

**ANS**

Determining Meteorological Information at Nuclear Facilities

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ANSI/ANS-3.11-2015

An American National Standard

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**American National Standard
Determining Meteorological
Information at Nuclear Facilities**

Secretariat
American Nuclear Society

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Foreword

(This foreword is not a part of American National Standard, “Determining Meteorological Information at Nuclear Facilities,” ANSI/ANS-3.11-2015.)

Meteorological data collected at nuclear facilities play an important role in determining the effects of radiological and toxic chemical effluents on workers, facilities, the public, and the environment; and these data have many other useful applications, such as determining the effects of non-radiological/non-toxic water vapor releases (e.g., cooling tower plumes) and implementing emergency response plan Emergency Action Levels (e.g., in instances of high winds). Accordingly, meteorological program design should be based on the needs and objectives of the facility and the guiding principles for making accurate and valid meteorological measurements. ANSI/ANS-2.5-1984 (R1990) (withdrawn), “Determining Meteorological Information at Nuclear Power Sites,” was issued in 1984 to address nuclear power facility meteorological data acquisition programs. ANSI/ANS-2.5-1984 (R1990) (withdrawn) was referenced by second proposed Revision 1 to Regulatory Guide 1.23, “Meteorological Measurement Program for Nuclear Power Plants.” ANSI/ANS-2.5-1984 (R1990) (withdrawn) was, however, narrowly focused on commercial nuclear power plant siting considerations and did not provide adequate guidance on meteorological data application from startup to operations to decommissioning (i.e., life cycle).

In 1996, the Nuclear Utility Meteorological Data Users Group and the U.S. Department of Energy (DOE) Meteorological Coordinating Council jointly undertook comprehensive reviews of the applicability of ANSI/ANS-2.5-1984 (R1990) (withdrawn) and recommended major refinements in the following areas:

- (1) operational data applications (especially emergency preparedness) in addition to siting applications;
- (2) availability of guidance for both public and private sector entities;
- (3) life cycle considerations of meteorological monitoring systems;
- (4) the need to monitor multiple locations to acquire sufficient data for models to characterize three-dimensional flows in regions of complex terrain;
- (5) inclusion of state-of-the-art meteorological monitoring equipment, including remote sensing instrumentation.

The meteorological data that are acquired, according to ANSI/ANS-2.5-1984 (R1990) (withdrawn) principles, are primarily used in supporting licensing applications of commercial nuclear power plants. More common operational applications to support protection of the health and safety of site personnel and the public, such as emergency preparedness consequence assessments and environmental compliance analyses, were not addressed because these programs had not fully matured at that time. Meteorological data required to support consequence assessments associated with emergency response differ significantly from the archived data used for climate characterization, environmental impact assessment, and compliance analysis purposes in that data must be available in real time. Real-time meteorological data availability may require significant upgrades to existing monitoring systems to limit data loss and to focus attention on the diurnal and seasonal effects that complex terrain, if present, have on the meteorological wind fields (and therefore plume trajectory) in the region of transport.

Nuclear facilities in the public sector and non-regulatory domains of the DOE and the U.S. Department of Defense were not represented in ANSI/ANS-2.5-1984 (R1990) (withdrawn). Government agencies resorted to issuing their own technical guidance (such as “Environmental Radiological Effluent Monitoring and Environmental Surveillance Handbook,” DOE-HDBK-1216-2015, in which Chapter 5 addressed meteorological measurements). The need to develop a standard that was also applicable to the public sector

was enhanced by the recent DOE initiative, through its Technical Standards Program, which set a goal of operating DOE facilities under voluntary standards by 2000, in compliance with the Federal guidance contained in the Office of Management and Budget's circular OMB-119A, "Federal Participation in the Development and Use of Voluntary Consensus Standards and in Conformity Assessment Activities."

Meteorological data monitored at public sector nuclear facilities are used for

- (1) routine radiological and chemical release consequence analyses;
- (2) operating procedures, with respect to severe weather;
- (3) operations and maintenance considerations for heat sinks (e.g., cooling towers, ponds);
- (4) real-time consequence assessments of accidental releases of radiological and chemical species;
- (5) potential environmental and control room habitability impacts resulting from design-basis accidents from projected new facilities or from modifications to existing facilities.

