Product Manual

System

CPEC300/306/310

Closed-Path Eddy-Covariance Systems

Revision: 08/2021

RELIABLE SINCE 1974 MONITORING

CAMPBELL SCIENTIFIC

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1. Introduction

The CPEC300, CPEC 306, and CPEC310 (denoted as CPEC300 series from this point forward) are closed-path, eddy-covariance (CPEC) flux systems used for long-term monitoring of atmosphere–biosphere exchanges of carbon dioxide, water vapor, heat, and momentum. The series replaces Campbell Scientific's CPEC200, which was a complete, turnkey system that included a closed-path gas analyzer (EC155), a sonic anemometer head (CSAT3A), data logger (CR3000), sample pump, and optional valve module for automated zero and span.

The CPEC300 series provides users with three options that cater to various eddy covariance applications. All CPEC 300 systems use a CR6 data logger and the closed-path version of the data logger program *EasyFlux® DL* for automated post-processing flux calculations. All CPEC300 series systems also include the latest improvements for compact packaging and mounting, as well as advancements in long-term automated operation. All CPEC300 series systems now come with the current vortex intake technology on the EC155 gas analyzer.

The CPEC300 series is available as three systems:

- CPEC300 – a compact system with pump module
- CPEC306 – a mid-level, expandable system with pump module
- CPEC310 – an expandable system with pump module and three-valve, zero-and-span module

NOTE This manual discusses three separate instrument packages each suited to better address a wide variety of user needs. The three instrument packages are the CPEC300, CPEC306, and CPEC310. Throughout the manual, when the section being discussed applies to all three systems, the systems will be referred to collectively as the CPEC300 series. Where the manual discusses specifics that are unique to one or two of the systems, they will be named specifically as a CPEC300, CPEC306, or CPEC310.

Before using any of the CPEC300-series instruments configurations, please study:

- Section 2, *Precautions* *(p. 2)*
- Section 3, *Initial Inspection* *(p. 2)*
- Section 5, *Installation* *(p. 24)*

Operational instructions critical to the preservation of the system are found throughout this manual. Before using a CPEC300 series, please study the entire manual. Further information pertaining to the CPEC300 series can be found in the Campbell Scientific publication *EC155 CO_2 and H_2O Closed-Path Gas Analyzer Manual*, available at www.campbellsci.com.

Other manuals that may be helpful include:

- *CR6 Product Manual*
- *CSAT3B Three-Dimensional Sonic Anemometer Manual*
- *LoggerNet Instruction Manual*
- *ENC10/12, ENC16/18 Instruction Manual*
- *CM106 Tripod Instruction Manual*
- *Tripod Installation Manual Models CM110, CM115, CM120*

2. Precautions

- WARNING:
  - Do not connect or disconnect the EC155 gas analyzer head or the CSAT3A sonic anemometer head from the EC100 electronics while the EC100 is powered. Doing so can result in unpredictable performance of the system or damage to the instrument head.
  - Grounding electrical components in the measurement system is critical. Proper earth (chassis) grounding will ensure maximum electrostatic discharge (ESD) protection and higher measurement accuracy.
  - Use care when connecting and disconnecting tube fittings to avoid introducing dust or other contaminants.
  - Do not overtighten the tube fittings. Consult Appendix F, *Using Swagelok Fittings* *(p. F-1)*, for information on proper connection.
  - A power source for a CPEC300-series system should be designed thoughtfully to ensure uninterrupted power. Contact Campbell Scientific for assistance, if needed.
  - Retain all spare caps and plugs, as these are required when shipping or storing any CPEC300-series system.

3. Initial Inspection

Upon receipt of a CPEC300-series system, inspect the packaging and contents for damage. File damage claims with the shipping company.

Verify receipt of all components of the CPEC300-series system purchased. Model numbers are found on each product. On cables, the model number is usually found at the connection end of the cable. Check this information against the enclosed shipping documents to verify the expected products and the correct lengths of cable are included.

4. Overview

The CPEC300, CPEC306, and CPEC310 are three closely related closed-path, eddy-covariance (EC) systems, used for long-term monitoring of atmosphere–biosphere exchanges of carbon dioxide, water vapor, heat, and momentum. The CPEC300 is a basic, entry-level system, the CPEC306 is a mid-level, expandable system, and the CPEC310 is the high-end, expandable system.

The CPEC306 and CPEC310 have options for a CDM-A116 that allows for additional sensors for energy-balance and meteorological measurements. The CPEC310 is equipped with a three-valve module to allow automatic zero and span.

Each system comes as a complete, standalone system consisting of Campbell's EC100 electronics module, closed-path gas analyzer (EC155), sonic anemometer (CSAT3A), and sample pump. Systems come wired for a CR6 data logger that can be purchased with the system, or wired by users that already have a CR6 data logger. Section 4.1, *CPEC300/306/310 System Components* *(p. 3)*, describe the basic components of all three systems. Section 4.2, *CPEC300* *(p. 5)*, Section 4.3, *CPEC306* *(p. 7)*, and Section 4.4, *CPEC310* *(p. 10)*, below describe the specifics of each individual system in greater detail.

4.1 CPEC300/306/310 System Components

The following sections describe the components that come standard with any of the CPEC300-series systems.

4.1.1 EC100 Electronics

The EC100 electronics module (FIGURE 4-1) controls the EC155 and CSAT3A. In the CPEC300 system, the CR6 is attached to the lid of the EC100 electronics enclosure (see Section 4.5.1, *CR6 Data Logger* *(p. 12)*). In the CPEC306 and 310 systems, the EC100 exists as a standalone enclosure. The EC100 electronics must be mounted within 3.0 m (10.0 ft) of the EC155 and CSAT3A.

FIGURE 4-1. EC100 electronics module

4.1.2 EC155 Gas Analyzer

The EC155 is a closed-path, infrared CO_2/H_2O gas analyzer. It shares integrated electronics (EC100 electronics) with the CSAT3A sonic anemometer head in CPEC systems. The EC155 includes a patented[1/] vortex

[1/] U.S. Pat. No. 9,217,692

intake, which reduces intake maintenance, has an absolute pressure sensor in the sample cell for more accurate measurements, and improved sample cell corrosion protection. The EC155 with vortex intake, shown in FIGURE 4-2, is included as part of CPEC300, CPEC306, and CPEC310 systems. For detailed information and specifications, see the EC155 manual at *www.campbellsci.com*.

FIGURE 4-2. EC155 closed-path CO2/H2O gas analyzer

4.1.3 CSAT3A Sonic Anemometer Head

The CSAT3A is the Campbell Scientific 3D sonic anemometer sensor head. It shares integrated electronics (EC100 electronics) with the EC155 gas analyzer. The CSAT3A and EC155 are mounted on the same platform to reduce the separation between the instruments. In January 2016, starting with CSAT3A serial number 2000, the mounting platform of the CSAT3A was updated. Other changes also increased the stiffness of the head for improved long-term accuracy of sonic temperature. For detailed information and specifications, see the CSAT3B manual.

NOTE Campbell Scientific's standalone sonic anemometer, the CSAT3B, has its own electronics, whereas the CSAT3A shares the EC100 electronics with the EC155 gas analyzer to ensure optimal synchronization between the two sensors. The measurement specifications for the CSAT3A and CSAT3B are the same.

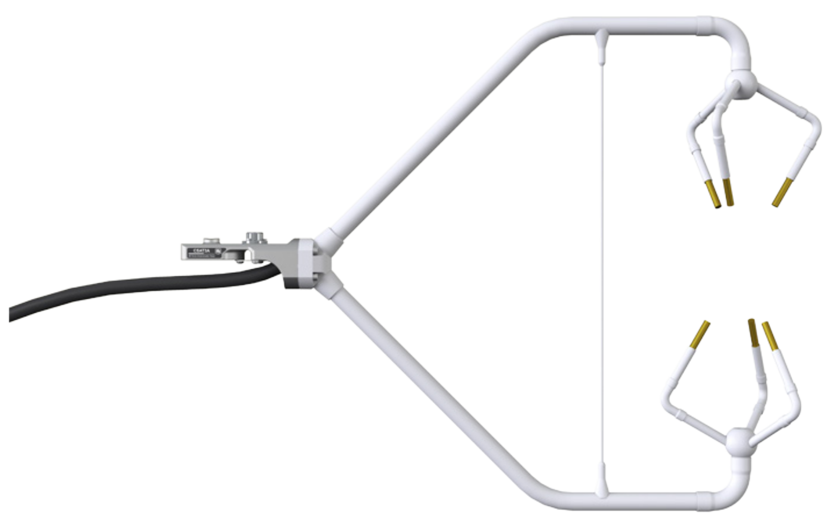


FIGURE 4-3. CSAT3A sonic anemometer

4.1.4 Pump Module

All three CPEC systems use a small, low-power diaphragm pump to draw air through the EC155 sample cell. The pumping speed is automatically controlled to maintain the volumetric flow at the set point (3 to 9 LPM). The pump module is temperature controlled to keep the pump in its operating temperature range of 0 to 55 °C. The pump module includes a large-capacity filter to protect the pump from contamination and dampen pressure fluctuations in the sample cell caused by the pump.

Section 4.2, *CPEC300* ***(p. 5)***; Section 4.3, *CPEC306* ***(p. 7)***; and Section 4.4, *CPEC310* ***(p. 10)***, below describe each of the individual systems in greater detail.

4.2 CPEC300

The CPEC300 is the most compact of the three systems, yet has the core capabilities provided by the EC100 controlling the EC155 and CSAT3A, and the measurement and control capabilities of the CR6 data logger.

Shown in FIGURE 4-4 is a typical configuration of a CPEC300 system.

The CPEC300 comes with two system enclosures: the CPEC300 enclosure, which houses the EC100 electronics and the CR6 data logger (see FIGURE 4-5 and FIGURE 4-6); and the CPEC300 pump module enclosure which houses the system pump (see FIGURE 4-7).

FIGURE 4-4. CPEC300 system

FIGURE 4-5. CPEC300 enclosure

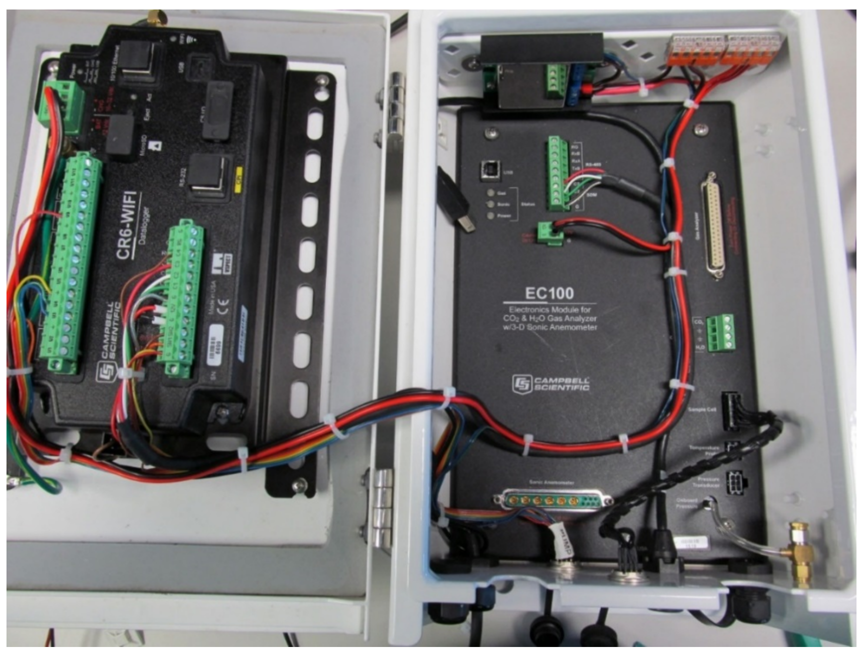


FIGURE 4-6. CPEC300 enclosure with EC100 electronics and CR6

FIGURE 4-7. CPEC300 pump module

4.3 CPEC306

The CPEC306 is a mid-level system that includes all components of the CPEC300 but has a larger enclosure, which is separate from the EC100 electronics. FIGURE 4-8 shows a typical configuration of a CPEC306 system.

The two enclosures of the CPEC306 system are the EC100 electronics enclosure and data logger and pump module enclosure. Unlike the CPEC300, the EC100 electronics are housed separately from the data logger (FIGURE 4-1). The CR6 data logger is positioned within the CPEC306 enclosure (FIGURE 4-9 and FIGURE 4-10). The CPEC306 enclosure also includes the pump module and capacity for optional CDM-A116 modules (see Section 4.6.1, *CDM-A116* *(p. 13)*) for energy balance and meteorological measurements.

FIGURE 4-8. CPEC306 system

FIGURE 4-9. CPEC306 system enclosure

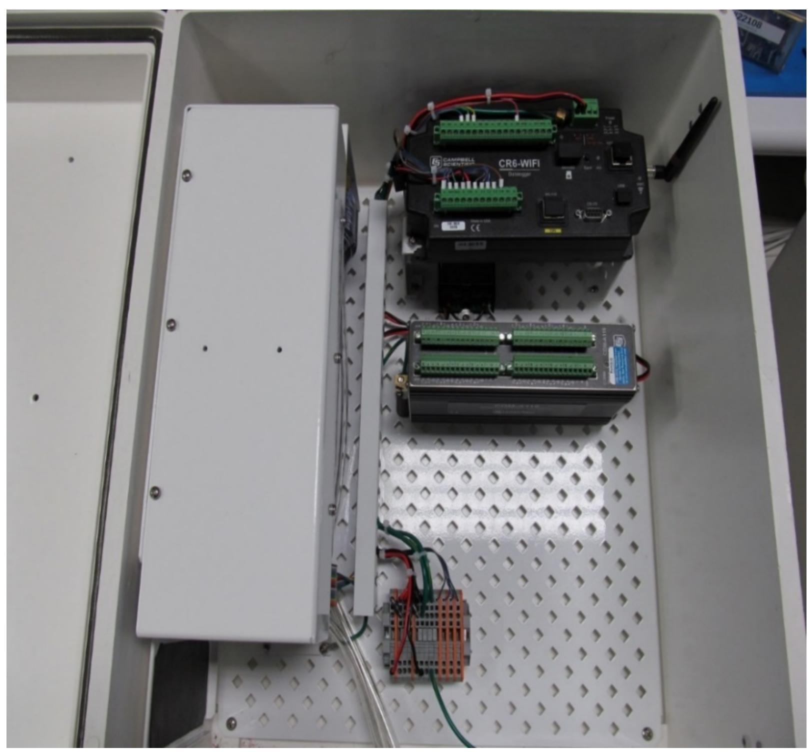


FIGURE 4-10. Interior of CPEC306 system enclosure

4.4 CPEC310

Of the three CPEC systems, the CPEC310 includes the most features. As with the CPEC306, there is the capacity for a CDM-A116. A three-valve module is included and allows automatic zero and span. The CPEC310 can also be equipped with an optional scrub module providing a source of zero air for performing the zero-and-span procedures. A CPEC310 requires a CO_2 reference tank (as shown in FIGURE 4-11) and either a scrub module or a zero air reference tank to execute the automatic zero and span. (Campbell Scientific does not sell these reference tanks.)

FIGURE 4-11 shows a typical CPEC310 system, including a scrub module.

FIGURE 4-11. Fully configured CPEC310 system

FIGURE 4-12. CPEC310 system enclosure

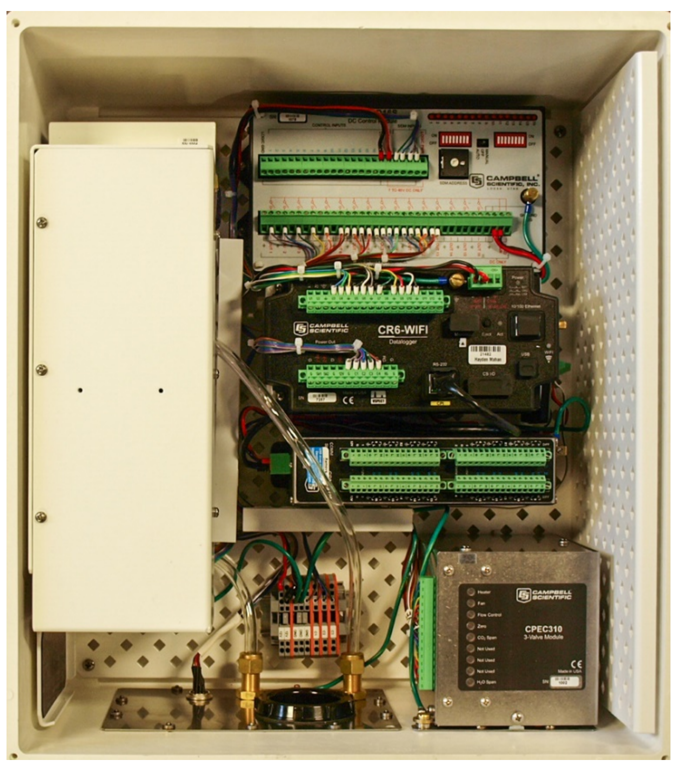


FIGURE 4-13. Interior of CPEC310 system enclosure

The CPEC310 three-valve module (FIGURE 4-14) is housed in the CPEC310 enclosure and is used to automate zero and CO_2 span checks, and automatically perform a field zero and field CO_2 span on a user-defined interval. Field H_2O span requires a dewpoint generator and cannot be automated because the dewpoint generator is a laboratory instrument and not designed for the long-term field deployment necessary for the automated zero-and-span operation. Therefore, H_2O spans must be performed under manual control.

FIGURE 4-14. CPEC310 valve module

4.5 Other Components

The following section describes the CR6 data logger that is required for any of the CPEC300-series systems. As many users already own the CR6 data logger, CPEC300-series systems do not include the CR6 data logger in a standard system.

4.5.1 CR6 Data Logger

The CR6 and *EasyFlux DL* are the core of the CPEC300 systems. They store the raw data, process that data and store fluxes, allow for remote communications to the station, and provide diagnostic information about the system. Additionally, the CR6 (FIGURE 4-15) is used for system control of the pump and valves.

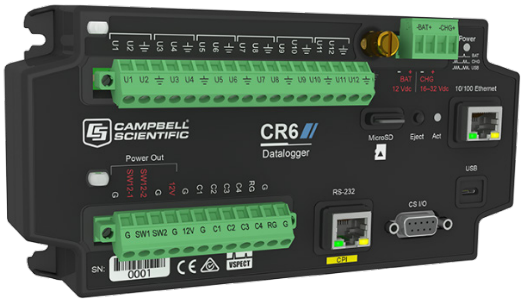


FIGURE 4-15. CR6 measurement and control data logger

4.6 Optional Components

The following sections describe optional components that are available to expand the capabilities of the CPEC306 or the CPEC310. The specific configurations will depend on specific site conditions, data requirements, and research goals.

4.6.1 CDM-A116

The CDM-A116 (FIGURE 4-16) is a 24-bit analog input module that can increase the capacity of analog channels in a data logger system. The CDM-A116 has 16 additional channels available. The CPEC306 and CPEC310 enclosures both allow for the addition of a CDM-A116 module, making it possible to add energy balance and meteorological sensors. For more information on adding these sensors, see Section 6, *Configure the EasyFlux® DL Program* ***(p. 34)***. and Appendix C, *Wiring the CR6 and Optional Energy Balance Sensors* ***(p. C-1)***.

FIGURE 4-16. CDM-A116

4.6.2 CPEC310 Scrub Module

The CPEC310 scrub module provides a source of zero air used for zeroing the EC155. It consists of a pump and a three-stage molecular sieve and connects to the CPEC310 system enclosure. The scrub module (shown in FIGURE 4-17 and FIGURE 4-18) eliminates the need for a cylinder of zero air. A cylinder of known CO_2 is still required. The module reduces the need for one of the two cylinders for zero/span and is useful in locations where transporting and replacing cylinders is inconvenient. Additional information regarding installation and maintenance of the CPEC310 scrub module is found in Appendix G, *CPEC310 Scrub Module Installation, Operation, and Maintenance* ***(p. G-1)***.

FIGURE 4-17. CPEC310 scrub module enclosure

FIGURE 4-18. CPEC310 scrub module (shown with enclosure lid open)

4.7 Other Components

4.7.1 Carrying Cases

The EC155 and the CSAT3A may be ordered with optional carrying cases. If the carrying cases are not ordered, the sensors are shipped in cardboard boxes.

4.7.2 Enclosure Mounting Options

The enclosures for any of the CPEC300-series systems can be configured with one of several mounting options. The CPEC306 or CPEC310 system enclosure is similar to the Campbell Scientific ENC16/18 enclosure, and the CPEC300 pump module enclosure is similar to the ENC10/12 enclosure. The same mounting options are available and outlined below:

- Triangular tower (UT10, UT20, or UT30)
- Tripod mast 3.8 cm (1.5 in) to 4.8 cm (1.9 in) diameter
- Tripod leg (CM106 or CM106K tripod only)
- Large pole 10.2 cm (4.0 in) to 25.4 cm (10.0 in) diameter
- No mounting bracket

Consult the *ENC10/12, ENC16/18 Instruction Manual*, available at *www.campbellsci.com*, for details on mounting bracket options.

4.8 Common Accessories

There are several items that may be required to complete the installation, but are not included in a CPEC300-series system. Some of the more common accessories are:

System Power Cable: Two power cables are required for a CPEC300 series; one for the main CPEC300-series system and one for the EC100 electronics.

The preferred power cable, CABLEPCBL-L, consists of a twisted red/black pair of wire gauge (AWG) 16 within a rugged Santoprene jacket. It is cut to the specified length and the end is finished for easy installation.

NOTE The "-L" designation after certain parts designates a cable or tube length in feet. The length is specified by the user at the time of order.

SDM Cable: An SDM communication cable is required to connect the EC100 to the CPEC300 system enclosure. The preferred SDM cable is CABLE4CBL-L. This cable consists of four conductors with a shield and drain wire, and a rugged Santoprene jacket. It is cut to the specified length and the end is finished for easy installation.

Pump Tube: A tube must be used to connect the EC155 to the pump module. If the EC155 is within 50 ft of the CPEC300-series pump module, 3/8-in OD tubing is recommended. For longer distances (up to 500 ft), a larger 1/2-in OD tube is recommended to minimize pressure drop in the tube. Pre-swaged pump tube assemblies, 3/8-in OD or 1/2-in OD, are available for this purpose.

NOTE The fittings on the EC155 and the pump module are sized for 3/8-in OD tubing. A reducer is required at each end for the larger tubing size. These reducers are supplied as part of the pre-swaged tube assembly.

Zero/span tubes: Tubes must be used to connect the EC155 and the zero-and-CO_2 span cylinders to the valve module of the CPEC310. Bulk tubing with an aluminum core (to minimize diffusion through the tubing wall) and a

UV-resistant, black, high-density polyethylene jacket can be cut to length and installed onsite. The tubing should be of 1/4-in OD to fit the Swagelok fittings on the EC155 and the valve module.

Minimize the length of these tubes to reduce the amount of equilibration time required after the zero or CO_2 span cylinder is selected. One long tube is required to connect the valve module to the EC155, and two short tubes are required to connect the zero and CO_2 span cylinders to the valve module. Pre-swaged tube assemblies are available for this purpose and are cut to a user-specified length.

USB Memory Card Reader/Writer: The USB memory card reader/writer is shown in FIGURE 4-19. It is a single-slot, high-speed reader/writer that allows a computer to read a memory card. When used with Campbell Scientific equipment, the memory card reader/writer typically reads data stored on microSD cards, but it can read many different types of memory cards.

FIGURE 4-19. USB memory card reader/writer

4.9 Support Software

There are several software products available for interfacing a computer to the CR6 data logger.

EasyFlux DL: *EasyFlux DL* for Closed-Path Eddy Covariance systems is a CRBasic program that comes pre-installed into the CR6 that was purchased with this system. If a user has a system that was not ordered with a CR6 or has an older CPEC system, the *EasyFlux DL* program can be downloaded here: *www.campbellsci.com/easyflux-dl*. *EasyFlux DL* for Closed-Path Eddy Covariance systems enables a CR6 data logger to collect fully corrected fluxes of CO_2, latent heat (H_2O), sensible heat, ground surface heat flux (optional), and momentum from a Campbell Scientific open-path EC system with optional energy balance sensors. The program processes the EC data using commonly applied corrections in scientific literature. A more detailed description of this program and how to properly configure it for your application can be found in Section 6, *Configure the EasyFlux® DL* Program *(p. 34)*.

PC200W: *PC200W* is a free, starter software package that provides basic tools such as clock set, program download, monitor data, retrieve data, etc. *PC200W* supports direct connections between PC and data logger but has no telecommunications or scheduled data-collection support.

PC400: *PC400* is a mid-level software package that supports a variety of telecommunication options, manual data collection, data display, and includes a full-featured CRBasic program editor. *PC400* does not support combined communication options (for example, phone-to-RF), PakBus routing, or scheduled data collection.

***LoggerNet*:** *LoggerNet* is a full-featured software package that supports programming, communication, and data collection and display. *LoggerNet* consists of a server application and several client applications integrated into a single product. This package is recommended for applications that require telecommunications support, scheduled data retrieval, or for large data logger networks.

4.10 Replacement Parts

Vortex Filter: For EC155 analyzers with a vortex intake, the bypass line from the vortex has a filter that will become clogged over time (typically many months) and requires replacement. The filter consists of a 25 µm particulate filter with ¼-in Swagelok nuts on either side as shown in FIGURE 4-20. Replace the filter when the signal strength has dropped to 0.8 or less.

FIGURE 4-20. Vortex filter for EC155 intake

Sonic Wicks: A Spare Sonic Wicks Kit is used to replace the wicks on the CSAT3A. The kit includes three top wicks, three bottom wicks, and an installation tool (see FIGURE 4-21).

FIGURE 4-21. Sonic wick spares kit

Silica Desiccant Bags: Silica desiccant bags (FIGURE 4-22) are used to desiccate the CPEC300-series system enclosure and should be periodically replaced. These can be purchased as a single, four-unit pack, or as a quantity of 20.

FIGURE 4-22. Single desiccant pack

Humidity Indicator Card: The replacement humidity indicator card (FIGURE 4-23) provides a visual reference of humidity level inside the enclosure.

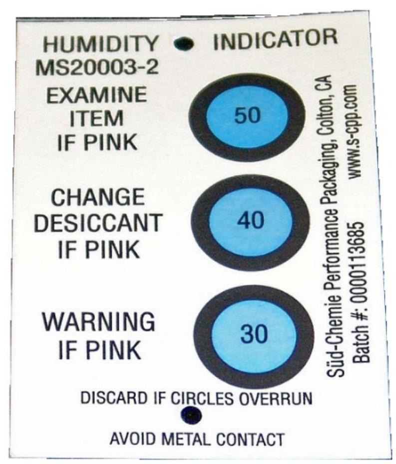


FIGURE 4-23. Humidity indicator card

EC155 Replacement Molecular Sieve: The EC155 has two small bottles filled with molecular sieve to remove CO_2 and water vapor from inside of the sensor head. Two bottles are included when purchasing the replacement.

Diaphragm Pump: The pump module for any of the CPEC300-series systems includes a small double-head diaphragm pump with a brushless DC motor. The pump includes a speed-control input and a tachometer to measure actual pumping speed. It is mounted in an insulated, temperature-controlled box inside the CPEC300 system enclosure. If the pump fails, a replacement pump (FIGURE 4-24) is available. The part includes the connector for easy installation. See Appendix H, *CPEC300 Series Pump Replacement* (p. H-1), for instructions on replacing the pump.

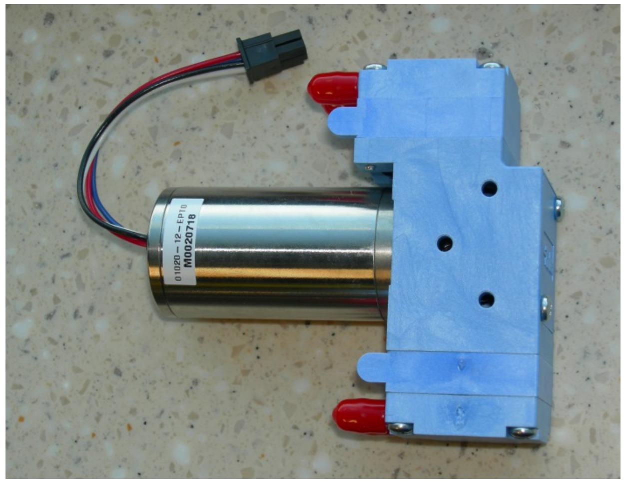


FIGURE 4-24. Diaphragm pump used in CPEC300-series systems

4.11 Theory of Operation

Any of the CPEC300-series systems can be used for long-term monitoring of atmosphere–biosphere exchanges of carbon dioxide, water vapor, heat, and momentum. These systems all include a closed-path gas analyzer (EC155), a sonic anemometer head (CSAT3A), a sample pump, and are designed to work only with a CR6 data logger. The CR6 can be purchased with any of the three systems or specified to be pre-wired for installation of a pre-purchased CR6. The CPEC306 and CPEC310 allow for increased sensor capacity with CDM-A116 modules to accommodate additional sensor measurements. The CPEC310 comes equipped with a three-valve module for automated zero and CO2 span of the EC155.

4.11.1 EC155 Gas Analyzer

The EC155 (FIGURE 4-25) is Campbell Scientific's closed-path, mid-infrared absorption gas analyzer that measures molar mixing ratios of CO_2 and water vapor. More information about the operation of the EC155 can be found in the manual, *EC155 CO_2 and H_2O Closed-path Gas Analyzer* at *www.campbellsci.com*.

FIGURE 4-25. EC155 gas analyzer

4.11.2 CSAT3A Sonic Anemometer Head

The CSAT3A, as shown in FIGURE 4-26, is an ultrasonic anemometer sensor head for measuring wind speed in three dimensions. It shares integrated electronics, the EC100 electronics, with the EC155 gas analyzer. It is similar to the sensor head for the CSAT3B sonic anemometer, with the primary difference being that the CSAT3B can be used as a standalone anemometer because it includes independent electronics.

The CSAT3A uses three nonorthogonal pairs of transducers to sense the wind velocity vector. Each pair of transducers transmits and receives ultrasonic pulses to determine the time of flight, which is directly related to the speed of sound and the wind speed along the line between the pair of transducers. The CSAT3A transforms the results into orthogonal wind components u_x, u_y, and u_z, referenced to the anemometer head.

The CSAT3A also determines the speed of sound for each transducer pair. These measurements are averaged and converted to sonic virtual temperature (T_s) based on the relationship between speed of sound and air temperature. For more detailed information and specifications, see the CSAT3B manual, available at *www.campbellsci.com*.

