DISCUSSION OF AN ENVIRONMENTAL DOSE METHODOLOGY TO OBTAIN COMPLIANCE WITH DOSE LIMITS IN THE CASE OF POSTULATED ACCIDENTS

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INTRODUCTION

In the case of postulated accidents in nuclear facilities the Radiation Protection Ordinance of the F.R.G. demands sufficient protection of the public by technical design of the plant. Thus the worst case individual annual dose shall be kept within the given accident dose limits of 50, 150 and 300 mSv for total body, thyroid and bone respectively. These limits comprise all exposure pathways including the exposure via ingestion of contaminated food.

In order to achieve compliance with these demands, a practical methodology for the assessment of radiological impacts caused by postulated accidents has been developed. Thereby special attention is paid to the conservatism of its assumptions and its compatibility with the methodology of routine releases according to the existing regulations (1).

DOSE CONCEPT

The judgement of accidental releases concentrates on the radiological consequences of short-term emissions. Consequently the accident dose methodology is based on the concept of the committed environmental dose. Due to the equivalence between equilibrium dose and dose commitment based on the same boundary conditions (2), (3), (4), the calculated committed dose can directly be compared with the dose limits given as maximum annual doses in the German Radiation Protection Ordinance.

For the purpose of dose assessment it is significant to base the calculations on the three-compartment scheme of the ecosphere shown in fig. 1. Then one transfer function for each compartment can be defined which is determined by its output to input ratio. Due to the time dependence of the release rate in the case of an accident, the radionuclides undergo a time dependent transfer in the environment. Thus each of the transfer functions is also principally determined by the time dependence of the release rate. However, as our investigations concerning the nuclide dynamic in the environment have proved

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(5), the time dependence of the different ecosystems "atmosphere", "biosphere" and "man" can be temporally decoupled. Hence, each of the corresponding transfer functions A, B und D can now be determined irrespective of the time dependence of the output of the donor compartment as a peak response.

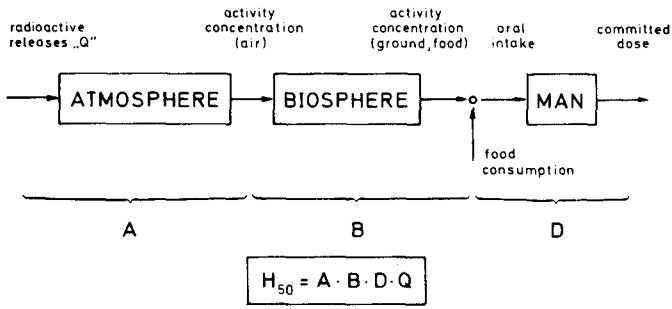

fig. 1

Due to this procedure the committed environmental dose for all exposure pathways"i"is now generally given by the following simplified formula

$$H_{50} = A_i \cdot B_{50,i} \cdot D_{50,i} \cdot Q \qquad [1]$$

where A is the atmospheric dispersion or deposition factor, B the transfer factor for the biosphere, D the dose conversion factor and Q the accidental source strength.

The dosimetric models on which the determination of the different transfer factors in equation [1] is based, are explained in more detail in (5).

DISCUSSION OF THE MODELS

The meteorological dispersion and deposition factors (A) represent the most unfavourable weather conditions, e.g. pessimistic wind velocities, high precipitation rates, etc., and thus lead to an upper limit of air and ground contamination.

According to the conclusions in (5) all dose conversion factors (D) derived for continuous releases can be applied to short-term releases as well.

In the case of external irradiation from the cloud or from the contaminated ground, the dose conversion factors are in fact "dose rate conversion factors" being de-

fined as dose rate to air concentration ratio, and thus do not depend on the type of releases.

For internal irradiation (inhalation and ingestion) the applicability of the dose conversion factors for continuous releases to short-term releases is due to the equivalence between the committed dose and the equilibrium dose concept.

The use of the proposed biosphere transfer factors (B) results in conservative doses for the corresponding exposure pathways.

This is valid for the inhalation exposure, particularly caused by the conservative assumptions for the respiration rates. In case of resuspension being considered, this causes an additional contribution to the conservatism of the dose.

For γ-ground irradiation the model represents the dose of a person exposed for 50 years on contaminated paved surface. Possible shielding or wash-off effects are neglected. This neglection causes an overestimation of the dose up to a factor of 7 (5).

In the case of ingestion there are various simplifying assumptions which give rise to different systematic errors in dose calculation. So the temporal decoupling of the compartments in fig. 1 may cause systematic underestimation of the dose up to 90 % (factor 10). Moreover the soil contamination for the milk and beef pathway may be underestimated up to 50 % (factor 2). The remaining assumptions, i.e. using soil-plant transfer factors for continuous instead of short-term releases with no distinction between vegetation period and the rest of the year, and the application of pessimistic consumption rates for the different food pathways result in reasonable overestimations of the dose between a factor of about 3 to 11. Hence the overall overestimation is a factor of 2 to 10.

This systematic error is valid only for activity uptake via root transfer. For the consumption of food directly contaminated by the deposition of radionuclides on the above surface parts of the vegetation, the systematic error is considerably smaller. Thus, due to the dominating importance of the latter type of contamination, the total overestimation of the ingestion dose does not exceed a factor of 3.

If one assumes administrative preclusion of food consumption after an accident, the calculable ingestion dose would then be reduced to values between 60 % for Sr 90 and 0,03 % for I 131 compared to the case without any restrictions.

CONCLUSIONS

The proposed methodology for dose assessments in the case of postulated accidents shows compliance with the

F.R.G. Radiation Protection Ordinance and has the following main characteristics

1) Due to the equivalence between the committed dose concept and the concept of equilibrium dose, the methodology shows sufficient compatibility with that for routine releases. This is valid not only for the dose calculation, i.e. the total ecosystem but also for each subsystem in the ecosphere. Therefore both the routine and the accident calculations can be based on the same ecological data and dose conversion factors.

2) The dose calculations for postulated accidents based on the ecological parameters which are determined for the equilibrium case result in conservative assessments.

3) The determination of one transfer function for each compartment ("atmosphere", "biosphere" and "man") supplies theoretical measures, which partly offer the opportunity of direct validation of the corresponding model by measurements following accidental releases.

4) For a planning engineer these measures, calculated and fixed beforehand, enhance the practicability of the methodology as a tool in decision-making. Using these measures dose assessments become simple and feasible without deeling with the radiological problems being involved.

5) The methodology results in considerable reduction of the computational efforts.

REFERENCES

1. Der Bundesminister des Inneren(1977): Allgemeine Berechnungsgrundlagen für die Bestimmung der Strahlenexposition durch Emission radioaktiver Stoffe mit der Abluft, Bonn
2. Lindell, B. (1973): Assessment of Population Exp., IAEA-SM-179/B, Aix-en-Provence
3. Brenk, H.D. (1979): Konzept zur Berechnung der Umweltbelastung durch kerntechnische Anlagen in der BR Deutschland, Fachtagung Radioökologie des Deutschen Atomforum, Bonn
4. Brenk, H.D. (1978): Ein anwendungsbezogenes Konzept zur Berechnung der Umweltbelastung durch Abluftemissionen kerntechnischer Anlagen für Standorte in der BR Deutschland, Jül-1485
5. Brenk, H.D., Vogt, K.J. (1979): Radiation Exposure Caused by Postulated Accidents in Nuclear Installations (Jül-report to be printed)
6. ICRP-Publ. 29 (1979): Radionuclide Release into the Environment: Assessment of Doses to Man, Pergamon Press New York