FINAL

ONONDAGA LAKE PRE-DESIGN INVESTIGATION: METEOROLOGICAL MONITORING PROGRAM MANUAL

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SECTION 1

INTRODUCTION

This Standard Operating Procedures and Quality Assurance (SOP/QA) Project Procedures Manual has been prepared as a guide for the operation of the two 10-meter tower meteorological data collection programs conducted by Parsons on behalf of Honeywell International, Inc. in support of Honeywell's Onondaga Lake Remediation Program. Two meteorological monitoring sites have been established to support this program – one in the vicinity of the southwestern Lake shore to provide data representative of the Sediment Management Units (SMUs) and a second site a short distance inland from the lakeshore in the middle of the settling basin area to provide data representative of the Sediment Containment Area (SCA) where sediment disposal activities will be conducted. Collected data will be used in support of overall remediation program activities, including a comprehensive dispersion modeling air quality impact assessment using USEPA's AERMOD dispersion model.

This manual contains specific background information on the program objectives, design and equipment used; standard procedures for the routine operation and maintenance, and calibration of the meteorological instrumentation; procedures for field quality assurance calibrations and audits on the measurement systems; and procedures for the reduction, processing, validation, and reporting of collected data.

This SOP/QA Project Procedures Manual is a program-specific manual which incorporates the guidance set forth in:

- Ambient Monitoring Guidelines for Prevention of Significant Deterioration (PSD), EPA 450/4-80-012. November 1980 (As Revised - EPA-450/4-87-007, 1987).
- Quality Assurance Handbook for Air Pollution Measurement Systems, Volume I: A Field Guide to Environmental Quality Asurance, EPA-600/R-94/038a. April 1994.
- Quality Assurance Handbook for Air Pollution Measurement Systems, Volume IV: Meteorological Measurements Version 1 (draft), EPA-454/D-06-001. October 2006.
- Meteorological Monitoring Guidance for Regulatory Modeling Applications, EPA-454/R-99-005, February 2000.
- All relevant New York State Department of Environmental Conservation (NYSDEC) guidelines for meteorological monitoring, including DAR guides DAR-2 (DEC oversight of Private Air Monitoring Networks) and DAR-10 (NYSDEC Guidelines on Dispersion Modeling Procedures for Air Quality Impact Analysis).

The operating procedures contained herein place significant emphasis on quality assurance procedures which extend to all aspects of the data collection activities. These procedures, when properly followed, comprise the basis for an effective quality assurance program. Instructions for the documentation forms used in routine program operations, plus completed sample forms, are provided.

This manual, plus the vendor operating instruction and maintenance manuals for each piece of equipment used on the program, provide a full complement of reference materials for use in operating the program. Adherence to all operating and quality assurance guidelines is requisite to establishing a complete, accurate, and valid data base in support of Honeywell's Onondaga Lake Remediation Program meteorological data collection objectives.

SECTION 2

MONITORING PROGRAM DESCRIPTION

2.1 MONITORING PROGRAM OBJECTIVES

One of the elements of the Onondaga Lake Remediation Program will be the estimation - via dispersion modeling - of the magnitude of ambient air contaminant and odor concentrations for certain Chemicals of Interest (COI's) emitted by the various remediation activities to ensure that they are below applicable ambient air quality standards and guideline values. In addition, ambient air monitoring may be conducted before and during remediation activities to measure actual levels of various compounds in the ambient air and analyses will be conducted to correlate these levels with specific emission sources and concurrent meteorological conditions.

The magnitudes and locations of maximum project-related air impacts estimated in the dispersion modeling will be a function of the atmospheric conditions governing the transport and diffusion of the emitted compounds. In order to develop the most realistic estimations of ambient concentrations of remediation related emissions, it is necessary to have available for input to the model meteorological data that is most representative of the specific areas under study. This data is being obtained by establishing a site-specific meteorological monitoring program in the vicinity of the emission sources and to collect data on the specific parameters needed as input for the dispersion model proposed for the actual analysis.

The need for site-specific data is important considering several factors:

- First, the relative distances between the emission sources and potential receptor areas (i.e., residential areas, sensitive receptors such as schools and public buildings, and other "ambient air" areas generally accessible to the public) are typically quite small; generally only a few hundred meters or less. The use of non-representative data in the model, especially regarding wind direction, could result in misleading estimations of the areas in which impacts may occur.
- Secondly, the study area is characterized by a major land-water interface, and the different surface characteristics and temperatures will tend to create some highly localized wind flow and stability patterns that are not represented by data from other more distant sources. A preliminary comparison of data collected at other locations, including a mid-lake station versus Syracuse Airport, has confirmed that major differences in flow patterns exist over short distances.
- Third, the model proposed for use in the ensuing dispersion modeling analysis (i.e., USEPA's AERMOD Model) requires and/or accepts as input data values for several atmospheric parameters that are not routinely measured at most monitoring sites, but which will be utilized in this study. These additional parameters, including vertical temperature profile data and vertical wind component data, are included in the site-specific meteorological monitoring program.

- Fourth, in order to ensure that the most precise data is used in the analysis, site specific data will be collected using sensory instrumentation and data acquisition hardware and software that fully meets the performance and operating specifications in USEPA's guidelines for the most sophisticated air quality related modeling applications. Existing monitoring systems in the area do not all meet these guideline specifications.

In order to establish a site-specific meteorological data base comprised of the parameters specified for input to the AERMOD model, the overall investigation includes the installation and operation of two 10-meter meteorological towers near the two major sources of concern; namely the SCA and the Sediment Management Units (primarily SMU's 1,2,6, and 7).

This has been accomplished by installation of one of the 10-meter towers a short distance inland from the western shore of the Lake in an open area atop existing Settling Basin 13. Data collection at this location began on December 1, 2005. Settling Basin 13 (hereinafter referred to as Wastebed 13) will serve as the SCA where sediment dredged from the Lake will be deposited for treatment and storage.

The second tower is situated near the southwest shoreline off of Willis Avenue and data collection at this location began one year after the first tower on December 1, 2006. The Lakeshore/Willis Avenue tower is directly across Route I690 from the proposed Onondaga Lake staging area that is expected to support support the lake dredging activities.

Preliminary estimates of air and odor emission rates from remediation activities indicate that emissions from the SCA may be the highest of the remediation sources. Emissions may also occur as a result of the majority of dredging activities near the southwestern portion of the Lake itself in SMU's 1, 2, 6, and 7. Additional dredging will also occur in SMU's 3, 4, and 5, which encompass the balance of the Lake shoreline, although potential air emissions from these additional dredge areas are expected to be less.

The specific design and operational components of the meteorological monitoring program are outlined below and detailed in the following sections of this Project Procedures Manual.

2.2 MONITORING PROGRAM DESIGN CRITERIA

To develop a program that satisfies the above-noted monitoring program objectives for providing site-specific data suitable for the anticipated dispersion modeling analyses, key design specifications for this meteorological data collection system are:

1. The monitoring program must provide representative and accurate measurements of the parameters required for model input. At a minimum, these include:
   a. wind speed and direction measurements at a height representative of emission transport conditions;
   b. measurements of atmospheric turbulence for use in determining stability parameters at the EPA specified height of 10-meters (33-ft);

c. temperature at near-surface (2-meters or 6 ft) and 10-meter (33-ft) heights.

d. Surface based radiation and barometric pressure readings

2. Instrumentation must be situated in adherence to current EPA exposure and siting criteria.
3. The program must be designed and operated to meet current data quality assurance and validation guidelines and requirements.
4. The program will have to provide a minimum of 1-year of on-site data, and likely longer, with a 90 percent minimum annual data recovery rate for each parameter.
5. The program will achieve a 90 percent combined minimum annual data recovery rate for transport scalar wind speed and direction, and stability.
6. All data will be collected and reported in accordance with USEPA and NYSDEC monitoring guidelines
7. The program must be acceptable to NYSDEC.

The above program data collection and design objectives have been met with the installation of two 10 meter-tall instrumented towers in openly exposed areas on Honeywell property in the SCA and close to the SMU's in a parcel of land accessed from Willis Avenue, and through installation of appropriate measurement instrumentation, which when operated and maintained in accordance with the procedures described herein, will provide the requisite data.

Each site is further described below.

2.3 MONITORING SITE DESCRIPTIONS

2.3.1 Wastebed 13 Tower

The locations of the Honeywell Onondaga Lake 10-meter tower meteorological monitoring sites are shown in an aerial view in **Figure 2-1**. These locations are also presented superimposed on a topographic map in **Figure 2-2**. Each site is further described below.

The Wastebed 13 site is located in the eastern portion of the Town of Camillus, and is approximately 2 to 2.5 miles inland from the northwest-to-southeast oriented western shoreline of Onondaga Lake. The site is situated atop the old industrial wastebeds in this area, and is specifically located just off an access road at the junctures of Wastebeds 12, 13, and 14.

The site is located at:

Latitude: 43.071 N

Longitude: 76.255 W

UTM Northing: 4769504.35 N

UTM Easting: 397820.66 E

Wastebed 13 has been selected as the SCA for the Onondaga Lake Remediation Project, where material dredged from the Lake during remediation activities will be deposited, treated, and permanently stored. It is anticipated that the SCA and related materials handling activities could be a primary source of project-related air emissions. Siting the meteorological tower essentially at the SCA is therefore intended to directly provide the project specific "source-oriented" meteorological data that will be used in subsequent dispersion modeling air quality impact analyses.

These wastebeds cover an area of several hundred acres. The tops of these beds are relatively flat and are at an elevation of approximately 475 ft above mean sea level (MSL) and 50 ft above the local surrounding terrain. Vegetative cover generally consists of grasses and small brush, with pockets of small stands of trees approximately 20 to 30 ft in height, and a few stands of taller trees.

Figures 2-3 and 2-4 are a series of photographs showing the meteorological tower site and surrounding environs. **Figure 2-3** is a photograph of the tower site looking from the south, while **Figure 2-4** contains a series of photographs basically showing a panorama of the area looking from the tower base toward each of four cardinal wind directions (north, east, south, and west.). The area around the tower has been generally cleared of brush and trees that exceeded the 10-to-1 distance to height ratio for nearby obstructions. As a result, the site provides an open and unobstructed exposure to windflows from all directions over the SCA area, and has an underlying ground surface comparable to that generally characteristic of the entire SCA area.

This site is considered to be the best location with respect to SCA activities which satisfies all siting and exposure criteria for meteorological monitoring purposes; and which will provide a representative site-specific meteorological data base for use in the dispersion modeling impact assessment and other data analysis activities.

2.3.2 Lakeshore/Willis Ave Tower

The Lakeshore/Willis Ave site is located in the eastern portion of the Town of Solvay, and is approximately 300 yards inland from the southwestern shoreline of Onondaga Lake. The site is situated in an open area directly across I690 from the Lake staging area that will support the Lake dredging activities.

The site is located at:

Latitude: 43.068 N

Longitude: 76.201 W

UTM Northing: 4769013.38 N

UTM Easting: 402284.18 E

The Lakeshore Willis Ave site was selected due to its close proximity to where a majority of the material will be dredged from the Lake during remediation activities. It is anticipated that these dredging activities and related materials handling activities could be a source of project-related air emissions. Siting the meteorological tower essentially at the site where dredging will occur is therefore intended to directly provide the project specific "source-oriented" meteorological data that will be used in subsequent dispersion modeling air quality impact analyses.

The cleared area occupied by the tower is relatively flat with an elevation of approximately 387 ft above MSL. Nearby vegetative cover generally consists of small trees and brush. Route I690 separates the tower site from the lake to the east and some industry (railroad, power plant, wastewater treatment plant) are located to the west.

Figures 2-5 and 2-6 are a series of photographs showing the meteorological tower site and surrounding environs. **Figure 2-5** is a photograph of the tower site looking from the south, while **Figure 2-6 contains a series of** photographs basically showing a panorama of the area looking from the tower base toward each of four cardinal wind directions (north, east, south, and west.). The area around the tower has been generally cleared of brush and trees that exceeded the 10-to-1 distance to height ratio for nearby obstructions. As a result, the site provides an open and unobstructed exposure to windflows from all directions over the area.

This site is considered to be the best location with respect to dredging activities which satisfies all siting and exposure criteria for meteorological monitoring purposes, and which will provide a representative site-specific meteorological data base for use in the dispersion modeling impact assessment and other data analysis activities.

2.4 PARAMETERS MEASURED

In order to provide the requisite data for model input, the towers are instrumented at two (2) levels (2- and 10-meters), plus with ground-based equipment, to collect the following measurements:

Ground-Based:

-Precipitation (WB-13 only)

2-meter level:

-Temperature

-Relative Humidity

-Dew Point Temperature (computed)

-Net Radiation (WB-13 only)

-Solar Radiation (LS/WA only)

-Barometric Pressure

10-meter level:

-Horizontal Wind Speed

-Horizontal Wind Direction (plus Sigma-Theta computed)

-Vertical Wind Speed (plus Sigma-W and Sigma Phi computed)

-Temperature (plus 2-meter to 10-meter Delta-Temperature computed)

The parameters measured at each site, along with the corresponding units of measurement, are also summarized in **Table 2.1**.

Note: Sigma-Theta is the standard deviation of the horizontal wind direction fluctuations about the mean. Sigma-W is the standard deviation of the vertical wind speed fluctuations about the mean. Sigma Phi is the standard deviation of the vertical wind direction, calculated based on the horizontal wind speed and Sigma W.

Since the emission sources are essentially surface-based, meteorological measurements will be taken at "standard" heights established for acquiring data for dispersion model input. The USEPA standard exposure height for wind and turbulence measurements is 10-meters. "Surface" based measurements (i.e., temperature, humidity, and pressure) are typically measured at a height of 2-meters above ground, although this may be adjusted to 3-meters to account for winter season snow cover.

Precipitation is measured at actual ground level. The tower is instrumented at both the surface and 10-meter levels for temperature in order to obtain measurements of temperature differential with height in the lowest air layer.

Additional exposure guidance suggests that wind sensors be exposed at distances at least 10 times the height of any nearby obstructions, while temperature probes either be at least four structure heights away from any obstructions, or sufficiently above any structures to avoid direct radiational and/or wind flow interferences on these measurements.

Vertical wind speed component measurements are included at the 10-meter level because, according to USEPA's current modeling guidelines for AERMOD, measured turbulence parameters are generally preferable for direct input to the model for determining stability conditions rather than internally computed values of turbulence.

Delta-temperature and net radiation measurements are included at the Wastebed 13 tower 2-meter level to provide radiation-based stability indicators in accordance with the most recent USEPA guidelines for AERMOD. Net radiation is routinely used and delta temperature optionally used by AERMOD for determining stability conditions on an hour-by-hour basis.

A digital data acquisition system is employed to provide both vector and scalar quantities for wind speed and direction measurements, and to compute standard deviations for horizontal and orthogonal wind parameters (i.e., sigma-theta, sigma-V and sigma-W).

2.5 MONITORING SYSTEM AND EQUIPMENT OVERVIEW

2.5.1 Meteorological Tower

The towers are 10-meter (33-ft) tall heavy-duty aluminum fold-over towers. The structures are of triangular design (i.e., three-faced) tower with each face having a width of approximately 18 inches at the base of the tower and tapering down to a small diameter post at the top of the tower. The tilt over design of the tower allows for easy access to the sensory instrumentation during maintenance and calibration activities as needed. The tower can also be climbed or accessed via a boom lift as necessary for access to the sensory instrumentation during field calibration and performance audit activities that are required to be performed with the instruments in their actual monitoring position.

Instruments at the 10-meter level are mounted on fixed place cross-arms and/or mounting extensions, which place the sensors more than the recommended distance away from the tower to avoid interferences. The 2-meter temperature probe radiation shield/aspirator assembly is mounted on a 2-ft boom bracketed to one leg of the tower, and both the 2- and 10-meter temperature aspirators and radiation shields are mounted such that the aspirator openings face to the northwest; i.e., into the prevailing wind and away from direct sunlight to minimize the effect of solar radiation heating on the temperature sensors.

Because the meteorological towers are less than 200 ft above grade, they do not need to be painted international orange and white or outfitted with multiple levels of obstruction lights per FAA regulations.

2.5.2 Equipment Housing

The ground-based electronics and support equipment are housed in National Electrical Manufacturers Association (NEMA) environmentally protected and insulated enclosures mounted at the base of each tower. This enclosure provides a protected operating environment for the monitoring systems' signal conditioning electronics and the data logging device.

2.5.3 Meteorological Monitoring Instrumentation

The monitoring instrumentation consists of modular components manufactured by Climatronics Corporation, including the Climatronics F460 Wind Sensor System. A complete listing of the primary components on the towers is as follows:

Model 100075 F460 Wind Speed Sensor

Model 100076 F460 Wind Direction Sensor

Model 101994-G2 F460 Crossarm Assembly

Model 102236-G0 Vertical Wind Speed Sensor

Model 100093 Matched Dual Element Thermistor Temperature Probes

Model 102425 Relative Humidity Sensor

Model 100325-G0-H0-J0 Motor Aspirated Temperature Shields

Model 102341 NR Lite Net Radiometer (Net Radiation Sensor - WB-13 only)

Model 102725-10 Solar Radiation Sensor (Lakeshore/Willis Ave only)

Model 102270-G3 Barometric Pressure Sensor

Model 100097 Precipitation Sensor (Tipping Bucket Rain Gauge - WB-13 only)

Model 101760 IMP-860 Signal Conditioner/Data Logger

Detailed operating and performance specifications on the proposed Climatronics sensory components are provided in **Section 3.0 – "Equipment Descriptions and Specifications",** and on the vendor specification sheets contained in **Appendix A**.

The operating and performance characteristics of the proposed instrumentation meet or exceed USEPA guideline specifications for meteorological monitoring. All instrumentation is installed and calibrated in accordance with applicable USEPA and NYSDEC requirements. Prior to declaring the systems operational, complete field calibration checks of all monitoring instrumentation were performed.

2.5.4 Data Acquisition System

Data are digitally collected and preprocessed at each site via an IMP-860 data logger connected to a PC-based Digital Data Acquisition System at a remote location. The DAS system hardware and software components are fully configured and tailored to process the parameters measured and/or calculated as part of this program.

The IMP-860 data logger scans all input channels at 1-second intervals and records, processes, and stores data in accordance with USEPA requirements for data acquisition and handling. In addition, the DAS serves as an operator tool for routinely checking monitoring system performance. This system is capable of converting the measurement signals into the basic data values (5, 15, and 60 minute averages), calculating digitally derived values, displaying current and recent past data values on-site, and allowing for remote surveillance of the monitoring systems via a cellular phone-based dial-up communications system.

To facilitate the dial-up communications, the DAS includes telecommunications software for providing remote dial-up access to the system via a cell phone link and modem. Data are subsequently retrieved either by dialing up the system or manual transfer of data direct to a laptop PC or PDA.

The software features include system diagnostics, operator aids, and automatic restarts (i.e., the PC automatically boots-up) following any power disruptions.

Complete details on the operating specifications of the DAS systems are included in Section 3.0 and Appendix A.

2.5.6 Power System

There are no sources of commercial power available at the monitoring sites. As a result, the monitoring system components and operating specifications have initially been designed to draw a minimum of electrical power. Power is supplied via a system consisting of a series of marine batteries recharged by a solar panel array.

In order to minimize power draw, the system will initially be operated without running the electrical heaters on the wind sensors and precipitation gauge. This may result in some data loss during severe icing episodes during the winter months. The potential loss is deemed as an acceptable compromise in order to collect as much site-specific data as possible (primarily for the spring, summer, and fall remediation activity seasons) until such time as commercial power is brought to the SCA area when sediment dredging and transfer activities commence. At that time, the system may be converted to commercial power.

2.6 PROGRAM OPERATIONS ELEMENTS OVERVIEW

The remaining portions of this section briefly describe the major operations and maintenance procedures, quality assurance activities, and data processing, validation, and reporting procedures that apply to this program. Complete details describing these procedures are contained in subsequent sections of this manual.

2.6.1 Routine Field Operations and Maintenance

The routine field operations phase of the program is conducted by local field technicians from the Parsons Syracuse office under the direction of Parsons Boston office Air Group. Routine on-site checks are conducted at least one or two times per month by the local field technician. The site is also visited as soon as possible after any unusual weather phenomena or if remote data checks indicate suspect data values. Routine activities are supplemented by once-per-quarter visits by a Parsons senior air quality meteorologist from the Air Group, or through additional visits if needed to resolve specific non-routine maintenance issues.

The routine operations and maintenance activities are part of the overall quality assurance plan intended to minimize the potential for instrument downtime or collection of bad data. Upon visiting each site, monitoring program personnel follow a prescribed list of activities in checking the status of the equipment.

The supplemental quarterly site visits are primarily part of the scheduled preventive maintenance and field calibration activities conducted as part of the quality assurance plan.

Section 5.0 contains complete details of the “Routine Operations and Maintenance Procedures” for the Onondaga Lake meteorological monitoring program. This section includes specific step-by-step procedures for performing routine field checks and documenting results.

2.6.2 Quality Assurance Program

A complete quality assurance plan has been implemented and will be documented as part of the ongoing monitoring program operations. The basic purposes of the quality assurance plan are to:

1. Ensure that the monitoring instrumentation and associated electronic equipment are always operating within specification;
2. Ensure that the collected data are complete, valid, and defensible; and
3. Ensure that the monitoring systems are meeting stated objectives and requirements.

Section 7.0 contains specific procedures for activities comprising the Quality Assurance aspects of this meteorological monitoring program. It details specific step-by-step procedures for conducting both the routine quality procedures and also the field calibrations and performance audits summarized below.

2.6.2.1 Quality Assurance Procedures

The overall quality assurance plan represents the integration of quality assurance activities in all phases of program operations.

Routine equipment status forms and operating logs represent the first phase of the quality assurance plan. Entries on these forms provide continuous documentation, and ultimately the history of equipment operation, performance, and any maintenance performed. Specific entries are made that enable monitoring program personnel to diagnose and to track the operating status of the equipment as well as any malfunctions that may occur. The occurrence, nature, and actions taken with regard to any suspected or observed equipment malfunction, as well as results of all routine and non-routine calibrations, are also documented in the operating log.

Along with the routine documentation of all field activities, the quality assurance plan consists of subjecting the meteorological monitoring system to a series of checks as follows:

- At least twice weekly remote real-time surveillance.
- Monthly site checks and maintenance.
- Quarterly in-situ field calibration checks of sensor accuracy and performance.

An additional element of the overall quality assurance plan includes the documentation of certificates of calibration and/or National Institute of Standards and technology (NIST) traceability for all the monitoring instrumentation, as well as for all calibration and test equipment used on the program.

2.6.2.2 Quality Assurance Audits

An additional, independent element of the overall quality assurance plan consists of a series of scheduled semi-annual, independent field audits. The independent field audit comprises both a systems and performance audit portion. Field audits conducted in this manner allow the auditor to determine as completely as possible whether or not a sensory system is producing valid data, as well as to check if the formal quality assurance procedures are being followed.

The ultimate product of the independent field audit will be the documentation that proves the "in control" status of the monitoring system and that backs up the claim for validity of the collected data. This is accomplished by providing a comprehensive audit report that not only summarizes audit activities and results, but also details audit procedures and methodologies. Refer to Section 7.0 for details on the specific field calibration and audit methods that are used.

2.6.3 Data Processing, Validation, and Reporting

All data collected through operation of the meteorological monitoring program are reduced, processed, validated, and reported by Parsons in a manner consistent with the overall Onondaga Lake Program data reporting procedures and any relevant NYSDEC requirements. The bulk of the data reduction and processing, however, is accomplished on-site via the combination IMP-860 data logger and the remote PC-based data acquisition system.

The on-site systems reduce and process data by scanning each input channel at 1-second intervals, converting the signals to appropriate engineering units, computing digitally-derived parameters (i.e., vector wind speed and direction, and horizontal and vertical wind standard deviations), and computing and storing hourly-averaged values for each parameter.

The hourly-averaged values that are archived are the basis for all subsequent data processing. The data processing tasks relate to the quality assurance validation and finalization of the database, and the preparation of data reports. These functions ensure that reported meteorological data are both representative and defensible, and that data recovery rates are maximized.

The first phase of data processing/validation includes the assembly and initial review of all field and in-office materials including operating logs. Then a series of data cross-checks and consistency and screening checks are made to ensure that the data are accurate and representative of actual meteorological conditions.

Finalization of the database is completed after any missing data are accounted for and any necessary data adjustment or calibration factors are applied to the hourly data. The final validated database can then be used for all subsequent data reporting.

Collected data are routinely reported to Onondaga Lake Program personnel and other interested parties as follows:

A monthly report containing hard copy listings of all hourly data values. This includes a series of daily and monthly data summaries, wind frequency tabulations, graphical wind roses, and statistical diagnostics.

Monthly CD or email submittals of data in client- or project- specified formats.

Also, at the end of each month, the data are archived for subsequent processing into a format suitable for AERMOD model input.

Section 9.0 contains complete details of the routine Data Processing, Validation and Reporting Procedures for this monitoring program. It includes specific step-by-step procedures for performing routine data handling, processing, validation, analysis, and reporting components of this aspect of the program.

Table 2-1

Honeywell Onondaga Lake
Meteorological Monitoring Program Manual
List of Measured Parameters

Measurement Level / Parameter	Units of Measure
Ground Based Measurements	
Precipitation (WB-13 only)	inches
2-Meter Level Measurements	
Temperature	degrees Fahrenheit
Relative Humidity	percent
Dew Point Temperature (computed)	degrees Fahrenheit
Net Radiation (WB-13 only)	watts per square meter
Solar Radiation (LS/WA only)	watts per square meter
Barometric Pressure	inches of mercury
10-Meter Level Measurements	
Horizontal Wind Speed	miles per hour
Horizontal Wind Direction	degrees from true north
Sigma Theta (computed standard deviation of horizontal wind direction)	degrees
Vertical Wind Speed	miles per hour
Sigma W (computed standard deviation of vertical wind speed)	miles per hour
Sigma Phi (computed standard deviation of vertical wind direction)	degrees
Temperature	degrees Fahrenheit
Delta-Temperature (computed 10-m minus 2-m temperature)	degrees Fahrenheit

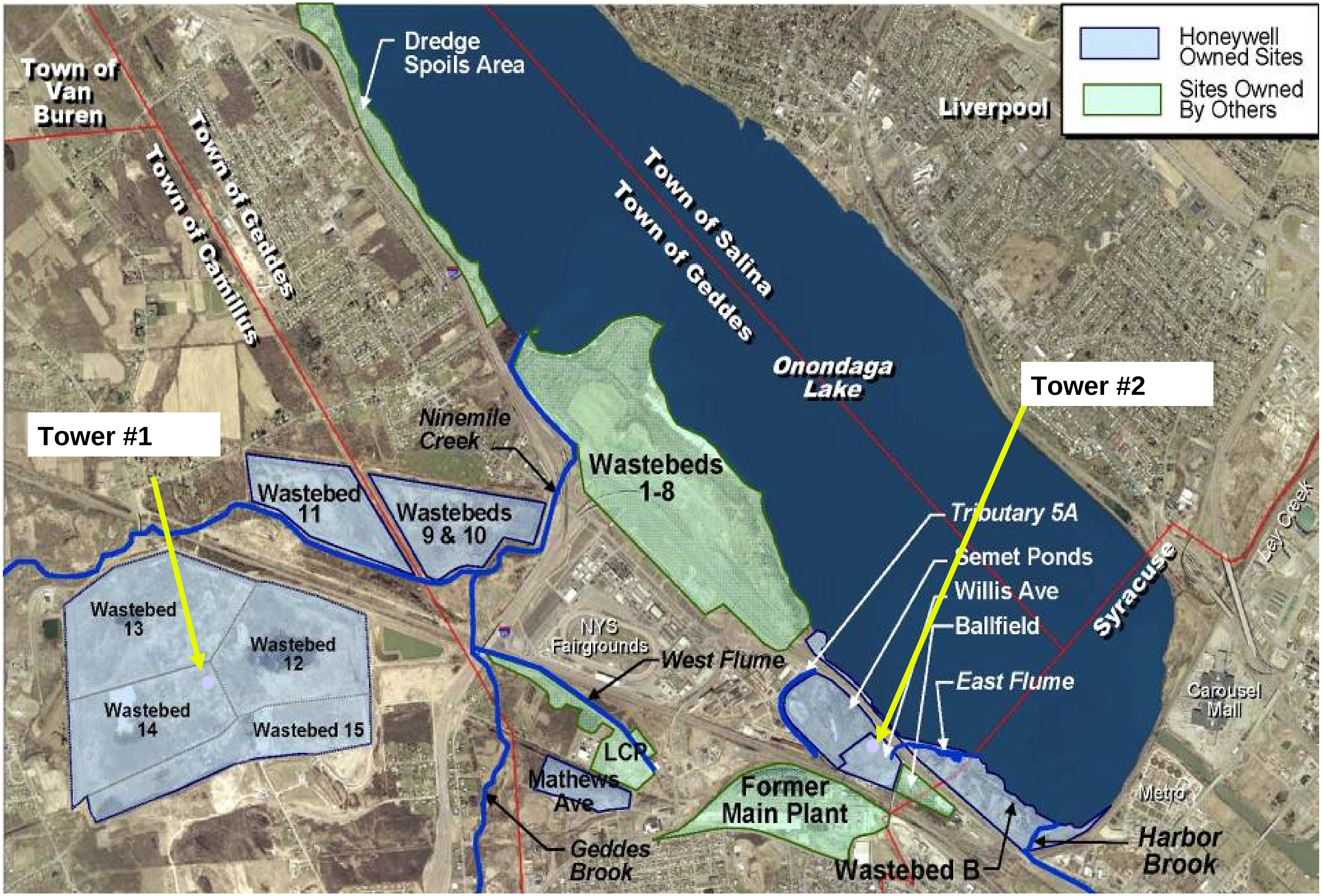


FIGURE 2.1

Honeywell

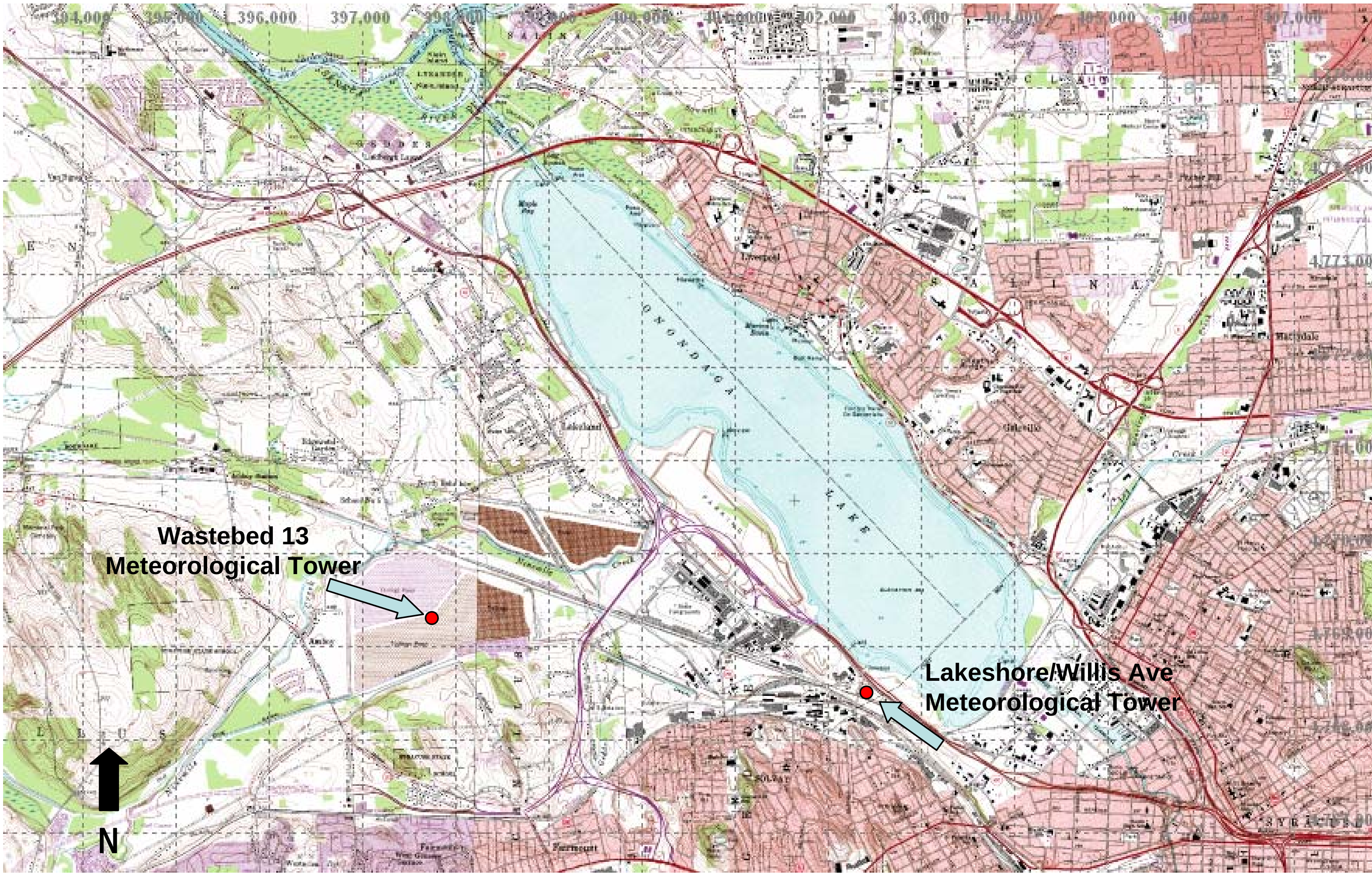
Onondaga Lake
Syracuse, New York

Meteorological Station Location Map

PARSONS

290 ELWOOD DAVIS ROAD, SUITE 312, LIVERPOOL, NY 13088 PHONE: (315) 451-9560

Figure 2-2
Location of Wastebed 13 Meteorological Monitoring Site and Surrounding Environs



Grid in meters (1 in = 1600m)

Figure 2-3
Wastebed 13 10-Meter Tall Meteorological Monitoring Tower

Figure 2-4
Photographs Taken from Base of WB-13 Met Tower
Looking Toward Each of Four Cardinal Wind Directions

Looking North

Looking East

Looking South

Looking West

Figure 2-5
Lakeshore/Willis Avenue 10-Meter Tall Meteorological Monitoring Tower

Figure 2-6
Photographs Taken from Base of LS/WA Met Tower
Looking Toward Each of Four Cardinal Wind Directions

Looking North

Looking East

Looking South

Looking West

SECTION 3

EQUIPMENT DESCRIPTIONS AND SPECIFICATIONS

3.1 METEOROLOGICAL MONITORING EQUIPMENT

Meteorological sensory and electronic signal processing instrumentation manufactured and supplied by **Climatronics Corporation, Inc.** are the key components of the meteorological monitoring systems. This equipment meets or exceeds the accuracy, response, and performance specifications established by regulatory agencies for air quality related applications.

