Air Quality Monitoring Network Standard Operating Procedures for Meteorological Sensors

Confederated Tribes of the Colville Reservation

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Introduction

This document provides the standard operation procedures (SOP) for meteorological (Met) sensors at two monitoring sites within the exterior boundaries of the Colville Reservation. Both sites have a Beta Attenuation Monitor (BAM) model 1020 configured to measure particulate matter (PM) 2.5 microns or smaller, manufactured by Met One Instruments Inc. The Met sensors mentioned in this SOP support those monitors.

Both monitors operate as Non-regulatory for comparison to the National Ambient Air Quality Standards (NAAQS). Every effort will be made to assure that data gained by meteorological sensors are rigorously controlled by the procedures set in this SOP.

Scope and Applicability

This SOP applies to the meteorological sensor portion of the monitoring network established within the exterior boundaries of the Colville Reservation. The two sites, Nespelem and Inchelium, are equipped with sensors purchased at separate times, 2005 and 2011 respectively. Table 1 provides specific information and serial numbers for each sensor at the two sites.

Table 1: Meteorological Sensors and Components

Component	Location	
	Nespelem	Inchelium
BX-596 AT/BP Sensor		M5917
BX-592 Temperature Probe and Shield	E5672	
Model 50.5 Wind Sensor	E6920	M4395
Model 50.5PS Heater Power Supply	Yes	Yes
Tower, 10m Aluminum, 18 Inch Base	Yes	Yes
Relative Humidity Sensor, 083D-1-35	E6859	
Barometric Sensor 090D (26/32-1)	E6799	
Rain Gauge 375 0.01 Inches	E5806	

Health and Safety Warnings

Safety precautions should be followed during the setup and operation of all meteorological sensors. Standard safety rules regarding electricity and power tools should be observed at all time. Installation of the 10 meter meteorological tower requires several precautions. Follow manufactures installation procedures for initial setup and reverse these if dissembling. The tower should be placed 2 times the height at a minimum away from hazards such as electric lines. Plan the process before beginning and coordinate with all involved. Do not use metal ladders; work on wet or windy days. Wear rubber soled shoes and other personal protective equipment.

Personnel Qualifications/Responsibilities

The quality assurance (QA) procedures detailed in this SOP require an understanding of all meteorological sensors, calibration protocol and normal operating processes. EPA *Guidance for Quality Assurance Project Plans* (U.S. Environmental Protection Agency, 2002) recommends that all field operations personnel be familiar with environmental field measurement techniques. The Air Quality Program (AQP) encourages all personnel working with the sensors to read this SOP and the individual documentation for each pieces of equipment.

Equipment

This SOP describes setup, operation, maintenance and quality control for all meteorological sensors associated with the monitoring network. The two sites have similar yet different sensor models to accomplish the data gathering. Table 1 list the sensors by location and provides serial numbers where appropriate. Manuals for all sensors are found in Appendices A – E at the end of this SOP. Many of the manuals can be downloaded from the Met One Inc. website: http://www.metone.com/. All documents are kept on file in the AQP office and at each monitoring site.

Procedures

Sensors will be inspected after receiving for shipping damage or other flaws. If problems are discovered the manufacture will be contacted for return or repair instructions.

BX-596 Air Temperature and Barometric Pressure Sensor

The BX-596 combination ambient temperature (AT) and barometric pressure (BP) sensor is a required accessory for all Federal Equivalent Method (FEM) BAM 1020 configured to sample PM2.5 levels. The sensor provides ambient temperature and pressure data to the unit for actual flow control and flow statistics during the hourly sample cycle. The BX-596 is only compatible with BAM 1020 firmware version 3.2.4 or later. Attach the sensor to the sample tube using the hardware provided and rout the cable into the cabinet. Follow the wiring pairing as shown in Table 2 when connecting to the back of the BAM 1020 on channel 6 when the monitor is turned off. The BAM will automatically detect the ID voltage and configure input channels six and seven to read and scale the outputs from the sensor. Table 3 provides specifications for the combination sensor.

Table 2: Wiring Connections between the BX-596 AT and BP Sensor and the BAM 1020 Terminal Strip

BX-596 AT/BP Sensor	
Wire Color	Terminal Name
Yellow	Channel 6 SIG
Black/Shield	Channel 6 COM
Red	Channel 6 Power
Green	Channel 6 ID
White	Channel 7 SIG

Table 3: BX-596 AT and BP Sensor Specifications

BX-596	Barometric Pressure	Ambient Temperature
Voltage Output	0 to 2.5 volts	0 to 2.5 volts
Range	525 to 825 mmHg	-40 to +55 degrees C
Accuracy	± 0.25 mmHg at 25˚ C	± 1.5˚ C above -30˚
ID Voltage	4.10 volts DC ± 0.02	

After installing the sensor a flow calibration is performed following the instructions in the Air Quality Monitoring Network Standard Operating Procedures for BAM 1020 PM 2,5 Monitors. The AT and BP can be adjusted in the STD column based on the reference standard measurements. The Default hot key can be pressed to reset the user calibration from the selected parameter and replace it with a factory setting if values appear to deviate from expected.

The BX-596 temperature output may also be checked in an ice bath. The ice bath test is usually never done except in some cold weather environments. First calibrate the sensor at ambient temperature, and then use the following steps:

1. Remove the stop screw from the bottom of the mounting bracket so that the electronics module is free to rotate. Rotate the module counter-clockwise until it disengages from the keyhole slots and comes free from the radiation shield.
2. The sensor comes with an 18 inch long ice bath extension harness. This may be used to allow the temperature bead to reach the ice bath if necessary. Carefully unplug the black temperature bead assembly from the top of the electronics module and install the harness between the bead and the module.
3. Insert the temperature bead into the ice water bath along with your reference sensor. Avoid immersing the bead assembly past the connector.
4. Allow the bead to equilibrate, then compare the AT reading in the TEST> FLOW screen to your reference sensor. The tolerance for the regular BX-596 standard range sensor is ± 2.5 C in temperatures below -30C.
5. Remove the ice bath harness and reassemble the sensor.

During operation of the BAM-1020, the output from the BX-596 can be viewed from the main flow statistics screen or the OPERATE screens.

Simple maintenance practices will keep the BX-596 operational, which include:

1. Make sure the four holes in the cover plate are clear by removing the bottom cover for inspection.
2. Clean the radiation shield assembly once each year
3. The black temperature bead assembly may be replaced if the bead becomes damaged. The assembly simply plugs into the top of the electronics module. The sensor will need to be recalibrated any time the temperature bead is replaced.
4. The circuit board can only be serviced by the manufacture.

BX-592 Temperature Probe and Shield

This sensor provides temperature measurement of the outside air used to determine the correction value as part of the volumetric flow calculation. The sensor is designed to be connected directly to one of the analog input channels of the BAM1020. The sensor comes with

30 feet of cable and mounting hardware. The sensor is mounted on the sample tube below the PM10 and Sharp Cut Cyclone (SCC) air intakes. The cable entry into the enclosure can be by a weather tight hole in the top or side.

Connect the cable onto the channel 6 location on the back of the BAM 1020 following the pairing in Table 2. Table 3 provides specifications for the temperature sensor.

Table 4 Wiring Connections between the BX-592 AT Sensor and the BAM 1020 Terminal Strip

BX-592 AT Sensor	
Wire Color	Terminal Name
Yellow or White	Channel 6 SIG
Black/Shield	Channel 6 COM
Red	Channel 6 Power
Green	Channel 6 ID

The sensor shield provides protection for the temperature probe from direct solar radiation. The shape allows for the wind to naturally aspirate the shield to reduce the total effect of solar radiation on the temperature measurement.

Table 5: BX-952 Temperature Sensor and Shield Specifications

Temperature Probe Type	Thermistor Bead, multi-element
Temperature Accuracy	± 0.02˚ degrees C
Temperature Range	-30˚ C to + 50˚ C
Sensor Output	0 to 1 VDC for temperature range
Time Constant	10 Seconds in still air

Maintenance and calibration of the BX-592 consists of simple procedures recommended by Met One Inc. Maintenance includes cleaning the radiation shield once each year to prevent buildup of material that would alter or decrease the reflectivity. Temperatures are checked and/or adjusted during the flow verification process of the BAM 1020 as outlined in the monitoring network SOP. The temperature probe is not adjustable in the field and should only be repaired by the manufacturer.

Model 50.5 Wind Sensor

The 50.5 Wind Sensors are a solid-state ultrasonic instrument capable of measuring wind speed and wind direction in the U and V axes. Sonic pulses are generated at the transducers and are received by opposing transducers. Mathematics derived for these sonic pulses provide a wind velocity measurement in each of the corresponding axes.

The 50.5 uses a microprocessor-based, digital electronic measurement system to control the sample rate and compute the wind speed and wind direction. The sensor is factory calibrated and requires no field calibration. In the field, the operation of the sensor can be quickly checked using a combination of simple tests. A zero chamber or bag is used to verify the zero reference by covering the entire sensor, or individual outputs are checked by blocking various combinations of sensors.

The sensor is designed for installation in a Model 3188 mounting and alignment fixture (Figure 1). This provides a mount for use on a horizontal ¾ inch IPS pipe boom. The 3188 Sensor Mounting Fixture includes a keyed bushing, which will be adjusted for alignment to North orientation enabling the sensor to be removed and replaced without realignment. Three captive machine screws are used to secure the sensor to the keyed bushing. Review page 22 of the operation manual (Appendix C) for a diagram of a top of tower installation.

Orientation of the sensor to true north can be accomplished by following the instruction on page 8 of the operation manual and should be necessary only on setup. To prevent birds from perching on the sensors, stainless steel wire deterrents are installed prior to securing to the alignment fixture. Safety precautions should be followed during this operation because the deterrents are very sharp.

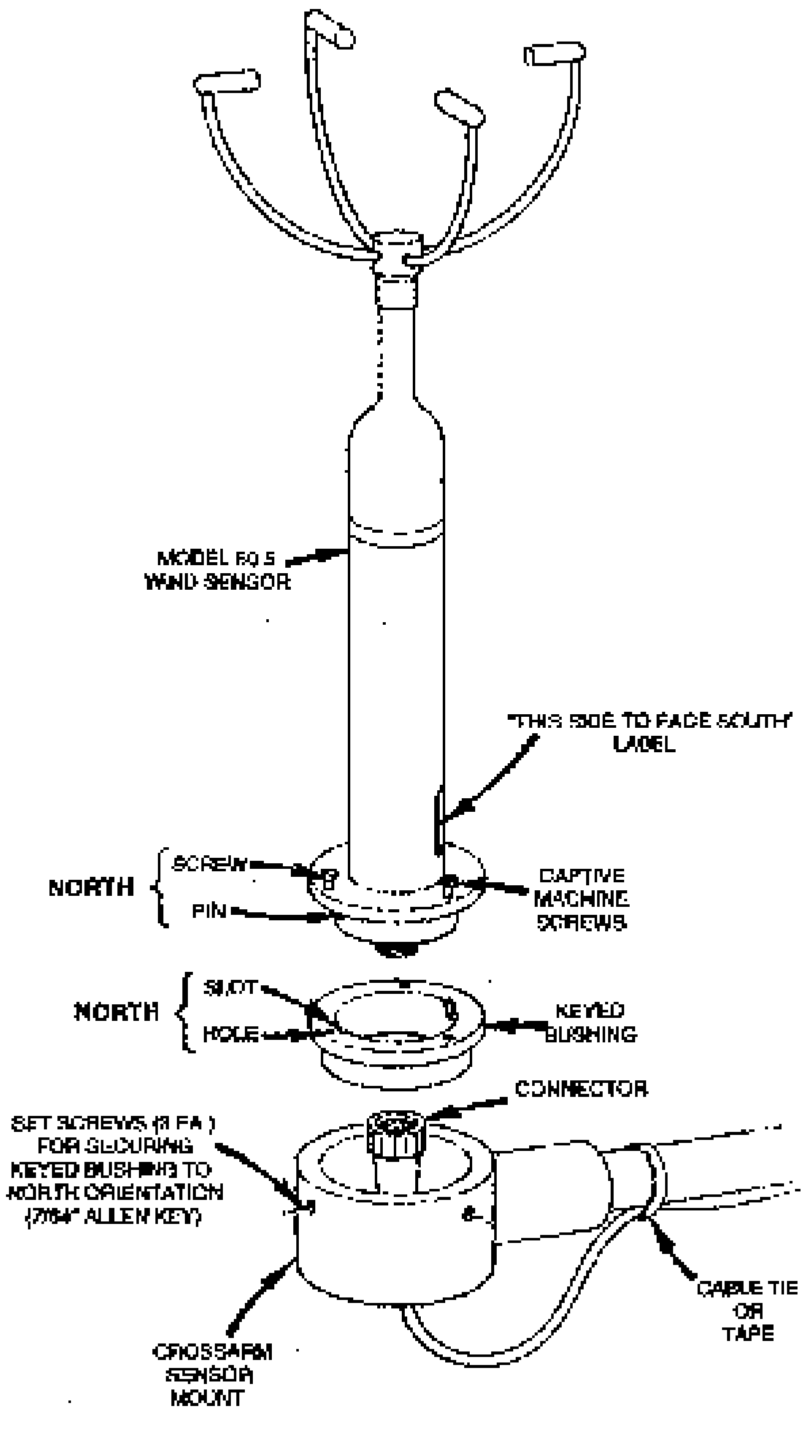
The External Heater provides de-icing for the sensor arms and prevents the accumulation of ice, which might block the sonic elements. The heater consists of a laminated material that is wrapped around the four sensor arms and sonic sensor element housings. Heater power is supplied from a Met One Instruments power unit in a weatherproof box. The heater is activated at 38 degrees F and will keep the arms ice-free at temperatures down to below -20 degrees F. The connection information can be found in Appendix C of this manual.

The temperature controller electronics box should be mounted no more than 5 feet from the sensor using the U-bolts and cable supplied with the heater controller. A two conductor cable spans the distance from the heater controller to the heater power supply. The power supply fastened to the tower with the U-bolts provided and then plugs into a three prong 120 volt AC receptacle.

Follow the instructions on page 12 of the operations manual for details on connecting the data cable to the data logger. Several options are available depending on which connection is needed. The data cable from the sensor to the data logger should be secured to the boom and tower with cable ties. The two wind sensors differ in voltage output; 0 to 2.5 volts at Nespelem and 0 to 1.0 volt at Inchelium. This difference is important when configuring the data loggers at each site.

Operation of the 50.5 is essentially automatic; no specific sensor calibration is required. The sensor has been calibrated in a wind tunnel at the factory prior to shipment. The sealed sensor cannot be adjusted in the field and there are no replaceable parts. To ensure that the recorder is scaled properly, the manufacture recommends that zero and span tests are performed after the sensor is connected and operational.

Figure 1: Model 50.5 Wind Sensor Components



A zero test requires the prevention of air movement across the sensor by covering the array. A plastic bag can be placed over the array, using care not to contact the transducers or block the sonic paths between transducers. The bag should be spaced at least 2" above the transducers to avoid sonic reflections, which may affect readings. The bag can be tied at the bottom with a tie wrap or tape to prevent air movement from below; the wind can deflect the bag, causing air movement inside. With no air movement across the array, the sensor should indicate 0.0 to 0.1 m/s wind speed. The wind direction output will wander to any value between 0 and 360 degrees.

The sensor is designed to produce known default outputs if an object blocks the sonic signal path between the transducers. This feature is useful for verifying sensor operation and recorder scaling. For testing purposes, the sonic path can be blocked by placing a finger (or any solid object) on the face of one or more transducers.

The outputs, after blocking the transducers, are shown in Table 6 below.

Table 6: Span Test Outputs for Blocked Transducers

Wind Speed				
Blocked Axis	Serial Output	Analog Output	0-1.0 V	0-2.5 V
North-South	100 m/s	50 m/s	1.00 V	2.50 V
East-West	100 m/s	50 m/s	1.00 V	2.50 V
Both	100 m/s	50 m/s	1.00 V	2.50 V

Wind Direction				
Blocked Axis	Serial Output	Analog Output	0-1.0 V	0-2.5 V
North-South	10 degrees	10 degrees	0.03 V	0.07 V
East-West	160 degrees	160 degrees	0.44 V	1.11 V
Both	170 degrees	170 degrees	0.47 V	1.18 V

The testing of the transducers can easily be accomplished when the tower is tipped down for the yearly inspection. Table 7 lists the specifications for the wind sensor.

Table 7: Model 50.5 Wind Sensor Specifications

Wind Speed	**Specifications**
Range:	0 to 50 m/sec
Accuracy:	± 0.2 m/sec ≤ 11.3 m/sec or ± 2% ≥11.3 m/sec
Resolution:	0.1 m/sec
Wind Direction	
Range:	0 to 360°
Accuracy:	±3°
Resolution:	1˚

Operation	
Sample Rate:	5 per second
Data Output Rate:	1 per second
Sonic frequency:	200 KHz
Output Signals	
Wind speed voltage:	0-5.0 VDC
Wind direction voltage:	0-5.0 VDC
RS-232:	1200 to 19.2K Baud
Power requirement	
Sensor:	9-18 VDC @ 10 mA @ 12 VDC Average power
External Heater Option:	15 VDC @ 50 Watts
Environmental	
Maximum Measurement range:	0 to 65 mls
Operating Temperature:	-40°C to +55°C no ice
Extended Temperature Range:	-50°C to +55°C with external heater
Physical	
Weight:	5.5 lbs
Dimensions:	19.29in high, 9.38in diameter

Model 083D Relative Humidity / Temperature Sensor

The 083D-1-35 Sensor is an extremely accurate and sensitive relative humidity and temperature sensor. Response is linear with small hysteresis and negligible temperature dependence. The sensors are installed in a radiation shield before shipping. The 73B radiation shield (Figure 2) mounts on the opposite end of the boom from the 50.5 wind sensor on top the tower. The radiation Shields and cables have Mil Spec screw-on or twist-on cable connectors that are pre-fitted by Met One. The cable should be secured to the boom and tower with cable ties.

The Relative Humidity/Temperature Sensor has been calibrated at the factory and will not change unless it is damaged. Blow on the sensor for a quick check for operation; the RH will rise. To check for reasonableness of operation compare the measurement with a local weather service facility. The reading will not be exactly the same but should be similar. Compare the temperature measurement to the delta Cal standard reading when conducting flow verifications.

The sensor may need cleaning due to the accumulation of dust or other substances that will affect measurements. Turn off power to the sensor before attempting to clean and keep off until dry. Cleaning with distilled water will be adequate in most instances. If extremely dirty or covered with substance water will not remove isopropanol can be used. Follow the instruction in the operations manual to prevent damage to the sensor when cleaning with liquids.

Figure 2: Model 073B Radiation Shield

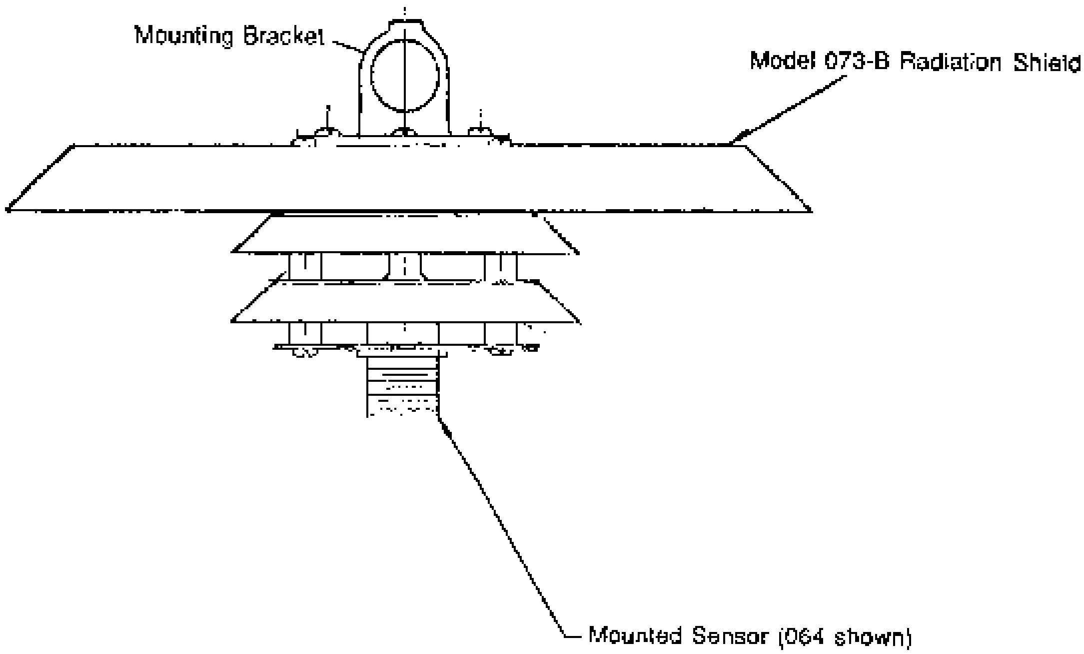


Table 8 Model 083D RH and Temp Sensor Specifications

Sensing Element	Thin-film Capacitor
RH Range	0 - 100%
Temp Range	-50° to +50°C
Response Time	15 seconds at 20°C
RH Accuracy	±2% RH between 10% and 100% RH
Temp Accuracy	0.1°C
Hysteresis	For 0% to 100% to 0% excursion ≤ 1%
Temperature Coefficient	±0.04% per 1°C
Output	0 - 1 V full scale
Input Power	12V DC

Barometric Sensor 090D

The 090D (26/32-1) uses an active solid-state device to sense barometric pressure with a range of 26 to 32 inches of mercury and a voltage output of 0 – 1 volt. The sensor attaches to the tower or other convenient location with a “J” bolt. Orient the J box with the pressure inlet port facing down. Install the cable through the water tight fitting and connect as shown in Figure 2.

Figure 3: Installing the Barometric Sensor 090D Wiring

SIG Terminal = Signal Output (Wht)
COM Terminal = Signal Common (Grn)
+12 Terminal = +12V Power (Red)
COM Terminal = Power Com(Blk)

The sensor has been calibrated at the factory and will not change unless damaged. No field modification or calibrations can occur. To check for proper operation compare to a local weather station to see if the readings are reasonable. The measurement will not be exactly the same due to differences in elevation and measurement parameter, absolute or normalized to sea level. This sensor measures absolute inches of mercury. BP can also be checked when conducting regular flow verifications or calibrations on the BAM 1020. The deltaCal standard measures BP as millimeter (mm) or millibars (mb) and can be converted to inches mercury by multiplying; mm X 0.3937 and mb X 0.0295.

