DOSE ASSESSMENT IN RADIOACTIVE MATERIAL TRANSPORT

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As of 1961, AIEA has issued regulations for the safe transport of various modifications, principally owing to the increase in number of packages transported and to the different chemical-phisycal characteristics of the radioisotopes used in the course of the twenty years following.

This paper deals whith air, road and rail transport under normal conditions. Conseguently, the assessment of possible ionizing radiation doses received by transport personnel and by the public must be performed especially on the basis of the transport index and radiation level of the packages. The most recent pubblication of AIEA regulations on the subject dates back to 1985. As with the preceding 1973 publication, it indicates three categories of packages with reference to the afore mentioned transport index and radiation level, measured in sievert (Sv):

Category I	- White: radiation level:	$\leq$ 0.005 mSv/h
Category II	- Yellow: radiation level:	0.005 $<$ D $\leq$ 0.5
	mSv/h-transport index:	1
Category III	- Yellow: radiation level:	0.5 $<$ D $\leq$ 2 mSv/h
	radiation level:	$\leq$ 10 mSv/h for "full load"
	transport index:	10

For the first time, the 1985 publication makes esplicit and complete reference to the norms of radiation protection issued by AIEA itself in collaboration with OIT, Who and the NEA of OCDE (Basic Safety Standards for Radiation Protection, 1982, Ed. Safety Series No. 9). In these norms, AIEA establishes for trasport workers a dose level of 5 mSv per year. The aforementioned radiation protection norms shall serve as reference for the administrative and organizational aspects with regards to remaining within these dose levels. These norms must, of course, take into account the particular conditions under wich they are applied. As far as nuclear installation are concerned, or the use of radioisotopes or order ionizing radiation sources, the problem of assessing and cheking the doses received can be performed using parameter which can be established and maintained at least within certan limits. The case of transport is completely different because the only objectively known fact, as far as we are concerned, is the previously mentioned irradiatione of packages. It is a particulary difficult task, however, to shift from the latter to evaluating possible doses because this involves a large number of parameters which cannot always be known and properly evaluated (i.e. doses received at work stations and time spent at them; number of packages per irradiation category; distances from packages belonging to different categories; division of initial loads over different routes via different transport means, etc.). There is presently a nationwide drive towards special regulation setting load limits and the distance of workers from the loads so as to limit the absorption of possible doses (Cfr. Italy, Regolamento per il Trasporto di Merci Pericolose per Ferrovia - tr.n. Regulation for Transport of Dangerous Goods via Rail). Other methods are utilized experimentally to evaluate the doses absorbed. We find that all these methods, however, are based on the irradiation of packages and not on methods, however, are based on the irradiation of pakcages and not on dose measurements.

In the behalf that the assessment of doses from packages irradiation is somewhat difficult and consequently involves a high degree af approximation, we have elaborated a form which we propose with this paper. our proposed solution practically overturns the problem, and thus may appear oversimplified. We in any case welcome any semplification if it can prove useful to improving or, at least, facilitating the evaluation of the possible dose absorbed by transporters of radiactive material. This proposal choses to ignore the external packages irradiation, of course accepting those established by AIEA, in favour of directly measuring the doses in question. Form no. 1, which refers to drivers and escorts, records the real or possible dose measured at the onset of each transport in the worker's work station; of the various values recorded, we chose the one which guarantees the greatest precautions, which is to say the highest one measured. This value, multiplied by the time duration of the trip, gives the probably absorbed dose value per trip. Hence, it is easy for the supervisor to calculate the annual dose or to take the proper measures if he foresees that a worker might surpass the maximum dose admitted (5 mSv/y). An assessment performed in this manner doubtlessly safeguards workers if accompanied by very strict orders, such as not sleeping in the cabin during possible stops.

The problem for loading and unloading is more complex, given the nature of the operations themselves. However, for these tasks too, there is a form (no. 2). It must record the dose value measured in the trolley driving station. This measurements must be performed by loading the packages taken as examples inthe worst condition with respect to package irradiation, for each trolley used and not for each transport. The dose values measured shall be multiplied by the time duration of the operations, and thus we obtain the values of the presumed dose absorption by the workers involved in these operations. These values are so precautionary as to make additional doses owing to manual operation negligible. We must bear in mind, in this regard, that the percentage of III-Yellow packages (dose up to 2 mSv/h transported is generally rather modest. In 1984, 1985 and 1986, in Italy this percentage averaged approxipately 7-8% of the total number of packages transported containing radioactive material. This estimate refers to a significant sample (about 50% of total packages). With regards to the public, it is especially important to know the main traffic flow routes and those which transit through inhabitated areas or areas frequented by the public. Here it is sufficient to make evaluations which take into account the measurements taken autside the means of transport and of the time the public is exposed to them at various distances.

Air transport merits special consideration. Here passengers (the public) could absorb unreasonable and rather high doses if they are frequently present in aircraft transporting packages containg radioactive material. These situations require a careful examination of the main traffic flow routes. Aircraft personnel can be considered as on a par with the workers concerned by form no. 1,and thus use the same form.

The considerations made above, especially as concerns forms no. 1 and 2, may lead to modifications in packages irradiatio, to be proposed to AIEA, or to special equipment on the means of transport.

It is significant that the 1985 AIEA publication established for transport workers a dose level of 5 mSv per year, for members of the public a dose level of no more than 1 mSv per year, whith explicit reference to the aforementioned "Basic Safety Standards". This makes possible to perform assessments using the aforementioned forms, effecting any adjustment deemed proper or necessary for each individual carrier, on the transports and loads in question.

Form. no. 1 (*)

Worker name ....
Year ....

Measured dose (mSv/h) (**)	Date (+)	Trip Duration (Hours)	Total Dose (mSv/trip) (++)

....

Total Annual Dose ('') ....

(*) For transport workers, drivers or escort, or aircraft staff.
(**) Refers to the dose measured (see text) in the worker's work station, real or possible, for each individual transport. The dose must be measured at transport onser, choosing the highest value measured.
(+) The date must be that of departure.
(++) Obtained by multiplying the value of the measured dose by the time duration of the trip.
('') Must not be higher than 5 mSv.

Form. no. 2 (*)

Worker name ....
Year ....
Dose in Sv/h measured in the trolley driving station having a supposed load arranged in the conditions to produce the highest dose value, on the basis of packages transported by the firm or board which employs the worker (see text)........................

Date	Time employed in Hours for each movement	Dose in Sv calculated for each movement (**)

....

Total Annual Dose (+) ....

(*) For workers involved in loading and unloading operations
(**) Obtained by multiplying the value of the dose measured by the time employed for each movement.
(+) It must not be higher than 5 mSv.