The use of meteorological data can also play an important role in various types of environmental, decontamination and decommissioning, air quality, wind loading, and engineering studies. Other uses of meteorological data include assessments of environmental remediation activities, industrial hygiene, construction, and waste management. Ideally, meteorological data needed to design or evaluate nuclear facilities complying with the requirements of ANSI/ANS-2.3-2011, "Estimating Tornado, Hurricane and Extreme Straight Line Wind Characteristics at Nuclear Facilities," and other applicable standards should be collected and analyzed in accordance with this standard. A comprehensive meteorological monitoring system requires instrumentation that will meet the programmatic purposes for which it is intended.

Meteorological measurements are most commonly taken with in situ sensors that are mounted on towers and are directly in contact with the atmosphere. Additionally, atmospheric properties can be inferred with "remote" sensors, which emit or propagate electromagnetic or acoustic waves into the atmosphere. The criteria for upgrading a sensor include improved accuracy, durability, and/or dependability, or a decrease in required maintenance that would increase the level of data recovery and cost-effectiveness of the measurement system while maintaining or improving appropriate measurement capabilities. When it becomes necessary to replace, upgrade, or supplement the meteorological monitoring system equipment, the most effective technology available that is appropriate to meet the objectives is normally employed. In the case where a new type of sensor replaces an existing sensor, a demonstration of the effectiveness of the new sensor is necessary before the replacement is completed (see ASTM D4430-96, "Standard Practice for Determining the Operational Comparability of Meteorological Measurements"). The following document provided useful information related to the subject of this standard: "National Technology Transfer and Advancement Act," PL 104-113; accessible online at http://gsi.nist.gov/global/docs/pubs/NISTIR_5967.pdf.

ANSI/ANS-3.11-2000 was developed to address life cycle issues associated with meteorological monitoring programs at nuclear facilities. This standard was also developed to address technological advances for in situ and remote sensing instrumentation to monitor meteorological parameters (e.g., sonic anemometers, lidar, Doppler sodar, radar wind profilers, etc.), modifications in analytical requirements, and other considerations. The aforementioned remote sensing systems provide the nuclear facility meteorologist

or meteorological program manager with additional means to acquire sufficient data to characterize the three-dimensional wind field in the vicinity of the facility and within the region of transport. ANSI/ANS-3.11-2000 also provides additional information on instrument siting and measurement issues, based on the results of wind tunnel studies, which have given insight into the aerodynamic effects of obstacles on a local wind field.

ANSI/ANS-3.11-2000 was designed with sufficient depth and breadth to address the needs of the entire meteorological monitoring community associated with all nuclear facilities nationwide, including commercial electric generating stations and nuclear installations at federal sites, ranges, and reservations. It does not attempt to define the exact monitoring criteria for every possible type of facility or site environment. It does identify the minimum information that comprises a successful monitoring program and requires that the details of such programs be delegated to subject matter expert meteorologists who analyze each particular site and application in order to arrive at an acceptable program for that particular application.

The ANS-3.11 Working Group was reconstituted in February 2003 to evaluate the currency of the three-year-old standard and to determine whether it should be simply reaffirmed on its February 18, 2005, sunset or it needed to be updated to account for new reference standards, advances in ex situ and in situ instrumentation, advances in data management equipment and techniques, advances in meteorological program management, integration with facility programs (e.g., configuration management), and other considerations. The Working Group unanimously determined to update the standard, and ANSI/ANS-3.11-2005 is a result of this work. In 2008, the ANS-3.11 Working Group again reevaluated the actions to be taken on the standard prior to its five-year sunset in December 2010. The Working Group unanimously determined to reaffirm the standard, and ANSI/ANS-3.11-2005 (R2010) is a result of this work.

The ANS-3.11 Working Group was reconstituted in August 2012 to revise ANSI/ANS-3.11-2005 (R2010). The revision is needed to account for new reference standards, advances in ex situ and in situ instrumentation, advances in data management equipment and techniques, advances in meteorological program management, improvements in integration with facility programs (e.g., configuration management), cyber security, software quality assurance, and other programmatic considerations. The appendices provide supplemental information needed for the design and implementation of a meteorological monitoring program.

This standard does not incorporate the concepts of generating risk-informed insights, performance-based requirements, or a graded approach to quality assurance. The user is advised that one or more of these techniques could enhance the application of this standard.

This standard might reference documents and other standards that have been superseded or withdrawn at the time the standard is applied. A statement has been included in the references section that provides guidance on the use of references.

