Protocol Manual for the Operation and Maintenance of Campbell Scientific Canada Corp. Quick Deploy Weather Systems

Document prepared by Campbell Scientific Canada Corp in conjunction with the Government of Newfoundland and Labrador, Department of Municipal Affairs and Environment.

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Introduction

The purpose of this protocol manual is to establish guidelines for both the end user (Government of Newfoundland and Labrador Department of Municipal Affairs and Environment) and the manufacturer (Campbell Scientific Canada Corp.) by which the quick deploy systems are maintained and operated over the course of each year.

These tasks are very important to ensure not only the longevity of the equipment but, more importantly, to ensure the accuracy and validity of the data that is being reported.

Outlined herein are the tasks that should be performed by both parties throughout each maintenance interval. There may also be instances where it is deemed that the manufacturer should be involved outside of scheduled maintenance intervals.

Collection of data is the responsibility of the end user.

Operational Tasks

Programming

The programming of the stations will remain in control of the user; however the manufacturer should be informed of any changes to better facilitate any support at a later date. It is highly recommended that when the number of similar stations exceeds three, the program becomes standardized – ensuring that the data received from each station is consistent. Should the need be to have a significantly different program at a particular station, the name of this program should be changed to reflect this difference.

Syntax of the station program names should be as follows: NL_MET_mm_yyyy.CR1

This syntax allows for the quick identification that a particular station is operating the correct version of program as per the standards set in this manual.

Programs should incorporate metadata at the beginning of the program. This metadata is used to describe the location of the station, program author and revisions that have been made to the program. If incorporating metadata in the program is not preferred, then adding a metadata file on the Datalogger is also an option. The following format should be used for denoting revisions in the Meta Data section:

Revision Number:
Date:
Revised By:
Reason for Revision(s):
Revision(s) made:
The most recent revision is to be located above all others. A copy of the program can be viewed in Appendix A.

Program Data Output

The program which operates the measurement sequence as well as the storage of data has a fixed hourly output. These outputs are produced based on *AES Guidelines for Co-Operative Climatological Autostations* (Environment Canada, 1992). The data output list is as follows:

Paramater	Output Type	Shef Code
Battery Voltage	Minimum	VB
Air Temperature	Average Last 1 Minute	TA
Relative Humidity	Average Last 1 Minute	XR
Dew Point	Sample	TD
Wind Speed	Average Last 10 Minutes	US
Wind Speed	Maximum	UP
Wind Speed	Time/Date when maximum occurred	N/A
Wind Direction	Sample at point of max Wind Speed	UR
Wind Direction	Average Last 10 Minutes	UD
Snow Depth	Sample	SD
Accumulated Snow	Sample	SF
Solar Radiation KJ/m2	Total	RI
Sun Hours	Total	RT
Barometric Pressure	Sample	PA
Precipitation	Total	PU

Maintenance

The end user shall be responsible for the year round maintenance to the station compounds as well as general cleaning of the system. It is recommended that the end user visit each site monthly. It is very important that prior to performing any work on the sensors or datalogger that the data be collected to prevent loss of data! During these visits a Weather Station Field Checklist shall be completed by the technician responsible for the station visited. See Appendix B

Replacement and inspection of sensors, specific parts, and materials should be done according to Appendix C For efficiency, planning station visits according to the maintenance schedule is advisable.

The manufacturer will visit each site on a yearly basis or when otherwise required. The purpose of this visit will be to calibrate the necessary sensors in order to ensure optimal measurements. After completion of this trip, the manufacturer will provide the end user with maintenance logs documenting the calibrations and, where possible, before and after values.

Grounds

The grounds inside the compound should be kept in good order. High grass and weeds pose a problem for access to the station and may impede the measurements performed by the SR50A snow depth sensor.

Task	Responsible Party
Mowing and Edging	ENVC Regional Staff
General Maintenance and Trash Removal	ENVC Regional Staff

Equipment

Maintenance on equipment is split between the end user and manufacturer/supplier. General maintenance and cleaning is generally performed by the end user while factory calibrations are generally performed through Campbell Scientific Canada.

CR1000 Datalogger

Figure 1: CR1000 Datalogger

The CR1000 datalogger requires very little maintenance. The CR1000 utilizes non-volatile memory. This means that the memory of the data logger is kept powered using an internal ½" AA battery. These batteries should be replaced every 4 years or when its voltage falls below 3 VDC. This voltage will be noted on the manufacturer's maintenance log every year.

All Campbell Scientific dataloggers should be factory calibrated every 24 months to ensure the measurement accuracy of all channels and desiccant remains fresh. Field calibrations are not possible for any datalogger.

To send in a CR1000 datalogger for calibration, it is not required to remove the wires from the wiring panel. The datalogger module can be removed from the wiring panel and replaced with another for calibration purposes by removing the two thumb screws on the back side and gently pulling the two apart. Reverse this process to install the newly calibrated datalogger module.

Task	Responsible Party
½ AA Battery Backup Check and Replacement	ENVC Environmental Monitoring Specialist
Biennial CR1000 Calibration	Campbell Scientific Canada

Snow Depth

Figure 2: SR50A Snow Depth Sensor

The SR50A snow depth sensor requires very little maintenance. During each site visit, the condition of the measurement transducer should be noted. If the transducer becomes pitted or begins to peel, it should be replaced. If replacement is not immediately possible, it should be noted so that it may be replaced during the manufacturer's visit.

During the manufacturer field visit, the SR50A will be inspected. The desiccant inside the transducer will be replaced and if required, the transducer will be replaced with a new unit. The measurement known as Distance to Ground will also be taken and entered into the program if required. This distance is critical in measuring Total Snowfall. Making this measurement every year will account for any settling or shifting in the sensor's targeted surface.

Task	Responsible Party
Transducer Inspection	ENVC Regional Staff / ENVC Environmental Monitoring Specialist
Desiccant Replacement	Campbell Scientific Canada
Distance to Ground Confirmation / Update	ENVC Environmental Monitoring Specialist / Campbell Scientific Canada

Precipitation

Figure 3: TE525WS with CS705 Snowfall Adaptor

Precipitation gauges should be kept clear of debris in the spring, summer and fall months. Debris, such as leaves, causes a delay of the flow of water into the sensing mechanism. In some cases, debris may stop the water flow altogether. Because smaller debris may also be deposited into the inside of the gauge, it is a good practice to remove and clean both the funnel and bucket portion of the unit. It is also crucial to note if the bucket is level when cleaning. Tipping bucket rain gauges must be level in order for the tipping mechanism to be activated by the proper amount of water. An unlevelled sensor may require more water to activate, causing inaccurate readings.

In the winter months (November to April) the CS705 snowfall adapter should be installed on the tipping bucket rain gauge to facilitate the measurement of snowfall as precipitation. The CS705 requires minimal maintenance, however frequent visits should be made especially during high snowfall events as the antifreeze solution may become slushy causing inaccurate or no measurements. Refer to the CS705 Snowfall Adapter Instruction Manual (Campbell Scientific, Inc., 2014), Section 8 to determine the freeze up characteristics.

During site visits, it is essential to verify the slot in the top of the overflow tube is free from ice or debris and remove any debris from the catch orifice. If the slot in the overflow tube becomes plugged, the overflow tube my create a siphon and draw down the antifreeze level.

The Tipping Bucket Rain Gauge calibration is verified using a known volume of water. Should the instrument not report the expected number of tips, the unit will be calibrated and rechecked to ensure the proper calibration.

Task	Responsible Party
General Maintenance and Debris Removal	ENVC Regional Staff
Deployment and Maintenance of Snowfall Adapter	ENVC Regional Staff / Environmental Monitoring Specialist
Calibration Check	Campbell Scientific Canada

Solar Radiation

Figure 4: Sp Lite Pyranometer

Solar Radiation measurements rely on a clear south-facing view of the sky. The best maintenance for a solar radiation sensor is to keep the lens clean and free of debris and dust. A cleaning of this sensor will be performed by the manufacturer during their visit; however, should errors occur in the measurements between visits, a cleaning by the end user may be required to correct the problem. Use water or alcohol and a clean cloth or paper towel to clean the lens. Care should be taken to ensure the lens does not become scratched as this can affect the accuracy of the measurement.

Solar radiation sensors are not field serviceable nor can they be field calibrated. The Sp Lite requires a factory calibration that is recommended every 24 months. If required, the SP Lite can be removed by the manufacturer and returned to the factory for calibration while on site.

Task	Responsible Party
Lens Cleaning	ENVC Regional Staff / Environmental Monitoring Specialist
Calibration	Campbell Scientific Canada

Wind Speed and Direction

Figure 5: 05103(AP)-10 Anemometer

While the sensor deployed on the stations is generally maintenance free, it is important when on-site to take note of any irregularities. It is common for birds to perch upon these sensors and occasionally cause them to crack and/or bend. It is also possible that the sensor could develop problems with its internal bearings. This often cannot be diagnosed without removing the sensor. If the bearings are degraded enough, however, it may be possible to hear them as they spin. If either of these conditions are observed, please make arrangements as soon as possible to have the sensor repaired or replaced as poor bearing performance will reduce the sensors ability to produce accurate readings.

During the manufacturer visit, these sensors will be cleaned and the flange bearings replaced. On alternate years (approximately every 24 months) along with the flange bearings, the vertical shaft bearings and internal potentiometer will also be replaced. Since the calibration is affected after a potentiometer replacement, this unit will require calibration every 24 months; however calibration verification should be performed to ensure accurate data. Any other parts that require replacement will be replaced when noted.

Task	Responsible Party
Audio / Visual inspection of bearings	ENVC Regional Staff / ENVC Environmental Monitoring Specialist
Bearing Replacement	ENVC Environmental Monitoring Specialist
Potentiometer Repalcement	Campbell Scientific Canada
Calibration Check	Campbell Scientific Canada / Environmental Monitoring Specialist?

Barometric Pressure

Figure 6: 61302V Barometer

The barometric sensor is located inside the fiberglass enclosure. This sensor requires no maintenance on behalf of the end user.

During manufacturer site visits, the QDP Hydro Vent hydrophobic filter will be checked and replaced if required. The 61302V is not field serviceable nor can it be field calibrated. While on site the manufacturer will verify the readings to ensure they are within operating specifications. The sensor should be factory calibrated every 12 months.

Task	Responsible Party
Annual Calibration	Campbell Scientific Canada

Temperature and Relative Humidity

Figure 7: HMP45C Temperature and Relative Humidity Sensor

These sensors are installed in a radiation shield. The purpose of this shield is to provide cover from direct sunlight while allowing proper ventilation to effectively equalize the temperature of the sensor with the outside air temperature. Because this aspiration is critical to the accuracy of the measurement, the end user should ensure that the shield is kept clear from debris.

During the manufacturer visit, the sensor will be cleaned and calibrated noting before and after values. While the temperature sensor in general does not require replacement, the relative humidity sensor on occasion does require replacement. If the Relative Humidity (RH) sensor is deemed defective, it will be replaced and the sensor calibrated.

It should be noted that, with the exception of Sandy Brook station, all ENVC weather stations make use of the HMP45C sensor for these parameters. This sensor has been discontinued due to difficulty in purchasing replacement parts. Budgets should allow for the replacement of these sensors sometime in the future ensuring continuous operation.

Task	Responsible Party
Calibration Check	Campbell Scientific Canada
RH Sensor Replacement	Campbell Scientific Canada

Snow Water Equivalency

Figure 8: CS725 Snow Water Equivalency Sensor

This sensor requires no maintenance on behalf of the end user or the manufacturer; however, it should be returned to the factory for factory maintenance every 7 years. **This instrument utilises a fine bead-like insulation called Aerogel Nanogel manufactured by Cabot Corporation. DO NOT DISSASEMBLE OR OPEN THE CS725 PRIOR TO OBTAINING THE PROPER MSDS AND INSTRUCTION SHEETS!