In most cases, each of the two towers is equipped with identical instrumentation and associated data logging or telecommunications equipment. When this is not the case, it will be noted.

3.1.1 Meteorological Tower

The towers are **Climatronics Model C33HD** 10-meter (33-ft) tall heavy-duty aluminum fold-over towers. Each structure is a triangular design (i.e., three-faced) tower with each face having a width of approximately 18 inches at the base of the tower and tapering down to a small diameter post at the top of the tower. The tilt over design of the towers allows for easy access to the sensory instrumentation during maintenance and calibration activities. The towers will also be climbed as necessary and/or an aerial boom will be used for access to the sensory instrumentation during field calibration and performance audit activities that are required to be performed with the instruments in their actual monitoring position.

Instruments at the 2- and 10-meter levels are mounted on fixed place cross-arms and/or booms, which place the sensors more than the recommended distance away from the tower to avoid interferences. The crossarms for wind speed and direction measurements are mounted at the top of the tower and oriented along the north-south axis as recommended by the wind instrument manufacturer. The 2-meter temperature probe radiation shield/aspirator assemblies are mounted on booms bracketed to two legs of the tower such that the aspirator openings are facing to the north approximately 3 ft from the tower. The 10-meter level radiation shield/aspirator assemblies are also facing to the north to help minimize the effect of solar radiation heating on the temperature sensor. The radiation sensors are mounted on booms at the 3-meter level extending out to the south of the tower to avoid shadows cast by the tower or the power system solar panels.

Because the meteorological tower height will be less than 200 ft above grade, they will not need to be painted international orange and white or outfitted with multiple levels of obstruction lights per Federal Aviation Administration (FAA) regulations.

3.1.2 Equipment Housing

The ground-based electronic and support equipment is housed in insulated, environmentally controlled NEMA enclosures that are mounted at the base of each tower. By maintaining environmentally-controlled conditions, this enclosure permits a consistent operating environment for the monitoring systems' signal conditioning electronics and data logging devices, as well as for the telecommunications hardware.

3.1.3 Wind Speed and Direction

Wind speed measurements are made via **Climatronics F460 Model 100075-G0-H0** photo-chopper-type wind sensors with **Model 102104** Lexan three-cup rotating anemometer assemblies. In this type of sensor, the rotating sensor shaft turns a photo-cell chopper assembly. The frequency of the interrupted light pulses is output by the transmitter in the form of a variable-frequency square wave that is proportional to the wind speed. The frequency output (pulse count) is then passed on to the CR1000 where it is converted to a linear output suitable for continuous digital data logging and averaging. The raw result is a frequency value, which when scaled with a multiplier of 0.10514 and an offset of 0.3000 produces the wind speed measurement.

Wind direction measurements are made via **Climatronics F460 Model 100076-G0-H0** potentiometer-type wind direction sensors with **Model 101907** counter-balanced wind vane assemblies. In this type of sensor, the vane motion is coupled to a low-torque potentiometer by a high-precision shaft and bearing assembly. The potentiometer output (variable dc voltage) is proportional to the position of the wind vane and, hence, the wind direction. The electrical output is then passed on to the CR1000 where a half bridge electrical measurement technique is used to convert the sensor signal to a linear output suitable for continuous digital data logging and averaging. In this technique, a small excitation voltage is applied to the measurement channel, followed by a delay and then a measurement of the single ended sensor output voltage. The raw result is the ratio of the measured voltage to the excitation voltage, which when scaled with a multiplier of 396.0 and an offset of zero produces the wind direction measurement. Potential problems associated with "crossovers" that would otherwise occur when the vane rotates through 360° are eliminated via the sensor circuitry and data logger computations.

Manufacturer supplied technical specifications for the wind speed and direction measurement systems are listed below.

Wind Speed: **F460 Model 100075-G0-H0 WS Sensor** with **Model 102104 F460 Lexan** three-cup anemometer assembly:

Accuracy:	±0.15 mph (±0.07 m/s) for speeds from 0.3 mph to 15 mph (±1% of speed from 15 mph to 125 mph)
Range:	0 to 125 mph (0 to 56 m/s)
Distance Constant:	<1.5 m (4.9 ft) of air maximum
Threshold:	0.3 mph (0.13 m/s)

Anemometer Cup
Transfer Function: Freq (Hz) = (mph – 0.3) x 9.511

Wind Direction: F460 Model 100076-G0-H0 WD Sensor with **Model 101907 F460 Vane**:

Accuracy:	±2°
Range:	0-360° mechanical
Distance Constant:	1.1 m (3.7 ft) of air, maximum
Damping Ratio:	0.4 at 10° initial attack angle
Threshold:	0.5 mph (0.22 m/s)

3.1.4 Vertical Wind Speed

Vertical wind speed is measured at the 10-meter level via **a Climatronics Model 102236-G0 Gill Component Anemometer**. The sensor is mounted vertically atop the cross-arm and is fitted with a 4-blade polystyrene propeller. The propeller freely rotates in either direction depending on the direction of the vertical component (up or down) of the wind flow. The slender profile and aerodynamic shape of the sensor is intended to minimize turbulence introduced into the airstream. The propeller drives a miniature DC tachometer generator which provides an analog voltage output directly proportional to wind speed (an updraft results in clockwise rotation which produces a positive voltage, while a downdraft results in counter-clockwise rotation which produces a negative voltage). The sensor output is passed to the CR1000 where a differential voltage measurement technique is used to convert the signal to a linear output suitable for continuous digital data logging and averaging. In this technique, the voltage difference between the Hi and Low inputs of a differential channel are measured by the data logger. The raw result is a millivolt value (± 500 mV corresponding to ± 1800 RPM), which when scaled with a multiplier of 0.050325 and an offset of zero produces the vertical wind speed measurement.

Technical specifications for the vertical wind measurement system are as follows:

Accuracy:	±1.0 percent
Threshold:	0.5 mph (0.3 m/s)
Range:	-25 to +25 mph (±11.2 m/s)
Distance Constant:	2.1 m (6.9 ft) of air (63% recovery)
Propeller Transfer Function:	mph = 0.01398 x RPM m/s = 0.00625 x RPM

3.1.5 Temperature and Temperature Difference

The temperature probes are mounted at the 2- and 10-meter levels. Temperature is measured using a **Climatronics Model 100093 Dual Element Thermistor** temperature probe mounted in a **Model 100325-G0-H2-J0 Motor Aspirated Temperature Shield**.

The thermistor temperature sensor operates on the principle that the electrical resistance of a metallic oxide semiconductor varies inversely with temperature. The thermistor is encased in a protective stainless steel sheath. A low excitation voltage is applied to the thermistor through the system power supply. The resistance of the sensor is measured by a half bridge circuit via the CR1000 data logger, which converts the sensor signal to a linear output suitable for continuous digital data logging and averaging. The raw result is the ratio of the measured voltage to the excitation voltage, which when scaled with a multiplier of 264.837 and an offset of -60.406 produces the temperature measurement.

The motor-aspirated radiation shield for the temperature sensor is mounted with its intake facing northward. A rear-mounted blower motor draws ambient air across the probe at a rate of 10 ft/second. This aspirator unit employs a triple shield design to protect the sensor from both incoming short-wave solar radiation and outgoing long-wave terrestrial radiation.

Technical specifications for the temperature measurement system are:

Accuracy (sensor):	±0.27°F (±0.15°C) over full range
Accuracy (shield):	0.2°F (0.11°C) @ 1100 W/m^2
Range:	-22 to 122°F (-30 to 50 °C)
Linearity:	±0.29°F (±0.16°C)
Time Constant:	3.6 seconds
Aspiration Rate:	10 ft/sec at sensor location

3.1.6 Relative Humidity (RH)

The relative humidity sensors are mounted at the 2-meter level. Relative humidity is measured using a **Climatronics Model 102425 RH Probe,** which is also mounted in the **Model 100325-G0-H2-J0 Motor Aspirated Radiation Shield** along with the temperature probe. The RH probe is mounted in the shield’s motor housing downstream of the fan.

The RH Probe is a high accuracy capacitive-polymer-type humidity sensor. This RH probe offers superior linearity, stability, sensitivity, and resistance to corrosion, which makes this sensor the ideal choice for long-term field monitoring. The RH Probe is encased in a stainless steel sheath to protect the sensing element. The sensor signal is conditioned by the CR1000, which converts the signal to a linear output suitable for continuous digital data logging and averaging. The CR1000 measures the voltage at a single ended input with respect to ground. The raw result is a dc voltage, which when scaled with a multiplier of 0.1 and an offset of zero produces the relative humidity measurement.

The motor-aspirated radiation shield is typically mounted with its intake facing northward. A rear-mounted blower motor draws ambient air across the RH probe at a rate of 10 ft/second.

This aspirator unit employs a triple shield design to protect the sensor from both incoming short-wave solar radiation and outgoing long-wave terrestrial radiation.

Technical specifications for the RH probe are:

Accuracy:	±3% RH from 0 to 90 % RH @ 68 °F (20°C) ±5% RH from 90 to 100 % RH @ 68 °F (20°C)
Range:	0 to 100 % RH
Stability:	±2% RH over 2 years
Operating temperature:	+14 to 140 °F (-10 to 60 °C)

3.1.7 Barometric Pressure

The barometric pressure sensors are mounted in the NEMA enclosure mounted at the base of each tower. Barometric pressure is measured using a Climatronics Model 102270 Barometric Pressure Sensor (a Setra Model 276 Barometric Pressure Transducer).

The barometric pressure sensor is an accurate and stable transducer based on Setra's proven Setraceram^{TM} sensing element. The element is a glass fused ceramic variable-capacitance sensing capsule that has inherent thermal stability, low hysteresis and a fundamentally simple design, which makes it well suited for the environmental extremes typically found in long-term meteorological monitoring applications. The sensor works on the principle that the symmetrical ceramic capsule will deform proportionally to applied pressure. The sensor signal is conditioned by the CR1000, which converts the signal to a linear output suitable for continuous digital data logging and averaging. The CR1000 measures the voltage at a single ended input with respect to ground. The raw result is a dc voltage, which when scaled with a multiplier of 0.00181 and an offset of 23.439 produces the barometric pressure measurement.

Technical specifications for the barometric pressure sensor are:

Accuracy (RSS Method):	±0.25% Full Scale
Range:	800 to 1100 mb (23.62 to 32.48 in Hg)
Time Constant:	10 milliseconds to 90% final output
Stability:	± 0.25% FS over 6 months
Operating temperature:	0 to 175 °F (-18 to 79 °C)
Thermal Effects	
Compensated Range:	30 to 130 °F (0 to 55 °C)
Zero and Span Shifts:	1% Full Scale

3.1.8 Net Radiation

The net radiation sensor is mounted on a south facing boom at the 3-meter level of the Wastebed-13 tower. Net radiation is measured using a Climatronics Model 102341 Net Radiometer (a Kipp & Zonen Model NR Lite Net Radiometer).

The NR Lite is designed for the routine measurement of net radiation, which is the net differential or balance between incoming solar radiation (insolation) and outgoing terrestrial radiation under typical outdoor conditions. It is unique and easy to use, and well suited for the environmental extremes typically found in long-term meteorological monitoring applications. The radiation detector utilizes two Teflon™ coated, weather resistant black conical absorbers – one facing up and the other down. The overall sensor is based on a thermopile sensor design and works on the principle that the variable voltage produced is directly proportional to the net radiation present. The sensor output is passed to the CR1000 where a differential voltage measurement technique is used to convert the signal to a linear output suitable for continuous digital data logging and averaging. In this technique, the voltage difference between the Hi and Low inputs of a differential channel are measured by the data logger. The raw result is a millivolt value (± 25 mV corresponding to ± 2000 W/m^2), which when scaled with a multiplier of 74.627 and an offset of zero produces the net radiation measurement.

Technical specifications for the net radiometer are:

Sensitivity (nominal):	10 $\mu V/W/m^2$
Spectral Range:	0.2 to 100 µm
Measurement range:	-2000 to +2000 W/m^2
Response Time:	< 20 seconds to 63% final output
Stability:	<± 2.0 % per year
Directional error:	< ±30 W/m^2 (0-60 deg at 1000 W/m^2)
Sensor asymmetry:	± 20 %
Operating temperature:	-22 to 158 °F (-30 to 70 °C)

3.1.9 Solar Radiation

The solar radiation sensor is mounted on a south facing boom at the 3-meter level of the Lakeshore/Willis Avenue tower. Solar radiation is measured using a Climatronics Model 102725-10 Solar Radiation Sensor (a Kipp & Zonen Model CMP3 Pyranometer).

The CMP3 is designed for the routine measurement of total hemispheric radiation, or direct incoming solar radiation (insolation) plus shortwave sky radiation under typical outdoor conditions. With its small size, sealed construction and ease of use, it is well suited for the environmental extremes typically found in long-term meteorological monitoring applications. The radiation detector utilizes a level plane black absorbing surface facing skyward and is protected by a glass dome to keep the surface clean. The overall sensor is based on a thermopile sensor design and works on the principle that the variable voltage produced is directly proportional to the solar radiation present at a given location. The sensor output is passed to the CR1000 where a differential voltage measurement technique is used to convert the signal to a linear output suitable for continuous digital data logging and averaging. In this technique, the voltage difference between the Hi and Low inputs of a differential channel are measured by the data logger. The raw result is a millivolt value (typically 0 to 15 mV corresponding to 0 to +2000 W/m^2), which when scaled with a multiplier of 73.638 and an offset of zero produces the solar radiation measurement.

Technical specifications for the pyranometer are:

Sensitivity:	5 to 20 µV/W/m^2 (13.58 for this sensor)
Temperature Dependence of Sensitivity:	± 5 % (-10 to +40 °C)
Daily Sum Accuracy:	± 10 %
Spectral Range:	310 to 2800 nm
Measurement range:	0 to +2000 W/m^2
Response Time:	< 18 seconds to 95% final output
Stability:	± 1.0 % per year
Directional error:	± 20 W/m^2 (0-80 deg at 1000 W/m^2)
Tilt Error:	± 3 % @ 1000 W/m^2
Operating temperature:	-40 to 176 °F (-40 to 80 °C)

3.1.10 Precipitation

The precipitation sensor (bucket) is mounted on a wood platform approximately 2 ft off the ground at the Wastebed 13 tower site. Precipitation is measured using a Climatronics Model 100097-1-G0 8-inch Precipitation Gauge (a Met One instruments Model 375C 8” Rain Gauge).

The opening of the rain gauge is mounted approximately 3.5 ft above ground level (2-ft platform plus 18 inch high precipitation bucket). Precipitation (rain or melted snow) is captured in an 8-inch wide collector and is channeled into a triangular tipping bucket mechanism. A heater, when operational (the heater is not used due to its power requirements), prevents data loss during freezing conditions and melts snow so that the water content (total liquid) may be measured. The bucket tips for every 0.01 inch of water that is collected. When the bucket tips, a magnet and reed switch is activated which transmits a “pulse’ signal to the signal conditioner. The output signal (pulse count) is passed on to the CR1000 where it is converted to a linear output suitable for continuous digital data logging and averaging. The raw result is a pulse count where every count equals 0.01 inches of water, which when scaled with a multiplier of 0.01 and an offset of zero produces the precipitation measurement.

Technical specifications for the precipitation sensor are:

Accuracy:	± 1.0 % @ 1 to 3 inches per hour at 70 °F

Range:	0 to 1 inches (before resetting)
Threshold:	0.01 inches

3.1.11 Wind Sensor Mounting

The wind speed and direction sensors at each measurement level are mounted at opposite ends of a 43-5/8 inches long **Climatronics F460 Model 101994-G2** pre-wired cross-arm assembly which is affixed to the mast at the top of the tower. The vertical wind speed sensor is mounted vertically at the center of the cross-arm, such that the propeller is situated approximately 1 ft higher than the cups and vane.

The crossarm is oriented true north-south so that the alignment key feature of the direction sensor shaft ensures proper orientation of any newly replaced sensors.

The wind speed, wind direction, and vertical wind speed sensors are equipped with internal heaters that automatically activate during the winter season to help prevent sensor freeze-ups caused by snow or freezing rain. The temperature system aspirator at 10 meters is mounted under the wind sensors and off to the side so as not to influence airflow around the sensors.

3.1.12 Support Electronics

Support electronics for the ground-based portion of the meteorological sensory systems include a Climatronics Model 102654-G2-H0 IMP-865 Datalogger and NEMA Enclosure, NEMA enclosure wiring and connectors, Model 101904 Signal Line Surge Protection Boards, and a Model 415 AC Surge Protection Unit.

The signal line surge protection boards are situated in-line between the sensors and the ground-based electronics, and are physically placed on the left side of the NEMA enclosure. The boards are multistage circuits designed to protect both the signal lines and the low-current power lines on most of the instruments. In normal operation, the boards pass the signals, as would normal lines. In any case where surges above 15 volts appear on the lines, the circuits switch from an open circuit to a clamping state with a response time of less than 10 nanoseconds. The circuit status returns to normal once the surge has dissipated.

The AC surge protection system operates on the power lines by switching rapidly to a clamping state whenever a power surge exceeds the specified clamping threshold. The system automatically returns to normal once the surge passes.

3.2 DATA ACQUISITION AND SIGNAL CONDITIONING EQUIPMENT

3.2.1 Data Logger and Control System

The primary on-site data acquisition system is a **Climatronics Model IMP-865** datalogger, which is manufactured by **Campbell Scientific, Inc. (CSI)**. The CSI model number for this unit is **CR1000**. The CR1000 measurement and control system is a rugged, battery-operated datalogger unit that provides precision measurement and data processing and storage capabilities. The CR1000 includes CPU and analog and digital inputs and outputs. The on-board, BASIC-like programming language allows for custom data processing and analysis routines. When coupled with its companion LoggerNet 3.1 datalogger network support software, the CR1000 system provides program generation and editing, data retrieval, and performs a variety of on-site data acquisition, processing, real-time monitoring display, and recording functions.

The hardware components of the CR1000 system include the following:

- Memory
  - 2 MB Flash EEPROM for operating system
  - 128 K of Flash to store configuration settings
  - 2MB SRAM for program and data storage
- Measurement Inputs
  - 8 differential or 16 single-ended analog inputs for measuring voltages up to ± 5V
  - 3 switched voltage excitation channels providing precision programmable voltages within the ± 2.5V range for bridge measurements
  - 2 Pulse input channels for counting pulses from high-level frequency, switch closure, or low-level A/C signals
  - 8 digital input/output channels
  - 3 synchronous device for measurement (SDM) connections
  - Switched 12 volt SW-12 terminals that can be on/off controlled
- Communication and Optional Data Storage
  - 9-pin serial I/O port
  - RS-232 port to allow direct connection to most PCs
  - CSI peripheral port for attaching optional data storage or communication peripherals
- AirLink Model Raven100 CDMA/1xRTT Digital Cellular Modem
  - 800 MHz cellular, 1.9 GHz PCS dual-band support
  - Supports communication modes allowing data to be retrieved via the internet or phone system
  - Communicates at rates up to 153.6 kbps forward (76.8 kbps reverse channel)
  - RS-232 data rates from 1200 bps to 115.2 kbps

In this system, the analog output signals from the various sensors are input to the CR1000 via signal line surge protection boards mounted in the NEMA enclosure. The datalogger is the basic component of CR1000. It provides the ability to develop adaptable data collection routines that can be adjusted to meet the exact needs of the monitoring program and is easily modified to handle expanded data collection requirements with minimal change to the existing system. The datalogger serves as the center of the data collection and archiving functions of the system. Instantaneous, 5-minute, 15-minute (sigma-theta only), and 1-hour data values are continuously available for the project personnel to view via the on-site keyboard display unit (**Climatronics Model CCR1000KD**) or remotely from a PC running LoggerNet. This allows the technician to view both current and past data values when evaluating the performance of the system or during calibration sequences.

Additional details describing the hardware and software portions of the **Climatronics Model IMP-865** data acquisition system are contained in **Section 8**.

3.2.2 Support Software

The CR1000 data logger system, when coupled with the **LoggerNet 3.1** software, provides full data acquisition system capabilities for data logger program generation and editing, data retrieval and archiving, and a variety of data acquisition, processing, real-time data review, and tabular/graphical report generation functions.

3.2.3 Data Channel Assignment

Table 3.1 lists the current channel assignments and identification for each parameter as input to the CR1000 (IMP-865) digital data acquisition system. Each parameter's position on the on-site keyboard display unit and the real-time data display window via LoggerNet is also fully labeled by appropriate headings.

3.3 METEOROLOGICAL SYSTEM ACCURACIES AND RESOLUTIONS

The meteorological monitoring system consists of several components which are linked together to form a data measurement and recording system. The overall accuracy of each monitoring system is a function of the accuracies of all individual components of that system.

According to the *On-Site Meteorological Program Guidance for Regulatory Modeling Applications, EPA-450/4-87-013, June 1987*, "accuracy" is defined as "the amount by which a measured variable deviates from a value accepted as true or standard."

The overall system accuracy is calculated as the square root of the sum of the squares of each individual component accuracy (A_i) as follows:

$$\textit{System Accuracy} = \left(\sum_{i=1}^{n} A_i^2 \right)^{1/2}$$

The individual accuracy of each system component and all system accuracies for this meteorological monitoring program are provided in **Table 3.2**.

Resolution of digital and analog systems differ as a result of the inherent differences between the two systems. The measurement resolution of the digital system is the smallest incremental variation which can be detected by this voltage measurement and analog-to-digital converting system, while the measurement resolution of the analog (i.e. strip chart) system is the smallest incremental variation that can be accurately detected and reduced from strip chart by the human eye.

The measurement resolutions for the digital and analog systems are also provided in **Table 3.2**. The reporting resolutions, which are the resolution to which the final data are reported, are also provided.

3.4 EQUIPMENT MANUALS

Additional details regarding the design specifications, features, performance criteria, and operation and maintenance of the various individual equipment items comprising this meteorological monitoring program, including subcomponents thereof, are contained in a series of detailed operator manuals provided by the respective vendors. Each manual will be maintained at Parsons' offices.

From this point on, this procedures manual is oriented principally toward the implementation, execution, and documentation of a **system-based** operations and quality assurance (QA) program. The QA program is designed to successfully establish a complete, accurate, and valid data base consistent with stated program objectives.

Table 3-1

Honeywell
Onondaga Lake
Meteorological Monitoring Program
Data Channel Assignments

Parameter	Data Logger Input Channel WB-13	LS/WA	Type
10-Meter Wind Speed	P1	P1	Pulse count
10-Meter Wind Direction	SE01/E1	SE01/E1	Single ended voltage with excitation
10-Meter Air Temperature	SE02/E2	SE02/E2	Single ended voltage with excitation
2-Meter Air Temperature	SE04/E2	SE03/E2	Single ended voltage with excitation
2-Meter Relative Humidity	SE05	SE04	Single ended voltage
Barometric Pressure	SE06	SE05	Single ended voltage
Net Radiation	Diff04	nm	Differential voltage
Solar Radiation	nm	Diff04	Differential voltage
10-Meter Vertical Wind Speed	Diff05	Diff05	Differential voltage
Precipitation	P2	nm	Pulse count

Note:
nm = not measured

Table 3-2

Honeywell
Onondaga Lake
Meteorological Monitoring Program
Meteorological System Accuracies and Resolutions

Digital System	**Digital System Component Accuracy**				
	Sensor	**CR1000 Data Logger**	**Cumulative System Accuracy**	**Measurement Resolution**	**Reporting Resolution**
Wind Speed (F460) 0.5 mph (threshold speed)	0.15 mph	+/-0.03%	0.15 mph	0.001 mph	0.1 mph
125 mph (upper limit)	+/-1.25 mph	+/-0.03%	+/-1.25 mph	0.001 mph	0.1 mph
Wind Direction (F460)	+/-2 deg	+/-0.03%	+/-2 deg	0.01 deg	1.0 deg
Vertical Wind Speed 0.5 mph (threshold speed)	+/-1 %	+/-0.03%	+/-1 %	0.001 mph	0.01 mph
125 mph (upper limit)	+/-1 %	+/-0.03%	+/-1 %	0.001 mph	.01 mph
Temperature	+/-0.27 deg F	+/-0.03%	+/-0.27 deg F	0.01 deg F	0.1 deg F
Relative Humidity	+/- 1%	+/-0.03%	+/- 1%	0.01%	0.10%
Barometric Pressure	+/-0.25%	+/-0.03%	+/-0.25%	0.01 in Hg	0.01 in Hg
Net Radiation	+/- 1%	+/-0.03%	+/- 1%	0.001 W/m^2	0.01 W/m^2
Solar Radiation	+/- 1%	+/-0.03%	+/- 1%	0.001 W/m^2	0.01 W/m^2
Precipitation	+/- 1%	+/-0.03%	+/- 1%	0.01 in H_2O	0.01 in H_2O

SECTION 4

INVENTORY CONTROL

The primary purpose of inventory control is to maintain continuity in the monitoring system's configuration and to ensure that data losses do not occur due to shortages of essential spare parts or expendable supplies.

4.1 CONFIGURATION CONTROL

The monitoring program has been designed so that all monitoring instrumentation and support equipment meet or exceed applicable regulatory agency criteria for operating specifications and accuracy. It is important that the stringency in equipment specifications not be relaxed as the program progresses.

To ensure continuity in the program configuration, a complete inventory of all major components is continually maintained. This inventory is then compared with the original program specifications. Any needed replacement parts or spare components to be purchased must be identical or equivalent to the originally specified components.

4.2 ADEQUACY OF SUPPORT EQUIPMENT AND SUPPLIES

Major program disruptions involving data losses can occur if essential components fail or if supplies run out. Delivery times for many key components are long. Therefore, advance planning is required to secure and maintain adequate stocks of spare parts, expendables, and operating supplies.

It is the program technician's responsibility to routinely check existing stocks of operating support equipment and supplies, and provide ample notification of program needs to the person responsible for the procurement of routine parts, operating supplies, and documentation forms.

4.3 PROCUREMENT OF EQUIPMENT

The program technician has the primary responsibility for logistical support to the field program, including routine requisition, purchase, and/or supply of necessary equipment, support items, and documentation forms.

4.4 PROCEDURES AND DOCUMENTATION

The following procedures and documentation will be used in maintaining inventory control for the monitoring systems:

1. A complete **Site Inventory (Form MON-212)** of all monitoring system components will be compiled. This inventory will list all equipment at each site. It will include

the manufacturer, instrument description, model number, and serial number of all capital equipment items, and will also indicate the operational status of each item.

Each updated inventory will be reviewed to ensure that ample equipment exists to properly conduct the program. The list will also be used to determine if any equipment requires repair or replacement.

An example of a **Site Inventory** sheet is included at the end of this section.

2. A **Support Supply Inventory (Form MON-224)** will be completed by the program technician as necessary. This is an inventory of key spare parts and expendables needed to maintain the data collection activities. The information contained therein will be used to determine whether and when stocks should be replenished. The program technician has the option of requesting specific items if he knows, for example, that upcoming maintenance activities will deplete existing stocks.

   An example **Support Supply Inventory** form is included at the end of this section.

3. A master **Vendor Listing (Form MON-216)** for all equipment and support supplies used on the program is maintained as part of this manual. It lists vendor names, addresses, telephone numbers, and sales department representatives for each item and also lists approximate delivery times for each type of equipment.

   This **vendor listing** is intended to expedite the order and delivery of key items by (1) having this information available for use by the purchasing department in processing purchase orders; and (2) having the technician know approximately when and from whom shipments can be expected. In emergency situations, the technician can contact vendors directly for parts or service assistance.

A Master Vendor List relevant to the configuration for this monitoring program is presented as **Table 4-1**.

4.5 RECEIVING INSPECTION PROCEDURES

All goods received into the monitoring program must be inspected to ensure the early detection of potentially faulty items and to verify the shipment against the purchase order and packing slip. The following procedures should be followed:

1. Verify the correctness of the model or part number against that requested.
2. Verify that the quantity of the item received is equal to that requested.
3. Verify the presence of all accessories as specified on the purchase order.
4. Review the condition of the items received, noting any damage incurred during shipment.

Once the shipment has been inspected and found complete and acceptable, the packing slip should be signed by the receiver and given to the technician or other program representative.

Table 4-1

Honeywell Onondaga Lake
Meteorological Monitoring Program

MASTER VENDOR LIST

Vendor	Product/Component	Average Delivery Time
Climatronics Corporation 140 Wilbur Place Airport International Plaza Bohemia, NY 11716 **Contact: Mr. Jon Berry (Technical Support)** **Phone No.: (516) 567-7300** **Fax No.: (516) 567-7585**	Meteorological Instrumentation and Support Equipment	1-2 Weeks Next Day avbl.
Campbell Scientific 815 West 1800 North Logan, Utah 84321-1784 **Contact: Sales Department** **Phone No.: (435) 753-2342**	Datalogger	1-2 Weeks Next Day avbl.
Met One Instruments 1600 Washington Blvd Grants Pass, Oregon 97526 **Contact: Sales/Service** **Phone No.: (541) 471-7111**	Precipitation Bucket	1-2 Weeks Next Day avbl.
Kipp & Zonen B.V. P.O. Box 507 2600 AM Delft, The Netherlands **Contact: Sales** **Phone No.: (31(0)15 2755 210**	Net Radiation Sensor	1-2 Weeks
Vaisala, Inc. 10-D Gill Street Woburn, MA 01801 **Contact: Sales Department** **Phone No.: (781) 537-1025** **Fax No.: (781) 933-8029**	Relative Humidity Sensor	1-2 Weeks Next Day avbl.
Setra 159 Swanson Road Boxborough, MA 01719 **Contact: Sales Department** **Phone No.: (978) 263-1400** **Fax No.: (978) 264-0292**	Barometric Pressure Sensor	1-2 Weeks Next Day avbl.

SECTION 5

ROUTINE OPERATIONS AND MAINTENANCE PROCEDURES

The meteorological monitoring instrumentation used on this program has been designed to operate unattended in harsh environments for extended periods of time. Nevertheless, a schedule of routine operational checks and field calibrations is followed to ensure the collection and documentation of accurate and representative data.

The procedures described in this manual are effective when they are followed and performed properly and on a timely basis. Schedules established for various tasks are intended to ensure continued system operation and the collection of valid and defensible data. These routine operating procedures and activity schedules are described in detail in the following sections.

Documentation of the routine field and surveillance procedures is also essential to provide the basis for the four level quality assurance data validation process. The four level process is described throughout this manual starting with the routine field operations and remote real-time surveillance procedures in this section. The required documentation will be condensed into a series of log sheets, status check sheets, and calibration forms. All documentation required on these forms is discussed in detail in subsequent sections.

A convenient reference summary of key operations and maintenance tasks, schedules, and applicable documentation forms is contained in **Table 5.1**.

5.1 DOCUMENTATION

The quality assurance validation effort relies heavily on the information documented on the real-time data review status check sheets and field calibration forms. This information forms the basis for the Level 0 – 1 data validation and verification process. The forms are structured specifically to provide adequate information for data validation staff to assess instrument performance, and to provide information for follow-up investigations to correct any potential problems. To minimize guesswork and uncertainty in determining problems and corrective action, it is necessary to have complete, detailed, and legible back-up information. All information required on the forms must be recorded and any other information that may be useful noted on the forms.

