

**STATE OF NEW JERSEY
DEPARTMENT OF TRANSPORTATION
TRENTON, NEW JERSEY 08625**

SPECIFICATIONS FOR MAINTENANCE WEATHER STATION

N.J. Specification No. EBM-MAINT-WSTA-1

Effective Date: July 1, 2001

New Jersey Department of Transportation Specifications for a Maintenance Weather Station.

The purpose of these specifications is to describe the minimum acceptable design and operating requirements for a maintenance weather station. This station accurately determines the temperature, relative humidity, wind speed and direction, presence or absence of active precipitation and presence of ice on the pavement in real-time. The sensor data is collected and processed by a remote processing unit which transmits the weather sensor data to a Central Station Processor via a standard EIA RS-232 serial port connected to a standard dialup telephone service or radio.

All hardware and software supplied as part of this specification shall be fully compatible with the Department's existing weather station equipment.

GENERAL - I

1-1 Components

Each remote weather station shall consist of one subsurface temperature probe one precipitation sensor, one temperature/relative humidity sensor, one wind speed sensor, one wind direction sensor, and four pavement sensors connected to a Remote Processing Unit (RPU). The weather station shall also include communications electronics, mounting equipment, cabinets and cables. The Central Station Processor shall communicate to the Remote Processing Unit(s) to gather data and present it in tabular and graphical display and have the capability of providing thermal mapping displays. The Central Station Processor shall communicate to the remote Processing Unit(s) to gather data and present it in tabular and graphical displays.

1-2 Certification

The installation and operation of the device shall not require any special licensing, frequency assignment or permits from the FCC or other Federal agency to operate as described in this specification. The licensing requirements for the radio shall be the responsibility of the Department.

1-3 Operating Environment

All components of the weather station shall operate correctly as defined in these specifications under the following environmental conditions:

A. Ambient Temperature

The weather station equipment shall function within an ambient temperature range between -22 °C to +122 °C.

B. Relative Humidity

The weather station equipment shall function within a relative humidity range from 0% to 100%.

C. Forms of Precipitation

The weather station equipment shall function under all forms of precipitation (rain, sleet, snow, etc.)

1-4 Mounting

The weather station shall be shelf or rack-mountable.

1-5 Electrical Power

All weather station components shall operate from standard 120 volts AC electrical service. The weather station shall operate as specified over a voltage range of 105 to 125 volts AC at 60 hertz.

WEATHER STATION - II

2-1 Sensors

The weather station components shall be compatible with the RPU and supported by the same vendor.

A. Wind Speed/Direction

This sensor shall be a combined wind speed/direction sensor. It is a wind vane assembly with a four blade propeller rotation which produces a signal whose frequency is directly proportional to speed. The wind direction is measured by the wind vane shaft varying position of a potentiometer.

- Measuring Range: 0 – 161 kilometers per hour (no display below 5 kilometers per hour)
- Accuracy: less than 1% error
- Operating Temperature Range: -40 °C to +40 °C
- Measuring Range: 0°-360° mechanical, 0°-355° electrical

B. Air Temperature/Relative Humidity

This sensor shall provide a relative humidity measurement range of 10% to 100% with an accuracy of $\pm 2\%$ and have an operating range of $-30\text{ }^{\circ}\text{C}$ to $+50\text{ }^{\circ}\text{C}$. The temperature measurement range shall be $-30\text{ }^{\circ}\text{C}$ to $+50\text{ }^{\circ}\text{C}$ with an accuracy of $\pm 0.2\text{ }^{\circ}\text{C}$. The survival operating range shall be $-37\text{ }^{\circ}\text{C}$ to $+80\text{ }^{\circ}\text{C}$. The sensor shall be capable of being recalibrated with one or two references.

System dew point temperature is calculated from the air temperature and relative humidity. The display accuracy of the dew point temperature shall be $+1\text{ }^{\circ}\text{C}$ or $1.5\text{ }^{\circ}\text{C}$ in the range of 50% to 100% RH.

