TempVue™10

PT-100 RTD Class A Precision Air Temperature Sensor

RELIABLE MONITORING SINCE 1974

Campbell SCIENTIFIC®

Please read first

About this manual

Please note that this manual was originally produced by Campbell Scientific Inc. primarily for the North American market. Some spellings, weights and measures may reflect this origin.

Some useful conversion factors:

Area: 1 in^2 (square inch) = 645 mm^2

Length: 1 in. (inch) = 25.4 mm
1 ft (foot) = 304.8 mm
1 yard = 0.914 m
1 mile = 1.609 km

Mass: 1 oz. (ounce) = 28.35 g
1 lb (pound weight) = 0.454 kg

Pressure: 1 psi (lb/in^2) = 68.95 mb

Volume: 1 UK pint = 568.3 ml
1 UK gallon = 4.546 litres
1 US gallon = 3.785 litres

In addition, while most of the information in the manual is correct for all countries, certain information is specific to the North American market and so may not be applicable to European users.

Differences include the U.S standard external power supply details where some information (for example the AC transformer input voltage) will not be applicable for British/European use. Please note, however, *that when a power supply adapter is ordered it will be suitable for use in your country*.

Reference to some radio transmitters, digital cell phones and aerials may also not be applicable according to your locality. Some brackets, shields and enclosure options, including wiring, are not sold as standard items in the European market; in some cases alternatives are offered. Details of the alternatives will be covered in separate manuals.

Part numbers prefixed with a "#" symbol are special order parts for use with non-EU variants or for special installations. Please quote the full part number with the # when ordering.

Recycling information

At the end of this product's life it should not be put in commercial or domestic refuse but sent for recycling. Any batteries contained within the product or used during the products life should be removed from the product and also be sent to an appropriate recycling facility.

Campbell Scientific Ltd can advise on the recycling of the equipment and in some cases arrange collection and the correct disposal of it, although charges may apply for some items or territories.

For further advice or support, please contact Campbell Scientific Ltd, or your local agent.

Table of contents

1. Introduction

The TempVue™10 represents the next generation of air-temperature measurement sensors, meeting all relevant World Meteorological Organization (WMO[1]) temperature recommendations.

Designed with the customer in mind, the TempVue 10 easily interfaces with Campbell Scientific or third-party data loggers and fits a wide range of passive solar radiation shields. The sensor comes with a short, attached cable and terminates with an M12 connector, which provides exceptional convenience, environmental protection, and data integrity for use in a variety of applications. The TempVue 10 can be wired as a 2- or 4-wire PT-100 sensor, allowing full flexibility and compatibility with your systems.

2. Precautions

- READ AND UNDERSTAND the Safety section at the back of this manual.
- When opening the shipping package, do not damage or cut the cable jacket. If damage to the cable is suspected, consult with a Campbell Scientific support engineer.
- Although rugged, the TempVue 10 should be handled as a precision scientific instrument.
- Do not bend or damage the measurement tip of the TempVue 10 because this can affect the measurement quality and potentially damage the sensor.
- Do not modify or attempt to repair the TempVue 10 unit without consulting Campbell Scientific.
- This temperature probe meets UKCA and EU declarations of conformity, citing international standards applicable to the product.
- The TempVue 10 should not be buried in soil or submerged in water. Refer to www.campbellsci.com/soil-temperature or www.campbellsci.com/water-temperature for a list of sensors that are appropriate for soil, road surface, or water temperature applications.

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[1]WMO, 2008. See References (p. 20).

3. Initial inspection

- Upon receipt of the TempVue 10, inspect the packaging and contents for damage. File damage claims with the shipping company.

- Immediately check package contents against the shipping documentation. Contact Campbell Scientific about any discrepancies.

- The calibration certificate shipped with each TempVue 10 includes the Ratio of Rf to Rs (see Figure 3-1 [p. 2]). This value is unique for each sensor. Cross check this serial number on the certificate against the serial number on your sensor to ensure the given Ratio of Rf to Rs corresponds to your sensor. The ratio of Rf to Rs is used as the calibration factor as PRTs vary in their resistance at 0 degrees C, and this is the ratio (a multiplier) of the unit under test to its resistance at 0 C. This provides a more accurate calibration adjustment over a wider range of temperatures.
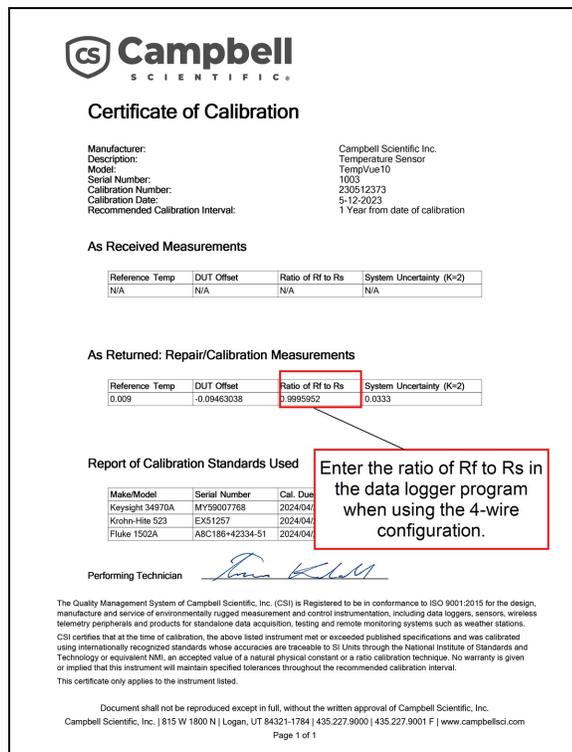
Figure 3-1. Example calibration certificate

- Table 3-1 (p. 3) shows the components typically shipped with the TempVue 10.

Table 3-1: TempVue 10 components			
Component	Quantity	Description	Image
TempVue 10	1	Measures air temperature	
Extension cable (ordered as an option)	1	Connects the sensor to the data logger	
Quick deploy guide	1	Provides siting, mounting, and wiring information	
Shield extender	1	Allows sensor to be housed in a 10-plate or 14-plate radiation shield.	
Calibration certificate	1	Provides the Rf to Rs ratio needed for programming.	

- Figure 3-2 (p. 4) shows the TempVue 10 and shield extender in the shipping box.

Figure 3-2. Box containing the TempVue 10 and shield extender.

- Refer to Installation in a radiation shield (p. 15) for instructions about attaching the extender tube to the TempVue 10 for use in longer radiation shields.

- Accessories and replacement parts are listed on the web site product page (see https://www.campbellsci.com/tempvue10).

4. QuickStart

A video that describes data logger programming using **Short Cut** is available at: www.campbellsci.com/videos/cr1000x-data logger-getting-started-program-part-3 ▶ . **Short Cut** is an easy way to program your data logger to measure the sensor and assign data logger wiring terminals. **Short Cut** is available as a download on www.campbellsci.com ↗. It is included in installations of **LoggerNet**, **RTDAQ**, and **PC400**.

The following procedure shows using **Short Cut** to program the TempVue 10.

