ON THE EXTENT OF EMERGENCY ACTIONS FOR THE PROTECTION OF THE PUBLIC AFTER ACCIDENTAL ACTIVITY RELEASES FROM NUCLEAR POWER PLANTS

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Emergency actions for the protection of the public are necessary only after those nuclear accidents which are termed "hypothetical" and which involve core meltdown and failure of the leak tightness of the containment. Such accidents have been analysed in the German Reactor Risk Study (1). The analysis showed, however, that only a small part of the core meltdown accidents analysed have the potential of releasing radioactive material into the atmosphere to an extent that - if they occur in combination with unfavourable meteorological situations - they require extended and immediate protective actions. Such unfavourable meteorological conditions mostly involve precipitation which is an effective means to wash out the radioactive material and to deposit it on the ground. For this reason the accident consequence calculation model applied in (1) has been analysed for the accuracy of the contaminated areas calculated.

AREAS COVERED BY PROTECTIVE ACTIONS

The protective action model applied in (1) has been developed in consistency with official German recommendations (2). It takes into account the specific problems of nuclear accidents (ground contamination, time scale of radioactive decay, efficiency of decontamination, etc.) as well as the high density of population in the F.R.G.. The areas are defined as follows, see fig. 1:
- area A, fixed size, evacuation in any case of core meltdown,
- areas B_1 and B_2, potential early fatalities (bone marrow dose due to external irradiation during 7 days exceeds 100 rad),
- area C, no early fatalities, but ground contamination too high for early decontamination (whole body dose due to external irradiation during 30 years exceeds 250 rad),
- area D, ground decontamination necessary and sufficient (whole body dose due to external irradiation during 30 years exceeds 25 rad).

Consecutive steps of the actions are:
- sheltering in buildings or basements in areas A and B_1,
- evacuation of area A after 8 hours,
- subsequent relocation of the population in areas B_1 and B_2, later relocation of the population in area C,
- immediate decontamination of area D,
- later decontamination of area A, B_1, B_2 and C,
- crop and milk interdiction.

ACTIVITY DEPOSITION MODEL

The external radiation from the ground is the main exposure pathway considered in the following investigation. The activity depo-

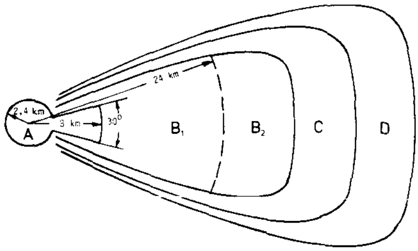

Fig. 1. Areas of protective actions.

sited on the ground is calculated according to conventional models (1). Dry deposition is characterised by the deposition velocity, wet deposition by the washout coefficient. The values of these parameters are choosen in accordance with (3), but the washout coefficient is assumed to depend on the precipitation intensity. The plume depletion is described by the "source depletion model:" the plume inventory is decreased by the deposited amount of activity.

Fig. 2 is a three-dimensional graph of the dose equivalent by external irradiation from the ground. The two pronounced peaks are mainly due to washout by rain during two separate periods of time. The graph is characteristic of the local dose rate distribution in cases where ground contamination is caused by washout.

The following feature of the consequence model tends to over-predict the area contaminated by washout: Activity concentration and ground contamination are calculated at discrete mesh points. The number of mesh points is limited for reasons of computer costs. At distances greater than about 20 km from the source the plume travel time from one grid point to the next exceeds one hour. If washout takes place during only part of that time, the activity being washed out is distributed nevertheless over the total interval. The resulting over-estimate of the area and underestimate of the contamination would tend to sometimes overestimate and sometimes underestimate the areas B, C and D. It will be investigated below whether a serious error is involved by this feature of the model.

RESULTS

The area size distribution function of the B_1, $B_1 + B_2$ and C areas is shown in fig. 3. For this figure, the occurence of one of the accidents considered is assumed. The areas of most concern are B_1 and B_2, as here the external radiation is high enough to cause early fatalities, and therefore, the time available for relocation is limited. Such areas are mainly a consequence of a release characterised by the release category 1 (core meltdown and "steam explosion") or 2 (core meltdown and large containment leak). It should be added here that it is still questionable whether the release category 1 involving "steam explosion" is to be postulated in reactor risk assessments or not.