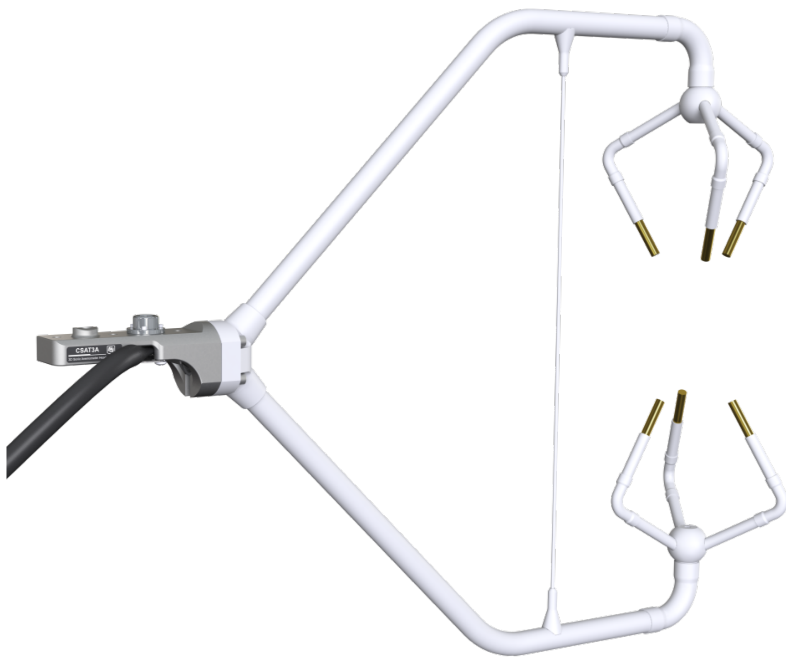


FIGURE 4-26. CSAT3A sonic anemometer head

4.11.3 Valve Module – CPEC310

The three-valve module, shown in FIGURE 4-14, is housed in the CPEC310 enclosure and is used to perform manual and automated zero and CO_2 span checks, and manually and automatically perform a zero and CO_2 span on a user-defined interval. As described in Section 4.4, *CPEC310* ***(p. 10)***, H_2O span requires a dewpoint generator and cannot be automated.

NOTE In this section and later in the manual, the names or labels on ports, as well as variable names in the data logger program, are denoted by the usage of bold font.

The CPEC310 zero and CO_2 span inlets are not bypass equipped, meaning that they flow only when selected. This allows the zero and CO_2 span tanks to be continuously connected for automatic, unattended operation.

The **H_2O Span** input is bypassed (vented to the atmosphere through the **H_2O Span Bypass** outlet) when it is not selected to permit continuous flow. This allows a dewpoint generator to be connected directly to the **H_2O Span** inlet. The dewpoint generator's internal pump can push air into the valve module even when the **H_2O Span** valve is not selected, minimizing errors caused by pressurization inside the dewpoint generator. When the **H_2O Span** valve is selected, the dewpoint generator pushes moist air through the valve module to the EC155.

The CPEC310 pushes the zero/span flow backward through the EC155 sample cell and exhausts it through the intake tube to the atmosphere. Flow through the intake tube causes the sample-cell pressure to rise slightly above ambient pressure. The CPEC310 infers the flow rate from this pressure rise.

The EC155 has a pressure sensor in the sample cell to measure this pressure rise directly, but its accuracy is affected by a small offset drift. The accuracy of this pressure measurement can be improved by stopping all flow through the EC155, allowing the pressure in the sample cell to equilibrate with ambient pressure, and measuring the offset between sample cell and ambient pressures. This offset is then subtracted from subsequent measurements used to control the flow.

Because the pressure sensor offset can change over time, this offset is measured at the beginning of every zero/span cycle. This step requires at least 10 seconds to complete; 5 seconds for the pressure to equilibrate, and 5 seconds to average and store the pressure offset measurement.

The CPEC310 valve module has a proportional control valve to actively control the flow of zero and span gas to the EC155. The *Easyflux DL* program for the CPEC310 adjusts public variable **valve_ctrl_press** as needed for the measured flow **valve_flow** to reach the desired flow, as indicated by **valve_flow_set_pt**.

The default value for **valve_flow_set_pt** is 1.0 LPM. This flow is adequate for lower measurement heights (allowing a shorter tube between the valve module and the EC155), but setting a higher flow rate may be required with long zero/span delivery tubes used on tall towers. The proportional valve is opened fully during an H_2O span operation to prevent pressurizing the dewpoint generator.

NOTE Even with higher flow rates, the time required to flush and equilibrate the delivery tubes on an extremely tall tower may make the automatic zero/span impractical. In this case, a manual zero/span as described in the EC155 manual should be performed.

The CPEC310 valve module includes a heater and a fan to keep the valves within their operating range of 0 to 60 °C. The valve heater turns on/off at 2 °C. The valve fan turns on at 50 °C and stays on until the valve temperature drops to 48 °C. To conserve power, temperature control is active just prior to and during the time when valves are in use. If the valves cannot be maintained within the temperature range, the valves are disabled. The valve module temperature control can be manually activated so that manual zero/span can be performed by the station operator on site or remotely. If starting from the minimum ambient temperature (–30 °C), the valves may take as much as 15 min to warm up to the operating range of 0 to 60 °C.

4.11.4 CPEC300-Series Pump Module

The pump module for the CPEC300-series systems, pulls air through the system and exhausts it through the **Exhaust** fitting on the bottom of the enclosure. It uses a small double-head diaphragm pump with a brushless DC motor. This pump includes a speed control input and a tachometer to measure the actual pumping speed. It is mounted in an insulated, temperature-controlled box located inside the weather-tight fiberglass enclosure. The pump module includes a large filter cartridge to dampen the pressure fluctuations from the pump and to protect the pump from particulates or debris.

If the pump fails, a replacement pump is available (see Section 4.10, *Replacement Parts* *(p. 17)*). See Appendix H, *CPEC300 Series Pump Replacement* *(p. H-1)*, for instructions on replacing the pump. The filter cartridge in the pump module is unlikely to clog over the lifetime of any CPEC300-series system.

The following sections describe operating parameters of the pump.

Pump Speed: The pump tachometer is measured, converted to volumetric flow rate, and reported in public variable **pump_flow_raw**. A CPEC300-series system will set the value of public variable **pump_flow_duty_cycle** to a value between 0 (off) and 1 (full speed) to adjust the pump's speed as needed to match **pump_flow_raw** to the setpoint flow **pump_flow_set_pt**. **Pump_flow_set_pt** is a system configuration variable.

Pump Inlet Pressure: The measured inlet pressure of the pump is reported in public variable **pump_press**. This pressure will normally be slightly lower (~1 kPa) than the EC155 sample cell pressure due to the pressure drop in the pump tube.

Pump Temperature: The temperature of the pump module is reported in public variable **pump_tmpr**. The operating range of the pump is 0 to 55 °C. If the pump temperature is outside this range, the CPEC300-series system will disable the pump. The pump module has a heater (drawing 8 W while operational) that turns on if the pump temperature falls below 2 °C. If the CPEC300-series system is started at cold temperature, it may take up to 50 minutes to warm the pump module (from –30 to 0 °C). When it reaches 2 °C the heater will cycle on/off as needed to maintain this temperature.

The pump module has a fan (drawing 0.7 W while operational) that turns on if the pump temperature rises above 45 °C. The fan will stay on until the pump temperature falls below 40 °C.

The outlet of the pump connects the **Exhaust** fitting on the bottom of the pump module enclosure. This fitting has a screen to prevent insects or debris from entering when the pump is off.

4.12 Specifications

System	
Operating temperature:	–30 to 50 °C
Input voltage:	10.5 to 16.0 VDC
Power:	12 W (typical), 35 W (max; at cold startup)
System enclosure	
Dimensions	
CPEC300:	34 x 25 x 13 cm (13.4 x 9.8 x 5.1 in)
CPEC306/310:	54 x 44.5 x 29.7 cm (21.3 x 17.5 x 11.7 in)
Ingress protection	
CPEC300	IP65[2/]
Weight basic system	
CPEC300:	4.0 kg (8.9 lb)
CPEC306:	13.7 kg (30.3 lb)
CPEC310:	15.4 (33.9 lb)
CDM-A116 module:	0.9 kg (1.95 lb)
Pump module	
Cable length:	3.0 m (10 ft)
Inlet connection:	3/8-in Swagelok
Pressure sensor range:	15 to 115 kPa
Pumping speed:	3 to 9 LPM (automatically controlled at the set point, typically 7 LPM)
Dimensions CPEC300:	35.6 x 29.2 x 13.5 cm (14.0 x 11.5 x 5.3 in)
Weight w/out mounting:	5.4 kg (11.8 lb)
CPEC310 three-valve module	
Inlets:	Zero, CO_2 span, and H_2O span
Outlets:	Analyzer and H_2O bypass
Connections:	1/4-in Swagelok
Flow rate:	0.5 to 5 LPM (automatically controlled at user-entered set point)
Dimensions:	14.0 x 12.7 x 14.0 cm (5.5 x 5.0 x 5.5 in.)
Weight:	1.5 kg (3.3 lb)

EC155 and CSAT3A Specifications: see the user manual: *EC155* CO_2 *and* H_2O *Closed-path Gas Analyzer Manual* and *CSAT3B Three-Dimensional Sonic Anemometer Manual*

View compliance documentation at *www.campbellsci.com/cpec300*.

[2/] Not intended for marine environments

5. Installation

The following tools are required to install a CPEC300-series system in the field. Additional tools may be required for a user-supplied tripod or tower.

- 9/16-in, open-end wrench
- 1/2-in, open-end wrench
- 11/16-in, open-end wrench
- Adjustable wrench
- Small, flat-tip screwdriver (included with EC100 and CPEC300-series system)
- Large, flat-tip screwdriver
- Sledgehammer (to drive grounding rod into the ground)
- 3/16-in hex-key wrench (included with CM250 leveling mount)

5.1 Mounting

5.1.1 Support Structure

A CPEC300-series system has three major components that must be mounted to a user-provided support structure.

EC sensors (EC155 and CSAT3A): Mounted on a horizontal round pipe of 3.33 cm (1.31 in) outer diameter, such as the CM20X crossarm as in FIGURE 5-1.

EC100 electronics (denoted as "CPEC300 Closed-Path Eddy-Covariance System" for the CPEC300): Mounted within 3.0 m (10.0 ft) of the EC sensors. The EC100 mounting bracket will accommodate a pipe at any orientation, with outer diameter from 2.5 cm to 4.8 cm (1.0 in to 1.9 in).

For CPEC 300:

CPE300 pump module enclosure: Mounted within 3.0 m (10.0 ft) of the CPEC300 enclosure. The pump module enclosure is similar to the ENC10/12, with the same mounting options (tower, tripod, leg, or pole).

For CPEC306/310:

CPEC306 or CPEC310 enclosure: Mounted where it can be accessed easily to retrieve data from the microSD cards in the data logger. The CPEC306 or 310 enclosure is similar to the ENC16/18, with the same mounting options (tower, tripod, leg, or pole).

The following sections describe a typical application using a CM210 tripod and CM202 crossarm. The CM210 tripod and leg mounting options are ideal for a low EC measurement height to minimize wind disturbance.

5.1.2 Mount Enclosures

Mount the EC100 electronics within 3.0 m (10.0 ft) of the EC sensors (this measurement corresponds to the length of the cables on the EC155 and the CSAT3A).

For the EC100 and the system enclosure, open the sealed bag containing the desiccant packs and humidity card. Place two of the desiccant packs and the humidity indicator card in the mesh pocket in the enclosure door. Reseal the remaining two desiccant packs in the bag for later use.

NOTE The EC100 should be mounted vertically to prevent the ingress of water from precipitation.

The mounting bracket will accommodate a horizontal, vertical, or angled pipe from 2.5 cm to 4.8 cm (1.0 in to 1.9 in) diameter. See the *EC155 CO_2 and H_2O Closed-path Gas Analyzer* manual for details on configuring the EC100 mounting bracket.

CPEC300:

Mount the CPEC300 enclosure and the CPEC300 pump module within 3.0 m (10.0 ft) distance. The enclosure and pump module are shown mounted vertically on the CM210 tripod in FIGURE 4-4, but they may also be mounted on the leg of the tripod, triangular tower, or large-diameter pole, depending on the site requirements and the mounting options ordered.

NOTE The CPEC300 enclosure is not intended for marine environments. The ingress protection is not sufficient for the salinity of these environments, and corrosion will occur to components within the enclosure.

CPEC306:

The CPEC306 enclosure and the EC100 electronics are mounted as shown in FIGURE 4-8, with the CPEC306 enclosure and EC100 enclosure mounted on the legs of a tripod. They can also be mounted on a triangular tower, or large-diameter pole, depending on the site requirements and the mounting options ordered.

CPEC310:

The CPEC310 enclosure and the EC100 electronics are mounted as shown in FIGURE 4-11, with the CPEC306 enclosure and EC100 enclosure mounted on the legs of a tripod. They can also be mounted on a triangular tower or large-diameter pole, depending on the site requirements and the mounting options ordered. If a scrub module for zeroing the system has been included with the system, then that can be mounted on the leg of the tripod or near the CPEC310 enclosure. Cylinders of CO_2 and zero air (needed if there is not a scrub module) should be situated close to the base of the tower and secured with harnesses and additional poles to prevent the cylinders from falling over and damaging the system or injuring personnel.

5.1.3 Install EC Sensors

Install a horizontal mounting crossarm at the height desired for the EC measurement. This crossarm must be within ±15 degrees of horizontal to level the sonic anemometer. Point the crossarm into the predominant wind direction to minimize wind disturbance caused by wind flowing past the mounting structure and EC sensors. The outer diameter of the crossarm should be 3.3 cm (1.3 in). The CM202 crossarm is shown in FIGURE 5-1.

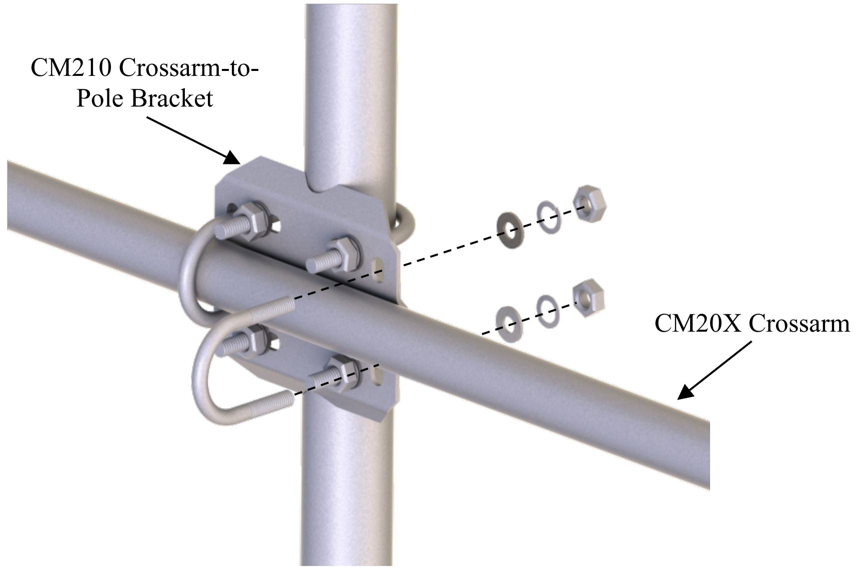


FIGURE 5-1. CM210 mounting bracket on a tripod mast

The EC155 gas analyzer and CSAT3A sonic anemometer head are mounted on the end of the crossarm using the CM250 leveling mount and the CPEC300-series mounting platform. FIGURE 5-2 shows mounting for the EC155 with vortex intake. Adjust the tilt of the mounting platform to level the CSAT3A. For more details, see instructions in the *EC155 CO_2 and H_2O Closed-path Gas Analyzer* manual.

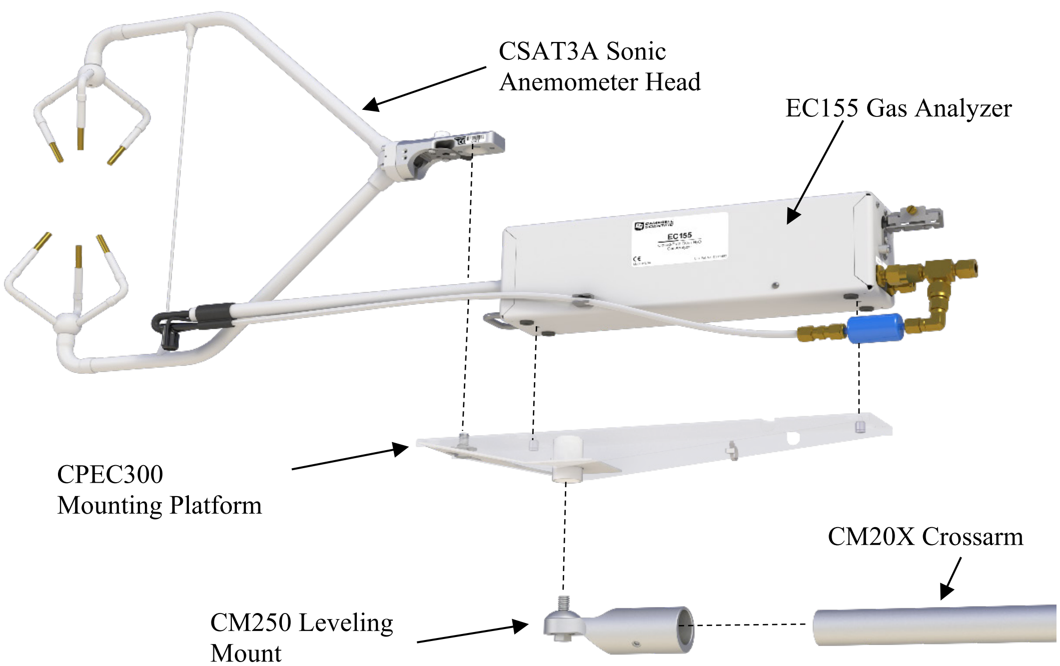


FIGURE 5-2. Mounting of EC155 and CSAT3A

5.2 Plumbing

FIGURES 5-3 through 5-5 show an overview of the basic plumbing configuration of a CPEC300, CPEC306, and CPEC310, respectively. FIGURE 5-3 shows how a CPEC300 enclosure is connected to the pump module and EC155. The EC155 is connected to the CPEC300 pump module's **Inlet** connector and the pump module umbilical cord is connected to the connector labeled **Pump Module** on the CPEC300 enclosure.

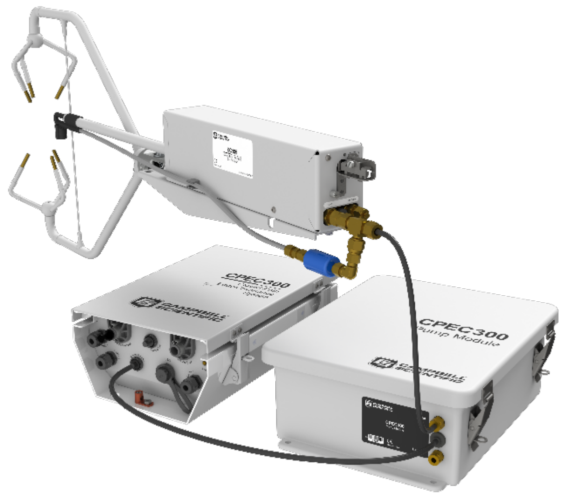


FIGURE 5-3. Plumbing connections for CPEC300

FIGURE 5-4 depicts the plumbing required for the CPEC306. The only plumbing required is the connection of the EC155 to the inlet connector of the pump on the bottom of the CPEC306 enclosure.

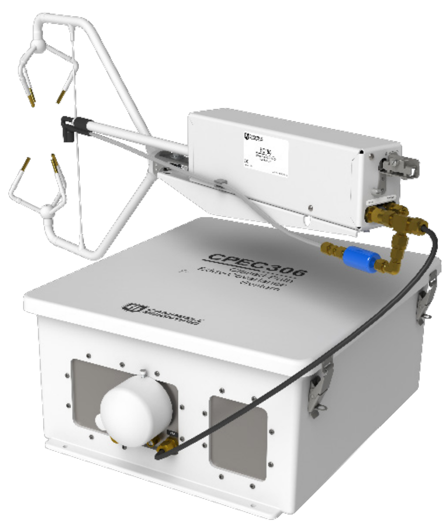


FIGURE 5-4. Plumbing connections for CPEC306

FIGURE 5-5 depicts the plumbing for the CPEC310. The EC155 connects to the **Inlet** connector of the pump on the bottom of the CPEC310. To zero and span the EC155, a 1/4-in OD tubing that has been swaged on both ends is used to connect the EC155 to the valve module. A CO_2 cylinder and either a Zero gas (ultra-pure nitrogen) cylinder or scrub module are connected to the valve module for zero and spanning. More information on zero and span procedures can be found in Section 7, *Zero and Span* *(p. 81)*.

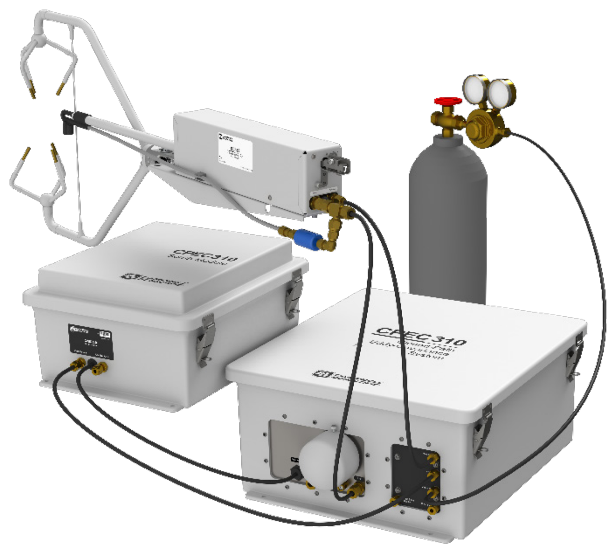


FIGURE 5-5. Plumbing for CPEC310 with optional scrub module

5.2.1 Pump Module

For the CPEC300 connect the EC155 to the pump module as shown in FIGURE 5-3. If the EC155 is within 15 m (50 ft) of the pump module, 3/8-in OD tubing is recommended. For longer distances, up to 150 m (500 ft), a 1/2-in OD tube minimizes pressure drop in the tube.

NOTE The fittings on the EC155 and the pump module are sized for 3/8-in OD tubing. A reducer is required at each end for the larger tubing size. Campbell Scientific supplies pre-swaged pump tube assemblies with reducers at each end for this purpose.

Connect one end of the pump tube to the last fitting of the vortex assembly which is connected to the port labeled **Pump** on the back of the EC155 analyzer. Connect the other end to the fitting labeled **Inlet** on the CPEC300 pump module as shown in FIGURE 5-3.

5.2.2 Zero/Span with the CPEC310

The CPEC310 can perform automated zero (CO_2 and H_2O) and CO_2 span of the EC155. The user must supply cylinders of zero air and CO_2 span gas with appropriate regulators. If the user has chosen the optional CPEC310 scrub module, then no cylinder of zero air is required.

The rest of this section assumes the use of cylinders of compressed gas, but see Appendix G, *CPEC310 Scrub Module Installation, Operation, and Maintenance* *(p. G-1)*, for details on the scrub module.

Install cylinders in close proximity to the CPEC310 system enclosure. Each cylinder must have a pressure regulator to control the outlet pressure at 10 psig and must have a 1/4-in Swagelok fitting on the outlet. Connect regulators to the valve module inlets using 1/4-in OD tubing or pre-swaged tube assemblies. Minimize the length of these tubes to reduce the equilibration time after the zero or CO_2 span cylinder is selected. Refer to Appendix F, *Using Swagelok Fittings* *(p. F-1)*, for information on installing and replacing Swagelok fittings.

NOTE Flow meters and needle valves are not needed because the CPEC310 valve module has a proportional-control valve to actively control the flow of zero and span gas to the EC155.

NOTE Make sure there are no leaks in the regulators or the connections to the valve module. For automatic operation, the tank shutoff valves are left continuously open. A plumbing leak could cause the contents of the tank to be lost.

NOTE When inlets are not in use, replace the Swagelok plugs to keep the system clean.

Connect the valve module's **Analyzer** outlet to the **Zero/Span** fitting on back of the EC155 analyzer. Similar tubing or pre-swaged tube assembly is recommended for this connection. The length of this tube should also be minimized to reduce equilibration time.

Open the shutoff valves on the cylinders and set the pressure regulators for 10 ± 5 psig delivery pressure.

NOTE If the pressure is adjusted too high, slightly loosen the tube fitting to bleed off the excess pressure. Retighten the fitting when the proper setting is reached.

The **H2O Span** inlet is bypass equipped, allowing continuous flow. This inlet can be connected directly to the output of a dewpoint generator. The bypass on this inlet will avoid pressurizing the dewpoint generator.

NOTE Some systems, such as the AP200 CO_2/H_2O Atmospheric Profile system, require a tee in the connection from the dewpoint generator to bleed off excess flow and avoid pressurizing the dewpoint generator. Do not use a tee to connect a dewpoint generator to the CPEC310.

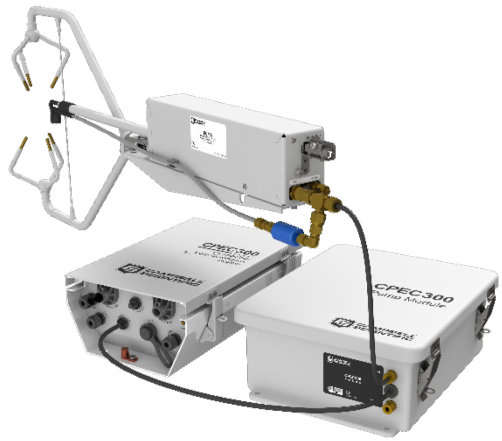


FIGURE 5-6. Connecting pump tube from EC155 analyzer to pump module

The CPEC306 and CPEC310 do not have a separate pump module since the pump resides in the main enclosure. Therefore, pump tubing is connected to the main enclosure that is labeled **Inlet**.

5.3 Wiring

5.3.1 Ground Connections

Any CPEC300-series system enclosure and the EC100 electronics must be earth grounded as illustrated in FIGURE 5-7. Ground the tripod and enclosures by attaching heavy gauge grounding wire (12 AWG minimum) to the grounding lug found on the bottom of each enclosure. The other end of the wire should be connected to earth ground through a grounding rod. For more details on grounding, see the grounding section of the CR6 Product Manual.

FIGURE 5-7. Enclosure and tripod grounded to a copper-clad grounding rod

5.3.2 EC Sensor Cables

Ensure the EC100 is not powered. Connect the EC155 gas analyzer head, EC155 sample cell, and CSAT3A sonic anemometer head to the EC100 electronics (FIGURE 5-8).

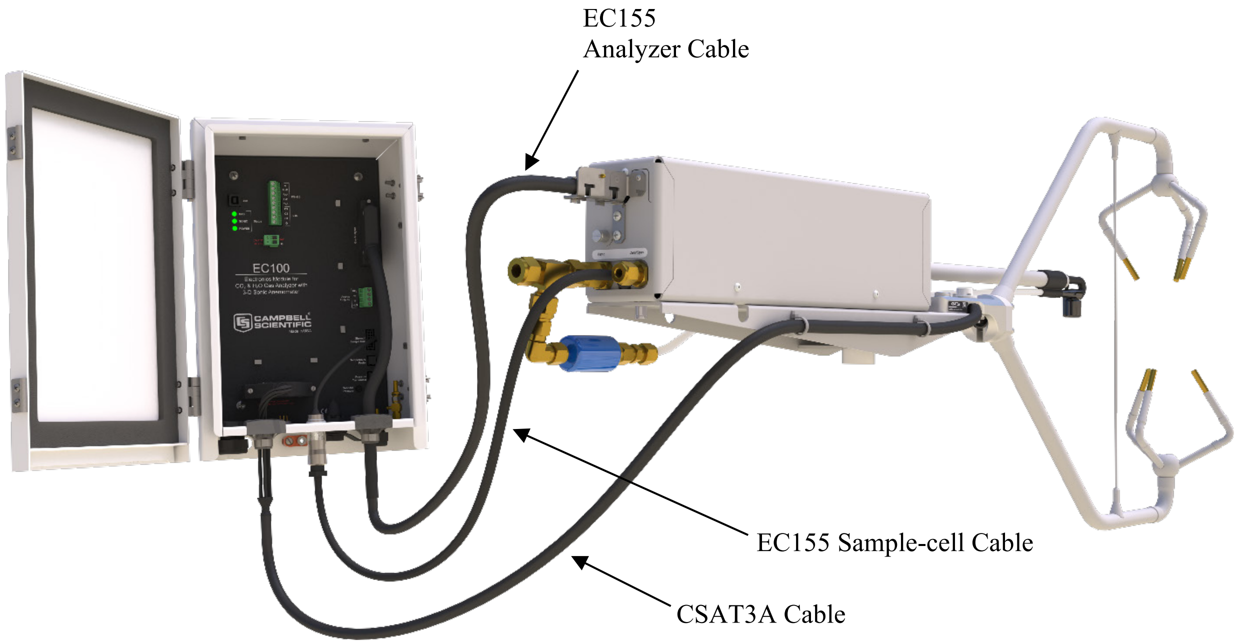


FIGURE 5-8. EC155 and CSAT3A electrical connections; mounting hardware and tubing not shown)

NOTE CPEC300-series instruments that are ordered with a CR6, are pre-wired with the appropriate EC100 wiring. For users that need to wire the system, follow the next sections to wire the connection between the EC100 and the CPEC300-series enclosure.

Wire the SDM communications cable (CABLE4CBL-L) between the EC100 and the CPEC300-series enclosure as shown in FIGURE 5-9 and FIGURE 5-10. TABLE 5-1 shows the color scheme of the SDM wires.

TABLE 5-1. SDM Wiring

Description	Wire Color	EC100	CR6
SDM Data	Green	SDM-C1	SDM-C1
SDM Clock	White	SDM-C2	SDM-C2
SDM Enable	Red/Brown	SDM-C3	SDM-C3
Digital Ground	Black	Ground	Ground
Shield	Clear	Ground	Ground

NOTE To bring cables into the CPEC306 and CPEC310 enclosure, remove the cap from the cable feedthrough by loosening the thumbscrew and pulling the cap off.

NOTE The CPEC306 and CPEC310 wires connect to a DIN rail located inside of the main enclosure. This DIN rail then connects to the CR6 data logger. To connect a wire to the DIN rail terminal blocks of the CPEC306 and CPEC310 enclosure, insert a small screwdriver into the square hole to open the spring-loaded contacts. Insert the wire into the corresponding round hole and then remove the screwdriver. Gently tug the wire to confirm it is secure.

Ensure the CPEC306 and CPEC310 enclosure is not powered, and wire the power cable (CABLEPCBL-L) from the EC100 electronics to the enclosure as shown in FIGURE 5-9 and FIGURE 5-10.