5.2 CHECKLIST FOR FIELD STATION OPERATION

The following equipment and resources have been established for this program:

- A secure and protected operating environment for the signal conditioning and data acquisition equipment.

- Meteorological sensory and signal processing instrumentation whose performance and accuracy specifications satisfy agency acceptability criteria for the parameters being measured and for monitoring objectives.
- Calibration capabilities allowing the system to be challenged against known test inputs.
- A suitable tower structure that meets the applicable exposure criteria for the meteorological parameters being measured.
- Signal cables, which run from the tower instrumentation to the signal conditioning equipment in the electronics enclosure that are compatible with the instrumentation used with respect to length of cable run and electrical characteristics.
- A digital data acquisition system for continuously measuring and logging output signals from the monitoring systems. This system will be the primary method of data collection.
- Appropriate tools, supplies, reference materials (including manufacturer's operating instruction manuals), and log forms to calibrate and maintain the measuring system; and to document the operations, maintenance, and calibration status of the equipment consistent with established operating specifications and quality control procedures.

5.3 SITE VISITS

5.3.1 Frequency

The tower site will be visited periodically one to two times per month by a local field technician. The site should also be visited as soon as possible after any unusual weather phenomena (e.g., electrical storms, unusually high wind speeds, major precipitation events, etc.), or if data checks indicate potentially spurious data values, to ensure that measurements are representative of the observed conditions.

Each time the meteorological monitoring site is visited, the technician follows a prescribed set of visual verification procedures in checking the physical and operating status of each component of the system.

5.3.2 Site Inspection

Routine procedures to be followed during each site visit include the following:

- Upon arrival at the tower site, the technician conducts a general inspection of the exterior of the tower and peripheral equipment for signs of physical damage, breach of security, or vandalism. The structural integrity of the tower and the tower instrumentation is inspected for damage from lightning, heavy winds, or other adverse conditions. The mechanical integrity of the sensors can be affected not only by damage from weather conditions, but also by many unpredictable variables such as birds, vandalism, excessive vibration or electrical failures. In particular, the technician checks that:

  - Wind vanes and cups appear to be responding properly;
  - Sensor mounts are vertically oriented;
  - No loose cables or wires are dangling from towers or instrument booms;
  - Wind vanes and cups have no holes or missing sections;
  - There are no obstacles (e.g., tape, cable, heat tape) interfering with the movement of the vanes or cups;
  - The tower is vertically oriented and stable; and
  - The temperature aspirator blower motor is functioning properly.
- Inside the NEMA enclosure, check that electronic equipment appear to be operating normally and are securely in place, with power plugs firmly plugged in or power cables firmly connected and that instrument wiring is intact.
- Utilizing the keyboard display unit, check the datalogger system clock for proper date and time. If a discrepancy of more than ±5 minutes is indicated, re-enter the correct time. (Monitoring network time is Local Standard Time [i.e., EST] and is **never changed**.)

5.3.3 Meteorological Consistency Checks

Using the keyboard display unit, visual data verification checks on the output from the meteorological monitoring system are completed during each site visit. Basic checks include direct checks of the sensors, as well as some subjective checks of the system, to compare readings to perceived weather conditions. The extent and effectiveness of these checks increase as the technician's experience with the system and perception of ambient weather conditions develop. Examples of these subjective observations include:

- Wind direction readings and variability. The current digital output should correspond to the direction the wind vane is pointing during the visit, and the oscillation of the readings should exemplify the variability of the current wind conditions. Lower wind speeds often tend to result in a variable wind direction that drifts over much of the measurement range. Higher winds generally promote more constant wind directions that vary only slightly.
- Relative rotational speed of the wind cups and output from the speed sensors. These should be consistent with the perceived wind speed during the time of the site visit.
- Temperature sensor output. These should be consistent with perceived ambient temperature conditions and/or with readings from other sources (e.g., radio weather reports). The temperature output should normally exhibit a diurnal pattern of maximum temperatures during the afternoon hours and minimum temperature during the late evening to early morning hours.

- The delta-temperature readings should normally exhibit a diurnal pattern of positive values during the evening hours and slightly negative values during daylight hours. During high wind conditions, the delta-temperatures should be very close to zero.
- Relative Humidity sensor output. This should be consistent with perceived ambient relative humidity conditions and/or with readings from other sources (e.g., other RH measurement systems, radio weather reports, etc.). The relative humidity trend should normally exhibit a diurnal pattern of maximum levels at night and minimum levels during the day.
- Solar radiation readings should exhibit a diurnal "bell-shaped" curve during daylight hours with flat baseline readings at night. On cloudy days, the readings should be relatively low and on partly cloudy days the output is likely to be bell-shaped but erratic.
- Barometric pressure reading should be relatively stable over short to intermediate time periods as atmospheric pressure conditions generally do not change rapidly. The readings should be consistent with the daily passing of weather systems; that is, rising as high pressure areas approach and falling as storm systems and weather fronts approach.
- The precipitation output should be flat (readings of zero) during dry periods and should display a "stepping" pattern during rain events. The steepness of the stepping pattern is a function of the intensity of the precipitation.

The meteorological consistency checks are routinely performed using the real-time and time-averaged data as displayed on the keyboard display unit during site visits.

Any apparent inconsistencies in the measured data or data validity check flags from the datalogger that persist must be further examined. There is either a logical reason for the disparity or there is a failure in the measurement system that must be corrected. If this is the case, the QA Field Support Coordinator or other Boston office personnel must be contacted.

5.3.4 Leaving the Site

- Verify that all instrumentation is returned to normal operating mode prior to leaving the site.
- Note any materials, supplies, or expendables that should be acquired for continued proper operation of the meteorological system.
- Make an entry in the field notebook noting the status of the system at departure, the time of departure, and the initials of the technician completing the work. .
- Verify that the site is properly secure upon departure.

5.4 REMOTE REAL-TIME SURVEILLANCE

The web-enabled capability of the data acquisition systems is used to perform remote surveillance of the meteorological monitoring systems at both tower locations. As experience is gained the remote surveillance activities can be reduced to a frequency that best meets the program needs. In addition to monitoring the system performance, access to various data listings and files can be made through the remote communication capabilities of the system.

A twice weekly frequency of remote real-time surveillance that works well and covers typical contingencies has been adopted for this data collection effort. The monitoring sites are "called-up' each Monday and then again on Thursdays to both download and review all collected data and to monitor the real-time data collection at the time of the connection. This frequency enables the reviewer to monitor the systems for problems that may have developed over the weekend as well as to catch any problems that could develop during the week and be able to address them before the work week ends.

To perform remote surveillance activities follow these procedures:

1. Connect to the system over the internet by following the LoggerNet remote communications instructions that are contained in **Section 8.2.4**.
2. Download data using the "Collect Now" button. This button downloads all files beginning where the last download ended.
3. View current meteorological conditions via the Numeric Data Display button No. 1. Check the instantaneous values on the left side of the data display window for reasonable values (use the meteorological consistency check guidelines from Section 5.3.3).
4. Record the 5-minute average data values (middle column) from the Numeric Data Display in a Real-Time Data Review Status Check sheet/log.
5. Terminate the remote communications with one station by selecting the "Disconnect" button.
6. Connect to the second station using the "Connect" button and repeat Steps 2 to 5 (Note: the "Connect" and "Disconnect" buttons are the same button and change status depending on whether a connection is active or not)
7. Record current weather conditions from the Syracuse International Airport on the Real-Time Data Review Status Check sheet/log. Current conditions can be found here: http://forecast.weather.gov/MapClick.php?site=buf&FcstType=text&MapType=3&site=buf&Ci Template=1&map.x=275&map.y=153.
8. Compare current Syracuse Airport readings to the data values recorded from the monitoring stations. The three sets of values should be reasonably close. Any differences among the data sets should be fully checked out to either provide a satisfactory explanation or to identify potential monitoring stations problems for follow-up investigation.

5.5 PREVENTIVE MAINTENANCE

A schedule of routine monthly, quarterly, and semi-annual preventive maintenance procedures is specified to limit the amount of down time and increase the efficiency through which the meteorological program is maintained. A complete and current maintenance and repair record must accompany each component as a reference in the data validation and performance auditing procedures. The "Quality Assurance Inventory/Service Record" is a maintenance log used as such a record.

5.5.1 Monthly Maintenance

The routine operating procedures described thus far in **Sections 5.1** through **5.4** comprise the first part of an effective preventive maintenance program. They are intended to ensure and document that system components are functioning normally, and to identify potential problems enabling corrective action to take place, thereby minimizing down time and periods of lost or inaccurate data. The monthly maintenance activities are performed by both field technicians and office personnel.

5.5.2 Quarterly Maintenance

In addition to the routine preventive maintenance activities, quarterly maintenance procedures include several physical inspections and checks of the tower sensors and cabling systems. The quarterly maintenance procedures are performed by the QA Field Support Coordinator.

Key tasks of the quarterly maintenance program include:

1. Check all cable connections between the tower and the NEMA enclosure verifying that all connections are secure, and are not deteriorating, broken, or susceptible to water leaks.
2. Verify that all wiring contact points in the NEMA enclosure are clean and fit firmly into place. Data can be lost when the signal leaving the sensor is erratically interrupted due to loose fittings or dirty electrical connections.
3. Check the tower for damage and loose cables.
4. Verify that the tower is vertically aligned.
5. Check all cable connections between the NEMA enclosure and the tower sensors. Verify that all connections are secure and are not deteriorating or broken. Also verify that the cables are securely attached to the tower and sensor crossarm.
6. Check the signal cable/sensor connections verifying that they are secure and have not allowed water to enter.
7. Verify that the sensors are securely attached to the crossarm.
8. Verify that the crossarm is secure and has not moved since the last inspection, and that the booms are properly extended.

9. If applicable, check the external heater sleeves verifying that they are not interfering with the operation of the sensors and that they are still operating correctly.
10. Check all vanes, propellers, and cups for damage and verify that they are securely mounted on the shafts.
11. Visually verify that all sensors are vertically aligned. If the sensor leans in one direction or the other, it will bias the data collected toward the direction of the angle.
12. Check that the temperature radiation shield aspirator motor is functioning normally. Do this by placing a hand on the blower motor casing and noting the vibration, and also by placing a hand underneath the exhaust port and checking that the airflow is normal.
13. All maintenance performed on system components must be documented in the "Quality Assurance Inventory/Service Record" and should include the following information:
    - Component model number and serial number;
    - Date and time of maintenance;
    - Technician completing the maintenance;
    - Description of the work completed;
    - A schedule for suggested part inspections, replacements, calibrations, and other recommendations; and
    - Destination, shipping and return dates of any component that leaves the site.

5.5.3 Semi-Annual and Annual Maintenance

Semi-annual and annual preventive maintenance procedures include the routine monthly and quarterly procedures outlined above and a series of 4-month field calibration checks and quality assurance audits.

As part of the ongoing quality assurance program, one set of wind sensors and their components are removed and returned to the manufacturer for inspection, repair and/or recalibration. The set removed from the tower is replaced with the spare set of wind sensors. During subsequent 4-month field calibration check/quality assurance audits, the set of wind sensors that were originally left on the tower are removed and replaced with the set of newly repaired and/or recalibrated sensors. Each time a set is removed from service, this set is returned to the manufacturer for recalibration and repairs if necessary.

This part of the preventive maintenance and quality assurance program provides additional certification documentation on sensor calibration and accuracy. Periodically, it may also be necessary to return sensors on a case-by-case basis when potential problems are noted. Any sensor removed from the tower should be immediately sent in for repair so that the repaired sensor can be returned and placed back in the on-site inventory of ready spares.

5.6 FIELD CALIBRATION CHECKS

Accuracy checks on the meteorological sensors consist of a series of both field checks and laboratory calibrations. These calibrations are necessary in evaluating the performance of the entire meteorological system and the quality of the data being produced. These tests are completed on the **sensors** measuring the variables. For this reason, the conditions under which these checks are completed must be the same under which the system collects data. Therefore, these checks must be completed while the sensor is on the tower or under strict laboratory conditions.

5.6.1 Frequency

Field calibration checks must be completed at the following frequency:

- During the initial installation;
- Every four months (trimester based);
- After component failure or replacement;
- Immediately after a maintenance sequence;
- During semi-annual field QA audits; and
- During the site shutdown.

5.6.2 Field Calibration Procedures

Field calibration/check procedures performed according to any of the above criteria are identical to those specified for the semi-annual quality assurance audits. Refer to Section 7 for the full set of procedures.

5.7 NON-ROUTINE MAINTENANCE

Non-routine maintenance activities are implemented to correct problems in the system's operations and to minimize the downtime of any component and the amount of invalid or missing data.

The existence of a potential problem is found by one or more of the following:

- Routine operational checks
- Meteorological consistency checks
- Preventive maintenance checks
- Field calibration checks
- Field quality assurance audits

The first step in the non-routine maintenance task is to isolate the cause of the problem to:

- Physical damage to the sensor

- Misalignment of the sensor
- Sensor malfunction
- Sensor calibration
- Cabling and/or connectors
- Surge board malfunction
- Electrical interferences or failure
- Digital system failures

Once the cause(s) have been identified, appropriate corrective action must be taken. This will typically include repair, recalibration, or replacement of the specific component(s) causing the problems. In the case of electrical failures, outside help from the solar power systemvendor must be sought.

On meteorological monitoring systems, most problems or outages are traced to failures in the sensors themselves, and usually require replacement. For this reason, ample inventories of working spare components are to be maintained for the program at all times.

In replacing a failed sensor, follow the manufacturer's instructions for proper installation and hook-up. Then perform a field calibration check on the new sensor in accordance with the procedures for that sensor before formally declaring the problem corrected.

5.8 TOWER MAINTENANCE

Once every year or two, the overall structural integrity of the towers should be checked, including the "plumbing" of the tower if necessary. Periodically replumbing the tower is necessary to correct any structural weaknesses that may occur due to wind/ice/snow loads on the structures or due to the effects of major seasonal temperature changes.

These structural checks are performed in the interest of safety and also to minimize swaying and vibrational influences on the booms, cables, and sensors. The checks should be performed by the original vendor of the tower or other qualified tower or meteorological personnel.

TABLE 5-1

HONEYWELL ONONDAGA LAKE

METEOROLOGICAL MONITORING PROGRAM MANUAL
ROUTINE OPERATION AND MAINTENANCE SCHEDULE

Tasks	Scheduling	Procedures	Manual Section	Forms Used	
Routine Dial-Up of Site	Two Times Per Week	- Check DAS Time and correct if necessary - Check Validity of Data - Download Data - QA data and archive for monthly processing	5.4	MON 222	"Site Dial-Up & Operating Log"
Support Supply Inventory	Quarterly	- Develop an inventory of all parts and supplies needed to maintain the monitoring network for the next 3 months. - This list should include part descriptions, model numbers, quantity on hand, and quantity needed. - This Inventory should be used as a purchasing and maintenance tool.	4.0	MON 224	"Support Supply Inventory"
Meteorological Field Calibration Checks	Every 4 Months	- Completed while instruments are in a typical operating mode and configuration. - Completed before and after component exchange or maintenence. - Follow procedures specified in Section 8.0 - Completed as part of quality assurance audit	7.5	MON-208 MON-209 MON-210 MON-211 MON-217	"Wind Direction Field Alignment Audit Data Form" "Temperature/Delta-Temperature Audit Data Form" "Wind Speed/Vertical Wind Speed Audit Data Form" "Aerometric Monitoring Instrumentation General Purpose Audit Form" "Dewpoint/Relative Humidity Audit Data Form"

SECTION 6

CHAIN-OF-CUSTODY

The chain-of-custody record is the documentation tracking the data's status and location throughout the data collection and reduction process. Without it, one cannot be sure that the data ultimately reported is the same as the data actually measured at a particular time and place. Therefore, the data is handled by persons directly associated with the data collection, validation, and reporting process.

Every person handling the data or other materials must be able to trace from whom the item was received and to whom it has been delivered. The required practice for transferring data (downloading data) from the field site to the data validation staff is to have an In-House Data Record– **Form MON-206** - completed, starting at the point of origin and listing the following information:

- Date/time the data were transferred from the site,
- Contents of data (type, locations),
- Initials of originator,
- Comments.

For the routine transfer of actual data from the field site (i.e., the data stored in the DAS system) to the Boston Office for data base processing and archiving, the basic method of transfer will be electronic via the web-enabled cell phone and datalogger system and procedures as described in Sections 5.0, 8.0, and 9.0. The project meteorologist performing the routine data transfers will maintain a log for these data transfers, indicating:

- Date the data transfer was completed,
- Period of Record of data transferred,
- File into which the data were entered,
- Any obvious transfer problems or obvious gaps in the data record
- Initials of person completing the file transfer.

If any hardcopy records or other materials are going to be mailed or shipped to another location, a shipping log (Form 207A) should be prepared at the point of origin which indicates:

- Date shipped,
- Contents (explicit),
- Method of transport (including shipping information),

- Comments,
- Signature of originator.

One copy of the shipping log accompanies the data package. A second copy is retained at the field site.

When using the Postal Service to transport data, only certified or registered mail is used, and a return receipt should be requested. When using the commercial delivery services (e.g., Federal Express, UPS, etc.), or similar means of shipment, the data inventory is placed on the Bill of Lading. The package is also sent to the attention of the specific person designated to receive the data. Upon reaching its destination the data package is opened and the packing slip and contents compared. If the contents of the package agree with the packing slip, the slip is signed and dated by the receiver.

The receiver then documents the data package information in a receiving log (Form 207B), recording the following:

- Date received,
- Originator,
- Contents,
- Method of transport,
- Initials of receiver,
- Comments.

The data validation staff is responsible for the data once it reaches the office and oversees the internal movement of the data through the data base management process. The data record **(Form MON-206)** is established by the designated person in the office and completed by all personnel responsible for:

- Data assembly,
- Data reduction,
- Meteorological data quality assurance,
- Final Report development/review.

The information in this record sufficiently identifies who has handled the data, the date of each validation phase completion, and a brief description of the data validation and reporting results. Additional sheets may be appended by appropriate personnel if necessary to describe any problems, results, or activities in more detail. The final entry on the data record designates the date the monitoring report is signed off by the Air Monitoring Supervisor and is sent to the appropriate project recipients and regulatory agency or agencies. This date coincides with the filing of that batch of data in a designated file directory. All data and accompanying program operations records are stored in an accessible storage location for future reference for a period no less than 5 years after the end of the program.

Examples of shipping logs, receiving logs and a processing record are found and are described in further detail in **Section 10**.

SECTION 7

FIELD CALIBRATION AND QUALITY ASSURANCE AUDIT PROCEDURES

7.1 INTRODUCTION AND OBJECTIVES

As part of the overall quality assurance program for meteorological monitoring systems, a series of field calibrations and internal quality assurance audits are conducted to assess the performance of the system, and the accuracy and validity of collected data. Included are checks of the past and current performance status of the system, checks of the operational and preventive maintenance procedures employed along with associated documentation, and a series of on-site field calibration checks of the various sensor and system components.

The key purposes are to provide both a qualitative and quantitative assessment of the systems overall performance, to formulate recommendations for improving system performance or operation protocol, and to assess the adequacy of collected data relative to program objectives. The field calibrations and internal QA audits are conducted by a field technician and senior air monitoring personnel at four-month intervals. The procedures employed in the field calibrations are the same as those specified for the quarterly preventive maintenance checks.

The following sections outline the field calibration and audit procedures that apply specifically to the individual meteorological monitoring system components.

7.2 FREQUENCY

As stated above, the routine field calibration checks performed as part of the preventive maintenance program are conducted three times per year at four-month intervals. The formal and comprehensive internal QA audits are incorporated into these field checks. An audit report containing the results of the QA audit, and an assessment and recommendations for the monitoring program is also provided. To the extent possible, QA audits are scheduled during the transitional seasons of spring and fall (e.g., March-April and October-November) to provide comfortable working conditions for the field work; and, more importantly, to more thoroughly check the system immediately before and after the more extreme weather conditions that occur during winter and summer. Ideally, a summer field calibration is scheduled evenly in between, but with more flexibility to account for seasonal weather conditions.

7.3 GENERAL AUDIT PROCEDURES

The internal QA audits consist of two parts: the systems audit portion and the performance audit portion.

7.3.1 Systems Audit

The systems audit is a general assessment of how the system as a whole is performing, and how it is being operated, relative to stated monitoring program objectives and established standard operating and quality control procedures.

Specific items to be addressed as part of the systems audit portion include:

- Review the current operating status of the monitoring system and its performance history since the previous audit. Note any changes that have been made in the system configuration and the status or results of any recommendation implemented as a result of the previous audit. Also review the details of any real or suspected instrument outages, component failures, or malfunctions that may have affected the quality and quantity (i.e., recovery rates) of collected data.
- Review the disposition and/or uses of monitored data and assess whether the type of field measurements, the data recovery rates, and the form of the output data have been sufficient for the program objectives.
- Review the results of the preventive maintenance program and any non-routine maintenance activities conducted since the last audit, including the reasons for any component replacement and the disposition of failed components.
- Review field notes, real-time data review status check sheets, calibration sheets, and maintenance logs to determine if they represent adequate and complete documentation records for system operations.
- Assess the degree to which routine operations, maintenance, calibration, and quality assurance activities have adhered to procedures outlined in this manual.
- Review the results of actual instrument calibrations and checks performed since the last audit.
- Review the current inventory of spare parts and support supplies and the adequacy of the inventory to continue to support the system.
- Review orally with field technicians and other project personnel the key findings and results of the system audit. This will be followed up by written documentation.

7.3.2 Performance Audit

The performance audit is a quantitative assessment of the accuracy of collected data. It consists of a series of actual field calibration checks on the individual sensory systems and on elements of the data acquisition and recording system (i.e., measured input versus processed output relative to specific test criteria).

The specific test criteria for each component check define the extent to which the check represents a true calibration or simply a check of certain response characteristics. In turn, they define the extent to which field calibration or audit results would be acceptable or unacceptable in the development and application of calibration adjustment factors to the data.

For example, field alignment of a wind vane to azimuth markers whose locations are accurately pinpointed provides a highly accurate assessment of the sensor output relative to vane position. However, this field check does not fully account for potential errors that might occur in the normal measurement mode if the vane is unbalanced or warped. Similarly, laboratory-style calibrations of temperature sensors can be successfully replicated in the field using controlled temperature baths and NIST-traceable reference thermometers. However, these calibration checks do not account for errors that may occur in the normal operating mode at the sensor/air interface due to inadequate aspiration or radiation shielding.

Also, for some sensory components, there are no practical methods of field calibration. They must be returned periodically to the laboratory for calibration under stringently controlled conditions or against laboratory-maintained transfer standards. The quality assurance program, therefore, consists of a series of both field calibration checks and laboratory calibrations. Further, if the results of a field check suggest that the accuracy of a given component is questionable, that sensor should be subjected to further laboratory calibration checks prior to determining the final disposition of the data in question.

In general, the components comprising this meteorological monitoring program are among the most rugged, precise, and reliable available. The sensors are also deemed to have an excellent exposure and are configured to provide representative measurements of local ambient conditions. The results of the field calibration checks are assumed to provide reasonably valid indications of data accuracy for use in a quality assurance assessment.

7.4 ACCEPTANCE CRITERIA FOR FIELD CALIBRATION CHECKS

Listed below are the limits of acceptability for field calibration check results on the various instruments. These tolerance limits generally conform to limits specified by the USEPA for meteorological measurements recorded as part of PSD monitoring programs. These limits are assumed to be appropriate for this program in that meteorological data is being collected primarily in support of air quality related issues. These limits help ensure that the data will be acceptable to regulatory agencies if future applications include use in air quality dispersion modeling activities.

Wind Speed:	1.0 mph threshold (upper limit) ±0.5 mph accuracy to 10 mph; ±5% above 10 mph
Wind Direction:	1.0 mph threshold (upper limit) ±5° accuracy
Vertical Wind Speed:	0.5 mph threshold ±0.5 mph accuracy to 10 mph; ±5% above 10 mph
Temperature:	±0.5°C (±0.9°F) accuracy
Delta-Temperature:	±0.1°C (±0.18°F) accuracy

Relative Humidity:	± 5.0 %
Solar Radiation:	10 W/m^2 threshold ± 5.0 % of observed
Net Radiation:	10 W/m^2 threshold ± 5.0 % of observed
Precipitation:	0.01 inch threshold ± 10.0 % of observed
Barometric Pressure:	± 3.0 mb (0.09 inHg)

When field or laboratory calibration check results fall within the above limits, the instruments will be assumed to be operating in calibration and providing data accurate to within specified program tolerances.

Results falling outside these limits do not automatically necessitate deletion or adjustment of the data, or replacement of sensory components. Rather, they imply that further assessments should be made on a case-by-case basis, depending upon how far out-of-limit the results actually were. Possible follow-up and remedial actions include:

1. Repeating the calibration check under a set(s) of ambient conditions different from those under which the audit checks were conducted.
2. Subjecting the sensor to additional, more accurate laboratory calibration tests.
3. Replacing the sensor and assessing whether the newly installed component yields more satisfactory results.
4. Altering the limits of acceptability if confident that revised accuracy limits would not jeopardize the usefulness, credibility, representativeness, or defensibility of the data relative to stated purposes.

In any case, the results of all field audit checks and laboratory calibration results will be made available to all users of the data so they can independently assess whether data accuracy is sufficient to meet requirements for each specific application.

7.4.1 General Instructions

The following instructions generally apply to the field calibration checks of all sensors. Some instructions are specific to individual instruments.

1. **Scheduling** - Try to schedule field work on days with "favorable" weather conditions. If possible, avoid working under extremely high wind conditions (could damage vanes during alignments), or extremely cold temperatures (could interfere with temperature

calibrations). Also, favorable conditions increase working comfort and decrease the possibility of technician error.

Initially schedule a window of 2 or more days for field work. Then check the latest area weather conditions and forecasts and select the best day(s) from that window.

Also, schedule ample time to complete all work in a systematic manner, allowing for possible logistical or mechanical problems, and include a provision for repeating certain specific tests if necessary. In general, full-scale system and performance audits for one monitoring station are scheduled for completion over a 2-day period.

2. **Materials and Supplies** - Make sure that all materials, supplies, tools, documentation records, reference materials, and certifications needed to perform the work are available and in good order prior to arrival on-site.

3. **Activity Coordination and Planning** - The actual sequences of events during full field performance audits are not always the same, due to a variety of factors and considerations. Therefore, prior to initiating any actual work, field personnel fully assess any constraining factors (time, weather, etc.) and formulate a plan for the day that most **effectively** allows specified tasks to be accomplished. Be sure to account for all required procedures and documentation.

4. **Weather Condition Constraints** - Certain field calibration checks provide meaningful and accurate measures of instrument performance only to the extent that they are performed under reasonable conditions. For example:

   Avoid temperature checks during strong wind conditions or during midday hours if skies are clear and solar intensity is high. Perform these checks during light winds, cloudy skies, or during the early morning or late evening hours when the sun's intensity is decreased and there is ample shaded area in which to conduct the test.

   Avoid performing wind sensor checks during high wind speeds. Strong wind can make it difficult to check bearing performance on speed sensors or to hold vanes sufficiently steady for accurate alignment checks. Attempting to oppose wind forces during these checks could result in damage to the cups or vanes.

   Avoid performing wind direction vane alignment checks if obstructions to visibility (fog, haze, precipitation) prevent a clear view of azimuth markers.

5. **Ambient Meteorological Conditions** - Prior to initiating any on-site work, document the existing ambient weather conditions. This includes noting the current output readings from the on-site sensors as well as the technician's observation regarding sky condition, cloudiness, visibility, obstructions to visibility, etc. Also document any significant changes in weather conditions that occur during the course of activity. This information is used to perform meteorological consistency checks as outlined in **Section 5.3.3**. It is also useful in "after-the-fact" evaluations of field audit results.

7.5 METEOROLOGICAL SENSOR CALIBRATION CHECK PROCEDURES

The following sections describe the procedures for performing and documenting the results of field calibration checks on each sensory system comprising the meteorological monitoring portion of this program. All of these checks are performed as part of both the four-month field calibration checks and the quality assurance audits.

The same procedures for field calibrating any given sensor must be performed and documented whenever a new component is placed in service. It should not be automatically assumed that ready spare components are in perfect calibration. The "beginning-of-period" field calibration will document the calibration status of new sensors.

7.5.1 Wind Direction System Field Check

A wind direction system field calibration requires several specialized components and specific information in order to accurately assess the performance of the wind system and to obtain information that is necessary to interpret the instrument responses:

- A torque watch gauge (3.0-21.0 gm-cm range)
- Linearity test fixture
- Several azimuth direction landmarks within visual distance of the meteorological tower (see **Table 7.1** at the end of this section for a listing of azimuth check points)
- Calibration Form MON-208, "Wind Direction Field Alignment Audit Data Form"
- CR1000 keyboard display unit
- Two (2) technicians
- Good visibility

7.5.1.1 Wind Direction Sensor Alignment Procedures

1. Complete the site and system information (site and instrument serial numbers and model numbers) on the "Wind Direction Field Alignment Audit Data Form" verifying that each entry is current and correct. For assistance on completing this form see Form Description MON-208.
2. Verify the alignment of the instrument crossarm to within $\pm$2 degrees of the proper orientation. This is accomplished with a Brunton Pocket Transit mounted on a tripod and binoculars. The wind instrument crossarms are oriented true North/South, with the speed sensor on the north end of the crossarm.
3. Refer to **Table 7.1** and complete the expected degree responses on the "Wind Direction Field Alignment Audit Data Form" for each azimuth point to be used in checking the wind direction sensor alignment. For each azimuth point there should be a "tip" and "tail" response. All expected azimuth readings are expressed as the angle, in degrees from true north, from the sensor to the designated landmark or other

reference check point. The expected "tip" response is equal to the angle from the tower to the landmark. The tail response is equal to:

- The base azimuth plus (+) 180° for base azimuths of 0°-180°,
- The base azimuth minus (-) 180° for azimuths of 181°-360°.

4. Note on the field data form the following information:
   - Name of the monitoring site and parameter;
   - "Field Calibration";
   - Date and time that the calibration starts;
   - Initials of the technician completing the calibration; and
5. Establish one additional reference point prior to performing the actual vane alignments. This reference point should be approximately equal to 005°. This is not an alignment point (unless a suitable marker is at this azimuth), but is to be used as a "near zero" base reference point from which the vane is rotated clockwise when aiming at all subsequent tip and tail check azimuths. The vane tip should be repositioned towards this reference point at the start of each azimuth alignment check.
6. Rotate the wind vane clockwise until the tip is physically aimed at the first known azimuth point. Once the vane has been aligned on the point it should be held as steady as possible for several minutes so that a stable reading can be obtained.
7. Document the DAS responses for the azimuth point on the "Wind Direction Field Alignment Audit Data Form." On the field data form note:
   - The azimuth point identification;
   - Response from the DAS (via keyboard display unit).
8. Return to the reference position. The vane should be turned clockwise until the vane tail is pointing directly toward the landmark. This position should now be held until a stable reading can be obtained. This point is the tail response for the known azimuth point.
9. Document the results as described above. Return the vane to the reference point.
10. Align the vane to the next azimuth point, following the procedures presented above in Step Nos. 6 through 9 for that point.
11. Review the results once all the test alignment points are checked. If any point differs from the expected results by more than ±003°, that point should be repeated. If the point remains inconsistent and the other azimuth points demonstrate a good correlation with the expected results, note the discrepancy on the calibration sheet and contact the Air Monitoring Supervisor. The base data for that point may be in error, or there may be a sensor linearity problem.

12. Realign the wind direction sensor if all of the azimuth points show a common discrepancy between the observed responses and the expected responses (i.e., constant offset).
13. Realign the instrument mount by pointing the vane toward a known azimuth, loosening the set screws holding the mount to the crossarm, and turning the mount until the wind direction sensor outputs the correct reading. Re-tighten the set screws.
14. Repeat the complete alignment calibration as discussed previously, once the sensor and/or crossarm alignment has been corrected.
15. Remove the sensor if it cannot be aligned and replace it with a spare sensor.
16. After replacing a malfunctioning sensor with a newly calibrated and certified sensor, the new sensor must also be subjected to a field calibration check to document the "beginning-of-period" calibration status. Repeat steps 1 through 14 on this sensor.

7.5.1.2 Wind Direction Sensor Linearity Test Procedures (Optional)

1. Remove the sensor from the crossarm and bring it to ground level or install the test fixture with the sensor on the tower as per the manufacturers' instructions.
2. Connect the linearity test fixture wiring to the rear of the wind direction processor board for the level from which the sensor was mounted. Refer to the manufacturer operating instructions for proper wiring of the test fixture.
3. Install the sensor on the test fixture stand.
4. Place the calibrated alignment wheel on the hub of the sensor and fit it into place.
5. Fit the pointer into one of the 30-degree notches on the calibration wheel.
6. Once a stable reading is obtained on the DAS output, note in the site log the first alignment point and record the direction from the DAS in the log and on the "Wind Direction Sensor Linearity Test Form.
7. Increment the test fixture wheel one position (30 degrees) and record the response as was done previously.
8. Continue to increment the test fixture and record the responses until all of the points have been tested.
9. If the sensor is consistently out of range by more than ±3.0 degrees, a linearity problem does exist and the sensor should be removed from service.
10. A linearity test should also be performed on new sensors to document "beginning-of-period" calibration status.