Task	Responsible Party
Maintenance and Calibration	Campbell Scientific Canada

Imagery

Figure 9: CC640 Web Cam

The installed camera is housed in an environmental enclosure, however, the enclosure is not completely air tight and so there is a requirement for the use of desiccant in the enclosure. While it is hard to determine the duration that the desiccant would remain effective, it is good practice to replace the desiccant in the enclosure 6 months following the manufacturer visit with a minimum of two 4 unit (large) packages. The lens on the enclosure should also be kept clean to ensure the best possible image quality.

During the manufacturer visit, the lens of the CC640 will be cleaned as well as desiccant packs replaced to ensure no moisture infiltration throughout the year. Moisture infiltration can cause images to take on a "psychedelic" appearance.

Task	Responsible Party
Focus Adjustment and aiming	ENVC Regional Staff / ENVC Weather Station Specialist
Desiccant Replacement	ENVC Regional Staff / ENVC Weather Station Specialist
Lens Cleaning	ENVC Regional Staff / ENVC Weather Station Specialist

Winter Considerations

During winter months, special considerations should be observed, especially regarding ice accumulation on sensors.

Solar radiation and wind measurements, in particular, are most affected by this. The solar sensor can accumulate ice and snow causing an inaccurate or no reading condition while the wind instrument may report reduced speed measurements and incorrect direction measurements. For this reason, it is important to report wind direction standard deviation in order to diagnose this as a potential inaccuracy in the data.

The CS705 snowfall adapter requires approximately 2.5 Gallons of 1:1 mix of PGE (propylene glycol : ethanol) or equivalent with the addition of eight ounces of a low-freezing-point, environmentally-safe oil to the antifreeze reservoir to be effective. By covering the entire liquid surface with oil the antifreeze solution is prevented from evaporating. Some unscented baby oils (lightweight mineral oil) work well.

The PGE solution becomes more dilute as precipitation is captured and mixed. Initially, the CS705 is charged with a pure antifreeze mixture giving it a 1:0 antifreeze: water ratio. The ratio increases to 1:1 with the equivalent of six inches of precipitation, 1:2 with eight inches, and 1:3 with nine inches. The 1:1 solution becomes slushy at a temperature of ~ -35oC, the 1:2 solution becomes slushy at ~ -20oC, and the 1:3 solution at ~ -10oC (McGurk, 1992). Ratios greater than 1:3 are not recommended.

Returning Equipment to Manufacturer

Prior to shipping any equipment, contact must be made with a Campbell Scientific Canada employee (DJ Snodgrass or Christina Dymond, see Appendix D) to request a Return Materials Authorisation (RMA) form. The completed form demands that any contaminated equipment is treated to eliminate any possible exposure of equipment technicians to harmful substances. The completed forms can be packed with the equipment and shipped to Campbell Scientific Canada.

Summary

The maintenance and upkeep of Environment and Conservation's Quick Deploy Weather Systems is split between government personnel and Campbell Scientific Canada staff; this document attempts to outline the responsibilities between both parties.

Site visits should be made frequently to weather stations for general upkeep and site maintenance. Each visit should be documented (according to the Weather Station Field Checklist). Typically, maintenance to specific parts, sensors, and replaceable materials is on a six to twelve month basis (according to the Maintenance Schedule). Careful planning of maintenance activities and general station maintenance will help keep visits to a minimum.

For further information about the function of each sensor and maintenance methods, see Appendix E

Appendix A CRBasic Program

```
Program: GooseBayMet.CR1
'Declare Public Variables
Public PTemp
Public batt_volt
Public AirTC
Public RH
Public WS_kph
Public WindDir
Public Solar_Raw
Public Solar_KJm2
Public Solar_MJm2
Public Solar_Wm2
Public SR50(2)
Public Temp_Corr_Distance
Public Snow_Depth
Public BaroPressure
Public RainFall_mm
Public P
Public Offset
Public Inter_Air(2)
Public Inter_Wind(4)
Public DewPointHrly
Public Accum_Snow(2)
Public RF1
Public RF1Sunshine
Public GoesResult
Public GoesTime(4)
Public ClkValues(7)
Public Pressure_Timer
Public SR50AFlag As Boolean
Public BaroFlag As Boolean
Public GoesSetupFlag As Boolean
Public Picture_Aquire_Flag As Boolean
Dim So
Dim CalendarDay
Dim MinIntoDay
Dim JDay100
Dim Sin_d
Dim Cos_d
Dim EqnTime
Dim Sin_1
Dim RTime(9)
Dim HrMin
Alias Inter_Wind(1) = WS_kph_Hrly
Alias Inter_Wind(2) = WD_Hrly
Alias Inter_Wind(3) = WD_STD_DEV
Alias Inter_Air(1) = Air1MinAvg
Alias Inter_Air(2) = RH1MinAvg
Alias Accum_Snow(1) = SnowDepth
Alias Accum_Snow(2) = AccumulatedSnow
Alias SR50(1)=Raw_Dist
Alias SR50(2)=SignalQuality
Alias RTime(1)=Year
Alias RTime(4)=HourOfDay
Alias RTime(5)=MinOfHour
Alias RTime(9)=DayOfYear
Units PTemp = Deg C
Units batt_volt = Volts
Units Air1MinAvg = Deg C
Units RH1MinAvg = %
Units WS_kph = km/h
Units WS_kph_Hrly = km/h
Units WD_Hrly = Degrees
Units WD_STD_DEV = Degrees
Units SnowDepth = CM
Units AccumulatedSnow = CM
Units BaroPressure = KPA
Units RainFall_mm = mm
Units Solar_Wm2 = W/m2
Units Solar_KJm2 = KJ/m2
Units Solar_MJm2 = MJ/m2
Units So=W/m2
Units RF1=W/m2
Units RF1Sunshine=Hrs
'Define Data Tables
ConstTable
'Declare the initial distance of the SR50A from the ground in m
Const Initial_Distance = 2.356
'Declare the SolarCal Sensitivity Number
Const SolarCal = 73
'Declare Elevation for Pressure Compensation
Const Elevation = 10
Const Latitude = 53.20
' To calculate LongitudeCor use the following formula:
' Lc = (Ls - L)/15
' where Lc = Longitude Correction
' Ls = Standard Time Meridian
' L = Station Longitude
' Make sure To use Ls For the proper Time Zone of
' station As follows:
' Time Zone Ls
' NST 52.5
' AST 60
' EST 75
' CST 90
' MST 105
' PST 120
Const LongitudeCor = -0.0166
EndConstTable
DataTable (MinuteAir,1,2)
TableHide
DataInterval (0,1,Min,10)
```

```
Average (1,AirTC,FP2,False)
Average (1,RH,FP2,False)
EndTable
DataTable (TenMinuteWind,1,2)
TableHide
DataInterval (0,10,Min,10)
WindVector (1,WS_kph,WindDir,FP2,False,0,0,0)
EndTable
DataTable (Hourly,1,-1)
DataInterval (0,60,Min,10)
Minimum (1,batt_volt,FP2,False,False)
FieldNames ("Min_Battery:VB")
Sample (1,Air1MinAvg,FP2)
FieldNames ("Air1MinAvg:TA")
Sample (1,RH1MinAvg,FP2)
FieldNames ("RH1MinAvg:XR")
Sample (1,DewPointHrly,FP2)
FieldNames ("DewPointHrly:TD")
Sample (1,WS_kph_Hrly,FP2)
FieldNames ("WS_kph_Hrly:US")
Maximum (1,WS_kph,FP2,False,True)
FieldNames ("WS_kph_Max:UP")
SampleMaxMin (1,WindDir,FP2,False)
FieldNames ("WindDir_Peak:UR")
Sample (1,WD_Hrly,FP2)
FieldNames ("WD_Hrly:UD")
Sample (1,Snow_Depth,FP2)
FieldNames ("Snow_Depth:SD")
Sample (1,AccumulatedSnow,FP2)
FieldNames ("New_Snow:SF")
Totalize (1,Solar_KJm2,FP2,False)
FieldNames ("Solar_KJ/m2:RI")
Totalize (1,RF1Sunshine,FP2,False)
FieldNames ("RF1Sunshine:RT")
Sample (1,BaroPressure,FP2)
FieldNames ("BaroPressure:PA")
Totalize (1,RainFall_mm,FP2,False)
FieldNames ("RainFall_mm:PU")
EndTable
'Subroutine to calculate sunshine hours
Sub SunshineCalc
'Bright Sunshine calculation from Pyranometer measurement
'Calculates the following parameters:
'So Potential solar radiation at the top
' of the atmosphere on a horizontal
' surface.
'0.5 * So Threshold solar radiation value.
'Sunshine Computed from measured radiation AND
' threshold figure.
'Reference: Campbell Scientific Technical Note
'NOTE!! Calculations require that the correct station
' latitude AND longitude are set in the ConstTable
CalendarDay=(DayOfYear*24+HourOfDay)-7
If CalendarDay<0 Then CalendarDay=CalendarDay+8760
CalendarDay=CalendarDay*.04167
JDay100=CalendarDay*.01
Sin_d=(-.37726)+(-.10564*JDay100)+(1.2458*(JDay100^2))+(-.75478
If CalendarDay>=180 Then
EqnTime=JDay100-1.8
EqnTime=(-.05039)+(-.33954*EqnTime)+(.04084*(EqnTime^2))+(1.8
Else
EqnTime=(-.04056)+(-.74503*JDay100)+(.08823*(JDay100^2))+(2.0
EndIf
'Cosine Computation from Trigonometric Identity
' COS(d) = SQRT(1 - SIN²(d)
Cos_d=SQR (1-(Sin_d^2))
'Elevation Angle of Sun (phi)
' SIN(phi) = SIN(d) SIN(l) + COS(d) COS(l) COS[15(t-To)]
' where d = solar declination angle
' l = station latitude
' t = clock time
' To = time of solar noon
'
' To = 12 - Lc - Et (hr)
' Lc = longitude correction
' Et = Equation of Time
MinIntoDay=((HourOfDay*60)+MinOfHour)-420
If MinIntoDay<0 Then MinIntoDay=MinIntoDay+1440
Sin_1=(SIN (Latitude)*Sin_d)+((SIN (Latitude+90))*Cos_d*(SIN ((
If Sin_1<0 Then Sin_1=0
So=Sin_1*1373*.5
If Solar_Wm2>=So AND Sin_1>=0.1 Then
RF1Sunshine=0.00139
ElseIf Sin_1<0.1 Then
RF1Sunshine=0
Else
RF1Sunshine=0
EndIf
EndSub
'Main Program
BeginProg
'Enter Goes setup for station.
GOESSetup (GoesResult,&HA1B0015AE,10,79,300,0,100,"00_01_00_00"
SerialOpen (Com4,115200,4,0,10000)
Accum_Snow(1) = 0
SetStatus("USRDriveSize",1700000)
Scan (5,Sec,0,0)
PanelTemp (PTemp,250)
Battery (batt_volt)
RealTime(RTime())
PortSet(1,1)
Delay(0,150,mSec)
'Measure Air Temperature
VoltSe(AirTC,1,mV2500,1,True,0,_60Hz,0.1,-40.0)
'Measure RH
VoltSe(RH,1,mV2500,2,True,0,_60Hz,0.1,0)
```

```
PortSet(1,0)
If RH >=100 AND RH <=108 Then RH = 100
'Measure Wind Speed
PulseCount (WS_kph,1,1 ,1,1,.3528,0)
'Measure Wind Direction
BrHalf(WindDir,1,mV2500,3,1,1,2500,True,0,_60Hz,355,0)
If WindDir>=360 Then WindDir=0
If WindDir < 0 Then WindDir=0
'Measure Solar Radiation
VoltDiff (Solar_Raw,1,mV250,3,True ,0,_60Hz,1.0,0)
Solar_KJm2 = Solar_Raw*(5 *(1/SolarCal))
Solar_Wm2 = Solar_Raw *(1000/SolarCal)
Solar_MJm2 = Solar_KJm2/1000
Call SunshineCalc
'Calculate the Pressure correction Factor
P = 1013.25 * ( 1 - ( 1 - Elevation/44307.69231 ) ^5.253283 )
'Measure Barometric Pressure
If TimeIntoInterval(59,60,Min) OR BaroFlag = True Then
SW12(1)
EndIf
If TimeIntoInterval(0,60,Min) OR BaroFlag = True Then
Offset = 600 + P
VoltDiff (BaroPressure,1,mV2500,4,True ,0,_60Hz,0.2,Offset)
BaroPressure = BaroPressure *.1
SW12(0)
Pressure_Timer = Timer(1,Sec,3)
EndIf
'Measure RainFall
PulseCount (RainFall_mm,1,2,2,0,0.254,0)
'Measure the SR50A:
'Use SDI12 command "M1!" to receive Distance
'and Signal quality from the SR50AT
If TimeIntoInterval(0,15,Min) Then SR50AFlag = True
If SR50AFlag = True Then
SDI12Recorder (SR50(),3,0,"M1!",1,0)
SR50AFlag = False
EndIf
'Use Air_Temp to calculate corrected distance:
Temp_Corr_Distance=Raw_Dist*(SQR((AirTC+273.15)/273.15))
'Subtract the corrected distance from the initial distance of
Snow_Depth=Initial_Distance-Temp_Corr_Distance
'Calculate New Snow value and total Depth in centimeters
If TimeIntoInterval(0,1,hr) Then
Accum_Snow(2) = ((Snow_Depth* 100) - Accum_Snow(1))
Accum_Snow(1) = (Snow_Depth * 100)
EndIf
CallTable MinuteAir
CallTable TenMinuteWind
If TimeIntoInterval(0,60,min) Then
GetRecord (Inter_Wind(),TenMinuteWind,1)
GetRecord (Inter_Air(),MinuteAir,1)
DewPoint (DewPointHrly,Inter_Air(1),Inter_Air(2))
EndIf
CallTable Hourly
'Pulse Port P2 to cause CC640 to take an image.
If Picture_Aquire_Flag = True Then
PulsePort(2,20000)
Picture_Aquire_Flag = False
EndIf
If TimeIntoInterval(45,60,Min) Then PulsePort (2 ,20000)
'Send Goes Data
If TimeIntoInterval (1,60,Min) Then
GOESData (GoesResult,Hourly,0,1,1)
EndIf
If GoesSetupFlag = True Then
GOESSetup (GoesResult,&HA1B0015AE,10,79,300,0,100,"00_01_00
GoesSetupFlag = False
EndIf
NextScan
EndProg
```