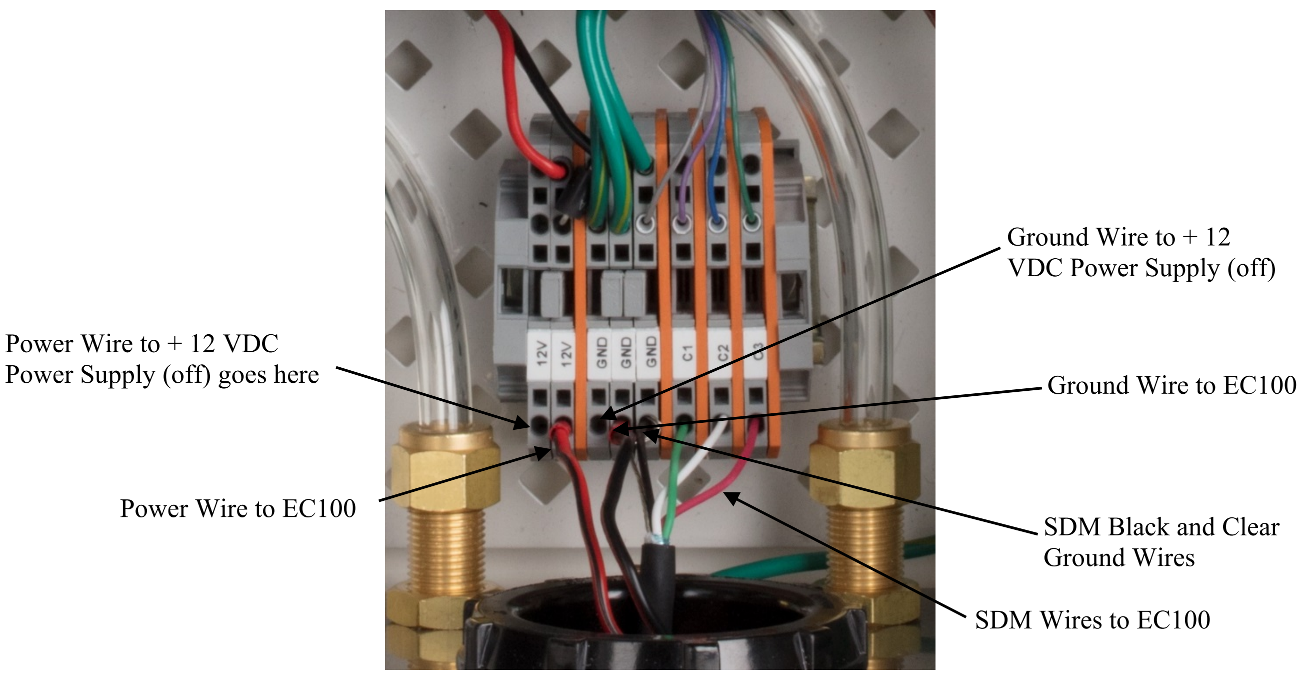


FIGURE 5-9. Wiring the EC100 to a CPEC306 and CPEC310 enclosure

Secure the SDM and power cables in the EC100 with a cable tie.

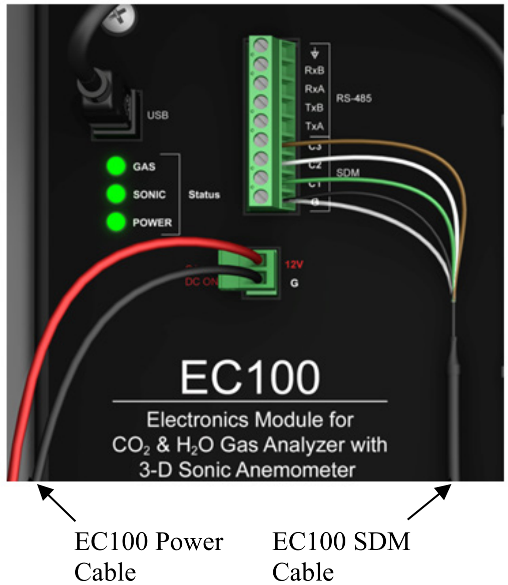


FIGURE 5-10. Wiring to EC100 electronics

5.3.3 Pump Module Cable for a CPEC300

Ensure the CPEC300 system is not powered, and connect the pump module cable to the bottom of the CPEC306 or CPEC310 system enclosure (or CPEC300 pump module enclosure).

5.3.4 Apply Power

All CPEC300-series systems require a 10.5 to 16.0 VDC power source. Its average power consumption is 12 W typically but will be slightly higher at cold temperatures, especially at startup in cold weather. In typical remote applications the power will be supplied from a user-provided 12 VDC battery system charged with solar panels.

NOTE Before applying power, verify all of the tubes and cables have been connected according to the instructions above.

CAUTION To reduce the risk of shorting the power supply, especially when using batteries, connect the power cable to the CPEC300-series system first, then connect to the power source. Carefully design any DC power source to ensure uninterrupted power. If needed, contact Campbell Scientific for assistance.

Connect a power cable (CABLEPCBL-L) from the CPEC306 and CPEC310 power terminals, as shown in FIGURE 5-10, to a user-supplied, 12 VDC power supply.

For the CPEC300, the power cables will be plugged into the orange splicing switches attached to the top of the enclosure, as shown in FIGURE 5-11.

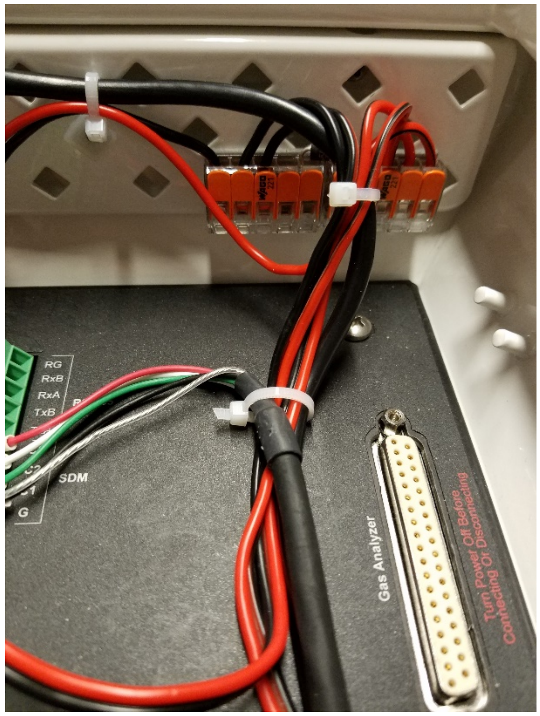


FIGURE 5-11. CPEC300 splicing switches

Replace the cap on the CPEC306 and CPEC310 enclosure feedthrough. Gently bend the cables back as you slide the cap on and rotate the cap to minimize the space around the cables. Tighten the thumbscrew to further relieve strain on the cable. This will also minimize air infiltration and extend the life of the enclosure desiccant packs.

NOTE In very humid conditions or locations with insects and small rodents it may be helpful to seal the cable feedthrough with plumber's putty.

6. Configure the *EasyFlux*® *DL* Program

EasyFlux® *DL CR6CP* is a CRBasic program that enables a CR6 data logger to collect fully corrected fluxes of CO_2, latent heat (H_2O), sensible heat, ground surface heat (optional), and momentum from any CPEC300-series system with optional GPS and energy balance sensors. The program processes EC data using commonly used corrections in the scientific literature. Because the number of analog channels on the CR6 is limited, the program also supports the addition of a CDM-A116 analog channel expansion module, which allows a full suite of energy balance sensors, thus enabling the program to calculate the ground surface heat flux and energy closure.

Specifically, the program supports data collection and processing from the following systems and sensors.

- CPEC300
  - EC155 CO_2/H_2O Gas Analyzer with EC100 Electronics
  - CAST3A sonic anemometer
  - CR6 data logger (housed in EC100)
  - Pump Module
- CPEC306

  In additional to components listed for CPEC300 above, the CPEC306 includes a:
  - Optional CDM-A116 analog channel expansion module
  - System Enclosure (houses CR6, pump module, CDMA-116 module)
- CPEC310

  In addition to components used for CPEC300 and CPEC306 above, the CPEC310 includes a:
  - valve module for automated zero and span of the gas analyzer
  - SDM-CD16S Solid-State DC Controller
  - optional scrub module for providing zero gas (i.e., gas without CO_2 or H_2O for zeroing the analyzer)

GPS Receiver (optional, qty 0 to 1)

- GPS16X-HVS

Fine-wire thermocouple (optional, qty 0 to 1)

- FW05
- FW1
- FW3

Biometeorology and energy balance sensors (optional for CPEC306 and CPEC310 systems, not supported for CPEC300 systems)

- Temperature/Relativity Humidity (RH) Probe (qty 0 to 1)
  - HMP155A
  - EE181
- Radiation measurements
  - Option 1
    - NR-LITE2 Net Radiometer (qty 0 to 1)
    - CS301 or CS320 Pyranometer (qty 0 to 1)
    - CS310 Quantum Sensor (qty 0 to 1)
    - SI-111 Infrared Radiometer (qty 0 to 1)
  - Option 2
    - SN500SS, or NR01, or CNR4 4-Way Radiometer (qty 0 to 1; if using CNR4, the CNF4 Ventilation and Heating Unit is also supported)
- TE525MM Rain Gauge (qty 0 to 1)
- TCAV Soil Thermocouple Probe (qty 0 to 3)
- Soil Water Content Reflectometer (qty 0 to 3)
  - CS650
  - CS655
- Soil Heat Flux Plates (qty 0 to 3)
  - Option 1: HFP01 plates (qty 0 to 3)
  - Option 2: HFP01SC self-calibrating plates (qty 0 to 3)

NOTE It may be possible to customize the program for other sensors or quantities in configurations not described here. Contact Campbell Scientific for more information.

If the CPEC300-series system was ordered with the CR6 factory installed, the system is shipped with the *EasyFlux DL CR6CP* program installed. For users that will install a previously purchased CR6 into a CPEC300-series system or for wiring of the optional sensors mentioned above, refer to Appendix C, *Wiring the CR6 and Optional Energy Balance Sensors* *(p. C-1)*.

6.1 Operation

Operating the *EasyFlux DL CR6CP* requires the user to enter or edit certain constants and input variables unique to the program or site. Constants are typically edited only once when first initializing the program. Site-specific variables are edited upon initial deployment, but also periodically as site conditions change (e.g., canopy height is a variable that may need to be adjusted throughout a growing season). Section 6.2, *Set Constants* *(p. 36)*, gives details on editing constants, and Section 6.3, *Edit Input Variables* *(p. 43)*, gives details on editing variables.

Typical operation also includes periodic zeroing and spanning of the EC155 gas analyzer. Section 7, *Zero and Span* *(p. 81)*, provides more details on zeroing and spanning, either manually for the CPEC300 and CPEC306, or automatically with the CPEC310.

6.2 Set Constants

6.2.1 Categories of Constants

To begin program operation, the values for constants should be set or verified. TABLE 6-1 lists all constants with descriptions. Generally, the constants fall into five categories:

System Configuration Constants
These are constants that indicate the model of the system, which measurement peripherals are being used (e.g., CDMA-116, Scrub Module, etc.), and settings related to the system configuration (e.g., EC100 bandwidth, EC155 sample cell type).

Program Function Constants
These are constants that determine the timing of code execution, frequency of writing to output tables, memory allocation, data transfer options, etc. In most cases, the default constants for these values can be maintained.

Sensor Selection Constants
All sensor selection constants begin with the prefix *SENSOR*. The value is set to **TRUE** in the constant table if the system includes the sensor. For example, if a system has a fine-wire thermocouple, the constant **SENSOR_FW** should be set to **TRUE**. When set to **TRUE**, the wiring in TABLE C-13 will apply to the sensor and the data from that sensor will be included in the data output tables.

If a sensor is not used, ensure the constant is set to **FALSE**.

Sensor Quantity Constants
The value for these constants indicates the number of each type of sensor in the system. For example, if three soil heat flux (SHF) plates were being used, the constant **NMBR_HFP** would be set to **3**.

Sensor Calibration Constants
Some sensors have unique parameters for their measurement working equations (e.g., multipliers and/or offsets for linear working equations) that are used to convert their raw measurements into the values applicable in analysis. Typically, these parameter values are found on the calibration sheet from the sensor's original manufacturer. For example, if an NR-LITE2 net radiometer is being used, a unique multiplier is set in the following line of code: **Constant NRLIT_SNSTVT = 16**. The value entered is the sensor sensitivity provided in the NR-LITE2 calibration sheet.

NOTE Constants relating to a particular sensor have been grouped together and have the sensor selection constant at the beginning, such that if the sensor selection constant is set to **FALSE**, the other constants for that sensor may be ignored. For example, all of the constants dealing with the Temp/RH probe are grouped together with the **SENSOR_TMPR_RH** constant at the top. If a Temp/RH probe is not being used, **SENSOR_TMPR_RH** should be set to **FALSE** and the next four constants dealing with multipliers and offsets will be ignored in the program.

6.2.2 Accessing the Constants

The constants may be accessed for editing by opening the program code in CRBasic editor. Find the constants near the top of the program code, just after the introductory comments in a section titled "USER-DEFINED CONFIGURATION CONSTANTS" (see FIGURE 6-1); a user may also search for the word "unique" to find lines of code with user-editable constants.

Once changes are completed, the program must be recompiled and saved. Save the program under a new or modified file name to keep track of different program versions. Finally, send the program to the CR6 using *LoggerNet*, *PC400*, or *PC200W* user-interface software. After sending the program, its site-specific variables are ready to be reviewed and edited; see Section 6.3, *Edit Input Variables* *(p. 43)*.

NOTE After constants are edited in CRBasic editor and the program is loaded and running on the data logger, constants may still be viewed by accessing the Const Table using the CR1000KD keypad or through the *LoggerNet* Connect Screen.

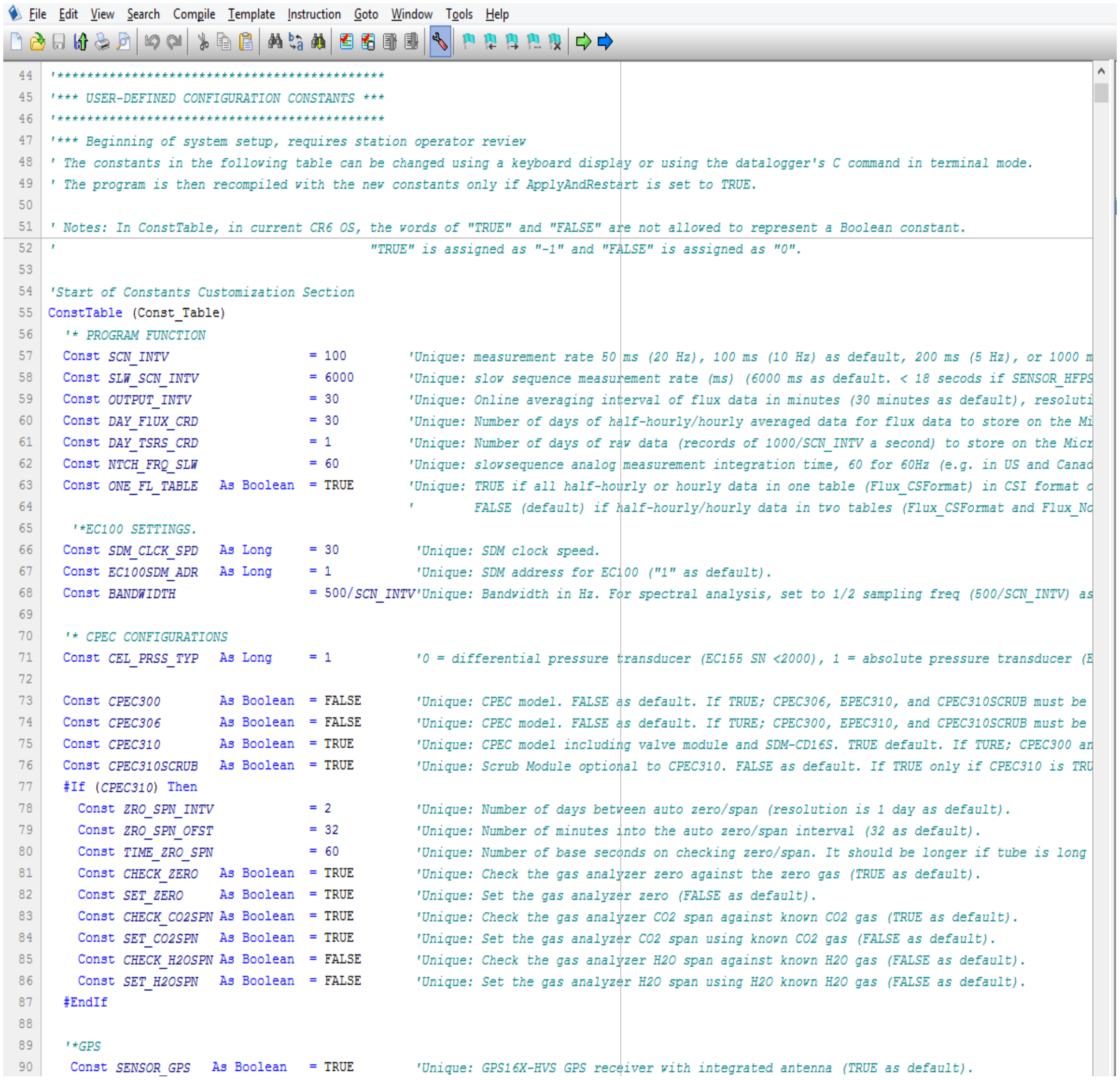


FIGURE 6-1. Example screen from CRBasic editor showing user-defined configuration constants

TABLE 6-1. Program Constants

Indented constant names indicate they are only applicable if the prior non-indented constant is true/applicable. Constants in shaded rows are only applicable and set to TRUE for CPEC306 and CPEC310 systems with a CDM-A116.

Constant Name	Default Value	Description
SCN_INTV	100	Measurement rate in milliseconds. Valid options: 50 (20 Hz) and 100 (10 Hz).
SLW_SCN_INTV	5000	Slow sequence measurement rate in milliseconds
OUTPUT_INTV	30	Interval in minutes over which to compute statistics and fluxes
DAY_FLUX_CRD	30	Number of days of data to write to each flux data output file stored on the card before beginning a new file
DAY_TSRS_CRD	1	The number of days of data to write to each time series output files stored on the card before beginning a new file.
NTCH_FRQ_SLW	60	Analog integration parameter for measurements in the slow sequence. Options: 60 (filters 60 Hz noise), 50 (filters 50 Hz noise). Choose the option that matches the AC power Hz at site.
ONE_FL_TABLE	TRUE	Set to **TRUE** to combine the *Flux_CSIFormat* and anciliary *Flux_Notes* tables into one full or large table. Set to **FALSE** to keep the two tables separate.
SDM_CLCK_SPD	30	SDM clock bit period in microseconds (µs). If long cables are used that result in skipped scans, this value should be increased. In most cases, the default is adequate.
EC100SDM_ADR	1	The SDM address of the EC100.
BANDWIDTH	500/SCN_INTV	The bandwidth for measurements from the EC100. For spectral analysis and general use, set to one half the sampling frequency (same as 500/SCN_INTV). If spectra are not considered, may be set to 20Hz for any sample rate. Options: 5, 10, 12.5, or 20 Hz.
CEL_PRSS_TYP	1	Set to 1 to indicate an absolute pressure sensor in the sample cell.
CPEC300	FALSE	Set to **TRUE** for CPEC300, else set to **FALSE**.
CPEC306	FALSE	Set to **TRUE** for CPEC306, else set to **FALSE**.
CPEC310	TRUE	Set to **TRUE** for CPEC310, else set to **FALSE**.
CPEC310SCRUB	FALSE	Set to **TRUE** if the system has a scrub module, else set to **FALSE**.
ZRO_SPN_INTV	1	Number of days between each automatic zero and span.
ZRO_SPN_OFST	32	Number of minutes to offset the automatic zero/span. For example, if ZRO_SPN_INTV is 1, and ZRO_SPN_OFST is 32, then the auto zero/span will occur at 12:32AM each day.

TABLE 6-1. Program Constants *Indented constant names indicate they are only applicable if the prior non-indented constant is true/applicable. Constants in shaded rows are only applicable and set to TRUE for CPEC306 and CPEC310 systems with a CDM-A116.*		
Constant Name	**Default Value**	**Description**
TIME_ZRO_SPN	60	Number of seconds on sites or steps in the automatic zero and span (see TABLE 7-2: Site Sequence and Timing in the Auto Zero and Span Cycle). Allow enough time for equilibration. For tall tower applications that have a large distance between CPEC310 system enclosure and the EC155 gas analyzer, this may need to be increased.
CHECK_ZERO	TRUE	Set to **TRUE** to measure and record the gas readings while zero gas is flowing but before the analyzer is zeroed. Set to **FALSE** to not measure and record.
SET_ZERO	TRUE	Set to **TRUE** to set the analyzer readings to zero while zero gas is flowing. Set to **FALSE** to not set the readings to zero.
CHECK_CO2SPN	TRUE	Set to **TRUE** to measure and record the gas readings while CO_2 span gas is flowing but before setting the span. Set to **FALSE** to not measure and record.
SET_CO2SPN	TRUE	Set to **TRUE** to set the analyzer CO_2 readings to the span gas concentration while CO_2 span gas is flowing. Set to **FALSE** to not set the readings to the CO_2 span concentration.
CHECK_H2OSPN	FALSE	Set to **TRUE** to measure and record the gas readings while H_2O span gas is flowing but before setting the span. Set to **FALSE** to not measure and record. Note: this is typically set to **FALSE** since having an autonomous field H_2O span gas source is difficult.
SET_H2OSPN	FALSE	Set to **TRUE** to set the analyzer H_2O readings to the span gas concentration while H_2O span gas is flowing. Set to **FALSE** to not set the readings to the H_2O span concentration. Note: this is typically set to **FALSE** since having an autonomous field H_2O span gas source is difficult.
SENSOR_GPS	TRUE	Set to **TRUE** if using a GPS16X sensor, if not, set to **FALSE**.
UTC_OFST	– 7	Difference between local time and UTC/GMT time in hours.
SENSOR_FW	FALSE	Set to **TRUE** if using a fine wire thermocouple, if not, set to **FALSE**.
SOIL_HT_FLUX	TRUE	Set to **TRUE** if sensors for calculating soil heat flux are used (i.e., the constants SENSOR_CS65X and SENSOR_HFP01/HFPSC are TRUE), else set to **FALSE**.

TABLE 6-1. Program Constants

Indented constant names indicate they are only applicable if the prior non-indented constant is true/applicable. Constants in shaded rows are only applicable and set to TRUE for CPEC306 and CPEC310 systems with a CDM-A116.

Constant Name	Default Value	Description
DVC_CDM_A116	FALSE	Set to **TRUE** for the CPEC306 or CPEC310 if they include the optional CDM-A116 device. Set to **FALSE** for the CPEC300.
CDM_SN	0000	The serial number of the CDM-A116.
CPI_ADDR_CDM	1	The CPI address of the CDM-A116.
CPI_DEVICE	"CDMA116"	A custom name the user can give the CDM-A116. It must be in quotation marks.
SENSOR_T_RH	FALSE	Set to **TRUE** if using a Temp/RH probe, else set to **FALSE**.
TMPR_MULT	0.14	The multiplier for the raw temperature reading. Set to 0.14 for HMP155A or 0.1 for EE181.
TMPR_OFST	– 80.0	The offset for the temperature reading. Set to – 80 for HMP155A or – 40 for EE181.
RH_MULT	0.1	Multiplier for raw RH reading. Set to 0.1 for HMP155A or EE181.
RH_OFST	0.0	Offset for RH reading. Set to 0 for HMP155A or EE181.
SENSOR_NRLIT	FALSE	Set to **TRUE** if using an NR-LITE2, if not, set to **FALSE**. If **TRUE**, SENSOR_NR01, SENSOR_CNR4, and SENSOR_SN500 must be set to **FALSE**.
RNLIT_SNSTVT	16.0	If using an NR-LITE2, enter the unique sensitivity as reported on the sensor's calibration sheet. Units: $\mu V \cdot W^{-1} \cdot m^{-2}$
SENSOR_CS301	FALSE	Set to **TRUE** if using a CS301 pyranometer, else set to **FALSE**. If **TRUE**, the following constants must be set to **FALSE**: SENSOR_CS320, SENSOR_NR01, SENSOR_CNR4, and SENSOR_SN500.
PYRAN_MULT	5	Multiplier for the pyranometer reading. Set to 5 for CS301. Units: $W \cdot m^{-2} \cdot mV^{-1}$
SENSOR_CS320	FALSE	Set to **TRUE** if using a CS320 pyranometer, else set to **FALSE**. If **TRUE**, the following constants must be set to **FALSE**: SENSOR_CS301, SENSOR_NR01, SENSOR_CNR4, and SENSOR_SN500.
CS320SDI_ADR	"A"	SDI address of the CS320.
SENSOR_CS310	FALSE	Set to **TRUE** if using a CS310, else set to FALSE. If **TRUE**, SENSOR_NR01, SENSOR_CNR4, and SENSOR_SN500 must be set to **FALSE**.
QUNTM_MULT	100	Units: $\mu mol \cdot m^{-2} \cdot s^{-1} \cdot mV^{-1}$
SENSOR_SI111	FALSE	Set to **TRUE** if using the SI111, if not, set to **FALSE**. If **TRUE**, SENSOR_NR01, SENSOR_CNR4, and SENSOR_SN500 must be set to **FALSE**.

TABLE 6-1. Program Constants
Indented constant names indicate they are only applicable if the prior non-indented constant is true/applicable. Constants in shaded rows are only applicable and set to TRUE for CPEC306 and CPEC310 systems with a CDM-A116.

Constant Name	Default Value	Description
m0_SI111	0	Enter the unique calibration parameter called "m0" found on the sensor calibration sheet.
m1_SI111	0	Unique sensor calibration parameter.
m2_SI111	0	Unique sensor calibration parameter.
b0_SI111	0	Unique sensor calibration parameter.
b1_SI111	0	Unique sensor calibration parameter.
b2_SI111	0	Unique sensor calibration parameter.
SENSOR_NR01	FALSE	Set to **TRUE** if using a NR01, if not, set to **FALSE**. If **TRUE**, the following constants must be set to **FALSE**: SENSOR_NRLIT, SENSOR_CNR4, SENSOR_SN500, SENSOR_CS301, SENSOR_CS320, SENSOR_CS310, and SENSOR_SI111.
SENSOR_CNR4	FALSE	Set to **TRUE** if using a CNR4, else set to **FALSE**. If **TRUE**, the following sensors must be set to **FALSE**: SENSOR_NRLIT, SENSOR_NR01, SENSOR_SN500, SENSOR_CS301, SENSOR_CS320, SENSOR_CS310, and _SI111.
SW_IN_SNSTVT	15.0	If using a NR01 or CNR4, enter the unique sensitivity of the upward facing pyranometer as reported on the sensor calibration sheet. Units: $\mu V \cdot m^2 \cdot W^{-1}$
SW_OUT_SNSTVT	15.0	Unique sensitivity of the downward facing pyranometer. Units: $\mu V \cdot m^2 \cdot W^{-1}$
LW_IN_SNSTVT	8.0	Unique sensitivity of the upward facing pyrgeometer. Units: $\mu V \cdot m^2 \cdot W^{-1}$
LW_OUT_SNSTVT	8.0	Unique sensitivity of the downward facing pyrgeometer. Units: $\mu V \cdot m^2 \cdot W^{-1}$
SENSOR_SN500	FALSE	Set to **TRUE** if using a SN500SS, else set to **FALSE**. If **TRUE**, the following constants must be set to **FALSE**: SENSOR_NRLIT, SENSOR_NR01, SENSOR_CNR4, SENSOR_CS301, SENSOR_CS320, SENSOR_CS310, and SENSOR_SI111.
SN500SDI_ADR	B	SDI address of the SN500SS.
SENSOR_TE525	FALSE	Set to **TRUE** if using a TE525-series rain gauge, if not set to 0 **FASLE**.
TE525_MULT	0.1	If using a TE525-series rain gauge, enter the multiplier. Units: mm per tip. Multiplier for TE525MM = 0.1 mm/tip as default, TE525 = 0.254 mm/tip, TE525WS = 0.254 mm/tip, TE525/WS w/ 8 in funnel 0.1459 mm/tip.
SENSOR_TCAV	FALSE	Set to **TRUE** if using a TCAV, if not, set to **FALSE**.
NMBR_TCAV	0	Number of TCAV probes used. Max: 3

TABLE 6-1. Program Constants
Indented constant names indicate they are only applicable if the prior non-indented constant is true/applicable. Constants in shaded rows are only applicable and set to TRUE for CPEC306 and CPEC310 systems with a CDM-A116.

Constant Name	Default Value	Description
SENSOR_CS65X	FALSE	Set to **TRUE** if a CS650 or CS655 is used, if not, set to **FALSE**.
NMBR_CS65X	0	Number of CS650 or CS655 probes used. Max: 3
CSSDI12_ADR1	1	SDI12 address of the first CS65X probe.
CSSDI12_ADR2	2	SDI12 address of the second CS65X probe.
CSSDI12_ADR3	3	SDI12 address of the third CS65X probe.
SENSOR_HFP01	FALSE	Set to **TRUE** if using a HFP01, if not, set to **FALSE**. If **TRUE**, SENSOR_HFPSC must be set to **FALSE**.
SENSOR_HFPSC	FALSE	Set to -1 (TRUE) if using a HFP01SC, if not, set to 0 (FALSE). If **TRUE**, SENSOR_HFP01 must be set to **FALSE**.
NMBR_HFP	0	Number of HFP01 or HFP01SC sensors used. Max: 3
HFP_SNSTVT_1	62.0	If using heat flux plates, enter the unique sensitivity of the first plate as reported on the sensor calibration sheet. Units: $\mu V \cdot m^2 \cdot W^{-1}$
HFP_SNSTVT_2	62.0	Unique sensitivity of second heat flux plate. Units: $\mu V \cdot m^2 \cdot W^{-1}$
HFP_SNSTVT_3	62.0	Unique sensitivity of third heat flux plate. Units: $\mu V \cdot m^2 \cdot W^{-1}$
CAL_INTV	1440	If using a HFP01SC, this is the time interval in minutes between auto calibrations.