7.5.1.3 Wind Direction Sensor Torque Watch Test

1. While the sensor is removed from the crossarm, install the torque watch meter on the sensor following the manufacturer's operating instructions.

2. Slowly rotate the torque meter until the sensor shaft begins to rotate. Record the torque necessary to begin rotation of the sensor shaft on the Wind Direction Field Alignment Audit Data Form.
3. Repeat the torque watch test at least five times. If the average starting torque is above 15.0 gm-cm, the sensor should be removed and replaced with a newly calibrated and certified sensor.

7.5.2 Wind Speed System Field Checks

A wind speed system field calibration requires several specialized components and specific information in order to accurately assess the performance of the wind system and to obtain information that is necessary to interpret the instrument responses:

- A variable RPM synchronous motor calibration unit;
- A torque watch gauge (0.1 - 2.0 gm-cm range);
- Calibration Form MON-210, "Wind Speed/Vertical Wind Speed Audit Form";
- CR1000 keyboard display unit;and
- Two technicians

7.5.2.1 Wind Speed System Synchronous Motor Tests

1. Complete the site and system information (site and instrument serial numbers and model numbers) on the "Wind Speed/Vertical Wind Speed Audit Form," verifying that each entry is current and correct.
2. Complete the expected speed responses on Form MON-210 for each rpm test point to be used to challenge the system. The responses are based on zero, and variable upscale rpm test points.
3. Note on the field data form the following information:
   - Name of the monitoring site and the parameter;
   - "Field Calibration";
   - Date and time that the calibration starts;
   - Initials of the technician completing the calibration; and
4. The DAS should be continually displaying current readinds.
5. Verify that at rest the wind speed sensor is producing a response equal to the expected zero response for the system. This is done by removing the anemometer cups from the sensor so that the sensor remains at rest.
6. Document the DAS voltage response for zero on the calibration form. On the field data form, list:
   - "Zero";

   - DAS response.

7. Fit the RPM motor over the shaft, and introduce the first test rpm point to the system. **Table 7.2** lists the test points to be used when auditing this system. Run the rpm test point until a stable DAS output can be read. The response will vary from sensor to sensor and will be listed as part of the sensor's wind tunnel calibration information. See **Table 7.2** for the equation to use to convert rpm readings to mph readings for this system.
8. Document the mph responses for the test point on the Data Form. On the field data form, list:
   - "rpm" input;
   - DAS response.
9. Repeat the test for three test points representing low-scale, mid-scale, and up-scale wind speeds (see **Table 7.2**).
10. Check the response from the sensor. If it is within ±0.5 mph for speeds up to 11 mph, or ±5 % above 11 mph, then the sensor is still within calibration tolerance limits and can be left on the tower.
11. If the sensor responses fall outside the tolerance limits, replace the sensor and return to the manufacturer for repair or recalibration.
12. A newly calibrated and certified sensor must also be subjected to a field calibration check after replacing a malfunctioning sensor. Repeat steps 5 through 11 on the replacement sensor to document "beginning-of-period" calibration status.

7.5.2.2 Wind Speed Sensor Torque Watch Test

1. Remove the sensor from the crossarm and bring it to a level platform for testing.
2. Install the torque watch meter fixture on the sensor following the manufacturer's operating instructions.
3. Slowly rotate the torque watch meter until the sensor shaft begins to rotate. Record the torque necessary to begin rotation of the sensor shaft on Form MON-210
4. Repeat the torque watch test five times. If the average starting torque is greater than 0.12 gm-cm, the sensor should be removed and replaced with a newly calibrated and certified sensor.

7.5.3 Vertical Wind Speed Component System Field Checks

The following procedures are used to perform a field calibration check for the vertical wind speed component sensors. Essentially, the checks are performed by inputting known signals into the system. To do this, zero and up-scale rpm synchronous motor signals are input and the results recorded. The sensors must otherwise be returned to the laboratory for full wind tunnel calibrations at the sensor exchange interval.

7.5.3.1 Calibration Equipment and Materials

The following equipment and materials are needed to complete a dynamic calibration check on the vertical wind speed system.

- A certified digital voltmeter;
- 60 RPM synchronous motor (with clockwise and counterclockwise rotation);
- Torque disc;
- Calibration Form MON-210, "Wind Speed/Vertical Wind Speed Audit Form";
- CR1000 keyboard display unit; and
- Two technicians.

7.5.3.2 Vertical Wind Speed System Synchronous Motor Tests

1. Complete the site and system information (site and instrument serial numbers and model numbers) on the "Wind Speed/Vertical Wind Speed Audit Form," verifying that each entry is current and correct.
2. For each sensor rotational direction, complete the expected speed responses on Form MON-210 for each test point to be used to challenge the system. The synchronous motor is designed to operate both clockwise and counterclockwise, simulating flows in each axial direction for each component. Clockwise rotation simulates motion along the sensor axis or a positive speed response, and counterclockwise rotation simulates motion toward the sensor or a negative speed response. The responses are based on a zero test point, and two positive and two negative upscale rpm test points.
3. Note on the field data form the following information:
   - Name of the monitoring site and parameter,
   - "Field Calibration";
   - Date and time that the calibration starts;
   - Initials of the technician completing the calibration; and
4. The DAS should be continually displaying current readings on the keyboard display.
5. Remove the propeller to verify the vertical wind speed sensor is producing a response equal to the expected zero response for the system.
6. Document the DAS response for zero on the calibration form. On the field data form, list:
   - "Zero";
   - DAS response.
7. With the propeller still removed, fit the synchronous motor over the propeller shaft, and introduce the first clockwise (positive) test rpm point to the system. **Table 7.2** lists the

test points to be used when auditing this system. Run the rpm test point until a stable DAS output can be read. The response will vary from sensor to sensor and will be listed as part of the sensor's wind tunnel calibration information. See **Table 7.2** for the equation to use to convert rpm readings to mph readings for this system.

8. Document the mph responses for the test point on the Data Form. On the field data form, list:
   - "rpm" input;
   - DAS response.
9. Repeat the test for the corresponding counterclockwise (negative) test point as well as for the second positive/negative test point (see **Table 7.2**).
10. Check the response from each test. If it is within ±0.5 mph, then the sensor is still within calibration tolerance limits and can be left on the tower.
11. If the sensor responses fall outside the tolerance limits, replace the sensor and return the original to the manufacturer for repair or recalibration.
12. Any newly calibrated and certified sensor must also be subjected to a field calibration check after replacing a malfunctioning sensor. Repeat steps 3 through 11 on this replacement sensor to document "beginning-of-period" calibration status.

7.5.3.3 Vertical Wind Speed Sensor Torque Watch Tests

1. The desired starting threshold is 0.5 mph which is equivalent to a torque of 0.1 gm-cm. A torque of 0.1 gm-cm is produced by placing a 0.1 gm weight in the 1.0 cm radius on the torque disc.
2. Remove the sensor from the crossarm and bring it to a level platform.
3. Install the torque disc with the weight in place on the sensor shaft following the manufacturer's operating instructions.
4. While holding the sensor horizontal, level; and facing the torque disc, rotate the disc until the weight is on the right side and is also horizontal. Release the disc.
5. If the disc rotates clockwise, the bearings have passed the starting torque test.
6. Repeat the torque test for counterclockwise rotation by moving the weights to the left and releasing the disc.
7. If a sensor is replaced, the new sensor should also be tested before installation.

7.5.4 Temperature/Delta-Temperature System Field Checks

The temperature and temperature difference measurement systems are tested at three controlled temperature points. This is done by immersing the sensor probes and an NIST traceable thermometer in an ice water bath and then two upscale temperature water baths. The responses obtained from the DAS and the thermometer for each test point are then compared.

7.5.4.1 Calibration Equipment and Materials

The following equipment, materials, and personnel are needed to complete a dynamic calibration check of the temperature and delta-temperature systems.

- Calibration Form MON-209, "Temperature/Delta-Temperature Audit Data Form";
- One insulated container with a tight-sealing lid with a hole in it large enough to fit two temperature probe s and a thermometer through it;
- A certified digital voltmeter,
- One certified mercury thermometer;
- A thermos of warm water,
- Distilled water and ice;
- CR1000 keyboard display unit; and
- Two technicians.

7.5.4.2 Temperature Probe Thermal Mass Tests

Note: this procedure, which includes delta-temperature checks, requires the removal of the upper level radiation shield and temperature probe from the top of the tower in order to mount it side by side with the lower level shield and probe for performing the checks. Once the upper level radiation shield with probe is removed and lowered, it is connected to a patch cable at the bottom of the tower so DAS reading can be obtained. The two probes are immersed in the same ice/water baths throughout the checks.

1. Prepare a mixture of **ice** and **distilled water** in the insulated container. Leave enough room in the container for the temperature sensors and the thermometer.
2. Remove the temperature sensors from the aspirated radiation shields.
3. Insert the temperature sensors and thermometer through the hole in the container lid, and place the lid on the container. The sensors and thermometer must not be touching the bottom or sides of the container.
4. Allow the sensors and thermometer to stabilize in the container for about 10 minutes.
5. The second technician will prepare the "Temperature/Delta-Temperature Field Calibration Sheet" for recording the calibration check information.
6. While monitoring the responses have the other technician shake the container gently from side to side to circulate the ice water mixture around the sensors and thermometer.
7. Record the thermometer reading and corresponding DAS responses for the temperature and delta-temperature sensors on the calibration sheet and on the field data form once the responses have stabilized.
8. Remove the temperature sensors and thermometer from the ice bath and dump out the ice water mixture.

9. Repeat the temperature test for at least two more points spanning the range of the system. Warm (i.e., ambient) and hot point conditions are typically simulated.
10. Proceed to step 11 if the sensor response is within the tolerance limits of ±0.9°F for temperature measurements and ±0.18°F for the delta-temperature measurement (relative to the mercury thermometer). If the temperature sensor responses are outside the tolerance limits, notify the Air Monitoring Supervisor.
11. Complete the calibration check, replace the temperature sensors in their respective mounting assemblies, and put the mounting assemblies back in the aspirated shields.
12. Return the temperature system to operation and verify that the recorded response typifies ambient conditions.
13. Verify that all calibration information has been recorded on the calibration form, including the times that the sensors were removed from and placed back into normal operation.

7.5.5 Relative Humidity System Field Check

The relative humidity measurement system is tested at a single point ambient condition using a Sling Psychrometer containing NIST-certified wetbulb and drybulb thermometers. The relative humidity and dewpoint temperature calculated from the wetbulb and drybulb readings is compared to the concurrent system-measured response obtained from the DAS.

7.5.5.1 Calibration Equipment and Materials

The following equipment, materials, and personnel are needed to complete this collocated measurement check of the relative humidity system.

- Calibration Form MON-217, "Dewpoint/Relative Humidity Field Calibration Form",
- A Sling Psychrometer containing NIST-certified wetbulb and dry bulb thermometers
- Distilled water, and
- Psychrometric calculator.

7.5.5.2 Relative Humidity System Calibration Check Procedures

1. Carefully remove the sling psychrometer from its case and saturate the wick of the wetbulb thermometer with distilled water. Make sure that the wick is clean, free of film, and securely affixed to the bulb of the thermometer.
2. If at all possible, find a location close to the relative humidity sensor, in the shade and facing into the wind. Rotate or “sling” the thermometers for several minutes, occasionally reading the wet and drybulb temperatures until both readings stabilize after several readings.
3. Record the wet and drybulb readings, along with the DAS response for the relative humidity system and computed dewpoint temperature on the calibration form.

4. Perform this series of checks at a couple of different time during the course of the 2-day audit period under different sets of meteorological conditions if possible. Best results are obtained on overcast days with light winds.
5. Calculate the relative humidity and dewpoint temperature for each set of readings using the psychrometeric calculator, following the instructions printed on the calculator, and document the results on Form MON-217.
6. Calculate the absolute and percent differences between actual relative humidity calculated using the sling psychrometer versus the measured relative humidity values from the monitoring system.
7. If the average difference in psychrometer measured relative humidity values for all checks exceeds the acceptability limit of 5 %, the sensor is most likely out of calibration. If this is the case, the RH sensor should be replaced.
8. If a newly replaced RH sensor continues to yield readings outside acceptance limits (as may often happen with this particular sensor), a decision will have to be made to (1) revise the limits, (2) establish some other criteria for acceptance, such as percent difference, (3) use the calibration check result to develop and apply adjustment factors to the measured data, or (4) consider another type of dewpoint/humidity measuring device if more precise measurements are required.

7.5.6 Solar and Net Radiation Sensor Field Checks

Calibration of the solar and net radiation measurement systems in the true sense is not possible in the field and must be performed in a properly equipped laboratory under strictly controlled conditions. This is because it is difficult to create a true reference test condition against which to compare the systems' responses. It is possible however, to perform a simple check to determine if the sensor is responding to incoming solar and outgoing long-wave radiation. This procedure involves covering the sensor with a material of sufficient density to block out exposure to radiation, and then monitoring the processor output to determine if the sensor is appropriately responding to sunlight, darkness, and outgoing radiation.

7.5.6.1 Calibration Equipment and Materials

The following equipment and materials are needed to complete an operational check of the Solar and Nat Radiation sensors.

- A certified digital voltmeter
- CR1000 keyboard display unit,
- A thick covering material and/or container filled with Styrofoam insulation pellets.
- Calibration form MON-211 - "General Purpose Audit Form",

7.5.6.2 Solar Radiation Sensor Operation Check

1. Note on the field data form the time that the check of the solar radiation system is about to begin. Note the date, time, site, parameter, and operators initials.

2. Assuming the test is conducted during daylight hours, and that the solar radiation sensor is outputting a positive radiation reading, place an object or material of sufficient density to block out light (i.e. a coat, jacket, trash bag) carefully over the sensor to block out direct incoming solar radiation. Be careful not to damage the glass dome that covers the sensor.
3. Monitor the output of the solar radiation sensor via the voltmeter and/or DAS readings. The voltage and solar radiation readings should begin to decrease and stabilize at zero (or the typical non-zero baseline reading of the system).
4. When the voltage and DAS output have appeared to stabilize, record the voltage and DAS response. When completely shielded, the sensor should yield a solar radiation reading of 0.0 W/m^2.
5. Remove the covering material from the sensor and monitor the voltage and DAS responses. The responses should return to normal pre-test values after several minutes.
6. Note on the form that the sensor check has been completed. Note the date, time, site, parameter, and operators initials.
7. If the sensor fails to yield a zero or typical non-zero baseline reading of the system (i.e., a reading very close to zero) when covered, or if it has been two years since the previous laboratory calibration of the sensor, return the sensor to the manufacturer for laboratory calibration against a transfer standard. When removing the sensor from its mounting, be sure to cover the mounting plate, connector plugs, and lead wires with protective material to prevent damage by dirt and/or rain.

7.5.6.3 Net Radiation Sensor Operation Check

1. Note on the field data form the time that the check of the net radiation system is about to begin. Note the date, time, site, parameter, and operators initials.
2. Assuming the test is conducted during daylight hours, and that the net radiation sensor is outputting a positive net radiation reading, place an object or material of sufficient density to block out light (i.e., a coat, jacket, trash bag) carefully over the top portion of the sensor to block out direct incoming solar radiation. Leave the downward facing portion of the sensor exposed.
3. Monitor the output of the net radiation sensor via the voltmeter and/or DAS readings. The voltage and net radiation readings should begin to decrease and in fact register negative values.
4. Next, hold a piece of insulating material below the downward-facing portion of the sensor. This will partially block out the long-wave radiation.
5. Monitor the output of the net radiation processor via the voltmeter and/or DAS readings. The voltage and net radiation readings should begin to increase and register a more positive value.

6. Third, carefully immerse the entire sensor into a small container of Styrofoam pellets so that both the upward and downward facing components of the sensor are insulated. This may not block out all long-wave radiation but will block out much of it temporarily.
7. When the voltage and DAS output have appeared to stabilize, record the voltage and DAS response. When completely shielded, the sensor should yield a net radiation reading of near 0.0 W/m^2.
8. Remove the covering material from the sensor and monitor the voltage and DAS responses. The responses should return to normal pre-test values after several minutes.
9. Note on the form that the sensor check has been completed. Note the date, time, site, parameter, and operators initials.
10. If the sensor fails to yield at least the proper trends in outputs for the above tests, or if it has been two years since the previous laboratory calibration of the sensor, return the sensor to the manufacturer for laboratory calibration against a transfer standard. When removing the sensor from its mounting, be sure to cover the mounting plate, connector plugs, and lead wires with protective material to prevent damage by dirt and/or rain.

7.5.7 Precipitation Gauge Field Check

The following procedures are used to perform a field calibration check on the precipitation measurement system. The checks are performed by simulating known precipitation amounts. Two different precipitation amounts are input into the system and are equivalent to 0.12 and 0.24 inches.

7.5.7.1 Calibration Equipment and Materials

The following equipment and materials are needed to perform a dynamic calibration check on the precipitation system.

- A certified digital voltmeter,
- 100 mll pipet,
- Distilled water, Calibration form MON-211 - "General Purpose Audit Form",
- Carpenter's level, and
- Two technicians

7.5.7.2 Sensor Calibration Check

1. To check the sensor mechanism, remove the debris screen and funnel from the bucket base. Do this by pulling the top portion of the bucket vertically upward.
2. Inspect the sensor for any clogged or broken tubing, or loose electrical connections. Also check that the collector bucket is level and that the internal tipping (toggle) bucket moves freely.

3. As a preliminary check of system operation and response, manually trip the tipping mechanism several times. Each tip should register a response equal to 0.01 inches of liquid precipitation. Thus, tripping the mechanism slowly 20 times should result in a reading of 0.2 inches of precipitation on the DAS. Once it confirmed that the tipping system per se is registering properly, proceed to Step 4 to ensure the system's proper response to known quantities of water entering the guage.
4. Before challenging the system with a known amount of water, carefully wet all the inside surfaces of the bucket. Disregard the readings on the DAS for this step of the procedure.
5. Using the 100 mlpipet and an exact 100 ml volume, measure out an amount of water equivalent to approximately 0.12 inches of precipitation. Refer to the manufacturer's instruction manual for the conversion of milliliters to inches of water for the rain guage in use.
6. VERY slowly, and without splashing, pour the measured water into the sensor bucket. While pouring the water, the technician should hear the tipping bucket switch "clicking" as it alternately fills with the water and pours out.
7. While this is being done, the second technician should record the DAS voltage and engineering unit response, and note these on the calibration form.
8. Repeat steps 5-7 for the second known amount of water (0.24 inches).
9. If any of the tests do not yield the correct responses, repeat the test. Occasionally, the collector bucket will "bounce" during a tip and cause the switch controlling the signal to respond more than once.
10. At the end of the audit, be sure that the collector bucket is level, there are not obstructions in the tubing, and all components have been properly re-installed.
11. Note the start and stop times of the field check on the calibration form.

7.5.8 Barometric Pressure Sensor Field Check

The barometric pressure measurement system is field checked simply by comparing the sensor output readings to reading obtained from a certified barometer. The system does not have to be altered or taken off line in order to perform this comparison. As part of the QA process, the sensor should be returned to the laboratory on a once-per-year basis for laboratory calibration and certification.

7.5.8.1 Calibration Equipment and Materials

The following equipment and materials are needed to complete an operational check of the Barometric Pressure measurement system.

- A certified digital voltmeter
- CR1000 keyboard display,

- A certified Reference barometer.
- Calibration form MON-211 - "General Purpose Audit Form",

7.5.8.2 Sensor Operation Check

1. The barometric sensor check is best accomplished by recording a series of comparative readings between the sensor output and the reference barometer during the course of the audit. Therefore, note on the calibration form the time that the audit began and ended, along with the times during the audit that comparative reading were taken. Note the date, time, site, parameter, and operators initials.
2. For each test, simply record the sensor output reading from the DAS and the corresponding pressure reading from the reference barometer. Note these readings on the form. Compute the absolute difference (in inches of mercury) between each set of readings. The difference should be less than 0.09 inches of mercury.
3. Note on the form that the barometric pressure sensor check has been completed. Note the date, time, site, parameter, and operators initials.
4. If the sensor fails to yield measurement differences from the reference barometer within stated limits, or if it has been two years since the previous laboratory calibration of the sensor, return the sensor to the manufacturer for laboratory calibration against a transfer standard. When removing the sensor from its mounting, be sure to cover the mounting plate, connector plugs, and lead wires with protective material to prevent damage by dirt and/or rain.

7.6 AUDIT RESULTS AND DOCUMENTATION

Document the results of all field activities and sensor calibration checks in a running log maintained by the audit crew. Make notes on specific calibration forms and in a field notebook where appropriate. Particular emphasis should be placed on logging the times that various components of the monitoring system are "off-line" for audit checking so that these periods of data can be removed from the program data base.

Prepare field data sheets of calibration results in duplicate. One set is left on-site and the second set is used by the auditors to document the results of the audit and to write a follow-up report. The results of performance audits on each individual sensor are compared to the limits of acceptability specified in **Section 7.4**.

Preliminary recommendations for the repair, replacement, or recalibration of any sensor failing to meet established limits, or for the disposition of data collected by that sensor, is formulated at the time of the audit. This is in the interest of taking immediate corrective action if warranted and possible.

Subsequently, a follow-up written report is prepared and submitted to the Air Monitoring Supervisor, the project file, and any other interested parties. The report documents all on-site activities, audit results and findings, final recommendations, and steps taken to correct any deficiencies or improve the system and/or operating procedures. The audit report should be distributed by the thirtieth day following the audit.

The final audit report includes descriptions of:

- Date and time of audit, conditions under which audit was performed, names and titles of field audit crew;
- Status of system upon arrival;
- Field calibration check results;
- Other systems audit and field activities;
- Status of system upon departure; and
- Conclusion and follow-up recommendations.

TABLE 7-1

HONEYWELL ONONDAGA LAKE
METEOROLOGICAL MONITORING PROGRAM
VANE ALIGNMENT POINTS

Wastebed 13 Monitoring Site

Alignment Point Identification		Azimuth Degrees
North/South (Cross Arm)	Tip:	000°
	Tail:	180°
Smith Hill Water Tank	Tip:	216°
	Tail:	036°
Lakeland Water Tank	Tip:	015°
	Tail:	195°

Lakeshore/Willis Ave Monitoring Site

Alignment Point Identification		Azimuth Degrees
North/South (Cross Arm)	Tip:	000°
	Tail:	180°
White Water Tower	Tip:	352°
	Tail:	172°
Blue Water Tower	Tip:	013°
	Tail:	193°
Radio Tower	Tip:	112°
	Tail:	292°
Trigen Stack	Tip:	249°
	Tail:	069°

TABLE 7-2

HONEYWELL ONONDAGA LAKE
METEOROLOGICAL MONITORING PROGRAM
SYNCHRONOUS MOTOR TEST POINTS

Horizontal Wind Speed

RPM Input	MPH
0	0
300	15.8
600	31.6
900	47.4
1200	63.1

Vertical Wind Speed

RPM Input	MPH
0	0
+300	4.2
-300	-4.2
+600	8.4
-600	-8.4

SECTION 8

DATA ACQUISITION SYSTEM OPERATING PROCEDURES

8.1 SYSTEM DESCRIPTION

8.1.1 General Description

The **Climatronics Model IMP-865** Data Acquisition Systems consists of a **CSI CR1000** datalogger with built-in analog to digital (A/D) capability, AirLink Model Raven 100 CDMA digital cellular modem, keyboard display unit, and LoggerNet software for web-enabled telecommunications and data review. The system is designed to serve as both a digital data acquisition and recording system, as well as a tool to assist field personnel and data processing staff in readily assessing the operating status, calibration results, and data outputs of the various monitoring systems.

The **CR1000** system scans all input channels at 1-second intervals, and logs both the incoming data signals and any attendant data flags. The instantaneous scan readings are converted to appropriate scientific units and used to compute time-based average values for all parameters corresponding to 5-minute, 15-minute (wind direction only), and 1-hour time periods. The wind direction scans are used to calculate 15-minute sigma-theta values, which in turn are used to calculate 1-hour sigma-theta values based on the four 15-minute values for each hour. The LoggerNet software includes several operating features such as sensor status and data-flagging functions, a tracking system for logging periods of power outages and missing data, and an operator message logging system. The system is typically equipped with an uninterruptible power supply source (UPS) that prevents downtime from short duration power outages. The systems on this program are run off a bank of batteries that are continuously being charged by solar panels, so an UPS is not required. Should power to the system be lost for any period of time, the system will automatically "reboot" itself following the power interruption.

In addition, the system controls the communication and flow of data to project personnel to facilitate the various operational and QA tasks associated with the long-term operation of field data collection programs. It is also anticipated that the system will control the communication and flow of data to all project team members and any third-parties as necessary to meet the overall needs of the project.

8.1.2 Basic CR1000 Features

Features of the two CR1000 systems used in this monitoring program include:

- 1-second scanning rate for all data channels;
- Calculation of 5-minute, 15-minute, hourly, and daily averages;
- Manual and automatic data-flagging routines;

- 5-minute and hourly vector computations based on individual scans for wind parameters;
- Output of 5-minute, hourly, and daily averages, including flag status and error messages, in several forms:
  - ASCII data files,
  - End-user work station via web-enabled feature of LoggerNet support software,
  - CCR1000 keyboard display unit,
  - Laptop computer in the field via LoggerNet support software;
- Laptop or keyboard display of the latest sensor scan values in engineering units (i.e., ppm, mph, °C, etc.);
- Automatic reboot feature following loss of power;
- Logs system errors to an error file;
- Internet access feature to view data collection in real-time.

8.1.3 Data Calculations for Meteorological Parameters

The **CR1000** calculations for the meteorological parameters measured on this monitoring program are described below. The CR1000 datalogger outputs values for both directly measured variables as well as parameters derived from these measurements.

Measured Variable	Output Parameters
Wind Speed	Scalar Wind Speed Vector Wind Speed
Wind Direction	Scalar Wind Direction Vector Wind Direction Sigma-Theta (5-min, 15-min, and 1-hour avgs.)
Vertical Wind Speed	Vertical Wind Speed Sigma-W
Temperature	Temperature Delta-Temperature
Relative Humidity	Relative Humidity Dew Point Temperature
Solar Radiation	Solar Radiation
Net Radiation	Net Radiation

Barometric Pressure	Barometric Pressure
Precipitation	Liquid Precipitation

To provide the designated output parameters, several types of data calculations are employed, including:

- Scalar averaging
- Vector averaging
- Standard deviation calculation
- Value totaling
- Value conversion

Time-based values corresponding to 5-minute, 15-minute, 1-hour, and 24-hour averaging periods are calculated on the basis of the individual scans for each measured parameter, as follows:

- 5-minute values are computed on the basis of three hundred (300) 1-second scan values in each 5-minute period,
- The 15-minute sigma-theta values are computed on the basis of nine hundred (900) 1-second scan values in each 15-minute period. An hourly sigma-theta value is then calculated from the four 15-minute values,
- One-hour values are separately computed on the basis of thirty-six hundred (3,600) 1-second scans in each hourly period,
- Daily averages (24-hour average) are computed as the average of the twenty-four (24) 1-hour values for each parameter. The daily average values are computed on a midnight-to-midnight basis (i.e., 0000-2359 EST).

Time-based values may be calculated on the basis of fewer scans per period as a function of the defined manual and automatic data flagging routines.

Data calculations are based on the scans of voltage or other electrical signal inputs corresponding to the measurement range of each meteorological sensor. A summary of the measurement ranges corresponding to the 0-5 volt range for each sensor type employed is as follows:

Wind Speed	0-125 mph
Wind Direction	0-360°
Vertical Wind Speed	-25 to 25 mph
Temperature	-22° to +122°F

Relative Humidity	0 to 100 %
Solar Radiation	0 to 2000 W/m^2
Net Radiation	-2000 to 2000 W/m^2
Barometric Pressure	23.62 to 32.48 inches Hg
Precipitation	0 to 1 inch

The initial step in all subsequent calculations is to convert the electrical signal input to appropriate scientific units for each measured variable. For example, for a linear voltage range the calculation is as follows:

$$y_{eu} = (y_v \text{ x } r_{eu}/r_v) + 1_{eu}$$

where:
- y_{eu} is the sensor output in engineering units
- y_v is the sensor output volts
- r_{eu} is the sensor measurement range in engineering units
- r_v is the sensor measurement range in volts
- 1_{eu} is the sensor's lowest measurable value in engineering units

Once the electrical signal scan is converted, all subsequent data calculations are based on the individual sensor scan values in engineering units. For 5-minute calculations, all scan values are used regardless of flag status. For hourly calculations, only non-flagged scan values are used. In the event all scan values are flagged during the hour, however, the hourly calculations are based on the flagged values, and the flag is appended to that value.

Simple **scalar averaging** is employed for calculations of scalar wind speed, temperature, relative humidity, solar/net radiation, and barometric pressure.

The following equation is used for scalar averaging:

$$Y_{avg} = \frac{1}{n}\sum_{i=1}^{n} Y_{eu}$$

where:
- Y_{avg} is the scalar average value
- Y_{eu} is the sensor output in engineering units
- n is the number of scans made during the averaging period

Vector averaging is employed for wind direction calculations. In order to account for wind direction's circular range, **scalar average wind direction values** are actually calculated as unit vector averages. The individual wind direction values ($\emptyset_i$) are first resolved into north-south and east-west components by taking the sine and cosine of each reading. The resulting net direction is derived by taking the arctangent of the sum of the sine values divided by the sum of the cosine values, as follows:

$$scalar\ WD = ARCTAN\left(\frac{-\frac{1}{n}\sum_{i=1}^{n}\sin\emptyset_i}{-\frac{1}{n}\sum_{i=1}^{n}\cos\emptyset_i}\right)$$

where: $\emptyset_i$ represents the individual wind direction sensor output readings in degrees

Similar to the scalar wind direction computations, **vector wind directions** are also computed by resolving the individual wind direction readings into north-south and east-west components, but for vector wind direction, the individual direction readings are weighted by speed, as follows:

$$vector\ WD = ARCTAN\left(\frac{-\frac{1}{n}\sum_{i=1}^{n}u_i\sin\emptyset_i}{-\frac{1}{n}\sum_{i=1}^{n}u_i\cos\emptyset_i}\right)$$

where: $\emptyset_i$ represents the individual wind direction readings in degrees, and

u_i represents the individual wind speed sensor outputs in mph

Vector wind speed is calculated from the same summed wind components as follows:

$$vector\ WS\ = \left[\frac{1}{n}\left(\sum_{i=1}^{n}u_i\sin\emptyset_i\right)^2 + \left(\sum_{i=1}^{n}u_i\cos\emptyset_i\right)^2\right]^{\frac{1}{2}}$$

Standard deviation calculations are employed to compute sigma-theta (i.e., the standard deviation of the horizontal wind direction) and sigma-W (i.e., the standard deviation of the vertical wind speed). Sigma-theta is defined with respect to the mean scalar wind direction and is calculated at the end of each 5-minute, 15-minute, and hourly averaging period by the following steps:

- For each individual wind direction reading, determine the difference from the mean scalar wind direction:

$diff_i = \emptyset_i - \emptyset$

if $diff_i > 180°$, $diff_i = diff_i - 360°$

if $diff_i < -180°$, $diff_i = diff_i + 360°$

- calculate sigma-theta:

$$Sigma - Theta = \sqrt{\left(\frac{\sum_{i=1}^{n}(diffi)^2}{n-1}\right)}$$

The same procedure is used to compute sigma-W, which is defined with respect to the mean vertical wind speed and is calculated at the end of each 5-minute and hourly averaging period.

The 15-minute sigma-theta is calculated using the above equation, but the hourly average using the four 15-minute sigma-theta values is calculated as:

$$Hourly\ Sigma - Theta = \sqrt{\frac{Sigma_1{}^2 + Sigma_2{}^2 + Sigma_3{}^2 + Sigma_4{}^2}{4}}$$

All wind parameters are output and archived by the system as calculated above. There are no provisions for converting and specifically listing any measured values as CALM or VARIABLE wind readings. The state of the wind for any averaging period is adequately described by the combination of vector and scalar direction and speed values plus sigma-theta. If necessary, conversions to CALM or VARIABLE readings based on specific sets of criteria can be made during post-processing of the data.

A totaling function is used to compute 5-minute and hourly precipitation totals.

8.2 SYSTEM OPERATIONS

8.2.1 System Start-up

The **CR1000** datalogger comes pre-installed in the NEMA enclosure as part of the meteorological system. To start up the **CR1000**, all that is required is to ensure that a valid station-specific datalogger program has been uploaded to the unit, that all sensors output signal wires are connected to the correct channels (refer to **Table 3.1** in **Section 3.2.3**) and that all cable connections are secure before providing a 12V DC power source to connect to the Power In terminals. The CR1000 operates on DC power only. It will begin collecting data as soon as the power connection is made.