C. Precipitation

This shall be a forward scatter type optical sensor that measures meteorological visibility and precipitation type and intensity. The precipitation type shall be determined to be one of the following classifications based on user defined limits on measured variables:

- Precipitation - non distinguished
- Rain
- Light Drizzle
- Snow
- Mixture(Rain/Snow)

These parameters shall provide intensity indicators of None, Heavy, Light and Moderate. The control circuit boards for this shall be housed in an independent NEMA Type 4 enclosure.

D. Road Surface

The sensor shall be constructed of materials which have thermal characteristics similar to common pavement materials. The top of the sensor shall approximate the roadway pavement color and texture. It shall be installed with epoxy sealer so the top is flush with the surrounding roadway surface and does not allow moisture to enter the pavement structure.

The sensor shall be thermally passive, providing stable operation over a temperature range from $-30\text{ }^{\circ}\text{C}$ to $+50\text{ }^{\circ}\text{C}$. The sensor and cable shall withstand a temperature range of $-37\text{ }^{\circ}\text{C}$ to $+80\text{ }^{\circ}\text{C}$ without sustaining damage. Its performance shall not be degraded by climatic conditions, traffic impacts or use of ice control chemicals. The sensor shall not require cleaning or adjustment to operate continuously.

This sensor electronically samples the following pavement surface conditions:

- Surface Temperature
- Surface Condition

Dry	Snow & Ice ≤ 0 °C
Wet >0 °C	Dew
Wet ≤ 0 °C	Frost
Chemically Wet	Chemical Factor

Relative amount of deicing chemical (range = 0.25 to 12.5 mm)
 Freezing point temperature of the moisture/ice-control chemical solution present on the surface of the sensor.
 Percent of ice particles present in the moisture/ice-control chemical solution present on the surface of the sensor.

E. Radiation Shield

This shall be used to protect the temperature/humidity sensor from solar radiation and rain. The shield shall be UV-proof, well ventilated, and maintenance free.

F. Subsurface

This sensor shall be provided to measure the temperature 425 millimeters below the surface of the pavement and located in the center of the traveled roadway.

2-2 Remote Processing Unit

The RPU design shall maximize the use of solid state components and each connection to sensor outputs/controls shall be protected against lightning. The RPU shall provide stable operation over a temperature range of -30 °C to +65 °C and 0-90% RH non-condensing.

Each RPU shall be microprocessor based and capable of collecting data from the following sensors:

- 1 to 4 Surface Sensors
- 1 to 4 Sub-Surface Temperature Probes
- Air Temperature/Relative Humidity Sensor
- Precipitation Classification Visibility Sensor
- Wind Speed/Direction Sensor
- Present Weather Sensor

Powered by 110 volts AC, the RPU shall operate in a range of 100-130 volts AC at 50-60 hertz and require a maximum of 100 watts continuous power. The RPU shall be housed in a NEMA Type 4 enclosure manufactured of stainless steel and of sufficient size to accommodate all required equipment plus 25% free space (not volume) for future add on equipment.

A watchdog timer shall reset the processor if program execution halts for 60 seconds, DC power supply varies, or upon request.

2-3 Maintenance

The weather station shall require minimal or no maintenance for correct operation as described in these specifications. Under normal conditions, the weather station shall

require only periodic cleaning of the lens cover not more than four times per year to maintain effective operation.

2-4 Communications

The weather station shall transmit the specified sensor data within one second after a request by the central processor. The Supplier shall provide documentation that fully describes the weather station operation and the communications protocol required for accessing the sensor data directly from the central monitoring station.

The communication protocol information shall be supplied as part of the submittal information. The weather station shall be capable of communicating via dialup telephone or radio. When the supplemental specifications require a radio to be provided it shall be the following:

- A. The radio shall operate at 15 watts power with a 3 dB gain mobile antenna and power supply on 800 megahertz, Type II operation and be 100% compatible with the NJ State Police Trunked Radio System.
- B. The radio modem shall be a 1200/2400 baud wireless modem with wiring kits for making cables. The modem shall be 100% compatible with the radio and the outputs of the RPU.
- C. The compatibility of the radio and modem to be provided shall be demonstrated before approval.
- D. The installation and final testing of the radio shall be coordinated with the Department's Radio Communications Shop.

