University of Minnesota

A St. Anthony Falls Laboratory Project Report

Eolos Meteorological Tower and Associated Sensor System

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Executive Summary

An instrumented meteorological (met) tower, first made operational on November 11, 2011, provides key wind and atmospheric information at the Eolos site. The design of the Eolos met tower was strongly patterned after those in existence at NRELs National Wind Technology Center near Boulder, Colorado. Guidance on tower design and instrument selection, installation, and operation was also taken from IEC 61400-12-1 Ed.1: Wind turbines - Part 12-1: Power performance measurements of electricity producing wind turbines. The met tower height of 425ft (129.5m) was selected to correspond to the upper extent of turbine rotor swept area (130m). Instrumentation is located at roughly the limits of the rotor swept area (30m and 130m), hub height (80m), rotor blade mid span (55m and 105m) and 10m for a total of 6 instrumented elevations designated 1 through 6, Elev. 1 being at the top. Elev. 6, the 10m elevation, was added to allow comparison of Eolos data with other more commonly available meteorological data. Wind measurement instruments are located on 12ft and 18ft booms. Sonic Anemometers are located at Elev. 1, 3, 5, and 6 at the ends of 18ft booms. Accelerometers capable of static and dynamic measurement are attached to these anemometers to assess tower sway and boom arm vibration. Cup anemometers and wind vanes are mounted on cross arms at the ends of 12ft boom arms at all 6 instrumented elevations. Air temperature and relative humidity are measured at all 6 instrumented elevations, the probes being housed in gill radiation shields attached to the tower itself. A barometric pressure sensor is located on the tower at hub height (80m, Elev. 3). Power to and signals from all instrumentation are routed through junction boxes located on the tower at each of the 6 instrumented elevations, through homerun cables secured to tower legs and leading to ground level, and finally through subsurface conduits to 2 datalogger enclosures (Enclosure A and Enclosure B) located at ground level adjacent to the tower. These enclosures house 2 Campbell Scientific CR3000 data loggers each of which as an NL115 network interface and 2GB SD memory card. The NL115s have assigned IP addresses and provide Ethernet connectivity to the Eolos data center. The data from all loggers are time stamped. Clock synchronicity between the 2 met tower loggers, as well as the other loggers at Eolos including the two monitoring strain and movement in the turbine tower foundation, and the one monitoring turbine power output, is maintained to an accuracy of about 10mSec by GPS based clock setting that occurs once per second. Data acquisition rates

are 20hz for the sonic anemometer and associated accelerometer data and 1hz for the cup anemometer, wind vane, air temperature, relative humidity, and barometric pressure data. The Eolos met tower, having sonic and cup anemometers and wind vanes at 4 of the 6 elevations, allows a somewhat unique data quality assessment method. One need simply compare sonic and cup/vane data at the same elevation where available. It should be noted that the sonic anemometers are located on different boom arms 3m above the cup anemometers and vanes but for this purpose, the difference can be considered negligible. It was by doing so that it was decided early in 2013 that much of the cup anemometer data showed a significant velocity deficit when compared with the nearby sonic data and that they should be replaced with new MEASNET calibrated Class One anemometers. This was done on June 3, 2013.

Contents

1 Background

A critical component of scientific research designed to understand and improve the performance of wind turbines is the accurate and detailed measurement of wind characteristics, particularly those which are non-uniform in space and time, that affect and drive the turbine. An instrumented meteorological (met) tower, first made operational on November 11, 2011, provides this important information at the Eolos site. The design of the Eolos met tower was strongly patterned after those in existence at NRELs National Wind Technology Center near Boulder, Colorado. Guidance on tower design and instrument selection, installation, and operation was also taken from IEC 61400-12-1 Ed.1: Wind turbines - Part 12-1: Power performance measurements of electricity producing wind turbines.

2 System Description and Design

The Eolos met tower is located at Latitude: 44 degrees 43.693 minutes, Longitude: -93 degrees -2.8858 minutes. Prevailing winds in the Eolos area are from the south. The met tower is located due south of the turbine at a distance of 525ft (160m) which is 1.66 times the turbine rotor diameter of 96m and is less than the IEC recommended distance of 2 rotor diameters (200m). This location was chosen on the basis of a correlation analysis of expected wind turbulence characteristics. Since the met tower at the Eolos facility is providing data for scientific research rather than the more common purpose that the IEC Standard was written for, namely, certification of turbine performance, it was deemed appropriate to reduce the IEC recommended separation distance. The met tower height of 425ft (129.5m) was selected to allow for measurements to the upper extent of turbine rotor swept area (128m). Instrumentation is located at roughly the limits of the rotor swept area (30m and 130m), hub height (80m), rotor blade mid span (55m and 105m) and 10m for a total of 6 instrumented elevations designated 1 through 6, Elev. 1 being at the top. Elev. 6, the 10m elevation, was added to allow comparison of Eolos data with other more commonly available meteorological data. Wind measurement instruments are located on 12ft and 18ft booms. Sonic Anemometers are located at Elev. 1, 3, 5, and 6 at the ends of 18ft booms. Accelerometers capable of static and dynamic measurement are attached to these anemometers to assess tower sway and boom arm vibration.

Cup anemometers and wind vanes are mounted on cross arms at the ends of 12ft boom arms at all 6 instrumented elevations. Air temperature and relative humidity are measured at all 6 instrumented elevations, the probes being housed in gill radiation shields attached to the tower itself. A barometric pressure sensor is located on the tower at hub height (80m, Elev. 3). A rain gage is located 3m north of the tower at a 3m height above ground. In addition to the wind and weather instrumentation, the met tower is equipped with 2 Basler BIP2-1300c IP cameras mounted 82.5m above the ground and pointed north to observe the turbine. Strobe beacons were installed on the tower per FAA requirements. The lighting system installed on the Eolos met tower is a TWR Lighting, Inc. Model E2-3DBSL. It consists of three large LED strobes, one at the top of the tower and two and the midpoint. These strobes flash white during the day and flash red at night. There are also 2 sets of three smaller LED lights that are on only at night and dont flash. A lightning strike on the met tower could have disastrous results, destroying many of the sensitive measurement devices. To decrease the chances of a lightning strike, static dissipators were purchased from Nott Ltd. and installed on the met tower according to specifications provided by Nott Ltd. Static dissipators work by allowing the tower to dissipate the large electric fields that build up before and during a thunderstorm. Made up of an array of spikes exposed the air, the static dissipators work by conducting the static electricity of the tower into the air by ionizing the air molecules at the tip of each spike. This slow discharge of electricity can prevent an instantaneous discharge of electricity from a lightning strike. The appendix of this document includes the manuals for the two Nott Ltd. products that were purchased and installed on the tower. Optic fiber based internet accessibility and 110VAC power was routed to and installed in an enclosure adjacent to the tower base where a WIFI router is also located that provides wireless internet access to the Eolos turbine/met tower area. The tower structure was designed, supplied, and erected by Rohn Products (using a subcontractor). Rohns subcontractor also installed the instrument mount boom arms on the tower in the correct locations, but did not install the instrumentation. See Appendix A for drawings and specifications. The instrumentation was selected by SAFL and incorporated into a measurement system designed and fabricated by Campbell Scientific, Inc. and installed by Vertical Limit Construction. 18ft instrument mount boom arms were designed by Martin/Martin and fabricated by SAFL. 12ft boom arms were designed and fabricated by Tower Systems Inc. (TSI).

3 Instrumentation and Measurement System

As mentioned, all instrumentation was selected by SAFL personnel in consultation with personnel from NRELs National Wind Technology Center. Power to and signals from all instrumentation are routed through junction boxes located on the tower at each of the 6 instrumented elevations, through homerun cables secured to tower legs and leading to ground level, and finally through subsurface conduits to 2 datalogger enclosures (Enclosure A and Enclosure B) located at ground level adjacent to the tower. These enclosures house 2 Campbell Scientific CR3000 data loggers each of which as an NL115 network interface and 2GB SD memory card. The NL115s have assigned IP addresses and provide Ethernet connectivity to the Eolos data center. The logger in Enclosure A (named MetA) connects to all instrumentation located at tower elevations 1, 2, and 3 while the logger in Enclosure B (named MetB) connects to all instrumentation located at tower elevations 4, 5, and 6 as well as the ground level rain gage. The data from all loggers are time stamped. Clock synchronicity between the 2 met tower loggers, as well as the other loggers at Eolos including the two monitoring strain and movement in the turbine tower foundation, and the one monitoring turbine power output, is maintained to an accuracy of about 10mSec by GPS based clock setting that occurs once per second. Data acquisition rates are 20hz for the sonic anemometer and associated accelerometer data and 1hz for the cup anemometer, wind vane, air temperature, relative humidity, and barometric pressure data. The junction boxes, home run cables, data logger enclosures including terminal connections, power supplies, and initial data logger software were designed and built by Campbell Scientific. Refinement/maintenance of the logger software has been performed by SAFL personnel on an ongoing basis. Photos of one of the logger enclosures and the Eolos site including the met tower and the current versions of the CR3000 programs can be found in Appendix B. A description of all instrumentation, measurement specifications, data descriptions, wiring diagrams and drawings of mounting details can be found in Appendix C. 5 of the 6 originally installed cup anemometers (Met One Model 014A) were replace by 3 Thies Class One MEASNET calibrated anemometers (Model 4.3351.00.000, Elevations 1,2, and 4) and 2 Met One Class One MEASNET calibrated anemometers (Model 011E, Elevations 5 and 6) on June 3, 2013. The table headings include Pre 6/3/2013 or Post 6/3/2013 to reflect this anemometer substitution.

4 Installation

Tower erection, including the mounting of the boom arms, was performed in the fall of 2011 by Rohn Products. The measurement and data acquisition systems were installed by Vertical Limit with support from SAFL in November, 2011. See Appendix D for installation procedures and drawings.

5 Calibration and Validation

All sonic anemometers (Campbell Scientific model CSAT3) were serviced and calibrated at the factory prior to installation on the tower. The 5 or the 6 originally installed cup anemometers (Met One model 014A) were originally purchased in 2004 and had not been serviced or calibrated since that time. The 6th cup anemometer, located at hub height or Elev. 3, (Thies Class One model 4.3351.00.000) was purchased new and MEASNET calibrated prior to installation. All wind vanes (Met One model 024A) were individually calibrated by Campbell Scientific personnel prior to installation. All other sensors (air temperature, relative humidity, barometric pressure, rain gage) were purchased new with factory calibrations prior to installation. The Eolos met tower, having sonic and cup anemometers and wind vanes at 4 of the 6 elevations, allows a somewhat unique data quality assessment method. One need simply compare sonic and cup/vane data at the same elevation where available. It should be noted that the sonic anemometers are located on different boom arms 3m above the cup anemometers and vanes but for this purpose, the difference can be considered negligible. It was by doing so that it was decided early in 2013 that much of the cup anemometer data showed a significant velocity deficit when compared with the nearby sonic data and that they should be replaced with new MEASNET calibrated Class One anemometers. As noted above, this was done on June 3, 2013.

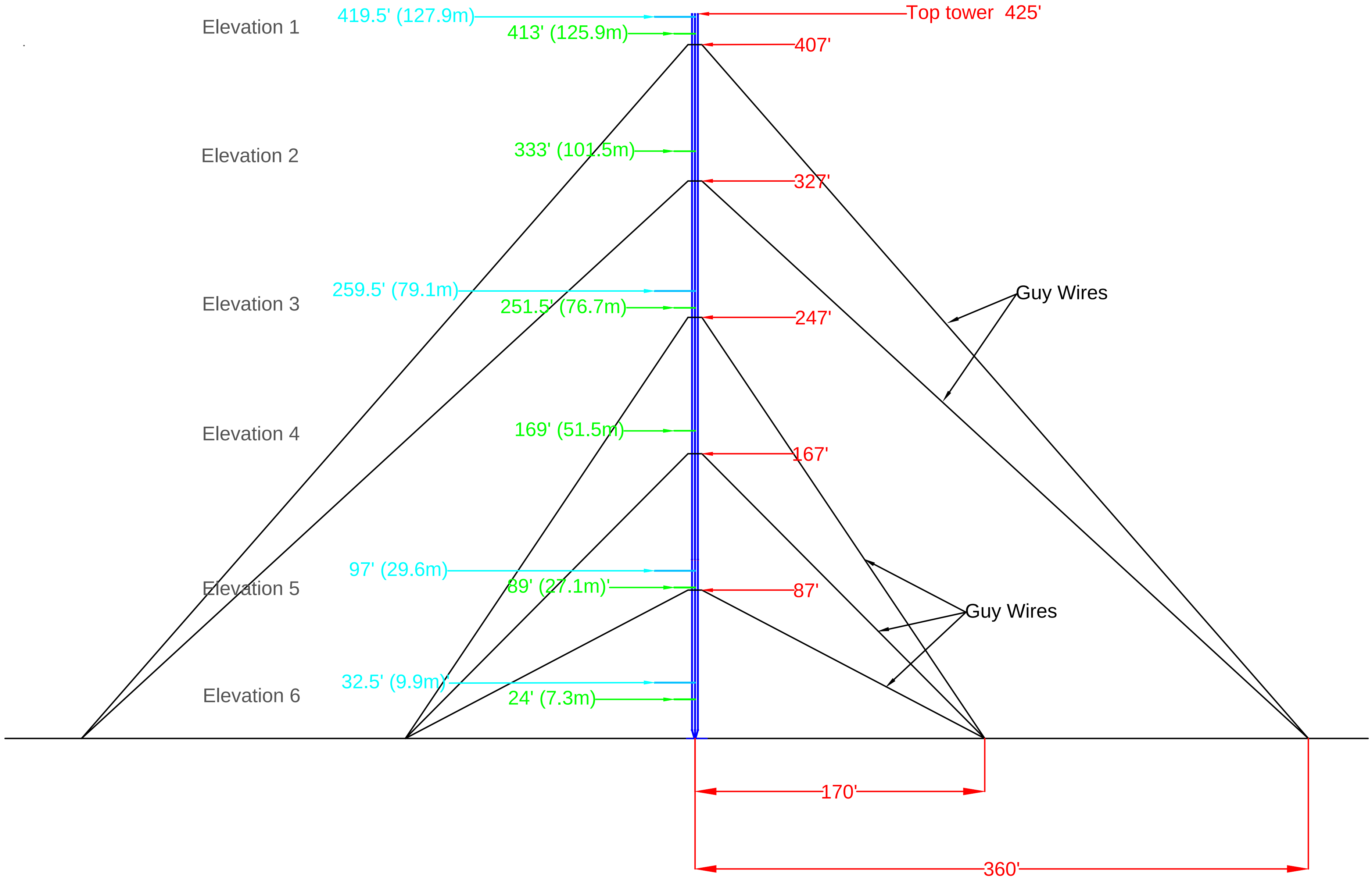
6 Data Organization and Maintenance

Using Campbell Scientifics Loggernet software, data from both met tower dataloggers is retrieved every 5 minutes and saved as a .dat file on a server located at UMore Park about 1 mile from the wind turbine. These data files are backed-up and are also loaded into an SQL database that is also located in the UMore Park server room. The SQL database is searchable and sortable by any parameter the user specifies, making data analysis simple even with the extremely large datasets collected by the Eolos met tower.

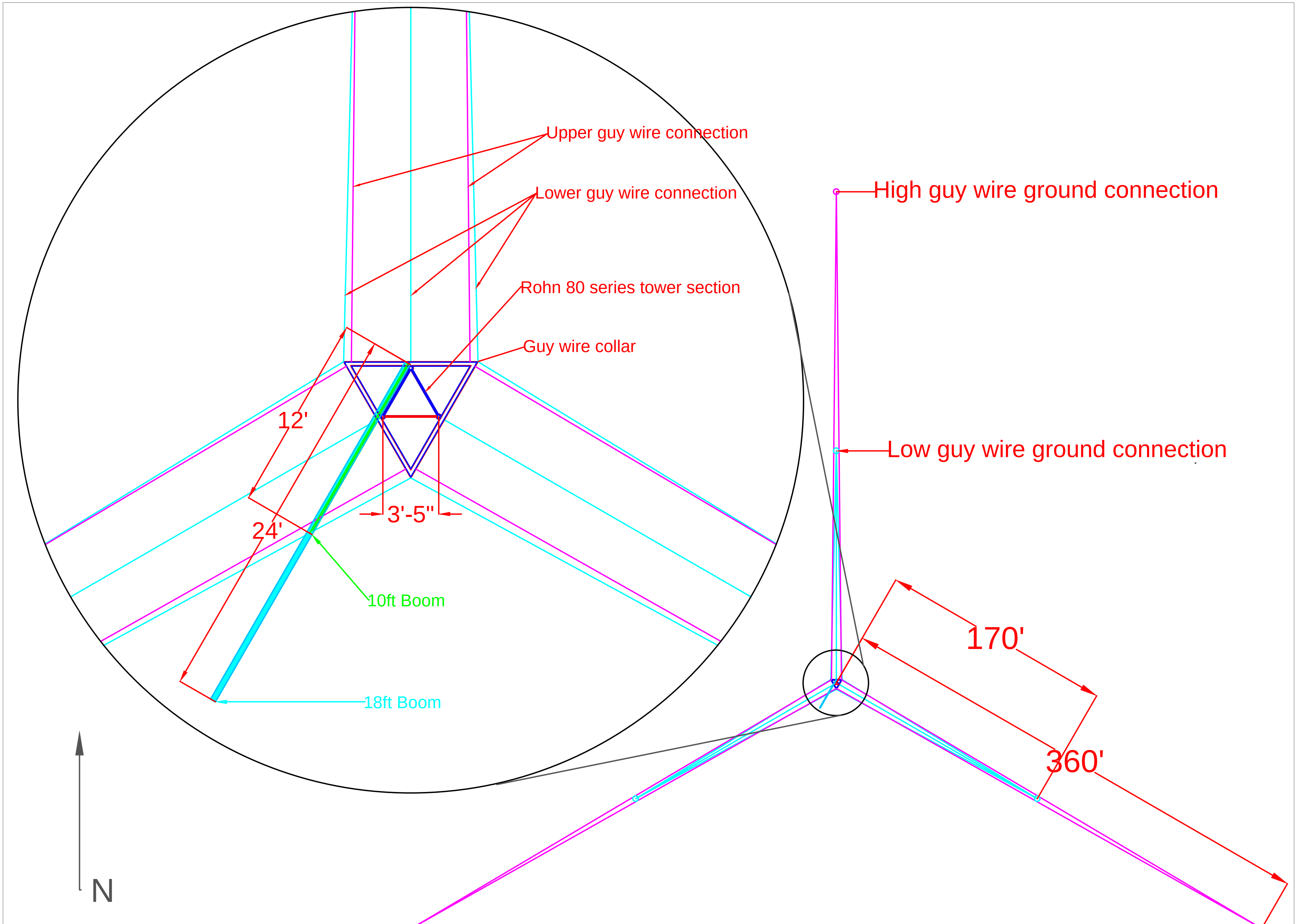
7 Ongoing Maintenance

Required maintenance is determined on the basis of ongoing data quality analysis. Measurement limits or thresholds, gradients, and other data parameters are used on a near real time basis to perform these analyses and provide fault detection and alarms. These alarms are communicated to Eolos technical staff via email notices. Detected faults are the main tool used to decide when maintenance is required. Recommended maintenance and calibration schedules are provided by the manufacturers of all met tower instrumentation. Recommended recalibration periods a listed in the documents titled Eolos Meta Device Measurement Specifications found in Appendix C.

8 Appendix A: Tower Design Drawings and Specifications



Eolos Meteorological Tower UMore Park, Rosemount MN 55068	Rohn 80 Series Tower. Guy Wire and Boom Arm Placement	Color Key: Cyan: 18' CSAT Booms Green: 10' Cup & Vane Anemometers, Temp and RH	Elevation View North-South	Updated: 05 Nov 2013



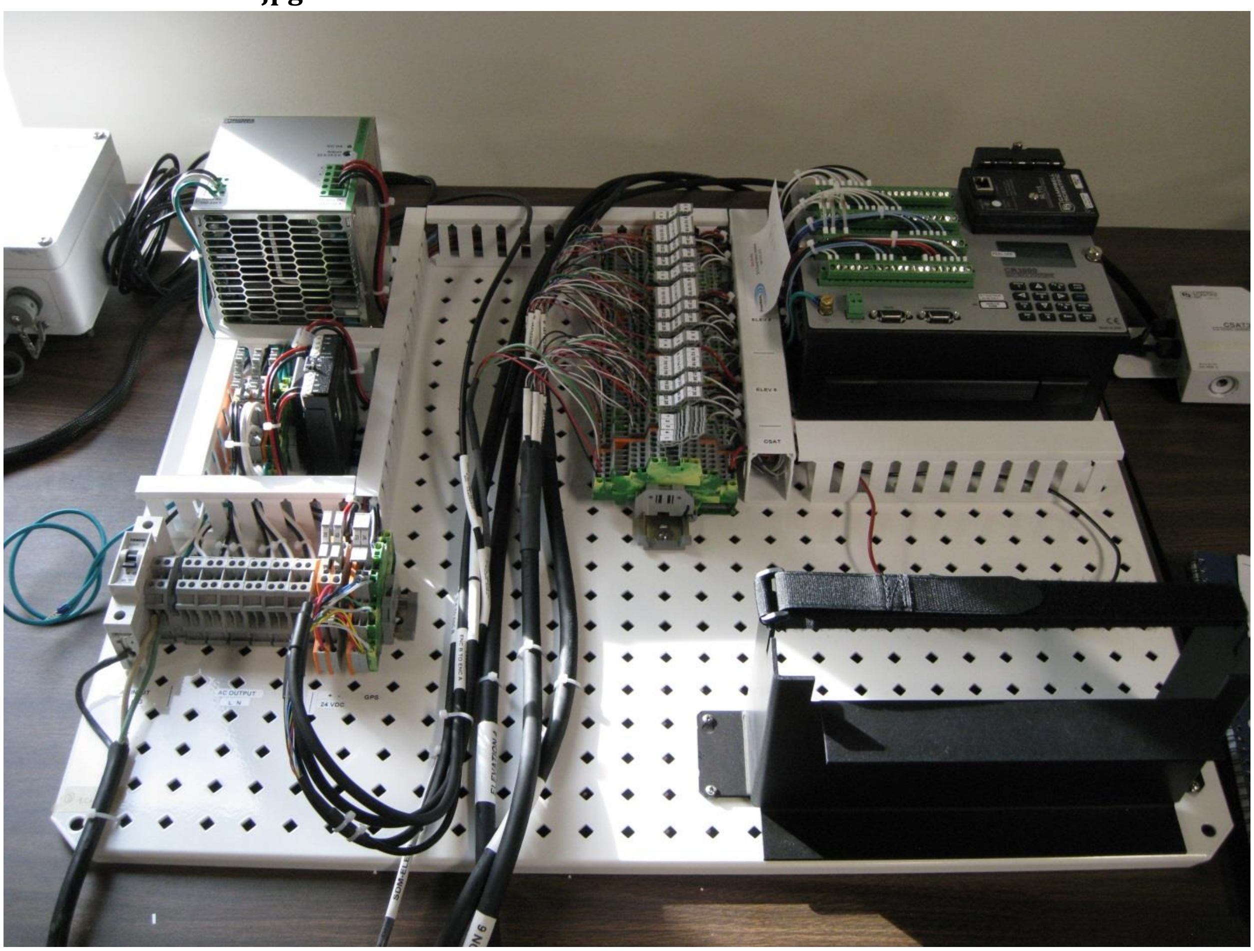
Eolos Meteorological Tower UMore Park, Rosemount MN 55068	Rohn 80 Series Tower. Guy Wire and Boom Arm Placement	Color Key: Cyan: 18' CSAT Booms Green: 10' Cup & Vane Anemometers, Temp and RH	Plan View	Updated: 05 Nov 2013

9 Appendix B: Datalogger Layout and Programs

9.1 Photos of Dataloggers and Enclosures

Eolos met tower and logger enclosure.jpg

Enclosure B Wired.jpg



9.2 Datalogger Codes

MetA code: MetA rev5.CR3

This is the code that runs on the MetA Datalogger:

```
PipeLineMode

Const SCAN_INTERVAL = 50 '50us = 20Hz
Const CSAT_OPT=INT(1000/SCAN_INTERVAL)
'Const LOCAL_TIME_OFFSET = -6 'Local time offset relative to UTC time
Const LOCAL_TIME_OFFSET = 0 'set clock to UTC time

'_________________CSAT3 Variables_____________________
Public CSAT(6,5) = NAN

Alias CSAT(1,1)=Ux1
Alias CSAT(1,2)=Uy1
Alias CSAT(1,3)=Uz1
Alias CSAT(1,4)=Ts1
Alias CSAT(1,5)=CSATDiag1
Units Ux1 = m/s
Units Uy1 = m/s
Units Uz1 = m/s
Units Ts1 = degC

'Alias CSAT(2,1)=Ux2
'Alias CSAT(2,2)=Uy2
'Alias CSAT(2,3)=Uz2
'Alias CSAT(2,4)=Ts2
'Alias CSAT(2,5)=CSATDiag2
'Units Ux2 = m/s
'Units Uy2 = m/s
'Units Uz2 = m/s
'Units Ts2 = degC

Alias CSAT(3,1)=Ux3
Alias CSAT(3,2)=Uy3
Alias CSAT(3,3)=Uz3
Alias CSAT(3,4)=Ts3
Alias CSAT(3,5)=CSATDiag3
Units Ux3 = m/s
Units Uy3 = m/s
Units Uz3 = m/s
Units Ts3 = degC

'____________________CSAT3 Diagnostic Variables_______________
Public CSATDiagBits(6,4) As Boolean 'Warning flags.
Units CSATDiagBits() = samples
Dim CSATDiag_work(6) As Long
Dim DisableFlagOn(6,2) As Boolean
Public CSATCounter(6)
Public LastCSATCounter(6)
Public CSATCounterError(6) As Boolean
```

```
Alias CSATDiagBits(1,1) = DelTmpWrn1 'Delta temperature warning flag.
Alias CSATDiagBits(1,2) = SigLckWrn1 'Poor signal lock warning flag.
Alias CSATDiagBits(1,3) = AmpHiWrn1 'Amplitude high warning flag.
Alias CSATDiagBits(1,4) = AmpLoWrn1 'Amplitude low warning flag.

'Alias CSATDiagBits(2,1) = DelTmpWrn2 'Delta temperature warning flag.
'Alias CSATDiagBits(2,2) = SigLckWrn2 'Poor signal lock warning flag.
'Alias CSATDiagBits(2,3) = AmpHiWrn2 'Amplitude high warning flag.
'Alias CSATDiagBits(2,4) = AmpLoWrn2 'Amplitude low warning flag.

Alias CSATDiagBits(3,1) = DelTmpWrn3 'Delta temperature warning flag.
Alias CSATDiagBits(3,2) = SigLckWrn3 'Poor signal lock warning flag.
Alias CSATDiagBits(3,3) = AmpHiWrn3 'Amplitude high warning flag.
Alias CSATDiagBits(3,4) = AmpLoWrn3 'Amplitude low warning flag.

'____________CSAT3 Coordinate Conversion Variables_____________________
Public Un(6)
Public Uw(6)
Public Umag(6)
Public Udir(6)
Alias Un(1) = Un1
'Alias Un(2) = Un2
Alias Un(3) = Un3
Alias Uw(1) = Uw1
'Alias Uw(2) = Uw2
Alias Uw(3) = Uw3
Alias Umag(1) = Umag1
'Alias Umag(2) = Umag2
Alias Umag(3) = Umag3
Alias Udir(1) = Udir1
'Alias Udir(2) = Udir2
Alias Udir(3) = Udir3
Units Un() = m/s
Units Uw() = m/s
Units Umag() = m/s
Units Udir() = deg

Public alpha = 210  'Direction of CSAT3 mounting arms (0 = North)
AngleDegrees

'____________Cup Anemometer and Vane Variables____________________
Public WindSpd(3) '014A's (1&2), Theis (3)
Units WindSpd() = m/s
Alias WindSpd(1) = WndSpd1
Alias WindSpd(2) = WndSpd2
Alias WindSpd(3) = WndSpd3
'Elev. 1 Thies anemometer, Model 4.3351.00.0000, SN 05130019, MEASNET
Calibration Mult = 0.04573, Offset = 0.2869
'Elev. 2 Thies anemometer, Model 4.3351.00.0000, SN 05130018, MEASNET
Calibration Mult = 0.04592, Offset = 0.2426
'Elev. 3 Thies anemometer, Model 4.3351.00.0000, SN 09114705, MEASNET
Calibration Mult = 0.04621, Offset = 0.21735
Public WS_Mult(3) = {0.04573, 0.04592, 0.04621}
```

```
Public WS_Offset(3) = {0.2869, 0.2426, 0.21735}

Public WindDir(3) '024A's
Units WindDir() = deg
Alias WindDir(1) = WndDir1
Alias WindDir(2) = WndDir2
Alias WindDir(3) = WndDir3

Public WindDirNewMult(3) = {729.1,728.3,716.6}

'_Air Temperature, Relative Humidity, Barometric Pressure, Rain
Variables__
Dim X(3)
Dim Rs(3)
Public AirTemp(3)
Units AirTemp() = degC
Alias AirTemp(1) = AirTemp1
Alias AirTemp(2) = AirTemp2
Alias AirTemp(3) = AirTemp3
Public RH(3)
Units RH() = %
Alias RH(1) = RH1
Alias RH(2) = RH2
Alias RH(3) = RH3
Public BarPres
Units BarPres = mBar
Public Rain
Units Rain = mm

'__________________Accelerometer Variables_________________________
Public Accel(6) 'Accelerometers
Units Accel() = g
'Elev. 1 accelerometer SN 1670A00031
Alias Accel(1)=Accel1_X  'Channel 1:  Sensitivity: 989.57mV/g, Offset:
2.5003V
Alias Accel(2)=Accel1_Z  'Channel 2:  Sensitivity: 1003.87mV/g, Offset:
2.5011V
Alias Accel(3)=Accel1_Y  'Channel 3:  Sensitivity: 1005.02mV/g, Offset:
2.4998V
'Elev. 3 accelerometer SN 1670A00028
Alias Accel(4)=Accel3_X  'Channel 1:  Sensitivity: 1013.19mV/g, Offset:
2.4995V
Alias Accel(5)=Accel3_Z  'Channel 2:  Sensitivity: 991.51mV/g, Offset:
2.4994V
Alias Accel(6)=Accel3_Y  'Channel 3:  Sensitivity: 996.54mV/g, Offset:
2.4992V
'Elev. 2 accelerometer not installed
'Alias Accel(7)=Accel2_X  'Channel 1:  Sensitivity: mV/g, Offset: V
'Alias Accel(8)=Accel2_Z  'Channel 2:  Sensitivity: mV/g, Offset: V
'Alias Accel(9)=Accel2_Y  'Channel 3:  Sensitivity: mV/g, Offset: V

Public AccelMult(6)={-1/989.57,1/1003.87,1/1005.02,-
1/1013.19,1/991.51,1/996.54}
```

```
Public AccelOffset(6)={2500.3/989.57,-2501.1/1003.87,-
2499.8/1005.02,2499.5/1013.19,-2499.4/991.51,-2499.2/996.54}
'Note:  Channel 1 (X) Mult and Offset sign reversed to conform to CSAT
local coordinate system
'X positive toward mounting arm, Y positive toward left looking at
mounting arm, Z positive upward
Public AccelKnownOffset(6) = {0,1,0,0,1,0}
Public AccelZeroFlag As Boolean
Public AccelScanFlag As Boolean = True
Public AccelZeroMode

'____________________GPS Variables_____________________________
Public nmea_sentence(2) As String * 90
Public gps_data(15)
Alias gps_data(1) = latitude_a 'Degrees latitude (+ = East; - = West)
Alias gps_data(2) = latitude_b 'Minutes latitude
Alias gps_data(3) = longitude_a 'Degress longitude (+ = East; - = West)
Alias gps_data(4) = longitude_b 'Minutes longitude
Alias gps_data(5) = speed 'Speed
Alias gps_data(6) = course 'Course over ground
Alias gps_data(7) = magnetic_variation 'Magnetic variation from true north
(+ = East; - = West)
Alias gps_data(8) = fix_quality 'GPS fix quality: 0 = invalid, 1 = GPS, 2
= 'differential GPS, 6 = estimated
Alias gps_data(9) = nmbr_satellites 'Number of satellites used for fix
Alias gps_data(10) = altitude 'Antenna altitude
Alias gps_data(11) = pps 'Elapsed ms since last pulse per second (PPS)
from GPS
Alias gps_data(12) = dt_since_gprmc 'Time since last GPRMC string,
normally less than '1 second
Alias gps_data(13) = gps_ready 'Counts from 0 to 10, 10 = ready
Alias gps_data(14) = max_clock_change 'Maximum value the clock was changed
Alias gps_data(15) = nmbr_clock_change 'Number of times the clock was
changed
'Define Units to be used in data file header
Units latitude_a = degrees
Units latitude_b = minutes
Units longitude_a = degrees
Units longitude_b = minutes
Units speed = m/s
Units course = degrees
Units magnetic_variation = unitless
Units fix_quality = unitless
Units nmbr_satellites = unitless
Units altitude = m
Units pps = ms
Units dt_since_gprmc = s
Units gps_ready = unitless
Units max_clock_change = ms
Units nmbr_clock_change = samples

'________________Other Variables____________________________
Public CalFileLoaded As Boolean = False
Public CalStartIdx = 1
```

```
Public FieldCalAvgs = 20
Const n = 1
Dim i,j,k
Public PTemp, batt_volt
Public MetB_IP As String = "192.168.69.85"
Public ClockError_mS
Public LastSkippedRecord1
Public CurrentSkippedRecord1
Public CurrentSkippedSlowScan1

'____________________Output Tables________________________
DataTable (CSAT,True,-1)
  DataInterval (0,SCAN_INTERVAL,mSec,10)
  CardOut (0 ,-1)
  Sample (1,Un1,FP2)
  Sample (1,Uw1,FP2)
  Sample (2,Uz1,FP2)
  Sample (1,CSATDiag1,UINT2)
  Sample (1,Un3,FP2)
  Sample (1,Uw3,FP2)
  Sample (2,Uz3,FP2)
  Sample (1,CSATDiag3,UINT2)
EndTable

DataTable (Accel,True,-1)
  DataInterval (0,SCAN_INTERVAL,mSec,10)
  CardOut (0 ,-1)
  Sample (6,Accel(),IEEE4)
EndTable

DataTable (_1Sec,True,-1)
  DataInterval (0,1,sec,10)
  CardOut (0 ,-1)
  Average (1,Umag1,FP2,Umag1=NAN)
  Average (1,Umag3,FP2,Umag3=NAN)
'  Average (1,WndSpd1,FP2,WndSpd1=NAN)
'  Average (1,WndSpd2,FP2,WndSpd2=NAN)
'  Average (1,WndSpd3,FP2,WndSpd3=NAN)
  Sample (1, WndSpd1,FP2)
  FieldNames("WndSpd1_Avg:m/s:Avg")
  Sample (1, WndSpd2,FP2)
  FieldNames("WndSpd2_Avg:m/s:Avg")
  Sample (1, WndSpd3,FP2)
  FieldNames("WndSpd3_Avg:m/s:Avg")
  Average (1,Udir1,FP2,Udir1=NAN)
  Average (1,Udir3,FP2,Udir3=NAN)
'  WindVector(1,Umag1,Udir1,FP2,Udir1=NAN,0,0,3)  'Wind Direction Only
'  WindVector(1,Umag3,Udir3,FP2,Udir3=NAN,0,0,3)  'Wind Direction Only
  Sample (3,WndDir1,FP2)
  Sample (3,AirTemp1,FP2)
  Sample (3,RH1,FP2)
  Sample (1,BarPres,IEEE4)
EndTable
```

```
DataTable (_5Min,True,-1)
  DataInterval (0,5,Min,10)
  CardOut (0 ,-1)
  Average (1,Umag1,FP2,Umag1=NAN)
  Maximum (1,Umag1,FP2,Umag1=NAN,False)
  StdDev (1,Umag1,FP2,Umag1=NAN)
  Average (1,Umag3,FP2,Umag3=NAN)
  Maximum (1,Umag3,FP2,Umag3=NAN,False)
  StdDev (1,Umag3,FP2,Umag3=NAN)
  Average (1,WndSpd1,FP2,WndSpd1=NAN)
  Maximum (1,WndSpd1,FP2,WndSpd1=NAN,False)
  StdDev (1,WndSpd1,FP2,WndSpd1=NAN)
  Average (1,WndSpd2,FP2,WndSpd2=NAN)
  Maximum (1,WndSpd2,FP2,WndSpd2=NAN,False)
  StdDev (1,WndSpd2,FP2,WndSpd2=NAN)
  Average (1,WndSpd3,FP2,WndSpd3=NAN)
  Maximum (1,WndSpd3,FP2,WndSpd3=NAN,False)
  StdDev (1,WndSpd3,FP2,WndSpd3=NAN)
  Average (1,Udir1,FP2,Udir1=NAN)
  Average (1,Udir3,FP2,Udir3=NAN)
  Average (3,WndDir1,FP2,False)
'  WindVector(1,Umag1,Udir1,FP2,Udir1=NAN,0,0,3)  'Wind Direction Only
'  WindVector(1,Umag3,Udir3,FP2,Udir3=NAN,0,0,3)  'Wind Direction Only
'  WindVector(3,WndSpd1,WndDir1,FP2,False,0,0,3)  'Wind Direction Only
  Average (3,AirTemp1,FP2,False)
  Average (3,RH1,FP2,False)
  Average (1,BarPres,IEEE4,False)
  Totalize (1,Rain,FP2,False)
  Average (6,Accel(),IEEE4,False)
  StdDev (6,Accel(),IEEE4,False)
  Sample (1,PTemp,FP2)
  Minimum (1,batt_volt,FP2,False,False)
  Sample (1,ClockError_mS,FP2)
EndTable

DataTable (Daily,True,-1)
  DataInterval (0,1,Day,10)
  CardOut (0 ,-1)
  Minimum (1,batt_volt,FP2,False,False)
  Maximum (1,PTemp,FP2,False,False)
  Minimum (1,PTemp,FP2,False,False)
  Average (1,ClockError_mS,FP2,False)
  Minimum (1,ClockError_mS,FP2,False,True)
  Maximum (1,ClockError_mS,FP2,False,True)
EndTable

DataTable(CalHist,NewFieldCal,50)
  SampleFieldCal
EndTable

DataTable (CSAT_Stats,TRUE,-1)
  DataInterval (0,5,Min,10)
  CardOut (0 ,-1)
  'CSAT_1 Summary Stats
```

```
  Average (4,Ux1,FP2,DisableFlagOn(1,1))
  StdDev (4,Ux1,FP2,DisableFlagOn(1,1))
  Totalize (1,n,FP2,DisableFlagOn(1,1))
  FieldNames ("CSAT1_ValidMeas")
  Totalize (1,n,FP2,NOT (DisableFlagOn(1,1) OR DisableFlagOn(1,2)))
  FieldNames ("CSAT1_Wrns_Tot")
  Totalize (1,n,FP2,NOT (DelTmpWrn1) OR NOT (DisableFlagOn(1,2)))
  FieldNames ("CSAT1_DeltaT_Tot")
  Totalize (1,n,FP2,NOT (SigLckWrn1) OR NOT (DisableFlagOn(1,2)))
  FieldNames ("CSAT1_SigLock_Tot")
  Totalize (1,n,FP2,NOT (AmpHiWrn1) OR NOT (DisableFlagOn(1,2)))
  FieldNames ("CSAT1_AmpHi_Tot")
  Totalize (1,n,FP2,NOT (AmpLoWrn1) OR NOT (DisableFlagOn(1,2)))
  FieldNames ("CSAT1_AmpLo_Tot")
  Totalize (1,n,FP2,NOT (CSATCounterError(1))
  FieldNames ("CSAT1_CntErr_Tot")
  'CSAT_3 Summary Stats
  Average (4,Ux3,FP2,DisableFlagOn(3,1))
  StdDev (4,Ux3,FP2,DisableFlagOn(3,1))
  Totalize (1,n,FP2,DisableFlagOn(3,1))
  FieldNames ("CSAT3_ValidMeas")
  Totalize (1,n,FP2,NOT (DisableFlagOn(3,1) OR DisableFlagOn(3,2)))
  FieldNames ("CSAT3_Wrns_Tot")
  Totalize (1,n,FP2,NOT (DelTmpWrn3) OR NOT (DisableFlagOn(3,2)))
  FieldNames ("CSAT3_DeltaT_Tot")
  Totalize (1,n,FP2,NOT (SigLckWrn3) OR NOT (DisableFlagOn(3,2)))
  FieldNames ("CSAT3_SigLock_Tot")
  Totalize (1,n,FP2,NOT (AmpHiWrn3) OR NOT (DisableFlagOn(3,2)))
  FieldNames ("CSAT3_AmpHi_Tot")
  Totalize (1,n,FP2,NOT (AmpLoWrn3) OR NOT (DisableFlagOn(3,2)))
  FieldNames ("CSAT3_AmpLo_Tot")
  Totalize (1,n,FP2,NOT (CSATCounterError(3))
  FieldNames ("CSAT3_CntErr_Tot")
EndTable

DataTable(SkippedRecords,True,500)
  DataEvent (10,(CurrentSkippedRecord1 > LastSkippedRecord1),-1,10)
  Sample (1,CurrentSkippedRecord1,UINT2)
  Sample (1,Status.SkippedScan,UINT2)
  Sample (1,CurrentSkippedSlowScan1,UINT2)
  'Sample (1,Status.MeasureTime,UINT2)
  Sample (1,Status.ProcessTime,UINT4)
  'Sample (1,Status.MaxProcTime,UINT4)
  Sample (1,Status.BuffDepth,UINT2)
  'Sample (1, Status.MaxBuffDepth,UINT2)
EndTable

Sub TransformCSATCoords
  Dim i
  For i = 1 To 3 Step 2
    'Uw postive from West to East, Un positive from North to South, Uz 
positive from down to up
    Uw(i)=-CSAT(i,1)*SIN(alpha)+CSAT(i,2)*COS(alpha)  'CSAT(i,1) is Uxi, 
CSAT(i,2) is Uyi
```

```
    Un(i)=CSAT(i,1)*COS(alpha)+CSAT(i,2)*SIN(alpha)  'CSAT(i,1) is Uxi,
CSAT(i,2) is Uyi
    Umag(i)=(Un(i)*Un(i)+Uw(i)*Uw(i))^.5
    Udir(i)=(-ATN2(Uw(i),Un(i))+360) MOD 360
  Next i
EndSub

Sub ProcessCSATDiagnostics
  Dim i
  For i = 1 To 3 Step 2
    'Define 61502 as NaN.
    If CSAT(i,5) = NaN Then CSAT(i,5) = 61502  'CSAT(i,5) is CSATDiagi
    'Break up the four CSAT3 warning flags into four separate bits.
    CSATDiag_work(i) = CSAT(i,5)
    CSATDiagBits(i,1) = CSATDiag_work(i) AND &h8000  'DelTmpWrn - Delta
temperature warning flag.
    CSATDiagBits(i,2) = CSATDiag_work(i) AND &h4000  'SigLckWrn - Poor
signal lock warning flag.
    CSATDiagBits(i,3) = CSATDiag_work(i) AND &h2000  'AmpHiWrn - Amplitude
high warning flag.
    CSATDiagBits(i,4) = CSATDiag_work(i) AND &h1000  'AmpLoWrn - Amplitude
low warning flag.
    'Turn on the intermediate processing disable flag when any CSAT3
warning flag is
    'high, including the special cases NaN (61502), a Lost Trigger
(61440), No Data
    '(61503), an SDM error (61441), or wrong CSAT3 embedded code (61442).
    DisableFlagOn(i,1) = CSATDiag_work(i) AND &hf000
    'Turn on only when CSAT3 diagnostic warning flags are set.
    DisableFlagOn(i,2) = ( DisableFlagOn(i,1) AND NOT (CSAT(i,4) = NaN) )
'CSAT(i,4) is Tsi
    'Save the four most significant bits of the CSAT3 diagnostics, except
for the
    'special cases NaN (61502), a Lost Trigger (61440), No Data (61503),
an SDM
    'error (61441), or wrong CSAT3 embedded code (61442).
    If ( CSATDiag_work(i) < &hf000 ) Then ( CSATDiag_work(i) = INT
(CSATDiag_work(i)/&h1000) )
    CSATCounter(i) = CSAT(i,5) MOD 64
    If CSATCounter(i) <> LastCSATCounter(i) + 1 Then
      CSATCounterError(i) = True
    Else
      CSATCounterError(i) = False
    EndIf
    LastCSATCounter(i) = CSATCounter(i)
    If LastCSATCounter(i)  = 63 Then LastCSATCounter(i)  = -1
  Next i
EndSub

BeginProg
  SDMSpeed(45)
  CalFileLoaded = LoadFieldCal(0)
  NetworkTimeProtocol("",LOCAL_TIME_OFFSET*3600,0)
```

```
  WriteIO(&B11,&B11)   'Set ports 1,2 high -  These are the Accel Test
pins (C1>>Elev1, C2>>Elev3)

  Scan (SCAN_INTERVAL,mSec,500,0)

    GPS (latitude_a,Com4,LOCAL_TIME_OFFSET*3600,0,nmea_sentence(1))

    SDMTrigger
    CSAT3 (Ux1,1,1,98,CSAT_OPT)
    'CSAT3 (Ux2,1,2,98,CSAT_OPT)
    CSAT3 (Ux3,1,3,98,CSAT_OPT)

    TransformCSATCoords
    ProcessCSATDiagnostics

'    '014A Wind Speed Sensor measurement (Elev. 1&2)
'    TimerIO (WindSpd(),11111111,00022000,60,Sec)
'    For i = 1 To 2
'      If WindSpd(i) > 0 Then WindSpd(i) =  WindSpd(i) * 0.8 + 0.447
'    Next i
    'Thies Wind Speed Sensor at Elev. 1-3
    PulseCount (WindSpd(),3,1,0,1000, WS_Mult(),WS_Offset())  '1 sec
rolling average
    'PulseCount (WindSpd(),3,1,0,1, WS_Mult(),WS_Offset())
    If WndSpd1 <= WS_Offset(1) Then  WndSpd1 = 0
    If WndSpd2 <= WS_Offset(2) Then  WndSpd2 = 0
    If WndSpd3 <= WS_Offset(3) Then  WndSpd3 = 0

    'TE525 Tipping Bucket Rain Gage (0.01" per tip)
    PulseCount(Rain,1,4,2,0,0.254,0)  'convert output to mm

    'Accelerometers
    If AccelZeroFlag Then
      If AccelScanFlag Then
        AccelZeroMode = 1
        AccelScanFlag = False
      EndIf
      If (AccelZeroMode <= 0) OR (AccelZeroMode = 6) Then AccelZeroFlag =
0
    Else
      AccelScanFlag = True
    EndIf

    VoltDiff (Accel(),6,mV5000,6,True,0,250,AccelMult(),AccelOffset())
    FieldCal
(1,Accel(),6,0,AccelOffset(),AccelZeroMode,AccelKnownOffset(),CalStartIdx,
FieldCalAvgs)

    CallTable CSAT
    CallTable Accel
    CallTable _1Sec
    CallTable _5Min
    CallTable Daily
    CallTable CalHist
```

```
    CallTable CSAT_Stats

  NextScan

  SlowSequence
  Scan (1,Sec,50,0)

    '024A Wind Direction Sensor measurement WindDir
    BrHalf(WindDir(),3,mV5000,4,1,1,5000,True,0,_60Hz,1,0)
    For j = 1 To 3
      WindDir(j) = WindDir(j) * WindDirNewMult(j)  'individually
calibrated by Matt Perry at CSI
      WindDir(j) = (WindDir(j)+180) MOD 360 '180 added to correct for
mounting the vanes pointing North instead of South
    Next j

    'MetOne 083E-1-35 AirTemp/RH
    BrHalf (X(),3,mv5000,8,Vx1,1,2500,True,0,_60Hz,1,0)
    For k = 1 To 3
      Rs(k) = 23100 * (X(k)/(1-X(k)))  'Rs=thermistor resistance (ohms)
      AirTemp(k) = (((1/((1/Rs(k))+(1/23100)))-13698.3)/-129.163)  'page
12 in Met One manual
    Next k

    VoltSe (RH(),3,mV5000,1,1,0,_60Hz,0.1,0)  'RH(%)=0.1*Output(mV)

    'MetOne 092 BarPres Sensor
    'See Table 5-1 and 5-2 in Met One manual
    'SW1 set to 0-5V output range (Off Off)
    'SW2 set to 600-1100mbar range (Off Off On On)
    VoltSe (BarPres,1,mV5000,7,1,0,_60Hz,0.1,600)
'BP(mbar)=0.1*Output(mV)+600

    If TimeIntoInterval(3599,3600,Sec) Then ClockError_mS =
NetworkTimeProtocol(MetB_IP,LOCAL_TIME_OFFSET*3600,600000)
    If TimeIntoInterval(40,86400,Sec) Then ClockReport(ComSDC7,0,7)
'TurbinePower CR800 is Pakbus 7

    CurrentSkippedRecord1 = Status.SkippedRecord(1)
    CurrentSkippedSlowScan1 = Status.SkippedSlowScan(1)
    'If CurrentSkippedRecord1 > LastSkippedRecord1 Then CallTable
SkippedRecords
    CallTable SkippedRecords
    LastSkippedRecord1 = CurrentSkippedRecord1

  NextScan
  EndSequence

  SlowSequence
  Scan (1,Min,10,0)
    PanelTemp (PTemp,250)
    Battery (batt_volt)
    WriteIO(&B11,&B11)   'Reset ports 1,2 high -  These are the Accel Test
pins (C1>>Elev1, C2>>Elev3)
```

```
  NextScan
  EndSequence

EndProg
```

MetB Code: MetB rev5.CR3

```
PipeLineMode

Const SCAN_INTERVAL = 50 '50us = 20Hz
Const CSAT_OPT=INT(1000/SCAN_INTERVAL)
Const LOCAL_TIME_OFFSET = 0 'set clock to UTC time

'_________________CSAT3 Variables_____________________
Public CSAT(6,5) = NAN

'Alias CSAT(4,1)=Ux4
'Alias CSAT(4,2)=Uy4
'Alias CSAT(4,3)=Uz4
'Alias CSAT(4,4)=Ts4
'Alias CSAT(4,5)=CSATDiag4
'Units Ux4 = m/s
'Units Uy4 = m/s
'Units Uz4 = m/s
'Units Ts4 = degC

Alias CSAT(5,1)=Ux5
Alias CSAT(5,2)=Uy5
Alias CSAT(5,3)=Uz5
Alias CSAT(5,4)=Ts5
Alias CSAT(5,5)=CSATDiag5
Units Ux5 = m/s
Units Uy5 = m/s
Units Uz5 = m/s
Units Ts5 = degC

Alias CSAT(6,1)=Ux6
Alias CSAT(6,2)=Uy6
Alias CSAT(6,3)=Uz6
Alias CSAT(6,4)=Ts6
Alias CSAT(6,5)=CSATDiag6
Units Ux6 = m/s
Units Uy6 = m/s
Units Uz6 = m/s
Units Ts6 = degC

'___________________CSAT3 Diagnostic Variables_______________
Public CSATDiagBits(6,4) As Boolean 'Warning flags.
Units CSATDiagBits() = samples
Dim CSATDiag_work(6) As Long
Dim DisableFlagOn(6,2) As Boolean
Public CSATCounter(6)
Public LastCSATCounter(6)
Public CSATCounterError(6) As Boolean

'Alias CSATDiagBits(4,1) = DelTmpWrn4 'Delta temperature warning flag.
'Alias CSATDiagBits(4,2) = SigLckWrn4 'Poor signal lock warning flag.
'Alias CSATDiagBits(4,3) = AmpHiWrn4 'Amplitude high warning flag.
'Alias CSATDiagBits(4,4) = AmpLoWrn4 'Amplitude low warning flag.
```

```
Alias CSATDiagBits(5,1) = DelTmpWrn5 'Delta temperature warning flag.
Alias CSATDiagBits(5,2) = SigLckWrn5 'Poor signal lock warning flag.
Alias CSATDiagBits(5,3) = AmpHiWrn5 'Amplitude high warning flag.
Alias CSATDiagBits(5,4) = AmpLoWrn5 'Amplitude low warning flag.

Alias CSATDiagBits(6,1) = DelTmpWrn6 'Delta temperature warning flag.
Alias CSATDiagBits(6,2) = SigLckWrn6 'Poor signal lock warning flag.
Alias CSATDiagBits(6,3) = AmpHiWrn6 'Amplitude high warning flag.
Alias CSATDiagBits(6,4) = AmpLoWrn6 'Amplitude low warning flag.

'____________CSAT3 Coordinate Conversion Variables_____________________
Public Un(6)
Public Uw(6)
Public Umag(6)
Public Udir(6)
'Alias Un(4) = Un4
Alias Un(5) = Un5
Alias Un(6) = Un6
'Alias Uw(4) = Uw4
Alias Uw(5) = Uw5
Alias Uw(6) = Uw6
'Alias Umag(4) = Umag4
Alias Umag(5) = Umag5
Alias Umag(6) = Umag6
'Alias Udir(4) = Udir4
Alias Udir(5) = Udir5
Alias Udir(6) = Udir6
Units Un() = m/s
Units Un() = m/s
Units Uw() = m/s
Units Umag() = m/s
Units Udir() = deg

Public alpha = 210  'Direction of CSAT3 mounting arms (0 = North)
AngleDegrees

'____________Cup Anemometer and Vane Variables____________________
Public WindSpd(3) '014A's
Units WindSpd() = m/s
Alias WindSpd(1) = WndSpd4
Alias WindSpd(2) = WndSpd5
Alias WindSpd(3) = WndSpd6
'Elev. 4 Thies anemometer, Model 4.3351.00.0000, SN 05130017, MEASNET
Calibration Mult = 0.04588, Offset = 0.2463
'Elev. 5 Met One anemometer, Model 011E, SN N4859, MEASNET Calibration
Mult = 0.04026, Offset = 0.2308
'Elev. 6 Met One anemometer, Model 011E, SN M8855, MEASNET Calibration
Mult = 0.04075, Offset = 0.1969
Public WS_Mult(3) = {0.04588, 0.04026, 0.04075}
Public WS_Offset(3) = {0.2463, 0.2308, 0.1969}


Public WindDir(3) '024A's
Units WindDir() = deg
```

```
Alias WindDir(1) = WndDir4
Alias WindDir(2) = WndDir5
Alias WindDir(3) = WndDir6

Public WindDirNewMult(3) = {728.3,730.0,729.2}

'_____Air Temperature and Relative Humidity Variables___________
Dim X(3)
Dim Rs(3)
Public AirTemp(3)
Units AirTemp() = degC
Alias AirTemp(1) = AirTemp4
Alias AirTemp(2) = AirTemp5
Alias AirTemp(3) = AirTemp6
Public RH(3)
Units RH() = %
Alias RH(1) = RH4
Alias RH(2) = RH5
Alias RH(3) = RH6

'__________________Accelerometer Variables_________________________
Public Accel(6) 'Accelerometers
Units Accel() = g
'Elev. 5 accelerometer SN 1670A00030
Alias Accel(1)=Accel5_X  'Channel 1:  Sensitivity: 979.51mV/g, Offset:
2.4997V
Alias Accel(2)=Accel5_Z  'Channel 2:  Sensitivity: 1008.47mV/g, Offset:
2.5006V
Alias Accel(3)=Accel5_Y  'Channel 3:  Sensitivity: 1008.47mV/g, Offset:
2.5006V
'Elev. 6 accelerometer SN 1670A00029
Alias Accel(4)=Accel6_X  'Channel 1:  Sensitivity: 1006.44mV/g, Offset:
2.4998V
Alias Accel(5)=Accel6_Z  'Channel 2:  Sensitivity: 1006.05mV/g, Offset:
2.5006V
Alias Accel(6)=Accel6_Y  'Channel 3:  Sensitivity: 1004.62mV/g, Offset:
2.5008V
'Elev. 4 accelerometer not installed
'Alias Accel(7)=Accel4_X  'Channel 1:  Sensitivity: mV/g, Offset: V
'Alias Accel(8)=Accel4_Z  'Channel 2:  Sensitivity: mV/g, Offset: V
'Alias Accel(9)=Accel4_Y  'Channel 3:  Sensitivity: mV/g, Offset: V

Public AccelMult(6)={-1/979.51,1/1008.47,1/997.29,-
1/1006.44,1/1006.05,1/1004.62}
Public AccelOffset(6)={2499.7/979.51,-2500.6/1008.47,-
2501.2/997.29,2499.8/1006.44,-2500.6/1006.05,-2500.8/1004.62}
'Note:  Channel 1 (X) Mult and Offset sign reversed to conform to CSAT
local coordinate system
'X positive toward mounting arm, Y positive toward left looking at
mounting arm, Z positive upward
Public AccelKnownOffset(6) = {0,1,0,0,1,0}
Public AccelZeroFlag As Boolean
Public AccelScanFlag As Boolean = True
Public AccelZeroMode
```

```
'____________________GPS Variables_____________________________
Public nmea_sentence(2) As String * 90
Public gps_data(15)
Alias gps_data(1) = latitude_a 'Degrees latitude (+ = East; - = West)
Alias gps_data(2) = latitude_b 'Minutes latitude
Alias gps_data(3) = longitude_a 'Degress longitude (+ = East; - = West)
Alias gps_data(4) = longitude_b 'Minutes longitude
Alias gps_data(5) = speed 'Speed
Alias gps_data(6) = course 'Course over ground
Alias gps_data(7) = magnetic_variation 'Magnetic variation from true north
(+ = East; - = West)
Alias gps_data(8) = fix_quality 'GPS fix quality: 0 = invalid, 1 = GPS, 2
= 'differential GPS, 6 = estimated
Alias gps_data(9) = nmbr_satellites 'Number of satellites used for fix
Alias gps_data(10) = altitude 'Antenna altitude
Alias gps_data(11) = pps 'Elapsed ms since last pulse per second (PPS)
from GPS
Alias gps_data(12) = dt_since_gprmc 'Time since last GPRMC string,
normally less than '1 second
Alias gps_data(13) = gps_ready 'Counts from 0 to 10, 10 = ready
Alias gps_data(14) = max_clock_change 'Maximum value the clock was changed
Alias gps_data(15) = nmbr_clock_change 'Number of times the clock was
changed
'Define Units to be used in data file header
Units latitude_a = degrees
Units latitude_b = minutes
Units longitude_a = degrees
Units longitude_b = minutes
Units speed = m/s
Units course = degrees
Units magnetic_variation = unitless
Units fix_quality = unitless
Units nmbr_satellites = unitless
Units altitude = m
Units pps = ms
Units dt_since_gprmc = s
Units gps_ready = unitless
Units max_clock_change = ms
Units nmbr_clock_change = samples

'________________Other Variables____________________________
Public CalFileLoaded As Boolean = False
Public CalStartIdx = 1
Public FieldCalAvgs = 20
Const n = 1
Dim i,j,k
Public PTemp, batt_volt
Public MetA_IP As String = "192.168.69.84"
Public ClockError_mS
Public LastSkippedRecord1
Public CurrentSkippedRecord1
Public CurrentSkippedSlowScan1
```

```
'Public CSAT5DAout(2)
'Alias CSAT5DAout(1) = Umag5DAout
'Alias CSAT5DAout(2) = Udir5DAout

'____________________Output Tables________________________
DataTable (CSAT,True,-1)
  DataInterval (0,SCAN_INTERVAL,mSec,10)
  CardOut (0 ,-1)
  Sample (1,Un5,FP2)
  Sample (1,Uw5,FP2)
  Sample (2,Uz5,FP2)
  Sample (1,CSATDiag5,UINT2)
  Sample (1,Un6,FP2)
  Sample (1,Uw6,FP2)
  Sample (2,Uz6,FP2)
  Sample (1,CSATDiag6,UINT2)
EndTable

DataTable (Accel,True,-1)
  DataInterval (0,SCAN_INTERVAL,mSec,10)
  CardOut (0 ,-1)
  Sample (6,Accel(),IEEE4)
EndTable

DataTable (_1Sec,True,-1)
  DataInterval (0,1,sec,10)
  CardOut (0 ,-1)
  Average (1,Umag5,FP2,Umag5=NAN)
  Average (1,Umag6,FP2,Umag6=NAN)
'  Average (1,WndSpd4,FP2,WndSpd4=NAN)
'  Average (1,WndSpd5,FP2,WndSpd5=NAN)
'  Average (1,WndSpd6,FP2,WndSpd6=NAN)
    Sample (1, WndSpd4,FP2)
    FieldNames("WndSpd4_Avg:m/s:Avg")
    Sample (1, WndSpd5,FP2)
    FieldNames("WndSpd5_Avg:m/s:Avg")
    Sample (1, WndSpd6,FP2)
    FieldNames("WndSpd6_Avg:m/s:Avg")
  Average (1,Udir5,FP2,Udir5=NAN)
  Average (1,Udir6,FP2,Udir6=NAN)
'  WindVector(1,Umag5,Udir5,FP2,Udir5=NAN,0,0,3)  'Wind Direction Only
'  WindVector(1,Umag6,Udir6,FP2,Udir6=NAN,0,0,3)  'Wind Direction Only
  Sample (3,WndDir4,FP2)
  Sample (3,AirTemp4,FP2)
  Sample (3,RH4,FP2)
EndTable

DataTable (_5Min,True,-1)
  DataInterval (0,5,Min,10)
  CardOut (0 ,-1)
  Average (1,Umag5,FP2,Umag5=NAN)
  Maximum (1,Umag5,FP2,Umag5=NAN,False)
  StdDev (1,Umag5,FP2,Umag5=NAN)
  Average (1,Umag6,FP2,Umag6=NAN)
```

```
  Maximum (1,Umag6,FP2,Umag6=NAN,False)
  StdDev (1,Umag6,FP2,Umag6=NAN)
  Average (1,WndSpd4,FP2,WndSpd4=NAN)
  Maximum (1,WndSpd4,FP2,WndSpd4=NAN,False)
  StdDev (1,WndSpd4,FP2,WndSpd4=NAN)
  Average (1,WndSpd5,FP2,WndSpd5=NAN)
  Maximum (1,WndSpd5,FP2,WndSpd5=NAN,False)
  StdDev (1,WndSpd5,FP2,WndSpd5=NAN)
  Average (1,WndSpd6,FP2,WndSpd6=NAN)
  Maximum (1,WndSpd6,FP2,WndSpd6=NAN,False)
  StdDev (1,WndSpd6,FP2,WndSpd6=NAN)
  Average (1,Udir5,FP2,Udir5=NAN)
  Average (1,Udir6,FP2,Udir6=NAN)
  Average (3,WndDir4,FP2,False)
'  WindVector(1,Umag5,Udir5,FP2,Udir5=NAN,0,0,3)  'Wind Direction Only
'  WindVector(1,Umag6,Udir6,FP2,Udir6=NAN,0,0,3)  'Wind Direction Only
'  WindVector(3,WndSpd4,WndDir4,FP2,False,0,0,3)  'Wind Direction Only
  Average (3,AirTemp4,FP2,False)
  Average (3,RH4,FP2,False)
  Average (6,Accel(),IEEE4,False)
  StdDev (6,Accel(),IEEE4,False)
  Sample (1,PTemp,FP2)
  Minimum (1,batt_volt,FP2,False,False)
  Sample (1,ClockError_mS,FP2)
EndTable

DataTable (Daily,True,-1)
  DataInterval (0,1,Day,10)
  CardOut (0 ,-1)
  Minimum (1,batt_volt,FP2,False,False)
  Maximum (1,PTemp,FP2,False,False)
  Minimum (1,PTemp,FP2,False,False)
  Average (1,ClockError_mS,FP2,False)
  Minimum (1,ClockError_mS,FP2,False,True)
  Maximum (1,ClockError_mS,FP2,False,True)
EndTable

DataTable(CalHist,NewFieldCal,50)
  SampleFieldCal
EndTable

DataTable (CSAT_Stats,TRUE,-1)
  DataInterval (0,5,Min,10)
  CardOut (0 ,-1)
  'CSAT_5 Summary Stats
  Average (4,Ux5,FP2,DisableFlagOn(5,1))
  StdDev (4,Ux5,FP2,DisableFlagOn(5,1))
  Totalize (1,n,FP2,DisableFlagOn(5,1))
  FieldNames ("CSAT5_ValidMeas")
  Totalize (1,n,FP2,NOT (DisableFlagOn(5,1) OR DisableFlagOn(5,2)))
  FieldNames ("CSAT5_Wrns_Tot")  'one or more of the 4 diagnostic bits
high
  'the next 4 are total occurances of each bit less those associated with
the "special"
```

```
  'diagnostic words (61440, 61441, 61442, 61503) which only occur when the
CSAT data is NaN
  Totalize (1,n,FP2,NOT (DelTmpWrn5) OR NOT (DisableFlagOn(5,2)))
  FieldNames ("CSAT5_DeltaT_Tot")
  Totalize (1,n,FP2,NOT (SigLckWrn5) OR NOT (DisableFlagOn(5,2)))
  FieldNames ("CSAT5_SigLock_Tot")
  Totalize (1,n,FP2,NOT (AmpHiWrn5) OR NOT (DisableFlagOn(5,2)))
  FieldNames ("CSAT5_AmpHi_Tot")
  Totalize (1,n,FP2,NOT (AmpLoWrn5) OR NOT (DisableFlagOn(5,2)))
  FieldNames ("CSAT5_AmpLo_Tot")
  Totalize (1,n,FP2,NOT (CSATCounterError(5))
  FieldNames ("CSAT5_CntErr_Tot")
  'CSAT_6 Summary Stats
  Average (4,Ux6,FP2,DisableFlagOn(6,1))
  StdDev (4,Ux6,FP2,DisableFlagOn(6,1))
  Totalize (1,n,FP2,DisableFlagOn(6,1))
  FieldNames ("CSAT6_ValidMeas")
  Totalize (1,n,FP2,NOT (DisableFlagOn(6,1) OR DisableFlagOn(6,2)))
  FieldNames ("CSAT6_Wrns_Tot")
  Totalize (1,n,FP2,NOT (DelTmpWrn6) OR NOT (DisableFlagOn(6,2)))
  FieldNames ("CSAT6_DeltaT_Tot")
  Totalize (1,n,FP2,NOT (SigLckWrn6) OR NOT (DisableFlagOn(6,2)))
  FieldNames ("CSAT6_SigLock_Tot")
  Totalize (1,n,FP2,NOT (AmpHiWrn6) OR NOT (DisableFlagOn(6,2)))
  FieldNames ("CSAT6_AmpHi_Tot")
  Totalize (1,n,FP2,NOT (AmpLoWrn6) OR NOT (DisableFlagOn(6,2)))
  FieldNames ("CSAT6_AmpLo_Tot")
  Totalize (1,n,FP2,NOT (CSATCounterError(6))
  FieldNames ("CSAT6_CntErr_Tot")
EndTable

DataTable(SkippedRecords,True,500)
  DataEvent (10,(CurrentSkippedRecord1 > LastSkippedRecord1),-1,10)
  Sample (1,CurrentSkippedRecord1,UINT2)
  Sample (1,Status.SkippedScan,UINT2)
  Sample (1,CurrentSkippedSlowScan1,UINT2)
  'Sample (1,Status.MeasureTime,UINT2)
  Sample (1,Status.ProcessTime,UINT4)
  'Sample (1,Status.MaxProcTime,UINT4)
  Sample (1,Status.BuffDepth,UINT2)
  'Sample (1, Status.MaxBuffDepth,UINT2)
EndTable

Sub TransformCSATCoords
  Dim i
  For i = 5 To 6
    'Uw postive from West to East, Un positive from North to South, Uz
positive from down to up
    Uw(i)=-CSAT(i,1)*SIN(alpha)+CSAT(i,2)*COS(alpha)  'CSAT(i,1) is Uxi,
CSAT(i,2) is Uyi
    Un(i)=CSAT(i,1)*COS(alpha)+CSAT(i,2)*SIN(alpha)  'CSAT(i,1) is Uxi,
CSAT(i,2) is Uyi
    Umag(i)=(Un(i)*Un(i)+Uw(i)*Uw(i))^.5
    Udir(i)=(-ATN2(Uw(i),Un(i))+360) MOD 360
```

```
  Next i
EndSub

Sub ProcessCSATDiagnostics
  Dim i
  For i = 5 To 6
    'Define 61502 as NaN.
    If CSAT(i,5) = NaN Then CSAT(i,5) = 61502  'CSAT(i,5) is CSATDiagi
    'Break up the four CSAT3 warning flags into four separate bits.
    CSATDiag_work(i) = CSAT(i,5)
    CSATDiagBits(i,1) = CSATDiag_work(i) AND &h8000  'DelTmpWrn - Delta
temperature warning flag.
    CSATDiagBits(i,2) = CSATDiag_work(i) AND &h4000  'SigLckWrn - Poor
signal lock warning flag.
    CSATDiagBits(i,3) = CSATDiag_work(i) AND &h2000  'AmpHiWrn - Amplitude
high warning flag.
    CSATDiagBits(i,4) = CSATDiag_work(i) AND &h1000  'AmpLoWrn - Amplitude
low warning flag.
    'Turn on the intermediate processing disable flag when any CSAT3
warning flag is
    'high, including the special cases NaN (61502), a Lost Trigger
(61440), No Data
    '(61503), an SDM error (61441), or wrong CSAT3 embedded code (61442).
    DisableFlagOn(i,1) = CSATDiag_work(i) AND &hf000
    'Turn on only when CSAT3 diagnostic warning flags are set.
    DisableFlagOn(i,2) = ( DisableFlagOn(i,1) AND NOT (CSAT(i,4) = NaN) )
'CSAT(i,4) is Tsi
    'Save the four most significant bits of the CSAT3 diagnostics, except
for the
    'special cases NaN (61502), a Lost Trigger (61440), No Data (61503),
an SDM
    'error (61441), or wrong CSAT3 embedded code (61442).
    If ( CSATDiag_work(i) < &hf000 ) Then ( CSATDiag_work(i) = INT
(CSATDiag_work(i)/&h1000) )
    CSATCounter(i) = CSAT(i,5) MOD 64
    If CSATCounter(i) <> LastCSATCounter(i) + 1 Then
      CSATCounterError(i) = True
    Else
      CSATCounterError(i) = False
    EndIf
    LastCSATCounter(i) = CSATCounter(i)
    If LastCSATCounter(i)  = 63 Then LastCSATCounter(i)  = -1
  Next i
EndSub

BeginProg
  SDMSpeed(45)
  CalFileLoaded = LoadFieldCal(0)
  NetworkTimeProtocol("",LOCAL_TIME_OFFSET*3600,0)
  WriteIO(&B11,&B11)   'Set ports 1,2 high -  These are the Accel Test
pins (C1>>Elev5, C2>>Elev6)

  Scan (SCAN_INTERVAL,mSec,500,0)
```

```
    GPS (latitude_a,Com4,LOCAL_TIME_OFFSET*3600,0,nmea_sentence(1))

    SDMTrigger
    'CSAT3 (Ux4,1,1,98,CSAT_OPT)
    CSAT3 (Ux5,1,5,98,CSAT_OPT)
    CSAT3 (Ux6,1,6,98,CSAT_OPT)

    TransformCSATCoords
    ProcessCSATDiagnostics

    '    '***following added for UTRC sound study****
    '    ExciteCAO(CAO1,Umag6*200,True)  'Umag/25*5000  Umag=0 >> 0volts,
Umag=25 >> 5volts
    '    ExciteCAO(CAO2,Udir6/.072,True)  'Udir/360*5000  Udir=0 >>
0volts, Udir=360 >> 5volts
    '    VoltSe(CSAT6DAout(),2,mV5000,27,False,0,250,1,0)

    '***modified 6/27/12 to switch source from CSAT6 to CSAT5 due to dead
CSAT6****
    'ExciteCAO(CAO1,Umag5*200,True)  'Umag/25*5000  Umag=0 >> 0volts,
Umag=25 >> 5volts
    'ExciteCAO(CAO2,Udir5/.072,True)  'Udir/360*5000  Udir=0 >> 0volts,
Udir=360 >> 5volts
    'VoltSe(CSAT5DAout(),2,mV5000,27,False,0,250,1,0)

    '    TimerIO (WindSpd(),11111111,00222000,60,Sec)
    '    For i = 1 To 3
    '      If WindSpd(i) > 0 Then WindSpd(i) =  WindSpd(i) * 0.8 + 0.447
    '    Next i

    'Thies (Elev. 4) and Met One 011E (Elev. 5&6) Wind Speed Sensor
measurement
    PulseCount (WindSpd(),3,1,0,1000,WS_Mult(),WS_Offset())  '1 second
running average
    'PulseCount (WindSpd(),3,1,0,1,WS_Mult(),WS_Offset())
    If WndSpd4 <= WS_Offset(1) Then  WndSpd4 = 0
    If WndSpd5 <= WS_Offset(2) Then  WndSpd5 = 0
    If WndSpd6 <= WS_Offset(3) Then  WndSpd6 = 0

    'Accelerometers
    If AccelZeroFlag Then
      If AccelScanFlag Then
        AccelZeroMode = 1
        AccelScanFlag = False
      EndIf
      If (AccelZeroMode <= 0) OR (AccelZeroMode = 6) Then AccelZeroFlag =
0
    Else
      AccelScanFlag = True
    EndIf

    VoltDiff (Accel(),6,mV5000,6,True,0,250,AccelMult(),AccelOffset())
```

```
    FieldCal
(1,Accel(),6,0,AccelOffset(),AccelZeroMode,AccelKnownOffset(),CalStartIdx,
FieldCalAvgs)

    CallTable CSAT
    CallTable Accel
    CallTable _1Sec
    CallTable _5Min
    CallTable Daily
    CallTable CalHist
    CallTable CSAT_Stats

  NextScan

  SlowSequence
  Scan (1,Sec,50,0)

    '024A Wind Direction Sensor measurement WindDir
    BrHalf(WindDir(),3,mV5000,4,1,1,5000,True,0,_60Hz,1,0)
    For j = 1 To 3
      WindDir(j) = WindDir(j) * WindDirNewMult(j)  'individually
calibrated by Matt Perry at CSI
      WindDir(j) = (WindDir(j)+180) MOD 360 '180 added to correct for
mounting the vanes pointing North instead of South
    Next j

    'MetOne 083E-1-35 AirTemp/RH
    BrHalf (X(),3,mv5000,8,Vx1,1,2500,True,0,_60Hz,1,0)
    For k = 1 To 3
      Rs(k) = 23100 * (X(k)/(1-X(k)))  'Rs=thermistor resistance (ohms)
      AirTemp(k) = (((1/((1/Rs(k))+(1/23100)))-13698.3)/-129.163)  'page
12 in Met One manual
    Next k

    VoltSe (RH(),3,mV5000,1,1,0,_60Hz,0.1,0)  'RH(%)=0.1*Output(mV)

    If TimeIntoInterval(3598,3600,Sec) Then ClockError_mS =
NetworkTimeProtocol(MetA_IP,LOCAL_TIME_OFFSET*3600,600000)

    CurrentSkippedRecord1 = Status.SkippedRecord(1)
    CurrentSkippedSlowScan1 = Status.SkippedSlowScan(1)
    'If CurrentSkippedRecord1 > LastSkippedRecord1 Then CallTable
SkippedRecords
    CallTable SkippedRecords
    LastSkippedRecord1 = CurrentSkippedRecord1

  NextScan
  EndSequence

  SlowSequence
  Scan (1,Min,10,0)
    PanelTemp (PTemp,250)
    Battery (batt_volt)
    If batt_volt < 12 Then
```

```
      SW12(1,0)  'turn off Elev. 5 011E heater
      SW12(2,0)  'turn off Elev. 6 011E heater
    Else
      SW12(1,1)  'turn on Elev. 5 011E heater
      SW12(2,1)  'turn on Elev. 6 011E heater
    EndIf
    WriteIO(&B11,&B11)   'Reset ports 1,2 high -  These are the Accel Test
pins (C1>>Elev5, C2>>Elev6)
  NextScan
  EndSequence

EndProg
```

