U.S. NUCLEAR REGULATORY COMMISSION

March 2007
Revision 1

REGULATORY GUIDE

OFFICE OF NUCLEAR REGULATORY RESEARCH

REGULATORY GUIDE 1.23

(Draft was issued as DG-1164, dated October 2006)

METEOROLOGICAL MONITORING PROGRAMS FOR NUCLEAR POWER PLANTS

A. INTRODUCTION

This revised regulatory guide provides licensees and applicants with improved guidance concerning criteria for an onsite meteorological measurements program that the staff of the U.S. Nuclear Regulatory Commission (NRC) considers acceptable for the collection of basic meteorological data needed to support plant licensing and operation.

For stationary power reactor site applications submitted before January 10, 1997, Title 10, Section 100.10(c)(2), of the *Code of Federal Regulations* [10 CFR 100.10(c)(2), Ref. 1] states that meteorological conditions at the site and in the surrounding area should be considered in determining the acceptability of a site for a power reactor. As an aid in evaluating a proposed site, 10 CFR 100.11(a) states that meteorological conditions pertinent to the site should be used, along with an assumed fission product release from the core and the expected containment leak rate, to ensure that prescribed dose limits for the exclusion area and low-population zone, as defined in 10 CFR 50.2, "Definitions" (Ref. 2), are met.

For stationary power reactor site applications submitted on or after January 10, 1997, 10 CFR 100.20(c)(2) requires consideration of the meteorological characteristics of the site that are necessary for safety analysis or that may have an impact upon plant design in determining the acceptability of a site for a nuclear power plant. In addition, 10 CFR 100.21(c) requires the evaluation of site atmospheric dispersion characteristics and the establishment of dispersion parameters such that (1) radiological effluent release limits associated with normal operation from the type of facility proposed to be located at the site can be met for any individual located off site, and (2) radiological dose consequences of postulated accidents meet the prescribed dose limits at the exclusion area and low-population zone distances set forth in 10 CFR 50.34(a)(1).

The "General Design Criteria [GDC] for Nuclear Power Plants" set forth in Appendix A to 10 CFR Part 50, "Domestic Licensing of Production and Utilization Facilities" (Ref. 2), establish minimum requirements for the principal design criteria for water-cooled nuclear power plants. Specifically, GDC 19, "Control Room," requires that a control room be provided from which actions can be taken to operate the nuclear power unit safely under normal conditions and to maintain it in a safe condition under accident conditions. Adequate radiation protection must be provided to permit access to and occupancy of the control room for the duration of accident conditions. For plants that use alternate source terms, 10 CFR 50.67(b)(2)(iii) provides similar criteria. Atmospheric dispersion estimates are significant inputs in assessments performed to demonstrate compliance with this requirement.

In 10 CFR Part 50 (Ref. 2), Paragraphs 50.47(b)(4), 50.47(b)(8), and 50.47(b)(9), as well as Section IV.E.2 of Appendix E, "Emergency Planning and Preparedness for Production and Utilization Facilities," require each applicant for an operating license or combined license to describe its plans for coping with radiological emergencies. These plans must include provisions for equipment for determining the magnitude and continuously assessing the impact of the release of radioactive materials to the environment. These plans must also include a standard emergency classification and action level scheme for determining minimum initial offsite response measures. In addition, if plant meteorological program parameters (i.e., wind speed, wind direction, and an indicator of atmospheric stability) are available on in-plant computer systems, they must be made available in a digital data stream to the Emergency Response Data System (ERDS) maintained by the NRC, pursuant to Section VI of Appendix E to 10 CFR Part 50.[1] In this regard, it is necessary for the applicant to establish and maintain a meteorological program capable of rapidly assessing critical meteorological parameters.

In addition, in 10 CFR Part 50, Appendix I, "Numerical Guides for Design Objectives and Limiting Conditions for Operation to Meet the Criterion 'As Low as is Reasonably Achievable' for Radioactive Material in Light-Water-Cooled Nuclear Power Reactor Effluents," provides numerical guidance for the design objectives of equipment intended to control releases of radioactive material in effluents from nuclear power reactors. An assessment of the maximum potential annual radiation dose to the public resulting from the routine release of radioactive materials in gaseous effluents is required to assist in demonstrating that operations will be or are being conducted within the limits of 10 CFR Part 20, "Standards for Protection Against Radiation" (Ref. 3), and Appendix I to 10 CFR Part 50 and to ensure that effluent control equipment design objectives and proposed operating procedures meet the Commission's requirements for keeping levels of radioactive material in effluents to unrestricted areas as low as practicable. In addition, 10 CFR 50.36a(a)(2) requires nuclear power plant licensees to submit a report to the Commission annually that specifies the quantity of each of the principal radionuclides released to unrestricted areas in liquid and gaseous effluents during the previous 12 months, including any other information that the Commission may need to estimate maximum potential annual radiation doses to the public resulting from effluent releases. A knowledge of meteorological conditions in the vicinity of the reactor is important to provide the basis for estimating maximum potential annual radiation doses resulting from radioactive materials released in gaseous effluents.

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1 The ERDS is a direct, near-real-time electronic data link between the licensee's onsite computer system and the NRC Operations Center that provides for the automated transmission of a limited data set of selected plant parameters in the event of a radiological emergency.