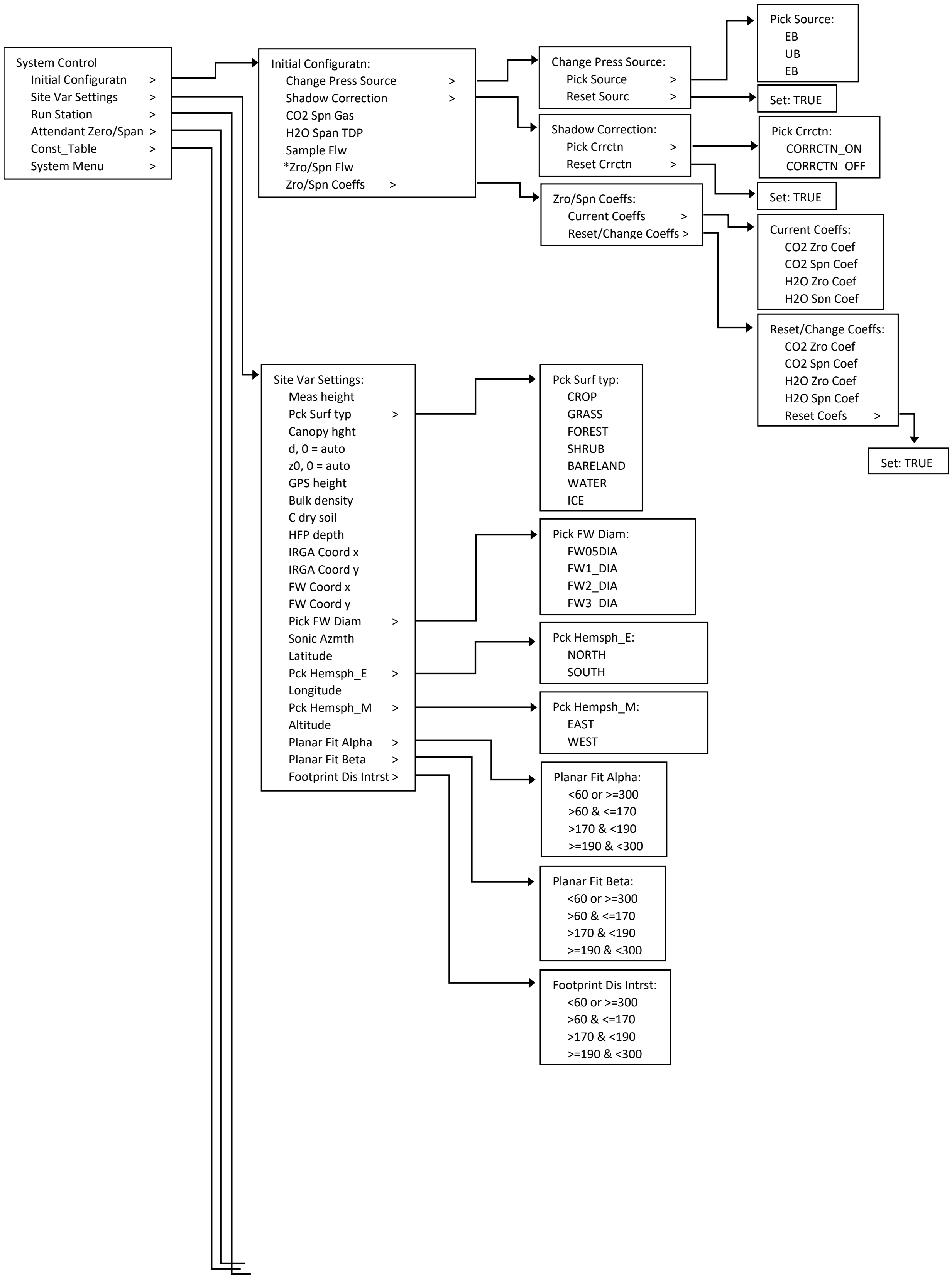
6.3 Edit Input Variables

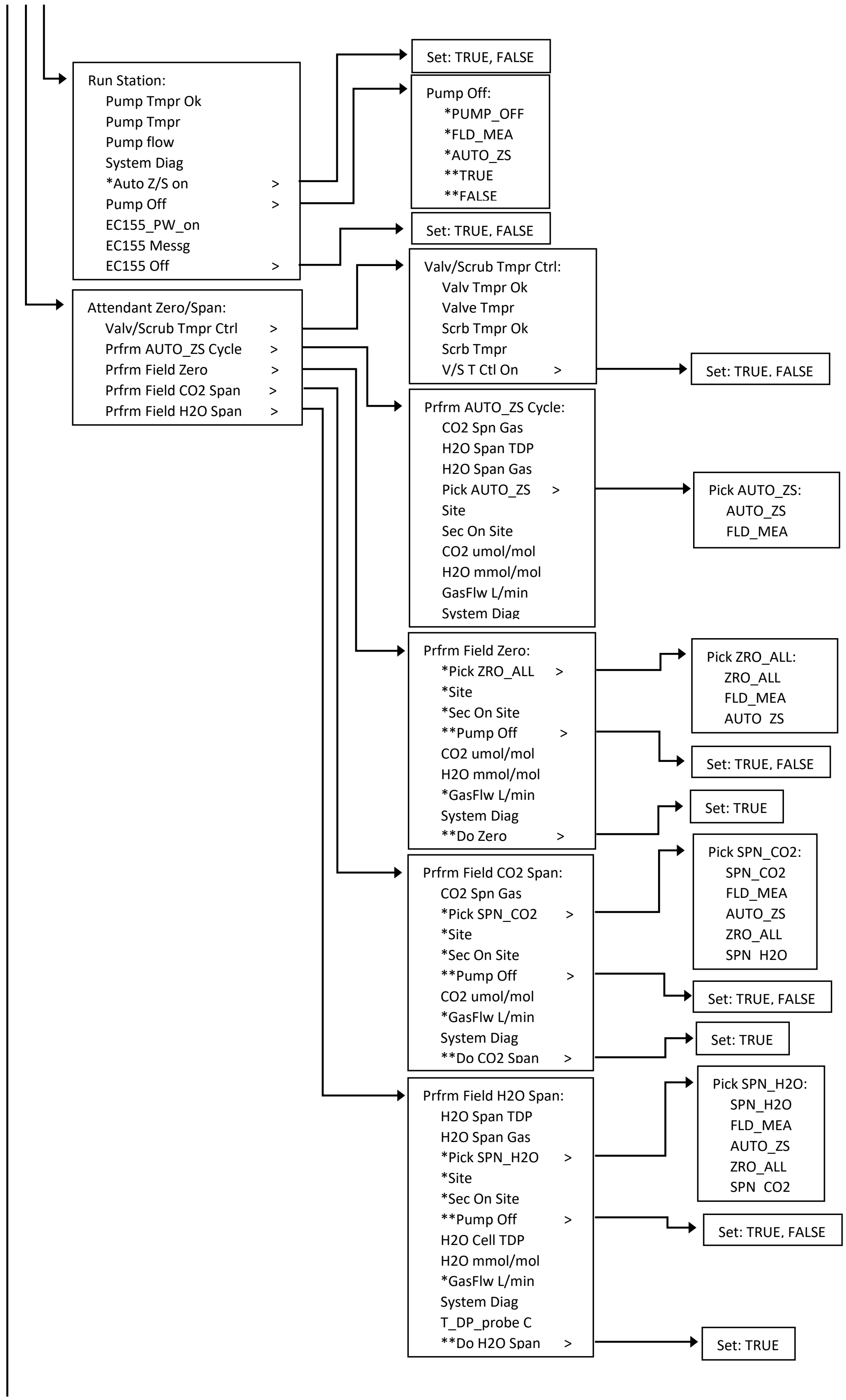
Before data and fluxes are processed correctly, the user must review and edit variables. This is done most conveniently with a CR1000KD keypad. After the CR1000KD is connected to the CS I/O port of the CR6 data logger and after the program is loaded and running, press **Enter** twice to access the main menu. FIGURE 6-2 shows an organizational schematic for all the keypad menus. Under the main menu, use the keypad's down arrow to scroll down to each of the submenus. To select a submenu, make sure the desired submenu is highlighted and press **Enter**. To return to a previous menu, press **Esc**. The three submenus titled *Initial Configuratn, Site Var Settings,* and *Run Station* contain the variables that must be reviewed A description of the variables in each of these submenus is found in TABLES 6-2, 6-3, and 6-4, respectively.

If a CR1000KD is not available, an alternative option is to review and edit variables using LoggerNet. Under the Connect Screen's Table Monitor, select the Public Table and then scroll to the appropriate variables. The last column in TABLES 6-2, 6-3, and 6-4 shows the corresponding variable name in the Public Table. To change a value of a variable in the Table Monitor, click on the cell to the right of the variable name, type the new value, and press **Enter**.

The values of user-input variables are stored in memory such that if the station loses power, the values will be retained.

NOTE FIGURE 6-2 is a schematic of the entire menu structure. When beginning operation of a system, the user must review and set variables in the following menus: *Initial Configuration, Site Var Settings,* and *Run Station*. The other menus shown in the schematic relate to doing a zero and span of the gas analyzer. More details on zeroing and spanning are found in Section 7, *Zero and Span* ***(p. 81)***.


System Control
Initial Configuratn >
Site Var Settings >
Run Station >
Attendant Zero/Span >
Const_Table >
System Menu >
Initial Configuratn:
Change Press Source >
Shadow Correction >
CO2 Spn Gas
H2O Span TDP
Sample Flw
*Zro/Spn Flw
Zro/Spn Coeffs >
Change Press Source:
Pick Source >
Reset Sourc >
Pick Source:
EB
UB
EB
Set: TRUE
Shadow Correction:
Pick Crrctn >
Reset Crrctn >
Pick Crrctn:
CORRCTN_ON
CORRCTN OFF
Set: TRUE
Zro/Spn Coeffs:
Current Coeffs >
Reset/Change Coeffs >
Current Coeffs:
CO2 Zro Coef
CO2 Spn Coef
H2O Zro Coef
H2O Spn Coef
Reset/Change Coeffs:
CO2 Zro Coef
CO2 Spn Coef
H2O Zro Coef
H2O Spn Coef
Reset Coefs >
Set: TRUE
Site Var Settings:
Meas height
Pck Surf typ >
Canopy hght
d, 0 = auto
z0, 0 = auto
GPS height
Bulk density
C dry soil
HFP depth
IRGA Coord x
IRGA Coord y
FW Coord x
FW Coord y
Pick FW Diam >
Sonic Azmth
Latitude
Pck Hemsph_E >
Longitude
Pck Hemsph_M >
Altitude
Planar Fit Alpha >
Planar Fit Beta >
Footprint Dis Intrst >
Pck Surf typ:
CROP
GRASS
FOREST
SHRUB
BARELAND
WATER
ICE
Pick FW Diam:
FW05DIA
FW1_DIA
FW2_DIA
FW3 DIA
Pck Hemsph_E:
NORTH
SOUTH
Pck Hempsh_M:
EAST
WEST
Planar Fit Alpha:
<60 or >=300
>60 & <=170
>170 & <190
>=190 & <300
Planar Fit Beta:
<60 or >=300
>60 & <=170
>170 & <190
>=190 & <300
Footprint Dis Intrst:
<60 or >=300
>60 & <=170
>170 & <190
>=190 & <300


Run Station:
Pump Tmpr Ok
Pump Tmpr
Pump flow
System Diag
*Auto Z/S on >
Pump Off >
EC155_PW_on
EC155 Messg
EC155 Off >
Set: TRUE, FALSE
Pump Off:
*PUMP_OFF
*FLD_MEA
*AUTO_ZS
**TRUE
**FALSE
Set: TRUE, FALSE
Attendant Zero/Span:
Valv/Scrub Tmpr Ctrl >
Prfrm AUTO_ZS Cycle >
Prfrm Field Zero >
Prfrm Field CO2 Span >
Prfrm Field H2O Span >
Valv/Scrub Tmpr Ctrl:
Valv Tmpr Ok
Valve Tmpr
Scrb Tmpr Ok
Scrb Tmpr
V/S T Ctl On >
Set: TRUE, FALSE
Prfrm AUTO_ZS Cycle:
CO2 Spn Gas
H2O Span TDP
H2O Span Gas
Pick AUTO_ZS >
Site
Sec On Site
CO2 umol/mol
H2O mmol/mol
GasFlw L/min
System Diag
Pick AUTO_ZS:
AUTO_ZS
FLD_MEA
Prfrm Field Zero:
*Pick ZRO_ALL >
*Site
*Sec On Site
**Pump Off >
CO2 umol/mol
H2O mmol/mol
*GasFlw L/min
System Diag
**Do Zero >
Pick ZRO_ALL:
ZRO_ALL
FLD_MEA
AUTO_ZS
Set: TRUE, FALSE
Set: TRUE
Prfrm Field CO2 Span:
CO2 Spn Gas
*Pick SPN_CO2 >
*Site
*Sec On Site
**Pump Off >
CO2 umol/mol
*GasFlw L/min
System Diag
**Do CO2 Span >
Pick SPN_CO2:
SPN_CO2
FLD_MEA
AUTO_ZS
ZRO_ALL
SPN_H2O
Set: TRUE, FALSE
Set: TRUE
Prfrm Field H2O Span:
H2O Span TDP
H2O Span Gas
*Pick SPN_H2O >
*Site
*Sec On Site
**Pump Off >
H2O Cell TDP
H2O mmol/mol
*GasFlw L/min
System Diag
T_DP_probe C
**Do H2O Span >
Pick SPN_H2O:
SPN_H2O
FLD_MEA
AUTO_ZS
ZRO_ALL
SPN_CO2
Set: TRUE, FALSE
Set: TRUE

- Const_Table:
  - SCN_INTV
  - SLW_SCN_INTV
  - OUTPUT_INTV
  - DAY_FLUX_CRD
  - DAY_TSRS_CRD
  - NTCH_FRQ_SLW
  - ONE_FL_TABLE
  - SDM_CLCK_SPD
  - EC100SDM_ADR
  - BANDWIDTH
  - CEL_PRSS_TYP
  - CPEC300
  - CPEC306
  - CPEC310
    - CPEC310SCRUB
    - ZRO_SPN_INTV
    - ZRO_SPN_OFST
    - TIME_ZRO_SPN
    - CHECK_ZERO
    - SET_ZERO
    - CHECK_CO2SPN
    - SET_CO2SPN
    - CHECK_H2OSPN
    - SET_H2OSPN
  - SENSOR_GPS
  - UTC_OFST

- Const_Table Cont'd:
  - SENSOR_FW
  - SOIL_HT_FLUX
  - DVC_CDM_A116
    - CDM_SN
    - CPI_ADDR_CDM
    - CPI_DEVICE
  - SENSOR_TMPR_RH
    - TMPR_MULT
    - TMPR_OFST
    - RH_MULT
    - RH_OFST
  - SENSOR_NRLIT
    - NRLIT_SNSTVT
  - SENSOR_CS301
    - PYRAN_MULT
  - SENSOR_CS320
    - CS320SDI_ADR
  - SENSOR_CS310
    - QUNTM_MULT
  - SENSOR_SI111
    - m0_SI111
    - m1_SI111
    - m2_SI111
    - b0_SI111
    - b1_SI111
    - b2_SI111

- Const_Table Cont'd:
  - SENSOR_NR01
  - SENSOR_CNR4
    - SW_IN_SNSTVT
    - SWOUT_SNSTVT
    - LW_IN_SNSTVT
    - LWOUT_SNSTVT
  - SENSOR_SN500
    - SN500SDI_ADR
  - SENSOR_TE525
    - TE525_MULT
  - SENSOR_TCAV
    - NMBR_TCAV
  - SENSOR_CS65X
    - NMBR_CS65X
    - CSSDI12_ADR1
    - CSSDI12_ADR2
    - CSSDI12_ADR3
  - SENSOR_HFP01
  - SENSOR_HFPSC
    - NMBR_HFP
    - HFP_SNSTVT_1
    - HFP_SNSTVT_2
    - HFP_SNSTVT_3
    - CAL_INTV

FIGURE 6-2. Custom keypad menu; arrows indicate submenus. The single asterisk (*) marks variables that are only displayed if the system is a CPEC310, and the double asterisk (**) marks variables that are only displayed if the system is a CPEC300 or CPEC306. In the constants table, indented constants are only applicable if the preceding non-indented constant is applicable.

TABLE 6-2. Variables from *Initial Configuration* Menu

Station Variable		Default	Description	Name of variable in Public Table (when no CR1000KD available)
Change Press Source	Pick Source	EB	Used to select the barometer to use for measurements of ambient pressure. Set to **EB** for EC100 enhanced barometer, **BB** for the EC100 on-board basic barometer, or **UB** for a user-supplied barometer.	press_source 0 = **BB** 1 = **UB** 2 = **EB**
	Reset Sourc	FALSE	If the variable **Pick Source** has been changed, this variable must be set to **TRUE** to enable the change. The program will return **Reset Sourc** to **FALSE** once the change has been applied.	set_press_source_flg –1 = True 0 = False
Shadow Correction	Pick Corrctn	CORRCTN_OFF	Used to enable the Kaimal sonic transducer wind shadowing correction as described in the CSAT3B manual. **CORRCTN_ON** enables the correction, while **CORRCTN_OFF** disables it.	shadow_corr –1 = CORRCTN_ON 0 = CORRCTN_OFF
	Set C0rrctn	FALSE	If the variable **Pick Crrctn** has been changed, this variable must be set to **TRUE** to enable the change. The program will return **Set Crrctn** to **FALSE** once the change has been applied.	set_shadow_corr_flg –1 = True 0 = False
CO2 Spn Gas		400 ppm	The dry molar mixing ratio concentration of the CO_2 span gas. A concentration close to ambient is recommended.	CO2_span_gas
H2O Span TDP		10 deg C	The dewpoint temperature of the H_2O span gas (i.e., the dewpoint temperature setting of the dewpoint generator).	Td_span_gas
Sample Flw		8 L min^{-1}	The set point for total flow into the gas analyzer. Note: If the vortex intake is installed, a portion of this flow will be diverted to the vortex bypass. See the *EC155 CO_2 and H_2O Closed-Path Gas Analyzer Manual* for more details.	pump_flow_set_pt

TABLE 6-2. Variables from *Initial Configuration* Menu				
Station Variable		**Default**	**Description**	**Name of variable in Public Table (when no CR1000KD available)**
Zro/Spn Flw		1 L min^{-1}	Only applicable to a CPEC310 with valve module. This is the set point for flow of zero or span gas through the gas analyzer. If the system is not a CPEC310, this variable is omitted.	valve_flow_set_pt
Zero Span Coeffs: Current Coeffs	CO2 Zro Coef	–	A read-only variable reporting the current value of the CO_2 zero coefficient.	ec100_setting_array(5,2)
	CO2 Spn Coef	–	A read-only variable reporting the current value of the CO_2 span coefficient.	ec100_setting_array(6,2)
	H2O Zro Coef	–	A read-only variable reporting the current value of the H_2O zero coefficient.	ec100_setting_array(7,2)
	H2O Spn Coef	–	A read-only variable reporting the current value of the H_2O span coefficient.	ec100_setting_array(8,2)
Zero Span Coeffs: Reset/Change Coeffs	CO2 Zro Coef	1	Used to restore gas analyzer coefficients to 1 or a previously user-recorded value. Enter the desired value and then set **Reset Coefs** variable to **TRUE** in order to apply. The program will return **Reset Coefs** to **FALSE** once the change has been applied.	dflt_CO2_zero_coeff
	CO2 Spn Coef	1	Used to restore gas analyzer coefficients to 1 or a previously user-recorded value. Enter the desired value and then set **Reset Coefs** variable to **TRUE** in order to apply. The program will return **Reset Coefs** to **FALSE** once the change has been applied.	dflt_CO2_span_coeff
	H2O Zro Coef	1	Used to restore gas analyzer coefficients to 1 or a previously user-recorded value. Enter the desired value and then set **Reset Coefs** variable to **TRUE** in order to apply. The program will return **Reset Coefs** to **FALSE** once the change has been applied.	dflt_H2O_zero_coeff

TABLE 6-2. Variables from *Initial Configuration* Menu				
Station Variable		**Default**	**Description**	**Name of variable in Public Table (when no CR1000KD available)**
	H2O Spn Coef	1	Used to restore gas analyzer coefficients to 1 or a previously user-recorded value. Enter the desired value and then set **Reset Coefs** variable to **TRUE** in order to apply. The program will return **Reset Coefs** to **FALSE** once the change has been applied.	dflt_H2O_span_coeff
	Reset Coefs	FALSE	Used to apply and send new coefficient variables to the gas analyzer. Once sent, the variable will return to **FALSE**.	reset_coeff_flg

TABLE 6-3. Variables and Settings in *Site Var Settings* Menu				
Station Variable	**Units**	**Default**	**Description**	**Name of variable in Public Table (when no CR1000KD available)**
Meas height	m	2	The height of the center of the eddy-covariance sensor measurement volumes above ground.	height_measurement
Pck surf typ	–	GRASS	Type of surface at the measurement site. Options are CROP, GRASS, FOREST, SHRUB, BARELAND, and WATER. This is used to estimate displacement height,	surface_type 1 = CROP 2 = GRASS 3 = FOREST 4 = SHRUBLAND 5 = BARELAND 6 = WATER 7 = ICE
Canopy hght	m	0.5	The average height of the canopy.	height_canopy
d	m	0 (Auto)	Displacement height. Set to zero (0) for program to auto-calculate.	displacement_user
z_0	m	0 (Auto)	Roughness length. Set to zero (0) for program to auto-calculate.	roughness_user
GPS height	m	1	The height of the GPS reciever above the ground surface. If GPS is not used, this variable is omitted.	height_GPS16X
Bulk density	$kg \cdot m^{-3}$	1300	Average bulk density of soil. If energy balance sensors are not used, this variable is omitted.	soil_bulk_density

TABLE 6-3. Variables and Settings in *Site Var Settings* Menu				
Station Variable	**Units**	**Default**	**Description**	**Name of variable in Public Table (when no CR1000KD available)**
C dry soil	$J \cdot kg^{-1} K^{-1}$	870	Specific heat of dry mineral soil. If energy balance sensors are not used, this variable is omitted.	cds
HFP depth	m	0.08	Depth of the soil heat flux plates. If energy balance sensors are not used, this variable is omitted.	thick_abv_HFP
IRGA Coord x	m	0.15020	Distance along the sonic x-axis between the sonic sampling volume and the EC155 gas analyzer intake.	separation_x_IRGA
IRGA Coord y	m	-0.03218	Distance along the sonic y-axis between the sonic sampling volume and the EC155 gas analyzer intake.	separation_y_IRGA
FW Coord x	m	0.02627	Distance along the sonic x-axis between the sonic sampling volume and fine-wire thermocouple. If no fine-wire thermocouple is being used, this variable is omitted.	separation_x_FW
FW Coord y	m	-0.02306	Distance along the sonic y-axis between the sonic sampling volume and the fine-wire thermocouple. If no fine-wire thermocouple is being used, this variable is omitted.	separation_y_FW
FW Diam	m	FW05_DIA	The diameter of the fine-wire thermocouple. A numberical value may be entered, or for convenience, the following pre-defined constants may be selected: FW05_DIA, FW1_DIA and FW3_DIA. Each constant corresponds to the diameter of the FW05, FW1, or FW3 thermocouple, and their diameters are 1.27×10^{-5}, 2.54×10^{-5}, and 7.62×10^{-5} m, respectively. If no fine-wire thermocouple is being used, this variable is omitted.	FW_diameter Predefined constants: FW05_DIA FW1_DIA FW3_DIA
Sonic Azmth	decimal degrees	0	The compass direction in which the sonic negative x-axis points (i.e., the compass direction in which the sonic head is pointing).	sonic_azimuth
Latitude	decimal degrees	41.766	The site latitude in degrees north or south.	Latitude
Pck Hemsph_E	–	NORTH	The site's hemisphere, either north or south of the equator. Options are **NORTH** or **SOUTH**.	hemisphere_NS 1 = North –1 = South

TABLE 6-3. Variables and Settings in *Site Var Settings* Menu

Station Variable		**Units**	**Default**	**Description**	**Name of variable in Public Table (when no CR1000KD available)**
Longitude		decimal degrees	111.855	The site longitude in degrees east or west.	Longitude
Pck Hemsph_M		–	WEST	The site's longitudinal hemisphere, either east or west of the prime meridian. Options are **EAST** or **WEST**.	hemisphere_EW 1 = East –1 = West
Altitude		m	1356	The site altitude or elevation above sea level.	altitude
Planar Fit Alpha	≤ 60 or ≥ 300	decimal degrees	0	Planar-fit alpha angle used to rotate the wind when the mean horizontal wind is blowing from the sector of 0 to 60 and 300 to 360 degrees in the sonic coordinate system (wind blowing into sonic head).[1/]	alpha_PF_60_300
	> 60 & ≤ 170	decimal degrees	0	Planar-fit alpha angle used to rotate the wind when the mean horizontal wind is blowing from the sector of 60 to 170 degrees in the sonic coordinate system (wind blowing from the sector left and behind sonic head).[1/]	alpha_PF_60_170
	> 170 & < 190	decimal degrees	0	Planar-fit alpha angle used to rotate the wind when the mean horizontal wind is blowing from the sector of 170 to 190 degrees in the sonic coordinate system (wind blowing from behind sonic head).[1/]	alpha_PF_170_190
	≥ 190 & < 300	decimal degrees	0	Planar-fit alpha angle used to rotate the wind when the mean horizontal wind is blowing from the sector of 190 to 300 degrees in the sonic coordinate system (wind blowing from the sector right and behind sonic head).[1/]	alpha_PF_190_300
Planar Fit Beta	≤ 60 or ≥ 300	decimal degrees	0	Planar-fit beta angle used to rotate the wind when the mean horizontal wind is blowing from the sector of 0 to 60 and 300 to 360 degrees in the sonic coordinate system (wind blowing into sonic head).[1/]	beta_PF_60_300
	> 60 & ≤ 170	decimal degrees	0	Planar-fit beta angle used to rotate the wind when the mean horizontal wind is blowing from the sector of 60 to 170 degrees in the sonic coordinate system (wind blowing from left and behind sonic head).[1/]	beta_PF_60_170

TABLE 6-3. Variables and Settings in *Site Var Settings* Menu

Station Variable		Units	Default	Description	Name of variable in Public Table (when no CR1000KD available)
	> 170 & < 190	decimal degrees	0	Planar-fit beta angle used to rotate the wind when the mean horizontal wind is blowing from the sector of 170 to 190 degrees in the sonic coordinate system (wind blowing from behind sonic head).[1/]	beta_PF_170_190
	≥ 190 & < 300	decimal degrees	0	Planar-fit beta angle used to rotate the wind when the mean horizontal wind is blowing from the sector of 190 to 300 degrees in the sonic coordinate system (wind blowing from right and behind sonic head).[1/]	beta_PF_190_300
Footprint Dis Intrst	≤ 60 or ≥ 300	m	100*z*	The upwind distance of interest from the station when the mean horizontal wind is blowing from the sector of 0 to 60 and 300 to 360 degrees in the sonic coordinate system (wind blowing into sonic head). Note: The program will report the percentage of cumulative footprint from within this distance. The default value is 100 times the aerodynamic height, *z*. Recall that *z* is the difference between the measurement height and displacement height.	dist_intrst_60_300
	> 60 & ≤ 170	m	100*z*	The upwind distance of interest from the station when the mean horizontal wind is blowing from the sector of 60 to 170 degrees in the sonic coordinate system (wind blowing from left and behind sonic head).	dist_intrst_60_170
	> 170 & < 190	m	100*z*	The upwind distance of interest from the station when the mean horizontal wind is blowing from the sector of 170 to 190 degrees in the sonic coordinate system (wind blowing from behind sonic head).	dist_instrst_170_190

TABLE 6-3. Variables and Settings in *Site Var Settings* Menu					
Station Variable		**Units**	**Default**	**Description**	**Name of variable in Public Table (when no CR1000KD available)**
	≥ 190 & < 300	m	100*z*	The upwind distance of interest from the station when the mean horizontal wind is blowing from the sector of 190 to 300 degrees in the sonic coordinate system (wind blowing from right and behind sonic head).	dist_intrst_190_300
[1/] Leave *all* planar fit alpha and beta angles set to 0 to use Tanner and Thurtell (1969) method of double coordinate rotations and have the rotation angles auto-calculated each averaging interval.					

TABLE 6-4. Variables from the *Run Station* Menu			
Variable Name	**Default**	**Description**	**Name of variable in Public Table (in case no CR1000KD available)**
Pump Tmpr Ok	–	This is a display (read-only) variable indicating whether the pump temperature is within its operating range.	pump_tmpr_ok
Pump Tmpr	–	This is a display (read-only) variable showing the temperature of the pump in °C.	pump_tmpr
Pump flow	8.0 L·min^{-1}	This is a display (read-only) variable showing the volumentric air flow to the pump. If using vortex intake, this includes both flow through sample cell and through vortex bypass.	pump_flow
System Diag	–	System diagnostic word. If set to 0, there are no error conditions detected. For more details on system diagnostic word, see Appendix C.	system_diag
Auto Z/S on	FALSE	Set to **TRUE** to initiate an automatic zero and CO_2 span of the gas analyzer. The system will return **Auto Z/S on** to **FALSE** once the zero/span is initiated, and the system will return to EC field measurements upon completion of the zero/span. This variable is ommitted if the system is a CPEC300 or CPEC306 (i.e., no valve module).	prfm_auto_zero_span_flg

TABLE 6-4. Variables from the *Run Station* Menu

Variable Name	Default	Description	Name of variable in Public Table (in case no CR1000KD available)
Pump Off	FALSE	For CPEC300 and CPEC306 systems, select **TRUE** to disable the pump. Set to **FALSE** to enable the pump. For CPEC310 systems, the options are **PMP_OFF** to disable the pump, **FLD_MEA** to re-enable pump and resume normal EC measurements, or **AUTO_ZS** to initiate an automatic zero/span cycle.	sample_pump_off_flg
EC155_PW_on	–	This is a read-only variable indicating whether the EC155 is powered on.	EC155_actual_pwr_on
EC155 Messg	–	This is a read-only string describing the current status of the EC155.	message
EC155 Off	FALSE	Set to TRUE to power down the EC155. Set to FALSE to power on EC155.	ec155_pwr_off_flg

6.4 Data Retrieval

The program stores a very limited amount of data to the internal CPU of the data logger, so a microSD Flash card should be used with the CR6. TABLE 6-5 shows the number of days of data a 2 GB, 8 GB, and 16 GB card will typically hold before the memory is full and data starts to be overwritten. For a real-time estimate of number of days remaining on the card, refer to the public variable **card_storage_available_days**.

In cases where real-time remote monitoring is desired, various telemetry options (for example, cellular, radio, etc.) are available to transmit the processed flux data. Certain conditions may also allow remote transmittal of time series data. Contact Campbell Scientific for more details.

TABLE 6-5. microSD Flash Card Fill Times

microSD Flash card size	Fill time with gas analyzer and sonic only	Fill time with gas analyzer, sonic, FW, and biomet/energy balance sensors)[1/]
2 GB	~29 days	~23 days
8 GB	~121 days	~92 days
16 GB	~242 days	~184 days

[1/]Biomet and energy balance sensors used for this fill time estimate include the following: HMP155A, NR-LITE2, CS300, LI200, LI190, SI-111, TE525MM, TCAV (qty 3), CS655 (qty 3), and HFP01 (qty 3)

NOTE microSD Flash cards from various manufacturers may have slightly different memory sizes on their 2 GB, 8 GB, and 16 GB cards, respectively. Also, as a card ages some of its sectors may become unusable, decreasing the available memory. Fill time estimates given in TABLE 6-5 are approximations for new cards.

CAUTION Campbell Scientific recommends and supports only the use of microSD cards obtained from Campbell Scientific. These cards are industrial grade and have passed Campbell Scientific hardware testing. Use of consumer grade cards substantially increases the risk of data loss.

6.5 Output Tables

Besides the **Const_Table** (see Section 6.2, *Set Constants* *(p. 36)*) and the standard **Public**, **Status**, **CPI Status**, and **DataTableInfo** tables that the data logger reports, the program has eight output tables. TABLE 6-6 gives the names of these output tables, along with a short description, the frequency at which a record is written to the table, and the amount of memory allocated from the CPU and SD card for each table.

NOTE The variable naming conventions used by AmeriFlux and other flux networks have been adopted. Additionally, an output table called **Flux_AmeriFluxFormat** reports the variables in the order and format prescribed by AmeriFlux.

(see *http://ameriflux.lbl.gov/data/aboutdata/data-variables/*).