The datalogger support software (**LoggerNet Version 3.1.5**) comes on a CD and is licensed software that needs to be used under the terms and conditions of the License Agreement. The recommended minimum requirements for LoggerNet are:

- 300 MHz Pentium II processor
- Windows® NT®, 2000®, or XP®
- 64 megabytes of RAM

- 800x600 screen resolution
- TCP/IP support installed
- 50 MB hard drive space for installation of program files
- 25 MB hard drive space for default log files

To install the LoggerNet support software and connect to the CR1000 datalogger, perform the following steps:

- Insert CD into the CD-ROM drive and use the Run command to run D:\Setup.exe off of the CD (where D = CD ROM Drive)
- Follow the set-up instructions until the program installation is complete. When complete, a Loggernet icon (shortcut to program) will exist on your PC's desk top.
- Double click on the LoggerNet icon for the program to open. When it opens, it will be in the form of a "tool bar" that can be positioned anywhere on your computer screen.
- Select the EZSetup button on the far left of the program bar or the Setup button next to it (second button from the left). The EZSetup button activates a setup wizard that guides you step by step through a process for providing the basic (minimal) information needed to be able to connect to a CR1000 datalogger for downloading and viewing data. In contrast, the regular Setup button does not have a step by step process to follow. It brings you to a setup screen that allows the user to add and delete devices and setup datalogger networks. Once one or more devices are added, they are displayed graphically via a "directory structure". Clicking on any part of the structure will open a window with a series of screens that allows you setup or change the setting for that particular device. If the user is not familiar with a CR1000 data logger, associated hardware devices, and Loggernet software, it is better to use the EZSetup button to connect to a datalogger for the first time.
- Using the EZSetup wizard, select the datalogger type (CR1000 for this program) you want to connect to and name it.
- Select the type of communication that will be used for connecting to each station's datalogger. Use "IP Port" for web-enabled communications or "Phone Modem" if a dial-up routine will be used to connect to the datalogger. The IP Port option requires that the datalogger be attached to a TCP/IP serial server interface device that is assigned a fixed IP address. This is the option to use for this program (each station has a cellular modem attached to the datalogger). There is also a direct connect option that can be used when bringing a laptop to the station. The direct connect option uses an RS-232 connection between the datalogger and laptop.
- For the IP Port option, provide the internet IP address and the port number to which the datalogger is connected.
- Enter the following datalogger setting information: Baud Rate (select 9600), PakBus Address (select 1), Security Code and Extra Response Time. The baud rate and

PakBus address selections are required, while no selection is actually needed for the other settings at the time of initial set-up.

- The next step in the EZSetup wizard allows you to test the communications with the datalogger. The test must be successful for communications to work properly. Proceeding with successfully checking the communications will also allow you to complete the last four steps of the EZSetup wizard.
- The last four steps of the EZSetup wizard should only be performed by authorized personnel responsible for installation and start-up of the meteorological monitoring station. These four steps are:
  - Setting the datalogger date and time and synchronizing them (or not) with the date/time of the computer running the LoggerNet software,
  - Uploading a compiled program to the datalogger (the program instructs the data logger on what and how to measure the incoming sensor signals and the building of data tables within the unit),
  - Selecting datalogger table output file names and protocols, and
  - Scheduling automatic data collection and download routines.

8.2.2 Use of Keyboard Display Unit

The keyboard display unit is a handheld device that a technician can bring to the site and connect to the CR1000 data logger to review the system status and data values. It should routinely be used during all site visits to the monitoring stations.

Use of the device is described in detail in the CR1000 Overview chapter (Section OV5) of the CR1000 Operator's manual. Please refer to the CR1000 Operator's Manual for illustrations on the various uses of the device.

8.2.3 Data Retrieval In the Field

Data retrieval at the station is accomplished by direct connection of a laptop computer to the CR1000 via the RS232 port. The laptop computer must be loaded with the LoggerNet support software to initiate the download. Follow these steps:

1. Start the LoggerNet program by double clicking on the desktop icon.
2. Select the "Connect" button which opens up the connect screen
3. On the left side of the window, select the station you are at and the connect button at the bottom (at this point the program will automatically identify the device it is connecting to, check its status, and notify the user that the connection has been made).
4. Select the "Collect Now" button. This initiates a download of all predefined data tables starting at the point in time when the last download ended. An "end of download" window will pop up at the completion of the download. This can be clicked off when it appears.

5. Select the "Disconnect" button.
6. Physically disconnect the RS232 connection between the datalogger and the laptop.

There is no reason to delete any data files on the datalogger as the internal memory is recycled continuously and automatically. As new data is recorded and added to the data files, the oldest data is truncated if memory space is needed.

8.2.4 Remote Communications and Data Downloads

The following procedures enable communications with the CR1000 datalogger from a remote computer over the internet. The remote communications capability allows for viewing of data in real time, viewing of archived data, and downloading data files.

Remote data download is the routine procedure for accessing and retrieving data on an ongoing basis. Twice weekly form the Boston office, each station is accessed via the internet through use of the LoggerNet support software. The following steps are used:

1. Start the LoggerNet program by double clicking on the desktop icon.
2. Select the "Connect" button which opens up the connect screen
3. On the left side of the window, select the station you wish to connect to and then select the connect button at the bottom (at this point the program will automatically identify the device it is connecting to, check its status, and notify the user that the connection has been made).
4. Select the "Collect Now" button. This initiates a download of all predefined data tables starting at the point in time when the last download ended. An "end of download" window will pop up at the completion of the download. This can be clicked off when it appears.
5. Select the "Disconnect" button.
6. Close the "Connect" window.

There is no reason to delete any data files on the datalogger as the internal memory is recycled continuously and automatically. As new data is recorded and added to the data files, the oldest data is truncated if memory space is needed.

8.2.5 Date/Time Corrections

The **CR1000** system must be kept on Local Standard Time (EST for New York) at all times. In the event the system date and/or time are incorrect (outside of +/- 5 minutes), perform the following steps:

1. Start the LoggerNet program by double clicking on the desktop icon.
2. Select the "Connect" button which opens up the connect screen

3. On the left side of the window, select the station you wish to connect to and then select the connect button at the bottom (at this point the program will automatically connect to the station).
4. On the right side of the Connect window the current station and server (the server is the computer running LoggerNet) date/time are displayed and there are two options directly below for either checking or changing the date/time of the station's clock or the server clock.
5. Select the "Set Station's Clock" button to change the time to the true local time in EST. Do not assume that the server time is correct. Follow the on-screen instructions.
6. Select the "Disconnect" button.
7. Close the "connect" window.
8. Log the date and time of the system time correction on the Real-Time Data Review Status Check sheet/log.

Note: This procedure can also be performed in the field with either a direct datalogger connection to a laptop running LoggerNet or via the keyboard display unit. Once a connection between the laptop and datalogger is made (refer to Section 8.2.3) follow the same steps as shown above.

8.3 ROUTINE OPERATOR CHECKLIST

The following checklist describes the procedures that the technician should follow each time the site is visited to ensure error-free operation of the CR1000 datalogger system:

1. Verify that the datalogger power on indicator light is on.
2. Verify that the cellular modem transmitter light is on and blinking.
3. Check the connection between the datalogger and modem to ensure that it is secure.
4. Check that the sensor signal wiring to the datalogger is intact and secure.
5. Connect the keyboard display unit to the datalogger and confirm that display is showing the correct datalogger program name for the station.
6. Check that the date and time being displayed are correct. If not, the procedure for changing date/time as shown above in Section 8.2.5 will need to be followed to correct this situation.
7. Perform the following before leaving:
   - Verify that the system is scanning the input channels and recording data (this is accomplished by watching the instantaneous readings fluctuate on the keyboard display unit and the 5-minute averages get updated).
   - Check the keyboard display STATUS window to see if any manual flags may have been left on unintentionally.

- Disconnect the keyboard display unit.
- Close and secure the NEMA enclosure door.

SECTION 9.0

DATA PROCESSING, VALIDATION, AND REPORTING

9.1 DATA RETRIEVAL FROM THE FIELD

On a routine basis, data from the monitoring program is downloaded electronically by a project meteorologist and compiled in the Boston Office of Parsons. However, the overall data retrieval necessary for processing, 4-level validation (Levels 0 – 3), and reporting of the data includes the actual data as monitored by the DAS, as well as all supporting and relevant data collection materials, including field data forms and notes, calibration/maintenance forms, support documentation, and any other information describing the operating and calibration status of all equipment components during the period (for Level 0 – 1 validation) . The data and support materials are then reviewed before proceeding with the formal data processing, Level 2 and 3 validation, and reporting activities.

The digital data records from each station's datalogger are routinely retrieved and downloaded by the project meteorologist via the web-enabled cellular-based telecommunications system. This will be done at least twice per week, and sometimes more often. Any hardcopy field records and documentation are retrieved from the site by the field personnel so that all original records become part of the project file. On a day-to-day working basis, field data sheets and documentation forms may be sent as ".pdf" files to help expedite the data processing effort.

9.1.1 Frequency

Electronic downloads of data stored in the on-site DAS will be accomplished on at least a twice weekly basis.

Other materials and records describing field operations and calibration activities will be routinely retrieved by the field staff and submitted to the project meteorologist on a minimum once per month basis e.g., (after the last day of each month). Each submittal includes all the field notes, calibration forms, and other operational notes generated subsequent to the previous submittal. The end of the month retrieval should be performed on the first practical day of the next month. For example, March data should be retrieved on the first practical day in April. This data retrieval schedule ensures that all information relevant to data through the final hour (2400) of the last day of each month is acquired on a timely basis.

9.1.2 Ongoing Field Validation Procedures

Many of the ongoing field procedures discussed in earlier sections are important in the 4-level data validation process. Therefore, the first step for the field personnel is to ensure that all of the requirements for documentation and calibration checks are accomplished on a routine basis, because attempts to back-track and compile operations data after the fact are typically inaccurate and, very often, impossible. Briefly, the field personnel ensure that the following items are complete and included in each data submittal:

- Calibration sequences have been reviewed and identified on the appropriate forms and in field notes;
- All field data forms are complete, legible, and accurate and cover the entire data period being submitted;
- All calibration and maintenance information is complete, legible, and accurate and covers the entire period to be submitted.

9.1.3 The Field Submittal Package

For each submittal, the technician or appropriate field personnel collects all information and data relevant to the monitoring period being retrieved. A check list for materials to be collected at the site includes:

- All log notes for the monitoring period;
- All calibration information for the monitoring period; and
- Any other support documentation regarding operations and maintenance activities.
- Any updated Site Inventory Forms

Once all information collected, it is reviewed to ensure that the package is complete and accurate. A completed Shipping Log is created that accompanies the data submittal to Parsons. Before the data are removed from the site, the person to whom the data are being sent is documented in field notes or in a shipping/receiving log in accordance with the Chain-of-Custody procedures described in Section 6.0..

9.2 INITIAL DATA REVIEW

Immediately following receipt of all data and supporting field operations and calibration information, the project meteorologist performs an initial review to identify specific periods for which data are obviously erroneous and must be removed from the final data base. Data values monitored during calibration sequences, maintenance periods, or other periods of obvious instrument malfunctions are also identified during this preliminary review to save time during the more intensive quality assurance review of the final data report. The periods of data identified are noted, along with the reason why values are missing for any given parameter or group of parameters.

9.2.1 Data Record

At the beginning of each data processing period (e.g., monthly), a data record is initiated which tracks the flow of data through the entire data processing, validation, and reporting process. This record provides enough space for notes to document and explain any revisions made as the data passes through the validation process. There are designated locations where each person involved in the process can note and sign off on specific steps taken in creating the final data base. The data record includes space for a final sign-off by the data validation personnel and Air Monitoring Supervisor signifying that the data have been fully validated and reported. It is the intent of such a report to summarize in one place all staff activities and modifications to the data base applied in creating the final report.

9.2.2 Raw Data Files

In addition to the basic hourly data files, which will be used to develop the master program data base, the raw downloaded files of 5-minute values will also be reviewed as part of the data validation process.

The project meteorologist will review the shorter term values to ensure that trends in the values of recorded parameters are consistent with expectations for a given weather situation or pattern. Also, for periods of questionable or missing data, the review of short-term values may provide additional indications of the time and cause of any problems.

The raw data files will be retained in the data base for a period of 24 months, after which they will be transferred to back-up storage media for long term storage.

9.3 DATA REDUCTION

The raw data collected via the sensory equipment in the field site must typically be reduced from monitoring units (e.g., voltages, frequency counts, etc)) and converted to standard time-based reporting units and format. This procedure is accomplished primarily by the on-site DAS. The DAS is programmed to perform time-based data averaging, convert each parameter into the appropriate engineering units, and store the resulting data values for follow-up download and reporting. The system has been designed with the most sophisticated and reliable equipment available for use at a remote site with no power. There are no back-up strip recorders to serve as a secondary means of recording and reducing the field data.

The basic data elements for most air quality and meteorological data collection and reporting programs are the 1-hour average values for continuously measured parameters. On this program, the meteorological data are also averaged on-site over 5-minute periods although these values are not routinely subject to any further processing. They are principally examined as part of the on-site QA and office data validation process. Fifteen minute averages of wind direction are also computed but only used in the calculation of sigma-theta (they are not saved). It is the 1-hour averages that are subsequently used to formulate other time-based values, such as 3-hour, 24-hour, monthly, and annual average values.

A minimum of 30 minutes of meteorological data is required to formulate a valid hourly average. The DAS is programmed to flag any hourly values not meeting this requirements.

9.3.1 Data Resolution

The accuracy of reported data is no greater than the resolution of the measurement and recording systems. The reporting resolution of each measured parameter for this program is as follows:

Parameter	Number of Decimal Places	Example
Wind Direction (degrees)	0	275°
Wind Speed (mph)	1	14.5 mph
Vertical Wind Speed (mph)	2	0.45 mph
Temperature (°F)	1	67.8°F
Delta-Temperature	2	1.23 F degrees
Relative Humidity	0	72%
Net Radiation	2	30.45 W/m^2
Barometric Pressure	2	29.92 inches Hg
Precipitation	2	4.56 inches

Calculated parameters may be reported to higher degrees of resolution consistent with calculation schemes, ranges of resultant variables, and USEPA guidelines as follows:

Parameter	Number of Decimal Places	Example
Sigma-Theta	1	28.4°
Sigma-W	2	0.12 mph
Sigma-Phi	1	7.2 °
Dew Point	1	56.7°F

9.3.2 Digital Data Reduction

Depending on the type, capacity, and sophistication of the hardware and software components, a digital data acquisition system's data reduction functions can vary from simple averaging to on-line processing, scaling, calibration, error checking, report generation, and archiving. These systems are also used to digitally compute additional parameters from the measured data signals such as vector wind direction values and standard deviation of horizontal and vertical wind measurements (i.e., sigma-theta, sigma-w, and sigma-phi).

Digital data reduction generally involves programming the computer system to:

1. Scan each incoming data and/or status channel at regular intervals. Preferred scanning rates are anywhere from 1 to 30 seconds for air quality parameters and 1 to 5 seconds for meteorological parameters. The CR1000 data logger uses a 1 second scanning frequency.

2. Convert sensor output signals to digital form.
3. Store the individual values collected over a 1-hour period and formulate the hourly average at the end of each hour. This is done by converting each individual sensor signal (e.g., voltage, count, etc.) to appropriate engineering units, storing the converted values and computing the average value at the end of the hour.
4. Reject from the hourly averaging process any data signals received when the status channel indicates an instrument is in a calibration or maintenance mode. Calibration signals may be logged separately and similarly averaged to automatically develop and record zero and span calibration results.

The DAS data acquisition system employed on this meteorological monitoring program performs these functions.

As part of the data reduction process, the digitally derived data values are re-checked to ensure that the system is performing these calculations correctly, and that the averages generated are representative of actual monitored conditions.

Meteorological measurements reduced via a digital system are enhanced through computations of vector-averaged, in addition to, scalar-averaged wind direction and speed, plus sigma-theta. These values are particularly useful in assessing transport and dispersion patterns in air quality-related monitoring applications. The values represent a convenient way to obtain meaningful wind speed and direction values for light and/or variable wind conditions. Vector wind computations also overcome some of the potential problems in reducing wind data such as "crossovers" and overlapping scales.

On this program, hourly vector wind parameters, sigma-theta, and sigma-W are computed on-site by the CR1000 datalogger.

9.3.3 Missing Data

In reducing data, it is best to develop a data file that has an entry for each and every hour and parameter, including coded entries for any missing or invalid data points. This is to ensure that each hour is fully accounted for and to prevent data from one period being inadvertently coded or shifted into file positions left blank due to missing data from another period. In addition, it is helpful to distinguish between data missing or deleted due to scheduled calibration and maintenance activities versus data that are missing or deleted due to component malfunctions or power outages.

Coding formats for missing data flags can be compatible with those for actual data, but should be comprised of pre-defined values or values outside the normal range of measurement. For example, a coding scheme of "99XX" fields offer easily recognizable values to flag missing data.

Once the file of reduced hourly averaged data is established, it is subjected to the calibration adjustment and data validation procedures described in the following sections. In practice, calibration adjustments are infrequently used.

9.4 DATA PROCESSING

The data processing of air quality and meteorological data is carried out by Parsons using our AIRDAT III Data Base Management, Analysis, and Reporting System.

AIRDAT III is a generic, modular program that is used to process, validate, analyze, report, and archive data from aerometric monitoring programs. It includes several different processing, reporting and statistical analysis routines, and outputs a series of standard data listings, summaries, and reports.

Detailed procedures for entering field data, executing AIRDAT III, and generating data listings and reports are contained in Parson' in-house AIRDAT III Program Documentation and User's Guide.

9.4.1 Data Base Management

In order to use aerometric monitoring data in dispersion modeling activities, to submit data reports internally or to government agencies in varying formats, or to generate specialized analyses and summary reports, it is necessary to employ some type of master computerized data base. AIRDAT III serves this function, and includes software that is used to:

- Create and manipulate a monitoring program data base; and
- Create readable reports or data subsets from the master data base.

Specifically, the data base management software for creating and manipulating the data base, is designed to perform the following tasks:

- Create a data base;
- Input data from formatted on-line telemetry, disk, or card-image files;
- Incorporate and apply calibration adjustment factors to specific parameters, sites, and time periods;
- Add, delete, or modify data values for specific parameters, sites, and time periods; and
- Compute calculated parameters, such as daily resultant wind speed and direction, or sigma phi.

The software used for creating data reports and subsets is used to:

- Generate daily, monthly, and cumulative summaries for specific parameters and sites;
- Generate monthly coded reports, such as AIRS files, acceptable for submittal to government agencies; and

- Create data subsets for use as input files in dispersion models or for special analytical routines.

In creating the data base, each parameter is assigned a unique format and identification code that identifies the day, date, time, and location of the measurement as well as the type of measurement and its location in the data file. Special codes (e.g., “S” or “N”) are set up to identify missing data, and designate whether data are missing as a result of "scheduled" outages (e.g., calibrations) or "non-scheduled" outages (e.g., power and equipment failures). Normally, the basic data element processed is the 1-hour average for continuously measured parameters and 24-hour averages for non-continuous parameters (i.e., particulate). Other data base parameters may be computed as part of the processing activity, such as using hourly wind speed and direction values to compute a daily resultant wind vector. Data are generally processed and stored in calendar month blocks.

Other than appropriate data base changes to apply calibration adjustment factors, edit values in or out, or to calculate additional parameters, no adjustments are made to empirically change or otherwise re-classify individual data values. For example, a standard convention used in dispersion modeling activities is that wind speed values less than 1.0 meter per second (2.24 mph) are set to equal 1.0 meter per second. Similarly, wind speed values less than the sensor starting threshold are considered as "calm" and set to equal 1.0 meter per second. In the AIRDAT III data base management system, all values are stored, processed, reported, and archived as directly measured. For any subsequent analysis activity or use of the data that requires such empirical re-classification, the adjustments are made as part of that subsequent activity, e.g., during pre-processing of data files for input to sequential dispersion models.

9.4.2 Data Input Schemes

Field data are input into the data base from the files stored in, directly downloaded from, the on-site DAS.

9.4.3 Application of Calibration Factors

Once the data has been put into the data base, there is often a need to adjust specific parameters. The calibration equation used by AIRDAT III is:

$$\text{calculated value} = \frac{(\text{span in - zero in})}{(\text{span out - zero out})} \text{ x (raw value - zero out) + zero in}$$

where: calculated value is the adjusted raw data value

span in is the known or expected calibration span (i.e., upscale) value

span out is the actual calibration span response

zero in is the known or expected calibration “zero” value

zero out is the actual calibration “zero” response

raw value is the raw data value being adjusted

9.4.4 Data Editing

Once the data is in the data base, the data base management system is used to edit the file to correct missing or bad values. Also, the special codes used in the data base to signify data missing due to "scheduled" reasons (maintenance) or due to "unscheduled" problems (such as power or equipment failures) are assigned and entered at this point. Finally, any data values that were initially in the file, but subsequently determined to be invalid, are deleted and replaced with one of the missing value codes.

9.4.5 Special Calculations

Finally, the data base management software is used to sort data or compute calculated parameters, such as means, extremes, daily resultant wind information, high and second-high air quality values, and data recovery rates.

Data recovery rates are computed two ways. A recovery rate "based on all hours" essentially defines the data base relative to the total amount of time in the monitoring period. The recovery rate "based on operating schedule" is a measure of data collection performance. It is the percentage of data collected relative to the actual amount that could have been collected that accounts for a certain amount of scheduled downtime for required calibration and scheduled preventive maintenance.

9.4.6 Report Generation

Once the data base is finalized, the report generator is used to:

- generate daily, monthly, and cumulative summaries of specific parameters and sites;
- generate monthly coded reports, such as AIRS files acceptable for submittal to government agencies;
- analyze specific parameters to produce printed and graphical reports; and
- generate formatted data subsets for input files in dispersion modeling.

In addition to printed AIRS reports, these reports are output to CD or diskette for submittal of client data to the regulatory agencies. Other reports, analytical summaries, and graphics products are developed as on-going program needs dictate. The final product prepared is a data base that can be suitably reformatted to support an air quality impact assessment or for use as model input.

9.5 LEVEL 2 AND 3 DATA VALIDATION ELEMENTS

9.5.1 Data Screening Checks

A key first step in the data validation process is to "screen" the digitally recorded data (e.g., compare the measured value with some expected value or range of values). Screening the data will help identify out-of-range data values and physically impossible data values. The screening process is accomplished automatically through the use of the AIRDAT III Data Base Management System as well as manually by data validation personnel.

The end result of the screening process is the identification and flagging of certain data values for subsequent investigation. Air quality data values will be screened primarily on the basis of whether they fall within the measurement range of the system or whether elevated values persist for long periods of time. For meteorological parameters, data values will be flagged according to the following criteria. Flag the data if the value of:

Parameter:	**Screening Criteria:**
Wind Speed	- is less than 0.6 mph or greater than 56 mph - does not vary by more than 0.2 mph for 3 consecutive hours - does not vary by more than 1.1 mph for 12 consecutive hours - exceeds the measurement range
Wind Direction	- is negative or greater than 360 degrees - does not vary by more than 1 degree for more than 3 consecutive hours - does not vary by more than 10 degrees for 18 consecutive hours - exceeds the measurement range
Vertical Wind Speed	- is greater than 5 mph or less than -5 mph - is 0.0 mph for more than four hours
Temperature	- exceeds the measurement range - is greater than a 9°F change from the previous hour - does not vary by more than 0.9°F for 12 consecutive hours
Delta-Temperature	- exceeds the measurement range - is greater than 10°F or less than -5°F - changes sign twice in three hours
Relative Humidity	- varies widely or erratically over short time periods
Solar Radiation	- is greater than zero at night - is greater than the maximum possible for the date and latitude
Precipitation	- is greater than 1 inch in one hour - is greater than 4 inches in 24 hours - is less than 2 inches in three months
Barometric Pressure	- varies widely or erratically over short time periods

Note: All the above values can be adjusted based on local climate based on the judgment of the project meteorologist.

9.5.2 Calibration Review

Another step in the data validation process is to review the routine sensor calibration checks and the meteorological field calibration results. This is to verify the accuracy and precision of the data base and to develop appropriate calibration factors needed to adjust the data. The person applying these factors should be familiar with the field operation of the equipment, but is not necessarily involved with the actual hands-on maintenance of the system. During this process the data base is reviewed again for potential problems and invalid data.

9.5.3 Auto-Calibration Review (For Monitoring Systems with this Feature)

The next step in the data validation process is to compile a listing of all zero and span responses from the daily auto calibration sequences (if this feature is being used). Once the list has been completed, review the zero responses and note the following:

- Trends in the zero responses, which indicates a monitoring system's baseline drift from electronic "noise" in the system. Some positive and negative drift can be expected but it should not exceed ± 1.0 % of the system's full scale range (i.e., upper measurement limit). Excessive zero drift indicates a problem in the monitoring system. Excessive negative zero drift could take a period of data outside adjustable limits causing a loss in data recovery.
- Abrupt changes in the zero responses. Sudden positive or negative changes in the zero response could indicate the beginning of an instrument malfunction.
- An absence of auto-calibration zero responses. If there is no zero or span response for an expected auto-calibration sequence, it signifies a problem with the on-site calibration system.
- Erratic zero responses. Zero responses that demonstrate an erratic trace could be influenced by an interference in the system and could be inaccurate.
- Elevated zero responses suggest that a problem could exist whereby a true "zero" test input is not occurring. The cause must be checked and corrected.

The same checks as listed above for the auto-calibration zero results also need to be made with respect to the span responses. Noticeable variations in the daily span responses could signify potential problems with the monitoring system. All problems noted in this auto-calibration results evaluation routine are brought to the attention of the QA Field Support Coordinator or Air Monitoring Supervisor so the proper corrective action can be implemented.

9.5.4 Documentation Review

All field notes and field calibration sheets are similarly reviewed for indications of potential equipment problems that could affect the data, and a determination made whether any such conditions should be corrected. During this review, all the information and the computations listed in the field documentation are re-checked for accuracy before applying any calibration factors to raw data values in the data base.

9.5.5 Development of Data Correction Factors

Data correction factors are not absolutely required unless calibration results are more than 10-15% out of limit. However, it is good practice to routinely generate a final data base that is as accurate and as representative as possible of actual conditions. This consistency promotes more reliable comparisons of data from one time frame to another and presents a stronger basis on which to perform detailed data analysis and make sound decisions.

Correction factors are used to scale a raw data point up or down by an appropriate percentage, or adjust each value by adding or subtracting a fixed amount to more accurately reflect the true value. For example, if a wind speed measuring system is found to be reading 10 % low at several points over the range of the sensor, then the raw output values are adjusted upward by multiplying each individual by a factor of 1.1. Similarly, if a wind direction measuring system is found to be out of alignment (e.g., sensor or crossarm misaligned) by 015° and all wind direction readings are 015° "too clockwise," then the raw output values are readjusted by subtracting 015° from each individual value. Recognize that a special test is required for near-zero wind direction readings (i.e., if reading minus 015° is less than zero, then add 360° to result. Example: 010°-015° = -005° + 360° = 355°).

Any calibration factors needed to adjust meteorological data values are derived from the routine sensor field calibration checks, and laboratory or wind tunnel calibration results. Electronic calibration checks are only used to control electronic drift in the system's output; all other correction factors are determined from the results of sensory calibrations. To apply calibration factors to meteorological data values, the following steps are to be followed:

- Convert all calibration test inputs and output responses to the engineering or raw data units being used in the data base (e.g., degrees, volts, chart units, etc.).
- Develop a linear regression of the form y = mx + b between the test input values (x) and instrument output responses (y) where:

  x = test input value

  y = test output response

  m = calibration slope

  b = calibration intercept
- Once this information has been developed, the regression equation is transformed to

$$x = \frac{y - b}{m}$$

for use with the actual data in order to compute the adjusted input measurements based on recorded outputs where:

x = adjusted data value

y = observed output

m = calibration slope

b = calibration intercept

- This approach is suitable where there are sufficient calibration data points to develop a valid regression and/or where any calibration errors can safely be assumed to be linear over the instruments' measurement range. Other measures are taken on a case-by-case basis to attempt to adjust data values where calibration results indicate a non-linear or non-standard error.
- These correction factors are used until the next calibration. If an adjustment is made during the calibration, two calibration regressions are developed, one for the instrument responses before adjustments and another for the responses after adjustments. The calibration regression prior to the adjustment is used only to correct any data measured before the calibration sequence, while the calibration regression after the adjustment is applied to data measured after the calibration sequence.
- Adjustments for any sensor zero drift are made by incorporating the zero response from each calibration sequence into the above equation. This does not significantly change the most current calibration correction factor.

9.6 QUALITY ASSURANCE REVIEW

The quality assurance review of the data base is the final step before the data is reported. It is a subjective overall interpretation and assessment of the monitoring conditions, instrument performance, and calibration results and validity of the final data base. The persons responsible for the quality assurance review of the data should be familiar with all aspects of the monitoring operations and capable of interpreting the many variables that affect the data. The task is generally performed by a senior air quality meteorologist.

The final quality assurance review of the data base should verify that the data is reasonably representative of actual conditions. This is a subjective interpretation of the data and applies the reviewer's familiarity with the monitoring system and the parameters being examined. With experience, one is able to determine when a component may be malfunctioning by noting conditions or values that are not typical of the parameter being measured. For example, temperatures are generally expected to rise during daylight hours and fall in the evening. Air pollutants should be expected to increase and decrease as the activities from local air emission sources and wind directions change. Even day-to-day trends should become predictable as experience with the system and data assessment increases. Other data sources such as weather maps and measurements from other nearby sites can also be helpful tools during this final subjective review of the data.

9.7 DATA REPORTING

Once the data has been verified as being accurate, it is structured into the final reporting format and all data validation documentation is signed off. The final data report, along with a detailed description of the data collection and validation activities, is turned over to the Air Monitoring Supervisor. One copy of the data report is given to all parties on the distribution list. A minimum of two copies are kept as file copies. A copy of the final report and a summary of all data notes are provided to field personnel, and all problems brought to their attention so that corrective action can be taken.

The Air Monitoring Supervisor is responsible for submitting the final report and supplemental information to the client, governmental agencies, and the appropriate interoffice personnel.

SECTION 10

FORMS DESCRIPTIONS

Proper execution and documentation of program operations and quality assurance procedures are manifested in the entries made on each of the forms routinely filled out for all aspects of the project. Entries on various status, log, and calibration sheets provide a day-to-day documentation and, ultimately, the history of equipment operation, performance, and maintenance performed. Specific entries are made that enable the field technicians and other project personnel to track the operating status of the equipment and assess the accuracy and validity of collected data.

To the extent possible, the execution and documentation phases of meteorological program operations and quality assurance activities are distilled into a series of log forms, calibration and maintenance records, and status check forms. The basic premise for this approach is that entering accurate and complete information required on each form necessitates maximum adherence to established operating practices and quality assurance/quality control procedures. Routine review of this information imposes further quality assurance checks on all phases of program operations, and the records themselves provide complete documentation of QA/QC program results. This documentation is used to substantiate the validity of collected data and to generate reports to management, to the client, and to regulatory agencies.

Table 10.1 is a master list of the various forms currently in use for this program. This list is updated and form descriptions added or deleted as revisions to program procedures dictate.

SECTION 10

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Table 10-1 is a master list of the various forms currently in use for this program. This list is updated and form descriptions added or deleted as revisions to program procedures dictate.

TABLE 10-1

HONEYWELL ONONDAGA LAKE
METEOROLOGICAL MONITORING PROGRAM MANUAL
MASTER LIST OF FORMS CURRENTLY USED FOR PROGRAM

	Form Title
MON 222	"Site Dial-Up & Operating Log"
MON 224	"Support Supply Inventory"
MON-208	"Wind Direction Field Alignment Audit Data Form"
MON-209	"Temperature/Delta-Temperature Audit Data Form"
MON-210	"Wind Speed/Vertical Wind Speed Audit Data Form"
MON-211	"Aerometric Monitoring Instrumentation General Purpose Audit Form
MON-217	"Dewpoint/Relative Humidity Audit Data Form"
MON-206	"In-House Data Record"
MON-207A	"Shipping Log"
MON-207B	"Receiving Log"

Site Dial-Up and Operating Log (MON-222)

A twice weekly frequency of remote real-time surveillance that works well and covers typical contingencies has been adopted for this data collection effort. The monitoring sites are "called-up' each Monday and then again on Thursdays to both download and review all collected data and to monitor the real-time data collection at the time of the connection. This frequency enables the reviewer to monitor the systems for problems that may have developed over the weekend as well as to catch any problems that could develop during the week and be able to address them before the work week ends. This form is filled out by one of the Boston office meteorologists and documents the results of each remote surveillance conducted on the sites.

