STUK

GUIDE **YVL 7.5** / 28 MAY 2003

METEOROLOGICAL MEASUREMENTS OF A NUCLEAR POWER PLANT

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Authorisation

By virtue of the below acts and regulations, the Radiation and Nuclear Safety Authority (STUK) issues detailed regulations that apply to the safe use of nuclear energy and to physical protection, emergency preparedness and safeguards:

- Section 55, paragraph 2, point 3 of the Nuclear Energy Act (990/1987)
- Section 29 of the Government Resolution (395/1991) on the Safety of Nuclear Power Plants
- Section 13 of the Government Resolution (396/1991) on the Physical Protection of Nuclear Power Plants
- Section 11 of the Government Resolution (397/1991) on the Emergency Preparedness of Nuclear Power Plants
- Section 8 of the Government Resolution (398/1991) on the Safety of a Disposal Facility for Reactor Waste
- Section 30 of the Government Resolution (478/1999) on the Safety of Disposal of Spent Nuclear Fuel.

Rules for application

The publication of a YVL guide does not, as such, alter any previous decisions made by STUK. After having heard those concerned, STUK makes a separate decision on how a new or revised YVL guide applies to operating nuclear power plants, or to those under construction, and to licensees' operational activities. The guides apply as such to new nuclear facilities.

When considering how new safety requirements presented in YVL guides apply to operating nuclear power plants, or to those under construction, STUK takes into account section 27 of the Government Resolution (395/1991), which prescribes that *for further safety enhancement, action shall be taken which can be regarded as justified considering operating experience and the results of safety research as well as the advancement of science and technology.*

If deviations are made from the requirements of the YVL guides, STUK shall be presented with some other acceptable procedure or solution by which the safety level set forth in the YVL guides is achieved.

Translation. Original text in Finnish.

1 General

It is necessary for the licence-holder to conduct meteorological measurements in the vicinity of a nuclear power plant to assess the dispersion of radioactive releases in the atmosphere on the basis of the measurement results. The results of dispersion assessments are used to calculate the radiation doses in the power plant environment caused by the releases. Dispersion assessments are made by the licence-holder and, if necessary, the authorities (the Radiation and Nuclear Safety Authority and the Finnish Meteorological Institute).

Government Resolutions (395/1991) and (397/1991) lay down general requirements for the safety and emergency preparedness arrangements of nuclear power plants. In accordance with Section 26 of the Resolution (395/1991), *releases of radioactive materials from a nuclear power plant and their concentrations in the environment shall be effectively monitored.* In accordance with Section 5 of the Resolution *(397/1991), on the site of a nuclear power plant provisions shall be made to carry out radiological and meteorological measurements in an emergency to assess the dispersion of radioactive substances.* In accordance with Section 2.2 of Guide YVL 1.0, *reliable, real-time assessment of the spreading of radioactive substances into the environment must be possible by meteorological measurement devices.*

This Guide defines the requirements for the meteorological measurement system of a nuclear power plant. Several other YVL Guides deal with the utilization of meteorological measurement results. Dispersion assessment and calculation methods are discussed in Guide YVL 7.3 "Calculation of the dispersion of radioactive releases from a nuclear power plant", and assessment and calculation methods of the radiation doses during nuclear power plant operation and in emergency situations in Guide YVL 7.2 "Assessment of radiation doses to the population in the environment of a nuclear power plant". The reporting of meteorological data is dealt with in Guide YVL 7.8 "Environmental radiation safety reports of nuclear power plants". Guide YVL 7.4, "Nuclear power plant emergency preparedness", discusses the emergency preparedness operations of a nuclear power plant.

The design of nuclear power plant systems is discussed in Guide YVL 2.0 "Systems design for nuclear power plants", safety classification in Guide YVL 2.1 "Nuclear power plant systems, structures and components and their safety classification", and safety analyses in Guide YVL 2.2 "Transient and accident analyses for justification of technical solutions at nuclear power plants". Guide YVL 5.5, "Instrumentation systems and components at nuclear facilities", deals with the instrumentation and control systems and equipment of nuclear facilities.