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Determining Meteorological Information at Nuclear Facilities

1 Scope

This consensus standard provides criteria for gathering, assembling, processing, storing, and disseminating meteorological information at commercial nuclear electric generating stations, U.S. Department of Energy / National Nuclear Security Administration nuclear facilities, and other national or international nuclear facilities. While well-established monitoring and analysis methods are adequately addressed, this revision provides information on newer systems, both hardware and software, and more modern methods to keep up with the state of the science.

Meteorological data collected, processed, stored, and disseminated through implementation of this standard are utilized to support the full life cycle (i.e., siting, construction, operation, and decommissioning) of nuclear facilities. The meteorological data are employed in a large number of applications associated with determining environmental impacts, enabling consequence assessments in routine release and design-basis accident evaluations, supporting emergency preparedness and response programs, and other important applications, such as evaluating beyond design-basis events.

2 Acronyms and definitions

2.1 Acronyms

ABL:	atmospheric boundary layer
QA:	quality assurance
DQOs:	data quality objectives
FAA:	Federal Aviation Administration
HVAC:	heating, ventilating, and air conditioning
lidar:	<u>l</u> ight <u>d</u> etection and <u>r</u> anging
MADIS:	Meteorological Assimilation Data Ingest System
NIST:	National Institute of Standards and Technology
NOAA:	National Oceanic and Atmospheric Administration
NEXRAD:	next-generation weather radar
NWS:	National Weather Service
radar:	<u>r</u> adio <u>d</u> etection and <u>r</u> anging
RASS:	radio acoustic sounding system
SA:	system accuracy
sodar:	<u>s</u> ound <u>d</u> etection and <u>r</u> anging
SRDT:	solar radiation/delta-T
TIBL:	thermal internal boundary layer
TKE:	turbulence kinetic energy

2.2 Shall, should, and may

The word “shall” is used to denote a requirement; the word “should” is used to denote a recommendation; and the word “may” is used to denote permission, neither a requirement nor a recommendation.

2.3 Definitions

air temperature: The temperature indicated by a thermometer exposed to the air in a place sheltered from direct solar radiation [1].¹⁾

atmospheric/barometric pressure: The pressure exerted by the atmosphere as a consequence of gravitational attraction exerted upon the “column” of air lying directly above the point in question [1].

atmospheric turbulence: Fluctuations occurring in all three velocity components and unpredictable in detail; however, statistically distinct properties of the turbulence can be identified and profitably analyzed. Turbulence exhibits a broad range of spatial and temporal scales resulting in efficient mixing of fluid properties [1].

calm: Any wind speed below the starting threshold of the wind speed or direction sensor; or any wind speed below that which is appropriate for input into plume models, whichever is greater. In the U.S., calm is typically defined as any speed less than 1 mph.

damped natural wavelength: A characteristic of a wind vane empirically related to the delay distance and the damping ratio [2].

damping: The more or less steady diminishing in time or space (or both) of the amplitude of any physical quantity.

damping ratio: Ratio of the actual damping, related to the inertial-driven overshoot of wind vanes to direction changes, to the critical damping, the fastest response where no overshoot occurs.

delay distance: The distance that air flowing past a wind vane moves while the vane is responding to 50% of the step change in the wind direction [2].

dew point temperature: The temperature to which a given air parcel must be cooled at constant pressure and constant water vapor content in order for saturation to occur [1].

gravity wave: A wave disturbance in which buoyancy acts as the restoring force on parcels displaced from hydrostatic equilibrium [1].

gust: According to U.S. weather observing practice, gusts are reported when the peak wind speed reaches at least 16 knots and the variation in wind speed between the peaks and lulls is at least 9 knots. The duration of a gust is usually less than 20 s [1].

horizontal wind direction: The direction from which the wind is blowing relative to the horizon. Values are reported in degrees azimuth measured clockwise from true north and ranging from 0 to <360 degrees azimuth (i.e., north is 0 degrees azimuth; east is 90 degrees azimuth; south is 180 degrees azimuth; west is 270 degrees azimuth).