Appendix B Weather Station Field Checklist

Weather Station Field Checklist

Date	
Time	
Weather Station Visited	
Staff Present	
Weather Conditions	
General Inspection	☐ Compound Secure ☐ Lock Functional Notes:
Snowfall Adapter	☐ Installed Snowfall Adapter for snow season ☐ Removed Snowfall Adapter for summer ☐ Antifreeze in good Condition ☐ New Antifreeze Added Amount of Antifreeze Added:________________________ ☐ Drain Line Functional ☐ Emptied Drain Reservoir Notes:
Data Variance	☐ Data Variance Form Completed Notes:
Logger/Communication Box	☐ Cleared Snow/Ice Accumulation ☐ Replaced Desiccant ☐ Manually Downloaded Data ☐ Verified Measurements are being performed Notes:
Site Maintenance	☐ Mowed Compound & Perimeter ☐ Sensors Cleaned as required Notes:

Appendix C Maintenance Schedule

CAMPBELL SCIENTIFIC (CANADA) CORP. RECOMMENDED EQUIPMENT MAINTENANCE & PART REPLACEMENT SUMMARY

Interval (months)	Model Number	Replacement Part Number	Parts Required/Maintenance Action Description	Quantity
	SR50A-316SS	L4091	Replacement Desiccant	2
6	SBP270	Done at Site	Compare to Standard	N/A
	CS100 / CS106	Done at Site	Compare to Standard	N/A
	013A/014A	M1898	Met One Bearing	2
		L1184	Reed Switch	1
	05103	R05163PG	Flange Bearing, for Nose Cone (Grease Filled)	2
	05106	R05124VG	Vertical Shaft Bearing (Grease Filled)	2
		R05163PW	Flange Bearing, Nose Cone/Waterproof Grease	2
	05305	R05324	Vertical Shaft Bearing (Oil Filled)	2
		R27122	Flange Bearing, for Nose Cone (Oil Filled)	2
	85000 / 85004	Verify Calibration	Compare to Standard or Wind Tunnel Calibration	N/A
	81000	Verify Calibration	Compare to Standard or Wind Tunnel Calibration	N/A
	HC-S3 / HC2-S3	C2091 (HC-S3)	Clean Radiation Shield, Clean or Replace Filter Cap when Required	N/A
12	HMP45C HMP45CF HMP45C212	HMP45C-PET	Sensor Performance Evaluation Test	N/A
	32500	Calibration	Sensor Recalibration	N/A
	CC5MPX	C2641	Replacement Desiccant	3
	All Tipping Bucket Rain Gauges	Calibration	Calibration	N/A
	SR50 / SR50A	DSC 50/2/L4091	Inspect Annually	1
	SR50A-316SS	L4091	Replacement Desiccant	2
		C2258	SR50A-316 Maintenance Kit	1
	SBP270	Done at Site	Compare to Standard	N/A
	CS100 / CS106	Done at Site	Compare to Standard	N/A
	61302V, 61205V, 61202L	Calibration	Sensor Calibration	N/A
	61302V, 61205V, 61202L	Calibration	Sensor Calibration	N/A
	SR50A-316SS	L4091	Replacement Desiccant	2
18	SBP270	Done at Site	Compare to Standard	N/A
	CS100 / CS106	Done at Site	Compare to Standard	N/A
	013A/014A	M1898	Met One Bearing	2
		L1184	Reed Switch	1
	023A/024A	M1898	Met One Bearing	2
24		M1656 / L2905	Met One Potentiometer	1
	05103	R05163PG	Flange Bearing, for Nose Cone (Grease Filled)	2
		R05124VG	Vertical Shaft Bearing (Grease Filled)	2
		R05133B	Potentiometer 10k 0.25% Lin Cond Plastic	1
	05106	R05124VG	Vertical Shaft Bearing (Grease Filled)	2

Interval (months)	Model Number	Replacement Part Number	Parts Required/Maintenance Action Description	Quantity
		R05163PW	Flange Bearing, Nose Cone/Waterproof Grease	2
		R05133B	Potentiometer 10k 0.25% Lin Cond Plastic	1
	05305	R05324	Vertical Shaft Bearing (Oil Filled)	2
		R27122	Flange Bearing, for Nose Cone (Oil Filled)	2
		R05133B	Potentiometer 10k 0.25% Lin Cond Plastic	1
	85000 / 85004	Verify Calibration	Compare to Standard or Wind Tunnel Calibration	N/A
	81000	Verify Calibration	Compare to Standard or Wind Tunnel Calibration	N/A
	HC-S3 / HC2-S3	C2091 (HC-S3)	Clean Radiation Shield, Clean or Replace Filter Cap when Required	N/A
	HMP45C HMP45CF HMP45C212	HMP45C-PET	Sensor Performance Evaluation Test	N/A
	HMP60	L9598	RH Replacement Chip	1
	32500	Calibration	Sensor Recalibration	N/A
	CC5MPX	C2641	Replacement Desiccant	3
	All Kipp & Zonen Products	Calibration	Calibrate Sensor (Contact CSC)	N/A
	All Dataloggers	Calibration	Calibration (Contact CSC)	N/A
	All Tipping Bucket Rain Gauges	Calibration	Calibration	N/A
	SR50 / SR50A	DSC 50/2/L4091	Inspect Annually	1
	SR50A-316SS	L4091	Replacement Desiccant	2
		C2258	SR50A-316 Maintenance Kit	1
	SBP270	Done at Site	Compare to Standard	N/A
	CS100 / CS106	Done at Site	Compare to Standard	N/A
		Calibration	Sensor Calibration	N/A
	61302V, 61205V, 61202L	Calibration	Sensor Calibration	N/A
	All Dataloggers	Calibration	Calibration	N/A
	SR50A-316SS	L4091	Replacement Desiccant	2
30	SBP270	Done at Site	Compare to Standard	N/A
	CS100 / CS106	Done at Site	Compare to Standard	N/A
	013A/014A	M1898	Met One Bearing	2
		L1184	Reed Switch	1
	023A/024A	M1898	Met One Bearing	2
		M1656 / L2905	Met One Potentiometer	1
	05103	R05163PG	Flange Bearing, for Nose Cone (Grease Filled)	2
36	05106	R05124VG	Vertical Shaft Bearing (Grease Filled)	2
		R05163PW	Flange Bearing, Nose Cone/Waterproof Grease	2
	05305	R05324	Vertical Shaft Bearing (Oil Filled)	2
		R27122	Flange Bearing, for Nose Cone (Oil Filled)	2
	85000 / 85004	Verify Calibration	Compare to Standard or Wind Tunnel Calibration	N/A

Interval (months)	Model Number	Replacement Part Number	Parts Required/Maintenance Action Description	Quantity
	81000	Verify Calibration	Compare to Standard or Wind Tunnel Calibration	N/A
	HMP45C HMP45CF HMP45C212	HMP45C-PET	Sensor Performance Evaluation Test	N/A
	32500	Calibration	Sensor Recalibration	N/A
	CC5MPX	C2641	Replacement Desiccant	3
	All Tipping Bucket Rain Gauges	Calibration	Calibration	N/A
	SR50 / SR50A	DSC 50/2/L4091	Inspect Annually	1
		C1251/C2158	Replace Transducer Every Three Years (Note: This activity falls outside a 6/12 month maintenance interval).	1
	SR50A-316SS	L4091	Replacement Desiccant	2
		C2258	SR50A-316 Maintenance Kit	1
	SBP270	Done at Site	Compare to Standard	N/A
	CS100 / CS106	Done at Site	Compare to Standard	N/A
	61302V, 61205V, 61202L	Calibration	Sensor Calibration	N/A
	SR50A-316SS	L4091	Replacement Desiccant	2
42	SBP270	Done at Site	Compare to Standard	N/A
	CS100 / CS106	Done at Site	Compare to Standard	N/A
	013A/014A	M1898	Met One Bearing	2
		L1184	Reed Switch	1
	023A/024A	M1898	Met One Bearing	2
		M1656 / L2905	Met One Potentiometer	1
	05103	R05163PG	Flange Bearing, for Nose Cone (Grease Filled)	2
		R05124VG	Vertical Shaft Bearing (Grease Filled)	2
		R05133B	Potentiometer 10k 0.25% Lin Cond Plastic	1
	05106	R05133B	Potentiometer 10k 0.25% Lin Cond Plastic	1
		R05124VG	Vertical Shaft Bearing (Grease Filled)	2
		R05163PW	Flange Bearing, Nose Cone/Waterproof Grease	2
	05305	R05324	Vertical Shaft Bearing (Oil Filled)	2
48		R27122	Flange Bearing, for Nose Cone (Oil Filled)	2
		R05133B	Potentiometer 10k 0.25% Lin Cond Plastic	1
	85000 / 85004	Verify Calibration	Compare to Standard or Wind Tunnel Calibration	N/A
	81000	Verify Calibration	Compare to Standard or Wind Tunnel Calibration	N/A
	HC-S3 / HC2-S3	C2091 (HC-S3)	Clean Radiation Shield, Clean or Replace Filter Cap when Required	N/A
	HMP45C HMP45CF HMP45C212	HMP45C-PET	Sensor Performance Evaluation Test	N/A
	HMP60	L9598	RH Replacement Chip	1
	32500	Calibration	Sensor Recalibration	N/A
	CC5MPX	C2641	Replacement Desiccant	3