The **Flux_CSFormat** and **Flux_Notes** tables may have some of the same outputs as they did in prior versions of closed-path flux system programs, although variable names have been updated to conform to AmeriFlux convention. If the user would prefer to have the data fields contained in the **Flux_Notes** table appended to the end of the **Flux_CSFormat** table rather than being placed in a separate output table, this is possible by changing the constant **ONE_FULL_TABLE** from **FALSE** to **TRUE** (see Section 6.2, *Set Constants* *(p. 36)*, for details on changing constants).

TABLE 6-6. Data Output Tables

Table Name	Description	Recording Interval	Memory on CR6 CPU	Memory on SD Card
Time_Series	Time series data (aligned to account for electronic delays)	SCAN_INTERVAL (default 100 ms)	Auto-Allocate (typically less than 1 hour)	Time_Series is broken up into files of size DAY_TSRS_CRD (default is 1-day files). (See TABLE 6-5 for estimates of total days)
Diagnostic	Reports most recent diagnostic flags from gas analyzer and sonic anemometer	SCAN_INTERVAL (default 100 ms)	1 record (most recent scan)	0 records
EC100_Config_Notes	Reports settings for the gas analyzer and sonic anemometer	Whenever settings are changed or system is power cycled	128 records	10*DAY_FLUX_CRD records (default 300 records)
Flux_AmeriFluxFormat	Processed flux and statistical data following reporting conventions and order of AmeriFlux	OUTPUT_INTERVAL (default 30 minutes)	NMBR_DAY_CPU (default 7 days)	Broken up into multi-day files, where the number of days on each file is defined by DAY_FLUXCRD (default 30 days); see TABLE 6-5 to calculate number of files
Flux_CSFormat	Processed flux and statistical data	OUTPUT_INTERVAL (default 30 minutes)	NMBR_DAY_CPU (default 7 days)	Broken up into multi-day files, where the number of days on each file is defined by DAY_FLUXCRD (default 30 days); see TABLE 6-5 to calculate number of files
Flux_Notes	Intermediate variables, station constants, and correction variables used to generate flux results	OUTPUT_INTERVAL (default 30 minutes)	NMBR_DAY_CPU (default 7 days)	Broken up into multi-day files, where the number of days on each file is defined by DAY_FLUXCRD (default 30 days); see TABLE 6-5 to calculate number of files
ZeroSpan_Check_Notes	Summary of field calibration data at the time of a zero or span check	When a zero or span check is performed	NUMBR_RCRDS_CHCK_NOTES_CPU (default 30 records or approximately 1 month)	NUMBR_RCRDS_CHCK_NOTES_CRD (default 1,398 records or approximately 1 year)
System_Operatn_Notes	Records any change in system status	When there is a change in system status	NMBR_RCRDS_OPRTN_NOTES_CPU (default 24 records)	NMBR_RCRDS_OPRTN_NOTES_CRD (default 1198 records)

TABLES 6-7 through 6-14 give a description of all data fields found in each data output table and when each data field is included in the table.

NOTE

Prior to coordinate rotations, the orthogonal wind components from the sonic anemometer are denoted as U_x, U_y, and U_z. Following coordinate rotations, the common denotation of u, v, and w is used, respectively.

NOTE Variables with _R denote that the value was computed after coordinate rotations were done. Variables with a _F denote that the value was calculated after frequency corrections were applied. Similarly, _SND and _WPL refer to variables that have had the SND correction or the WPL correction applied, respectively.

TABLE 6-7. Data Fields in the Time_Series Data Output Table

Data Field Name	Units	Description	Data Field Included
Ux	$m \cdot s^{-1}$	Wind speed along sonic x-axis	Always
Uy	$m \cdot s^{-1}$	Wind speed along sonic y-axis	Always
Uz	$m \cdot s^{-1}$	Wind speed along sonic z-axis	Always
T_SONIC	deg C	Sonic temperature	Always
diag_sonic	–	Raw sonic diagnostic value (**0** indicates no diagnostic flags set)	Always
CO2	$\mu mol \cdot mol^{-1}$	CO_2 dry molar mixing ratio	Always
H2O	$mmol \cdot mol^{-1}$	H_2O dry molar mixing ratio	Always
diag_irga	–	Raw gas analyzer diagnostic value (**0** indicates no diagnostic flags set)	Always
TA_1_1_1	deg C	Air temperature calculated from sonic temperature and humidity	Always
T_cell	deg C	Sample cell temperature	Always
PA_cell	kPa	Air pressure inside sample cell	Always
CO2_sig_strgth	–	CO_2 signal strength	Always
H2O_sig_strgth	–	H_2O signal strength	Always
PA_diff	kPa	Differential pressure (the difference between sample cell pressure and ambient pressure)	Always
PA	kPa	Ambient pressure	Always
pump_flow	$L \cdot min^{-1}$	Volumetric air flow to pump; if using vortex intake, this includes sample flow and vortex bypass flow	Always
sampling_regime	Binary number	For CPEC310 this identifies the current sampling regime. Bits 0 through 3 correspond to the current sampling site, and bit 4 is the omit flag. For computing fluxes, filter all values not equal to 1. (**1** corresponds to site 1 which is sampling ambient air with no omit flag set.) See Appendix B for more information on sampling regimes and sites.	If system is a CPEC310
FW	deg C	Air temperature measured by fine-wire thermocouple	If FW05, FW1, or FW3 is used

TABLE 6-8. Data Fields in the Diagnostic Output Table		
Data Field Name	**Description**	**Data Field Included**
system_diag	System diagnostic word. If **0**, no system errors detected. See Appendix C for more details on system diagnostic.	Always
sonc_er	Sonic error flag (**TRUE** or **– 1** if any sonic diagnostic flag detected)	Always
irga_er	EC155 error flag (**TRUE** or **– 1** if any irga diagnostic flag detected)	Always
pump_tmpr_er	Pump temperature error flag	Always
pump_flow_er	Pump flow error flag	Always
valv_tmpr_er	Valve temperature error flag	If CPEC310 with valve module
valv_flow_er	Valve flow error flag	If CPEC310
scrb_tmpr_er	Scrub temperature error flag	If scrub module used
diag_sonic	CSAT3A diagnostic word. If **0**, no error flags set. See *EC155 CO_2 and H_2O Closed-Path Gas Analyzer Manual* for more details.	Always
sonic_amp_l_f	Amplitude low diagnostic flag	Always
sonic_amp_h_f	Amplitude high diagnostic flag	Always
sonic_sig_lck_f	Signal lock diagnostic flag	Always
sonic_del_T_f_f	Delta Temp diagnostic flag	Always
sonic_aq_sig_f	Acquiring signal diagnostic flag	Always
sonic_cal_err_f	Calibration error diagnostic flag	Always
diag_irga	EC155 diagnostic word. If 0, no error flags set. See *EC155 CO_2 and H_2O Closed-Path Gas Analyzer Manual* more details.	Always
irga_bad_data_f	Any gas analyzer diagnostic flag is set	Always
irga_gen_fault_f	General system fault diagnostic flag	Always
irga_startup_f	Startup diagnostic flag	Always
irga_motor_spd_f	Motor speed diagnostic flag	Always
irga_tec_tmpr_f	Thermoelectric cooler (TEC) temperature diagnostic flag	Always
irga_src_pwr_f	Source power diagnostic flag	Always
irga_src_tmpr_f	Source temperature diagnostic flag	Always
irga_src_curr_f	Source current diagnostic flag	Always
irga_off_f	Gas head power down diagnostic flag	Always
irga_sync_f	Synchronization diagnostic flag	Always
irga_amb_tmpr_f	Ambient temperature probe diagnostic flag	Always
irga_amb_press_f	Ambient pressure diagnostic flag	Always
irga_CO2_I_f	CO_2 I signal diagnostic flag	Always

TABLE 6-8. Data Fields in the Diagnostic Output Table		
Data Field Name	**Description**	**Data Field Included**
irga_CO2_Io_f	CO_2 I_o signal diagnostic flag	Always
irga_H2O_I_f	H_2O I signal diagnostic flag	Always
irga_H2O_Io_f	H_2O I_o signal diagnostic flag	Always
irga_CO2_Io_var_f	CO_2 I_o variation diagnostic flag	Always
irga_H2O_Io_var_f	H_2O I_o variation diagnostic flag	Always
irga_CO2_sig_strgth_f	CO_2 signal strength diagnostic flag	Always
irga_H2O_sig_strgth_f	H_2O signal strength diagnostic flag	Always
irga_cal_err_f	Calibration file read error flag	Always
irga_htr_ctrl_off_f	Heater control off diagnostic flag	Always
irga_diff_press_f	Differential pressure out of bounds flag	Always
CO2_sig_strgth	CO_2 signal strength (service sample cell when < 80%, see *EC155 CO_2 and H_2O Closed-Path Gas Analyzer Manual*)	Always
H2O_sig_strgth	H_2O signal strength (service sample cell when < 80%, see *EC155 CO_2 and H_2O Closed-Path Gas Analyzer Manual*)	Always

TABLE 6-9. Data Field in the EC100_Config_Notes Output Table			
Data Field Name	**Units**	**Description**	**Data Field Included**
Config_type	String	A string indicating why the EC100 was reconfigured.	Always
mode	String	A string indicating the sampling mode. See Appendix B for more details on modes.	If system is a CPEC310
site	String	A string indicating the sampling site. See Appendix B for more details on sites.	If system is a CPEC310
bandwidth_freq	Hz	EC100 bandwidth (5, 10, 12, or 20 for 5 Hz, 10 Hz, 12.5 Hz, or 20 Hz respectively)	Always
press_source	–	A parameter indicating the sensor used by EC100 for ambient pressure (**0** for EC100 Basic Barometer, **1** for user/custom barometer, **2** for EC100 Enhanced Barometer)	Always
diff_press_select	–	A parameter indicating whether to report ambient pressure (open-path system) or differential pressure (closed-path system). It should be set to **2**, which will auto-select.	Always
sample_cell_press_type	–	A parameter indicating whether the sample cell pressure sensor is differential or absolute. Set to **0** for EC155 gas head serial numbers less than 2000, and set to **1** for serial numbers 2000 and greater.	Always

TABLE 6-9. Data Field in the EC100_Config_Notes Output Table			
Data Field Name	**Units**	**Description**	**Data Field Included**
tmpr_source	–	A parameter indicating the sensor used by EC100 for ambient temperature (**0** for EC100 Temperature Probe, no other values valid)	Always
CO2_zero_coeff	–	CO_2 zero coefficient set from last CO_2 zero	Always
CO2_span_coeff	–	CO_2 span coefficient set from last CO_2 span	Always
CO2_span_mixra	$\mu mol \cdot mol^{-1}$	CO_2 mixing ratio of span gas	Always
H2O_zero_coeff	–	H_2O zero coefficient set from last H_2O zero	Always
H2O_span_coeff	–	H_2O span coefficient set from last H_2O span	Always
H2O_span_T_DP	deg C	Dewpoint temperature of span gas	Always
EC155_pwr_off	-	A parameter indicating whether the EC155 gas head is in sleep or power-down mode. Set to **0** for power on; set to **1** for power off.	Always
CR6_Volts	V	Battery voltage as measured at the CR6 battery input terminal	Always
Heater_volts	V	Heater Control Setting (**–1** for disabled, **–2** for auto control)	Always
Shadow_corr	–	Application of transducer shadowing correction (**0** for off, **1** for on)	Always

TABLE 6-10. Data Fields in the Flux_AmeriFluxFormat Output Table			
Data Field Name	**Units**	**Description**	**Data Field Included**
TIMESTAMP_START	YYYYMMDDHHMM	Start time of the averaging period	Always
TIMESTAMP_END	YYYYMMDDHHMM	End time of the averaging period	Always
CO2	$\mu mol \cdot mol^{-1}$	CO_2 flux after corrections	Always
CO2_SIGMA	$\mu mol \cdot mol^{-1}$	Standard deviation of CO_2	Always
H2O	$mmol \cdot mol^{-1}$	Average H_2O molar mixing ratio (dry basis)	Always
H2O_SIGMA	$mmol \cdot mol^{-1}$	Standard deviation of H_2O	Always
FC	$\mu mol \cdot m^{-2} \cdot s^{-1}$	CO_2 flux after corrections	Always
FC_SSITC_TEST	–	Result of steady state and integral turbulence characteristics for FC according to Foken et al. (2004)	Always
LE	$W \cdot m^{-2}$	Latent heat flux after corrections	Always
LE_SSITC_TEST	–	Result of steady state and integral turbulence characteristics for LE according to Foken et al. (2004)	Always
ET	$mm \cdot hour^{-1}$	Evapotranspiration	Always

TABLE 6-10. Data Fields in the Flux_AmeriFluxFormat Output Table

Data Field Name	Units	Description	Data Field Included
ET_SSITC_TEST	–	Result of steady state and integral turbulence characteristics for ET according to Foken et al. (2004)	Always
H	$W{\cdot}m^{-2}$	Sensible heat flux after corrections	Always
H_SSITC_TEST	–	Result of steady state and integral turbulence characteristics for FC according to Foken et al. (2004)	Always
G	$W{\cdot}m^{-2}$	Calculated heat flux at the ground surface	If using energy balance sensors
SG	$W{\cdot}m^{-2}$	The change in heat storage in the soil above the soil heat flux plates during the averaging interval	If using energy balance sensors
FETCH_MAX	m	Distance upwind where the maximum contribution to the footprint is found	Always
FETCH_90	m	Upwind distance that contains 90% of cumulative footprint. If NAN is returned, integration of the model never reached 90% within the allowable distance of integration.	Always
FETCH_55	m	Upwind distance that contains 55% of footprint	Always
FETCH_40	m	Upwind distance that contains 40% of footprint.	Always
WD	decimal degrees	Average wind direction	Always
WS	$m{\cdot}s^{-1}$	Average wind speed	Always
WS_MAX	$m{\cdot}s^{-1}$	Maximum wind speed	Always
USTAR	$m{\cdot}s^{-1}$	Friction velocity	Always
ZL	–	Stability	Always
TAU	$kg{\cdot}m^{-1}{\cdot}s^{-2}$	Momentum Flux	Always
TAU_SSITC_TEST	–	Result of steady state and integral turbulence characteristics for FC according to Foken et al. (2004)	Always
MO_LENGTH	m	Monin-Obukhov length	Always
U	$m{\cdot}s^{-1}$	Average streamwise wind	Always
U_SIGMA	$m{\cdot}s^{-1}$	Standard deviation of streamwise wind	Always
V	$m{\cdot}s^{-1}$	Average crosswind	Always
V_SIGMA	$m{\cdot}s^{-1}$	Standard deviation of crosswind	Always
W	$m{\cdot}s^{-1}$	Average vertical wind	Always

TABLE 6-10. Data Fields in the Flux_AmeriFluxFormat Output Table			
Data Field Name	**Units**	**Description**	**Data Field Included**
W_SIGMA	$m \cdot s^{-1}$	Standard deviation of vertical wind	Always
PA	kPa	Average atmospheric Pressure	Always
PA_SIGMA	kPa	Standard deviation of atmospheric Pressure	Always
TA_1_1_1	deg C	Average air temperature calculated from sonic temperature and H_2O mixing ratio	Always
TA_SIGMA_1_1_1	deg C	Standard deviation of air temperature calculated from sonic temperature and H_2O mixing ratio	Always
RH_1_1_1	%	Average relative humidity calculated from TA_1_1_1, H_2O mixing ratio, and pressure.	Always
T_DP_1_1_1	deg C	Average dewpoint temperature calculated from H_2O mixing ratio and pressure.	Always
TA_2_1_1	deg C	Average air temperature measured by temp/RH probe	If using temp/RH probe
RH_2_1_1	%	Average relative humidity measured by temp/RH probe	If using temp/RH probe
T_DP_2_1_1	deg C	Average dewpoint temperature calculated from temp/RH probe measurements	If using temp/RH probe
VPD	hPa	Vapor pressure deficit	If using temp/RH probe
T_SONIC	deg C	Average sonic temperature	Always
T_SONIC_SIGMA	deg C	Standard deviation of sonic temperature	Always
PBLH	m	Estimated planetary boundary layer height	Always
SWC_x_1_1	%	Average volumetric soil water content. x is an index for the number of sensors.	If using CS650 or CS655
TS_x_1_1	deg C	Average soil temperature. x is an index for the number of soil temperature measurements made.	If using TCAV or CS65X
ALB	–	Albedo	If using NR01, CNR4, or SN500SS
NETRAD	$W \cdot m^{-2}$	Net radiation	If using NR01, CNR4, SN500SS,or NRLITE2
PPFD_IN	$\mu mol \cdot m^{-2} \cdot s^{-1}$	Photosynthetic photon density	If using CS310

TABLE 6-10. Data Fields in the Flux_AmeriFluxFormat Output Table

Data Field Name	Units	Description	Data Field Included
SW_IN	$W \cdot m^{-2}$	Incoming shortwave radiation	If using NR01, CNR4, SN500SS, CS301, or CS320
SW_OUT	$W \cdot m^{-2}$	Outgoing shortwave radiation	If using NR01, CNR4, or SN500SS
LW_IN	$W \cdot m^{-2}$	Incoming longwave radiation	If using NR01, CNR4, or SN500SS
LW_OUT	$W \cdot m^{-2}$	Outgoing longwave radiation	If using NR01, CNR4, or SN500SS
P	mm	Precipitation in output interval	If using TE525
T_CANOPY	deg C	Canopy temperature	If using SI111

TABLE 6-11. Data Fields in the Flux_CSFormat Data Output Table

Data Field Name	Units	Description	Data Field Included
FC	$\mu mol \cdot m^{-2} \cdot s^{-1}$	Final corrected CO_2 flux	Always
FC_mass	$mg \cdot m^{-2} \cdot s^{-1}$	Final corrected CO_2 flux	Always
FC_QC	grade	Overall quality grade for Fc_molar and Fc_mass following Foken et al. 2012. See Appendix D for quality grade definitions.	Always
FC_samples	count	The total number of time series samples used in calculation of Fc	Always
LE	$W \cdot m^{-2}$	Final corrected latent heat flux	Always
LE_QC	grade	Overall quality grade for LE following Foken et al. 2012. See Appendix D for quality grade definitions.	Always
LE_samples	count	The total number of time series samples used in calculation of LE	Always
H	$W \cdot m^{-2}$	Final corrected sensible heat flux derived from sonic sensible heat flux	Always
H_QC	grade	Overall quality grade for Hs following Foken et al. 2012. See Appendix D for quality grade definitions.	Always
H_samples	count	The total number of time series samples used in calculation of H	Always
H_FW	$W \cdot m^{-2}$	Final corrected sensible heat flux derived from fine-wire thermocouple measurements	If using FW05, FW1, or FW3
H_FW_samples	count	The total number of time series samples used in calculation of H_FW	If using FW05, FW1, or FW3 used

TABLE 6-11. Data Fields in the Flux_CSFormat Data Output Table

Data Field Name	Units	Description	Data Field Included
NETRAD	$W \cdot m^{-2}$	Average net radiation (corrected for wind)	If using NR-LITE2, NR01, CNR4, or SN500SS
G	$W \cdot m^{-2}$	Heat flux at the ground surface	If using energy balance sensors
SG	$W \cdot m^{-2}$	The change in heat storage in the soil above the soil heat flux plates during the averaging interval	If using energy balance sensors
energy_closure	fraction	The ratio of sensible and latent heat fluxes over surface heat flux plus net radiation	If using energy balance sensors
poor_enrg_clsur	–	If **TRUE (non-zero)**, energy closure is poor even though micrometeorological conditions are reasonably good with no precipitation (alerts user to examine instruments)	If using energy balance sensors and rain gauge
Bowen_ratio	fraction	The ratio of final sensible heat flux over final latent heat flux	Always
TAU	$kg \cdot m^{-1} \cdot s^{-2}$	Final corrected momentum flux	Always
TAU_QC	grade	Overall quality grade for tau following Foken et al. 2012. See Appendix D for quality grade definitions.	Always
USTAR	$m \cdot s^{-1}$	Friction velocity after coordinate rotations and frequency corrections	Always
TSTAR	deg C	Scaling temperature after coordinate rotations, frequency corrections, and SDN correction	Always
TKE	$m^2 \cdot s^{-2}$	Specific turbulence kinetic energy after coordinate rotations	Always
TA_1_1_1	deg C	Average ambient temperature calculated from sonic temperature and H_2O mixing ratio	Always
TA_SIGMA_1_1_1	deg C	Standard deviation of ambient temperature calculated from sonic temperature and H_2O mixing ratio	Always
RH_1_1_1	%	Relative humidity calculated from TA_1_1_1, H_2O mixing ratio, and pressure.	Always
T_DP_1_1_1	deg C	Average dewpoint temperature calculated using H_2O mixing ratio and ambient pressure	Always
e	kPa	Average water vapor pressure calculated using H_2O mixing ratio and ambient pressure	Always

TABLE 6-11. Data Fields in the Flux_CSFormat Data Output Table			
Data Field Name	**Units**	**Description**	**Data Field Included**
e_sat	kPa	Average saturated water vapor pressure calculated using TA_1_1_1 and ambient pressure	Always
TA_2_1_1	deg C	Average ambient temperature measured by temp/RH probe	If using temp/RH probe
RH_2_1_1	%	Average relative humidity measured by temp/RH probe	If using temp/RH probe
T_DP_2_1_1	deg C	Average dewpoint temperature calculated using temp/RH probe measurements	If using temp/RH probe
e_probe	kPa	Average water vapor pressure calculated from temp/RH probe measurements	If using temp/RH probe
e_sat_probe	kPa	Average saturated water vapor pressure calculated from temp/RH probe measurements	If using temp/RH probe
H2O_probe	$g\cdot m^{-3}$	Average water vapor density calculated from temp/RH probe measurements	If using temp/RH probe
PA	kPa	Average ambient air pressure	Always
PA_SIGMA	kPa	Standard deviation of ambient air pressure	Always
VPD	kPa	Average vapor pressure deficit	Always
U	$m\cdot s^{-1}$	Mean streamwise wind speed after coordinate rotations	Always
U_SIGMA	$m\cdot s^{-1}$	Standard deviation of streamwise wind after coordinate rotations	Always
V	$m\cdot s^{-1}$	Average crosswind speed after coordinate rotations	Always
V_SIGMA	$m\cdot s^{-1}$	Standard deviation of crosswind after coordinate rotations	Always
W	$m\cdot s^{-1}$	Average vertical wind speed after coordinate rotations	Always
W_SIGMA	$m\cdot s^{-1}$	Standard deviation of vertical wind after coordinate rotations	Always
T_SONIC	deg C	Average sonic temperature	Always
T_SONIC_SIGMA	deg C	Standard deviation of sonic temperature	Always
sonic_azimuth	decimal degrees	Compass direction to which the sonic arms point (i.e., sonic negative x-axis points in this direction)	Always
WS	$m\cdot s^{-1}$	Average wind speed	Always
WS_RSLT	$m\cdot s^{-1}$	Average horizontal wind speed	Always

TABLE 6-11. Data Fields in the Flux_CSFormat Data Output Table			
Data Field Name	**Units**	**Description**	**Data Field Included**
WD_SONIC	decimal degrees	Average wind direction in the sonic coordinate system	Always
WD_SIGMA	decimal degrees	Standard deviation of wind direction	Always
WD	decimal degrees	Average compass wind direction	Always
WS_MAX	$m \cdot s^{-1}$	Maximum wind speed	Always
CO2	$\mu mol \cdot mol^{-1}$	Average CO_2 dry molar mixing ratio	Always
CO2_SIGMA	$\mu mol \cdot mol^{-1}$	Standard deviation of CO_2 dry molar mixing ratio	Always
CO2_density	$mg \cdot m^{-3}$	Average CO_2 mass density	Always
CO2_density_SIGMA	$mg \cdot m^{-3}$	Standard deviation of CO_2 mass density	Always
H2O	mmol·mol-1	Average H_2O dry molar mixing ratio	Always
H2O_SIGMA	mmol·mol-1	Standard deviation of H_2O dry molar mixing ratio	Always
H2O_density	$mmol \cdot mol^{-1}$	Water vapor mass density	Always
H2O_density_SIGMA	$mmol \cdot mol^{-1}$	Standard deviation of water vapor mass density	Always
CO2_sig_strgth_Min	–	Minimum CO_2 signal strength	Always
H2O_sig_strgth_Min	–	Minimum H_2O signal strength	Always
FW	deg C	Average fine-wire thermocouple temperature	If using FW05, FW1, or FW3 used
FW_SIGMA	deg C	Standard deviation of fine-wire thermocouple temperature	If using FW05, FW1, or FW3 used
P	mm	Total precipitation	If using TE525MM
NETRAD_meas	$W \cdot m^{-2}$	Average net radiation (raw, not corrected for wind)	If using NR-LITE2
ALB	–	Average albedo	If using CNR4, NR01, or SN500SS
SW_IN	$W \cdot m^{-2}$	Average incoming short wave radiation	If using CS301, CS320, CNR4, NR01, or SN500SS
SW_OUT	$W \cdot m^{-2}$	Average outgoing short wave radiation	If using CNR4, NR01, or SN500SS
LW_IN	$W \cdot m^{-2}$	Average incoming long wave radiation	If using CNR4, NR01, or SN500SS
LW_OUT	$W \cdot m^{-2}$	Average outgoing long wave radiation	If using CNR4, NR01, or SN500SS
T_nr	K	Average sensor body temperature	If using CNR4 or NR01

TABLE 6-11. Data Fields in the Flux_CSFormat Data Output Table			
Data Field Name	**Units**	**Description**	**Data Field Included**
T_nr_in	K	Average sensor body temperature for incoming pyrgeometer measuring LW_IN	If using SN500SS
T_nr_out	K	Average sensor body temperature for pyrgeometer measuring LW_OUT	If using SN500SS
R_LW_in_meas	$W \cdot m^{-2}$	Average raw incoming long wave radiation	If using CNR4 or NR01
R_LW_out_meas	$W \cdot m^{-2}$	Average raw outgoing long wave radiation	If using CNR4 or NR01
PPFD_IN	$\mu mol \cdot s^{-1} \cdot m^{-2}$	Average density of photosynthetic active radiation	If using CS310
sun_azimuth	decimal degrees	Solar azimuth	Always
sun_elevation	decimal degrees	Solar elevation	Always
hour_angle	decimal degrees	Solar hour angle	Always
sun_declination	decimal degrees	Solar declination	Always
air_mass_coeff	–	Air mass coefficient: Ratio of the path length between the current solar position to the solar noon	Always
daytime	fraction	Day time in fraction of an output interval	Always
T_CANOPY	deg C	Average temperature of targeted object	If using SI111
T_SI111_body	deg C	Average temperature of sensor body	If using SI111
TS_x_1_1	deg C	Average soil temperature for each soil temperature sensor; x is an index for the number of sensors	If using TCAV or CS650 or CS655
SWC_x_1_1	$m^3 \cdot m^{-3}$	Average volumetric soil water content for each CS650 or CS655; x is an index for the number of each sensor model above	If using CS650 or CS655 sensors
CS65x_ec_x_1_1	$dS \cdot m^{-1}$	Average electrical conductivity for each sensor; x is an index for the number of CS650 or CS655	If using CS650 or CS655
G_PLATE_x_1_1	$W \cdot m^{-2}$	Average heat flux through plate; x is an index for the number of HFP01 or HFP01SC	If using HFP01 or HFP01SC

TABLE 6-11. Data Fields in the Flux_CSFormat Data Output Table			
Data Field Name	**Units**	**Description**	**Data Field Included**
shfp_cal_x_1_1	$W \cdot m^{-2} \cdot mV^{-1}$	Coefficients found from the HFP01SC self-calibration and used to calculate shf_plate_x_1_1; x is an index for the number of HFP01 or HFP01SC	If using HFP01SC
G_x_1_1	$W \cdot m^{-2}$	Soil heat flux at the ground surface; x is an index for the number of soil sensor sets	If using HFP01(SC) and CS65X
SG_x_1_1	$W \cdot m^{-2}$	Change in soil heat storage; x is an index for the number of soil sensor sets	If using HFP01(SC) and CS65X
FETCH_MAX	m	Distance upwind where the maximum contribution to the footprint is found	Always
FETCH_90	m	Upwind distance that contains 90% of cumulative footprint	Always
FETCH_55	m	Upwind distance that contains 55% of footprint	Always
FETCH_40	m	Upwind distance that contains 40% of footprint. If **NAN** is returned, integration of the model never reached 90% within the allowable distance of integration.	Always
UPWND_DIST_INTRST	m	Upwind distance of interest for the average wind direction	Always
FTPRNT_DIST_INTRST	%	Percentage of footprint from within the upwind range of interest	Always
FTPRNT_EQUATION	text	Returns either **Kljun** or **KormannMeixner**; the model of Kljun et al. (2004) is used for applicable atmospheric conditions, else the model of Kormann & Meixner (2001) is used.	Always

TABLE 6-12. Data fields in the Flux_Notes Output Table			
Data Field Name	**Units**	**Description**	**Data Field Included**
Ux	$m \cdot s^{-1}$	Average U_x	Always
Ux_SIGMA	$m \cdot s^{-1}$	Standard deviation of U_x	Always
Uy	$m \cdot s^{-1}$	Average U_y	Always
Uy_SIGMA	$m \cdot s^{-1}$	Standard deviation of U_y	Always
Uz	$m \cdot s^{-1}$	Average U_z	Always
Uz_SIGMA	$m \cdot s^{-1}$	Standard deviation of U_z	Always
UxUy_cov	$m^2 \cdot s^{-2}$	Covariance of U_x and U_y	Always

TABLE 6-12. Data fields in the Flux_Notes Output Table

Data Field Name	Units	Description	Data Field Included
UxUz_cov	$m^2 \cdot s^{-2}$	Covariance of U_x and U_z	Always
UyUz_cov	$m^2 \cdot s^{-2}$	Covariance of U_y and U_z	Always
TsUx_cov	deg $C \cdot m \cdot s^{-1}$	Covariance of T_s and U_x	Always
TsUy_cov	deg $C \cdot m \cdot s^{-1}$	Covariance of T_s and U_y	Always
TsUz_cov	deg $C \cdot m \cdot s^{-1}$	Covariance of T_s and U_z	Always
USTAR_R	$m \cdot s^{-1}$	Friction velocity after coordinate rotations	Always
UV_cov	$m \cdot s^{-1}$	Covariance of streamwise and crosswind after coordinate rotations	Always
UW_cov	$m \cdot s^{-1}$	Covariance of streamwise and crosswind after coordinate rotations	Always
VW_cov	$m \cdot s^{-1}$	Covariance of crosswind and vertical wind after coordinate rotations	Always
UT_SONIC_Cov	$m \cdot °C \cdot s^{-1}$	Covariance of streamwise wind and sonic temperature after coordinate rotations	Always
VT_SONIC_Cov	$m \cdot °C \cdot s^{-1}$	Covariance of crosswind and sonic temperature after coordinate rotations	Always
WT_SONIC_Cov	$m \cdot °C \cdot s^{-1}$	Covariance of vertical wind (after coordinate rotations) and sonic temperature	Always
UW_Cov_fc	$m^2 \cdot s^{-2}$	Covariance of streamwise and vertical wind after coordinate rotations and frequency corrections	Always
VW_Cov_fc	$m^2 \cdot s^{-2}$	Covariance of cross and vertical wind after coordinate rotations and frequency corrections	Always
WT_SONIC_Cov_fc	$m \cdot °C \cdot s^{-1}$	Covariance of vertical wind and sonic temperature after coordinate rotations and frequency corrections	Always
WT_SONIC_Cov_fc_SND	$m \cdot °C \cdot s^{-1}$	Covariance of vertical wind and sonic temperature after coordinate rotations, frequency corrections, and SND correction	Always
sonic_samples	count	Number of raw sonic samples in averaging period without diagnostic flags	Always
no_sonic_head_Tot	count	Number of sonic samples where no sonic head was detected	Always
no_new_sonic_data_Tot	count	Number of scans where no sonic data were received	Always
sonic_amp_l_f_Tot	count	Number of sonic samples with amplitude low diagnostic flag	Always