Maintenance consists of inspecting the pressure inlet port for blockages and removing obstructions if found. If service or recalibration becomes necessary then send the sensor to the manufacture.

Rain Gauge 375 0.01 Inches

This sensor measures precipitation on a continuous basis and is low-maintenance. The tipping bucket collects 0.01 inches of precipitation then tips and drains. This triggers a switch closure pulse that is counted. The tipping bucket and rain gauge are heated to prevent accumulation of snow and ice. The sensor has been calibrated at the manufacture and should not require adjustments after installation. Mount the sensor level on a platform using the built in level and three adjusting legs. Follow the instruction in the operations manual (Appendix F) for complete installation instructions. A debris screen should be removed during the winter when snow will accumulate.

After installation manually actuate the tip bucket mechanism three times and confirm the tips have registered on the data logger. Inspect and clean the tipping buckets periodically and physically tip to verify recording on the data logger. If the sensor has been damaged or appears to need calibration follow the instruction in the operations manual.

Table 9: Model 375C Rainfall Sensor Specifications

Orifice:	8 Inch Diameter
Calibration	.01 Inches Rain per Switch Closure
Accuracy:	± 1% at 1 to 3 inches per hour at 70 F°
Switch Type:	Magnet and Reed
Mounting:	3 Pad for 1/4 inch bolts
Dimensions:	8 Inch Diameter

Power Requirement:	110 VAC
Weight:	7.5 Pounds

Quality Control and Quality Assurance

Quality Control (QC) and Quality Assurance measure are minimal due to the reliability and low maintenance of the meteorological sensors employed. The following table list all standards used, maintenance needed and actions. If sensors exhibit characteristics outside of these parameters the manufacturer will be contacted for instructions. Records related to Meteorological sensors will be tracked on the site log and summaries semiannually.

Table 10: Meteorological Sensor Quality Control and Assurance Measures

Sensor	Criteria	Action
BX-596 AT/BP Sensor	BP varies more than ±10 mm Hg from deltaCal Standard	BAM 1020 Calibration Following SOP
	Temperature varies more than ±2°C from deltaCal Standard	BAM 1020 Calibration Following SOP
	Sensor shield and/or probe damaged	Contact Met One for instructions
BX-592 Outside Temperature Sensor, Volumetric Flow	Temperature varies more than ±2°C from deltaCal Standard	BAM 1020 Calibration Following SOP
	Temperature shield and/or probe damaged	Contact Met One for instructions
Model 50.5 Wind Sensor	Yearly zero test reading 0.0 to 0.1 m/s wind speed.	Contact Met One for instructions if greater than these readings
	Yearly span test	Contact Met One for instructions if readings do not match those shown in Table 6
	Heater not functioning	Contact Met One for instructions
Relative Humidity/Temperature Sensor, 083D	Yearly check for reasonableness	Compare with local weather station,
	Yearly check for operation	Blow on sensor and confirm RH rise
Barometric Sensor 090D	Yearly inspection	Clean pressure inlet port for blockages when needed
	Compare to deltaCal Standard	Contact Met One for instructions if values do not compare reasonably
Rain Gauge 375 0.01 Inches	Yearly check for operation	Manually tip bucket and confirm reading
	Yearly check for level	Use adjustment legs to level
	Damage or bucket set screws loose	Follow instructions in operation manual for calibration

Reference

EPA Requirements for Quality Assurance Project Plans, EPA QA/R-5, Office of Environmental Information, Washington DC, EPA/240/B-01/003, March 2001

Guidance for Quality Assurance Project Plans, EPA QA/G5, Office of Environmental Information, Washington DC, EPA/240/R-02/009, December 2002

Guidance for Preparing Standard Operating Procedures (SOPs), EPA QA/G-6, Office of Environmental Information Washington DC, EPA/6000/B-07/001, April 2007

Met One Instruments, Inc., (2008) BAM 1020 particulate monitor operation manual. Prepared by Met One Instruments, Inc., Grants Pass, OR, BAM-1020-9800 Rev G.

Standard Operating Procedure for the Continuous Measurement of Particulate Matter Monitoring Sites, Confederated Tribes of the Colville Reservation, Air Quality Program, August 2011

Appendices

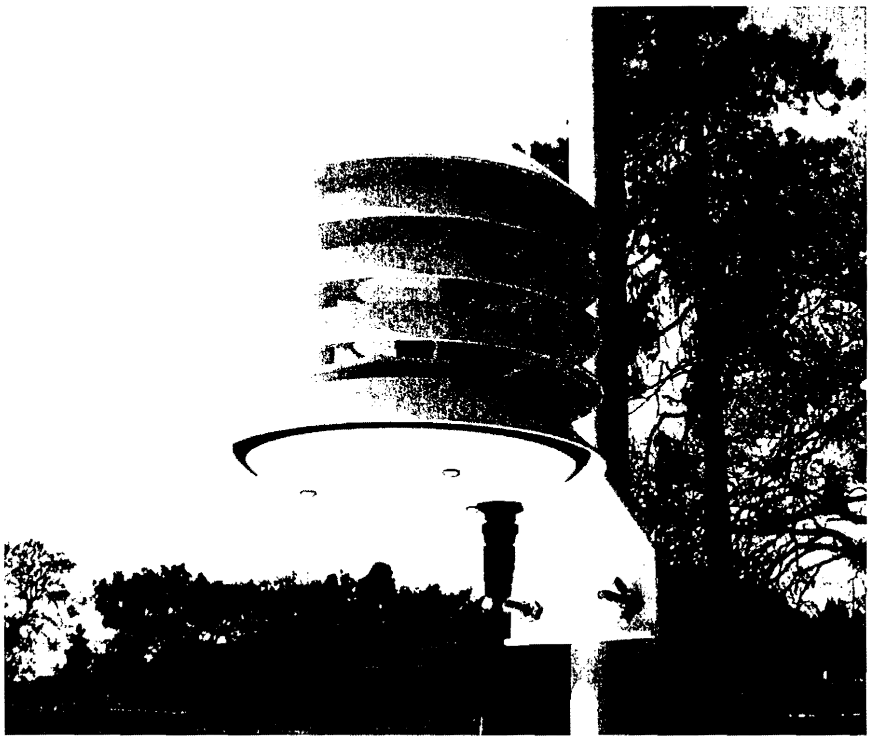
BX-596 AT/BP
SENSOR MANUAL

Met One Instruments, Inc
1600 Washington Blvd.
Grants Pass, Oregon 97526
Telephone 541-471-7111
Facsimile 541-541-7116

About this Manual:

The BX-596 is an optional combination ambient temperature and barometric pressure sensor for use with the BAM-1020 particulate monitor. The BX-596 sensor is a required accessory for all BAM-1020 configured to sample $PM_{2.5}$ levels, effective March 2007. The sensor provides ambient temperature and pressure data to the unit for actual (volumetric) flow control and flow statistics during the hourly sample cycle. The BX-596 is only compatible with BAM-1020 firmware version 3.2.4 or later. This manual describes the installation and operation of the BX-596 sensor. Refer to the BAM-1020 operation manual as needed.

The BX-596-1 is an extended range version for extreme cold or high altitude environments.



BX-596 Temperature/Pressure Sensor Installed on a BAM-1020 Inlet Tube

Specifications:

BX-596	**Barometric Pressure**	**Ambient Temperature**
Voltage Output:	0 to 2.5 volts	0 to 2.5 volts
Range:	525 to 825 mmHg	-40 to +55 deg C
Accuracy:	±0.25 mmHg @ 25 C	± 1.5C above -30
ID Voltage:	3.50 volts DC ± .02	

BX-596-1	**Barometric Pressure**	**Ambient Temperature**
Voltage Output:	0 to 2.5 volts	0 to 2.5 volts
Range:	400 to 825 mmHg	-50 to +50 deg C
Accuracy:	±1.5 mmHg	± 1.5C full scale
ID Voltage:	4.10 volts DC ± .02	

Installation and Setup:

Ensure that the BAM-1020 is sited and installed properly per the instructions in the operation manual.

During the installation process, you will need to provide an access point for the BX-596 sensor cable to enter the shelter where the BAM-1020 is installed. In some cases it is easiest to simply drill a 3/8" hole through the roof of the shelter about six inches away from the inlet tube, then feed the cable through the hole and caulk around it to prevent leaks.

There may be a better place to feed the cable into the shelter in some applications. The BX-902/903 environmental shelters supplied by Met One have pre-formed access holes in the side to allow the sensor cable to be routed to the BAM-1020. Decide the best way to route the cable into the shelter. The BX-596 comes with a standard 25-foot sensor cable. Longer cables may be ordered if required.

Remove the PM_{10} head and $PM_{2.5}$ cyclone from the top of the BAM inlet tube. Attach the BX-596 to the inlet tube (about 8 to 18 inches from the top) with the supplied U-bolt hardware. Make sure that the sensor is level and tighten the U-bolt securely.

Make sure the BAM-1020 is turned off, then attach the sensor cable to the connector on the bottom of the BX-596. Route the loose end of the cable into the shelter and to the back of the BAM-1020. Coil up any excess length of cable. Attach the cable to the back of the BAM as shown in the following table.

BX-596 AT/BP Sensor Connections		
Wire Color	**Function**	**BAM Terminal**
Yellow	AT Signal Output	Channel 6 SIG
Black/Shield	Ground	Channel 6 COM
Red	+12 VDC	Channel 6 POWER
Green	Auto ID Signal 3.50V	Channel 6 ID
White	BP Signal Output	Channel 7 SIG

Reinstall the PM_{10} head and $PM_{2.5}$ cyclone and seal around the cable hole with silicone if required.

Operation:

When the BAM-1020 is powered up with a BX-596 installed, the unit will automatically sense the ID voltage from the sensor and configure input channels six and seven to read and scale the outputs from the sensor. **Note**: The BX-596 sensor requires BAM-1020 firmware revision 3.2.0 or later. The BX-596-1 extended range version requires BAM-1020 firmware revision 3.6.2 or later. If the BAM firmware is not current enough, then the BAM will not automatically identify and scale the sensor.

Turn ON the BAM-1020 and perform a calibration of the BX-596. Note: The calibration is performed in the TEST > FLOW screen which *will not be available* unless the FLOW TYPE is set to ACTUAL in the SETUP > CALIBRATE screen. You will need a reference standard measurement for ambient temperature and barometric pressure.

```
MULTIPOINT FLOW CALIBRATION
              TARGET     BAM       STD
<CAL>          AT:       23.8      23.8 C
               BP:        760       760 mmHg
        FLOW 1: 15.0     15.0      15.0 LPM
        FLOW 2: 18.3     18.3      18.3 LPM
        FLOW 3: 16.7     16.7      16.7 LPM
  CAL        NEXT       DEFAULT      EXIT
```

1. Enter the TEST > FLOW menu as shown above. The nozzle will lower automatically when this screen is entered. The "BAM" column is what the BAM-1020 measures for each parameter, and the "STD" column is where you will enter the correct values from your reference standard. The <CAL> symbol will appear next to the parameter selected for calibration.
2. Measure the ambient temperature with your reference standard positioned near the BX-596 sensor. Enter the value from your reference standard into the STD field using the arrow keys. Press the CAL hot key to correct the BAM reading. The BAM and STD values should now be the same.
3. Press the NEXT hot key to move the <CAL> indicator to the BP field, and repeat the same steps for barometric pressure.

The DEFAULT hot key can be pressed to reset the user calibration from the selected parameter and replace it with a factory setting. The DEFAULT calibration should be fairly close in most cases.

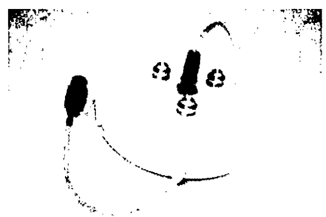
The BX-596 sensor is almost always calibrated as part of a BAM-1020 flow calibration. Always calibrate the AT and BP channels before calibrating the flow channels, as the flow rate is affected by the temperature and pressure of the ambient air.

The BX-596 temperature output may also be checked in an ice bath. The ice bath test is usually never done except in some cold weather environments. First calibrate the sensor at ambient temperature, then use the following steps:

1. Remove the stop screw from the bottom of the mounting bracket so that the electronics module is free to rotate. Rotate the module counter-clockwise until it disengages from the keyhole slots and comes free from the radiation shield.
2. The sensor comes with an 18 inch long ice bath extension harness. This may be used to allow the temperature bead to reach the ice bath if necessary. Carefully unplug the black temperature bead assembly from the top of the electronics module and install the harness between the bead and the module.
3. Insert the temperature bead into the ice water bath along with your reference sensor. Avoid immersing the bead assembly past the connector.

4. Allow the bead to equilibrate, then compare the AT reading in the TEST > FLOW screen to your reference sensor. The readings should match within ±1.5 degrees C for the BX-596-1 extended range sensor. **Note**: The tolerance for the regular BX-596 standard range sensor is ± 2.5 C in temperatures below -30C.
5. Remove the ice bath harness and reassemble the sensor.

During operation of the BAM-1020, the output from the BX-596 can be viewed from the main flow statistics screen or the OPERATE screens. See the BAM-1020 manual.



Ice Bath Extension Harness

Maintenance:

The BX-596 is designed to be low-maintenance, easy to access, and resistant to harsh environments. There are only a few maintenance items for the sensor besides routine calibration checks.

- Remove the bottom cover and make sure that the four holes in the cover plate are clear and have not been obstructed by insects or debris. These holes allow the air pressure to equilibrate inside the sensor for the barometric pressure reading. Clean the inside of the electronics enclosure every 12 months or as needed.
- Clean the radiation shield assembly at least once per year. Dirty shields reflect away solar radiation less efficiently.
- The circuit board is not intended to be removed or serviced by the customer.
- The black temperature bead assembly may be replaced if the bead becomes damaged. The assembly simply plugs into the top of the electronics module. The sensor will need to be recalibrated any time the temperature bead is replaced.

Technical Support:

Should you still require support after consulting your printed documentation, we encourage you to contact one of our expert Technical Service representatives during normal business hours of 7:00 a.m. to 4:00 p.m. Pacific Standard Time, Monday through Friday. In addition, technical information and service bulletins are often posted on our website. Please contact us and obtain a Return Authorization (RA) number before sending any equipment back to the factory. This allows us to track and schedule service work and expedite customer service.

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Grants Pass, OR 97526

Warranty

Products manufactured by Met One Instruments, Inc. are warranted against defects in material and workmanship for a period of one (1) year from the date of shipment from the factory. Offered products not manufactured by Met One Instruments, Inc. will be warranted to the extent and in the manner warranted by the manufacturer of that product.

Any product found to be defective during the warranty period will, at the option of Met One Instruments, Inc., be replaced or repaired. In no case shall the liability of Met One Instruments, Inc. exceed the purchase price of the product.

This warranty may not apply to products that have been subject to misuse, negligence, accident, acts of nature or that have been altered or modified other than by Met One Instruments, Inc. Consumable items such as bearings and batteries are not covered under this warranty.

Other than the warranty set forth herein, there shall be no other warranties, whether expressed, implied or statutory, including warranties of fitness or merchantability.

Service

Any product being returned to Met One Instruments, Inc. for service, repair or calibration must be assigned a return authorization (RA) number. Please call (541) 471-7111 or (972) 412-4715 for an RA number and shipping instructions.

Products manufactured by Met One Instruments, Inc. that are returned for service, repair or calibration are warranted against defects in material and workmanship for ninety(90) days from date of shipment, under the same conditions as stated above.

9/99

Temperature Probe & Shield
Model BX-592

Operation Manual
BX-592-9800

Met One Instruments

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Model BX-592 Temperature Probe & Shield Operation and Installation Manual

INTRODUCTION

The Model BX-592 is a temperature probe and shield for use with the BAM-1020 particulate analyzer. The BX-592 is used specifically with the BX-962 Volumetric Flow Control System used on the BAM-1020. This sensor provides temperature measurement of the outside air used to determine the temperature correction value as part of the volumetric flow calculation. The sensor is designed to be connected directly to one of the analog input channels of the BAM-1020. The BX-592 is used when there is no other source of analog temperature output from an existing temperature system at the owners location. The BX-592 includes 30 ft of cable as well as a mounting adapter that attaches to the inlet tube of the BAM-1020.

INSTALLATION

The BX-592 is installed outside near the intake of the BAM-1020 particulate analyzer. Mounting hardware is provided for direct mounting on the BAM-1020 inlet tube as shown in figure 1.0. Attach the temperature probe and shield to the horizontal bar using the clips on the top of the temperature shield. Push the shield up onto the horizontal bar, and press the grey plastic clips together until you hear the "snap" of the retainer locking inplace.

The fitting on the mounting arm should be mounted in a convenient place near the top of the inlet tube and out of the way of the supports used to hold the inlet tube in place. Tighten the set screws on the mounting adapter to hold it in place on the inlet tube. The horizontal bar can be moved as necessary to mount the shield in a suitable location near the inlet tube and the PM-10 or PM-2.5 inlet assembly.

The cable from the sensor can then be run down through the roof of the shelter or building so that it can be connected to the sensor input channel terminal block on the back of the BAM-1020 unit.

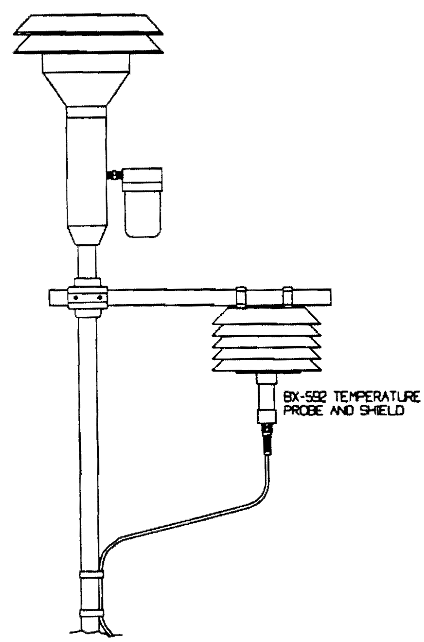

Figure 1 Temperature Sensor Installation

The sensor input connection should be made at sensor location six. This input channel is the one used for any external temperature analog input used for the temperature correction input required by the volumetric flow controller.

The BX-592 Temperature Sensor and Shield provides a special identification output signal that is used by the BAM-1020 to determine what type of sensor is connected to the BAM, as well as determine what the range of the temperature sensor. The electrical connections to the BAM-1020 can be see in Figure #2. Be sure that the color code of the individual wires of the cable is followed so that the sensor is not connected incorrectly to the BAM-1020. There are four wires which are connected to the four terminals of the analog inputs at the back of the BAM unit.

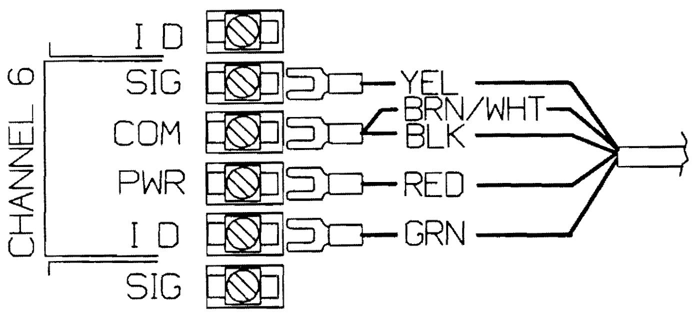

Figure 2 Sensor Connections to BAM

Figure 2 shows the connections from the BX-592 Temperature Sensor and Shield to the BAM-1020 Particulate Analyzer. Be sure that the temperture sensor cable is connected to channel 6 of the BAM-1020, otherwise the voltage output of the sensor will not be able to be used as the temperature reference of the volumetric flow controler.

For correct operation of the volumetric flow control option BX-961, the BAM-1020 must be programmed for volumetric flow operation. This is done from the SETUP, then CALIBRATE and then FLOW TYPE screen. The default is “metered” flow, and will need to be set for “volumetric” flow for this option to work correctly. See the BAM-1020 Manual section 4.14 for information on the Calibrate Screen and in section 6.3 for information on the field calibration of the flow system.

SPECIFICATIONS

The following are the specifications of the BX-592 Temperature Sensor and Shield. These are subject to change as determined by Met One Instruments, Inc. The shield of the BX-592 provides protection of the temperature probe from errors that are caused by direct solar radiation. The shape allows for the wind to naturally aspirate the shield to reduce the total effect of solar radiation on the temperature measurement.

Temperature Probe Type	Thermistor Bead, multi-element
Temperature Accuracy	± 0.2° C
Temperature Range	-30° C to +50°C
Sensor Output	0 to 1 VDC for temperature range
Time Constant	10 Seconds in still air

The shield is mounted from the top of the shield using two snap clamps designed for a 1" diameter tube or a ¾" IPS Pipe. The mounting adapter and a short boom are provided for attachment to the inlet tube of the BAM-1020.

MAINTENANCE & CALIBRATION

The temperature probe and shield require no specific maintenance other than normal cleaning of dirt and dust to prevent the degredataion of the reflectiveness of the shield. If there is any build up of materials inside the shield, they should be cleaned out, so that there is a free path for air flow around the temperature probe.

On a regular basis, the output of the temperature probe displayed on the screen of the BAM-1020 should be checked against a reference thermometer to be sure that the BX-592 is providing accurate information for the calculation of volumetric flow. There are no adjustments inside the temperature probe, and any repairs should be handled by the factory.

Before returning a faulty probe, the factory should be contacted, a RA (Return Authorization) should be obtained, and the problem noted on the RA. This will insure that the repairs are made quickly, and returned for installation.

