use.

## 4. UNPLANNED RELEASE OF RADIOACTIVE MATERIALS ARISING FROM NUCLEAR EMERGENCIES.

Unplanned release of radioactivity of significant magnitude in nuclear emergencies are very improbable. Minor, more frequent, misha[illegible] giving rise to small releases can usually be treated as part of th[illegible] program of planned releases.

When the radioactive inventary of the installation is sufficiently large to constitute a potential hazard to people outside the facility, and as a consecuence there is a possibility of accidents resulting in doses exceeding the Dose Limits by a substantial factor, it may be necessary to prepare plans for eventual emergency surveys. The ICRP has given general guidance for planning adequate emergency surveys (32).

Dose Limits have no meaning in emergency and accidental exposures and the competent authority must set "actions levels" to be included in the emergency plan which is required for the obtention of the license
The lowest actions levels are the usually called Emergency Reference Levels (ERL). These are values, usually of dose but sometimes of an environmental measurement, which divides situations in which counter-measures are unlikely to be justified from those in which counter-measures are desirable if they can be carried out safely and effectively. (33).

It is clear that the application of counter-measures could be desirable but not mandatory where the levels are higher than the emergency reference levels.The choice of action will depend on a balance between the radiation risk which is avoided by the counter measure and the risk counter-measure itself.

Another well defined "action level" is a level for which the counter-measures are mandatory. This level should not exceed a value for which the disease by acute irradiation is possible and the probability of induction of malignancies is substantial in the order of the percent. For example a likelihood of whole body dose of 100 Rads would always call for action. (4)

A part of the emergency programme is the plan for emergency surveys, the objective primary of which "is to obtain rapid information on the magnitude and location of the inmediate hazard to men, so as to define the type and extent of any necessary emergency procedures and counter-measures" (32)

Due to the wide range of individual circumstances characterizing an accident it is not feasible to specify for general use all the possible counter-measures actions.

The ICRP has summarized the possible actions into the following categories: (5) a. Action to control the original source of exposure; b. Remedial action to reduce the environmental levels, and c. Measures taken to minimize the dose received in tissue.

The levels to be compared with the action levels must be measured in the critical group or in some link of a critical pathway.

The ICRP has recommended as a secondary objective of the emergenc survey "the assesstment of radiation dose actually incurred by the public, taking into account any counter-measures which have been applied" (32). For this evaluation the dosimetric procedure used in normal operations can be applied, introducing the parameters which are appropriate for the conditions present during the emergency.

## 5. CONCLUSION.

Environmental assessments related to the management of wastes generated in nuclear emergencies can be taylored using the basic concepts and phylosophies of radiation protection, as developed by the ICRP, and implemented by procedures which can be found in IAEA publications. It must however be borne in mind that practica reasons may in many cases force a departure from a self-consisten phylosophy and the adoption of more practicable even if less coherent approach.

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