STUK

GUIDE **YVL 7.3** / 23 JANUARY 1997

CALCULATION OF THE DISPERSION OF RADIOACTIVE RELEASES FROM A NUCLEAR POWER PLANT

This Guide is in force as of 1 March 1997 until further notice. It replaces Guide YVL 7.3 issued on 12 May 1983.

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Authorisation

By virtue of section 55, second paragraph, point 3 of the Nuclear Energy Act (990/1987) and section 29 of the Government Resolution (395/1991) on General Regulations for the Safety of Nuclear Power Plants, the Radiation and Nuclear Safety Authority (STUK) issues detailed regulations concerning the safety of nuclear power plants.

YVL guides are rules an individual licensee or any other organisation concerned shall comply with, unless STUK has been presented with some other acceptable procedure or solution by which the safety level set forth in the YVL guides is achieved. This guide does not alter STUK's decisions, which were made before the entry into force of this guide, unless stated otherwise by STUK.

Translation. Original text in Finnish.

1 General

The use of nuclear energy is prescribed in the Nuclear Energy Act (990/1987) and the Nuclear Energy Decree (162/1988) as well as in the Government Resolutions (395/1991, 396/1991 and 397/1991). In addition, section 2 (General principles) and chapter 9 (Radiation work) of the Radiation Act (592/1991) apply to the use of nuclear energy.

According to section 3 of the Government Resolution (395/1991) *the general objective is to ensure nuclear power plant safety so that nuclear power plant operation does not cause radiation hazards which could endanger safety of workers or population in the vicinity or could otherwise harm the environment or property.* Section 7 of the Resolution prescribes that *radiation exposure arising from the operation of a nuclear power plant shall be kept as low as reasonably achievable. A nuclear power plant and its operation shall also be designed so that the limits presented in this resolution are not exceeded.*

In accordance with section 9 of the Nuclear Energy Act *it shall be the licence-holder's obligation to assure the safe use of nuclear energy.* The licensee and the applicant for a construction and operating licence are obliged to demonstrate fulfilment of safety requirements. For this purpose the licensee/applicant for a licence shall assess the radiation exposure of the surrounding population.

This guide sets forth requirements that apply to calculations assessing the dispersion of radioactive substances discharged from the power plant into the atmosphere and to water systems, which are utilised to demonstrate that the radiation exposure of surrounding populations complies with established safety requirements. It also covers assessment of the dispersion of releases during an accident. This guide may be applied to other nuclear facilities as well. Assessment of the radiation exposure of surrounding populations is dealt with in Guide YVL 7.2.

Reliable models shall be used in the dispersion calculations. The licensee may use simplified calculation models that deviate from the detailed requirements of this guide. However, it shall then be justifiably demonstrated that the model used is conservative.

2 General requirements

2.1 Dispersion of radioactive substances in the atmosphere

To assess the dispersion of radioactive discharges in the atmosphere, radioactive substances release data and meteorological data affecting dispersion must be known. Release data include the quantities of radioactive substances released to the atmosphere, the physical-chemical properties of substances affecting dispersion and deposition as well as the release height.

The release height shall be given in the form of effective release height, taking into account downwash. The plume rise caused by the flow rate and heat content of discharge gases shall also be analysed, if necessary. Release heights shall be conservatively chosen and diverse heights are to be considered.

As meteorological dispersion data, the following are required: wind direction and speed as well as dispersion parameters at diverse distances that depend on atmospheric turbulence and represent vertical and horizontal mixing. Requirements that apply to a meteorological measurement programme for determining dispersion data are given in Guide YVL 7.5. Wind speed at heights where no measurements are made shall be assessed by calculations. During the design of the nuclear power plant analyses shall employ long-term meteorological observations onsite and in the environment of the facility.

The parameters needed for dispersion calculations shall be determined in accordance with Guide YVL 7.5 either by direct turbulence measurements or, indirectly, by first determining stability class. Stability classification may be based on temperature difference and wind speed measurements, on temperature difference measurements only, or on wind direction fluctuation measurements. Stability classification shall primarily be based on the Pasquill method [1].

Vertical dispersion parameter values corresponding to various stability categories shall be modified according to topography. When evaluating vertical dilution, the presence of a thermal boundary layer or an inversion layer shall be considered. In selecting a parameter that depicts horizontal mixing the duration of the release situation shall be considered. In addition, the effect of buildings shall be taken into account when choosing dispersion parameters. In place of a model based on a vertical dispersion parameter, a model based on a vertical diffusion parameter may be applied.

For collective radiation dose calculations in particular, and in case changes in weather parameters in coastal areas could significantly affect radiation dose, the use of observations from meteorological stations further off is recommended to complement the results yielded by the licensee's meteorological measurement programme.

When assessing ground deposition, both dry and wet deposition shall be considered. If a simplified procedure is chosen for deposition assessment, it is to be ensured that concentrations of radioactive substances in the air, ground deposition, or collective dose further off the facility and especially under stable dispersion conditions are not underestimated.

Radioactive decay and formation of daughter nuclides shall be considered prior to the start of a release, during dispersion and in deposited material.

2.2 Dispersion of radioactive substances in water systems

Release data for evaluating the dispersion of radioactive effluents in the aquatic environment include the following: the quantities and characteristics of liquid radioactive effluents, the flow rate and temperature of cooling water as well as the structures of the release point.

When assessing the dispersion of radioactive substances in water systems, the following factors at least shall be considered: natural water movements and flows caused by facility operation; turbulent mixing; location of the release point; size, geometry and shape of the bottom of the receiving body of water; cooling water recirculation, sedimentation and resuspension; radioactive decay, and the formation of daughter nuclides.