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

2. Double-click the data logger model.

3. In the **Available Sensors and Devices** box, type TempVue 10. You can also locate the sensor in the **Sensors** > **Temperature** folder. Double click the sensor model. Type the **Ratio of Rf to Rs** value provided in the calibration certificate that was shipped with the sensor. The temperature defaults to degree C. This can be changed by clicking the **Temperature** box

and selecting one of the other options.
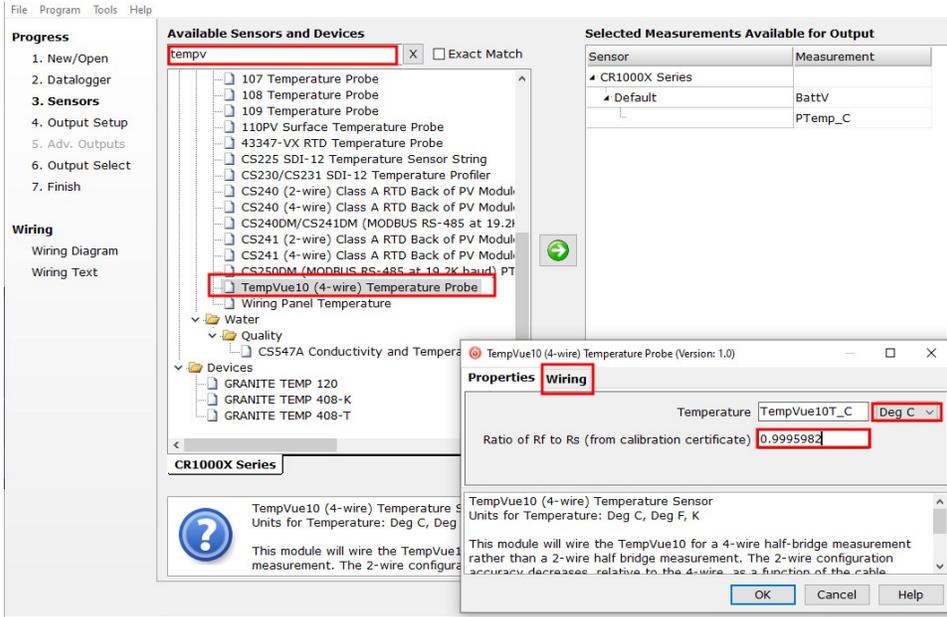
4. Click on the **Wiring** tab, wire the sensor, then click **OK**.
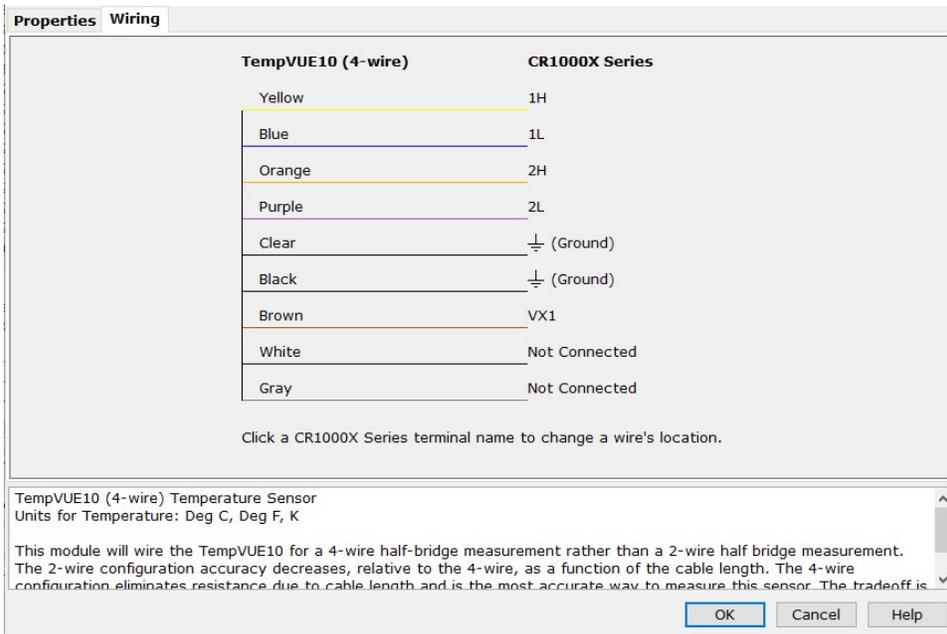
5. Repeat steps three and four for other sensors you want to measure. Click **Next**.

6. In **Output Setup**, type the scan rate, a meaningful table name, and the **Data Output Storage Interval**.
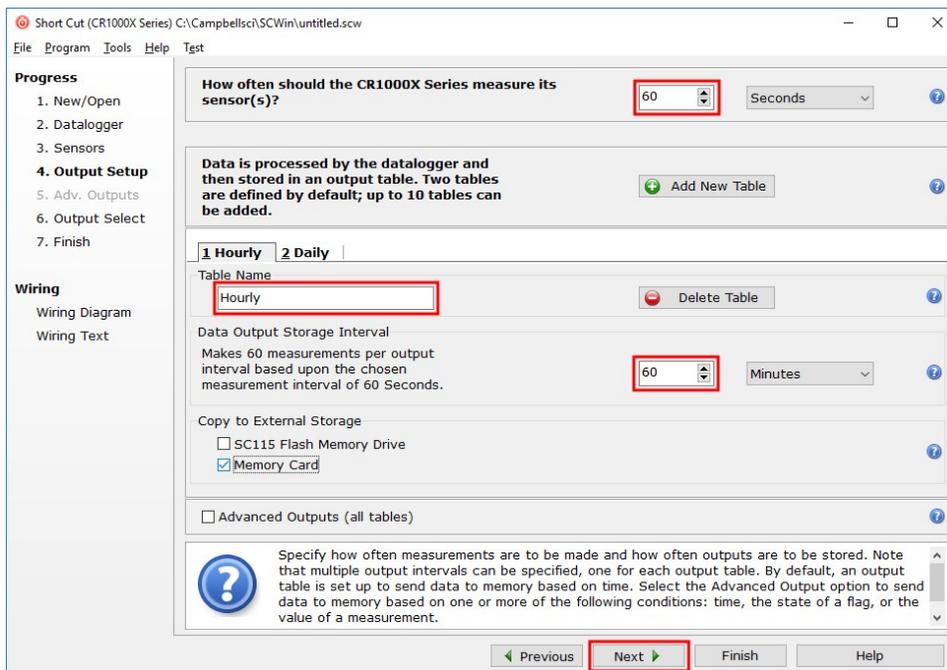
7. Select the measurement and its associated output option.
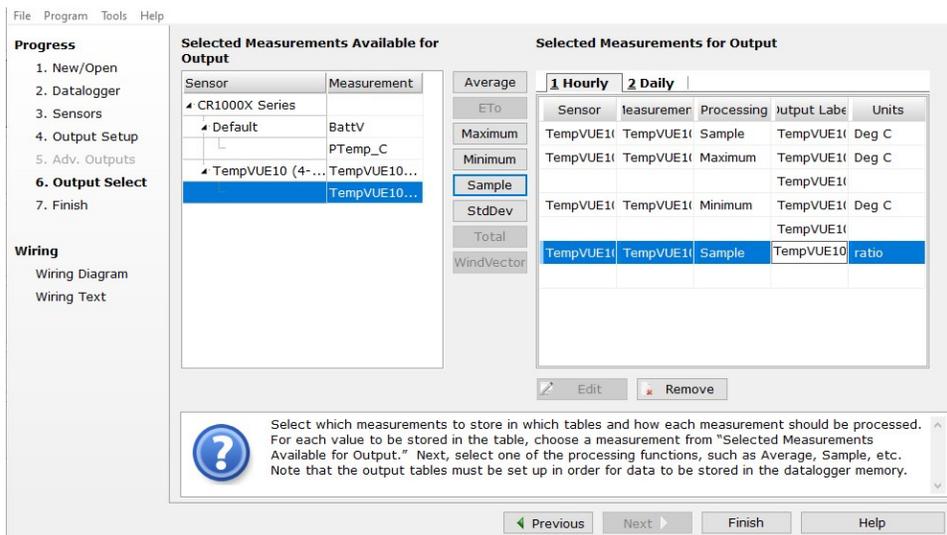
8. Click **Finish** and save the program. If the data logger is connected to the computer, send the program just created to the data logger.