TABLE 6-12. Data fields in the Flux_Notes Output Table			
Data Field Name	**Units**	**Description**	**Data Field Included**
sonic_amp_h_f_Tot	count	Number of sonic samples with amplitude high diagnostic flag	Always
sonic_sig_lck_f_Tot	count	Number of sonic samples with signal lock diagnostic flag	Always
sonic_del_T_f_Tot	count	Number of sonic samples with delta temp diagnostic flag	Always
sonic_aq_sig_f_Tot	count	Number of sonic samples with acquiring signal diagnostic flag	Always
sonic_cal_err_f_Tot	count	Number of sonic samples with calibration error diagnostic flag	Always
UxCO2_Cov	$mg \cdot m^{-2} \cdot s^{-1}$	Covariance of U_x and CO_2 density	Always
UyCO2_Cov	$mg \cdot m^{-2} \cdot s^{-1}$	Covariance of U_y and CO_2 density	Always
UzCO2_Cov	$mg \cdot m^{-2} \cdot s^{-1}$	Covariance of U_z and CO_2 density	Always
UxH2O_Cov	$g \cdot m^{-2} \cdot s^{-1}$	Covariance of U_x and water vapor density	Always
UyH2O_Cov	$g \cdot m^{-2} \cdot s^{-1}$	Covariance of U_y and water vapor density	Always
UzH2O_Cov	$g \cdot m^{-2} \cdot s^{-1}$	Covariance of U_z and water vapor density	Always
UCO2_Cov	$mg \cdot m^{-2} \cdot s^{-1}$	Covariance of streamwise wind and CO_2 density after coordinate rotations	Always
VCO2_Cov	$mg \cdot m^{-2} \cdot s^{-1}$	Covariance of crosswind and CO_2 density after coordinate rotations	Always
WCO2_Cov	$mg \cdot m^{-2} \cdot s^{-1}$	Covariance of vertical wind and CO_2 density after coordinate rotations	Always
UH2O_Cov	$g \cdot m^{-2} \cdot s^{-1}$	Covariance of streamwise wind and H_2O density after coordinate rotations	Always
VH2O_Cov	$g \cdot m^{-2} \cdot s^{-1}$	Covariance of crosswind and H_2O density after coordinate rotations	Always
WH2O_Cov	$g \cdot m^{-2} \cdot s^{-1}$	Covariance of vertical wind and H_2O density after coordinate rotations	Always
WCO2_Cov_fc	$mg \cdot m^{-2} \cdot s^{-1}$	Covariance of vertical wind and CO_2 density after coordinate rotations and frequency corrections	Always
WH2O_Cov_fc	$g \cdot m^{-2} \cdot s^{-1}$	Covariance of vertical wind and H_2O density after coordinate rotations and frequency corrections	Always
CO2_samples	count	Number of CO_2 samples without diagnostic flags, within threshold for CO_2 signal strength (set in code to default of 0.7), and within factory calibrated CO_2 measurement range (0 to 1000 $\mu mol \cdot mol^{-1}$).	Always

TABLE 6-12. Data fields in the Flux_Notes Output Table			
Data Field Name	**Units**	**Description**	**Data Field Included**
H2O_samples	count	Number of H_2O samples without diagnostic flags, within threshold for H_2O signal strength (set in code to default of 0.7), and within factory calibrated H_2O measurement range (0 to 72 mmol·mol^{-1}).	Always
no_irga_head_Tot	count	Number of samples where no gas analyzer head was detected	Always
no_new_irga_data_Tot	count	Number of scans where no gas analyzer data were received	Always
irga_bad_data_f_Tot	count	Number of IRGA samples with any IRGA diagnostic flag set high	Always
irga_gen_fault_f_Tot	count	Number of gas analyzer samples with general system fault diagnostic flag	Always
irga_startup_f_Tot	count	Number of gas analyzer samples with startup diagnostic flag	Always
irga_motor_spd_f_Tot	count	Number of gas analyzer samples with motor speed diagnostic flag	Always
irga_tec_tmpr_f_Tot	count	Number of gas analyzer samples with TEC temperature diagnostic flag	Always
irga_src_pwr_f_Tot	count	Number of gas analyzer samples with source power diagnostic flag	Always
irga_src_tmpr_f_Tot	count	Number of gas analyzer samples with source temperature diagnostic flag	Always
irga_src_curr_f_Tot	count	Number of gas analyzer samples with source current diagnostic flag	Always
irga_off_f_Tot	count	Number of gas analyzer samples with gas head power down diagnostic flag	Always
irga_sync_f_Tot	count	Number of gas analyzer samples with synchronization diagnostic flag	Always
irga_amb_tmpr_f_Tot	count	Number of gas analyzer samples with ambient temperature probe diagnostic flag	Always
irga_amb_press_f_Tot	count	Number of gas analyzer samples with ambient pressure diagnostic flag	Always
irga_CO2_I_f_Tot	count	Number of gas analyzer samples with CO_2 I signal diagnostic flag	Always
irga_CO2_Io_f_Tot	count	Number of gas analyzer samples with CO_2 I_o signal diagnostic flag	Always
irga_H2O_I_f_Tot	count	Number of gas analyzer samples with H_2O I signal diagnostic flag	Always
irga_H2O_Io_f_Tot	count	Number of gas analyzer samples with H_2O I_o signal diagnostic flag	Always

TABLE 6-12. Data fields in the Flux_Notes Output Table			
Data Field Name	**Units**	**Description**	**Data Field Included**
irga_CO2_Io_var_f_Tot	count	Number of gas analyzer samples with CO_2 I_o variation diagnostic flag	Always
irga_H2O_Io_var_f_Tot	count	Number of gas analyzer samples with H_2O I_o variation diagnostic flag	Always
irga_CO2_sig_strgth_f_Tot	count	Number of gas analyzer samples with CO_2 signal strength diagnostic flag	Always
irga_H2O_sig_strgth_f_Tot	count	Number of gas analyzer samples with H_2O signal strength diagnostic flag	Always
irga_cal_err_f_Tot	count	Number of gas analyzer samples with calibration file read error flag	Always
irga_htr_ctrl_off_f_Tot	count	Number of gas analyzer samples with heater control off diagnostic flag	Always
irga_diff_press_f_Tot	count	Number of gas analyzer samples with differential pressure out of range diagnostic flag	Always
UxFW_cov	deg $C \cdot m \cdot s^{-1}$	Covariance of U_x and fine-wire thermocouple temperature	If using FW05, FW1, or FW3
UyFW_cov	deg $C \cdot m \cdot s^{-1}$	Covariance of U_y and fine-wire thermocouple temperature	If using FW05, FW1, or FW3
UzFW_cov	deg $C \cdot m \cdot s^{-1}$	Covariance of U_z and fine-wire thermocouple temperature	If using FW05, FW1, or FW3
UFW_cov	deg $C \cdot m \cdot s^{-1}$	Covariance of streamwise wind and fine-wire thermocouple temperature after coordinate rotations	If using FW05, FW1, or FW3
VFW_cov	deg $C \cdot m \cdot s^{-1}$	Covariance of crosswind and fine-wire thermocouple temperature after coordinate rotations	If using FW05, FW1, or FW3
WFW_cov	deg $C \cdot m \cdot s^{-1}$	Covariance of vertical wind and fine-wire thermocouple temperature after coordinate rotations	If using FW05, FW1, or FW3
WFW_cov_fc	deg $C \cdot m \cdot s^{-1}$	Covariance of vertical wind and fine-wire thermocouple temperature after coordinate rotations and frequency corrections	If using FW05, FW1, or FW3
FW_samples	count	The number of valid fine-wire thermocouple measurements in the averaging period from which covariances may be calculated	If using FW05, FW1, or FW3
pump_tmpr	deg C	Average pump temperature	Always

TABLE 6-12. Data fields in the Flux_Notes Output Table			
Data Field Name	**Units**	**Description**	**Data Field Included**
pump_press	kPa	Average pump pressure	Always, but data are excluded during CO_2 or H_2O span
pump_flow_duty_cycle	Adimensional	Average pump duty cycle (0 is off, and 1 is full power)	Always, but data are excluded during CO_2 or H_2O span
pump_flow_set_pt	kPa	Pressure set point of the sample cell	Always
pump_heater_secs	s	Number of seconds in the interval that the pump heater was on	Always
pump_fan_secs	s	Number of seconds in the interval that the pump fan was on	Always
valve_tmpr	deg C	Average temperature of the valve module	If the system has a valve module (i.e., CPEC310)
valve_heater_secs	s	Number of seconds in the interval the valve module heater was on	If the system has a valve module (i.e., CPEC310)
valve_fan_secs	s	Number of seconds in the interval the valve module fan was on	If the system has a valve module (i.e., CPEC310)
scrub_tmpr	deg C	Average temperature of the scrub module	If the system has a scrub module
scrub_press	kPa	Average pressure of the scrub module	If the system has a scrub module
scrub_heater_secs	s	Number of seconds in the interval that the scrub module heater was on	If the system has a scrub module
scrub_fan_secs	s	Number of seconds in the interval that the scrub module fan was on	If the system has a scrub module
cell_tmpr	deg C	Average temperature of the sample cell	Always
cell_tmpr_SIGMA	deg C	Standard deviation of the sample cell temperature	Always
cell_press	kPa	Average pressure inside the sample cell	Always
cell_press_SIGMA	kPa	Standard deviation of the sample cell pressure	Always

TABLE 6-12. Data fields in the Flux_Notes Output Table			
Data Field Name	**Units**	**Description**	**Data Field Included**
diff_press	kPa	The differential pressure; that is, the difference in pressure between the sample cell and ambient	Always
pump_flow	L·min-1	Average volumetric flow to pump (sum of sample flow and vortex bypass flow)	Always
pump_flow_SIGMA	L·min-1	Standard deviation of pump flow	Always
cell_e	kPa	Average vapor pressure in sample cell	Always
cell_T_DP	deg C	Average dewpoint temperature inside sample cell	Always
cell_e_sat	kPa	Average saturation vapor pressure inside sample cell	Always
cell_RH	%	Average relative humidity inside sample cell	Always
alpha	decimal degrees	Alpha angle used for coordinate rotations (regardless of planar fit or double rotation method, angle convention of Wilczak et al. 2001 used)	Always
beta	decimal degrees	Beta angle used for coordinate rotations (regardless of planar fit or double rotation method, angle convention of Wilczak et al. 2001 used)	Always
gamma	decimal degrees	Gamma angle used for coordinate rotations (regardless of planar fit or double rotation method, angle convention of Wilczak et al. 2001 used)	Always
height_measurement	m	User entered measurement height of EC sensors	Always
height_canopy	m	User entered canopy height	Always
surface_type_text	text	User entered surface type	Always
displacement_user	m	User entered displacement height; 0 for auto calculation	Always
d	m	Displacement height used in calculations; it will equal displacement_user if user entered a non-zero value; if displacement_user is zero, program will auto calculate	Always
roughness_user	m	User entered roughness length; 0 for auto calculation	Always
z0	m	Roughness length used in calculations; it will equal roughness_use if user entered a non-zero value; if roughness_user is zero, program will auto calculate	Always
z	m	Aerodynamic height	Always

TABLE 6-12. Data fields in the Flux_Notes Output Table			
Data Field Name	**Units**	**Description**	**Data Field Included**
MO_LENGTH	m	Monin-Obukhov length	Always
ZL	$m \cdot m^{-1}$	Atmospheric surface layer stability	Always
iteration_FreqFactor	count	Number of iterations for recalculating Monin-Obukhov length and frequency factors	Always
latitude	decimal degrees	Latitude; positive for Northern hemisphere, negative for Southern hemisphere	Always
longitude	decimal degrees	Longitude; positive for Eastern hemisphere, negative for Western hemisphere	Always
altitude	m	Altitude or elevation above sea level	Always
UTC_offset	hr	Time offset in hours between local time zone and UTC/GMT	Always
separation_x_irga	m	Separation between sonic and gas analyzer with respect to sonic x-axis	Always
separation_y_irga	m	Separation between sonic and gas analyzer with respect to sonic y-axis	Always
separation_lat_dist_irga	m	Separation distance between sonic and gas analyzer along the axis perpendicular to oncoming wind	Always
separation_lag_dist_irga	m	Separation distance between sonic and gas analyzer along the axis parallel to oncoming wind	Always
separation_lag_scan_irga	scans	Number of scans to lag gas analyzer data relative to sonic data to account for separation along the axis of oncoming wind and wind velocity	Always
separation_x_FW	m	Separation between sonic and fine-wire thermocouple with respect to sonic x-axis	If FW05, FW1, or FW3 is used
separation_y_FW	m	Separation between sonic and fine-wire thermocouple with respect to sonic y-axis	If FW05, FW1, or FW3 is used
FW_diameter	m	Effective diameter of fine-wire thermocouple junction	If FW05, FW1, or FW3 is used
separation_lat_dist_FW	m	Separation distance between sonic and fine-wire thermocouple along axis perpendicular to oncoming wind	If FW05, FW1, or FW3 is used
separation_lag_dist_FW	m	Separation distance between sonic and fine-wire thermocouple along axis parallel to oncoming wind	If FW05, FW1, or FW3 is used

TABLE 6-12. Data fields in the Flux_Notes Output Table			
Data Field Name	**Units**	**Description**	**Data Field Included**
separation_lag_scan_FW	scans	Number of scans to lag fine-wire thermocouple data relative to sonic data to account for separation along axis of oncoming wind and wind velocity	If FW05, FW1, or FW3 is used
time_const_FW	m	Calculated time constant of the fine-wire thermocouple	If FW05, FW1, or FW3 is used
MAX_LAG	scans	Maximum number of scans to lag gas analyzer or fine-wire thermocouple data with respect to sonic data when doing cross correlation for covariance maximization. For example, if MAX_LAG = 2, the program will consider lags of –2, –1, 0, +1, and +2.	Always
lag_CO2	scans	The lag applied to CO_2 data with respect to sonic data that maximizes covariance	Always
lag_H2O	Scans	The lag applied to H_2O data with respect to sonic data that maximizes covariance	Always
lag_FW	scans	The lag applied to fine-wire thermocouple data with respect to sonic data that maximizes covariance	Always
FreqFactor_UW_VW	number	Frequency correction factor applied to momentum fluxes	Always
FreqFactor_WT_SONIC	number	Frequency correction factor applied to wTs covariance	Always
FreqFactor_WCO2	number	Frequency correction factor applied to wCO_2 covariance	Always
FreqFactor_WH2O	Number	Frequency correction factor applied to wH_2O covariance	Always
FreqFactor_WFW	number	Frequency correction factor applied to fine-wire thermocouple derived wFW covariance	Always
rho_d	$g \cdot m^{-3}$	Average density of dry air calculated from EC sensors	Always
rho_a	$kg \cdot m^{-3}$	Average density of ambient moist air calculated from EC sensors	Always
rho_d_probe	$g \cdot m^{-3}$	Average density of dry air calculated from temp/RH probe measurements	If a temp/RH probe is used
rho_a_probe	$kg \cdot m^{-3}$	Average density of ambient moist air calculated from temp/RH probe measurements	If a temp/RH probe is used
Cp	$J \cdot kg^{-1} \cdot K^{-1}$	Specific heat of ambient (moist) air at constant pressure	Always

TABLE 6-12. Data fields in the Flux_Notes Output Table			
Data Field Name	**Units**	**Description**	**Data Field Included**
Lv	$J \cdot g^{-1}$	Latent heat of vaporization	Always
T_panel	deg C	Average temperature of the data logger wiring panel	Always
T_panel_CDMA_x	deg C	Average panel temperature of the CDM-A116, where x at the end of the name is an index from 1 to 4, representing the each of the thermistors under the terminal strips of the CDM-A116	If a CDM-A116 is used
batt_volt	volt	Average battery voltage supplying power to the data logger	Always
slowsequence_Tot	count	Number of slow sequences during the averaging interval (for example, the number of times biomet and energy balance sensors were measured)	Always
process_time	ms	Average processing time for each scan	Always
process_time_SIGMA	ms	Standard deviation of scan time	Always
process_time_Max	ms	Maximum processing time for a scan	Always
process_time_Min	ms	Minimum processing time for a scan	Always
buff_depth	number	Average number of records stored in the buffer	Always
buff_depth_Max	number	Maximum number of records stored in the buffer	Always
cnr4_fan_secs	s	Number of seconds in the interval that the CNF4 fan was on	If using CNF4 with CNR4
cnr4_heater_1_secs	s	Number of seconds in the interval that the CNF4 Heater 1 was on	If using CNF4 with CNR4
cnr4_heater_2_secs	s	Number of seconds in the interval that the CNF4 Heater 2 was on	If using CNF4 with CNR4
sn500_heater_secs	s	Number of seconds in the interval that the SN500SS heater was on	If using SN500SS
nr01_heater_secs	s	Number of seconds in the interval that the NR01 heater was on	If using NR01 radiometer
V_CS320	mV	mV output from CS320	If using CS320
T_CS320	deg C	Body temperature of CS320	If using CS320
x_incline	decimal degrees	Degrees from level about the sensor's x-axis	If using CS320

TABLE 6-12. Data fields in the Flux_Notes Output Table			
Data Field Name	**Units**	**Description**	**Data Field Included**
y_incline	decimal degrees	Degrees from level about the sensor's y-axis	If using CS320
z_incline	decimal degrees	Degrees about z-axis that the sensor is oriented	If using CS320

TABLE 6-13. Data Fields in the ZeroSpan_Check_Notes Table			
Data Field Name	**Units**	**Description**	**Data Field Included**
check	adimensional	A string indicating which type of zero or span the record corresponds to; possible types: zero, CO2Span, H2OSpan	Always
drifted_f	Boolean	Reads TRUE if the zero or span measurement drifted beyond a 95% probability of it being within a normal distribution of the expected value	Always
CO2_reference	$\mu mol \cdot mol^{-1}$	CO_2 mixing ratio of the reference gas used for the zero or span check	Always
CO2	$\mu mol \cdot mol^{-1}$	Measured CO_2 mixing ratio during the zero or span check	Always
H2O_reference	$mmol \cdot mol^{-1}$	H_2O mixing ratio of reference gas during zero or span check	Always
H2O	$mmol \cdot mol^{-1}$	Measured H_2O mixing ratio during zero or span check	Always
cell_tmp	deg C	Sample cell temperature during zero or span check	Always
cell_press	kPa	Sample cell pressure during zero or span check	Always
diff_press	kPa	Differential pressure between ambient and sample cell during zero or span check	Always
valv_diff_press_offset	kPa	Offset in differential pressure measured while pump is off	Always
Td_reference	deg C	Dewpoint temperature of reference gas during zero or span check	Always
Cell_T_DP	deg C	Dewpoint temperature inside sample cell during zero or span check	Always
valve_flow	$L \cdot min^{-1}$	Mean flow during the zero or span check	Always
valve_flow_set	$L \cdot min^{-1}$	Set point for flow during the zero or span check	Always
scrub_press	kPa	Scrub module gauge pressure during zero	If using scrub module

TABLE 6-13. Data Fields in the ZeroSpan_Check_Notes Table

Data Field Name	Units	Description	Data Field Included
CO2_sig_strgth_zero	adimensional	CO_2 signal strength during zero	Always
H2O_sig_strgth_zero	adimensional	H_2O signal strength during zero	Always
valve_tmpr_ok	Boolean	TRUE means the valve module's temperature is within operating range	If system is CPEC310
scrub_tmpr_ok	Boolean	TRUE means the scrub module's temperature is within operating range	If system is CPEC310 and using scrub module
system_diag	adimensional	System diagnostic word. If 0, no system errors detected. See Appendix C for more details on system diagnostic.	Always

TABLE 6-14. Data Field in the System_Operatn_Notes Output Table

Data Field Name	Units	Description	Data Field Included
Message	Text string	A message describing a change of system status	Always
Current Value	Text string	Additional information corresponding to the Message	Always
Previous Value	Text String	Additional information corresponding to the Message	Always

6.6 Program Sequence of Measurement and Corrections

The main correction procedures and algorithms implemented into the program are listed below. For a more detailed, stepwise description of measurements made and corrections applied, refer to Appendix A, *EasyFlux DL CR6CP Process Flow* *(p. A-1)*.

1. Despike and filter raw time series data using sonic and gas analyzer diagnostic codes, and signal strength and measurement output range thresholds.

2. Coordinate rotations with an option to use the double rotation method (Tanner and Thurtell 1969), or planar fit method (Wilczak et al. 2001).

3. Lag CO_2 and H_2O measurements relative to sonic wind measurements for maximization of CO_2 and H_2O covariances (Horst and Lenschow 2009, Foken et al. 2012), with additional constraints to ensure lags are physically possible.

4. Frequency corrections using commonly used cospectra (Moore 1986, van Dijk 2002a, Moncrieff et al. 1997) and transfer functions of block averaging (Kaimal et al. 1989), line/volume averaging (Moore 1986, Moncrieff et al. 1997, Foken et al. 2012, van Dijk 2002a), time

constants (Montgomery 1947, Shapland et al. 2014, Geankoplis 1993), sensor separation (Horst and Lenschow 2009, Foken et al. 2012), and tube attenuation (Ibrom et al. 2007, Burgon et al. 2016).

5. A modified SND correction (Schotanus et al. 1983) to derive sensible heat flux from sonic sensible heat flux following the implementation as outlined in van Dijk 2002b. Additionally, fully corrected real sensible heat flux computed from fine-wire thermometry may be provided.

6. Data quality qualifications based on steady state conditions, surface-layer turbulence characteristics, and wind directions following Foken et al. 2012 (or Foken et al. 2004 for the Flux_AmeriFluxFormat output table).

7. If energy balance sensors are used, calculation of energy closure based on energy balance measurements and corrected sensible and latent heat fluxes.

8. Footprint characteristics are computed using Kljun et al (2004) and Kormann and Meixner (2001).

NOTE The appendices in the *EasyFlux DL CR6OP* manual describe the implementation of the major corrections in *EasyFlux DL CR6CP*, with the exception of frequency correction for tube attenuation, which is described in Ibrom et al. 2007, Burgon et al. 2016, and the code itself. It should also be noted that the appendix on WPL density corrections for open-path is not applicable here since the closed-path analyzer gas concentrations are output as dry molar mixing ratios.

7. Zero and Span

Since a CPEC310 system includes a valve module, it may be configured to self-initiate an automatic zero and span of the EC155 gas analyzer. The timing, whether the system will simply check the drift or actually set new zero/span coefficients, and whether the automatic zero/span will include an H_2O span, are all determined by user-entered constants relating to a CPEC310 (see constants that are indented under the constant "CPEC310" in TABLE 6-1, *Program Constants)*. An automatic zero and span cycle on a CPEC310 may be manually initiated at any time; instructions to do so are found in Section 7.1, *User-Initiated Zero/Span for CPEC310* *(p. 85)*.

For CPEC310 systems that are not set up with a continuously available source of H_2O span gas, which is typically the case, H_2O spans must be manually setup and initiated by the user. More details are found in Section 7.1.2, *CPEC310 Manual H2O Span* *(p. 88)*.

CPEC300 and CPEC306 systems require the user to manually setup and initiate the zero, CO_2 span, and/or H_2O span since these systems do not include a valve module. More details are found under Section 7.2, *User-Initiated Manual Zero/Span for CPEC300 or CPEC306* *(p. 88)*.

Regardless of system type, perfoming a user-initiated zero or span is most easily done using the CR1000KD keypad. This requires connecting a CR1000KD to the CS I/O port of the CR6 data logger and while the program is running. Pressing **Enter** twice will access the main menu. Under the main menu, use the keypad's down arrow to scroll down until the submenu **Attendant Zero/Span** is highlighted and press **Enter**. This menu accesses all menus and variables needed for doing a zero and span as explained in the sections below.

NOTE If a tall tower installation requires the CR6 to be far away from the EC155 gas analyzer, making it inconvenient to access the CR1000KD, it may be more practical to use a laptop running *ECMon* software to set the zero and spans, as explained in the *EC155 CO_2 and H_2O Closed-Path Gas Analyzer Manual*.

For reference, FIGURE 6-2 shows an organizational schematic for all the keypad menus. To return to a previous menu at any time, press **Esc**.

NOTE TABLE 7-1 lists the variables found within the *Attendant Zero/Span* menu and its submenus. The table also shows the equivalent variable names in the data logger's Public Table. If a CR1000KD is not available, performing a zero/span may alternatively be done from *LoggerNet* software by using the *Connect Screen* to create a Numberic Display that includes all of the variables in TABLE 7-1. Follow the instructions in the sections above, substituting public table variable names (last column in TABLE 7-1) for the variable names in the menus (first colum in TABLE 7-1).

NOTE Aliases have been used for public variables found in the zero and span menus in order to make the meanings of the variable more readily understood or to shorten the length of the variable names so they fit on the keypad display screen.

TABLE 7-1. Variables Found in Menus for Zero and Span			
Variable Name	**Default**	**Description**	**Name of variable in Public Table (when no CR1000KD available)**
Valv Tmpr Ok	–	This is a TRUE/FALSE read-only variable. It must read **TRUE** in order to perform an auto zero/span. If it reports **FALSE**, the valve module temperature is not within its operating range and **Valv T Ctl On** should be set to **TRUE** to bring the temperature within range. This variable is ommitted if the system is not a CPEC310.	valve_tmpr_ok
Valv Tmpr	–	This is a read-only variable showing the temperature in °C of the valve module. This variable is ommitted if the system is not a CPEC310.	valve_tmpr
Scrb Tmpr Ok	–	This is a TRUE/FALSE read-only variable. It must read **TRUE** in order to perform an auto zero using the scrub module as the zero gas source. If it reports **FALSE**, the scrub module temperature is not within its operating range and **V/S T Ctl On** should be set to **TRUE** to bring the temperature within range. This variable is ommitted if the system does not have a scrub module.	scrub_tmpr_ok
Scrb Tmpr	–	This is a read-only variable showing the temperature in °C of the scrub module. This variable is ommitted if the system does not have a scrub module.	scrub_tmpr
Val T Ctl On (If scrub module included, variable name is V/S T Ctl On)	FALSE	Set this variable to **TRUE** to enable temperature control (heaters and fans) of the valve module (and scrub module if applicable). Following an auto zero/span, this variable may be set back to **FALSE** to conserve power.	valve_tmpr_ctrl_flg
CO2 Span Gas	400	The dry molar mixing ratio of the CO_2 span gas in $\mu mol \cdot mol^{-1}$.	CO2_span_gas
H2O Span TDP	10	The dewpoint temperature setting on the H_2O span gas source in °C.	Td_span_gas

TABLE 7-1. Variables Found in Menus for Zero and Span			
Variable Name	**Default**	**Description**	**Name of variable in Public Table (when no CR1000KD available)**
H2O Span Gas	–	This is a read-only variable showing the calculated dry molar mixing ratio of the H_2O span gas in mmol·mol^{-1}. The air pressure difference between ambient and the dewpoint generator is taken into account when calculating.	H2O_span_gas
Pick AUTO_ZS Pick ZRO_ALL Pick SPN_CO2 Pick SPN_H2O	FLD_MEA	This variable indicates the current sampling mode. Depending on which keypad menu is viewed, this variable will be named to indicate which value to choose. For example, under the **Prfrm AUTO_ZS cycle** menu, the value of **Pick AUTO_ZS** should be changed from field measurements mode (**FLD_MEA**) to **AUTO_ZS** to initiate the auto zero/span cycle.	mode Options: 1 = FLD_MEA 3 = ZRO_ALL 4 = SPN_CO2 5 = SPN_H2O 7 = AUTO_ZS
Site	–	This is a read-only variable showing the current sampling site. Monitor this variable to see progress of zero/span. See Appendix B for more details on sampling sites.	site_ Options: fld smp, offst P, chk CO2, chk zro, set zro, set CO2, chk H2O, set H2O, equilib, irg_off
Sec On Site	–	This is a read-only variable showing the number of seconds the system has been on the current site.	sec_on_site
Pump Off	FALSE	This is a variable used to disable the pump. The pump should be disabled before conducting a manual zero or span.	pump_off_flg
CO2 umol/mol	–	This is a read-only variable showing the current measurement of CO_2 inside the sample cell in µmol·mol^{-1}.	sonic_irga_raw(6)
H2O Cell TDP	–	This is a read-only variable showing the current measurement of dewpoint temperature inside the sample cell in °C.	cell_T_DP

TABLE 7-1. Variables Found in Menus for Zero and Span

Variable Name	Default	Description	Name of variable in Public Table (when no CR1000KD available)
H2O mmol/mol	–	This is a read-only variable showing the current measurement of H_2O dry molar mixing ratio inside the sample cell in mmol·mol^{-1}.	Sonic_irga_raw(7)
GasFlw L/min	–	This is a read-only variable showing the current flow in L·min^{-1} through the sample cell.	valve_flow
System Diag	–	This is a read-only variable showing the system diagnostic word. A non-zero result indicates an error condition is detected. For an interpretation of the system diagnostic word, see Appendix C.	system_diag
Do Zero	FALSE	Change this variable to **TRUE** to manually zero the analyzer. (Zero gas should be flowing and **Pump Off** set to **TRUE**.)	do_zero_flg
Do CO2 Span	FALSE	Change this variable to **TRUE** to manually do a CO_2 span of the analyzer. (CO_2 span gas should be flowing and **Pump Off** set to **TRUE**).	do_CO2_span_flg
Do H2O Span	FALSE	Change this variable to **TRUE** to manually do an H_2O span of the analyzer. (H_2O span gas should be flowing and **Pump Off** set to **TRUE**).	do_H2O_span_flg

7.1 User-Initiated Zero/Span for CPEC310

Before beginning a user-initiated zero/span, the temperature of the valve module (and scrub module if applicable) must be within operating range. Select the submenu **Valv Tmpr Ctrl** (or **Valv/Scrub Tmpr Ctrl** if using the scrub module), found under the **Attendant Zero/Span** menu by highlighting it and pressing **Enter.** The display will show some read-only values of the module's temperature and whether it is within safe operating range. If the temperature is out of range, scroll down to the variable called **VAL T Ctl On** (or **V/S T Ctl On** if using scrub module)**,** press **Enter,** highlight **TRUE,** and press **Enter.** This will enable the module's temperature control. Continue to monitor the module's temperature readings shown in this menu until they are within operating range.

NOTE Upon completion of a zero/span in a CPEC310 system, navigate again to **VAL T Ctl On** (or **V/S T Ctl On** if using scrub module) and set its value back to **FALSE** to save power.