TROUBLE SHOOTING

Symptom	Identify Problem	Solution
Incorrect Temperature indicated on BAM Display	Verify that connections to the rear panel of the BAM are correct and to channel 6.	Change wiring to follow diagram as indicated in figure #2 of this manual
	From setup menu, channel parameters screen verify that channel #6 is set for Auto ID and not in MANUAL Mode.	Change settings from MANUAL Mode to Auto ID mode for probe to work correctly.
	Examine output of BX-592 to verify that it has the correct voltage output for the current ambinet temperature.	Using a volt meter, measure voltage between the black and white wires. 0-1 volt is equivalent to –30 to 50 degrees C. i.e. 21°C = .637 volts. If this is not correct, return probe for repair.
Volumetric Flow Control is not operating.	Go to the Setup then Calibrate screen menu and verify that the flow type is set to volumetric and not metered.	Default setting is for metered, it will be necessary to change setting to volumetric flow type.
	Examine rear of BAM-1020 and see if there is a flow adjusment knob on the back of the unit right above the vacuum line.	If there is a knob here, it is most likely that volumetric flow control is not installed on this unit. Contact Met One Instruments, for advice.
Volumetric flow value does not match audit flow meter connected to BAM.	From setup menu, select flow and examine the current measured flow value of the BAM.	Recalibrate the BAM flow meter using the proceedure in the manual section 6.3 Field Calibration of Flow System
	Verify that the audit instrument being used has been calibrated for volumetric flow monitoring.	Adjust flow audit device for correct measurement of volumetric flow.

For any other specific problems with the BX-592 or the Volumetric Flow Option BX-961, contact the factory.

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MODEL 50.5
WIND SENSOR

OPERATION MANUAL
Document No. 50.5-9800

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50.5 Sonic Wind Sensor Manual

Technical Support

Should you require support, please consult your printed documentation to resolve your problem. If you are still experiencing difficulty, you may contact a Technical Service representative during normal business hours—7:30 a.m. to 4:00 p.m. Pacific Standard Time, Monday through Friday.

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MODEL 50.5 WIND SENSOR OPERATION MANUAL

1. GENERAL INFORMATION

The Met One Instruments Model 50.5 Wind Sensor is a solid-state ultrasonic instrument capable of measuring wind speed and wind direction in the U and V axes. Sonic pulses are generated at the transducers and are received by opposing transducers. Mathematics derived for these sonic pulses provide a wind velocity measurement in each of the corresponding axes.

The 50.5 uses a microprocessor-based, digital electronic measurement system to control the sample rate and compute the wind speed and wind direction. The sensor is factory calibrated and requires no field calibration. In the field, the operation of the sensor can be quickly checked using a combination of simple tests. A zero chamber or bag is used to verify the zero reference by covering the entire sensor, or individual outputs are checked by blocking various combinations of sensors.

The 50.5 provides are variety of outputs to suit the connection requirements of the user. Standard outputs are voltage and RS-232. SDI-12 and RS422/485 outputs are configured at the factory.

2. INSTALLATION

2.1 UNPACKING

Carefully remove the sensor from its shipping container and inspect it for damage. Referring to the packing list, check for shortages. Any claims for damages should be filed promptly with the carrier.

The sensor is a precision, electromechanical transducer. Always handle it with care, exercising particular caution to ensure that the instrument is not subjected to side loading, shock or other abuse. After initial inspection, keep the sensor in its shipping container for protection until actual installation.

2.2 PREPARATION

For accurate measurements, the sensor mount must be rigid with little or no movement from the wind. The sensor is designed for installation in a Model 3188 mounting and alignment fixture. This provides a mount for use on a horizontal ¾" IPS pipe (1.05" O.D.) boom. Mounting information and diagrams can be found in Appendix B of this manual.

The 3188 Sensor Mounting Fixture includes a keyed bushing, which will be adjusted for alignment to North orientation. This enables the sensor to be removed and replaced without requiring realignment. Three captive machine screws are used to secure the sensor to the keyed bushing.

If a temperature shield such as the Model 073B is to be used in the configuration, the Model 1539-4 Arm and 1552 Mount is recommended. These parts provide the necessary mounting for a vertical mast of ¾" IPS pipe (1.05" O.D). This same configuration can also be used to mount other sensors as well as providing a way to mount the sensor on a vertical mast. (See Appendix B for Mounting Details)

2.3 SENSOR SITING

The primary objective of instrument siting is to place the instrument in a location where it can make precise measurements that are representative of the general state of the atmosphere in that area. Because most atmospheric properties change dramatically with height and surroundings, certain somewhat arbitrary conventions must be observed so that measurements can be compared.

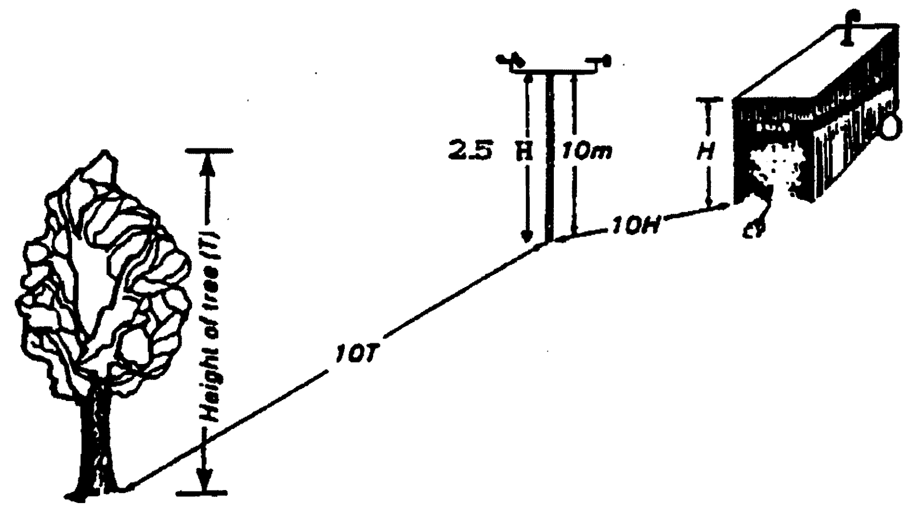


Figure 2-1 Siting Wind Instruments

The standard exposure of wind instruments over level, open terrain is 10 meters above the ground. (WMO 1971), however optimum measurement height may vary according to data needs. Open terrain is defined as an area where the horizontal distance between the wind sensor and any obstruction is at least ten (10) times the height of that obstruction. An obstruction may be man-made (such as a building) or natural (such as a tree) (See Figure 2-1)

The wind instrument should be securely mounted on a mast that will not twist, rotate or sway. If it is necessary to mount the wind instrument on the roof of a building, it should be mounted high enough to be out of the area in which the airflow is disturbed by the building. This is usually 1.5 times the height of the building above the roof so that it is out of the wake of the obstruction. This is not a good practice, however, and should only be resorted to when absolutely necessary.

Wind instruments are best sited when they are used on towers. The tower should be located in an open level area, representative of the area under study. Towers should be of the open grid type of construction, such as is typical of most television and radio broadcast towers. Enclosed towers, stacks, water storage tanks, grain elevators, cooling towers and similar structures should not be used.

Wind instruments should be mounted above the top of the tower on booms projecting horizontally out from the tower. If a boom is used, it should support the sensor at a distance equal to minimum of twice or at best three times the maximum diameter or diagonal of the tower away from the nearest point on the tower. On large towers with large verticals, it may be best to place the sensor at least 5 tower leg diameters from the tower leg. The boom should project into the direction, which provides the least distortion for the most important wind direction. For example, a boom mounted to the east of the tower will provide least distortion for north or south winds.

Weather sensors are sensitive to direct or nearby lightning strikes. A well-grounded metal rod or frame should be placed above the sensor installation. In addition, the shield on the signal cable leading to the translator must be connected to a good earth ground at the translator end and the cable route should not be vulnerable to lightning.

2.4 ORIENTATION WITH FIXTURE

The Orientation Fixture, Model 70.5, is used for very accurate positioning of the 50.5 sensor with respect to a benchmark or other object that can be visually observed. If a compass is used to establish a benchmark, the reading should be taken away from heavy metal objects, which can affect the reading and should be corrected for declination of the magnetic north pole. The benchmark is set to true north of the sensor site. Information on determining true North can be found in Appendix A of this manual.

The fixture contains a telescopic sight with crosshairs and includes a keyed base identical to that on the sensor. The fixture is specifically designed for use with the 3188 Sensor Mounting Fixture. The base of the fixture is keyed so that the object lens of the sight assumes the same position as the north side of the sensor.

Before orienting the sensor, ensure that it is vertical and adjust the cross arm as necessary. Orientation of the sensor is then performed with the fixture installed on the cross arm in place of the sensor. (The three screws in the base of the fixture must be tightened to ensure proper orientation in the cross arm). Loosening the three setscrews on the side of the sensor mount allows free rotation of the keyed bushing and orientation fixture. The ring and fixture are then rotated to position the benchmark in the center of the sight crosshairs. The sight can be tilted as necessary by loosening the slotted screw on the side of the fixture. The set screws are then tightened, the fixture removed, and the sensor installed in its place. The sensor is now oriented for zero (north) wind direction signal output when the wind is from north.

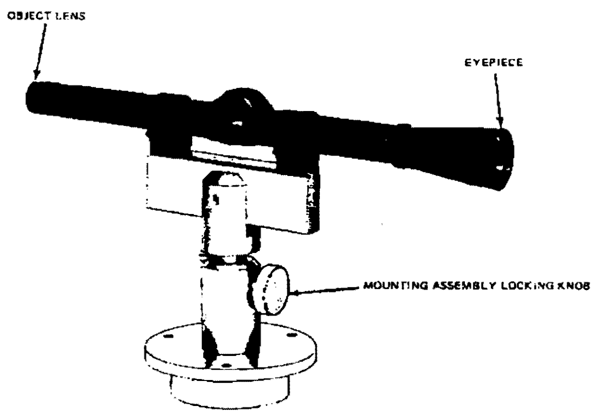


Figure 2-2 Orientation Fixture

The electrical connector on the bottom of the sensor should be properly mated to the cable connector, and the three captive screws on the base of the sensor should be tightened.

When using the orientation fixture, assure that the two-piece mounting assembly is properly aligned. The upper half of the assembly contains a horizontal peg, which must seat in the V-notch located in the lower half. The knurled knob on the lower half is used to secure the two sections and should be tight.

2.5 ORIENTATION WITHOUT FIXTURE (See FIGURE 2-3 and 2-4)

Establish a True North benchmark. See Appendix A for aids to determine True North. This should be a point directly north from the sensor's mounted location. This point should allow easy access so that a person may sight the sensor with a spotting telescope. If a compass is used to establish a benchmark, the reading should be taken away from heavy metal objects, which can affect the reading and should be corrected for declination of the magnetic north pole. The benchmark is set due north of the sensor site.

One person is located at True North benchmark equipped with a spotting scope. A second person is located at the sensor. The sensor alignment may be established as follows.

A. Install the sensor into the alignment bushing and secure with the two setscrews under the 3188 Alignment Fixture. Keep the three setscrews around the ring of the fixture loose so that the ring can be rotated into position.

B. Turn the sensor so that the sensor points to the North benchmark. Tighten the 3 setscrews and recheck alignment.

C. Connect the 9574-cable assembly to the sensor. Secure cable to boom with cable ties or tape to prevent damage.

D. The sensor can be removed without requiring realignment at any time. Simply remove the sensor. The alignment bushing remains properly oriented in the fitting.

2.6 EXTERNAL HEATER

The Optional External Heater provides de-icing for the sensor arms and prevents the accumulation of ice, which might block the sonic sensor elements. The heater consists of a laminated heater material that is custom designed and wrapped around the four sensor arms and sonic sensor element housings. The heater controller requires 15 to 24 VAC/VDC at approximately 4-5 amps at startup. There are jumper connections on the controller board for the selection of power source. The controller is normally provided with the jumpers not installed. This is for 24 volts AC operation of the heaters. Heater power can be supplied from a power transformer or a Met One Instruments supplied power unit in a weatherproof box. The proportional controlled heater uses maximum current at start-up and power requirement goes down as the sensor/heater reaches stability. The heater is activated at 38 degrees F and will keep the arms ice-free at temperatures down to below –20 degrees F. The connection information can be found in Appendix C of this manual.

The temperature controller electronics box should be mounted no more than 5 feet from the sensor using the cable supplied with the heater controller. The power cable should be of minimum 16 AWG wire and cable length should be at a minimum to prevent power loss due to cable resistance at the 4-amp power requirement.

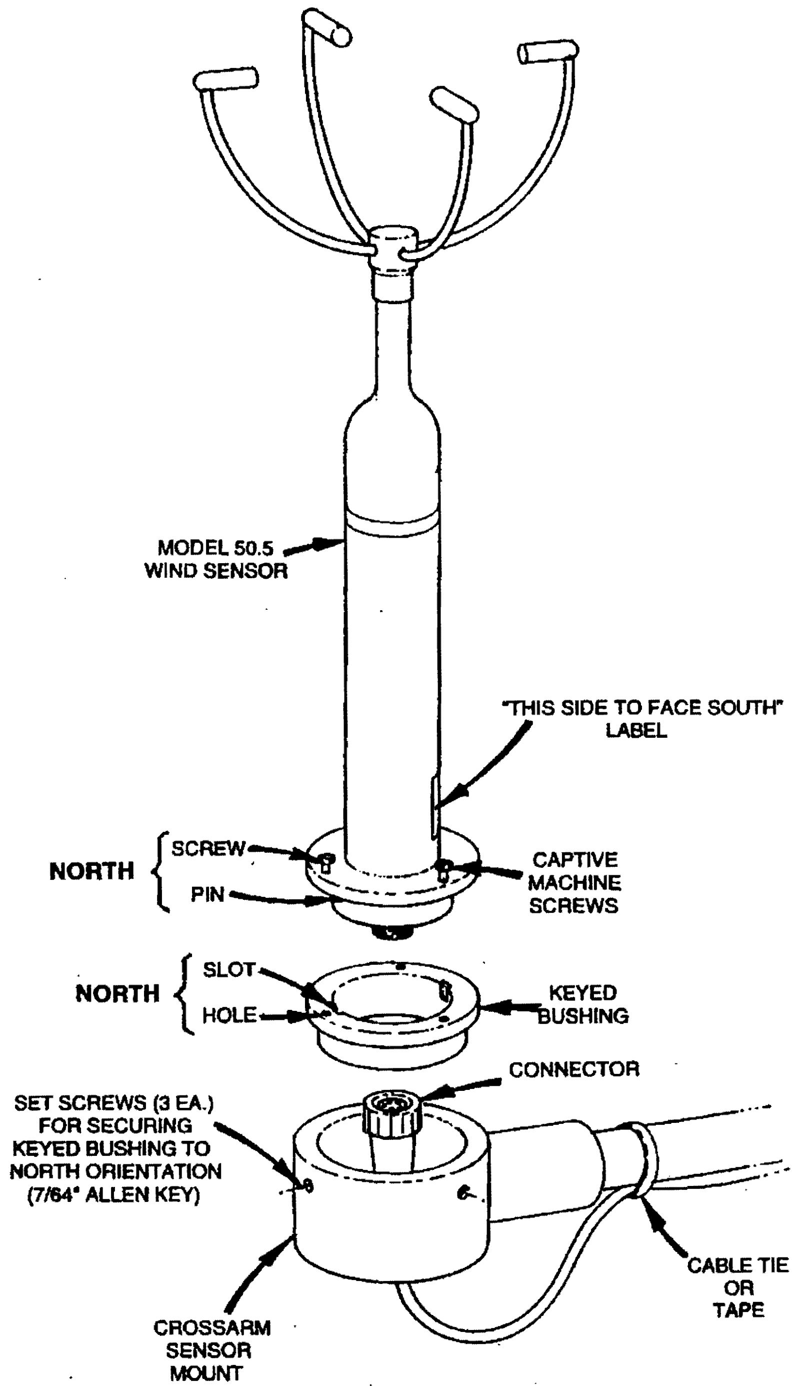


Figure 2-3 50.5 Wind Sensor Components

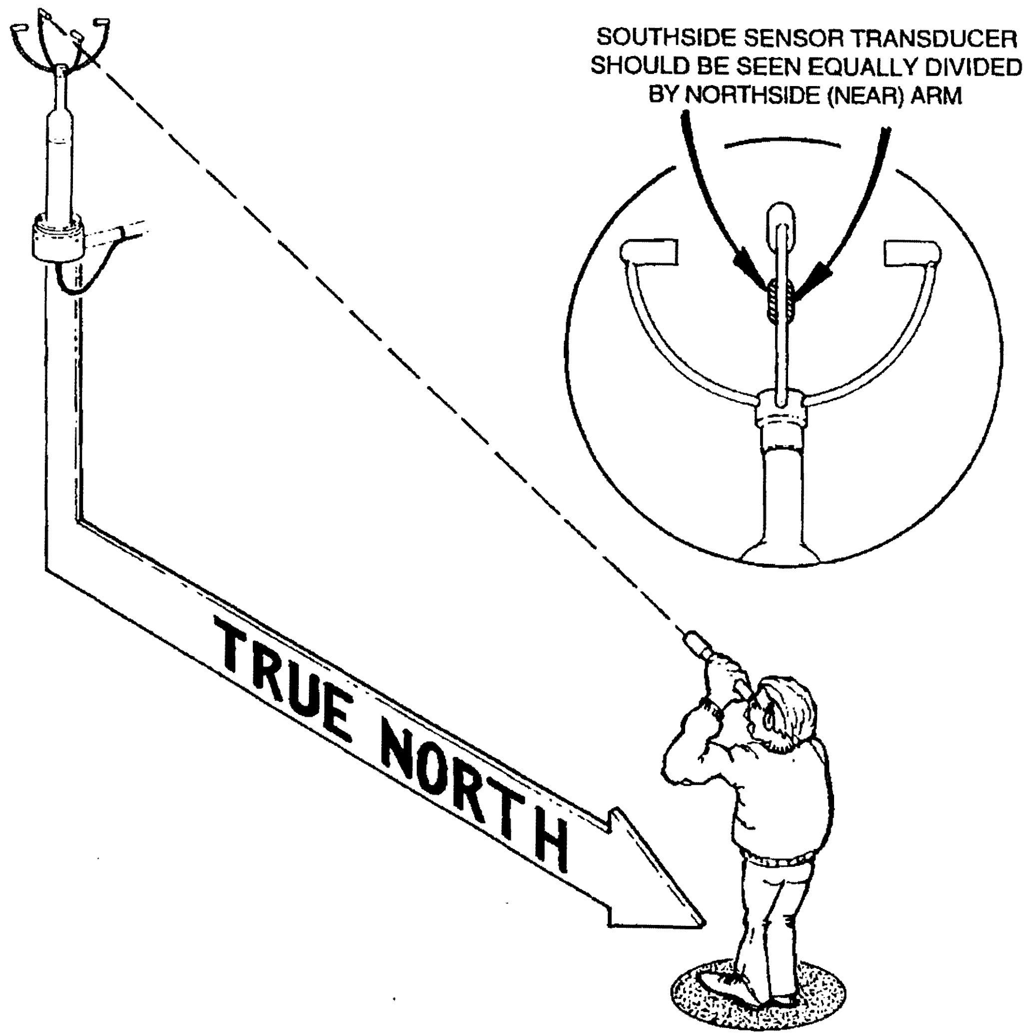


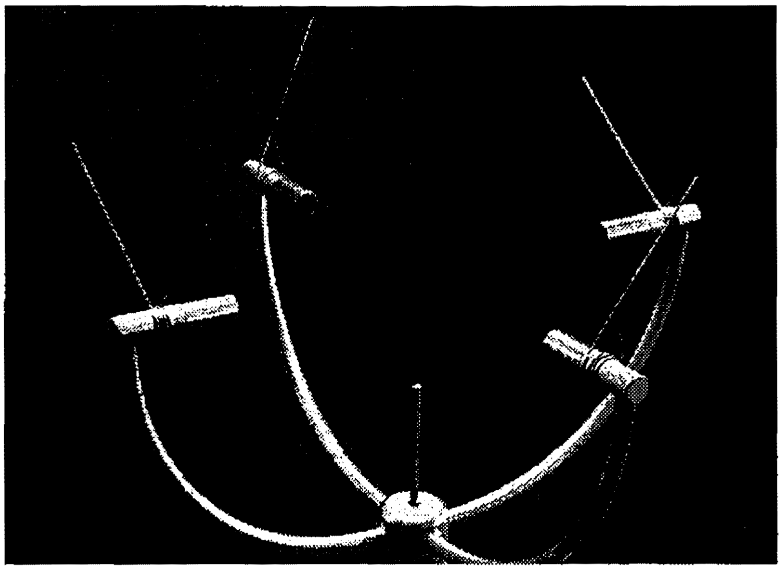
Figure 2-4 Alignment of Sensor to True North

2.7 INSTALLATION OF AVERY DETERRENTS

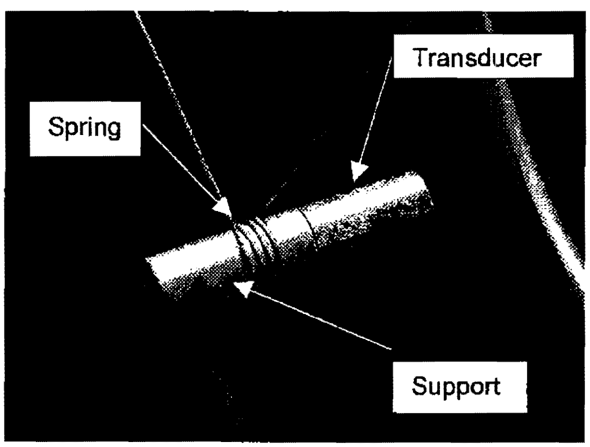
To prevent birds from entering the pathway between the sensors a vertical stainless steel rod is located in the center of the sensor array. To keep birds from perching on the sensors, stainless steel wire "aviary deterrent" need to be installed on the sensor prior to installation in the fixture.

NOTE: The stainless steel wires used for the aviary deterrents are very sharp. The wire is spring steel and there is the possibility that it could slip off during the installation. Use care when installing the aviary deterrent, and be careful after installation.

PROTECTIVE GLASSES SHOULD BE WORN DURING INSTALLATION



Installed Aviarv Deterrents



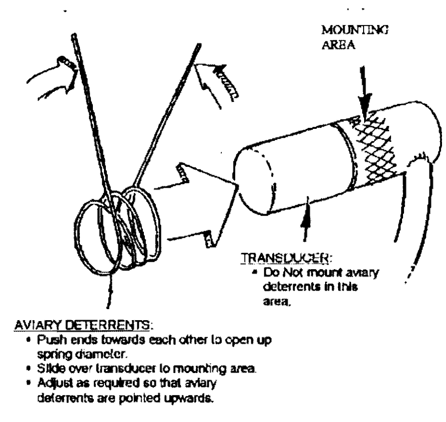


Figure 2-5 Installation of Aviary Deterrents

WARNING: If the aviary deterrents are not properly installed. The sensor may experience signal degradation. Install as shown. DO NOT allow for the spring section of the aviary deterrent to contact the transducer portion of the sensor array.