9. If the sensor is connected to the data logger, check the output of the sensor in the data display in *LoggerNet*, *RTDAQ*, or *PC400* to make sure it is making reasonable measurements.

5. Overview

The sensor consists of a wire-wrapped, four-wire Pt100 Resistance Temperature Detector (RTD) element encapsulated in an epoxy-filled, stainless-steel housing. The thin yet robust housing, combined with the Pt100 sensing element, provide the first true WMO-compliant sensor to meet the 20-second step response time with an ambient wind speed of only 1 m/s (3.3 ft/s).

The TempVue 10 has a maximum measurement uncertainty of only 0.3 K over the entire measurement range of -80 to +60 °C, with only 0.1 Kelvin (K) over the most common temperature range of -40 to +40 °C.

When exposed to environments with high wind, sun, or precipitation levels, the TempVue 10 must be housed in a radiation shield, such as the RAD06 6-plate shield.
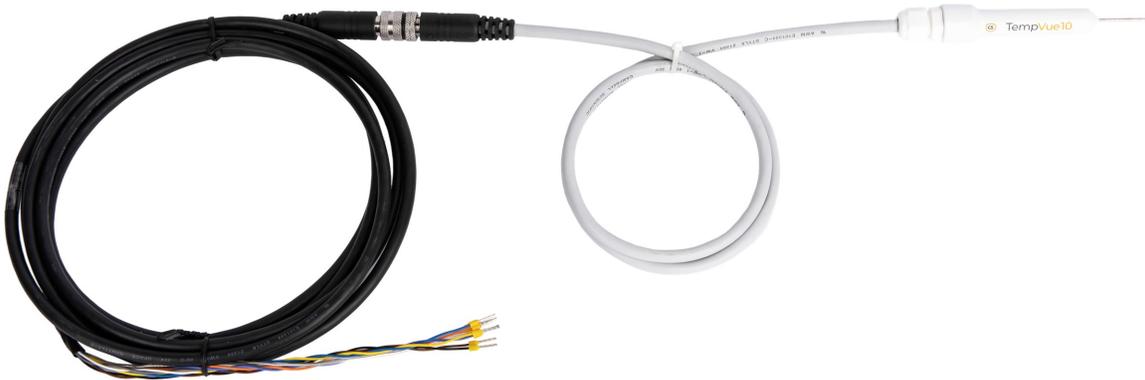
Figure 5-1. TempVue 10 with the cable attached

Features:

- Meets WMO step change response time at 1 m/s (3.28 ft/s)
- Maintains high measurement stability over both time and temperature
- Incredibly easy to install or remove for calibration checks
- Highly durable, providing sensor element protection in even the harshest environmental conditions
- Can be wired with a 2-wire or 4-wire platinum resistance thermometer (PRT) configuration
- Allows for cable length adjustments without the need for calibration changes

- Compatible data loggers: GRANITE-series, CR6, CR1000X, CR800 series, CR350-series, CR300-series. CR3000, CR1000

6. Specifications

Sensor description:	100 ohm Class A platinum (PT100)[1]
Measurement uncertainty[2]:	±0.1 K over –40 to +40 °C (-40 to +104 °F) range
	±0.3 K over –80 to +60 °C (-112 to +140 °F) range
Temperature measurement range:	–80 to 60 °C (–112 ° to +140 °F)
Time constant in air:	20 seconds to 63% of step change in 1 m/s wind
Resolution:	Three decimal places (0.001 °C)
Connector type:	M12 (to extend beyond 1 m [3 ft] standard cable length)
Signal type/output:	Analog
Probe diameter:	1.9 cm (0.75 in) maximum
Probe length:	12.1 cm (4.75 in) tip to end of cable gland
Extended probe length:	18.1 cm (7.125 in) tip to end of shield extender
Weight:	70 g (0.15 lb) for probe with shield extender, including standard 1 m (3 ft) cable with M12 connector
Compliance:	View documents at: www.campbellsci.com/tempvue10

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[1]Class A refers to ISO 60751:2008 class A standards and the corresponding ASTM E1137 Class A standards.
[2]Kelvin is the SI unit (International System of Units) for temperature, and used for uncertainty measurements, whereas the range of the product is in Celsius and therefore both are used in these specifications. The WMO guide to Instruments and Observations, Guide no. 8, also uses both Kelvin and Celsius in their recommendation. Regarding resolution of the unit, 1 Kelvin = 1 °Celsius.

7. Installation

If you are programming your data logger with *Short Cut*, skip Wiring (p. 9) and Programming (p. 11). *Short Cut* does this work for you. See QuickStart (p. 1), for a *Short Cut* tutorial.

This section discusses the following.

7.1 Wiring

The TempVue 10 includes a completion resistor integrated in the sensor housing, allowing the sensor to directly connect to the data logger without using a bridge module, such as the 4WPB100 or 3WHB10K. Campbell Scientific offers extension cables in lengths up to 10 m, which connect to the TempVue 10 M12 connector. Contact Campbell Scientific if a longer cable is required.

The TempVue 10 can be wired as a 2- or 4-wire configuration. The 4-wire PRT measurement is the preferred wiring choice, as this provides the highest measurement accuracy and ensures the best quality signal. All TempVue 10 sensors have been calibrated using a 4-wire configuration. Where possible, Campbell Scientific strongly recommends using the 4-wire set up. The specifications are all based on 4-wire operation and the TempVue 10 will meet or exceed WMO recommendations in this configuration. The 2-wire configuration requires fewer terminals, but reduces the measurement quality and increases error.

Data logger connections for these configurations are provided in the following sections.

7.1.1 4-wire configuration

For this configuration, the TempVue 10 probe requires two consecutive differential terminals and one voltage excitation terminal (one excitation terminal can be used for two probes). If the yellow and blue wires connect to **Diff 1H** and **1L**, respectively, then the orange and purple wires should connect to **Diff 2H** and **2L**, respectively.

Connections to Campbell Scientific data loggers are provided in Table 7-1 (p. 10). When **Short Cut** software is used to create the data logger program, wire the sensor to the terminals shown on the wiring diagram created by **Short Cut**.