SITE DIAL-UP AND OPERATING LOG

PROJECT: ______________________

METEOROLOGIST: ______________________

DATE/TIME	SITE	TIME CHECK OK?	DATA VALIDITY CHECK OK?	DOWNLOAD OK?	COMPARISON TO NWS DATA OK?

COMMENTS:

____

____

____

____

PARSONS
150 Federal Street, Boston, Massachusetts 02110
Telephone 617-946-9400 - Fax 617-946-9777

SITE DIAL-UP AND OPERATING LOG

PROJECT: ONONDAGA LAKE

METEOROLOGIST: SMITH

DATE/TIME	SITE	TIME CHECK OK?	DATA VALIDITY CHECK OK?	DOWNLOAD OK?	COMPARISON TO NWS DATA OK?
1/5/07 0830	WB-13	YES	YES	YES	YES
1/5/07 0845	LS/WA	YES	YES	YES	YES

COMMENTS:

SITES AGREE w/ OBSERVED SYRACUSE DATA
ALL SITES REPORTING TEMPS 29-30°F w/ NW
winds 10-15 mph last 3 hrs
Downloaded all DEC 06 DATA for processing

PARSONS
150 Federal Street, Boston, Massachusetts 02110
Telephone 617-946-9400 - Fax 617-946-9777

MON-222

Site Inventory (MON-212)

This inventory will list all equipment at each site. It will include the manufacturer, instrument description, model number, and serial number of all capital equipment items, and will also indicate the operational status of each item.

Each updated inventory will be reviewed to ensure that ample equipment exists to properly conduct the program. The list will also be used to determine if any equipment requires repair or replacement. The field technician as well as Boston staff will keep this form updated.

SITE INVENTORY

PROJECT: ____________________

SITE: ____________________

DATE: ____________________

EQUIPMENT:	Manufacturer	Serial No.	Model No.	Quantity	Use Comments

PARSONS
150 Federal Street, Boston, Massachusetts 02110
Telephone 617-946-9400 - Fax 617-946-9777

MON-212

SITE INVENTORY

PROJECT: ONONDAGA LAKE

SITE: WB-13

DATE: 1/5/07

Page 1 of 1

EQUIPMENT:	Manufacturer	Serial No.	Model No.	Quantity	Use Comments
F460 WS Sensor	Climatronics	1084	100075	1	ON LINE 6/06
F460 WD Sensor	Climatronics	333	100076	1	ON LINE 6/06
Vertical WS Sensor	Climatronics	2717	102236	1	ON LINE 9/06

PARSONS
150 Federal Street, Boston, Massachusetts 02110
Telephone 617-946-9400 - Fax 617-946-9777

Support Supply Inventory (MON-224)

This is an inventory of key spare parts and expendables needed to maintain the data collection activities. The information contained therein will be used to determine whether and when stocks should be replenished. The field technician has the option of requesting specific items if he knows, for example, that upcoming maintenance activities will deplete existing stocks. The field technician as well as Boston staff will keep this form updated.

SUPPORT SUPPLY INVENTORY

PROJECT: ______________________ START-UP DATE: ______________________

SITE: ______________________ TECHNICIAN ______________________

	INVENTORY												ORDER
ITEM	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	Amount / Date

PARSONS
150 Federal Street, Boston, Massachusetts 02110
Telephone 617-946-9400 - Fax 617-946-9777

SUPPORT SUPPLY INVENTORY

PROJECT: ONONDAGA LAKE
SITE: LAKE SHORE/WILLE AVE

START-UP DATE: 12/05
TECHNICIAN: SMITH

	INVENTORY												ORDER
ITEM	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	Amount / Date
F460 WS SENSOR	1	1	1	1	1								
WS CUPS	1	1	1	1	1								
F460 WD SENSOR	1	0	1	1	1								1 2/15/06
WD VANE	1	1	1	1	0								1 5/2/06
TEMPERATURE SENSOR	1	1	1	1	0								1 5/2/06

PARSONS
150 Federal Street, Boston, Massachusetts 02110
Telephone 617-946-9400 - Fax 617-946-9777

Vendor Listing (MON-216)

This form is intended to expedite the order and delivery of key items by (1) having this information available for use by the purchasing department in processing purchase orders; and (2) having the technician know approximately when and from whom shipments can be expected. In emergency situations, the technician can contact vendors directly for parts or service assistance. This form is maintained by the Boston office staff.

VENDOR LISTING

PROJECT: ____________________

SITE: ____________________

TECHNICIAN: ____________________

ITEM	VENDOR NAME	ADDRESS	TELEPHONE	FAX	CONTACT	DELIVERY TIME

VENDOR LISTING

PROJECT: Onondaga Lake

SITE: WB-13

TECHNICIAN: Smith

ITEM	VENDOR NAME	ADDRESS	TELEPHONE	FAX	CONTACT	DELIVERY TIME
Wind Speed / Wind Direction Sensors	Climatronics	140 Wilbur Place Bohemia, NY	631-567-7300	631-567-7585	Jon Berry	next day

Wind Direction Field Alignment Audit Data Form (MON-208)

This form documents the results of field calibration checks and the every four-month quality assurance audits conducted on the wind direction portions of the meteorological monitoring systems. The same procedures for field calibrating any given sensor must be performed and documented whenever a new component is placed in service. It should not be automatically assumed that ready spare components are in perfect calibration. The Boston office meteorologists will be responsible for maintaining these forms.

WIND DIRECTION
FIELD ALIGNMENT AUDIT FORM

CLIENT: ______________________ DATE: __________

SITE: ______________________ TIME: __________

Measurement Level: ______________________

REFERENCE POINTS			OBSERVED RESULTS			
LANDMARK		AZIMUTH (DEGREES)	DAS DEGREES	DAS DEGREES	DAS DEGREES	AVERAGE DIFFERENCE (degrees)
	TIP:					
	TAIL:					
	540:					
	TIP:					
	TAIL:					
	540:					
	TIP:					
	TAIL:					
	540:					

Sensor S/N: ______ Sensor Torque: ____ Vane S/N: __________

Sensor S/N: ______ Sensor Torque: ____ Vane S/N: __________

NOTES:

PARSONS
150 Federal Street, Boston, Massachusetts 02110
Telephone 617-946-9400 Fax 617-946-9777

WIND DIRECTION
FIELD ALIGNMENT AUDIT FORM

CLIENT: Honeywell Onondaga Lake

DATE: 9/21/2006

SITE: Wastebed 13

TIME: 1415

Measurement Level: 10-meter Level

REFERENCE POINTS			OBSERVED RESULTS			
LANDMARK		AZIMUTH (DEGREES)	DAS DEGREES	DAS DEGREES	DAS DEGREES	AVERAGE DIFFERENCE (degrees)
Smith Hill	TIP:	216	216.9	216.6	217.7	1.1
Water Tank	TAIL:	36	36.8	36.8	36.9	0.8
(EOP)	540:					
Lakeland	TIP:	15	15.2	15.3	15.9	0.5
Water Tank	TAIL:	195	195.8	195.4	196.2	0.8
(EOP)	540:					
NORTH/	TIP:	0	2.5	2.2	1.9	2.2
SOUTH	TAIL:	180	181.4	181.9	182.5	1.9
(EOP)	540:					
Smith Hill	TIP:	216	216.7	216.1	216.2	0.3
Water Tank	TAIL:	36	35.8	36	36.1	0.0
(BOP)	540:					
Lakeland	TIP:	15	14.9	14.9	15.1	0.0
Water Tank	TAIL:	195	195.2	195.3	195.4	0.3
(BOP)	540:					
NORTH/	TIP:	0	2.3	1.9	2	2.1
SOUTH	TAIL:	180	181.9	182.3	182	2.1
(BOP)	540:					

Sensor S/N: 4712 EOP Sensor Torque: good Vane S/N: 3700

Sensor S/N: 4711 BOP Sensor Torque: ____ Vane S/N: ____

NOTES:
EOP=end of period ; BOP=beginning of period

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Temperature/Delta Temperature Audit Data Form (MON-209)

This form documents the results of field calibration checks and the every four-month quality assurance audits conducted on the temperature portions of the meteorological monitoring systems. The same procedures for field calibrating any given sensor must be performed and documented whenever a new component is placed in service. It should not be automatically assumed that ready spare components are in perfect calibration. The Boston office meteorologists will be responsible for maintaining these forms.

TEMPERATURE/DELTA TEMPERATURE
AUDIT FORM

CLIENT: ______________________

DATE: ______________

SITE: ______________________

TIME: ______________

REFERENCE POINTS			OBSERVED RESPONSE				
SENSOR / LEVEL	REF. THERM. Deg F.		2m DAS Deg F.	10m DAS Deg F.	AVERAGE 2m DIFFERENCE Deg F.	AVERAGE 10m DIFFERENCE Deg F.	DELTA TEMP Deg F.

2-meter: Probe S/N: Aspirator S/N: ______ Reference Thermometer S/N:

10-meter: Probe S/N: Aspirator S/N: ______ Reference Thermometer S/N:

NOTES:

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MON-209

TEMPERATURE/DELTA TEMPERATURE
AUDIT FORM

CLIENT: Honeywell Onondaga Lake

DATE: 9/22/2006

SITE: Waste Bed 13

TIME: 1000

REFERENCE POINTS			OBSERVED RESPONSE			
SENSOR / LEVEL	REF. THERM. Deg F.			DAS Deg F.	AVERAGE DIFFERENCE Deg F.	Delta Temp Deg F.
Hot Point: 10-Meter Level	94.8			95.4	0.63	
	94.6			95.2		
	94.3			95.0		
Ambient: 10-Meter Level	68.1			68.9	0.77	
	68.1			68.9		
	68.2			68.9		
Ice Bath: 10-Meter Level	32.2			32.9	0.70	
	32.2			32.9		
	32.2			32.9		
Delta-Temp Ice Bath	0.83			0.83	0.04	
	0.83			0.86		
	0.83			0.93		

Probe S/N: ________ Aspirator S/N: ________ Reference Thermometer S/N: ________

Probe S/N: ________ Aspirator S/N: ________ Reference Thermometer S/N: ________

NOTES:

Delta-temp ranged from a low of 0.25 to generally around 0.40 deg. F based on instantaneous readings.

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Wind Speed/Vertical Wind Speed Audit Data Form (MON-210)

This form documents the results of field calibration checks and the every four-month quality assurance audits conducted on the wind speed and vertical wind speed portions of the meteorological monitoring systems. The same procedures for field calibrating any given sensor must be performed and documented whenever a new component is placed in service. It should not be automatically assumed that ready spare components are in perfect calibration. The Boston office meteorologists will be responsible for maintaining these forms.

WIND SPEED / VERTICAL WIND SPEED
AUDIT DATA FORM

CLIENT: ______________________ DATE: ______________________

SITE: ______________________ TIME: ______________________

REFERENCE POINTS			SYSTEM RESPONSES			
SENSOR / LEVEL	RPM	MPH	DAS MPH	DAS MPH	DAS MPH	AVERAGE DIFFERENCE
	______	______				
Sensor: ______	______	______				
Level: ______	______	______				
S/N: ______	______	______				
Prop S/N: ______	______	______				
	______	______				
Sensor: ______	______	______				
Level: ______	______	______				
S/N: ______	______	______				
Cup S/N: ______	______	______				
	______	______				
Sensor: ______	______	______				
Level: ______	______	______				
S/N: ______	______	______				
Cup S/N: ______	______	______				

WS Sensor Torque: ______________

VWS Sensor Torque: ______________

NOTES:

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WIND SPEED / VERTICAL WIND SPEED
AUDIT DATA FORM

CLIENT: Honeywell Onondaga Lake

DATE: 9/21/2006

SITE: Wastebed 13

TIME: 0922

REFERENCE POINTS				SYSTEM RESPONSES			
SENSOR / LEVEL		RPM	MPH	DAS MPH	DAS MPH	DAS MPH	AVERAGE DIFFERENCE
		0	0	0.000	0.017	0.008	0.008
Sensor:	VWS	300 cw	4.2	4.220	4.240	4.160	0.007
Level:	10-meter	600 cw	8.4	8.430	8.400	8.460	0.030
S/N:	138	300 ccw	-4.2	-4.150	-4.150	-4.220	0.027
Prop S/N:	63271	600 ccw	-8.4	-8.330	-8.390	-8.470	0.003
		0	0	0.3	0.3	0.3	0.30
Sensor:	Wind Speed	300	16.3	15.97	15.86	15.86	-0.40
Level:	10-meter	600	32	31.42	31.53	31.63	-0.47
S/N:	5014	900	47.8	47.5	47.08	47.19	-0.54
Cup S/N:	2232	1200	63.5	62.75	62.02	62.23	-1.17
		0					
Sensor:							
Level:							
S/N:							
Cup S/N:							

Sensor Torque: NA

Sensor Torque:

NOTES:
These results represent end-of-period (EOP) for these sensors

Aerometric Monitoring Instrumentation General Purpose Audit Form (MON-211)

This form documents the results of field calibration checks and the every four-month quality assurance audits conducted on the barometric pressure, net solar radiation, solar radiation, and precipitation portions of the meteorological monitoring systems. The same procedures for field calibrating any given sensor must be performed and documented whenever a new component is placed in service. It should not be automatically assumed that ready spare components are in perfect calibration. The Boston office meteorologists will be responsible for maintaining these forms.

AEROMETRIC MONITORING INSTRUMENTATION
GENERAL PURPOSE AUDIT FORM

CLIENT: ______________________ DATE: __________

SITE: ______________________ TIME: __________

PARAMETER	EXPECTED RESPONSE		OBSERVED RESPONSE		
	TEST INPUT	Time	DAS	DIFF	
Parameter: Sensor: M/N: S/N: Level:	1. ____ 2. ____ 3. ____ 4. ____ 5. ____	____ ____ ____ ____ ____			
Parameter: Sensor: M/N: S/N: Level:	1. ____ 2. ____ 3. ____ 4. ____ 5. ____	____ ____ ____ ____ ____			
Parameter: Sensor: M/N: S/N: Level:	1. ____ 2. ____ 3. ____ 4. ____ 5. ____	____ ____ ____ ____ ____			
Parameter: Sensor: M/N: S/N: Level:	1. ____ 2. ____ 3. ____ 4. ____ 5. ____	____ ____ ____ ____ ____			

NOTES:

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AEROMETRIC MONITORING INSTRUMENTATION
GENERAL PURPOSE AUDIT FORM

CLIENT: Honeywell Onondaga Lake

DATE: 9/22/2006

SITE: Wastebed 13

TIME: 830

PARAMETER		EXPECTED RESPONSE		OBSERVED RESPONSE		
		TEST INPUT	DAS	DAS		
Parameter:	BAROMETRIC PRESSURE	1. 29.64	29.64	29.76		
Sensor:		2. 29.64	29.64	29.76		
M/N:		3.				
S/N:		4.				
Level:	2-meter	5.				
Parameter:	PRECIPITATION	1. 100 ml.	.12 in	.11 in		
Sensor:		2. 100 ml.	.12 in	.11 in		
M/N:		3. 100 ml.	.12 in	.11 in		
S/N:		4.				
Level:	Surface	5.				
Parameter:		1.				
Sensor:		2.				
M/N:		3.				
S/N:		4.				
Level:		5.				
Parameter:		1.				
Sensor:		2.				
M/N:		3.				
S/N:		4.				
Level:		5.				

NOTES:

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Dew-Point/Relative Humidity Audit Data Form (MON-217)

This form documents the results of field calibration checks and the every four-month quality assurance audits conducted on the dew-point and relative humidity portions of the meteorological monitoring systems. The same procedures for field calibrating any given sensor must be performed and documented whenever a new component is placed in service. It should not be automatically assumed that ready spare components are in perfect calibration. The Boston office meteorologists will be responsible for maintaining these forms.

DEWPOINT / RELATIVE HUMIDITY
AUDIT FORM

CLIENT: ______________________ DATE: __________

SITE: ______________________ TIME: __________

Probe S/N: ________ Aspirator S/N: __________

REFERENCE POINTS		SYSTEM RESPONSES			
	PSYCHROMETER Deg. F	DAS	DAS	DAS	AVERAGE DIFFERENCE
DRY BULB (deg F)					
WET BULB (deg F)					
W.B. DEPRESSION					
DEW POINT (deg F)					
RELATIVE HUMIDITY (%)					
DRY BULB (deg F)					
WET BULB (deg F)					
W.B. DEPRESSION					
DEW POINT (deg F)					
RELATIVE HUMIDITY (%)					
DRY BULB (deg F)					
WET BULB (deg F)					
W.B. DEPRESSION					
DEW POINT (deg F)					
RELATIVE HUMIDITY (%)					

Dry Bulb Thermometer Serial S/N:
Wet Bulb Thermometer Serial S/N:

NOTES:

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DEWPOINT / RELATIVE HUMIDITY
AUDIT FORM

CLIENT: Honeywell Onondaga Lake   DATE: 9/22/2006

SITE: Wastebed 13   TIME: 830

Probe S/N: ________   Aspirator S/N: ________

REFERENCE POINTS		SYSTEM RESPONSES			
	PSYCHROMETER Deg. F	DAS	DAS	DAS	AVERAGE DIFFERENCE
DRY BULB (deg F)	68.5				
WET BULB (deg F)	58				
W.B. DEPRESSION	10.5				
DEW POINT (deg F)	50.4	46	45		-4.9
RELATIVE HUMIDITY (%)	52.5	49.9	48.2		-3.5
DRY BULB (deg F)	70				
WET BULB (deg F)	57.5				
W.B. DEPRESSION	12.5				
DEW POINT (deg F)	48	46.2			-1.8
RELATIVE HUMIDITY (%)	45.5	44.8	45.5		-0.4
DRY BULB (deg F)					
WET BULB (deg F)					
W.B. DEPRESSION					
DEW POINT (deg F)					
RELATIVE HUMIDITY (%)					

Dry Bulb Thermometer Serial S/N: ____________
Wet Bulb Thermometer Serial S/N: ____________

NOTES:

In-House Data Record (MON-206)

At the beginning of each data processing period (e.g., monthly), an In-House Data Record is initiated which tracks the flow of data through the entire data processing, validation, and reporting process. This record provides enough space for notes to document and explain any revisions made as the data passes through the validation process. There are designated locations where each person involved in the process can note and sign off on specific steps taken in creating the final data base. The data record includes space for a final sign-off by the data validation personnel and Air Monitoring Supervisor signifying that the data have been fully validated and reported. It is the intent of such a report to summarize in one place all staff activities and modifications to the data base applied in creating the final report.

IN-HOUSE DATA RECORD

PROJECT: ____________________ FIELD TECHNICIAN: ____________________

JOB NO.: ____________________ MONITORING PERIOD: ____________________

DATA ASSEMBLED BY: ______________________________ DATE: __________

NOTES:

DATA REDUCTION:

METEOROLOGY ______________________________ DATE: __________

AIR QUALITY ______________________________ DATE: __________

NOTES:

MET. DATA Q.A. BY: ______________________________ DATE: __________

NOTES:

AIR QUALITY DATA Q.A. BY: ______________________________ DATE: __________

NOTES:

FINAL REPORT REVIEWED BY: ______________________________ DATE: __________

______________________________ DATE: __________

NOTES:

Shipping Log (MON-207A) and Receiving Log (MON-207B)

If any hardcopy records or other materials are going to be mailed or shipped to another location, a shipping log (Form 207A) should be prepared at the point of origin which indicates:

- Date shipped,
- Contents (explicit),
- Method of transport (including shipping information),
- Comments,
- Signature of originator.

One copy of the shipping log accompanies the data package. A second copy is retained at the field site..

When using the Postal Service to transport data, only certified or registered mail is used, and a return receipt should be requested. When using the commercial delivery services (e.g., Federal Express, UPS, etc.), or similar means of shipment, the data inventory is placed on the Bill of Lading. The package is also sent to the attention of the specific person designated to receive the data. Upon reaching its destination the data package is opened and the packing slip and contents compared. If the contents of the package agree with the packing slip, the slip is signed and dated by the receiver.

The receiver then documents the data package information in a receiving log (Form 207B), recording the following:

- Date received,
- Originator,
- Contents,
- Method of transport,
- Initials of receiver,
- Comments.

IN-HOUSE DATA RECORD

PROJECT: ONONDAGA LAKE

FIELD TECHNICIAN: SMITH

JOB NO.: 1111-111-22

MONITORING PERIOD: OCT 06

DATA ASSEMBLED BY: SC

DATE: 11/2/06

NOTES:

ALL DATA ACCOUNTED FOR FROM WB-13 SITE

DATA REDUCTION:

METEOROLOGY ______________________ DATE: __________

AIR QUALITY ______________________ DATE: __________

NOTES: —

MET. DATA Q.A. BY: SR

DATE: 11/8/06

NOTES:

- No missing data during month
- All data validated
- 100% Recovery Rates

AIR QUALITY DATA Q.A. BY: ______________________

DATE: __________

NOTES:

NA

FINAL REPORT REVIEWED BY: GP

DATE: 11/14/06

______________________ DATE: __________

NOTES:

ALL DATA VALIDATED

PARSONS

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SHIPPING LOG

DATE SHIPPED	TO	CONTENTS	SHIPPED VIA	INITIALS	COMMENTS
8/30/06	DAVE SMITH PARSONS BOSTON	SPARE Relative Humidity Sensor	FED EX	SJ	Replaced sensor and sent off line sensor for calibration/repair

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MON-207A

SHIPPING LOG

DATE SHIPPED	TO	CONTENTS	SHIPPED VIA	INITIALS	COMMENTS

PARSONS
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Telephone 617-946-9400 - Fax 617-946-9777

RECEIVING LOG

DATE RECEIVED	FROM	CONTENTS	SHIPPED VIA	INITIALS	COMMENTS
9/1/06	STEVE JONES	RELATIVE HUMIDITY SENSOR	FED EX	DS	Received sensor for cal/repair

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RECEIVING LOG

DATE RECEIVED	FROM	CONTENTS	SHIPPED VIA	INITIALS	COMMENTS

PARSONS
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APPENDIX A

Vendor Equipment Specification Sheets

WEATHER STATIONS for PSD MONITORING

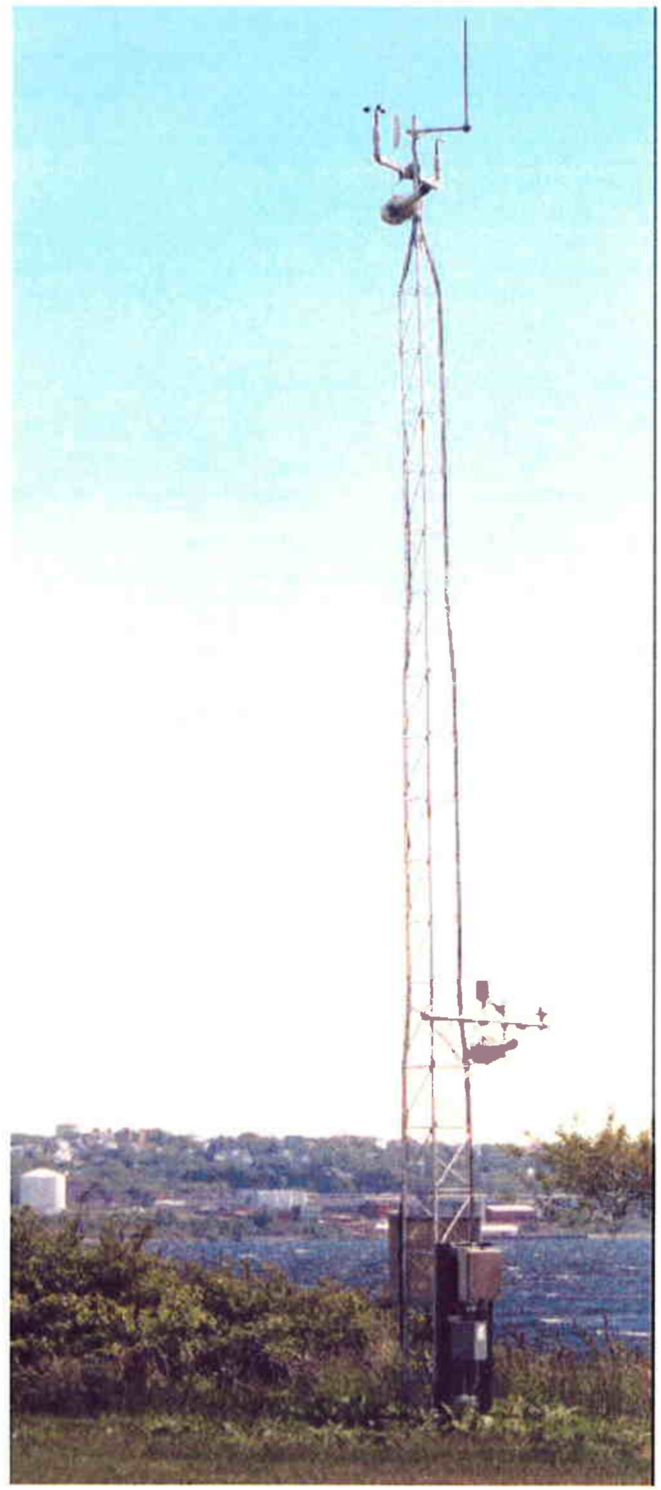
FEATURES:

- **Stand-alone, Fold-over 10-m Tower**
- **High Accuracy & Reliability Sensors**
- **Pre-wired Plug & Play Installation**
- **Industry Standard ASCII Data Format**
- **Data Retrieval & Communications Options**

U.S. Environmental Protection Agency guidelines assist operators of potential air pollution sources in complying with the 1977/1990 Clean Air Act Amendments. Operators are required to gather ambient air quality measurements, including meteorological data, at the site of the new air pollution source to estimate its impact on the vicinity and prevent significant deterioration (PSD) of the existing air quality.

The meteorological database should include hourly average wind speed and direction and the standard deviation of wind direction, measured at a standard height of 10 meters. Sites with complex terrain or tall structures often require monitoring at higher levels. The air temperature and the global hemispherical solar radiation are measured at a height of 2 meters above the ground, plus the vertical temperature difference (Delta-T) between 2 and 10 meters above the ground. These measurements will provide the required database for determining the site atmospheric stability category based on the EPA preferred SRDT (Solar Radiation, Delta Temperature) method. The EPA may also require other measurements such as relative humidity (dew point temperature), precipitation or barometric pressure. Minimum equipment specifications are detailed in the sensor section.

All temperature sensors must be protected from the effects of solar radiation, and, therefore, must be properly aspirated. A minimum of 90 percent data recovery and periodic calibrations and inspections, no less than every six months, are required for every meteorological system. Quality assurance of your meteorological data may be achieved by employing a monitoring system that complies with all of the requirements listed above.



SENSOR DESCRIPTION:

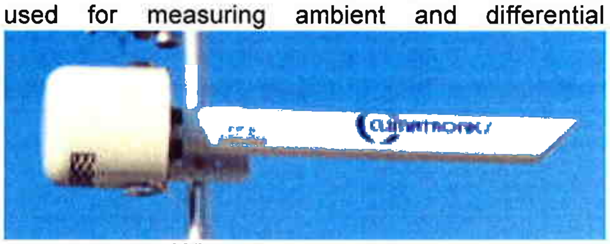
WIND SENSOR

Our WM-III sensors are the most widely used for PSD measurements by federal, state and local governments, industry and consultants. The low starting threshold of .45 m/s (.95 mph) is far less than PSD requires, which allows room for normal bearing degradation. The WM-III sensors have a low power design so that they can be used in both AC and DC applications. Where multilevel measurements are specified, the F460 wind speed, P/N 100075, and direction, P/N 100076,

sensors, with their better accuracy and plug-in modular design, are preferred. If the highest reliability and accuracy is desired, consider our P/N 102263 Sonimometer™ (sonic anemometer), which measures both wind speed, and wind direction using no moving parts.

TEMPERATURE SENSORS

Climatronics' Temperature Sensor, P/N 100093 is used for measuring ambient and differential



temperatures. When this thermistor sensor is used with a P/N 100325 motor aspirated shield, it yields an accuracy of ±0.15°C (±0.1°C for Delta-T with a matched pair). Naturally aspirated shields are also available and should be used with the P/N 102259 sensor/connector assembly.

RELATIVE HUMIDITY SENSOR (DEW POINT)

The Relative Humidity Sensors P/N 102273 or P/N 102425 measures the relative humidity of the atmosphere using a highly accurate, fast response capacitive polymer transducer. If the humidity measurement is of significant concern, we recommend that the P/N 102273 sensor be used due to its higher accuracy. A separate naturally aspirated shield is required for this sensor, while the P/N 102425 sensor will fit in one of the P/N 100325 motor aspirated shield. The relative humidity

combined with the air temperature measurement is used to calculate the dew point temperature.

PRECIPITATION GAUGE

Climatronics' Precipitation Gauge is a tipping bucket type with a collection diameter of 6 or 8 inches. A frictionless, reed switch gives a contact closure for each .25 mm (0.01") event. Heaters can be provided to convert snow and freezing rain to a measurable liquid state. Windshields are also available.

SOLAR RADIATION SENSOR

The Solar Radiation Sensor uses a thermopile transducer protected by a quartz glass dome that provides the 285 – 2800 nanometer spectral range required when providing data for the SRDT method. A silicon cell (photovoltaic) pyranometer is also available and is ideal where a narrower spectral range and 5 percent measurement accuracy is acceptable.

BAROMETRIC PRESSURE SENSOR

The barometric pressure sensor, P/N 102270, uses a glass fused ceramic capacitive transducer with excellent thermal stability and low hysteresis. The standard range is 800 – 1100 hPa, but other ranges are available. This sensor is typically mounted in the system NEMA-4X enclosure with the data logger and other peripherals.

When deciding what weather station will be needed for your particular application you should consider the following questions:

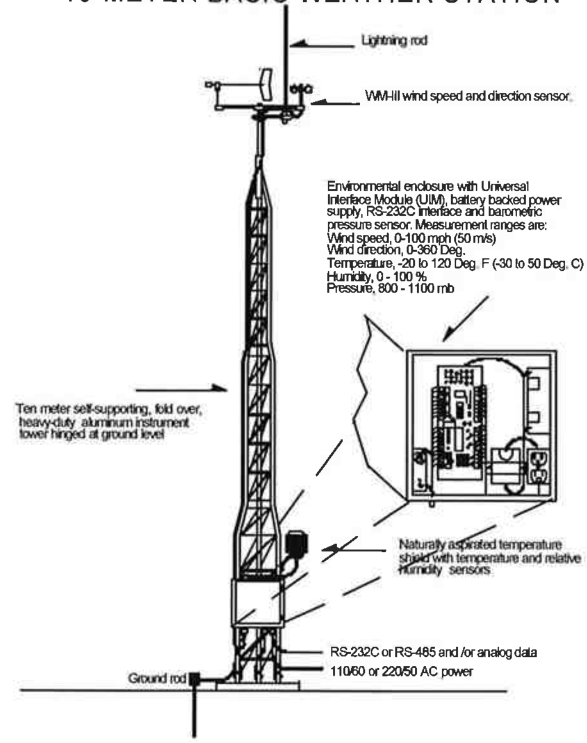
1. Is this a PSD requirement?
2. AC or DC site power?
3. Preferred data retrieval method?
4. Outside of the required parameters of wind, temperature, delta temperature and solar radiation, does any other variable(s) have to be recorded?
5. What is the desired data logger program definition – scan rates, averages, standard deviations, etc.

BASIC WEATHER STATION

Battery-Operated 10-Meter System with data logger or Universal Interface Module (UIM). Climatronics' Basic Weather Station (BWS) operates on AC or DC power. The data logger or the UIM card provides the power and interface for the sensors. Data can be recorded remotely, on site with the logger or to a local PC with the UIM and WeatherView software. The system can operate from batteries for up to one week or indefinitely with the solar panel/rechargeable battery option or from commercial AC power.

102083 Wind speed & direction sensor
102090 Temperature sensor w/connector
102425 Relative Humidity sensor (Optional)
102080 Shield
102270 Pressure sensor (Optional)
100508 Precipitation sensor (Optional)
102342 Solar radiation sensor (Optional)
102467 Data logger
LOGGERNET Data Logger Support software
102278 UIM (Optional, instead of data logger)
102455 WeatherView software (Optional)
101423 J-Box Mounting Brackets
C33HD 10-meter tower w/ tilt down base
100924 Full height grounding kit
PS1282L 8 Ah rechargeable battery
100800-G1 10-Watt solar panel (Optional)**
Cables and various mounting hardware
Data retrieval or communications options.
Data display options.