2.8 CONNECTIONS TO RECORDING ELECTRONICS

Route the cable to the data-recording device. Secure the cable with cable ties or tape. The 9574-cable assembly contains 7 wires and a shield. Typical wiring hookup is shown in the figures below. Actual wiring will depend upon the version of the sensor. To determine which of the three connections drawings apply examine the cable part number at both ends of the cable.

Cable type 9574 includes the 9573 Differential Amplifier; it is located at the end of the cable opposite the sensor connector. The amplifier provides high immunity to any noise that might be picked up the sensor cables. It is recommended that this cable with amplifier be used whenever connected to a single ended input recorder. If necessary to remove the differential amplifier, a wiring diagram has been included in the top of the small amplifier enclosure. A small screwdriver is provided, for use on the small terminal screws on the PC Board of the 9573 Amplifier. Be sure that the connection color codes are followed, so that no wiring error occurs. See below.

Warning: If you are connecting this 50.5 to an older 3155-cable assembly and are using the black wire as signal common, disconnect it because it will short out the RS-232 transmitter. No damage will occur to the circuit but the 50.5 current consumption will increase by 20 mA.

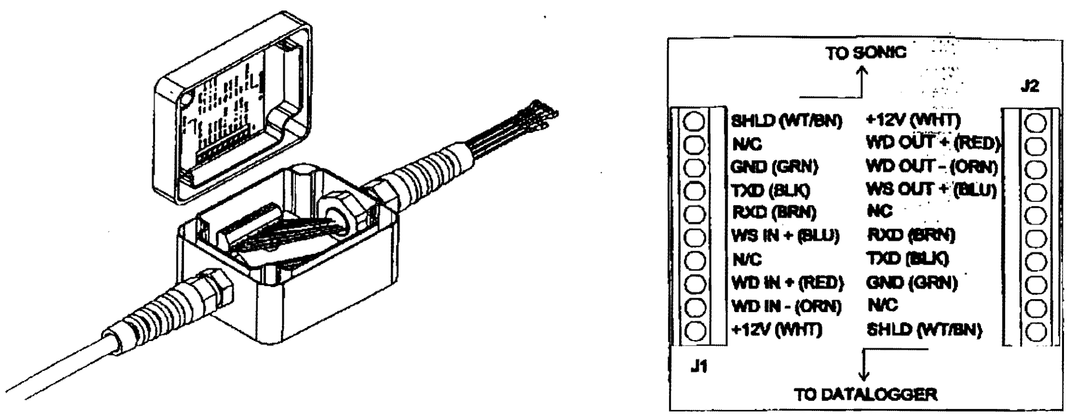


Figure 2-6 Amplifier (9573) attached to Cable (9574) and wiring in box

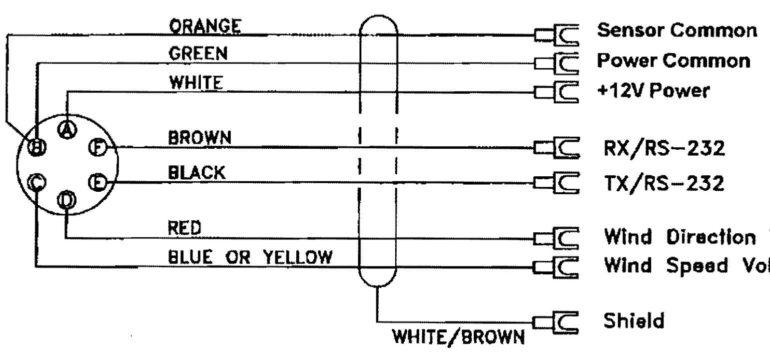


Figure 2-7 Factory Standard Analog & RS-232 Output Connections (Cable 9574 w/ Differential Amplifier 9573)

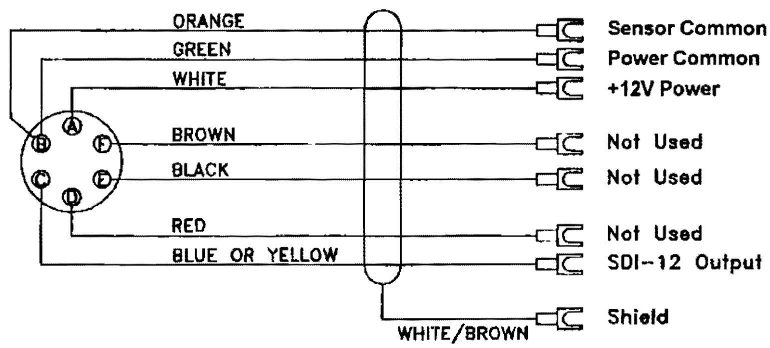


Figure 2-8 Factory Custom SDI-12 Output Connections

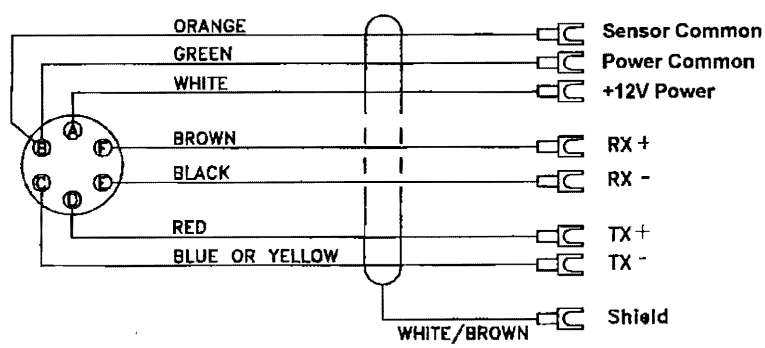


Figure 2-9 Factory Custom RS422/485 Output Connections

2.8 SIGNAL OUTPUTS – Analog, RS-232, and SDI-12

The standard configuration of the sensor provides for a voltage outputs for wind speed and direction as well as RS-232 Data. The default output voltage is 1.0 volts full scale for 50 meters/second and 360 degrees of direction. Alternate full-scale values can be changed by using the RS-232 command set discussed in Appendix D. The RS-232 output occurs every second in the format S sss.s D ddd <cr><lf> where sss.s is the wind speed value up to 999.9 and the direction ddd up to a value of 360. RS-232 output is at 9600 baud 8 data bits, 1 stop bit, and no parity.

As an option, an output of SDI-12 Data from the sensor is available. In this configuration it is the only available output and is in the format +sss.s+ddd <cr><lf>. The same values for sss.s and ddd as the RS-232 format are output. The SDI-12 handshake is per the SDI-12 specifications and format. In this configuration, the RS-232 output or analog output is no longer available from the sensor.

2.9 SIGNAL OUTPUTS – RS422 and RS485

In this configuration. the sensor has no analog outputs (see diagram "Factory Custom RS422/RS485 Output Connections". The correct sensor cable for this configuration is part number 3379.

The default serial trigger (sensor address) is "1". After receiving 1, the sensor will return wind speed and wind direction in the same format as with RS232 (S sss.s D ddd <cr><lf>).

To use the RS232 Command Set defined in Appendix D, the sensor must first be put into Terminal Mode by sending "!!!" (three exclamation points). The serial trigger is not used in this case, and there must be only one sensor connected on the serial buss. The sensor will return "!" when in Terminal Mode, and will then accept RS232 commands. The QU (quit) command will take the sensor out of Terminal Mode and return it to normal operating mode.

3. OPERATIONAL CHECK-OUT AND CALIBRATION

3.1 GENERAL

Operation of the 50.5 is essentially automatic, and no specific sensor calibration is required for normal operation. The sensor has been calibrated in a wind tunnel at the factory prior to shipment.

3.2 RECORDING ELECTRONICS

The sensor may be connected to a variety of data recorders and translators. Standard wind speed range is 0-50 m/s and wind direction range is 0-360 degrees. Standard output voltage is 0-1.0V, with 0-2.5V and 0-5.0V as available options. Refer to the calibration certificate supplied with the sensor to determine the actual output.

To ensure that the recorder is scaled properly, it is recommended that zero and span tests are performed after the sensor is connected and operational.

3.3 ZERO TEST

A zero test requires no air movement across the sensor array, so a means of covering the array is needed. A plastic bag can be placed over the array, using care not to contact the transducers or block the sonic paths between transducers. The bag should be spaced at least 2" above the transducers to avoid sonic reflections, which may affect readings. The bag can be tied at the bottom with a tie wrap or tape to prevent air movement from below. Keep in mind that wind can deflect the bag, causing air movement inside.

The preferred method is to use a box insulated with foam to prevent reflections, and spaced so that the top is at least 2" above the transducers. Again, the bottom should be sealed around the sensor to isolate the array from ambient air movement.

With no air movement across the array, the sensor should indicate 0.0 to 0.1 m/s wind speed. The wind direction output will wander to any value between 0 and 360 degrees.

3.4 SPAN TEST

The sensor is designed to produce known default outputs if an object blocks the sonic signal path between the transducers. This feature is useful for verifying sensor operation and recorder scaling. For testing purposes, the sonic path can be blocked by placing a finger (or any solid object) on the face of one or more transducers.

NOTE: The following table defines the sensor outputs with blocked paths.

Wind Speed

Blocked Axis	***Serial Output***	***Analog Output***	***0-1.0V***	***0-2.5V***	***0-5.0V***
North-South	100 m/s	50 m/s	1.00V	2.50V	5.00V
East-West	100 m/s	50 m/s	1.00V	2.50V	5.00V
Both	100 m/s	50 m/s	1.00V	2.50V	5.00V

Wind Direction

Blocked Axis	***Serial Output***	***Analog Output***	***0-1.0V***	***0-2.5V***	***0-5.0V***
North-South	10 Deg	10 Deg	0.03V	0.07V	0.14V
East-West	160 Deg	160 Deg	0.44V	1.11V	2.22V
Both	170 Deg	170 Deg	0.47V	1.18V	2.36V

4. MAINTENANCE AND TROUBLESHOOTING

The 50.5 sensor is sealed and there are no replaceable parts contained therein. The sensor does not require periodic calibration, and there are no internal adjustments that can be made.

4.1 GENERAL MAINTENANCE SCHEDULE*

12-24 month intervals

The Model 50.5 Wind Sensor should be inspected periodically for physical damage to the sensor array assembly, cable, and cable connections. Inspect all transducers to be sure they are securely fastened.

*Schedule based on average to adverse conditions.

4.2 TROUBLESHOOTING

Symptom	Probable Cause	Action to Repair
Wind Speed output goes to full scale.	Blocked pathway. Failed sensor.	1 – Check path and clear. 2 – If clear, contact factory for Return Authorization to repair sensor.
Wind Speed output high, but not full scale. supply, inputs	Common mode voltage.	1 – Replace cable with part number 9574 (with 9573 differential-to- single-ended converter). 2 – Use 3379 cable and power sensor with isolated power separate from recorder power supply. 3 – Use 3379 cable and connect sensor signals to differential on recorder.

5. THEORY OF OPERATION

5.1 SPEED OF SOUND IN AIR

The speed of sound in still air can be measured accurately between two points a few centimeters apart by two ultrasonic transducers set at that distance. The resulting speed of sound is a known function of the air temperature and composition.

The speed of sound waves in an ideal gas may be written

$$C = \sqrt{\frac{LRT}{M}}$$

where R is the universal gas constant (0831.34 mJ/mol K), T is the temperature in Kelvin, M is the molecular weight (grams/mol) of the gas, and L is the ratio of heat capacities C_p and C_v; C_p and C_v are the specific heats at constant pressure and constant volume of the gas, respectively.

5.2 SPEED OF SOUND PRINCIPLE

The transit time of a sound signal traveling from one end of a sound path to the other, separated by distance d, can be written as follows (Schotland, 1955):

$$t = \left[\frac{\sqrt{C^2 - Vn^2} \pm Vd}{C^2 + V^2} \right] d$$

where V is the total velocity, V_d and V_n are velocity components in the directions parallel and normal to the sound path, and C is the velocity of sound in still air. If two transit times, t_1 and t_2 in opposite directions on the same path are directed, V_d can be obtained independent from V and V_n as follows:

$$Vd = \left[\frac{1}{t_1} - \frac{1}{t_2} \right]$$

It is this principle that is used to compute the velocity of the air in the path between two opposing transducers.

5.3 CALCULATION OF THE WIND VELOCITY

In still air, t_1 and t_2 are equal. For a distance 15 cm at 20° C, the transit time is approximately 450 µs. If a 20 m/s wind is in the direction of the sonic pulse, the transit time t_1 will be approximately 427 µs. If the wind is opposing the sonic pulse, the transit time will be approximately 482 µs. If these two values are used in the previous equation, the resultant velocity from equation will be 20 m/s.

6. SPECIFICATIONS

Sonic Wind Sensor Model 50.5

Wind Speed	
Range:	0 to 50 m/sec
Accuracy:	$\pm$ 0.2 m/sec $\leq$ 11.3 m/sec or $\pm$ 2% $\geq$ 11.3 m/sec
Resolution:	0.1 m/sec
Wind Direction	
Range:	0 to 360°
Accuracy:	±3°
Resolution:	1°
Operation	
Sample Rate:	5 per second
Data Output Rate:	1 per second
Sonic frequency:	200 KHz
Output Signals	
Wind speed voltage:	0 – 5.0 VDC (Specified at time of purchase)
Wind direction voltage:	0 – 5.0 VDC (Specified at time of purchase)
RS-232:	1200 to 19.2K Baud
Optional Digital Outputs:	SDI-12, RS-422 or RS-485 (Specified at time of purchase)
Power requirement	
Sensor:	9-18 VDC @ 10 mA @ 12 VDC Average power requires .75 amp pulse for 2msec.
External Heater Option:	15 VDC @ 50 Watts
Environmental	
Maximum Measurement range:	0 to 65 m/s
Operating Temperature:	-40°C to +55°C no ice
Extended Temperature Range:	-50°C to +55°C with external heater
Physical	
Weight:	5.5 lbs (2.5 Kg)
Dimensions:	19.29in (490mm) high, 9.38in (238mm) diameter
Options	
Signal Cable:	PN 9574 – Specify length
Horizontal Mount & Orientation Fixture:	PN 3188
External Heater with Control Box:	50.5H
External Heater Power Source:	50.5PS (100 to 240 VAC 50/60 HZ), 15VDC @ 4 amps
Programming Cable & Power Supply:	TBD

*Heater Options must be specified at time of purchase.
*Specifications Subject to Change without prior Notice.

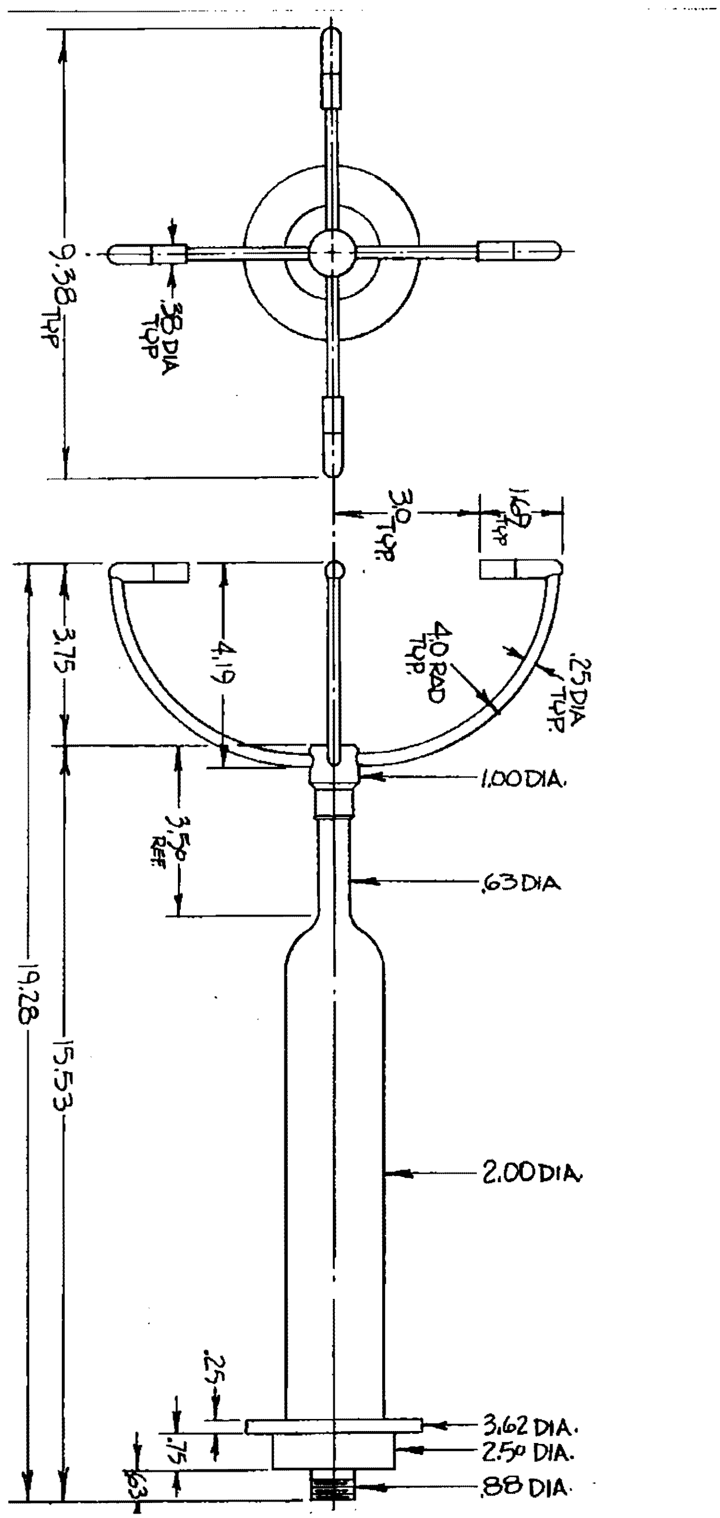


FIGURE 6-1 50.5 Wind Sensor Outline Dimensions

APPENDIX A - WIND DIRECTION SENSOR ORIENTATION

INTRODUCTION:
Determining True North or Magnetic Declination is very important to the proper setup and orientation of the wind direction portion of the sonic wind sensor. The declination value is used to determine the difference between True North and magnetic North. This value varies around the world depending upon your location. The following procedure can be used to either point the sonic wind sensor to True North.

ADJUSTMENT:
Orientation of the wind direction sensor is done after the location of True North has been determined. True North is usually found by reading a magnetic compass and applying the correction for magnetic declination; where magnetic declination is the number of degrees between True North and Magnetic North. Magnetic declination for a specific site can be obtained from a USGS topographic map, pilots maps, local airport, or through a computer service offered by the USGS called GEOMAG.

The following map showing magnetic declination for the contiguous United States is shown in the figure #1, can be used for determination of declination. This will depend upon the accuracy requirement required. Alternately use a more accurate method of determining declination from magnetic North.

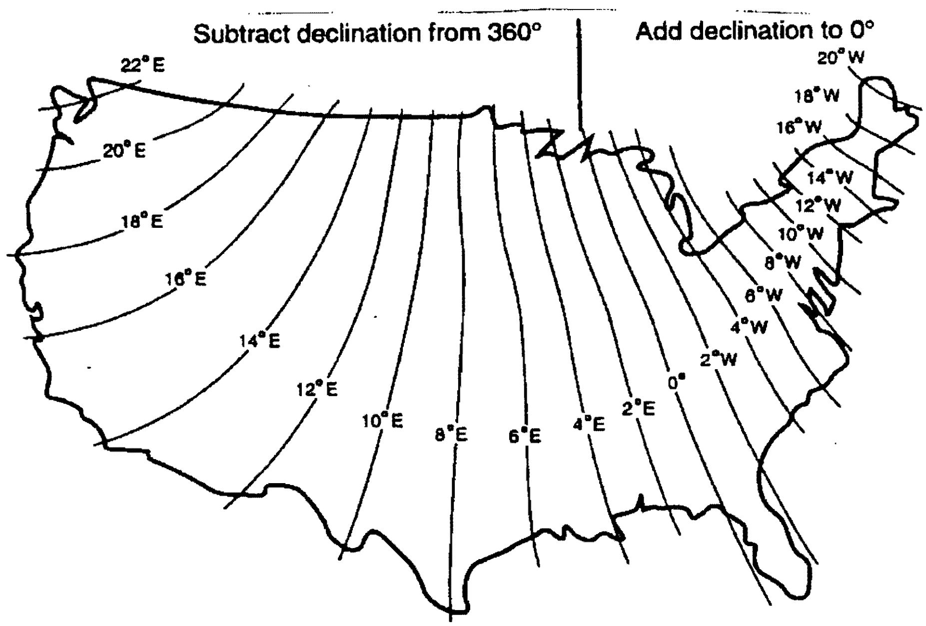


Figure #1 typical declination values in the USA

Declination angles east of True North are considered negative, and are subtracted from 0 or (360) degrees to get True North as shown in figure #2. Declination angles west of True North are considered positive, and are added to 0 degrees to get True North as shown in figure #3. For example, the declination for Grants Pass, Oregon is 17° East. True North is 360° -17°, or 343° as read on a compass.

Alignment to North
Orientation is most easily done with two people, one to aim and adjust the sensor, while the other observes the wind direction display. (Once True North is located, the South reference can be determined)

1. Establish a reference point on the horizon for True North.
   Sighting down the instrument centerline, aim the two arms of the North/South pair at True North with the locking set screw pointed South.

2. Align the sensor adapter or adapter mount.
   Loosen the setscrews that secure the base of the sensor to the cross arm. While viewing the position/rotation of the North/South sensor arms, slowly rotate the sensor base until the two arms point to True North that was determined by earlier measurement using compass.

   Other methods employ observations using the North Star or the sun, and are discussed in the Quality Assurance Handbook for Air Pollution Measurement Systems, Volume IV Meteorological Measurements.

Determining Local Magnetic Declination
Several resources for determining the magnetic declination of any site in the world can be found on the internet or can be accessed by modem using any common terminal program.