7.1.1 CPEC310 Auto Zero/Span

To initiate the auto zero/span cycle or sequence, return to the **Attendant Zero/Span** menu and select the menu **Prfrm AUTO_ZS cycle**. Once in the menu, verify that the value for **CO2 Span Gas** matches the molar mixing ratio in ppm of the CO_2 span gas. If it needs to be edited, highlight the variable, press **Enter**, type in the correct value, and press **Enter** again to save. If the user-entered CPEC310-related constants were set such that an H_2O span would be included in the automatic zero/span cycle (see TABLE 6-1, *Program Constants*), also confirm that the value of **H2O Span TDP**, the H_2O span gas dewpoint temperature, is correct.

Next, highlight **Pick AUTO_ZS**, press **Enter**, make sure **AUTO_ZS** is highlighted, and press **Enter**. This initiates the automatic zero/span cycle; TABLE 7-2 shows the sequence and timing through the automatic zero and span cycle. The progress of the cycle may be monitored on the CR1000KD screen by watching **Site** and **Sec On Site**. Real-time values of CO_2, H_2O, gas flow, and system diagnostic are also provided in the menu. Upon completion, the value for variable **Pick AUTO_ZS** will return to **FLD_MEA**, indicating that the system's measurement mode has returned to normal EC field sampling, and **Site** will return to **fld smp**, indicating all zero/span valves are closed and ambient air is being pulled into the sample cell.

NOTE For more information on sampling modes, regimes, and sites, refer to Appendix B, *Sampling Site, Regime, and Mode* *(p. B-1)*.

TABLE 7-2. Site sequence and timing in the auto zero and span cycle. Timing on most sites is determined by the user-set constant **TIME_ZRO_SPN**. Some sites may also be skipped, depending on CPEC310-related constants set by the user; see TABLE 6-1, *Program Constants*.

TABLE 7-2. Site Sequence and Timing in the Auto Zero and Span Cycle

Step in Auto Zero/Span Cycle	Description	Site Name	Timing (seconds)	Omit Status (seconds of measurements that are ommitted from statistics or stored data)
1	Transition from EC field measurements to the zero/span sequence	fld smp	1	1
2	The pump is turned off and the system measures the offset between the sample cell pressure sensor and the ambient pressure sensor.	offst P	15	10 (i.e., the first 10 seconds are ommitted so the system may equilibrate. The last 5 seconds of measurements are used and stored.)

TABLE 7-2. Site Sequence and Timing in the Auto Zero and Span Cycle				
Step in Auto Zero/Span Cycle	**Description**	**Site Name**	**Timing (seconds)**	**Omit Status (seconds of measurements that are ommitted from statistics or stored data)**
3	CO_2 span gas flows from its tank to the sample cell. The pump is off. The system measures CO_2 but does not set CO_2 readings to the CO_2 span gas concentration.	chk CO2	TIME_ZRO_SPN Default: 60	TIME_ZRO_SPN – 5 Default: 55
4	Zero gas flows from the scrub module or a tank to the sample cell. The pump is off. The system measure CO_2 and H_2O but does not set them to zero.	chk zro	TIME_ZRO_SPN + 20 Default: 80	TIME_ZRO_SPON – 5 Default: 75
5	Zero gas flows from the scrub module or a tank to the sample cell. The pump is off. The analyzer CO_2 and H_2O measurements are zeroed.	set zro	10	10
6	CO_2 span gas flows from the tank to the sample cell. The pump is off. The CO_2 span is set during the last 10 seconds.	set CO2	TIME_ZRO_SPN + 30 Default: 90	TIME_ZRO_SPN + 30 Default: 90
7[1/]	H_2O span gas flows from its source to the sample cell. The pump is off. The H_2O span is not set, just measured.	chk H2O	3*TIME_ZRO_SPN Default: 180	3*TIME_ZRO_SPN – 5 Default: 175
8[1/]	H_2O span is set on the analyzer.	set H2O	10	10
9	The system prepares to resume operation in normal EC field measurement mode. All valves to zero and span gases are closed. The pump is turned on, and ambient air is pulled through sample cell.	equilib	30	30

[1/]Because it is difficult to have an autonomous field H_2O span gas source, the constants CHECK_H2OSPN and SET_H2OSPN (see TABLE 6-1, *Program Constants*) are typically set to FALSE, and these steps in the auto zero/span sequence are skipped.

7.1.2 CPEC310 Manual H_2O Span

If the CPEC310 automatic zero/span cycle does not include an H_2O span, a manual H_2O span may be setup and initiated as follows.

The user must first connect tubing from an H_2O span gas source (e.g., dewpoint generator) to the **H_2O Span** port on the CPEC310 system enclosure. Turn on the dewpoint generator and allow H_2O span gas to flow. Even though the valve module is not yet allowing H_2O span gas to flow to the analyzer, back pressure is not an issue as the CPEC310 system enclosure is designed to vent excess H_2O span gas flow.

Next, navigate to the **Prfrm Field H2O Span** menu found under the **Attendant Zero/Span** menu. Within this menu, verify the value of **H2O Span TDP** matches the dewpoint setting of the H_2O span gas source/generator. If this value needs to be edited, highlight it, press **Enter**, type in the new value, and press **Enter** again to save. Next, highlight **Pick SPN_H2O**, press **Enter**, select **SPN_H2O**, and press **Enter**. This will initiate an automatic sequence that is a subset of the auto zero/span cycle shown in TABLE 7-2; specifically, it will progress only through steps 1, 6, 7, and 8 of the steps shown in TABLE 7-2. Progress of the H_2O span may be monitored by viewing the variables **Site** and **Sec on Site**. While **Site** reads **chk H2O**, monitor the real-time readings of H_2O in the sample cell and ensure they have reached equilibrium (i.e. are not changing) before **Site** switches to **set H2O**. If equilibrium was not reached, the constant TIME_ZRO_SPN needs to be increased (see Section 6.2, *Set Constants* (p. 36)).

Upon completion of the H_2O span, the value of **Pick SPN_H2O** will return to **FLD_MEA**, indicating that the system's measurement mode has returned to normal EC field sampling, and **Site** will return to **fld smp**, indicating all zero/span valves are closed and ambient air is being pulled into the sample cell. TABLE 7-1 includes descriptions of varaibles in the the menus related to zero and span.

NOTE If the CPEC310 system enclosure is a long distance from the EC155 gas analyzer (e.g., tall tower installation), it may be necessary to increase the value of the constant TIME_ZRO_SPN (see Section 6.2, *Set Constants* (p. 36)) to allow for more equilibration time, especially for H_2O. If the tubing is so long that it becomes impractical to wait for equilibration, the dewpoint generator may be taken up the tower and connected via a short length of tubing to the Zero/Span port on the back of the EC155. If this type of manual setup for doing an H_2O span is used, it may be easier to take a laptop PC up the tower and use *ECMon* software to do the H_2O span. See the *EC155 CO_2 and H_2O Closed-Path Gas Analyzer Manual* for details on doing a span using *ECMon*.

7.2 User-Initiated Manual Zero/Span for CPEC300 or CPEC306

Neither the CPEC300 nor the CPEC306 contains a valve module, therefore, these systems require the user to manually connect and flow a zero or span gas through the gas analyzer. The tubing carrying the zero or span gas should be connected to the port labeled **Zero/Span** on the back of the EC155 gas analyzer head, and the zero or span gas flow should be set using a flow regulator as described in the *EC155 CO_2 and H_2O Closed-Path Gas Analyzer*

Manual. Once plumbing connections are prepared, the following sections may be followed to set the zero, CO_2 span, or H_2O span.

NOTE When doing manual zero and/or spans, track the drift of the analyzer. This requires the user to first check the CO_2 and/or H_2O readings against their span gas concentrations and against the zero gas before setting either the zero or span. Refer to the *EC155 CO_2 and H_2O Closed-Path Gas Analyzer Manual* for more information on tracking the analyzer gain and offset.

NOTE If errors in setting up and performing a zero or span lead to nonsensical measurements or a despondent state of the analyzer, the analyzer's CO_2 and H_2O coefficients may be restored to previous values by navigating to **Zero Span Coeffs** under the **Initial Configuratn** menu. Once in this menu, highlight **Reset/Change Coeffs** and press **Enter**. To change a coefficient, highlight it, press **Enter**, type the desired value, and press **Enter** again to save the value. If the previous coefficient value is unknown, enter 1.00, which will restore it to its factory settings. After entering values, scroll to **Reset Coeffs**, press **Enter**, highlight **TRUE**, and press **Enter.** The analyzer is now reset, and a proper zero/span may be attempted again.

7.2.1 CPEC300/CPEC306 Manual Zero

If zeroing the analyzer, use the CR1000KD keypad to navigate to the **Attendant Zero/Span** menu and then to the **Prfrm Field Zero** menu. Scroll down and highlight **Pump Off**, press **Enter**, highlight **TRUE**, and press **Enter**. The pump is now turned off. Make sure the zero gas tubing is connected to the **Zero/Span** port on the back of the EC155 gas analyzer head and allow zero gas to flow. If needed, use higher flows (> 1 $L \cdot min^{-1}$) initially to flush out the sample cell, and then return to a low flow (< 0.5 $L \cdot min^{-1}$) when preparing to check and/or set the zero.

As zero gas is flowing, watch the CO_2 and H_2O readings until they indicate that the zero gas has flushed the sample cell and equilibrium has been reached. Then, highlight **Do Zero** found at the bottom of the menu, press **Enter**, highlight **TRUE**, and press **Enter** again. The zero will take a few seconds to set, during which time the gas analyzer measurements may not be updated. Upon completion of setting the zero, the value of **Do Zero** will return to **FALSE**. Throughout the process of performing the zero, real-time measurements of CO_2, H_2O, and system diagnostic are displayed in the **Prfrm Field Zero** menu for convenience. If no additional zeros or spans are to be performed, **Pump Off** should be set back to **FALSE** to resume operation of the pump and resume normal EC field measurements.

7.2.2 CPEC300/CPEC306 Manual CO_2 Span

If performing a CO_2 span of the analyzer, use the CR1000KD keypad to navigate to the **Attendant Zero/Span** menu and then to the **Prfrm Field CO2 Span** menu. Scroll down and highlight **Pump Off**, press **Enter**, highlight **TRUE**, and press **Enter**. The pump is now turned off. Make sure the CO_2 span gas tubing is connected to the **Zero/Span** port on the back of the EC155 gas analyzer head and allow CO_2 span gas to start flowing. If needed, use higher flows (> 1 L•min^{-1}) initially to flush out the sample cell, and then return to a low flow (< 0.5 L•min^{-1}) before checking and/or setting the CO_2 span. Within the **Prfrm Field CO2 Span** menu verify that the variable **CO2 Spn Gas** matches the concentration reported on the tank of the CO_2 span gas. If this value needs editing, highlight it, press **Enter**, type in the new value, and press **Enter** again to save the value. The **Prfrm Field CO2 Span** menu also includes readings of CO_2 molar mixing ratio. Watch the readings until they indicate that the span gas has flushed out the sample cell and equilibrium has been reached.

Once equilibrium is attained, highlight **Do CO2 Span** found at the bottom of the menu, press **Enter**, highlight **TRUE**, and press **Enter**. Setting the CO2 span will take a few seconds, during which time measurements from the gas analyzer may not be updated. Upon completion of the CO_2 span, the value of **Do CO2 Span** will return to **FALSE**. Throughout the CO_2 span, real-time measurements of CO_2 and system diagnostic are included in the **Prfrm Field CO2 Span** menu for convenience. If no additional zeros or spans are to be performed, **Pump Off** should be set back to **FALSE** to resume operation of the pump and resume normal EC field measurements.

7.2.3 CPEC300/CPEC306 Manual H_2O Span

If performing an H_2O span of the analyzer, use the CR1000KD keypad to navigate to the **Attendant Zero/Span** menu and then to the **Prfrm Field H2O Span** menu. Scroll down and highlight **Pump Off**, press **Enter**, highlight **TRUE**, and press **Enter**. The pump is now turned off. Make sure the H_2O span gas tubing is connected to the **Zero/Span** port on the back of the EC155 gas analyzer head and allow H_2O span gas to start flowing. If needed, use higher flows (> 1 L/min) initially to flush out the sample cell, and then return to a low flow (< 0.4 L/min) before checking or setting the H_2O span. Within the **Prfrm Field H2O Span** menu verify that the variable **H2O Span TDP** is set to the dewpoint temperature setting on the dewpoint generator or other H_2O span gas source. If this value needs editing, highlight it, press **Enter**, type in the new value, and press **Enter** again to save.

The **Prfrm Field H2O Span** menu includes readings of H_2O molar mixing ratio in the sample cell. Watch the readings until they indicate that the span gas has flushed out the sample cell and equilibrium has been reached. Once equilibrium is attained, highlight **Do H2O Span** found at the bottom of the menu, press **Enter**, highlight **TRUE**, and press **Enter**. Setting the H_2O span will take a few seconds, during which time the gas analyze measurements ma not be updated. Upon completion of the H_2O span, **Do H2O Span** will return to **FALSE**. Throughout the H_2O span, real-time measurements of H_2O and system diagnostic are included in the **Prfrm Field H2O Span** menu for convenience. If the system includes a temp/RH probe, the ambient dewpoint temperature is also reported for reference. If no additional zeros or spans are to be performed, **Pump Off** should be set back to **FALSE** to resume operation of the pump and resume normal EC field measurements.

8. Maintenance and Troubleshooting

Most of the basic diagnostic and troubleshooting issues for the CPEC300-series systems are indicated in the Diagnostic data output table. The section that follows provides additional detail on some issues that may arise with hardware components.

8.1 Enclosure Desiccant

Check the humidity indicator card in the mesh pocket in the CPEC300-series system enclosure door and the EC100 enclosure door. The humidity indicator card has three colored circles that indicate the percentage of humidity (see FIGURE 4-23). Desiccant packets inside the enclosure should be replaced with fresh packets when the upper dot on the indicator begins to turn pink. The indicator card does not need to be replaced unless the colored circles overrun. Both the desiccant packs and humidity cards can be purchase as replacements. See Section 4.10, *Replacement Parts* *(p. 17)*, for more detail.

CAUTION Campbell Scientific strongly suggests replacing desiccant instead of reactivating old desiccant. Improper reactivation can cause the desiccant packets to explode.

If the desiccant packs in a CPEC300-series system enclosure require frequent replacement, check that the feedthrough cap is properly installed. In very humid conditions it may be helpful to seal the cable feedthrough with plumber's putty as described in Section 5.3.4, *Apply Power* *(p. 33)*.

8.2 EC155 Windows

The EC155 gas analyzer reports a signal strength for both CO_2 and H_2O that decreases as the optics become contaminated. The factory calibration procedure allows some tolerance to window contamination. In general, the tolerance is higher for contaminates that are uniformly distributed on the windows and have flat spectral characteristics than for contaminates, such as water droplets, that can greatly disperse or refract the optical beam. The signal strength should be monitored as part of any quality assurance/quality check of incoming data. If the signal strength has dropped, CO_2 and H_2O values should be checked for validity and windows should be cleaned during the next site visit. Clean the windows as instructed in the *EC155 CO_2 and H_2O Closed-Path Gas Analyzer Manual* before the CO_2 and H_2O signals reach 0.80.

NOTE In an EC155 that has the vortex intake, a decrease in signal strength likely means that the vortex filter is plugging and should be replaced.

8.3 EC155 Molecular Sieve Bottles

If zero-and-span readings have drifted excessively, the molecular sieve bottles within the EC155 analyzer head should be replaced as detailed in the *EC155 CO_2 and H_2O Closed-Path Gas Analyzer Manual*.

8.4 Pump Module Filter

In very humid conditions, water may condense and collect inside the housing of the filter that is located in the pump module enclosure. This is normal and will have no effect on the measurements. In most cases, the water will evaporate as ambient conditions change.

8.5 Testing Wind Offset

Usually the CSAT3A sonic anemometer calibration remains valid unless a transducer fails or damage to the instrument leads to a change in geometry. The sonic anemometer requires calibration under two conditions:

- When it develops a wind offset greater than the specification
- When it sets diagnostic flags under dry conditions with little to no wind and with no obstruction in the ultrasonic paths

The wind offset is tested by creating a zero-wind environment. This is best done in a laboratory setting with HVAC vents closed or covered to reduce air currents, and by encircling the mounted sensor with a large plastic bag (for example, an unused refuse bag). Caution should be used to not block the sonic paths. Once the CSAT3A is connected to an EC100 and powered on, wind offsets may be viewed by connecting the EC100 to a PC and using ECMon to graph u_x, u_y, and u_z wind components. In this zero-wind environment, u_x and u_y should be less than ± 8 $cm \cdot s^{-1}$ (± 0.08 $m \cdot s^{-1}$) and uz should be less than ± 4 $cm \cdot s^{-1}$ (± 0.04 $m \cdot s^{-1}$). If recalibration is deemed necessary, contact Campbell Scientific.

9. Repair

All of the CPEC300-series systems are designed to give years of trouble-free service with reasonable care. However, if factory repair is needed, contact Campbell Scientific to obtain an RMA number. An RMA number and product safety documents are required prior to any repair shipments being accepted at Campbell Scientific. See details in the *Assistance* section at the beginning of this document.

Contact Campbell Scientific to determine which parts or assemblies should be sent for repair. See *www.campbellsci.com/cpec300* for the appropriate contact. If the system enclosure is to be returned, plug the inlets and cap the ends of all tubes to keep debris out. Swagelok caps and plugs have been provided for this purpose.

Appendix A. EasyFlux DL CR6CP Process Flow

Sequence of Program Functions

Every SCAN_INTERVAL (default 100 ms)

Collect raw data from GPS sensor, battery voltage, CDM panel temp, FW, and rain gauge

⇩

Store FW measurements in a table to be used later to align with sonic data

⇩

Check for conditions that require EC100 reconfiguration

⇩

Store previous scan's sonic and gas data in temporary tables that will be used in later steps to align measurements and calculate covariances

⇩

If the time for zero/span is approaching, turn on valve module heater (and scrub module heater if applicable)

⇩

Calculate mean variables (i.e., call site_block_mean table)

⇩

Check to see if the mode of operation has changed. If yes, perform functions associated with that mode (e.g., zero and span) and when finished, return to EC field measurements.

⇩

Record the prior scan's time series data into final storage

⇩

Parse out sonic diagnostic data, and filter bad sonic data from being included in statistical data

⇩

Send sonic data to covariance tables to be included for 5 min and averaging interval covariances

Parse out gas diagnostic data, and filter bad gas data from being included in statistical data

⇩

Calculate climate and gas variables (e.g., e, rho_d, rho_a, Td, CO2_mixratio, H2O_mixratio, RH)

⇩

Store gas data into multiple datasets or temporary tables that each have a different lag relative to sonic data (to be used later in cross correlation; lags from –MAX_LAG TO +MAX_LAG are used; MAX_LAG default is 2). For each dataset with a particular lag, recalculate cell and ambient climate variables.

⇩

If using FW, store raw data in multiple datasets, each dataset with a different lag applied to FW data relative to sonic data (to be used later in cross correlation; lags from -MAX_LAG to +MAX_LAG are used; MAX_LAG default is 2)

⇩

Control pump speed to achieve pressure set point

⇩

Measure rain gauge

⇩

Record time series measurement diagnostics in the *Diagnostic* output table

⇩

Ingest new raw sonic and gas measurements from the EC100

Every SLOWSEQUENCE_SCAN_INTERVAL (default 5 s)

Measure CR6 panel temp

⇩

Measure biomet and energy balance (slow response) sensors

⇩

Calculate albedo

⇩

If using self-calibrating heat flux plates and a new calibration interval has started, perform the auto calibration

⇩

If station variables have changed, save new values to memory

⇩

System power control (if needed, power down gas analyzer and pump)

⇩

Temp control for valve and scrub modules

⇩

If a zero/span has completed, save new gain and offset values and store zero/span outputs to ZeroSpan_Check_Notes and EC100_config _Notes tables

Every 5 Minutes

Do coordinate rotations and find the 5-minute covariances for u with w, v with w, Ts with w, CO_2 with w, and H_2O with w (used later for steady state test for quality grading; see Appendix F in *EasyFlux DL CR6OP* manual on Data Quality Grading for more details).

Every AVERAGING_INTERVAL (default 30 minutes)

Filter out data with diagnostic flags or signal strengths or measurements outside of acceptable ranges.

⇩

Do coordinate rotations (use double coordinate rotation method unless planar fit angles have been entered by user) to find rotated orthogonal wind components, *u*, *v*, and *w.* Calculate sonic-related covariances (e.g., wTs, wu, vw). (See *EasyFlux DL CR6OP* manual, Appendix B on Double Coordinate Rotation and Appendix C on Planar Fit Rotation.)

⇩

Use rotated wind components to find turbulent kinetic energy, friction velocity, and preliminary values of Obukhov length and stability.

⇩

Calculate frequency correction factors for wTs, wu, and vw to account for block averaging and line averaging. If conditions are stable, iteratively calculate Obukhov length, cospectral equations, and correction factors until factors change by <0.0001 or until 10 iterations have completed. (See in *EasyFlux DL CR6OP* manual, Appendix D on Frequency Corrections.)

⇩

Calculate value for steady state test using the 30-minute momentum covariances and the 5-minute momentum covariances. (see *EasyFlux DL CR6OP* manual, Appendix F on Data Quality Grading.)

⇩

Calculate the overall quality grade for momentum flux. (See *EasyFlux DL CR6OP* manual, Appendix F on Data Quality Grading.)

⇩

Calculate and use a new roughness length if 1) user didn't enter a fixed value, 2) there is neutral stability, 3) wind speed is >3 m/s, and momentum flux quality grading is adequate ($\tau_{QC} \leq 6.0$). (See in *EasyFlux DL CR6OP* manual, Appendix G on Footprint.)

⇩

Calculate footprint characteristics using the Kljun et al (2004) model if conditions are appropriate, else use Kormann and Meixner (2001) model. (See in *EasyFlux DL CR6OP* manual, Appendix G on Footprint.)

⇩

Calculate the covariance of CO_2 and wind components for each lagged dataset and do coordinate rotation on covariances

⇩

Find the effective lateral separation distance between gas analyzer and sonic (to use in frequency correction) and the effective separation scan lag (used to constrain which lagged datasets are physically possible). (See in *EasyFlux DL CR6OP* manual, Appendix D on Frequency Corrections.)

⇩

Find the dataset with the physically possible lag that maximizes the covariance of CO_2 and vertical wind. Use this dataset for the FLUX_AMERIFLUXFORMAT and FLUX_CSFORMAT output tables. If any results are invalid, continue with lag of zero. (See *EasyFlux DL CR6OP* manual, Appendix D on Frequency Corrections.)

⇩

Calculate cospectra functions and the frequency correction factor for CO_2-related covariances, taking into account attenuation from block averaging, line averaging, spatial separation, and tube attenuation. (See *EasyFlux DL CR6OP* manual, Appendix D on Frequency Corrections, Ibrom et al 2007, Brugon et al. 2016, and program code.)

⇩

Calculate covariances of H_2O and wind components for each lagged dataset and do coordinate rotation on covariances.

⇩

Find the dataset with the physically possible lag that maximizes the covariance of H_2O and vertical wind. Use this dataset for the FLUX_AMERIFLUXFORMAT and FLUX_CSFORMAT output tables. If any results are invalid, continue with lag of zero. (See *EasyFlux DL CR6OP* manual, Appendix D on Frequency Corrections.)

⇩

Calculate the frequency correction factor for covariances of H_2O and rotated wind components, taking into account attenuation from block averaging, line averaging, spatial separation, and tube attenuation. (See *EasyFlux DL CR6OP* manual, Appendix D on Frequency Corrections, Ibrom et al 2007, Brugon et al. 2016, and program code.)

⇩

Calculate final momentum flux from rotated and frequency corrected covariances of u with w and v with w.

⇩

Apply SND correction to the rotated and frequency corrected covariance of w and Ts.

⇩

Calculate specific heat of ambient (moist) air and calculate final sensible heat flux.

⇩

Calculate scaling temperature (used for data quality grading). (See *EasyFlux DL CR6OP* manual Appendix F on Data Quality Grading.)

⇩

Calculate Bowen Ratio

⇩

Calculate the overall quality grades for fluxes of sensible heat, latent heat, and CO_2. (See *EasyFlux DL CR6OP* manual, Appendix F on Data Quality Grading.)

⇩

If energy balance sensors are used

Calculate soil surface energy flux for the averaging interval. (See *EasyFlux DL CR6OP* manual, Appendix H on Surface Flux.)

Get calculated measurements of H, LE, and Rnet for the averaging interval.

⇩

Calculate energy closure

⇩

If FW05, FW1, or FW3 is used

Calculate the covariance of FW temperature and wind components for each lagged dataset and then perform coordinate rotations on covariances.

⇩

Find the effective lateral separation distance between FW and sonic (to use in frequency correction) and the effective separation scan lag (used to constrain which lagged datasets are physically possible). (See *EasyFlux DL CR6OP* manual, Appendix D on Frequency Corrections.)

⇩

Find the dataset with the lag that maximizes the covariance of FW temperature and vertical wind. Use this dataset for the FLUX_AMERIFLUXFORMAT and FLUX_CSFORMAT output tables. If any results are invalid, continue with lag of zero.

⇩

Calculate the time constant for the FW (to be used in frequency corrections). (See *EasyFlux DL CR6OP* manual, Appendix D on Frequency Corrections.)

⇩

Calculate frequency correction factors for covariances of FW temperature and rotated wind components, taking into account attenuation from block averaging, line averaging, spatial separation, and the FW time constant. (See *EasyFlux DL CR6OP* manual, Appendix D on Frequency Corrections.)

⇩

Calculate final fine-wire sensible heat flux

⇩

Write records to the Flux_AmeriFluxFormat, Flux_CSFormat, and Flux_Notes output tables

⇩

Calculate the number of days remaining on the data logger’s data storage card

Appendix B. Sampling Site, Regime, and Mode

Sampling sites, regimes, and modes are applicable to the CPEC310 and help distinguish certain states of the system. A sampling site refers to a particular valve selection or air sampling source. TABLE B-1 provides a list of the defined sampling sites.

A sampling regime consists of a site designation, a state of the pump (on or off), and an omit status, which is whether or not the current measurements are being included in calculations and statistics. For example, the steps in the auto zero/span sequence in TABLE 7-2 each describe a sampling regime. The sampling regime at a given moment is described by the variable *sampling_regime,* which is included in the Time_Series output table, where bits 0 through 3 correspond to the site number, and bit 4 is set when measurements are being omitted from calculations. For example, if the system has just finished an auto zero and span cycle and has returned to normal EC measurements (site 1), it will omit measurements from the covariance and other calculations for 25 seconds in order for the sample cell to be thoroughly flushed and the pressure equilibrated; during this 25 second time period, *sampling_regime* will have a value of 17, where the fourth bit is set high (decimal value of 16) to indicate omitted measurements, and bit zero is set to 1 (decimal value of 1), corresponding to site 1. After the 25 second period has passed, *sampling_regime* will show a value of 1, indicating the measurements are no longer omitted and the current site is Site 1.

A sampling mode, or simply mode, is a timed or controlled sequence of one or more sampling regimes. TABLE B-2 below lists the various modes. For example, in the case of Auto Z/S mode, a sequence of several sampling regimes is completed in order to perform a zero and span of the gas analyzer.

TABLE B-1. Site Numbers, Text Descriptors, and Descriptions

Site Number	Text Descriptor of Site (used on CR1000KD display)	Description
1	fld smp	Normal field sampling. The pump is on and pulling ambient air into the sample cell.
2	offst P	The pump is off. This setting is used to measure the offset between the sample cell pressure sensor and the EC100 barometer.
3	chk CO2	Check CO_2 span
4	chk zro	Check Zero
5	set zro	Set Zero

TABLE B-1. Site Numbers, Text Descriptors, and Descriptions		
Site Number	**Text Descriptor of Site (used on CR1000KD display)**	**Description**
6	set CO2	Set CO_2 span
7	chk H2O	Check H_2O Span
8	set H2O	Set H_2O span
9	equilib	Idle or equilibration with ambient mode; pump is off
10	irg_off	Sleep or power-saver mode: EC155 and pump turned off while CSAT3A remains on

TABLE B-2. Mode Names and Descriptions	
Mode Name	**Description**
FLD_MEA	EC field measurement mode. The pump is on, and ambient air is sampled (site 1). Measurements from the first 25 seconds after switching to this mode are omitted from calculations.
PUMP_OFF	Pump off mode. The pump is turned off, the sample cell pressure equilibrates to ambient pressure, and a measurement of the pressure offset is made.
ZRO_ALL	User-initiated automatic zero all mode. This mode is applicable to CPEC310 systems. After a zero gas source is connected to the CPEC310 system enclosure and gas is flowing, this mode may be selected, which will result in the system going through a sequence of sampling regimes that will zero the gas analyzer.
SPN_CO2	User-initiated automatic CO_2 span mode. This mode is applicable to CPEC310 systems. If a CO_2 span gas source is connected to the CPEC310 system enclosure and gas is flowing, this mode may be selected, resulting in the system going through a sequence of sampling regimes that will span the CO_2 of the gas analyzer.
SPN_H2O	User-initiated automatic H_2O span mode. This mode is applicable to CPEC310 systems. After an H_2O span gas source is connected to the CPEC310 system enclosure and gas is flowing, this mode may be selected, resulting in the system going through a sequence of sampling regimes that will span the H_2O of the gas analyzer.

TABLE B-2. Mode Names and Descriptions	
Mode Name	**Description**
IRG_SLP	IRGA sleep mode. This mode powers down the gas analyzer and pump and leaves the CSAT3A powered on and making measurements.
AUTO_ZS	Automatic zero and span mode. This mode automatically will check and/or set the zero and CO_2 span of the gas analyzer. Whether or not the zero and span are set depends on the values to which the user set the zero/span constants. See Section 6.2, *Set Constants* ***(p. 36)***.

Appendix C. Wiring the CR6 and Optional Energy Balance Sensors

C.1 Overview

Install sensors and system components according to the respective product manuals. When wiring the sensors to the data logger or CDM-A116, the default wiring schemes, along with the number of instruments *EasyFlux DL CR6CP* supports, should be followed if the standard version of the program is being used. TABLES C-1 through C-13 present the wiring schemes.

The minimum required equipment to operate *EasyFlux DL CR6CP* is one of the CPEC300-series systems with its core components, as described in the introduction. The additional sensors described in Sections C.1.3 through C.1.12 are optional. Many of the optional sensors are only available for a CPEC306 or CPEC310 system since it includes a CDM-A116 module. The CDM-A116 is required for some optional sensors since the CR6 itself does not contain enough channels for a full energy balance sensor suite; the CDM-A116 effectively increases the CR6 analog channels. If one or more of the optional sensors are not used, the data logger or CDM module terminals assigned to the wires of that sensor should be left unwired.

NOTE If the standard data logger program is modified, the wiring presented in TABLE C-1 may no longer apply. In these cases, refer directly to the program code to determine proper wiring, or contact a Campbell Scientific sales engineer for assistance.

C.1.1 IRGA and Sonic Anemometer

A closed-path EC155 gas analzyer and CSAT3A sonic anemometer must be connected to the EC100 electronics, and the EC100 must be wired to a CR6 data logger (via a wiring terminal if using the CPEC306 or CPEC310) for *EasyFlux DL CR6CP* to be functional. TABLE C-1 shows the default wiring for these sensors.