Table 7-1: Wire color, function, and data logger connection for 4-wire configuration		
Color	Wire function	Data logger connection
Yellow	RTD signal/– RTD	**DIFF H** (differential high, analog-voltage input) or CR6 **U** terminal configured for differential high analog input[1]
Blue	RTD signal ref	**DIFF L** (differential low, analog-voltage input) or CR6 **U** terminal configured for differential low analog input[1]
Orange	Sense signal	**DIFF H** (differential high, analog-voltage input) or CR6 **U** terminal configured for differential high analog input[1]
Purple	Sense signal ref	**DIFF L** (differential low, analog-voltage input) or CR6 **U** terminal configured for differential low analog input[1]
Brown	Volt excite/+ RTD	**VX** (voltage excitation), **EX** (voltage excitation), or CR6 **U** terminal configured for voltage excitation[1]
Black	Excitation reference	⏚ (analog ground)
Clear	Shield G	⏚ (earth ground)
[1]**U** terminals are automatically configured by the measurement instruction.		

The white and gray wires are not used.

7.1.2 2-wire configuration

For this configuration, the TempVue 10 probe requires one single-ended terminal and one voltage excitation terminal (one excitation terminal can be used for two probes). The 2-wire PRT measurement is a secondary wiring option, with decreased measurement quality. This setup reduces the number of terminals needed on the data logger; however, for best measurement practice use the 4-wire set up.

The calibration supplied by Campbell Scientific is valid only for the 4-wire set up. It is recommended to obtain a new TempVue 10 calibration offset from a third-party accredited laboratory to use in the data logger program. Additionally, it is important to use the correct AC noise rejection or signal integration frequency in the CRBasic program measurement parameter.

Connections to Campbell Scientific data loggers are given in Table 7-2 (p. 11).

Table 7-2: Wire color, function, and data logger connection for 2-wire configuration		
Color	Wire function	Data logger connection
Orange	RTD signal/– RTD	**SE** (single-ended, analog-voltage input) or CR6 **U** terminal configured for single-ended analog input[1]
Brown	Volt excite/+ RTD	**VX** (voltage excitation), **EX** (voltage excitation), or CR6 **U** terminal configured for voltage excitation[1]
Black	Excitation reference	$\perp$ (analog ground)
Clear	Shield G	$\perp$ (analog ground)
[1]**U** terminals are automatically configured by the measurement instruction.		

The yellow, purple, blue, white, and gray wires are not used.

7.2 Programming

Short Cut is the best source for up-to-date programming code for Campbell Scientific data loggers. If your data acquisition requirements are simple, you can probably create and maintain a data logger program exclusively with *Short Cut*. If your data acquisition needs are more complex, the files that *Short Cut* creates are a great source for programming code to start a new program or add to an existing custom program.

> NOTE:
> *Short Cut* cannot edit programs after they are imported and edited in *CRBasic Editor*.

A *Short Cut* tutorial is available in QuickStart (p. 4). If you wish to import *Short Cut* code into *CRBasic Editor* to create or add to a customized program, follow the procedure in Importing Short Cut code into CRBasic Editor (p. 21). Programming basics for CRBasic data loggers are provided in the following sections.

7.2.1 CRBasic programming

The CRBasic program needs to measure the resistance and then convert the resistance measurement to a temperature measurement. The CRBasic instruction used to measure the resistance depends on whether it is a 4-wire or 2-wire configuration. The `PRTCalc()` instruction is used to convert the resistance to a temperature measurement. The CRBasic instructions are described in the following sections. Complete program examples can be found in Example programs (p. 22).

7.2.1.1 BrHalf4W()

The BrHalf4W() CRBasic instruction is used to measure the TempVue 10 in a 4-wire configuration. It applies an excitation voltage and makes two differential voltage measurements. The first measurement is made across the fixed resistor (Rf), the second is made across the RTD (Rs). The result is the ratio of the two resistances (Rs/Rf), which is not affected by cable length.

The BrHalf4W() instruction has the following form:

```
BrHalf4W(Dest, Reps, Range1, Range2, DiffChan, ExChan, MeasPEx, ExmV, RevEx,
RevDiff, SettlingTime, fN1, Mult, Offset)
```

Use the Ratio of Rf to Rs value for the Mult. The ratio of Rf to Rs value is included on the calibration sheet and is unique to each sensor. Campbell Scientific recommends using a 50000 µsec SettlingTime. Refer to Reducing measurement noise (p. 18) if in electrically noisy environments.

7.2.1.2 BrHalf()

The BrHalf() CRBasic instruction is used to measure the 2-wire configuration. It applies an excitation voltage, delays a specified amount of time, and then makes a single ended voltage measurement.

The BrHalf() instruction has the following form:

```
BrHalf(Dest, Reps, Range, SEChan, ExChan, MeasPEx, EXmV, RevEx, SettlingTime, fN1,
Mult, Offset)
```

Campbell Scientific recommends using a 50000 µsec SettlingTime. For the Offset, use a TempVue 10 calibration from a third party accredited laboratory.

For the 2-wire configuration, before the resistance value is converted to temperature, the CRBasic program needs to calculate the Rs/R0 ratio. To do this, include the following:

```
'Calculate the value of Rs
Rs = Rf*X/(1-X)

'Calculate the ratio of Rs/R0
TempVue10RsR0 = Rs/R0
```

Where,

Rf = 10100 (the resistance of Rf)

R0 = 100 (the resistance of the PRT at 0 °C)

X= the Dest variable that stores the BrHalf() measurement. Refer to CRBasic Example 2 (p. 24) for more information.

7.2.1.3 **PRTCalc()**

The **PRTCalc()** instruction converts the Rs/R0 ratio to a temperature measurement. The **PRTCalc()** instruction has the following form:

```
PRTCalc(Dest, Reps, Source, PRTType, Mult, Offset)
```

Use option 1 (IEC 60751:2008) for the **PRTType**.

Source is the Rs/R0 ratio. When using the **BrHalf4W()** instruction, this is the variable that stores the **BrHalf4W()** measurement. When using the **BrHalf()** instruction, the CRBasic program needs to calculate the Rs/R0 ratio (see BrHalf() [p. 12] and Example programs [p. 22] for more information).

7.3 Siting

The TempVue 10 is intended for air temperature measurements only. The general EPA guidance for standard meteorological stations is to locate the sensor over an open, level area at least 9 m (29.5 ft) in diameter. The surface should be covered by short grass or the natural earth surface where grass does not grow. Sensors should be located at a distance of at least ten times the height of any nearby obstruction and at least 30 m (98.4 ft) from large, paved areas. Sensors should be protected from thermal radiation and adequately ventilated. Protect the filter at the top of the sensor from exposure to liquid water.
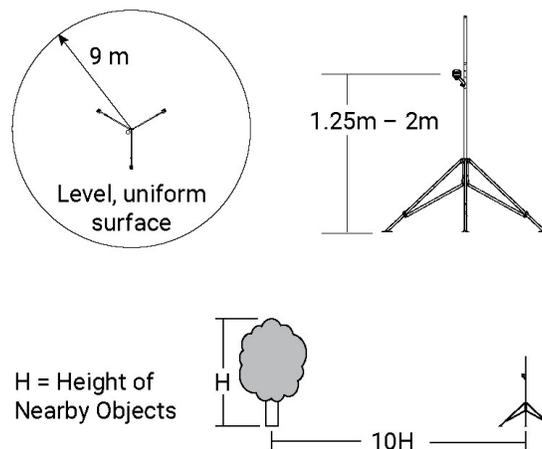
Figure 7-1. Clearances

The sensor should be installed at a standard measurement height which varies depending on the guides being used:

- 1.5 m (4.92 ft) (AASC)
- 1.25 to 2.0 m (4.1 to 6.5 ft) (WMO)
- 2.0 m (6.5 ft) (EPA)

See References (p. 20) for a list of references that discuss temperature sensors.