10 Appendix C: Instrumentation, Wiring, and Data Details and Drawings

10.1 Eolos Met Tower Instrumentation Description and Location Prior to June 3, 2013

EOLOS Met Tower Instrumentation Description and Location (Pre 6/3/2013)

Elev	Description	Manufacturer	Model	Serial No.	Supply	Current	Accessories	Model	Supply	Power	Elevation	Elevation	Boom Length	Meas Rate	Output
					VDC	mA				watts	ft	m	ft	sec-1	
1	Sonic Anemometer	Campbell Scientific	CSAT3		12	100	-				423.2	129	18	20	u,v,w,T, Diag.
	Accelerometer	Spectrum Sensors and Controls	XL403A	1670A00031	12	12	-				423.2	129	18	20	ax,ay,az
	Junction Box	Campbell Scientific	ENC16/18								420.0	128			
	Temperature/Relative Humidity	Met One Instruments	083E-1-35	M8372	12	<5	Gill Radiation Shield				420.0	128		1	T,RH
	Cup Anemometer	Met One Instruments	014A-L30	D1480	5	<1	Heater Block	2260	120VAC	25	413.4	126	12	1	speed
	Vane	Met One Instruments	024A-L30	M2887	12	1.2	Heater Block	2260	120VAC	25	413.4	126	12	1	direction
2	Junction Box	Campbell Scientific	ENC16/18								341.2	104			
	Temperature/Relative Humidity	Met One Instruments	083E-1-35	M8371	12	<5	Gill Radiation Shield				341.2	104		1	T,RH
	Cup Anemometer	Met One Instruments	014A-L30	D1487	5	<1	Heater Block	2260	120VAC	25	334.7	102	12	1	speed
	Vane	Met One Instruments	024A-L30	M2892	12	1.2	Heater Block	2260	120VAC	25	334.7	102	12	1	direction
3	Sonic Anemometer	Campbell Scientific	CSAT3		12	100	-				262.5	80	18	20	u,v,w,T, Diag.
	Accelerometer	Spectrum Sensors and Controls	XL403A	1670A00028	12	12	-				262.5	80	18	20	ax,ay,az
	Junction Box	Campbell Scientific	ENC16/18								259.2	79			
	Temperature/Relative Humidity	Met One Instruments	083E-1-35	M9257	12	<5	Gill Radiation Shield				259.2	79		1	T,RH
	Barometric Pressure	Met One Instruments	092		12	10					259.2	79			
	Cup Anemometer	Thies	4.3351.00.000	09114705	12	<1	Internal Heater		24VDC	25	252.6	77	12	1	speed
	Vane	Met One Instruments	024A-L30	M2299	12	1.2	Heater Block	2260	120VAC	25	252.6	77	12	1	direction
4	Junction Box	Campbell Scientific	ENC16/18								177.2	54			
	Temperature/Relative Humidity	Met One Instruments	083E-1-35	M9258	12	<5	Gill Radiation Shield				177.2	54		1	T,RH
	Cup Anemometer	Met One Instruments	014A-L30	D1479	5	<1	Heater Block	2260	120VAC	25	170.6	52	12	1	speed
	Vane	Met One Instruments	024A-L30	M2896	12	1.2	Heater Block	2260	120VAC	25	170.6	52	12	1	direction
5	Sonic Anemometer	Campbell Scientific	CSAT3		12	100	-				98.4	30	18	20	u,v,w,T, Diag.
	Accelerometer	Spectrum Sensors and Controls	XL403A	1670A00030	12	12	-				98.4	30	18	20	ax,ay,az
	Junction Box	Campbell Scientific	ENC16/18								95.1	29			
	Temperature/Relative Humidity	Met One Instruments	083E-1-35	M9252	12	<5	Gill Radiation Shield				95.1	29		1	T,RH
	Cup Anemometer	Met One Instruments	014A-L30	D7478	5	<1	Heater Block	2260	120VAC	25	88.6	27	12	1	speed
	Vane	Met One Instruments	024A-L30	M2904	12	1.2	Heater Block	2260	120VAC	25	88.6	27	12	1	direction
6	Sonic Anemometer	Campbell Scientific	CSAT3		12	100	-				32.8	10	18	20	u,v,w,T, Diag.
	Accelerometer	Spectrum Sensors and Controls	XL403A	1670A00029	12	12	-				32.8	10	18	20	ax,ay,az
	Junction Box	Campbell Scientific	ENC16/18								29.5	9			
	Temperature/Relative Humidity	Met One Instruments	083E-1-35	M9251	12	<5	Gill Radiation Shield				29.5	9		1	T,RH
	Cup Anemometer	Met One Instruments	014A-L30	D7477	5	<1	Heater Block	2260	120VAC	25	23.0	7	12	1	speed
	Vane	Met One Instruments	024A-L30	M2886	12	1.2	Heater Block	2260	120VAC	25	23.0	7	12	1	direction
Ground	Rain	Campbell Scientific	TE525-L10		5	<1					9.8	3		NA	rainfall

10.2 Eolos Met Tower Instrumentation Description and Location After June 3, 2013

EOLOS Met Tower Instrumentation Description and Location (Post 6/3/2013)

Elev	Description	Manufacturer	Model	Serial No.	Supply VDC	Current mA	Accessories	Model	Supply	Power watts	Elevation ft	Elevation m	Boom Length ft	Meas Rate sec-1	Output
1	Sonic Anemometer	Campbell Scientific	CSAT3		12	100	-				423.2	129	18	20	u,v,w,T, Diag.
	Accelerometer	Spectrum Sensors and Controls	XL403A	1670A00031	12	12	-				423.2	129	18	20	ax,ay,az
	Junction Box	Campbell Scientific	ENC16/18								420.0	128			
	Temperature/Relative Humidity	Met One Instruments	083E-1-35	M8372	12	<5	Gill Radiation Shield				420.0	128		1	T,RH
	Cup Anemometer	Thies	4.3351.00.000	05130019	12	<1	Internal Heater		24VDC	25	413.4	126	12	1	speed
	Vane	Met One Instruments	024A-L30	M2887	12	1.2	Heater Block	2260	120VAC	25	413.4	126	12	1	direction
2	Junction Box	Campbell Scientific	ENC16/18								341.2	104			
	Temperature/Relative Humidity	Met One Instruments	083E-1-35	M8371	12	<5	Gill Radiation Shield				341.2	104		1	T,RH
	Cup Anemometer	Thies	4.3351.00.000	05130018	12	<1	Internal Heater		24VDC	25	334.7	102	12	1	speed
	Vane	Met One Instruments	024A-L30	M2892	12	1.2	Heater Block	2260	120VAC	25	334.7	102	12	1	direction
3	Sonic Anemometer	Campbell Scientific	CSAT3		12	100	-				262.5	80	18	20	u,v,w,T, Diag.
	Accelerometer	Spectrum Sensors and Controls	XL403A	1670A00028	12	12	-				262.5	80	18	20	ax,ay,az
	Junction Box	Campbell Scientific	ENC16/18								259.2	79			
	Temperature/Relative Humidity	Met One Instruments	083E-1-35	M9257	12	<5	Gill Radiation Shield				259.2	79		1	T,RH
	Barometric Pressure	Met One Instruments	092		12	10					259.2	79			
	Cup Anemometer	Thies	4.3351.00.000	09114705	12	<1	Internal Heater		24VDC	25	252.6	77	12	1	speed
	Vane	Met One Instruments	024A-L30	M2299	12	1.2	Heater Block	2260	120VAC	25	252.6	77	12	1	direction
4	Junction Box	Campbell Scientific	ENC16/18								177.2	54			
	Temperature/Relative Humidity	Met One Instruments	083E-1-35	M9258	12	<5	Gill Radiation Shield				177.2	54		1	T,RH
	Cup Anemometer	Thies	4.3351.00.000	05130017	12	<1	Internal Heater		24VDC	25	170.6	52	12	1	speed
	Vane	Met One Instruments	024A-L30	M2896	12	1.2	Heater Block	2260	120VAC	25	170.6	52	12	1	direction
5	Sonic Anemometer	Campbell Scientific	CSAT3		12	100	-				98.4	30	18	20	u,v,w,T, Diag.
	Accelerometer	Spectrum Sensors and Controls	XL403A	1670A00030	12	12	-				98.4	30	18	20	ax,ay,az
	Junction Box	Campbell Scientific	ENC16/18								95.1	29			
	Temperature/Relative Humidity	Met One Instruments	083E-1-35	M9252	12	<5	Gill Radiation Shield				95.1	29		1	T,RH
	Cup Anemometer	Met One Instruments	011E-L30	N4859	12	3					88.6	27	12	1	speed
	Vane	Met One Instruments	024A-L30	M2904	12	1.2	Heater Block	2260	120VAC	25	88.6	27	12	1	direction
6	Sonic Anemometer	Campbell Scientific	CSAT3		12	100	-				32.8	10	18	20	u,v,w,T, Diag.
	Accelerometer	Spectrum Sensors and Controls	XL403A	1670A00029	12	12	-				32.8	10	18	20	ax,ay,az
	Junction Box	Campbell Scientific	ENC16/18								29.5	9			
	Temperature/Relative Humidity	Met One Instruments	083E-1-35	M9251	12	<5	Gill Radiation Shield				29.5	9		1	T,RH
	Cup Anemometer	Met One Instruments	011E-L30	M8855	12	3					23.0	7	12	1	speed
	Vane	Met One Instruments	024A-L30	M2886	12	1.2	Heater Block	2260	120VAC	25	23.0	7	12	1	direction
Ground	Rain	Campbell Scientific	TE525-L10		5	<1					9.8	3		NA	rainfall

10.3 Eolos Meta Device Measurement Specifications Pre 6/3/2013

EOLOS Meta Device Measurement Specifications, Pre 6/6/2013

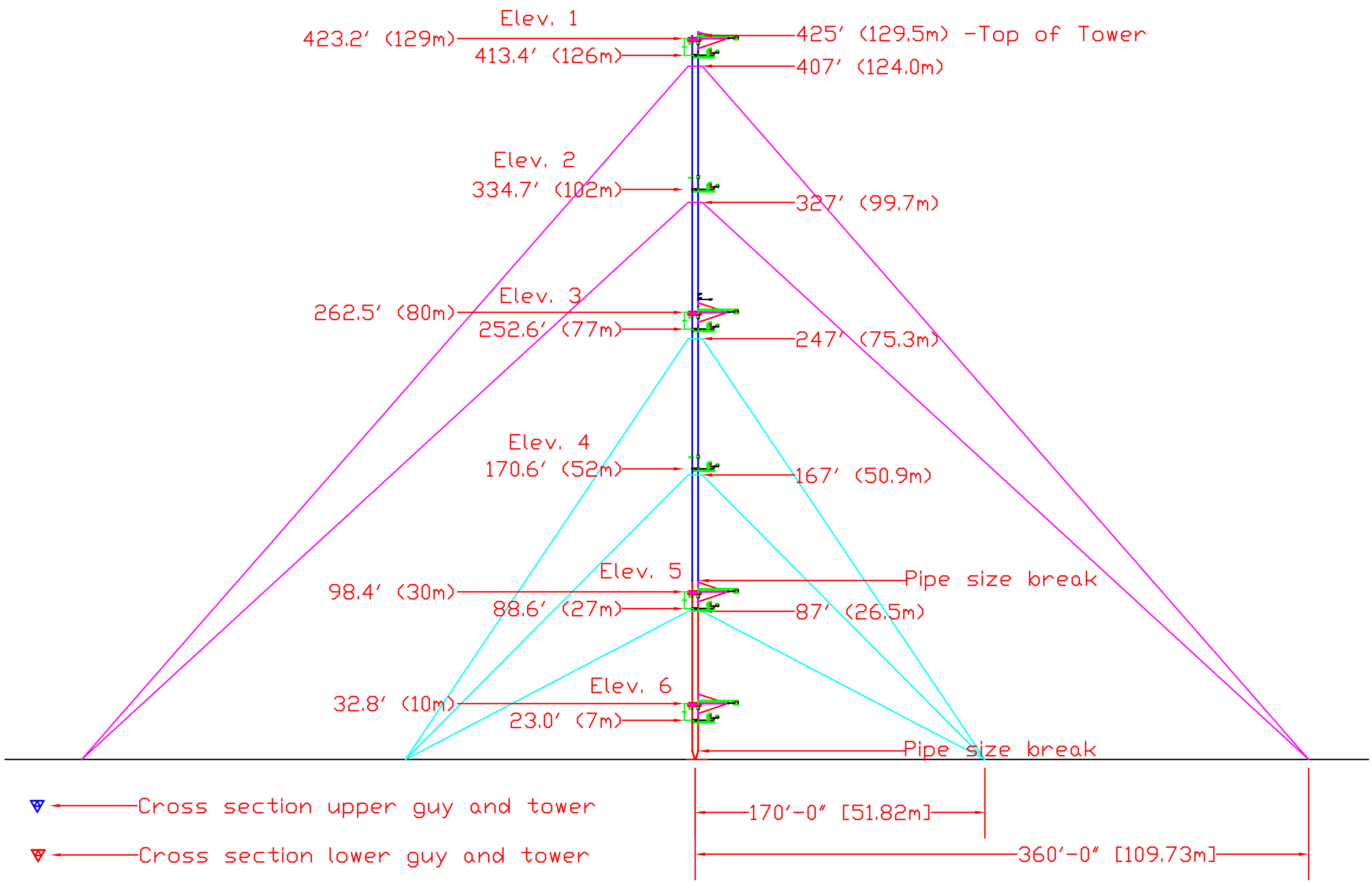
SignalID	DeviceID	Manufacturer	Serial No.	Logger Channel #	Description	Meas. Rate (Hz)	Resolution	Threshold low	Threshold high	Calibrated Range low	Calibrated Range high	Calibration Slope	Calibration Offset	Recalibration Period recommended - months	Accuracy +/-	Units
Ux1	CSAT3_1	Campbell Scientific		Met A, SDM C1,C2,C3	Sonic Anemometer	20	0.01	0	30	0	30	NA	NA	NA	0.08+5% of meas	m/s
Uy1	CSAT3_1	Campbell Scientific		Met A, SDM C1,C2,C3	Sonic Anemometer	20	0.01	0	30	0	30	NA	NA	NA	0.08+5% of meas	m/s
Uz1	CSAT3_1	Campbell Scientific		Met A, SDM C1,C2,C3	Sonic Anemometer	20	0.01	0	30	0	30	NA	NA	NA	0.04+5% of meas	m/s
Ts1	CSAT3_1	Campbell Scientific		Met A, SDM C1,C2,C3	Sonic Anemometer	20	0.01	-30	50	-30	50	NA	NA	NA	Unknown	deg C
CSATDiag1	CSAT3_1	Campbell Scientific		Met A, SDM C1,C2,C3	Sonic Anemometer	20	1	NA	NA	NA	NA	NA	NA	NA	NA	None
Accel1_X	XL403A_1	Spectrum Sensors and Controls	1670A00031	Met A, Diff 6H	3 Axis Accelerometer	20	0.000001	-2	2	-2	2	989.57mV/g	2.5003V	Unknown	$>.0001/(Hz)^{0.5}$	g
Accel1_Z	XL403A_1	Spectrum Sensors and Controls	1670A00031	Met A, Diff 7H	3 Axis Accelerometer	20	0.000001	-2	2	-2	2	1003.87mV/g	2.5011V	Unknown	$>.0001/(Hz)^{0.5}$	g
Accel1_Y	XL403A_1	Spectrum Sensors and Controls	1670A00031	Met A, Diff 8H	3 Axis Accelerometer	20	0.000001	-2	2	-2	2	1005.02mV/g	2.4998V	Unknown	$>.0001/(Hz)^{0.5}$	g
WndSpd1	014A_1	Met One	D1480	Met A, C4	Cup Anemometer	20	0.01	0.447	53	0.45	45	0.8m/s/hz	0.447m/s	12-24	max(1.5% of meas, 0.11)	m/s
WndDir1	024A_1	Met One	M2887	Met A, SE 4	Wind Vane	1	0.1	0.447m/s	53m/s	0	360	729.1deg/Vo	0deg	24-36	5	deg
AirTemp1	083E-1-35_1	Met One	M8372	Met A, SE 8	Temperature Sensor	1	0.01	-50	50	-50	50	see manual	see manual	12	0.1	deg C
RH1	083E-1-35_1	Met One	M8372	Met A, SE 1	Relative Humidity Sensor	1	0.1	0	100	0	100	0.1%/mV	0%	12	2	%
WndSpd2	014A_2	Met One	D1487	Met A, C5	Cup Anemometer	20	0.01	0.447	53	0.45	45	0.8m/s/hz	0.447m/s	12-24	max(1.5% of meas, 0.11)	m/s
WndDir2	024A_2	Met One	M2892	Met A, SE 5	Wind Vane	1	0.1	0.447m/s	53m/s	0	360	728.3deg/Vo	0deg	24-36	5	deg
AirTemp2	083E-1-35_2	Met One	M8371	Met A, SE 9	Temperature Sensor	1	0.01	-50	50	-50	50	see manual	see manual	12	0.1	deg C
RH2	083E-1-35_2	Met One	M8371	Met A, SE 2	Relative Humidity Sensor	1	0.1	0	100	0	100	0.1%/mV	0%	12	2	%
Ux3	CSAT3_3	Campbell Scientific		Met A, SDM C1,C2,C3	Sonic Anemometer	20	0.01	0	30	0	30	NA	NA	NA	0.08+5% of meas	m/s
Uy3	CSAT3_3	Campbell Scientific		Met A, SDM C1,C2,C3	Sonic Anemometer	20	0.01	0	30	0	30	NA	NA	NA	0.08+5% of meas	m/s
Uz3	CSAT3_3	Campbell Scientific		Met A, SDM C1,C2,C3	Sonic Anemometer	20	0.01	0	30	0	30	NA	NA	NA	0.04+5% of meas	m/s
Ts3	CSAT3_3	Campbell Scientific		Met A, SDM C1,C2,C3	Sonic Anemometer	20	0.01	-30	50	-30	50	NA	NA	NA	Unknown	deg C
CSATDiag3	CSAT3_3	Campbell Scientific		Met A, SDM C1,C2,C3	Sonic Anemometer	20	1	NA	NA	NA	NA	NA	NA	NA	NA	None
Accel3_X	XL403A_3	Spectrum Sensors and Controls	1670A00028	Met A, Diff 9H	3 Axis Accelerometer	20	0.000001	-2	2	-2	2	1013.19mV/g	2.4995V	Unknown	$>.0001/(Hz)^{0.5}$	g
Accel3_Z	XL403A_3	Spectrum Sensors and Controls	1670A00028	Met A, Diff 10H	3 Axis Accelerometer	20	0.000001	-2	2	-2	2	991.51mV/g	2.4994V	Unknown	$>.0001/(Hz)^{0.5}$	g
Accel3_Y	XL403A_3	Spectrum Sensors and Controls	1670A00028	Met A, Diff 11H	3 Axis Accelerometer	20	0.000001	-2	2	-2	2	996.54mV/g	2.4992V	Unknown	$>.0001/(Hz)^{0.5}$	g
WndSpd3	4.3351.00.000_3	Thies	09114705	Met A, P4	Class One Cup Anemometer	20	0.01	0.3	80	0.3	80	0.04621m/s/hz	0.21735m/s	Unknown	max(1.0% of meas, 0.2)	m/s
WndDir3	024A_3	Met One	M2299	Met A, SE 6	Wind Vane	1	0.1	0.447m/s	53m/s	0	360	716.6deg/Vo	0deg	24-36	5	deg
AirTemp3	083E-1-35_3	Met One	M9257	Met A, SE 10	Temperature Sensor	1	0.01	-50	50	-50	50	see manual	see manual	12	0.1	deg C
RH3	083E-1-35_3	Met One	M9257	Met A, SE 3	Relative Humidity Sensor	1	0.1	0	100	0	100	0.1%/mV	0%	12	2	%
BarPres	092_3	Met One		Met A, SE 7	Barometric Pressure Sensor	1	1	600	1100	600	1100	0.1mBar/mV	600mBar	12	1	mbar
WndSpd4	014A_4	Met One	D1479	Met B, C4	Cup Anemometer	20	0.01	0.447	53	0.45	45	0.8m/s/hz	0.447m/s	12-24	max(1.5% of meas, 0.11)	m/s
WndDir4	024A_4	Met One	M2896	Met B, SE 4	Wind Vane	1	0.1	0.447m/s	53m/s	0	360	728.3deg/Vo	0deg	24-36	5	deg
AirTemp4	083E-1-35_4	Met One	M9258	Met B, SE 8	Temperature Sensor	1	0.01	-50	50	-50	50	see manual	see manual	12	0.1	deg C
RH4	083E-1-35_4	Met One	M9258	Met B, SE 1	Relative Humidity Sensor	1	0.1	0	100	0	100	0.1%/mV	0%	12	2	%
Ux5	CSAT3_5	Campbell Scientific		Met B, SDM C1,C2,C3	Sonic Anemometer	20	0.01	0	30	0	30	NA	NA	NA	0.08+5% of meas	m/s
Uy5	CSAT3_5	Campbell Scientific		Met B, SDM C1,C2,C3	Sonic Anemometer	20	0.01	0	30	0	30	NA	NA	NA	0.08+5% of meas	m/s
Uz5	CSAT3_5	Campbell Scientific		Met B, SDM C1,C2,C3	Sonic Anemometer	20	0.01	0	30	0	30	NA	NA	NA	0.04+5% of meas	m/s
Ts5	CSAT3_5	Campbell Scientific		Met B, SDM C1,C2,C3	Sonic Anemometer	20	0.01	-30	50	-30	50	NA	NA	NA	Unknown	deg C
CSATDiag5	CSAT3_5	Campbell Scientific		Met B, SDM C1,C2,C3	Sonic Anemometer	20	1	NA	NA	NA	NA	NA	NA	NA	NA	None
Accel5_X	XL403A_5	Spectrum Sensors and Controls	1670A00030	Met B, Diff 6H	3 Axis Accelerometer	20	0.000001	-2	2	-2	2	979.51mV/g	2.4997V	Unknown	$>.0001/(Hz)^{0.5}$	g
Accel5_Z	XL403A_5	Spectrum Sensors and Controls	1670A00030	Met B, Diff 7H	3 Axis Accelerometer	20	0.000001	-2	2	-2	2	1008.47mV/g	2.5006V	Unknown	$>.0001/(Hz)^{0.5}$	g
Accel5_Y	XL403A_5	Spectrum Sensors and Controls	1670A00030	Met B, Diff 8H	3 Axis Accelerometer	20	0.000001	-2	2	-2	2	1008.47mV/g	2.5006V	Unknown	$>.0001/(Hz)^{0.5}$	g
WndSpd5	014A_5	Met One	D7478	Met B, C5	Cup Anemometer	20	0.01	0.447	53	0.45	45	0.8m/s/hz	0.447m/s	12-24	max(1.5% of meas, 0.11)	m/s
WndDir5	024A_5	Met One	M2904	Met B, SE 5	Wind Vane	1	0.1	0.447m/s	53m/s	0	360	730.0deg/Vo	0deg	24-36	5	deg
AirTemp5	083E-1-35_5	Met One	M9252	Met B, SE 9	Temperature Sensor	1	0.01	-50	50	-50	50	see manual	see manual	12	0.1	deg C
RH5	083E-1-35_5	Met One	M9252	Met B, SE 2	Relative Humidity Sensor	1	0.1	0	100	0	100	0.1%/mV	0%	12	2	%
Ux6	CSAT3_6	Campbell Scientific		Met B, SDM C1,C2,C3	Sonic Anemometer	20	0.01	0	30	0	30	NA	NA	NA	0.08+5% of meas	m/s
Uy6	CSAT3_6	Campbell Scientific		Met B, SDM C1,C2,C3	Sonic Anemometer	20	0.01	0	30	0	30	NA	NA	NA	0.08+5% of meas	m/s
Uz6	CSAT3_6	Campbell Scientific		Met B, SDM C1,C2,C3	Sonic Anemometer	20	0.01	0	30	0	30	NA	NA	NA	0.04+5% of meas	m/s
Ts6	CSAT3_6	Campbell Scientific		Met B, SDM C1,C2,C3	Sonic Anemometer	20	0.01	-30	50	-30	50	NA	NA	NA	Unknown	deg C
CSATDiag6	CSAT3_6	Campbell Scientific		Met B, SDM C1,C2,C3	Sonic Anemometer	20	1	NA	NA	NA	NA	NA	NA	NA	NA	None
Accel6_X	XL403A_6	Spectrum Sensors and Controls	1670A00029	Met B, Diff 9H	3 Axis Accelerometer	20	0.000001	-2	2	-2	2	1006.44mV/g	2.4998V	Unknown	$>.0001/(Hz)^{0.5}$	g
Accel6_Z	XL403A_6	Spectrum Sensors and Controls	1670A00029	Met B, Diff 10H	3 Axis Accelerometer	20	0.000001	-2	2	-2	2	1006.05mV/g	2.5006V	Unknown	$>.0001/(Hz)^{0.5}$	g
Accel6_Y	XL403A_6	Spectrum Sensors and Controls	1670A00029	Met B, Diff 11H	3 Axis Accelerometer	20	0.000001	-2	2	-2	2	1004.62mV/g	2.5008V	Unknown	$>.0001/(Hz)^{0.5}$	g
WndSpd6	014A_6	Met One	D7477	Met B, C6	Cup Anemometer	20	0.01	0.447	53	0.45	45	0.8m/s/hz	0.447m/s	12-24	max(1.5% of meas, 0.11)	m/s
WndDir6	024A_6	Met One	M2886	Met B, SE 6	Wind Vane	1	0.1	0.447m/s	53m/s	0	360	729.2deg/Vo	0deg	24-36	5	deg
AirTemp6	083E-1-35_6	Met One	M9251	Met B, SE 10	Temperature Sensor	1	0.01	-50	50	-50	50	see manual	see manual	12	0.1	deg C
RH6	083E-1-35_6	Met One	M9251	Met B, SE 3	Relative Humidity Sensor	1	0.1	0	100	0	100	0.1%/mV	0%	12	2	%

10.4 Eolos Meta Device Measurement Specifications Post 6/3/2013

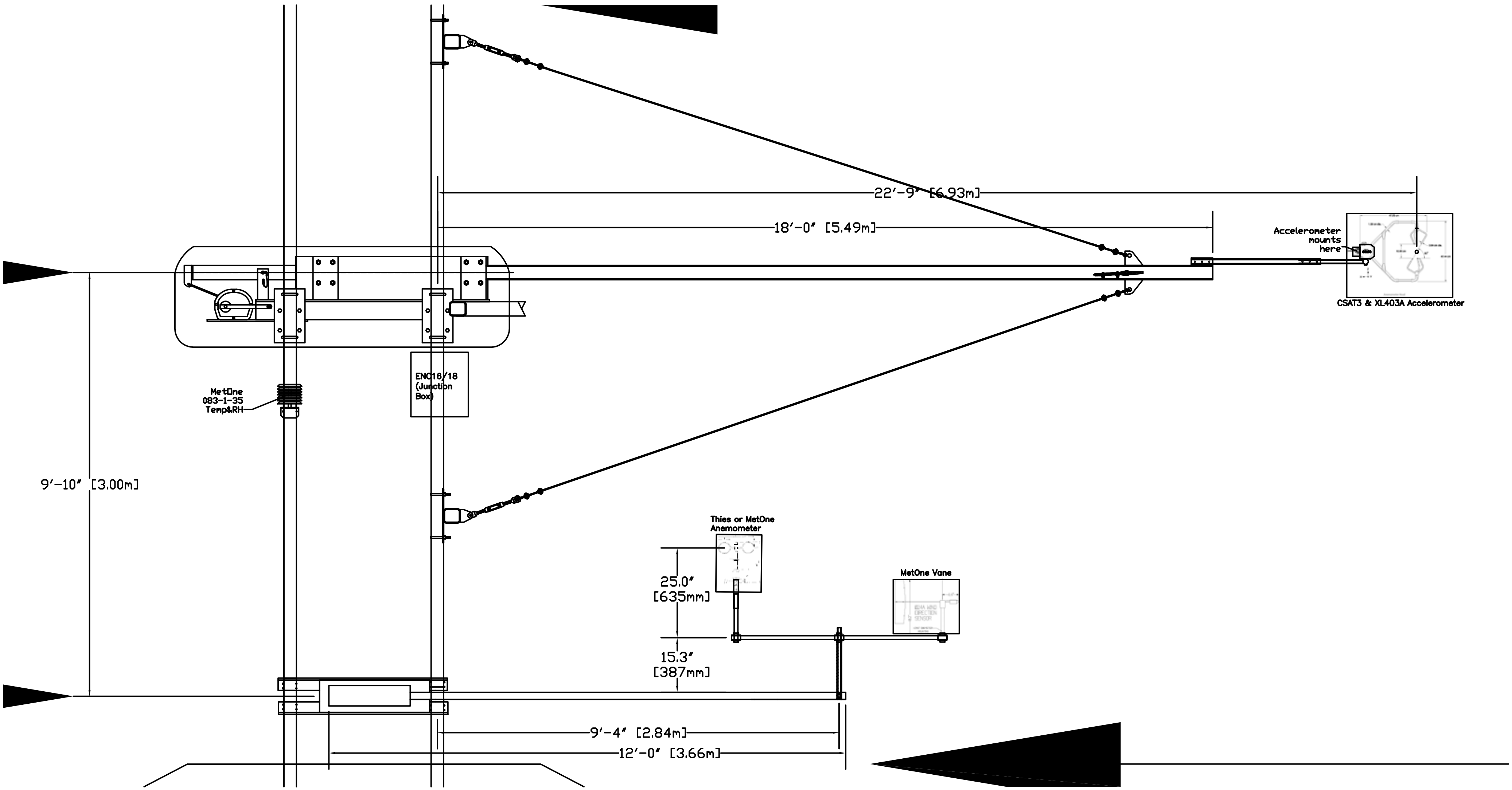
EOLOS Meta Device Measurement Specifications, Post 6/6/2013

SignalID	DeviceID	Manufacturer	Serial No.	Logger Channel #	Description	Meas. Rate (Hz)	Resolution	Threshold		Calibrated Range		Calibration		Recalibration Period	Accuracy	Units
								low	high	low	high	Slope	Offset	recommended - months	+/-	
Ux1	CSAT3_1	Campbell Scientific		Met A, SDM C1,C2,C3	Sonic Anemometer	20	0.01	0	30	0	30	NA	NA	NA	0.08+5% of meas	m/s
Uy1	CSAT3_1	Campbell Scientific		Met A, SDM C1,C2,C3	Sonic Anemometer	20	0.01	0	30	0	30	NA	NA	NA	0.08+5% of meas	m/s
Uz1	CSAT3_1	Campbell Scientific		Met A, SDM C1,C2,C3	Sonic Anemometer	20	0.01	0	30	0	30	NA	NA	NA	0.04+5% of meas	m/s
Ts1	CSAT3_1	Campbell Scientific		Met A, SDM C1,C2,C3	Sonic Anemometer	20	0.01	-30	50	-30	50	NA	NA	NA	Unknown	deg C
CSATDiag1	CSAT3_1	Campbell Scientific		Met A, SDM C1,C2,C3	Sonic Anemometer	20	1	NA	NA	NA	NA	NA	NA	NA	NA	None
Accel1_X	XL403A_1	Spectrum Sensors and Controls	1670A00031	Met A, Diff 6H	3 Axis Accelerometer	20	0.000001	-2	2	-2	2	989.57mV/g	2.5003V	Unknown	>.0001/(Hz)$^{0.5}$	g
Accel1_Z	XL403A_1	Spectrum Sensors and Controls	1670A00031	Met A, Diff 7H	3 Axis Accelerometer	20	0.000001	-2	2	-2	2	1003.87mV/g	2.5011V	Unknown	>.0001/(Hz)$^{0.5}$	g
Accel1_Y	XL403A_1	Spectrum Sensors and Controls	1670A00031	Met A, Diff 8H	3 Axis Accelerometer	20	0.000001	-2	2	-2	2	1005.02mV/g	2.4998V	Unknown	>.0001/(Hz)$^{0.5}$	g
WndSpd1	4.3351.00.000_3	Thies	05130019	Met A, P1	Class One Cup Anemometer	20	0.01	0.2869	80	0.2869	80	0.04573m/s/hz	0.2869m/s	Unknown	max(1.0% of meas, 0.2)	m/s
WndDir1	024A_1	Met One	M2887	Met A, SE 4	Wind Vane	1	0.1	0.447m/s	0.447m/s	0	360	729.1deg/Vo	0deg	24-36	5	deg
AirTemp1	083E-1-35_1	Met One	M8372	Met A, SE 8	Temperature Sensor	1	0.01	-50	50	-50	50	see manual	see manual	12	0.1	deg C
RH1	083E-1-35_1	Met One	M8372	Met A, SE 1	Relative Humidity Sensor	1	0.1	0	100	0	100	0.1%/mV	0%	12	2	%
WndSpd2	4.3351.00.000_3	Thies	05130018	Met A, P2	Class One Cup Anemometer	20	0.01	0.2426	80	0.2426	80	0.04592m/s/hz	0.2426m/s	Unknown	max(1.0% of meas, 0.2)	m/s
WndDir2	024A_2	Met One	M2892	Met A, SE 5	Wind Vane	1	0.1	0.447m/s	0.447m/s	0	360	728.3deg/Vo	0deg	24-36	5	deg
AirTemp2	083E-1-35_2	Met One	M8371	Met A, SE 9	Temperature Sensor	1	0.01	-50	50	-50	50	see manual	see manual	12	0.1	deg C
RH2	083E-1-35_2	Met One	M8371	Met A, SE 2	Relative Humidity Sensor	1	0.1	0	100	0	100	0.1%/mV	0%	12	2	%
Ux3	CSAT3_3	Campbell Scientific		Met A, SDM C1,C2,C3	Sonic Anemometer	20	0.01	0	30	0	30	NA	NA	NA	0.08+5% of meas	m/s
Uy3	CSAT3_3	Campbell Scientific		Met A, SDM C1,C2,C3	Sonic Anemometer	20	0.01	0	30	0	30	NA	NA	NA	0.08+5% of meas	m/s
Uz3	CSAT3_3	Campbell Scientific		Met A, SDM C1,C2,C3	Sonic Anemometer	20	0.01	0	30	0	30	NA	NA	NA	0.04+5% of meas	m/s
Ts3	CSAT3_3	Campbell Scientific		Met A, SDM C1,C2,C3	Sonic Anemometer	20	0.01	-30	50	-30	50	NA	NA	NA	Unknown	deg C
CSATDiag3	CSAT3_3	Campbell Scientific		Met A, SDM C1,C2,C3	Sonic Anemometer	20	1	NA	NA	NA	NA	NA	NA	NA	NA	None
Accel3_X	XL403A_3	Spectrum Sensors and Controls	1670A00028	Met A, Diff 9H	3 Axis Accelerometer	20	0.000001	-2	2	-2	2	1013.19mV/g	2.4995V	Unknown	>.0001/(Hz)$^{0.5}$	g
Accel3_Z	XL403A_3	Spectrum Sensors and Controls	1670A00028	Met A, Diff 10H	3 Axis Accelerometer	20	0.000001	-2	2	-2	2	991.51mV/g	2.4994V	Unknown	>.0001/(Hz)$^{0.5}$	g
Accel3_Y	XL403A_3	Spectrum Sensors and Controls	1670A00028	Met A, Diff 11H	3 Axis Accelerometer	20	0.000001	-2	2	-2	2	996.54mV/g	2.4992V	Unknown	>.0001/(Hz)$^{0.5}$	g
WndSpd3	4.3351.00.000_3	Thies	09114705	Met A, P3	Class One Cup Anemometer	20	0.01	0.21735	80	0.21735	80	0.04621m/s/hz	0.21735m/s	Unknown	max(1.0% of meas, 0.2)	m/s
WndDir3	024A_3	Met One	M2299	Met A, SE 6	Wind Vane	1	0.1	0.447m/s	0.447m/s	0	360	716.6deg/Vo	0deg	24-36	5	deg
AirTemp3	083E-1-35_3	Met One	M9257	Met A, SE 10	Temperature Sensor	1	0.01	-50	50	-50	50	see manual	see manual	12	0.1	deg C
RH3	083E-1-35_3	Met One	M9257	Met A, SE 3	Relative Humidity Sensor	1	0.1	0	100	0	100	0.1%/mV	0%	12	2	%
BarPres	092_3	Met One		Met A, SE 7	Barometric Pressure Sensor	1	1	600	1100	600	1100	0.1mBar/mV	600mBar	12	1	mbar
WndSpd4	4.3351.00.000_3	Thies	05130017	Met B, P1	Class One Cup Anemometer	20	0.01	0.2463	80	0.2463	80	0.04588m/s/hz	0.2463m/s	Unknown	max(1.0% of meas, 0.2)	m/s
WndDir4	024A_4	Met One	M2896	Met B, SE 4	Wind Vane	1	0.1	0.447m/s	0.447m/s	0	360	728.3deg/Vo	0deg	24-36	5	deg
AirTemp4	083E-1-35_4	Met One	M9258	Met B, SE 8	Temperature Sensor	1	0.01	-50	50	-50	50	see manual	see manual	12	0.1	deg C
RH4	083E-1-35_4	Met One	M9258	Met B, SE 1	Relative Humidity Sensor	1	0.1	0	100	0	100	0.1%/mV	0%	12	2	%
Ux5	CSAT3_5	Campbell Scientific		Met B, SDM C1,C2,C3	Sonic Anemometer	20	0.01	0	30	0	30	NA	NA	NA	0.08+5% of meas	m/s
Uy5	CSAT3_5	Campbell Scientific		Met B, SDM C1,C2,C3	Sonic Anemometer	20	0.01	0	30	0	30	NA	NA	NA	0.08+5% of meas	m/s
Uz5	CSAT3_5	Campbell Scientific		Met B, SDM C1,C2,C3	Sonic Anemometer	20	0.01	0	30	0	30	NA	NA	NA	0.04+5% of meas	m/s
Ts5	CSAT3_5	Campbell Scientific		Met B, SDM C1,C2,C3	Sonic Anemometer	20	0.01	-30	50	-30	50	NA	NA	NA	Unknown	deg C
CSATDiag5	CSAT3_5	Campbell Scientific		Met B, SDM C1,C2,C3	Sonic Anemometer	20	1	NA	NA	NA	NA	NA	NA	NA	NA	None
Accel5_X	XL403A_5	Spectrum Sensors and Controls	1670A00030	Met B, Diff 6H	3 Axis Accelerometer	20	0.000001	-2	2	-2	2	979.51mV/g	2.4997V	Unknown	>.0001/(Hz)$^{0.5}$	g
Accel5_Z	XL403A_5	Spectrum Sensors and Controls	1670A00030	Met B, Diff 7H	3 Axis Accelerometer	20	0.000001	-2	2	-2	2	1008.47mV/g	2.5006V	Unknown	>.0001/(Hz)$^{0.5}$	g
Accel5_Y	XL403A_5	Spectrum Sensors and Controls	1670A00030	Met B, Diff 8H	3 Axis Accelerometer	20	0.000001	-2	2	-2	2	1008.47mV/g	2.5006V	Unknown	>.0001/(Hz)$^{0.5}$	g
WndSpd5	011E_5	Met One	N4859	Met B, P2	Class One Cup Anemometer	20	0.01	0.2308	53	0.2308	60	0.04026m/s/hz	0.2308m/s	12-24	max(1.0% of meas, 0.1)	m/s
WndDir5	024A_5	Met One	M2904	Met B, SE 5	Wind Vane	1	0.1	0.447m/s	0.447m/s	0	360	730.0deg/Vo	0deg	24-36	5	deg
AirTemp5	083E-1-35_5	Met One	M9252	Met B, SE 9	Temperature Sensor	1	0.01	-50	50	-50	50	see manual	see manual	12	0.1	deg C
RH5	083E-1-35_5	Met One	M9252	Met B, SE 2	Relative Humidity Sensor	1	0.1	0	100	0	100	0.1%/mV	0%	12	2	%
Ux6	CSAT3_6	Campbell Scientific		Met B, SDM C1,C2,C3	Sonic Anemometer	20	0.01	0	30	0	30	NA	NA	NA	0.08+5% of meas	m/s
Uy6	CSAT3_6	Campbell Scientific		Met B, SDM C1,C2,C3	Sonic Anemometer	20	0.01	0	30	0	30	NA	NA	NA	0.08+5% of meas	m/s
Uz6	CSAT3_6	Campbell Scientific		Met B, SDM C1,C2,C3	Sonic Anemometer	20	0.01	0	30	0	30	NA	NA	NA	0.04+5% of meas	m/s
Ts6	CSAT3_6	Campbell Scientific		Met B, SDM C1,C2,C3	Sonic Anemometer	20	0.01	-30	50	-30	50	NA	NA	NA	Unknown	deg C
CSATDiag6	CSAT3_6	Campbell Scientific		Met B, SDM C1,C2,C3	Sonic Anemometer	20	1	NA	NA	NA	NA	NA	NA	NA	NA	None
Accel6_X	XL403A_6	Spectrum Sensors and Controls	1670A00029	Met B, Diff 9H	3 Axis Accelerometer	20	0.000001	-2	2	-2	2	1006.44mV/g	2.4998V	Unknown	>.0001/(Hz)$^{0.5}$	g
Accel6_Z	XL403A_6	Spectrum Sensors and Controls	1670A00029	Met B, Diff 10H	3 Axis Accelerometer	20	0.000001	-2	2	-2	2	1006.05mV/g	2.5006V	Unknown	>.0001/(Hz)$^{0.5}$	g
Accel6_Y	XL403A_6	Spectrum Sensors and Controls	1670A00029	Met B, Diff 11H	3 Axis Accelerometer	20	0.000001	-2	2	-2	2	1004.62mV/g	2.5008V	Unknown	>.0001/(Hz)$^{0.5}$	g
WndSpd6	011E_5	Met One	M8855	Met B, P3	Class One Cup Anemometer	20	0.01	0.1969	53	0.1969	60	0.04075m/s/hz	0.1969m/s	12-24	max(1.0% of meas, 0.1)	m/s
WndDir6	024A_6	Met One	M2886	Met B, SE 6	Wind Vane	1	0.1	0.447m/s	0.447m/s	0	360	729.2deg/Vo	0deg	24-36	5	deg
AirTemp6	083E-1-35_6	Met One	M9251	Met B, SE 10	Temperature Sensor	1	0.01	-50	50	-50	50	see manual	see manual	12	0.1	deg C
RH6	083E-1-35_6	Met One	M9251	Met B, SE 3	Relative Humidity Sensor	1	0.1	0	100	0	100	0.1%/mV	0%	12	2	%

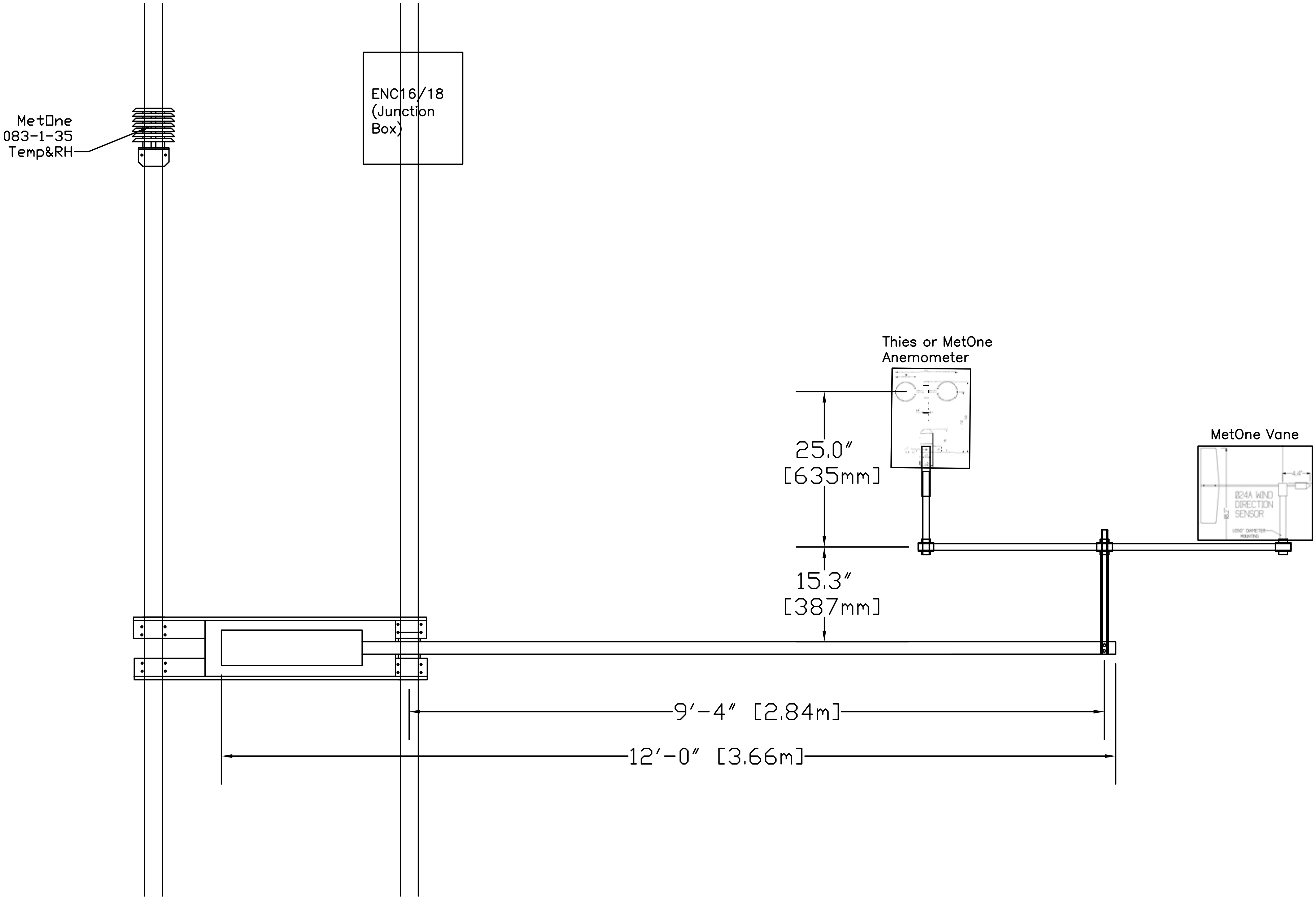
10.5 Met Tower Drawing with Boom Locations


Elev. 1
423.2′ (129m)
413.4′ (126m)
425′ (129.5m) -Top of Tower
407′ (124.0m)
Elev. 2
334.7′ (102m)
327′ (99.7m)
Elev. 3
262.5′ (80m)
252.6′ (77m)
247′ (75.3m)
Elev. 4
170.6′ (52m)
167′ (50.9m)
Elev. 5
98.4′ (30m)
88.6′ (27m)
Pipe size break
87′ (26.5m)
Elev. 6
32.8′ (10m)
23.0′ (7m)
Pipe size break
Cross section upper guy and tower
Cross section lower guy and tower
170′-0″ [51.82m]
360′-0″ [109.73m]

10.6 Detail Drawings of Booms 1,3,5,6


22'-9" [6.93m]
18'-0" [5.49m]
Accelerometer mounts here
CSAT3 & XL403A Accelerometer
MetOne 083-1-35 Temp&RH
ENC16/18 (Junction Box)
9'-10" [3.00m]
Thies or MetOne Anemometer
MetOne Vane
25.0" [635mm]
15.3" [387mm]
9'-4" [2.84m]
12'-0" [3.66m]

10.7 Detail Drawings of Booms 2 and 4



MetOne
083-1-35
Temp&RH
ENC16/18
(Junction
Box)
Thies or MetOne
Anemometer
MetOne Vane
024A WIND
DIRECTION
SENSOR
25.0"
[635mm]
15.3"
[387mm]
9'-4" [2.84m]
12'-0" [3.66m]

10.8 Wiring Diagrams

DATALOGGER ENCLOSURE A

CABLE	GROUP LABEL	COLOR	LOG ENC TERMINAL	LOG ENC COMPONENT	COLOR	COMPONENT TERMINAL	SENSOR	NOTES
ELEVATION 1	GROUP1	BLK	1	CH200	RED	12V	---	
		WHT	2	CH200	RED	12V	---	
		RED	3	CH200	RED	12V	---	
	GROUP2	BLK	4	CH200	BLACK	G	---	
		WHT	5	CH200	BLACK	G	---	
		GRN	6	CH200	BLACK	G	---	
								Shields (1&2) to GND Terminal
								ORANGE DIVIDER
	GROUP3	BLK	7	CR3000	RED	12VDC	083E	
		WHT	8	CR3000	BLACK	G	083E	
		RED	9	CR3000	WHITE	SE1	083E	
		GRN	10	CR3000	BLACK	AG-1	083E	
		BLU	11	CR3000	WHITE	SE15	083E	(JUMPER 23.1K 0.1% TO VX1)
		BRN	12	---	---	---	---	
	GROUP4	BLK	13	CR3000	LT BLUE	P1	014A	
		WHT	14	CR3000	BLACK	AG-18	014A	
		RED	15	---	---	---	---	
		GRN	16	---	---	---	---	
								Shields (3&4) to GND Terminal
	GROUP5	BLK	17	CR3000	WHITE	SE4	024A	
		WHT	18	CR3000	BLACK	AG-2	024A	
		RED	19	CR3000	BLUE	VX1	024A	
		BLU	20	---	---	---	---	
	GROUP6	BLK	21	CR3000	WHITE	SE18	ACCELO	
		WHT	22	CR3000	WHITE	SE19	ACCELO	
		RED	23	CR3000	WHITE	SE20	ACCELO	
		BRN	24	CR3000	BLACK	AG-10	ACCELO	
								Shields (5,6&7) to GND Terminal
	GROUP7	BLK	25	---	---	---	---	
		WHT	26	---	---	---	---	
		RED	27	---		---	---	
		VLT	28	CR3000	WHITE	C1	ACCELO	
								ORANGE DIVIDER+STOPPER

DATALOGGER ENCLOSURE A

CABLE	Group Label	COLOR	LOG ENC TERMINAL	LOG ENC COMPONENT	COLOR	COMPONENT TERMINAL	SENSOR	NOTES
ELEVATION 2	GROUP1	BLK	---	CH200	RED	12V	---	NO FIELD WIRE
		WHT	---	CH200	RED	12V	---	NO FIELD WIRE
		RED	---	CH200	RED	12V	---	NO FIELD WIRE
	GROUP2	BLK	---	CH200	BLACK	G	---	NO FIELD WIRE
		WHT	---	CH200	BLACK	G	---	NO FIELD WIRE
		GRN	---	CH200	BLACK	G	---	NO FIELD WIRE
								Shields (1&2) to GND Terminal
								ORANGE DIVIDER
	GROUP3	BLK	7	CR3000	RED	12VDC	083E	
		WHT	8	CR3000	BLACK	G	083E	
		RED	9	CR3000	WHITE	SE2	083E	
		GRN	10	CR3000	BLACK	AG-1	083E	
		BLU	11	CR3000	WHITE	SE16	083E	(JUMPER 23.1K 0.1% TO VX2)
		BRN	12	---	---	---	---	
	GROUP4	BLK	13	CR3000	LT BLUE	P2	014A	
		WHT	14	CR3000	BLACK	AG-19	014A	
		RED	15	---	---	---	---	
		GRN	16	---	---	---	---	
								Shields (3&4) to GND Terminal
	GROUP5	BLK	17	CR3000	WHITE	SE5	024A	
		WHT	18	CR3000	BLACK	AG-3	024A	
		RED	19	CR3000	BLUE	VX2	024A	
		BLU	20	---	---	---	---	
	GROUP6	BLK	21	---	---	---	---	
		WHT	22	---	---	---	---	
		RED	23	---	---	---	---	
		BRN	24	---	---	---	---	
								Shields (5,6&7) to GND Terminal
	GROUP7	BLK	25	---	---	---	---	
		WHT	26	---	---	---	---	
		RED	27	---	---	---	---	
		VLT	28	---	---	---	---	
								ORANGE DIVIDER+STOPPER

DATALOGGER ENCLOSURE A

CABLE	Group Label	COLOR	LOG ENC TERMINAL	LOG ENC COMPONENT	COLOR	COMPONENT TERMINAL	SENSOR	NOTES
ELEVATION 3	GROUP1	BLK	1	CH200	RED	12V	---	
		WHT	2	CH200	RED	12V	---	
		RED	3	CH200	RED	12V	---	
	GROUP2	BLK	4	CH200	BLACK	G	---	
		WHT	5	CH200	BLACK	G	---	
		GRN	6	CH200	BLACK	G	---	
								Shields (1&2) to GND Terminal
								ORANGE DIVIDER
	GROUP3	BLK	7	CR3000	RED	12VDC	083E	
		WHT	8	CR3000	BLACK	G	083E	
		RED	9	CR3000	WHITE	SE3	083E	
		GRN	10	CR3000	BLACK	AG-2	083E	
		BLU	11	CR3000	WHITE	SE17	083E	(JUMPER 23.1K 0.1% TO VX3)
		BRN	12	---	---	---	---	
	GROUP4	BLK	13	CR3000	LT BLUE	P3	014A	
		WHT	14	CR3000	BLACK	AG-20	014A	
		RED	15	CR3000	LT BLUE	P4	THEIS	
		GRN	16	CR3000	BLACK	AG-21	THEIS	
								Shields (3&4) to GND Terminal
	GROUP5	BLK	17	CR3000	WHITE	SE6	024A	
		WHT	18	CR3000	BLACK	AG-3	024A	
		RED	19	CR3000	BLUE	VX3	024A	
		BLU	20	---	---	---	---	
	GROUP6	BLK	21	CR3000	WHITE	SE21	ACCELO	
		WHT	22	CR3000	WHITE	SE22	ACCELO	
		RED	23	CR3000	WHITE	SE23	ACCELO	
		BRN	24	CR3000	BLACK	AG-11	ACCELO	
								Shields (5,6&7) to GND Terminal
	GROUP7	BLK	25	CR3000	WHITE	SE7	---	
		WHT	26	CR3000	BLACK	AG-4	---	
		RED	27	CR3000	WHITE	C3	THEIS	
		VLT	28	CR3000	WHITE	C2	ACCELO	
								ORANGE DIVIDER+STOPPER

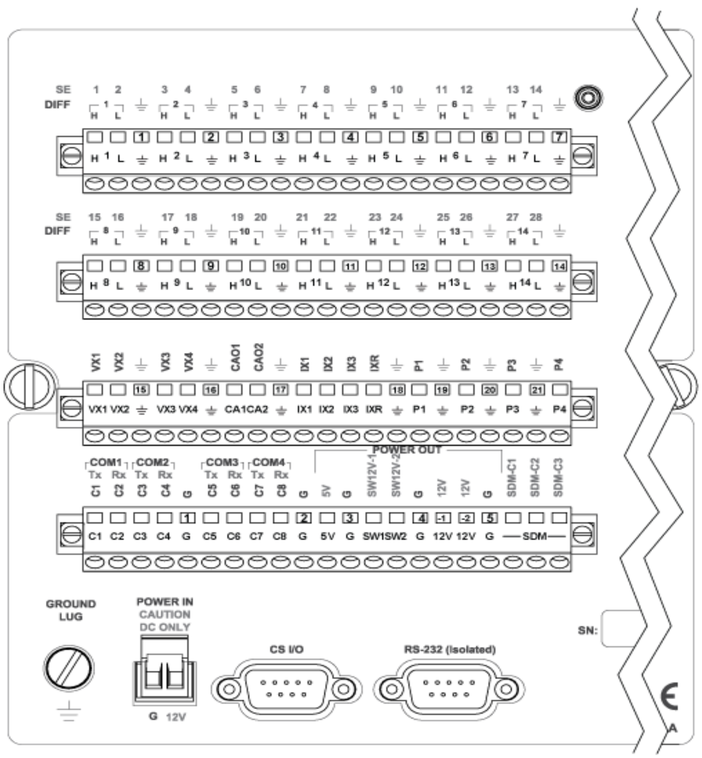
DATALOGGER ENCLOSURE A

CABLE	COLOR	LOG ENC TERMINAL	LOG ENC COMPONENT	COLOR	COMPONENT TERMINAL	SENSOR	NOTES
SDM -ELEV3	GREEN	1	CR3000	GREEN	SDM-C1	CSAT	
	YELLOW	2	CR3000	WHITE	SDM-C2	CSAT	
	RED	3	CR3000	BROWN	SDM-C3	CSAT	
	BLACK	4	CR3000	BLACK	G-5	CSAT	
							ORANGE DIVIDER+STOPPER

CABLE	COLOR	LOG ENC TERMINAL	LOG ENC COMPONENT	COLOR	COMPONENT TERMINAL	SENSOR	NOTES
GPS JUMPER	---	31	CR3000	RED	C7	GPS	DO NOT WIRE
	---	32	CR3000	BLACK	C8	GPS	DO NOT WIRE
	BLUE	33	CR3000	BLACK	G	GPS	
	YELLOW	34	CR3000	BLACK	12V	GPS	
	GREEN	35	CR3000	LT BLUE	G	GPS	
	WHITE	36	CR3000	LT BLUE	G	GPS	
	SHIELD	GND	GROUND	---	---		

CABLE	COLOR	ENC TERMINAL	LOG ENC COMPONENT	
24 VDC	RED	CIRCUIT BREAKER	CH200	CHG
	BLACK	GREY TERMINAL	CH200	CHG
RF401	NTN MALE	SURGE SUPPRESSOR	RF401	CR3000
ANTENNA		NTN FEMALE	Antenna	CS I/O

CR3000
MICROLOGGER



DATALOGGER ENCLOSURE B

CABLE	Group Label	CABLE ELEVATION 1	LOG ENC TERMINAL	LOG ENC COMPONENT	COLOR	COMPONENT TERMINAL	SENSOR	NOTES
ELEVATION 4	GROUP1	BLK	---	CH200	RED	12V	---	NO FIELD WIRE
		WHT	---	CH200	RED	12V	---	NO FIELD WIRE
		RED	---	CH200	RED	12V	---	NO FIELD WIRE
	GROUP2	BLK	---	CH200	BLACK	G	---	NO FIELD WIRE
		WHT	---	CH200	BLACK	G	---	NO FIELD WIRE
		GRN	---	CH200	BLACK	G	---	NO FIELD WIRE
								Shields (1&2) to GND Terminal
								ORANGE DIVIDER
	GROUP3	BLK	7	CR3000	RED	12VDC	083E	
		WHT	8	CR3000	BLACK	G	083E	
		RED	9	CR3000	WHITE	SE1	083E	
		GRN	10	CR3000	BLACK	AG-1	083E	
		BLU	11	CR3000	WHITE	SE15	083E	(JUMPER 23.1K 0.1% TO VX1)
		BRN	12	---	---	---	---	
	GROUP4	BLK	13	CR3000	LT BLUE	P1	014A	
		WHT	14	CR3000	BLACK	AG-18	014A	
		RED	15	---	---	---	---	
		GRN	16	---	---	---	---	
								Shields (3&4) to GND Terminal
	GROUP5	BLK	17	CR3000	WHITE	SE4	024A	
		WHT	18	CR3000	BLACK	AG-2	024A	
		RED	19	CR3000	BLUE	VX1	024A	
		BLU	20	---	---	---	---	
	GROUP6	BLK	21	---	---	---	---	
		WHT	22	---	---	---	---	
		RED	23	---	---	---	---	
		BRN	24	---	---	---	---	
								Shields (5,6&7) to GND Terminal
	GROUP7	BLK	25	---	---	---	---	
		WHT	26	---	---	---	---	
		RED	27	---		---	---	
		VLT	28	---	---	---	---	
								ORANGE DIVIDER+STOPPER

DATALOGGER ENCLOSURE B

CABLE	Group Label	CABLE ELEVATION 2	LOG ENC TERMINAL	LOG ENC COMPONENT	COLOR	COMPONENT TERMINAL	SENSOR	NOTES
ELEVATION 5	GROUP1	BLK	1	CH200	RED	12V	---	
		WHT	2	CH200	RED	12V	---	
		RED	3	CH200	RED	12V	---	
	GROUP2	BLK	4	CH200	BLACK	G	---	
		WHT	5	CH200	BLACK	G	---	
		GRN	6	CH200	BLACK	G	---	
								Shields (1&2) to GND Terminal
								ORANGE DIVIDER
	GROUP3	BLK	7	CR3000	RED	12VDC	083E	
		WHT	8	CR3000	BLACK	G	083E	
		RED	9	CR3000	WHITE	SE2	083E	
		GRN	10	CR3000	BLACK	AG-1	083E	
		BLU	11	CR3000	WHITE	SE16	083E	(JUMPER 23.1K 0.1% TO VX2)
		BRN	12	---	---	---	---	
	GROUP4	BLK	13	CR3000	LT BLUE	P2	014A	
		WHT	14	CR3000	BLACK	AG-19	014A	
		RED	15	---	---	---	---	
		GRN	16	---	---	---	---	
								Shields (3&4) to GND Terminal
	GROUP5	BLK	17	CR3000	WHITE	SE5	024A	
		WHT	18	CR3000	BLACK	AG-3	024A	
		RED	19	CR3000	BLUE	VX2	024A	
		BLU	20	---	---	---	---	
	GROUP6	BLK	21	CR3000	WHITE	SE18	ACCELO	
		WHT	22	CR3000	WHITE	SE19	ACCELO	
		RED	23	CR3000	WHITE	SE20	ACCELO	
		BRN	24	CR3000	BLACK	AG-10	ACCELO	
								Shields (5,6&7) to GND Terminal
	GROUP7	BLK	25	---	---	---	---	
		WHT	26	---	---	---	---	
		RED	27	---	---	---	---	
		VLT	28	CR3000	WHITE	C1	ACCELO	
								ORANGE DIVIDER+STOPPER

DATALOGGER ENCLOSURE B

CABLE	Group Label	CABLE ELEVATION 2	LOG ENC TERMINAL	LOG ENC COMPONENT	COLOR	COMPONENT TERMINAL	SENSOR	NOTES
ELEVATION 6	GROUP1	BLK	1	CH200	RED	12V	---	
		WHT	2	CH200	RED	12V	---	
		RED	3	CH200	RED	12V	---	
	GROUP2	BLK	4	CH200	BLACK	G	---	
		WHT	5	CH200	BLACK	G	---	
		GRN	6	CH200	BLACK	G	---	
								Shields (1&2) to GND Terminal
								ORANGE DIVIDER
	GROUP3	BLK	7	CR3000	RED	12VDC	083E	
		WHT	8	CR3000	BLACK	G	083E	
		RED	9	CR3000	WHITE	SE3	083E	
		GRN	10	CR3000	BLACK	AG-2	083E	
		BLU	11	CR3000	WHITE	SE17	083E	(JUMPER 23.1K 0.1% TO VX3)
		BRN	12	---	---	---	---	
	GROUP4	BLK	13	CR3000	LT BLUE	P3	014A	
		WHT	14	CR3000	BLACK	AG-20	014A	
		RED	15	---	---	---	---	
		GRN	16	---	---	---	---	
								Shields (3&4) to GND Terminal
	GROUP5	BLK	17	CR3000	WHITE	SE6	024A	
		WHT	18	CR3000	BLACK	AG-3	024A	
		RED	19	CR3000	BLUE	VX3	024A	
		BLU	20	---	---	---	---	
	GROUP6	BLK	21	CR3000	WHITE	SE21	ACCELO	
		WHT	22	CR3000	WHITE	SE22	ACCELO	
		RED	23	CR3000	WHITE	SE23	ACCELO	
		BRN	24	CR3000	BLACK	AG-11	ACCELO	
								Shields (5,6&7) to GND Terminal
	GROUP7	BLK	25	---	---	---	---	
		WHT	26	---	---	---	---	
		RED	27	---	---	---	---	
		VLT	28	CR3000	WHITE	C2	ACCELO	
								ORANGE DIVIDER+STOPPER

DATALOGGER ENCLOSURE B

Group Label	CABLE ELEVATION 2	LOG ENC TERMINAL	LOG ENC COMPONENT	COLOR	COMPONENT TERMINAL	SENSOR	NOTES
SDM -ELEV3	GREEN	1	CR3000	GREEN	SDM-C1	CSAT	
	WHITE	2	CR3000	WHITE	SDM-C2	CSAT	
	BROWN	3	CR3000	BROWN	SDM-C3	CSAT	
	BLACK	4	CR3000	BLACK	G-5	CSAT	
							ORANGE DIVIDER+STOPPER

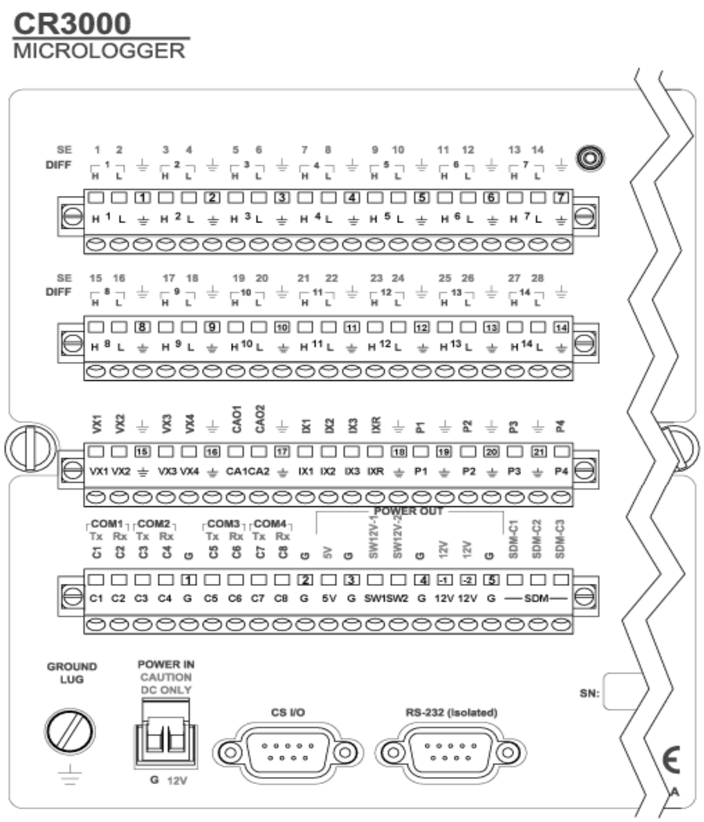
CABLE	COLOR	ENC TERMINAL	LOG ENC COMPONENT
AC IN	BLACK	CIRCUIT BREAKER	POWER ADAPTER AC/DC
	WHITE	GREY TERMINAL	24VDC 10A W/ UNIVERSAL
	GREEN	GREY TERMINAL	INPUTS (100-240VAC)
AC OUT ELEV 1	L	POWER BUS	CIRCUIT BREAKER
	N	POWER BUS	GREY TERMINAL
AC OUT ELEV 2	L	POWER BUS	CIRCUIT BREAKER
	N	POWER BUS	GREY TERMINAL
AC OUT ELEV 3	L	POWER BUS	CIRCUIT BREAKER
	N	POWER BUS	GREY TERMINAL
AC OUT ELEV 4	L	POWER BUS	CIRCUIT BREAKER
	N	POWER BUS	GREY TERMINAL
AC OUT ELEV 5	L	POWER BUS	CIRCUIT BREAKER
	N	POWER BUS	GREY TERMINAL
AC OUT ELEV 6	L	POWER BUS	CIRCUIT BREAKER
	N	POWER BUS	GREY TERMINAL

ORANGE DIVIDER+STOPPER

CABLE	COLOR	ENC TERMINAL	LOG ENC COMPONENT
24 VDC JUMPER	RED	37	POWER ADAPTER AC/DC
	BLACK	38	24VDC 10A W/ UNIVERSAL
THEIS HEAT	RED	39	INPUTS (100-240VAC)
	BLACK	40	

ORANGE DIVIDER+STOPPER

CABLES	COLOR	LOG ENC TERMINAL	LOG ENC COMPONENT	COLOR	COMPONENT TERMINAL	SENSOR	NOTES
GPS16X-HVS	RED	31	CR3000	RED	C7	GPS	
GPS JUMPER	BLACK	32	CR3000	BLACK	C8	GPS	
	BLUE	33	CR3000	BLACK	G	GPS	
	YELLOW	34	CR3000	BLACK	12V	GPS	
	GREEN	35	CR3000	LT BLUE	G	GPS	
	WHITE	36	CR3000	LT BLUE	G	GPS	
	SHIELD	GND	GROUND	---	---		


CR3000
MICROLOGGER
SE
DIFF
GROUND LUG
POWER IN
CAUTION
DC ONLY
G 12V
CS I/O
RS-232 (Isolated)
SN:
POWER OUT
COM1
COM2
COM3
COM4

JUNCTION BOX
ELEVATION 1

			JBOX ENC	DOWN TOWER CABLE		COMPONENT	
			TERMINAL	(GROUP) LABEL	COLOR	TERMINAL	NOTES
SENSOR	**FUNCTION**	**WIRE COLOR**					ORANGE DIVIDER+STOPPER
CSAT3	12VDC	RED	1	GROUP 1	BLACK	12V	Vertical Jumper
			2	GROUP 1	WHITE	12V	Vertical Jumper
XL403A	_+Vs (PIN 8)	PURPLE	3	GROUP 1	RED	12V	Vertical Jumper
							ORANGE DIVIDER+STOPPER
XL403A	GND (PIN 9)	GREY	4	GROUP 2	BLACK	G	Vertical Jumper
			5	GROUP 2	WHITE	G	Vertical Jumper
CSAT3	POWER REF	BLACK	6	GROUP 2	GREEN	G	Vertical Jumper
							ORANGE DIVIDER
083E-1-35	POWER	WHITE	7	GROUP 3	BLACK	12VDC	
TEMP/RH	COMMON GND	GREEN	8	GROUP 3	WHITE	G	
	RH SIGNAL	BLUE	9	GROUP 3	RED	SE1	
	TEMP SIGNAL REF	BLACK	10	GROUP 3	GREEN	AG-1	
	TEMP SIGNAL	RED	11	GROUP 3	BLUE	SE15	(JUMPER 23.1K 0.1% TO VX1)
			12	GROUP 3	BROWN	---	
014A	SIGNAL REF	RED	13	GROUP 4	BLACK	P1	
WS	SIGNAL	BLACK	14	GROUP 4	WHITE	AG-18	
			15	GROUP 4	RED	---	
			16	GROUP 4	GREEN	---	
	SHIELD	WHITE/BROWN					Shields (3&4) to GND Terminal
024A	SIGNAL	RED	17	GROUP 5	BLACK	SE4	
WD	COMMON GND	WHITE	18	GROUP 5	WHITE	AG-2	
	POWER	BLACK	19	GROUP 5	RED	VX4	
			20	GROUP 5	BLUE	---	
XL403A	SIGNAL X1 (PIN1)	BLACK	21	GROUP 6	BLACK	SE18	
ACCELO	SIGNAL X2 (PIN 2)	WHITE	22	GROUP 6	WHITE	SE19	
	SIGNAL X3 (PIN 3)	BROWN	23	GROUP 6	RED	SE20	
	SIGNAL GND (PIN 4)	RED	24	GROUP 6	BROWN	AG-10	
							Shields (5,6&7) to GND Terminal
			25	GROUP 7	BLACK	---	
			26	GROUP 7	WHITE	---	
			27	GROUP 7	RED	---	
XL403A	SELF TEST (PIN 7)	BLUE	28	GROUP 7	VIOLET	C1	
							ORANGE DIVIDER+STOPPER
CSAT3	SDM DATA	GREEN	31	CSAT3 E1 TO E2	GREEN	SDM-C1	Vertical Jumper
ELEV 1	SDM CLOCK	WHITE	34	CSAT3 E1 TO E2	YELLOW	SDM-C2	
	SDM ENABLE	BROWN	37	CSAT3 E1 TO E2	RED	SDM-C3	Vertical Jumper
	DIGITAL GROUND	BLACK	40	CSAT3 E1 TO E2	BLACK	G-5	
							ORANGE DIVIDER+STOPPER

