

§2. A Method to Estimate Incremental Photon Dose Rate in the Vicinity of Nuclear Facilities

Ikebe, Y., Akhmad, Y.R. (Dept. Nuc. Eng. Nagoya Univ.)
 Obayashi, H., Sakuma, Y., Yamanishi, H., Kodaira, J.

One of the difficulties in estimating man-made dose contribution in the environment accurately is that we have to consider significant fluctuation in the background dose level either with time at a given location or with location for a given period. It may need several years of pre-operation period of the facilities to determine the uncertainty from these factors to obtain the representative background to be used in isolating a small dose increment during operation period at given locations. If we restrict the scope of problems and concentrate ourselves on estimating the exposure contribution from down-ward radiations of airborne radionuclides in the atmosphere as well as direct and sky-shine radiations due to nuclear facilities, the following proposed method may be helpful. The environmental radiation model is illustrated in Fig. 1. The measuring locations are assumed as flat-land and source distribution of U, Th and K in the soil is uniform. If we have

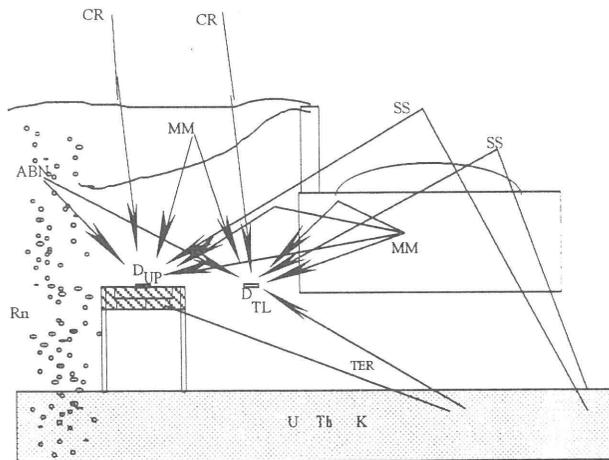


Fig. 1. Environmental radiation model for developing the method.

some small and passive type detectors which have the same characteristics, then by using Pb shield of 10 cm thickness the dose contribution from the facility producing photons that travel in down-ward direction can be decided easily as

follows: Take two measuring locations, one as the reference location where the effect of the facility is negligible and the other location is a location in question. The relation between environmental dose components and the dosimeter response for environmental condition illustrated in Fig. 1 is (the asterisks mean that the related dose is inferred from reference location):

$$D_{TL} = D_{TER} + D_{SS} + D_{CR} + D_{ABN} + D_{MM} \quad (1)$$

$$D_{UP} = D_{SS} + D_{CR} + D_{ABN} + D_{MM} \quad (2)$$

$$D_{TL}^* = D_{TER}^* + D_{SS}^* + D_{CR}^* + D_{ABN}^* \quad (3)$$

$$D_{UP}^* = D_{SS}^* + D_{CR}^* + D_{ABN}^* \quad (4)$$

where

D_{TER} = Responses of detectors to terrestrial gamma radiation excluding its sky-shine component.

D_{SS} = Responses of detectors to sky-shine radiation of terrestrial gamma radiation that scattered toward ground surface due to interaction with atoms in the atmosphere.

D_{CR} = Responses of detector to cosmic radiations.

D_{ABN} = Responses of detectors to airborne radioactive materials mainly from ^{222}Rn daughters in the atmosphere.

D_{MM} = Responses of detectors to downward (direct and sky-shine) radiation and radioactive materials in the atmosphere released from nuclear facility. Equations (2) and (4) can be used to estimate the contribution from the facility due only to downward radiation component by subtraction as follows:

$$D_{MM} = (D_{UP} - D_{UP}^*) - (D_{SS} - D_{SS}^*) \quad (5)$$

From the Monte Carlo simulation it was found that the air absorbed dose from sky-shine radiation has 10% of magnitude of dose that produced by the forward component of terrestrial gamma radiation. Thus, we get

$$D_{SS} = 0.1 \times D_{TER} = 0.1 \times (D_{TL} - D_{UP}) \quad (6)$$

Hence, by substitution Equation (6) into Equation (5), the man made dose D_{MM} can be calculated simply with the following equation:

$$D_{MM} = 1.1 \times (D_{UP} - D_{UP}^*) - 0.1 \times (D_{TL} - D_{TL}^*) \quad (7)$$

Limitations: If the topographical problem is extremely complicated the above equation can not be used. In case the problem not so complicated the formula can be used by inserting correction factor. This factor should be inferred during pre-operation period. Hence the formula becomes :

$$D_{MM} = 1.1 \times (D_{UP} - D_{UP}^*) - 0.1 \times (D_{TL} - D_{TL}^*) \pm D_{TP} \quad (8)$$