GEOMAG is a resource that can be accessed by telephone or the Internet (Telnet) connection. GEOMAG is accessed by calling 1-800-358-2663 with a computer and telephone modem, and communications program such as HyperTerminal. GEOMAG can also be accessed by the internet using the address: telnet://neis.cr.usgs.gov

GEOMAG prompts the caller for site latitude, longitude, and elevation, which it uses to determine the magnetic declination and annual change. The following Menu and prompts are from GEOMAG: Use the username: "QED".

MAIN MENU
Type Q for Quick Epicenter Determinations (QED)
L for Earthquake Lists (EQLIST)
M for Geomagnetic Field Values (GEOMAG)
X to log out

Enter program option: M

Would you like information on how to run GEOMAG (Y/N)? N

Options:
1 = Field Values(D, I, H,X,Z, F)
2 = Magnetic Pole Positions
3 = Dipole Axis and Magnitude
4 = Magnetic Center

Display values twice	[N]: press return
Name of field model	[USCON95]: press return
Date	[Current date]: press return
Latitude	: 42/25 N
Longitude	: 123/20 W
Elevation	: 1000
Units (m/km/ft)	: ft

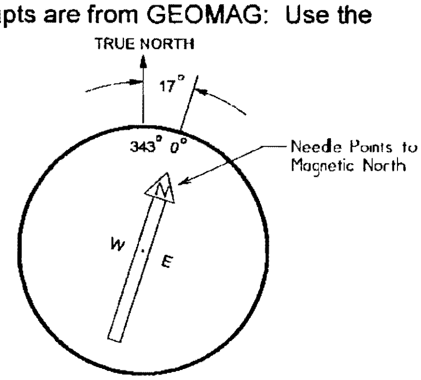


FIGURE 2 Declination Angles East of True North Are Subtracted from 0 to Get True North

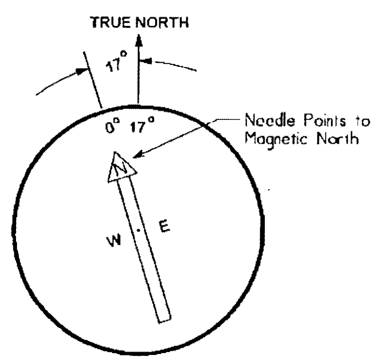


FIGURE 3 Declination Angles West of True North Are Added to 0 to Get True North

Example of report generated by GEOMAG:

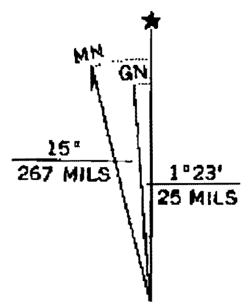
Model: USCON95 Latitude : 42/25 N

Date : 2/13/99 Longitude: 123/20 W Elevation: 1000.000 ft

	D		I		H	X	Y	Z	F
	deg	min	deg	min	nT	nT	nT	nT	nT
	17	17.5	65	7.3	22056	21059	6555	47560	52425
Annual change:	0	-2.4	0	-1.7	-2.9	1.8	-15.6	-66.2	-61.3

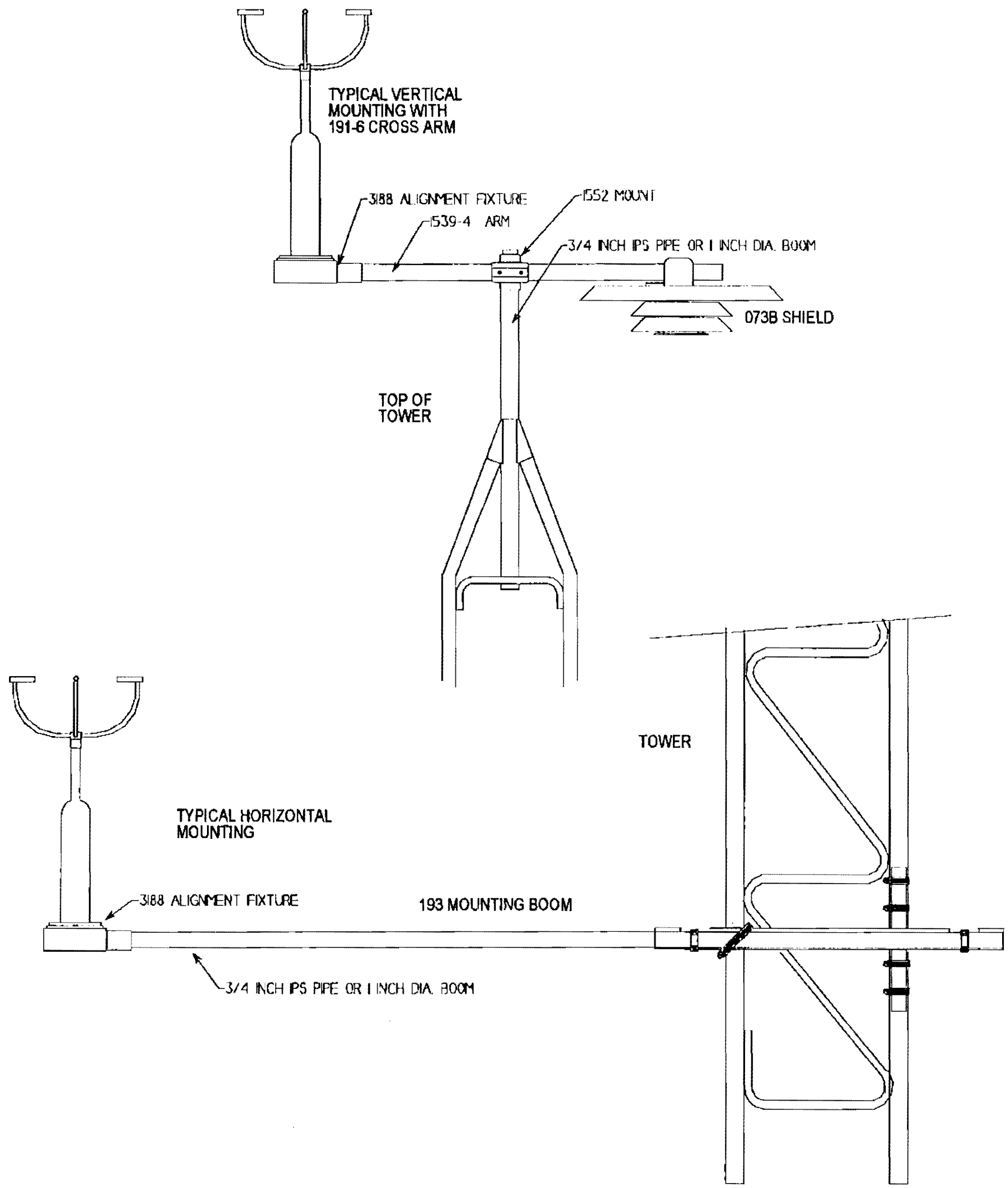
The calculated declination would be 17 degrees and 17.5 minutes for Grants Pass, Oregon.
The declination in the example above is listed as 17 degrees and 17.5 minutes. Expressed in degrees, this would be 17.3 degrees. As shown in Figure #1, the declination for Oregon is east, so True North for this site is 360 – 17.3, or 342.7 degrees. The annual change is –2.4 minutes. In this case a value 343 degrees would probably be sufficient for most measurement accuracy.

An alternative method is to find a USGS map and examine the text at the bottom center of the map. At this point either a written indication is given, or a symbol similar to the one seen below will be found. This would indicate a declination of 15 degrees West-showing MN (magnetic North) to True North (Star). Other sources such as the local airport can be helpful in determining the correct declination.

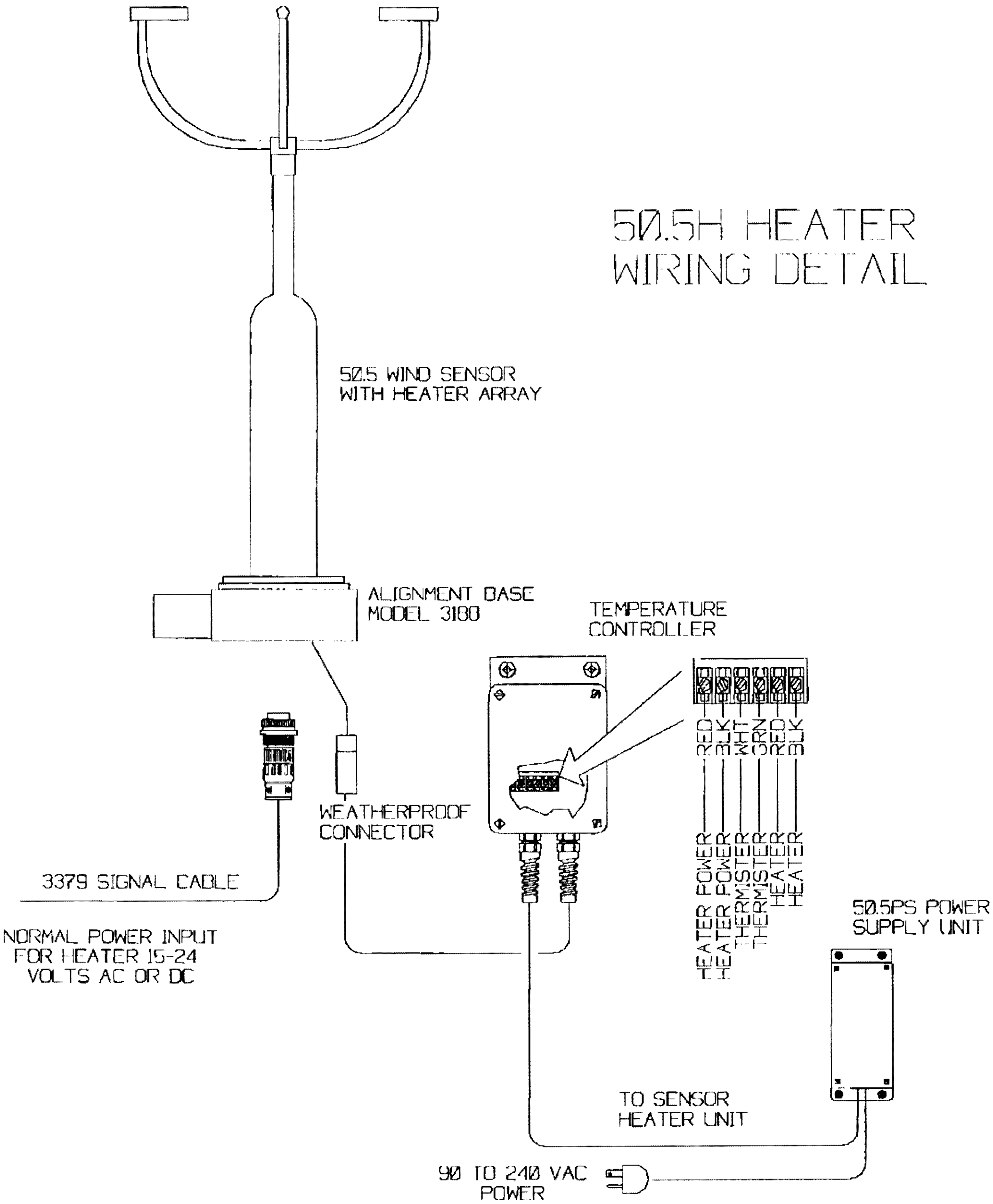


UTM GRID AND 1971 MAGNETIC NORTH
DECLINATION AT CENTER OF SHEET

APPENDIX B - WIND SENSOR MOUNTING OPTIONS

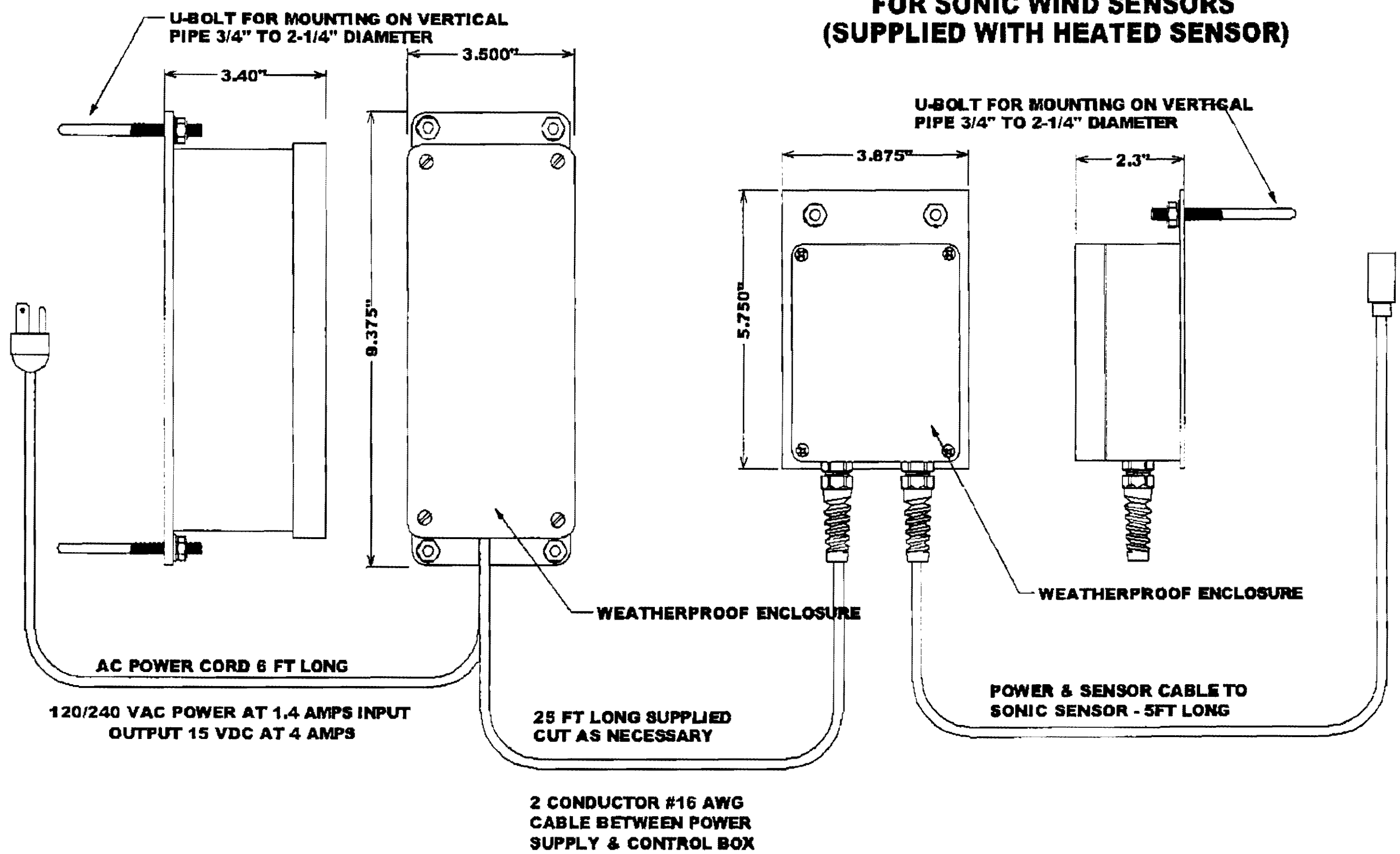


APPENDIX C - HEATER CONFIGURATION AND WIRING



OPTIONAL
50.5 PS SONIC WIND SENSOR
HEATER POWER SUPPLY

HEATER CONTROL UNIT PART 3254
FOR SONIC WIND SENSORS
(SUPPLIED WITH HEATED SENSOR)



FOR USE WITH SONIC WIND SENSORS 50.5H AND 035A-H

APPENDIX D – RS232 Command Set

General Protocol

The computer interface commands use a simple ASCII packet protocol. Only one command is transferred per packet.

To enter the command mode, send the exclamation point (!) character until the unit returns '!'.

The unit will remain in the command mode until the quit command (QU) is received or a power reset.

Command packets are constructed with a two (2) character command, and if required a data string.

All commands must end with a carriage return (0x0D).

The unit will echo back the command string terminated with a carriage return and line feed (0x0A).

Data string requirements are described with each command.

A command with no argument returns the current setting.

The default RS-232 configuration is 9600, 8, N, 1.

There are two command sets—User and Factory.

1. RS-232 Data Output Protocol

The typical RS-232 data output stream has the following format.

S sss.s D ddd<cr><lf>

Where sss.s is the wind speed value and ddd is the wind direction value.
The range of the direction value is 0 to 359 degrees.

The units of sss.s are determined by the SU (Speed Units) settings.

The data output rate is determined by the TS (Sample Period) settings.

Parameter labels can be suppressed by the LB setting. The output format follows.

sss.s ddd<cr><lf>

The sonic temperature reading can be added to the data output with the TT (Sonic Temperature) setting. The output format follows.

S sss.s D ddd T ttt.t<cr><lf>

The units of ttt.t are in degrees C.

The sonic error code can be added to the data output with the EE (Sonic Error Code) setting. The output form follows.

S sss.s D ddd T ttt.t E eee<cr><lf>

1.1 Error Code

There is a time-of-flight window establish to determine sensor failures. If the receive signal arrives before the window it is considered early. If is arrives after the window it is considered late. There is an early and late error code for each sensor.

The firing order is NWSE so the receive order is SENW.
The error code table follows.

	Early	Late
N	1	2
S	4	8
W	16	32
E	64	128

The error code output is the sum of the sensor failures.
An error code does not mean the speed or direction values are invalid. Here is an example.

```
S  3.4  D  77  E  16<cr><lf>
```

The speed or direction values are invalid when an axis failure has occurred for three (3) consecutive sample periods.

An axis failure is when each sensor of the sensor pair has a failure—early or late. When this condition occurs the speed is set to an equivalent of 100.0 meter-per-second. The actual speed report is determined by the SU setting. The direction is equal to the error code.

For example, if the north-south axis is block and SU is MPS the data output looks like this.

```
S 100.0  D  10  E  10<cr><lf>
```

If the east-west axis is block and SU is MPH the data output looks like this.

```
S 223.7  D 160  E 160<cr><lf>
```

If the north-south and east-west axis is block and SU is KPH the data output looks like this.

```
S 360.0  D 170  E 170<cr><lf>
```

2. User Command Set

Note: <cr> refers to a carriage return

2.1 LB-Verbose Control of RS-232 PARAMETER labels

Display or suppress parameter labels of Wind Speed (S), Wind Direction (D), Sonic Temperature (T), and Error Code (E) at RS-232 output.

COMMAND	RESULT
LB<cr>	Report Present Setting
LB0<cr>	Suppress parameter labels
LB1<cr>	Display parameter labels

2.2 MS-Maximum Full Scale Wind Speed

Set the unit's full-scale Wind Speed output for full-scale analog output. Note that these numbers MUST correspond to units set in "SU" below.

Example:

COMMAND	RESULT
MS<cr>	Report Present Setting
MS50<cr>	50 Meters per second when SU = 0
MS111.85<cr>	111.85 MPH when SU = 1
MS180.0<cr>	180 KPH when SU = 2
MS97.19<cr>	97.19 KNOTS when SU = 4

2.3 SU-Wind Speed Units

Set units for Wind Speed.

COMMAND	RESULT
SU<cr>	Report Present Units selected
SU0<cr>	MPS
SU1<cr>	MPH
SU2<cr>	KPH
SU4<cr>	Knots

These values are mutually exclusive.

2.4 QU-Quit

Exit the command mode and save any changes.

COMMAND: QU<cr>
Note: This command not supported by SDI-12.

2.5 SB-Serial Baud Rate

Read or Set the unit's Baud rate.
Note: This command is not supported by SDI-12.

COMMAND	RESULT
SB<cr>	Report Present Baud Rate
SB1<cr>	Set 1200 BAUD
SB2<cr>	Set 2400 BAUD
SB3<cr>	Set 4800 BAUD
SB4<cr>	Set 9600 BAUD
SB5<cr>	Set 19200 BAUD

Baud rate changes take effect after turning off the power to the sensor and turning it back on again.

2.6 ST-Serial Trigger (RS-485 Only)

Set the string used in RS-485 mode to serve as a trigger for the unit's send data command.

COMMAND: STx<cr> Where x can be any set of one to six alphanumeric characters except three "!" in a row.

2.7 TT-Sonic Temperature

Enable or disable Sonic Temperature RS-232 output.

COMMAND	RESULT
TT<cr>	Report Present Output Status
TT0<cr>	Disable Sonic Temperature Output
TT1<cr>	Enable Sonic Temperature Output

2.8 VN-Version Number

Returns the Firmware version number.

COMMAND: VN<cr> Example Report: 3194-02 R2.60

2.9 VS-Full Scale Analog Output Voltage for Wind Speed and Wind Direction

Set the full-scale analog output voltage for the full-scale wind speed and wind direction.

COMMAND: VSx.x<cr> Where x.x is the full-scale analog output voltage at the full-scale wind speed and wind direction.

The range of x.x is 0.0 to 5.0 volts at the full scale

Warranty

Products manufactured by Met One Instruments, Inc. are warranted against defects in material and workmanship for a period of one (1) year from the date of shipment from the factory. Offered products not manufactured by Met One Instruments, Inc. will be warranted to the extent and in the manner warranted by the manufacturer of that product.

Any product found to be defective during the warranty period will, at the option of Met One Instruments, Inc., be replaced or repaired. In no case shall the liability of Met One Instruments, Inc. exceed the purchase price of the product.

This warranty may not apply to products that have been subject to misuse, negligence, accident, acts of nature or that have been altered or modified other than by Met One Instruments, Inc. Consumable items such as bearings and batteries are not covered under this warranty.

Other than the warranty set forth herein, there shall be no other warranties, whether expressed, implied or statutory, including warranties of fitness or merchantability.

Service

Any product being returned to Met One Instruments, Inc. for service, repair or calibration must be assigned a return authorization (RA) number. Please call (541) 471-7111 or (972) 412-4715 for an RA number and shipping instructions.

Products manufactured by Met One Instruments, Inc. that are returned for service, repair or calibration are warranted against defects in material and workmanship for ninety(90) days from date of shipment, under the same conditions as stated above.

