RECENT TRENDS TOWARDS THE DOSE HAZARD REFERENCE IN STANDARDS FOR DIFFERENT NUCLEAR ACTIVITIES

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ABSTRACT

Dose hazards using radionuclides groupings are considered, with a view to the importance of including the nuclides utilization modes in their classification.

The problem of giving quantitative values to parameters for the evaluation of dosage risk is analyzed, changing from the concept of curies to the concept of rems, giving IAEA regulations for transportation of radioactive materials as an example.

Value of the reference dose is examined, mentioning the priority meter used in Italy in surveillance activities on instruments containing isotopes.

Radioprotection rules, prepared by international organizations as recommendations, regulations and directives, are, in most cases, completed by a radionuclides grouping called 'radiotoxicity grouping'. It considers the various degrees of hazard, mostly on the basis of metabolism and damages which can consequently caused to man.

These groupings are very important, since they provide the basis for any further consideration on the risk in the different uses of radionuclides. It is not correct, however, to associate radiotoxicity with risk. In fact, radiotoxicity represents only one, even if important, of the elements which characterize risk.

That is to say that the said groupings represent a fundamental theoretical basis, but are not sufficient to calculate dose risks, since they do not consider the modes of nuclide utilization.

For example, with respect to hazard, it is not sufficient to place ^{241}Am in the first radiotoxicity group and ^{131}I in the second group, without considering the modes of utilization. It is clear that a sealed source of ^{241}Am is much less hazardous than a source of ^{131}I, of the same activity, used in therapy.

On the contrary, this distinction is of fundamental importance from the point of view of the different radiotoxicity and it constitutes the basis for a further formulation which considers the other parameters already mentioned.

Euratom radioprotection directives determine certain statements or authorization obligations for definite radioactivity levels, based on radiotoxicity groupings. For the group with the highest radiotoxicity, such level is fixed at 0.1 µCi; for the next group in 1 µCi and then in 10 and 100 µCi for the other two groups. These levels do not take into consideration the modes of utilization.

With the experience of decades, we cannot forget that the activity level of the particular nuclide utilized cannot be the only determining criterion of the hazard.

The possibility is foreseen, then, to reach classifications which, besides radiotoxicity, take also into account the modalities of usage.

Consequently, two main problems arise.

The first one concerns the characterization and definition of parameters which, for the different modes of usage, permit the evaluation of dosage risk.

When possible, it would be opportune and, from the scientific point of view, certainly more suitable to give quantitative values to these parameters. For some of them, it is rather easy. If we consider, for example, a ^{192}Ir source, we may think, even being conservative, to give zero value to this source for the dispersion parameter, considering the metal shell (layer) and the lack of brittleness of the source. We cannot do the same with ^{60}Co, for example, nothwithstanding its metallic state, but because of its brittleness, when used in conditions where this brittleness can be involved.

The radiation parameter of a pure alpha particles emitting source is certainly different and lower than of a beta or gamma emitter, on the basis of the scheme contained in the instrument used.

The problem is not easy, since it is necessary to examine each radionuclide and for each of them, give different quantitative values to the usage conditions parameters, and to their radiotoxicity with reference to the dose absorption risk. On the contrary, parameters choice and definition could be the same for all radionuclides and for all uses.

The above statement, besides being substantial from the practical point of view, presents a formulation of principle which is very different from the one used in radioprotection by some international organizations and, consequently, by some national rules.

The new radioprotection formulation is a change from the concept of curies to the concept of rems. This means to substitute the capability of the dose risk pertaining to the radionuclide and to the different characteristics of modes of usage to the discriminative and determinant capability of the radioactivity value connected to the radiotoxicity of the single nuclides.

IAEA regulations for transportation of radioactive materials[1] are based substantially on the above concept. In those regulations, the maximum activity allowed in "type A" packages is fixed on the basis of a radionuclides radiotoxicity classification which is connected, however, to their hazards in the particular field of transportation, with consideration to the maximum permissible dose in case of accident, assuming certain dispersion and possible absorption conditions. In the last regulations, the radionuclides classification was abolished, because of the opportunity to consider the chemical and physical characteristics of each of them.[2]

This means that IAEA always considered nuclides in connection to the type of utilization (transportation), with reference to the dose hazard they may have in case of accident, on the basis of the above mentioned parameters.

The second problem which presents itself in view of this new optics of radioprotection is connected with the value of the reference dose.

In the mentioned regulations, IAEA always assumed the value of 3 rems.