JUNCTION BOX
ELEVATION 2

			JBOX ENC	DOWN TOWER CABLES		COMPONENT	
			TERMINAL	(GROUP) LABEL	COLOR	TERMINAL	NOTES
SENSOR	FUNCTION	WIRE COLOR					ORANGE DIVIDER+STOPPER
			1	GROUP 1	BLACK	12V	Vertical Jumper
			2	GROUP 1	WHITE	12V	Vertical Jumper
XL403A	_+Vs (PIN 8)	PURPLE	3	GROUP 1	RED	12V	Vertical Jumper
							ORANGE DIVIDER+STOPPER
XL403A	GND (PIN 9)	GREY	4	GROUP 2	BLACK	G	Vertical Jumper
			5	GROUP 2	WHITE	G	Vertical Jumper
			6	GROUP 2	GREEN	G	Vertical Jumper
							ORANGE DIVIDER
083E-1-35	POWER	WHITE	7	GROUP 3	BLACK	12VDC	
TEMP/RH	COMMON GND	GREEN	8	GROUP 3	WHITE	G	
	RH SIGNAL	BLUE	9	GROUP 3	RED	SE2	
	TEMP SIGNAL REF	BLACK	10	GROUP 3	GREEN	AG-1	
	TEMP SIGNAL	RED	11	GROUP 3	BLUE	SE16	(JUMPER 23.1K 0.1% TO VX2)
			12	GROUP 3	BROWN	---	
014A	SIGNAL REF	RED	13	GROUP 4	BLACK	P2	
WS	SIGNAL	BLACK	14	GROUP 4	WHITE	AG-18	
			15	GROUP 4	RED	---	
			16	GROUP 4	GREEN	---	
	SHIELD	WHITE/BROWN					Shields (3&4) to GND Terminal
024A	SIGNAL	RED	17	GROUP 5	BLACK	SE5	
WD	COMMON GND	WHITE	18	GROUP 5	WHITE	AG-3	
	POWER	BLACK	19	GROUP 5	RED	VX2	
			20	GROUP 5	BLUE	---	
XL403A	SIGNAL X1 (PIN1)	BLACK	21	GROUP 6	BLACK	---	
ACCELO	SIGNAL X2 (PIN 2)	WHITE	22	GROUP 6	WHITE	---	
	SIGNAL X3 (PIN 3)	BROWN	23	GROUP 6	RED	---	
	SIGNAL GND (PIN 4)	RED	24	GROUP 6	BROWN	---	
							Shields (5,6&7) to GND Terminal
			25	GROUP 7	BLACK	---	
			26	GROUP 7	WHITE	---	
			27	GROUP 7	RED	---	
XL403A	SELF TEST (PIN 7)	BLUE	28	GROUP 7	VIOLET	---	
							ORANGE DIVIDER+STOPPER
			31	CSAT3 E1 TO E2	GREEN	---	Vertical Jumper
			32	CSAT3 E2 TO E3	GREEN		
			34	CSAT3 E1 TO E2	YELLOW	---	Vertical Jumper
			35	CSAT3 E2 TO E3	YELLOW		
			37	CSAT3 E1 TO E2	RED	---	Vertical Jumper
			38	CSAT3 E2 TO E3	RED		
			40	CSAT3 E1 TO E2	BLACK	---	Vertical Jumper
			41	CSAT3 E2 TO E3	BLACK		
							ORANGE DIVIDER+STOPPER

JUNCTION BOX
ELEVATION 3
HUB HEIGHT

			JBOX ENC	DOWN TOWER CABLES		COMPONENT	
			TERMINAL	(GROUP) LABEL	COLOR	TERMINAL	NOTES
SENSOR	FUNCTION	WIRE COLOR					ORANGE DIVIDER+STOPPER
CSAT3	12VDC	RED	1	GROUP 1	BLACK	12V	Horizontal&Vertical Jumper
_092	(+12V IN)	RED	2	GROUP 1	WHITE	12V	Horizontal&Vertical Jumper
XL403A	_+Vs (PIN 8)	PURPLE	3	GROUP 1	RED	12V	Horizontal&Vertical Jumper
THEIS	_+Us	BLUE	1	GROUP 1	BLACK	12V	Horizontal&Vertical Jumper
							ORANGE DIVIDER+STOPPER
XL403A	GND (PIN 9)	GREY	4	GROUP 2	BLACK	G	Horizontal&Vertical Jumper
_092	(GND)	BLACK	5	GROUP 2	WHITE	G	Horizontal&Vertical Jumper
CSAT3	POWER REF	BLACK	6	GROUP 2	GREEN	G	Horizontal&Vertical Jumper
			4	GROUP 2	BLACK	G	Horizontal&Vertical Jumper
							ORANGE DIVIDER
083E-1-35	POWER	WHITE	7	GROUP 3	BLACK	12VDC	
TEMP/RH	COMMON GND	GREEN	8	GROUP 3	WHITE	G	
	RH SIGNAL	BLUE	9	GROUP 3	RED	SE3	
	TEMP SIGNAL REF	BLACK	10	GROUP 3	GREEN	AG-1	
	TEMP SIGNAL	RED	11	GROUP 3	BLUE	SE17	(JUMPER 23.1K 0.1% TO VX3)
			12	GROUP 3	BROWN	---	
			13	GROUP 4	BLACK	---	
			14	GROUP 4	WHITE	---	
THEIS	SIGNAL REF	GREEN	15	GROUP 4	RED	P4	
WS	SIGNAL	WHITE	16	GROUP 4	GREEN	AG-21	
							Shields (3&4) to GND Terminal
024A	SIGNAL	RED	17	GROUP 5	BLACK	SE6	
WD	COMMON GND	WHITE	18	GROUP 5	WHITE	AG-3	
	POWER	BLACK	19	GROUP 5	RED	VX3	
			20	GROUP 5	BLUE	---	
XL403A	SIGNAL X1 (PIN1)	BLACK	21	GROUP 6	BLACK	SE21	
ACCELO	SIGNAL X2 (PIN 2)	WHITE	22	GROUP 6	WHITE	SE22	
	SIGNAL X3 (PIN 3)	BROWN	23	GROUP 6	RED	SE23	
	SIGNAL GND (PIN 4)	RED	24	GROUP 6	BROWN	AG-11	
							Shields (5,6&7) to GND Terminal
_092	SIGNAL	WHITE	25	GROUP 7	BLACK	SE7	
BP	SIGNAL REF	GREEN	26	GROUP 7	WHITE	AG-4	
THEIS	HGND	YELLOW	27	GROUP 7	RED	C3	
XL403A	SELF TEST (PIN 7)	BLUE	28	GROUP 7	VIOLET	C2	
							ORANGE DIVIDER+STOPPER
CSAT3	SDM DATA	GREEN	31	CSAT3 E2 TO E3	GREEN	---	Vertical Jumper
ELEV 3	SDM CLOCK	WHITE	32	CSAT3 E3 TO ENC A	GREEN	---	
	SDM ENABLE	BROWN	34	CSAT3 E2 TO E3	YELLOW	---	Vertical Jumper
	DIGITAL GROUND	BLACK	35	CSAT3 E3 TO ENC A	YELLOW	---	
			37	CSAT3 E2 TO E3	RED	---	Vertical Jumper
			38	CSAT3 E3 TO ENC A	RED	---	
			40	CSAT3 E2 TO E3	BLACK	---	Vertical Jumper
			41	CSAT3 E3 TO ENC A	BLACK	---	
							ORANGE DIVIDER+STOPPER
THEIS	(+) HEAT	RED	43	24VDC	RED	24V	Theis Heated
THEIS	(-) HEAT	BLACK	46	24VDC	BLACK	G	Theis Heated

JUNCTION BOX
ELEVATION 4

			JBOX ENC	DOWN TOWER CABLES		COMPONENT	
			TERMINAL	(GROUP) LABEL	COLOR	TERMINAL	NOTES
SENSOR	FUNCTION	WIRE COLOR					ORANGE DIVIDER+STOPPER
			1	GROUP 1	BLACK	12V	Vertical Jumper
			2	GROUP 1	WHITE	12V	Vertical Jumper
XL403A	_+Vs (PIN 8)	PURPLE	3	GROUP 1	RED	12V	Vertical Jumper
							ORANGE DIVIDER+STOPPER
XL403A	GND (PIN 9)	GREY	4	GROUP 2	BLACK	G	Vertical Jumper
			5	GROUP 2	WHITE	G	Vertical Jumper
			6	GROUP 2	GREEN	G	Vertical Jumper
							ORANGE DIVIDER
083E-1-35	POWER	WHITE	7	GROUP 3	BLACK	12VDC	
TEMP/RH	COMMON GND	GREEN	8	GROUP 3	WHITE	G	
	RH SIGNAL	BLUE	9	GROUP 3	RED	SE1	
	TEMP SIGNAL REF	BLACK	10	GROUP 3	GREEN	AG-1	
	TEMP SIGNAL	RED	11	GROUP 3	BLUE	SE15	(JUMPER 23.1K 0.1% TO VX1)
			12	GROUP 3	BROWN	---	
014A	SIGNAL REF	RED	13	GROUP 4	BLACK	P1	
WS	SIGNAL	BLACK	14	GROUP 4	WHITE	AG-18	
			15	GROUP 4	RED	---	
			16	GROUP 4	GREEN	---	
	SHIELD	WHITE/BROWN					Shields (3&4) to GND Terminal
024A	SIGNAL	RED	17	GROUP 5	BLACK	SE4	
WD	COMMON GND	WHITE	18	GROUP 5	WHITE	AG-2	
	POWER	BLACK	19	GROUP 5	RED	VX4	
			20	GROUP 5	BLUE	---	
XL403A	SIGNAL X1 (PIN1)	BLACK	21	GROUP 6	BLACK	---	
ACCELO	SIGNAL X2 (PIN 2)	WHITE	22	GROUP 6	WHITE	---	
	SIGNAL X3 (PIN 3)	BROWN	23	GROUP 6	RED	---	
	SIGNAL GND (PIN 4)	RED	24	GROUP 6	BROWN	---	
							Shields (5,6&7) to GND Terminal
			25	GROUP 7	BLACK	---	
			26	GROUP 7	WHITE	---	
			27	GROUP 7	RED	---	
XL403A	SELF TEST (PIN 7)	BLUE	28	GROUP 7	VIOLET	---	
							ORANGE DIVIDER+STOPPER
			31	CSAT3 E4 TO E5	GREEN	---	Vertical Jumper
			32	CSAT3 E4 TO E5	WHITE	---	
			34	CSAT3 E4 TO E5	BROWN	---	Vertical Jumper
			35	CSAT3 E4 TO E5	BLACK	---	
							ORANGE DIVIDER+STOPPER

JUNCTION BOX
ELEVATION 5

SENSOR	FUNCTION	WIRE COLOR	JBOX ENC TERMINAL	DOWN TOWER CABLES (GROUP) LABEL	COLOR	COMPONENT TERMINAL	NOTES
							ORANGE DIVIDER+STOPPER
CSAT3	12VDC	RED	1	GROUP 1	BLACK	12V	Vertical Jumper
			2	GROUP 1	WHITE	12V	Vertical Jumper
XL403A	_+Vs (PIN 8)	PURPLE	3	GROUP 1	RED	12V	Vertical Jumper
							ORANGE DIVIDER+STOPPER
XL403A	GND (PIN 9)	GREY	4	GROUP 2	BLACK	G	Vertical Jumper
			5	GROUP 2	WHITE	G	Vertical Jumper
CSAT3	POWER REF	BLACK	6	GROUP 2	GREEN	G	Vertical Jumper
							ORANGE DIVIDER
083E-1-35	POWER	WHITE	7	GROUP 3	BLACK	12VDC	
TEMP/RH	COMMON GND	GREEN	8	GROUP 3	WHITE	G	
	RH SIGNAL	BLUE	9	GROUP 3	RED	SE2	
	TEMP SIGNAL REF	BLACK	10	GROUP 3	GREEN	AG-1	
	TEMP SIGNAL	RED	11	GROUP 3	BLUE	SE16	(JUMPER 23.1K 0.1% TO VX2)
			12	GROUP 3	BROWN	---	
014A	SIGNAL REF	RED	13	GROUP 4	BLACK	P2	
WS	SIGNAL	BLACK	14	GROUP 4	WHITE	AG-19	
			15	GROUP 4	RED	---	
			16	GROUP 4	GREEN	---	
	SHIELD	WHITE/BROWN					Shields (3&4) to GND Terminal
024A	SIGNAL	RED	17	GROUP 5	BLACK	SE5	
WD	COMMON GND	WHITE	18	GROUP 5	WHITE	AG-3	
	POWER	BLACK	19	GROUP 5	RED	VX2	
			20	GROUP 5	BLUE	---	
XL403A	SIGNAL X1 (PIN1)	BLACK	21	GROUP 6	BLACK	SE18	
ACCELO	SIGNAL X2 (PIN 2)	WHITE	22	GROUP 6	WHITE	SE19	
	SIGNAL X3 (PIN 3)	BROWN	23	GROUP 6	RED	SE20	
	SIGNAL GND (PIN 4)	RED	24	GROUP 6	BROWN	AG-10	
							Shields (5,6&7) to GND Terminal
			25	GROUP 7	BLACK	---	
			26	GROUP 7	WHITE	---	
			27	GROUP 7	RED	---	
XL403A	SELF TEST (PIN 7)	BLUE	28	GROUP 7	VIOLET	C1	
							ORANGE DIVIDER+STOPPER
CSAT3	SDM DATA	GREEN	31	CSAT3 E4 TO E5	GREEN	---	Vertical Jumper
ELEV 5	SDM CLOCK	WHITE	32	CSAT3 E5 TO E6	GREEN	---	
	SDM ENABLE	BROWN	34	CSAT3 E4 TO E5	WHITE	---	Vertical Jumper
	DIGITAL GROUND	BLACK	35	CSAT3 E5 TO E6	WHITE	---	
			37	CSAT3 E4 TO E5	BROWN	---	Vertical Jumper
			38	CSAT3 E5 TO E6	BROWN	---	
			40	CSAT3 E4 TO E5	BLACK	---	Vertical Jumper
			41	CSAT3 E5 TO E6	BLACK	---	
							ORANGE DIVIDER+STOPPER

JUNCTION BOX
ELEVATION 6

			JBOX ENC TERMINAL	**DOWN TOWER CABLES (GROUP) LABEL**	**COLOR**	**COMPONENT TERMINAL**	**NOTES**
SENSOR	**FUNCTION**	**WIRE COLOR**					ORANGE DIVIDER+STOPPER
CSAT3	12VDC	RED	1	GROUP 1	BLACK	12V	Vertical Jumper
			2	GROUP 1	WHITE	12V	Vertical Jumper
XL403A	_+Vs (PIN 8)	PURPLE	3	GROUP 1	RED	12V	Vertical Jumper
							ORANGE DIVIDER+STOPPER
XL403A	GND (PIN 9)	GREY	4	GROUP 2	BLACK	G	Vertical Jumper
			5	GROUP 2	WHITE	G	Vertical Jumper
CSAT3	POWER REF	BLACK	6	GROUP 2	GREEN	G	Vertical Jumper
							ORANGE DIVIDER
083E-1-35	POWER	WHITE	7	GROUP 3	BLACK	12VDC	
TEMP/RH	COMMON GND	GREEN	8	GROUP 3	WHITE	G	
	RH SIGNAL	BLUE	9	GROUP 3	RED	SE3	
	TEMP SIGNAL REF	BLACK	10	GROUP 3	GREEN	AG-2	
	TEMP SIGNAL	RED	11	GROUP 3	BLUE	SE17	(JUMPER 23.1K 0.1% TO VX3)
			12	GROUP 3	BROWN	---	
014A	SIGNAL REF	RED	13	GROUP 4	BLACK	P3	
WS	SIGNAL	BLACK	14	GROUP 4	WHITE	AG-21	
			15	GROUP 4	RED	---	
			16	GROUP 4	GREEN	---	
	SHIELD	WHITE/BROWN					Shields (3&4) to GND Terminal
024A	SIGNAL	RED	17	GROUP 5	BLACK	SE6	
WD	COMMON GND	WHITE	18	GROUP 5	WHITE	AG-3	
	POWER	BLACK	19	GROUP 5	RED	VX3	
			20	GROUP 5	BLUE	---	
XL403A	SIGNAL X1 (PIN1)	BLACK	21	GROUP 6	BLACK	SE21	
ACCELO	SIGNAL X2 (PIN 2)	WHITE	22	GROUP 6	WHITE	SE22	
	SIGNAL X3 (PIN 3)	BROWN	23	GROUP 6	RED	SE23	
	SIGNAL GND (PIN 4)	RED	24	GROUP 6	BROWN	AG-11	
							Shields (5,6&7) to GND Terminal
			25	GROUP 7	BLACK	---	
			26	GROUP 7	WHITE	---	
			27	GROUP 7	RED	---	
XL403A	SELF TEST (PIN 7)	BLUE	28	GROUP 7	VIOLET	C2	
							ORANGE DIVIDER+STOPPER
CSAT3	SDM DATA	GREEN	31	CSAT3 E6 TO ENC B	GREEN	---	Vertical Jumper
ELEV 6	SDM CLOCK	WHITE	32	CSAT3 E5 TO E6	GREEN	---	
	SDM ENABLE	BROWN	34	CSAT3 E6 TO ENC B	WHITE	---	Vertical Jumper
	DIGITAL GROUND	BLACK	35	CSAT3 E5 TO E6	WHITE	---	
			37	CSAT3 E6 TO ENC B	BROWN	---	Vertical Jumper
			38	CSAT3 E5 TO E6	BROWN	---	
			40	CSAT3 E6 TO ENC B	BLACK	---	Vertical Jumper
			41	CSAT3 E5 TO E6	BLACK	---	
							ORANGE DIVIDER+STOPPER

EOLOS WIND RESEARCH STATION METEOROLOGICAL TOWER

UNIVERSITY OF MINNESTA,
SAINT ANTHONY FALLS
LABORATORY

REVISION 00
ON APRIL 30, 2012

CAMPBELL SCIENTIFIC

LEGEND

(NOT ALL ITEMS ON THIS LIST WILL APPLY)

FACTORY WIRE (INSIDE ENCLOSURE)

FIELD WIRING (FROM SENSOR TO TERMINAL STRIP)

HOME RUN CABLE (THE CABLE FROM A JUNCTION BOX TO THE DATALOGGER ENCLOSURE)

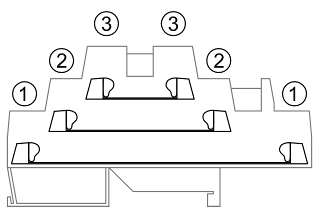
GREEN / YELLOW TERMINAL ARE ALL INTERNALLY CONNECTED

ORANGE BARRIERS ON TERMINAL STRIP INDICATE SENSOR GROUPS

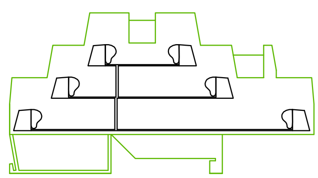
JUMPER (INTERNAL TO GREEN WAGO BLOCK)

JUMPER (BETWEEN TERMINALS EXTERNAL TO WAGO BLOCK)

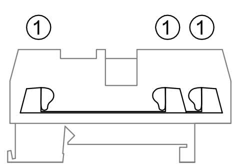
GENERAL NOTES:
* WIRE COLORS USED ON SENSOR SIDE OF TERMINAL STRIP ARE GENERIC IN NATURE. IF THERE IS ANY DISCREPANCY WIRE FUNCTION TAKES PRECEDENCE



INSIDE GRAY TRIPLE DECK WAGO TERMINAL BLOCK



INSIDE CONNECTIONS FOR GREEN TRIPLE DECK WAGO TERMINAL BLOCK

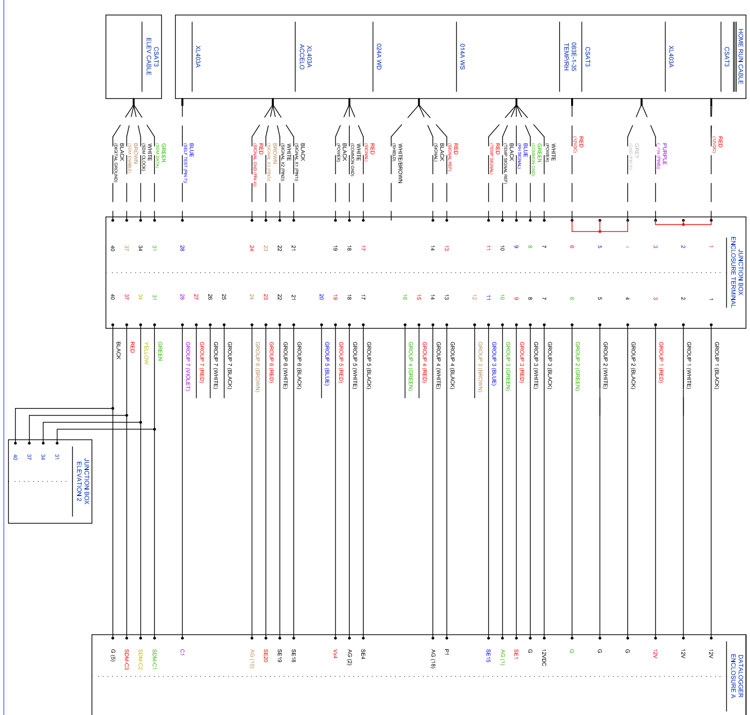


INSIDE SINGLE LEVEL WAGO TERMINAL BLOCKS

REVISION 01
ON APRIL 12, 2011

CAMPBELL® SCIENTIFIC

JUNCTION BOX ELEVATION 1



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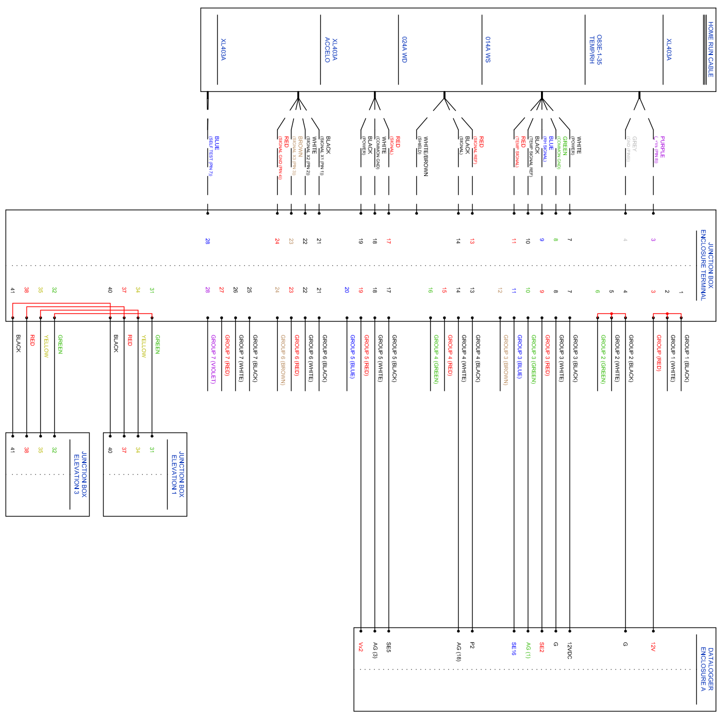
DESIGN BY:	DRAWN BY:	COPYRIGHT:	DATE OF LAST REV:	FUNCTION:	SALES ORDER NUMBER:
M. PERRY	S. PERCIVAL	20 MAR 12	30 APR 12	WIRING SCHEMATIC	258813

DESCRIPTION:	PROJECT TITLE:	SHEET:
EOLOS WIND RESEARCH STATION METEOROLOGICAL TOWER	CAMPBELL SCIENTIFIC CUSTOM METEOROLOGICAL TOWER	1 OF 16

	DRAWING FILE:	CUSTOMER:	REV:
CAMPBELL SCIENTIFIC	SCH SO#258813.DWG	UNIVERSITY OF MINNESOTA, SAINT ANTHONY FALLS LABORATORY	00

JUNCTION BOX ELEVATION 2



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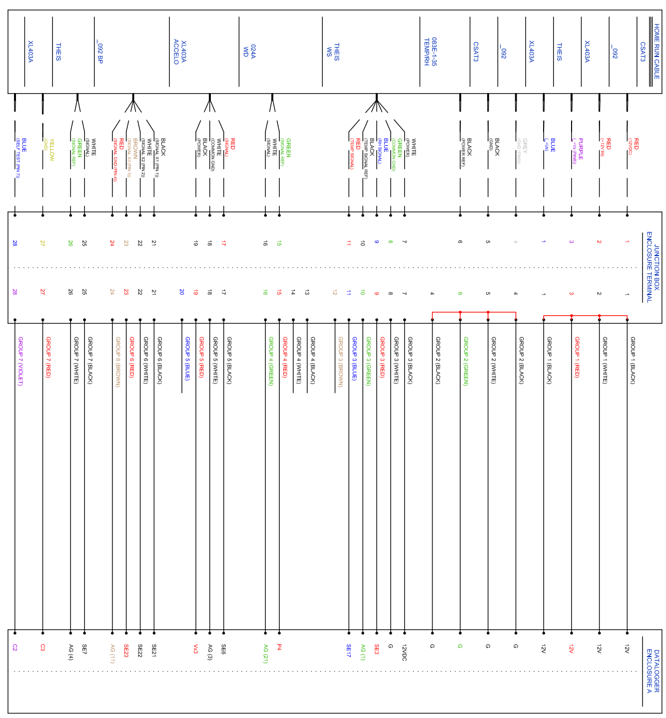
	DESCRIPTION: EOLOS WIND RESEARCH STATION METEOROLOGICAL TOWER				PROJECT TITLE: CAMPBELL SCIENTIFIC CUSTOM METEOROLOGICAL TOWER	SHEET: 2 OF 16
	CAMPBELL SCIENTIFIC		DRAWING FILE: SCH SO#258813.DWG		CUSTOMER: UNIVERSITY OF MINNESOTA, SAINT ANTHONY FALLS LABORATORY	REV: 00

JUNCTION BOX ELEVATION 3



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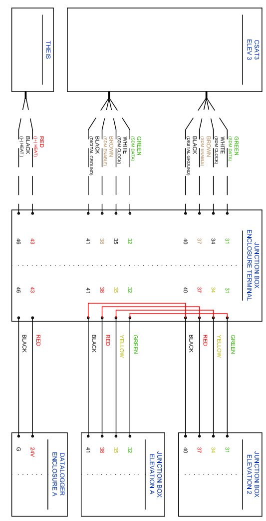
	DESCRIPTION: EOLOS WIND RESEARCH STATION METEOROLOGICAL TOWER				PROJECT TITLE: CAMPBELL SCIENTIFIC CUSTOM METEOROLOGICAL TOWER	SHEET: 3 OF 16
	CAMPBELL SCIENTIFIC		DRAWING FILE: SCH SO#258813.DWG		CUSTOMER: UNIVERSITY OF MINNESOTA, SAINT ANTHONY FALLS LABORATORY	REV: 00

JUNCTION BOX ELEVATION 3



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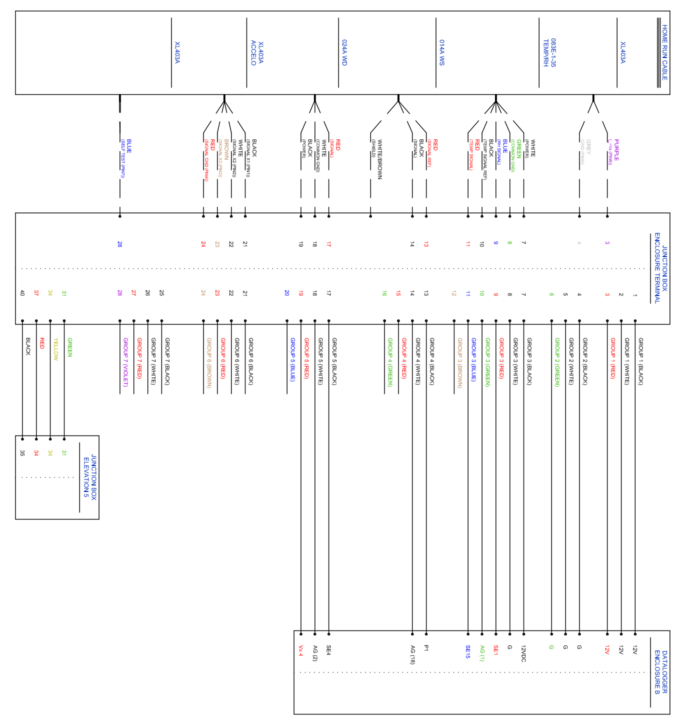
	DESCRIPTION: EOLOS WIND RESEARCH STATION METEOROLOGICAL TOWER				PROJECT TITLE: CAMPBELL SCIENTIFIC CUSTOM METEOROLOGICAL TOWER	SHEET: 4 OF 16
	CAMPBELL SCIENTIFIC		DRAWING FILE: SCH SO#258813.DWG		CUSTOMER: UNIVERSITY OF MINNESOTA, SAINT ANTHONY FALLS LABORATORY	REV: 00

JUNCTION BOX ELEVATION 4



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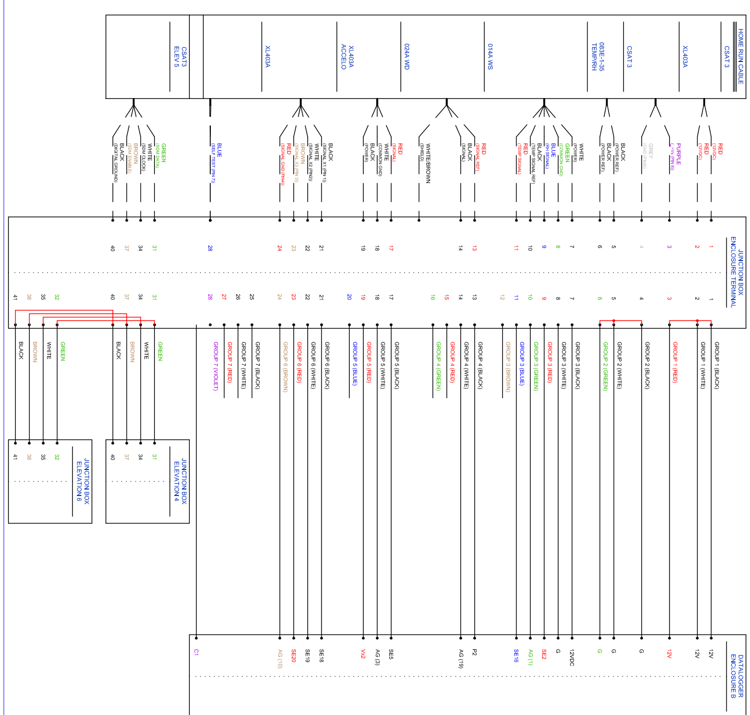
	DESCRIPTION: EOLOS WIND RESEARCH STATION METEOROLOGICAL TOWER				PROJECT TITLE: CAMPBELL SCIENTIFIC CUSTOM METEOROLOGICAL TOWER
	CAMPBELL SCIENTIFIC		DRAWING FILE: SCH SO#258813.DWG		CUSTOMER: UNIVERSITY OF MINNESOTA, SAINT ANTHONY FALLS LABORATORY

SALES ORDER NUMBER:	258813
SHEET:	5 OF 16
REV:	00

JUNCTION BOX ELEVATION 5



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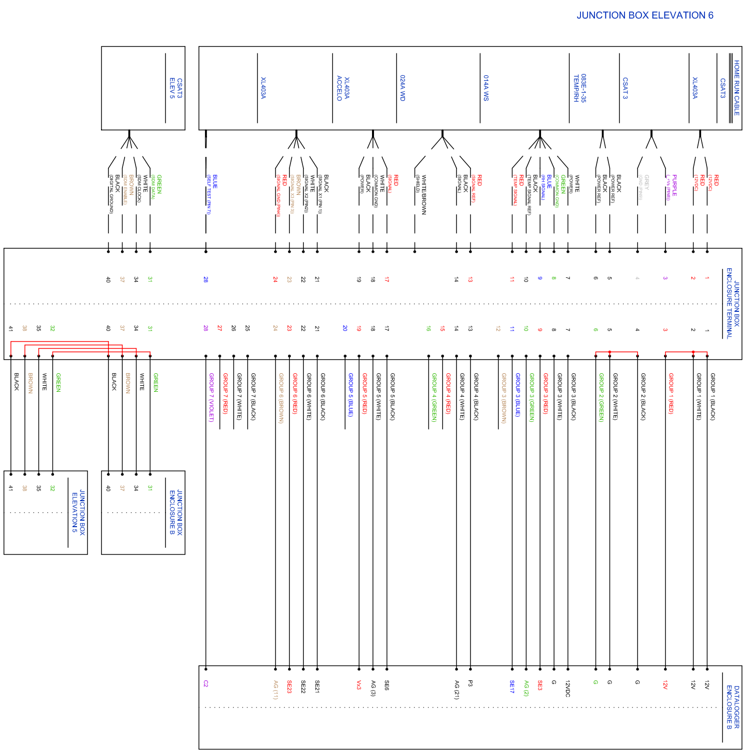
	DESCRIPTION: EOLOS WIND RESEARCH STATION METEOROLOGICAL TOWER				PROJECT TITLE: CAMPBELL SCIENTIFIC CUSTOM METEOROLOGICAL TOWER	SHEET: 6 OF 16
	CAMPBELL SCIENTIFIC		DRAWING FILE: SCH SO#258813.DWG		CUSTOMER: UNIVERSITY OF MINNESOTA, SAINT ANTHONY FALLS LABORATORY	REV: 00



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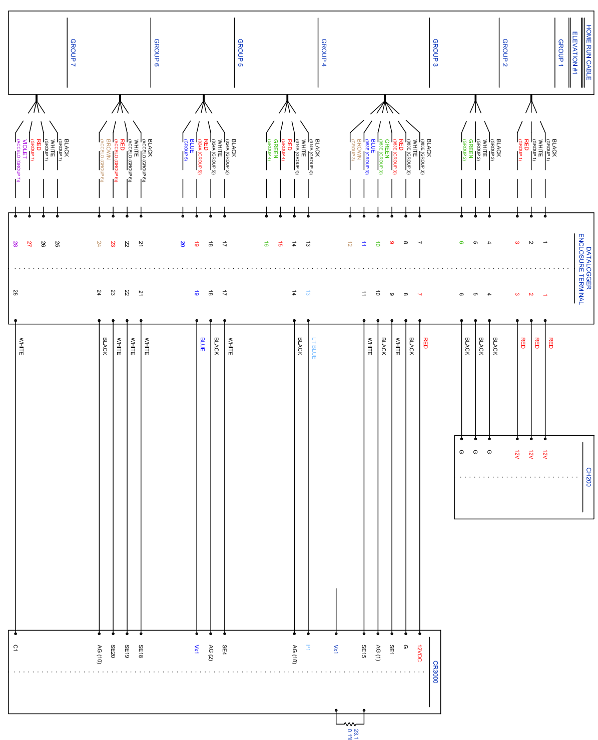
M. PERRY	S. PERCIVAL	20 MAR 12	30 APR 12	WIRING SCHEMATIC	258813
DESCRIPTION: EOLOS WIND RESEARCH STATION METEOROLOGICAL TOWER				PROJECT TITLE: CAMPBELL SCIENTIFIC CUSTOM METEOROLOGICAL TOWER	SHEET: 7 OF 16
CAMPBELL SCIENTIFIC		DRAWING FILE: SCH SO#258813.DWG		CUSTOMER: UNIVERSITY OF MINNESOTA, SAINT ANTHONY FALLS LABORATORY	REV: 00

DATALOGGER ENCLOSURE A



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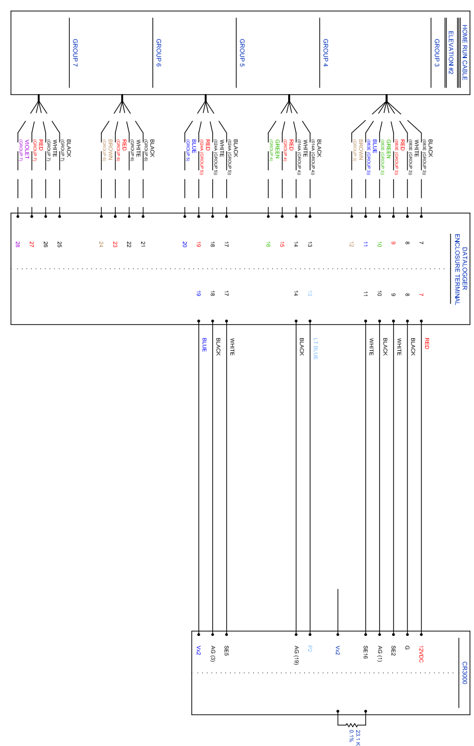
M. PERRY	S. PERCIVAL	20 MAR 12	30 APR 12	WIRING SCHEMATIC	258813

DESCRIPTION:	PROJECT TITLE:	SHEET:
EOLOS WIND RESEARCH STATION METEOROLOGICAL TOWER	CAMPBELL SCIENTIFIC CUSTOM METEOROLOGICAL TOWER	8 OF 16

	DRAWING FILE:	CUSTOMER:	REV:
CAMPBELL SCIENTIFIC	SCH SO#258813.DWG	UNIVERSITY OF MINNESOTA, SAINT ANTHONY FALLS LABORATORY	00

DATALOGGER ENCLOSURE A



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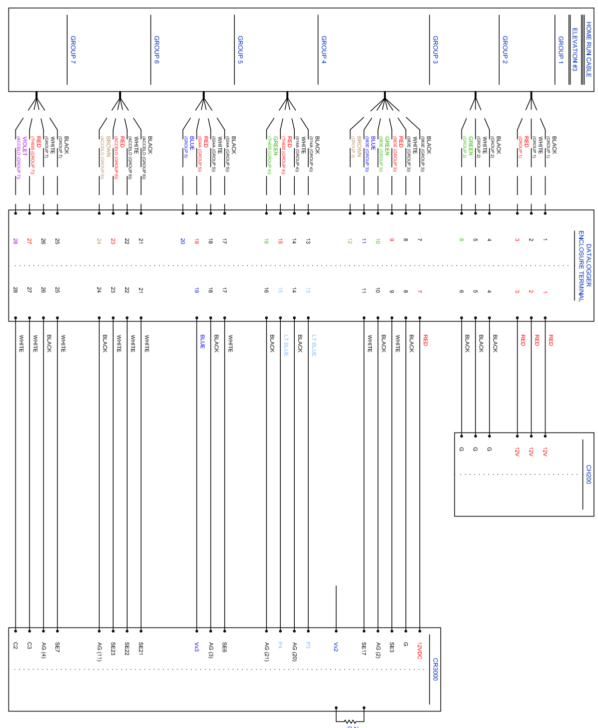
	CAMPBELL SCIENTIFIC		DRAWING FILE: SCH SO#258813.DWG		CUSTOMER: UNIVERSITY OF MINNESOTA, SAINT ANTHONY FALLS LABORATORY	REV: 00

DATALOGGER ENCLOSURE A



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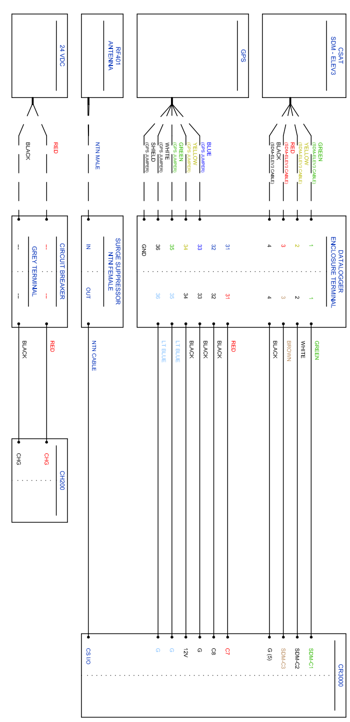
	DESCRIPTION: EOLOS WIND RESEARCH STATION METEOROLOGICAL TOWER				PROJECT TITLE: CAMPBELL SCIENTIFIC CUSTOM METEOROLOGICAL TOWER	SHEET: 10 OF 16
	CAMPBELL SCIENTIFIC		DRAWING FILE: SCH SO#258813.DWG		CUSTOMER: UNIVERSITY OF MINNESOTA, SAINT ANTHONY FALLS LABORATORY	REV: 00

DATALOGGER ENCLOSURE A



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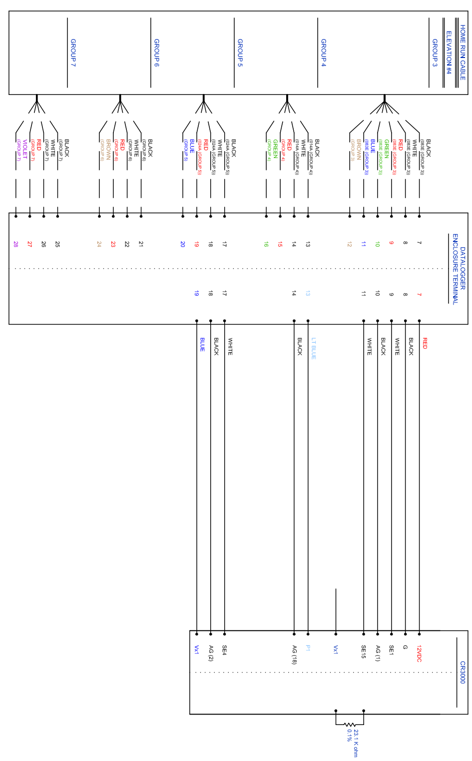
	DESCRIPTION: EOLOS WIND RESEARCH STATION METEOROLOGICAL TOWER				PROJECT TITLE: CAMPBELL SCIENTIFIC CUSTOM METEOROLOGICAL TOWER	SHEET: 11 OF 16
	CAMPBELL SCIENTIFIC		DRAWING FILE: SCH SO#258813.DWG		CUSTOMER: UNIVERSITY OF MINNESOTA, SAINT ANTHONY FALLS LABORATORY	REV: 00

DATALOGGER ENCLOSURE B



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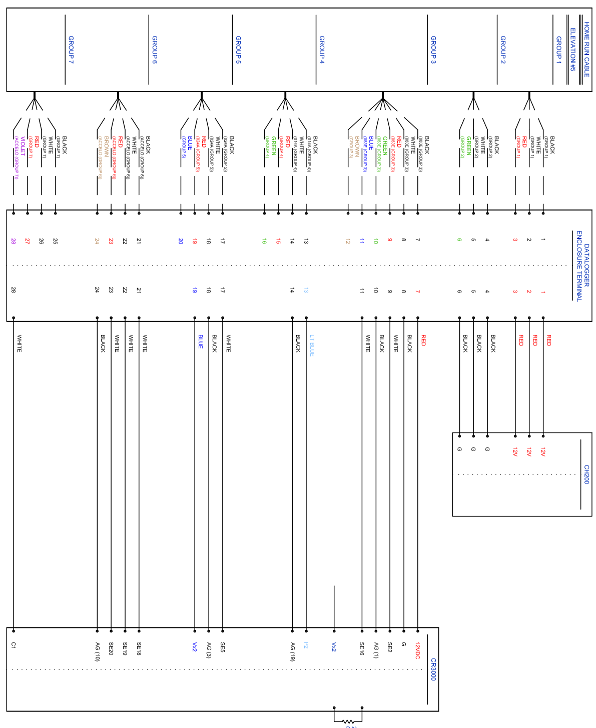
	DESCRIPTION: EOLOS WIND RESEARCH STATION METEOROLOGICAL TOWER				PROJECT TITLE: CAMPBELL SCIENTIFIC CUSTOM METEOROLOGICAL TOWER	SHEET: 12 OF 16
	CAMPBELL SCIENTIFIC		DRAWING FILE: SCH SO#258813.DWG		CUSTOMER: UNIVERSITY OF MINNESOTA, SAINT ANTHONY FALLS LABORATORY	REV: 00

DATALOGGER ENCLOSURE B



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DESIGN BY:	DRAWN BY:	COPYRIGHT:	DATE OF LAST REV:	FUNCTION:	SALES ORDER NUMBER:
M. PERRY	S. PERCIVAL	20 MAR 12	30 APR 12	WIRING SCHEMATIC	258813
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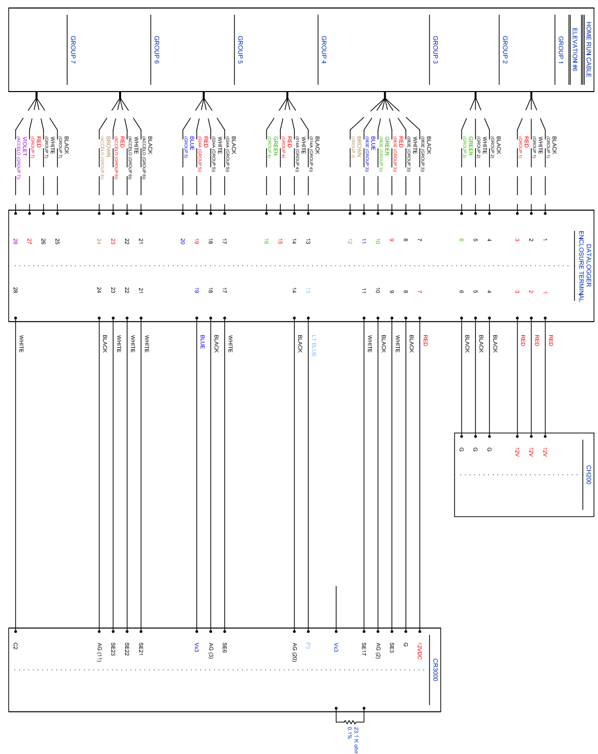

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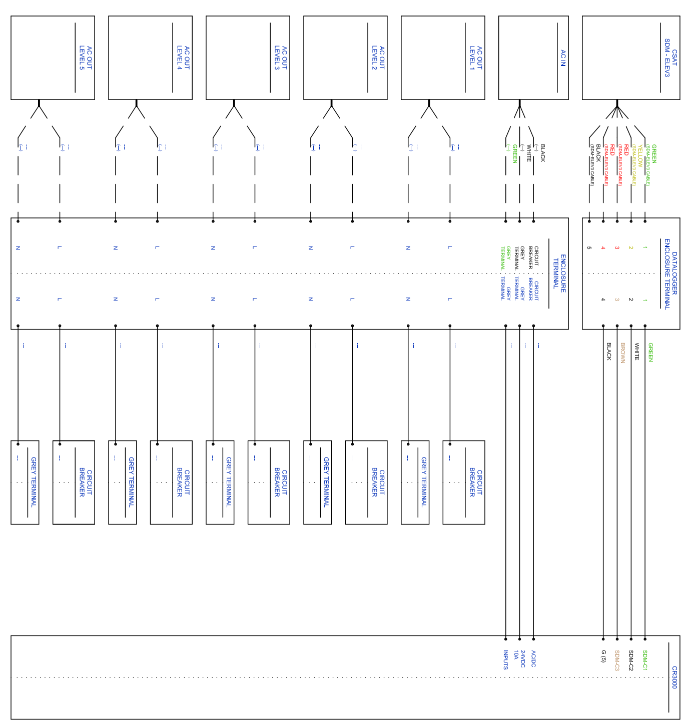
	CAMPBELL SCIENTIFIC		DRAWING FILE: SCH SO#258813.DWG		CUSTOMER: UNIVERSITY OF MINNESOTA, SAINT ANTHONY FALLS LABORATORY	REV: 00

DATALOGGER ENCLOSURE B



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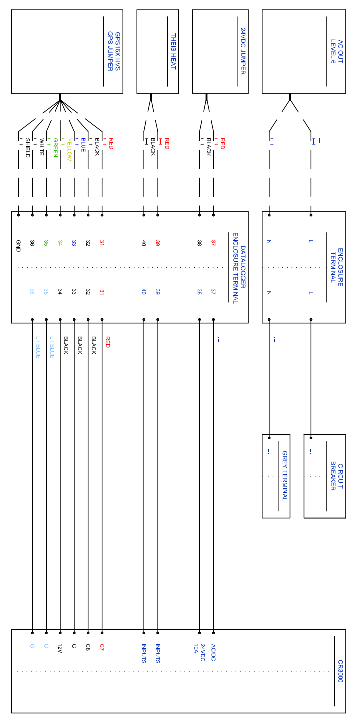
M. PERRY	S. PERCIVAL	20 MAR 12	30 APR 12	WIRING SCHEMATIC	258813
DESCRIPTION: EOLOS WIND RESEARCH STATION METEOROLOGICAL TOWER				PROJECT TITLE: CAMPBELL SCIENTIFIC CUSTOM METEOROLOGICAL TOWER	SHEET: 15 OF 16
CAMPBELL SCIENTIFIC		DRAWING FILE: SCH SO#258813.DWG		CUSTOMER: UNIVERSITY OF MINNESOTA, SAINT ANTHONY FALLS LABORATORY	REV: 00



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M. PERRY	S. PERCIVAL	20 MAR 12	30 APR 12	WIRING SCHEMATIC	258813
DESCRIPTION: EOLOS WIND RESEARCH STATION METEOROLOGICAL TOWER				PROJECT TITLE: CAMPBELL SCIENTIFIC CUSTOM METEOROLOGICAL TOWER	SHEET: 16 OF 16
CAMPBELL SCIENTIFIC		DRAWING FILE: SCH SO#258813.DWG		CUSTOMER: UNIVERSITY OF MINNESOTA, SAINT ANTHONY FALLS LABORATORY	REV: 00

11 Appendix D: Equipment Installation Procedures and Drawings

Eolos Wind Energy Research Met Tower

Instrumentation Installation Plan

Parties Involved:

St. Anthony Falls Laboratory:

- University of Minnesota Lab responsible for general oversight of turbine construction and research.
- Fabricating the 18’ instrument booms in-house

Ryan Companies:

- General Contractor for the construction of the turbine and met tower.

Campbell Scientific:

- Contracted by the University of Minnesota to assemble, test and program the data acquisition system (DAQ) and provide assistance to tower installers and UMN employees to get the system installed and functioning correctly.

Rohn Inc.

- Manufacturer of tower; responsible for erection of the tower and installation of all boom arms and instruments

Martin Martin Inc.

- Engineering Consulting firm responsible for the design of the 18’ instrument booms. Will be available over the phone for technical advice on fabrication and installation of booms.

Scope of Work:

St. Anthony Falls Laboratory:

1. Fabrication of 4 - 18’ boom arms
    a. Will be fabricated to fit the tower in the specified locations
    b. Guy cables will be adjusted to proper tensioning in fab shop and location of boom relative to roller box will be marked so allow tower installers to achieve proper tension in the field.
2. Procurement of 6 - 12’ boom arms
3. Delivery of booms to UMore

Campbell Scientific:

1. Procurement of all sensors and data acquisition systems (except the 5 Met-One cup anemometers that are already in the UMN’s possession)
2. Assembly, programing and testing of DAQ system
3. Labeling of all wires and terminations
4. Shipment of all sensors, cables and DAQ systems to UMore Park
5. Provide assistance to tower installers and UMN researchers in installing the sensor system and configuring correctly.

Rohn Subcontracted tower installers:

1. Erect met tower
2. Install all boom arms at specified locations and in fashion specified by UMN and Martin/Martin Inc.
3. Install instruments on booms as specified my UMN and route all cables downtower.

Ryan Companies:

1. Oversight of all activities
2. Responsible for onsite safety

Instrumentation Plan:

Boom 1

Location: 23’

Type: 12’ TSI boom

Estimated weight: 50 lbs

Connection to tower: U-bolts through angle-iron on the roller-box (see drawing attached); U-bolts through small brackets with eyes for guy wires (see drawings)

Sensors:

Sensor	Model Number:	Location
Cross arm Assembly	191-1	Boom End (on provided riser pipe)
Met One Wind Direction Sensor	024-L30	On Cross-arm
Met One Wind Speed Sensor	014A	On Cross-arm
Met One heater block	2308	1 on Vane and 1 on cups
Met One heater block controller	2267	In 23’ junction box
Met One Temperature and Relative Humidity sensor	083E-1-35	Mid-point on boom
Met One Barometric Pressure	092	Mid-point on boom
Junction box		On tower near boom connection

Boom 2

Location: 33’

Type: 18’ M/M boom

Estimated weight: 1500 lbs

Connection to tower: U-bolts through plate on the roller-box assembly (see drawing attached); U-bolts through square tubes with eyes for guy wires (see drawings)

Sensors:

Sensor	**Model Number:**	**Location**
Sonic Anemometer and accelerometer bundle	CSAT3	Boom end using provided mounting brackets.
Junction box		On tower near boom connection

Boom 3

Location: 88’

Type: 12’ TSI boom

Estimated weight: 50 lbs

Connection to tower: U-bolts through angle-iron on the roller-box (see drawing attached); U-bolts through small brackets with eyes for guy wires (see drawings)

Sensors:

Sensor	Model Number:	Location
Cross arm Assembly	191-1	Boom End (on provided riser pipe)
Met One Wind Direction Sensor	024-L30	On Cross-arm
Met One Wind Speed Sensor	014A	On Cross-arm
Met One heater block	2308	1 on Vane and 1 on cups
Met One heater block controller	2267	In 23’ junction box
Met One Temperature and Relative Humidity sensor	083E-1-35	Mid-point on boom
Junction box		On tower near boom connection

Boom 4

Location: 98’

Type: 18’ M/M boom

Estimated weight: 1500 lbs

Connection to tower: U-bolts through plate on the roller-box assembly (see drawing attached); U-bolts through square tubes with eyes for guy wires (see drawings)

Sensors:

Sensor	Model Number:	Location
Sonic Anemometer and accelerometer bundle	CSAT3	Boom end using provided mounting brackets.
Junction box		On tower near boom connection

Boom 5

Location: 170'

Type: 12' TSI boom

Estimated weight: 50 lbs

Connection to tower: U-bolts through angle-iron on the roller-box (see drawing attached); U-bolts through small brackets with eyes for guy wires (see drawings)

Sensors:

Sensor	Model Number:	Location
Cross arm Assembly	191-1	Boom End (on provided riser pipe)
Met One Wind Direction Sensor	024-L30	On Cross-arm
Met One Wind Speed Sensor	014A	On Cross-arm
Met One heater block	2308	1 on Vane and 1 on cups
Met One heater block controller	2267	In 23' junction box
Met One Temperature and Relative Humidity sensor	083E-1-35	Mid-point on boom
Junction box		On tower near boom connection

Boom 6

Location: 253’

Type: 12’ TSI boom

Estimated weight: 50 lbs

Connection to tower: U-bolts through angle-iron on the roller-box (see drawing attached); U-bolts through small brackets with eyes for guy wires (see drawings)

Sensors:

Sensor	Model Number:	Location
Cross arm Assembly	191-1	Boom End (on provided riser pipe)
Met One Wind Direction Sensor	024-L30	On Cross-arm
1st Class Anemometer	4.3350.00 .000	On Cross-arm
Met One heater block	2308	1 on Vane and 1 on cups
Met One heater block controller	2267	In 23’ junction box
Met One Temperature and Relative Humidity sensor	083E-1-35	Mid-point on boom
Junction box		On tower near boom connection

Boom 7

Location: 263’

Type: 18’ M/M boom

Estimated weight: 1500 lbs

Connection to tower: U-bolts through plate on the roller-box assembly (see drawing attached); U-bolts through square tubes with eyes for guy wires (see drawings)

Sensors:

Sensor	**Model Number:**	**Location**
Sonic Anemometer and accelerometer bundle	CSAT3	Boom end using provided mounting brackets.
Junction box		On tower near boom connection

Boom 8

Location: 335’

Type: 12’ TSI boom

Estimated weight: 50 lbs

Connection to tower: U-bolts through angle-iron on the roller-box (see drawing attached); U-bolts through small brackets with eyes for guy wires (see drawings)

Sensors:

Sensor	**Model Number:**	**Location**
Cross arm Assembly	191-1	Boom End (on provided riser pipe)
Met One Wind Direction Sensor	024-L30	On Cross-arm
Met One Wind Speed Sensor	014A	On Cross-arm
Met One heater block	2308	1 on Vane and 1 on cups
Met One heater block controller	2267	In 23’ junction box
Met One Temperature and Relative Humidity sensor	083E-1-35	Mid-point on boom
Junction box		On tower near boom connection

Boom 9

Location: 415'

Type: 12' TSI boom

Estimated weight: 50 lbs

Connection to tower: U-bolts through angle-iron on the roller-box (see drawing attached); U-bolts through small brackets with eyes for guy wires (see drawings)

Sensors:

Sensor	**Model Number:**	**Location**
Cross arm Assembly	191-1	Boom End (on provided riser pipe)
Met One Wind Direction Sensor	024-L30	On Cross-arm
Met One Wind Speed Sensor	014A	On Cross-arm
Met One heater block	2308	1 on Vane and 1 on cups
Met One heater block controller	2267	In 23' junction box
Met One Temperature and Relative Humidity sensor	083E-1-35	Mid-point on boom
Junction box		On tower near boom connection

Boom 10

Location: 422’

Type: 18’ M/M boom

Estimated weight: 1500 lbs

Connection to tower: U-bolts through plate on the roller-box assembly (see drawing attached); U-bolts through square tubes with eyes for guy wires (see drawings)

Sensors:

Sensor	**Model Number:**	**Location**
Sonic Anemometer and accelerometer bundle	CSAT3	Boom end using provided mounting brackets.
Junction box		On tower near boom connection

Other

Static Dissipaters:

One large static dissipater will need to be installed on the top of the tower prior to tower erection.

3 smaller dissipaters will be connected to the tower at the 200' level. They will mount to the tower legs using brackets provided by the manufacturer.

Instrumentation Cabinets:

2 30" x 48" x 10" steel enclosures will be mounted on 4x4 posts 6' from the center of the tower. All instrumentation cables will be terminated inside this enclosure.

Cameras:

2 Basler cameras in heated housings mounted to the tower legs at 270' with brackets to be provided by SAFL. Cut sheets are attached to this document.

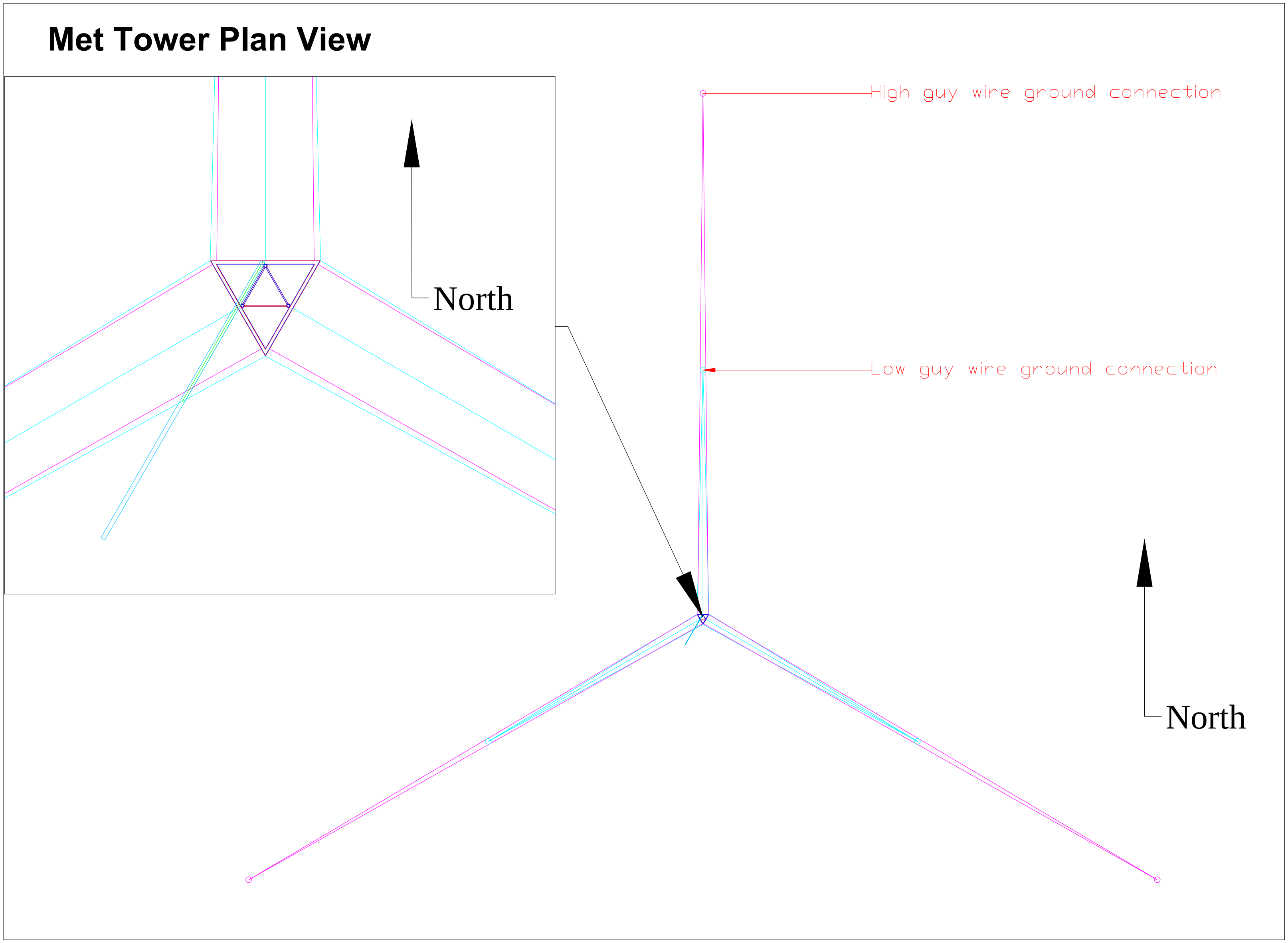
Wireless Access Points:

The wireless access point should be mounted at 20' ft elevation on the north side of the tower. The PoE injector required to power the device will be in the electrical cabinet at the base of the met tower. All equipment for installation of the access point will be provided by UMN. See attached page for installation instructions.

Tower top static dissipater (aka: Eagles Nest).

1 of 3 dissipaters at 200'

Met Tower Plan View



General Notes

No.	Revision/Issue	Date
1	CMM	08.23.11

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Chris Milliren
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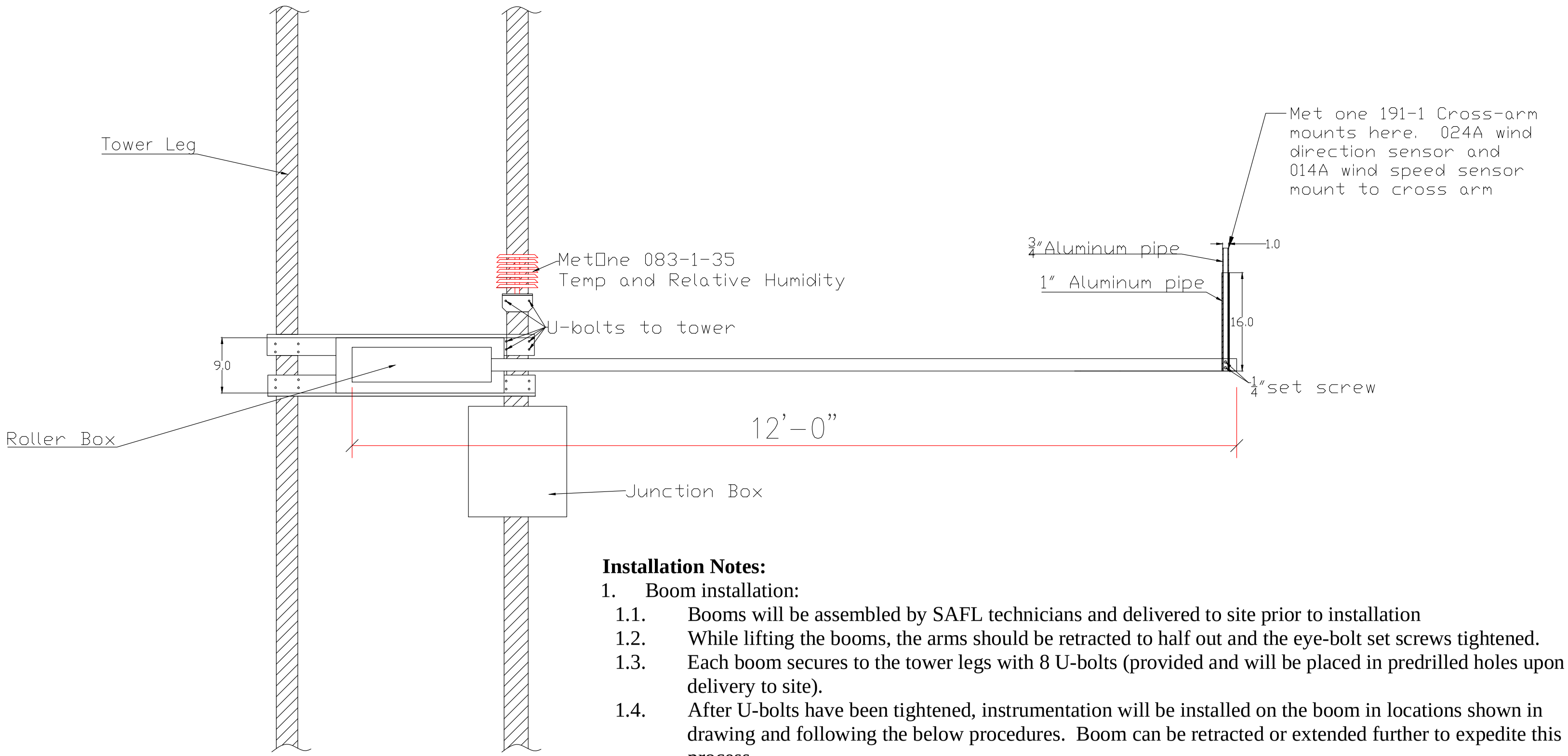
Project Name and Address
Eolos Wind Research Turbine
University of Minnesota
2685 152nd Street E
Rosemount, MN
55068

Project: Eolos Met Tower
Date: 8/17/11
Scale: No Scale
Sheet: 00

TSI 12' Boom

Instrumentation Installation Details

Boom 1



Installation Notes:

1. Boom installation:
   - 1.1. Booms will be assembled by SAFL technicians and delivered to site prior to installation
   - 1.2. While lifting the booms, the arms should be retracted to half out and the eye-bolt set screws tightened.
   - 1.3. Each boom secures to the tower legs with 8 U-bolts (provided and will be placed in predrilled holes upon delivery to site).
   - 1.4. After U-bolts have been tightened, instrumentation will be installed on the boom in locations shown in drawing and following the below procedures. Boom can be retracted or extended further to expedite this process.
   - 1.5. After instruments have been installed, the booms should be extended. Instrumentation cables should be secured to the underside of the boom using bands of electrical tape approximately every 12".
   - 1.6. When boom is fully extended, tighten eye-bolt set-screws and tighten jam nut.
2. Sensor Installation
   - 2.1. Wind direction sensor (024A) and wind speed sensor (014A) will be mounted to the Met One 191-1 cross arm by SAFL technicians on the ground. Once these sensors have been properly mounted to the cross arm, they can be installed by tower crew onto the 1" OD aluminum riser pipe.
   - 2.2. Temperature and humidity probe will be mounted to the tower leg with a U-bolt as shown in the drawing.
   - 2.3. Instrumentation cables should be secured to the underside of the boom with bands of electrical tape approximately every12".
   - 2.4. Junction boxes will mount directly below the boom on the nearest tower leg with 2 provided U-bolts.
   - 2.5. Cables will be run from underside of boom arms through glands in the underside of the junction box.
   - 2.6. The downtower homerun cable will exit the J-box through a glad.

General Notes

Boom Location: 23'
Type: 12' TSI
Estimated Weight: 50 lbs

Tower leg Diameter: 3.5"

No.	Revision/Issue	Date
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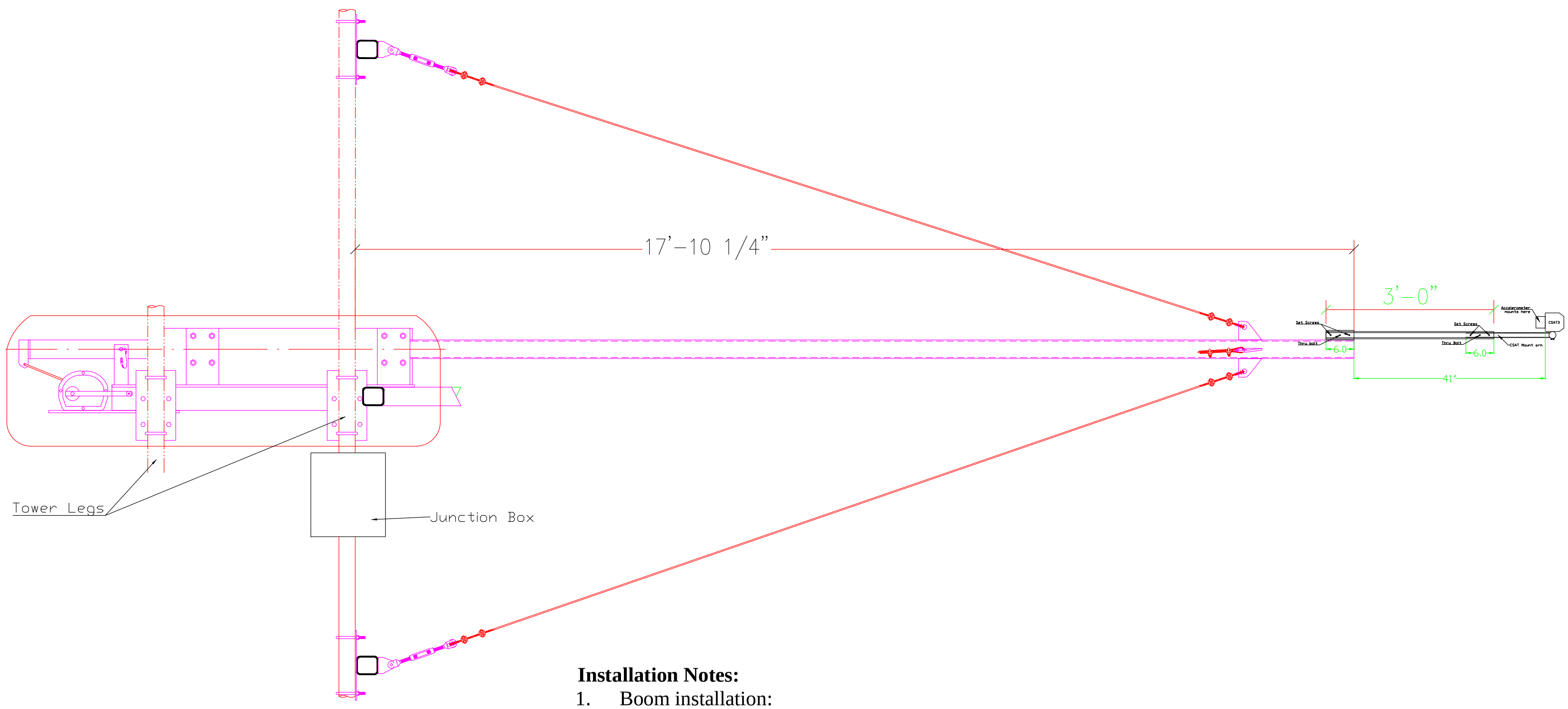
55068

Project: Eolos Met Tower
Date: 8/17/11
Scale: No Scale
Sheet: 01

M/M 18' Boom

Instrumentation Installation Details

Boom 2



Installation Notes:

1. Boom installation:
   - 1.1. Booms and all associated components will be assembled by technicians at SAFL and delivered to the turbine and met tower site.
   - 1.2. Boom installation should be done following guidelines provided by Martin Martin Co.
2. Sensor Installation
   - 2.1. CSAT3 (sonic anemometer), accelerometer and static wick assembly will be bolted together by the SAFL technicians and delivered to site by the sensor installation date.
   - 2.3. Senor assembly can be attached to the M/M booms by sliding the chrome pipe into the collar welded to the 4" steel tube of the boom. One through bolt and two set screws will secure the sensor assembly to the boom.
   - 2.4. Sensor cables should be routed back along the underside of the boom and secured with electrical tape approximately every 12".
   - 2.5. Cables should be routed from the boom into the junction box through a cable gland.
   - 2.6. Downtower homerun cable will exit the junction box through a glad and run downtower.

General Notes

Boom Location: 33'
Type: 18' M/M
Estimated Weight: 1500 lbs

Tower Leg Diameter: 3.5"

No.	Revision/Issue	Date
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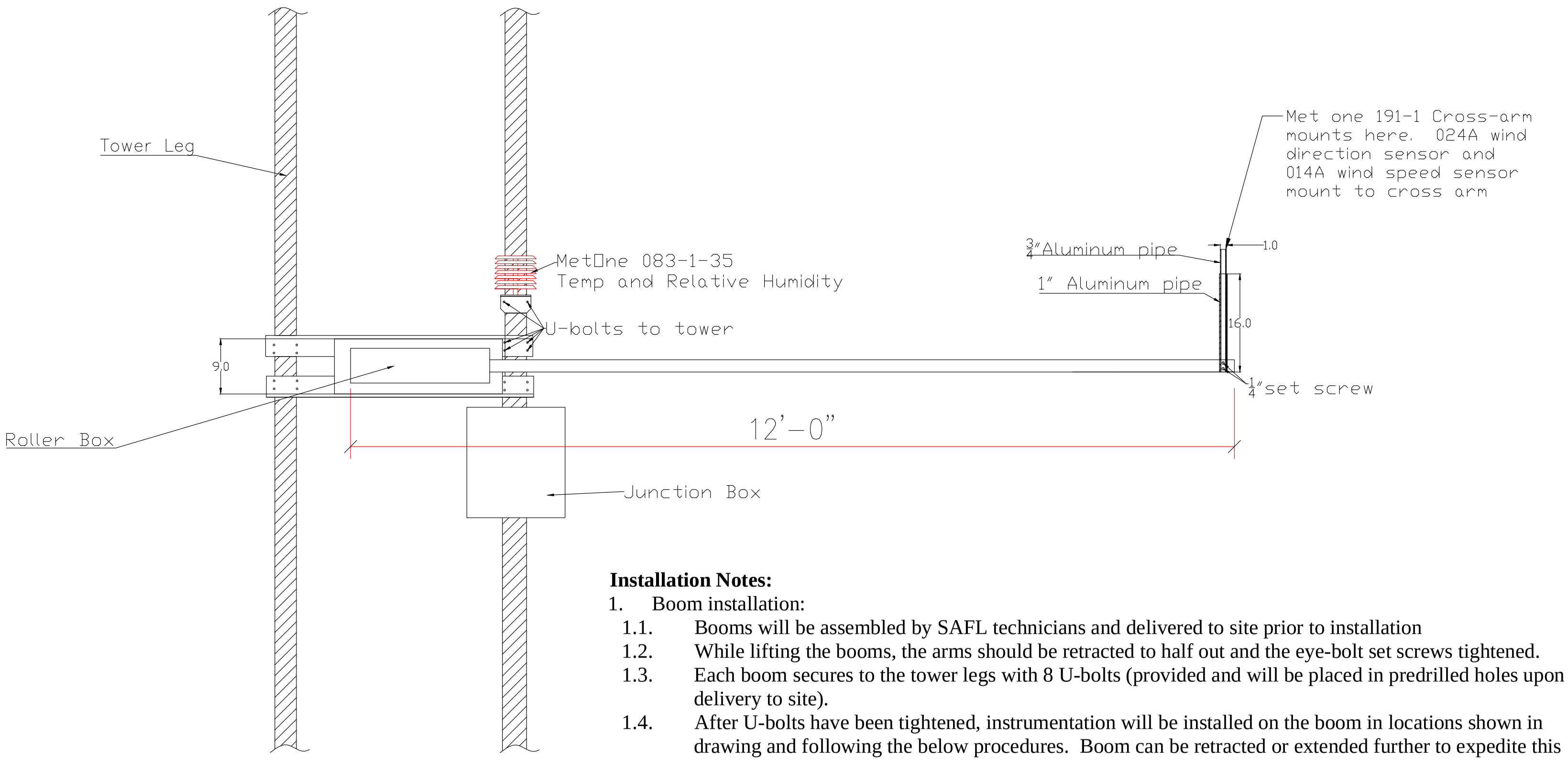
Project: Eolos Met Tower
Date: 8/17/11
Scale: No Scale
Sheet: 02

TSI 12' Boom

Instrumentation Installation Details

Boom 3



Installation Notes:

1. Boom installation:
   - 1.1. Booms will be assembled by SAFL technicians and delivered to site prior to installation
   - 1.2. While lifting the booms, the arms should be retracted to half out and the eye-bolt set screws tightened.
   - 1.3. Each boom secures to the tower legs with 8 U-bolts (provided and will be placed in predrilled holes upon delivery to site).
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   - 1.6. When boom is fully extended, tighten eye-bolt set-screws and tighten jam nut.
2. Sensor Installation
   - 2.1. Wind direction sensor (024A) and wind speed sensor (014A) will be mounted to the Met One 191-1 cross arm by SAFL technicians on the ground. Once these sensors have been properly mounted to the cross arm, they can be installed by tower crew onto the 1" OD aluminum riser pipe.
   - 2.2. Temperature and humidity probe will be mounted to the tower leg with a U-bolt as shown in the drawing.
   - 2.3. Instrumentation cables should be secured to the underside of the boom with bands of electrical tape approximately every12".
   - 2.4. Junction boxes will mount directly below the boom on the nearest tower leg with 2 provided U-bolts.
   - 2.5. Cables will be run from underside of boom arms through glands in the underside of the junction box.
   - 2.6. The downtower homerun cable will exit the J-box through a glad.