When used in the field, the TempVue 10 must be housed in a radiation shield. Compatible radiation shields include the RAD06, RAD10E, and RAD14 unventilated radiation shields and the TS100SS fan-aspirated radiation shield. The white color of these shields reflects solar radiation.

The unventilated radiation shields have a louvered construction that allows air to pass freely though, thereby keeping the sensor at or near ambient temperature. The RAD06, RAD10E, and RAD14 have a double-louvered design that offers improved sensor protection from insect intrusion and driving rain and snow. In addition, compared to shields of a similar appearance, the RAD shields have lower self-heating in bright sunlight combined with low wind speeds giving a better measurement. The RAD shields attach to a crossarm, mast, or user-supplied pipe with a 2.5 to 5.3 cm (1.0 to 2.1 inch) outer diameter.

The Apogee Instruments aspirated TS100SS shield can also be used where minimal solar errors and a fast speed of response is desired. It mounts on a crossarm or horizontal pipe (1-1/4 inch to 2 inch IPS).

Tools required for installing a radiation shield to a tripod or tower include:

- adjustable wrench (to suit 12 mm (1/2 in) nuts)
- small screwdriver provided with data logger
- small Phillips screwdriver
- UV-resistant cable ties
- small pair of diagonal-cutting pliers
- adjustable wrench with a minimum 50 mm (2 in) jaw size.

7.4 Installation in a radiation shield

1. If using a 10- or 14-plate shield, attach the shield extender.

10
Plate

14
Plate
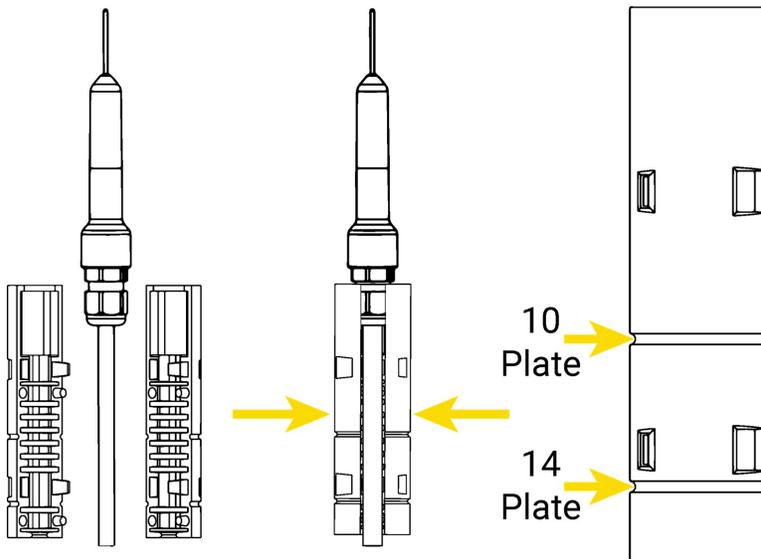
2. If using a RAD06, RAD10E, or RAD14 shield, loosen the nut on the entry gland at the bottom of the shield.

3. Insert the sensor into the gland.
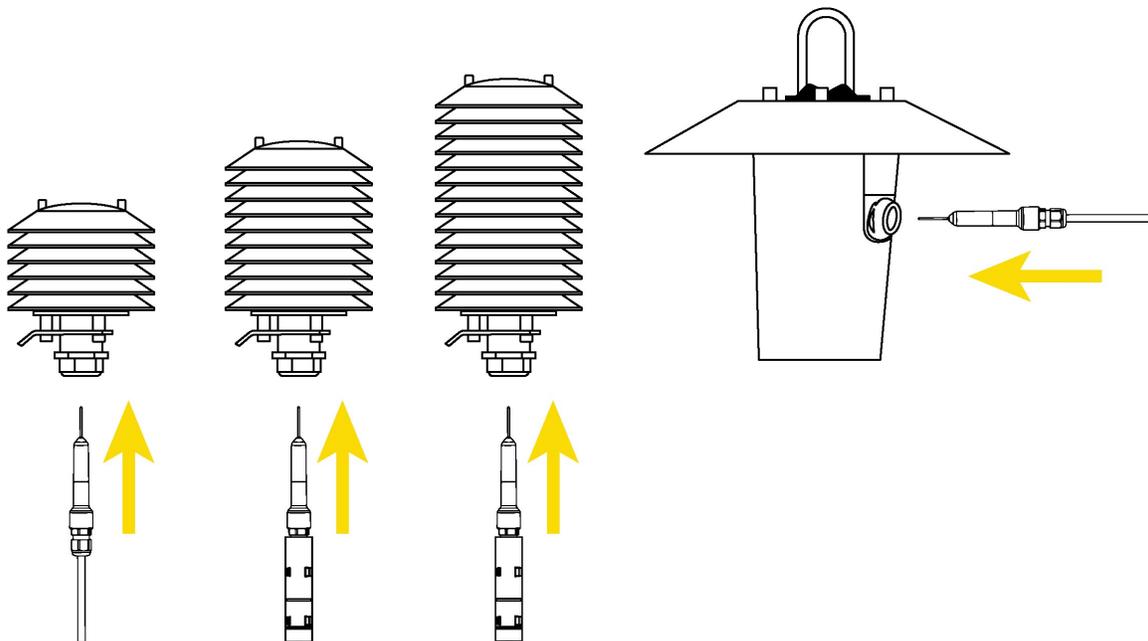
4. If using an unventilated shield, first tighten, by hand, the nut on the radiation shield gland until the sensor is held firmly in place. Then use the large adjustable wrench to further

tighten the gland by 1/2 to 1 turn. Do not overtighten the nut as you risk damaging the sensor body and also making service of the sensor more difficult in the future.

Figure 7-2. Cut away view shows TempVue 10 insertion in a RAD shield

7.5 Mount the shield

1. Attach the radiation shield to the tripod mast, crossarm, or tower leg using the supplied U-bolt or band clamp. See Figure 7-2 (p. 16).

2. Connect the cable to the sensor.

3. Route the cable to the data logger, and secure the cable to the mounting structure using cable ties.

   > CAUTION:
   > Failure to secure the cable can lead to breakage of the wires due to fatigue caused by blowing back and forth in the wind.