In order for the Commission to fulfill its responsibilities under the National Environmental Policy Act of 1969, as amended (Ref. 4), and in accordance with the requirements of Subpart A, "National Environmental Policy Act — Regulations Implementing Section 102(2)," of 10 CFR Part 51, "Environmental Protection Regulations for Domestic Licensing and Related Regulatory Functions" (Ref. 5), basic meteorological information must be available for use in assessing (1) the environmental effects of radiological and nonradiological emissions and effluents resulting from the construction or operation of a nuclear power plant and (2) the benefits of design alternatives.

Thus, each nuclear power plant site has multiple needs for an onsite program to measure and document basic meteorological data. These data may be used to develop atmospheric transport and diffusion parameters that, with appropriate atmospheric dispersion models, may be used to estimate potential radiation doses to the public resulting from actual routine or accidental releases of radioactive materials to the atmosphere or to evaluate the potential dose to the public and control room as a result of hypothetical reactor accidents. These data may also be used to assess nonradiological environmental effects resulting from the construction or operation of a nuclear power plant, such as the impacts of the plant's heat dissipation system. This regulatory guide describes a suitable onsite program to provide meteorological data needed to estimate these potential impacts.

This regulatory guide relates to information collections that are covered by the requirements of 10 CFR Parts 50 and 52, which the Office of Management and Budget (OMB) has approved under OMB control numbers 3150-0011 and 3150-0151, respectively. The NRC may neither conduct nor sponsor, and a person is not required to respond to, an information collection request or requirement unless the requesting document displays a currently valid OMB control number.

B. DISCUSSION

The NRC issued the original version of Regulatory Guide 1.23 in February 1972 to describe a suitable onsite meteorological measurements program to collect the basic meteorological data needed to determine the environmental impacts of the plant, perform consequence assessments supporting routine release and design-basis accident evaluations, and support emergency preparedness programs and other applications at power reactor sites.

The NRC subsequently issued a proposed Revision 1 of Regulatory Guide 1.23 for public comment in September 1980 in response to the accident at Three Mile Island. That first proposed Revision 1 of Regulatory Guide 1.23 contained "special considerations for emergency planning," which included (1) provisions for remote interrogation of the meteorological system by the NRC and other emergency response organizations during emergency situations, and (2) a viable backup system to obtain real-time local meteorological data. The NRC never officially adopted its first proposed Revision 1 of Regulatory Guide 1.23.

The NRC issued a second proposed Revision 1 for public comment in April 1986. That second proposed Revision 1 endorsed, with some minor exceptions, the "Standard for Determining Meteorological Information at Nuclear Power Sites," which the American National Standards Institute/American Nuclear Society (ANSI/ANS) promulgated as ANSI/ANS-2.5-1984 (Ref. 6). Although ANSI/ANS-2.5-1984 did not contain the "special considerations for emergency planning" included in the first proposed Revision 1 of Regulatory Guide 1.23, it did update other provisions of the earlier revision. Nonetheless, the NRC never officially adopted the second proposed Revision 1 of Regulatory Guide 1.23, and ANSI/ANS-2.5-1984 has since been withdrawn and is currently inactive.

The NRC solicited public comment on a third proposed Revision 1 of this guide by publishing Draft Regulatory Guide DG-1164 (Ref. 7) in October 2006.

This revised guide replaces the original (February 1972) version of Regulatory Guide 1.23. This revision clarifies regulatory requirements and updates regulatory guidance regarding the criteria for an onsite meteorological measurements program to collect the basic meteorological data needed to support plant licensing and operation. In so doing, this revision better reflects current regulatory requirements and best practices, using guidance provided in ANSI/ANS-3.11-2005, "Determining Meteorological Information at Nuclear Facilities" (Ref. 8), where appropriate, with explicit references to the NRC's regulatory requirements.[2]

An onsite meteorological measurements program at a nuclear power plant site should be capable of providing the meteorological information needed to make the following assessments:

- a conservative assessment by both the applicant and the regulatory staff of the potential dispersion of radioactive material from, and the radiological consequences of, design-basis accidents to aid in evaluating the acceptability of a site and the adequacy of engineered safety features for a nuclear power plant in accordance with 10 CFR Part 100 criteria[3]
- an assessment by both the applicant and the regulatory staff of the maximum potential annual radiation dose to the public resulting from the routine release of radioactive materials in gaseous effluents to assist in demonstrating that operations will be or are being conducted within the limits of 10 CFR Part 20 and Appendix I to 10 CFR Part 50, and to ensure that effluent control equipment design objectives and proposed operating procedures meet the Commission's requirements for keeping levels of radioactive material in effluents to unrestricted areas as low as practicable[4]

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[2] Whereas ANSI/ANS-2.5-1984 (Ref. 6) was primarily intended to support licensing applications of commercial nuclear power plants, ANSI/ANS-3.11-2005 (Ref. 8) has an expanded scope that includes nuclear installations at Federal sites, ranges, and reservations (e.g., U.S. Department of Energy and Department of Defense facilities). Because the nature and extent of the radiological and hazardous chemical materials present at Federal sites can differ significantly from similar materials present at commercial nuclear power plants, ANSI/ANS-3.11-2005 provides additional guidance beyond what the NRC considers to be basic meteorological monitoring program criteria applicable to commercial nuclear power plants.

[3] Regulatory Guide 1.145, "Atmospheric Dispersion Models for Potential Accident Consequence Assessments at Nuclear Power Plants" (Ref. 9), provides specific guidance on atmospheric dispersion modeling for evaluating the potential offsite radiological consequences of design-basis reactor accidents.

[4] Regulatory Guide 1.111, "Methods for Estimating Atmospheric Transport and Dispersion of Gaseous Effluents in Routine Releases from Light-Water-Cooled Reactors" (Ref. 10), provides specific guidance on atmospheric dispersion modeling for evaluating the potential offsite radiological consequences of routine releases from power reactors.