In accordance with the Government Resolution (397/1991), the licence-holder shall maintain the preparedness for measures related to rescue operations during an accident, and exercises shall be arranged jointly with the authorities concerned. At a nuclear power plant, the emphasis of operations is connected with the immediate environmental threat in the near-field of the plant. In addition to the emergency organization of a nuclear power plant, the Radiation and Nuclear Safety Authority assesses the plant situation and the radiation levels, defines the risk areas and assesses the harmful effects on the population and the environment. The Finnish Meteorological Institute assesses and predicts the long-range dispersion of radioactive materials in the atmosphere and maintains the weather service linked with radiation survey, which offers meteorological expert advice in assessing the situation, if necessary.

2 Objectives and general requirements for the meteorological measurement system

2.1 Objectives of the meteorological measurements

Meteorological measurements in the vicinity of a nuclear power plant are needed to assess the dispersion of the releases of radioactive materials in the atmosphere in the following cases:

- the releases of radioactive materials to be considered in the safety analyses of a nuclear power plant;

- the releases caused by the normal operation and transients of a nuclear power plant;
- the releases caused by accidents of a nuclear power plant.

Safety analyses that deal with accidents of a nuclear power plant help assess fulfilment of the dose-rate criteria pertaining to radiation exposure of the population. The objective is to verify that the dimensioning of the nuclear power plant safety systems is adequate. These analyses, which are carried out as early as in the design and construction phases of a nuclear power plant, utilize meteorological data that represent the site concerned. These data are complemented by meteorological measurements conducted in the vicinity of the plant. On the basis of measurements conducted during operation of the nuclear power plant, it is verified that the hypotheses proposed in the analyses about the dispersion conditions are sufficiently conservative with regard to the consequences of potential accidents, i.e. they overemphasize the consequences of accidents.

During the operation of a nuclear power plant, meteorological measurements are carried out in such a way that the radiation exposure of the population in the plant environment can be assessed on the basis of measurement results and release data. Government Resolution 395/1991 on the general regulations for the safety of nuclear power plants defines the dose limits relating to the population.

Furthermore, a major objective of the meteorological measurement system of a nuclear power plant is to assess the radiation doses in the plant environment (the protective zone and the emergency planning zone of rescue operations) during a potential accident of the nuclear power plant on the basis of release data and estimates, and real-time meteorological measurement results. These data on radiation doses are needed to plan and conduct rescue operations in the emergency planning zone and to assess the timing of a potential controlled release of radioactive materials. In addition, the authorities make national dispersion and dose predictions concerning a more extensive area and, possibly, similar predictions affecting other countries.

2.2 General requirements for the meteorological measurements during the operation of a nuclear power plant

During the nuclear power plant operation, the licence-holder shall conduct meteorological measurements in the vicinity of the plant (plant site, protective zone), with the aid of which it is possible to establish instantaneous and long-term dispersion conditions in the near-field. These measurements shall be carried out to obtain information on the wind direction and velocity, the structure of the mixing layer and the precipitation in such a way that it is possible to assess radiation doses to the population in accordance with Guide YVL 7.2. If a nuclear power plant is located on the seashore, adequate information shall be obtained on the structure of the mixing layer above land and sea in the near-field, in addition to the structure of the mixing layer at the plant site. Even an archipelago, warm condensing water in the sea area and the land/sea breeze phenomenon may interfere with the measurements and utilization of their results.

The meteorological measurement system of a nuclear power plant shall have a sufficient and representative number of observation stations, considering the local environmental factors. Observations of other meteorological stations located in the near-field of the nuclear power plant can also be used to assess the dispersion of radioactive materials in the environment.

The meteorological measurement system shall function reliably under all anticipated environmental conditions. The power supply of the measuring and data transmission systems shall be secured by an independent system for a sufficiently long time. In addition, the measuring and data transmission systems shall be doubled where necessary. For this purpose, the functions that must tolerate a single failure shall be specified. These functions include at least measurement of the wind direction and velocity, and determination of the stability of the lower-level atmosphere, which indicates dispersion.

The control room and the emergency centre of a nuclear power plant shall be fitted with displays of the meteorological measurement results neces-

sary for dispersion calculations and of the quantities calculated on their basis. Furthermore, the measurement results shall be processed in such a manner that they are also available to the Radiation and Nuclear Safety Authority and the Finnish Meteorological Institute, reliably and in real time.

The measurement results shall be recorded in such a way that enables the meteorological conditions at a given time to be subsequently established.