Interval (months)	Model Number	Replacement Part Number	Parts Required/Maintenance Action Description	Quantity
	All Kipp & Zonen Products	Calibration	Calibrate Sensor (Contact CSC)	N/A
	All Dataloggers	Calibration	Calibration (Contact CSC)	N/A
	All Tipping Bucket Rain Gauges	Calibration	Calibration	N/A
	SR50 / SR50A	DSC 50/2/L4091	Inspect Annually	1
	SR50A-316SS	L4091	Replacement desiccant	2
		C2258	SR50A-316 Maintenance Kit	1
	SBP270	Done at Site	Compare to Standard	N/A
	CS100 / CS106	Done at Site	Compare to Standard	N/A
		Calibration	Sensor Calibration	N/A
	61302V, 61205V, 61202L	Calibration	Sensor Calibration	N/A
	All Dataloggers	Calibration	Calibration	N/A
	HMP45C HMP45CF HMP45C212	C1413	RH Replacement Chip	1
60	All Tipping Bucket Rain Gauges	CALIBRATION	CALIBRATION	N/A
Interval marked as N/A	05103	R05145C	Potentiometer Mounting and Coil Assembly	1
	05106	R05145C	Potentiometer Mounting and Coil Assembly	1
	05305	R05145C	Potentiometer Mounting and Coil Assembly	1
	HMP45C HMP45CF HMP45C212	C1472, C853	Small and Large O-Rings, Respectively	1 Each
		C959	Replacement Filter Cap	1
	All Dataloggers	L4091	Replacement desiccant	
As Required		Reefer to Manual	Check internal Li battery voltage and replace if less than spec	1 – 2
	SBP270	SBP270 Cal	Sensor calibration	N/A
	CS547A-L	C1769, C1770, C1771	Calibration Solution (Dependent on background)	1
	CS526-L	C1540, C1541, C1542	pH Buffer solution	1 Each
	HMP45C HMP45CF HMP45C212	Done at Site	Clean Radiation Shield	N/A
	HMP60	Done at Site	Clean Radiation Shield	N/A
	CC5MPX	Done at Site	Wipe Lens Clean	N/A
Periodically		Done at Site	Inspect 3 O-Rings for wear	N/A
	All Kipp & Zonen Products	Done at Site	Wipe Sensor clean and check for level	N/A
	All Tipping Bucket Rain Gauges	Done at Site	Level and clean bucket of debris	N/A
	SBP270	DSC 50/2	Replace desiccant	1

Based on Rev. July, 2013.

Appendix D Sending Product to Factory for Calibration or Repair

In order to send any item to Campbell Scientific Canada for Calibration or repair, Return Materials Authorization must first be obtained.

To obtain an RMA, simply contact your Campbell Scientific Canada measurement consultant or measurement specialist.

DJ Snodgrass
Atlantic Region Representative
506-261-9461
DJ.Snodgrass@Campbellsci.ca

Christina Dymond
Measurement Consultant
780-733-8452
Christina.Dymond@Campbellsci.ca

Upon receiving your RMA from CSC, you will notice two attachments. The first attachment contains printable shipping labels containing our factory address to which you will ship your item. Simply print and attach to your package.

The second attachment is what's referred to as the Product Decontamination or PCD form.

It is the policy of Campbell Scientific (Canada) Corp. (CSC) to protect the health of our employees and provide a safe working environment. In support of this policy, CSC requires this form be completed for all product returns. Potential for contamination may include water or soil related applications, configured weather systems, or exposure to hazardous materials, chemicals, insects or animals (including feces).

Use this form to describe the environment from which the equipment was taken, any hazardous substances to which the equipment was exposed, and the decontamination process performed. Include any MSDS (Material Safety Data Sheets) where applicable.

ANY RETURNS WITHOUT THIS COMPLETED FORM WILL NOT BE PROCESSED. If the form is not received within 3 business days of product receipt, or found to be incomplete, the product will be returned at the sender's expense. CSC reserves the right to refuse service on product where specific applications may cause health and safety concerns for its employees.

We apologize for any inconvenience but hope you understand and can support our focus on employee health and safety.

Appendix E Important Documents and Manuals

AES Guidelines for Co-Operative Climatological Autostations. (1992). Environment Canada. Retrieved from: http://www.jcommops.org/dbcp/doc/AES_Canada_Guide20.pdf on December 9, 2014.

CR1000 Measurement and Control System Instruction Manual (2013). Campbell Scientific, Inc. Retrieved from: https://s.campbellsci.com/documents/ca/manuals/cr1000_man.pdf on December 9, 2014.

SR50A Sonic Ranging Sensor Instruction Manual. (2014). Campbell Scientific, Inc. Retrieved from: https://s.campbellsci.com/documents/ca/manuals/sr50a_man.pdf on December 9, 2014.

TE525 Tipping Bucket Rain Gauge Instruction Manual. (2014). Campbell Scientific, Inc. Retrieved from: https://s.campbellsci.com/documents/ca/manuals/te525_man.pdf on December 9, 2014

CS705 Snowfall Adapter Instruction Manual. (2014). Campbell Scientific, Inc. Retrieved from: https://s.campbellsci.com/documents/ca/manuals/cs705_man.pdf on December 9, 2014.

SP Lite2 Pyranometer Instruction Manual. (2014). Campbell Scientific, Inc. Retrieved from: http://s.campbellsci.com/documents/ca/manuals/splite2_man.pdf on December 9, 2014

R.M. Young Wind Monitors 05103, 05103-10, 05106, 05106-10, 05108, 05108-10, 05305, 05305-10 Instruction Manual. (2014). Campbell Scientific, Inc. Retrieved from: https://s.campbellsci.com/documents/ca/manuals/rmy_man.pdf on December 9, 2014.

Model 61302L Barometric Pressure Sensor. (2014). R. M. Young Company. Retrieved from: http://s.campbellsci.com/documents/ca/manuals/61302l_man.pdf on December 9, 2014.

HMP45C Temperature and Relative Humidity Probe Instruction Manual. (2014). Retrieved from: https://s.campbellsci.com/documents/ca/manuals/hmp45c_man.pdf on December 9, 2014.

CS725 Snow Water Equivalent Sensor Instruction Manual. (2014). Campbell Scientific, Inc. Retrieved from: https://s.campbellsci.com/documents/ca/manuals/cs725_man.pdf on December 9, 2014.

CC640 Digital Camera Instruction Manual. (2010). Campbell Scientific, Inc. Retrieved from: https://s.campbellsci.com/documents/ca/manuals/cc640_man.pdf on December 9, 2014.

Appendix F Detailed Sensor Maintenance

Snow Depth

As discussed above in the Equipment section (Page 4) the SR50 snow sensor contains a transducer that will eventually wear down and become pitted. See figure 10 below for an example of a pitted transducer foil. Note the yellow spots seen between the grate. Transducer foil should look fairly uniform across its surface. Bumps without color change can be left alone.

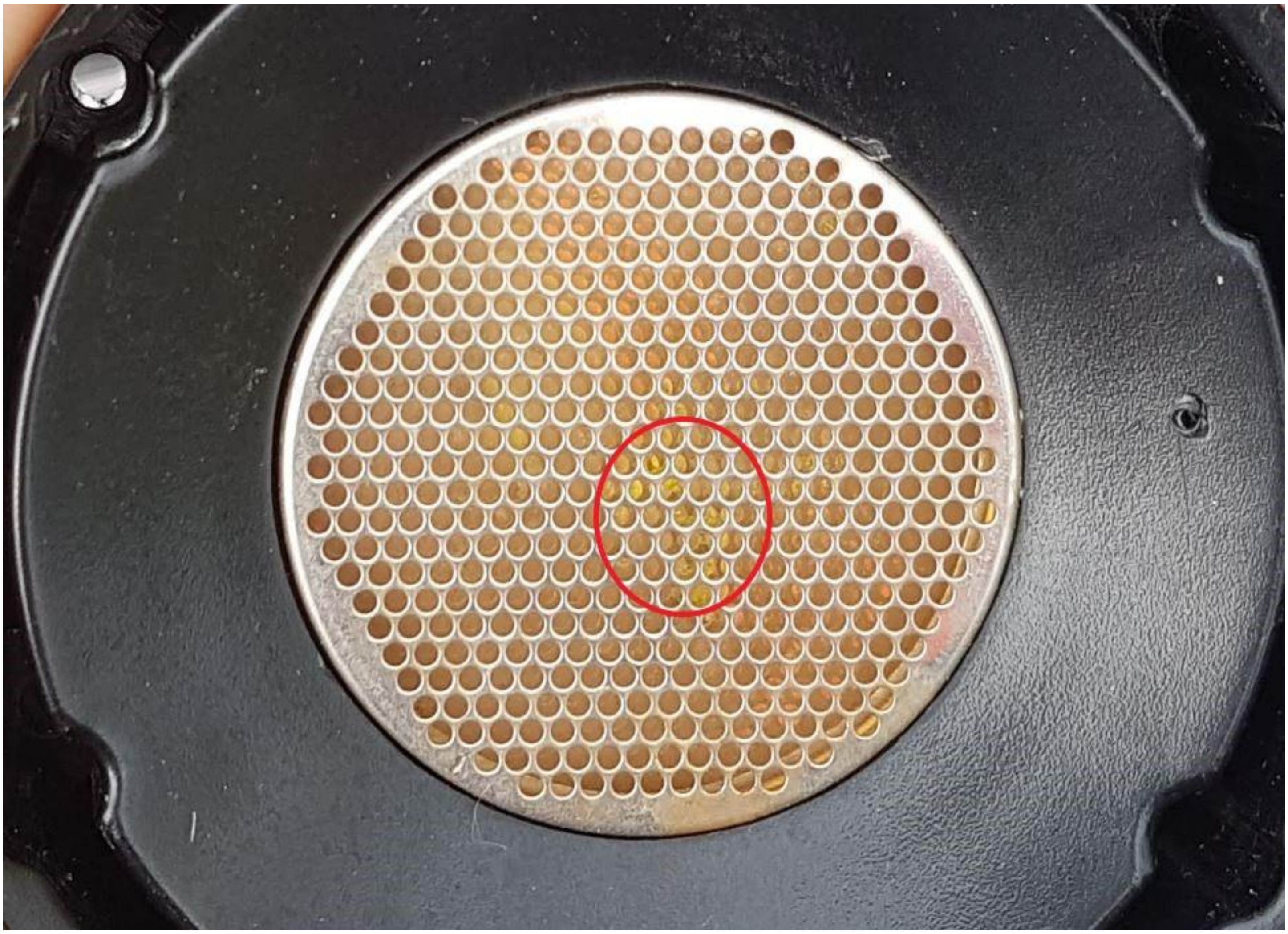


Figure 10: Pitted Transducer

A pitted transducer will give inaccurate distance measurements, and thus cause the DataLogger to receive the wrong value for how high the snow is off the ground. It should be noted that the SR50 at the Badger MET station has a special long lasting transducer foil. Something about the environment near Badger causes the foil on this sensor to degrade at a much quicker pace than those elsewhere on the island. It also does not have a grate separating it and the environment. The procedure for changing a pitted transducer is as follows:

Replacing the Pitted Transducer

1. Take power off sensor. Note the distance between the sensor and ground. Remove all 6 screws on the underside of the sensor in a star pattern. They are slightly hidden and deep down. Philips head. **Do not lose these screws, there are no extras**. After they are removed, the black section of the sensor should come off. It will still be attached by a few wires. Do not pull it off right away.