¹⁾Numbers in brackets refer to corresponding numbers in Section 9, “References.”

horizontal wind speed: The ratio of the distance covered by the movement of air to the time taken to cover it relative to the horizon [1].

instrument system: All components from sensor to and including data recording and display (Herein referred to as “system.”).

long-wave radiation: A term used loosely to distinguish radiation at wavelengths longer than approximately 4 μm , usually of terrestrial origin, from those at shorter wavelengths (shortwave radiation), usually of solar origin [1].

mesoscale: The scale of atmospheric phenomena having overall horizontal dimensions from a few kilometers to several hundred kilometers with time scales from approximately 1 hour to 12 hours and vertical extents from tens of meters to the depth of the troposphere [3].

mixing height: The height above ground to which pollutants are mixed by turbulence caused by convective currents, vertical shear in the horizontal wind, or mechanical mixing.

net radiation: The downward radiation (i.e., direct and diffuse solar radiation) minus the upward radiation reflected and upwelling long-wave radiation emitted from a surface, also known as terrestrial radiation.

precipitation: The amount, usually expressed in millimeters or inches of liquid water depth, of the water substance that has fallen at a given point over a specified period of time [1].

sensor accuracy: The accuracy of the sensor used to make a meteorological measurement. Sensor accuracy can be based on manufacturer specifications, test results, or direct comparison with a standard (i.e., calibration).

sigma phi: The standard deviation of the vertical wind direction.

sigma theta: The standard deviation of the horizontal wind direction.

software quality assurance: All the planned and systematic activities implemented within a quality system that can be demonstrated to provide confidence that a software product or service will fulfill requirements for quality.

soil temperature: The temperature that is measured at a given soil depth, typically at 2, 4, 8, and sometimes 20 and 40 in. [1].

solar radiation: The total electromagnetic radiation emitted by the sun [1].

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

starting threshold (wind speed): The minimum wind speed above which the measuring instrument is performing within its minimum specification.

survival speed: The maximum wind speed at which the sensor can operate properly.

system accuracy: The extent to which results of a calculation or the readings of an instrument approach the true values of the calculated or measured quantities. System accuracy encompasses all components of

the system (i.e., sensor, data processing equipment, computer, calibrations, data displays, etc.). System accuracy is compared with applicable requirements to evaluate the adequacy of the monitoring program.

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

traceability: The documented ability to trace the history, application, or location of an entity. In a calibration sense, traceability relates measuring equipment to national or international consensus standards, primary standards, basic physical constants or properties, or reference materials. In a data collection sense, it relates calculations and data generated throughout the process back to the requirements for quality for the project [4].

true north: The direction from any point on the earth's surface toward the geographic North Pole. [1]

vertical temperature difference: Also known as delta-T, a simple representation of the mean lapse rate within a layer of the atmosphere, obtained by calculating the difference between observed temperatures at the bottom and top of the layer [5].

vertical wind direction: The wind elevation angle relative to the horizon. Values are reported in degrees elevation and are positive when wind is from below (updraft) and negative when from above (downdraft).

vertical wind speed: The ratio of the distance covered by the movement of air to the time taken to cover it perpendicular to the horizon. Values are positive when wind is from below (i.e., updraft) and negative when from above (i.e., downdraft).

wet-bulb temperature: The temperature an air parcel would have if cooled adiabatically to saturation at constant pressure by evaporation of water into it, with all latent heat being supplied by the parcel [1].

3 Meteorological monitoring system

Deployed meteorological monitoring systems shall meet site-specific and facility-specific requirements, while adhering to standard measurement heights, if possible. A basic meteorological monitoring program shall consist of measurements of horizontal wind speed; horizontal wind direction; air temperature, including the difference between air temperatures at two vertical levels on a tower; liquid precipitation; and any combination of additional measurements necessary to determine atmospheric stability (see Sec. 3.2). Supplemental meteorological measurements, involving more sophisticated monitoring approaches or monitoring at more than one location, shall be deployed where appropriate, to adequately meet site and facility data requirements. Meteorological measurements shall meet the criteria for accuracy and resolution defined in Table 1.

3.1 Basic meteorological measurements

3.1.1 Horizontal wind speed

Horizontal wind speed shall be measured with a sensor suitable for continuous, accurate operation. Horizontal wind speed sensors shall have a starting threshold of no higher than 0.5 ms^{-1} (1.1 mph). The sensor shall operate over a range of horizontal wind speeds up to at least 22 ms^{-1} (50 mph) unless expected local conditions require a higher range. The survival speed shall be approximately twice the normal operating range.

Table 1 – Minimum system accuracy and resolution requirements

This table provides values for a monitoring system using typical tower-mounted sensors and digital data processing systems.

