RELEASE OF RADIOACTIVITY DUE TO AN ACCIDENT OCCURRING ON A FLY-OVER IN THE URBAN ENVIRONMENT

A.N.NANDAKUMAR
RADIOLOGICAL SAFETY DIVISION
ATOMIC ENERGY REGULATORY BOARD
MUMBAI 400 094, INDIA

ABSTRACT

In the event of an accident involving a vehicle carrying dispersible radioactive material, occurring on a fly-over the residents living nearby can receive some dose. The problem is significant in the urban environment since the population density and the probability of accidents in cities are high, although the probability of a severe enough accident to cause significant release of activity, in a city, is low. The dose received at a location following a release is determined by the concentration of activity there. In such an accident in a city, persons residing on the higher floors close to the height of release would experience increased concentration of activity. At these locations, concentration of activity in the nearby residences are calculated.

STATEMENT OF THE PROBLEM

Assessment of dose due to urban transport of radioactive material has attracted many workers' attention and much work has been done on the situations peculiar to the urban environment [1, 2]. In order to ease the heavy traffic, numerous fly-overs are constructed in the cities. While, efforts are taken to minimise transportation of radioactive material through the thick of urban traffic, the radiological consequences of an accident occurring on an urban fly-over need to be examined. The presence of tall buildings in the immediate vicinity of the fly-over can result in dose to the inmates, should an accident occur on a fly-over resulting in the failure of containment integrity. This paper examines an accident scenario from the point of view of dose that may result from such an accident.

ACCIDENT SCENARIO

The scenario postulated in the present study involves an accident occurring on a fly-over involving a package containing a radioactive material. In a city road it is reasonable to consider the transport of radioisotopes which are taken from the supplier to the user institution or the airport. The particulars are described below:

Type of package	:	Type B(U)
Radioactive Content	:	^{131}I or ^{99}Mo or ^{201}Tl or ^{67}Ga

Physical form	:	Readily dispersible
Exposure pathway	:	Inhalation
Severity of the accident	:	Equivalent to regulatory tests for Type B(U) Packages
Package failure fraction	:	Equivalent to the regulatory limit
Release rate (Assuming uniform release rate so that in one week the accumulated release $\leq A_2$)	:	A_2 / 168 TBq h^{-1}
Distance of the nearest tall building	:	Less than 100 m
Weather at the time of accident	:	Category D
Wind speed	:	6 m/s [3]
Number of damaged packages	:	1
Period of exposure of persons living in the tall buildings in the vicinity of the fly over	:	1 hour

The activity released would depend upon the severity of the accident. In this study, the dose values were calculated on the basis of the assumed severity of the accident. The assumptions used in the dose computation are discussed in the sections that follow. The calculation was made separately for each radioisotope. The radionuclides selected for the study were those which are most commonly used in nuclear medicine and are likely to be transported through urban streets from the producer to the dispenser / hospital.

CALCULATION OF DOSE FOLLOWING ATMOSPHERIC RELEASE

The basic equation[4] for calculating the concentration at the ground level is

$$\chi / Q = (1 / \pi \; u \, \sigma_y \, \sigma_z) \; \exp [- (h^2 / \; \sigma_z^{\,2})] \qquad s \, m^{-3}$$

where u is the mean wind speed = 6 m/s

Q is the release rate of activity in Bq s^{-1}

χ is the ground level concentration in Bq m^{-3}

σ_y and σ_z are the dispersion factors in the lateral and vertical directions in m and

h is the effective height of release.

This equation assumes elevated release which may appear to be appropriate for a release occurring on a fly-over. However, for the purpose of the present study, it is assumed to be ground release and the equation reduces to

$$\chi / Q = (1 / \pi \ u \sigma_y \sigma_z)$$

For short distances, taking the values of σ_y and σ_z as 13 m and 7.8 m respectively [4] the quantity, χ / Q, can be calculated as 1.570371×10^{-3} s m^{-3}

Concentration of activity
at the point of interest, Bq m^{-3} = Release rate Bq s^{-1} x Dilution factor s m^{-3}

In the above situation, though the release of radioactivity may occur at a height above the ground level, it may be assumed as ground release from the point of view of the residents of the tall buildings in the immediate vicinity. In addition, at distances less than 100 m, ground release may be assumed..