- a conservative assessment by both the applicant and the regulatory staff of the habitability of the control room during postulated design-basis radiological accidents and hazardous chemical releases to demonstrate that the control room can remain occupied under accident conditions in accordance with GDC 19[5]
- a near-real-time ongoing assessment by the licensee of atmospheric transport and diffusion immediately following an accidental release of airborne radioactive materials to provide input to the evaluation of the consequences of radioactive releases to the atmosphere and to aid in the implementation of emergency response decisions in accordance with the requirements in Appendix E to 10 CFR Part 50
- an assessment by the licensee of natural phenomena being experienced or projected beyond usual levels (e.g., high winds) for the purposes of emergency classification in accordance with 10 CFR 50.47(b)(4) and Section IV.B of Appendix E to 10 CFR Part 50
- a realistic assessment by both the applicant and the regulatory staff of the potential dispersion of radioactive materials from, and the radiological consequences of, a spectrum of accidents to aid in evaluating the environmental risk posed by a nuclear power plant in accordance with Subpart A to 10 CFR Part 51
- a realistic assessment by both the applicant and the regulatory staff of nonradiological environmental effects, such as fogging, icing, and salt drift from cooling towers or ponds, to aid in evaluating the environmental impact of a nuclear power plant in accordance with Subpart A to 10 CFR Part 51

While the specific types of meteorological information needed differ for each of the above assessments, a single set of instruments can generally be used to obtain the basic data needed for all of them. For this reason, when establishing a meteorological program for an initial site survey, careful consideration should be given to the operational needs for meteorological information. In particular, care should be taken to locate the instrumentation where the measurements will accurately represent the overall site meteorology and, if possible, where singular topographic features and vegetation or the construction of additional structures at a later date will not significantly influence wind patterns. For cases where a meteorological monitoring system is being "upgraded" due to age or when any change to the system is warranted, a review of appropriate new technologies should be undertaken to consider whether the meteorological monitoring system should utilize up-to-date technologies that may provide improved data sources.

The minimum amount of onsite meteorological data to be provided at the time of application (1) for a construction permit is a representative consecutive 12-month period; (2) for an operating license is a representative consecutive 24-month period, including the most recent 1-year period; and (3) for an early site permit or a combined license that does not reference an early site permit is a consecutive 24-month period of data that is defendable, representative and complete, but not older than 10 years from the date of the application. However, 3 or more years of data are preferable and, if available, should be submitted with the application.

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[5] Regulatory Guide 1.194, "Atmospheric Relative Concentrations for Control Room Radiological Habitability Assessments at Nuclear Power Plants" (Ref. 11), provides specific guidance on atmospheric dispersion modeling for design-basis control room radiological habitability assessment. Regulatory Guide 1.78, "Evaluating the Habitability of a Nuclear Power Plant Control Room During a Postulated Hazardous Chemical Release" (Ref. 12), provides guidance on assessing the habitability of the control room during and after a postulated external release of hazardous chemicals.

C. REGULATORY POSITION

This section describes a suitable onsite program to collect the basic meteorological data needed to determine the environmental impacts of the plant, perform consequence assessments supporting routine release and design-basis accident evaluations, and support emergency preparedness programs and other applications at power reactor sites.

1. Definitions

Ambient Temperature: A measure of the hotness or coldness of the ambient air, as measured by a suitable instrument.

Calm: Any wind speed below the starting threshold of the wind speed or direction sensor, whichever is greater.

Channel Check: The qualitative assessment, by observation, of channel behavior during operation. This determination should include, where possible, comparison of the channel indication and status to other indications or status derived from independent instrument channels measuring the same parameter.

Dew Point Temperature: The temperature to which a given parcel of air must be cooled at constant pressure and constant water-vapor content in order for saturation to occur.

Gaussian Plume Model: A basic atmospheric dispersion model that assumes that the plume spread has a Gaussian distribution in both the horizontal and vertical directions and, therefore, uses the standard deviations of plume concentration distribution in the horizontal (σ_y) and vertical (σ_z).

Precipitation: Any of the forms of water particles, whether liquid or solid, that fall from the atmosphere and reach the ground.

Relative Humidity: The ratio of the vapor pressure to the saturation vapor pressure with respect to water.

Pasquill Stability Class: A classification of atmospheric stability, or the amount of turbulent mixing in the atmosphere and its effect on effluent dispersion.

Starting Threshold: The minimum wind speed above which the measuring instrument is performing within its minimum specification.

System Accuracy: The amount by which a measured variable deviates from a value accepted as true or standard. System accuracy encompasses all the components of the system, from sensors through processors, data recorders, and displays.

System Calibration: The process of validating the output of an observing system against known reference observations or standards.

Vertical Temperature Difference (ΔT): The measured difference in ambient temperature between two elevations on the same tower. It is defined as the upper level temperature measurement minus the lower level temperature measurement.

Water Equivalent: The amount of water, in inches, measured at ground level from rain and/or melted frozen precipitation (e.g., snow, freezing precipitation).

Wet-Bulb Temperature: The temperature an air parcel would have if cooled adiabatically to saturation at constant pressure by evaporation of water into it, all latent heat being supplied by the parcel.

Wind Direction: The direction from which the wind is blowing. Wind direction is reported in degrees azimuth, measured clockwise from true north and ranging from 0° to 360° (e.g., north is 0° or 360°, east is 90°, etc.).