The calculation is based on the reference sample and on the test sample of weather sequences. A weather sequence contains the atmospheric transport and diffusion data (wind speed, diffusion category,

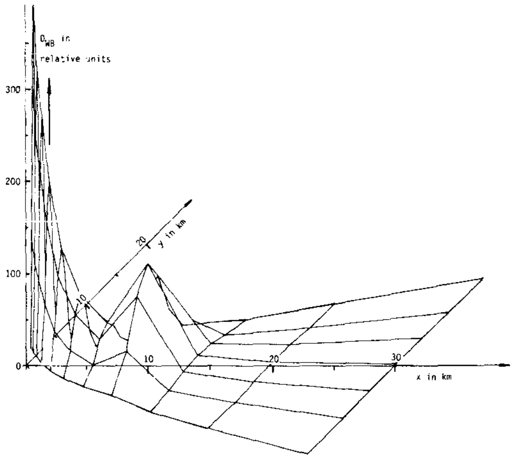

Fig. 2. Whole body dose D_{WB} due to external radiation from the ground.
Release category 2

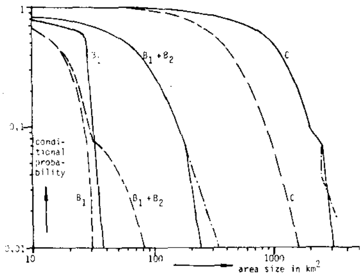

Fig. 3. Protective action area size distribution

release category 1
——— fine meshed grid
-·-·- coarse " "
- - - - release category 2 coarse meshed grid

precipitation) of subsequent hours, starting at the presumed time of emission. These data are inputs to the plume dispersion calculation. The weather sequences chosen for calculation should adequately cover the variety of meteorological situations, but their number is limited. In (1) 115 reference weather sequences have been taken into account.To investigate the accuracy of the model, a test sample of 98 weather sequences has been chosen alternatively, each involving precipitation during at least one of the first hours. The area sizes have been calculated using two different spacings of the grid mesh-points:

a) fine-mesh grid (the travel time from one mesh pont to the next does not exceed one hour);
b) coarse-mesh grid (the reference spacing of 18 grid points up to a distance of 500 km).

The result is shown in tab. 1 and fig. 3. The area B_1 is not affected, as up to a distance of 24 km (size limit of area B_1) the reference grid is fine enough. The maximum of the areas $B_1 + B_2$ is overestimated by 45 % when using the coarse-mesh grid, whereas the average area B_1+ B_2 is slightly underestimated. The same is found for area C, but the overestimate is not as drastic. For area D the effect is negligible, since this area is mainly caused by dry deposition which is not affected by the grid spacing. In fig. 3 the distribution functions of the reference and the test sample (coarse-mesh grid) do not differ markedly.

Tab. 1. Emergency Action Areas

	A	B_1	$B_1 + B_2$	C
average area size fine-mesh grid coarse " "	 33 km^2 "	 19.8 km^2 "	 71.2 km^2 66,4 "	 1101 km^2 1090 "
error by coarse grid	-	-	-7 %	-1 %
maximum area size fine-mesh grid coarse " "	 "	 39.3 km^2 "	 241 km^2 349 "	 3180 km^2 3710 "
error by coarse grid	-	-	+45 %	+17 %
minimum area size fine-mesh grid coarse " "	 " "	 0 0	 0 0	 117 133

CONCLUSION

The models applied in reactor risk calculations are designed to give satisfactory answers in terms of the overall risk which is related rather to average than to maximum values of single parameters. Maximum values,however, are likely to be used as a guideline for emergency planning. It has been shown that the average areas covered by protective actions are only negligibly affected by model refinements, that the maximum of the area of fast relocation (area $B_1 + B_2$), however, is overestimated by a factor of about 1.5 unless a refined analysis is applied. Such methods will be studied in more detail in the second phase of the German Reactor Risk Study.

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