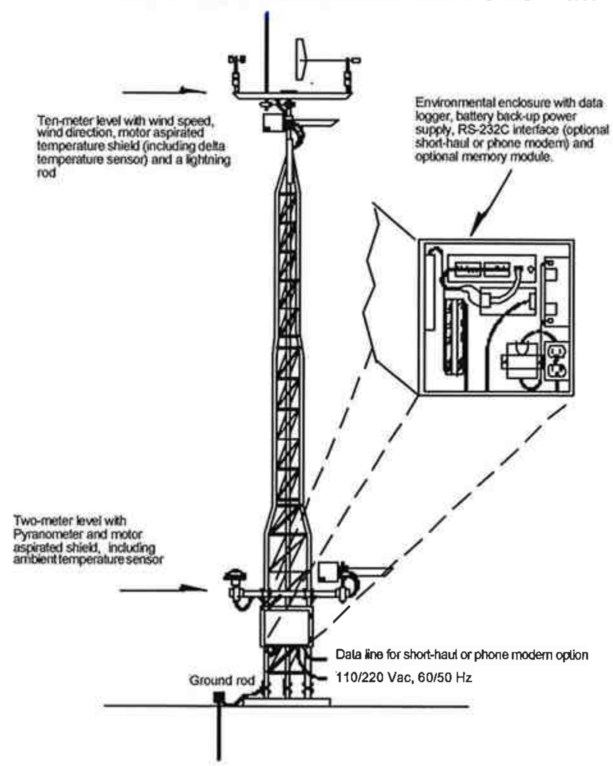
10-METER BASIC WEATHER STATION



SRDT WEATHER STATION

10-Meter Level
100075 F460 Wind Speed Sensor
100076 F460 Wind Direction Sensor
101994 Prewired Crossarm
100093 Temperature Sensor
100325 Motor Aspirated Temperature Shield
2-Meter Level
100093 Temperature Sensor
102425 Relative Humidity sensor
100325-1 Motor Aspirated Temperature/RH Shield
102318 Pyranometer (with mount & boom)
Ground Level
100508 Precipitation Gage, (Optional)
101760-G0-H0 Data logger
LOGGERNET Data Logger Support software
102278 UIM (Optional, instead of data logger)
101423 J-Box Mounting Brackets
102455 WeatherView software (Optional)
C33HD 10-meter tower w/ tilt down base
100924 Full height grounding kit
101139 Power supply w/ battery backup**
Cables and various mounting hardware
Data retrieval or communications options.

SRDT METEOROLOGICAL SYSTEM



**Depending on site location and data retrieval method desired, battery powered systems with solar panel recharging require special engineering considerations. Please consult with Climatronics for further details.

MULTI-LEVEL TOWER SYSTEM

Where multi-level, tall tower monitoring is specified, an expanded data logger system or a remote monitoring system such as a SODAR may be your best solution. With these types of systems, a variety of different options are available such as instrument elevators that bring the sensors to the ground level for service or calibration. Consult a Climatronics sales engineer with your specific requirements.

DATA ACQUISITION

The IMP-850, IMP-860, IMP-890 data loggers or the UIM are extremely versatile, low-power units tailored to the requirements of meteorological data acquisition. The IMP-850 is a 24-channel unit with an integral keyboard and display. The IMP-850 provides all required sensor excitation and logs the sensor data directly to memory. Data processing functions include averages, max/min, standard deviations, and trigonometric functions. Data can be retrieved via an RS-232C port, remote data link, or from a removable, solid-state storage module.

The IMP-860 and IMP 890 are direct descendants of the IMP-850. The IMP-860 has 12 analog input channels and 2 counter inputs. Like the other IMP-800 series data loggers, it can be programmed from a computer (via an RS-232C interface) or via a remote telemetry link. The IMP-890 is designed specifically for a small station with a limited number of inputs (4 analog, 2 frequency) and no input expansion requirements. All three data loggers use the same Windows based, LOGGERNET PC support software.

The UIM module was designed to provide a cost effective interface between the various system sensors and a PC or SCADA system when real time data display is a requirement and on-site data storage is not. The UIM card connects directly to the sensors and has 8-analog and 2-counter inputs. The standard output is RS-232C compatible, printable ASCII with options for RS-422/485 and analog 0-1 or 0-5 VDC or isolated 4-20 mA. A limited amount of computations such as data averaging, standard deviation of wind direction (sigma theta), dew point or wet bulb temperature, etc., can be performed by the UIM.

For further information about the IMP-850, IMP-860 or IMP-890 data loggers, or the UIM module, please refer to their individual data sheets.

DATA COMMUNICATIONS

Climatronics provides several types of communication equipment, which allow the user to relay the data to a central location. The IMP series data loggers can support both telephone and radio telemetry requirements. They can use either dedicated copper or fiber optic lines for short-haul modems, or standard dial-up lines or mobile telephone using low power, auto-answer modems. The auto-answer modems communicate at 9600 baud. Radio telemetry systems use an RF Modem Interface coupled with a VHF or UHF transceiver, or RS-232C compatible license free Spread Spectrum radios. Complete systems with antennas and coaxial cables are available. Please consult one of our sales engineers for your specific needs.

SOFTWARE

The LOGGERNET 32-bit software supports programming, communication, and reliable exchange of data between a PC and our IMP-800 series data loggers. It features a set of programs that allow the user to interact in real-time with a series of remote sites from a PC Windows environment. Further, the package can establish and maintain communication and automatic data retrieval with a network of up to 100 remote stations at individual sites. The software includes built-in help and error messages, which allow the user to learn and operate the network with a minimum need for manuals. Our "WeatherView" software is designed to run in a Windows environment and will display and record the data from one to eight weather stations. Two different types of displays are provided and engineering units may be selected from the menu bar "on the fly". The data may be networked through TCP/IP data protocol. For additional details, see the LOGGERNET or WeatherView data sheets.

Climatronics has several types of meteorological systems that comply with the PSD regulations. All systems meet the requirements of the EPA guidelines by offering the following features:

- Quality sensors with specifications that meet or exceed PSD Guidelines.
- Motor-aspirated shields with flow rates greater than 3 m/sec.
- Digital data loggers or UIM for primary data recovery. The digital data loggers and the UIM both will calculate the standard deviation of wind direction (sigma theta) using EPA-approved algorithms.
- Data retrieval software and NIST - traceable factory calibration services.

References: "Ambient Monitoring Guidelines for Prevention of Significant Deterioration (PSD)," EPA-450/4-87-007, May 1987.

"Meteorological Monitoring Program Guidance for Regulatory Modeling Applications," EPA-454/R-99-005, February 2000.

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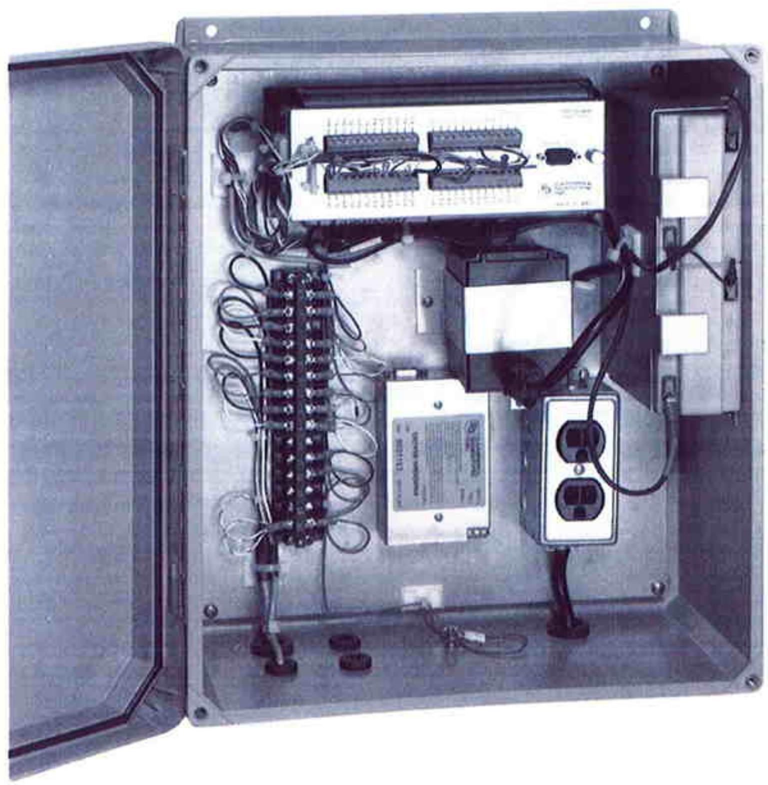
IMP-860 DATA ACQUISITION SYSTEM

FEATURES:

- **Direct Sensor inputs**
- **Control Outputs**
- **Internal/External Solid-State Storage**
- **Phone/Dedicated Line or Radio Telemetry**
- **Low Power**
- **Built-In Surge Protection**

The IMP-860 is a versatile digital data acquisition system suitable for environmental monitoring applications. It can function as a stand-alone station or be operated via a computer singly or in a network.

Direct sensor interface including the supply of excitation voltages is possible with the IMP-860. The input signals will then be processed as required. Data will either be stored in internal memory, a removable solid-state storage module, or a remote computer for later processing. The solid-state storage module can be used to transport and download a new operating program.



User programming of the IMP-860 is easily accomplished via an IBM PC-compatible computer with support software or an optional, portable keyboard/display unit. A comprehensive on board instruction set is included which can be programmed to perform calculations on any desired channel including interactions between channels. A custom operating program is factory supplied and can be modified by the user.

The basic IMP-860 (P/N 101760-G0-H0) consists of a P/N 102279 data logger mounted in a 16 x 14 x 6 inch, NEMA-4X enclosure with 128Kbytes of internal memory capable of storing up to 62,000 final data points. The G1 option provides an enclosure size of 18 x 16 x 8 inches and the G2 option is 24 x 24 x 8 inches. The H1 option adds 1 Mbyte of internal memory and the H2 option 2 Mbyte. A rack mountable version of the IMP-860 is also available (P/N 101761-G0-H0) which uses only 5-1/4 x 19 inches of panel space.

The IMP-860 requires a 12-volt DC power source such as the 8AH battery backup power supply shown in the picture (P/N 101139). When battery backup is not required, our P/N 100520-G0-H1 power supply is provided.

A large selection of communications, storage, measurement and control peripherals are available. Please contact Climatronics for a system quotation based on your specific requirements.

SPECIFICATIONS

Electrical specifications are valid over a -25° to +50°C range unless otherwise specified; non-condensing environment required. To maintain electrical specifications, yearly calibrations are recommended.

PROGRAM EXECUTION RATE

Program is synchronized with real-time up to 64 Hz. One measurement with data transfer is possible at this rate without interruption. Burst measurements up to 750 Hz are possible over short intervals.

ANALOG INPUTS

NUMBER OF CHANNELS: 6 differential or 12 single-ended, individually configured. Channel expansion provided by CAM416 Relay Multiplexers and CAM25T Thermocouple Multiplexers.

ACCURACY: ±0.1% of FSR (-25° to 50°C); ±0.05% of FSR (0° to 40°C);
e.g., ±0.1% FSR = ±5.0 mV for ±2500 mV range

RANGE AND RESOLUTION:

Full Scale Input Range (mV)	*Resolution (μV) Differential*	*Resolution (μV) Single-Ended*
±2500	333	666
±250	33.3	66.6
±25	3.33	6.66
±7.5	1.00	2.00
±2.5	0.33	0.66

INPUT SAMPLE RATES: Includes the measurement time and conversion to engineering units. The fast and slow measurements integrate the signal for 0.25 and 2.72 ms, respectively. Differential measurements incorporate two integrations with reversed input polarities to reduce thermal offset and common mode errors.

Fast single-ended voltage:	2.6 ms
Fast differential voltage:	4.2 ms
Slow single-ended voltage:	5.1 ms
Slow differential voltage:	9.2 ms
Differential with 60 Hz rejection:	25.9 ms
Fast differential thermocouple:	8.6 ms

INPUT NOISE VOLTAGE (for ±2.5 mV range):

Fast differential:	0.82 μV rms
Slow differential:	0.25 μV rms
Differential with 60 Hz rejection:	0.18 μV RMS

COMMON MODE RANGE: ±2.5 V

DC COMMON MODE REJECTION: >140 dB

NORMAL MODE REJECTION: 70 dB (60 Hz with slow differential measurement)

INPUT CURRENT: ±9 nA maximum

INPUT RESISTANCE: 20 Gohms typical

ANALOG OUTPUTS

DESCRIPTION: 3 switched, active only during measurement, one at a time.

RANGE: ±2.5 V

RESOLUTION: 0.67 mV

ACCURACY: ±5 mV; ±2.5 mV (0° to 40°C);

CURRENT SOURCING: 25 mA

CURRENT SINKING: 25 mA

FREQUENCY SWEEP FUNCTION: The switched outputs provide a programmable swept frequency, 0 to 2.5 V square wave for exciting vibrating wire transducers.

RESISTANCE MEASUREMENTS

MEASUREMENT TYPES: The IMP-860 provides ratiometric bridge measurements of 4- and 6-wire full bridge, and 2-, 3-, and 4-wire half bridges. Precise dual polarity excitation using any of the switched outputs eliminates dc errors. Conductivity measurements use a dual polarity 0.75 ms excitation to minimize polarization errors.

ACCURACY: ±0.02% of FSR plus bridge resistor error.

PERIOD AVERAGING MEASUREMENTS

DEFINITION: The average period for a single cycle is determined by measuring the duration of a specified number of cycles. Any of the 12 single-ended analog input channels can be used. Signal attenuation and AC coupling are typically required.

INPUT FREQUENCY RANGE:

Signal peak-to-peak [1] Min.	***Max.***	***Min. Pulse w.***	***Max Freq. [2]***
500 mV	5.0 V	2.5 μs	200 kHz
10 mV	2.0 V	10 μs	50 kHz
5 mV	2.0 V	62 μs	8 kHz
2 mV	2.0 V	100 μs	5 kHz

1 Signals centered around data logger ground
2 Assuming 50% duty cycle

RESOLUTION: 35 ns divided by the number of cycles measured

ACCURACY: ±0.03% of reading

TIME REQUIRED FOR MEASUREMENT: Signal period times the number of cycles measured plus 1.5 cycles + 2 ms

PULSE COUNTERS

NUMBER OF PULSE COUNTER CHANNELS: 2 eight-bit or 1 sixteen-bit; software selectable as switch closure, high frequency pulse, and low level AC.

MAXIMUM COUNT RATE: 16 kHz, eight-bit counter; 400 kHz, sixteen-bit counter. Channels are scanned at 8 or 64 Hz (software selectable).

SWITCH CLOSURE MODE
Minimum Switch Closed Time: 5 ms
Minimum Switch Open Time: 6 ms
Maximum Bounce Time: 1 ms open without being counted

HIGH FREQUENCY PULSE MODE
Minimum Pulse Width: 1.2 μs
Maximum Input Frequency: 400 kHz
Voltage Thresholds: Count upon transition from below 1.5 V to above 3.5 V at low frequencies. Larger input transitions are required at high frequencies because of input filter with 1.2 μs time constant. Signals up to 400 kHz will be counted if centered around +2.5 V with deviations ≥ ±2.5 V for ≥1.2 μs.
Maximum Input Voltage: ±20 V

LOW LEVEL AC MODE
(Typical of magnetic pulse flow transducers or other low voltage, sine wave outputs.)
Input Hysteresis: 14 mV
Maximum AC Input Voltage: ±20 V
Minimum AC Input Voltage:

(Sine wave mV RMS)	Range (Hz)
20	1.0 to 1000
200	0.5 to 10,000
1000	0.3 to 16,000

DIGITAL I/O PORTS

8 ports, software selectable as binary inputs or control outputs. 3 ports can be configured to count switch closures up to 40 Hz.

OUTPUT VOLTAGES (no load): high 5.0V ±0.1V; low < 0.1V

OUTPUT RESISTANCE: 500 ohms

INPUT STATE: high 3.0 to 5.5 V; low -0.5 to 0.8 V

INPUT RESISTANCE: 100 kohms

SDI-12 INTERFACE STANDARD

DESCRIPTION: Digital I/O Ports C1-C8 support SDI-12 asynchronous communication; up to ten SDI-12 sensors can be connected to each port. Meets SDI-12 Standard version 1.2 for data logger and sensor modes.

IMP-860 TCR THERMOCOUPLE REFERENCE

POLYNOMIAL LINEARIZATION ERROR: Typically <±0.5°C (-35° to +50°C), <±0.1°C (-24° to +45°C).

INTERCHANGEABILITY ERROR: Typically <±0.2°C (0° to +60°C) increasing to ±0.4°C (at -35°C).

EMI and ESD PROTECTION

EMISSIONS: Meets or exceeds following standards:
Radiated: per EN 55022:1987 Class B
Conducted: per EN 55022:1987 Class B

IMMUNITY: Meets or exceeds following standards:
ESD: per IEC 801-2;1984 8 kV air discharge
RF: per IEC 801-3;1984 3 V/m, 27-500 MHz
EFT: per IEC 801-4;1988 1 kV mains, 500 V Other

CE COMPLIANCE (as of 01/98)

APPLICATION OF COUNCIL DIRECTIVE (S): 89/336/EEC as amended by 89/336/EEC and 93/68/EEC

STANDARD (S) TO WHICH CONFORMITY IS DECLARED:
ENC55022-1: 1995 and ENC50082-1: 1992

CPU AND INTERFACE

PROCESSOR: Hitachi 6303

PROGRAM STORAGE: Up to 16 Kbytes for active program; additional 16 Kbytes for alternate programs. Operating system stored in 128 Kbytes Flash memory.

DATA STORAGE: 128 Kbytes SRAM standard (approximately 60,000 data values). Additional 2 Mbytes Flash available as an option.

OPTIONAL KEYBOARD DISPLAY: 8-digit LCD (0.5" digits)

PERIPHERAL INTERFACE: 9 pin D-type connector for keyboard display, storage module, modem, printer, card storage module, and RS-232 adapter.

BAUD RATES: Selectable at 300, 1200, 9600 and 76,800 for synchronous devices. ASCII communication protocol is one start bit, one stop bit, eight data bits (no parity).

CLOCK ACCURACY: ±1 minute per month

SYSTEM POWER REQUIREMENTS

VOLTAGE: 9.6 to 16 Vdc

TYPICAL CURRENT DRAIN: 1 mA quiescent, 13 mA during processing, and 46 mA during analog measurement.

BATTERIES: Any 12 V battery can be connected as a primary power source. Several power supply options are available.
The Model CR2430 lithium battery for clock and SRAM backup has a capacity of 270 mAhr.

PHYSICAL SPECIFICATIONS

SIZE: 7.8" x 3.5" x 1.5" - Measurement & Control Module; 9" x 3.5" x 2.9" - with Wiring Panel. Additional clearance required for serial cable and sensor leads.

WEIGHT: 2 lbs

WARRANTY

Three years against defects in materials and workmanship.

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F460 WIND SENSORS

FEATURES

- **High Survivability**
- **Excellent Dynamic Response**
- **Low Threshold**
- **Low Power CMOS Design**
- **Optional External Heaters**

Climatronics' F460 Wind Sensors are capable of operation in virtually all weather conditions. Designed to meet the requirements of Specification No. F460-SP001 for the National Weather Service, the durability of these sensors makes them ideal for multi-level tower installations. Although moderately priced, the F460 wind sensors offer the combination of low starting threshold, quick response, and high accuracy with excellent reliability over a wide range of operating conditions.

The F460 Wind Speed Sensor P/N 100075 monitors the wind speed with a three-cup anemometer. An LED photo chopper device provides a frequency output directly proportional to the wind speed. NIST traceability is optionally available for each anemometer cup assembly by comparison testing against a NIST transfer standard in our wind tunnel test facility.

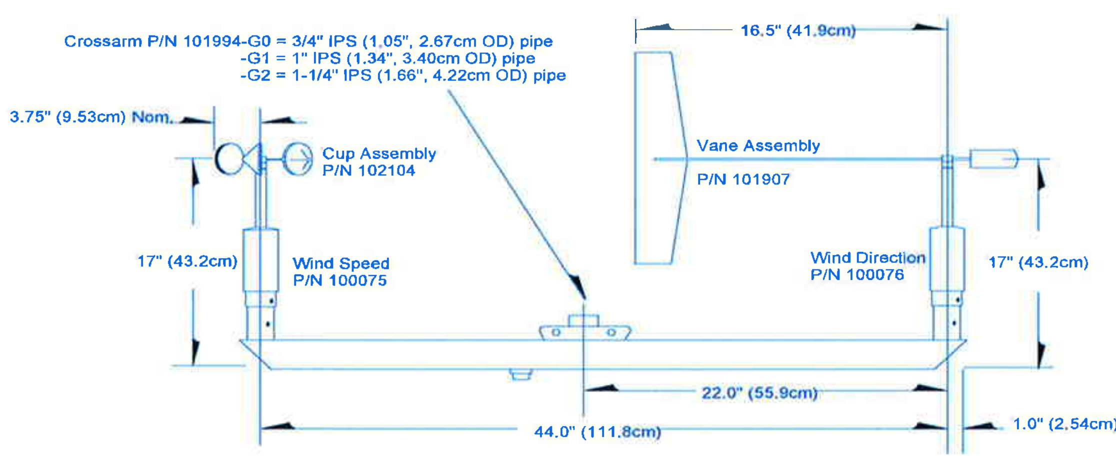
The F460 Wind Direction Sensor, P/N 100076, consists of a counter-balanced, lightweight vane and a precision, low torque, highly reliable potentiometer that yields a voltage output proportional to the wind direction. Once properly oriented on the keyed cross-arm, the wind direction sensor may be removed or replaced without requiring reorientation.

Installation is a simple matter of fastening each sensor to the crossarm, P/N 101994, which fits a ¾, 1, or 1-¼ inch IPS pipe. Optional, thermostatically controlled external heaters are also available. Our single-board signal conditioner, the Universal Interface Module (UIM), can be used with the F460 sensors. Please consult the Universal Interface Module (UIM) data sheet for more details. The sensors can also be directly interfaced to Climatronics' IMP-800 series of data loggers or other commonly available data acquisition units.

The Component Anemometer, P/N 102236, can be used in conjunction with the F460 System to measure the vertical component of the wind. Consult the Vertical Component Anemometer data sheet for additional details.

SPECIFICATIONS

	F460 Wind Speed P/N 100075	F460 Wind Direction P/N 100076
PERFORMANCE		
Accuracy	0.15 mph (± 0.07 m/s) or ± 1.0% of true air speed (whichever is greater)	± 2 degrees
Threshold	0.5 mph (0.22 m/s)	0.5 mph (0.22 m/s)
Distance Constant	102104 LEXAN <1.5 m (4.9 ft) 101287 HD Aluminum <4.0 m (13.1 ft) 100057 Stainless Steel <2.4 m (7.9 ft)	101907 Standard <1.0 m (3.0 ft) 101288 Heavy Duty <2.5m (8.2 ft)
Damping Ratio	N/A	>0.4 at 10° initial angle of attack
Operating Range	0 to 125 mph (0 to 60 m/s)	0 to 360 degrees - mechanical
ELECTRICAL SPECIFICATIONS		
Signal Output	Nominal 2.0 Vpp into 2.0 Kohm, frequency proportional to wind speed, amplitude dependant on supply voltage	Variable DC voltage, magnitude proportional to wind direction
Power Requirements	5 to 15 VDC @ 1 mA nominal	Max 1 mA through 10 Kohms
PHYSICAL SPECIFICATIONS		
Size	2.25 in (5.7 cm) max diameter 11.5 in (29.2 cm) high	2.25 in (5.7 cm) max diameter 11.5 in (29.2 cm) high
Weight	Less than 2 lbs (0.9 kg)	Less than 2 lbs (0.9 kg)
Turning Radius	3.75 in (9.5 cm)	16.5 in (41.9 cm)
Operating Temperature	-40° to 140° F (-40° to 60° C)	-40° to 140° F (-40° to 60° C)
CROSSARM SPECIFICATIONS		
Length	45 in (114.3 cm)	
Weight	7 lbs (3.2 kg)	
Mounting	1.66 in (4.2 cm) - O.D. 1-1/4 in IPS pipe (3/4 in & 1.0 in IPS also available)	
SENSOR HEATER SPECIFICATIONS		
Internal (P/N 101263)	12 VDC, 2 Watts per sensor	
External (P/N 101235)	115 VAC/60Hz 20 Watts per sensor, thermostatically controlled	



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Rev. 2/13/01

VERTICAL COMPONENT ANEMOMETER

FEATURES

- **Very Low Threshold**
- **Fast Response**
- **Photochopper Detector**
- **Built-In Signal Conditioning**
- **Minimal Induced Turbulence**
- **Optional Heater**

Climatronics' Vertical Component Anemometer (P/N 102236) is our latest generation of vertical wind speed sensors. It is an improved product superior in performance and directly interchangeable with our previous versions of component anemometers, P/N 101284 and P/N 101036, both which have been discontinued. Exceptionally low threshold and fast response are achieved through the use of mechanical features found in our proven F460 wind sensors. The anemometer body is slender and aerodynamic to ensure that minimal turbulence is introduced into the measured air stream.

The component anemometer may be supplied with either an expanded polystyrene (EPS) propeller featuring low threshold or a carbon fiber propeller for superior durability. Propeller rotation causes a 3-slot shutter to interrupt a solid-state light source. This pulse signal is processed by an internal signal conditioner which utilizes state-of-the-art surface mount technology.

The sensor produces a dual frequency and linear millivolt DC output. The DC output is identical to the DC generator output of our previous component anemometer (P/N 101284). Both signal outputs allow for full compatibility with Climatronics' and many other signal conditioning and data acquisition products. The component anemometer mates to its mount (P/N 102234) with a weatherproof connector identical to that of the previous component anemometer. The mount features a choice of three standard pipe adapters and includes a shielded signal cable prewired to the mating connector. The cable length may extend upwards of 1,000 ft. with no appreciable loss in signal strength or quality. The component anemometer and its propeller may be supplied with an optional NIST-traceable calibration (P/N 600025). An optional heater (P/N 101238) is available to prevent the build-up of snow and ice.

SPECIFICATIONS

PERFORMANCE

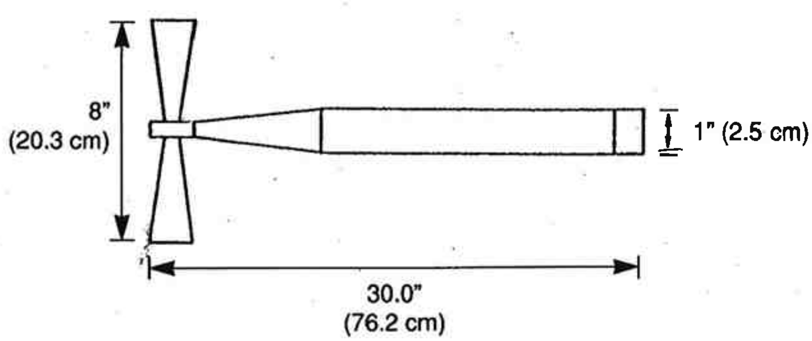
Accuracy	± 1.0% over range		
Threshold	G0:	0.5 mph (0.22 m/s)	Carbon Fiber
	G1:	0.3 mph (0.14 m/s)	EPS
Distance Constant	G0:	6.9 ft (2.1 m)	Carbon Fiber
	G1:	3.2 ft (1.0 m)	EPS
Operating Range	±40 mph (±20 m/s)		

ELECTRICAL

Signal Output	±500 mV corresponding to 1800 rpm = 20.00 mph (8.94 m/s)
Analog Frequency	90 Hz corresponding to 1800 rpm = 20.00 mph (8.94 m/s)
Power Requirements	6.0 mA at +12 VDC (±3 VDC)

PHYSICAL

Height	30 in (76.0 cm)	
Body Diameter	1 in (2.54 cm) tapering to 0.375 in (0.95 cm)	
Propeller Diameter	8 in (20.3 cm) (Nominal)	
Weight	Sensor	<1 lb (0.45 kg)
	Mount	1 lb (0.45 kg)
Mounting	102234-G0 for 1¼ in IPS pipe	
	G1 for 1 in IPS pipe	
	G2 for ¾ in IPS pipe	



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Rev. 10 Jan 2002

TEMPERATURE SENSORS

FEATURES

- **Maintenance Free**
- **Versatile**
- **Highly Accurate**
- **Durable**

Capable of meeting virtually any ambient measurement need, Climatronics' temperature sensors are accurate durable, and linear over a wide range, can be provided with NIST traceable calibration, and are well matched for high accuracy delta temperature applications.

The Air, Water/Soil, and Expanded Range Sensors encase a thermistor bead in a stainless steel or vinyl sheath. This casing, combined with Climatronics' temperature shield, gives the thermistor bead protection from solar radiation, precipitation, and corrosive, airborne particles. Such configurations transfer heat as rapidly as possible, yielding a typical time constant of 3.6 seconds. When direct exposure of the thermistor to the media being measured is permissible, our Fast Response Sensor reduces the time constant to a minimal 0.6 seconds.

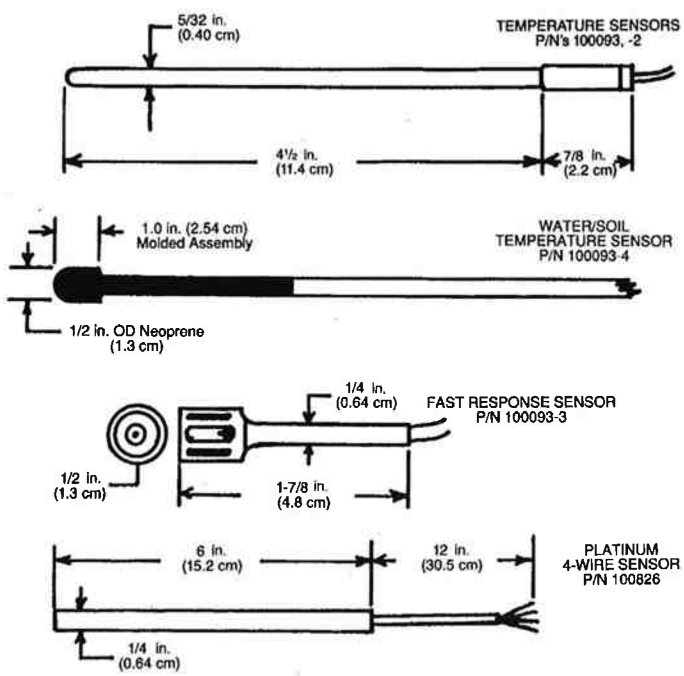
A second type of sensor, Platinum 4-Wire, operates on the principle that electrical resistance of a pure metal increases with temperature. Platinum's superior linearity, stability, sensitivity and resistance to corrosion, make it an ideal practical choice. The unit's four-wire design automatically compensates for possible lead resistance errors, and it is supplied with certified NIST traceability.

Sensors install easily in Climatronics' temperature shields. The TS-10 Motor Aspirated Shield, P/N 100325, provides a constant airflow past the sensor (as discussed in the TS-10 data sheet), while the Naturally Aspirated Shields (P/N 100552 or P/N 102080), rely on ambient air flow or convection for sensor aspiration.

Please consult Climatronics for assistance with the proper combination of sensor, shield, cable, and data acquisition electronics to meet your specific monitoring requirements.

SPECIFICATIONS

	Air, Water/Soil P/N's 100093 (102090*) 100093-4	Expanded Range P/N 100093-2 (102096*)	Fast Response P/N 100093-3	Platinum 4-Wire P/N100826 (102092*)
Accuracy	±0.27°F (±0.15°C) over full range	±0.18°F** (±0.10°C) over full range	±0.27°F (±0.15°C) over full range	±0.18°F (±0.1°C)
Range	-22.0° to 122.0°F (-30.0° to 50.0°C)	-58.0 to 122°F (-50.0° to 50.0°C)	-22.0° to 122.0°F (-30.0° to 50.0°C)	-58.0° to 122.0°F (-50.0 to 50.0°C)
Time Constant	3.6s	3.6s	0.6s	5.5s
Interchangeability	±0.27°F (±0.15°C)	±0.18°F (±0.10°C)	±0.27°F (±0.15°C)	±0.45°F(±.25°C) can be compensated
Linearity	±0.29°F (±0.16°C)	±0.25°F (±0.16°C)	±0.29°F (±0.16°C)	±0.09°F (±0.05°C) included in accuracy
Leads	3	4	3	4
Dimensions				
Diameter	5/32 in (0.40 cm) 0.5 in (1.3 cm)	5/32 in (0.40 cm)	½ in (0.64 cm)	¼ in (0.64 cm)
Length	4.5 in (11.4 cm) 1.0 in (2.54 cm)	4.5 in. (11.4 cm)	1-7/8 in (4.8 cm)	6.0 in (15.2 cm)



** Can be improved to ± 0.08°C with 0.02% accuracy composite resistors.
* Includes MS Connectors

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Rev. 8 Jan 2002

MOTOR ASPIRATED RADIATION SHIELD

FEATURES

- **Accurate to 0.2°F (0.1°C)**
- **Easy Access to Sensors**
- **Quick Release Sensor Mount**
- **High MTBF Ball Bearing Motor**
- **Accepts a Variety of Sensors**
- **Optional Airflow Warning Device**

Climatronics Motor-Aspirated Solar Radiation Shield, Motor TS-10 (P/N 100325), utilizes a triple-shield design and fan to provide the constant mass flow rate past the sensor(s) necessary to yield accurate temperature values. This shield is superior to a naturally aspirated shield, which relies on the wind conditions for sensor ventilation. Constant flow plus superior protection from incoming short-wave solar radiation and outgoing long wave radiation make the TS-10 shield a requirement for the most critical ambient measurements.