2-5 Tower, Foundation and Site Layout

A. Tower Design

The tower supplied shall be in conformance with all the requirements as needed for proper performance of the weather equipment that is to be mounted on the tower.

The structural design of the tower shall be in accordance with the current "AASHTO Standard Specifications for Structural Supports for Highway Signs, Luminaires and Traffic Signals" with the following conditions:

1. Design Ice Load shall be 144 pascals.
2. Design Wind Speed (V) shall be 129 kilometers per hour (50 year recurrence interval).
3. The Wind Drag Coefficient (C_d) shall be 1.0 for the wind speed/direction sensor, the temperature/humidity sensor, precipitation sensor and radio antenna.

4. The Wind Drag Coefficient (C_d) shall be 1.14 for the RPU Enclosure.
5. The maximum horizontal deflection at the top of the assembled tower with fixtures attached due to a 64 kilometers per hour wind speed (V) shall not exceed 1.25% of the total height of the structure.

All calculations shall be submitted in accordance with the Working Drawing procedure of the specification and shall bear an actual embossed seal of a Professional Engineer licensed to practice in the state of New Jersey.

B. Tower Materials

The tower may be constructed from steel or aluminum material in accordance with the following:

1. Steel Design

Structural steel shall conform to ASTM M270 (ASTM A709), Grade 36 and shall be hot-dipped galvanized in accordance with current NJDOT Standard Specifications. Structural steel pipes and tubes shall conform to ASTM A53, Type S or Type E, Grade B and shall be hot-dipped galvanized in accordance with current NJDOT Standard Specifications.

Structural steel bolts, nuts and washers shall conform to ASTM A307 and current NJDOT Standard Specifications and shall be hot-dipped galvanized in accordance with ASTM A153.

Structural steel yield strength (F_y) for pipes and tubes shall be 240 megapascals.

Structural steel yield strength (F_y) for other shapes shall 250 megapascals.

Welding and welds shall be in accordance with the ANSI/AASHTO/AWS D1.5 Bridge Welding Code and the NJDOT Standard Specifications.

2. Aluminum Design

Aluminum shall conform to the following ASTM Designations and alloy list below:

Application	ASTM Designation	ASTM Alloy
Rolled or Extruded Shapes	B308/B 308M	6061-T6
Plate	B209M	6061-T6
Extruded Tube	B221M	6061-T6
Drawn Tube	B210M	6061-T6

Stainless steel bolts, nuts and washers shall conform to ASTM A320/A320M, Grade B8, Class 2 (AISI Type 304) and NJDOT Bridge Specifications.

Welding and welds shall be in accordance with the ANSI/AASHTO/AWS D1.5 Bridge Welding Code and the NJDOT Standard Specifications. Filler material for welding aluminum shall conform to current ASTM B285, ASTM ER5556 or ER5356.

C. Tower Dimensions

The tower shall be free standing, fixed at the base, non-climbable, corrosion resistant and fold over at the 3 meter point for ease of maintenance. The tower shall be a minimum of 9 meters high. The tower shall be constructed as a vertical triangular or square truss. The footprint of the structure in plan view shall form an equilateral triangle or square. Siderail distance shall be a minimum of 325 millimeters out-to-out. The maximum spacing for bracing member shall be 380 millimeters.

D. Tower Foundation

The design of the tower foundation shall be in accordance with the NJDOT Design Manual for Bridges and Structures.

The maximum foundation bearing pressure shall be 0.120 megapascals. The footing shall be designed such that a minimum of 75 percent of the footing is always in contact with the soil.

Adverse foundation conditions, property lines, subsurface utilities, temporary sheeting, traffic maintenance, and other special conditions which may require individual foundation designs shall be investigated by the structural engineer at each tower location.

1. Concrete Design Criteria

Concrete shall be Class B Concrete in accordance with the NJDOT Standard Specifications.

Specified Concrete Compressive Strength (f_c) shall be 21 megapascals.

Concrete Extreme Fiber Compressive Stress (f_c) shall 8.4 megapascals.

2. Reinforcement Steel

Reinforcement steel shall conform to ASSHTO A615M, Grade 400.