9/93

MODEL 083D
RELATIVE HUMIDITY/TEMPERATURE SENSOR

OPERATION MANUAL

Met One Instruments

1600 Washington Blvd.
Grants Pass, Oregon 97526
Telephone 541-471-7111
Facsimile 541-471-7116

Regional Sales & Service
3206 Main St., Suite 106
Rowlett, Texas 75088
Telephone 972-412-4715
Facsimile 972-412-4716

083D RELATIVE HUMIDITY/TEMPERATURE SENSOR
OPERATION MANUAL

1.0 GENERAL INFORMATION

1.1 The 083D Sensor is an extremely accurate and sensitive relative humidity sensor which responds to the full range of 0-100% humidity. Response is linear with small hysteresis and negligible temperature dependence. The sensor is designed to be housed in a radiation shield when used outdoors. Certain models also contain a high-accuracy linearized air temperature sensor, permitting simultaneous measurement of relative humidity and temperature.

1.2 The 083D Sensor model number describes the sensor options as follows:

083D - A - B

X is the temperature option:

0 = no temperature sensor
1 = -50 to +50°C temperature sensor

Other temperature options are available.

Y is the radiation shield compatibility option:

- Y	Radiation Shield	Signal Cable
- 1	071	1873 -XX (XX = cable length in feet)
- 6	076	2144 -XX
- 6	077	2408 -XX
- 35	073B	2348 -XX
- 35	075B	2348 -XX
- 35	5980	2348 -XX

1.3 The Sensor Cable is vinyl-jacketed and shielded. Cable length is given in feet on each cable part number. The cable part number depends on which radiation shield the sensor is mounted in. The 077 Radiation Shield has a screw type terminal strip to accept wire leads from the 2408 cable. All other Radiation Shields and cables have Mil Spec screw-on or twist-on cable connectors.

The 083D-X-6 sensor mounts in either a 076B Radiation Shield, with a 2144-XX signal cable or a 077 Radiation Shield with a 2408-XX signal cable.
The 083D-X-35 mounts in a 073B, 075B, or 5980 Radiation Shield with a 2348-XX signal cable.

Table 1.1
Model 083D Relative Humidity Sensor Specifications

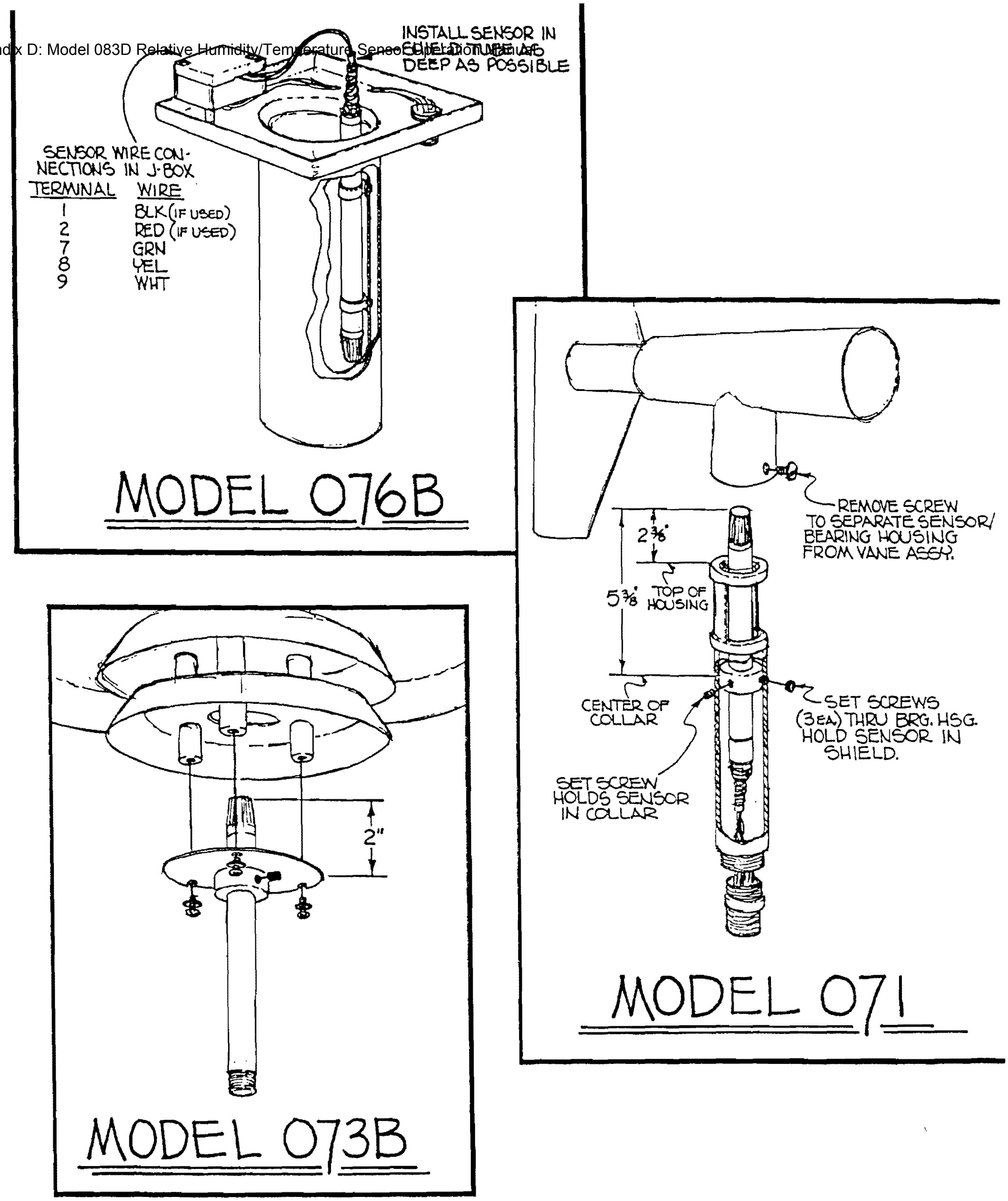
Sensing Element	Thin-film capacitor
Range	0-100% RH
Temperature Range	-20°C to +60°C
Response Time	15 seconds at 20°C 90% of final RH value
Accuracy	Better than ±2% RH between 10% RH and 100% RH
Hysteresis	For 0% to 100% to 0% excursion less than ± 1%
Temperature Coefficient	±0.04% per 1°C
Output	0 - 1V full scale (standard)
Input Power	12V DC ± 2V, 12 ma

Table 1.2
Model 083D-1 RH/Temp Sensor Specifications

Range	-50° to +50°C (standard range)	
	Accuracy	±0.10°C
Time Constant	10 sec.	

2.0 INSTALLATION

2.1 If sensor comes mounted in a radiation shield, refer to radiation shield manual section for mounting details. Sensors not furnished in a radiation shield should be mounted in a representative location having good air flow and shaded from sunlight or other heat radiation sources that would affect measurement of relative humidity or temperature.



TYPICAL 083D SENSOR INSTALLATIONS IN STANDARD RADIATION SHIELDS

3.0 OPERATIONAL CHECK-OUT AND CALIBRATION

3.1 Relative Humidity Measurement

3.2 Relative Humidity Sensor Check-out

1. To verify correct wiring and as a rough test of sensor operation, blow on the sensor. The relative humidity will rise to a higher level.

2. The Relative Humidity Sensor has been calibrated at the factory and will not change unless it is damaged. To check for proper operation of the sensor it is advised that the output signal be checked against a local weather service facility. Exact correlation is not to be expected due to atmospheric and geographical variations.

3.3 Temperature Sensor

1. Compare actual readings with precision mercury thermometer. As an alternative, measure sensor resistance with a Lo Current Digital Ohm Meter and compare readings of temperature vs resistance. See Table 4.2.

4.0 MAINTENANCE AND TROUBLE SHOOTING

4.1 General Maintenance Schedule*

6 - 12 Month Intervals:

A. Inspect sensors for proper operation per Section 3.0.

B. Clean Relative Humidity sensor element per Section 4.2A.

*Schedule is based on adverse to average environments.

4.2 083 Relative Humidity Sensor Maintenance and Calibration

Warning: *The sensor can be miscalibrated or permanently damaged through improper acts. Do not attempt a repair or calibration if you are unsure of the procedure. Do not touch the sensor element if you do not know the correct procedure.*

This instrument should operate for an extended period of time with a minimum of care or maintenance.

If parts or maintenance assistance are required, contact Met One Instruments. Obtain shipping instructions before returning any unit.

4.3 Sensor Element Maintenance

Cleaning the Sensor Element. Unscrew the filter. Dust and other particles may be removed by gently blowing on the sensor chip. DO NOT USE COMPRESSED AIR. DO NOT USE DETERGENTS. DO NOT APPLY POWER TO THE SENSOR WHEN CLEANING, and do not reconnect power to the sensor until the element has dried.

CAUTION: NEVER TOUCH THE SENSOR CHIP WITH BARE HANDS

1. The life of the sensor is related to the environment in which it operates. In a pure air and water vapor surrounding, the sensor element will have an indefinite life. The presence of chemical pollutants in the environment may corrode the materials of the sensor chip. The polymer material is resistant to most chemical attacks, but the metal electrodes, are sensitive to corrosion effects, particularly when a DC voltage is applied to the sensor. The most harmful pollutant has been sulphur dioxide absorption in small soot particles. When such particles fall on the thin metal electrode, they may, if water condensation is present, form traces of sulphuric acid to corrode the surface of the sensor. For these reasons, a careful cleaning as described in the preceding paragraph is recommended whenever the sensor has been exposed to corrosive pollutants. Also, a periodic cleaning every two weeks with an atomizer of distilled water, thoroughly washing the chip clean, may remove harmful particles before they can damage the sensor. Be sure that no power is applied when washing the chip and that power remains off until after the chip has dried.

2. The safest way is always to use distilled water. However, if the dirt can not be washed out with the water, you can use also isopropanol. In that case the instructions are:
-rinse the sensor in isopropanol during 1min (immersed, move it every now and then)
-rinse the sensor in water during 15min (can be left immersed in water)
-let the sensor dry

3. Replacement of Sensor Element. If the sensor element has been damaged, it can be easily replaced. Disconnect power to the probe. Unscrew the filter. Un-plug the old sensor element and plug a new one in its place. The sensor chip is very delicate, so observe the following precautions. DO NOT TOUCH THE SENSOR ELEMENT WITH BARE HANDS. Handle the sensor element only gripping the nylon edge. Do not bump the sensor element when reinstalling the protective grid.

4. After replacement of the sensor element, the humdity probe must be recalibrated.

SPARE PARTS:	820202	ELEMENT
	560014	FILTER, MEMBRANE
	560015	FILTER, BRONZE

4.4 Relative humidity Calibrator model 3226

It is essential that the functioning of an instrument is checked against a reference from time to time. Humidity Calibrator Model 3226 is used to make calibration and spot checking of humidity probes and transmitters easy and reliable.

The operating principle of the 3226 is based on the fact that a saturated salt solution generates a certain relative humidity in the air above it. The reading of the humdity probe or transmitter can then be adjusted accordingly. This is a generally accepted and reliable method for calibrating humidity instruments - many leading laboratories use this method. Usually two or three different salt solutions are used which are chosen according to the application.

The structure of the 3226 is designed to ensure fast and stable temperature equilibration. No external power is required. In addition to laboratory use it is also suitable for one-site checks. Special transit covers make the 3226 particularly simple to transport. These features together with the pre-measured salts with a long lifespan (even after taken into use) make the 3226 the ideal choice for the most demanding user.

The calibrator is provided with certified salts. A sample calibration is made from each batch in the Measurement Standards Laboratory (MSL). The uncertainities achieved using these salts at e.g.+20 ° C are given here:
- LiCl salt, 11%RH (± 1.3%RH)
- NaCl salt, 75%RH (±1.5%RH)

3226 includes a thermometer which is used for measuring the temperature during the calibration and can also be used for checking temperature measurement accuracy of the transmitter. The accuracy of the thermometer is ±0.3°C. Each thermometer has been calibrated.

4.5 Humidity Probe Calibration using 3226

1. The calibration method described in this instruction manual is based on the constant water vapor pressure over saturated salt solutions and constant temperature. Materials used for the calibration are Lithium Chloride (LiCl) and Sodium Chloride (NaCl). The former creates a humidity of approximately 11% and the latter approximately 75% in 68°F (20°C) ambient temperature. Both of these chemical agents are available from chemical suppliers. To guarantee accurate calibration, the salts must be of high purity.

2. Preparations for Calibration

   Refer to instructions with the calibration bottles for mixing the solutions.

   The calibration bottles can be used for up to one year without changing to fresh

The calibration bottles can be used for up to one year without changing to fresh chemicals. The bottles should be stored in a place with constant temperature, so as to have them ready for use with just a short preparation time. Do not shake the bottle with salt solution before use. Care should be taken to see that there are no droplets of salt solution inside the mouth piece of the bottle. This might affect the accuracy of the calibration. Do not get any salt solution on the sensor element directly.

TABLE 4.1
Calibration Tables

LITHIUM CHLORIDE

Ambient Temperature °C	10	15	20	25	30	35	40
Calibration Value % RH	11.3	11.3	11.3	11.3	11.3	11.3	11.2

SODIUM CHLORIDE

Ambient Temperature °C	10	15	20	25	30	35	40
Calibration Value % RH	75.7	75.6	75.5	75.3	75.1	74.9	74.7

A. CALIBRATION FOR LOW HUMIDITY (13% RH)

1. Unscrew the filter. Do not bump the sensor element while removing the grid.

2. Pull the rubber plug out of the lithium chloride (LiCl) bottle, and push the sensor probe in its place in the cork's sleeve. The sleeve is fitted with a safety flange and prohibits the probe from falling through.

3. Read the ambient room temperature.

4. Note the humidity percentage from the lithium chloride calibration table, which corresponds to the temperature in question.

5. After 1 hour, read the humidity value, If the reading differs from the table value, adjust R15, zero adjust.

6. After use, close the bottle tightly with the rubber plug.

B. CALIBRATION FOR HIGH HUMIDITY (76%)

Repeat the calibration procedure as described above, but now using the sodium chloride. Adjust R18 (span adjustment) if necessary.

C. Repeat steps A and B until no further adjustments are required.

TABLE 4.2

Sensor Model 083-1-x

Tc °C	Rt kΩ	Tc °C	Rt KΩ	Tc °C	Rt kΩ
-50	158.181	-14	47.173	19	21.908
-49	150.561	-13	45.997	20	21.423
-48	143.555	-12	44.861	21	20.949
-47	137.093	-11	43.761	22	20.484
-46	131.114	-10	42.696	23	20.029
-45	125.564	-9	41.665	24	19.583
-44	120.400	-8	40.665	25	19.147
-43	115.583	-7	39.696	26	18.719
-42	111.079	-6	38.755	27	18.300
-41	106.858	-5	37.843	28	17.899
-40	102.895	-4	36.957	29	17.147
-39	99.166	-3	36.097	30	17.092
-38	95.651	-2	35.260	31	16.705
-37	92.333	-1	34.447	32	16.325
-36	89.196	0	33.657	33	15.952
-35	86.224	1	32.888	34	15.586
-34	83.406	2	32.139	35	15.227
-33	80.729	3	31.410	36	14.875
-32	78.183	4	30.700	37	14.529
-31	75.760	5	30.009	38	14.190
-30	73.449	6	29.335	39	13.856
-29	71.245	7	28.677	40	13.528
-28	69.138	8	28.037	41	13.206
-27	67.124	9	27.411	42	12.890
-26	65.195	10	26.801	43	12.579
-22	58.242	11	26.206	44	12.274
-21	56.671	12	25.624	45	11.974
-20	55.160	13	25.056	46	11.678
-19	53.705	14	24.501	47	11.388
-18	52.303	15	23.959	48	11.102
-17	50.952	16	23.429	49	10.822
-16	49.648	17	22.911	50	10.545
-15	48.389	18	22.404		

Sensor Range = -50 to +50°C (-58 to +122°F)

Conversion Formulas:

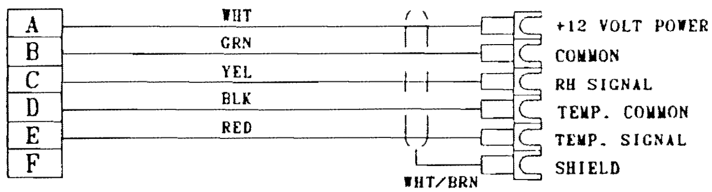
$T_c = (((R_t^{-1})+(23100^{-1}))^{-1} - 13698.3)/ - 129.163$

$R_t = ((((-129.163 T_c)+13698.3)^{-1}) - 23100^{-1})^{-1}$

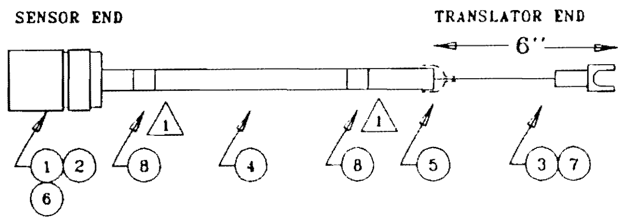
Where: T_c= Temperature in °C

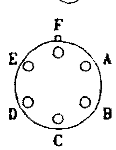
R_t = Sensor Resistance in Ohms (Ω)

REVISIONS			
REV	DESCRIPTION	DATE	APPROVED
C	REDRAWN PER E.O. 1131	9/11/91	DH



ITEM	PART NO.	DESCRIPTION	QTY
1	500391	CONNECTOR, 6 PIN, FEMALE	1
2	480508	CLAMP	1
3	600193	LUG, SPADE, #6	6
4	400014	CABLE, 5 COND., SHIELDED	A/R
5	960050	SLEEVING, 1/4", SHRINK	A/R
6	960075	SLEEVING, 1/8", SHRINK	A/R
7	980510	WIRE, 22 AWG, WHT/BRN	6"
8	960060	SLEEVING, 1/4", CLEAR SHRINK	A/R
9			
10			





SOLDER CUP VIEW

⚠1 IDENTIFY CABLE 18" FROM EACH END.
DASH NUMBER = LENGTH IN FEET.

MET ONE INSTRUMENTS	
ASSY, CABLE, 083 RH AND TEMPERATURE	
SIZE	FSCM NO.	DWG NO. 1873	REV C
SCALE	SHEET 1 OF 1

083D-9800 2/99

REVISIONS			
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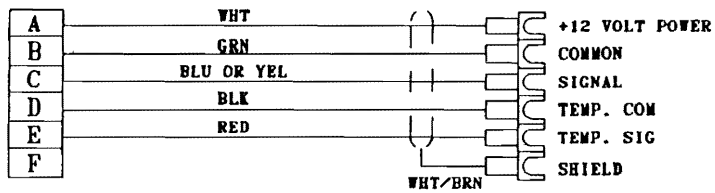
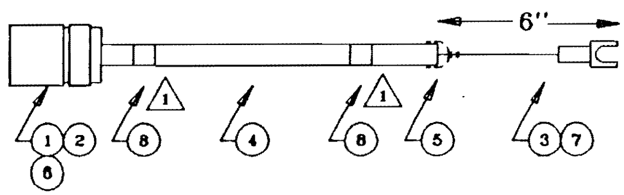
A	PROD REL	5/21/92	DH
B	EO 1191	6/5/92	DH

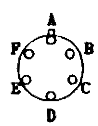


SENSOR END

TRANSLATOR END



ITEM	PART NO.	DESCRIPTION	QTY
1	500351	CONNECTOR, 6 PIN, FEMALE	1
2	480500	CLAMP	1
3	600193	LUG, SPADE, #6	6
4	400014	CABLE, 5 COND., SHIELDED	A/R
5	960050	SLEEVING, 1/4", SHRINK	A/R
6	960075	SLEEVING, 1/8", SHRINK	A/R
7	980510	WIRE, 22 AWG, WHT/BRN	6"
8	960060	SLEEVING, 1/4", CLEAR SHRINK	A/R
9			
10			



SOLDER CUP VIEW

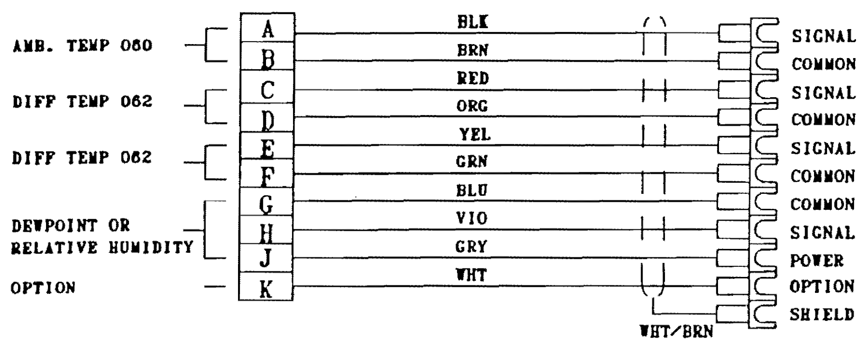
1 IDENTIFY CABLE 18" FROM EACH END.
DASH NUMBER = LENGTH IN FEET.

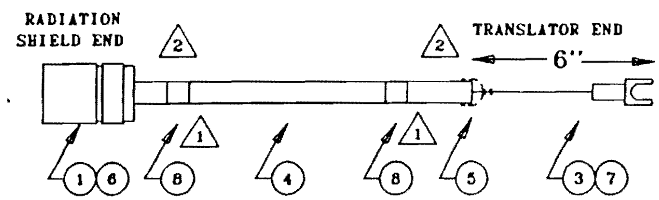
MET ONE INSTRUMENTS

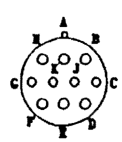
ASSY, CABLE, RELATIVE HUMIDITY AND TEMPERATURE

SIZE	FSCM NO.	DWG NO.	REV
		2348	A
SCALE		SHEET 1 OF 1	

REVISIONS			
REV	DESCRIPTION	DATE	APPROVED
D	REDRAWN AND ADD PARTS LIST	9/13/91	DH







SOLDER CUP VIEW

ITEM	PART NO.	DESCRIPTION	QTY
1	500296	CONNECTOR, 10 PIN	1
2			
3	600193	LUG, SPADE, #6	6
4	400017	CABLE, 12 WIRE, SHIELDED	A/R
5	960096	SLEEVING, 3/8, SHRINK	A/R
6	960093	SLEEVING, 3/32, SHRINK	A/R
7	980510.	WIRE, 22 AWG, WHT/BRN	6"
8	960065	SLEEVING, 1/2", CLEAR	A/R
9			
10			

1. IDENTIFY CABLE 18" FROM EACH END. DASH NUMBER = LENGTH IN FEET.

2. CUT OFF WHT/BRN AND WHT/BLK WIRES AT BOTH ENDS. SOLDER WHT/BRN WIRE TO SHIELD ON TRANSLATOR END. USE ITEM 6 TO COVER SOLDER JOINT ON SHEILD.