RESULTS

The committed effective dose (CDE) due to inhalation of the radionuclide was computed using the values for dose per unit intake for members of the public, taken from the IAEA Basic Safety standards.[5] The values for the selected radionuclides are given in Table 1. It is noted that CDE depends on two important factors, viz., the age of the person incurring internal exposure and also the absorption rate from the lung, which is classified as fast (F), medium (M) and slow (S). The maximum CDE is incurred, in all cases, by children of age less than 1 year. The minimum CDE is incurred by adults of age > 17 years. The absorption rate corresponding to each CDE is indicated in the table, as F, M and S. The calculated dose values for a period of exposure of one hour are provided in Table 2. The dose values for ^{99m}Tc are included in the table because, ^{99}Mo would be in equilibrium with its daughter ^{99m}Tc a few hours after loading it in the package, i.e., during transportation. The total dose following an accident involving a package containing ^{99}Mo would be the dose corresponding to ^{99}Mo plus 87% of the dose due to ^{99m}Tc since it is in this proportion that the daughter nuclide would be present.

DISCUSSION AND CONCLUSION

The dose values have been calculated for a period of exposure of one hour. The total dose varies linearly with the period of exposure. While it is true that accident frequencies are the highest in the urban environment, the probability of occurrence of severe accidents that are simulated by the regulatory tests are very small. Analysis of accident data indicate that the probability that such a severe accident occurs in a city would be in the region of 10^{-9} to 10^{-10} [6]. The probability-weighted dose values would not be significant even if the period of exposure is more than 1 hour. Thus one may conclude that the presence of high-rise residential quarters in the vicinity of fly-over dose not entail significant dose to the residents from probability-weighted dose point of view. However, if an accident does occur, the individual dose would not be significantly high except in the case of ^{131}I, which happens to be the radiopharmaceutical most commonly transported through the urban streets. It would be a measure of caution, if the residents are alerted to the possibility of exposure, which can be avoided, and simple counter measures such as keeping the windows closed or vacating the rooms nearest to the fly-over, are implemented. However, a combination of circumstances can be envisaged that can result in higher doses as discussed below:.

1. ***A large number of packages are damaged.***

2. ***The period of exposure is much longer due to difficulties in cleaning up.***

3. ***The residential quarters were much closer than considered in this study.***

4. ***The number of potentially affected persons is large.***

Another possibility is that, the activity release rate can be non- uniform and initially higher than assumed in this study and over this initial period, higher dose than calculated above would be received by the potentially exposed persons. This contingency may not contravene the regulatory requirements so long as it is demonstrated by the designer that following the regulatory tests the following condition is satisfied:

$$\int R(t)\, dt \le A_2$$

where R (t) is the rate of release of activity from the package in Bq/h and the release rate is integrated from 0 to 168 hours , i.e., one week.

Under these conditions, measures for preventing and mitigating the dose would need to be introduced.

Table 1

Committed Effective dose per unit intake via inhalation for members of the public [5]
(Sv Bq^{-1})

Radionuclide	CED – Minimum	CED – Maximum
^{67}Ga	6.4 E-11 F	1.0 E-9 M
^{99}Mo	2.2 E–10 F	4.8 E-9 S
^{99m}Tc	1.2 E-11 F	1.0 E-10 S
^{131}I	1.6 E-9 S	7.2 E-8 F
^{201}Tl	4.4 E-11 F	4.5 E-10 F

Note: F, M and S denote fast, medium and slow absorption from the lungs.

Table 2

Committed Effective dose per unit intake via inhalation for members of the public following an accident on the fly over for a period of exposure of one hour
(mSv)

Radionuclide	CED – Minimum	CED – Maximum
^{67}Ga	0.717884	11.21694
^{99}Mo	0.493545	10.76826
^{99m}Tc	0.179471	1.50E+00
^{131}I	4.19E+00	1.88E+02
^{201}Tl	6.58E-01	6.730164

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