Figure 11: SR50 Screw Location

2. Unclip the wire from the small PCB board. Push the small clip on the side the wires are connected to and pull out and away from the PCB board. Also note the notched section on the transducer (left circle). This notch must line up with the corresponding bit on the sensor base when it is put back together.

Figure 12: SR50 Wire Clip

3. Set aside old transducer for waste. Remove old O-Ring from sensor base.

Figure 13: O-Ring Removal

4. Get new Transducer Kit from supplies. Each kit should contain everything shown in the below image. Check foil of transducer, make sure there are no wrinkles. Work backwards to install. Apply O-Ring with **NO** silicone or any type of lubrication. Just dry.

Figure 14: Transducer Kit

5. Fill the compartment in the perimeter of the new transducer with fresh mini desiccant packs (included, see Figure 14, left. See below Figure 15 for placement).

Figure 15: Desiccant Packs Placement

6. Clip wire back into place on sensor base. Ensure eject clip is facing out so as to ensure ease of access for the next individual to replace the transducer. Hold transducer to base of sensor and replace the 6 Philips head screws, again in a star pattern. If cable ties were removed, replace them and make sure to create a new dew loop.
7. When tower is back up, measure the new distance between the bottom of the sensor and ground. In the DataLoggers program insert the new distance from ground value to ensure accurate readings from the SR50 sensor. Rename the stations program file and append todays date. Ensure the sensor is level with respect to ground so it does sense at an angle. An angle to ground will always be longer than a straight line to ground, resulting in a measurement that is higher than reality.

Temperature and Relative Humidity

There are two main types of Temp/RH sensors in the current climate station network. These are the HMP45C and HC-S3. Both models are from CampbellSci Inc., but the HMP45C is older and more difficult to find parts for. The HC-S3 requires a proprietary, difficult to get cable from CampbellSci in order to calibrate. Alternatively, CampbellSci has an exchange program where they will send calibrated replacement heads for HC-S3 sensors to be swapped out and the old heads need to be sent back to CampbellSci so they can be recalibrated.

When calibrating relative humidity sensors of any kind, note the current humidity value the DataLogger is reading before calibration and the value after the calibration has completed to check for any sensor drift.

Swapping the HC-S3 Sensor Head

1. Locate the radiation shield that is housing the HC-S3 sensor. Unscrew the split nut at the bottom that holds the sensor in place and remove from the shield.

Figure 16: Radiation Shield

2. Twist the sensor head so that the four dots shown below line up. This is the unlocking mechanism and will allow you to remove the head. Remove the old head and set aside. **<u>DO NOT LOSE THIS SENSOR HEAD. THIS WILL NEED TO BE SENT BACK TO CAMPBELLSCI FOR CALIBRATION.</u>**

Figure 17: HC-S3 Locked (Top) and Unlocked (Bottom)

3. Lock new sensor head onto mount and place back in radiation shield. Tighten split nut on bottom to ensure sensor remains in the shield. If cable ties were removed, replace them and ensure a dew loop is formed.
4. Check temperature measurement values from this sensor if CampbellSci exchange program was used. CampbellSci carries multiple different HC-S3 heads rated for different temperatures. If a -40°C rated sensor gets replaced by a -50°C rated sensor, all temperatures will be off by 10°C. Add an offset if the new sensor is rated for a different temperature than the old.

Calibrating the HMP45C

1. Prepare the Vaisala HMK15 salt solutions (see picture below) at least 24 hours before attempting calibration on HMP45C sensors. The 11% RH (LiCl) and 95% RH (K_2SO_4) solutions will be required for calibration. To prepare these solutions follow these instructions exactly:
    a. Measure 12ml of ion exchanged water and pour into the LiCl chamber
    b. Measure 10ml of ion exchanged water and pour into the K_2SO_4 chamber
    c. Measure 15g or 18ml of dry LiCl salt and **<u>SLOWLY</u>** sprinkle salt into LiCl chamber
        i. **<u>NOTE:</u> This solution gets surprisingly hot. Exothermic reaction. Do not handle chamber.**
    d. Rinse and dry measurement cup with <u>ion exchanged water</u>
    e. Measure 30g or 20ml of dry K_2SO_4 salt and **<u>SLOWLY</u>** sprinkle salt into K_2SO_4 chamber
    f. When all salt has been sprinkled into the chamber, the saturated salt solution should have the ratio of approximately 60-90% undissolved salt to 40-10% liquid. Cover the chambers with the included caps

Figure 18: Vaisala RH Calibration Kit

2. Remove the HMP45C from the radiation shield by loosening the split nut at the bottom of the shield.

Figure 19: HMP45C Radiation Shield

3. Remove the black plastic tip of the HMP45C along with the white filter that is inside it. **Be aware the chip underneath is very delicate.** A scratch could completely throw off readings. Scrape any residue on the inside of the black tip where the treads are to clean it and ensure it won't be too difficult to remove next time. Remove the filter inside with a screwdriver. Set aside tip and filter (**do not lose**), shift focus to rest of HMP45C.

Figure 20: Filter Removal

4. Inspect the sensor for any damage. Detach the sensor head from the base and check the connection pins. Note the pins will only connect to the sensor head in a certain orientation. Place sensor head back into base, be aware that it will only attach one way. Do not force the sensor on as the pins may break.

Figure 21: HMP45C Pins

5. Place connected sensor unit into the **LOW END** (i.e., LiCl, RH = 11%) salt solution first. The chip on the RH sensor should **NOT** be submerged into the solution, it should be held by the rubber stoppers just above the solution. Connect a field laptop with LoggerNet installed to the DataLogger and connect to the station. Over approximately 30 minutes, keep an eye on the RH value. Let it run until the value no longer changes by a significant amount.

    NOTE: The HMP45C is only accurate to the nearest ±2% while being field calibrated on the low end. Any value between 9-13% for the low end humidity is an acceptable value.

Figure 22: HMP45C Suspended Over LiCl Solution

6. While the HMP45C is equalizing, clean the filter and sensor tip with alcohol and a kim wipe. Let it stand to dry afterwards.

Figure 23: Alcohol/Kim Wipe Treatment

7. After the RH value on the DataLogger stops fluctuating, determine how close to the target humidity you are and make small adjustments with a small flat-head screwdriver to the screw marked **D** (dry) on the HMP45C until the reading on the DataLogger gets closer to the required 11%. NetLogger will update approximately every 5 seconds, so after making a small adjustment make sure to wait until the value is updated before changing again.

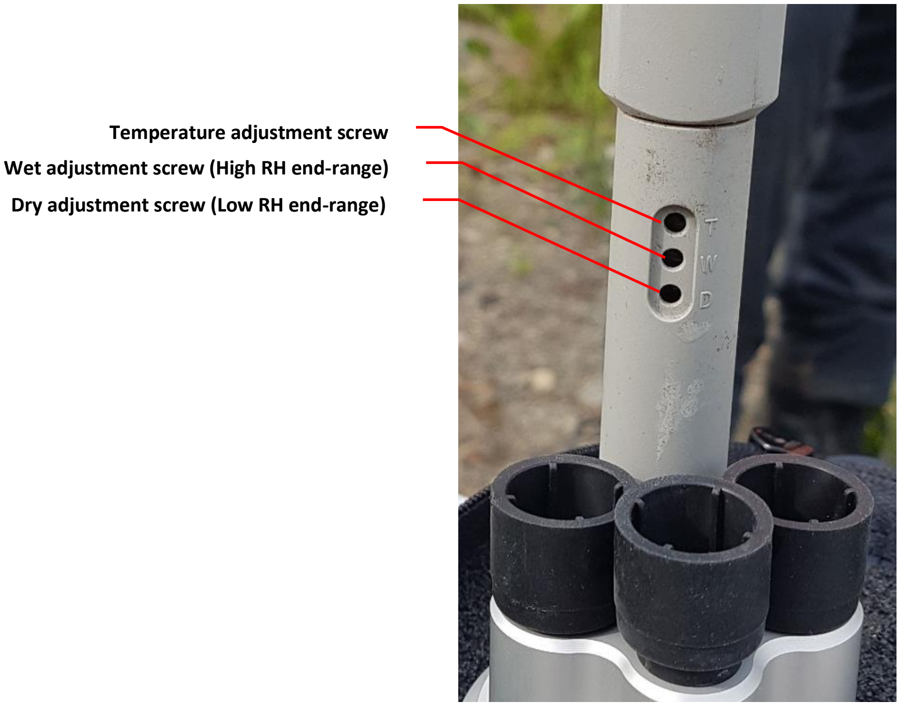


Figure 24: HMP45C Calibration

8. Once satisfied with what the DataLogger is showing, switch the HMP45C to the high end salt solution (i.e., K_2SO_4, RH = 95%). Again, the probe should hover over the solution, never getting submerged. This salt solution has a high reference of 95% relative humidity. As before, leave the sensor alone for about 30 minutes while the DataLogger's value equalizes.

    NOTE: For the high end reference, the sensor has an accuracy of ±3% resulting in an acceptable range of 92% - 98%.

9. If needed, make adjustments with a small flat-head screwdriver to the screw marked **W** (wet) on the HMP45C until the reading on the DataLogger gets closer to the required 92% - 98%. If no adjustment needed skip step 10.
10. **<u>If adjustment was required:</u>** the probe must be placed back into the low end reference to be rechecked. Repeat this process until the probe can go from low (11% ± 2%) reference to high (95% ± 3%) without needing to be adjusted. The probe is now properly calibrated.
11. With the now dried filter and filter cap, reassemble the HMP45C. Place it back in its radiation shield and tighten the split nut. If cable ties were used before, replace them and make sure to create a dew loop for excess moisture.

Precipitation

The tipping bucket at each weather station does not require an extensive amount of maintenance. If it is getting close to winter, the CS705 Snow Adapter should be installed. If it is spring and the snowfall adapter is in place, it should be removed.

1. Remove the wind guard to get access to the bucket. Lift up on the bar where the two red circles are.

Figure 25: Tipping Bucket Wind Guard

2. Check inside the catch and the bucket itself for any debris. Remove all debris as it could effect the measurements from the bucket.

Figure 26: Debris in Tipping Bucket

3. Replace wind guard when finished.

Wind Speed and Direction

The potentiometer has a life expectancy of approximately fifty million revolutions. As it becomes worn, the element may begin to produce noisy signals or become nonlinear. When signal noise or nonlinearity becomes unacceptable, replace the potentiometer. This is generally every two years. The anemometer also contains two sets of bearings, a pair in the nose cone assembly and a pair in the vertical shaft bearing rotor. The bearings in the nose cone assembly should be replaced on a yearly basis, and the bearings in the vertical shaft bearing rotor should be replaced, along with the potentiometer, every two years.

Note: Most of the parts in an anemometer are held in place with set screws. The included R.M. Young allen key is used to loosen/tighten these screws. Be aware they do not require much loosening/tightening to operate. The maximum allowed set screw torque is 80 oz-in.

Removing the Anemometer from the Tower

1. Take power off sensor. Remove anemometer from tower. After tower is lowered and anemometer is in reach, open junction box cover and document wiring connections with a picture and handwritten notes. Full wiring diagram available at end of section.