8. Operations

8.1 Sensor schematic
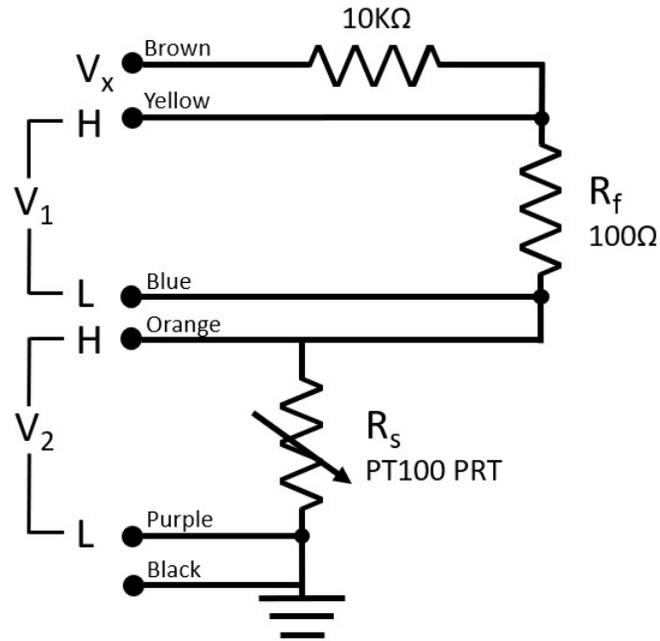
Figure 8-1. TempVue 10 4-wire schematic
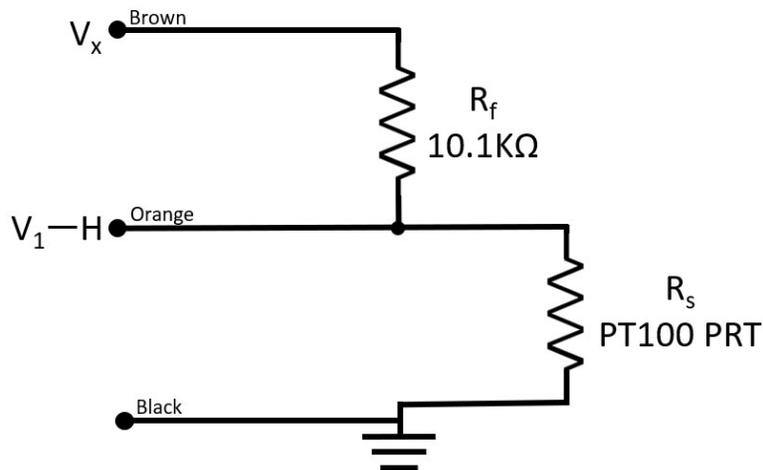
Figure 8-2. TempVue 10 2-wire schematic

8.2 Reducing measurement noise

Excess cable lengths may be prone to electrical noise. The cable should be long enough to form a drip loop, which helps prevent water ingress into the data logger enclosure. However, excess cable coiled in the enclosure should be avoided.

AC power lines, pumps, and motors can be the source of electrical noise. If the TempVue 10 probe or data logger is located in an electrically noisy environment, the measurement should be made with the 60 or 50 Hz rejection options.

Offsets in the measurement circuitry may be reduced by reversing the differential analog inputs (`RevDiff`).

9. Maintenance, troubleshooting, and calibration

> **NOTE:**
> All factory repairs and recalibrations require a returned material authorization (RMA) and completion of the "Statement of Product Cleanliness and Decontamination" form. Refer to the Assistance page at the end of this manual for more information.

9.1 Maintenance

The TempVue 10 requires minimal maintenance. Periodically check cabling for proper connections, signs of damage, and possible moisture intrusion.

Check the radiation shield monthly to make sure it is free from dust and debris. To clean the shield, first remove the sensor. Dismount the shield. Brush all loose dirt off. If more effort is needed, use warm, soapy water and a soft cloth or brush to thoroughly clean the shield. Allow the shield to dry before remounting.

Ensure the TempVue 10 probe is clean and free of dirt or any soiling by wiping carefully with a lint free cloth and warm soapy water.

9.2 Troubleshooting

Symptom: Temperature is NAN, –INF, –9999, –273

Verify wiring of sensor to the data logger; cross-reference data logger program or the measurement system wiring diagram.

Symptom: Incorrect Temperature

Check the cable for signs of damage and possible moisture intrusion.

Symptom: Unstable Temperature

Make sure the shield and ground wires are connected to data logger ground, and the data logger is properly grounded.

Symptom: Unusually high error detected

Measurements made using 2-wire configurations may have higher error, especially if the program and Rf to Rs ratio values are based on a 4-wire configuration. Please refer to 2-wire configuration (p. 10) for more information.

9.3 Calibration

For the 4-wire configuration, the recommended calibration interval is listed on the calibration certificate (see Figure 9-1 [p. 19]). For the 2-wire configuration, contact the third party accredited laboratory that performed the original calibration for the recommended calibration interval.
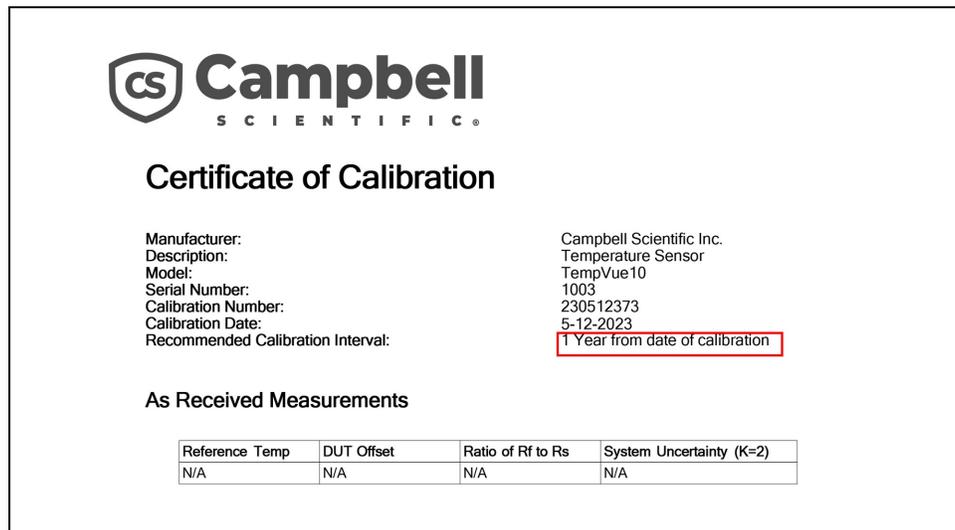
Figure 9-1. Location of recommended calibration interval on the calibration certificate

10. References

WMO, 2008. *Guide to Meteorological Instruments and Methods of Observation*. World Meteorological Organization No. 8, 7th edition, Geneva, Switzerland.

WMO, 2021. *Instruments and Observing Methods, Generic Automatic Weather Station (AWS) Tender Specifications.*. World Meteorological Organization, Report 136, Geneva, Switzerland.

AASC, 1985: The State Climatologist (1985) Publication of the American Association of State Climatologists: *Heights and Exposure Standards for Sensors on Automated Weather Stations*, v. 9, No. 4 October, 1985. (www.stateclimate.org/publications/state-climatologist/NOAA-NCY-SCBOOKS-SC77097/00000029.pdf)

EPA, 2008: *Quality Assurance Handbook for Air Pollution Measurement Systems*, Vol. IV, Meteorological Measurements, Ver. 2.0, EPA-454/B-08-002 (revised 2008). Office of Air Quality Planning and Standards, Research Triangle Park, NC 27711.