General Notes

Boom location: 88'
Type: 12' TSI
Estimated Weight: 50 lbs

Tower Leg Diameter: 3.5"

No.	Revision/Issue	Date
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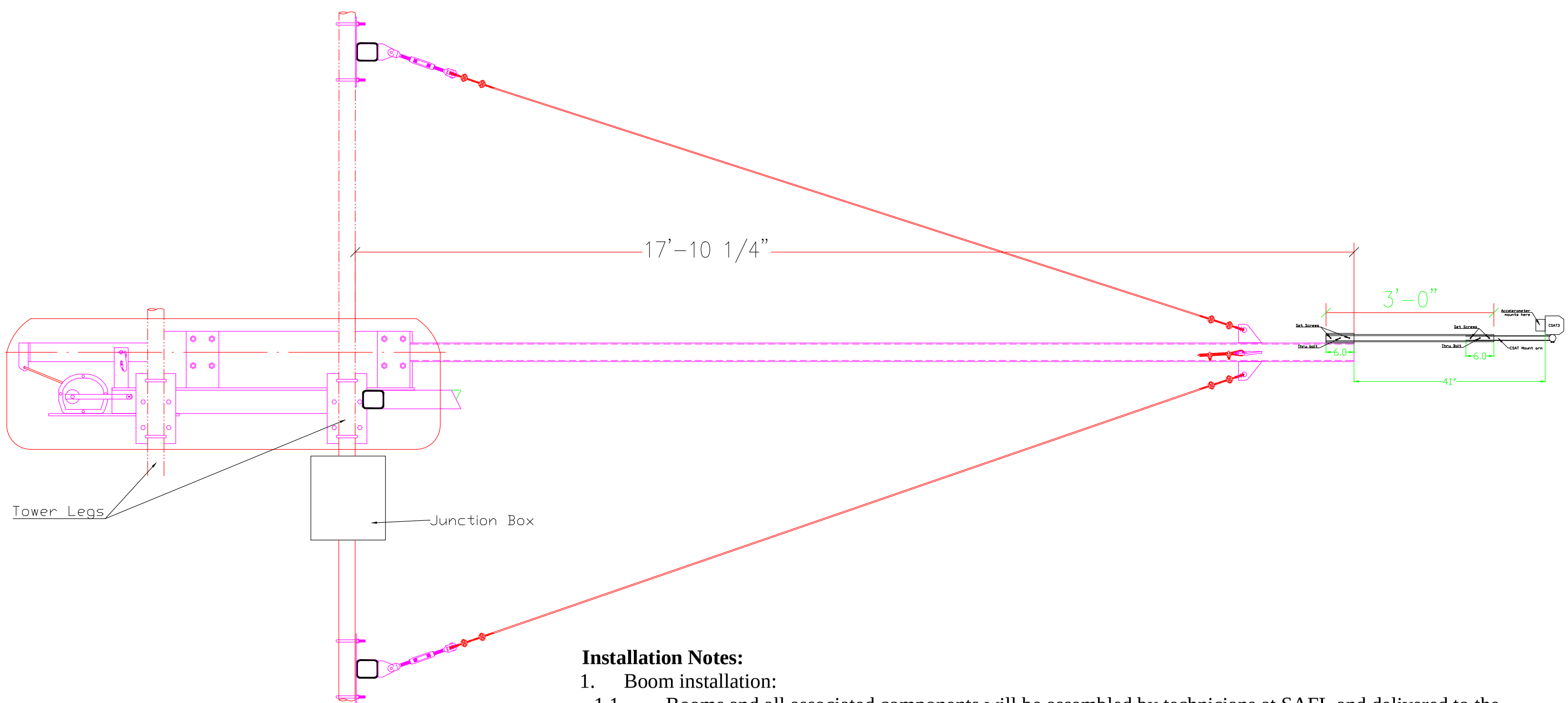
Project: Eolos Met Tower
Date: 8/17/11
Scale: No Scale
Sheet: 03

M/M 18' Boom

Instrumentation Installation Details

Boom 4



Installation Notes:

1. Boom installation:
   - 1.1. Booms and all associated components will be assembled by technicians at SAFL and delivered to the turbine and met tower site.
   - 1.2. Boom installation should be done following guidelines provided by Martin Martin Co.
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   - 2.3. Senor assembly can be attached to the M/M booms by sliding the chrome pipe into the collar welded to the 4" steel tube of the boom. One through bolt and two set screws will secure the sensor assembly to the boom.
   - 2.4. Sensor cables should be routed back along the underside of the boom and secured with electrical tape approximately every 12".
   - 2.5. Cables should be routed from the boom into the junction box through a cable gland.
   - 2.6. Downtower homerun cable will exit the junction box through a glad and run downtower.

General Notes

Boom Location: 98'
Type: 18' M/M boom
Estimated weight: 1500 lbs

Tower Leg Diameter: 3.5"

No.	Revision/Issue	Date
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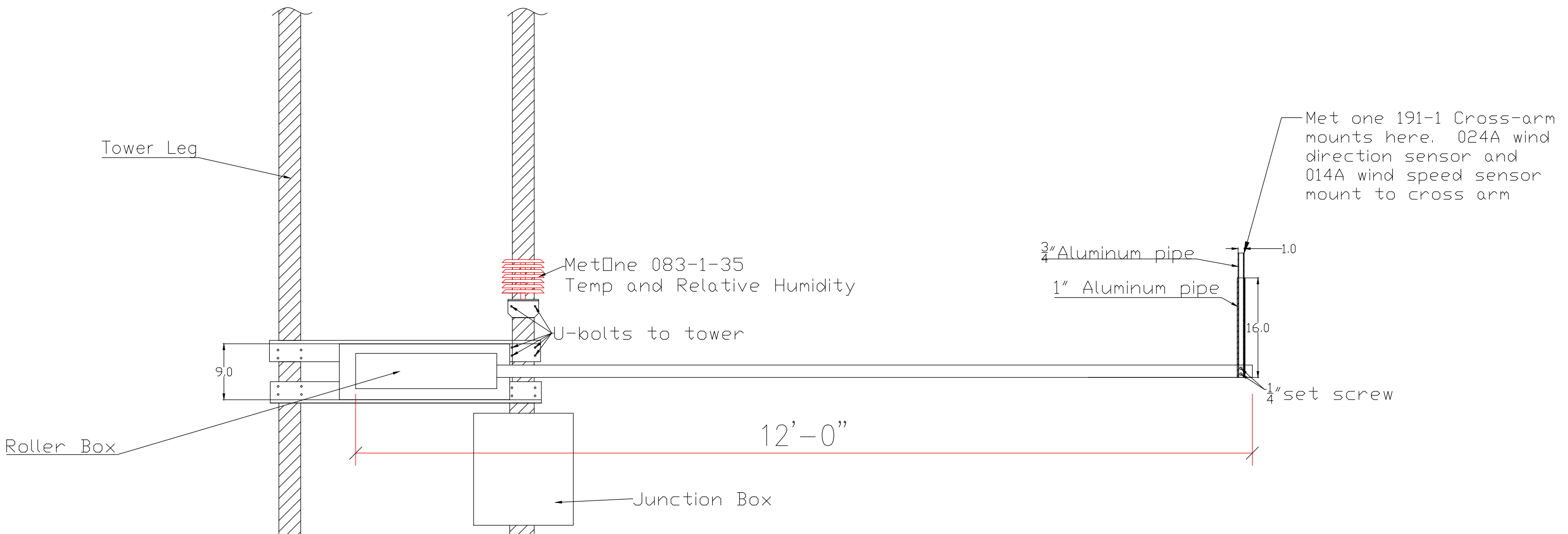
Project: Eolos Met Tower
Date: 8/17/11
Scale: No Scale
Sheet: 04

TSI 12' Boom

Instrumentation Installation Details

Boom 5



Installation Notes:

1. Boom installation:
   - 1.1. Booms will be assembled by SAFL technicians and delivered to site prior to installation
   - 1.2. While lifting the booms, the arms should be retracted to half out and the eye-bolt set screws tightened.
   - 1.3. Each boom secures to the tower legs with 8 U-bolts (provided and will be placed in predrilled holes upon delivery to site).
   - 1.4. After U-bolts have been tightened, instrumentation will be installed on the boom in locations shown in drawing and following the below procedures. Boom can be retracted or extended further to expedite this process.
   - 1.5. After instruments have been installed, the booms should be extended. Instrumentation cables should be secured to the underside of the boom using bands of electrical tape approximately every 12".
   - 1.6. When boom is fully extended, tighten eye-bolt set-screws and tighten jam nut.
2. Sensor Installation
   - 2.1. Wind direction sensor (024A) and wind speed sensor (014A) will be mounted to the Met One 191-1 cross arm by SAFL technicians on the ground. Once these sensors have been properly mounted to the cross arm, they can be installed by tower crew onto the 1" OD aluminum riser pipe.
   - 2.2. Temperature and humidity probe will be mounted to the tower leg with a U-bolt as shown in the drawing.
   - 2.3. Instrumentation cables should be secured to the underside of the boom with bands of electrical tape approximately every12".
   - 2.4. Junction boxes will mount directly below the boom on the nearest tower leg with 2 provided U-bolts.
   - 2.5. Cables will be run from underside of boom arms through glands in the underside of the junction box.
   - 2.6. The downtower homerun cable will exit the J-box through a glad.

General Notes

Boom location: 170'
Type: 12' TSI
Estimated Weight: 50 lbs

Tower Leg Diameter: 2.875"

No.	Revision/Issue	Date
1	CMM	08.23.11

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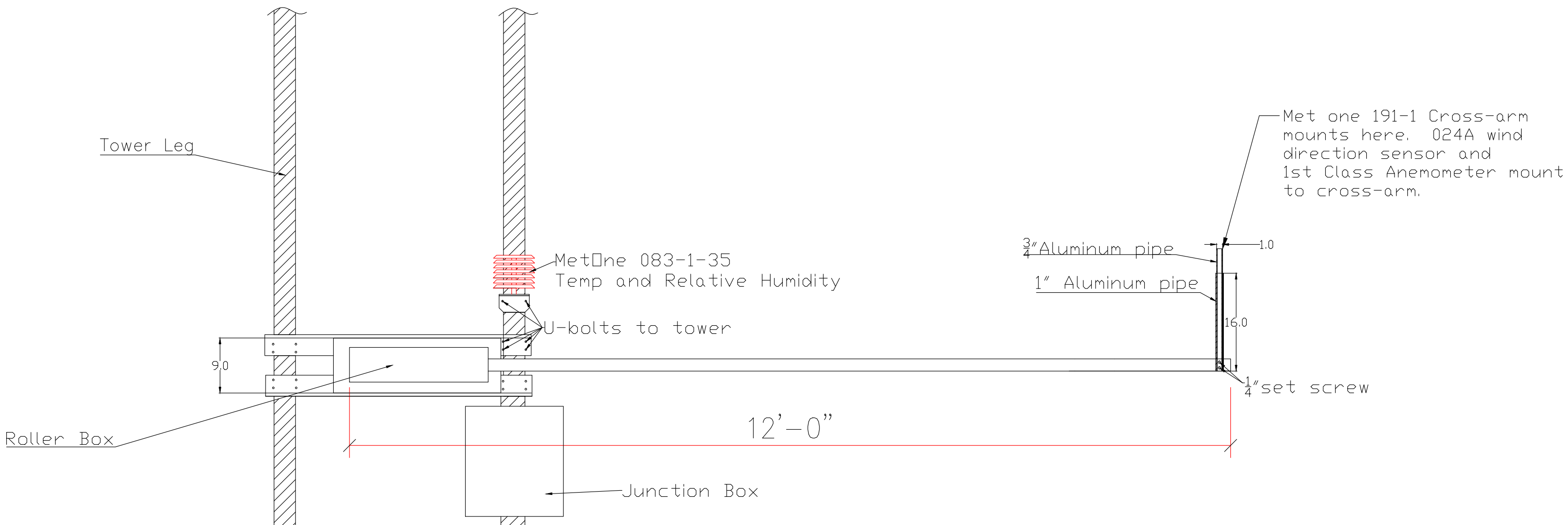
Project: Eolos Met Tower
Date: 8/17/11
Scale: No Scale
Sheet: 05

TSI 12' Boom

Instrumentation Installation Details

Boom 6



Installation Notes:

1. Boom installation:
   - 1.1. Booms will be assembled by SAFL technicians and delivered to site prior to installation
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   - 1.3. Each boom secures to the tower legs with 8 U-bolts (provided and will be placed in predrilled holes upon delivery to site).
   - 1.4. After U-bolts have been tightened, instrumentation will be installed on the boom in locations shown in drawing and following the below procedures. Boom can be retracted or extended further to expedite this process.
   - 1.5. After instruments have been installed, the booms should be extended. Instrumentation cables should be secured to the underside of the boom using bands of electrical tape approximately every 12".
   - 1.6. When boom is fully extended, tighten eye-bolt set-screws and tighten jam nut.
2. Sensor Installation
   - 2.1. Wind direction sensor (024A) and wind speed sensor (014A) will be mounted to the Met One 191-1 cross arm by SAFL technicians on the ground. Once these sensors have been properly mounted to the cross arm, they can be installed by tower crew onto the 1" OD aluminum riser pipe.
   - 2.2. Temperature and humidity probe will be mounted to the tower leg with a U-bolt as shown in the drawing.
   - 2.3. Instrumentation cables should be secured to the underside of the boom with bands of electrical tape approximately every12".
   - 2.4. Junction boxes will mount directly below the boom on the nearest tower leg with 2 provided U-bolts.
   - 2.5. Cables will be run from underside of boom arms through glands in the underside of the junction box.
   - 2.6. The downtower homerun cable will exit the J-box through a glad.

General Notes

Boom location: 253'
Type: 12' TSI
Estimated Weight: 50 lbs

Tower Leg Diameter: 2.875"

No.	Revision/Issue	Date
1	CMM	08.23.11

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University of Minnesota
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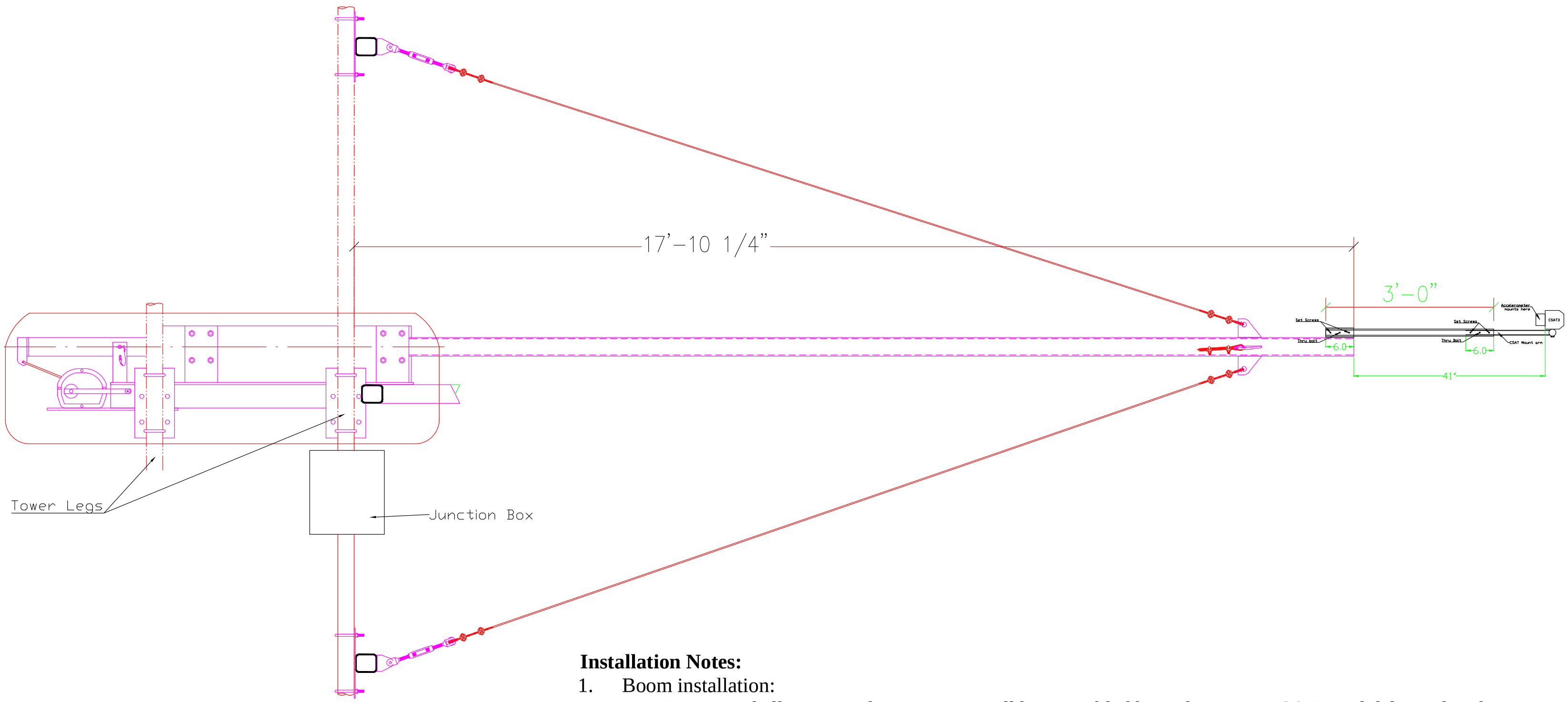
Rosemount, MN
55068

Project: Eolos Met Tower
Date: 8/17/11
Scale: No Scale
Sheet: 06

M/M 18' Boom

Instrumentation Installation Details

Boom 7



Installation Notes:

1. Boom installation:
   - 1.1. Booms and all associated components will be assembled by technicians at SAFL and delivered to the turbine and met tower site.
   - 1.2. Boom installation should be done following guidelines provided by Martin Martin Co.
2. Sensor Installation
   - 2.1. CSAT3 (sonic anemometer), accelerometer and static wick assembly will be bolted together by the SAFL technicians and delivered to site by the sensor installation date.
   - 2.3. Senor assembly can be attached to the M/M booms by sliding the chrome pipe into the collar welded to the 4" steel tube of the boom. One through bolt and two set screws will secure the sensor assembly to the boom.
   - 2.4. Sensor cables should be routed back along the underside of the boom and secured with electrical tape approximately every 12".
   - 2.5. Cables should be routed from the boom into the junction box through a cable gland.
   - 2.6. Downtower homerun cable will exit the junction box through a glad and run downtower.

General Notes

Boom Location: 263'
Type: 18' M/M boom
Estimated weight: 1500 lbs

Tower Leg Diameter: 2.875"

No.	Revision/Issue	Date
1	CMM	08.23.11

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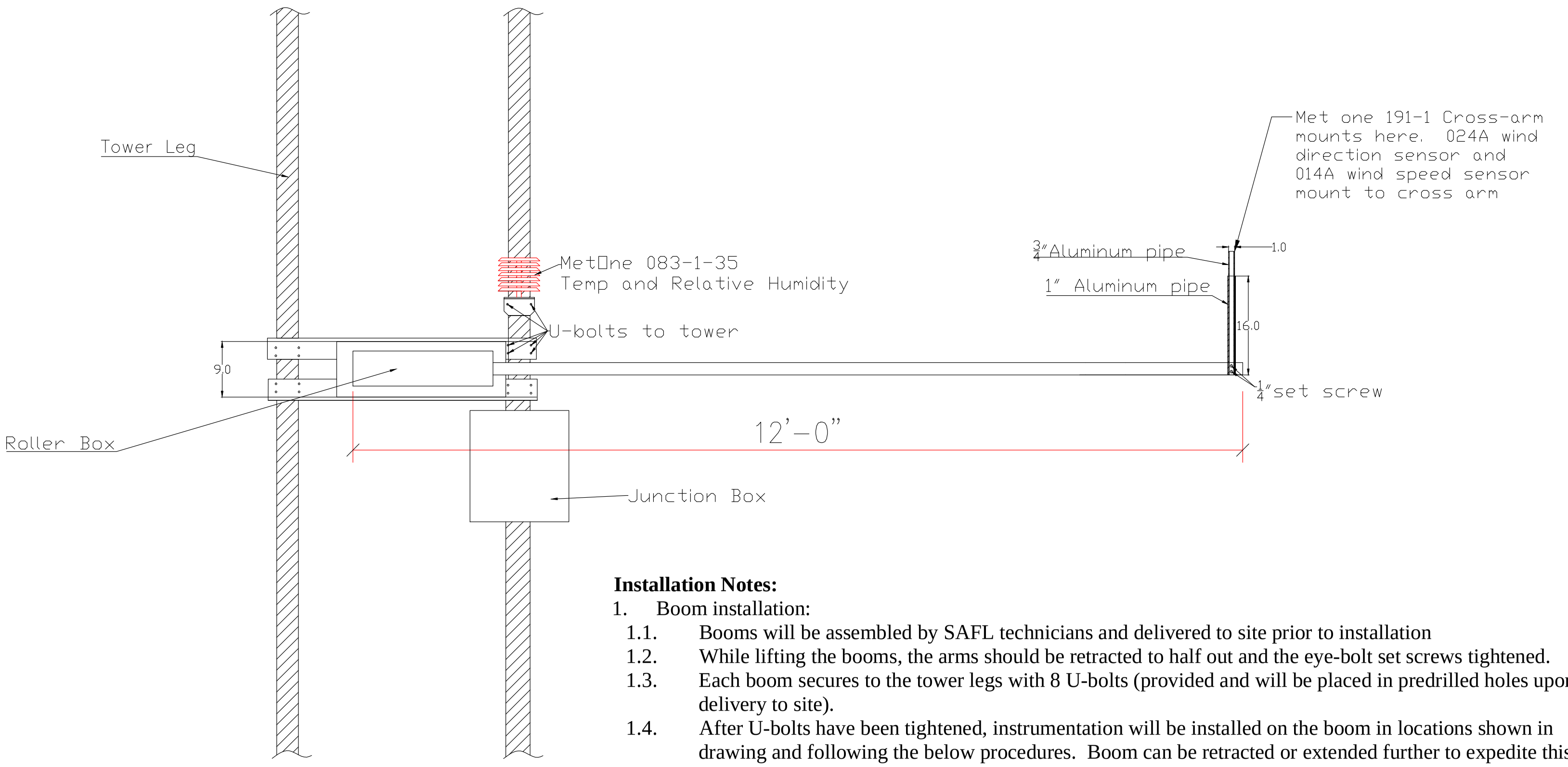
Project: Eolos Met Tower
Date: 8/17/11
Scale: No Scale
Sheet: 07

TSI 12' Boom

Instrumentation Installation Details

Boom 8



Installation Notes:

1. Boom installation:
   - 1.1. Booms will be assembled by SAFL technicians and delivered to site prior to installation
   - 1.2. While lifting the booms, the arms should be retracted to half out and the eye-bolt set screws tightened.
   - 1.3. Each boom secures to the tower legs with 8 U-bolts (provided and will be placed in predrilled holes upon delivery to site).
   - 1.4. After U-bolts have been tightened, instrumentation will be installed on the boom in locations shown in drawing and following the below procedures. Boom can be retracted or extended further to expedite this process.
   - 1.5. After instruments have been installed, the booms should be extended. Instrumentation cables should be secured to the underside of the boom using bands of electrical tape approximately every 12".
   - 1.6. When boom is fully extended, tighten eye-bolt set-screws and tighten jam nut.
2. Sensor Installation
   - 2.1. Wind direction sensor (024A) and wind speed sensor (014A) will be mounted to the Met One 191-1 cross arm by SAFL technicians on the ground. Once these sensors have been properly mounted to the cross arm, they can be installed by tower crew onto the 1" OD aluminum riser pipe.
   - 2.2. Temperature and humidity probe will be mounted to the tower leg with a U-bolt as shown in the drawing.
   - 2.3. Instrumentation cables should be secured to the underside of the boom with bands of electrical tape approximately every12".
   - 2.4. Junction boxes will mount directly below the boom on the nearest tower leg with 2 provided U-bolts.
   - 2.5. Cables will be run from underside of boom arms through glands in the underside of the junction box.
   - 2.6. The downtower homerun cable will exit the J-box through a glad.

General Notes

Boom location: 335'
Type: 12' TSI
Estimated Weight: 50 lbs

Tower Leg Diameter: 2.875"

No.	Revision/Issue	Date
1	CMM	08.23.11

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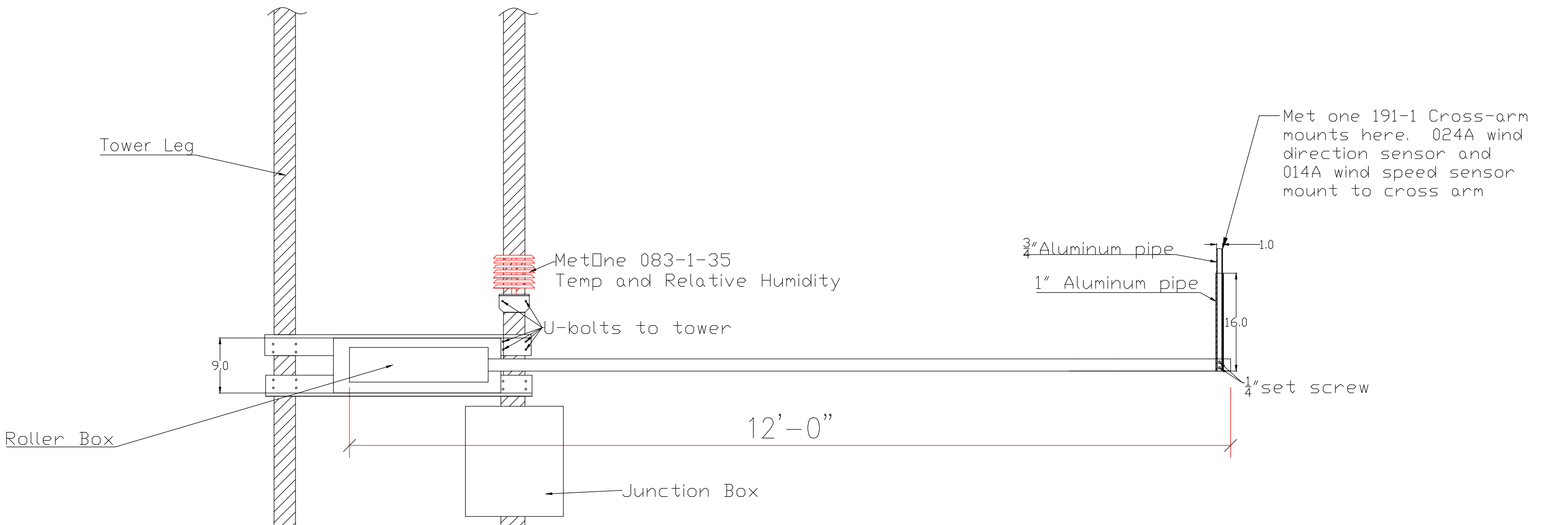
55068

Project	Sheet
Eolos Met Tower	08
Date: 8/17/11	
Scale: No Scale	

TSI 12' Boom

Instrumentation Installation Details

Boom 9



Installation Notes:

1. Boom installation:
   - 1.1. Booms will be assembled by SAFL technicians and delivered to site prior to installation
   - 1.2. While lifting the booms, the arms should be retracted to half out and the eye-bolt set screws tightened.
   - 1.3. Each boom secures to the tower legs with 8 U-bolts (provided and will be placed in predrilled holes upon delivery to site).
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   - 1.5. After instruments have been installed, the booms should be extended. Instrumentation cables should be secured to the underside of the boom using bands of electrical tape approximately every 12".
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2. Sensor Installation
   - 2.1. Wind direction sensor (024A) and wind speed sensor (014A) will be mounted to the Met One 191-1 cross arm by SAFL technicians on the ground. Once these sensors have been properly mounted to the cross arm, they can be installed by tower crew onto the 1" OD aluminum riser pipe.
   - 2.2. Temperature and humidity probe will be mounted to the tower leg with a U-bolt as shown in the drawing.
   - 2.3. Instrumentation cables should be secured to the underside of the boom with bands of electrical tape approximately every12".
   - 2.4. Junction boxes will mount directly below the boom on the nearest tower leg with 2 provided U-bolts.
   - 2.5. Cables will be run from underside of boom arms through glands in the underside of the junction box.
   - 2.6. The downtower homerun cable will exit the J-box through a glad.

General Notes

Boom location: 415'
Type: 12' TSI
Estimated Weight: 50 lbs

Tower Leg Diameter: 2.875"

No.	Revision/Issue	Date
1	CMM	08.23.11

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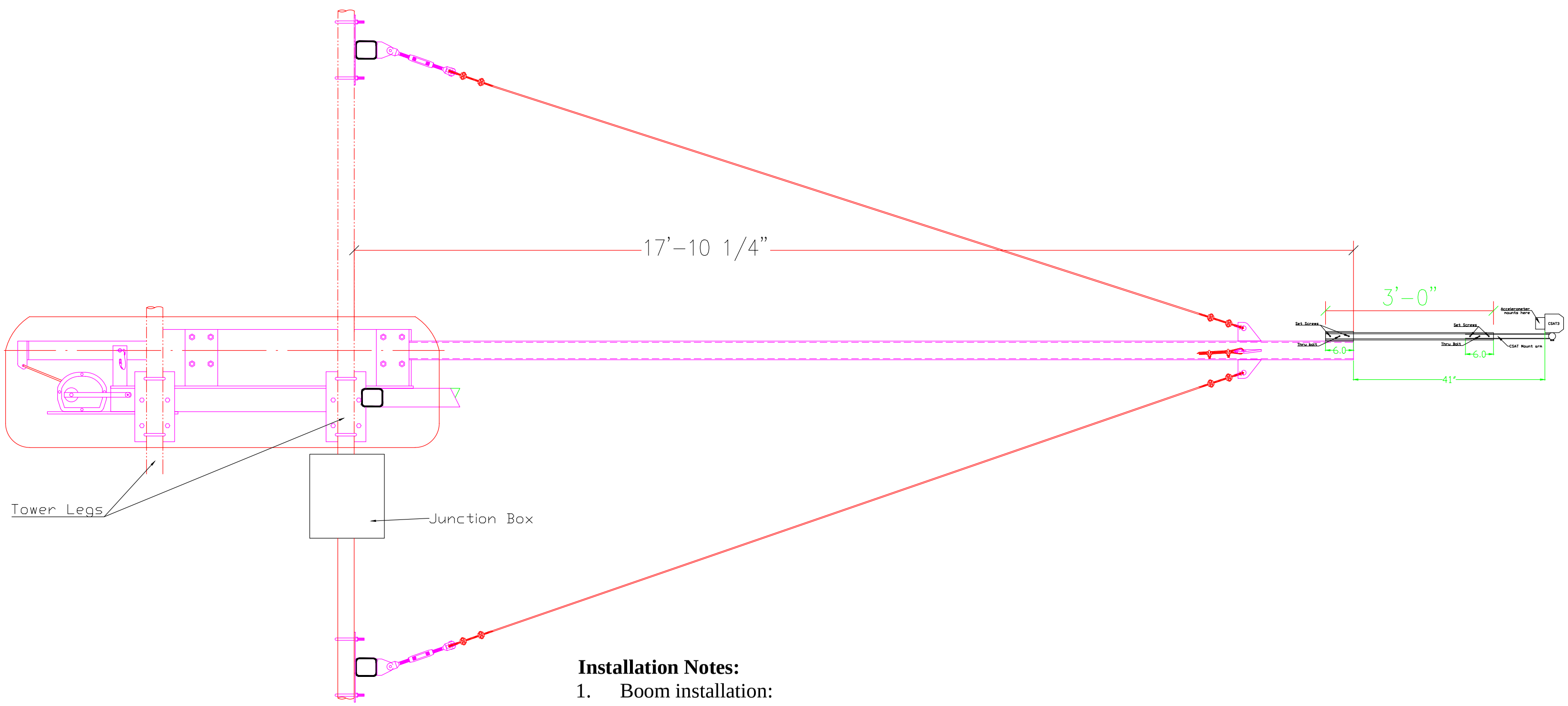
Project: Eolos Met Tower
Date: 8/17/11
Scale: No Scale
Sheet: 09

M/M 18' Boom

Instrumentation Installation Details

Boom 10



Installation Notes:

1. Boom installation:
   1.1. Booms and all associated components will be assembled by technicians at SAFL and delivered to the turbine and met tower site.
   1.2. Boom installation should be done following guidelines provided by Martin Martin Co.
2. Sensor Installation
   2.1. CSAT3 (sonic anemometer), accelerometer and static wick assembly will be bolted together by the SAFL technicians and delivered to site by the sensor installation date.
   2.3. Senor assembly can be attached to the M/M booms by sliding the chrome pipe into the collar welded to the 4" steel tube of the boom. One through bolt and two set screws will secure the sensor assembly to the boom.
   2.4. Sensor cables should be routed back along the underside of the boom and secured with electrical tape approximately every 12".
   2.5. Cables should be routed from the boom into the junction box through a cable gland.
   2.6. Downtower homerun cable will exit the junction box through a glad and run downtower.

General Notes

Boom Location: 263'
Type: 18' M/M boom
Estimated weight: 1500 lbs

Tower Leg Diameter: 2.875"

No.	Revision/Issue	Date
1	CMM	08.23.11

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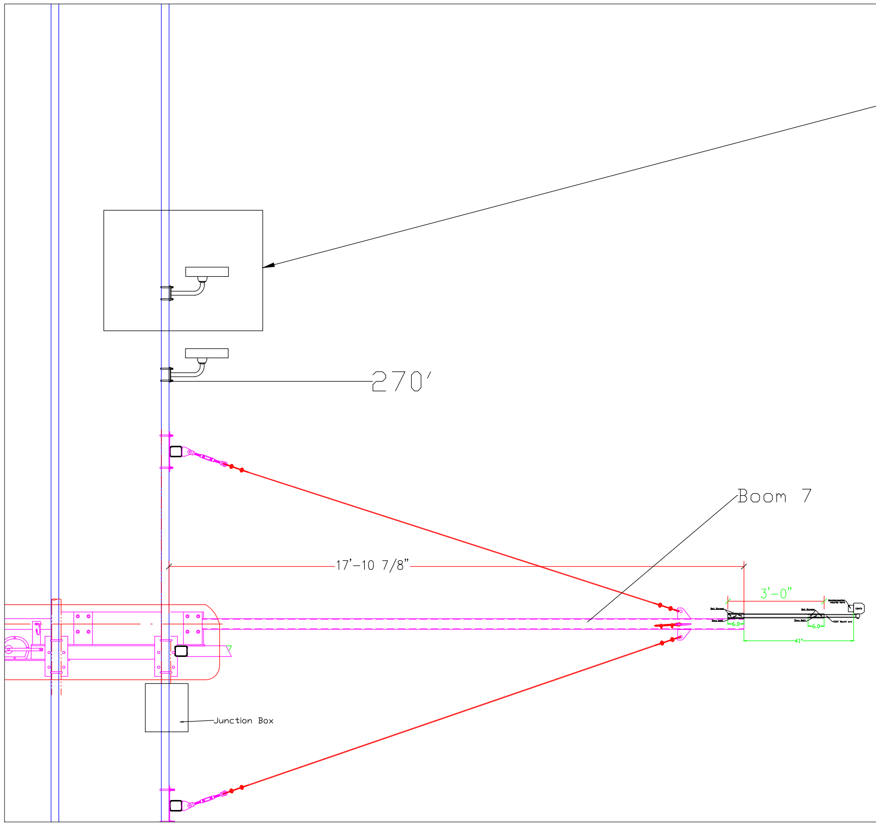
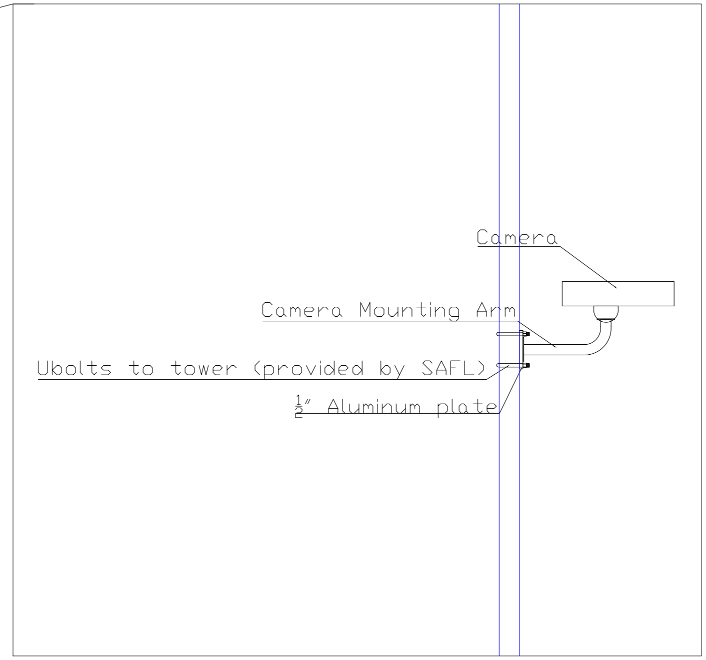
Project: Eolos Met Tower
Date: 8/17/11
Scale: No Scale
Sheet: 10

Camera Installation Details





Installation Notes:

1.1. 2 Basler IP cameras will be mounted to the tower using mounting brackets and U-bolts provided by SAFL.

1.2. Lower camera will be mounted at 270' height and upper camera at apoproximately 272'

1.3. 1 ethernet and 24VAC power cable will be routed to each camera and terminated in the electrical cabinet at the base of the Met tower.

1.4. Both cables should be secured to tower with electrical tape near the cameras to provide for some strain relief.

General Notes

Location: 270'

Tower Leg Diameter: 2.875"

No.	Revision/Issue	Date
1	CMM	08.23.11

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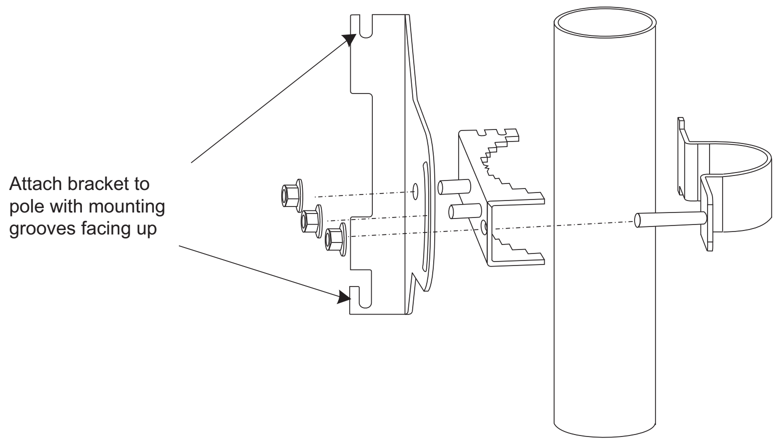
55068

Project: Eolos Met Tower
Date: 8/17/11
Scale: No Scale
Sheet: 11

Figure 3–1. Attaching the Bracket to the Pole

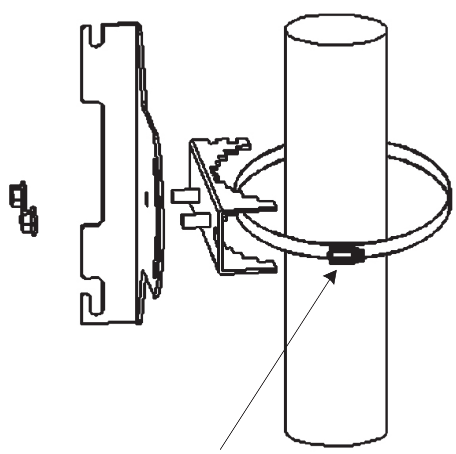


3. Use the included nuts to tightly secure the MP-620 to the bracket.

Mounting on Larger Diameter Poles

In addition, there is a method for attaching the pole-mounting bracket to a pole that is 5.08 to 12.7 cm (2 to 5 inches) in diameter using an adjustable steel band strap (not included in the kit). A steel band strap up to 0.5 inch (1.27 cm) wide can be threaded through the main part of the bracket to secure it to a larger diameter pole without using the U-shaped part of the bracket. This method is illustrated in the following figure.

Figure 3–2. Attaching the Bracket Using a Steel Band Strap



Using the Wall-Mounting Bracket

Perform the following steps to mount the unit to a wall using the wall-mounting bracket:

1. Always attach the bracket to a wall with the open end of the mounting grooves facing up (see following figure).

Figure 3–3. Wall-Mounting Bracket

18' Boom Martin/Martin Boom Mounting Instructions.

For installation, the support cross braces (A1-A, A2 and A1-B) should first be u-bolted to the tower. Than the roller box would be u-bolted to the tower and bolted to the support angle on cross brace A2. The boom can then be installed into the roller box. The cables should already be attached to the boom tip so they will just need to be attached back to the cross brace connection points. The winch cable can then be attached to the end of the boom and the boom can be extended with the winch and set at station 1. This is just an outline of how the boom and supports can be installed on the tower. Our drawings really only dictate the completed condition. The installer will typically develop their preferred installation procedure and address the sequence, stability and safety.

For tensioning the cables, the cables should be set to a length that puts approximately 400 pounds of tension on each cable when the boom is extended to station 1. It is best to have these lengths already set so that the guys in the field just have to extend the boom out with the winch and set it at station 1 with the pin. If Mike does a test set up in the fabrication shop he should be able to calibrate this. To calibrate the cable tension, the installation should be set up with all the cables attached and then the turnbuckles should be taken in to tension the cable. It is possible to calculate how much the cable needs to shorten (or how many times the turnbuckle should be turned once it is snug) but it might not be very accurate since fist grips might slip a little and the tip of the boom might deflect slightly when one cable is tensioned. I am not sure what Mike has in the fabrication shop but there are devices that can measure tension in a cable. The specified 400 pound pretension is not a very big load (basically just makes the cables taught) and does not need to be precisely calibrated.

I can discuss the cable tensioning with you and Mike on Wednesday (see my next email) when I come out to the fabrication shop.

Hope this helps.

Kevin

Kevin Haas, PE, CE, LEED AP
Project Engineer
PE (CO), CE (CA)

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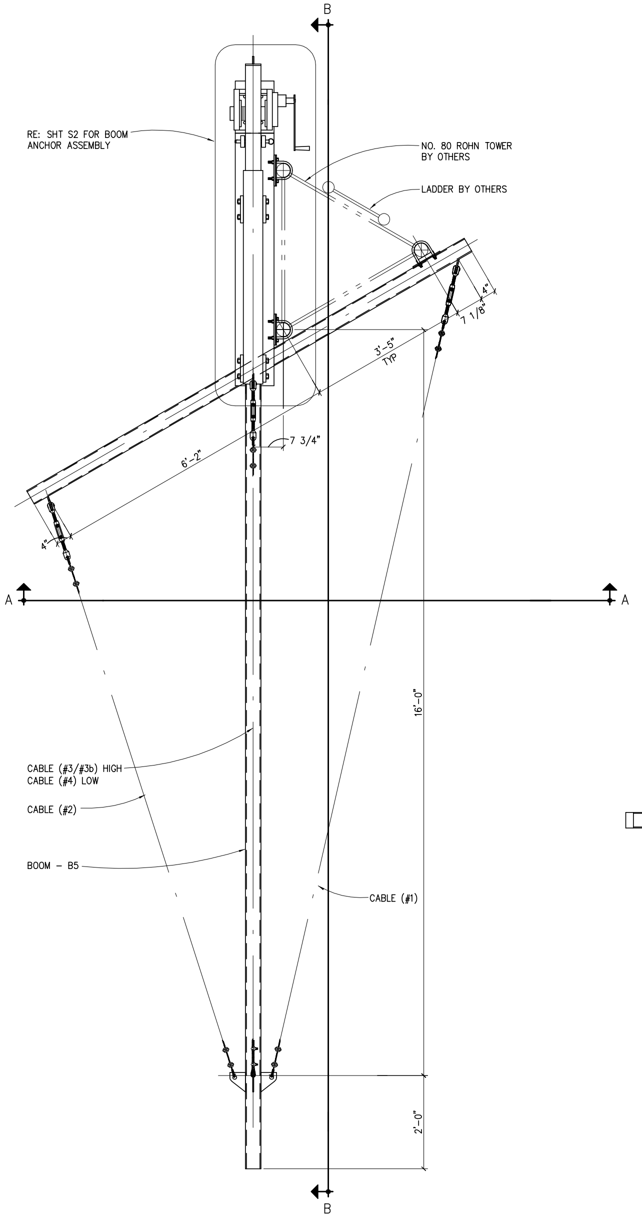
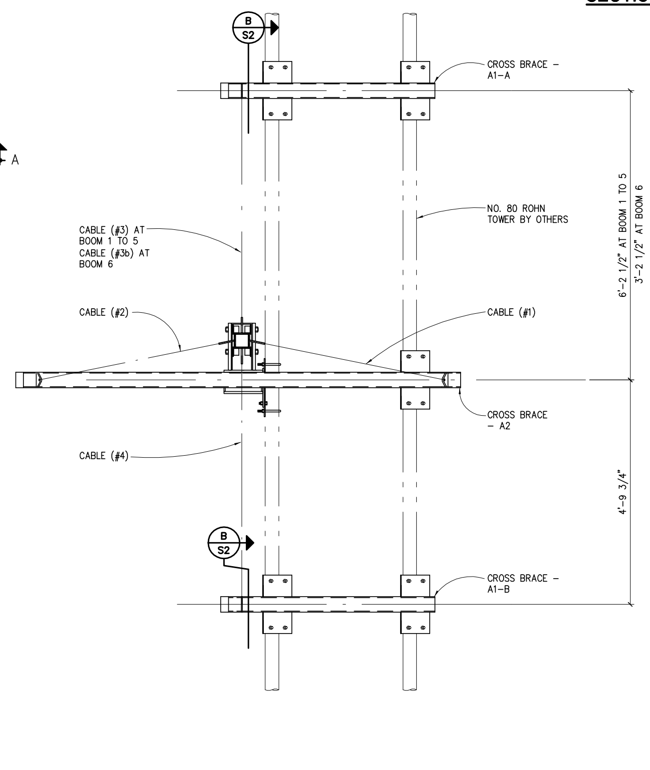
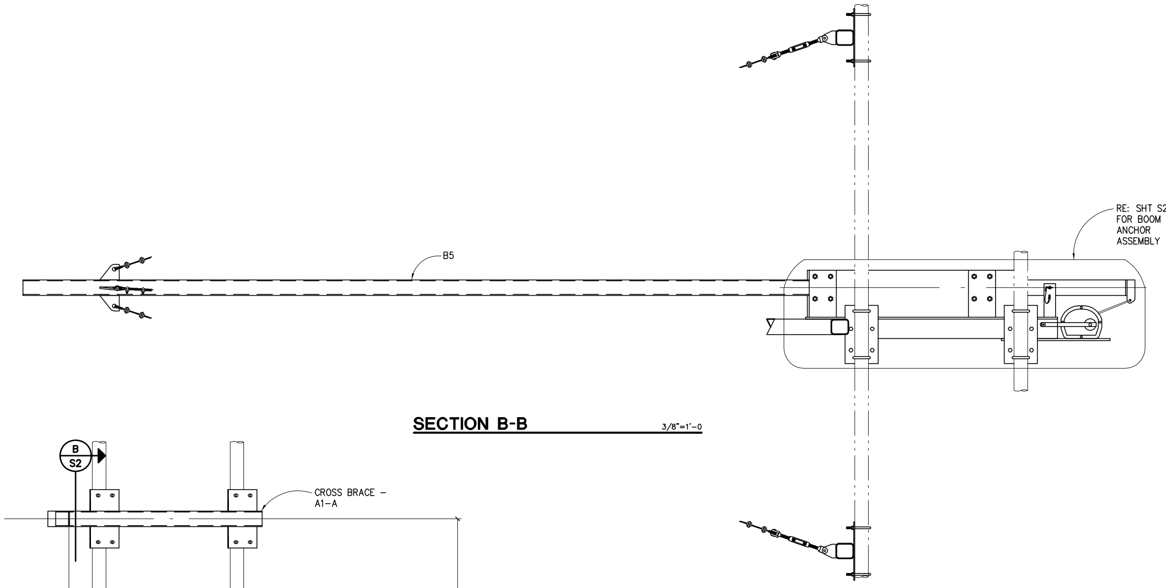


PLAN 3/8"=1'-0



SECTION A-A 3/8"=1'-0



SECTION B-B 3/8"=1'-0

BOOM ELEVATIONS

	Field Mark	Centerline Elevation	Remarks
BOOM 1			TOWER SECTION WITH 3.50"Ø LEG
	A1-A	38'-4 3/8"	
	A2	32'-1 7/8"	
	A1-B	27'-4 1/8"	
BOOM 2			TOWER SECTION WITH 3.50"Ø LEG
	A1-A	103'-4 3/8"	
	A2	97'-1 7/8"	
	A1-B	92'-4 1/8"	
BOOM 3			TOWER SECTION WITH 2.88"Ø LEG
	A1-A	185'-4 3/8"	
	A2	179'-1 7/8"	
	A1-B	174'-4 1/8"	
BOOM 4			TOWER SECTION WITH 2.88"Ø LEG
	A1-A	268'-4 3/8"	
	A2	262'-1 7/8"	
	A1-B	257'-4 1/8"	
BOOM 5			TOWER SECTION WITH 2.88"Ø LEG
	A1-A	352'-4 3/8"	
	A2	346'-1 7/8"	
	A1-B	341'-4 1/8"	
BOOM 6			TOWER SECTION WITH 2.88"Ø LEG
	A1-A	424'-4 3/8"	
	A2	421'-1 7/8"	
	A1-B	416'-4 1/8"	

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No.	Date	Description	By

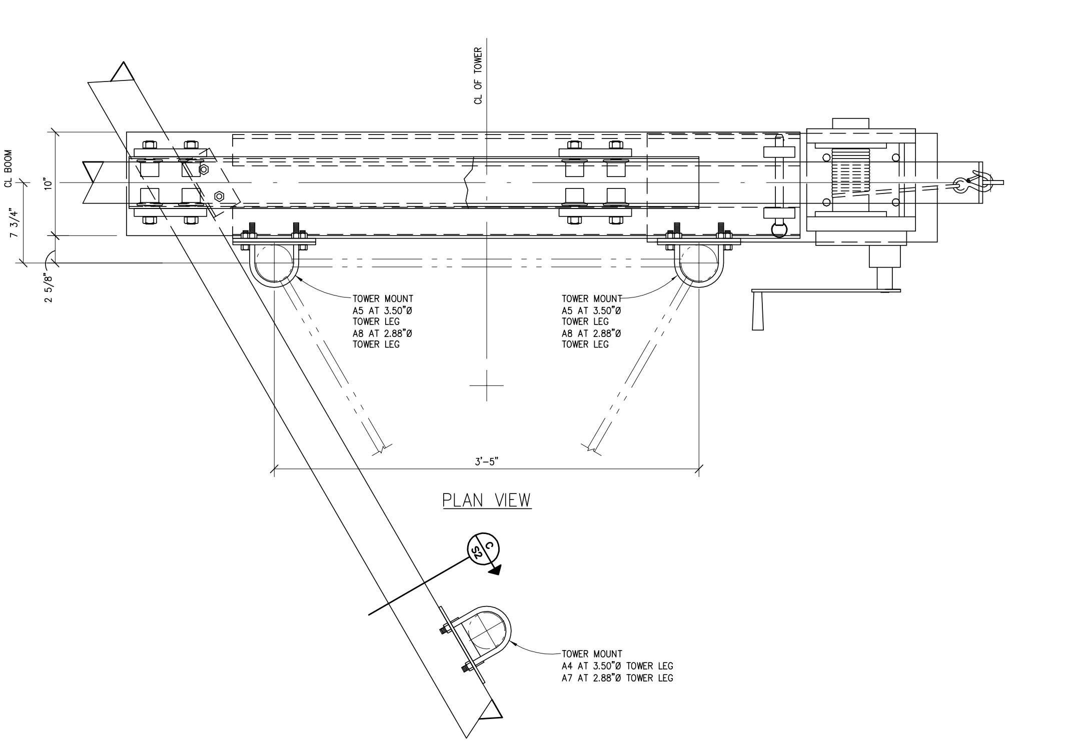
Revisions

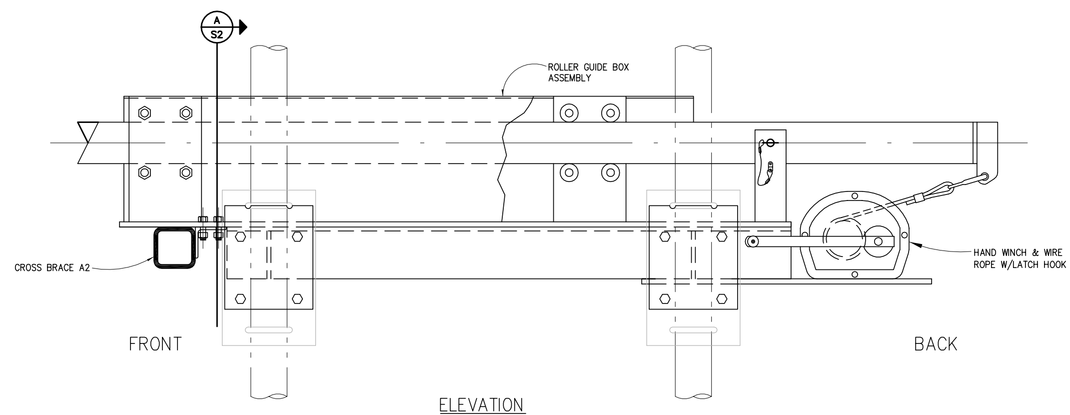
K. HAAS — Drawn By — JULY 25, 2011 Date
K. HAAS — Engineer
D. GILBERT — Checked By
J. M. McAFFREY — Approved By

University of Minnesota
MET Tower Booms

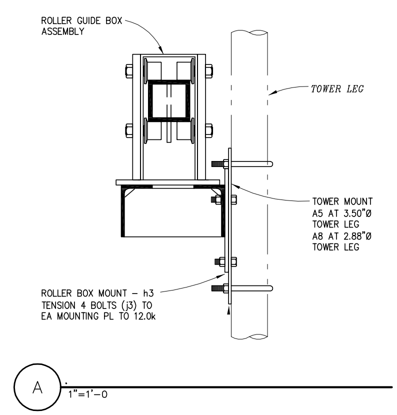
Sheet Title
General Arrangement Drawing

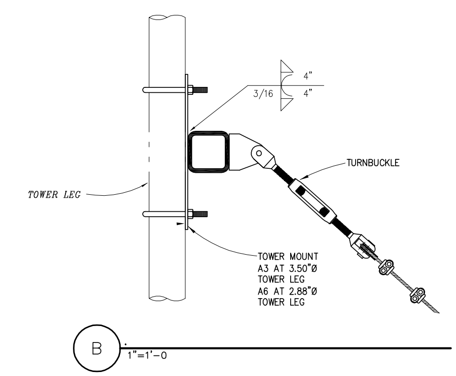
Sheet Number
S1

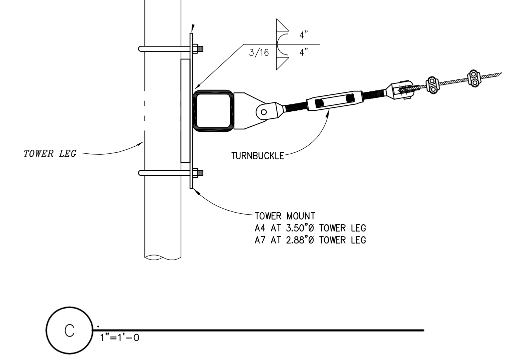




BOOM ANCHOR ASSEMBLY







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fax 303.431.4028

No.	Date	Description	By

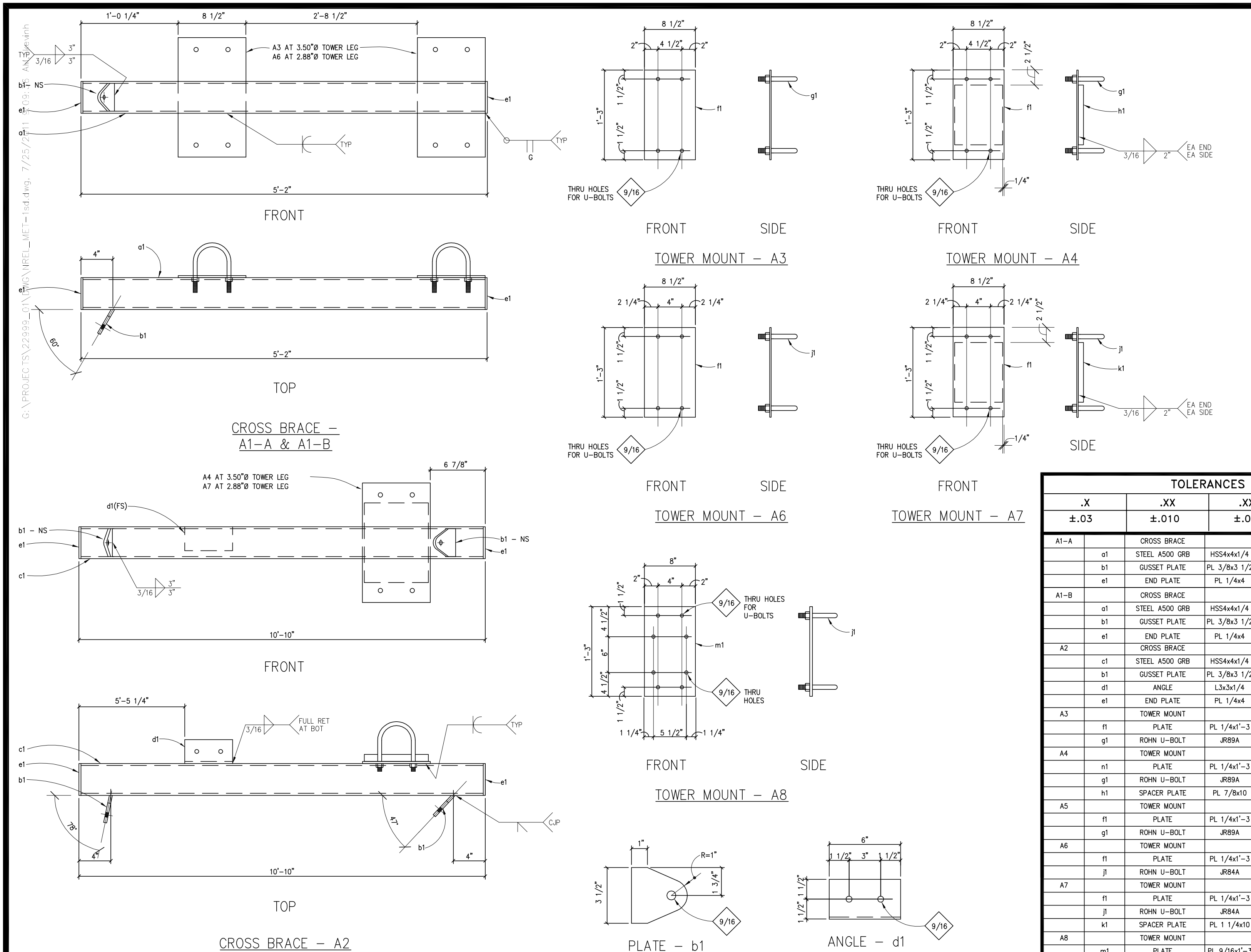
Revisions

K. HAAS — Drawn By — JULY 25, 2011 — Date
K. HAAS — Engineer
D. GILBERT — Checked By
J. M. McAFFREY — Approved By

University of Minnesota
MET Tower Booms

Sheet Title
BOOM ANCHOR ASSEMBLY & DETAILS

Sheet Number
S2



SHOP NOTES:
1. ALL FILLET WELDS CONT UNO.
2. ALL MATL ASTM A36 UNO.
3. CLEAN ALL STL PER SSPC-SP6 "COMMERCIAL BLAST CLEANING" APPLY 2 COATS, 3 MIL DFT PER COAT TNEMEC SPRA-SAF EN, SERIES 30.

TOLERANCES

.X	.XX	.XXX	ANGLE
±.03	±.010	±.002	±30'

Field Mark	Shop Mark	Description	Stock No.	Length	Qty Per Boom	No. of Booms
A1-A		CROSS BRACE				6
	a1	STEEL A500 GRB	HSS4x4x1/4	5'-1 1/2"	1	
	b1	GUSSET PLATE	PL 3/8x3 1/2	0'-3 1/2"	1	
	e1	END PLATE	PL 1/4x4	0'-4"	2	
A1-B		CROSS BRACE				6
	a1	STEEL A500 GRB	HSS4x4x1/4	5'-1 1/2"	1	
	b1	GUSSET PLATE	PL 3/8x3 1/2	0'-3 1/2"	1	
	e1	END PLATE	PL 1/4x4	0'-4"	2	
A2		CROSS BRACE				6
	c1	STEEL A500 GRB	HSS4x4x1/4	10'-9 1/2"	1	
	b1	GUSSET PLATE	PL 3/8x3 1/2	0'-3 1/2"	2	
	d1	ANGLE	L3x3x1/4	0'-6"	1	
	e1	END PLATE	PL 1/4x4	0'-4"	2	
A3		TOWER MOUNT				2
	f1	PLATE	PL 1/4x1'-3	0-8 1/2"	4	
	g1	ROHN U-BOLT	JR89A	–	8	
A4		TOWER MOUNT				2
	n1	PLATE	PL 1/4x1'-3	0-8"	1	
	g1	ROHN U-BOLT	JR89A	–	2	
	h1	SPACER PLATE	PL 7/8x10	0'-8"	1	
A5		TOWER MOUNT				2
	f1	PLATE	PL 1/4x1'-3	0-8 1/2"	2	
	g1	ROHN U-BOLT	JR89A	–	4	
A6		TOWER MOUNT				4
	f1	PLATE	PL 1/4x1'-3	0-8 1/2"	4	
	j1	ROHN U-BOLT	JR84A	–	8	
A7		TOWER MOUNT				4
	f1	PLATE	PL 1/4x1'-3	0-8 1/2"	1	
	j1	ROHN U-BOLT	JR84A	–	2	
	k1	SPACER PLATE	PL 1 1/4x10	0'-8"	1	
A8		TOWER MOUNT				4
	m1	PLATE	PL 9/16x1'-3	0-8"	2	
	j1	ROHN U-BOLT	JR84A	–	4	

LIST OF MATERIALS

MARTIN / MARTIN
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No.	Date	Description	By

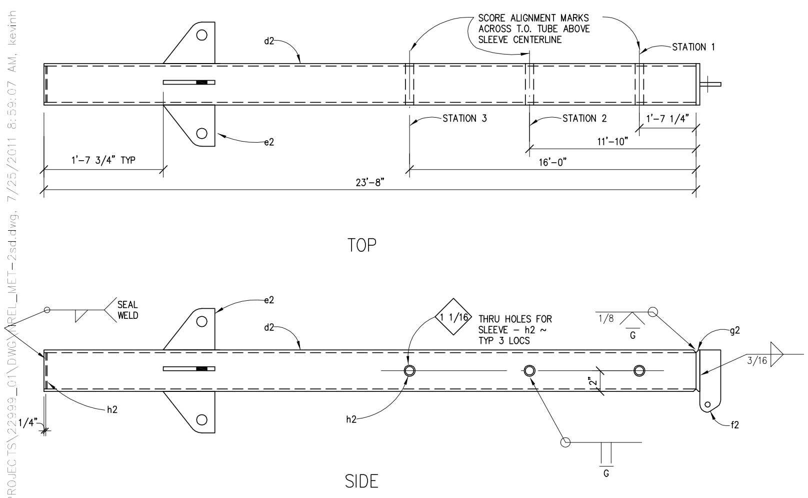
Revisions

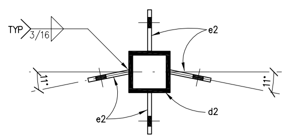
K. HAAS — Drawn By — JULY 25, 2011 — Date
K. HAAS — Engineer
D. GILBERT — Checked By
J. M. McAFFREY — Approved By

University of Minnesota
MET Tower Booms

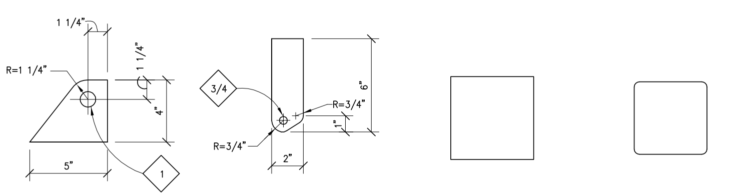
Sheet Title
Piece Drawing – Cross Braces and Tower Mounts

Sheet Number
1SD





BOOM – B5



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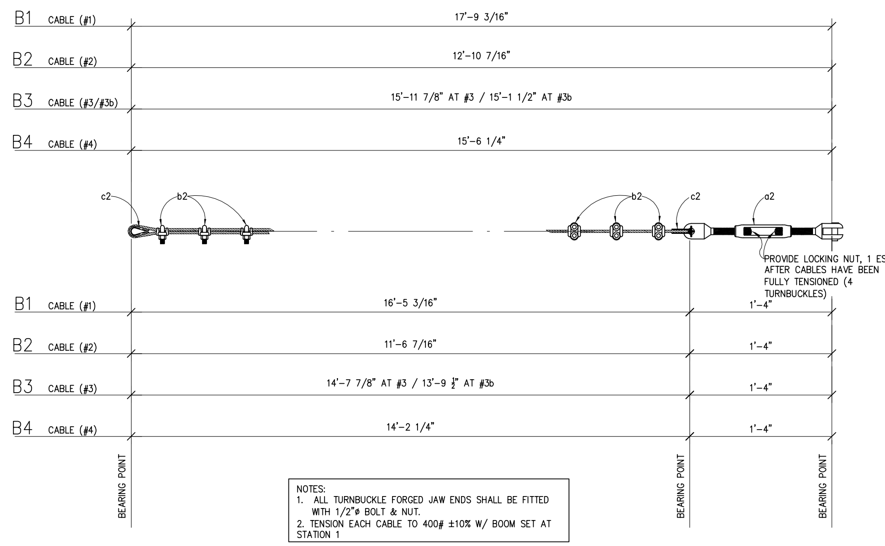


NOTES:
1. ALL TURNBUCKLE FORGED JAW ENDS SHALL BE FITTED WITH 1/2"ø BOLT & NUT.
2. TENSION EACH CABLE TO 400# ±10% W/ BOOM SET AT STATION 1

CABLES

TOLERANCES			
.X	.XX	.XXX	ANGLE
±.03	±.010	±.002	±30'

Field Mark	Shop Mark	Description	Stock No.	Material	Length	Qty Per Boom	No. of Booms
B1		CABLE (#1)		5/16" 6x19 IWRC GALV CABLE	17'-9 3/16"	1	6
	a2	CROSBY TURNBUCKLE (HG-227)	1031939	–		1	
	b2	CROSBY CLIP (G-450)	1010079	–		6	
	c2	STANDARD WIRE ROPE THIMBLE (G-411)	1037318	–		2	
B2		CABLE (#2)		5/16" 6x19 IWRC GALV CABLE	12'-10 7/16"	1	6
	a2	CROSBY TURNBUCKLE (HG-227)	1031939	–		1	
	b2	CROSBY CLIP (G-450)	1010079	–		6	
	c2	STANDARD WIRE ROPE THIMBLE (G-411)	1037318	–		2	
B3		CABLE (#3)		5/16" 6x19 IWRC GALV CABLE	15'-7 1/2"	1	5x#3 1x#3b
		CABLE (#3b)		5/16" 6x19 IWRC GALV CABLE	15'-7 1/2"	1	
	a2	CROSBY TURNBUCKLE (HG-227)	1031939	–		1	
	b2	CROSBY CLIP (G-450)	1010079	–		6	
	c2	STANDARD WIRE ROPE THIMBLE (G-411)	1037318	–		2	
B4		CABLE (#4)		5/16" 6x19 IWRC GALV CABLE	15'-6 1/4"	1	6
	a2	CROSBY TURNBUCKLE (HG-227)	1031939	–		1	
	b2	CROSBY CLIP (G-450)	1010079	–		6	
	c2	STANDARD WIRE ROPE THIMBLE (G-411)	1037318	–		2	
B5		BOOM					6
	d2	TUBE	4x4x1/4	ALUM 6061-T6	23'-8"	1	
	e2	GUSSET PL	PL 3/8x5	ALUM 6061-T6	0'-5"	4	
	f2	PLATE	PL 3/8x2	ALUM 6061-T6	0'-6"	1	
	g2	END PLATE	PL 3/8x4	ALUM 6061-T6	0'-4"	1	
	h2	SLEEVE	1"øx.065	ALUM 6061-T6	0'-4"	3	
	j2	END PLATE	PL 1/8x3 1/2	ALUM 6061-T6	0'-3 1/2"	1	

LIST OF MATERIALS

MARTIN / MARTIN
CONSULTING ENGINEERS
12499 WEST COLFAX AVENUE
LAKEWOOD, COLORADO 80215
303.431.6100
FAX 303.431.4866

No.	Date	Description	By

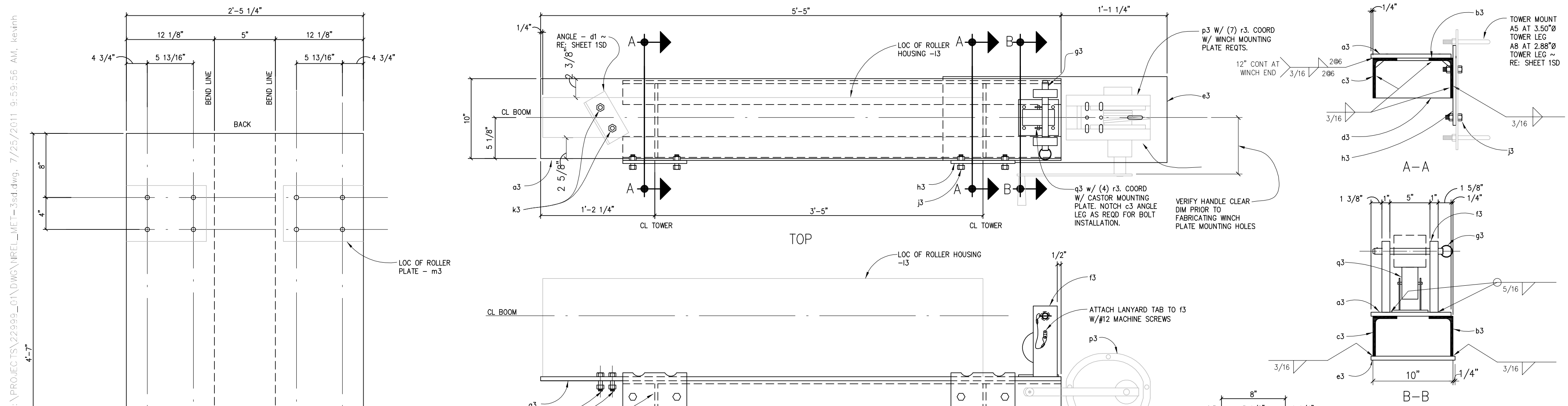
Revisions

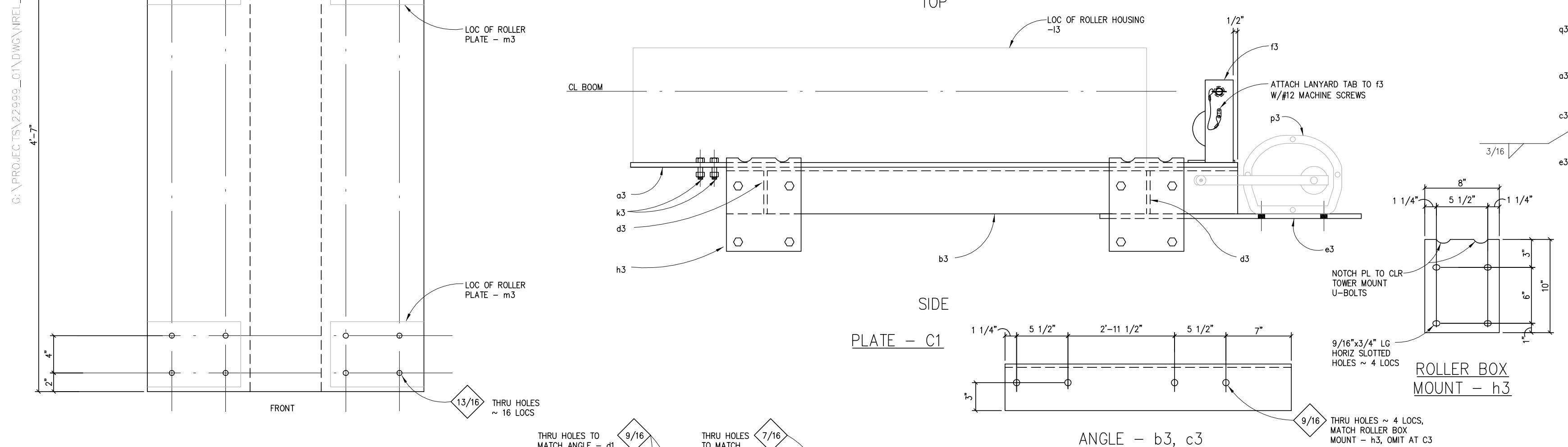
K. HAAS Drawn By	JULY 25, 2011 Date
K. HAAS Engineer	
D. GILBERT Checked By	
J. M. McAFFREY Approved By	

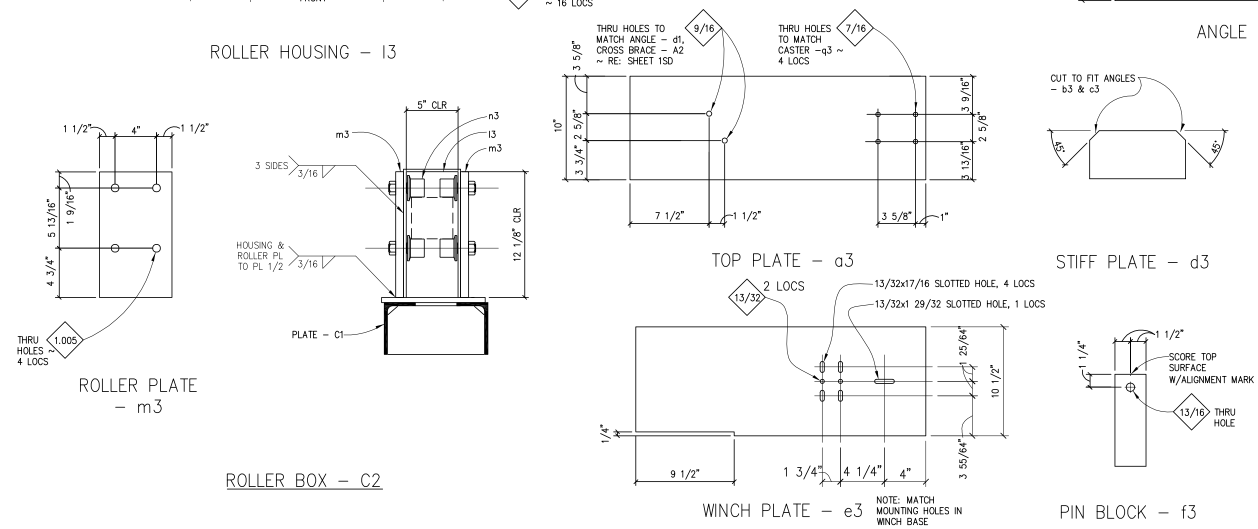
University of Minnesota
MET Tower Booms

Sheet Title
Piece Drawing – Cable Assembly and Boom

Sheet Number
2SD







SHOP NOTES:
1. ALL FILLET WELDS CONT UNO.
2. ALL MATL ASTM A36 UNO.
3. CLEAN ALL STL PER SSPC-SP6 "COMMERCIAL BLAST CLEANING" APPLY 2 COATS, 3 MIL DFT PER COAT TNEMEC SPRA-SAF EN, SERIES 30.