	MET ONE INSTRUMENTS
	ASSY, CABLE, SIGNAL OUT, 076B /JUNCTION BOX
SIZE	FSCM NO.
DWG NO.	2144
REV	D
SCALE	
SHEET	1 OF 1

MODEL 077 RADIATION SHIELD
WIRING TABLE
CABLE NO. 2408

COLOR	USE
RED	AT SIG
BLACK	AT COM
GREEN	RH COM
WHITE	RH +12V
YELLOW	RH SIG
WHT/BRN	SHIELD

MODEL 077 RADIATION SHIELD
WIRING TABLE
CABLE NO. 2409

COLOR	USE
RED	POWER
BLACK	COM

MODEL 090D
BAROMETRIC PRESSURE SENSOR

OPERATION MANUAL
DOCUMENT 090D-9800

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Facsimile 541-471-7116

Regional Sales & Service
3206 Main St., Suite 106
Rowlett, Texas 75088
Telephone 972-412-4715
Facsimile 972-412-4716

Barometric Pressure Sensor Model 090D
Operation Manual

1.0 GENERAL INFORMATION

1.1 090D Barometric Pressure Sensor uses an active solid-state device to sense barometric pressure. Self-contained electronics provide a regulated voltage to the solid state sensor and amplification for the signal output.

1.2 A 1169-XX Sensor Cable is a 4-conductor shielded, vinyl jacketed cable. Length is given in -XX feet on each cable part number label.

TABLE 1-1

Model 090D-26/32-1 Pressure Sensor Specifications

Performance

Calibrated Range	26-32" (standard)*
Calibrated Operating Range	-18°C to +50°C
Operating temperature range	-40°C to +50°C
Resolution	Infinite
Accuracy	±0.04 in Hg (±1.35 mb) or
Accuracy	±0.125% FS
Output	0-1V DC (standard)*

*Refer to model number of sensor. Example: 090D -26/32 -1

Basic Mod # — Range ("Hg) — Output Voltage

(In this example, the sensor output is 0-1v for a range of 26 to 32" Hg)

Electrical Characteristics

Power Requirement	11 ma @ 12 VDC
Sensor Output	0-1 VDC Standard
	0-5 VDC Optional

Physical Characteristics

Weight	2 lbs. 5 oz. (1.05 Kg)
Dimensions	5.5" x 5" x 7.5" (14x12x19 cm)

2.0 INSTALLATION

2.1 Mounting the Sensor. Mount sensor in a convenient location with pressure inlet port facing downward. Refer to drawings 6139 and 6140 for mounting details.

2.2 Installing the Cable. The 1169 Cable Assembly contains four wires. Install the cable into the water-tight gland and connect cable as follows:

SIG Terminal	=	Signal Output (Wht)
COM Terminal	=	Signal Common (Grn)
+12 Terminal	=	+12V Power (Red)
COM Terminal	=	Power Com(Blk)

3.0 OPERATION

3.1 The Barometric Pressure Sensor has been calibrated at the factory, and will not change unless it is damaged. To check for proper operation of the sensor and module, it is advised that the module's output be checked against a local weather service facility. Exact correlation is not to be expected, due to geographical and meteorological variations. The sensor reads absolute barometric pressure, whereas local weather services readings are normalized to sea level values.

3.2 One should keep in mind that nominal pressure, at sea level, is 30 inches of mercury and that for every 1,000 feet of elevation, the pressure decreases approximately one inch of mercury. EXAMPLE: A weather station at sea level may use a barometer with a range of 26 to 32 inches of mercury to cover all possible weather conditions. However, a weather station, located 4,000 above sea level, would require a range of 22 to 28 inches of mercury.

MODEL 090D BAROMETRIC PRESSURE SENSOR
RANGE SELECTION GUIDE

ELEVATION	RANGE ("Hg)
0 to 1,500	26/32
1,501 to 3,500	24/30
3,501 to 5,500	22/28
5,501 to 8,000	20/26
8,001 to 10,000	18/24
10,001 to 12,500	16/22
12,501 to 15,500	14/20
15,501 to 19,000	12/18

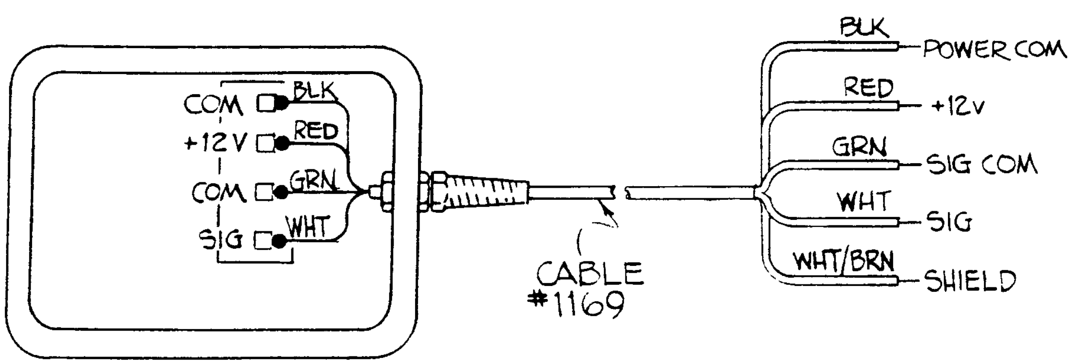
4.0 MAINTENANCE AND TROUBLESHOOTING

4.1 General Maintenance Schedule.

A. Inspect pressure inlet port occasionally to insure it is free of obstruction. No other periodic maintenance or calibration is required.

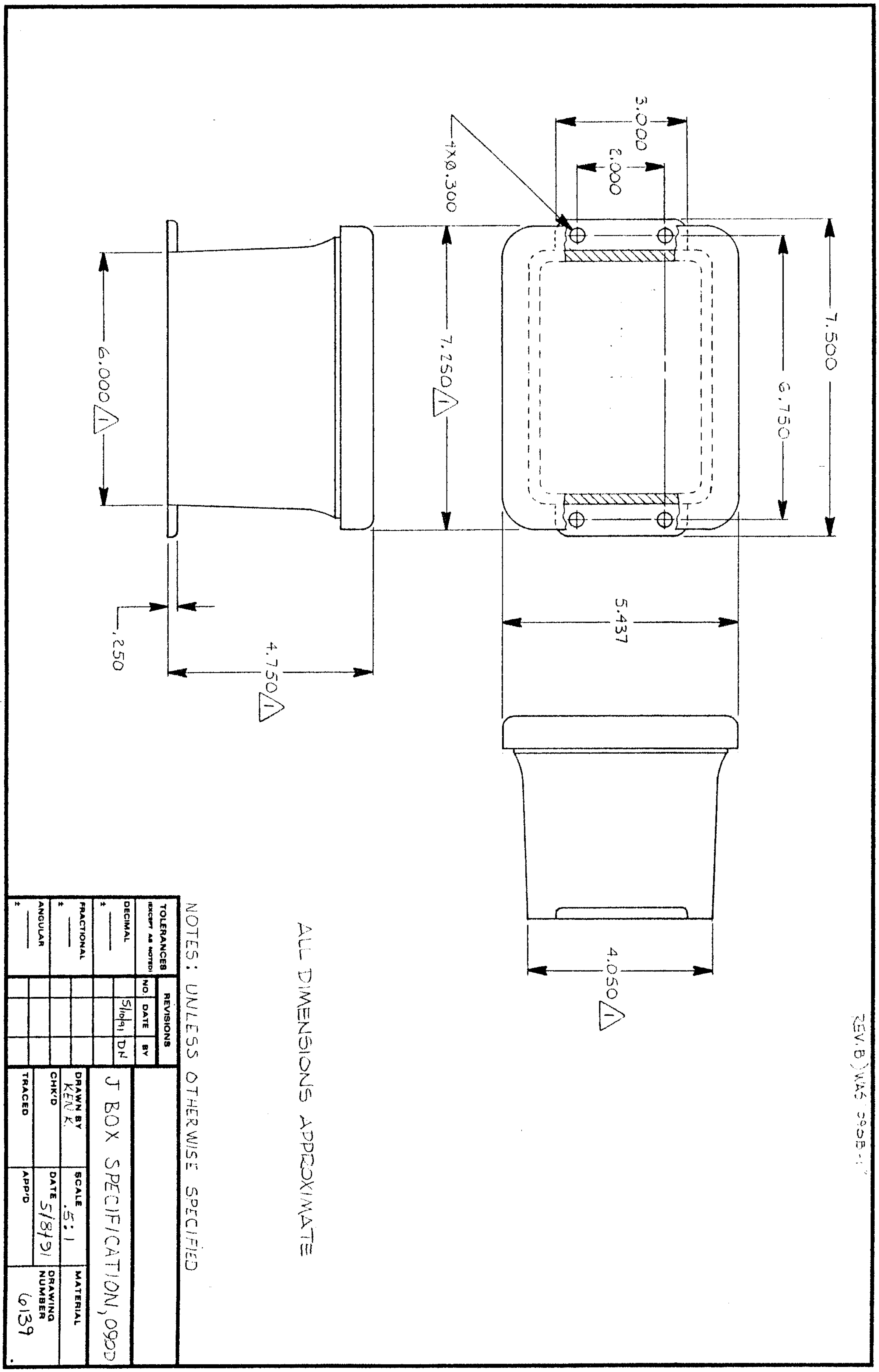
B. Inspect sensor for proper operation per Section 3.1.

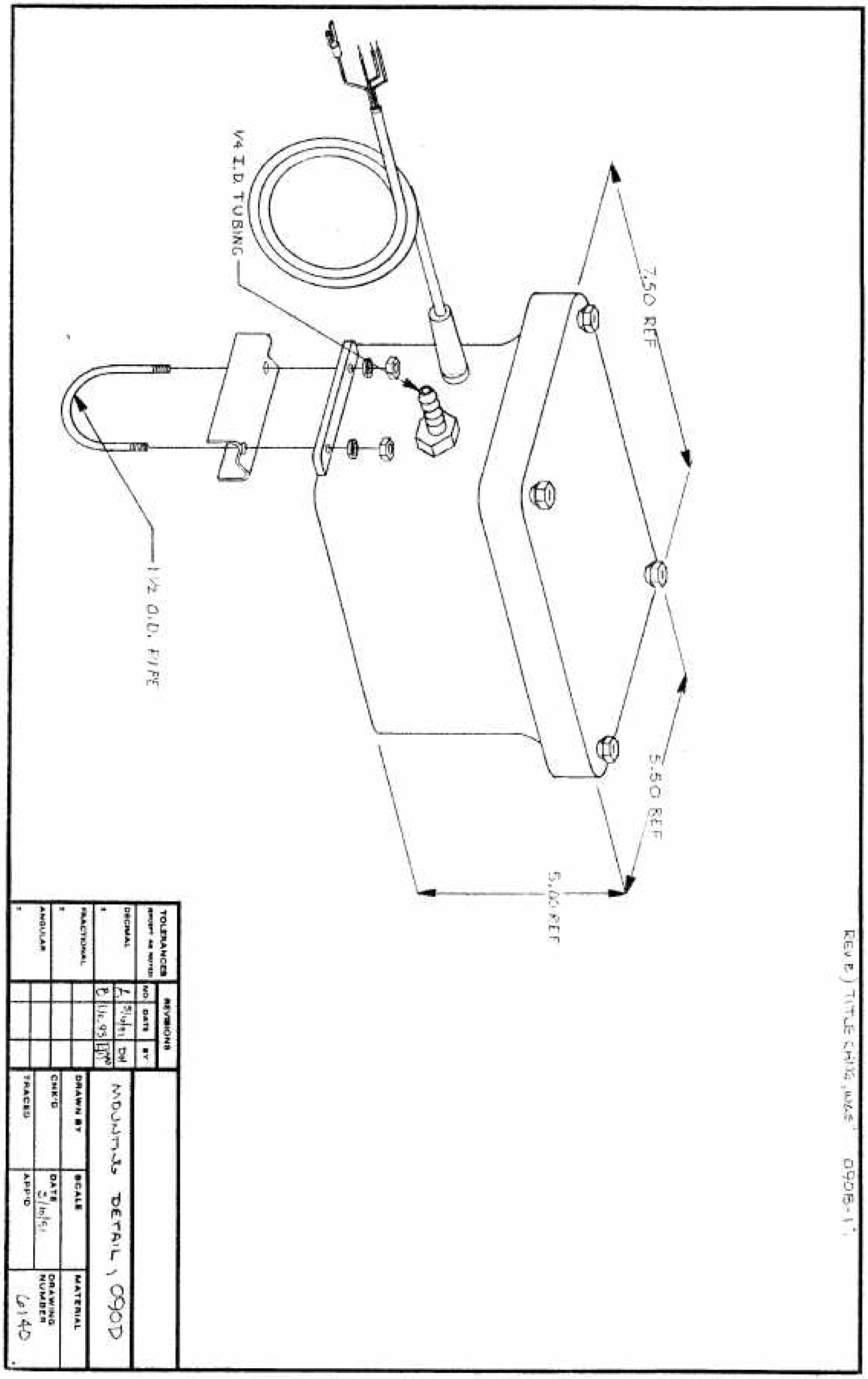
4.2 090D Pressure Sensor Maintenance. The pressure sensor is an inherently stable device that does not require periodic service or recalibration. Should service or recalibration become necessary, the sensor must be returned to the factory. Always inspect Model 090D Pressure Sensor to make sure that inlet port is clean and free from obstructions.



MODEL 090D BAROMETRIC PRESSURE SENSOR
CABLE CONNECTIONS

(See Section 2.2)


3.000
2.000
4X Ø.300
7.500
6.750
7.250
6.000
5.437
4.750
.250
4.050
ALL DIMENSIONS APPROXIMATE
NOTES: UNLESS OTHERWISE SPECIFIED
TOLERANCES (EXCEPT AS NOTED)
DECIMAL
FRACTIONAL
ANGULAR
REVISIONS
NO. DATE BY
5/10/91 DN
J BOX SPECIFICATION, 090D
DRAWN BY KEN K.
SCALE .5:1
MATERIAL
CHK'D
DATE 5/8/91
DRAWING NUMBER 6139
TRACED
APP'D


7.50 REF
5.50 REF
5.00 REF
1/4 I.D. TUBING
1/2 O.D. PIPE
TOLERANCES
DECIMAL
FRACTIONAL
ANGULAR
REVISIONS
NO
DATE
BY
MOUNTING DETAIL, 090D
DRAWN BY
SCALE
MATERIAL
CHK'D
DATE
DRAWING NUMBER
TRACED
APP'D
6140

MODEL 375C
8” RAIN GAUGE

OPERATION MANUAL
Document No. 375-9801

Met One
Instruments

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Facsimile 214-412-4716

MODEL 375C
ELECTRIC RAIN/SNOW SENSOR
OPERATION MANUAL

1.0 GENERAL INFORMATION

1.1 Model 375C Electric Heated Tipping Bucket Rain/Snow Gauge is an accurate, sensitive and low-maintenance sensor designed to measure rainfall on a continuous basis. Water does not collect in the sensor, but is drained each time an internal bucket fills with 0.01 inch of rainfall (standard calibration). At this time, a switch closure pulse is also sent to the translator module for counting. The sensor is calibrated prior to shipment and requires no adjustments after mounting.

1.2 Sensor Cable is a vinyl-jacketed 2-conductor shielded cable connecting to the sensor via an internal terminal strip. Cable length is designated in -xx feet on each cable part number label.

1.3 Power Cable is a vinyl-jacketed 3-conductor shielded cable connecting to the sensor heaters with wire nuts in an externally mounted J-Box. Cable length is designated in -xx feet on each cable part number label.

Table 1-1
Model 375C Rainfall Sensor Specifications

Orifice	8" Diameter
Calibration (standard) Calibration (options)	.01" Rain per switch closure 0.2mm, 0.25mm
Accuracy	±1% at 1" to 3" per hour at 70° F
Switch Type	Magnet & Reed
Mounting	3 Pads for 1/4 bolts on 9-21/32" (9.66") circle diameter
Dimensions	17-3/4" high, 8" diameter not including mounting pads
Power Requirement	110VAC, 50/60 Hz, 315W
Weight, less cables	7.5 lbs/3.4 kg (10 lbs shipping w/cables)

2.0 INSTALLATION

2.1 Choose a site where the height of any nearby trees or other objects above the sensor is no more than about twice their distance from the sensor. (Sample: 50 ft tree at least 100' away from gauge). A uniform surrounding of objects (such as an orchard) is beneficial as a wind break. Nonuniform surroundings (such as a nearby building) creates turbulence which affects accuracy.

2.2 Mount the sensor level on a platform, using the built in level as an aid. The three legs can be adjusted for leveling. Three 1/4" diameter bolts are used to mount the sensor on a 9-21/32" (9.66") bolt circle.

2.3 Remove shipping restraint (This may be tape, rubber band, or similar item) from sensor bucket and verify that bucket moves freely and that all adjusting screws are tight.

2.4 Connect the signal cable lugs to the terminal strip if not connected already. See diagram. Polarity is not important. See FIGURE 2-1.

2.5 Connect the power cable to the leads inside the condulet (see FIGURE 2-2) if not connected already.

2.6 Replace cover on sensor, tightening screws at base.

NOTE: If snowfall is anticipated, remove primary screen from funnel.

2.7 Route signal cable to the translator or datalogger and connect. Refer to the System Interconnect Diagram in your system manual for terminal identification.

2.8 Route the power cable to a 110VAC power source protected with a 15A GFI circuit. Connect (Ref. FIGURE 2-2). This wiring must conform to local and state wiring codes. If you are not familiar with these codes, an electrical contractor should be used.

Warning:

As with any AC power wiring, improper safety procedures can cause fatal injuries. If you are not qualified to do this work, call an electrical contractor to do it for you.

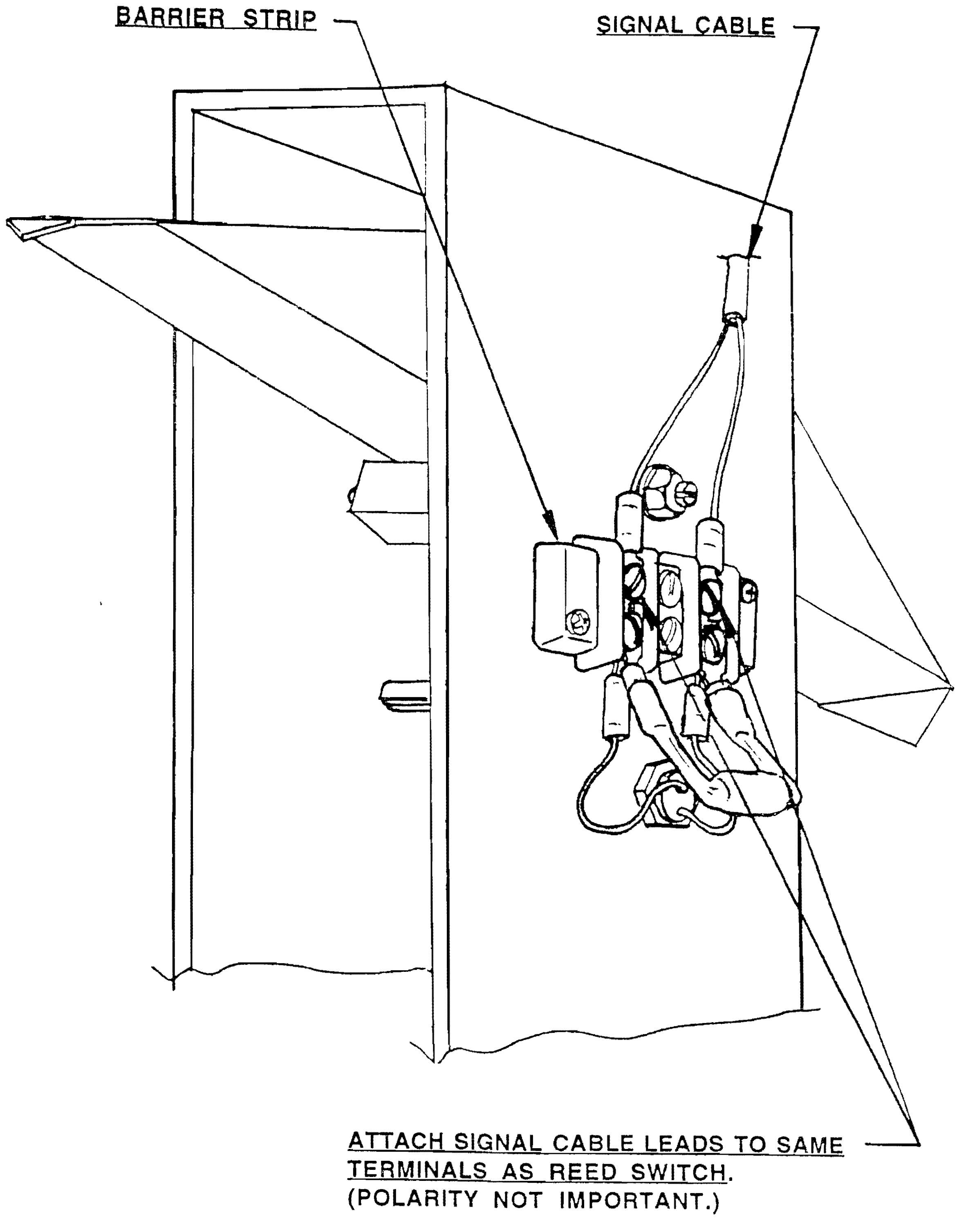
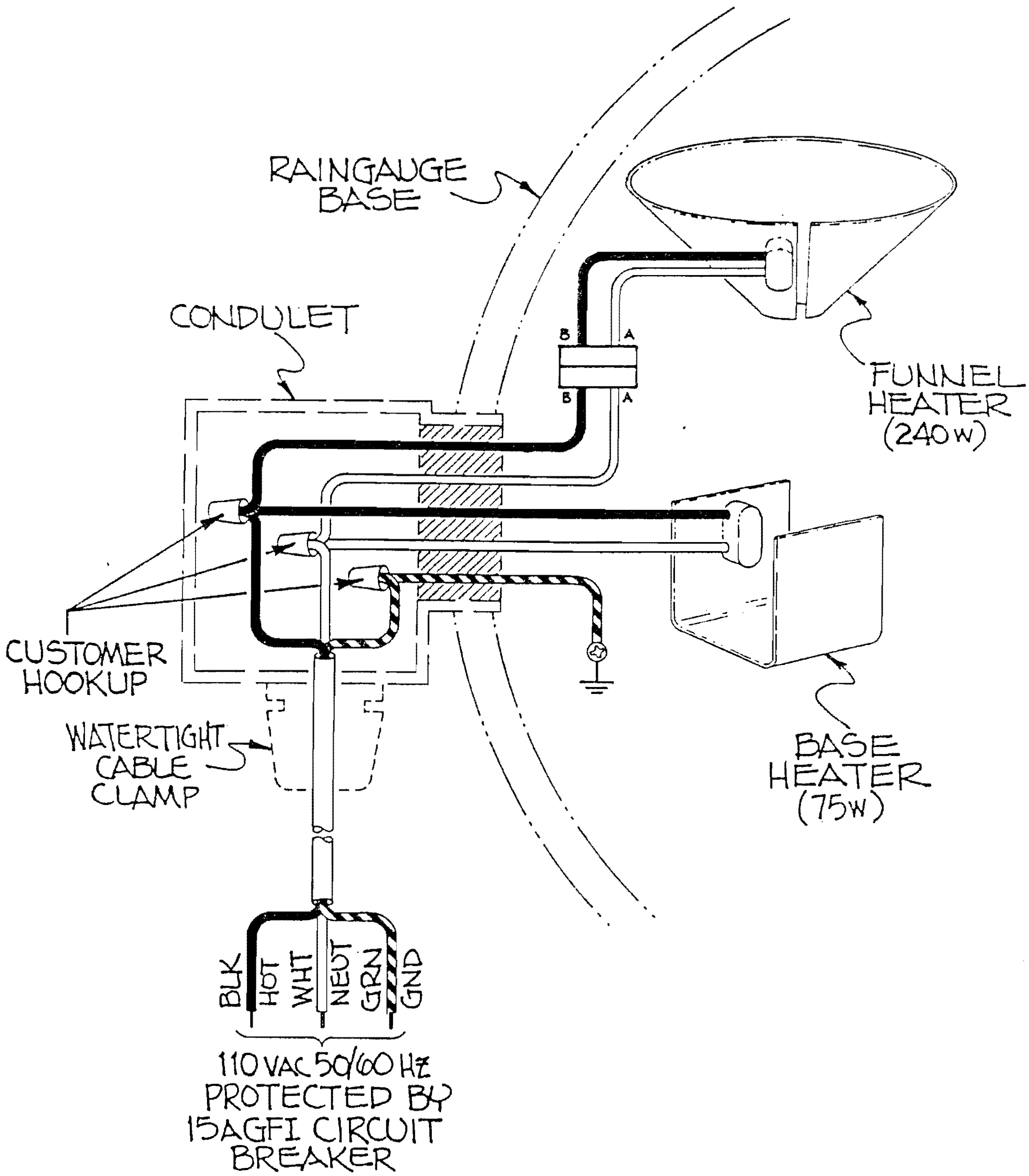

BARRIER STRIP
SIGNAL CABLE
ATTACH SIGNAL CABLE LEADS TO SAME
TERMINALS AS REED SWITCH.
(POLARITY NOT IMPORTANT.)