Wind Speed: The rate at which air is moving horizontally past a given point.

2. Meteorological Parameters

This section discusses the criteria for a basic meteorological monitoring system.

2.1 Wind Speed and Direction

Wind speed and direction should be measured on one open-lattice tower or mast measured at heights of approximately 10 meters (33 feet) and 60 meters (197 feet) above ground level. A measurement height other than 60 meters (197 feet) may be appropriate for those plants where the most probable atmospheric release height is other than 60 meters (197 feet). A third measurement height should be implemented at a representative level for stack releases that are 85 meters (279 feet) or higher.

2.2 Vertical Temperature Difference

Vertical temperature difference (ΔT) should be measured on the same open-lattice tower or mast as wind speed and wind direction between the 10-meter (33-foot) level and 60-meter (197-foot) levels and, if necessary, between the 10-meter (33-foot) level and a higher level that is representative of diffusion conditions from release points that are 85 meters (279 feet) or higher. Table 1 provides a definition of Pasquill stability classes as a function of ΔT.

Vertical temperature difference is the preferred method for determining Pasquill stability classes at nuclear power plants for licensing purposes because it is an effective indicator for the worst-case stability conditions (e.g., Pasquill stability classes E, F, and G). Also, certain Gaussian plume models endorsed by the NRC (such as the models referenced in Regulatory Guides 1.145 and 1.194, Refs. 9 and 11) are based on empirically derived plume meander factors from field tracer studies that used ΔT to classify atmospheric stability. Alternative methods may be used to classify atmospheric stability for licensing purposes if appropriate justification is provided. However, the use of alternative methods to classify atmospheric stability may require modifications of the models described in Regulatory Guides 1.145 and 1.194.

Alternative methods may be appropriate for classifying atmospheric stability for emergency response purposes if these methods can be shown to be compatible with the plant's emergency response dose assessment methodology.

Table 1. Classification of Atmospheric Stability

Stability Classification	Pasquill Stability Category	Ambient Temperature Change With Height (°C/100m)
Extremely unstable	A	$\Delta T \leq -1.9$
Moderately unstable	B	$-1.9 < \Delta T \leq -1.7$
Slightly unstable	C	$-1.7 < \Delta T \leq -1.5$
Neutral	D	$-1.5 < \Delta T \leq -0.5$
Slightly stable	E	$-0.5 < \Delta T \leq 1.5$
Moderately stable	F	$1.5 < \Delta T \leq 4.0$
Extremely stable	G	$\Delta T > 4.0$

2.3 Ambient Temperature

Ambient temperature should be monitored at approximately 10 meters (33 feet).

2.4 Precipitation

Precipitation should be measured near ground level near the base of the mast or tower.

While routine release or design-basis accident assessments of offsite dose consequences do not typically consider precipitation, the presence or absence of precipitation and its amount are important for severe accident assessments that are included in the applicant's environmental report and the staff's environmental impact assessment pursuant to Subpart A of 10 CFR Part 51. Severe accident dose consequence computer codes, such as Version 2 of the MELCOR Accident Consequence Code System (MACCS2) (Ref. 13), account for the efficient removal of particulate radionuclides from the plume by wet deposition. Precipitation information can also be useful as an input to developing emergency response protective action recommendations by indicating the potential for increased ground contamination as a result of wet deposition.

2.5 Atmospheric Moisture

At sites utilizing cooling towers, cooling lakes and ponds, or spray ponds as the plant's normal heat sink, the pre-operational monitoring program should include ambient temperature and atmospheric moisture measurements (e.g., dew point temperature, wet-bulb temperature, or relative humidity) at height(s) representative of water-vapor release. In the case of natural draft cooling towers, ambient temperature and atmospheric moisture measurements may be made at the highest measurement level on the meteorological tower.

These data are required to assess the physical and aesthetic impacts of vapor plumes from such heat dissipation facilities, including the length and frequency of elevated plumes, increases in ground-level humidity, frequency and extent of ground-level fogging and icing, drift deposition, cloud formation, cloud shadowing, and additional precipitation in the site vicinity as discussed in Section 5.1.4 of Regulatory Guide 4.2, "Preparation of Environmental Reports for Nuclear Power Stations"(Ref. 14), and Section 5.3.3.1 of NUREG-1555, "Environmental Standard Review Plan"(Ref. 15). These measurements need not be continued during the operational monitoring program, unless specified by the plant's Environmental Protection Program pursuant to 10 CFR 50.36b or 10 CFR 51.50.

3. Siting of Meteorological Instruments

To the extent practical, meteorological measurements should be made in locations that can provide data representative of the atmospheric conditions into which material will be released and transported. The tower or mast should be sited at approximately the same elevation as finished plant grade. Factors to be considered in selecting the appropriate measurement locations and installation of the instruments include the prevailing wind direction, topography, and location of manmade and vegetation obstructions.

Whenever possible, wind measurements should be made at locations and heights that avoid airflow modifications by obstructions such as large structures, trees, and nearby terrain. The sensors should be located over level, open terrain at a distance of at least 10 times the height of any nearby obstruction if the height of the obstruction exceeds one-half the height of the wind measurement.[6] Wind sensors should be located on top of the measurement tower or mast or extended outward on a boom to reduce airflow modification and turbulence induced by the supporting structure itself.

Because the tower structure can affect downwind measurements, wind sensors on the side of a tower should be mounted at a distance equal to at least twice the longest horizontal dimension of the tower (e.g., the side of a triangular tower). The sensors should be on the upwind side of the mounting object in areas with a dominant prevailing wind direction. In areas with two distinct prevailing wind directions (e.g., mountain valleys), the sensors should be mounted in a direction perpendicular to the primary two directions.