Tensile stress (f_s) for reinforcing steel shall be 160 megapascals.

E. Site Layout

A concrete work pad measuring 1 220 by 1 220 millimeters with 100 millimeters thickness shall be placed in front of the RPU cabinet. The tower shall have a grounding system as shown on the detail. A green vinyl chain link fence 1.8 meters high with 3 barbed wire strands on top angled outward and a 0.9 meter gate shall surround the weather station. The size of the fenced area shall be 5 meters by 5 meters and the entire area shall have all grass removed to 0.6 meter outside the fence line. The grassless area shall be covered with 19 millimeter crushed stone to a depth of 50 millimeters.

CENTRAL STATION - III

3-1 Communications

Communication between the central station and remote processors shall be via dial up telephone or radio. The central station shall include multiple RS232 ports which can be connected to a workstation. Over this channel, all weather information from any remote station shall be available and refreshed at least once a minute. The protocol for accessing this information shall be supplied as part of the submittal package.

3-2 Displays

The workstation processor or central station processor shall provide displays representing all data returned from the Remote Processing Units. This data shall be presented in the following formats:

- Graphical Displays indicating the development and trend of the measured and calculated variables.
- Tabular Displays showing data from several Remote Processing Units.

The System Displays to be provided shall be user friendly and provide the following as a minimum:

- A. Map Page displays shall be oriented to provide instant recognition of changing pavement surface and atmospheric conditions. Information provided automatically on the Maps include:
 1. Color coded roadway pavement surface condition status at each sensor to include:
 - Dry - Green
 - Wet- Blue
 - Wet but not frozen at or below 0 °C - Yellow
 - Snowy or icy at or below 0 °C - Red
 - Dew - Blue
 - Frost - Red
 2. Pavement surface temperature at each sensor head
 3. Percent of chemical solution present on each sensor head.

4. Percent of ice solution present on each sensor head.
5. Freeze point temperature of solution at each sensor head.
6. The subsurface temperature 425 millimeters below the pavement surface.

To enhance the "operational friendliness" of the system, 'locator' or 'icon' boxes shall be provided to visually indicate the availability of other display options.

The system shall be set up so that a map is continually displayed on the color enhanced monitor.

- B. Status Page shall display all the information received from an individual Remote Processing Unit (RPU). The Status Page displays shall show real-time data including the following parameters:

- Surface Status
- Surface Temperature
- Chemical Percentage
- Ice Percentage
- Freeze Point Temperature
- Air Temperature
- Relative Humidity
- Dew Point Temperature
- Wind Speed and Direction

The surface status shall be displayed in color unique to the status. Significant changes in the data shall be indicated with an * (asterisk).

- C. Summary Page displays shall show the current data from up to 16 sensors connected to the Region's RWIS network. The display shall allow the user to see "at a glance" the data from up to 16 sensors from the system.
- D. Long Term History Page displays shall show historical data from any sensor connected to the system. Each history page shall display up to twenty (20) significant changes which have occurred. A significant change is indicated on the History Page with an asterisk (*) to the left of the parameter that caused the report to be saved. Significant changes are recorded for:

- Surface Status
- Surface Temperature
- Dew Point
- Wind Speed
- Precipitation

- E. Graph History Page displays shall provide the user with a tool to evaluate trends of recorded surface and atmospheric weather parameters. For a selected Surface Sensor a color line graph will display surface, air and dew point temperatures, precipitation and the status of the surface condition.
- F. Bar Graph Page displays provide the user with graphically comparative real-time data summaries. Parameters displayed include:

Surface condition status
 Surface temperature
 Temperature trends
 Precipitation
 Air temperature
 Dew point temperature
 Up to 35 individual data bars shall be displayed for determining parameter trends.

3-3 Alarm System

Important messages shall be shown on the screen and/or printer. The threshold for these alarms shall be user definable. Important messages include changes in precipitation status, changes in pavement sensor status and significant changes in temperature.