Appendix A. Importing *Short Cut* code into *CRBasic Editor*

Short Cut creates a .DEF file that contains wiring information and a program file that can be imported into *CRBasic Editor*. By default, these files reside in the C:\campbellsci\SCWin folder.

Import *Short Cut* program file and wiring information into *CRBasic Editor*:

1. Create the *Short Cut* program, then save it. Click the **Advanced** tab then the **CRBasic Editor** button. Your program file will open in CRBasic with a generic name. Provide a meaningful name and save the CRBasic program. This program can now be edited for additional refinement.

   > NOTE:
   > Once the file is edited with *CRBasic Editor*, *Short Cut* can no longer be used to edit the program.

2. To add the *Short Cut* wiring information into the new CRBasic program, open the .DEF file located in the C:\campbellsci\SCWin folder. Copy the wiring information found at the beginning of the .DEF file.

3. Go into the CRBasic program and paste the wiring information at the beginning of the program.

4. In the CRBasic program, highlight the wiring information, right-click, and select **Comment Block**. This adds an apostrophe (') to the beginning of each of the highlighted lines, which instructs the data logger compiler to ignore those lines when compiling. The **Comment Block** feature is demonstrated at about 5:10 in the CRBasic | Features video ▶.

Appendix B. Example programs

These CR1000X example programs measure the resistance and convert the resistance to temperature in degree Celsius. CRBasic Example 1 (p. 23) uses the 4-wire configuration to measure the TempVue 10. The ratio of Rf to Rs is entered at the beginning of the program as a variable. This value needs to be changed according to the calibration certificate.

CRBasic Example 2 [p. 24] uses the 2-wire configuration to measure the TempVue 10. The 2-wire configuration uses fewer terminals, but the 4-wire configuration provides more accurate measurements.

The following table provides wiring for the example programs.

Table B-1: Wiring for example program		
Color	CR1000X 2-wire connection	CR1000X 4-wire connection
Brown	VX1	VX1
Orange	SE1	2H
Purple	not used	2L
Yellow	not used	1H
Blue	not used	1L
Black	⏚ (analog ground)	⏚ (analog ground)
Clear	⏚ (analog ground)	⏚ (analog ground)

The white and gray wires are not used.

```
'CR1000X
'
'This program measures the resistance using the BrHalf4W
'instruction and then converts the resistance to temperature
'using the PRTCalc instruction.

'Change RfRs to the Ratio of Rf to Rs value from
'on the calibration certificate
Const RfRs = 1.0000000

'Declare Variables and Units
Public BattV 'CR1000X battery voltage
Public PTemp_C  'CR1000X panel temperature
Public TV10RsR0 'TempVue 10 resistance measurement
Public TempVUE10T_C 'temperature measurement

Units BattV = Volts
Units PTemp_C = Deg C
Units TempVUE10T_C = Deg C

'Define Data Tables
DataTable (Hourly,True,-1 )
  DataInterval (0,60,Min,10)
  Sample (1,TempVUE10T_C,FP2)
  Average (1,TempVUE10T_C,FP2,False)
  Maximum (1,TempVUE10T_C,FP2,False,True)
  Minimum (1,TempVUE10T_C,FP2,False,True)
  Sample (1,TV10RsR0,FP2)
EndTable

DataTable(Daily,True,-1)
  DataInterval(0,1440,Min,10)
  Minimum(1,BattV,FP2,False,False)
  Maximum (1,BattV,FP2,False,False)
  Minimum(1,PTemp_C,FP2,False,False)
  Maximum (1,PTemp_C,FP2,False,False)
EndTable

'Main Program
BeginProg
  'Main Scan
  Scan(10,Sec,1,0)
    'Battery Voltage measurement 'BattV'
    Battery(BattV)

    'Wiring Panel Temperature measurement 'PTemp_C'
    PanelTemp(PTemp_C,60)
```

CRBasic Example 1: CR1000X program for TempVue 10 with 4-wire configuration

```
    'Measure the TempVue10 Resistance (4-wire) 'TV10RsR0'
    BrHalf4W(TV10RsR0,1,mV200C,mV200C,1,VX1,1,2100,True,True,50000,60,RfRs,0)

    'Convert the resistance to temperature in Deg Celsius
    PRTCalc (TempVUE10T_C,1,TV10RsR0,1,1,0)

    'Call Data Tables and Store Data
    CallTable Daily
    CallTable Hourly
  NextScan
EndProg
```

CRBasic Example 2: CR1000X program for TempVue 10 with 2-wire configuration

```
'CR1000X
'
'This program measures the resistance using the BrHalf instruction, calculating
'for Rs, calculates the ratio of Rs/R0, and then converts the resistance ratio
'to temperature using the PRTCalc instruction.

'Calibration Offset Value
'Note: This is NOT the DUT offset value on the calibration certificate.
'That calibration is only valid for the recommended 4-wire configuration.
'This offset value should be determined by the user from a calibration
'done with the 2-wire configuration and a reliable reference sensor.

'Caution: Using a 2-wire configuration without a calibration offset could
'result in inaccuracies greater than 1 degree Celsius.

Const Cal_Offset = 0.0
Const Rf = 10100 'Resistance of Rf
Const R0 = 100 'Resistance of the PRT at 0 Deg Celsius

'Declare Variables and Units
Public BattV 'CR1000X battery voltage
Public PTemp_C 'CR1000X Panel Temperature
Public X 'TempVue 10 resistance measurement
Public Rs 'Resistance of PT100
Public TempVue10RsR0 'Ratio of Rs/R0
Public TempVue10T_C 'temperature measurement

Units BattV = Volts
Units PTemp_C = Deg C
Units TempVue10T_C = Deg C
```

```
'Define Date Tables
DataTable (Hourly,True,-1)
  DataInterval (0,60,Min,10)
  Sample (1,TempVue10T_C,FP2)
  Average (1,TempVue10T_C,FP2,False)
  Maximum (1,TempVue10T_C,FP2,False,True)
  Minimum (1,TempVue10T_C,FP2,False,True)
  Sample (1,TempVue10RsR0,FP2)
EndTable

'Main Program
BeginProg
  'Main Scan
  Scan (1,Sec,1,0)
    'Battery Voltage measurement 'BattV'
    Battery(BattV)

    'Wiring Panel Temperature measurement 'PTemp_C'
    PanelTemp(PTemp_C,60)

    'Measure the Tempvue 10 resistance
    BrHalf (X,1,mV200C,1,Vx1,1,2500,True,50000,60,1,0)

    'Calculate the value of Rs
    Rs = Rf*X/(1-X)

    'Calculate the ratio of Rs/R0
    TempVue10RsR0 = Rs/R0

    'Convert the resistance ratio to temperature in Deg Celsius
    PRTCalc (TempVue10T_C,1,TempVue10RsR0,1,1,Cal_Offset)

    'Call Data Tables and Store Data
    CallTable Hourly
  NextScan
EndProg
```

Guarantee

This equipment is guaranteed against defects in materials and workmanship. We will repair or replace products which prove to be defective during the guarantee period as detailed on your invoice, provided they are returned to us prepaid. The guarantee will not apply to:

- Equipment which has been modified or altered in any way without the written permission of Campbell Scientific
- Batteries
- Any product which has been subjected to misuse, neglect, acts of God or damage in transit.