Ambient temperature and atmospheric moisture measurements should be made to avoid air modification by heat and moisture sources (e.g., ventilation sources, cooling towers, water bodies, large parking lots). For this reason, the tower or mast should not be located on or near permanent manmade surfaces, such as concrete or asphalt, or temporary land disturbances, such as coal piles, plowed fields, or storage areas. Temperature sensors should be mounted in fan-aspirated radiation shields to minimize the adverse influences of thermal radiation and precipitation. The aspirated temperature shields should either be pointed downward or laterally towards the north and the shield inlet should be at least 1½ times the tower horizontal width away from the nearest point on the tower.

Precipitation gauges should be equipped with wind shields to minimize the wind-caused loss of precipitation. Where appropriate, precipitation gauges should also be equipped with heaters or an antifreeze (i.e., ethylene glycol) to melt frozen precipitation. If heaters are used, they should be operated to minimize underestimation attributable to evaporation caused by the heater device.

4. Instrument Accuracy and Range

The time-average accuracies for digital systems should meet the criteria listed in Table 2. These accuracies are stated in terms of overall system accuracies and should include, where applicable, the errors introduced by sensors, cables, signal conditioners, temperature environments for signal conditioning and recording equipment, recorders, processors, data displays, and the data reduction process.

The ambient temperature and atmospheric moisture instrumentation should be capable of operating over the range of expected climatic extremes based on regional climatology.

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6 For example, trees 15 meters (49 feet) in height should be no closer than 150 meters (492 feet) from the tower or mast.

If the accuracies of the signal conditioning equipment and/or data acquisition system are sensitive to changes in temperature, they should be housed in a climate-controlled environment.

Table 2. Meteorological System Accuracies and Resolutions

Measurement	System Accuracy	Measurement Resolution
Wind Speed	±0.2 m/s (±0.45 mph) or 5% of observed wind speed starting threshold < 0.45 m/s (1 mph)	0.1 m/s or 0.1 mph
Wind Direction	±5 degree starting threshold < 0.45 m/s (1 mph)	1.0 degree
Ambient Temperature	±0.5 °C (±0.9 °F)	0.1 °C or 0.1 °F
Vertical Temperature Difference	±0.1 °C (±0.18 °F)	0.01 °C or 0.01 °F
Dew Point Temperature	±1.5 °C (±2.7 °F)	0.1 °C or 0.1 °F
Wet-Bulb Temperature	±0.5 °C (±0.9 °F)	0.1 °C or 0.1 °F
Relative Humidity	±4%	0.1%
Precipitation (water equivalent)	±10% for a volume equivalent to 2.54 mm (0.1 in.) of precipitation at a rate < 50 mm/h (<2 in./h)	0.25 mm or 0.01 in.
Time	±5 min	1 min

5. Instrument Maintenance and Servicing Schedules

Meteorological instruments should be inspected and serviced at a frequency that will ensure data recovery of at least 90 percent on an annual basis.[7] The 90-percent rate applies to the composite of all variables (e.g., the joint frequency distribution of wind speed, wind direction, stability class) needed to model atmospheric dispersion for each potential release pathway. In addition, the 90-percent rate applies individually to the other meteorological parameters.

Channel checks should be performed daily for operational monitoring programs, and channel calibrations should be performed semiannually for both pre-operational and operational monitoring programs, unless the operating history of the equipment indicates that either more- or less-frequent calibration is necessary. System calibrations should encompass entire data channels, including all recorders and displays (e.g., those local at the meteorological tower and in the emergency response facilities, as well as those used to compile the historical data set). System calibrations may be performed by a series of sequential, overlapping, or total channel steps, such that each channel from sensors to recorders and displays is calibrated. For guyed towers, guyed wires should be inspected annually, and anchors should be inspected once every 3 years in accordance with industry standards.

[7] The use of redundant sensors and/or recorders is an acceptable approach to achieve the 90-percent data recovery goal.

6. Data Reduction and Compilation

Meteorological monitoring systems should use electronic digital data acquisition systems as the primary data recording system. Data may be recorded and displayed in either English units (e.g., miles per hour, degrees Fahrenheit, inches) or metric units (e.g., meters per second, degrees Celsius, millimeters) and should meet the resolution criteria listed in Table 2.

A backup recording system (either analog or digital) may be used to provide a high assurance of valid data. Where analog data recording systems are used, wind speed and wind direction should be recorded on continuous trace strip charts. Other variables may be recorded on multipoint charts with a sampling rate of at least once per minute.

The digital sampling of data should be at least once every 5 seconds. The digital data should be (1) compiled as 15-minute average values for real-time display in the appropriate emergency response facilities (e.g., control room, technical support center, and emergency operations facility), and (2) compiled and archived as hourly values for use in historical climatic and dispersion analyses. The hourly values may be generated by (1) averaging all the samples taken during the hour, (2) using one 15-minute value per hour (if the same 15-minute period is used each hour), or (3) averaging all of the 15-minute values recorded during the hour.[8] For precipitation, the hourly value should represent the total amount of precipitation (water equivalent) measured during the hour. Appendix A shows the format for the electronic copy of the hourly database that should be submitted as a supplement to the application.

The basic data should also be compiled into annual joint frequency distributions of wind speed and wind direction by atmospheric stability class. Table 3 gives an example of a suitable format for data compilation and reporting purposes. Similar tables of joint frequency distribution should be prepared for each of the other atmospheric stability classes.