The TS-10 includes a quick release sensor mount assembly and a motor housing with safety chain to facilitate field-testing and scheduled preventative maintenance. This permits "on-site" calibration without tools. The aspirator motor, which features a re-circulating oil bath ball bearing design for the utmost in reliability, provides a continuous fresh air sample to the temperature sensor(s) at a rate of approximately 10ft/sec (3m/s) regardless of the prevailing wind conditions. The combination of forced aspiration with the highly effective triple-shield design insures that measurements errors due to direct or reflected radiation at any angle or temperature range do not exceed 0.2°F (0.1°C).

The TS-10 is modified for a dew point sensor by attaching a dew point shield. The shield is designed to provide stable dew point measurements while maintaining a sensor aspiration rate that does not degrade the response of the sensor.

A flow switch to indicate any obstruction of normal air flow or motor failure is available as an option. The device consists of a small vane that trips a SPDT switch, depending on airflow volume. The contacts of this switch are wired to the signal connector and may be applied to an input port of a data acquisition system. The entire aspirated shield is painted with a highly reflective and wear-resistant white paint and comes supplied with hardware for mounting on vertical pipes of various diameters. This aspirated shield will accommodate a variety of temperature, dew point or relative humidity sensors and combinations thereof.

SPECIFICATIONS

Shield Effectiveness	Under radiation intensities of 1100 W/m²(1.6 cal/cm2/min) measurement errors due to radiation will not exceed 0.2°F (0.1°C)
Aspiration Rate	10 ft/sec (3 m/s) at sensor location
Operating Temperature	-40° to 130°F (-40° to 55°C)
Power Requirement	120/220V 60/50 Hz @ 0.2A (+12VDC @ 0.3A, Optional)
Weight	12 lbs (5.4 kg)
Air Flow Detector	Detects air flow failure (NO/NC) contact output through connector
Shipping Data	Weight: 15 lbs (6.8 kg) Volume: 3.3 ft^3 (0.094 m^3)

The diagram to the right shows the two exterior configurations of the TS-10 Motor-Aspirated Shield.

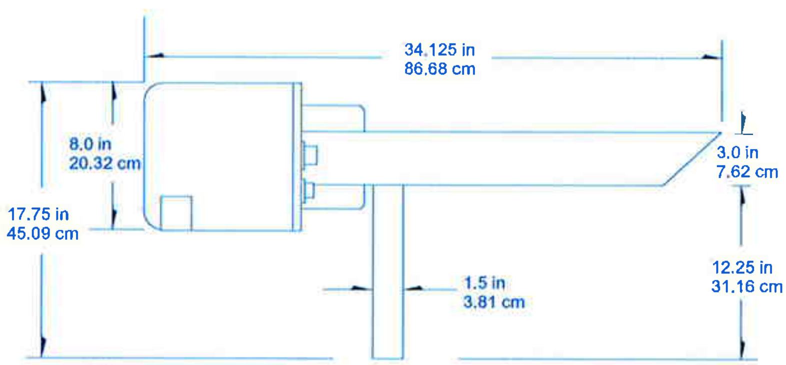
TS-10

TS-10WA

Options for the TS-10 Motor-Aspirated Shield (P/N 100325)*

Option	Part Number	Description
Temperature		
	100093	Standard ThermistorTemperature Sensor
	100093-2	Extended Range Thermistor Temperature Sensor
	100093-3	Fast Response Thermistor Temperature Sensor
	100826	Platinum 100 Ohm 4 wire Temperature
Dew Point Temperature	101197	Lithium Chloride Dew Point Sensor Safe Start for Dew Point Bobbin
Relative Humidity	102273,102425,101812	Capacitive Element Humidity Sensors
Flow Switch	100179	Air Flow Detector
Power Input		110/60, 220/50 VAC/Hz or 12 VDC
Mounting		¾, 1.0 or 1-¼ in Vertical Pipe

**Contact the factory or consult the individual data sheets for detailed specifications on these sensors*



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Rev. 2/13/01

RELATIVE HUMIDITY SENSORS

FEATURES

- **Inexpensive**
- **Excellent Long-Term Stability**
- **Wide Operating Temperature Range**
- **Contamination Resistant**
- **Optional Temperature Sensor**
- **Linear Voltage Output**
- **Compact Size**

Climatronics' capacitive relative humidity sensors, P/N 102273 and 102425 are specifically designed for meteorological monitoring systems. Very low power consumption makes these relative humidity sensors ideal for integration with data acquisition systems operating at remote locations. Both sensors provides a linear 0 to 1 VDC output signal corresponding to 0 to 100% relative humidity.

The sensors require a minimum of maintenance or calibration and features exceptional resistance to contaminants. Repeatability is also excellent, even after complete sensor saturation. The P/N 102273 sensor maintains its accuracy over the full range of humidity, even in conditions close to condensation. This is accomplished by electronic temperature compensation of the humidity element. The moderately priced P/N 102425 sensor does not have the high overall accuracy of the P/N 102273 and an increase in error at the upper and lower 10% of its range.

Both sensors include provision for adding a temperature measurement. The temperature option for the P/N 102273 is a dual bead thermistor with electrical and performance characteristics identical to that of Climatronics P/N 100093 temperature sensor. The temperature option of the P/N 102425 sensor is a PT100 platinum transducer, which produces a 0 to 1 VDC linear output of the specified temperature range. Dimensions and weight of the sensors remain the same with or without the temperature option.

SPECIFICATIONS

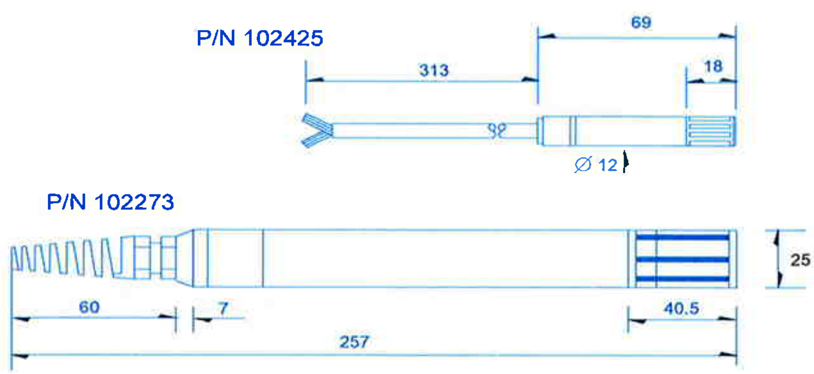
PERFORMANCE	P/N 102273	P/N 102425
Relative Humidity		
Accuracy	<+/- 1% RH from 0 to 100%	<+/- 3% RH from 10 to 90 %
Repeatability	+/-0.3% RH	
Operating Range	0 to 100 %	0 to 100 %
Operating Temperature Range	-40° to 60°C	-10° to 60°C
Long Term Stability	+/-1% over 12 months	+/- 5% RH over 24 months
Response Time (without filter)	10 seconds	10 seconds
Temperature		
Type	Dual bead thermistor	PT1000 DIN 43760B
Accuracy	+/- 0.15°C	+/- 0.6°C
Range	-30° to 50°C	-10° to 60°C

ELECTRICAL

Relative Humidity		
Excitation Power	4.8 to 30 VDC; 2.5 mA @ 12 VDC	7 to 28 VDC; 2 mA @ 12 VDC
Signal Output	0 to 1 VDC = 0 to 100%	0 to 1 VDC = 0 to 100%
Output Impedance	1000 Ohms	
Temperature		
Excitation Power	Precision DC voltage supplied by Climatronics data logger or signal conditioner	7 to 28 VDC; 2 mA @ 12 VDC
Signal output	Variable, low level DC voltage for input to data logger or signal conditioner	0 to 1 VDC = -40° to 60°C

PHYSICAL

Length	10.12 in (257 mm)	2.7 in (69 mm)
Transducer Diameter	0.98 in (25 mm)	0.47 in (12 mm)
Weight	0.15 lb (70 g)	0.15 lb (70 g)



Dimensions in mm / Modifications reserved

Climatronics Corporation
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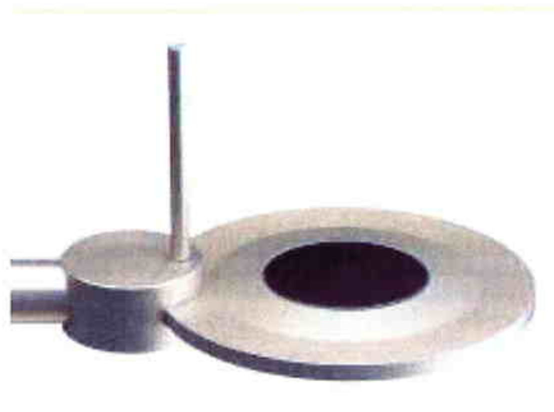
Rev. 10 Jan 2002

NET RADIOMETER

FEATURES

- **Inexpensive**
- **Excellent Long-Term Stability**
- **Wide Operating Temperature**
- **Analog Voltage Output**
- **Compact Size**



Climatronics' Net Radiometer (P/N 102341) is designed for routine measurement of net radiation which is the balance between incoming and outgoing radiation under outdoor conditions.

The design of the Net Radiometer is unique. The detector is based on a Teflon coated, weather resistant black conical absorber. In contrast to other sensor designs, NR-LITE requires no fragile plastic domes. This results in a virtually maintenance free design.

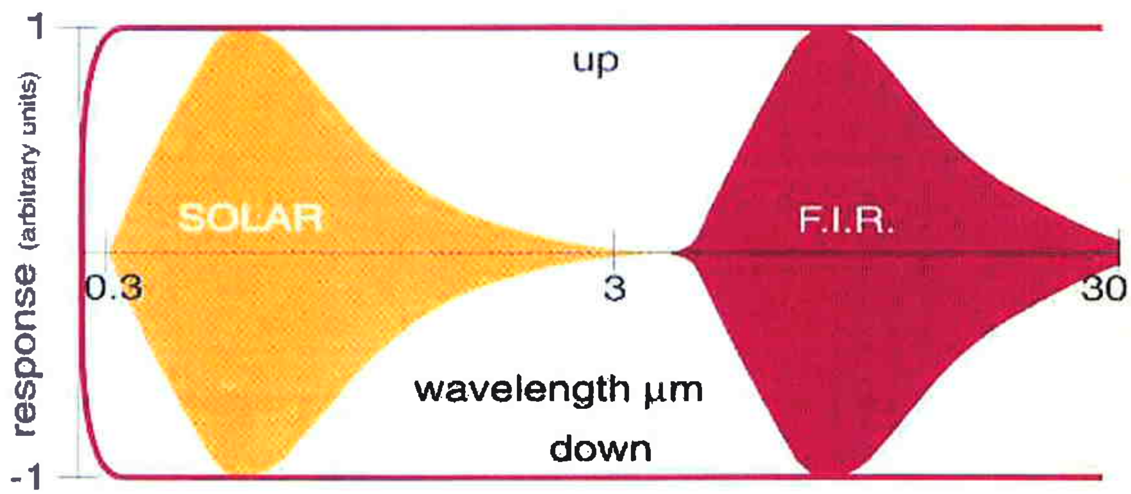
The Net Radiometer is suitable for: agricultural meteorology, the study of evapotranspiration calculations and crop damage prevention; building physics, the study of thermal stress and heat balance; and, road safety and highway condition monitoring

The Net Radiometer is easy to use. It is based on a thermopile sensor. The voltage output is proportional to the net radiation. It can be directly connected to voltmeter or data logger with a millivolt input.

SPECIFICATIONS

Spectral response	0 to 100 microns
Detector protection	Teflon coated (no domes)
Sensitivity (upper detector)	10 mV/W/m^2 (nominal)
Recommended output range For atmospheric application	-25 to 25 mV
Sensor asymmetry	± 20%
Range	-2000 to 2000 W/m^2
Response time(1/e)	20 sec (nominal)
Temperature range	-30°C to 70°C
Directional error	< 30 W/m^2 (0 to 60 degrees at 1000 W/m^2)

SPECTRAL RESPONSE



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Rev. 10 Jan 2002

Kipp & Zonen
SINCE 1830

CMP SERIES

PYRANOMETER RANGE

RADIATION MEASUREMENT FOR ATMOSPHERIC RESEARCH AND INDUSTRY

In the range of secondary standard pyranometers, Kipp & Zonen supplies equipment with special features; record breaking response time, exceptional levelling accuracy and a test certificate also covering the directional and temperature responses. These important parameters ensure the highest accuracy measurements.

Pyranometers are radiometers designed for measuring the irradiance on a plane surface resulting from radiant fluxes in the wavelength range from 300 to 3000 nanometers. Kipp & Zonen has been manufacturing pyranometers for over 75 years.

The instruments are used in meteorology, solar energy research, material testing, climate control in greenhouses, building physics science and many other applications. Kipp & Zonen can supply a full range of pyranometers and accessories, according to the ISO 9060 and World Meteorological Organisation (WMO) standards.

Common characteristics of the pyranometers are the robustness, and all-weather performance. The instruments are easy to use, require no power, and are all supplied with calibration certificates that are traceable to WRR (World Radiometric Reference). For ease of mounting, exchange and recalibration the instruments have a waterproof connector. The standard supplied 10 m shielded cable has the waterproof sealed counterpart connector.

The comparison table shows the specifications, dimensions and options of the various types and helps selection of the right model for a specific application.

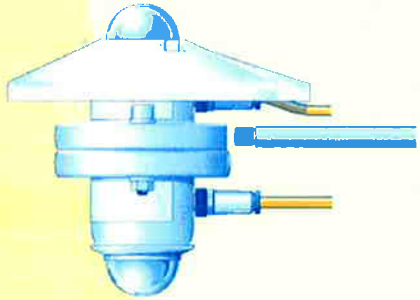
CMP 3 is smaller and lighter than all other CMP pyranometers. It has a robust 4 mm dome to protect the thermopile from external influences. A spirit level and leveling screws are mounted in the base of the pyranometer. The small size and sealed construction make this instrument the ideal choice for agricultural and industrial applications and networks.

CMP 6 has a similar detector to the CMP 3, but has improved performance due to the increased thermal mass and the double glass dome construction. It is ideal for cost-effective, good quality, measurements in hydrological networks and agriculture. The connector with gold-plated contacts allows for easy exchange and re-calibration.

CMP 11 uses higher quality glass domes and a version of the detector technology originally developed for the CM 22 and is a step up in performance from the CMP 6. It is particularly suitable for meteorological networks and the reduced response time of 1.66 seconds (63 %) meets the requirements for solar energy applications.

CMP 21 has the same detector as the previous CM 22 and individually optimised temperature compensation. A standard thermistor sensor is fitted to monitor the housing temperature. Each instrument is supplied with its own temperature and directional (cosine response) test data. It is the choice for scientific use and in top level solar radiation monitoring networks such as the BSRN (Baseline Surface Radiation Network) of WMO.

CMP 22 has all the features of CMP 21 but uses very high quality quartz domes for a wider spectral range, improved directional response, and reduced thermal offsets. Because of the high optical quality of these domes the directional error is reduced below 5 W/m². Kipp & Zonen is confident that CMP 22 is the best Pyranometer currently available.



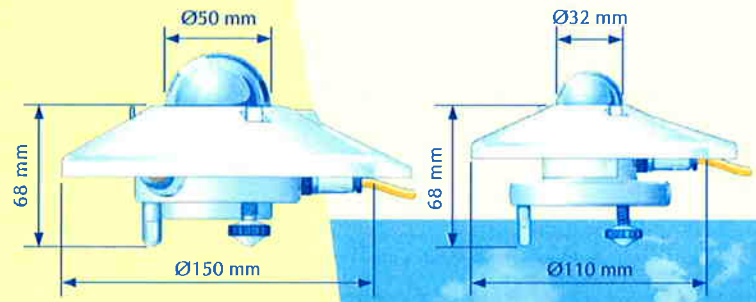
To create an albedometer two **CMP 3**'s can be mounted opposite to each other. A rod can be screwed in one of the housings for fixating the mounted instruments to a mast. Each sensor has a separate cable that can be fixed along the mounting rod.

CV 2 ventilation unit is designed for use with all CMP pyranometers (except the CMP 3) Ventilation and two levels of heating will improve the reliability and accuracy of the measurement under all weather conditions. Ventilation will keep the dome clean from precipitation and snow plus suppresses the infrared offset by stabilization of the dome temperature.

The combination of a pyranometer and shadow ring **CM 121B** offers a simple solution to the problem of measuring diffuse radiation from the sky. The shadow from the ring covers the pyranometer dome completely. The ring will not need adjustment for several days.

The **2AP** tracker is an all-weather, reliable and affordable tracking and positioning instrument. It is used to accurately point small and medium sized payloads, either as a dedicated Sun tracker or as a computer based Positioner. A wide range of accessories is available for mounting instruments and adaptation to extreme climate conditions. The 2AP specification match with the requirements for BSRN stations. (Baseline Surface Radiation Network)

AMPBOX is a current loop amplifier for the complete range of pyranometers. Pyranometers have output signals in the mV range, the AMPBOX can amplify this to a 4 - 20 mA level. Amplification is advised for noisy environments, read-out equipment with high-level inputs and for very long (> 100 m) cables.



Typical CMP series housing

CMP 3 housing

Note: The performance specifications quoted are worst-case and/or maximum values

Kipp & Zonen B.V. reserve the right to alter specifications of the equipment described in this documentation without prior notice

SPECIFICATIONS

	CMP 22	CMP 21	CMP 11	CMP 6	CMP 3
ISO CLASSIFICATION	Secondary Standard	Secondary Standard	Secondary Standard	First Class	Second Class
Response time (95 %)	5 s	5 s	5 s	18 s	18 s
Zero offsets (a) thermal radiation (200 W/m²) (b) temperature change (5 K/hr)	 ± 3 W/m² ± 1 W/m²	 ± 7 W/m² ± 2 W/m²	 ± 7 W/m² ± 2 W/m²	 ± 15 W/m² ± 4 W/m²	 ± 15 W/m² ± 5 W/m²
Non-stability (change/year)	± 0.5 %	± 0.5 %	± 0.5 %	± 1 %	± 1 %
Non-linearity (0 to 1000 W/m²)	± 0.2 %	± 0.2 %	± 0.2 %	± 1 %	± 2.5 %
Directional error (at 80 ° with 1000 W/m² beam)	± 5 W/m²	± 10 W/m²	± 10 W/m²	± 20 W/m²	± 20 W/m²
Temperature dependence of sensitivity	± 0.5 % (-20 to +50 °C)	± 1 % (-20 to +50 °C)	± 1 % (-10 to +40 °C)	± 4 % (-10 to +40 °C)	± 5 % (-10 to +40 °C)
Tilt error (at 1000 W/m²)	± 0.2 %	± 0.2 %	± 0.2 %	± 1 %	± 3 %
OTHER SPECIFICATIONS					
Sensitivity	7 to 14 μV/W/m²	7 to 14 μV/W/m²	7 to 14 μV/W/m²	5 to 16 μV/W/m²	5 to 20 μV/W/m²
Impedance	10 to 100 Ω	10 to 100 Ω	10 to 100 Ω	20 to 200 Ω	20 to 200 Ω
Level accuracy	0.1 °	0.1 °	0.1 °	0.5 °	1 °
Operating temperature	-40 to +80 °C	-40 to +80 °C	-40 to +80 °C	-40 to +80 °C	-40 to +80 °C
Spectral range (50 % points)	200 to 3600 nm	310 to 2800 nm	310 to 2800 nm	310 to 2800 nm	310 to 2800 nm
Typical signal output for atmospheric applications	0 to 15 mV	0 to 15 mV	0 to 15 mV	0 to 15 mV	0 to 15 mV
Maximum irradiance	4000 W/m²	4000 W/m²	4000 W/m²	2000 W/m²	2000 W/m²
Expected daily accuracy	± 1 %	± 2 %	± 2 %	± 5 %	± 10 %
Recommended applications	Scientific research requiring the highest level of measurement accuracy and reliability	Meteorological networks, reference measurements in extreme climates, polar or arid	Meteorological networks, PV panel and thermal collector testing, materials testing	Good quality measurements for hydrology networks, greenhouse climate control	Economical solution for routine measurements in weather stations, field testing

CMP instruments have a standard cable length of 10 m. Optional cable 25 or 50 m

Standard 10 k Thermistor or optional Pt-100 temperature sensor with CMP 21 and CMP 22

Individual directional response and temperature dependence test data with CMP 21 and CMP 22

SOLAR RADIATION INSTRUMENTS

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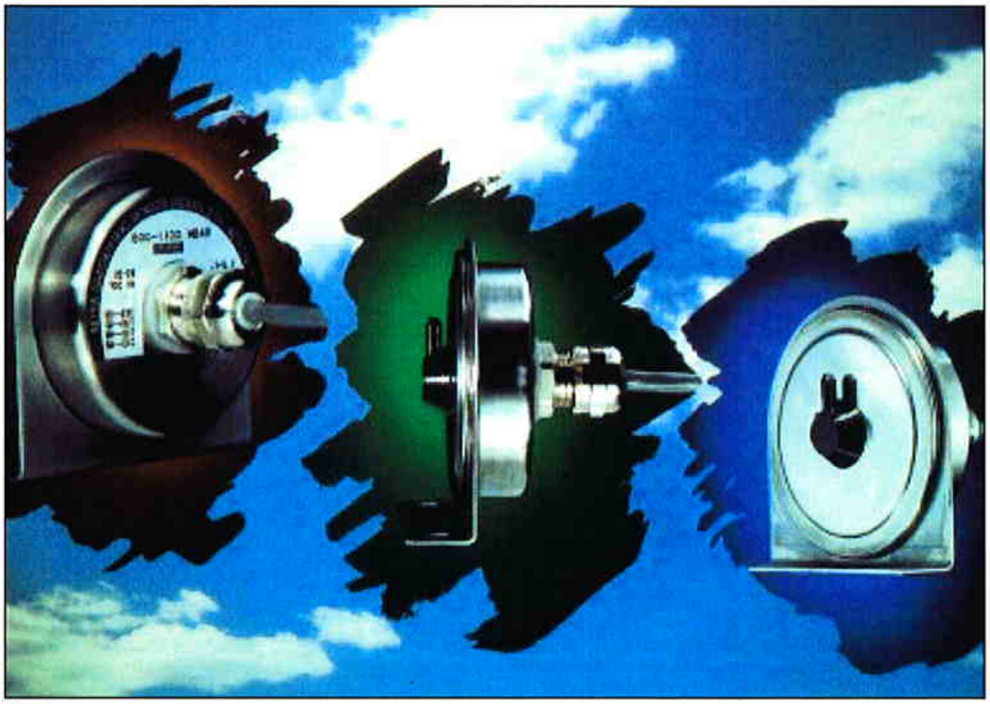
Kipp & Zonen

SINCE 1830

Model 276

Low Cost Barometric Pressure Transducer

Featuring the SETRACERAM™ Sensor
Barometric Pressure: 600-1100, 800-1100 hPa/mb
Absolute Pressure: 0-20 psia



Setra Systems has been a technology leader in Environmental Pressure Measurement for over three decades. The Model 276 is an extremely accurate and stable transducer based on the proven Setraceram™ sensing element. The glass fused ceramic capacitive sensing capsule is the heart of Setra's environmental pressure transducers because of its inherent thermal stability, low hysteresis and fundamentally simple design.

Another major feature of the 276 is Setra's custom Application Specific Integrated Circuit (ASIC). The ASIC works hand-in-hand with the Setraceram™ sensor to achieve long-term stability and high accuracy, unmatched by other manufacturers - even at a much higher cost. The ASIC circuit allows the 276 to operate with an excitation as low as 5 VDC for remote battery or solar powered applications.

NOTE: Setra quality standards are based on ANSI-Z540-1. The calibration of this product is NIST traceable.

U.S. Patent Nos. 4168518; 4054833

The 276 is designed specifically to give maximum flexibility to system integrators and OEM's. The standard unit has a convenient mounting bracket and simple 1/8" tube fitting for quick installations. Its low cost, small size and available options make it application configurable.

If your OEM environmental application requires low cost, combined with superior performance, specify Setra's Model 276 and apply the savings to the bottom line.

When it comes to a product to rely on - choose the Model 276. When it comes to a company to trust - choose Setra, an ESOP (Employee - Owned) company.

Type of Pressure	Pressure Range	Maximum Pressure
Barometric	600-1100 mb 800-1100 mb	20 PSIA 20 PSIA
Absolute	0-20 PSIA	30 PSIA

Applications

- Environmental Monitoring Systems
- Weather Measurement Systems
- Weather and Environmental Data Logging
- Barometric Pressure Compensation for Internal Combustion Engine Performance
- Cleanroom Barometric Pressure Compensation
- Automotive Emissions Test Equipment

Features

- Proven SETRACERAM™ Sensor
- 0.25% FS Accuracy
- Environmentally Rugged
- <±0.25% FS, 6 Month Stability
- Compact Size (2" dia. x 1")
- Excellent Long-Term Stability
- Low Power Consumption (for Solar or Battery Power)
- Instant Warm-Up
- Fast Response

ISO 9001 Certified

Visit Setra Online: http://www.setra.com

800-257-3872

159 Swanson Rd., Boxborough, MA 01719/Telephone: 978-263-1400/Fax: 978-264-0292

Model 276 Specifications

Performance Data

Accuracy RSS* (at constant temp)	±0.25% FS**
Thermal Effects***	
Compensated Range °F(°C)	+30 to +130 (0 to +55)
Zero Shift (Over Compensated Range)	1% FS
Span Shift (Over Compensated Range)	1% FS
Resolution	Infinite, limited only by output noise level (0.0005% FS)
Time Constant	10 milliseconds to reach 90% final output with step function pressure input.
Long Term Stability	0.25% FS/6 months

*RSS of Non-Linearity, Hysteresis and Non-Repeatability.
**FS = 300mb for 800-1100mb range; 500 for 600-1100mb range; and 20 PSI for 0 to 20 PSIA.
***Units calibrated at nominal 70°F. Maximum thermal error computed from this datum.

Environmental Data

Temperature	
Operating* °F (°C)	0 to +175 (-18 to +79)
Storage °F (°C)	-65 to +250 (-55 to +121)
Vibration	2g from 5 Hz to 500 Hz
Shock	50g (Operating, 1/2 sine 10 ms)
Acceleration	10g

*Operating temperature limits of the electronics only. Pressure media temperatures may be considerably higher or lower.

Physical Description

Case	Stainless Steel
Electrical Connection	2ft. Multiconductor Cable
Pressure Fitting	1/8" Tube Fitting

Electrical Data (Voltage)

Circuit	3-Wire* (Exc, Out, Com)
Specify One:	
Excitation	Output
12 VDC (9.0 to 14.5)	0.1 to 5.1 VDC
24 VDC (21.6 to 26.0)	0.1 to 5.1 VDC
5 VDC (4.9 to 7.1)	0.5 to 4.5 VDC
Power Consumption	0.2 Watts (24 VDC)
Output Impedance	5 ohms
Output Noise	<200 microvolts RMS (0 to 100 Hz)

*There are separate leads for +Exc, -Exc, +Out, -Out. The -Exc and -Out are commoned internally. The shield is connected to the case. For best performance, either the -Exc or -Out should be connected to the case. Unit is calibrated at the factory with the -Exc connected to the case. The insulation resistance between all signal leads tied together and case ground is 100 megohms minimum at 25 VDC.

Pressure Media

Non-condensing air or gas compatible with stainless steel, alumina ceramics, gold and elastomer.

Available Options

Performance Options

Option #715	0.1% FS (RSS) Accuracy

Mechanical Options

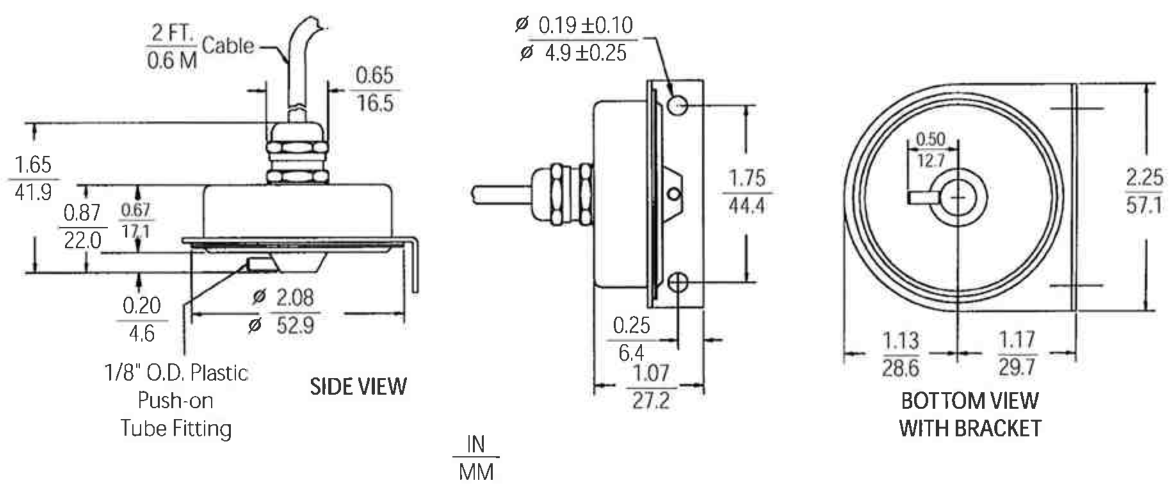
Option #803-825	Up to 25 ft. of cable can be supplied. Specify cable length when ordering (i.e., 805 for 5 ft. cable). Consult factory for cable lengths longer than 25 ft.
Option #839	1/8" NPT Pressure Connection

Calibration Certificate Option

Option #901	11-point Calibration Certificate

Specifications subject to change without notice.

Outline Drawings



SSP276 Rev.B 01/26/2000

ORDERING INFORMATION

Example: Order as a Model 276, specify Pressure Range, Excitation, Electrical Output and Options.

While we provide application assistance on all Setra products, both personally and through our literature, it is the customer's responsibility to determine the suitability of the product in the application.

159 Swanson Road, Boxborough, MA 01719/Tel: 978-263-1400; Toll Free: 800-257-3872; Fax: 978-264-0292; email: sales@setra.com

PRECIPITATION GAUGES

FEATURES

- **Reliable and Accurate**
- **Tipping or Weighing Buckets**
- **English or Metric Measurements**
- **Optional Electric Heat**

Climatronics offers a variety of accurate and durable precipitation gauges. Models are available for both AC and DC powered systems, with or without heaters.

Tipping bucket gauges are available with screened funnels of 6 or 8-inch* diameter. Precipitation is channeled to a triangular bucket, which tips for every 0.01-inch or 0.1 mm of water collected. When the bucket empties it momentarily activates a sealed reed switch,** which sends an event message to the signal conditioner or data acquisition system. Upon tipping, the accumulated water is drained.

Both of Climatronics' tipping bucket gauges can be provided with optional electric heaters for AC powered systems. The heaters prevent data loss during freezing conditions and melt snow so the tipping bucket may measure the water equivalent. Either type of gauge is easy to install, requiring a level piece of ground that is free from obstruction or the use of Climatronics P/N 102271 Rain Gauge Mounting Bracket. Signal conditioners are available in modular form with an input range of 0-1 inch (0-2.5 cm) or 0-10 inches (0-25 cm), and corresponding standard output ranges of 0-1 or 0-5 VDC. A wind shield (P/N 100097WS) is available to prevent uplift near the sensor funnel, insuring a representative data capture. A precipitation calibrator (P/N 260-2595) for field calibration of the tipping bucket mechanism is also available.

Weighing bucket, optical, all-season, present weather and other specialty precipitation gauges can also be provided on special order.

* Optional metric sizes available
** Optional mercury switch available

SPECIFICATIONS

	6-Inch Tipping Bucket* (P/N 100508)	8-Inch Tipping Bucket* (P/N 100097)
PERFORMANCE		
Accuracy	±1% for rain rates of up to 2 in/hr (5.1 cm/hr)	±1% for rain rates of 1 to 3 in/hr (2.54 to 7.6 cm/hr)
	±5% for rain rates of up to 10 in/hr (25 cm/hr)	±3% for rain rates of 0 to 6 in/hr (0 to 15.24 cm/hr)
Resolution/Sensitivity	0.01 in (0.25 mm) 0.004 in (0.1 mm)	0.01 in *(0.24 mm) 0.004 in (0.1 mm)
ELECTRICAL		
Power Requirements (without heat)	None†	None†
Output	Switch Closure	Switch Closure
Contact Rating	2A at 12 VDC	3A at 12 VDC
PHYSICAL		
Size	10.25 in H x 6.25 in diameter (26.0 cm H x 15.9 cm diameter)	18.25 in H x 8 in diameter (46.3 cm H x 20.3 cm diameter)
Weight	2.5 lbs (1.1 kg)	2.5 lbs (1.1 kg)
Operating Temperature (heated)	-40 to 140° F (-40 to 60° C)	-40 to 140° F (-40 to 60° C)

† *Excitation provided by signal conditioner or data acquisition system*
* *Electric heat available, 200 watts*

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