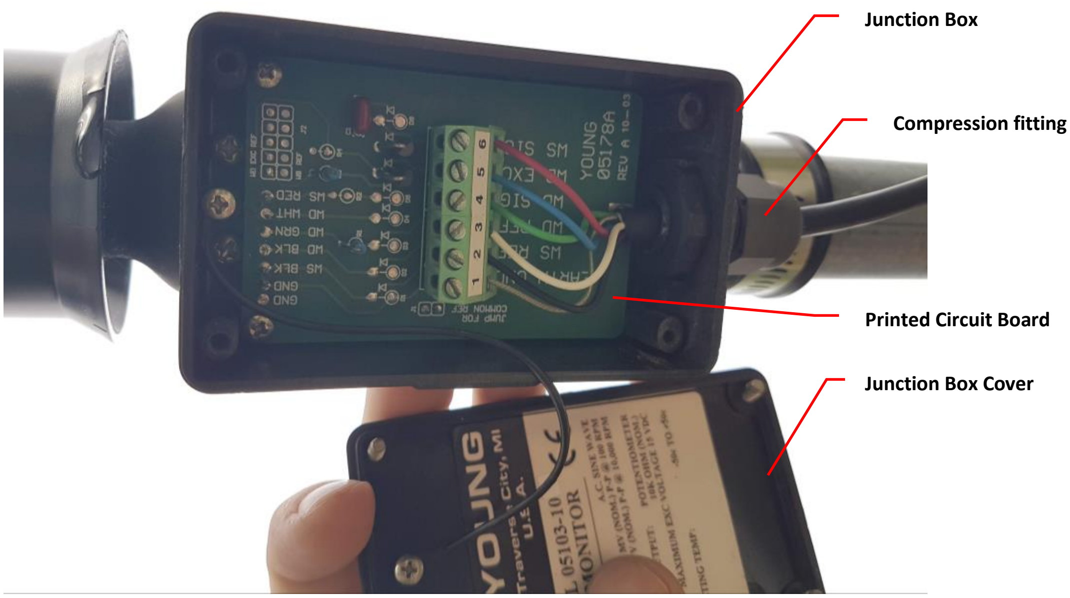


Figure 27: Anemometer Junction Box

2. Loosen flat head screws in terminal block that hold the six wires to the printed circuit board, and pull wires away from board.
3. Loosen compression fitting where cable enters into anemometer junction box and remove cable.
4. Loosen band clamp closest to the anemometer and pull anemometer off tower assembly. **Ensure that the band clamp holding the orientation ring in place is not loosened.** There is a small bump on the lip of the orientation ring that has been oriented to face due south when the tower is up. **This can not be moved.**

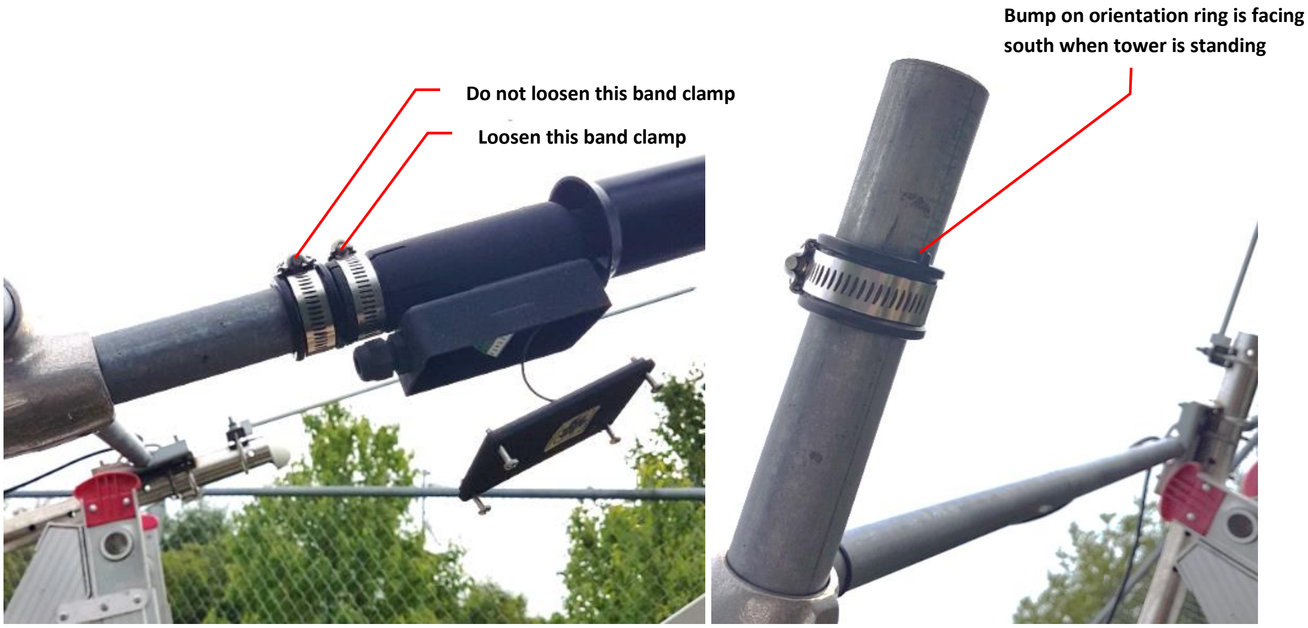


Figure 28: Anemometer Band Clamps

Changing the Speed Bearings – Nose Cone Assembly

1. Unscrew nose cone from main housing. Inspect O-Ring and if loose set aside for later use.

Figure 29: Nose Cone Assembly

2. Loosen set screw on magnet shaft collar and remove magnet.

Figure 30: Magnet Set Screw

3. Slide propeller shaft out of nose cone assembly.

Figure 31: Propeller Shaft

4. Remove dust cap which covers the front bearing. Remove both front and rear flange bearings from nose cone assembly. Use propeller shaft to push out front and rear flange bearings.

Figure 32: Flange Bearings

5. Insert new front and rear flange bearings into nose cone. They only fit in one orientation. Replace front bearing dust cap. Slide propeller shaft through bearings and ensure the shaft does not knock one or both of the bearings out of place.
6. Place magnet on propeller shaft and use an R.M. Young gap tool (Bearing Gap Gage) to allow 0.5mm (0.020") clearance from the rear flange bearing. Use the smaller end of the gap tool to set appropriate clearance.

Figure 33: Bearing Gap Gage

7. Tighten the set screw on the magnet shaft collar. If only the flange bearings are being replaced this particular year, screw the nose cone assembly back into the main housing and proceed with reattaching the anemometer to the tower.

Potentiometer and Vertical Shaft Bearing Replacement

Since the potentiometer and vertical shaft bearings both get replaced every two years, it is advisable to always do both of these replacements at the same time.

1. While holding the junction box securely, gently push down on the main housing latch with other hand. Pull vertical shaft bearing rotor down and out of the main housing.

Figure 34: Removing Vertical Shaft from Housing

2. Remove the three screws holding the printed circuit board to the junction box. Desolder the two wind speed coil wires (red, black, shorter than the other wires), then desolder the three potentiometer wires (white, green, black) and ground wire (clear). Desoldering the short wires first simply makes the other wires easier to work with.

Figure 35: Desoldering PCB Board

3. Loosen set screw on potentiometer coupling and remove it from potentiometer adjust thumbwheel.

Figure 36: Mounting Post Assembly – Potentiometer Coupling

4. Loosen set screw on potentiometer adjust thumbwheel and remove it from potentiometer shaft extension.

Figure 37: Removing Potentiometer Adjust Thumbwheel

5. Loosen set screws (two) at base of transducer assembly and remove from mounting post assembly. Set aside transducer assembly for potentiometer replacement.

Figure 38: Transducer Assembly Removal

6. Remove vertical shaft bearing rotor by sliding it upward off the mounting post assembly.

Figure 39: Vertical Shaft Bearing Rotor

7. Remove top and bottom vertical bearings and install new bearings. When inserting new bearings, be careful not to apply pressure to the bearings shields. Slide vertical shaft bearing rotor with new bearings back on to mounting post assembly. Ensure the housing latch points away from the junction box.

8. Unscrew the potentiometer housing from the potentiometer mounting and coil assembly.

Figure 40: Potentiometer Housing

9. Unravel the four potentiometer wind direction wires (white, green, thin black, thin red) from the two wind speed coil wires (red, black) and push potentiometer out of potentiometer mounting and coil assembly by applying firm but gentle pressure on potentiometer shaft extension.

Figure 41: Potentiometer Location

10. Ensure new potentiometer has an O-Ring on its shaft extension. Push new potentiometer into potentiometer mounting and coil assembly while lining the wires up with the notch created for them. Twist all six wires together (four from potentiometer – wind direction and two from transducer – wind speed) and feed all wires through the hole in the bottom of the potentiometer housing.

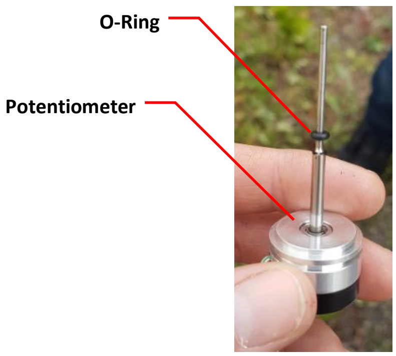


Figure 42: Potentiometer O-Ring and Feeding Wires

11. Screw potentiometer housing onto potentiometer mounting and assembly coil, pull through any extra slack, and apply a small amount of silicone sealant around the hole the wires are fed through.

Figure 43: Apply Silicone

12. Install transducer assembly on vertical shaft allowing 0.5mm (0.020") clearance from vertical bearing. Use the large end of the bearing gap gage. Tighten set screws (two) at bottom of transducer assembly.

Figure 44: Vertical Rotor Gap

13. Using needle-nose pliers or a solder hook, gently pull the six twisted potentiometer/transducer wires through the small hole in the junction box. Solder the wires back onto the printed PCB board according to wiring diagram. Observe the color code carefully. Secure circuit board in junction box using three screws removed in step 2. Do not overtighten.
14. Place potentiometer adjust thumbwheel on potentiometer shaft extension and tighten set screw.
15. Place potentiometer coupling on potentiometer adjust thumbwheel. **<u>Do NOT tighten set screw yet.</u>**
16. Place main housing over vertical shaft bearing rotor until potentiometer coupling is near the top of the main housing. Turn potentiometer adjust thumbwheel until potentiometer coupling is oriented to engage ridge in top of main housing. Set screw on potentiometer coupling should be facing the front opening. Ensure all parts highlighted below are in this orientation.

Figure 45: Insertion of Vertical Shaft

Calibration of the Anemometers Wind Direction Potentiometer

The new potentiometer that has been placed in the anemometer will be set at a random value after the assembly is put back together. In order to set it on the correct resistance value to get accurate measurements, it needs to be calibrated.

1. Connect anemometer excitation voltage and signal conditioning electronics to terminal strip according to wiring diagram. With mounting post held in position so junction box, and thus the south notch, is facing due south place anemometer onto anemometer calibration stand as shown below.

