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In the event of any differences in interpretation of this guide, the Finnish version shall take precedence over this translation.

EVALUATION OF POPULATION DOSES IN THE ENVIRONMENT OF NUCLEAR POWER PLANTS

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1. GENERAL

During licensing review, the applicant shall be able to demonstrate that the nuclear power plant is designed so that its operation will not cause radiation doses in excess of the limits set forth in Guide YVL 7.1.

During operation, the operator of the nuclear power plant shall demonstrate that the radiation dose limits determined in the license conditions are not exceeded.

Doses to the critical group and collective doses shall be calculated according to the principles presented in this guide using acceptable mathematical models and parameters.

Methods to evaluate the dispersion of radioactive substances are dealt with in Guide YVL 7.3.

2. SCOPE

This guide provides general guidelines for the estimation of the radiation doses received by the population in the vicinity of nuclear power plants.

3. CALCULATION OF RADIATION DOSES IN VARIOUS PHASES OF LICENSING PROCESS

The calculation of the radiation doses received by the population in the vicinity of a nuclear power plant is performed in three phases in keeping with the progress of the project.

1. During the construction permit review, the radiation doses caused by operating and accident conditions are calculated separately, using acceptable models. Data on the releases of radioactive subs-

tances calculated in the design phase of the plant and generally accepted parameter values describing the plant and the plant site are used as basic values.

2. During the operating license review, the same radiation doses are computed as in the construction permit phase, using locally determined parameters whenever possible.

3. During operation, the radiation doses are calculated on the basis of measured amounts of released radioactive substances, measured dispersion conditions and acceptable environmental parameters.

When necessary, the models in use shall be checked on the basis of the radiation dose and activity data obtained from the environmental radiation monitoring programme.

4. EXPOSURE PATHWAYS UNDER OPERATING CONDITIONS

The surveys shall cover doses to the critical group and collective doses which are caused by external radiation from the plant and from transports and by radioactive effluents released to air and water. The doses to be considered are presented as effective doses (cf. ICRP 26).

The critical group is determined specifically for each plant site. The group need not be exactly determined if it can be demonstrated, by means of a conservatively chosen, hypothetical group, that the guide dose limits are not exceeded.

The calculations of collective radiation doses can be limited to an area extending about 100 km from the plant, unless, in the vicinity of the area under survey, there is

a large population centre which would substantially increase the collective radiation dose, if taken into account. In addition, it shall be noted that the collective dose is also affected by certain long-lived nuclides that spread farther, such as ^{3}H, ^{14}C and ^{85}Kr. An estimate of the collective dose caused by these nuclides in the whole of Finland shall be given in the licensing review phase.

In addition to the radiation doses caused by various pathways, summaries shall be drawn out from the doses to the critical group and from the collective doses.

4.1.
External radiation from plant and transports

The locations and intensities of external radiation sources and the radiation shields at the plant shall be described and the radiation doses to the critical group caused by external radiation coming from the plant shall be evaluated. The collective radiation doses caused by this radiation can usually be ignored as insignificant.

A description shall be given of the location of the critical group in regard to the transportation route of spent fuel and radioactive wastes, and the doses to the critical group caused by external radiation coming from the transports shall be evaluated. The transportation routes for spent fuel and radiactive wastes and the number of inhabitants by the routes as well as the evaluated collective doses caused by external radiation resulting from the transports shall also be given. Only transports within the borders of Finland are taken into account in the evaluation.

4.2.

Doses caused by radioactive substances released into air

Doses to to the critical group and collective doses caused by radioactive substances released into air shall be calculated. At least the following exposure pathways shall be considered:

1. External radiation
   - from airborne radioactive substances
   - from deposited radioactive substances

2. Internal radiation
   - from inhaled radioactive substances
   - from radioactive substances in plants
   - from radioactive substances in milk
   - from radioactive substances in other animal products.

In calculating the doses caused by external radiation coming from airborne radioactive substances, the model of a semi-infinite cloud can be regarded as a sufficent calculation model for beta radiation. For gamma radiation it is possible to use a model where an integration is performed over the whole air volume containing radioactive substances, or the semi-infinite cloud model which is corrected with certain correction factors depending on the dispersion conditions. It is assumed that the critical group is full-time exposed to the external radiation coming from airborne radioactive substances without any shielding.

In calculating the beta and gamma doses caused by external radiation coming from deposited radioactive substances, observations shall be made 1 metre above the ground. The amount of radioactive substances contained in one unit area of ground is calculated from the concentrations of radioactive substances in air, taking into account dry and wet deposits. It is assumed that the critical group

is full-time exposed to radiation coming from the ground without any shielding.

In calculating the radiation doses caused by internal radiation coming from inhaled radioactive substances, it shall be assumed that the critical group is staying full-time at the distance of their dwellings.