TOLERANCES

.X	.XX	.XXX	ANGLE
±.03	±.010	±.002	±30'

Field Mark	Shop Mark	Description	Stock No.	Material	Length	Qty Per Boom	No. of Booms
C1		PLATE					6
	a3	TOP PLATE		PL 1/2x10	5'-5"	1	
	b3	ANGLE		L5x3x5/16	4'-6 3/4"	1	
	c3	ANGLE		L5x3x5/16	4'-6 3/4"	1	
	d3	STIFF PLATE		PL 3/8x4 1/2	0'-9 5/16"	2	
	e3	WINCH PLATE		PL 1/2x10 1/2	2'-4"	1	
	f3	PIN BLOCK		PL 1x3	0'-8 7/8"	2	
	g3	MCMASTER-CARR QUICK-RELEASE PIN W/LANYARD	98404A790 90312A66	–	0'-8" 1'-0"	1 1	
	h3	ROLLER BOX MOUNT		PL 3/8x10	0'-8"	2	
	j3	BOLTS W/ NUTS		1/2" A325	–	8	
	k3	BOLTS W/ NUTS		1/2" A325	–	2	
	p3	MCMASTER-CARR HAND WINCH & WIRE ROPE ASSEM.	3196T62 3308T57	– –		1 1	
	q3	MCMASTER-CARR SPARTAN CASTER	2856T82	–	–	1	
	r3	BOLTS W/ NUTS		3/8" A307	–	11	
C2		ROLLER BOX					6
	l3	ROLLER HOUSING		PL 3/16x2'-5 1/4	4'-7"	1	
	m3	ROLLER PLATE		PL 3/4x12 1/8	0'-7"	4	
	n3	CARTER MANUFACTURING FHRE BEARING	FHRE-175-A	–	–	16	

LIST OF MATERIALS

MARTIN / MARTIN CONSULTING ENGINEERS
12499 West Colfax Avenue
Lakewood, Colorado 80215
303.431.6100
fax 303.431.4866

No.	Date	Description	By

Revisions

K. HAAS — Drawn By — JULY 25, 2011 Date
K. HAAS — Engineer
D. GILBERT — Checked By
J. M. McAFFREY — Approved By

University of Minnesota
MET Tower Booms

Sheet Title
Piece Drawing – Roller Box

Sheet Number
3SD

12 Appendix E: Instrumentation and Data Logger Manuals

12.1 Met One Model 011 E-Class One Wind Speed Sensor

MODEL 011
E-CLASS ONE
WIND SPEED SENSOR

OPERATION MANUAL

Document No 011-9800 Rev A

MODEL 011 WIND SPEED SENSOR
OPERATION MANUAL

Met One Instruments, Inc.

Corporate Sales & Service: 1600 Washington Blvd., Grants Pass, OR 97526, Phone (541) 471-7111, Fax (541) 471-7116
Distribution & Service: 3206 Main Street, Suite 106, Rowlett, TX 75088, Phone (972) 412-4747, Fax (972) 412-4716
http://www.metone.com

1.0 GENERAL INFORMATION

1.1 The 011 Wind Speed Sensor uses a durable, three-cup anemometer assembly and solid-optical link with a 40-slot chopper disk to produce a pulsed output whose frequency is proportional to wind speed. An internal heater reduces moisture for extended bearing life. This sensor is usually mounted using a 191 Cross arm Assembly, or can be mounted vertically on top a ¾" schedule pipe using the 10392 vertical mount adaptor. The sensor may be used with a translator module, or used directly with a variety of data loggers.

1.2 The 10432 Sensor Cable has a quick-connect connector with vinyl jacketed, shielded cable. Cable length is given in -XX feet on each cable part number.

Table 1-1
Model 011 Wind Speed Sensor Specifications

<u>Performance Characteristics</u>

Maximum Operating Range	0-60 meters/sec (0-125 mph)
Starting Speed	0.19 meters/sec (0.43 mph)
Accuracy	±1% or 0.1 meters/sec (0.22 mph)
Temperature Range	-50°C to +85°C
Distance Constant	<3 meters of flow (15ft)

<u>Electrical Characteristics</u>

Power Requirements	9-27VDC, 3 mA @ 12VDC
Output Signal	Pulse output, amplitude is power supply
Output Impedance	100 ohms maximum
Heater Power Requirement	12 VDC at 350 mA
Standard Cable Length	150m (500ft) maximum (consult factory if longer cable is to be used for special requirements)

<u>Physical Characteristics</u>

Weight	0.68kg (1.5 pounds)
Finish	Anodized aluminum
Mounting	191 Crossarm or 10392 Vertical mount
Cabling	10432-XX Cable (XX is cable length in feet)

<u>Optional Accessories</u>

A. External heater and power supply for extreme low temperature operation.
.

2.0 INSTALLATION

2.1 The 011 Wind Speed Installation

A. Check to see that the cup assembly rotates freely.

B. Install the sensor in the end of the Model 191 Crossarm Assembly (the end without the bushing).

C. Tighten the locking set screw. Do not over-tighten. Apply a small amount of silicone grease to set screws to prevent freezing in adverse environments.

D. Connect the cable assembly to the keyed sensor receptacle and tape it to the mounting arm.

2.2 Wiring

A. The cable assembly contains five wires. Typical wiring hookup is shown in Figure 2-1.

2.3 Lightning Protection

A. 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.

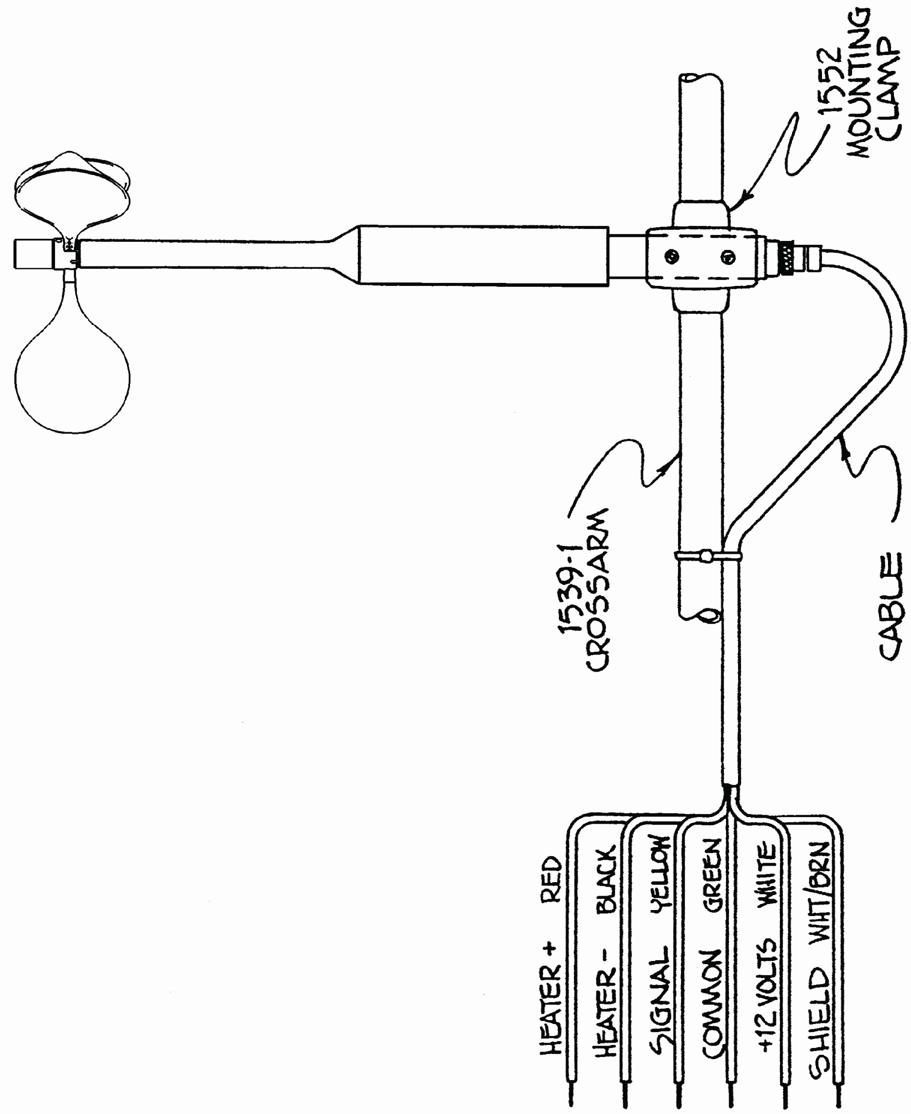


FIG. 2-1
TYPICAL 011 INSTALLATION

3.0 OPERATIONAL CHECK-OUT AND CALIBRATION

3.1 011 Wind Speed Sensor Check-Out

A. Spinning the anemometer cup assembly will produce a series of pulses (40 pulses per revolution). To verify sensor output, monitor this signal with either the translator module, data logger, or an oscilloscope. (Refer to Frequency vs. Wind Speed Table 3-1). Spinning the hub of the wind speed transmitter without the cup assembly mounted and allowing it to coast to a stop will give a good indication of threshold performance; a jerky or sudden stop indicates damage to bearings, bent drive shaft, or obstruction in the light chopper.

B. Inspect the cup assembly for loose cup arms or other damage. The cup assembly cannot change calibration unless a mechanical part has come loose or has been broken. If a cup arm is loose or broken the calibration of the sensor may be affected.

C. If the sensor heater is used, check internal heater operation by sliding sensor cover down and touching the housing behind the printed circuit board. The housing should feel warmer than the adjoining metal parts. The sensor has a built-in heater that is designed to provide a raise in the internal temperature, providing a small amount of positive pressure. This heater requires an external 12 V (@500ma) power supply.

FREQUENCY vs WIND SPEED FOR 011 SENSOR
TABLE 3-1

Transfer Functions

Miles per hour:

$V_{mph} = (f_{Hz} * .09194) + 0.43$

$V_{mph} = V_{m/s} / 0.44704$

$rpm = 16.221 * (V_{mph} - 0.43)$

$V_{mph} = (rpm / 16.221) + 0.43$

$f_{Hz} = rpm * 0.66667$

Meters per second:

$V_{m/s} = (f_{Hz} * 0.0411) + 0.19$

$V_{m/s} = V_{mph} * 0.44704$

$rpm = 36.496 * (V_{m/s} - 0.19)$

$V_{m/s} = (rpm / 36.496) + 0.19$

Conversion Tables

V_{mph}	$V_{m/s}$	f_{Hz}	rpm
10	4.47	104.1	155.2
20	8.94	212.9	317.4
30	13.41	321.6	479.7
40	17.88	430.4	641.9
50	22.35	539.2	804.1
60	26.82	647.9	966.3
70	31.29	756.7	1128.5
80	35.76	865.5	1290.7
90	40.23	974.2	1452.9
100	44.70	1083.0	1615.1
110	49.17	1191.8	1777.3
120	53.64	1300.5	1939.5
130	58.12	1409.3	2101.8

rpm	$V_{m/s}$	V_{mph}	f_{Hz}
100	2.93	6.59	66.67
200	5.67	12.76	133.3
300	8.41	18.92	200
400	11.15	25.09	266.7
500	13.89	31.25	333.3
600	16.63	37.42	400
700	19.37	43.58	466.7
800	22.11	49.75	533.3
900	24.85	55.91	600
1000	27.59	62.08	666.7
1100	30.33	68.24	733.3
1200	33.07	74.41	800
1300	35.81	80.57	866.7
1400	38.55	86.74	933.3
1500	41.29	92.90	1000
1600	44.03	99.07	1066.7
1700	46.77	105.23	1133.3
1800	49.51	111.40	1200

$V_{m/s}$	V_{mph}	f_{Hz}	rpm
2.5	5.59	56.20	84.3
5	11.18	117.03	175.5
7.5	16.78	177.86	266.8
10	22.37	238.69	358.0
12.5	27.96	299.51	449.3
15	33.55	360.34	540.5
17.5	39.15	421.17	631.7
20	44.74	482.00	723.0
22.5	50.33	542.82	814.2
25	55.92	603.65	905.5
27.5	61.52	664.48	996.7
30	67.11	725.30	1087.9
32.5	72.70	786.13	1179.2
35	78.29	846.96	1270.4
37.5	83.89	907.79	1361.7
40	89.48	968.61	1452.9
42.5	95.07	1029.44	1544.1
45	100.66	1090.27	1635.4
47.5	106.25	1151.09	1726.6
50	111.85	1211.92	1817.9
52.5	117.44	1272.75	1909.1
55	123.03	1333.58	2000.3
57.5	128.62	1394.40	2091.6
60	134.22	1455.23	2182.8

Abbreviations:

$V_{m/s}$ = Wind speed (meters per second)
V_{mph} = Wind speed (miles per hour)
f_{Hz} = Sensor output frequency (Hz)
rpm = Shaft speed (revolutions per minute)

Table 3-1

4.0 MAINTENANCE AND TROUBLESHOOTING

4.1 General Maintenance Schedule*

6 – 12 Month Intervals:

A. Inspect sensor for proper operation per Section 4.2.
B. Replace wind speed sensor bearings in extremely adverse environments per Section 4.5.

12 – 24 Month Intervals:

A. Recommended complete factory overhaul of sensor.

*Schedule is based on average to adverse environments.

Table 4-1
011 Wind Speed Sensor Troubleshooting

Symptom	Probable Cause	Solution	Refer to
No wind speed output	Loss of supply voltage	Check translator +12 supply & connecting cables	Figure 2-1
	Faulty integrated amplifier	Replace circuit board	Section 4.5
	Faulty diodes, D1, D2	Replace circuit board	Section 4.5
	Faulty detector	Replace detector	Section 4.6
No wind speed output below 2-5 mph	Bad bearing(s)	Replace bearing(s)	Section 4.4
	Faulty detector	Replace detector	Section 4.6
Wind speed signal drops as speed increases	Faulty detector	Replace detector	Section 4.6

4.2 011 Wind Speed Sensor: 6 – 12 Month Periodic Service

A. At the crossarm assembly, disconnect the quick disconnect plug from the sensor (leave the cable secured to the crossarm) and remove the sensor from the crossarm assembly.

B. Visually inspect the anemometer cups for cracks and breaks. Also, make sure that each arm is securely attached to the cup assembly hub.

C. Slide the sensor cover down to expose the light-chopper disc assembly, photointerrupter, and circuit board.

D. Inspect the interior of the sensor for any signs of corrosion and/or dust buildup.

E. Inspect the light-chopper for cracks, and make sure that all slots are free of corrosion.

F. Inspect the signal-conditioning module for cracks and corrosion around soldered connections.

G. Rotate the sensor hub assembly to ensure that it turns freely and that the sensor bearings are not damaged. Make sure the light-chopper assembly is not contacting the photointerrupter module.

H. Apply a small amount of silicone lubricant. (Dow-Corning DC-33 or equivalent) to the sensor O-ring seals; slide the cover up over the sensor and wipe off any excess lubricant.

I. A moisture vent is located on the base of the sensor; make sure that this vent is clear.

J. Re-install sensor according to installation procedure (Section 2.0); verify proper operation using procedures in Section 3.0.

4.3 011 Wind Speed Sensor Maintenance (Refer to 011 Sensor Assembly Drawing)

The following procedures require a relatively clean, dry work area, a source of 9-27 VDC power at approximately 3-7 mA, and an oscilloscope (DC to 10 KHz minimum range required.

4.4 Sensor Bearing Replacement. (Refer to 011 Sensor Assembly Drawing)

A. Remove sensor from tower. Refer to Section 4.2.

B. Disassemble sensor and remove old bearings (6).

1. Slide the sensor cover (16) down to expose the light-chopper disc assembly (10), detector assembly (12) and circuit board (18).

2. Loosen both special set screws on the shaft of the light chopper assembly (11).

3. Support the light-chopper assembly (10) with one hand and slowly pull the rotating hub/shaft assembly (2) out of the column (8).

4. Remove the shield (4) and slinger (5) from the column (8).

5. Remove the light-chopper assembly (10) from the sensor housing, being careful not to damage the slots located between the light-chopper holder and the lower bearing.

6. Insert the lower end of the rotating hub/shaft assembly into the upper bearing, cock it slightly to one side and push out the lower bearing.

7. Insert a right-angle type of tool, such as an Allen wrench, into the upper bearing; cock it slightly to one side and remove the bearing.

8. Clean dirt from bearing bores, using a cotton swab and alcohol.

C. Install the new bearings and assemble the sensor.

1. Install new upper and lower bearings in the column (8). Bearings should slide easily into bearing bores.

2. Install a slinger and shield (4, 5) on the column assembly. Use new parts if old ones are damaged or corroded.

3. Insert the rotating hub shaft (2) into the column assembly (8), through the shield (4), slinger, and upper bearing, until it starts to protrude through the lower bearing.

4. Support the light-chopper assembly (10) with one hand and slowly push the rotating hub shaft into it until the shaft almost touches the bottom.

5. Tighten both special set screws on the light-chopper assembly; do not over tighten as the set screw tips will damage the shaft.

6. Rotate the sensor hub assembly (2) to ensure that it turns freely and that an endplay of about .005” exists.

7. Hold sensor vertically and make sure that the light-chopper assembly (10) is not contacting the detector assembly (12).

8. Apply small amount of silicone lubricant (Dow-Corning DC-33 or equivalent) to the sensor O-rings (9); slide the cover (16) up over the sensor and wipe off any excess lubricant.

D. Replace cup assembly and re-install (refer to Section 2.0)

4.5 1200 Circuit Board Assembly Replacement (Refer to 011 Assembly Schematic)

A. Remove sensor from tower and remove cup assembly (refer to Section 4.2).

B. Slide the sensor cover (16) down to expose the light-chopper disc assembly (10), detector assembly (12), and circuit board (18).

C. Remove two screws (17) holding circuit board assembly (18) and lift circuit board away from sensor housing.

D. Note color of wires and then unsolder three wires to detector assembly from circuit board and three wires from connector (19).

E. Install new circuit board assembly by reversing above procedure.

4.6 Detector Assembly Replacement Refer to 011 Assembly Schematic)

A. Remove sensor from tower and remove cup assembly. Refer to Section 4.2.

B. Slide the sensor cover (16) down to expose the light-chopper disc assembly (10), detector assembly (12) and circuit board (18).

C. Remove two screws (17) holding circuit board assembly (18) and lift circuit board away from sensor housing.

D. Note color of wires and then unsolder three wires to detector assembly from circuit board (18).

E. Remove two screws (20) holding detector assembly (12) and remove assembly.

F. Install new detector assembly by reversing above procedures.

4.7 011 Wind Speed Sensor Repair and Recalibration Service

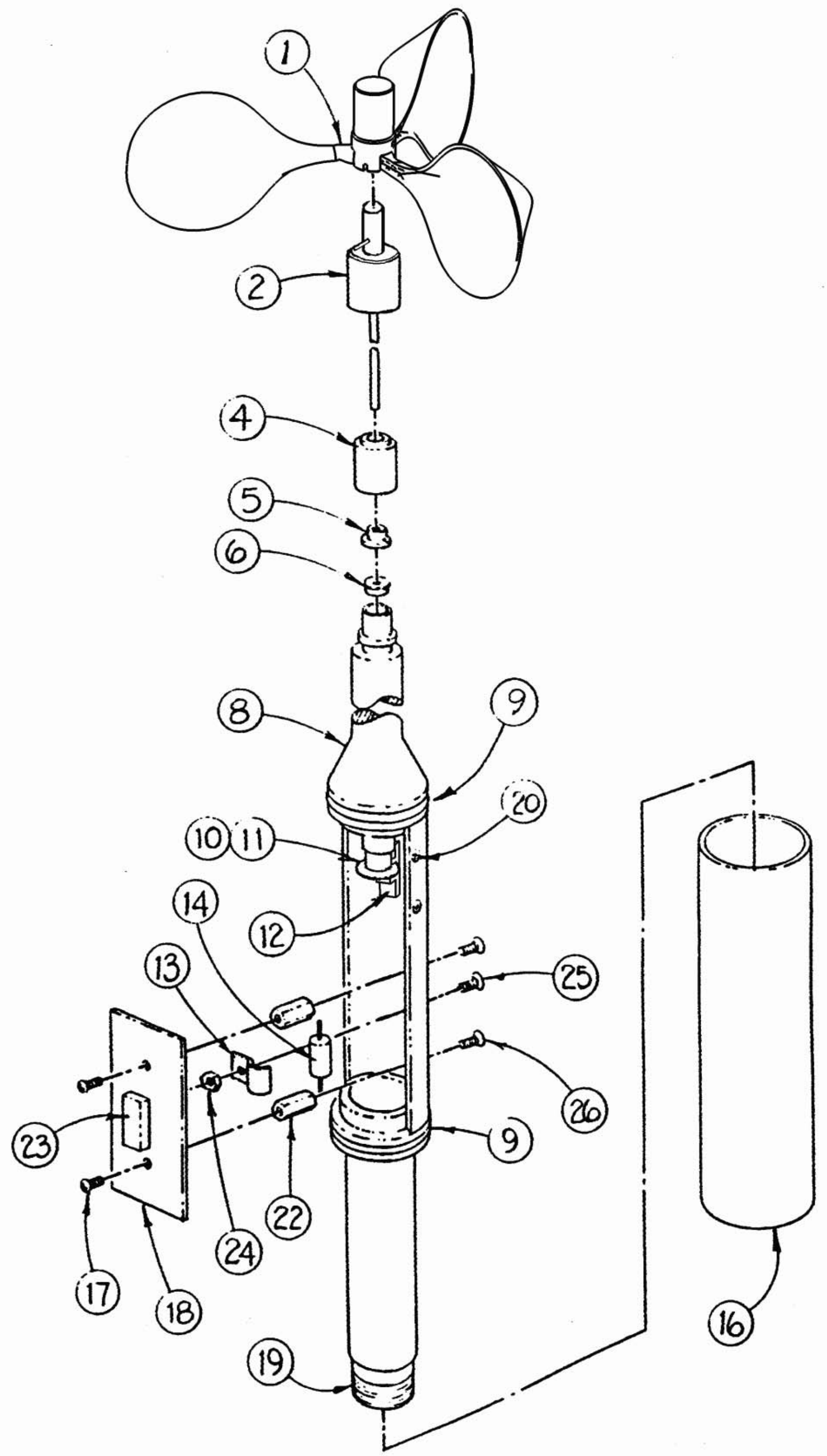
The factory provides fast, economical service for the user. This repair and calibration service includes disassembly and detailed inspection of all moving mechanical parts and electronic components.

Service includes replacement of bearings, regardless of apparent condition, and functional test of sensor. Replacement of the following items is also included: O-rings, shield and slinger, shaft, set screws. Other components will be replaced as required. Only charges for additional materials will be added to the basic service charge.

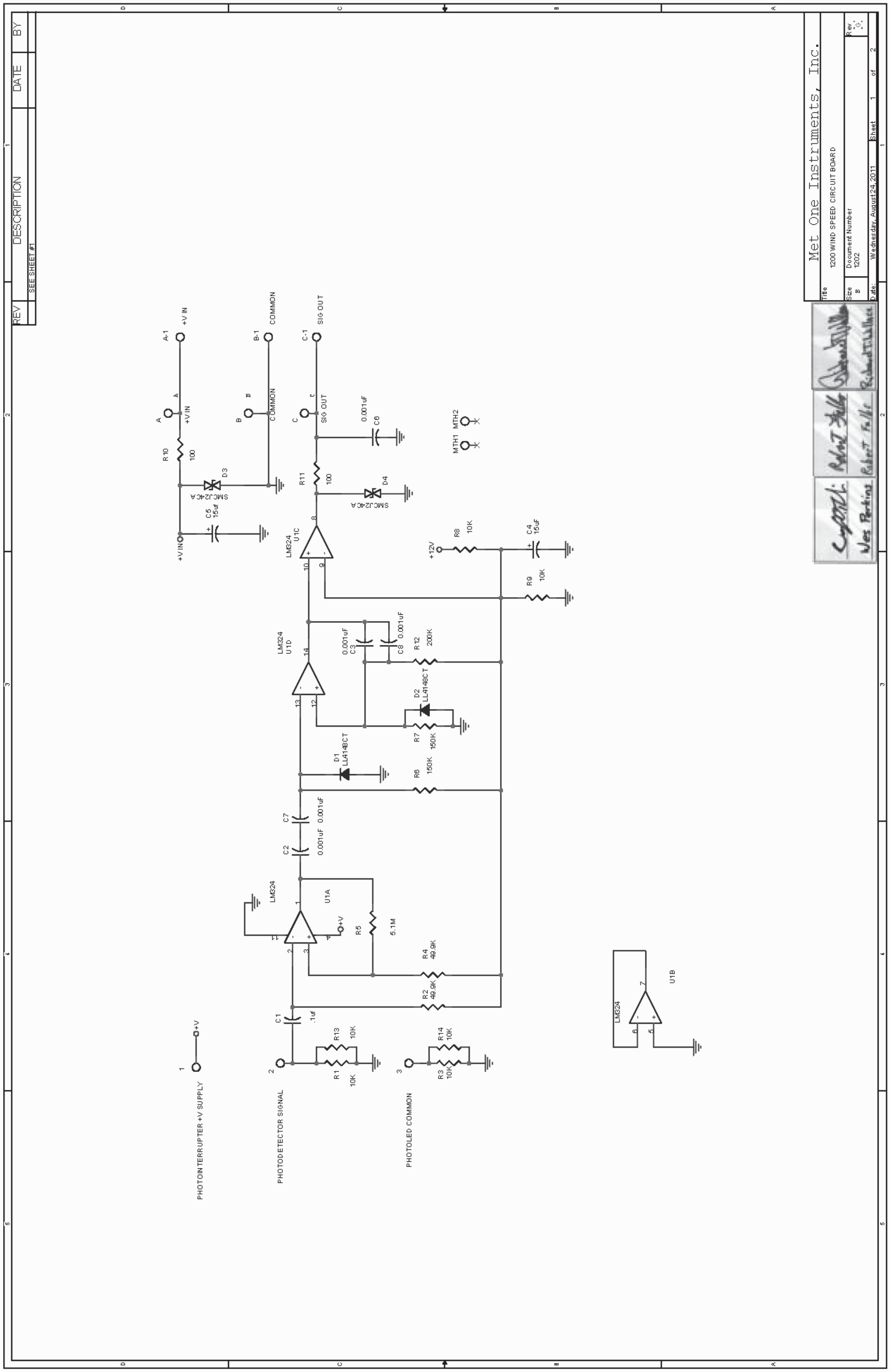
Factory serviced sensors will comply with all specifications and the consensus calibration curve. Individual wind tunnel calibrations are also available at an additional charge.

Table 4-2
Replacement 011 Parts List

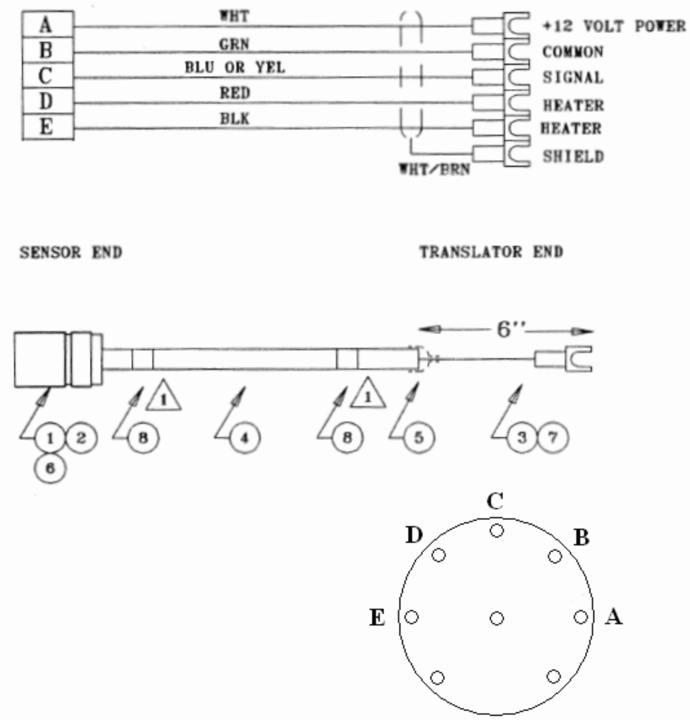
Ref No.	Description	Part No.
1	Cup Assembly	10425
2	Hub/Shaft Assy.	10434
4	Shield	1009
5	Slinger	1010
6	Bearing	1055
9	O-ring	720120
10	Chopper Wheel Assembly	2202
11	Set Screw	601250
12	Photo Detector	520253
13	Heater Clamp	480100
14	Heater	805080
16	Sensor Cover	2675
17	PCBA Mounting Screws	601240
18	PCBA	1200-1
20	Nut, Hex, 4-40	600405
22	Standoff	860050
23	Integrated Amplifier	620300
24	Nut, Hex, Kep 4-40	600400
25	Screw FH 82° 4-40 x 3/8	601330
26	Screw FH 82° 4-40 x ¼	601240



MODEL 011 WIND SPEED SENSOR


Met One Instruments, Inc.
1200 WIND SPEED CIRCUIT BOARD
Document Number
1202
Wednesday, August 24, 2011
REV
DESCRIPTION
DATE
BY
SEE SHEET #1
PHOTOINTERRUPTER +V SUPPLY
PHOTODETECTOR SIGNAL
PHOTOLED COMMON
+V IN
COMMON
SIG OUT
LM324
U1A
U1B
U1C
U1D
MTH1
MTH2

REVISIONS			
REV	DESCRIPTION	DATE	APPROVED
A	INITIAL RELEASE	7-14-11	WDP



SOLDER CUP VIEW

ITEM	PART NO.	DESCRIPTION	QTY
1	500155	CONNECTOR, 8 PIN CIRCULAR, FEM	1
2			
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			

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

MET ONE INSTRUMENTS			
CABLE ASSEMBLY, 011 E-CLASS ONE WS			
SIZE	FSCM NO.	DWG NO. 10432	REV A
SCALE		SHEET 1 OF 1	

12.2 Met One Model 014A Wind Speed Sensor

INSTRUCTION MANUAL

Model 014A Met One Wind Speed Sensor

Revision: 6/11

Warranty and Assistance

PRODUCTS MANUFACTURED BY CAMPBELL SCIENTIFIC, INC. are warranted by Campbell Scientific, Inc. ("Campbell") to be free from defects in materials and workmanship under normal use and service for twelve (12) months from date of shipment unless otherwise specified on the corresponding Campbell invoice. Batteries, fine-wire thermocouples, desiccant, and other consumables have no warranty. Campbell's obligation under this warranty is limited to repairing or replacing (at Campbell's option) defective products, which shall be the sole and exclusive remedy under this warranty. The customer shall assume all costs of removing, reinstalling, and shipping defective products to Campbell. Campbell will return such products by surface carrier prepaid within the continental United States of America. To all other locations, Campbell will return such products best way CIP (Port of Entry) INCOTERM® 2010, prepaid. This warranty shall not apply to any Campbell products which have been subjected to modification, misuse, neglect, improper service, accidents of nature, or shipping damage. This warranty is in lieu of all other warranties, expressed or implied. The warranty for installation services performed by Campbell such as programming to customer specifications, electrical connections to products manufactured by Campbell, and product specific training, is part of Campbell's product warranty. CAMPBELL EXPRESSLY DISCLAIMS AND EXCLUDES ANY IMPLIED WARRANTIES OF MERCHANTABILITY OR FITNESS FOR A PARTICULAR PURPOSE. Campbell is not liable for any special, indirect, incidental, and/or consequential damages.

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014A Table of Contents

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Appendices

Figures

Table

Met-One 014A Wind Speed Sensor

1. General

The 014A is a three-cup anemometer that is used to measure horizontal wind speed. Rotation of the cup wheel opens and closes a reed switch at a rate proportional to wind speed.

The accompanying Met One manual contains additional information on operating principals, installation, and maintenance.

Lead length for the 014A is specified when the sensor is ordered. Table 1-1 gives the recommended lead length for mounting the sensor at the top of the tripod/tower with a 019ALU or CM200 series crossarm.

TABLE 1-1. Recommended Lead Lengths

CM6	CM10	CM110	CM115	CM120	UT10	UT20	UT30
11’	14’	14’	19’	24’	14’	24’	37’

The 014A ships with:

(1) Calibration Sheet
(1) Instruction Manual
(1) 014ACBL-L Sensor Cable w/user specified length

2. Specifications

Threshold	0.45 m/s (1 mph)
Calibrated Range	0-45 m/s (0-100 mph)
Gust Survival	0-53 m/s (0-120 mph)
Accuracy	1.5% or .11 m/s (0.25 mph)
Temperature Range	-50 C to +70 C
Distance Constant*	
Standard:	Less than 4.6m (15 ft.) (Aluminum Cups)
Optional Fast Response:	Less than 1.5 m (5 ft.) (Lexan Cups)
Output Signal	Contact Closure, Reed Switch
Weight	680 grams (1.5 lbs)

* The distance traveled by the air after a sharp-edged gust has occurred for the anemometer to reach 63% of the new speed.

NOTE The black outer jacket of the cable is Santoprene® rubber. This compound was chosen for its resistance to temperature extremes, moisture, and UV degradation. However, this jacket will support combustion in air. It is rated as slow burning when tested according to U.L. 94 H.B. and will pass FMVSS302. Local fire codes may preclude its use inside buildings.

3. Installation

3.1 Siting

Locate wind sensors away from obstructions (e.g. trees and building). As a general rule of thumb there should be a horizontal distance of at least ten times the height of the obstruction between the windset and the obstruction. If it is necessary to mount the sensors on the roof of a building, the height of the sensors, above the roof, should be at least 1.5 times the height of the building. See Section 8 for a list of references that discuss siting wind speed and direction sensors.

3.2 Assembly and Mounting

Tools Required:

- 1/2” open end wrench
- 5/64” Allen wrench
- compass and declination angle for the site
- small screw driver provided with datalogger
- UV resistant cable ties
- small pair of diagonal-cutting pliers
- 6 - 10” torpedo level

Mount the 019ALU or CM200 series crossarm to the tripod or tower. Orient the crossarm north-south, with the 3/4” Nu-Rail or CM220 on the north end.

Insert the base of the 014A into the Nu-Rail or CM220 (Figures 3-1, 3-2) and tighten the set screws on the Nu-Rail, or U-bolts on the CM220 (do not over tighten).

Attach the sensor cable to the connector on the 014A. Make sure the connector is properly keyed, and finger-tighten the knurled ring. Route the sensor cable along the underside of the crossarm to the tripod/tower, and to the instrument enclosure. Secure the cable to the crossarm and tripod/tower using cable ties.

FIGURE 3-1. 014A Mounted on a CM200 Series Crossarm with PN 1049 (or 019ALU Crossarm)

FIGURE 3-2. 014A Mounted on a CM200 Series Crossarm with CM220

4. Wiring

Connections to Campbell Scientific dataloggers are given in Table 4-1. When Short Cut for Windows software is used to create the datalogger program, the sensor should be wired to the channels shown on the wiring diagram created by Short Cut.

TABLE 4-1. Connections to Campbell Scientific Dataloggers Pulse Channels

Color	Wire Label	CR800 CR850 CR5000 CR3000 CR1000	CR510 CR500 CR10(X)	21X CR7 CR23X	CR200(X)
Black	Signal	Pulse	Pulse	Pulse	P_SW
White	Signal Reference	⏚	G	⏚	⏚
Clear	Shield	⏚	G	⏚	⏚

A control port may also be used to measure the 014A. With this option the white wire is connected to the 5V terminal. Please note that the control port method cannot be used with a CR200(X), CR500, CR510, CR7, 21X, or CR10 datalogger.

TABLE 4-2. Connections to Campbell Scientific Dataloggers Control Ports

Color	Wire Label	CR800 CR850 CR5000 CR3000 CR1000	CR10X	CR23X
Black	Signal	C1-C8	C6-C8	C5-C8
White	Signal Reference	5 V	5 V	5 V
Clear	Shield	⏚	G	⏚

5. Programming

This section is for users who write their own programs. A datalogger program to measure this sensor can be created using Campbell Scientifics' Short Cut Program Builder software. You do not need to read this section to use Short Cut.

5.1 Wind Speed

Wind speed is typically measured with a pulse count instruction, using the switch closure configuration. For dataloggers programmed with Edlog, specify configuration code 22 to output frequency in Hertz.

The expression for wind speed (U) is:

$$U = MX + B$$

where

M = multiplier
X = number of pulses per second (Hertz)
B = offset

Table 5-1 lists the multipliers (M) and offsets (Off) to obtain meters/second or miles/hour when the pulse count instruction is configured to output the result in Hz.

TABLE 5-1. Wind Speed Multiplier (With Configuration Code 22*)

Model	Meters/Second	Miles/Hour
014A	M = 0.8000 Off = 0.447	M = 1.789 Off = 1.0
*When configuration code 12 is used, the multiplier above is divided by the execution interval in seconds.		

5.2 Example Programs

5.2.1 Pulse Port Examples

The following CR1000 and CR10X programs use a pulse port to measure the 014A every 5 seconds. The programs store mean wind speed (in m/s) every 60 minutes. Wiring for the examples is given in Table 5-2.

TABLE 5-2. Wiring for Pulse Port Example Programs

Color	Description	CR1000	CR10X
Black	Signal	P1	P1
White	Signal Reference	⏚	G
Clear	Shield	⏚	G

5.2.1.1 CR1000 Example Program

```
'CR1000
'Created by Short Cut (2.5)

'Declare Variables and Units
Public Batt_Volt
Public WS_ms

Units Batt_Volt=Volts
Units WS_ms=meters/second

'Define Data Tables
DataTable(Table1,True,-1)
    DataInterval(0,60,Min,10)
    Average(1,WS_ms,FP2,False)
EndTable

'Main Program
BeginProg
    Scan(5,Sec,1,0)
        'Default Datalogger Battery Voltage measurement Batt_Volt:
        Battery(Batt_Volt)
```

```
            '014A Wind Speed Sensor measurement WS_ms:
            PulseCount(WS_ms,1,1,2,1,0.8,0.447)
            If WS_ms<0.448 Then WS_ms=0
            'Call Data Tables and Store Data
            CallTable(Table1)
      NextScan
EndProg
```

5.2.1.2 CR10X Example Program

```
;{CR10X}
*Table 1 Program
   01:  5.0000          Execution Interval (seconds)

1:  Batt Voltage (P10)
   1:    1              Loc [ Batt_Volt ]

2:  Pulse (P3)
   1:    1              Reps
   2:    1              Pulse Channel 1
   3:    22             Switch Closure, Output Hz
   4:    2              Loc [ WS_ms     ]
   5:    0.8            Multiplier
   6:    0.447          Offset

3:  If (X<=>F) (P89)
   1:    2              X Loc [ WS_ms     ]
   2:    4              <
   3:    0.448          F
   4:    30             Then Do

4:  Z=F x 10^n (P30)
   1:    0              F
   2:    0              n, Exponent of 10
   3:    2              Z Loc [ WS_ms     ]

5:  End (P95)

6:  If time is (P92)
   1:    0              Minutes (Seconds --) into a
   2:    60             Interval (same units as above)
   3:    10             Set Output Flag High (Flag 0)

7:  Set Active Storage Area (P80)
   1:    1              Final Storage Area 1
   2:    101            Array ID

8:  Real Time (P77)
   1:    1220           Year,Day,Hour/Minute (midnight = 2400)

9:  Average (P71)
   1:    1              Reps
   2:    2              Loc [ WS_ms     ]
```

5.2.2 Control Port Example Program

The following CR5000 program uses control ports to measure three 014A anemometers. The program measures them every second and stores the mean wind speed (in m/s) every 15 seconds.

```
'CR5000 Series Datalogger
'Wind Speed using TimerIO Instruction

'Declare Variables and Units
Public J, WindSpeed(3)

'Define Data Tables
DataTable(Test,1,-1)
    DataInterval(0,15,Sec,10)
    Average(3,WindSpeed(),IEEE4,False)
EndTable

'Define Subroutines
'Sub
    'Enter Sub instructions here
'EndSub

'Main Program
BeginProg
    Scan (1,Sec,0,0)
        'Measure the WindSpeed Profile 014A, 3 anemometers connected to C4, C5, C6 ports

        TimerIO (WindSpeed(1),11000111,00222000,100,0)    'Frequency on falling edge
        'Convert measurement to m/s
        For j = 1 to 3
            WindSpeed(j) = 0.447 + WindSpeed(j)/1.25
        Next j
        CallTable Test
    Next Scan
End Prog
```

6. Maintenance

6.1 Suggested Maintenance Schedules

6.1.1 6-12 Month Periodic Service

Visually inspect the anemometer cups for cracks and breaks, and make sure that each arm is securely attached to the cup assembly hub. Also check to see that the vent hole, located at the base of the sensor, is unobstructed.

Special caution is advised under adverse conditions of high winds, heat, and/or sandy areas. Look for abrupt stopping of the cup assembly with slow cup rotation. If this occurs, the bearings may need to be replaced.

6.1.2 12-24 Month Service

Replace sensor bearings.

6.1.3 24-36 Month Service

A complete factory overhaul of the sensor is recommended. Contact Met-One directly for Wind Speed sensor repair and recalibration service. This repair and calibration service includes disassembly and detailed inspection of all moving mechanical parts and all electronic components. Service includes replacement of bearings, shaft, and set screws as well as a functional test of the sensor. Charges above the basic service charge may be added for replacement of additional materials.

Met-One Instruments Inc.
479 California Avenue
Grants Pass, OR 97526
(541) 471-7111
FAX (541) 479-3057

7. Troubleshooting

Symptom: No wind speed

1. Check that the sensor is wired to the Pulse channel specified by the Pulse count instruction.

2. Disconnect the sensor from the datalogger and use an ohm meter to check the reed switch. The resistance between the white and black wires should vary from infinite (switch open) to less than 1 ohm (switch closed) as the cup wheel is slowly turned.

3. Verify that the Configuration Code (Switch Closure, hertz), and Multiplier and Offset parameters for the Pulse Count instruction are correct for the datalogger type.

Symptom: Wind speed does not change

1. For the dataloggers that are programmed with Edlog, the input location for wind speed is not updated if the datalogger is getting “Program Table Overruns”. Increase the execution interval (scan rate) to prevent overruns.

8. References

The following references give detailed information on siting wind speed and wind direction sensors.

EPA, 1989: *Quality Assurance Handbook for Air Pollution Measurements System*, Office of Research and Development, Research Triangle Park, NC, 27711.

EPA, 1987: *On-Site Meteorological Program Guidance for Regulatory Modeling Applications,* EPA-450/4-87-013, Office of Air Quality Planning and Standards, Research Triangle Park, NC 27711.

The State Climatologist, 1985: *Publication of the American Association of State Climatologists: Height and Exposure Standards*, for Sensors on Automated Weather Stations, vol. 9, No. 4.

WMO, 1983: *Guide to Meteorological Instruments and Methods of Observation,* World Meteorological Organization, No. 8, 5th edition, Geneva, Switzerland.

Appendix A. Sensor Maintenance

A.1 Reed Switch Replacement Procedure

To verify parts and locations, refer to the parts diagram (Figure A-3) and the parts list (Table A-1).

A. Remove sensor from mounting arm and disconnect cable.

B. Remove the cup assembly.

C. Remove the three phillips screws at the top of the sensor and lift out the bearing mount assembly.

D. Unsolder the leads of the reed switch and remove the switch from the two mounting terminals, see the parts diagram.

E. Solder the new switch onto the sides of the switch mount terminals (form a loop in the relay leads to obtain proper lead length -- **DO NOT CUT THE RELAY LEADS.**) Measure the distance between the bottom of the rotating magnet and the top of the switch envelope, as shown in Figure A-1. The spacing should measure between 0.01 and 0.02 inches.

F. Spin the shaft to verify switch operation by listening for a faint sound of the switch closure. If the switch cannot be heard, move the switch slightly closer to the magnet assembly.

G. Reassemble sensor.

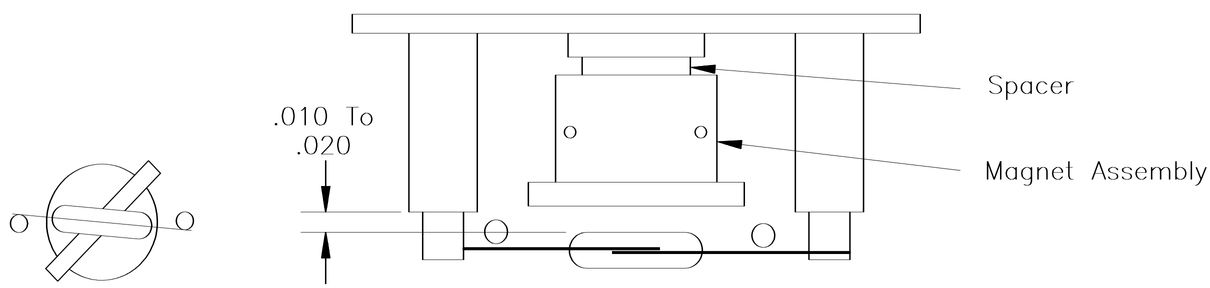

FIGURE A-1. Reed Switch Assembly

A.2 Bearing Replacement Procedure

The bearings used in the 014A Sensor are special stainless steel ball bearings with a protective shield. Bearings are lubricated and sealed. **DO NOT LUBRICATE BEARINGS AS THE LUBRICATION WILL ATTRACT DUST AND INHIBIT BEARING OPERATION.**

A. Follow steps 6.2 A, B, and C in reed switch replacement procedures.

B. Loosen set screws in magnet assembly, lift shaft and collar up and out of bearing mount. Be sure to retain lower spacer.

C. Insert a right-angle type of tool, such as an allen wrench, into bearing. Cock it slightly to one side and remove both bearings.

D. Install new bearings. Be careful not to introduce dirt particles into bearings. **CLEAN HANDS ONLY! DO NOT ADD LUBRICATION OF ANY KIND**.

E. Reassemble the sensor in reverse order. Be sure to include spacers over the bearings when replacing the shaft in the bearing mount. After the magnet assembly has been tightened, a barely perceptible amount of endplay should be felt when the shaft is moved up and down.

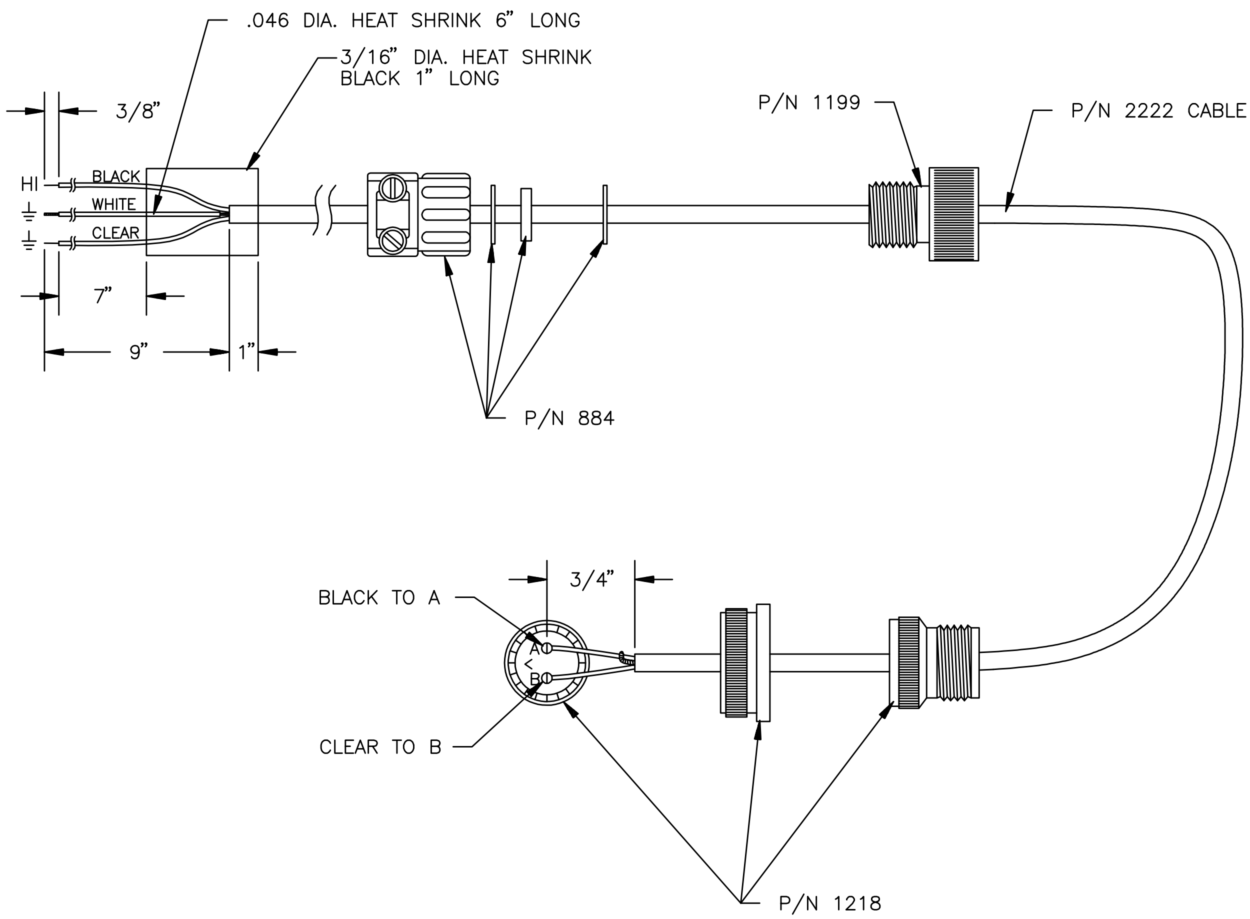

FIGURE A-2. Cable Diagram

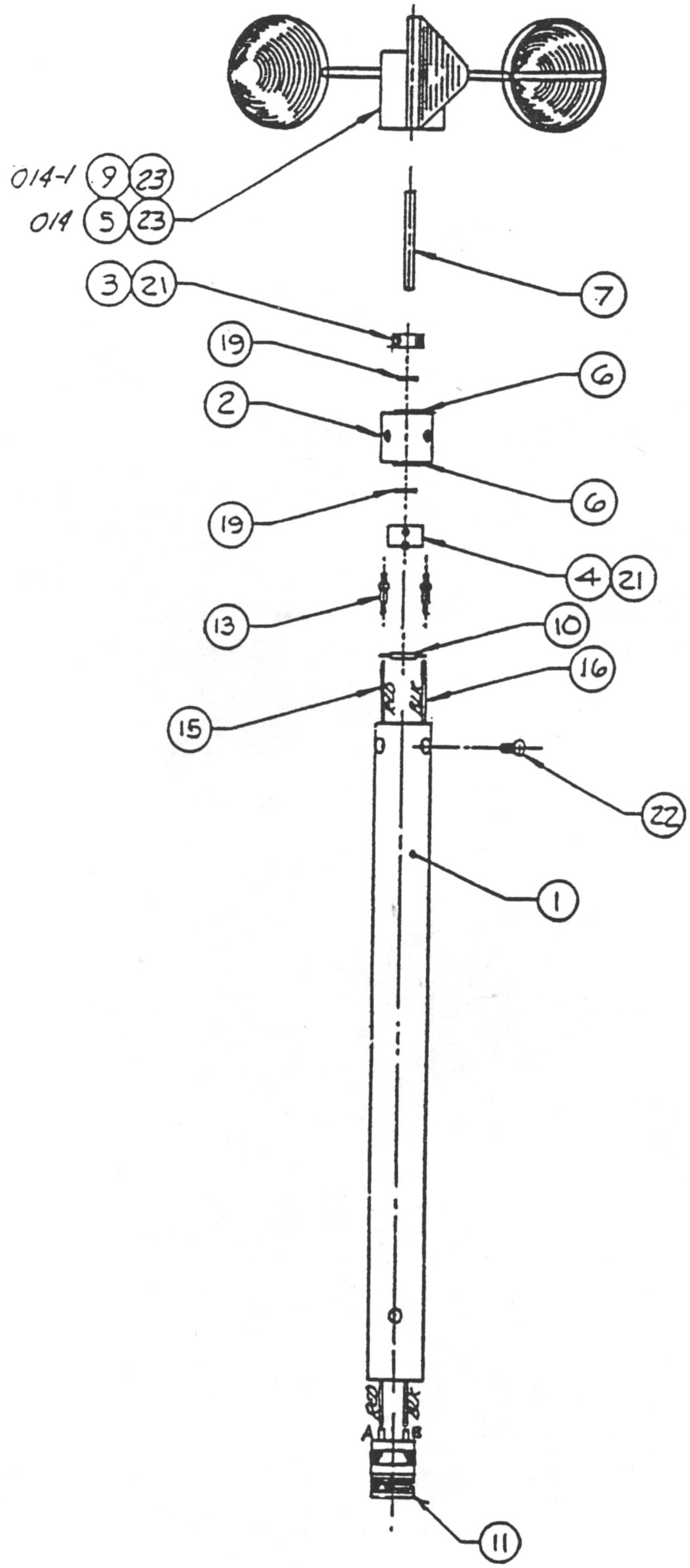

FIGURE A-3. Parts Diagram

TABLE A-1. Met-One Parts List

Reproduced by Campbell Scientific, Inc.

Item	Part No.	Description	Qty./Assy
1	1011685-2	Housing	1
2	101685-4	Bearing Mount	1
3	101685-7	Collar	1
4	101715	Magnet Assembly	1
5	101812	Assy, Cup (Alum)	1
6	101898	Bearing	2
7	86001	Shaft	1
8	101048-2	Label	1
9	1812-1	Assy, Cup (Lexan)	1
10	880160	Switch, Reed	1
11	500295	Conn, 2 Pin Male	1
12	510020	Cap	1
13	970062	Terminal	2
14			
15	9980480	Wire, 22G Red	18"
16	980445	Wire, 22GA Black	18"
17			
18			
19	860250	Spacer	2
20			
21	601250	SCR, SET A/H C/P 4-40x1/8	4
22	601230	SCR,FLT HD PHIL 4-40x1/4	3
23	601680	SCR,SET A/H C/P 8-23x3/8	2
24			
25	995120	Adhesive, (RTV 108)	A/R
26	995100	Adhesive, Epoxy (907)	A/R
27	995425	Locite 222-21	A/R
28	995060	Adhesive, Silicone	5 ml
29	995430	Locite 290-21	A/R
30	400010	Cable, 2 Cond.	REF
31	500372	Conn, 2 Pin Socket	REF
32	480500	Clamp	REF

Appendix B. Theory of Operation

B.1 Mechanical

The anemometer cup assembly consists of three aluminum cups mounted on a cup assembly hub. A stainless steel shaft, which rotates on precision-sealed ball bearings, connects the cup assembly to a magnet assembly. When the shaft is rotated, the turning magnet assembly causes a reed switch to close. There are two contacts (reed switch closures) per revolution. The frequency of closures is linear from threshold to 45 m/s.

B.2 Calibration

The 014A Anemometer has a threshold speed of 0.447 m/s and follows the equation:

$V = 0.447 + f/1.250$ where
V = wind speed (m/s), and
f = output frequency (hz,)

or, $V = 1.0 + f/0.5589$
where V = wind speed (mph), and
f = output frequency (hz.)

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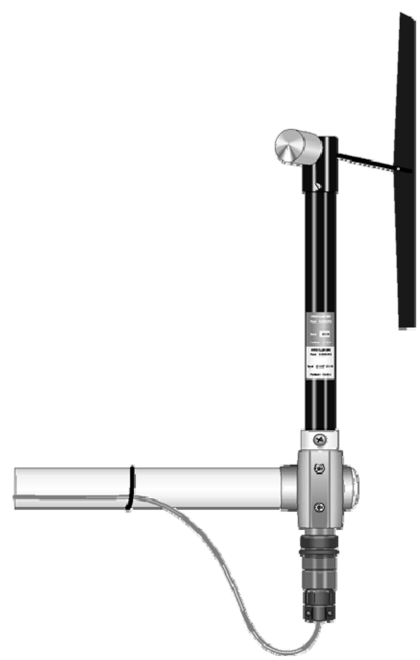
Please visit www.campbellsci.com to obtain contact information for your local US or International representative.

12.3 Met One Model 024A Wind Direction Sensor

INSTRUCTION MANUAL

Model 024A Met One Wind Direction Sensor

Revision: 3/12



Warranty

"PRODUCTS MANUFACTURED BY CAMPBELL SCIENTIFIC, INC. are warranted by Campbell Scientific, Inc. ("Campbell") to be free from defects in materials and workmanship under normal use and service for twelve (12) months from date of shipment unless otherwise specified in the corresponding Campbell pricelist or product manual. Products not manufactured, but that are re-sold by Campbell, are warranted only to the limits extended by the original manufacturer. Batteries, fine-wire thermocouples, desiccant, and other consumables have no warranty. Campbell's obligation under this warranty is limited to repairing or replacing (at Campbell's option) defective products, which shall be the sole and exclusive remedy under this warranty. The customer shall assume all costs of removing, reinstalling, and shipping defective products to Campbell. Campbell will return such products by surface carrier prepaid within the continental United States of America. To all other locations, Campbell will return such products best way CIP (Port of Entry) INCOTERM® 2010, prepaid. This warranty shall not apply to any products which have been subjected to modification, misuse, neglect, improper service, accidents of nature, or shipping damage. This warranty is in lieu of all other warranties, expressed or implied. The warranty for installation services performed by Campbell such as programming to customer specifications, electrical connections to products manufactured by Campbell, and product specific training, is part of Campbell's product warranty. CAMPBELL EXPRESSLY DISCLAIMS AND EXCLUDES ANY IMPLIED WARRANTIES OF MERCHANTABILITY OR FITNESS FOR A PARTICULAR PURPOSE. Campbell is not liable for any special, indirect, incidental, and/or consequential damages."

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CAMPBELL SCIENTIFIC, INC.
RMA#_____
815 West 1800 North
Logan, Utah 84321-1784

For all returns, the customer must fill out a "Statement of Product Cleanliness and Decontamination" form and comply with the requirements specified in it. The form is available from our web site at *www.campbellsci.com/repair*. A completed form must be either emailed to *repair@campbellsci.com* or faxed to (435) 227-9106. Campbell Scientific is unable to process any returns until we receive this form. If the form is not received within three days of product receipt or is incomplete, the product will be returned to the customer at the customer's expense. Campbell Scientific reserves the right to refuse service on products that were exposed to contaminants that may cause health or safety concerns for our employees.

024A Table of Contents

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Appendix

Figures

Tables

024A Met-One Wind Direction Sensor

1. Function

The Met-One 024A Wind Vane measures wind direction from 0 to 360 degrees with a 5 degree accuracy specification. The 024A utilizes a potentiometer to vary the sensor resistance in relation to wind direction.

Lead length for the 024A is specified when the sensor is ordered. Table 1-1 gives the recommended lead length for mounting the sensor at the top of a tripod/tower via a CM202 or 019ALU crossarm.

TABLE 1-1. Recommended Lead Lengths

CM6	CM10	CM110	CM115	CM120	UT10	UT20	UT30
11’	14’	14’	19’	24’	14’	24’	37’

2. Specifications

Range: 0 to 360 degrees

Threshold: 0.447 m/s (1.0 mph)

Accuracy: ±5 degrees

Temperature Range: -50° to +70°C

Delay Distance: Less than 1.5 m (5 ft.)

Damping Ratio
- **Standard:** 0.25
- **Optional:** 0.4

Potentiometer Specifications
- **Sand, Dust, and Fungus:** MIL-E-5272
- **Salt Spray:** MIL-E-12934
- **Resistance:** 0-10,000 Ohms

Weight: 450 g (1 lb.)

Dimensions
- **Overall Height:** 13.3 in. (33.8 cm)
- **Overall Length:** 17.6 in. (44.7 cm)
- **Tail Height:** 12 in. (30.5 cm)
- **Tail Width:** 3 in. (7.6 cm)

3. Installation

3.1 Siting

Locate wind sensors away from obstructions (e.g. trees and building). As a general rule of thumb there should be a horizontal distance of at least ten times the height of the obstruction between the windset and the obstruction. If it is necessary to mount the sensors on the roof of a building, the height of the sensors, above the roof, should be at least 1.5 times the height of the building. See Section 7 for a list of references that discuss siting wind direction sensors.

3.2 Assembly and Mounting

Remove the Allen hex screw in the lower part of the sensor housing and insert the 024A in the mounting bushing (see Figure 3-1). Tighten the screw in the bushing onto the sensor housing.

Mount the crossarm to the tripod or tower. Orient the crossarm North-South, with the CM220 mount or 17953 1 in. x 1 in. NU-RAIL fitting on the North end. Insert the sensor in the CM220 or NU-RAIL fitting. Align the sensor so that the counter weight points to true South and tighten the u-bolts on the CM220 or tighten the set screws on the NU-RAIL fitting.

NOTE Appendix A contains detailed information on determining and using a compass and the magnetic declination for the site.

Connect the cable assembly to the sensor receptacle.

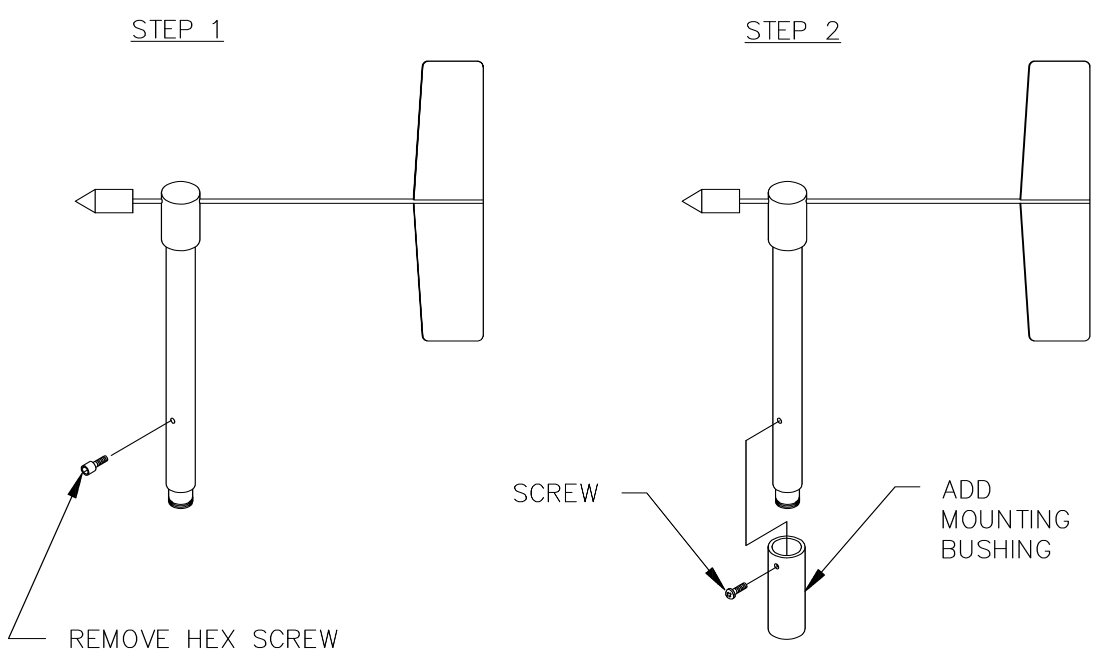

FIGURE 3-1. Bushing installation on 024A sensor

4. Wiring

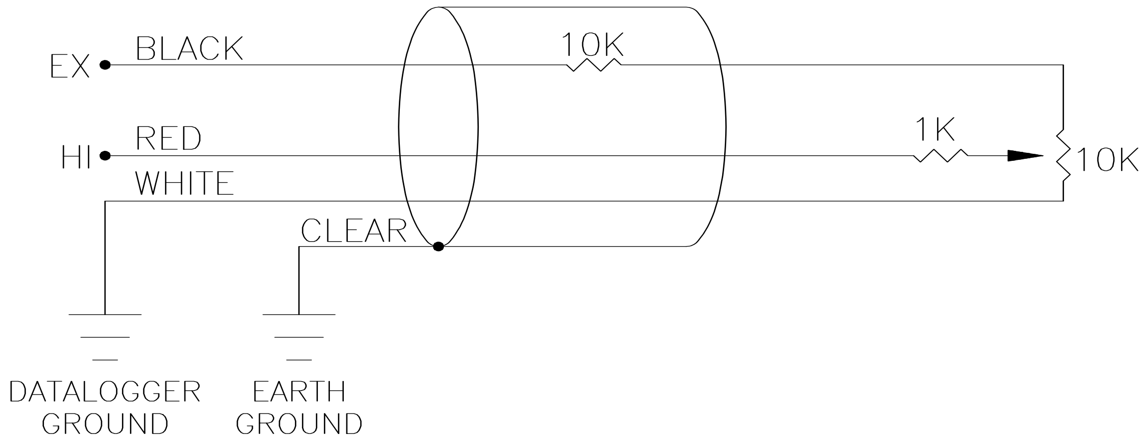

FIGURE 4-1. Schematic of 024A Wind Direction Sensor

Figure 4-1, Figure 6-1, and Table 4-1 shows wiring. When Short Cut for Windows software is used to create the datalogger program, the sensor should be wired to the channels shown on the wiring diagram created by Short Cut.

TABLE 4-1. Connections to Campbell Scientific Dataloggers

Color	Description	CR800 CR5000 CR3000 CR1000	CR510 CR500 CR10(X)	21X CR7 CR23X	CR200(X)
Red	Wind Dir. Signal	SE Analog	SE Analog	SE Analog	SE Analog
Black	Wind Dir. Excitation	Excitation	Excitation	Excitation	Excitation
White	Wind Dir. Reference	⏚	AG	⏚	⏚
Clear	Wind Dir. Shield	⏚	G	⏚	⏚

5. Programming

NOTE This section is for users who write their own programs. A datalogger program to measure this sensor can be created using Campbell Scientifics' Short Cut Program Builder software. You do not need to read this section to use Short Cut.

5.1 Datalogger Instruction

The datalogger instruction that measures the 024A is datalogger dependent. The **BRHalf()** measurement instruction is used for our CR800, CR850, CR1000, CR3000, and CR5000 dataloggers. Our CR200(X)-series dataloggers use the **EX-DEL_SE()**. Our Edlog dataloggers (e.g., CR510, CR10(X), CR23X) use Instruction 4 – Excite, Delay, Measure. Excitation voltages, range codes, and delays for CSI dataloggers are listed in Table 5-1. The process for determining the correct multiplier is provided in Section 5.2.

TABLE 5-1. Parameters for Wind Direction

	CR200(X)	**CR10(X), CR510**	**CR7, 21X, CR23X**	**CR800, CR850, CR1000**	**CR5000, CR3000**
Measurement Range	2500 mV	250 mV, fast	500 mV, fast	2500 mV, 250 microsecond integration, reverse excitation	5000 mV, 250 microsecond integration, reverse excitation
Excitation Voltage	2500 mV	500 mV	1000 mV	2500 mV	5000 mV
Delay or Settling Time	2 ms	2 ms	2 ms	2 ms	2 ms
Multiplier	See Section 5.2	See Section 5.2	See Section 5.2	See Section 5.2	See Section 5.2
Offset	0	0	0	0	0

5.2 Calibration and Orientation

Conversion of the voltage output into wind direction is done by entering the proper multiplier. The proper multiplier is calculated by dividing 360 by the full scale input voltage (i.e., 360/FSIV). The full scale input voltage (FSIV) is the maximum voltage output from the wind vane. This is found by creating a datalogger program with a multiplier of 1, the default excitation, and a fast scan interval. With a multiplier of 1, the value stored in the variable or input location is simply the voltage output. Slowly turn the wind vane; the shoulder screw must first be removed. The maximum value observed is the full scale input voltage (FSIV).

NOTE If the reading is -99999, exceeds 500 on the 21X or CR7, or exceeds 250 on the CR10, then reduce the millivolts of excitation by 5 mV.

Multiplier 360/FSIV*
Offset 0.0

*FSIV = Full scale input voltage

Enter the calculated multiplier in the program.

Orientation of the 024A Wind Direction Sensor should be complete if the 024A counter weight was aligned due south.

5.3 Example Programs

NOTE For these examples, the multiplier is listed as 1. The multiplier is unique to individual devices. Follow the procedure provided in Section 5.2 to acquire the correct multiplier for your sensor.

```
'CR200(X) Series
'Created by Short Cut (2.5)

'Declare Variables and Units
Public Batt_Volt
Public WindDir
Public NewMult

Units Batt_Volt=Volts
Units WindDir=degrees

'Define Data Tables
DataTable(Table2,True,-1)
    DataInterval(0,1440,Min)
    Minimum(1,Batt_Volt,False,False)
EndTable

'Main Program
BeginProg
    Scan(10,Sec)
        'Default Datalogger Battery Voltage measurement Batt_Volt:
        Battery(Batt_Volt)
        '024A Wind Direction Sensor measurement WindDir:
        ExDelSE(WindDir,1,1,1,2500,2000,1.0,0)
        NewMult=360/WindDir
        'Call Data Tables and Store Data
        CallTable(Table2)
    NextScan
EndProg
```

```
'CR1000
'Created by Short Cut (2.5 Beta)

'Declare Variables and Units
Public Batt_Volt
Public WindDir
Public NewMult

Units Batt_Volt=Volts
Units WindDir=degrees

'Define Data Tables
DataTable(Table1,True,-1)
    DataInterval(0,60,Min,10)
    Sample(1,WindDir,FP2)
EndTable

DataTable(Table2,True,-1)
    DataInterval(0,1440,Min,10)
    Minimum(1,Batt_Volt,FP2,False,False)
EndTable

'Main Program
BeginProg
    Scan(5,Sec,1,0)
        'Default Datalogger Battery Voltage measurement Batt_Volt:
        Battery(Batt_Volt)
        '024A Wind Direction Sensor measurement WindDir:
        BrHalf(WindDir,1,mV2500,1,1,1,2500,True,2000,250,1.0,0)
        NewMult=360/WindDir
        'Call Data Tables and Store Data
        CallTable(Table1)
        CallTable(Table2)
    NextScan
EndProg
```

```
'CR3000
'Created by Short Cut (2.5)

'Declare Variables and Units
Public Batt_Volt
Public WindDir
Public NewMult

Units Batt_Volt=Volts
Units WindDir=degrees

'Define Data Tables
DataTable(Table1,True,-1)
    DataInterval(0,60,Min,10)
    Sample(1,WindDir,FP2)
EndTable
```

```
DataTable(Table2,True,-1)
	DataInterval(0,1440,Min,10)
	Minimum(1,Batt_Volt,FP2,False,False)
EndTable

'Main Program
BeginProg
	Scan(5,Sec,1,0)
		'Default Datalogger Battery Voltage measurement Batt_Volt:
		Battery(Batt_Volt)
		'024A Wind Direction Sensor measurement WindDir:
		BrHalf(WindDir,1,mV5000,1,1,1,5000,True,2000,250,1.0,0)
		NewMult=360/WindDir
		'Call Data Tables and Store Data
		CallTable(Table1)
		CallTable(Table2)
	NextScan
EndProg
```

```
;{CR10X}
;
*Table 1 Program
  01:  10               Execution Interval (seconds)

;Measure sensor. Multiplier is unique to individual devices.
1:  Excite-Delay (SE) (P4)
  1:    1               Reps
  2:    14              250 mV Fast Range
  3:    1               SE Channel
  4:    1               Excite all reps w/Exchan 1
  5:    2               Delay (0.01 sec units)
  6:    500             mV Excitation
  7:    1               Loc [ wind_dir  ]
  8:    1.0             Multiplier
  9:    0.0             Offset

;Store measurements in final storage
2:  If time is (P92)
  1:    0000            Minutes (Seconds --) into a
  2:    60              Interval (same units as above)
  3:    10              Set Output Flag High (Flag 0)

3:  Set Active Storage Area (P80)
  1:    1               Final Storage Area 1
  2:    101             Array ID

4:  Real Time (P77)
  1:    1220            Year,Day,Hour/Minute (midnight = 2400)

5:  Sample (P70)
  1:    1               Reps
  2:    1               Loc [ wind_dir  ]
```

6. General Maintenance Schedule

6.1 6 to 12 Month Periodic Service *

Inspect sensor for physical damage and verify that the vane assembly rotates freely. To verify parts and locations, refer to the parts diagram (Figure 6-2) and the parts list (Table 6-1).