3-4 Workstation or Central Station Equipment

One (1) personal computer based on the Intel 80586DX2 - Pentium microprocessor shall be provided to run the Central Station Software. This system shall include the following components or features at a minimum:

- 1.0 gigabyte hard disk
- 16 megabytes RAM memory
- 90 millimeter drive (1.44 megabytes)
- CPU speed of 90 megahertz or greater
- 533 millimeter SVGA color monitor, dot pitch of 0.28 millimeters
- 250 megabyte Tape Backup
- Isobar power strip or equivalent
- All required MSDOS, XENIX, or OS/2 system software required to support the central weather station implementation
- Hewlett Packard Laser Jet 4 Printer or equivalent
- Procomm Software or equivalent
- Hewlett Packard Paintjet Printer or equivalent
- Internal Fax Modem (14.4K baud min.)
- Windows for Workgroups (current ver.)
- Quad speed CD ROM
- Backup power supply rated at 1250 volt-amperes

3-5 Portable Workstations

Two (2) Laptop computers shall be supplied with each project. The computer shall conform to the following as a minimum:

- CPU shall be 80586DX2, 90 megahertz
- Display shall be 213 millimeters minimum high color resolution VGA LCD active matrix type
- 16 megabytes RAM
- 500 megabyte hard drive
- 1.44 megabyte, 90 millimeters disk drive
- 14.4K baud internal fax modem
- DOS 6.22 (or current ver.)
- Windows for Workgroups (current ver.)
- One (1) spare battery pack
- Carrying case
- Communication and FAX software

TESTING - IV

All equipment defined in this specification shall be subject to factory testing as subsequently described. The factory test shall demonstrate or provide confirmation that all of the equipment operates over the specified environmental range for each component and meets the overall specifications. The factory test shall include at least two fully configured remote stations and one central station. The central station shall be connected to the remote stations via a multi-drop or direct null-modem RS232 connection. The procedure shall demonstrate the operation of the central station and the production of all interactive displays and reports. The factory test shall include a demonstration of the central interface port. In addition, methods shall be proposed for fully exercising all sensors for all environmental conditions encountered in New Jersey. The supplier shall be responsible for submitting a test plan which has been designed to exercise and monitor the equipment for the purpose of determining compliance with the specifications.

TRAINING - V

Prior to the acceptance of the first unit of each type, training shall be provided for the Department's engineering, maintenance and operations staff, at a facility provided by the Department. The training shall include all material and manuals required for each participant. The training schedule and material must be submitted for approval. The training shall be as follows:

5-1 User Training

User training shall be provided for a minimum of eight (8) hours for up to eight (8) NJDOT people with a background in snow and ice control operations. The training shall provide the user with a comprehensive knowledge of its capabilities and how to effectively utilize information from a Road Weather Information System (RWIS) using the software. The training shall provide the user with the necessary knowledge to utilize RWIS information in snow and ice control operational decisions. In addition, basic meteorological concepts relative to atmospheric and pavement conditions will be emphasized.

INSTRUCTIONS AND GUARANTEES - VI

- 6-1 One set of complete schematics and operations/maintenance manuals of each component shall be supplied with every field and central assembly furnished. Maintenance manuals shall include complete sub-component parts listing. Operations manuals shall include a complete description of the software protocol.
- 6-2 No changes or substitutions in these requirements will be acceptable unless authorized in writing. Inquiries regarding this specification shall be addressed to the Manager, Office of ITS Engineering, New Jersey Department of Transportation, P.O. Box 613, 1035 Parkway Avenue, Trenton, New Jersey 08625.
- 6-3 All components shall carry a one-year guarantee from the date of acceptance against any imperfections in workmanship or materials.
- 6-4 The supplier shall furnish any and all equipment which they deem necessary for safe and reliable field and central operation of the weather equipment as part of the quoted price for the specified equipment.
- 6-5 All components furnished under this specification shall be current production equipment and of recent manufacturer, identical models of which are in field operation in not less than one hundred sites worldwide. Untried or prototype units shall not be considered for acceptance.
- 6-6 Any repairs made by a manufacturer or representative shall be documented and returned with units when warranty repaired. This documentation shall include an explanation of the exact repairs made and identification of parts replaced by part number and circuit number. All warranty repairs shall be completed within thirty days of delivery of the equipment to the designated repair depot.