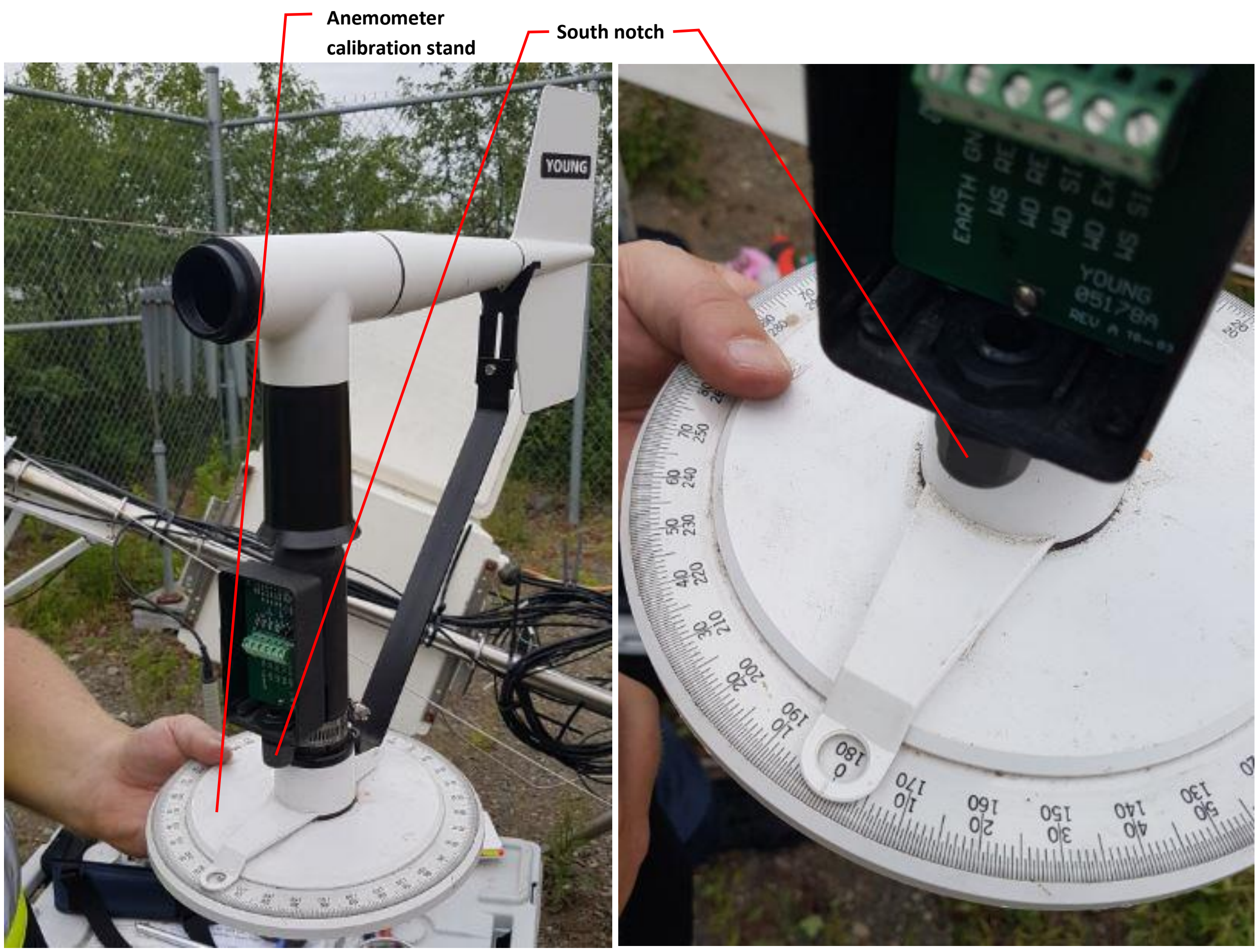


Figure 46: Anemometer Calibration Stand

2. Connect field laptop to the DataLogger and connect to the station through LoggerNet. Check the value of the wind direction in the table. If the wind direction does not read 180° when the stand shows 180° like above, reach into the main housing assembly and turn the potentiometer adjust thumbwheel. Wait approximately five seconds for LoggerNet to update and check the direction again. Repeat this process until LoggerNet reads 180°. The potentiometer adjust thumbwheel is <u>**VERY**</u> sensitive and even a small touch will change its value by a lot.
3. After making sure the anemometer reads 180°, when the stand is placed at 180°, tighten the set screw in the potentiometer coupling to ensure the potentiometer adjust thumbwheel does not move. Then check the other cardinal directions to ensure accuracy (e.g., 90°, 270°, 355°). The 355° direction is used as the potentiometer has a blind spot on its disc to make sure it doesn't short circuit itself. The anemometer will almost never read wind directions between 355-360°).

4. Reattach the nose cone assembly by screwing it into place until its O-Ring is seated in the main housing assembly. Be certain threads are properly engaged to avoid cross-threading. Spin the propeller and wait for a wind speed value to appear in the table on NetLogger. If a value appears, the wind speed transducer is working. No calibration is required for wind speed.
5. Slide anemometer back onto tower post. **<u>Make sure the peg on the orientation ring that was left on the tower matches up with the south notch on the junction box.</u>**

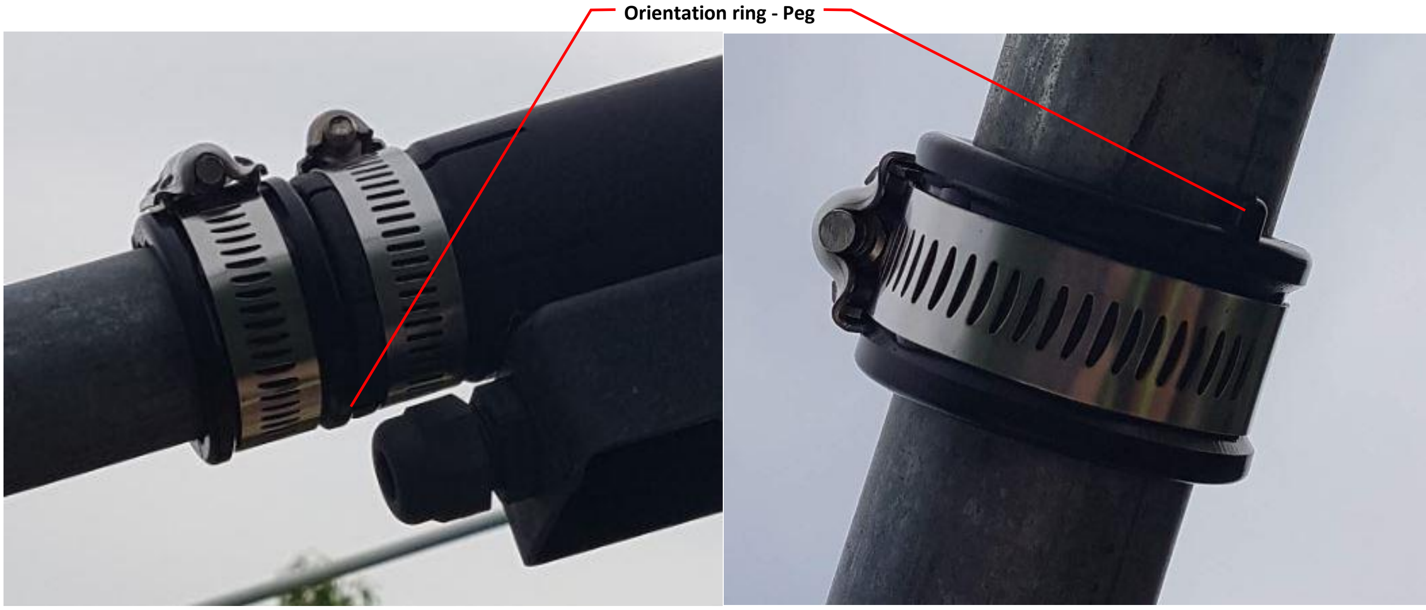


Figure 47: Tower Orientation Ring

6. If cable ties were used, replace any that were cut and make sure to create a new dew loop.

The following pages contain technical diagrams for the Anemometer's used in the Government of Newfoundland and Labrador's climate network.