6.2 24 to 36 Month Service *

A complete factory overhaul of the sensor, including the replacement of the potentiometer, is recommended. Contact Campbell Scientific and get a Return Materials number (RMA) before sending it to Campbell Scientific.

* Schedule is based on average to adverse environments.

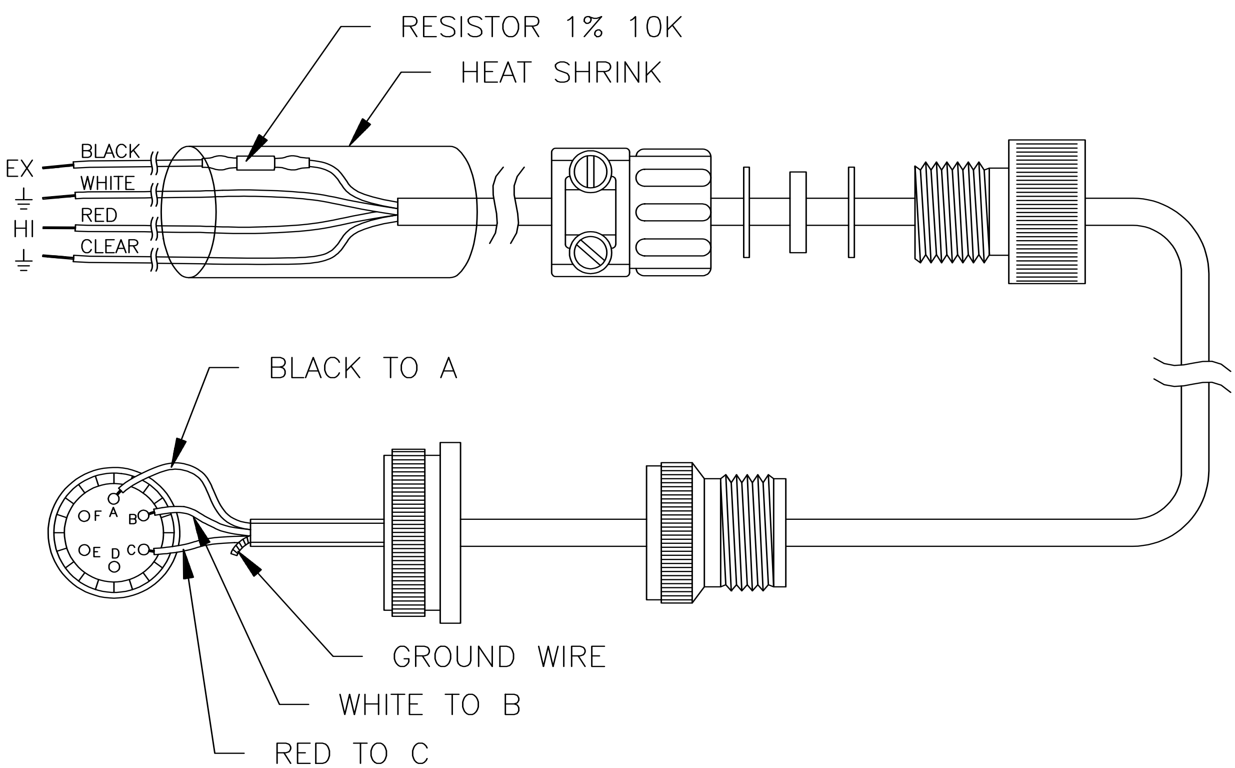

FIGURE 6-1. Cable diagram

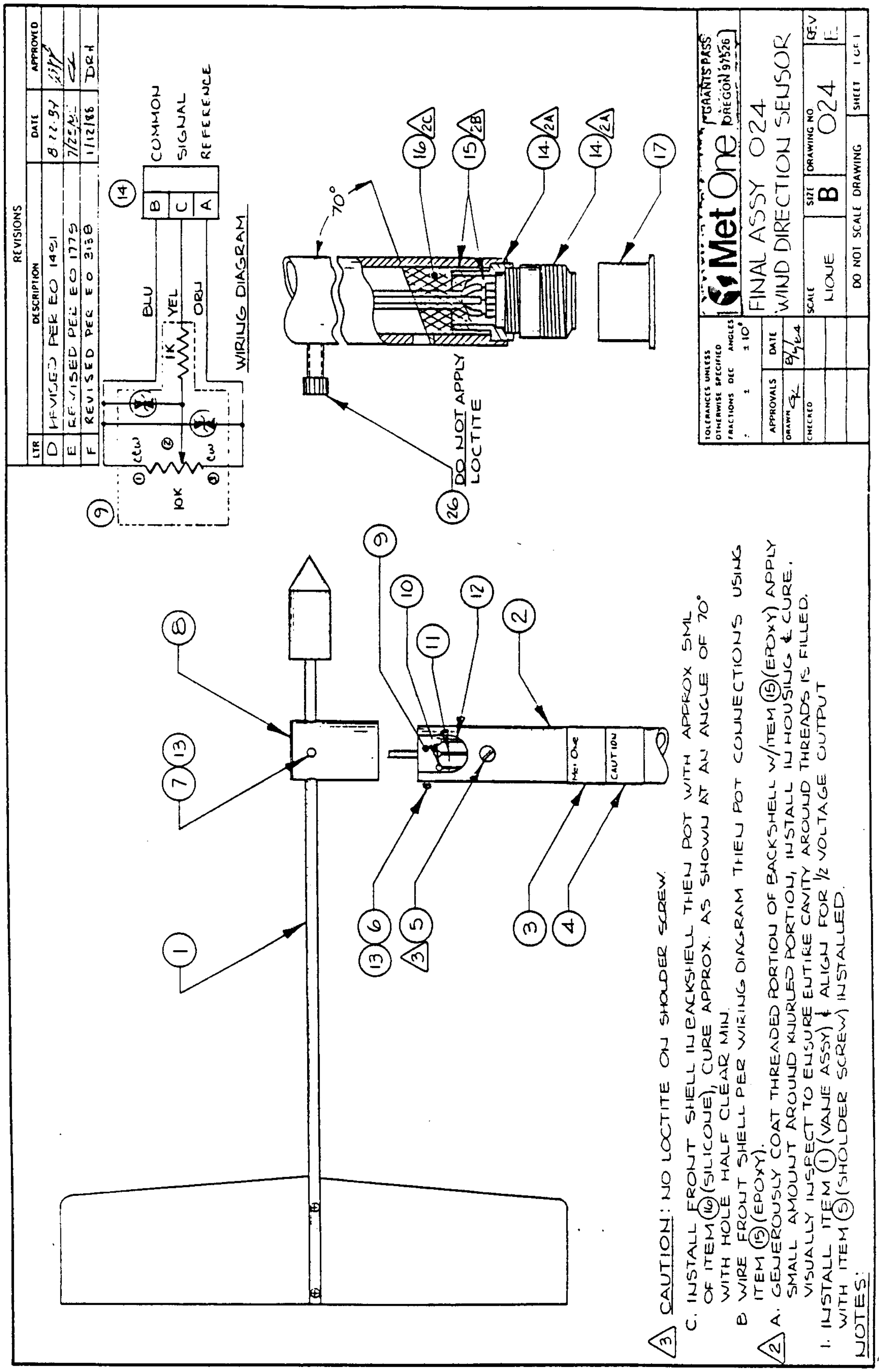

FIGURE 6-2. Parts diagram

TABLE 6-1. Met-One Parts List Reproduced by Campbell Scientific, Inc.

Item	Part No.	Description.	Qty./Assy
1	102105	Vane Assembly	1
2	101685-1	Wind Dir. Support	1
3	101049-2	Label, Wind Dir.	1
4	101789	Label, Caution	1
5	860015	Screw, Shoulder	1
6	601100	Screw, Pan Hd Ph, 2-56x3/16	3
7	601680	Scrw, Set A/H, 8-32x3/8	2
8	101687	Label, Met-One	1
9	102017	Assy, Potentiometer	1
10	980495	Wire, 22Ga, Yel	1
11	980450	Wire, 22Ga, Blu	1
12	980475	Wire, 22Ga, Orn	1
13	995425	Loctite 222	A/R
14	500280	Connector, 6 Pin	1
15	995100	Adhesive, Epoxy	A/R
16	995060	Adhesive, Silicone	5ml
17	510020	Cap	1
18			
19			
20			
21	101806	Assembly, Cable	Ref
22	101699	Assy Instructions	Ref
23	101706	014 & 024 Installation	Ref
24	101697	Wir. Diagram	Ref
25			
26	601850	Scrw, Cap A/H SS 10-32x5/8	1

7. References

The following references give detailed information on siting wind speed and wind direction sensors.

EPA, 1989: *Quality Assurance Handbook for Air Pollution Measurements System*, Office of Research and Development, Research Triangle Park, NC, 27711.

EPA, 1987: *On-Site Meteorological Program Guidance for Regulatory Modeling Applications,* EPA-450/4-87-013, Office of Air Quality Planning and Standards, Research Triangle Park, NC 27711.

The State Climatologist, 1985: *Publication of the American Association of State Climatologists: Height and Exposure Standards*, for Sensors on Automated Weather Stations, vol. 9, No. 4.

WMO, 1983: *Guide to Meteorological Instruments and Methods of Observation,* World Meteorological Organization, No. 8, 5th edition, Geneva, Switzerland.

Appendix A. Wind Direction Sensor Orientation

A.1 Determining True North and Sensor Orientation

Orientation of the wind direction sensor is done after the datalogger has been programmed, and 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. The preferred method to obtain the magnetic declination for a specific site is to use a computer service offered by NOAA at www.ngdc.noaa.gov/geomag. Magnetic declination can also be obtained from a map or local airport. A general map showing magnetic declination for the contiguous United States is shown in Figure A-1.

Declination angles east of True North are considered negative, and are subtracted from 0 degrees to get True North as shown Figure A-2. Declination angles west of True North are considered positive, and are added to 0 degrees to get True North as shown in Figure A-3. For example, the declination for Logan, Utah is 14° East. True North is 360° - 14°, or 346° as read on a compass.

Orientation is most easily done with two people, one to aim and adjust the sensor, while the other observes the wind direction displayed by the datalogger.

1. Establish a reference point on the horizon for True North.
2. Sighting down the instrument center line, aim the nose cone, or counterweight at True North. Display the input location or variable for wind direction using a hand-held keyboard display, PC, or palm.
3. Loosen the u-bolt on the CM220 or the set screws on the Nu-Rail that secure the base of the sensor to the crossarm. While holding the vane position, slowly rotate the sensor base until the datalogger indicates 0 degrees. Tighten the set screws.

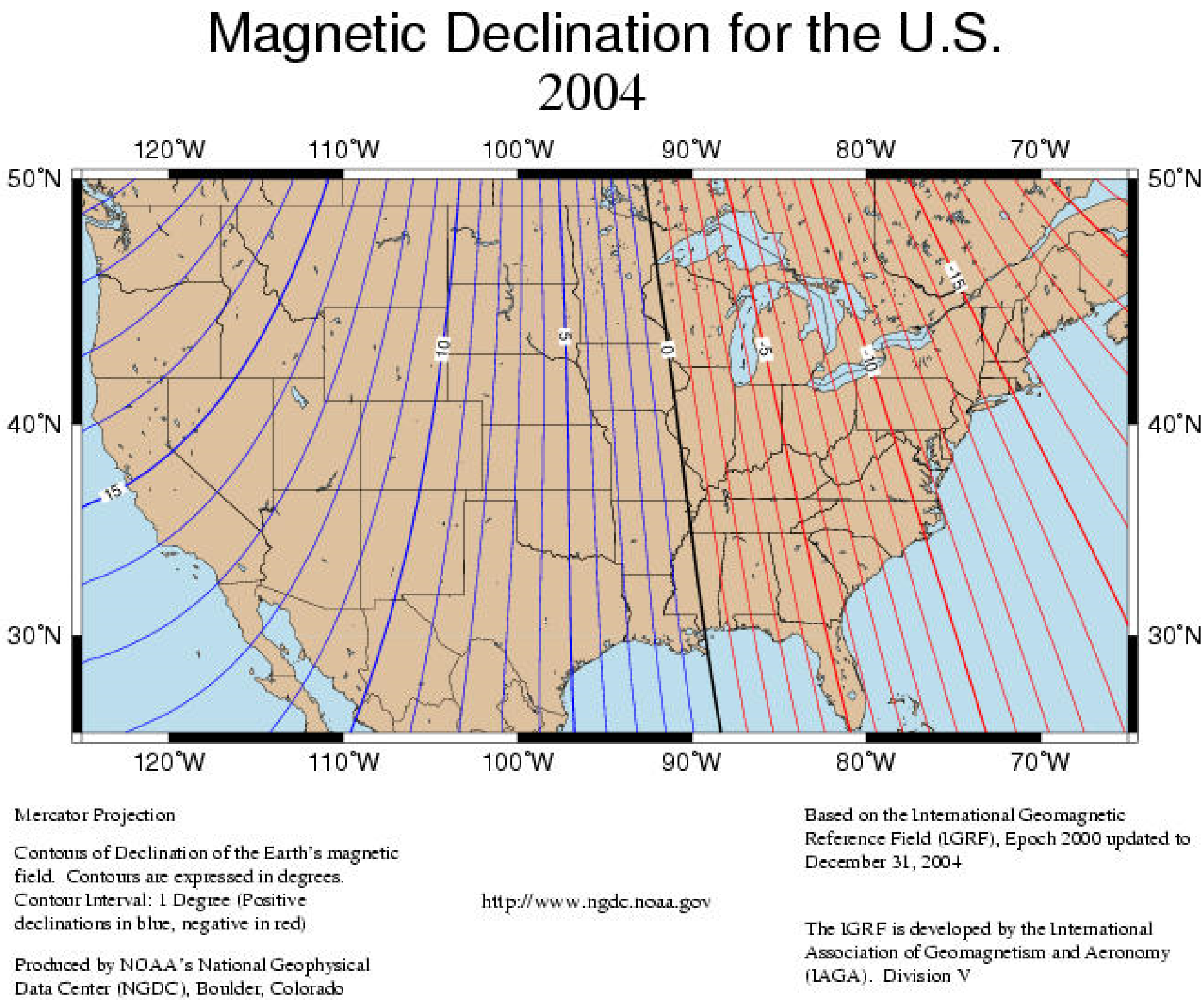

FIGURE A-1. Magnetic declination for the contiguous United States (2004)

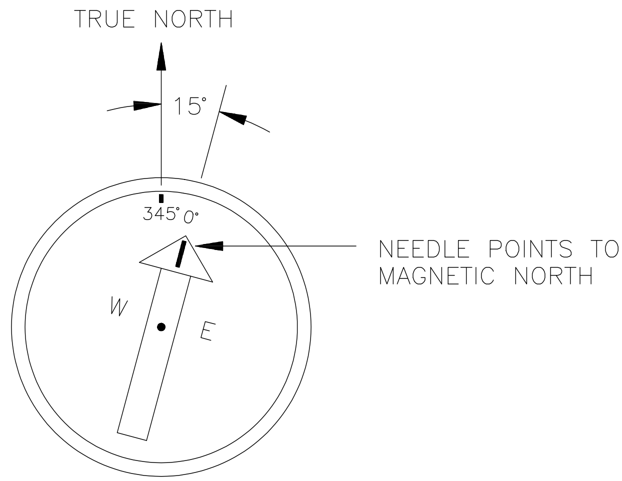

FIGURE A-2. Declination angles east of True North are subtracted from 0 to get True North

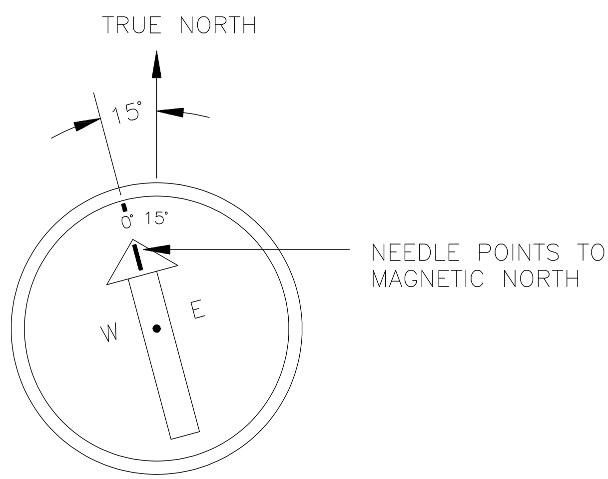

FIGURE A-3. Declination angles west of True North are added to 0 to get True North

Campbell Scientific Companies

Campbell Scientific, Inc. (CSI)
815 West 1800 North
Logan, Utah 84321
UNITED STATES
www.campbellsci.com • info@campbellsci.com

Campbell Scientific Africa Pty. Ltd. (CSAf)
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Somerset West 7129
SOUTH AFRICA
www.csafrica.co.za • cleroux@csafrica.co.za

Campbell Scientific Australia Pty. Ltd. (CSA)
PO Box 444
Thuringowa Central
QLD 4812 AUSTRALIA
www.campbellsci.com.au • info@campbellsci.com.au

Campbell Scientific do Brazil Ltda. (CSB)
Rua Luisa Crapsi Orsi, 15 Butantã
CEP: 005543-000 São Paulo SP BRAZIL
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Campbell Scientific Canada Corp. (CSC)
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Edmonton, Alberta T5M 1W7
CANADA
www.campbellsci.ca • dataloggers@campbellsci.ca

Campbell Scientific Centro Caribe S.A. (CSCC)
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Santo Domingo, Heredia 40305
COSTA RICA
www.campbellsci.cc • info@campbellsci.cc

Campbell Scientific Ltd. (CSL)
Campbell Park
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Shepshed, Loughborough LE12 9GX
UNITED KINGDOM
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Campbell Scientific Spain, S. L.
Avda. Pompeu Fabra 7-9, local 1
08024 Barcelona
SPAIN
www.campbellsci.es • info@campbellsci.es

Please visit www.campbellsci.com to obtain contact information for your local US or International representative.

12.4 Met One Model 038E/593A Relative Humidity/Temperature Sensor Manual

MODEL 083E / 593A RELATIVE HUMIDITY / TEMPERATURE SENSOR MANUAL

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

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

Copyright Notice

Model 084 Relative Humidity / Temperature 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.

Voice:	(541) 471-7111
Fax:	(541) 471-7116
E-Mail:	service@metone.com
Mail:	Technical Services Department Met One Instruments, Inc. 1600 Washington Boulevard Grants Pass, OR 97526

Safety Notice

The contents of this manual have been checked against the hardware and software described herein. Since deviations cannot be prevented entirely, we cannot guarantee full agreement. However, the data in this manual is reviewed regularly and any necessary corrections included in subsequent editions.

Faultless and safe operation of the product presupposes proper transportation, storage, and installation as well as careful operation and maintenance. The seller of this equipment cannot foresee all possible modes of operation in which the user may attempt to utilize this instrumentation. The user assumes all liability associated with the use of this instrumentation. The seller further disclaims any responsibility for consequential damages.

Warranty

Products manufactured by Met One Instruments, Inc. are warranted against defects in materials and workmanship for a period of (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 expense of Met One Instruments, Inc. be replaced or repaired and return freight prepaid. 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 or modified other than by Met One Instruments, Inc. Consumable items such as bearings 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.

Table of Contents

1. GENERAL INFORMATION

1.1. Description

The 083E sensor is an extremely accurate microprocessor controlled relative humidity and temperature sensor. The relative humidity sensor responds to the full range of 0 to 100% humidity. Response is linear with negligible hysteresis or temperature dependence. Some models contain a high accuracy linearized temperature sensor. The temperature sensor is a three-element composite thermistor type with linear response over the range of –50°C to +50°C. The sensor is designed to be mounted in a radiation shield when used outdoors. The exact model number you order will determine the functions of your sensor. The following section describes the model number feature assignments.

Figure 1 Model 083E-X-35 Sensor

Figure 2 Model 083E-X-6 Sensor

1.2. 083E Options

The 083E options are defined by dash numbers as follows:

083E-(Temp Option)-(Shield Option)

1.2.1. Temperature Option:

0 = RH (0 to 100%) only

1 = RH (0 to 100%) & Temperature (–50°C to +50°C)

1.2.2. Radiation Shield Compatibility Option:

6 = Use with Model 076B or 077 radiation shield. This sensor comes with 8-inch long pigtail wires for connection to the radiation shield junction box. Refer to the radiation shield manual for sensor and cable connections.

35 = Use with Model 073B or 5980 radiation shield. This sensor has a circular connector for use with Met One Instruments cable PN 2348.

1.3. Model 593A

The Model 593A is a special version of the sensor that measures relative humidity only, and includes a radiation shield. This sensor is designed for automatic sensor identification when connected to a Met One Instruments AutoMet data logger. This sensor has a circular connector for use with Met One Instruments cable PN 2348.

2. SENSOR SITING

The EPA recommends sensor mounting in a radiation shield at a 2 meter height, ideally over green mowed grass to minimize related terrestrial radiation errors on the temperature and relative humidity readings. Typical installations may vary significantly from these recommendations due to geographic limitations or specific monitoring requirements.

3. INSTALLATION

If the sensor is to be mounted in a radiation shield, refer to the radiation shield manual section for mounting details. Typical installations are shown below.

Sensors not installed in a radiation shield should be mounted in a representative location having good airflow and shaded from sunlight or other heat radiation sources that would affect measurement of relative humidity or temperature.

3.1. Mounting Instructions

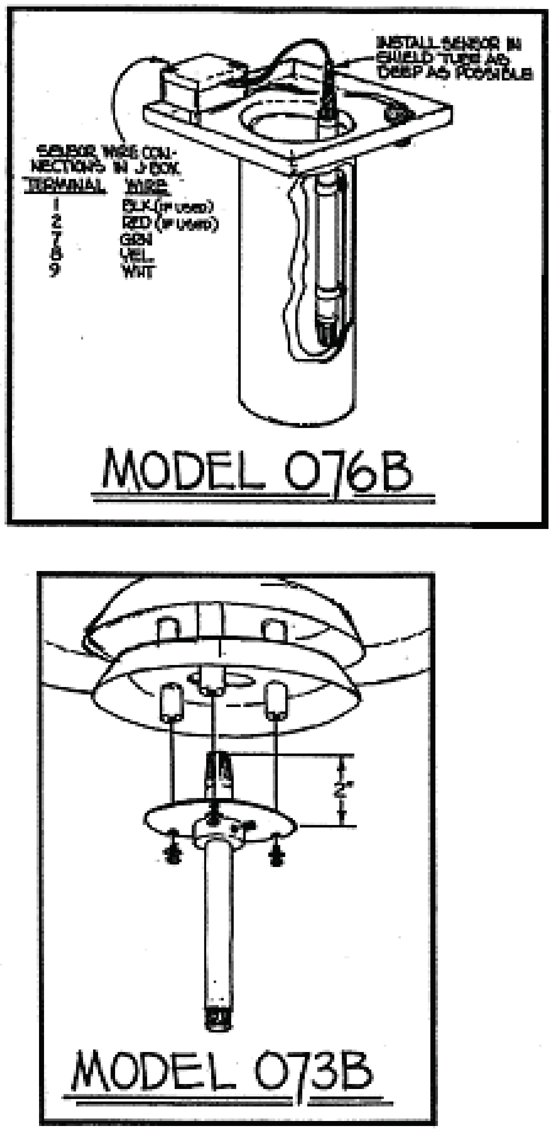


Figure 2 Radiation Shield Installation

3.2. Wiring Instructions

Sensor Connection	Wire Color	Description
Pin A	White	+10 to +18 VDC
Pin B	Green	Signal Ground
Pin C	Yellow	RH Analog Output
Pin D	Black	Temperature Common (Model 083E-1) No Connection (Model 083E-0) Auto ID Voltage (Model 593A)
Pin E	Red	Temperature Signal (Model 083E-1) No Connection (Model 083E-0)
Pin F	No Connection	No Connection
No Connection	White/Brown	Shield

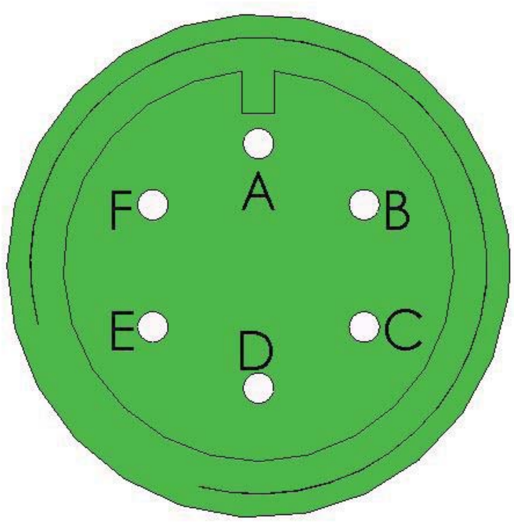


Figure 3 Electrical Connector

View looking at connector pins. (Pins are also identified on connector).

4. OPERATIONAL CHECK-OUT AND CALIBRATION

4.1. Relative Humidity Sensor Check-out

To verify correct wiring and test the basic sensor operation, blow on the sensor. The moisture in your breath should cause the relative humidity reading to rise.

The relative humidity sensor has been calibrated at the factory. To check for proper operation of the sensor it is advised that the output signal be checked against a local weather service facility or a local relative humidity measuring device such as a psychrometer. Due to normal atmospheric and geographical variations, the local weather service data should be used only as a guideline. Ambient air relative humidity can be expected to vary significantly over short distances and in brief periods of time.

4.2. Limitations of RH Measurements at Below Freezing Temperatures

The sensor's relative humidity output is referenced to saturated water vapor pressure above liquid water. When the air temperature is below freezing, the sensor's maximum theoretical measurement range is limited as follows:

Air Temperature (Deg C)	Maximum RH (%)
0	100
-5	96
-10	92
-15	88
-20	84
-25	80
-30	76
-35	72
-40	68
-45	64
-50	60

4.3. Temperature Sensor

Compare readings with a precision NIST-traceable temperature sensor. Calibration verification should be performed using a Met One Instruments Model 5472 Thermal Mass to assure that both instruments are at the same temperature. This is an aluminum mass with drilled recesses for the 083E sensor and a standard temperature sensor (NIST thermometer or RTD). The mass can be used in air, or can be partially submerged in ice or an ice bath. The 083E sensor should not be submerged.

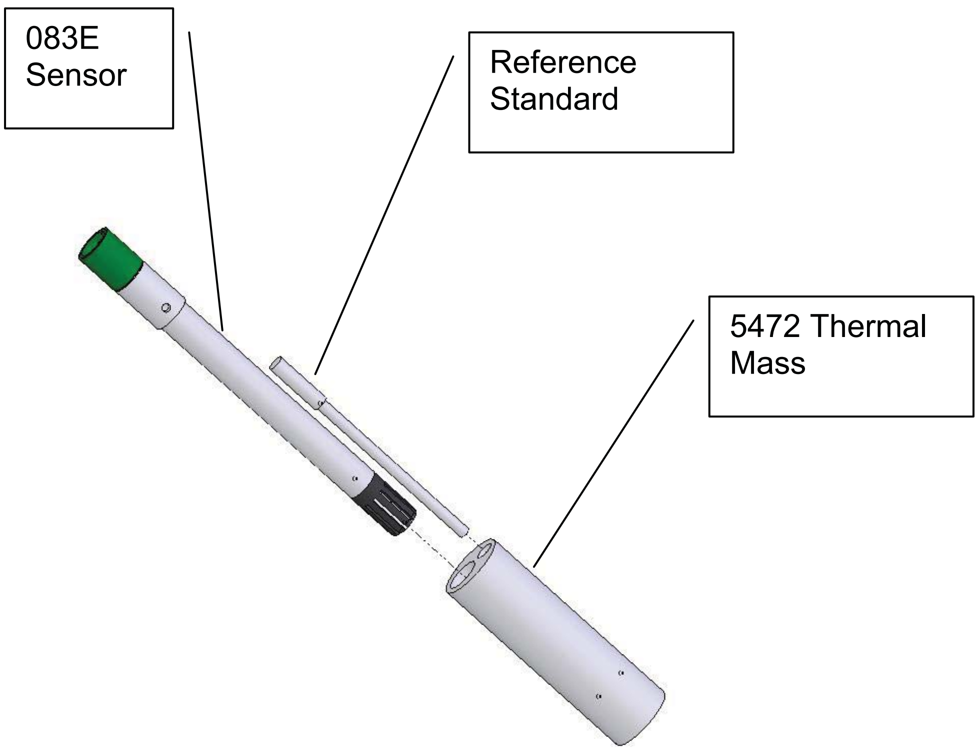


Figure 4 5472 Thermal Mass

4.4. Temperature Table

Model 083E-1-X Temperature vs. Sensor Resistance

Temp (° C)	RCAL (Ω Ohms)	Temp (° C)	RCAL (Ω Ohms)	Temp (° C)	RCAL (Ω Ohms)
-50	158181	-16	49648	18	22404
-49	150561	-15	48389	19	21908
-48	143555	-14	47173	20	21423
-47	137093	-13	45997	21	20949
-46	131114	-12	44861	22	20484
-45	125564	-11	43761	23	20029
-44	120400	-10	42696	24	19583
-43	115583	-9	41665	25	19147
-42	111079	-8	40665	26	18719
-41	106858	-7	39696	27	18300
-40	102895	-6	38755	28	17889
-39	99166	-5	37843	29	17487
-38	95651	-4	36957	30	17092
-37	92333	-3	36097	31	16705
-36	89196	-2	35260	32	16325
-35	86224	-1	34447	33	15952
-34	83406	0	33657	34	15586
-33	80729	1	32888	35	15227
-32	78183	2	32139	36	14875
-31	75760	3	31410	37	14529
-30	73449	4	30700	38	14190
-29	71245	5	30009	39	13856
-28	69138	6	29335	40	13528
-27	67124	7	28677	41	13206
-26	65195	8	28037	42	12890
-25	63348	9	27411	43	12579
-24	61576	10	26801	44	12274
-23	59875	11	26206	45	11974
-22	58242	12	25624	46	11678
-21	56671	13	25056	47	11388
-20	55160	14	24501	48	11102
-19	53705	15	23959	49	10822
-18	52303	16	23429	50	10545
-17	50952	17	22911		

RANGE -50 °C - + 50°C (-58°F to +122°F)
YSI THERMISTOR BEAD **44212**

$$Tc = ((((Rt^{-1}) + (23100^{-1}))^{-1}) - 13698.3) / {}^{-}129.163$$

$$Rt = ((((^{-}129.163\ Tc) + 13698.3)^{-1}) - 23100^{-1})^{-1}$$

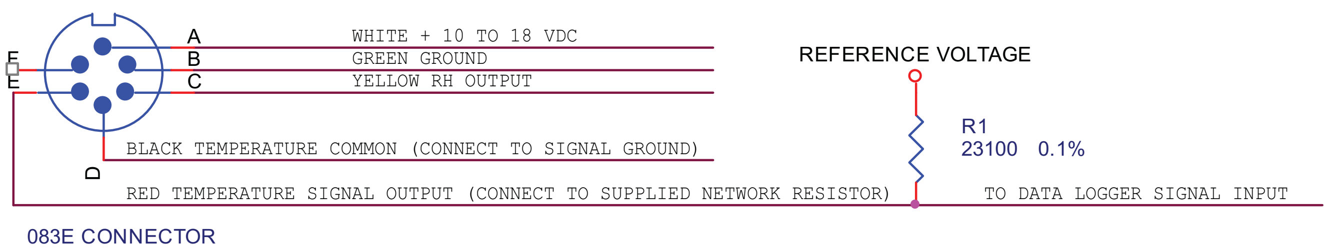
Where: Tc = Temperature in °C
Rt = Sensor Resistance in Ω Ohms

4.5. Temperature Sensor Data Logger Connection

The voltage across the sensor is linear with temperature when a precision 23100Ω ±0.1% resistor (Met One Instruments part number 805030) is connected in series with excitation voltage. This resistor is provided as part of all Met One Instruments translators designed for use with this sensor, and is included with Met One Instruments data loggers configured for this sensor. For applications with other equipment, contact Met One Instruments to obtain this special resistor. Maximum recommended excitation is 3.2V. Higher excitation voltage will cause self-heating of the thermistors, and resultant temperature measurement errors.

Reference Voltage	-50.0 °C	+50.0 °C
1.000	0.872 VDC	0.313 VDC
2.000	1.744 VDC	0.625 VDC
2.500	2.180 VDC	0.7825 VDC
5.000 (DO NOT USE)		

Signal Voltage vs. Temperature for Various Excitation Voltages



Data Logger Connection

4.6. General Maintenance Schedule

6 – 12 Month Intervals:

Inspect the sensor for proper operation per Section 4.0.

12 Month Interval:

Return the sensor to Met One Instruments for calibration.

Replace the two 720050 O-Rings.

Replace the 860014 Filter Membrane.

4.7. 083E Relative Humidity Sensor Maintenance and Calibration

WARNING: The sensor can be incorrectly calibrated 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.

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

The sensor should be re-calibrated every 12 months.

If parts or maintenance assistance are required, contact Met One Instruments. Obtain shipping instructions and a return authorization (RA) before returning any unit.

4.8. Sensor Maintenance

4.8.1. Sensor Element

The RH sensor element is not user-replaceable (replacement requires sensor recalibration). If the element becomes damaged please send the 083E sensor to Met One Instruments for repair. Please obtain shipping instructions and a return authorization (RA) number before returning any unit.

Met One Instruments manufactures an RH Calibration Kit part number 10233 which can be purchased to perform a calibration after the sensor element is replaced. Please contact the Met One Service Department to purchase the calibration kit.

4.8.2. Spare Parts

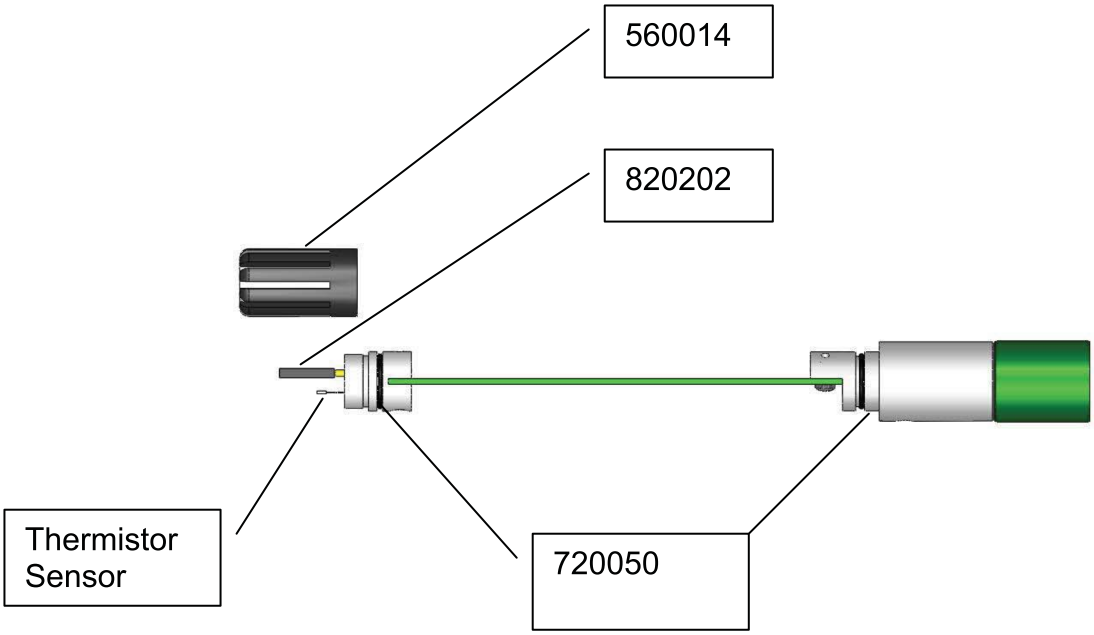


Figure 5 Spare Parts

820202	RH SENSOR ELEMENT (Requires factory calibration)
560014	FILTER, MEMBRANE
720050	O-RING (Two required)

5. Operational Specifications

Relative Humidity

Model Number:	083E
RH Sensing Element:	Thin film polymer capacitor
Range:	0 to 100% RH
Temperature Operation Range:	-50° C to +50° C (-58° F to 122° F)
Response Time:	10 sec. with 2 m/s aspiration
Accuracy:	± 2.0% from 0 to100% RH
Temperature Coefficient:	Compensated internally
Output:	0 to 1 VDC Standard 0 to 5.0 VDC Optional
AutoMet Auto ID:	Yes (Model 593A Only)

Temperature

Temperature Sensor:	Thermistor
Temperature Range:	-50° C to +50° C (-58° F to 122° F)
Accuracy	±0.10° C (0.18° F)
Output:	Resistive
AutoMet Auto ID:	No

General

Input Power	10 to 18 VDC @ < 5 mA
Dimensions	Length: 8.5 in (21.59 cm) Diameter: 0.75 in (1.91 cm)

12.5 Met One Barometric Pressure Sensor

MODEL 092

MODEL 6633A

MODEL 594

BAROMETRIC PRESSURE SENSOR

OPERATION MANUAL

Document No. 092-9800 Rev F

Met One Instruments

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Grants Pass, Oregon 97526
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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

1.0 INTRODUCTION

The Model 092 Barometric Pressure Sensor is designed to measure ambient atmospheric pressure and provide serial digital outputs and analog outputs all from the same sensor module. Pressure is sensed using a board mounted digital pressure sensor. An on board CPU scales pressure measurement and performs communications.

The Model 092 is simple to set up and use. The analog output voltage and pressure range limits are set with DIP switches. The DIP-switches allow quick configuration without requiring a laptop or data-logger for communication. Refer to Table 5-2 for switch settings.

Model 6633A is a special version with 4-20 mA output. It incorporates an additional circuit board to translate the 0-1 V sensor signal to 4-20 mA. Refer to Figure 3.6 for connection information.

Model 594 is identical to Model 092, but is configured with unique DIP-switch settings for compatibility with the Auto-ID feature on AutoMet data loggers. The range is 20-32 in.Hg and the analog output is 0-1 V. In addition, an Auto-ID output is provided to allow the data logger to automatically identify the sensor and scale the measurements. Refer to Table 5-2 for switch settings. Refer to Figure 3.2 for connection information.

Additional parameters may be configured with terminal connections (see section 10). The terminal connection accommodates standard RS-232 and RS-485. The SDI-12 interface parameters may be configured using an SDI-12 master in the transparent mode. Consult the manual for your particular data logger for additional information.

1.1 General Specifications:

Operational

Range:	600-1100 mbar (17.72-32.48 in Hg)*
Resolution:	0.1 mbar (.003 Hg)
Temp. Operating Range:	-40 to +55°C
Temp. Compensated Range:	-40 to 55°C
Accuracy:	±0.35 mbar @ 25°C
	±0.75 mbar @ 0 to55°C
	±1.5 mbar @ -40°C
Long Term Stability:	±1 mbar in 12 months

*Analog Output Range is user-selectable with DIP switches:
See Table 5-2 for switch settings and pressure conversions.
Factory default range: 900-1100 mbar.
Digital Output is fixed: 600-1100 mbar.

Analog Output Voltage - User selectable. See Table 5-1 for switch settings.
0 –1VDC (Factory default)
0 – 2VDC
0 – 2.5VDC
0 – 5VDC

Digital Outputs
RS-232
RS-485
SDI-12 (Default address = 0)

Communications Protocol
Terminal mode and for RS-232 and RS485
SDI-12

Serial Settings
Baud options = 1200, 2400, 4800, 9600, 19.2k
8 data bits, no parity, and 1 stop bit.
Default baud rate = 19.2k

Power
6-16 VDC, 10 ma @ 12VDC

Connections
Screw terminals on circuit board

Size
Polycarbonate Enclosure
120 x 80 x 55 mm 4.72 x 3.14 x 2.16 inches

CE Certification
See Appendix D

2.0 <u>INSTALLATION</u>

The sensor is designed for indoor or outdoor use. Refer to figures 3.1 thru 3.5 for wiring instructions depending on the intended use.

2.1 Mounting for outdoor use:
When designated for outdoor use, the unit is supplied with a solar shield and U-bolts. The sensor is provided attached to the solar shield. Install the solar shield with the U-bolts provided on any vertical pipe up to 2” IPS. Install the sensor so that it’s facing a northerly direction so that the solar shield protects the sensor enclosure from direct sunlight.

2.1 Mounting for indoor use:
For indoor mounting to a flat surface, mounting holes 1.97 x 4.25. Cover must be temporally removed to access mounting holes.

Note: The pressure sensor element is light sensitive, for accuracy in the measurement; do not operate the 092 with the top cover off.

3.0 INPUT/OUTPUT CONNECTIONS

See Figure 3.1 for Analog wiring.
See Figure 3.2 for 594 (AutoMet auto-ID) wiring.
See Figure 3.3 for RS232 wiring.
See Figure 3.4 for RS485 wiring.
See Figure 3.5 for SDI-12 wiring.
See Figure 3.6 for 6633A (4-20 mA Output) wiring.

4.0 USER DEFINED OPTIONS

None

5.0 USER INTERFACE

SW1-Analog Output Voltage Switch Settings

Range	SW1-1	SW1-2
0-1 V	On	On
0-2 V	On	Off
0-2.5 V	Off	On
0-5 V	Off	Off

Table 5-1

SW2 – Analog Output Pressure Range Switch Settings

RANGE SELECTION						SWITCH SETTINGS			
LOWER mbar	UPPER mbar	LOWER mm Hg	UPPER mm Hg	LOWER in Hg	UPPER in Hg	SW2-1	SW2-2	SW2-3	SW2-4
600	800	450	600	17.72	23.62	ON	ON	ON	ON
600	900	450	675	17.72	26.58	OFF	ON	ON	ON
600	1000	450	750	17.72	29.53	ON	OFF	ON	ON
600	1100	450	825	17.72	32.48	OFF	OFF	ON	ON
700	800	525	600	20.67	23.62	ON	ON	OFF	ON
700	900	525	675	20.67	26.58	OFF	ON	OFF	ON
700	1000	525	750	20.67	29.53	ON	OFF	OFF	ON
700	1100	525	825	20.67	32.48	OFF	OFF	OFF	ON
677.1	1083.6	508.0	812.8	20.00	32.00	ON	ON	ON	OFF
800	900	600	675	23.62	26.58	OFF	ON	ON	OFF
800	1000	600	750	23.62	29.53	ON	OFF	ON	OFF
800	1100	600	825	23.62	32.48	OFF	OFF	ON	OFF
						ON	ON	OFF	OFF
						OFF	ON	OFF	OFF
900	1000	675	750	26.58	29.53	ON	OFF	OFF	OFF
900	1100	675	825	26.58	32.48	OFF	OFF	OFF	OFF

Table 5-2

The two SW2 switch combinations shown with no pressure values are invalid settings. If the switches are set to either of these combinations, the analog output will default to the full range of 600-1100 mbar.

SW2 switch settings shown in Gray highlight will put the sensor into Model 594 (AutoMet plug & play) mode. In this mode, the analog output is fixed at 0-1V, and the SW1 switches are disabled. The sensor Auto-ID voltage is provided on the Aux Out terminal (terminal 10).

6.0 THEORY OF OPERATION

The 092 Barometric Pressure Sensor utilizes a piezoresistive pressure sensor module. This module contains an analog to digital converter, a temperature sensor, and non-volatile memory for storage of calibration coefficients. The pressure sensor module communicates with a highly integrated, mixed-signal microcontroller via a 3-wire serial peripheral interface (SPI).

The microcontroller contains two UARTS. One is connected to the RS-232 and RS-485 interfaces, while the second performs SDI-12 communications. The two serial ports function independently for the most part. The exception is the selection of pressure units which is common to both ports. It is possible to utilize the RS-232/485 port in interval or polled mode while an SDI-12 data recorder polls the sensor for data.

The microcontroller also contains a 12-bit digital to analog converter (DAC) for the sensor's analog output. The DAC is connected to a programmable gain amplifier stage. The gain of the output amplifier is set with dip switches (SW1). This allows the selection of 0-1, 0-2, 0-2.5, or 0-5 Volts for the analog output.

At startup the microcontroller reads the calibration coefficients from the pressure sensor module and compares them to values stored in its own non-volatile memory during factory calibration. An error message is displayed on the RS-232/485 port if the values do not match, indicating that one of the non-volatile memory sources may be corrupt or the sensor module may be malfunctioning.

The microcontroller polls the pressure sensor module once per second for the barometric pressure and ambient temperature. The raw readings are temperature corrected by the microcontroller. Then, second and third order temperature corrections are applied to the pressure reading. Finally, an individual factory determined calibration coefficient is applied and the pressure value is stored for output.

The microcontroller reads the state of the pressure range dip switches (SW2) once per second to determine the scaling of the analog output range. The pressure value is checked for under-range and over-range conditions and sent to the DAC for output. An under-range condition will produce an output of zero volts, while an over-range condition will set the analog output to the full-scale voltage as determined by the setting of the output range dip switches (SW1). Please note that analog output accuracy and resolution will be optimized by selecting the narrowest pressure range that will be encountered at the location where the sensor will be used.

The SW2 pressure range dip switch settings do not affect the range of the serial output. The serial message may deviate to values outside of the range of 600 to 1100 millibars if the sensor is subjected to ambient pressures outside of this range. Pressure conditions in the range of 10 to 10,000 millibars will not harm the sensor, but the measurement accuracy is not guaranteed beyond the range of 600 to 1100 millibars.

All input and output lines are protected from static surge damage by Transzorbs and current limiting resistors.

7.0 CALIBRATION

Calibration is performed against a NIST traceable standard. The calibration coefficients are stored in non-volatile memory at the factory. No user calibration is available. The sensor must be returned to Met One Instruments if periodic calibration is desired.

8.0 MAINTENANCE

Periodic cleaning of the sintered filter on the bottom of the unit may be required in dusty conditions. Remove the filter from the bottom of the unit and clean with distilled water.

Return of the sensor to Met One Instruments for a yearly recalibration is recommended.

9.0 CONTROL AND COMMUNICATION

Operational parameters of the 092 are set with board mounted DIP switches and by using one of the serial communications protocols. These protocols include; SDI-12 and simple two character terminal commands via RS-232 or RS-485.

10.0 TERMINAL MODE

The terminal emulator supports using a VT-100 terminal. Sending three (3) carriage returns within two seconds starts the terminal service. Terminal mode begins by displaying the Model Number, Date Code, Serial Number, and Firmware Version:
i.e. 092-YY-SSSSS-CCC-VV.V
where: YY is the Year of manufacture
SSSSS is the Serial Number
CCC is the Calibration Tracking Code
VV.V is the Firmware Version

Note: Pressure measurements are suspended while the terminal service is active. SDI-12 polls will return the last pressure value measured before terminal service was entered.

<table>
<tr><th>Command</th><th>Description</th></tr>
<tr><td>DR</td><td>Display range switch setting for analog output.
Command: DR<cr></td></tr>
<tr><td>HE</td><td>Display the Help menu
Command: HE<cr>
HE = This Help menu
DR = Display Range Switch setting for Analog Output.
LB = Toggle Verbose Label mode. Use with MicroMet or CR-10X logger.
LC = Display Last Calibration information
PU = Set Pressure Units
QU = Quit command mode and save any changes
SB = Set Baud rate.
ST = Set Serial Trigger Address (RS-485 Only)
VN = Display Firmware Version Number</td></tr>
<tr><td>LB</td><td>Verbose Control of RS-232/485 Parameter Labels for Data loggers
Command: LBx<cr>
Where x is:
1 = Enable Labels (default)
0 = Suppress Labels</td></tr>
<tr><td>LC</td><td>Display the last calibration information table.
Command: LC<cr>
Returns the serial number and date of last calibration.</td></tr>
<tr><td>OI</td><td>Select Output Interval
Command: OIx<cr>
Where x is:
0 = Serial Trigger. Address must be set with ST command.
1 = 1 second
2 = 5 seconds
3 = 10 seconds
4 = 15 seconds
5 = 30 seconds
6 = 60 seconds</td></tr>
</table>

Command	Description
PU	Pressure Units Sets the Engineering Units for Pressure Command: PUx<cr> Where x is: 0 = Millibars (default) 1 = Hectopascals 2 = Inches of Mercury 3 = Millimeters of Mercury 4 = Kilopascals
QU	Quit Save changes and exit Command or Terminal mode. Command: QU<cr> Not supported by SDI-12
SB	Serial Baud Rate Command: SBx<cr> Where x is: 1 = 1200 Baud 2 = 2400 Baud 3 = 4800 Baud 4 = 9600 Baud 5 = 19200 Baud (default)
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' is the serial trigger string. The 'x' character can be anything from one to six characters, but cannot be three "!" in row.
VN	Version Number Returns the firmware version number Command: VN<cr>

11.0 SDI-12 SERVICE

NAME	SDI-12 COMMAND	SENSOR RESPONSE
Address Query	?!	a<CR><LF> Where a = address
Acknowledge Active	a!	a<CR><LF> Where a = address
Send Identification	aI!	a13Climo 092 1.0 0Axxxxx<CR><LF> Where a=address and xxxxx = S/N
Change Address	aAb!	b<CR><LF> Where b = new address
Start Measurement	aM!	a0001<CR><LF> Where a = address
Start Measurement with CRC	aMC!	a0001<CR><LF> Where a = address
Send Data.	aD0!	a+1013.0<CR><LF> Where a = address
Start Concurrent Measurement	aC!	a00001<CR><LF> Where a = address
Start Concurrent Measurement with CRC	aCC!	a00001<CR><LF> Where a = address
Continuous Measurements	aR0!	a+xxxx.x<CR><LF> Where a = address and xxxx.x = data
Continuous Measurements with CRC	aRC0!	a+xxxx.x{crc}<CR><LF> Where a = address, xxxx.x = data and {crc} = CRC
* Display Last Calibration	aXLC!	aXLCyymmdd<CR><LF> Where yymmdd is date of last calibration
* Set Pressure Units	aXPUf!	aXPUf<CR><LF> Where f is: 0 for Millibars (default), or 1 for Hectopascals, or 2 for Inches of Mercury, or 3 for Millimeters of Mercury, or 4 for Kilopascals
* Display Version Number.	aXVN!	aXVNxx.x<CR><LF> Where a = address and xx.x = firmware version

* Extended SDI-12 commands not available with all data loggers.

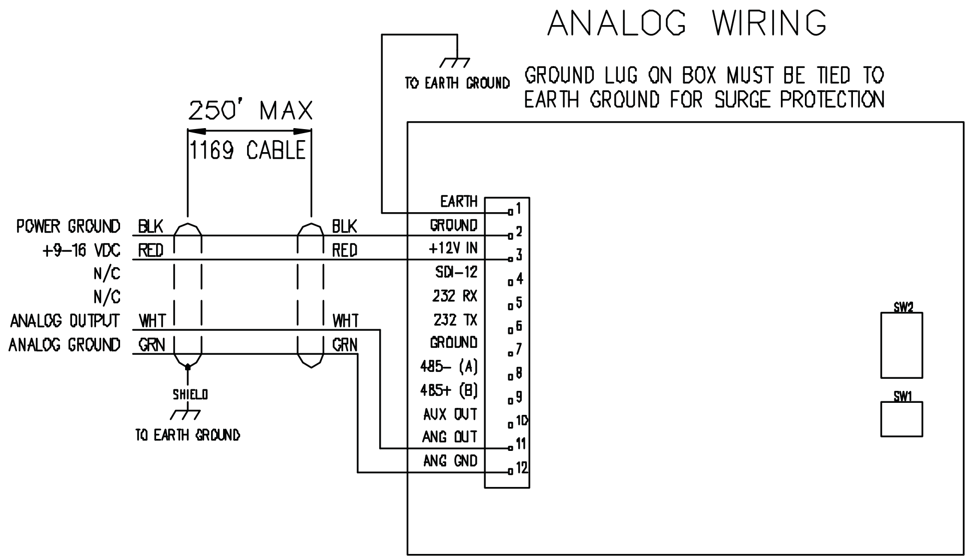


Figure 3.1 – Analog Wiring

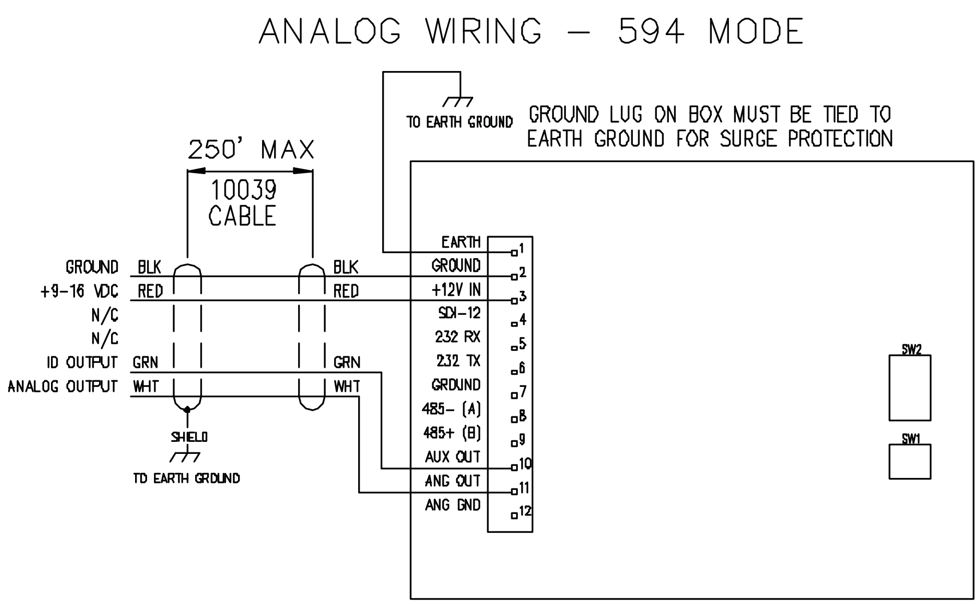


Figure 3.2 – Analog Wiring (594 Mode)

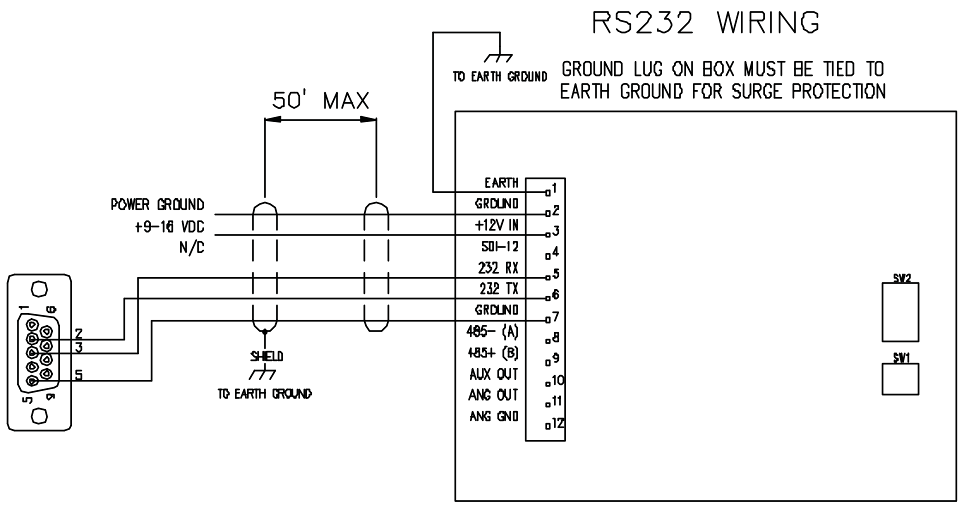


Figure 3.3 – RS232 Wiring

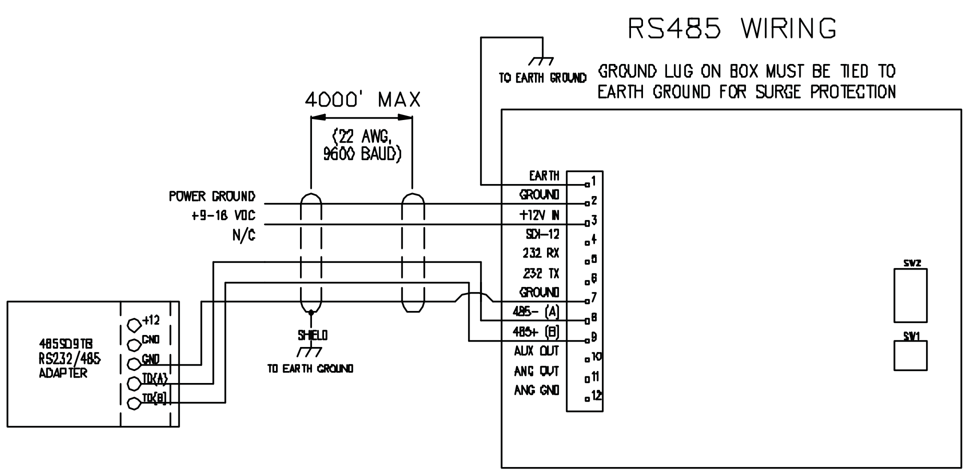


Figure 3.4 – RS485 Wiring

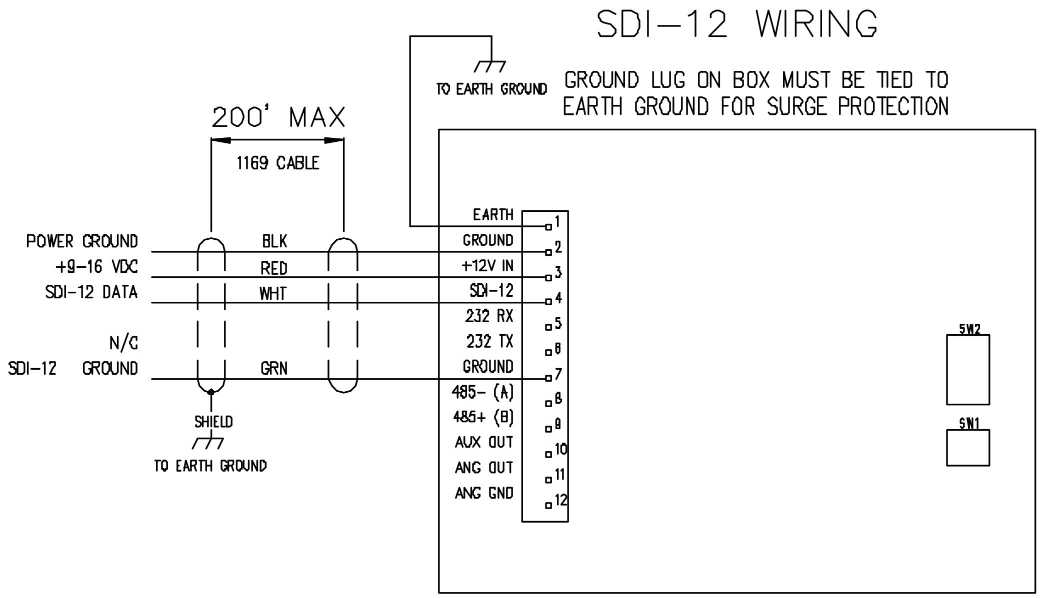


Figure 3.5 – SDI-12 Wiring

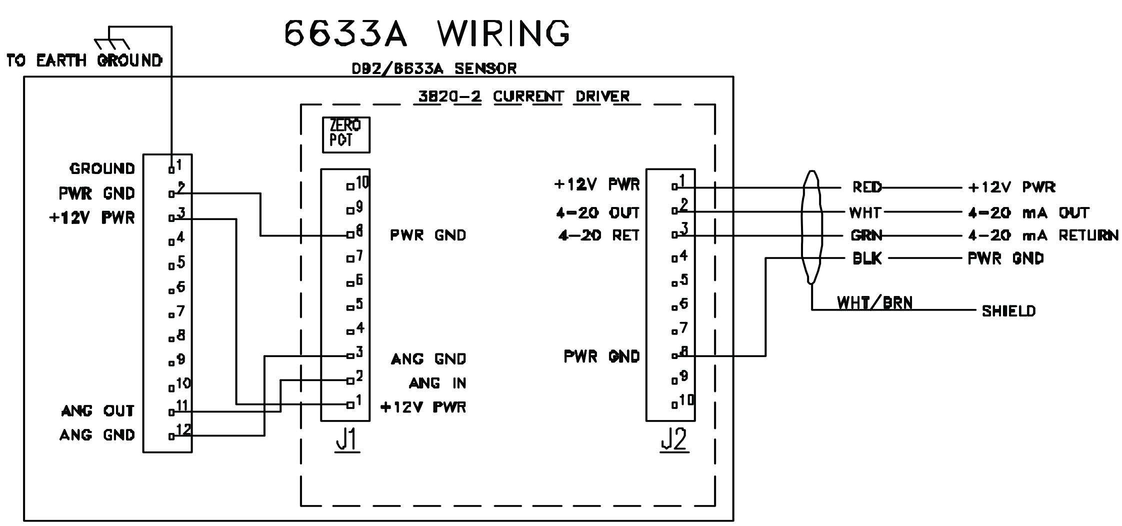


Figure 3.6 – 6633A Wiring

Appendix A

ABSOLUTE BAROMETRIC PRESSURE CORRECTION TO MEAN SEA LEVEL PRESSURE

Based on the ICAO standard Atmosphere

Elevation	Sea Level Correction Factor		
(feet)	in Hg	mm Hg	mbar
0	0.000	0.00	0.00
10	0.011	0.27	0.37
20	0.022	0.55	0.73
30	0.032	0.82	1.10
40	0.043	1.10	1.46
50	0.054	1.37	1.83
60	0.065	1.65	2.20
70	0.076	1.92	2.56
80	0.086	2.19	2.93
90	0.097	2.47	3.29
100	0.108	2.74	3.66
200	0.216	5.48	7.30
300	0.323	8.20	10.94
400	0.430	10.92	14.56
500	0.537	13.63	18.17
600	0.643	16.33	21.78
700	0.749	19.03	25.37
800	0.855	21.72	28.95
900	0.960	24.39	32.52
1000	1.066	27.07	36.08
2000	2.100	53.35	71.12
3000	3.105	78.86	105.13
4000	4.079	103.62	138.15
5000	5.025	127.64	170.18
6000	5.943	150.95	201.26
7000	6.833	173.56	231.40
8000	7.696	195.49	260.63
9000	8.533	216.74	288.97
10000	9.344	237.35	316.44
11000	10.130	257.31	343.05
12000	10.892	276.66	368.84

Add the correction to the absolute pressure reading to calculate Mean Sea Level Pressure. Subtract the correction from 1013.3 mbar (or 760.0 mm Hg, or 29.93 in Hg) to calculate the average Absolute Pressure at any elevation.

Elevation (meters)	Sea Level Correction Factor in.Hg	mm Hg	mbar
0	0.000	0.00	0.00
10	0.035	0.90	1.20
20	0.071	1.80	2.40
30	0.106	2.70	3.60
40	0.142	3.60	4.80
50	0.177	4.49	5.99
60	0.212	5.39	7.19
70	0.247	6.29	8.38
80	0.283	7.18	9.57
90	0.318	8.07	10.77
100	0.353	8.97	11.96
200	0.703	17.85	23.80
300	1.049	26.65	35.52
400	1.392	35.36	47.14
500	1.732	43.99	58.64
600	2.068	52.53	70.03
700	2.401	60.99	81.31
800	2.731	69.37	92.49
900	3.058	77.67	103.55
1000	3.381	85.89	114.51
2000	6.446	163.74	218.30
3000	9.218	234.14	312.17
4000	11.719	297.66	396.85

Add the correction to the absolute pressure reading to calculate Mean Sea Level Pressure. Subtract the correction from 1013.3 mbar (or 760.0 mm Hg, or 29.93 in Hg) to calculate the average Absolute Pressure at any elevation.

Appendix B

Site Elevation vs. Sensor Range

When using analog signals, it is recommended to keep the sensor's pressure range to a minimum in order to achieve optimum signal resolution. This is not a consideration when using digital signals – digital signals are always at full range (800-1100 mbar) and full resolution. The 092 sensor ranges can be customer-selected to accommodate installation at any elevation from below sea level to approximately 12000 feet.

Atmospheric pressure will decrease with increasing elevation at the rate of approximately 1% per 80 meters elevation. The tables in Appendix A can be used to correct absolute pressure (provided by the 092 sensor) to mean sea level pressure (MSLP). At any elevation, weather causes the atmospheric pressure to vary above and below the average. The sensor should be set to an appropriate range so that it can report any expected atmospheric pressure at a given elevation.

Mean sea level pressure (MSLP) is 1013mbar (hPa). Maximum and minimum pressures are considered to be as follows:
Maximum MSLP = 1070mbar.
Minimum MSLP = 940 mbar (non-hurricane)
Minimum MSLP = 880 mbar (hurricane)

The amount of deviation from average pressure also decreases with increasing elevation. Consequently, the elevation affects both the average pressure and the pressure deviation due to weather activity.

The following formulas can be used to calculate maximum and minimum expected absolute pressures at any elevation:
Maximum expected pressure = P_A * (1070/1013)
Minimum expected (non-hurricane) pressure = P_A * (940/1013)
Minimum expected (hurricane) pressure = P_A * (880/1013)

where: P_A = average absolute pressure at a specific elevation, computed from table in Appendix A.

These formulas and derivatives were used to compute the recommended sensor ranges for specific elevations in the tables below.

Recommended pressure ranges for given elevations above sea level

Elevation	Non-Hurricane Recommended Range
0 to 1200 ft.	900 to 1100 mbar
1200 to 1900 ft.	800 to 1100 mbar
1900 to 4400 ft.	800 to 1000 mbar
4400 to 6200 ft.	700 to 1000 mbar
6200 to 8000 ft.	700 to 900 mbar
8000 to 12000 ft.	600 to 800 mbar

Elevation	Hurricane Zone Recommended Range
0 to 1900 ft.	800 to 1100 mbar
1900 to 2600 ft.	800 to 1000 mbar
2600 to 6200 ft.	700 to 1000 mbar
6200 ±50 ft.	700 to 900 mbar
6200 to 7800 ft.	600 to 900 mbar
7800 to 10200 ft.	600 to 800 mbar

Practical elevation ranges for each 200-300 mbar sensor range

Pressure Range	Non-Hurricane Elevation	Hurricane Zone Elevation
900 to 1100 mbar	-750 to 1200 ft.	-750 to –600 ft.
800 to 1100 mbar	-750 to 4400 ft.	-750 to 2600 ft.
800 to 1000 mbar	1900 to 4400 ft.	1900 to 2600 ft.
700 to 1000 mbar	1900 to 8000 ft.	1900 to 6200 ft.
700 to 900 mbar	6200 to 8000 ft.	6200 ±50 ft.
600 to 900 mbar	6200 to 12000 ft.	6200 to 10200 ft
600 to 800 mbar	7800 to 12000 ft.	7800 to 10200 ft.

Appendix C

Units Conversion

One Atmosphere

1 atm	1013.3 mbar
	1013.3 hPa
	760.00 mm Hg
	760.00 Torr
	29.921 in Hg
	14.696 psia

Inches of Mercury to Millibars or to Millimeters of Mercury

in Hg	mbar / 33.864
	mbar * 0.02953
	mm Hg / 25.400
	mm Hg * 0.03937

Millimeters of Mercury to Millibars or to Inches of Mercury

mm Hg	mbar / 1.3332
	mbar * 0.750064
	in Hg / 0.03937
	in Hg * 25.400

Millibars to Millimeters of Mercury or to Inches of Mercury

mbar	mm Hg / 0.750064
	mm Hg * 1.3332
	in Hg / 0.02953
	in Hg * 33.864

Appendix D

CE MARK

Certificate of Conformance
European Community
Council Directive 2004/108/EC

Date of Issue: November, 2008

Issued By: Retlif Testing Laboratories
795 Marconi Avenue
Ronkonkoma, NY 11779

Issued To: Climatronics Corp.
140 Wilbur Place
Bohemia, NY 11716

Reference: Retlif Report Number R-12669

Retlif Testing Laboratories hereby acknowledges that compliance testing in accordance with the below listed standards was performed on a representative sample of the equipment listed below. Retlif Testing Laboratories further acknowledges that the test sample listed below was found to be in compliance with these standards.
This certificate is hereby issued to the above named grantee and is valid only for the equipment identified below.

Manufacturer: Climatronics Corp.
140 Wilbur Place
Bohemia, NY 11716

Equipment Tested: Barometric Pressure Sensor

Part Number: 102663/092

Serial Number: 42288

Brand Name: Climatronics Corp./Met One Instruments

Product Type: Measurement, Control Equipment and Laboratory Use

Note(s):
1) See attached report R-12669 for details and/or conditions pertaining to this certificate.
2) Conforms to the emissions requirements of EN 61326-1:2006; Clause 7.2
   CISPR 11:1Edition 4 2003 — Class A, Radiated Emissions, 30 MHz to 1 GHz
3) Conforms to the immunity requirements of EN 61326:2006-1:2006; Table 2

IEC 61000-4-2:2001	Electrostatic Discharge
IEC 61000-4-3:2002	Radiated Immunity
IEC 61000-4-4:2004	EFT/Burst, Power and I/O Leads
IEC 61000-4-5:2001	Surge Immunity, Power Leads
IEC 61000-4-6:2003	Conducted Immunity, Power and I/O Leads

12.6 Met One Model 2308/2267 Sensor Heater

Model 2308/2267 Sensor Heater
Operation Instructions

MET ONE NORTHWEST
1600 · WASHINGTON BLVD
GRANTS PASS, OR 97526
PHONE: 503-471-7111
FAX: 503-471-7116

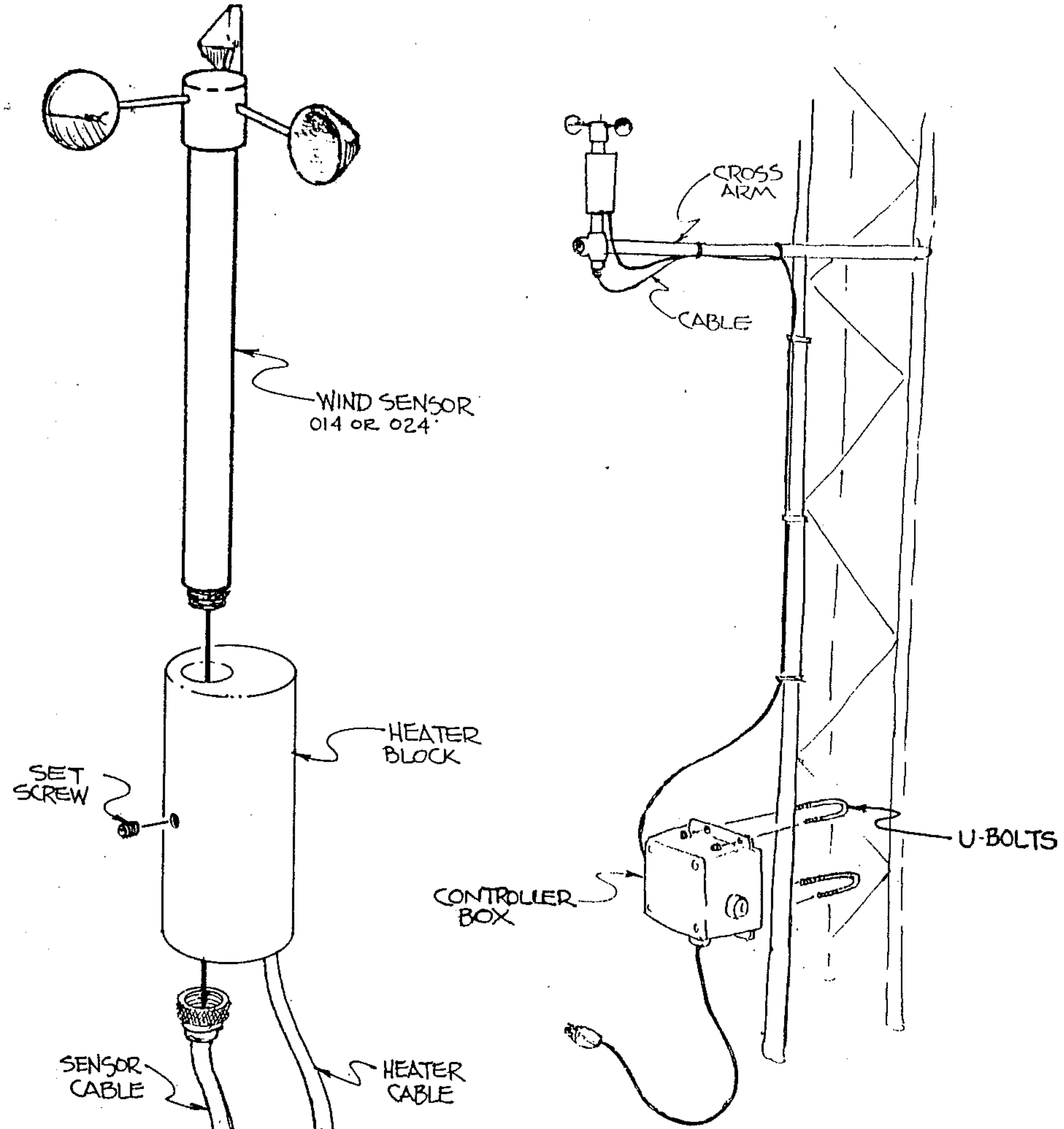
5/93

Model 2308/2267 Sensor Heater
Operation Instructions

1.0 The 2308/2267 Sensor Heaters/Heater Controller provide thermostatic controlled heat to a pair of Wind Speed and Wind Direction sensors to prevent icing and freeze-up in severe cold environments.

1.1 The 2308 Sensor Heaters consist of a pair of cartridge heaters mounted in heater blocks (thermal masses). The heater blocks are made to be easily installed onto Met One Northwest Model 014A Wind Speed and 024A Wind Direction sensors. Six-foot power cables are permanently attached to the heater blocks (optional lengths can be supplied if specified at time of order), and connect to the 2267 Heater Controller.

1.2 The 2267 Heater Controller supplies power (12VAC) to the 2308 Sensor Heaters. The Heater Controller can be powered from 115VAC or 230VAC (power should be specified at time of order, but can be easily converted in the field). It can also be used as a power source (115VAC or 230VAC) for a 076B Radiation Shield (optional configuration). Power is supplied to the Heater Controller via a 3-conductor 16 gauge cable; length of cable should be specified at time of order.