Measurement ¹⁾	Unit ²⁾	Accuracy ($\pm$) ³⁾	Resolution ⁴⁾
Wind speed	meters per second	0.2 or 5% of observed wind speed	0.1
Standard deviation of wind speed			
Sigma-v (horizontal)	meters per second	n/a ⁵⁾	0.01
Sigma-w (vertical)	meters per second	n/a	0.01
Wind direction			
Horizontal	degrees azimuth	5	1.0
Vertical	degrees elevation	5	0.1
Standard deviation of horizontal wind direction fluctuations			
Sigma theta (or sigma-a)	degrees azimuth	n/a	0.1
Standard deviation of vertical wind direction fluctuations			
Sigma phi (or sigma-e)	degrees elevation	n/a	0.1
Air temperature	degrees Celsius	0.5	0.1
Vertical air temperature difference (delta-T)	degrees Celsius	0.1	0.01
Dew point temperature	degrees Celsius	1.5	0.1
Wet-bulb temperature	degrees Celsius	0.5	0.1
Relative humidity	percent	4	0.1
Barometric pressure	millibars or hectopascals	3	0.1
Precipitation	millimeters	10% of volume ⁶⁾	0.25
Solar radiation	watts per	10	1
Net radiation	square meter	5% of observed	1
Soil temperature	degrees Celsius	1	0.5
Soil moisture	percent	10% of actual	1
Time	minutes	5	1

¹⁾For measurements that are not listed, accuracy should be based on the manufacturer's guidance.

²⁾Other measurement units (e.g., miles per hour, degrees Fahrenheit, inches, hours) may be used to be consistent with monitoring program DQOs.

³⁾These are both system accuracy and sensor accuracy values. The system accuracy encompasses all components impacting system accuracy (e.g., sensors, data processing equipment, computer, calibrations, etc.). The sensor accuracy applies to the manufacturer's instrument specification. If calculations described in 7.1 indicate that the system accuracy is not adequate, a sensor with accuracy better than that listed above may be required.

⁴⁾Resolutions are based on the recommended units.

⁵⁾n/a = not applicable

⁶⁾Accuracy is for volume equivalent to 2.54-mm (0.01-in.) precipitation and rate <50 mm/h (2 in./h).

The standard vertical location or height for horizontal wind speed measurements shall be at 10 m (33 ft.) above ground level. Additional measurements should be made at the level representative of the most probable atmospheric release height applicable to activities involving radioactive and toxic chemical substances, considering the input data requirements of dispersion models used by the facility analysts and emergency responders. In some cases, horizontal wind speed measurements may be taken at other levels to meet specific requirements of the meteorological monitoring program. Additional information on horizontal wind speed measurements can be found in [6], [7], [8], [9], [10], and [11].

3.1.2 Horizontal wind direction

Horizontal wind direction shall be measured with a sensor suitable for continuous, accurate operation. Horizontal wind vane sensors used for sigma theta (σ_θ) or sigma phi (σ_ϕ) applications shall have a damping ratio between 0.4 and 0.7 inclusive, at a 10-degree azimuth offset, and the damped natural wavelength shall be <10 m (<33 ft.). Horizontal wind direction sensors shall have a starting threshold of <0.5 ms⁻¹ (<1.1 mph) and shall operate over the expected range of horizontal wind speed conditions, or at least 22 ms⁻¹ (50 mph). The survival speed shall be approximately twice the normal operating range.

The standard vertical height for horizontal wind direction measurements shall be 10 m (33 ft.) above ground level. The criteria for determining the appropriate monitoring heights for horizontal wind direction are the same as those used for horizontal wind speed (see Sec. 3.1.1). Horizontal wind direction sensors shall be aligned such that the data collected will be referenced to true north. Additional information on horizontal wind direction measurements can be found in [6], [7], [8], [9], [10], and [11].

3.1.3 Air temperature

Air temperature shall be measured with a sensor suitable for continuous, accurate operation over the range of expected temperature extremes based on regional climatology. The monitoring level for air temperature shall be at a height applicable to program requirements or at 2 m (6.6 ft.). The monitoring levels for delta temperature shall be spaced such that the profile is representative of, and characterizes the magnitude of, atmospheric turbulence at any potential release height(s) from the affected facility. Typical pairing of sensor heights is 60 m (198 ft.) and 10 m (33 ft.) or 10 m (33 ft.) and 2 m (6.6 ft.) above ground level, depending on the turbulence determination methodology.