3 Technical requirements for the measuring instruments

3.1 General requirements

Meteorological measurements in the vicinity of a nuclear power plant shall be primarily conducted with the aid of continuous-operation measuring instruments located on weather masts or a combination of weather masts and the Doppler Sodar system intended for weather measurement. Under most conditions, the Doppler Sodar system enables observation data to be obtained from considerably higher levels than with mast measurements, but when using this system supplementary mast measurements shall be conducted nearer to the ground level. In addition, data provided by the measurement system of the Finnish Meteorological Institute or other authority can be utilized; these observations are usually made at a greater distance. Such systems may include, for instance, the wind scanner and the weather radar.

Sections 3.2–3.5 below deal with the requirements for measuring instruments. An example of the accuracy requirements for weather mast measurements is given in the Appendix to this Guide.

The measurement system shall be designed and implemented considering the general design requirements defined in Guides YVL 2.0 and YVL 5.5.

3.2 Mast measurement system

Weather masts and their measuring sensors shall be located in such a manner that the power plant buildings, the mast structures or the surrounding terrain have no disturbing effect on the measurement results. The observation point shall be high enough to obtain representative wind values and to determine the stability of the lower-level atmosphere and, if necessary, also the turbulence for dispersion studies. The stability of the atmosphere can be determined by means of wind and temperature measurements conducted at different heights or indirectly by means of the wind direction deviation measurements. The turbulence is determined using direct turbulence measurements or wind direction deviation measurements.

The meteorological measurement level located near the ground shall generally meet the international requirements for synoptic observations. The air temperature, air pressure, relative humidity as well as precipitation and time of precipitation are measured at a height of about 1–2 metres.

The lowest mast measurements shall be carried out at least twice as high as the average height of the roughness elements (e.g. trees) of the surrounding area. The highest measuring height shall be no less than the height of the power plant's ventilation stack. The highest measuring sensor of wind measurements shall be located on the top of the mast.

In temperature and wind measurements, measuring sensors shall also be located at one measuring height between the above-mentioned heights.

Anemometers shall be located in two directions at a disturbance-free distance from the mast, and their measuring sensors shall be fitted with a heating system to ensure their operation all year round. Temperature sensors shall be protected from the direct heating effect of the sun.

The structures of the weather mast shall withstand a maximum load caused by the extremely exceptional wind and freezing conditions (there is a 95% probability that the frequency of

occurrence is as high as or higher than the statistically calculated load once in a hundred years).

Further away from a nuclear power plant, it is possible to also use other existing mast structures; the weather measurement and data transmission systems located on them shall be implemented in such a way that they operate without interruption (considering the mast structures and other functions) and provide complementary data on the dispersion conditions above land.

3.3 Doppler Sodar system

The Doppler Sodar system is an acoustic measurement system, which has a minimum of three sound sources in different measuring directions. In each direction, the air velocity in the measuring beam direction is determined with the aid of the Doppler phenomenon. Combining measurements conducted in different directions, the system determines the wind components of the mixing layer at intervals of at least 50 metres in the vertical direction, up to the highest possible height in each weather situation. The wind direction and velocity, deviation of the wind direction as well as the deviation parameters and the height of the potential inversion layer, necessary for dispersion calculations, are determined on the basis of the measurement results.

When the Doppler Sodar system is used, it shall be located in a disturbance-free place in the vicinity of the nuclear power plant, at a sufficient distance from high buildings and any sound sources that might interfere with the measurement.

3.4 Wind scanning system

The wind scanner is a radar set operating in the VHF or UHF range in which the measuring beam is usually formed by a phased antenna field. While measuring, the air velocity in the beam direction is determined by means of the Doppler phenomenon. Combining measurements conducted vertically and at least in three oblique directions, the wind scanner determines the wind components of the mixing layer at intervals of at least 100 metres, up to the highest possible height in each weather situation. The wind direction and velocity, deviation of the wind direction and the deviation parameters necessary for dispersion calculations are determined on the basis of the measurement results.

The wind scanner can be fitted with an RASS (Radio Acoustic Sounding System). The propagation of the acoustic pulse transmitted by the RASS is monitored by the wind scanner, thus determining the velocity of propagation at different heights. The temperature profile and the height of the potential inversion layer are established in this way.

When the wind scanner–RASS system is used, it shall be located in a disturbance-free place at a sufficient distance from high buildings and any sound sources that might interfere with the measurement.