7. Special Considerations for Complex Terrain Sites

The plant's pre-operational meteorological monitoring program should provide an adequate basis for atmospheric transport and diffusion estimates for the exclusion area distance, the outer boundary of the low-population zone, and the hypothetical maximally exposed member of the public [e.g., the site boundary and the nearest resident, vegetable garden, and milk and meat animals within 8 kilometers (5 miles) in each downwind sector].

At some sites, because of complex flow patterns in nonuniform terrain, additional wind and temperature instrumentation and more comprehensive programs may be necessary. For example, the representation of circulation for a hill-valley complex or a site near a large body of water may need additional measuring points to determine airflow patterns and spatial variations of atmospheric stability. Occasionally, the unique diffusion characteristics of a particular site may also warrant the use of special meteorological instrumentation and/or studies.

The plant's operational meteorological monitoring program should provide an adequate basis for atmospheric transport and diffusion estimates within the plume exposure emergency planning zone [i.e., within approximately 16 kilometers (10 miles)].[9]

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8 Note that wind direction is a circular function with values between 0 and 360 degrees. The wind direction discontinuity at the beginning/end of the scale requires special processing to compute a valid average value.

9 For example, if the comparison of the primary and supplemental meteorological systems indicates convergence in a lake breeze setting, then a "keyhole" protective action recommendation (e.g., evacuating a 2-mile radius and 5 miles downwind) may not be appropriate.

8. Special Considerations to Support Emergency Preparedness

In order to identify rapidly changing meteorological conditions for use in performing emergency response dose consequence assessments, 15-minute average values should be compiled for real-time display in the appropriate emergency response facilities (e.g., control room, technical support center, and emergency operations facility). All the meteorological channels required for manual input to the dose assessment models should be available and presented in a format compatible for input to the models (e.g., wind speed is displayed in the proper units; atmospheric stability is displayed as a ΔT value versus a Pasquill stability class, etc.). Regulatory Guide 1.97, "Criteria for Accident Monitoring Instrumentation for Nuclear Power Plants" (Ref. 16), provides additional criteria for the display of meteorological data in control rooms.

If the basis for any of the emergency action levels includes the monitoring of onsite meteorological conditions (e.g., the occurrence of measured hurricane-force winds onsite as a basis for declaring an Unusual Event), the tower and its instrumentation should be capable of surviving, monitoring, and displaying the meteorological condition.

If the plant computer system collects wind speed, wind direction, and atmospheric stability data, these data should be submitted as inputs to the NRC's ERDS as provided for in Section VI of Appendix E to 10 CFR Part 50.

The applicant should have provisions in place to obtain representative meteorological data [e.g., wind speed and direction representative of the 10-meter (33-foot) level and an estimate of atmospheric stability that is not necessarily based on ΔT] from alternative sources during an emergency if the site meteorological monitoring system is unavailable.

9. Documentation

The safety analysis report should document the onsite meteorological measurements program, in accordance with 10 CFR 50.34(a)(1) and 50.34(b)(1).

Table 3. Example Joint Frequency Distribution of Wind Direction, Wind Speed, and Stability Class

Site/Plant Name: __________

Extremely Stable (ΔT exceeds 4.0 °C/100 m)
Pasquill Stability Class G

Period of Record: __________

Wind Direction	Wind Speed (m/s) at __ Meter Level; ΔT between __ Meters and __ Meters											
	<0.5	0.5–1.0	1.1–1.5	1.6–2.0	2.1–3.0	3.1–4.0	4.1–5.0	5.1–6.0	6.1–8.0	8.1–10.0	>10.0	TOTAL
N												
NNE												
NE												
ENE												
E												
ESE												
SE												
SSE												
S												
SSW												
SW												
WSW												
W												
WNW												
NW												
NNW												
VARIABLE												
Total												
Number of Calms:												
Number of Missing Hours:												

Values in this table can be in counts or percent of total valid hours.

D. IMPLEMENTATION

The purpose of this section is to provide information to licensees regarding the NRC staff's plans for using this regulatory guide. No backfitting is intended or approved in connection with the issuance of this guide.

Except in those cases in which a licensee proposes or has previously established an acceptable alternative method for complying with specified portions of the NRC's regulations, the NRC staff will use the methods described in this guide to evaluate the applicant's or licensee's onsite meteorological measurements program, as presented in (1) submittals in connection with applications for construction permits, standard plant design certifications, operating licenses, early site permits, and combined licenses; and (2) submittals from operating reactor licensees who voluntarily propose to initiate system modifications that have a clear nexus with the subject for which guidance is provided herein.

REGULATORY ANALYSIS / BACKFIT ANALYSIS

The regulatory analysis and backfit analysis for this regulatory guide are available in Draft Regulatory Guide DG-1164, "Meteorological Monitoring Programs for Nuclear Power Plants" (Ref. 7). The NRC issued DG-1164 in October 2006 to solicit public comment on the draft of this Revision 1 of Regulatory Guide 1.23.