Temperature sensors shall be mounted in protective shields to minimize the adverse influences of thermal radiation and precipitation. Shields shall provide at least natural ventilation of the sensor. Mechanically aspirated shields with internal airflow rates ranging from 3 ms⁻¹ (6.7 mph) to 10 ms⁻¹ (22.4 mph) shall be used when making delta temperature measurements for atmospheric stability determination purposes. The shield inlet should be a distance at least 1.5 times the tower horizontal width away from the nearest point on the tower. The shield inlet shall be pointed either downward or toward the north in the Northern Hemisphere, or either downward or toward the south in the Southern Hemisphere. Additional information on air temperature measurements can be found in [12].

3.1.4 Precipitation

The measurement of liquid precipitation shall be determined by direct measurements, taken with gauges or instruments. Gauges may be equipped, where necessary, with heater devices to melt frozen precipitation or with an antifreeze (i.e., ethylene glycol) solution, using a system appropriate for the location, and operated to minimize underestimation due to evaporation caused by the heater device. Use of a wind deflector shield (e.g., Alter-type shield) should be considered, as it can substantially improve gauge collection efficiency. Additional information on rain gauges can be found in [10] and [11].

3.2 Meteorological monitoring for atmospheric turbulence

The characterization of turbulence in the atmospheric boundary layer (ABL) is important for atmospheric dispersion modeling. The turbulence kinetic energy (TKE) can be described in a fundamental budget equation that shows the relative effects of local production, storage, advection, redistribution, and dissipation of turbulence in the ABL due to the presence of mechanical (i.e., shear), buoyancy, and pressure forces. For an overview of TKE and its application to the measurement of atmospheric turbulence, including a discussion of the Monin-Obukhov similarity theory commonly applied in contemporary atmospheric dispersion models, consult [13].

3.2.1 Direct measurement of turbulence using three-dimensional ultrasonic anemometers

Atmospheric turbulence can be measured using a three-dimensional ultrasonic anemometer (i.e., “3-D sonic”). Facilities should use 3-D sonics to collect the atmospheric turbulence data needed to determine the quantities essential to describing TKE in the ABL [i.e., friction velocity (u^*), convective velocity scale (w^*), and Obukhov length (L)]. For a complete discussion of these quantities, consult [13]. An independent method to measure or infer relevant turbulence quantities during relatively limited periods when a 3-D sonic or other instrumentation may not perform well (e.g., icing for 3-D sonics) shall be employed. A qualified meteorologist shall develop and document the approach to measure atmospheric turbulence at a nuclear facility [14]. This documentation should describe the sampling frequency, data statistics (i.e., means, covariances, fluxes, etc.), and the quality assurance (QA) process for raw and mean data values. This documentation should include appropriate peer-reviewed references and guidance documents.

3.2.2 Turbulence (stability) typing methods

Recognizing that not all facilities need to employ 3-D sonics, and that sites employing 3-D sonics may not utilize atmospheric dispersion models that apply similarity theory for explicit determination of TKE, stability-based methods for characterizing atmospheric turbulence are identified in the following sections. Generally, these typing methods were developed when turbulence-grade instrumentation was not readily available or feasible for meteorological monitoring applications. The most practical and widely used of the stability methods was developed by Pasquill and describes six classes (later expanded to seven by the U.S. Nuclear Regulatory Commission) discrete classes of atmospheric turbulence intensity in both the horizontal and vertical. Several appropriate schemes for determining Pasquill stability are available. These schemes rely on direct measurements of turbulence intensity or infer turbulence intensity through practical parameterizations of the effects of mechanical and buoyant forces on turbulence in the ABL. References on the proper application of these methods have been provided [13].

3.2.2.1 Delta temperature and the combination of solar radiation and delta temperature

The measurement of lapse rate in the ABL [i.e., air temperature difference (delta temperature) between two observation heights on a tower] has been used to enable Pasquill stability typing for many decades. However, delta temperature measurements alone are not recommended as a general scheme for Pasquill stability because there are limitations during the convective conditions that are often present on sunny days [13] and [15].

Measured solar radiation and delta temperature data, in combination with wind speed, provide a more complete characterization of the physical forces affecting turbulence intensity in the ABL. This method of determining Pasquill stability, commonly known as the solar radiation/delta-T (SRDT) method, is similar in concept to Turner’s method [16] and is based on values of solar radiation and wind speed during the day