Simplified Calculation Method for Radiation Dose Under Normal Condition of Transport

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BACKGROUND

In order to estimate radiation dose during transportation of radioactive materials, the following computer codes are available: RADTRAN, INTERTRAN, J-TRAN. Because these codes consist of functions for estimating doses not only under normal conditions but also in the case of accidents, when nuclei may leak and spread into the environment by air diffusion, the user needs to have special knowledge and experience.

According to the nuclear cycle plan in Japan, various packages of radioactive materials will be concentrated in one specified area. The estimations of doses will vary according to variations in such parameters as the distribution of the population, the quantity of material transported, activities of contents, the shape of packages, the velocity of transporters, etc.

In this presentation, we describe how, with a view to preparing a method by which a person in charge of transportation can calculate doses in normal conditions, the main parameters upon which the value of doses depends were extracted and the dose for a unit of transportation was estimated.

With this result, doses can be easily calculated with a pocket calculator even in cases where the parameters change in the future, and the integrated dose of various packages can be estimated.

METHODS

1) Standard Transportation

The average conditions for transportation of a package were established by considering previous conditions of transportation both in practice and in planning. "Standard transportation" was defined as "a transportation of one package at one time" under average conditions. The parameters of conditions, such as the transportation schedule or the environment in which the transportation occurs, which are easily liable to change, were extracted, and the doses in the case of such parameters were set up as the unit values (1 or 0, etc.)

2) Coefficient of Dose

As is well known, using the conversion factor K_0 which converts TI to dose rate, the dose of the crew of a transporter in normal transport conditions is calculated as follows:

$$D = Q_1 \cdot K_0 \cdot TI \cdot NP \cdot NT \cdot NC \cdot \frac{1}{r^2} \cdot F \cdot \frac{f_i}{v_i} \qquad (1)$$

where,

D : integrated dose of the crew of a transporter (mrem)
Q_1 : unit conversion factor = $2 \times 8 \times 10^{-4}$ · rem · m · h/mrem/km/sec
K_0 : TI - dose rate conversion factor (m^2)

$$K_0 = \left(1 + \frac{dp}{2}\right)^2$$

dp : diameter of package (m)
TI : transport index (mrem/h)
NP : number of packages per shipment
NT : number of times transported
NC : number of crewmen of transporter
F : distance per shipment (km)
f_i : fraction of travel in population zone i
v_i : velocity of transporter in population zone i
r : average distance source to crew (m)

Next, the coefficient C is defined as follows:

$$C = Q_1 \cdot K_0 \cdot TI \cdot NC \cdot \frac{1}{r^2} \cdot F \cdot \frac{f_i}{v_i} \qquad (2)$$

Using C, formula (2) is described as follows:

$$D = C \cdot NP \cdot NT \qquad (3)$$

By calculating C according to the transport conditions, the dose of the public and the workers is easily calculated, as long as the conditions which are included in C do not change.

In this case, C means the dose by the transportation of one package at one time.

Coefficient C implies that transport conditions other than NP and NT do not change. But, as a matter of course, if the kind of conditions included in coefficient C alter, then the dose can be calculated for other cases.

In this study, the extracted parameters are the following:

.... activity of radioactive source (number of packages)
.... frequency of transportation
.... size and shape of package
.... volume of traffic along route, distribution of population

By means of the method for setting up the values of these parameters, coefficients C1, C2, C3 for dose where established as shown below.

case	coefficient C	NP	NT	TI	dp	other conditions
1	C1	1	1	actual data	actual data	actual data
2	C2	1	1	1	actual data	actual data
3	C3	1	1	1	0.0	actual data

When the conditions of transportation are changed, dose is calculated using the C1, C2, C3 and inputting the condition for each parameters.

But if the other conditions change, the dose cannot be calculated by this method.

By establishing C, coefficient for the possible objects of radiation and for each stage in the transportation process, it becomes possible to arrive at more detailed values.

In our present research, the following were considered as possible objects of radiation.

public living near route
public on road
driver of transporter
loading and unloading workers

The transportation process was divided into the following stages.

loading
transporting
stop
unloading

3) The calculation of doses using the dose coefficients

The calculation of doses using the dose coefficients is as follows.

* Case 1 When making the number of times transported the parameter:

$$Dij = C1ij \cdot NT \cdot NP \qquad (4)$$

D : integrated exposure of workers and public
C1 : dose coefficient
NP : number of packages per shipment
NT : number of times transported
i : sufix over objects of radiation
j : sufix over stage of transportation process

* Case 2 When making the transport index and the number of times transported the parameters:

$$Dij = C2ij \cdot TI \cdot NP \cdot NT \qquad (5)$$

D : integrated exposure of workers and public
C2 : dose coefficient
TI : transport index
NP : number of packages per shipment
NT : number of times transported
i : sufix over objects of radiation
j : sufix over stage of transportation process

* Case 3 When making the size of package the parameters

$$Dij = C3ij \cdot \frac{(1 + \frac{dp}{2})^2}{K_0} \cdot TI \cdot NP \cdot NT \qquad (6)$$

D : integrated exposure of workers and public
C3 : dose coefficient
K_0 : TI-dose rate conversion factor
dp : size of package
TI : transport index
NP : number of packages per shipment
NT : number of times transported
i : sufix over objects of radiation
j : sufix over stage of transportation process

CASE STUDY

For the case study, the dose under normal conditions of transportation by road for each package was estimated.

For the first, a table of $C1_{ij}$, $C2_{ij}$, $C3_{ij}$ was drawn up and then the dose was calculated according to various conditions such as the number of packages, the number of times transported, and the transport index.

CONCLUSION

By means of this method, a person in charge of transportation can easily take into account the various conditions of transportaion. For this reason, this method has proved highly popular with those responsible for planning such operations.

Session 3:

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