It is clear that this problem, even if of great importance, is not difficult to solve, since, assuming a value and calculating parameters on its basis, it is easy to calculate its multiple and submultiples.

For example, IAEA fixed the maximum activities which can be contained in "type A" packages, by the utilization of certain parameters with a dose hazard of 3 rems. If utilization conditions and the matter would require a thousand times greater dose, it would be sufficient to multiply by a thousand the maximum values of the permissible activities in the mentioned packages.

In order to illustrate the instance above, we believe in the opportunity to mention a method for establishing a priority range in the surveillance activities on the different instruments containing isotopes for industrial applications that we used in Italy. Such formulation is based upon the different hazard which the instruments present on the basis of their particular type, the radionuclide and the number of instruments present at the same time in the same room.

The problem was limited to the instruments which are of wider use in Italy, as:

- gammaradiography apparatus, containing ^{60}Co, ^{137}Cs and ^{192}Ir,
- irradiators, containing ^{60}Co,
- analytical balances, containing ^{204}Tl and ^{90}Sr,
- light indicators, containing ^{60}Co, ^{137}Cs, ^{226}Ra, ^{241}Am and ^{90}Sr,
- gas chromatography apparatus, containing ^{63}Ni and ^{3}H,
- level indicators, containing ^{60}Co, ^{137}Cs, ^{226}Ra, ^{241}Am and ^{90}Sr,
- thickness meters, containing ^{204}Tl, ^{137}Cs, ^{226}Ra, ^{90}Sr, ^{85}Kr, ^{147}Pm and ^{144}Ce,
- lightning rods and fire monitors, containing ^{241}Am and ^{226}Ra,
- electrostatic discharge apparatus, containing ^{210}Po and ^{226}Ra,
- sulforimeters, containing ^{147}Pm and ^{3}H,
- calibration sources, containing ^{226}Ra, ^{137}Cs, ^{60}Co,
- moisture gauges, containing ^{241}Am,
- weight and density meters, containing ^{85}Kr, ^{204}Tl, ^{90}Sr, ^{241}Am and ^{137}Cs,
- fluorescence analyzers, containing ^{238}Pu,
- radiation monitors, containing ^{85}Kr
- powder analyzers, containing ^{85}Kr,
- production control instruments, containing ^{241}Am.

In order to define the priority criteria in surveillance, we considered dose hazards with respect to the instrument used, to the conditions of use and the contained radioisotope. The reference dose was the same adopted by the IAEA for trasportation, that is 3 rems, but it was considered as a dose hazard absorbable in one year, while IAEA consider it as a dose which may be absorbed only once in case of an accident involving "type A" packages. Parameters were the following:

- activity of the radionuclide contained in each instrument,
- M.P.C. in air ($\mu Ci/cm^3$) · 10^9 cm^3, which given an approximate dose of 3 rem,[3]
- number of instruments in each plant.

On the basis of the mentioned criteria, it was possible to list 160 plants, for a total of 1636 instruments for surveillance purposes. It can be noted that the radiation dose was not taken into consideration, since the gammaradiography apparatus and the irradiators were automatically included in the greater hazard class. Because of the radionuclides used and their activity, the other instruments present pre-eminent risk, because of contamination hazard rather than radiation hazard.

On the other hand, we are only making an approximation of the problem, since our only scope is to indicate a priority in the surveillance actions and not a scientific study, as it would be desirable if the new radioprotection formulation were accepted.

The plant classification, with respect to the dose hazard expressed in rem/year, is the following:

$$A \leq 3$$
$$3 < B \leq 3\cdot 10$$
$$3\cdot 10 < C \leq 3\cdot 10^2$$
$$3\cdot 10^2 < D \leq 3\cdot 10^3$$
$$E > 3\cdot 10^3$$

In the case of Italy, the following applies:

	Number plant	Hazard level
	2	A
	7	B
	11	C
	15	D
	125	E
Total	160	

In conclusion, we may try to summarize this complex matter as follows.

Radionuclide groupings on the basis of their radiotoxicity are certainly useful, but are not determinant in individuating hazard levels. For this purpose, it is necessary to complete these groupings with the modes of utilization of radioisotopes, determining a series of quantitative parameters. On the basis of the mentioned criteria, we will be able to classify them with consideration to dose risk, for which the radionuclide activity and its radiotoxicity shall have become only two of the parameters for the purpose of hazard specification.

This means to start anew and integrate what IAEA already made in the field of transportation, with a change of hazard evaluation from nuclide activity in curies to dose hazard in rems.

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