REFERENCES

1. *U.S. Code of Federal Regulations*, Title 10, "Energy," Part 100, "Reactor Site Criteria."[10]

2. *U.S. Code of Federal Regulations*, Title 10, "Energy," Part 50, "Domestic Licensing of Production and Utilization Facilities."[10]

3. *U.S. Code of Federal Regulations*, Title 10, "Energy," Part 20, Standards for Protection Against Radiation."[10]

4. National Environmental Policy Act of 1969, Pub. L. 91-190, 42 U.S.C. 4321-4347, United States Senate and House of Representatives, Washington, DC, January 1, 1970.[11]

5. *U.S. Code of Federal Regulations*, Title 10, "Energy," Part 51, "Environmental Protection Regulations for Domestic Licensing and Related Regulatory Functions."[10]

6. ANSI/ANS-2.5-1984, "Standard for Determining Meteorological Information at Nuclear Power Sites," American National Standards Institute/American Nuclear Society, 1984.[12]

7. Draft Regulatory Guide DG-1164 "Meteorological Monitoring Programs for Nuclear Power Plants," U.S. Nuclear Regulatory Commission, Washington, DC, October 2006.[13]

8. ANSI/ANS-3.11-2005, "Determining Meteorological Information at Nuclear Facilities," American National Standards Institute/American Nuclear Society, 2005.[12]

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[10] All NRC regulations listed herein are available electronically through the Public Electronic Reading Room on the NRC's public Web site, at http://www.nrc.gov/reading-rm/doc-collections/cfr/. Copies are also available for inspection or copying for a fee from the NRC's Public Document Room at 11555 Rockville Pike, Rockville, MD; the PDR's mailing address is USNRC PDR, Washington, DC 20555; telephone (301) 415-4737 or (800) 397-4209; fax (301) 415-3548; email PDR@nrc.gov.

[11] The National Environmental Policy Act of 1969 is available electronically through the NEPAnet Web site at http://ceq.eh.doe.gov/nepa/regs/nepa/nepaeqia.htm.

[12] Copies may be purchased from the American National Standards Institute/American Nuclear Society, 555 North Kensington Avenue, La Grange Park, Illinois 60526; telephone (708)352-6611; or fax (708)352-0499. Purchase information is available through the ANS Web site at http://www.ans.org/store/vc-stnd.

[13] Draft Regulatory Guide DG-1164 is available electronically under Accession #ML062540408 in the NRC's Agencywide Documents Access and Management System (ADAMS) at http://www.nrc.gov/reading-rm/adams.html. Copies are also available for inspection or copying for a fee from the NRC's Public Document Room (PDR), which is located at 11555 Rockville Pike, Rockville, Maryland; the PDR's mailing address is USNRC PDR, Washington, DC 20555-0001. The PDR can also be reached by telephone at (301) 415-4737 or (800) 397-4209, by fax at (301) 415-3548, and by email to PDR@nrc.gov.

9. Regulatory Guide 1.145, "Atmospheric Dispersion Models for Potential Accident Consequence Assessments at Nuclear Power Plants," U.S. Nuclear Regulatory Commission, Washington, DC.[14]

10. Regulatory Guide 1.111, "Methods for Estimating Atmospheric Transport and Dispersion of Gaseous Effluents in Routine Releases from Light-Water-Cooled Reactors," U.S. Nuclear Regulatory Commission, Washington, DC.[14]

11. Regulatory Guide 1.194, "Atmospheric Relative Concentrations for Control Room Radiological Habitability Assessments at Nuclear Power Plants," U.S. Nuclear Regulatory Commission, Washington, DC.[14]

12. Regulatory Guide 1.78, "Evaluating the Habitability of a Nuclear Power Plant Control Room During a Postulated Hazardous Chemical Release," U.S. Nuclear Regulatory Commission, Washington, DC.[14]

13. NUREG/CR-6613, "A Code Manual for MACCS2," SAND97-0594, D. Chanin and M.L. Young, U.S. Nuclear Regulatory Commission, Washington, DC, May 1998.[15]

14. Regulatory Guide 4.2, "Preparation of Environmental Reports for Nuclear Power Stations ," U.S. Nuclear Regulatory Commission, Washington, DC.[14]

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[14] All regulatory guides listed herein were published by the U.S. Nuclear Regulatory Commission or its predecessor, the U.S. Atomic Energy Commission. Most are available electronically through the Electronic Reading Room on the NRC's public Web site, at http://www.nrc.gov/reading-rm/doc-collections/reg-guides/. Single copies of regulatory guides may also be obtained free of charge by writing the Reproduction and Distribution Services Section, ADM, USNRC, Washington, DC 20555-0001, by fax to (301) 415-2289, or by email to DISTRIBUTION@nrc.gov. Active guides may also be purchased from the National Technical Information Service (NTIS). Details may be obtained by contacting NTIS at 5285 Port Royal Road, Springfield, Virginia 22161, online at http://www.ntis.gov, by telephone at (800) 553-NTIS (6847) or (703) 605-6000, or by fax to (703) 605-6900. Copies are also available for inspection or copying for a fee from the NRC's Public Document Room (PDR), which is located at 11555 Rockville Pike, Rockville, Maryland; the PDR's mailing address is USNRC PDR, Washington, DC 20555-0001. The PDR can also be reached by telephone at (301) 415-4737 or (800) 397-4209, by fax at (301) 415-3548, and by email to PDR@nrc.gov.

[15] NUREG/CR-6613 was developed by Sandia National Laboratories and published by the U.S. Nuclear Regulatory Commission. Copies are available for inspection or copying for a fee from the NRC's Public Document Room at 11555 Rockville Pike, Rockville, MD; the PDR's mailing address is USNRC PDR, Washington, DC 20555; telephone (301) 415-4737 or (800) 397-4209; fax (301) 415-3548; email PDR@nrc.gov. In addition, copies are available at current rates from the U.S. Government Printing Office, P.O. Box 37082, Washington, DC 20402-9328 (telephone 202-512-1800); or from the National Technical Information Service (NTIS) by writing NTIS at 5285 Port Royal Road, Springfield, Virginia 22161, online at http://www.ntis.gov, by telephone at (800) 553-NTIS (6847) or (703)605-6000, or by fax to (703) 605-6900.