In calculating the concentrations of radioactive substances in plants, attention shall be paid both to the radioactive substances that are deposited on the plants and to the substances that are uptaken from the ground by the plants. It is assumed that the critical group eats plants that are produced in the area.

In calculating the concentrations of radioactive substances in milk, attention shall be paid both to the radioactive substances deposited on grazing grass and to the substances uptaken from the ground by the grazing grass. It is assumed that the critical group drinks milk produced in the area.

In addition, radiation doses caused by radioactive substances contained in other animal products shall be taken into account if their significance is regarded as considerable.

The exposure pathways for collective radiation doses are the same as in the calculation of doses to the critical group. The survey area with a radius of about 100 km is divided into suitable sub-areas. When necessary, the population in the area is divided into age groups. In calculating the collective radiation doses caused by external radiation, the shielding given by buildings and other such structures can be taken into account. In calculating the collective doses caused by foodstuffs, attention is paid to the actual amounts of foodstuffs produced in the area.

4.3.

Doses caused by radioactive substances released into water

Doses to the critical group and collective doses caused by radioactive substances released into water shall be calculated. At least the following exposure pathways shall be considered.

1. External radiation
   - from radioactive substances accumulated on shores
2. Internal radiation
   - from radioactive substances in fish
   - from radioactive substances in drinking water, if water from the discharge water body is used as drinking water.

The amount of radioactive substances contained in one unit area of the shores can be calculated from the concentrations of radioactive substances in the water, using transfer factors. It is assumed that the critical group is exposed to the radiation coming from the shores without any shielding for a certain average time of the year.

The concentrations of radioactive substances in fish can be calculated from the concentrations of radioactive substances in water, using concentration factors. It is assumed that the critical group eats fish caught in the vicinity of the plant.

The exposure pathways for collective radiation doses are the same as in the calculation of doses to the critical group. The calculation of the collective doses caused by staying on the shore is based on the average times that the population spends on the shores of the discharge water body up to a distance of ca 10 - 20 km. In calculating the collective doses caused by radioactive substances in fish, attention is paid to the actual amounts of fish

caught in the area.

5.

CALCULATION OF RADIATION DOSES FROM THE RESULTS OF A RADIATION MONITORING PROGRAMME BASED ON ENVIRONMENTAL MEASUREMENTS

If the regulatory authorities so require, doses shall also be calculated from the results of a radiation monitoring programme based on environmental measurements. In practice, this applies in the first place to the following dose calculations for the critical group:

- internal radiation dose from inhaled radioactive substances based on measured concentrations of iodine and radioactive substances in particle form in the air,

- external radiation dose from deposited radioactive substances based on measured concentarations in rain water,

- internal radiation dose from iodine contained in milk based on measured concentrations in milk,

- internal radiation dose from radioactive substances in plants and in animal products based on measured concentrations.

The purpose of the radiation monitoring programme is above all to evaluate the radiation exposure caused by discharges from nuclear power plants. Therefore it is necessary to try to assess whether the measurement results are entirely or partly caused by discharges from nuclear power plants or whether they stem from the fallout of nuclear tests or from natural background radiation.

6.

EXPOSURE PATHWAYS IN ACCIDENT CONDITIONS

The doses that are generally observed at short distances in accident analyses and in real accident conditions are the dose to the bone marrow of an individual and the dose to a child's thyroid gland. The surveys shall cover individual doses caused by external radiation from airborne and deposited radioactive substances as well as by internal radiation from inhaled radioactive substances.

The calculation of doses caused by external gamma radiation coming from airborne radioactive substances shall at short distances be based on a model where an integration is performed over the whole air volume containing radioactive substances, or alternatively on the semi-infinite cloud model with correction factors depending on the dispersion conditions. The semi-infinite cloud model can also be used for beta radiation. It is assumed that the individual is full-time exposed to the external radiation coming from airborne radioactive substances without any shielding.

In calculating the beta and gamma doses caused by external radiation coming from deposited radioactive substances, observations shall be made 1 metre above the ground. The amount of radioactive substances contained in one unit area of ground is calculated from the concentrations of radioactive substances in air, taking into account dry and wet deposits. It is assumed that the individual is full-time exposed to radiation coming from the ground without any shielding.

In calculating the radiation doses caused by internal radiation coming from inhaled radioactive substances, it shall be assumed that the individual is staying full-time at the determined distance.

However, in actual accident conditions the aim is to make

the assumptions on exposure times, shielding factors, etc. on the basis of prevailing conditions.

In design, extra attention shall be paid to the use of a computer-based dose prediction system in actual accident conditions.

7.

RECOMMENDATIONS, REFERENCES

Calculation of Annual Doses to Man from Routine Releases of Reactor Effluents for the Purpose of Evaluating Compliance with 10 CFR Part 50, Appendix I, Regulatory Guide 1.109, Revision 1, U.S. Nuclear Regulatory Commission, October 1977.