2308/2267
HEATER BLOCK INSTALLATION
(ONTO 014 OR 024 WIND SENSOR)

RWMS 26OCT92 DWG# 6449

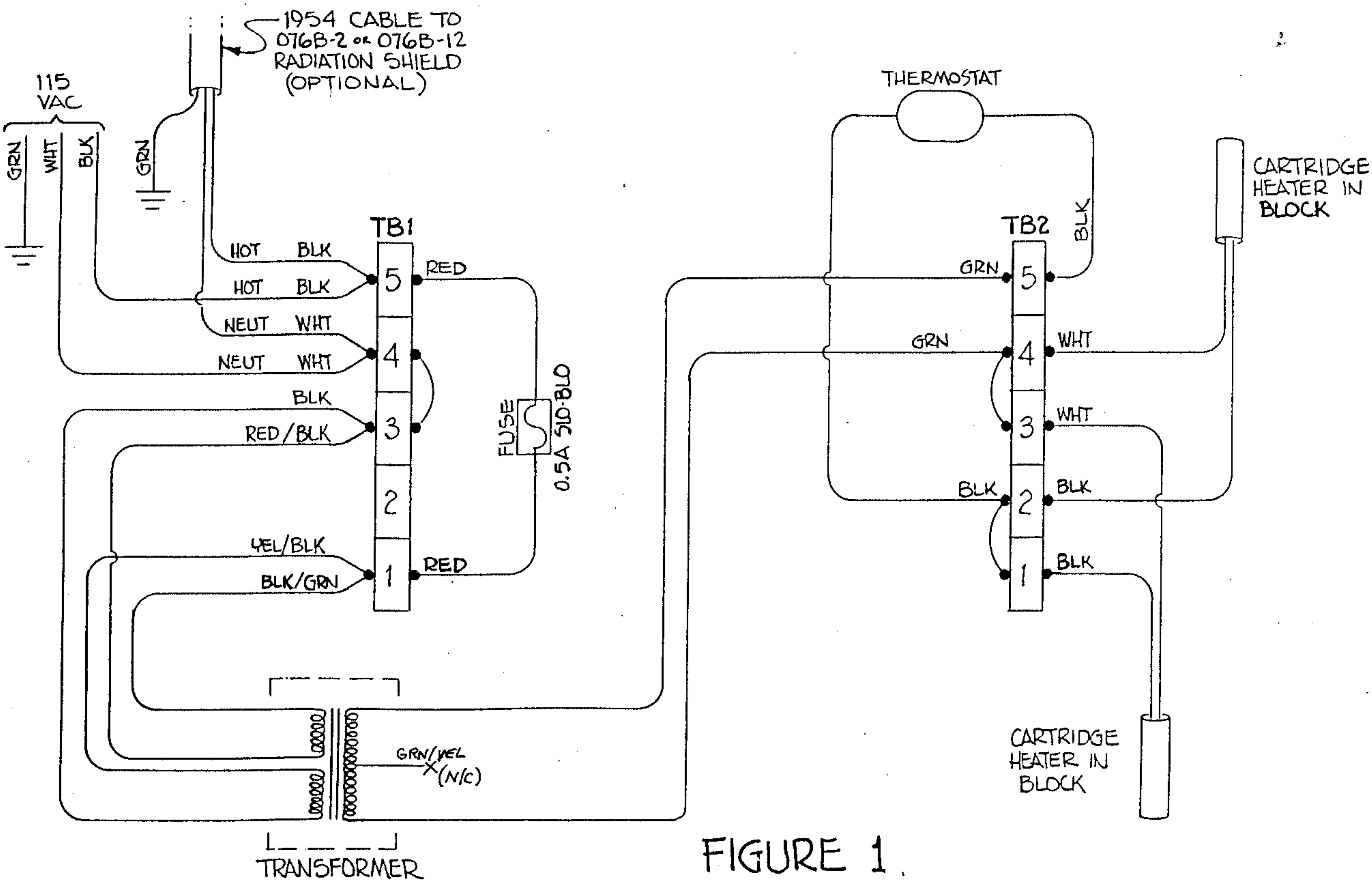


FIGURE 1

115 VAC WIRING DIAGRAM

2308/2267 SENSOR HEATER

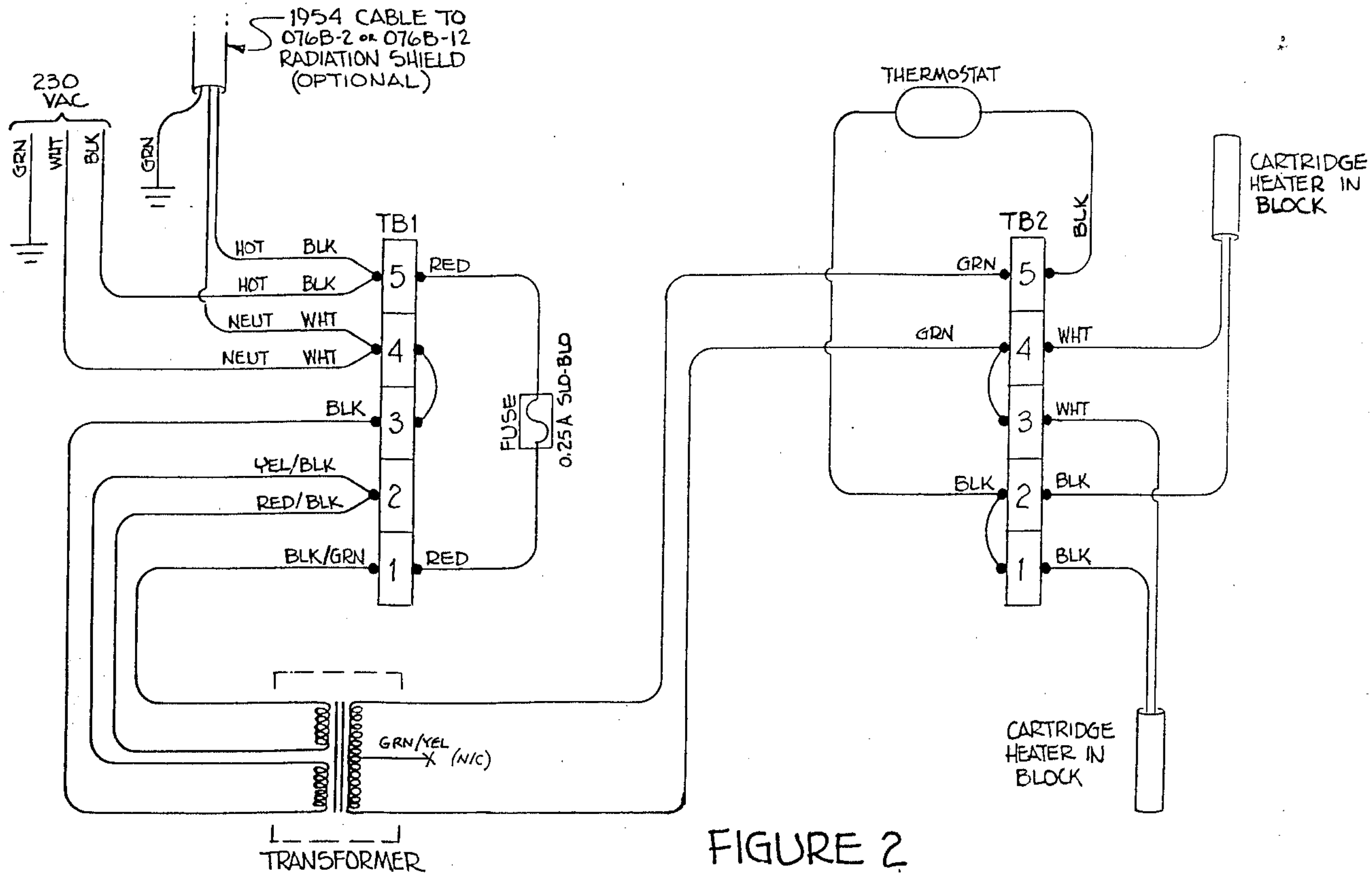


FIGURE 2

230 VAC WIRING DIAGRAM

2308/2267 SENSOR HEATER

12.7 Thies First Class Wind Speed Sensor

THE WORLD OF WEATHER DATA - THE WORLD OF WEATHER DATA - THE WORLD OF WEATHER DATA

Thies CLIMA

Instruction for Use

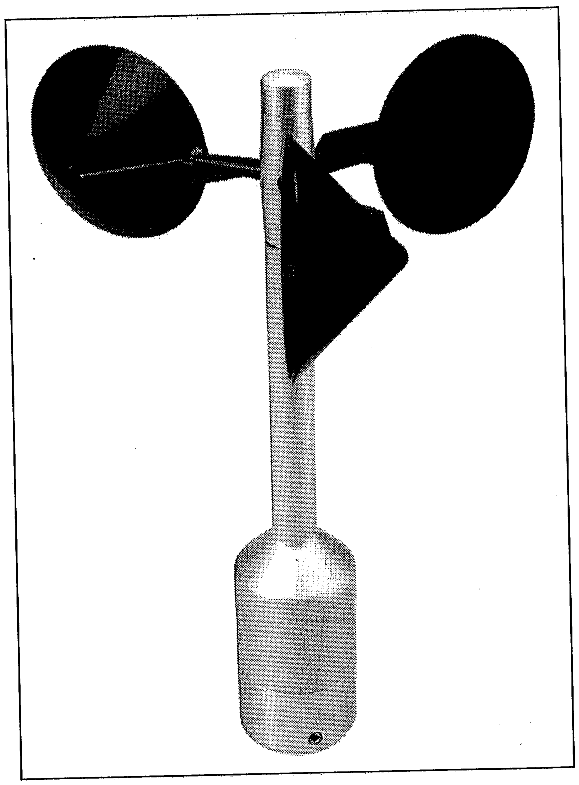
021519/01/09

Wind Transmitter „First Class“ Advanced

Classified according to IEC 61400-12-1 (2005-12)

4.3351.00.000

4.3351.10.000



ADOLF THIES GmbH & Co. KG

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Box 3536 + 3541 37025 Göttingen

Phone ++551 79001-0 Fax ++551 79001-65

www.thiesclima.com info@thiesclima.com

Contents

Patent

Patent Nr.: EP 1 398 637

Patent Nr.: DE 103 27 632

Patent Nr.: EP 1 489 427

1 Models available

Order - No.	Meas. range	Output Frequency	Supply	Heating
4.3351.00.000	0.3...75 m/s	1082 Hz @ 50 m/s	3.3 - 42 V DC	24V AC/DC, 25 W
4.3351.10.000	0.3...75 m/s	1082 Hz @ 50 m/s	3.3 - 42 V DC	w/o heating

The following parts are included in delivery:
1 Instrument
1 Terminal plug
1 Instruction for Use

2 Application

The wind transmitter is designed for the acquisition of the horizontal component of the wind speed in the field of meteorology and environmental measuring technology, evaluation of location, and measurement of capacity characteristics of wind power systems
Special characters are defined and optimised, dynamic behaviour also at high turbulence intensity, minimal over-speeding, and a low starting values.
The measuring value is available as digital signal at the output. It can be transmitted to display instruments, recording instruments, data loggers as well as to process control systems. For winter operation the instrument is optional equipped with an electronically regulated heating, which guarantees a smooth running of the ball bearings, and prevents the shaft and slot from icing-up.

Remark

When using fastening adapters (angle, traverses, etc) please take a possible effect to the measuring values by shading into consideration.

3 Construction and Mode of Operation

A low-inertia cup star with 3 cups, made of carbon-fibre-reinforced plastic, is set into rotation by the wind. The rotation is scanned opto-electronically, and is converted into a square wave signal. The frequency of this signal is proportional to the number or rotations. Depending on the supply voltage, the output signal ranges between maximal output voltage and ground or a potential (life-zero), lifted by approx. 1,2 V. The supply of the electronics can be done by DC-voltage of 3,3 V up to 42 V at a very low current consumption. An AC- or DC-voltage of 24 V is intended for the separate supply of the optional heating. In all probability, the heating guarantees a trouble-free function of the Wind Transmitter First Class even under extreme meteorological icing-conditions.

The outer parts of the instrument are made of corrosion-resistant anodised aluminium. Highly effective labyrinth gaskets and O-rings protect the sensitive parts inside the instrument against humidity and dust. The instrument is mounted onto a mast tube; the electrical plug-connection is located in the transmitter shaft.

4 Recommendation Side Selection / Standard Installation

In general, wind measuring instruments are supposed to record wind conditions over a large area. According to international regulations, the surface wind should be measured at a height of 10 m above even open terrain, in order to achieve comparable values. An open terrain is defined as terrain where the distance between the wind-measuring instrument and the next obstacle is at least ten times the height of this obstacle (Guide to Meteorological Instruments and Methods of Observation, Sixth Edition, WMO-No. 8). If this regulation cannot be fulfilled, the measuring instrument should be installed at a height at where the measurement values are not influenced by any local obstacles. In any case, the measuring instruments should be installed at a height of 6 to 10 m above the mean height of the buildings or trees in the vicinity. If it is necessary to install the instrument on a roof, it should be installed in the centre of the roof in order to avoid any preferential directions.

5 Installation

5.1 Electrical Mounting

Solder a shielded cable with diameter 7-8 mm and a core cross-section of 0,5...0,75 mm² to the enclosed coupling socket.

- The number of necessary wires is given in the connection diagram (chapter 8).

Cable recommendation	
Type/ No. of cores /Diameter	Cable diameter
LIYCY 4 x 0.75 mm²	ca. 7 mm
LIYCY 5 x 0.50 mm²	ca. 7 mm
LIYCY 6 x 0.75 mm²	ca. 7.7 mm
LIYCY 7 x 0.50 mm²	ca. 7.5 mm
LIYCY 8 x 0.50 mm²	ca. 8 mm

5.2 Mechanical Mounting

Mount the transmitter onto a pipe socket of R 1" (Ø 33.5 mm) and a length of 25 mm. The pipe socket must have an internal diameter of at least 25 mm as the wind transmitter must be connected electrically with a plug from below.

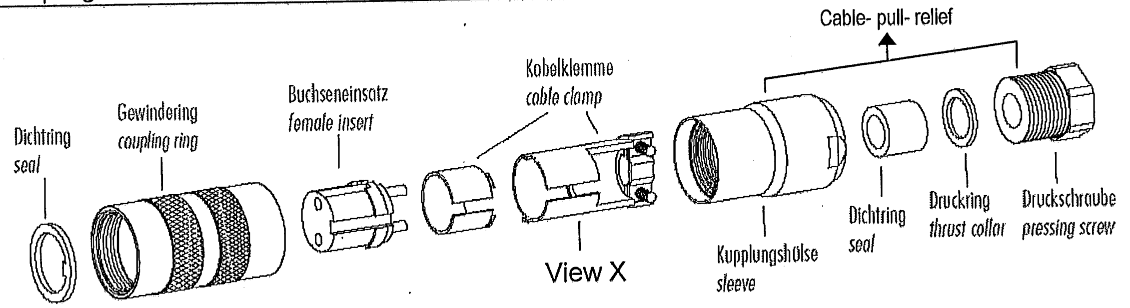
After electrical connection the wind transmitter is put onto the pipe socket, and is fixed by means of 2 threaded pins (female hexagon 3 mm) at the base of the transmitter.

Attention

Storing, mounting, and operation under weather conditions is permissible only in vertical position, as otherwise water can get into the instrument.

6 Plug Mounting

Coupling socket 507550 (Binder, Serial 423), EMC with cable clamp

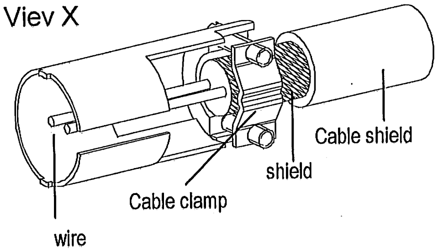


1. Stringing parts on cable acc. to plan given above.
2. Stripping cable sheath 20 mm
   Cutting uncovered shield 15 mm
   Stripping wire 5mm.

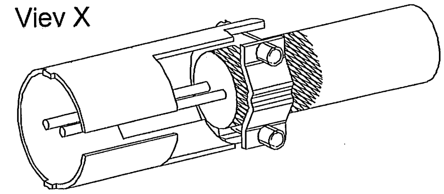
   Cable mounting 1
   Putting shrink hose or insolating tape between wire and shield.

   Cable mounting 2
   If cable diameter permits, put the shield backward on the cable sheath.
3. Soldering wire to the insert, positioning shield in cable clamp.
4. Screwing-on cable clamp.
5. Assembling remaining parts acc. to upper plan.
6. Tightening pull-relief of cable by screw-wrench (SW16 und 17).

Cable mounting 1
Viev X



Cable mounting 2
Viev X



7 Maintenance

If properly installed, the instrument requires no maintenance. Heavy pollution can lead to blockage of the slot between the rotating and the stable parts of the transmitter. Thus it is advisable to remove the accumulated dirt from the instrument .

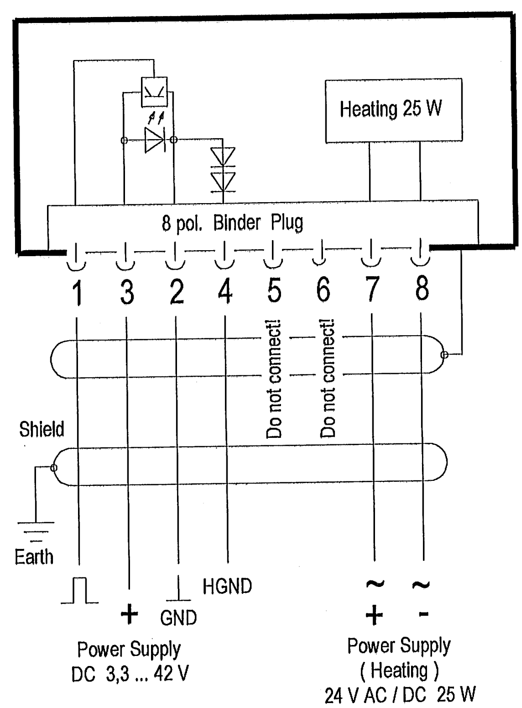
Certain symptoms of wear and tear can appear on the ball bearings after years of use. These symptoms are expressed in a lowered sensitivity of response, standstill or run-noises of the ball bearings. In case that such disturbances might occur we recommend to return the instrument - in original package – to the factory for maintenance work.

Remark
For transport of instrument please use original packing.

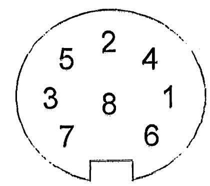
8 Connecting Diagram

Order – No.

4.3351.00.000
4.3351.10.000*



View on the soldered joint of the counter plug



*Order-No. 4.3351.**10**.. (without heating) Pin 7 u. 8 are not connected

⚠ Pin 5 u. 6: Do not connect!

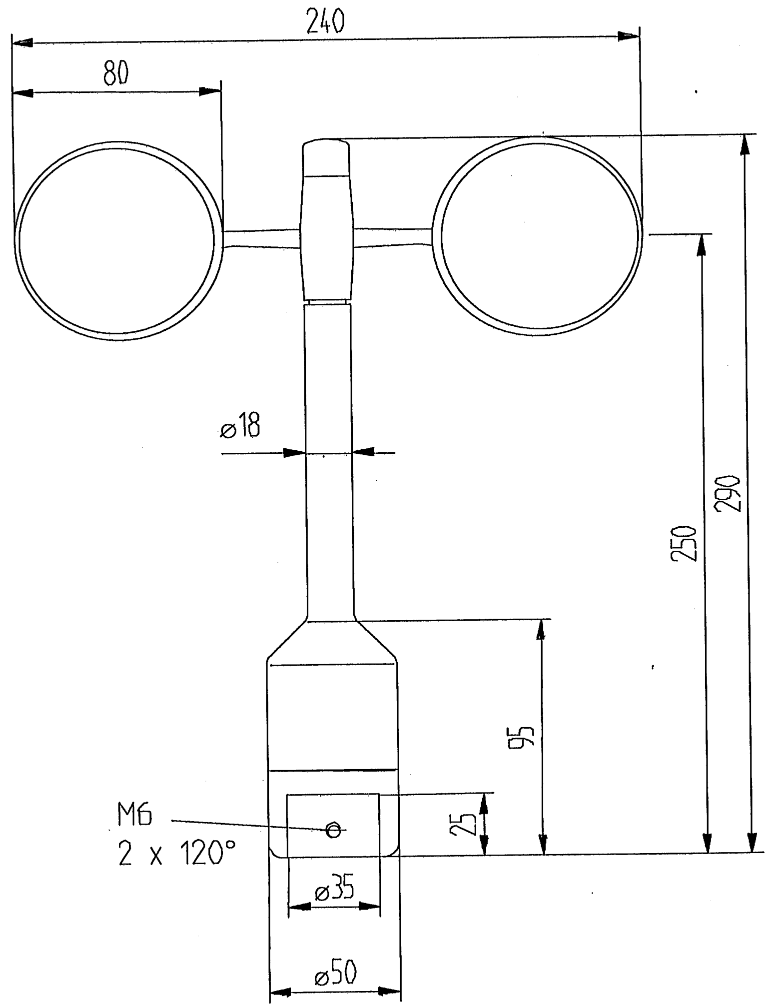
Pin	Name	Function
1	SIG	Signal (rectangle)
2	GND	Ground
3	+Us	Supply 3.3 V - 42 V DC
4	HGND	Ground at life-zero signal
5	⚠	Do not connect!
6	⚠	Do not connect!
7	HZG	Heating supply: voltage: 24 V AC/DC power: 25 W
8	HZG	
*Order-No. 4.3351.**10**.. (without heating) PIN 7 u. 8 are not connected		

9 Technical Data

Characteristic	Description
Measuring range	0.3...75 m/s
Accuracy	0.3...50 m/s 1% of meas. value or < 0.2 m/s
Survival speed	80 m/s (min. 30 minutes)
Permissible Ambient conditions	- 50...+ 80°C, all occurring situations of relative humidity (incl. dew moistening)
Output signal	**Form** rectangle **Frequency** 1082 Hz @ 50 m/s **Amplitude** is supply voltage, max. 15 V **Load** R > 1 kΩ (Push-pull output with 220 Ω in series) C < 200 nF (corresp. to length typical cable < 1km)
Linearity	Correlation factor r between frequency and wind speed y=0,0462* f +0,21 typical r > 0.999 99 (4…20 m/s)
Starting velocity	< 0.3 m/s
Resolution	0.05 m wind run
Distance constant	< 3 m (acc. to ASTM D 5096 – 96) 3 m acc. to ISO 17713-1
Turbulent flow	Deviation Δv turbulent compared with stationary horizontal flow -0.5% < Δv < +2% Frequency < 2 Hz
Classification	According to IEC 61400-12-1 (2005-12) Class A classification index A 0,9 Class B classification index B 3,0 Class S classification index S 0,5
Wind load	Approx.. 100 N @ 75 m/s
Heating	Surface temperature of housing neck > 0 °C at 20 m/s up to –10 °C air temperature, at 10 m/s up to –20 °C using the THIES icing standard 012002 on the housing neck. Heating regulated by temperature sensor
Electrical supply for opto-electronic scanning	Voltage: 3.3 - 42 V DC (galvanic isolation from housing) current: 0.3 ma @ 3.3 V typical (w/o external load) < 0.5 ma @ 5 V (w/o external load)
Electrical supply for heating	Voltage: 24 V AC/DC (galvanic isolation from housing) Idling voltage: max. 30 V AC, max. 42 V DC Capacity: 25 W
Connection	8-pole plug-connection for shielded cable in the shaft (see connecting diagram)
Mounting	Mounting on mast R 1", for ex. DIN 2441

	1½ " with separate adaptor (option)
Dimensions	See dimension diagram
Weight	approx. 0.5 kg
Protection	IP 55 (DIN 40050)
EMC	EN 61000-6-2:2001 (immunity) EN 55022:2001, class B (interfering transmission)

10 Dimensional Drawing



11 Accessories

The following accessories are available for the wind direction transmitter:

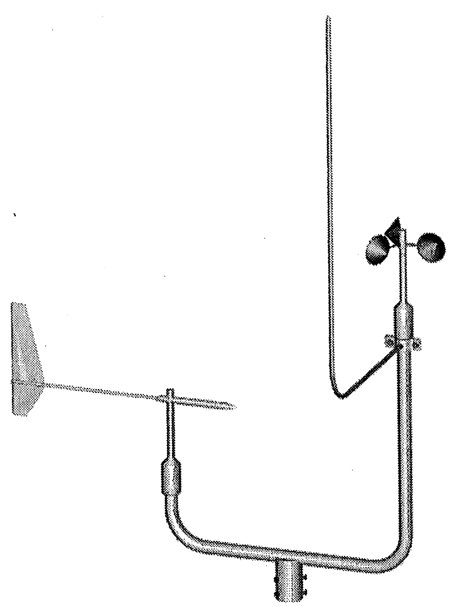
Traverse 0,6 m For mounting the wind speed and wind direction transmitter jointly onto a mast	4.3174.00.000	Horizontal sensor distance: 0.6 m Vertical sensor distance: 0.2 m Mast receptacle: 48 - 50 mm Material: Aluminum, anodised Dimensions: tube Ø 34x4mm, 668 mm long, 756 mm high

Hanger –FIRST CLASS- 1m For the lateral mounting of a wind speed and wind direction transmitter onto a mast tube..	4.3184.01.000	Sensor distance to mast: 1 m Mast clamp: 40 – 80 mm Tube diameter: 34 mm Material: Aluminum

Lightning rod For mounting the a/m traverse or hanger.	4.3100.98.000	Dimension: Ø 12 mm, 500 mm long, 1050 mm high Material: Aluminum

Please contact us for other accessories such as cables, power supply units, masts, as well as for additional mast- or system-constructions.

Example: Wind transmitter with traverse 4.3174.00.000 and lightning rod 4.3100.98.000.



Svend Ole Hansen ApS

SCT. JØRGENS ALLÉ 7 · DK-1615 KØBENHAVN V · DENMARK

TEL: (+45) 33 25 38 38 · FAX: (+45) 33 25 38 39 · WWW.SOHANSEN.DK

WIND ENGINEERING FLUID DYNAMICS

CERTIFICATE FOR CALIBRATION OF CUP ANEMOMETER

Certificate number: 11.02.6540

Date of issue: September 21, 2011

Type: Thies 4.3351.00.000

Serial number: 09114705

Manufacturer: ADOLF THIES GmbH & Co.KG, Hauptstrasse 76, 37083 Göttingen, Germany

Client: Sky Power Int'l LLC, 250 Sawdust Road, 29657-8521 Liberty SC, USA

Anemometer received: September 12, 2011

Anemometer calibrated: September 17, 2011

Calibrated by: mh

Calibration procedure: IEC 61400-12-1, MEASNET

Certificate prepared by: mlp

Approved by: Calibration engineer, kbk

Calibration equation obtained: v [m/s] = 0.04621 · f [Hz] + 0.21735

Standard uncertainty, slope: 0.00121

Standard uncertainty, offset: 0.05778

Covariance: -0.0000007 (m/s)²/Hz

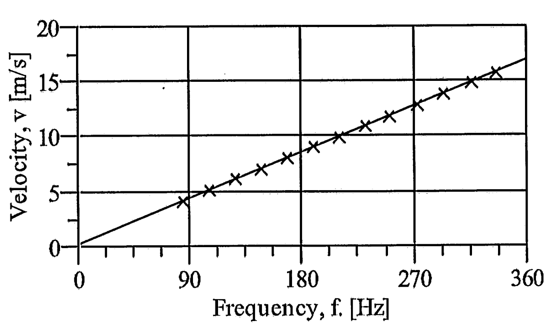
Coefficient of correlation: $\rho = 0.999992$

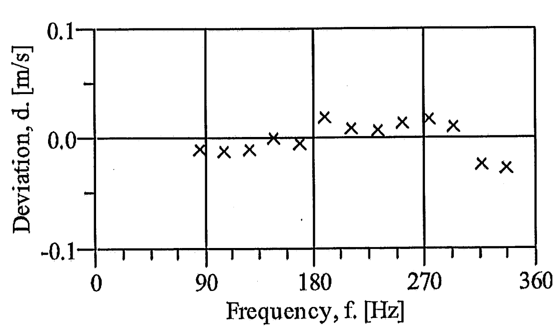
Absolute maximum deviation: -0.026 m/s at 15.752 m/s

Barometric pressure: 1012.1 hPa

Relative humidity: 29.2%

Succession	Velocity pressure, q. [Pa]	Temperature in wind tunnel [°C]	Temperature in control room [°C]	Wind velocity, v. [m/s]	Frequency, f. [Hz]	Deviation, d. [m/s]	Uncertainty u_c (k=2) [m/s]
2	10.00	31.1	23.5	4.165	85.6037	-0.009	0.028
4	15.11	31.0	23.5	5.118	106.2892	-0.011	0.032
6	21.40	31.0	23.5	6.091	127.2953	-0.009	0.037
8	28.85	30.9	23.5	7.072	148.2945	0.001	0.042
10	37.29	30.8	23.5	8.038	169.3289	-0.004	0.047
12	46.76	30.7	23.5	9.001	189.6356	0.019	0.053
13-last	57.39	30.7	23.5	9.971	210.8281	0.010	0.058
11	68.98	30.8	23.5	10.932	231.6840	0.008	0.064
9	81.23	30.8	23.5	11.865	251.6938	0.015	0.069
7	95.61	30.9	23.5	12.873	273.4538	0.018	0.075
5	110.31	31.0	23.5	13.829	294.2672	0.012	0.081
3	126.78	31.1	23.5	14.827	316.6145	-0.022	0.086
1-first	143.01	31.2	23.6	15.752	336.7016	-0.026	0.092





DANAK

CAL Reg.nr. 452

Accreditation to ISO 17025

12.8 CSAT Sonic Anemometers

The full manual for the CSAT Sonic Anemometers is too lengthy to be included in this document. However, it can be viewed here: `http://s.campbellsci.com/documents/us/manuals/csat3.pdf`

An abbreviated spec sheet is included below.

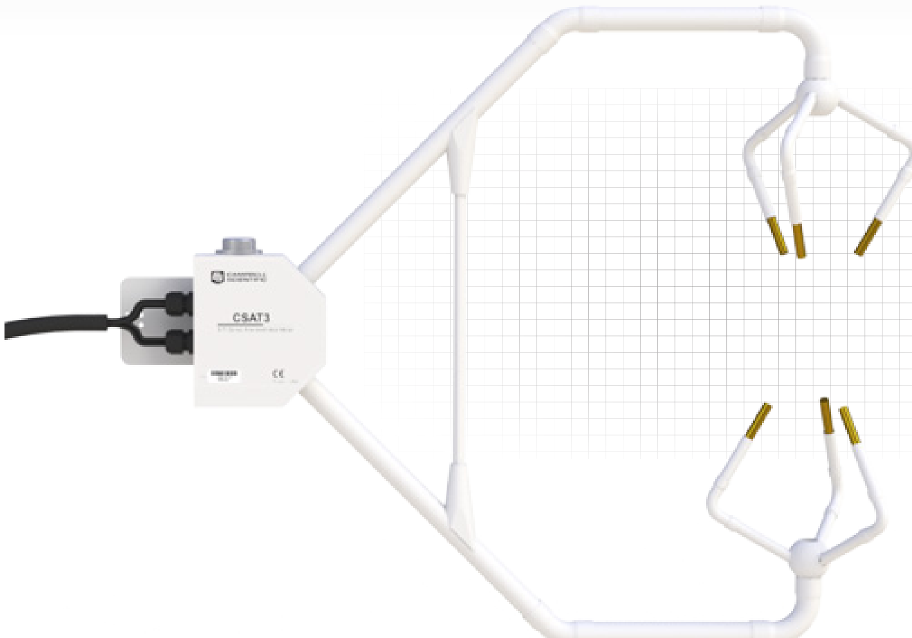
COMPONENT

CAMPBELL SCIENTIFIC

WHEN MEASUREMENTS MATTER

CSAT3

3D Sonic Anemometer



Precision Measurements

Best instrument for flux and other turbulence research projects

Overview

Campbell Scientific's CSAT3 3D Sonic Anemometer is the 3D sonic anemometer of choice for eddy-covariance measurements. It has an aerodynamic design, a 10 cm vertical measurement path, operates in a pulsed acoustic mode, and withstands exposure to harsh weather conditions. Three orthogonal wind components (u_x, u_y, u_z) and the speed of sound (c) are measured and output at a maximum rate of 60 Hz. Analog outputs and two types of digital outputs are provided.

Measurements can be triggered from three sources:

- Datalogger's SDM command
- CSAT3's internal clock
- PC-generated RS-232 command

The SDM protocol supports a group trigger for synchronizing multiple CSAT3s.

Benefits and Features

- Innovative design provides precision turbulence measurements with minimal flow distortion
- Can be combined with EC150 or EC155 gas analyzers giving near complete colocation for eddy-covariance measurements
- Compatible with most Campbell Scientific dataloggers
- Measurements can be used to calculate momentum flux and friction velocity
- Campbell Scientific's fine wire thermocouples are an option for fast-response temperature measurements
- Field rugged
- Rain: Innovative signal processing and transducer wicks considerably improves performance of the anemometer duringrain events
- Sealed sonic transducers and electronics

Specifications

Measurements

- Outputs: u_x, u_y, u_z, c (u_x, u_y, u_z are wind components referenced to the anemometer axes; c is speed of sound)
- Speed of Sound: Determined from three acoustic paths; corrected for crosswind effects
- Measurement Rate: programmable from 1 to 60 Hz, instantaneous measurements; two over-sampled modes are block averaged to either 20 Hz or 10 Hz

Measurement Precision RMS[a]

- u_x, u_y: 1 mm s^{-1} rms
- u_z: 0.5 mm s^{-1} rms
- c: 15 mm s^{-1} (0.025°C) rms

Accuracy[b]

- Offset error: <±8.0 cm s^{-1} (u_x, u_y), <±4.0 cm s^{-1} (u_z)
- Gain Error
  Wind Vector within ±5° of horizontal: <±2% of reading
  Wind Vector within ±10° of horizontal: <±3% of reading
  Wind Vector within ±20° of horizontal: <±6% of reading

Output Signals

- Digital SDM: CSI 33.3 k baud serial interface for datalogger/sensor communication. Data type is 2 B integer per output plus 2 B diagnostic

Digital RS-232

- Baud rate: 9600, 19200 bps
- Data type: 2-byte integer per output plus 2-byte diagnostic

Analog

- Number of outputs: 4
- Voltage range: ±5 V
- Number of bits: 12

Reporting Range

- Analog Outputs:

Output	Reporting Range	LSB
u_x, u_y	±30 m s^{-1}, ±60 m s^{-1}	15 mm s^{-1}, 30 mm s^{-1}
u_z	±8 m s^{-1}	4 mm s^{-1}
c	300 to 366 m s^{-1} (-50° to +60°C)	16 mm s^{-1} (0.026°C)

SDM and RS-232 Digital Outputs

- Full scale wind: ±65.535 m s^{-1} autoranging between four ranges; least significant bit is 0.25 to 2 mm s^{-1}
- Speed of Sound: 300 to 366 m s^{-1} (-50° to +60°C); least significant bit is 1 mm s^{-1} (0.002°C)

Physical Description

- Measurement Path Length: 10.0 cm vertical; 5.8 cm horizontal
- Path Angle from Horizontal: 60 degrees
- Transducer: 0.64 cm diameter
- Transducer Mounting Arms: 0.84 cm diameter
- Support Arms: 1.59 cm diameter

Dimensions

- Anemometer head: 47.3 cm (l) x 42.4 cm (h)
- Electronics box: 26 x 16 x 9 cm

Weight

- Anemometer head: 1.7 kg (3.7 lb)
- Electronics box: 3.8 kg (8.4 lb)

Materials

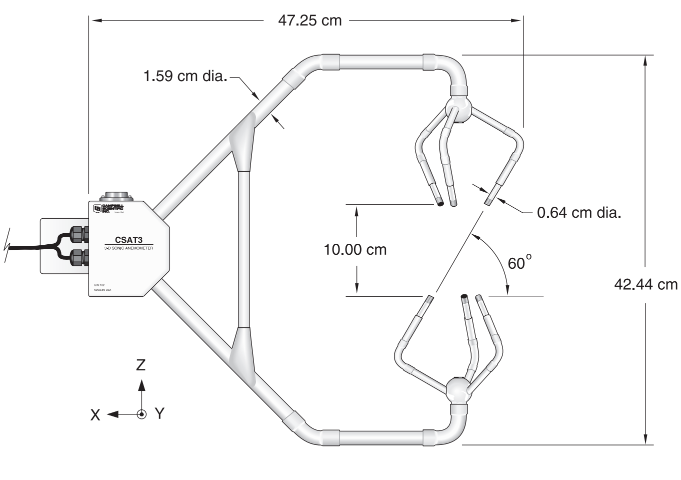
- Anemometer head: stainless steel tubing
- Electronics box: cast aluminum

Environmental

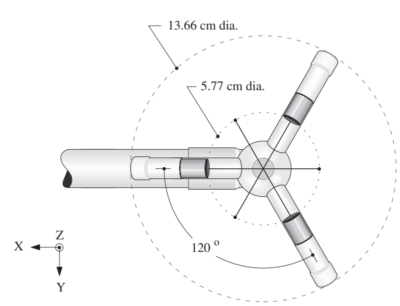
- Operating Temperature: -30° to +50°C

Power Requirements

- Voltage Supply: 10 to 16 Vdc
- Current: 200 mA @ 60 Hz measurement rate; 100 mA @ 20 Hz measurement rate



Anemometer Head



Lower Transducer Assembly Top View

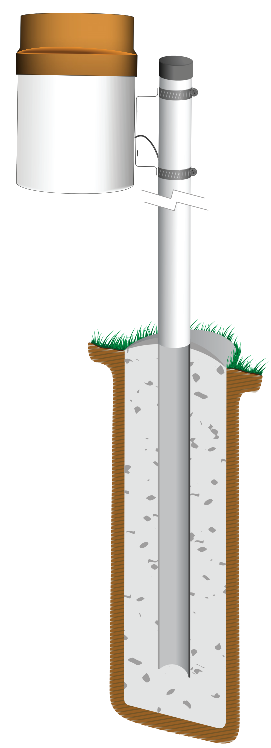
[a]*Resolution values are for instantaneous measurements made on a constant signal; noise is not affected by sample rate.*
[b]*Accuracy specifications assume -30° to +50°C operating range; wind speeds < 30 m s^{-1}; wind angles between ±170°.*

12.9 Rain Gauge Manual

INSTRUCTION MANUAL

TE525 Tipping Bucket Rain Gage

Revision: 10/13



Warranty

The TE525, TE525WS, and TE525MM are warranted for thirty-six (36) months subject to this limited warranty:

“PRODUCTS MANUFACTURED BY CAMPBELL SCIENTIFIC, INC. are warranted by Campbell Scientific, Inc. (“Campbell”) to be free from defects in materials and workmanship under normal use and service for twelve (12) months from date of shipment unless otherwise specified in the corresponding Campbell pricelist or product manual. Products not manufactured, but that are re-sold by Campbell, are warranted only to the limits extended by the original manufacturer. Batteries, fine-wire thermocouples, desiccant, and other consumables have no warranty. Campbell’s obligation under this warranty is limited to repairing or replacing (at Campbell’s option) defective products, which shall be the sole and exclusive remedy under this warranty. The customer shall assume all costs of removing, reinstalling, and shipping defective products to Campbell. Campbell will return such products by surface carrier prepaid within the continental United States of America. To all other locations, Campbell will return such products best way CIP (Port of Entry) INCOTERM® 2010, prepaid. This warranty shall not apply to any products which have been subjected to modification, misuse, neglect, improper service, accidents of nature, or shipping damage. This warranty is in lieu of all other warranties, expressed or implied. The warranty for installation services performed by Campbell such as programming to customer specifications, electrical connections to products manufactured by Campbell, and product specific training, is part of Campbell’s product warranty. CAMPBELL EXPRESSLY DISCLAIMS AND EXCLUDES ANY IMPLIED WARRANTIES OF MERCHANTABILITY OR FITNESS FOR A PARTICULAR PURPOSE. Campbell is not liable for any special, indirect, incidental, and/or consequential damages.”

Assistance

Products may not be returned without prior authorization. The following contact information is for US and international customers residing in countries served by Campbell Scientific, Inc. directly. Affiliate companies handle repairs for customers within their territories. Please visit *www.campbellsci.com* to determine which Campbell Scientific company serves your country.

To obtain a Returned Materials Authorization (RMA), contact CAMPBELL SCIENTIFIC, INC., phone (435) 227-9000. After an application engineer determines the nature of the problem, an RMA number will be issued. Please write this number clearly on the outside of the shipping container. Campbell Scientific's shipping address is:

CAMPBELL SCIENTIFIC, INC.
RMA#_____
815 West 1800 North
Logan, Utah 84321-1784

For all returns, the customer must fill out a "Statement of Product Cleanliness and Decontamination" form and comply with the requirements specified in it. The form is available from our web site at *www.campbellsci.com/repair*. A completed form must be either emailed to *repair@campbellsci.com* or faxed to (435) 227-9106. Campbell Scientific is unable to process any returns until we receive this form. If the form is not received within three days of product receipt or is incomplete, the product will be returned to the customer at the customer's expense. Campbell Scientific reserves the right to refuse service on products that were exposed to contaminants that may cause health or safety concerns for our employees.

Table of Contents

PDF viewers: These page numbers refer to the printed version of this document. Use the PDF reader bookmarks tab for links to specific sections.

Figures

Tables

TE525 Tipping Bucket Rain Gage

1. Introduction

The TE525 is an adaptation of the standard National Weather Service tipping bucket rain gage. Output is a switch closure for each bucket tip. Three models are available:

- TE525 6 in. orifice 0.01 in. tip
- TE525WS 8 in. orifice 0.01 in. tip
- TE525MM 24.5 cm orifice 0.1 mm tip

Before installing the TE525, please study:

- Section 2, *Cautionary Statements*
- Section 3, *Initial Inspection*
- Section 4, *Quickstart*

2. Cautionary Statements

- The TE525-series tipping bucket rain gages are precision instruments. Please handle them with care.

- Care should be taken when opening the package not to damage or cut the cable jacket.

- Sensor is factory calibrated and should not require field calibration. Refer to Section 9, *Maintenance*, for field calibration check and factory calibration.

- Debris filters, funnel, and bucket reservoirs should be kept clean.

- The black outer jacket of the cable is Santoprene® rubber. This compound was chosen for its resistance to temperature extremes, moisture, and UV degradation. However, this jacket will support combustion in air. It is rated as slow burning when tested according to U.L. 94 H.B. and will pass FMVSS302. Local fire codes may preclude its use inside buildings.

3. Initial Inspection

- Upon receipt of the tipping bucket, inspect the packaging and contents for damage. File damage claims with the shipping company.

- Immediately check package contents against the shipping documentation (see Section 3.1, *Ships With*). Contact Campbell Scientific about any discrepancies.

- The model number and cable length are printed on a label at the connection end of the cable. Check this information against the shipping documents to ensure the expected product and cable length are received.

3.1 Ships With

The TE525 ships with:

(1) Calibration sheet
(2) Hose clamps from original manufacturer
(1) ResourceDVD
(3) Screws from original manufacturer

4. Quickstart

Please review Section 7, *Operation*, for wiring, CRBasic programming, and Edlog programming.

4.1 Siting

The rain gage should be mounted in a relatively level spot which is representative of the surrounding area. The lip of the funnel should be horizontal and at least 30 cm above the ground. It should be high enough to be above the average snow depth. The ground surface around the rain gage should be natural vegetation or gravel. It should not be paved.

The rain gage should be placed away from objects that obstruct the wind. The distance should be 2 to 4 times the height of the obstruction.

- The pipe used to mount the bucket must be vertical. Use a torpedo level or something similar to get it as vertical as possible.

- Take the funnel off of the top of the bucket and look inside towards the bottom of the bucket — notice the bubble level. Center the bubble level while mounting the bucket to the pipe. Replace the funnel and seat it completely when the installation is complete.

4.2 Mounting

The CM300-series mounting poles provide a stainless steel 1.5 IPS vertical pole for mounting the TE525 rain gage. Pole length is 58 cm (23 in), 119 cm (47 in), and 142 cm (53 in) for the CM300, CM305, and CM310 models respectively. The CM300-series offers pedestal base options as well, as shown in FIGURE 4-2.

Use the enclosed hose clamps to mount the gage as shown in FIGURE 4-1. The lip of the gage should be at least 5 cm (2 in) above the post or pole. Level the rain gage after mounting it.

NOTE Before final leveling, press either end of the bucket down against its stop to make sure the bucket is NOT hung up in the center.

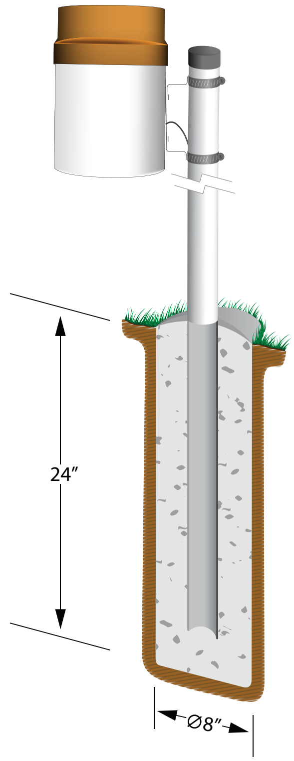


FIGURE 4-1. TE525 Tipping Bucket Rain Gage

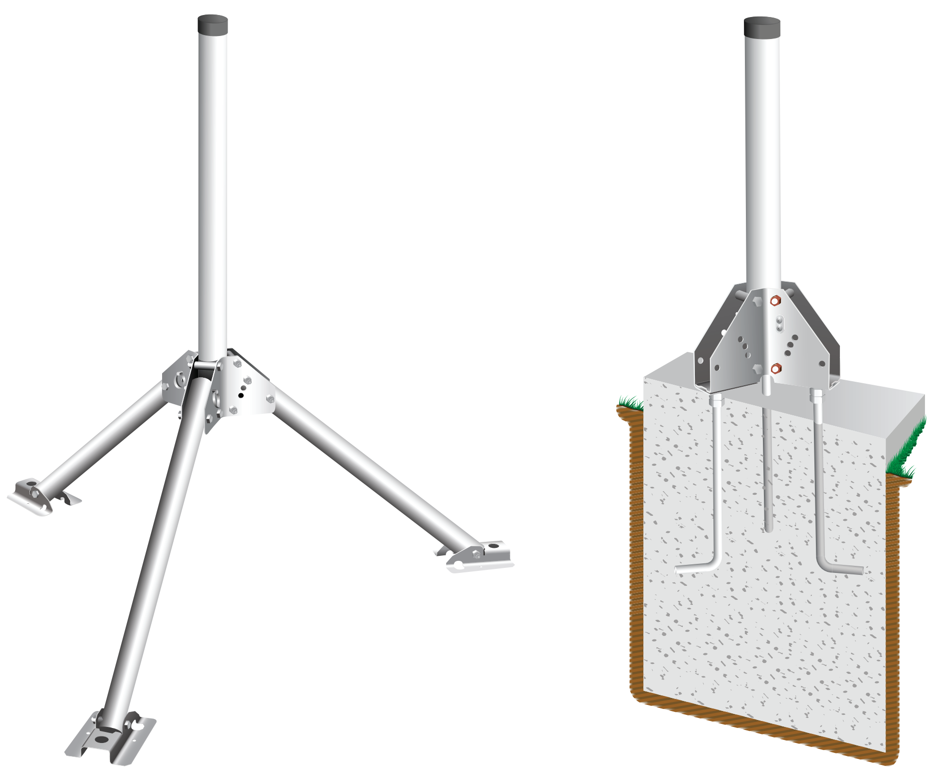


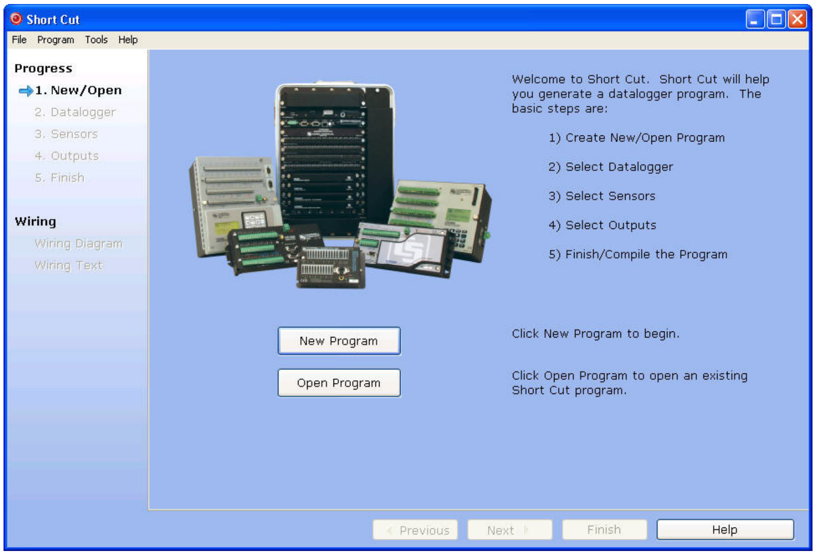
FIGURE 4-2. Pedestal base options

4.3 Use SCWin to Program Datalogger and Generate Wiring Diagram

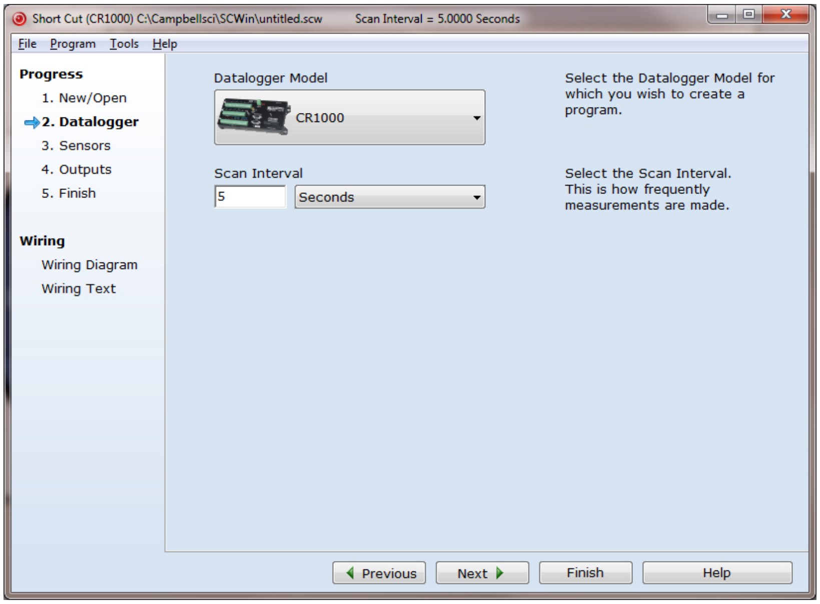
The simplest method for programming the datalogger to measure the tipping bucket rain gages is to use Campbell Scientific's SCWin Program Generator (Short Cut).

NOTE This section shows Short Cut's programming for the TE525/TE525WS. The TE52MM is done similarly.

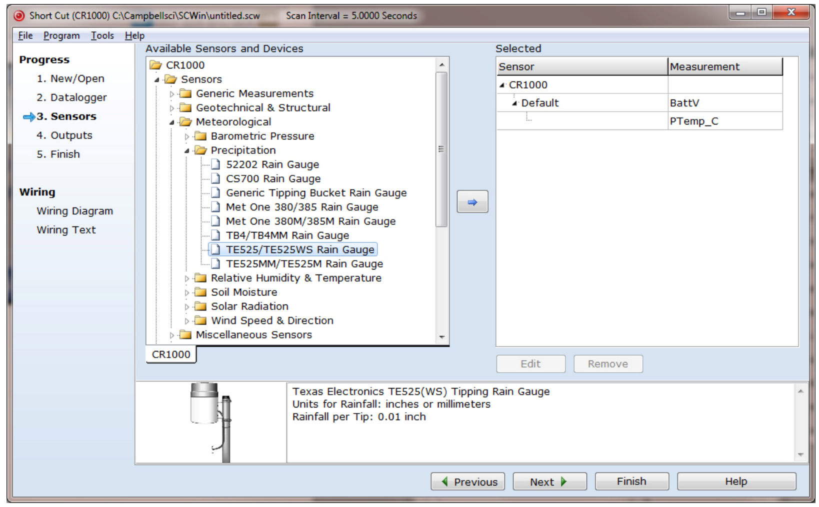
1. Open *Short Cut* and click on **New Program**.



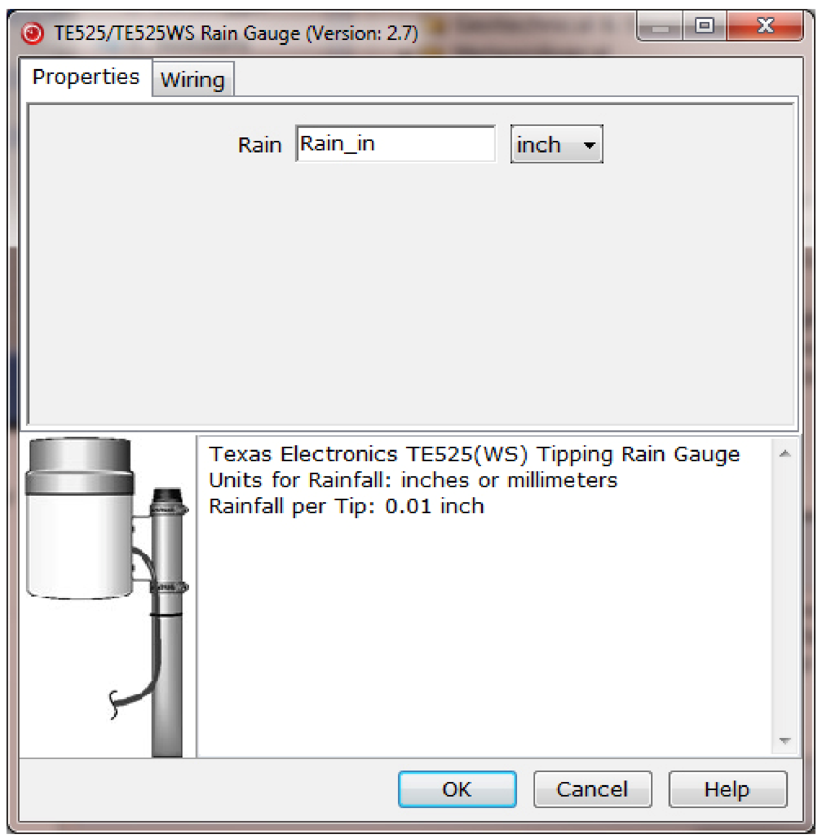
2. Select the **Datalogger** and enter the **Scan Interval**.



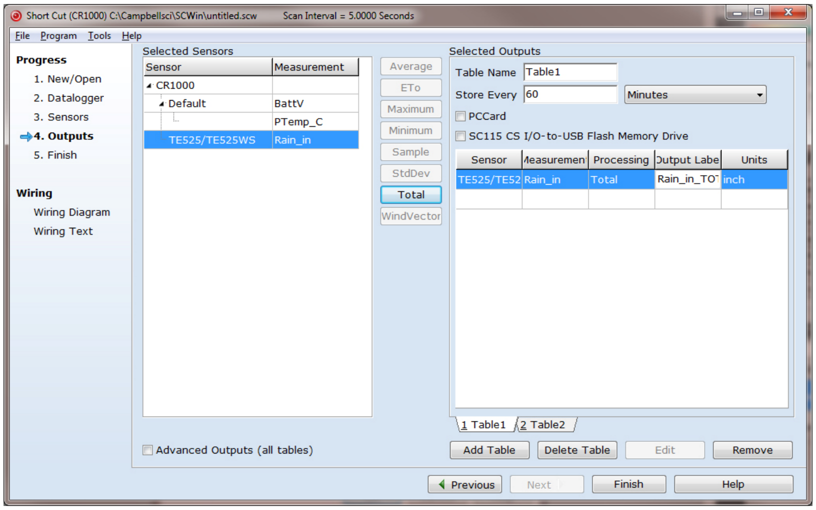
3. Select **TE525/TE525WS Rain Gauge,** and select the **right arrow** (in center of screen) to add it to the list of sensors to be measured, and then select **Next**.



4. Define the name of the **public variable** and the **measurement units**. After entering the information, click on **OK**, and then select **Next**.



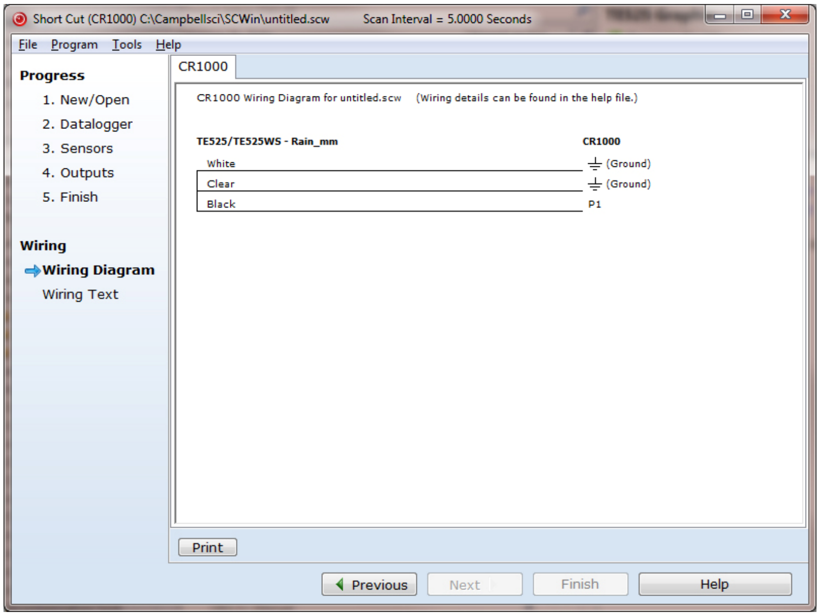
5. Choose the **Output** and then select **Finish**.



6. In the Save As window, enter an appropriate file name and select **Save**.

7. In the Confirm window, click **Yes** to download the program to the datalogger.

8. Click on **Wiring Diagram** and wire according to the wiring diagram generated by Short Cut.



5. Overview

The TE525-series tipping bucket rain gages funnel precipitation into a bucket mechanism that tips when filled to a calibrated level. A magnet attached to the tipping mechanism actuates a switch as the bucket tips. The momentary switch closure is counted by the pulse-counting circuitry of Campbell Scientific dataloggers.

The TE525-series tipping bucket rain gages are manufactured by Texas Electronics and then cabled by Campbell Scientific. The –L after the model number indicates the cable length is specified when ordered. The cable can terminate in:

- Pigtails that connect directly to a Campbell Scientific datalogger (option –PT).
- Connector that attaches to a prewired enclosure (option –PW). Refer to *www.campbellsci.com/prewired-enclosures* for more information.
- Connector that attaches to a CWS900 Wireless Sensor Interface (option –CWS). The CWS900 allows the probe to be used in a wireless sensor network. Refer to *www.campbellsci.com/cws900* for more information.
- Connector that attaches to a CS110 Electric Field Meter or ET-series weather station (cable termination option –C).
- Military-style connector that attaches to a RAWS-P Permanent Remote Automated Weather Station (cable termination option –RQ). This option is not available for the TE525MM.

5.1 Wind Screen

Campbell Scientific offers the 260-953 Wind Screen to help minimize the effect of wind on the rain measurements. This wind screen consists of 32 leaves that hang freely and swing as wind moves past them. Refer to the 260-953 manual for siting information and the installation procedure.

5.2 Snowfall Adapter

Campbell Scientific's CS705 Snowfall Conversion Adapter uses antifreeze to melt snow, allowing the TE525WS to measure the water content of snow. The CS705 cannot be directly used with either the TE525 or TE525MM. However, both the TE525 and TE525MM can be converted to a TE525WS by returning them to Campbell Scientific (see *Assistance* page at the beginning of this document). Refer to the CS705 manual for siting information and the installation procedure.

6. Specifications

Features:

- High precision
- Compatible with all Campbell Scientific dataloggers (including the CR200(X) series)
- TE525WS conforms to the National Weather Service recommendation for an 8-inch funnel orifice.
- TE525WS is directly compatible with the CS705 Snowfall Adapter allowing it to measure the measure the water content of snow.
- Campbell Scientific can modify a TE525 or TE525MM to it to be used with the CS705 Snowfall Adapter. Refer to *Assistance* page at the beginning of this document for the procedure for sending the tipping bucket to Campbell Scientific.

Compatible Dataloggers: CR200(X)-series
CR800 series
CR1000
CR3000
CR5000
CR9000X
CR510
CR500
CR10(X)
CR23X
CR7
21X

	TE525	TE525WS	TE525MM
Sensor Type	tipping bucket/potted magnetic momentary contact reed switch		
Switch Ratings	30 Vdc at 2 A; 115 Vac at 1 A; closure time: 135 ms; bounce settling time: 0.75 ms		
Bucket Material	white powder coated spun aluminum		
Funnel Collector Material	gold anodized spun aluminum		
Screen Material	gold anodized spun aluminum		
Locking Snap Ring Material	stainless steel		
Operating Temperature	0° to +50°C (32° to 125°F)		
Resolution	1 tip		
Volume per Tip	4.73 ml/tip (0.16 fl. oz/tip)	8.24 ml/tip (0.28 fl. oz/tip)	4.73 ml/tip (0.16 fl. oz/tip)
Rainfall per Tip	0.01 in (0.254 mm)		0.1 mm (0.004 in)
Accuracy	1.0% up to 2 in/hour (50 mm/hr)		
Knife Edge Funnel Collector Diameter	15.4 cm (6.1 in)	20.3 cm (8 in)	24.5 cm (9.7 in)

	TE525	TE525WS	TE525MM
Height	24.1 cm (9.5 in)	26.7 cm (10.5 in)	29.2 cm (11.5 in)
Tipping Bucket Weight	0.9 kg (2 lb)	1 kg (2.2 lb)	1.1 kg (2.4 lb)
Cable	2-conductor shielded cable		
Cable Weight	0.1 kg (0.2 lb) per 10 ft length		

7. Operation

7.1 Wiring

When Short Cut is used to generate the datalogger program, the sensor should be wired to the channels shown on the wiring diagram created by Short Cut.

The rain gage is typically wired to a datalogger's pulse channel (see TABLE 7-1).

TABLE 7-1. Wiring for Pulse Channel Input

Color	Description	CR800 CR850 CR1000 CR3000 CR5000 CR9000(X)	CR510 CR500 CR10(X)	21X CR7 CR23X	CR200(X) Series
Black	Signal	Pulse Channel	Pulse Channel	Pulse Channel	P_SW
White	Signal Return	⏚	G	⏚	⏚
Clear	Shield	⏚	G	⏚	⏚

Dataloggers listed in TABLE 7-2 have the capability of counting switch closures on some of their control ports. When a control port is used, the return from the rain gage switch must be connected to +5 V on the datalogger.

TABLE 7-2. Wiring for Control Port Input

Color	Description	CR800 CR850 CR1000 CR3000	CR500 CR510	CR10X	CR23X
Black	Signal	Control Port	C2/P3	Control Port	Control Port
White	Signal Return	5 V	5 V	5 V	5 V
Clear	Shield	⏚	⏚	G	⏚

The CR10 does not support the use of control port inputs with the **Pulse Count** instruction.

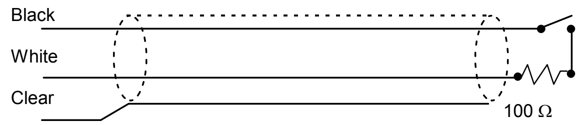


FIGURE 7-1. Rain Gage Schematic

In a long cable, there is appreciable capacitance between the lines. A built up charge could cause arcing when the switch closes, shortening switch life. A 100 Ω resistor is connected in series at the switch to prevent arcing by limiting the current (FIGURE 7-1). This resistor is installed on all rain gages currently sold by Campbell Scientific.

7.2 Datalogger Programming

This section is for users who write their own programs. A datalogger program to measure this sensor can be generated using Short Cut. You do not need to read this section to use Short Cut.

In CRBasic, the rain gage is measured using the **PulseCount()** instruction. Choose switch closure (code 2) for the *PConfig* parameter. Dataloggers that use CRBasic are the CR200(X), CR800, CR850, CR1000, CR3000, CR5000, and CR9000(X).

In Edlog, the **Pulse (P3)** is used to measure the rain gage. Choose switch closure (code 2) for parameter three. Dataloggers that use Edlog are the CR500, CR510, CR10(X), CR23X, CR7, and 21X.

The multiplier used in the **PulseCount()** or **Pulse (P3)** instruction determines the units in which rainfall is reported (see TABLE 7-3).

TABLE 7-3. Multipliers for Rain Measurement

Rain Gage	inches	millimeters
TE525	0.01	0.254
TE525WS	0.01	0.254
TE525MM	0.00394	0.1
TE525 or TE525MM w/8 in funnel	0.0057	0.1459

The volume of water required to cause a tip in the TE525 and the TE525MM is the same. The difference in calibration is strictly due to funnel size. If the CS705 Snowfall Adapter or other eight inch funnel is installed on these gages, use a multiplier from the last row in TABLE 7-3. (The CS705 will not install directly on the TE525MM; the MM funnel must first be replaced with an eight inch funnel.)

7.2.1 Pulse Count Example Programs

The following example programs use a pulse channel to read the output from the rain gage. The CR1000 example will also work with the CR800, CR850, CR3000, and CR5000. CR9000(X) programming is similar to the CR1000 except it has an additional parameter in the **PulseCount()** instruction to specify the pulse module's slot.

7.2.1.1 CR1000 Example Program

```
'CR1000
'TE525/TE525WS & TE525MM sample program
Public Rain_mm
Units Rain_mm=mm
DataTable(Rain,True,-1)
  DataInterval(0,60,Min,0)
  Totalize(1,Rain_mm,FP2,0)
EndTable

BeginProg
  Scan(1,Sec,1,0)
    'For TE525MM Rain Gage, use multiplier of 0.1 in PulseCount instruction
    PulseCount(Rain_mm,1,1,2,0,0.254,0)
    CallTable(Rain)
  NextScan
EndProg
```

7.2.1.2 CR200(X) Series Example Program

```
'CR200(X) Series

'Declare Variables and Units
Public Rain_mm

Units Rain_mm=mm

'Define Data Tables
DataTable(Rain,True,-1)
  DataInterval(0,60,Min)
  Totalize(1,Rain_mm,0)
EndTable

'Main Program
BeginProg
  Scan(1,Sec)
    'TE525/TE525WS Rain Gage measurement Rain_mm:
    PulseCount(Rain_mm,P_SW,2,0,0.254,0)
    'Call Data Tables and Store Data
    CallTable(Rain)
  NextScan
EndProg

'For TE525MM Rain Gage, use multiplier of 0.1 in PulseCount instruction
```

7.2.2 Control Port Example

This example measures a TE525 rain gage in millimeters. A different multiplier would be entered (TABLE 7-3) for other units.

7.2.2.1 CR1000 Example Program

```
'CR1000
'Declare Public Variables and Units
Public Rain_mm
Units Rain_mm=mm

DataTable (Rain,True,-1)
  DataInterval (0,60,Min,0)
  Totalize (1,Rain_mm,FP2,0)
EndTable

'Main Program
BeginProg
  Scan (1,Sec,1,0)
    'For TE525MM Rain Gage use multiplier of 0.1 in PulseCount Instruction.
    PulseCount (Rain_mm,1,18,2,0,.254,0)
    CallTable (Rain)
  NextScan
EndProg
```

8. Troubleshooting

Symptom: No Precipitation

1. Check that the sensor is wired to the Pulse Channel specified by the pulse count instruction.

2. Verify that the Configuration Code (Switch Closure), and Multiplier and Offset parameters for the Pulse Count instruction are correct for the datalogger type.

3. Disconnect the sensor from the datalogger and use an ohm meter to do a continuity check of the switch. The resistance measured at the terminal block on the inside of the bucket between the black and white leads should vary from infinite (switch open) when the bucket is tipped, to less than an ohm when the bucket is balanced.

9. Maintenance

The funnel and bucket mechanism must be kept clean. Routinely check for and remove any foreign material, dust, insects, etc. The following calibration check is advised every 12 months.

Field Calibration Check:

(1) Secure a metal can that will hold at least one quart of water.

(2) Punch a very small hole in the bottom of the can.

(3) Place the can in the top funnel of the rain gage and pour 16 fluid ounces (1 pint) of water into the can. (A 16 oz. soft drink bottle filled to within 2.5 inches of the top may be used for a rough field calibration. An exact volume will allow for a more precise calibration).

(4) If it takes less than 45 minutes for this water to run out, the hole in the can is too large.

(5) The following number of tips should occur:

TE525, TE525MM	100 ± 3
TE525WS	57 ± 2

(6) Adjusting screws are located on the bottom adjacent to the large center drain hole. Adjust both screws the same number of turns. Rotation clockwise increases the number of tips per 16 oz. of water; counter clockwise rotation decreases the number of tips per 16 oz. of water. One half turn of both screws causes a 2% to 3% change.

(7) Check and re-level the rain gage lid.

Factory Calibration:

If factory calibration is required, contact Campbell Scientific to obtain an RMA (see *Warranty* and *Assistance* at front of manual).

Appendix A. Edlog Program Examples

A.1 CR10X Pulse Count Example Program

The CR10X program will also work with the CR500, CR510, CR10, 21X or CR23X. CR7 programming is similar to the CR10X but has an additional parameter in the **Pulse (P3)** instruction to specify the slot that the pulse card is in.

```
;{CR10X}
*Table 1 Program
  01:  1.0000               Execution Interval (seconds)

1:  Pulse (P3)
  1:    1                   Reps
  2:    1                   Pulse Channel 1
  3:    2                   Switch Closure, All Counts
  4:    3                   Loc [ Rain_mm   ]
  5:    0.254               Multiplier
  6:    0                   Offset

2:  If time is (P92)
  1:    0                   Minutes (Seconds --) into a
  2:    60                  Interval (same units as above)
  3:    10                  Set Output Flag High (Flag 0)

3:  Set Active Storage Area (P80)
  1:    1                   Final Storage Area 1
  2:    101                 Array ID

4:  Real Time (P77)
  1:    1220                Year,Day,Hour/Minute (midnight = 2400)

5:  Totalize (P72)
  1:    1                   Reps
  2:    3                   Loc [ Rain_mm   ]

*Table 2 Program
  01:  0                    Execution Interval (seconds)

*Table 3 Subroutines

End Program
```

A.2 CR10X Control Port Example

This example measures a TE525 rain gage in millimeters. A different multiplier would be entered (TABLE 7-3) for other units.

```
;{CR10X}
;
*Table 1 Program
  01:  1                Execution Interval (seconds)

1:  Pulse (P3)
  1:   1                Reps
  2:   8                Control Port 8 (switch closure only)   ;Black wire connect to C8
  3:   2                Switch Closure, All Counts
  4:   1                Loc [ Rain_mm   ]
  5:   .254             Multiplier
  6:   0                Offset

2:  If time is (P92)
  1:   0                Minutes (Seconds --) into a
  2:   60               Interval (same units as above)
  3:   10               Set Output Flag High (Flag 0)

3:  Set Active Storage Area (P80)
  1:   1                Final Storage Area 1
  2:   101              Array ID

4:  Real Time (P77)
  1:   1220             Year,Day,Hour/Minute (midnight = 2400)

5:  Totalize (P72)
  1:   1                Reps
  2:   1                Loc [ Rain_mm   ]

*Table 2 Program
  02:  0.0000           Execution Interval (seconds)

*Table 3 Subroutines

End Program
```

Output **Instruction 72**, Totalize, is used in the output section of the program to output the total rainfall over the output interval. This section should be executed every scan and not placed in a subroutine or conditional statement.

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12.10 CR3000 Datalogger

The Campbell Scientific Datalogger Manual is too long to be including in this manual. An abbreviated spec sheet is included below and the full users manual can be found here: `http://s.campbellsci.com/documents/us/manuals/cr3000.pdf`

CR3000 Specifications

Electrical specifications are valid over a -25° to +50°C, non-condensing environment, unless otherwise specified. Recalibration recommended every two years. Critical specifications and system configuration should be confirmed with Campbell Scientific before purchase.

PROGRAM EXECUTION RATE
10 ms to one day @ 10 ms increments

ANALOG INPUTS *(SE1-SE28 or DIF1-DIF14)*
14 differential (DF) or 28 single-ended (SE) individually configured. Channel expansion provided by optional analog multiplexers.

RANGES, RESOLUTION: A single A/D conversion has 16-bit basic resolution (Basic Res). A DF measurement with input reversal has 17-bit resolution (twice the resolution of Basic Res).

Range (mV)[1]	*DF Res (μV)*[2]	*Basic Res (μV)*
±5000	83.33	167
±1000	16.67	33.4
±200	3.33	6.67
±50	0.83	1.67
±20	0.33	0.67

[1]Range overhead of ~9% on all ranges guarantees full-scale values will not cause over range.

[2]Resolution of DF measurements with input reversal.

ACCURACY[3]:
±(0.04% of reading + offset), 0° to 40°C
±(0.07% of reading + offset), -25° to 50°C
±(0.09% of reading + offset), -40° to 85°C (-XT only)

[3]Accuracy does not include sensor and measurement noise. Offsets are defined as:

Offset for DF w/input reversal = 1.5·Basic Res + 1.0 μV
Offset for DF w/o input reversal = 3·Basic Res + 2.0 μV
Offset for SE = 3·Basic Res + 5.0 μV

ANALOG MEASUREMENT SPEED:

Integration Type/ Code	*Integration Time*	*Settling Time*	*Total Time*[5] *SE w/ No Rev*	*DF w/ Input Rev*
250	250 μs	200 μs	~0.7 ms	~1.4 ms
60 Hz[4]	16.67 ms	3 ms	~20 ms	~40 ms
50 Hz[4]	20.00 ms	3 ms	~23 ms	~46 ms

[4]AC line noise filter.

[5]Includes 250 μs for conversion to engineering units.

INPUT NOISE VOLTAGE: For DF measurements with input reversal on ±20 mV input range; digital resolution dominates for higher ranges.
250 μs Integration: 0.4 μV RMS
50/60 Hz Integration: 0.19 μV RMS

INPUT LIMITS: ±5 Vdc

DC COMMON MODE REJECTION: >100 dB

NORMAL MODE REJECTION: 70 dB @ 60 Hz when using 60 Hz rejection

SUSTAINED INPUT VOLTAGE W/O DAMAGE: ±16 Vdc max.

INPUT CURRENT: ±1 nA typical, ±6 nA max. @ 50°C; ±120 nA @ 85°C

INPUT RESISTANCE: 20 Gohms typical

ACCURACY OF BUILT-IN REFERENCE JUNCTION THERMISTOR (for thermocouple measurements):
±0.3°C, -25° to 50°C;
±0.8°C, -40° to 85°C (-XT only)

ANALOG OUTPUTS *(Vx1-Vx4, Ix1-Ix3, CAO1, CAO2)*
4 switched voltage and 3 switched current outputs sequentially active during measurement. Two continuous outputs.