3.5 Weather radar

The weather radar is a radar set operating in the GHz range (5.6 GHz in Finland), which is fitted with a fully steerable parabolic antenna. While measuring, the scanner rotates at a steady speed in the horizontal direction (round the vertical axis) and the measurement is repeated at several elevation angles. The three-dimensional wind field and the precipitation (mm/h) are determined at intervals of 200 metres on the basis of the measurement results. In the summertime, the wind profile of the mixing layer is obtained even in dry weather, but in general the determination of the wind profile requires rainy weather.

4 Maintenance of the measurement system

The measurement system and related instruments shall be subjected to inspections and tests at regular intervals in accordance with a programme drawn up in advance. The calibration of the measurements shall be verified at intervals specified in the manufacturer's operating instructions and based on the operating experience. The inspection and test results as well as information on the repair and maintenance measures of the measuring instruments shall be documented.

The functioning of anemometers shall be controlled, the anemometers being detached from the mast, in a wind tunnel or with some other suitable method. If the instruments are adjusted or replaced during inspection, documents shall be kept, which contain the results of the inspection

of both the instrument removed from the mast and the instrument installed on the mast.

The orientation of the wind direction sensors shall be verified on the mast at an accuracy of ±3 direction degrees.

The measurement systems of temperature and humidity shall be designed and implemented in such a manner that the measuring sensors can be checked and calibrated under laboratory conditions in accordance with the accuracy requirements given in the Appendix.

5 Regulatory control by the Radiation and Nuclear Safety Authority

The documents concerning the meteorological measurement system of a nuclear power plant shall be submitted to the Radiation and Nuclear Safety Authority in accordance with Guides YVL 2.0 and YVL 5.5. With regard to a nuclear power plant that is being operated, a basic plan and preliminary inspection documents concerning modifications to the meteorological measurement system shall be submitted to the Radiation and Nuclear Safety Authority for approval.

The preliminary safety analysis report on the nuclear power plant shall contain a description of the meteorological conditions in the area and the mesoclimate. The description shall include the wind distributions, stability classifications and mixing height values at different times of year, which indicate the dispersion conditions in the area. Furthermore, the report shall include a plan for the meteorological measurements to be conducted at the plant site and in its vicinity. The justification included in the plans shall prove that the above-mentioned objectives and requirements can be met with the system. The justification may take account of the stationary radiation control equipment in the plant surroundings intended to monitor the releases and dispersion of radioactive materials in the event of accidents. The location of the measuring points of the system shall also be justified.

In addition, the final safety analysis report shall contain an account of the meteorological conditions in the area, which is drawn up on the basis of measurements conducted during a period of at least one year and other available data, as well as an updated climate report. The data contained in the safety analysis report shall be complemented at regular intervals on the basis of measurements carried out in the nuclear power plant area during operation. The report shall also contain a description of the meteorological measurements conducted at the plant site and in its vicinity, and their connection to the observation and data systems applied by the authorities.

As part of the emergency preparedness arrangements of a nuclear power plant, a secured system for the transmission of measurement data shall be available for on-site use by the emergency organization of the plant (site) and the Radiation and Nuclear Safety Authority.

The Radiation and Nuclear Safety Authority controls the operation of nuclear power plants, and as part of this work it also inspects the operation and maintenance of the weather measurement system at the plant site.

6 Literature

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APPENDIX Accuracy requirements for the measuring instruments

The requirements to be set for the measuring instruments depend on the system applied. The following define the accuracy requirements for the measuring instruments on a weather mast under laboratory conditions:

Wind velocity:
±0.2 m/s at wind velocities of less than 2 m/s (lowest detection limit of the measurement 0.4 m/s)
±5% at wind velocities higher than 2 m/s

Wind direction:
±5°

Temperature:
±0.15 °C

Temperature difference:
±0.2 °C/100 m

Precipitation:
±0.2 mm

Time of precipitation:
±5 min

Air pressure:
±0.3 hPa (mb)

Relative humidity:
±5%

When using a wind-direction indicator to calculate the horizontal deviation of wind direction, the required accuracy of measurement is ±1°.

When using turbulence measurement, the required time resolution of the measuring sensor is less than 0.5 seconds (the wind direction and velocity are defined at the above accuracies).