Campbell Scientific will return guaranteed equipment by surface carrier prepaid. Campbell Scientific will not reimburse the claimant for costs incurred in removing and/or reinstalling equipment. This guarantee and the Company's obligation thereunder is in lieu of all other guarantees, expressed or implied, including those of suitability and fitness for a particular purpose. Campbell Scientific is not liable for consequential damage.

Please inform us before returning equipment and obtain a Repair Reference Number whether the repair is under guarantee or not. Please state the faults as clearly as possible, and if the product is out of the guarantee period it should be accompanied by a purchase order. Quotations for repairs can be given on request. It is the policy of Campbell Scientific to protect the health of its employees and provide a safe working environment, in support of this policy a "Declaration of Hazardous Material and Decontamination" form will be issued for completion.

When returning equipment, the Repair Reference Number must be clearly marked on the outside of the package. Complete the "Declaration of Hazardous Material and Decontamination" form and ensure a completed copy is returned with your goods. Please note your Repair may not be processed if you do not include a copy of this form and Campbell Scientific Ltd reserves the right to return goods at the customers' expense. Note that goods sent air freight are subject to Customs clearance fees which Campbell Scientific will charge to customers. In many cases, these charges are greater than the cost of the repair.

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Safety

DANGER — MANY HAZARDS ARE ASSOCIATED WITH INSTALLING, USING, MAINTAINING, AND WORKING ON OR AROUND TRIPODS, TOWERS, AND ANY ATTACHMENTS TO TRIPODS AND TOWERS SUCH AS SENSORS, CROSSARMS, ENCLOSURES, ANTENNAS, ETC. FAILURE TO PROPERLY AND COMPLETELY ASSEMBLE, INSTALL, OPERATE, USE, AND MAINTAIN TRIPODS, TOWERS, AND ATTACHMENTS, AND FAILURE TO HEED WARNINGS, INCREASES THE RISK OF DEATH, ACCIDENT, SERIOUS INJURY, PROPERTY DAMAGE, AND PRODUCT FAILURE. TAKE ALL REASONABLE PRECAUTIONS TO AVOID THESE HAZARDS. CHECK WITH YOUR ORGANIZATION'S SAFETY COORDINATOR (OR POLICY) FOR PROCEDURES AND REQUIRED PROTECTIVE EQUIPMENT PRIOR TO PERFORMING ANY WORK.

Use tripods, towers, and attachments to tripods and towers only for purposes for which they are designed. Do not exceed design limits. Be familiar and comply with all instructions provided in product manuals. Manuals are available at www.campbellsci.com You are responsible for conformance with governing codes and regulations, including safety regulations, and the integrity and location of structures or land to which towers, tripods, and any attachments are attached. Installation sites should be evaluated and approved by a qualified engineer. If questions or concerns arise regarding installation, use, or maintenance of tripods, towers, attachments, or electrical connections, consult with a licensed and qualified engineer or electrician.

General

- Protect from over-voltage.
- Protect electrical equipment from water.
- Protect from electrostatic discharge (ESD).
- Protect from lightning.
- Prior to performing site or installation work, obtain required approvals and permits. Comply with all governing structure-height regulations, such as those of the FAA in the USA.
- Use only qualified personnel for installation, use, and maintenance of tripods and towers, and any attachments to tripods and towers. The use of licensed and qualified contractors is highly recommended.
- Read all applicable instructions carefully and understand procedures thoroughly before beginning work.
- Wear a hardhat and eye protection, and take other appropriate safety precautions while working on or around tripods and towers.
- Do not climb tripods or towers at any time, and prohibit climbing by other persons. Take reasonable precautions to secure tripod and tower sites from trespassers.
- Use only manufacturer recommended parts, materials, and tools.

Utility and Electrical

- You can be killed or sustain serious bodily injury if the tripod, tower, or attachments you are installing, constructing, using, or maintaining, or a tool, stake, or anchor, come in contact with overhead or underground utility lines.
- Maintain a distance of at least one-and-one-half times structure height, 6 meters (20 feet), or the distance required by applicable law, whichever is greater, between overhead utility lines and the structure (tripod, tower, attachments, or tools).
- Prior to performing site or installation work, inform all utility companies and have all underground utilities marked.
- Comply with all electrical codes. Electrical equipment and related grounding devices should be installed by a licensed and qualified electrician.
- Only use power sources approved for use in the country of installation to power Campbell Scientific devices.

Elevated Work and Weather

- Exercise extreme caution when performing elevated work.
- Use appropriate equipment and safety practices.
- During installation and maintenance, keep tower and tripod sites clear of un-trained or non-essential personnel. Take precautions to prevent elevated tools and objects from dropping.
- Do not perform any work in inclement weather, including wind, rain, snow, lightning, etc.

Internal Battery

- Be aware of fire, explosion, and severe-burn hazards.
- Misuse or improper installation of the internal lithium battery can cause severe injury.
- Do not recharge, disassemble, heat above 100 °C (212 °F), solder directly to the cell, incinerate, or expose contents to water. Dispose of spent batteries properly.

Use and disposal of batteries

- Where batteries need to be transported to the installation site, ensure they are packed to prevent the battery terminals shorting which could cause a fire or explosion. Especially in the case of lithium batteries, ensure they are packed and transported in a way that complies with local shipping regulations and the safety requirements of the carriers involved.
- When installing the batteries follow the installation instructions very carefully. This is to avoid risk of damage to the equipment caused by installing the wrong type of battery or reverse connections.
- When disposing of used batteries, it is still important to avoid the risk of shorting. Do not dispose of the batteries in a fire as there is risk of explosion and leakage of harmful chemicals into the environment. Batteries should be disposed of at registered recycling facilities.

Avoiding unnecessary exposure to radio transmitter radiation

- Where the equipment includes a radio transmitter, precautions should be taken to avoid unnecessary exposure to radiation from the antenna. The degree of caution required varies with the power of the transmitter, but as a rule it is best to avoid getting closer to the antenna than 20 cm (8 inches)

when the antenna is active. In particular keep your head away from the antenna. For higher power radios (in excess of 1 W ERP) turn the radio off when servicing the system, unless the antenna is installed away from the station, e.g. it is mounted above the system on an arm or pole.

Maintenance

- Periodically (at least yearly) check for wear and damage, including corrosion, stress cracks, frayed cables, loose cable clamps, cable tightness, etc. and take necessary corrective actions.
- Periodically (at least yearly) check electrical ground connections.

WHILE EVERY ATTEMPT IS MADE TO EMBODY THE HIGHEST DEGREE OF SAFETY IN ALL CAMPBELL SCIENTIFIC PRODUCTS, THE CUSTOMER ASSUMES ALL RISK FROM ANY INJURY RESULTING FROM IMPROPER INSTALLATION, USE, OR MAINTENANCE OF TRIPODS, TOWERS, OR ATTACHMENTS TO TRIPODS AND TOWERS SUCH AS SENSORS, CROSSARMS, ENCLOSURES, ANTENNAS, ETC.

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