FIGURE 2-1



HEATER POWER HOOKUP

FIG. 2-2

3.0 OPERATIONAL CHECK-OUT

3.1 Manually actuate tip bucket mechanism (stop-to-stop) three (3) times. Confirm that 3 tips have registered on the recording equipment. If not, refer to Troubleshooting Guide, Section 4-3.

4.0 MAINTENANCE AND TROUBLESHOOTING

4.1 General Maintenance Schedule*:
At six month intervals, perform the following steps:

a. Clean sensor funnel and buckets.
b. Do NOT lubricate the pivots, as any lubricant may attract dust and dirt and cause wear of the jewel bearings.
c. Verify that buckets move freely and that translator card or datalogger registers 0.01" or as calibrated for each bucket tip.

*Based on average to adverse environments.

4.2 Calibration. The sensor is factory calibrated; recalibration is not required unless damage has occurred or the adjustment screws have loosened. To check or recalibrate, perform the following steps:

a. Check to be sure the sensor is level.

b. Wet the mechanism and tipping bucket assembly. Using a graduated cylinder, slowly pour the measured quantity of water through the inner funnel to the tipping bucket, which should then tip. Repeat for the alternate bucket. If both buckets tip when filled with the measured quantity of water, the sensor is properly calibrated. If they do not, recalibrate as follows:

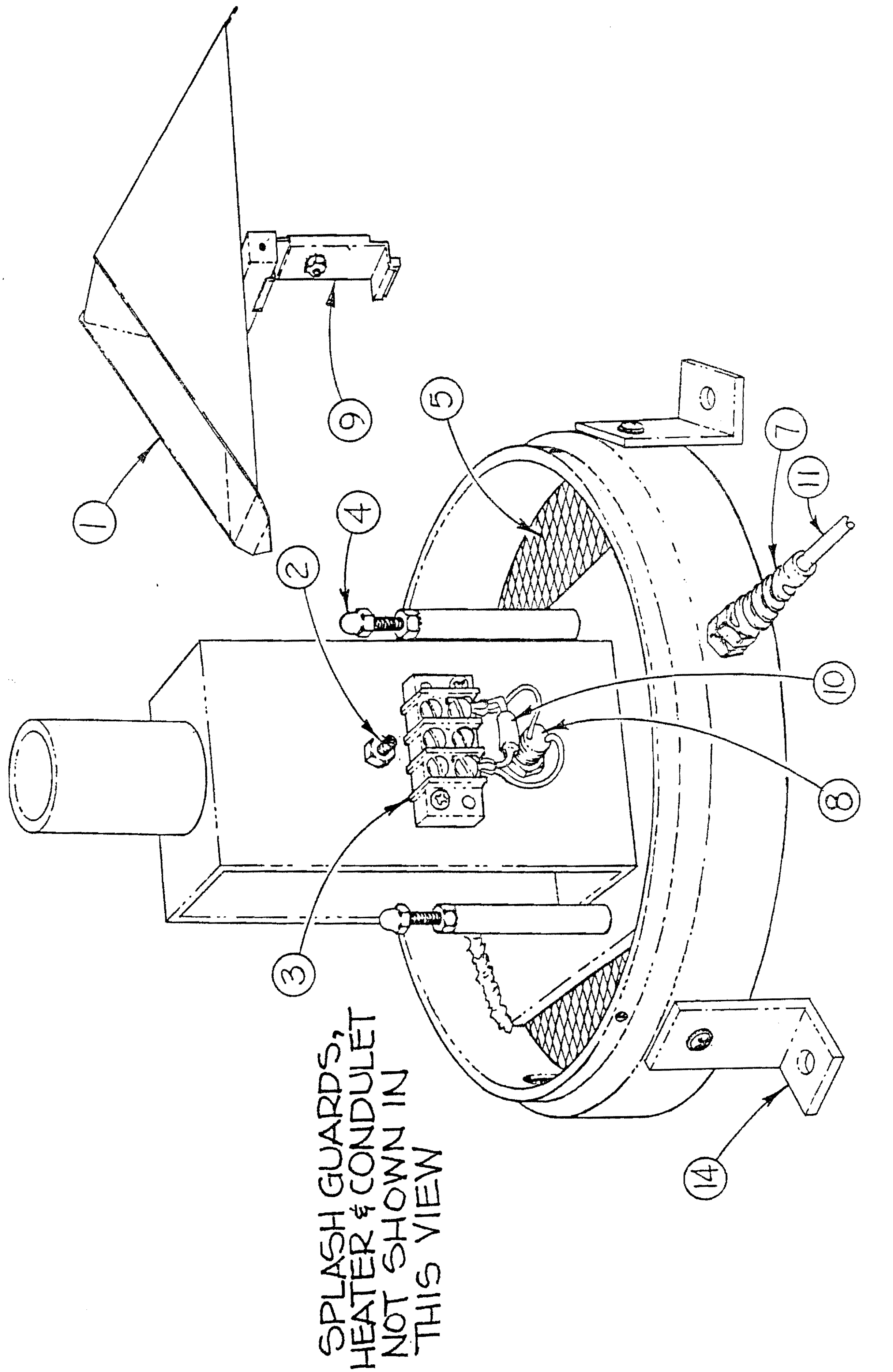
1. Release the lock nuts on the cup adjustments.
2. Move the adjustment screws down to a position that would place the bucket far out of calibration.
3. Allow the measured quantity of water to enter the bucket. (Refer to Table 4.1)
4. Turn the cup adjustment screw up until the bucket assembly tips. Tighten the lock nut.
5. Repeat steps 3 and 4 for the opposite bucket.
6. Measure the quantity of water necessary to tip each bucket several times to ensure proper calibration.
7. Replace the cover on the gauge.

Table 4.1
Calibration Quantities

Tip Calibration	Water Quantity
0.01" (standard)	8.24 milliliters
0.2mm	6.49 milliliters
0.25mm	8.11 milliliters

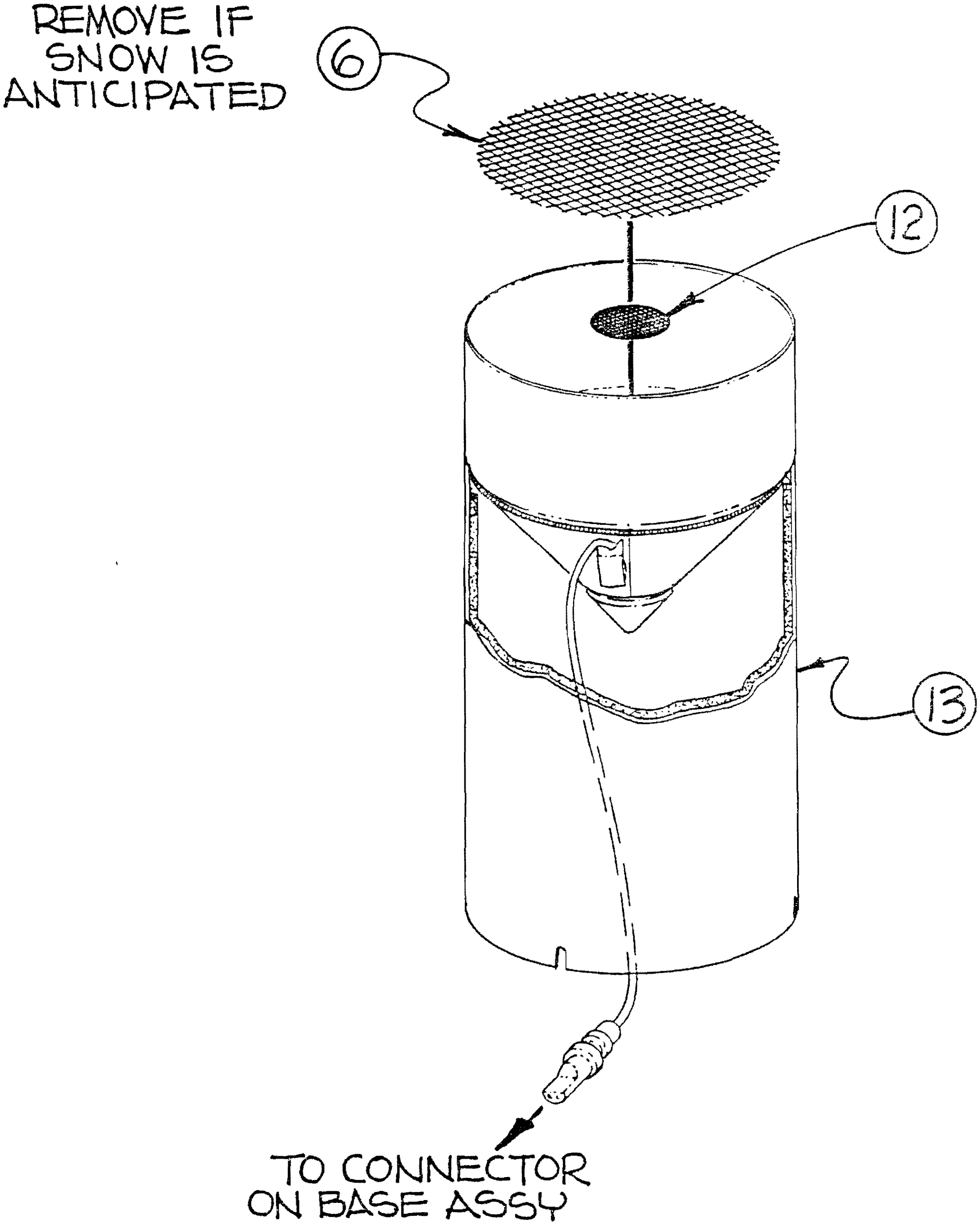
4.3 TROUBLESHOOTING

SYMPTOM	PROBABLE CAUSE	REMEDY
No sensor output	Faulty Reed Switch	Replace Reed Switch
	Signal Cable Connection	Check Connections
	Lightning Strike	Replace Reed Switch & Diode
	Debris in Funnel	Clean (See 4.1)
Erroneous Reading	Sensor not level	Re-level
	Sensor out of Calibration	Recalibrate (see 4.2)
	Site too near trees or other objects	Relocate (See 2.1)
Snow Not Melting	Heaters not getting power	Check circuit protector (customer provided)
	Heater Failure	Return unit to factory for repair.
	Primary Screen Installed	Remove Screen



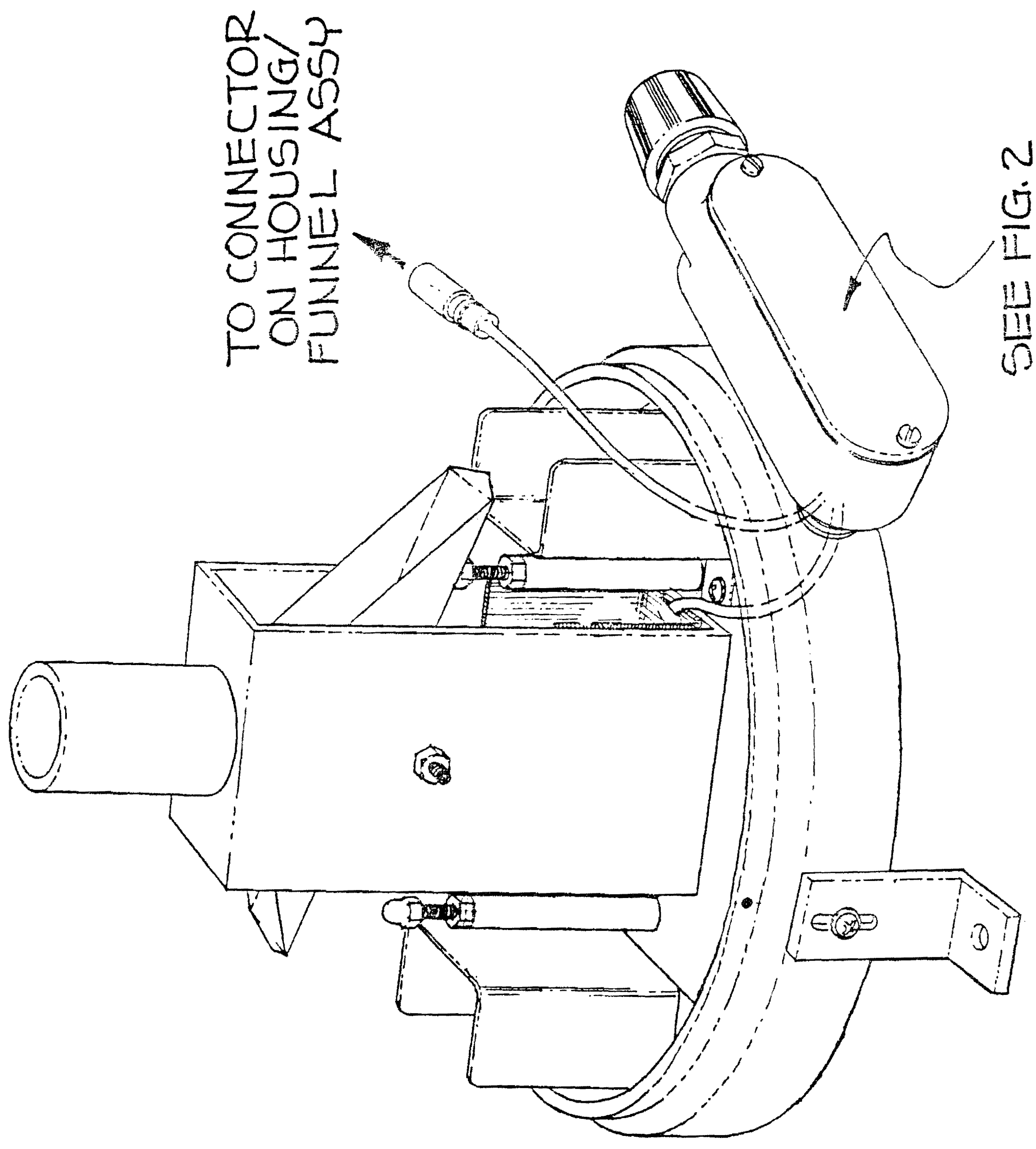
BASE ASSEMBLY

FIGURE 4-1



HOUSING/FUNNEL ASSEMBLY

FIGURE 4-3



BASE ASSEMBLY
(SHOWING HEATER COMPONENTS)
FIGURE 1-2

4.4 REPLACEABLE PARTS LIST

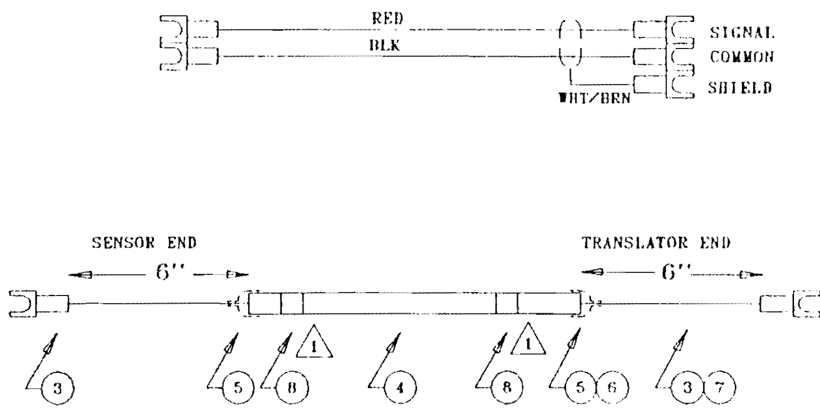
Model 375C Rain Gauge Parts List

I.D. No.	Part No.	Description
1	2545	Assembly, Tip Bucket (.01", .2mm, .25mm)
2	2492	Pin, Pivot
3	340070	Barrier, Strip - 3 pos.
4	480210	Nut, Crown, Nylon #8-32
5	2598	Screen, Base
6	2503	Screen, Primary Top
7	480510	Clamp, Liquid-Tight
8	2934	Reed Switch Cartridge
9	2936	Adjustable Magnet Bracket
10	2937	Lightning Protection Diode
11	1566	Standard Cable Assembly
11	2745	Cable Assembly (for use with Automet)
12	2504	Screen, Secondary
13	2666	Assembly, Housing/Funnel 8" (115VAC)
14	2516	Foot

4.5 REPAIR AND RECALIBRATION SERVICE

This service provided by Met One Instruments enables fast, economical service for the user. This repair and calibration service includes disassembly, inspection, cleaning, reassembly and calibration. Components will be replaced as required. Additional charges for additional materials only will be added to the basic service charge.

REVISIONS			
REV	DESCRIPTION	DATE	APPROVED
C	REDRAWN W/PARTS LIST	9/16/91	DH



ITEM	PART NO.	DESCRIPTION	QTY
1			
2			
3	600193	LUG, SPADE, #6	5
4	400010	CABLE, 2 WIRE, SHIELDED	A/R
5	960050	SLEEVING, 1/4", SHRINK	A/R
6			
7	980510	WIRE, 22 AWG, WHT/BRN	6"
8	960060	SLEEVING, 1/4", CLEAR SHRINK	A/R
9			
10			

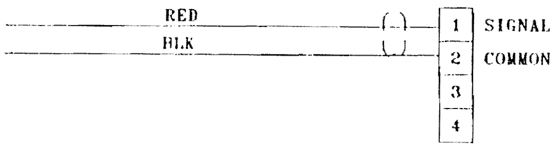
1 IDENTIFY CABLE 18" FROM EACH END.
DASH NUMBER = LENGTH IN FEET.

MET ONE INSTRUMENTS

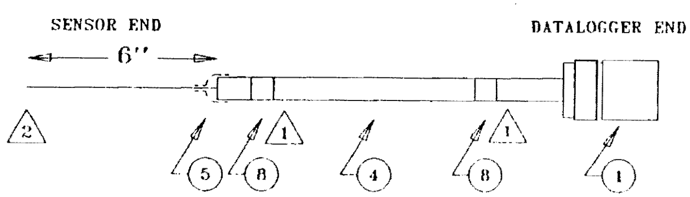
ASSY, CABLE, RAIN GAUGE

SIZE	FSCM NO.	DWG NO. 1566	REV C
SCALE		SHEET 1 OF 1	

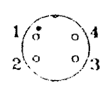
REVISIONS			
REV	DESCRIPTION	DATE	APPROVED
N/C	PROD REL	8/3/94	DH



ITEM	PART NO.	DESCRIPTION	QTY
1	500102	CONNECTOR, 4 PIN, FEMALE	1
2			
3			
4	400010	CABLE, 2 WIRE, SHIELDED	A/R
5	960050	SLEEVING, 1/4", SHRINK	A/R
6			
7			
8	960060	SLEEVING, 1/4", CLEAR SHRINK	A/R
9			
10			



1. IDENTIFY CABLE 18" FROM EACH END.
DASH NUMBER = LENGTH IN FEET.
STANDARD LENGTH = 50 FT
2. STRIP AND TIN WIRE ENDS 1/4"



SOLDER CUP VIEW

MET ONE INSTRUMENTS	
ASSY, CABLE, RAIN GAUGE	
SIZE / FSCM NO. / DWG NO. 2745	REV N/C
SCALE	SHEET 1 OF 1