Dispersion shall be evaluated by advanced mathematical models. Alternatively, a simplified conservative model adapted to the receiving body of water may be used. The results thus obtained are to be compared, insofar as possible, with those obtained by hydrographic measurements (flow measurements, fluctuating water level, recirculation, etc) of the receiving body of water.

3 Dispersion analyses related to licensing

3.1 Normal operational conditions

Applicable conservative release estimates, based on operational experience feedback from nuclear power plants, shall be employed in the analyses of normal operation made during the design and licensing of the nuclear power plant. Releases into the air during normal operation are usually long-term. As a dispersion model for these conditions, a simplified version may be used in which the horizontal concentration distribution is evenly distributed within the dispersion sector under examination.

3.2 Anticipated operational transients and accidents

In analyses justifying technical solutions for a nuclear power plant, radioactive releases during anticipated operational transients and accidents shall be estimated in accordance with Guide YVL 2.2. In addition, analyses shall be conducted for use in emergency response planning, with sufficient capabilities for real-time assessment of the dispersion of radioactive substances during an accident in accordance with Guide YVL 7.4.

The effective release height shall be separately selected for each release situation.

The parameters depicting a dispersion situation shall be conservatively selected. Their selection may be statistically justified. The dispersion situations analysed shall be separately selected depending on whether the release occurs at ground level or through a ventilation stack. In case the duration of the release increases, and after the initial phase, alternating wind direction may be assumed, i.e. increased horizontal mixing.

When selecting dispersion situations for detailed analysis, statistical computation methods shall be used to comprehensively cover a large number of diverse dispersion situations; assessment quantities most significant for each situation shall be evaluated at various distances. The situations and dispersion distances to be analysed in detail shall be chosen such that they represent every operational transient, accident, and release height examined. The situations analysed are to include at least those representative of the median of the statistical distribution of the quantity (such as dilution factor or total dose) on which the selection was based as well as the upper fractiles 95% and 99.5% at least. The form of representation and the scope of analysis of the results are to be illustrative and sufficiently versatile.

4 Dispersion analyses during operation

Radioactive releases discharged from the nuclear power plant during operation shall be evaluated on the basis of measurements. Guide YVL 7.6 deals with the measurement of radioactive releases. The results of meteorological measurements made onsite as described in Guide YVL 7.5 shall be used for dispersion analysis. In addition, there shall be a dispersion evaluation method for cases in which measurement arrangements are unavailable.

Dispersion analyses shall be statistical and based on the frequency of occurrence of quantities (dispersion direction and speed, stability, occurrence of rain) representing weather conditions in the period under analysis. Alternatively, weather situations covering one or more years may be systematically reviewed by calculation (by the hour, for example) in which case each weather situation is depicted by hourly parameter mean values. In such a case, coupled dispersion and dose calculations are recommended in order to facilitate a more careful consideration of seasonal variations. This is especially important when assessing dose accumulating from foodstuffs.

When atmospheric and aquatic discharges during normal operation are analysed their even distribution over the analysis period may be assumed.

The dispersion and dose estimates made in connection with the nuclear power plant's design and licensing shall be complemented during the plant's operation as the calculation methods develop and the data on dispersion conditions accumulate.

Unusual releases, the dispersion conditions prevalent during them and the subsequent radiation doses shall be separately analysed and reported in accordance with Guide YVL 1.5.

5 Assessment of dispersion of radioactive releases during an accident

The licensee shall have the capability of assessing the dispersion of atmospheric releases in real-time by calculation in an accident situation. The dispersion and dose calculations shall be made using a suitable computer programme. The licensee shall have a substitute calculation procedure as well.

When assessing the consequences of imminent releases, the dispersion situations prevalent during an accident and in the period following it shall be employed as well as release data adapted to the event's progression. Knowledge of weather conditions typical of plant site and

season shall be considered as well. The removal of radioactive substances from air may be taken into account, especially further from the facility.

The effective release height shall be separately evaluated for each case. The results shall be assessed on the basis of corresponding results obtained for the next closest release heights, unless a system for the real-time calculation of dispersion and dose during an accident is available or the results of advance calculations pertaining to a certain release height.

Guide YVL 7.5 requires in the nuclear power plant's control room a display showing the meteorological measurement results needed in dispersion calculations and the quantities calculated on their basis. This data shall be transferred to the facility's emergency response centre as well to facilitate its use for dispersion and dose calculations.

6 Regulatory control

The Finnish Radiation and Nuclear Safety Authority reviews documents submitted to it in connection with the licensing of nuclear power plants and controls the construction and operation of the plants according to Guide YVL 1.1. The Authority reviews analyses of the dispersion of radioactive substances and subsequent doses in connection with the review of the Preliminary Safety Analysis Report and the Final Safety Analysis Report and emergency plans.

Descriptions of the methods for assessing the dispersion of radioactive substances during operation and accidents as well as methods for defining atmospheric turbulence and stability class shall be submitted to the Radiation and Nuclear Safety Authority for approval. They shall describe how the models were qualified and their suitability for onsite conditions.

7 References

1. Atmospheric Dispersion in Nuclear Power Plant Siting, IAEA Safety Series No. 50-SG-S3, Vienna 1980.

2. Simmonds JR, Lawson G, Mayall A., Methodology for assessing the radiological consequences of routine releases of radionuclides to the environment, European Commission, Report EUR 15760 EN, Luxembourg 1995.

3. Stephensson W, Dutton LMC, Handy BJ, Smedley C, Realistic methods for calculating the releases and consequences of a large LOCA, European Commission, Report EUR 14179 EN, Luxembourg 1992.