Channel	*Range*	*Res.*	*Current Source/Sink*	*Compliance Voltage*
V_x	±5 V	17 mV	±50 mA	N/A
CAO	±5 V	17 mV	±15 mA	N/A
I_x	±2.5 mA	0.08 μA	N/A	±5 V

Vx & CAO ACCURACY:
±(0.04% of setting + 0.5 mV), 0° to 40°C
±(0.07% of setting + 0.5 mV), -25° to 50°C
±(0.09% of setting + 0.5 mV), -40° to 85°C (-XT only)

Ix ACCURACY:
±(0.1% of setting + 0.5 μA), 0° to 40°C
±(0.13% of setting + 0.5 μA), -25° to 50°C
±(0.15% of setting + 0.5 μA), -40° to 85°C (-XT only)

Vx FREQUENCY SWEEP FUNCTION: Switched outputs provide a programmable swept frequency, 0 to 5000 mV square wave for exciting vibrating wire transducers.

PERIOD AVERAGE MEASUREMENTS
Any of the 28 SE analog inputs can be used for period averaging. Accuracy is ±(0.01% of reading+resolution), where resolution is 68 ns divided by the specified number of cycles to be measured.

INPUT AMPLITUDE AND FREQUENCY:

Voltage Gain	*Input Range (±mV)*	*Signal (peak to peak)*[6] *Min. (mV)*	*Max (V)*	*Min Pulse Width (μV)*	*Max*[7] *Freq (kHz)*
1	1000	500	10	2.5	200
5	25	10	2	10	50
20	7.5	5	2	62	8
50	2.5	2	2	100	5

[6]With signal centered at datalogger ground.

[7]The maximum frequency = 1/(Twice Minimum Pulse Width) for 50% of duty cycle signals.

RESISTANCE MEASUREMENTS
MEASUREMENT TYPES: Ratiometric measurements of 4- and 6-wire full bridges, and 2-, 3-, and 4-wire half bridges. Precise, dual polarity excitation for voltage or current excitations eliminates DC errors. Offset values are reduced by a factor of 2 when excitation reversal is used.

VOLTAGE RATIO ACCURACY[8]: Assuming excitation voltage of at least 500 mV, not including bridge resistor errors
±(0.02% of voltage reading + offset)/V_x, 0° to 40°C
±(0.025% of voltage reading + offset)/V_x, -25° to 50°C
±(0.03% of voltage reading + offset)/V_x, -40° to 85°C

[8]Accuracy does not include sensor and measurement noise. Offsets are defined as:

Offset for DF w/input reversal = 1.5·Basic Res + 1.0 μV
Offset for DF w/o input reversal = 3·Basic Res + 2.0 μV
Offset for SE = 3·Basic Res + 5.0 μV

ACCURACY WITH CURRENT EXCITATION[9]:
±(0.02% of voltage reading + offset)/I_x, 0° to 40°C
±(0.025% of voltage reading + offset)/I_x, -25° to 50°C
±(0.03% of voltage reading + offset)/I_x, -40° to 85°C (-XT)

[9]Accuracy does not include sensor and measurement noise. Offsets are defined as:

Offset for DF w/input reversal = 1.5·Basic Res + 1.0 μV
Offset for DF w/o input reversal = 3·Basic Res + 2.0 μV
Offset for SE = 3·Basic Res + 5.0 μV

PULSE COUNTERS *(P1-P4)*
4 inputs individually selectable for switch closure, high frequency pulse, or low-level AC. Independent 24-bit counters (16.8 x 10^6 counts) for each input.

SWITCH CLOSURE MODE:
Minimum Switch Closed Time: 5 ms
Minimum Switch Open Time: 6 ms
Max. Bounce Time: 1 ms open w/o being counted

HIGH FREQUENCY PULSE MODE:
Maximum Input Frequency: 250 kHz
Maximum Input Voltage: ±20 V
Voltage Thresholds: Count upon transition from below 0.9 V to above 2.2 V after input filter with 1.2 μs time constant.

LOW LEVEL AC MODE: Internal AC coupling removes dc offsets up to ±0.5 Vdc.
Input Hysteresis: 12 mV RMS @ 1 Hz
Maximum ac Input Voltage: ±20 V
Minimum ac Input Voltage:

Sine Wave (mV RMS)	*Range(Hz)*
20	1.0 to 20
200	0.5 to 200
2000	0.3 to 10,000
5000	0.3 to 20,000

DIGITAL CONTROL PORTS *(C1-C8, SDM)*
8 ports software selectable as binary inputs or control outputs. Provide edge timing, subroutine interrupts/wake up, switch closure pulse counting, high frequency pulse counting, asynchronous communications (UARTs), SDI-12 communication, and SDM communications.

HIGH FREQUENCY MAX: 400 kHz

SWITCH CLOSURE FREQUENCY MAX: 150 Hz

EDGE TIMING RESOLUTION: 540 ns

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

OUTPUT RESISTANCE: 330 ohms

INPUT STATE: high 3.8 to 16 V; low -8.0 to 1.2 V

INPUT HYSTERESIS: 1.4 V

INPUT RESISTANCE: 100 kohm with < 6.2 Vdc, 220 ohm with inputs ≥6.2 Vdc

ADDITIONAL DIGITAL PORTS: SDM-C1, SDM-C2, SDM-C3 are dedicated for measuring SDM devices.

SWITCHED 12 V *(SW12V)*
Two independent 12 Vdc unregulated sources switched on and off under program control. Thermal fuse hold current = 900 mA @ 20°C, 650 mA @ 50°C, 360 mA @ 85°C.

CE COMPLIANCE
STANDARD(S) TO WHICH CONFORMITY IS DECLARED: IEC61326:2002

COMMUNICATION
RS-232 PORTS:
9-pin: DCE (electrically isolated) for computer or non-CSI modem connection
COM1 to COM4: Four independent Tx/Rx pairs on control ports (non-isolated); 0 to 5 Vdc UART
Baud Rate: Selectable from 300 to 115.2k bps.
Default Format: 8 data bits; 1 stop bit; no parity
Optional Format: 7 data bits; 2 stop bits; odd, even parity

CS I/O PORT: Interface with CSI telecommunication peripherals.

SDI-12: Digital Control ports 1, 3, 5, and 7 are individually configurable and meet Standard version 1.3 for datalogger mode. Up to ten SDI-12 sensors are supported per port.

PERIPHERAL PORT: 40-pin interface for attaching CompactFlash or Ethernet peripherals

PROTOCOLS SUPPORTED: PakBus, Modbus, DNP3, FTP, HTTP, XML POP3, SMTP, Telnet, NTCIP, NTP, SDI-12, SDM

SYSTEM
PROCESSOR: Renesas H8S 2674 (16-bit CPU with 32-bit internal core)

MEMORY: 2 MB of Flash for operating system; 4 MB of battery-backed SRAM for CPU usage, program storage and final data storage

RTC CLOCK ACCURACY: ±3 min. per year. Correction via GPS optional

RTC CLOCK RESOLUTION: 10 ms

SYSTEM POWER REQUIREMENTS
VOLTAGE: 10 to 16 Vdc

INTERNAL BATTERIES: 10 Ah alkaline or 7 Ah rechargeable base. 1200 mAh lithium battery for clock and SRAM backup typically provides 3 years of back-up.

EXTERNAL BATTERIES: 12 Vdc nominal (power correction is reverse polarity protected.

TYPICAL CURRENT DRAIN: Sleep Mode: 2 mA
1 Hz Sample Rate (one fast SE meas.): 3 mA
100 Hz Sample Rate (one fast SE meas.): 10 mA
100 Hz Sample Rate (one fast SE meas. w/RS-232 communications): 38 mA
Display on: add 1 mA to current drain
Backlight on: add 42 mA to current drain

PHYSICAL SPECIFICATIONS
SIZE: 24.1 x 17.8 x 9.6 cm (9.5 x 7.0 x 3.8 in.); additional clearance required for cables and leads.

WEIGHT:

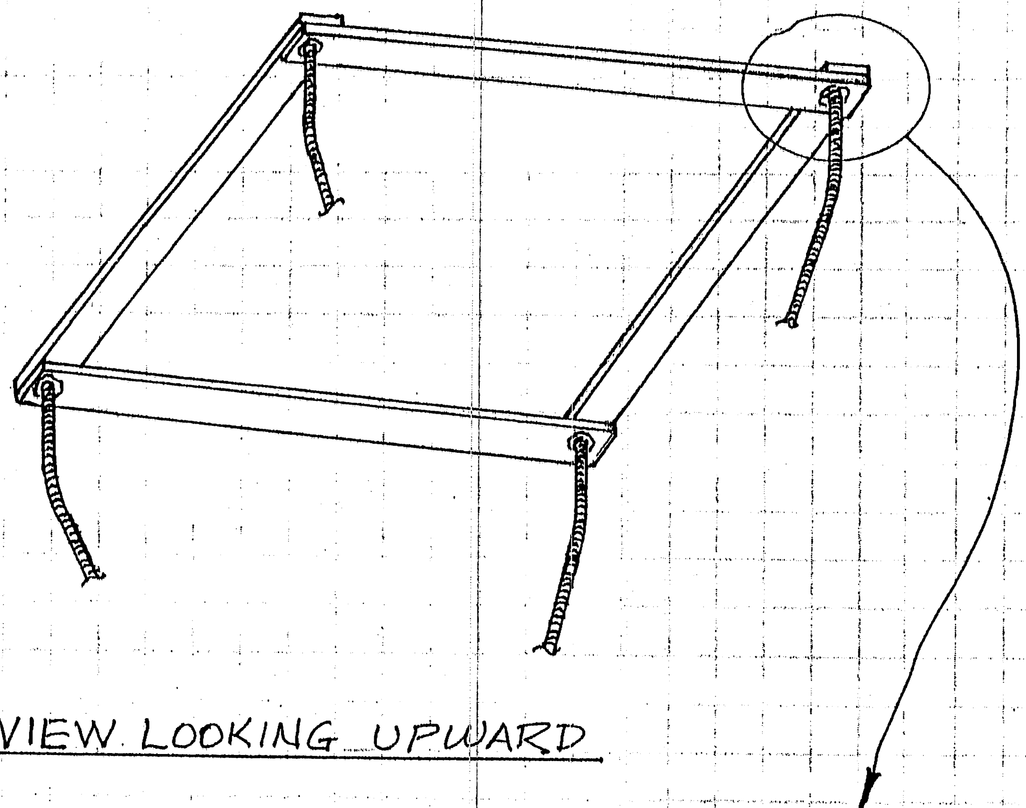
Base Type	*Mass (kg)*	*Weight (lb)*
Low profile	1.6	3.6
Alkaline	3.8	8.3
Rechargeable	4.8	10.7

WARRANTY
3 years against defects in materials and workmanship.

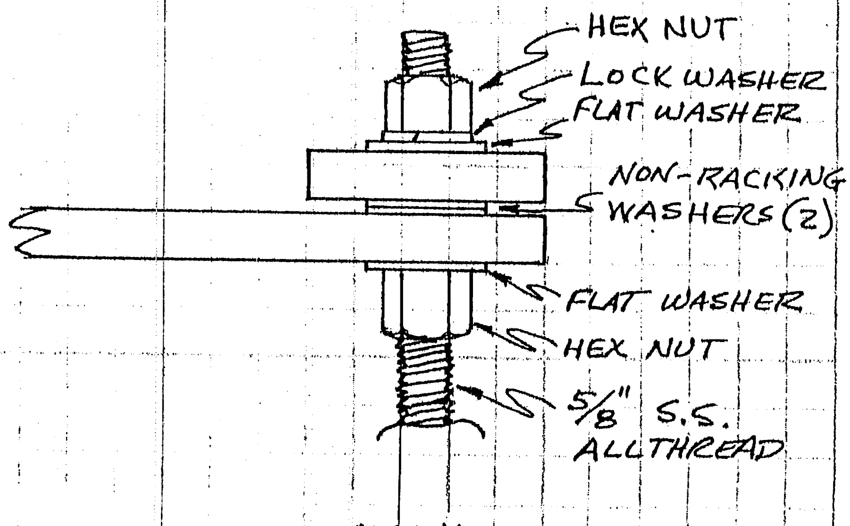
12.11 Static Dissipator Manuals

nott ltd. • 4001 La Plata Highway • Farmington, NM 87401 • (505) 327-5646

BY	DATE	SUBJECT	SHEET NO.
RN		EAGLE'S NEST	1 of
CHECKED BY	DATE	ASSEMBLY	JOB NO.



VIEW LOOKING UPWARD



DETAIL

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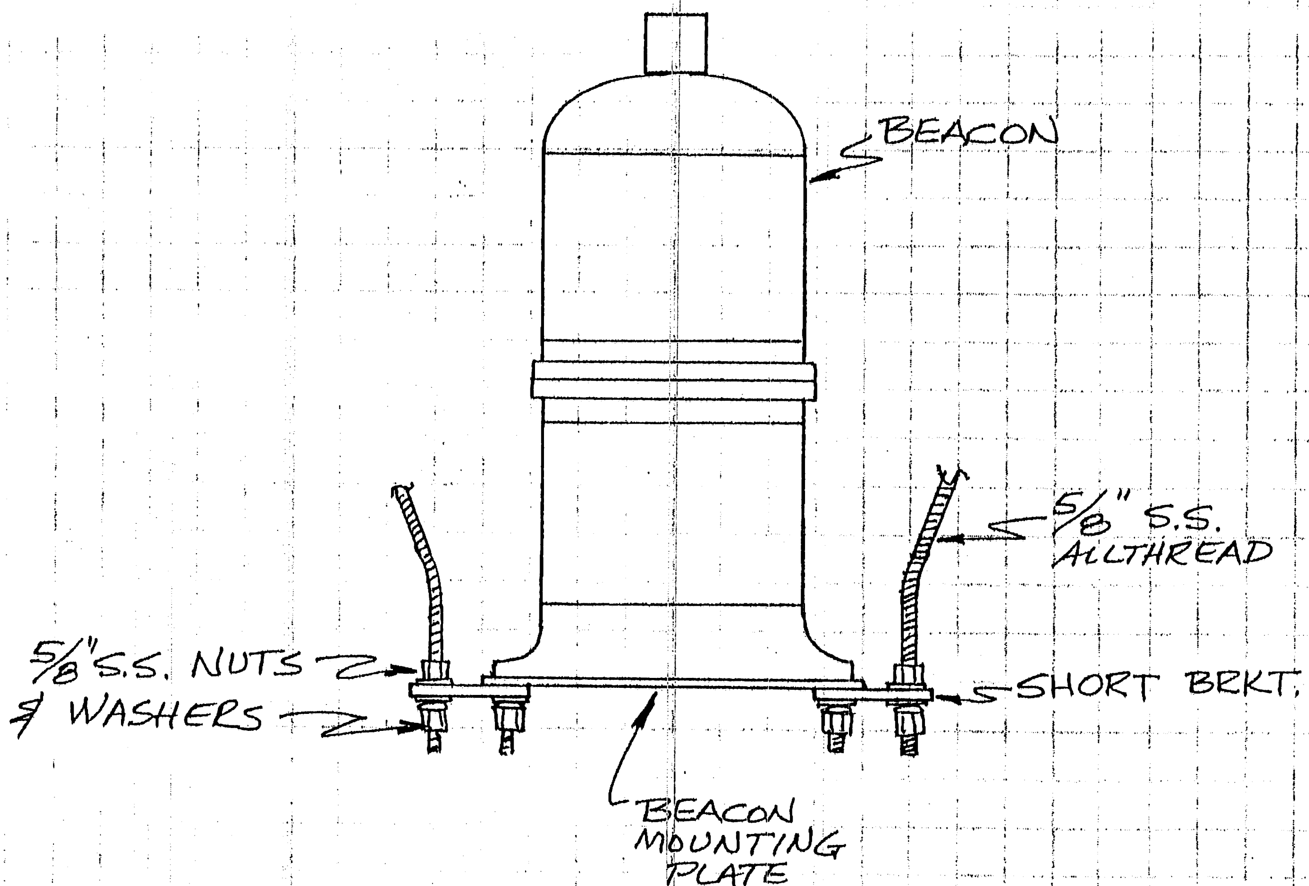
BY	DATE	SUBJECT	SHEET NO.
RN		EAGLES NEST	2 of
CHECKED BY	DATE	ASSEMBLY	JOB NO.



ELEVATION

atmospherics nott ltd. electromagnetics

4001 La Plata Highway • Farmington, New Mexico 87401, USA
(505) 327-5646 • Fax (505) 325-1142

INSTRUCTIONS FOR INSTALLATION OF THE EN-1 EAGLE'S NEST DISSIPATOR

The Eagle's Nest is installed using the existing holes in the tower beacon mounting plate. The beacon mounting bolts are removed and the short brackets are installed on the bottom side of the beacon plate with 2.5" long stainless steel bolts and nuts provided. The Eagle's Nest may be assembled on the ground and then hoisted to the top of the tower, taking great care to handle it safely.

1. Assemble the four bars of the EN-1 together with the four support rods. Note that the support rods are bent and they should be oriented so that they come toward each other so that they will slip into the holes on the short brackets. Be sure to place a pair of non-racking washers between the bars at each corner. These special washers prevent the EN-1 from getting out of square. Assemble using the 5/8" stainless steel hardware as shown on sheet 1 of the assembly drawings.

2. After the EN-1 is assembled, the 1/8" stainless steel rods may be shaped using the bender included. Take great care to avoid puncture wounds from the pointed rods. The out rows of the rods should be bent outward at angles of approximately 30 to 45 degrees from maximum contact with the surrounding air. The rods of the middle row should be bent alternately to opposite sides at angles of about 10 to 15 degrees.

3. Once the stainless steel rods are bent in step 2, make temporary protective wrappers of cardboard and tape.

4. Remove the four beacon mounting bolts and install the short brackets on the bottom side of the mounting plate using the 2.5" long bolts, nuts and washers provided. The short brackets should project out from under the mounting plate.

5. With the protective cardboard in place, hoist the EN-1 to the beacon mounting plate. Run a nut onto each stainless steel all-thread rod about 2 inches. With a flat washer on top of each of the short brackets, slip the rods into the holes of the four short brackets. Fasten each using a flat washer, a lock washer, and a hex nut. Remove the protective cardboard from the EN-1.

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INSTALLATIONS INSTRUCTIONS FOR THE GS-3 CHARGE DISSIPTOR

CAUTION: SHARP POINTS CAN PENETRATE SKIN

INTRODUCING THE NEW GS-4 GILA-STAT CHARGE DISSIPATOR

- **UPPER DISSIPATION POINTS ARE LONGER TO PROVIDE GREATER DISPERSAL TO CONTACT A GREATER VOLUME OF AIR!**
- **DISSIPATION POINTS ARE NOW CEMENENTED WITH CONDUCTIVE EPOXY!**

ASSEMBLY

Screw on hex nut and one flat washer onto the allthread rod leaving about 1.5 inches of rod exposed. Slip the Gila-Stat dissipator head onto the rod with the longer ends of the pointed rods away from the shaft. Then install a flat washer, a lock washer and finally, screw on another hex nut. Thoroughly tighten the nuts.

For shipment, the stainless steel rods are left straight. Prior to final mounting, these rods must be bent to provide optimum performance of the dissipator. A bender has been provided which is a 6 inch length of iron pipe. Slip the bender onto the rods one by one and flare the outer rows of rods outward from 45 to 60 degrees. Bend the rod in the inner row alternately 20 to 30 degrees. Bend the rods at the ends of the aluminum bar outward.

GROUNDING

A continuous, low resistance ground path is necessary for the proper operation of the dissipator. If mounted on a tower, the tower metal is adequate, but it must be grounded at its base. When the dissipator is mounted on other structures, a ground path may be provided with a number 8 or larger copper wire attached to on e or more 8; ground rods.

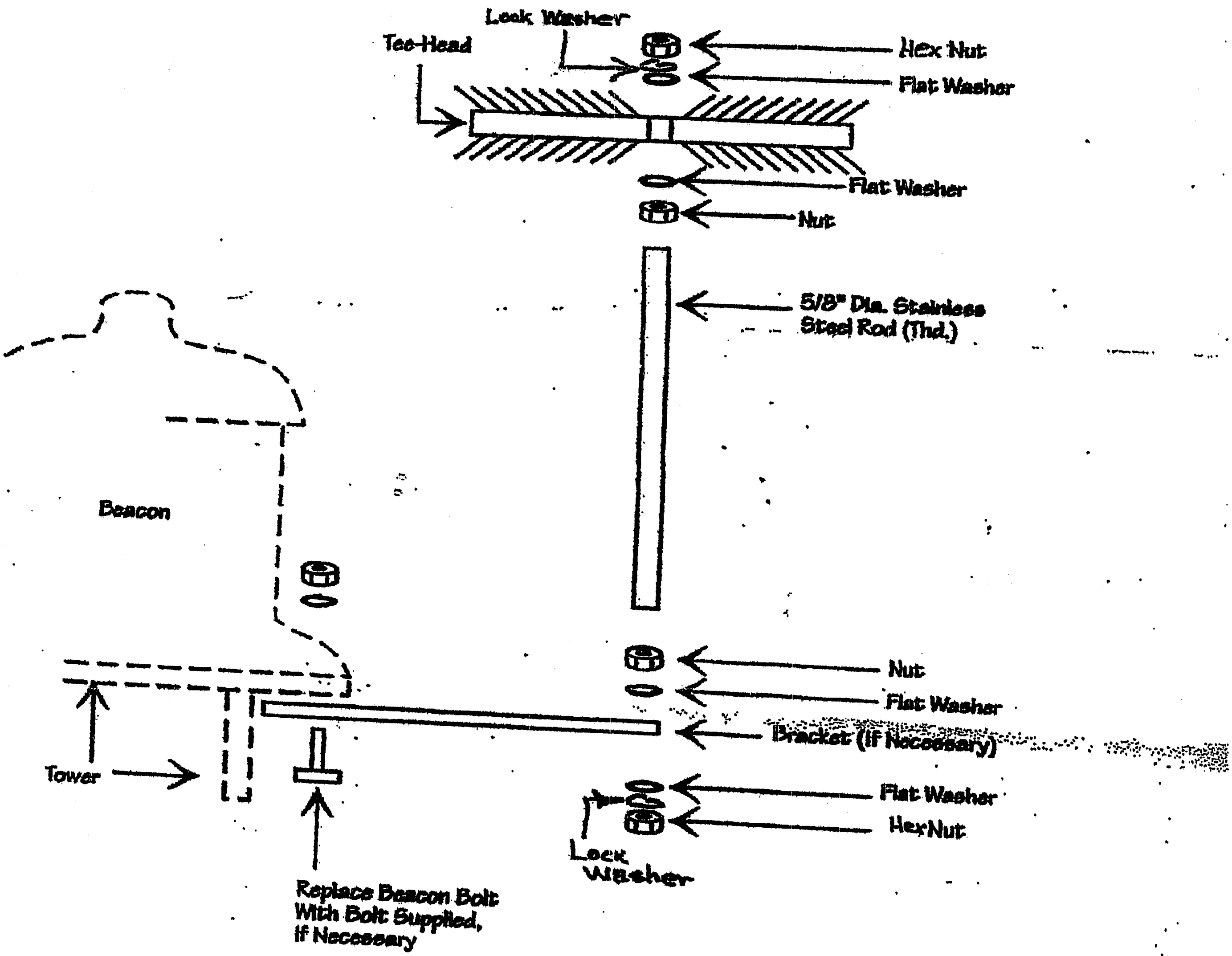
WARRANTY

Materials and workmanship re guaranteed for one year. Upon return of the equipment we will refund the price in full.

Nott ltd.
4001 La Plata Hwy
Farmington, NM 87401
505-327-5646
Fax 505-325-1142

nott ltd

ASSEMBLY INSTRUCTIONS FOR
TOP MOUNT USING EXISTING BOLT HOLE



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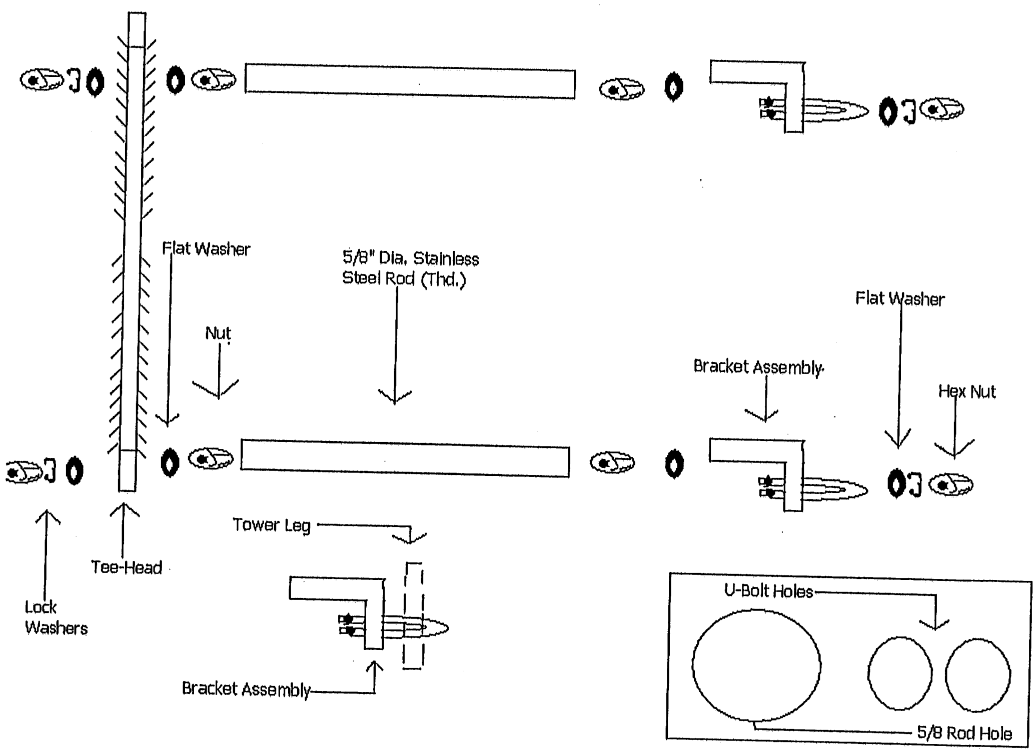
ASSEMBLY INSTRUCTIONS FOR

SIDE MOUNT WITH MOUNTING BRACKET



1. Assemble Tee-head on threaded rod as shown in drawing.
2. Insert rod through 5/8" bracket hole and install flat washer and nut on inside of mounting bracket.
3. See bracket drawing for U-Bolt assembly.
4. If possible, turn Tee-head to be horizontal as this will allow the greatest convective air flow past the points.

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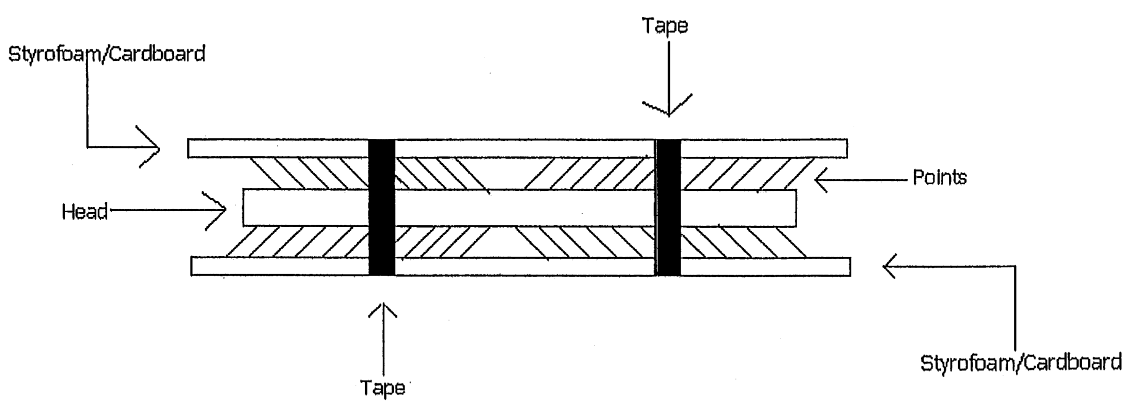
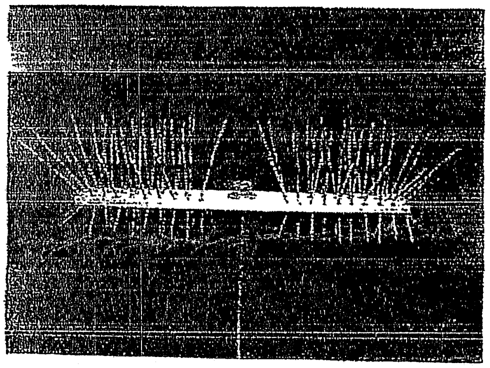
INSTALLATION AND SAFETY SUGGESTIONS

After you have bent out your points on the system, place Styrofoam or heavy cardboard over the sharp points. You can then use tape to secure the strips. We suggest a masking r similar tape because it is easy to cut and discard once the installation is complete.

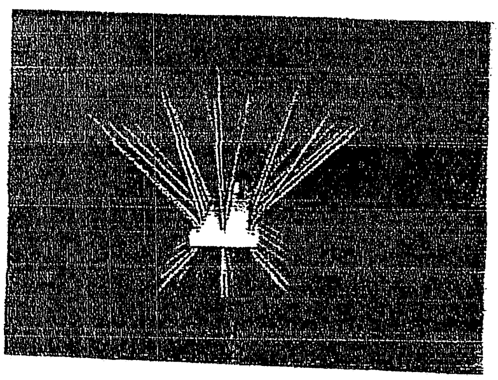
CAUTION: THE TIPS OF THE WIRES ARE VERY SHARP!



Proper Bending Illustrations



Front View to illustrate proper bending of rods. (EN-1 and GS-4 similar)



Side View of GS-3 with bent rods. (EN-1 and GS-4 similar)

12.12 IP Camera Manuals

BIP2-1300c /-dn Specifications

	BIP2-1300c / BIP2-1300c-dn
Image Sensor	Progressive Scan CCD
Effective Pixels	1280 (H) x 960 (V)
Efft. Optical Format	1/3”
Frame Rate	Full Resolution: MJPEG: 30 fps, MPEG-4: 30 fps, H.264: 30 fps
Pixel Size	3.75 µm x 3.75 µm
Day/Night	Removable IR-cut filter (BIP2-1300c-dn)
Minimum Illumination	Color: 0.34 lux (F1.2/33ms), Day/Night: 0.09 lux (F1.2/33ms)
Lens	CS-mount, DC iris drive (lens not included)
Image Settings	Automatic gain, exposure area, backlight compensation, white balance, electronic shutter, 180° image rotation, anti-flicker, electronic PTZ via AOI (API), text overlay, privacy masks, motion detection
Resolution	From 160 x 120 to 1280 x 960 (free scaling), 4:3, 16:9, multiple Areas of Interest (AOIs)
Video Compression	Motion JPEG: Multiple compression levels; MPEG-4: SP (Level 3); H.264 (MPEG-4 AVC): Baseline and high profile (levels up to 5.0)
Video Streaming	Multi-encoding and multistreaming for MJPEG, H.264, and MPEG-4; VBR und CBR für MJPEG und MPEG-4, VBR, CBR und CVBR für H.264, multicast and unicast
Alarm Management	Ring buffer for pre and post alarm, events triggered by motion detection or external input (real-time trigger), image upload over FTP, e-mail, or HTTP
Protocols	TCP/IP, HTTP, UDP, FTP, ICMP, ARP, DHCP, NTP, RTP, RTSP, RTCP, SMTP, IGMP, ZEROCONF, QoS Layer 3
Processor/Memory	Multimedia Video Processor, FPGA, 256 MB RAM, 32 MB Flash
Power	PoE (Power over Ethernet IEEE 802.3af Class 2) or 12 to 24 VDC, power consumption typ. 3.5 W at 12 VDC
Connectors	RJ-45 connector for 10/100 BASE-T Ethernet, full or half duplex, 8 pin terminal for DC power, digital I/O, and RS-485
Operating Conditions	0° to 50° C (32° to 122° F), < 90 % relative humidity (non-condensing)
Standards	DIN EN 50130-4, FCC Class B, CE, RoHS
Housing	109.7 mm x 29 mm x 44 mm (full metal casing)
Weight	~210 g

Specifications are subject to change without prior notice.

BIP2-1300c/-dn Information

Specifications
Dimensions
Camera Comparer

Downloads

IP Cameras Overview (Aug. 2011) - pdf, 991 KB
IP Camera Manuals

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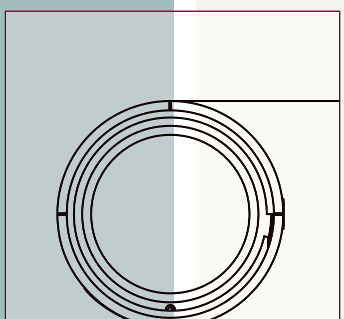
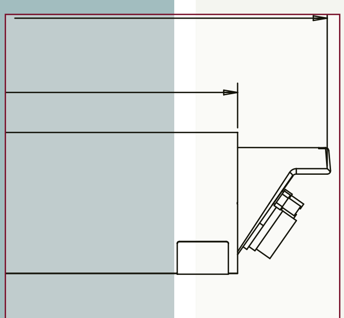
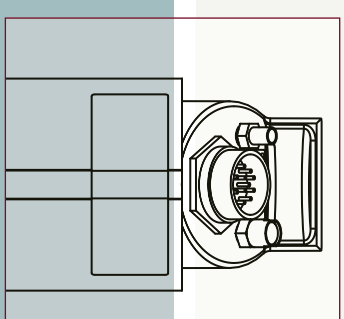
- All Aluminum Construction
- Built-in Handle for Easy Installation
- Excellent Protection Against Dust & Water
- Built-in Window Heater/ Defogger
- Pressurization Model Option

Specialty Series Outdoor Housings







HS9384 Series

The HS9384 Specialty Series outdoor housings are designed to protect a camera and lens from harsh environments. These IP68/NEMA-6P rated housings are constructed of extruded aluminum and include a camera/lens mounting cradle with front and rear-end caps. The front-end cap contains the glass viewing window with an integral heater design that minimizes fogging of the window in high humidity areas or freezing under cold temperature conditions. The aluminum rear-end cap contains three liquid-tight fittings that permit pass-through of video coax, AC power, and lens control wiring. The pressurized version includes one prewired military-style connector.

The permanent base permits mounting to pan/tilts, adjustable heads, and various wall mounts, and the built-in handle on the back of the housing allows for quick installation and service.

ORDERING GUIDE

Order the housing that meets your needs. Start with the Model number, then specify your power requirements. Select from the options available to complete your custom housing. If you need further customization - call the factory with your exact specification requirements.

EXAMPLE: HS9384-2HP-9

model	power	heater	pressurization	housing length*
HS9384	-2	H	P	-9
Specialty Outdoor Housing	-2 - 24 VAC, 50/60 Hz -5 - 220 VAC, 50/60 Hz -6 - 115 VAC, 50/60 Hz	H - window heater/ defogger	P - optional Pressurization model	-9 - 9 inch housing*

* All housings come standard 16-inch length, **-9** added to a part number is for a 9-inch length housing.

OPTIONS

		OPTION	
Rated Input (Voltage Range)		**-2H**	24 VAC, 50/60 Hz (21.6 to 26.4)
		-5H	220 VAC, 50/60 Hz (207 to 253)
		-6H	115 VAC, 50/60 Hz (108 to 132)
Heater		**-H**	Includes thermostatically controlled window heater/defogger. (Heater requires 10 watts)
Power Transformer (Voltage Output)		**-5H** **-6H**	The power transformers included with these housings are used to step voltage down from 115 VAC to 24 VAC
Cable Entry	Standard		Three liquid-tight fittings. Accepts the following cable diameters: one fitting 0.09 in to 0.25 in (2.3 mm to 6.4 mm), two fittings 0.15 in to 0.39 in (3.8 mm to 10 mm).
	Pressurization Models *	**-P**	One Corrosion-resistant 20 - 16 (shell size 20, 16-pin) MIL-C-26482 connector with mating connector and crimp pins supplied. Connections for Cat -5/6e, AC power, video, and lens control. Crimp pins accept wire gauges 20 - 16 AWG (24 - 20 AWG for 11 - pin and 24 - pin connectors). **Pressurization Model can be filled with Dry Nitrogen pressure upon request.**

* Other connectors are available (e.g. 18 - 11, 20 - 24). Call factory for specific requirements.

SPECIFICATIONS

Maximum Camera/Lens Size	
HS9384-5H, -6H, -5HP, -6HP	Accept cameras up to 2.5 x 2.3 in (64 W x 58 H mm), lenses up to 2.6 x 2.9 in (67 W x 75 H mm), and camera/lens combinations up to 11.5 in (292 mm).
HS9384-2H, -2HP	Accept cameras up to 2.5 x 2.3 in (64 W x 58 H mm), lenses up to 2.6 x 2.9 in (67 W x 75 H mm), and camera/lens combinations up to 14.0 in (355 mm).
HS9384-2H-9, -2HP-9	Accept cameras up to 2.5 x 2.3 in (64 W x 58 H mm), lenses up to 2.6 x 2.9 in (67 W x 75 H mm), and camera/lens combinations up to 5.75 in (146 mm).
Window	0.118 in (3 mm) thick glass. Includes thermostatically-controlled window heater/defogger.
Housing Mounting	Three (3) 1/4-20 tapped holes.
Camera Mounting	Removable cradle assembly with hole pattern for mounting camera/lens assembly. Cradle may be rotated through 360°.
Construction	**Non-Pressurized Models**: All aluminum construction. Extruded housing, one-piece camera cradle with front and rear caps. Front cap contains glass faceplate. Cradle secured by external captive screw at the rear of the unit. **Pressurized Models**: All aluminum construction. Extruded housing, two-piece camera cradle. Separate front cap secured by snap rings. Rear cap contains corrosion resistant connector, fill valve and relief valve. Camera cradle and rear cap secured in place by snap ring at rear of unit.
Finish	Light gray.
Dimensions	See drawings.

Weights

Model	Weight
HS9384-2HP-9	2.8 lbs (1.3 kg)
HS9384-2HP	4.6 lbs (1.3 kg)
HS9384-5HP	5.8 lbs (2.6 kg)
HS9384-6HP	5.8 lbs (2.6 kg)
HS9384-2H	4.0 lbs (1.9 kg)
HS9384-2H-9	2.8 lbs (1.3 kg)
HS9384-5H	5.2 lbs (2.4 kg)
HS9384-6H	5.2 lbs (2.4 kg)

Environmental

Temperature:
At external ambient temperatures of –40 °F to 122 °F (-40 °C to 50 °C), maintains internal temperatures between –4 °F to 131 °F (–20 °C to 55 °C).

Salt Atmosphere:
MIL-STD-810E, Method 509, Procedure I.

Enclosure Protection:
Designed to meet IP68/NEMA-6P.

Electromagnetic Compatibility

EMC Requirements:
Immunity: 89/336/EEC, EN50082-1.
Emission: 89/336/EEC, EN50081-1 Class B.

Safety:
CE: LVD Requirements: 73/23/EEC; EN60065.
UL: UL2044.
cUL: CSA 22.2, No.1.

Accessories

HS9384SS & HS9384SS-10 Sunshields: Provides protection from the direct rays of the sun and promotes cooling to reduce internal housing temperatures.

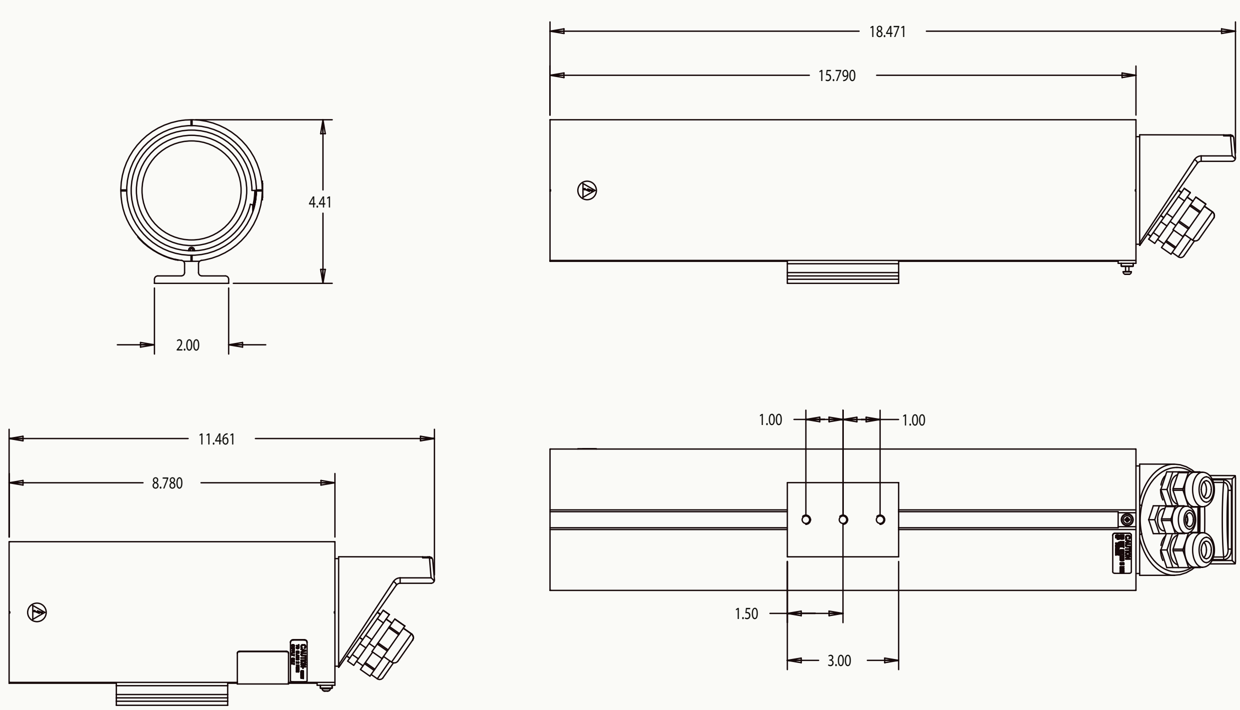
HS9384TK Tamper Resistant Kit: Includes screws and insertion tool to permit tamper-resistance for one housing.

MT9212: Wall mount, 12-inch, 20lb max load.

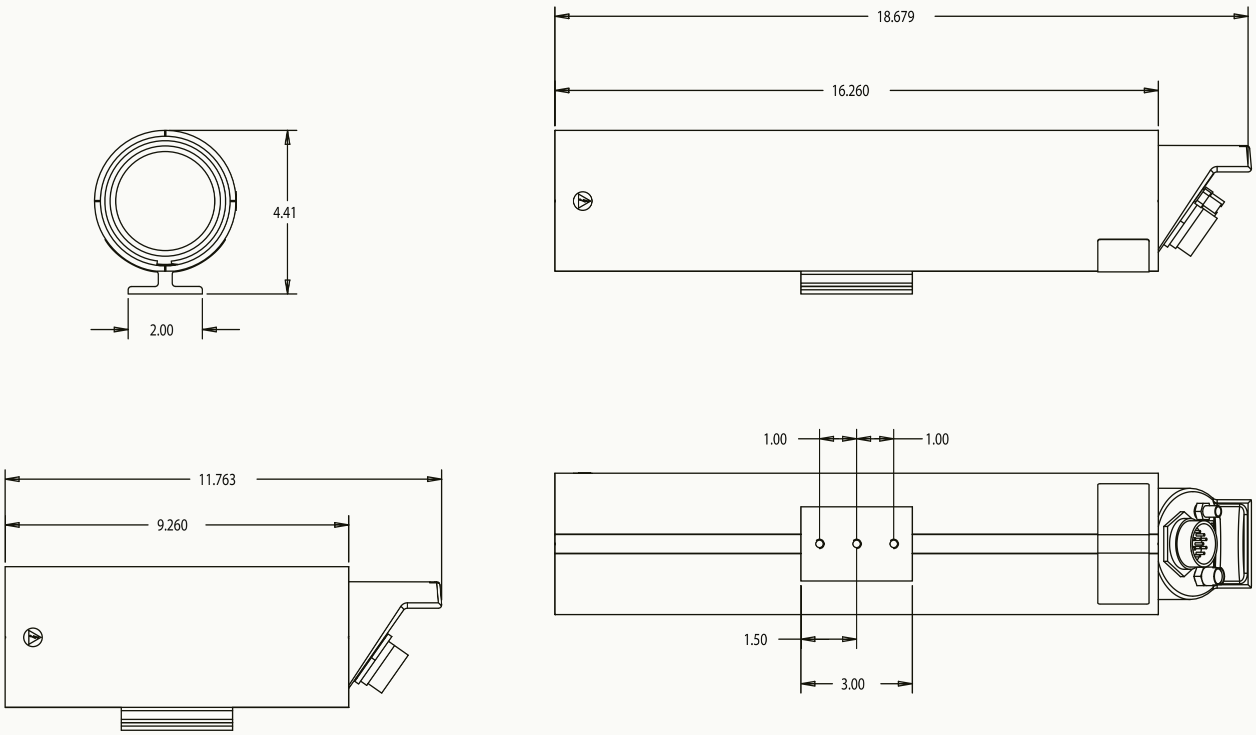
MT9210: Column mount, 8-inch, 20lb max load.

MT9223: Column mount, 24-inch, 20lb max load.

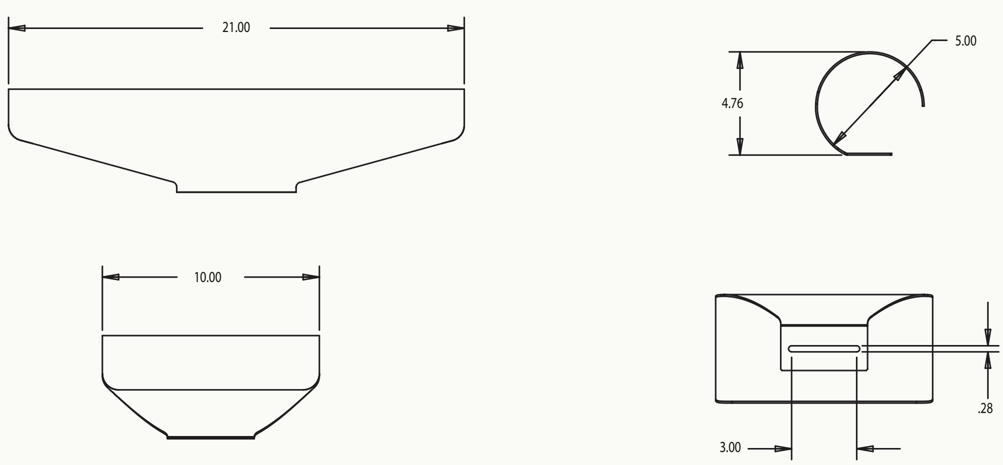
HS9384 Series Dimensional Outline



HS9384 Pressurization Models - Dimensional Outline



Sunshield Accessories - HS9384SS & HS9384SS-10



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13 Appendix F: Calibration Sheets

13.1 MEASNET Anemometer Calibration Sheets

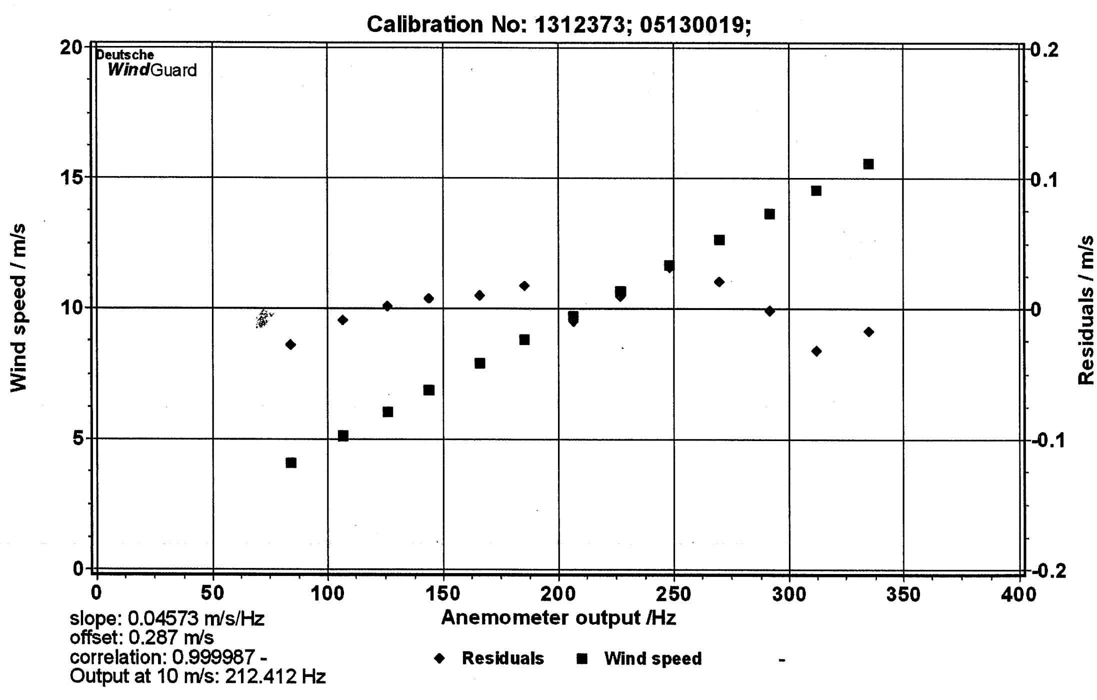
1 Detailed Calibration Results

DKD calibration no.	1312373
Serial no. 1	05130019
Serial no. 2	
Date	22.05.2013
Air temperature	21.9 °C
Air pressure	1008.3 hPa
Humidity	40.6 %

Linear regression analysis

Slope	0.04573 (m/s)/(Hz) ±0.00007 (m/s)/(Hz)
Offset	0.2869 m/s ±0.016 m/s
St.err(Y)	0.016 m/s
Correlation coefficient	0.999987

Remarks no



Deutsche WindGuard Wind Tunnel Services is accredited by MEASNET and by the Deutsche Akkreditierungsdienst – DAkkS (German Accreditation Service). Registration: D-K-15140-01-00

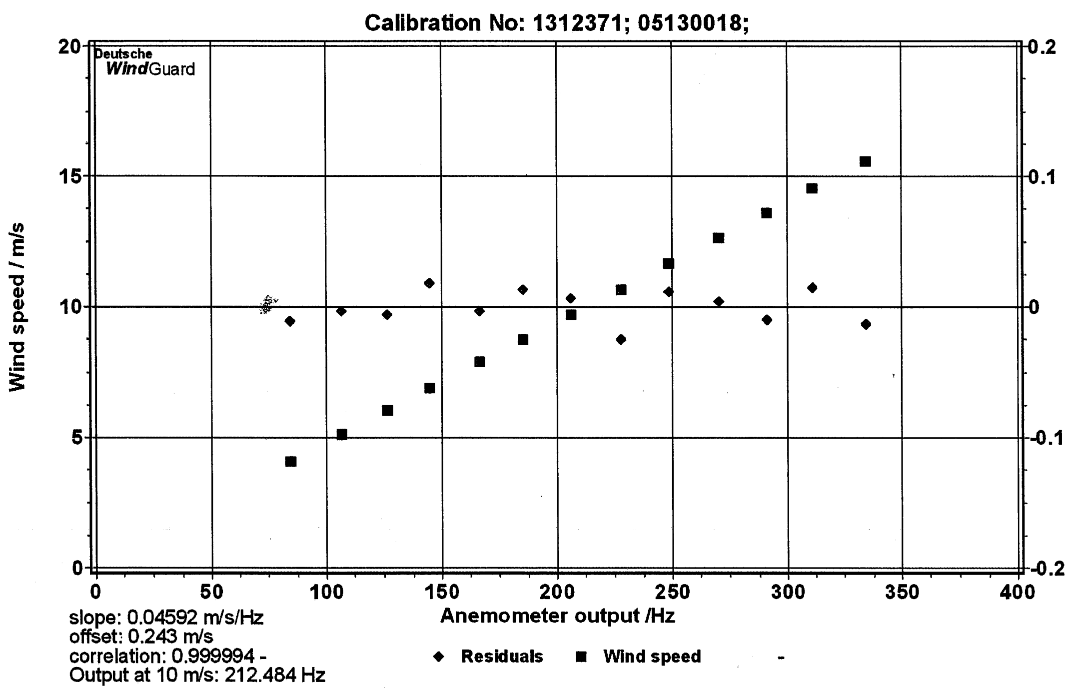
1 Detailed Calibration Results

DKD calibration no.	1312371
Serial no. 1	05130018
Serial no. 2	
Date	22.05.2013
Air temperature	21.7 °C
Air pressure	1008.2 hPa
Humidity	41.0 %

Linear regression analysis

Slope	0.04592 (m/s)/(Hz) ±0.00005 (m/s)/(Hz)
Offset	0.2426 m/s ±0.011 m/s
St.err(Y)	0.011 m/s
Correlation coefficient	0.999994

Remarks no



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Svend Ole Hansen ApS
SCT. JØRGENS ALLÉ 7 · DK-1615 KØBENHAVN V · DENMARK
TEL: (+45) 33 25 38 38 · FAX: (+45) 33 25 38 39 · WWW.SOHANSEN.DK

WIND ENGINEERING
FLUID DYNAMICS

ELEV. 3

CERTIFICATE FOR CALIBRATION OF CUP ANEMOMETER

Certificate number: 11.02.6540 **Date of issue:** September 21, 2011

Type: Thies 4.3351.00.000 **Serial number:** 09114705

Manufacturer: ADOLF THIES GmbH & Co.KG, Hauptstrasse 76, 37083 Göttingen, Germany

Client: Sky Power Int'l LLC, 250 Sawdust Road, 29657-8521 Liberty SC, USA

Anemometer received: September 12, 2011 **Anemometer calibrated:** September 17, 2011

Calibrated by: mh **Calibration procedure:** IEC 61400-12-1, MEASNET

Certificate prepared by: mlp **Approved by:** Calibration engineer, kbk

Calibration equation obtained: v [m/s] = 0.04621 · f [Hz] + 0.21735

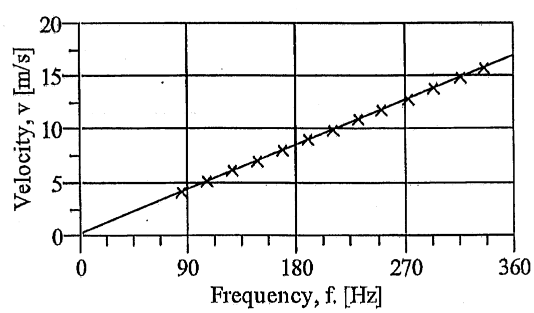
Standard uncertainty, slope: 0.00121 **Standard uncertainty, offset:** 0.05778

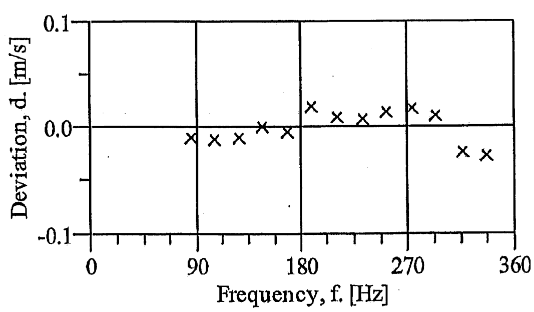
Covariance: -0.0000007 (m/s)²/Hz **Coefficient of correlation:** ρ = 0.999992

Absolute maximum deviation: -0.026 m/s at 15.752 m/s

Barometric pressure: 1012.1 hPa **Relative humidity:** 29.2%

Succession	Velocity pressure, q. [Pa]	Temperature in wind tunnel [°C]	Temperature in control room [°C]	Wind velocity, v. [m/s]	Frequency, f. [Hz]	Deviation, d. [m/s]	Uncertainty u_c (k=2) [m/s]
2	10.00	31.1	23.5	4.165	85.6037	-0.009	0.028
4	15.11	31.0	23.5	5.118	106.2892	-0.011	0.032
6	21.40	31.0	23.5	6.091	127.2953	-0.009	0.037
8	28.85	30.9	23.5	7.072	148.2945	0.001	0.042
10	37.29	30.8	23.5	8.038	169.3289	-0.004	0.047
12	46.76	30.7	23.5	9.001	189.6356	0.019	0.053
13-last	57.39	30.7	23.5	9.971	210.8281	0.010	0.058
11	68.98	30.8	23.5	10.932	231.6840	0.008	0.064
9	81.23	30.8	23.5	11.865	251.6938	0.015	0.069
7	95.61	30.9	23.5	12.873	273.4538	0.018	0.075
5	110.31	31.0	23.5	13.829	294.2672	0.012	0.081
3	126.78	31.1	23.5	14.827	316.6145	-0.022	0.086
1-first	143.01	31.2	23.6	15.752	336.7016	-0.026	0.092





ilac-MRA

DANAK
CAL Reg.nr. 452
Accreditation to ISO 17025

Svend Ole Hansen ApS · Wind Engineering · Denmark · measnet

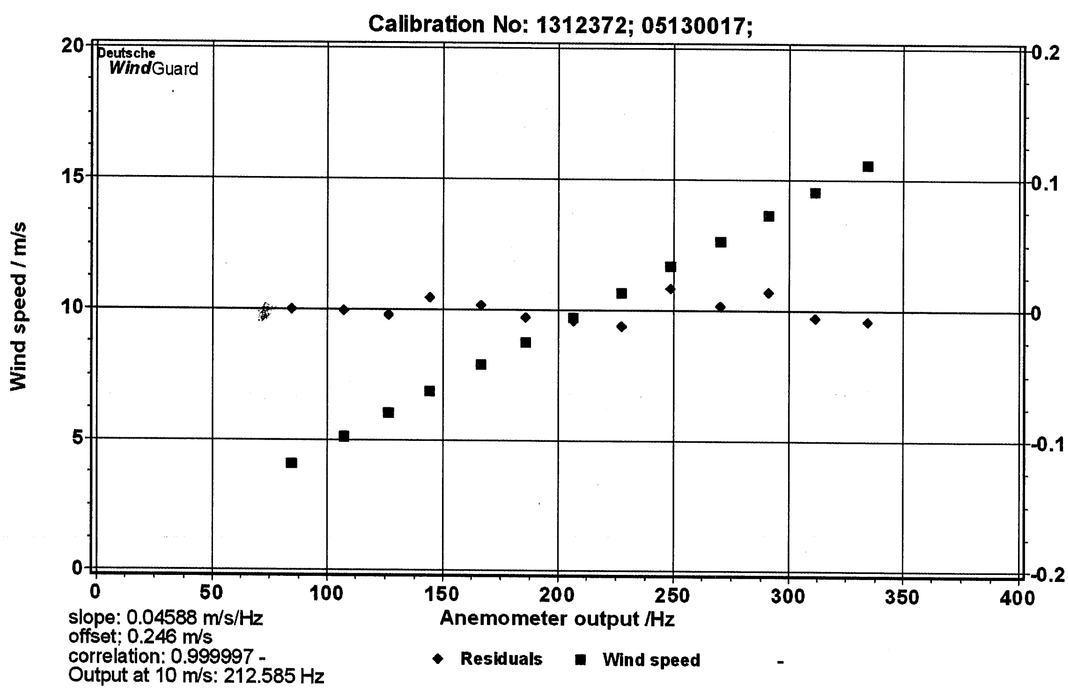
1 Detailed Calibration Results

DKD calibration no.	1312372
Serial no. 1	05130017
Serial no. 2	
Date	22.05.2013
Air temperature	21.6 °C
Air pressure	1008.1 hPa
Humidity	39.7 %

Linear regression analysis

Slope	0.04588 (m/s)/(Hz) ±0.00003 (m/s)/(Hz)
Offset	0.2463 m/s ±0.007 m/s
St.err(Y)	0.008 m/s
Correlation coefficient	0.999997

Remarks no



Deutsche WindGuard Wind Tunnel Services is accredited by MEASNET and by the Deutsche Akkreditierungsdienst – DAkkS (German Accreditation Service). Registration: D-K-15140-01-00

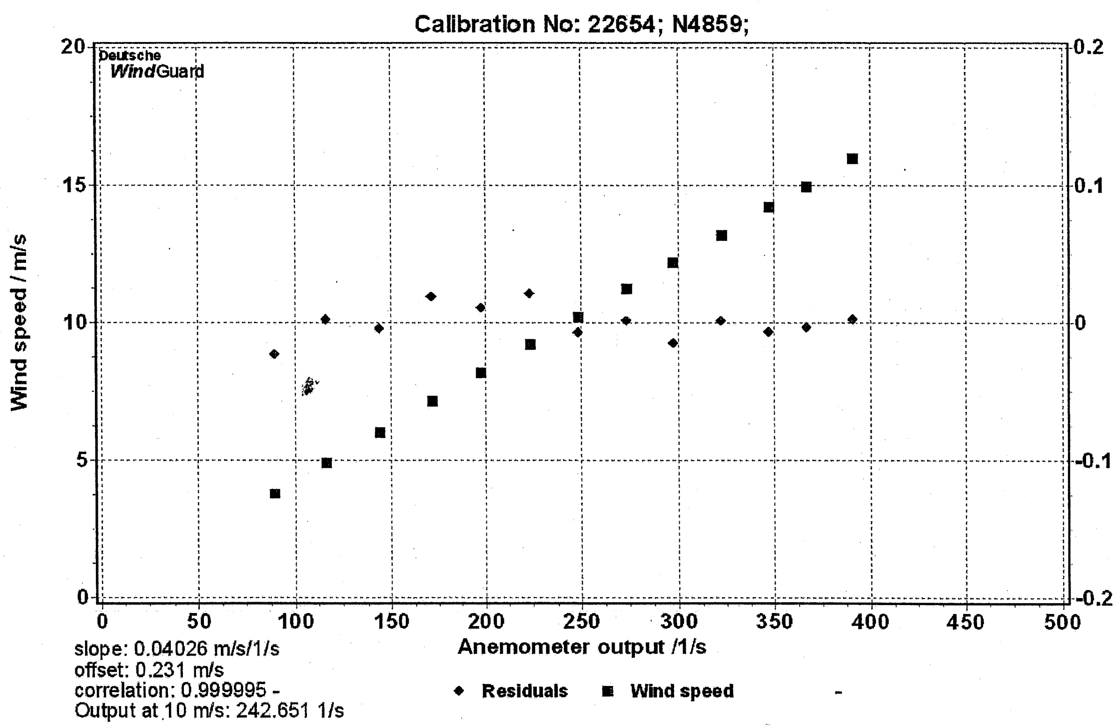
1 Detailed Calibration Results

DKD calibration no.	22654
Body no.	N4859
Cup no.	
Date	21.05.2012
Air temperature	24.2 °C
Air pressure	1001.7 hPa
Humidity	50.8 %

Linear regression analysis

Slope	0.04026 (m/s)/(1/s) ±0.00004 (m/s)/(1/s)
Offset	0.2308 m/s ±0.010 m/s
St.err(Y)	0.010 m/s
Correlation coefficient	0.999995

Remarks	no



Deutsche WindGuard Wind Tunnel Services is accredited by MEASNET and by the Deutsche Akkreditierungsdienst – DAkkS (German Accreditation Service). Registration: D-K-15140-01-00

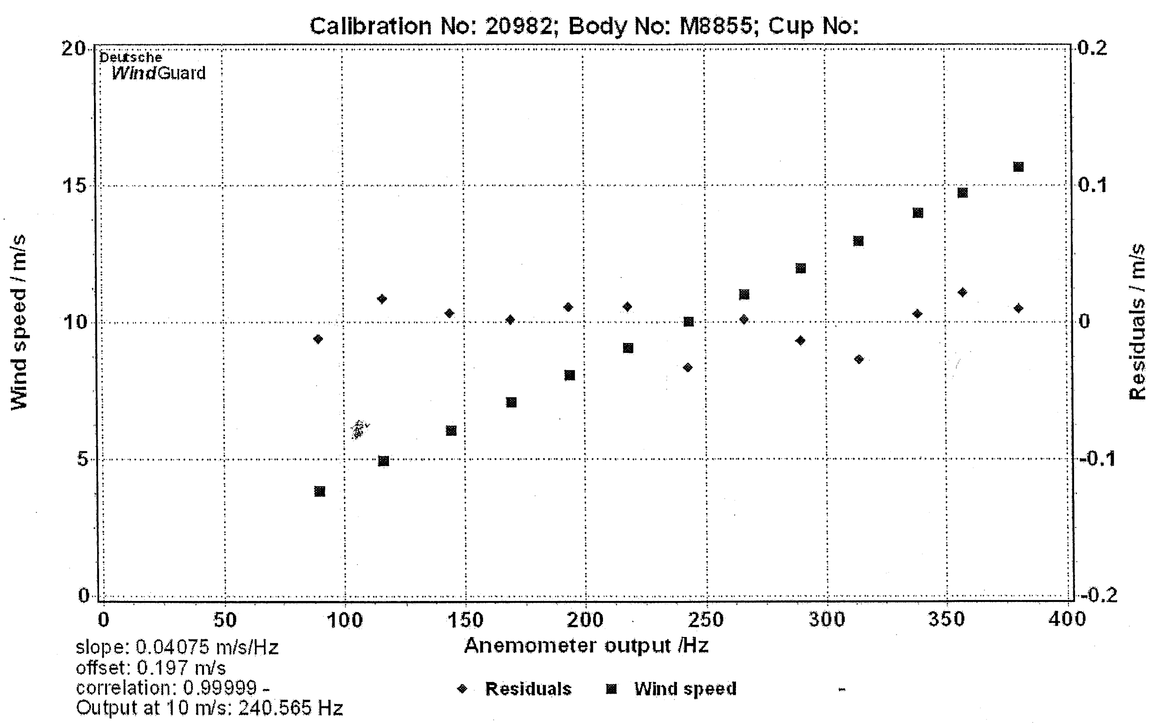
1 Detailed MEASNET[1] Calibration Results

DKD calibration no.	20982
Body no.	M8855
Cup no.	
Date	13.02.2012
Air temperature	18.5 °C
Air pressure	1017.4 hPa
Humidity	34.2 %

Linear regression analysis

Slope	0.04075 (m/s)/(Hz) ±0.00005 (m/s)/(Hz)
Offset	0.1969 m/s ±0.014 m/s
St.err(Y)	0.017 m/s
Correlation coefficient	0.999990

Remarks no



[1]) According to MEASNET Cup Anemometer Calibration Procedure 2009-10.
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13.2 Spectrum Accelerometer Calibration Sheets

XL403A Calibration Certificate

Serial Number: 1670A00028   Test Date: 11 Oct 2011 11:07:46
X3-R002-B010-T032D

	Measured Value	Units
Power Supply*		
Current @ 13.80V	16.40	mA
Mass (nom.)	38.0	grams

	1	2	3	Units
Range (nom.)*	-2.2/+2.2	-2.3/+2.3	-2.3/+2.3	g
Offset (output@0g)	2.4995	2.4994	2.4992	V
Misalignment	0.53	0.18	0.21	degrees
Sensitivity				
Along Axis 1	1013.19	-3.03	3.22	mV/g
Along Axis 2	2.78	991.51	-1.77	mV/g
Along Axis 3	8.92	-1.01	996.54	mV/g
Bandwidth*				
3dB Frequency	10	10	10	Hz
Tolerance (±)	5	5	5	%
Self Test*				
Change if asserted	-3.27	-3.17	-2.38	V

**For reference only.*   *Voltage tolerance ±200uV*
***Axis 3 is cross product of 1 into 2.*

XL403A Calibration Certificate

Serial Number: 1670A00029   Test Date: 11 Oct 2011 11:24:10
X3-R002-B010-T032D

	Measured Value	Units
Power Supply*		
Current @ 13.80V	15.20	mA
Mass (nom.)	38.0	grams

	1	2	3	Units
Range (nom.)*	-2.2/+2.2	-2.2/+2.2	-2.2/+2.2	g
Offset (output@0g)	2.4998	2.5006	2.5008	V
Misalignment	0.74	0.53	0.22	degrees
Sensitivity				
Along Axis 1	1006.44	-9.19	3.77	mV/g
Along Axis 2	8.59	1006.05	-0.89	mV/g
Along Axis 3	9.69	1.67	1004.62	mV/g
Bandwidth*				
3dB Frequency	10	10	10	Hz
Tolerance (±)	5	5	5	%
Self Test*				
Change if asserted	-3.33	-3.18	-2.41	V

**For reference only.*   *Voltage tolerance ±200uV*
***Axis 3 is cross product of 1 into 2.*

XL403A Calibration Certificate

Serial Number: 1670A00030   Test Date: 11 Oct 2011 11:37:52
X3-R002-B010-T032D

	Measured Value	Units
Power Supply*		
Current @ 13.80V	16.10	mA
Mass (nom.)	38.0	grams

	1	2	3	Units
Range (nom.)*	-2.3/+2.3	-2.2/+2.2	-2.3/+2.3	g
Offset (output@0g)	2.4997	2.5006	2.5012	V
Misalignment	1.00	0.59	0.27	degrees
Sensitivity				
Along Axis 1	979.51	-9.65	-2.28	mV/g
Along Axis 2	9.10	1008.47	-4.20	mV/g
Along Axis 3	14.53	3.82	997.29	mV/g
Bandwidth*				
3dB Frequency	10	10	10	Hz
Tolerance (±)	5	5	5	%
Self Test*				
Change if asserted	-3.29	-3.18	-2.39	V

**For reference only.*   *Voltage tolerance ±200uV*
***Axis 3 is cross product of 1 into 2.*

XL403A Calibration Certificate

Serial Number: 1670A00031   Test Date: 11 Oct 2011 11:53:33
X3-R002-B010-T032D

	Measured Value	Units
Power Supply*		
Current @ 13.80V	15.50	mA
Mass (nom.)	38.0	grams

	1	2	3	Units
Range (nom.)*	-2.3/+2.3	-2.2/+2.2	-2.2/+2.2	g
Offset (output@0g)	2.5003	2.5011	2.4998	V
Misalignment	1.29	0.78	0.11	degrees
Sensitivity				
Along Axis 1	989.57	-13.53	-1.03	mV/g
Along Axis 2	13.18	1003.87	-1.59	mV/g
Along Axis 3	17.87	1.64	1005.02	mV/g
Bandwidth*				
3dB Frequency	10	10	10	Hz
Tolerance (±)	5	5	5	%
Self Test*				
Change if asserted	-3.34	-3.15	-2.43	V

**For reference only.*   *Voltage tolerance ±200uV*
***Axis 3 is cross product of 1 into 2.*

13.3 MEASNET Calibration for Thies Hub Height Anemometer

Svend Ole Hansen ApS

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WIND ENGINEERING
FLUID DYNAMICS

CERTIFICATE FOR CALIBRATION OF CUP ANEMOMETER

Certificate number: 11.02.6540
Date of issue: September 21, 2011

Type: Thies 4.3351.00.000
Serial number: 09114705

Manufacturer: ADOLF THIES GmbH & Co.KG, Hauptstrasse 76, 37083 Göttingen, Germany

Client: Sky Power Int'l LLC, 250 Sawdust Road, 29657-8521 Liberty SC, USA

Anemometer received: September 12, 2011
Anemometer calibrated: September 17, 2011

Calibrated by: mh
Calibration procedure: IEC 61400-12-1, MEASNET

Certificate prepared by: mlp
Approved by: Calibration engineer, kbk

Calibration equation obtained: v [m/s] = 0.04621 · f [Hz] + 0.21735

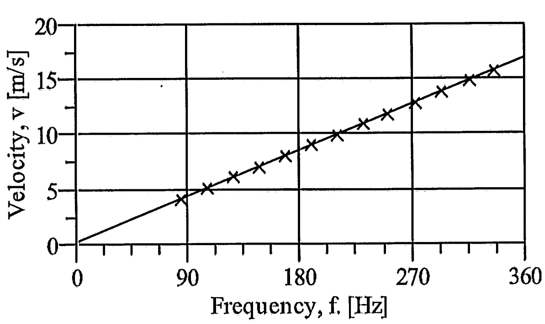
Standard uncertainty, slope: 0.00121
Standard uncertainty, offset: 0.05778

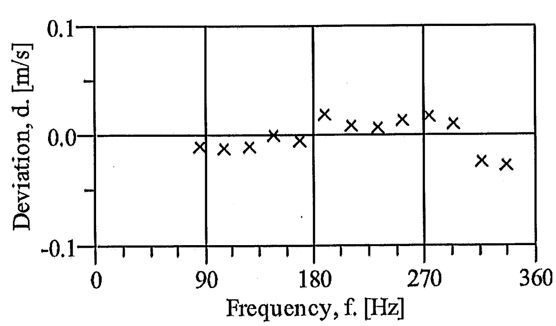
Covariance: -0.0000007 (m/s)²/Hz
Coefficient of correlation: ρ = 0.999992

Absolute maximum deviation: -0.026 m/s at 15.752 m/s

Barometric pressure: 1012.1 hPa
Relative humidity: 29.2%

Succession	Velocity pressure, q. [Pa]	Temperature in wind tunnel [°C]	Temperature in control room [°C]	Wind velocity, v. [m/s]	Frequency, f. [Hz]	Deviation, d. [m/s]	Uncertainty u_c (k=2) [m/s]
2	10.00	31.1	23.5	4.165	85.6037	-0.009	0.028
4	15.11	31.0	23.5	5.118	106.2892	-0.011	0.032
6	21.40	31.0	23.5	6.091	127.2953	-0.009	0.037
8	28.85	30.9	23.5	7.072	148.2945	0.001	0.042
10	37.29	30.8	23.5	8.038	169.3289	-0.004	0.047
12	46.76	30.7	23.5	9.001	189.6356	0.019	0.053
13-last	57.39	30.7	23.5	9.971	210.8281	0.010	0.058
11	68.98	30.8	23.5	10.932	231.6840	0.008	0.064
9	81.23	30.8	23.5	11.865	251.6938	0.015	0.069
7	95.61	30.9	23.5	12.873	273.4538	0.018	0.075
5	110.31	31.0	23.5	13.829	294.2672	0.012	0.081
3	126.78	31.1	23.5	14.827	316.6145	-0.022	0.086
1-first	143.01	31.2	23.6	15.752	336.7016	-0.026	0.092





DANAK
CAL Reg.nr. 452
Accreditation to ISO 17025

14 Photos

Figure 1: UMN Research Technicians perform maintenance on the instruments mounted to the 18ft boom located at Elevation 6 (10m)

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Figure 2: UMN Research Technicians perform maintenance on the instruments mounted to the 18ft boom located at Elevation 6 (10m)

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Figure 3: UMN Research Technicians perform maintenance on the instruments mounted to the 18ft boom located at Elevation 6 (10m)

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Figure 4: UMN Research Technicians perform maintenance on the instruments mounted to the 18ft boom located at Elevation 6 (10m)

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Figure 5: UMN Research Technicians perform maintenance on the instruments mounted to the 18ft boom located at Elevation 6 (10m)

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Figure 6: UMN Research Technicians perform maintenance on the instruments mounted to the 18ft boom located at Elevation 6 (10m)

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