15. NUREG-1555, "Standard Review Plans for Environmental Reviews for Nuclear Power Plants," Section 5.3.3.1, "Heat Dissipation to the Atmosphere," U.S. Nuclear Regulatory Commission, Washington, DC, October 1999.[16]

16. Regulatory Guide 1.97, "Criteria for Accident Monitoring Instrumentation for Nuclear Power Plants," U.S. Nuclear Regulatory Commission, Washington, DC.[14]

[16] Copies are available at current rates from the U.S. Government Printing Office, P.O. Box 37082, Washington, DC 20402-9328 (telephone 202-512-1800); or from the National Technical Information Service (NTIS) by writing NTIS at 5285 Port Royal Road, Springfield, Virginia 22161, online at http://www.ntis.gov, by telephone at (800) 553-NTIS (6847) or (703)605-6000, or by fax to (703) 605-6900. Copies are also available for inspection or copying for a fee from the NRC's Public Document Room (PDR), which is located at 11555 Rockville Pike, Rockville, Maryland; the PDR's mailing address is USNRC PDR, Washington, DC 20555-0001. The PDR can also be reached by telephone at (301) 415-4737 or (800)397-4209, by fax at (301)415-3548, and by email to PDR@nrc.gov. In addition, NUREG-1555 is available electronically through the Electronic Reading Room on the NRC's Public Web site at http://www.nrc.gov/reading-rm/doc-collections/nuregs/staff/sr1555/.

APPENDIX A

RECOMMENDED FORMAT FOR HOURLY METEOROLOGICAL DATA TO BE PLACED ON ELECTRONIC MEDIA

Hourly meteorological data should be submitted to the U.S. Nuclear Regulatory Commission (NRC) on mutually agreed-upon media. The file is a formatted, sequential access, ASCII text data file. Comma-delimited or binary data files should not be submitted. The data should be in files that are of a size that are convenient for use and storage. Annual data files are acceptable.

At the beginning of each file, use the first five records to give a file description. Include plant name, location (latitude, longitude), dates of data, information explaining data contained in the "other" fields if they are used, heights of measurements, and any additional information pertinent to the identification of the file (e.g., type of atmospheric moisture measurements). Ensure that all five records are included, even if some are blank. Use 160A1 as the format for the first five records. The remaining records, one per hour, contain the meteorological data in the format A4, I4, I3, I4, 25F5.1, F5.2, 3F5.1. The use of decimal points in the database is not required. Check the file to ensure quality (e.g., compare against the raw data to ensure that the electronic file has been properly formatted, unit conversions are correct, and invalid data are properly identified).

Provide all data to the tenth of a unit, except solar radiation, which should be provided to a hundredth of a unit. This does not necessarily indicate the accuracy of the data (e.g., wind direction is usually given to the nearest degree). Use all nines in any field to indicate a lost record (99999). Use all sevens in a wind direction field to indicate calm (77777). If there are only two levels of data, use the upper and lower levels. If there is only one level of data, use the upper level.

NOTE: The sigma theta, solar radiation, and visibility measurements listed in the following pages are not required measurements but should be provided if they are available. Ambient temperature and atmospheric moisture measurements should be provided at height(s) representative of water-vapor release for those sites utilizing cooling towers, cooling lakes and ponds, or spray ponds as the plant's normal heat sink.

METEOROLOGICAL DATA ON ELECTRONIC MEDIA

LOCATION:

DATE OF DATA RECORD:

A4	Identifier (can be anything)	
I4	Year	
I3	Julian Day	
I4	Hour (on 24-hour clock)	
		ACCURACY
F5.1	Upper Measurements: Level = _____ meters	_____
F5.1	Wind Direction (degrees)	_____
F5.1	Wind Speed (meters/second)	_____
F5.1	Sigma Theta (degrees)	_____
F5.1	Ambient Temperature (°C)	_____
F5.1	Atmospheric Moisture: _____	_____
F5.1	Other: _____	_____
F5.1	Intermediate Measurements: Level = _____ meters	_____
F5.1	Wind Direction (degrees)	_____
F5.1	Wind Speed (meters/second)	_____
F5.1	Sigma Theta (degrees)	_____
F5.1	Ambient Temperature (°C)	_____
F5.1	Atmospheric Moisture: _____	_____
F5.1	Other: _____	_____
F5.1	Lower Measurements: Level = _____ meters	_____
F5.1	Wind Direction (degrees)	_____

METEOROLOGICAL DATA ON ELECTRONIC MEDIA (Continued)

F5.1	Wind Speed (meters/second)	_____
F5.1	Sigma Theta (degrees)	_____
F5.1	Ambient Temperature (°C)	_____
F5.1	Atmospheric Moisture: _____	_____
F5.1	Other: _____	_____
F5.1	Temp. Diff. (Upper-Lower) (°C/100 meters)	_____
F5.1	Temp. Diff. (Upper-Intermediate) (°C/100 meters)	_____
F5.1	Temp. Diff. (Intermediate-Lower) (°C/100 meters)	_____
F5.1	Precipitation (millimeters)	_____
F5.2	Solar Radiation (calories/square centimeter/minute)	_____
F5.1	Visibility (kilometers)	_____
F5.1	Other: _____	_____
F5.1	Other: _____	_____