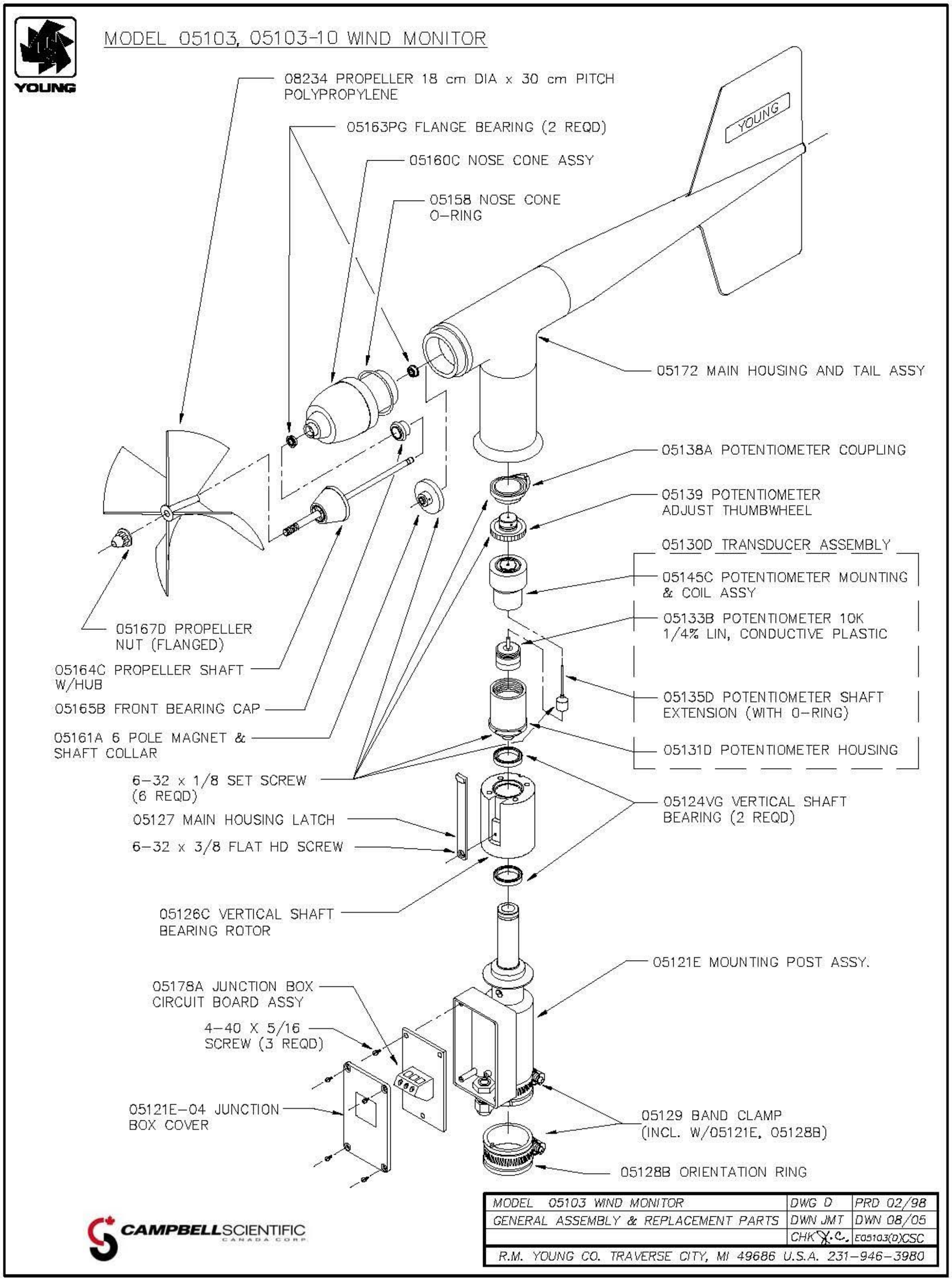


Figure 48: Anemometer Exploded View

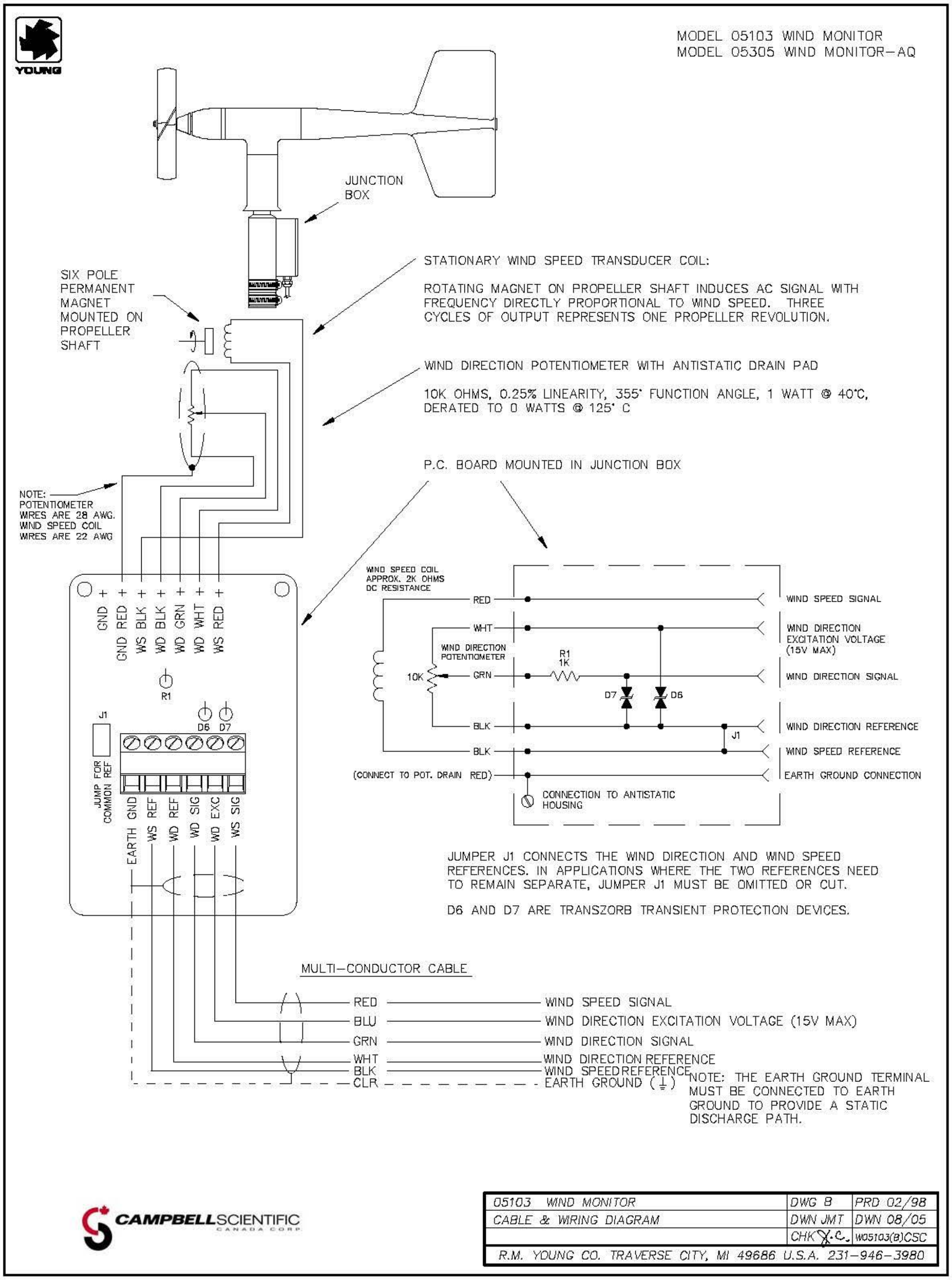
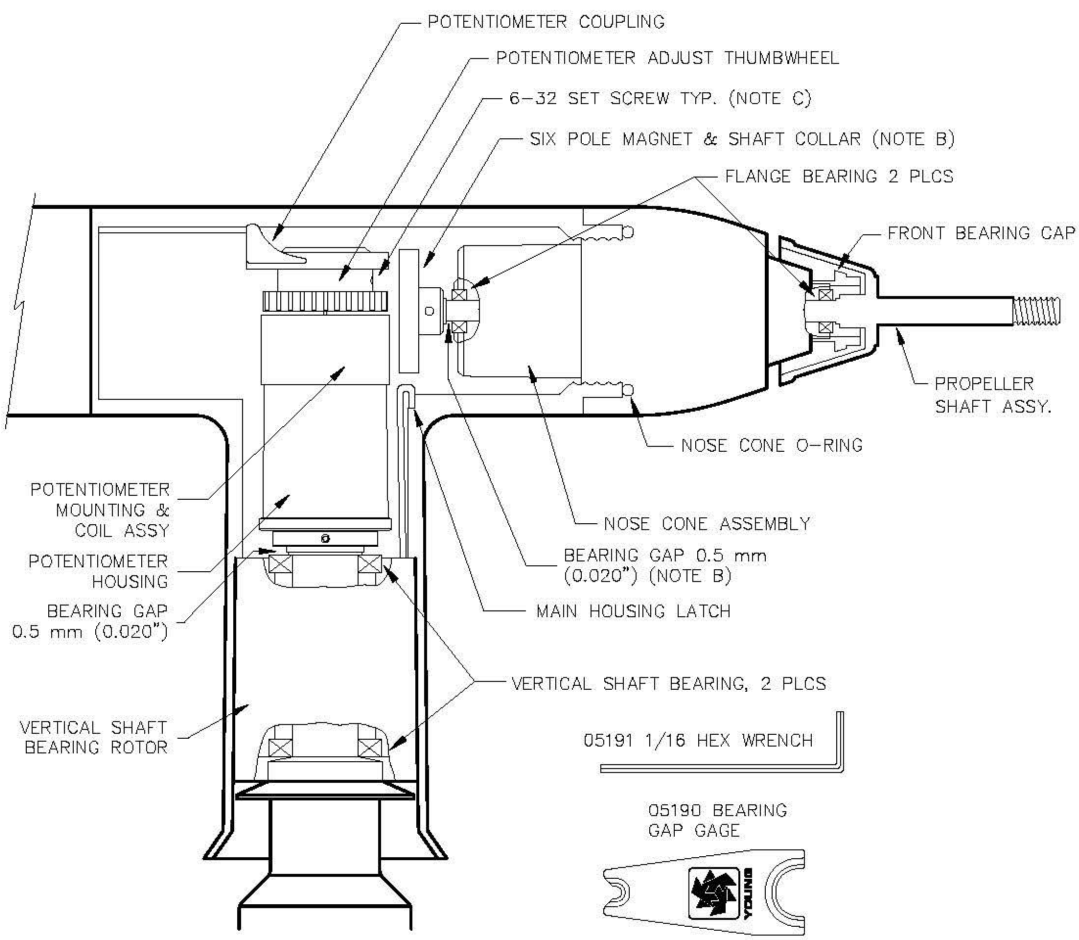


Figure 49: Anemometer Wiring Diagram

WIND MONITOR 05103, 05103-10, 05305, 05305-10 SECTION VIEW

BEARING REPLACEMENT/POTENTIOMETER ADJUSTMENT



NOTES:

A. TO REMOVE HOUSING – UNTHREAD NOSE CONE ASSEMBLY, PUSH MAIN HOUSING LATCH, LIFT UPWARD.

B. TO REPLACE ANEMOMETER FLANGE BEARINGS – UNTHREAD NOSE CONE, REMOVE SIX POLE MAGNET, SLIDE PROPELLER SHAFT AND HUB ASSEMBLY FOREWARD, REMOVE FRONT BEARING CAP AND FLANGE BEARINGS. AFTER BEARING REPLACEMENT, SET BEARING GAP TO 0.5mm (0.020")

C. TO ADJUST POTENTIOMETER OUTPUT SIGNAL – REMOVE NOSE CONE, LOOSEN SET SCREW IN POTENTIOMETER COUPLING, ADJUST OUTPUT SIGNAL BY MEANS OF POTENTIOMETER ADJUSTMENT THUMBWHEEL, RE-TIGHTEN SET SCREW.

CAMPBELLSCIENTIFIC CANADA CORP

WIND MONITOR SECTION VIEW	DWG B	PRD 02/90
BEARING REPLACEMENT/	DWN JMT	DWN 08/05
POTENTIOMETER ADJUSTMENT	CHK X.C.	505103(B)CSC
R.M. YOUNG CO. TRAVERSE CITY, MI 49686 U.S.A. 231-946-3980		

Figure 50: Quick Maintenance Guide

Imagery, Snow Water Equivalency and Solar Radiation

Imagery

- Check all connections between the camera and DataLogger
- If the camera is in an enclosure:
  - Inspect housing and check all locks/latches to make sure they are operable
  - Replace all desiccant packs
  - Remove any debris that made its way into the enclosure
  - Clean the enclosure window, inside and out
- If the camera is not in an enclosure:
  - Check to make sure it does not contain desiccant packs, if it does, replace them
- Wipe the camera lens
- Take a sample picture by connecting a field laptop to the DataLogger through NetLogger and forcing a trigger snap. Ensure this picture comes out fine. If focus/zoom adjustments need to be made, check image quality after every adjustment

Snow Water Equivalency

- Measure the distance between the bottom of the sensor and ground in centimeters.
- Connect to the DataLogger with a field laptop using NetLogger and open the stations program
- Make sure the GMON's distance to ground variable is equal to the new measurement
- Change the variable if it needs to be updated, save the new program with its name plus todays date and send it to the DataLogger

Solar Radiation

- Take a cotton swab, kim wipe, or Q-Tip and dab with alcohol
- Wipe lens on sensor **<u>carefully</u>**. Scratches on the lens may cause inaccurate measurements

Appendix G Equipment Required

This section outlines the materials required to complete a full weather station maintenance trip. Equipment will be sorted into sections based on the sensor or work they are required for. Always carry extra consumables. It is very easy to drop a small part on the ground and never find it again. If a sensor is not listed on this list, the required equipment has likely already been listed in the general section and there are no other specific components needed to complete its maintenance.

General

- Ladder
- Tower stand
- Winch
- General tools such as wrenches, pliers, allen keys, screwdrivers, hammer, etc.
- Sun screen
- Bug spray
- PPE
- Extra mounting hardware such as U-Bolts, nuts and bolts, etc.
- Shed/Site keys
- Desiccant
- Kim wipes/Q-Tips/cotton swabs
- Hand saw (for trees on the road)
- Table
- Extra DataLogger + Power cable
- Field laptop with LoggerNet installed
- Serial and RJ45 cables
- Alcohol
- Green pelican case (ADRS room)
- Camera
- Volcanized tape

Snow Depth

- Enough transducer kits for each station + extra (contains transducer, desiccant and O-Ring)
- Level
- Measuring tape

Temperature and Relative Humidity

- Vaisala salts kit (with salts prepared at least 24 hours in advance – see Temperature and Relative Humidity section of Appendix F Detailed Sensor Maintenance)
- Extra calibrated heads (HC-S3)
- Specialized HC-S3 calibrating cable (HC-S3 – Currently do not have one of these. Using calibrated heads from CampbellSci instead as cable is hard to get and expensive)
- Small allen key (HMP45C)

Wind Speed and Direction

- Anemometer calibration stand
- R.M. Young allen key (or any 1/16 allen key) and R.M. Young bearing gap gage tool
- For each sensor (bring extras):
  - Two speed bearings (small with flange)
  - Two vertical shaft bearings (large without flange)
  - Potentiometer
- Silicone sealant
- Solder and flux
- Battery operated soldering iron + extra batteries
- Solder sucker
- Extra anemometers (black pelican cases ADRS room)

Make sure to take LOTS of pictures. Get each sensor at different angles. Do a site tour to get images of the condition of the site itself. Record all serial numbers/models for inventory purposes.