TABLE C-1. Default Wiring for IRGA and Sonic Anemometer

Sensor	Quantity	Wire Description	Color	EC100 Terminal (for CPEC300)	CPEC System Enclosure Wiring Terminal (for CPEC306 and CPEC310)
EC155 & CSAT3A (from EC100)	1	SDM Data	Green	C1	C1
		SDM Clock	White	C2	C2
		SDM Enable	Red/Brown	C3	C3
		Signal Ground	Black	G (power ground)	G
		Shield	Clear	AG ⏚ (analog ground)	G

C.1.2 CDM-A116 Module (CPEC306 and CPEC310 only)

Due to the limitations on channel count of the CR6, a CDM-A116 module is required when using a fine-wire thermocouple, a temp/RH probe, radiation sensors, soil temperature probes, or soil heat flux plates. A CPEC306 or CPEC310 should already have a CDM-A116 installed, connected to the CR6, and configured, but in the case it needs to be reconfigured or in case a CDM-A116 is being manually added to a CPEC300, prepare it as follows:

1. Connect the CDM-A116 to a 10-32 VDC power source.
2. Launch Campbell Scientific's *Device Configuration Utility* software (v2.12 or newer) and select **CDM-A100 Series** among the list of **Peripheral** devices. If this is the first time connecting, follow the instruction on the main screen to download the USB driver to the PC.
3. Select the appropriate COM port and click on the **Connect** button.
4. Once connected, a list of settings is shown. Navigate to the bottom setting, **CPI Address**. Change this value to 1. Hit the **Apply** button at the bottom of the page and exit the software.
5. Use a Cat5e or Cat6 Ethernet Cable (included with the CPEC enclosure) to connect the CPI port on the module to the CR6 CPI port.

C.1.3 GPS Receiver

A GPS receiver such as the GPS16X-HVS is optional but will keep the data logger clock synchronized to GPS time. If the CR6 clock differs by one millisecond or more, *EasyFlux DL CR6CP* will resynchronize the data logger clock to match the GPS. The GPS receiver also calculates solar position. TABLE C-2 shows the default wiring for the GPS16X-HVS.

TABLE C-2. Default Wiring for GPS Receiver

Sensor	Quantity	Wire Description	Color	CR6 Terminal
GPS16X-HVS	0 or 1	PPS	Grey	U1
		TXD	White	U2
		Shield	Clear	AG ⏚
		12V	Red	12V
		Power Ground	Black	G

C.1.4 Fine-Wire Thermocouple

Several models of fine-wire thermocouple sensors are available that can be integrated with the IRGA and sonic anemometer for direct measurements of sensible heat flux. The *EasyFlux DL CR6CP* can support from zero to one fine-wire thermocouple along with the IRGA and sonic anemometer. Shown in TABLE C-3 are the available types and default wiring for adding a fine-wire thermocouple.

NOTE

Because CPEC300 systems do not have a CDM-A116, its wiring for a fine-wire thermocouple differs from the other two systems. The thermocouple's temperature reference is more accurate on a CDM-A116, so greater accuracy of fine-wire temperature is achieved with CPEC306 and CPEC310 systems.

TABLE C-3. Default Wiring for Fine-Wire Thermocouple					
Sensor	Quantity	Wire Description	Color	CPEC300 System	CPEC306 or CPEC310 System
FW05, FW1, or FW3	0 or 1	Signal	Purple	CR6 U5	CDM Diff 6H
		Signal Reference	Red	CR6 U6	CDM Diff 6L
		Shield	Clear	CR6 AG ⏚	CDM AG ⏚

C.1.5 Temperature and Relative Humidity Probe

The *EasyFlux DL CR6CP* can support from zero to one temperature and relative humidity probe. The default wiring for the HMP155A or EE181 is shown in TABLE C-4.

NOTE TABLE C-4 shows wiring for the HMP155A and EE181 temperature and humidity probes. Alternatively, an older model probe such as the HMP45C or HC2S3 may be used, but wiring for these models is not shown here. Instead, their wiring may be found in the respective product manuals found at *www.campbellsci.com*. In any case, be careful to note the colors of the wires and jumper wire configuration of the probe being used. TABLE C-4 shows wire colors for the HMP155A and EE181, where the colors for the EE181 are noted by italic text in TABLE C-4.

TABLE C-4. Default Wiring for Temperature and Relative Humidity Probe				
Sensor	Quantity	Wire Description	Color	CDM-A116 Terminal
HMP155A/ *EE181*	0 or 1	Temp Signal	Yellow/*Yellow*	CDM Diff 16H
		Temp Signal Reference	White/*Jumper to AG*⏚	CDM Diff 16L[1/]
		RH Signal	Blue/*Blue*	CDM Diff 14H
		RH Signal Reference	White/*Jumper to AG*⏚	CDM Diff 14L[1/]
		Shield	Clear/*Clear*	CDM AG ⏚
		Power	Red/*Red*	CDM +12 V
		Power Ground	Black/*Black*	CDM G
[1/]For the HMP155A, a jumper wire should be added to connect CDM Diff 13L to CDM Diff 14L. For the EE181, jumper wires should go from CDM Diff 13L and CDM Diff 14L to CDM AG ⏚.				

C.1.6 Radiation Measurements Option 1

There are two options for making radiation measurements with *EasyFlux DL CR6CP*. The program can support any combination of the four sensors described in TABLE C-5. Alternatively, it can support one of the two types of four-way radiometers described in TABLE C-6. TABLE C-5 gives the default wiring for Option 1. TABLE C-6 shows the details of the default wiring for Option 2.

TABLE C-5. Default Wiring for Radiation Measurement Option 1

Sensor	Quantity	Wire Description	Color	CDM-A116 Terminal
NR-LITE2 Net Radiometer	0 or 1	Radiation Signal	Red	CDM Diff 1H
		Signal Reference	Blue[1/]	CDM Diff 1L
		Shield	Black	CR6 AG ⏚
CS301, Pyranometer	0 or 1	Signal	White	CDM Diff 2H
		Signal Reference	Black	CDM Diff 2L[2/]
		Shield	Clear	CDM AG ⏚
CS320 Digital Heated Pyranometer	0 or 1	SDI-12 Signal	White	CR6 U11
		Signal Reference	Blue	CR6 AG ≑
		Shield	Clear	CR6 AG ≑
		Power	Red	CR6 12V
		Power Ground	Black	CR6 G
CS310 Quantum Sensor	0 or 1	Signal	White	CDM Diff 3H
		Ref/Ground	Black	CDM Diff 3L1/
		Ground/Shield	Clear	CDM AG ≑
SI-111 Infrared Radiometer	0 or 1	Target Temp Signal	Red	CDM Diff 4H
		Target Temp Reference	Black	CDM Diff 4L
		Shield	Clear	CDM AG ≑
		Sensor Temp Signal	Green	CDM Diff 5H
		Sensor Temp Reference	Blue	CDM AG ≑
		Voltage Excitation	White	CDM X1

[1/]Jumper required from CDM Diff 3L to CDM AG ≑ with user-supplied wire

[2/]Jumper required from CDM AG ≑ to CDM Diff 2L with user-supplied wire

C.1.7 Radiation Measurements Option 2

Three models of four-way radiometers are compatible with the program *EasyFlux DL CR6CP*: the SN500SS, NR01, and CNR4. However, only one model at a time can be used. The default wiring for each of the four-way radiometers is shown in TABLE C-6. TABLES C-7 and C-8 give information on adding an optional CNF4 ventilation and heater unit to the CNR4 4-way radiometer.

TABLE C-6. Default Wiring for Radiation Measurements Option 2

Sensor	Quantity	Wire Description	Color	CDM-A116 Terminal
SN500SS 4-Way Radiometer	0 or 1	SDI-12 Signal	White	CR6 U11
		Shield	Clear	CR6 AG ⏚
		Power	Red	CR6 12V
		Power Ground	Black	CR6 G
NR01 4-Way Radiometer	0 or 1	Pyranometer Up Signal	Red (cbl 1)	CDM Diff 1H
		Pyranometer Up Reference	Blue[1/] (cbl 1)	CDM Diff 1L[1/]
		Pyranometer Down Signal	White (cbl 1)	CDM Diff 2H
		Pyranometer Down Reference	Green/Black[1/] (cbl 1)	CDM Diff 2L[1/]
		Pyrgeometer Up Signal	Brown/Grey or Orange (cbl 1)	CDM Diff 3H
		Pyrgeometer Up Reference	Yellow[1/] (cbl 1)	CDM Diff 3L[1/]
		Pyrgeometer Down Signal	Purple or Pink/Brown (cbl 1)	CDM Diff 4H
		Pyrgeometer Down Reference	Grey/Green[1/] (cbl 1)	CDM Diff 4L[1/]
		PT100 Signal	White/Yellow (cbl 2)	CDM Diff 5H
		PT100 Reference	Green (cbl 2)	CDM Diff 5L
		Current Excite	Red (cbl 2)	CDM X2
		Current Return	Blue (cbl 2)	CDM AG ⏚
		Shields	Clear	CDM AG ⏚
CNR4 4-Way Radiometer	0 or 1	Pyranometer Up Signal	Red	CDM Diff 1H
		Pyranometer Up Reference	Blue[1/]	CDM Diff 1L[1/]
		Pyranometer Down Signal	White	CDM Diff 2H
		Pyranometer Down Reference	Black[1/]	CDM Diff 2L[1/]
		Pyrgeometer Up Signal	Grey	CDM Diff 3H
		Pyrgeometer Up Reference	Yellow[1/]	CDM Diff 3L[1/]
		Pyrgeometer Down Signal	Brown	CDM Diff 4H
		Pyrgeometer Down Reference	Green[1/]	CDM Diff 4L[1/]
		Thermistor Signal	White	CDM Diff 5H
		Thermistor V Excite	Red	CDM X2
		Thermistor Reference	Black	CDM AG ⏚
		Shields	Clear	CDM AG ⏚

[1/]Jumper to ⏚ with user-supplied wires

A CNF4 ventilation and heater unit may also be used with the CNR4 4-way radiometer for more accurate radiation measurements. The CNF4 requires a solid-state relay to control the ventilator and heater. For the CPEC306, an A21REL-12 4-channel relay driver must be ordered (sold separately) and installed in the CPEC306 system enclosure just below the CDM-A116 module. TABLE C-7 lists the wiring connections needed to power and control the A21REL-12.

A CABLE3CBL-1, or similar 3-conductor 22 AWG cable, is recommended for connections from the A21REL-12 to the CDM-A116, and a CABLEPCBL-1, or similar 16 AWG 2-conductor power cable, is recommended for power connections from the A21REL-12 to the CPEC306 DIN rail terminal block.

For the CPEC310, no additional relay driver is required since the system already includes a SDM-CD16S, however some wiring from the valve module must be modified to accommodate the CNF4 (see TABLE C-8). TABLE C-8 lists the wiring for the CNF4 for either the CPEC306 or the CPEC310.

TABLE C-7. A21REL-12 Wiring (Used with CNF4 in a CPEC306 System)

A21REL-12 Terminal	Connecting Terminal	Cable/Wire
+12V	CPEC306 enclosure DIN rail terminal block: 12V	CABLEPCBL-1, red wire
Ground	CPEC306 enclosure DIN rail terminal block: GND	CABLEPCBL-1, black wire
CTRL 1	CDM-A116 SW5V #1	CABLE3CBL-1, red wire
CTRL 2	CDM-A116 SW5V #2	CABLE3CBL-1, black wire
CTRL 3	CDM-A116 SW5V #3	CABLE3CBL-1, white wire

TABLE C-8. Default Wiring for a CNF4 in a CPEC306 or CPEC310 System					
Sensor	**Quantity**	**Wire Description**	**Color**	**CPEC306 Wiring**	**CPEC310 Wiring**
CNF4	0 or 1, only use if using a CNR4	Tachometer Output	Green	CR6 U7	CR6 U7[1/]
		Tachometer Reference	Grey	CR6 AG ⏚	CR6 AG ⏚[1/]
		Ventilator Power	Yellow	A21REL-12 REL 1 NO	SDM-CD16S OUT 14
		Ventilator Ground	Brown	A21REL-12 REL G	SDM-CD16S OUT G
		Heater #1 Power	White	A21REL-12 REL 2 NO	SDM-CD16S OUT 15
		Heater #1 Ground	Red	A21REL-12 REL G	SDM-CD16S OUT G
		Heater #2 Power	Black	A21REL-12 REL 3 NO	SDM-CD16S OUT 16
		Heater #2 Ground	Blue	A21REL-12 REL G	SDM-CD16S OUT G

[1/]In a CPEC310, wiring the CNF4 requires moving the valve module thermistor signal wire (green) from CR6 U7 to CDM-A116 Diff 5L and the valve module thermistor reference (yellow) from CR6 AG to CDM-A116 AG.

C.18 Precipitation Gauge

EasyFlux DL CR6OP can support a single tipping rain gauge such as the TE525MM, or a precipitation gauge can be omitted. The default wiring for the precipitation gauge is shown in TABLE C-9.

TABLE C-9. Default Wiring for Precipitation Gauge				
Sensor	**Quantity**	**Wire Description**	**Color**	**CR6 Terminal**
TE525MM Tipping Rain Gauge	0 or 1	Pulse Output	Black	U10
		Signal Ground	White	AG ⏚
		Shield	Clear	AG ⏚

C.19 Soil Temperature

The TCAV is an averaging soil thermocouple probe used for measuring soil temperature. *EasyFlux DL CR6CP* can support up to three TCAV probes. The order of wiring, however, is important. If only one TCAV sensor is used, it must be wired as described for TCAV #1 in TABLE C-10.

CAUTION

If only one TCAV is being used and it is wired to terminals 8H/8L or 9H/9L (leaving terminals 7H and 7L empty), the data logger will not record any TCAV measurements.

TABLE C-10. Default Wiring for Soil Thermocouple Probes				
Sensor	**Quantity**	**Wire Description**	**Color**	**CDM-A116 Terminal**
TCAV #1	1	Signal	Purple	CDM Diff 7H
		Signal Reference	Red	CDM Diff 7L
		Shield	Clear	CDM AG ⏚
TCAV #2	1	Signal	Purple	CDM Diff 8H
		Signal Reference	Red	CDM Diff 8L
		Shield	Clear	CDM AG ⏚
TCAV #3	1	Signal	Purple	CDM Diff 9H
		Signal Reference	Red	CDM Diff 9L
		Shield	Clear	CDM AG ⏚

NOTE The CS650 or CS655 sensors also measure soil temperature. If the CS650 or CS655 sensors are used but no TCAV probes are used, *EasyFlux DL CR6CP* will use soil temperature from the CS650 or CS655 to compute ground-surface heat flux. If available, soil temperature from the TCAV probe is preferred since it provides a better spatial average. See wiring details for these sensors in TABLE C-11.

C.1.10 Soil Water Content

EasyFlux DL CR6CP supports one of two models of soil water content sensors: CS650 or CS655; up to three of one model is supported. The default wiring for each is shown in TABLE C-11.

CAUTION If only one soil water content sensor is being used, wire it according to the first probe as described in TABLE C-11. If only one sensor is being used and it is wired according to the second or third sensor, *EasyFlux DL CR6CP* will not record any measurements from the soil water content sensor.

TABLE C-11. Default Wiring for Soil Water Content Probes				
Sensor	**Quantity**	**Wire Description**	**Color**	**CR6 Terminal**
CS650/CS655 #1	1	SDI-12 Data	Green	U11
		SDI-12 Power	Red	+12 V
		SDI-12 Reference	Black	G
		Shield	Clear	G
		Not Used	Orange	AG ⏚

TABLE C-11. Default Wiring for Soil Water Content Probes

Sensor	Quantity	Wire Description	Color	CR6 Terminal
CS650/CS655 #2	1	SDI-12 Data	Green	U11
		SDI-12 Power	Red	+12 V
		SDI-12 Reference	Black	G
		Shield	Clear	AG ⏚
		Not Used	Orange	G
CS650/CS655 #3	1	SDI-12 Data	Green	U11
		SDI-12 Power	Red	+12 V
		SDI-12 Reference	Black	G
		Shield	Clear	AG ⏚
		Not Used	Orange	G

C.1.11 Soil Heat Flux Plates

EasyFlux DL CR6CP can support from zero to three soil heat flux plates. They can be the HFP01 plates (non-self-calibrating) or the HFP01SC (self-calibrating) plates. The default wiring for the HFP01 standard soil heat flux plates is shown in TABLE C-12.

TABLE C-12. Default Wiring for Non-Calibrating Soil Heat Flux Plates

Sensor	Quantity	Wire Description	Color	CDM-A116 Terminal
HFP01 #1	1	Signal	White	CDM Diff 10H
		Signal Reference	Green	CDM Diff 10L
		Shield	Clear	CDM AG ⏚
HFP01 #2	1	Signal	White	CDM Diff 11H
		Signal Reference	Green	CDM Diff 11L
		Shield	Clear	CDM AG ⏚
HFP01 #3	1	Signal	White	CDM Diff 12H
		Signal Reference	Green	CDM Diff 12L
		Shield	Clear	CDM AG ⏚

C.1.12 Self-Calibrating Soil Heat Flux Plates

If using HFP01SC self-calibrating soil heat flux plates, *EasyFlux DL CR6CP* can support from zero to three of them. The default wiring for the self-calibrating soil heat flux plates is shown in TABLE C-13.

TABLE C-13. Default Wiring for Soil Heat Flux Plates (Self Calibrating).

Sensor	Quantity	Wire Description	Color	CDM-A116 Terminal
HFP01SC #1	1	Signal	White	CDM Diff 10H
		Signal Reference	Green	CDM Diff 10L
		Shield	Clear	CDM AG ⏚
		Heater Signal	Yellow	CDM Diff 13H
		Heater Reference	Purple	CDM Diff 13H
		Shield	Clear	CDM AG ⏚
		Heater Power	Red	CDM SW12-1[1/]
		Power Reference	Black	CDM G
HFP01SC #2	1	Signal	White	CDM Diff 11L
		Signal Reference	Green	CDM Diff 11L
		Shield	Clear	CDM AG ⏚
		Heater Signal	Yellow	CDM Diff 14L
		Heater Reference	Purple	CDM Diff 14H
		Shield	Clear	CDM AG ⏚
		Heater Power	Red	CDM SW12-1[1/]
		Power Reference	Black	CDM G
HFP01SC #3	1	Signal	White	CDM Diff 12H
		Signal Reference	Green	CDM Diff 12L
		Shield	Clear	CDM AG ⏚
		Heater Signal	Yellow	CDM Diff 15H
		Heater Reference	Purple	CDM Diff 15H
		Shield	Clear	CDM AG ⏚
		Heater Power	Red	CDM SW12-2[1/]
		Power Reference	Black	CDM G

[1/]The SW12 ports on the CDM-A116 are limited to 200mA output. Accordingly, no more than two HFP01SC sensors may be connected to each port. Connect heater power wires from HFP01SC #1 and #2 to SW12-1, and connect heater wires from HFP01SC #3 to SW12-2.

Appendix D. System Diagnostic Word

The system diagnostic word, **system_diag**, is an aggregate or sum of the system diagnostic bits or flags listed below in TABLE D-1.

TABLE D-1. Description of Bits for System Diagnostic Word.

Bit	Decimal	Name	Function
0	1	sonc_er	Sonic error. If any error condition or diagnostic flag is set on the sonic anemometer, this bit is set.
1	2	irga_er	IRGA error. If any error condition or diagnostic flag is set on the gas analyzer, this bit is set.
2	4	pump_tmpr_er	Pump temperature error. If pump temperatre is below 0 deg C or above 55 deg C, this bit is set.
3	8	pump_flow_er	Pump flow error. If pump flow is more than ±0.5 $L \cdot min^{-1}$ from the pump flow set point (default set point is 8 $L \cdot min^{-1}$), this bit is set.
4	16	valv_tmpr_er	Valve temperature error. If valve module temperature is below 0 deg C or above 60 deg C, this bit is set.
5	32	valv_flow_er	Valve flow error. If zero or span gas flow through valve module is more than ±0.5 $L \cdot min^{-1}$ from the valve flow set point (default set point is 1 $L \cdot min^{-1}$), this bit is set.
6	64	scrb_tmpr_er	Scrub temperature error. If scrub temperature is below 5 deg C or above 50 deg C, this bit is set.

Appendix E. Quality Grading

TABLES E-1 and E-2 below show the quality grade definitions. Refer to Foken et al. (2012) for more details, and refer to Appendix F of the *EasyFlux DL CR6OP* for more details on the implementation in the data logger program.

TABLE E-1. Grades of relative non-stationarity, relative integral turbulence characteristics, and wind direction in the sonic instrument coordinate system.

RN_{cov} Relative non-stationarity [model (2.3) in Foken et al. (2012)]		ITC_{sw} and ITC_{tau} Relative integral turbulence characteristics [model (2.5) in Foken et al. (2012)]		wnd_dir_sonic Wind direction	
Grade	**Range (%)**	**Grade**	**Range (%)**	**Grade**	**Range**
1 (best)	[0 , 15)	1 (best)	[0 , 15)	1 (best)	[0 – 150°], [210 – 360°]
2	[15 , 30)	2	[15 , 30)	2	[150 – 170°], [190 – 210°]
3	[30 , 50)	3	[30 , 50)	3 (worst)	[170 – 190°]
4	[50 , 75)	4	[50 , 75)		
5	[75 , 100)	5	[75 , 100)		
6	[100 , 250)	6	[100 , 250)		
7	[250 , 500)	7	[250 , 500)		
8	[500 , 1000)	8	[500 , 1000)		
9 (worst)	≥1,000%	9 (worst)	> 1,000%		

TABLE E-2. Overall grades for each flux variable by the grades of relative non-stationary, relative integral turbulence characteristic, and wind direction in sonic instrument coordinate system.[1/]			
Overall quality grade	***RN_{cov}*** **Relative non-stationarity**	***ITC_{sw}*** **Relative integral turbulence characteristic**	**wnd_dir_sonic** **Wind direction**
1 (best)	1	1 – 2	1
2	2	1 – 2	1
3	1 – 2	3 – 4	1
4	3 – 4	1 – 2	1
5	1 – 4	3 – 5	1
6	5	5	2
7	6	6	2
8	7 – 8	7 – 8	2
9 (worst)	9	9	3

[1/]Simplified Table 4.5 in Foken et al. (2012)

Appendix F. Using Swagelok Fittings

This appendix gives a few tips on using Swagelok tube fittings. For more information, consult your local Swagelok dealer or visit their web site at *www.swagelok.com*.

General Notes:

- Do not use fitting components from other manufacturers – they are not interchangeable with Swagelok fittings.
- Do not attempt to use metric fittings. Six mm is very close to 1/4 in, but they are not interchangeable. Metric fittings can be identified by the stepped shoulder on the nut and on the body hex.
- Make sure that the tubing rests firmly on the shoulder of the tube fitting body before tightening the nut.
- Never turn the fitting body. Instead, hold the fitting body and turn the nut.
- Keep tubing and fittings clean. Always use caps and plugs to keep dirt and debris out.
- Do not overtighten fittings as it will damage the threads.

If a nut cannot be easily tightened by hand, this indicates the threads have been damaged. Replace any damaged nuts and fittings.

F.1 Assembly

The first time a Swagelok fitting is assembled, the ferrules become permanently swaged onto the tube. Assembly instructions vary depending on plastic or metal tubing. The assembly instructions are also slightly different for an initial installation than for subsequent reassembly.

First-time assembly, plastic tubing:

1. Cut the tubing to length.

2. Make sure the cut is square and free of burrs.

3. Some types of plastic tubing have an aluminum layer. Take care not to flatten the tube as you cut it.

4. Push an insert into the end of the tubing.

5. Do not remove the nuts and ferrules from the fitting. Simply insert the tube into the assembled fitting until it bottoms out.

6. Rotate the nut finger-tight.

7. While holding the fitting body steady, tighten the nut one and one-quarter turns. (For 1/16 in or 1/8 in-sized fittings, tighten the nut three-quarters turn.)

First-time assembly, metal tubing:
Extra care is needed to avoid overtightening brass fittings when used with metal tubing. These notes apply to reducers and port connectors as well as metal tubing.

NOTE No insert is required with metal tubing.

1. Do not remove the nuts and ferrules from the fitting. Simply insert the tube into the assembled fitting until it bottoms out.

2. Rotate the nut finger tight.

3. While holding the fitting body steady, tighten the nut until it feels tight. This will normally be less than one full turn. Tightening a full one and one-quarter turns will damage the threads on the fitting and nut.

Reassembly, plastic or metal tubing:
You may disassemble and reassemble Swagelok tube fittings many times, but the assembly process is slightly different than the first assembly.

1. Insert the tube with pre-swaged ferrules into the fitting until the front ferrule seats against the fitting body.

2. Rotate the nut finger tight.

3. While holding the fitting body steady, tighten the nut slightly with a wrench.

F.2 Common Replacement Parts

Tubing
Campbell Scientific can provide several types and sizes of plastic tubing as shown in TABLE F-1. A tubing cutter can be used to cut these tubes.

TABLE F-1. Available plastic tubing sizes, construction, and usage guidelines

Tubing Type	OD (in)	ID (in)	Length (ft)	Construction	Notes
Synflex 1300	1/4	0.17	500	Black HDPE jacket, overlapped aluminum tape, ethylene copolymer liner	Aluminum layer limits diffusion; best for sample tubes
	3/8	1/4	250		
	1/2	3/8	250		
LLDPE	3/8	1/4	500	Black linear low-density polyethylene	More flexible than HDPE
	1/2	3/8	500		
HDPE	5/8	1/2	100	Black High-density polyethylene	Required for larger diameter

Tubing inserts

Inserts are recommended for use in plastic tubing. These inserts become permanently attached to the tubing at the first assembly, so spare inserts may be needed for replacing the ends of tubing.

FIGURE F-1. Swagelok insert

TABLE F-2. Dimensions and part numbers for Swagelok inserts		
Tubing OD (in)	**Tubing ID (in)**	**Swagelok part #**
1/4	1/8	B-405-2
1/4	0.17	B-405-170
1/4	3/16	B-405-3
3/8	1/4	B-605-4
1/2	3/8	B-815-6
5/8	1/2	B-1015-8

Ferrules

Each Swagelok fitting comes assembled with the front and back ferrules included. These ferrules are permanently swaged onto the tubing at the first assembly, so spare ferrules may be needed for replacing the ends of tubing.

Back ferrule

Front ferrule

FIGURE F-2. Front and back Swagelok ferrules

TABLE F-3. Dimensions and part numbers for Swagelok ferrules	
Tubing OD (in)	**Swagelok part number (front/back)**
1/8	B-203-1/B-204-1
1/4	B-403-1/B-404-1
3/8	B-603-1/B-604-1
1/2	B-813-1/B-814-1
5/8	B-1013-1/B-1014-1

Plugs
Swagelok plugs are used to plug a fitting when its tube is disconnected. It is strongly recommended to plug all fittings to keep them clean. Spare plugs may be needed if they become lost or damaged.

FIGURE F-3. Swagelok plug

TABLE F-4. Dimensions and part numbers for Swagelok plugs	
Tubing OD (in)	**Swagelok part number**
1/8	B-200-P
1/4	B-400-P
3/8	B-600-P
1/2	B-810-P
5/8	B-1010-P

Caps
Swagelok caps are used to cap the end of tubes when they are disconnected from the fitting. It is strongly recommended to cap all disconnected tubes to keep them clean. Spare caps may be needed if they become lost or damaged.

FIGURE F-4. Swagelok cap

TABLE F-5. Dimensions and part numbers for Swagelok caps	
Tubing OD (in)	**Swagelok part number**
1/8	B-200-C
1/4	B-400-C
3/8	B-600-C
1/2	B-810-C
5/8	B-1010-C

Appendix G. CPEC310 Scrub Module Installation, Operation, and Maintenance

The CPEC310 Scrub Module provides a stream of air that has been scrubbed of CO_2 and H_2O and is used for zeroing the EC155. The module is housed in a fiberglass enclosure that can generally be mounted to the same structure as the CPEC310 system enclosure. The enclosure is shown in FIGURE G-1, and the specifications can be found in Appendix G.2, *Scrub Module Specifications* *(p. G-2)*.

FIGURE G-1. CPEC310 scrub module

G.1 Theory of Operation

The CPEC310 Scrub Module provides an air stream with CO_2 and H_2O removed to zero the EC155. It includes a small diaphragm pump to push the zero air to the analyzer and three bottles containing a molecular sieve to remove CO_2 and water vapor from ambient air. The pump provides approximately 1.5 LPM flow. It has a heater and fan to keep it within its operating range (5 to 50 °C) over ambient temperatures down to –30 °C. The CPEC310 scrub module is intended to replace the cylinder of compressed zero air.

The CPEC310 scrub module pump pulls ambient air through three bottles of molecular sieve and pushes it to the valve module. The ambient air inlet and zero air outlet fittings are on the bottom of the enclosure. It uses a small diaphragm pump that is mounted in an insulated, temperature-controlled box inside the weather-tight fiberglass enclosure.

The following are descriptions of the operating parameters of the scrub pump.

Pump Control

The pump is turned on automatically when the **Zero Air** valve is selected. The pump has a maximum flow rate of approximately 2.0 LPM and a maximum pressure rise of approximately 90 kPa.

Scrub Pump Outlet Pressure

The measured outlet pressure of the pump is reported in public variable **scrub_press**. This pressure will normally be 1 to 23 kPa when it is running.

Scrub Pump Temperature

The temperature of the scrub pump is reported in public variable **scrub_tmpr**. The operating range of the pump is 5 to 50 °C. If the scrub temperature is within the operating range the public variable **scrub_tmpr_ok** will be set to **True**. If the scrub pump temperature is outside this range, the CPEC310 will disable the pump and the public variable **scrub_tmpr_ok** will be set to **False**. The scrub pump module has a heater (drawing 8W while operating) that turns on if the pump temperature falls below 7 °C. If the CPEC310 is started at cold temperature, it may take up to 20 minutes to warm the scrub pump module (from –30 to 5 °C). When it reaches 7 °C the heater will cycle on/off as needed to maintain this temperature.

The scrub pump module has a fan (drawing 0.7 W while operating) that turns on if the pump temperature rises above 45 °C. The fan will stay on until the scrub pump temperature falls below 40 °C.

G.2 Scrub Module Specifications

Operating temperature:	– 30 to 50 °C
Power consumption[1/]	
Quiescent:	0 W
With pump on:	2 W
With heater on:	8 W
With fan on:	0.7 W

G.3 Installation

There are numerous mounting options for the scrub module including tripod (mast or leg), tower, or pole. Enclosure mounts are specified when ordering the CPEC310 Scrub Module and mounting the module is accomplished in the

[1/]The typical average power consumption is generally negligible in a CPEC310 system because it is used for a short time each day.

same way as mounting other CPEC310 enclosures as described in Section 5.1, *Mounting* *(p. 24)*.

Connect the scrub module cable to the CPEC310 system enclosure, receptacle marked **Scrub Module**. Remove the Swagelok plugs from the inlet and outlet and store them in the mesh pocket in the door. Install the Swagelok nut with screen on the **Ambient Air** inlet. Connect a 1/4-in OD tube from scrub module to valve module on the **Zero** inlet. Remove the desiccant pack from its plastic bag and place the pack in the mesh pocket.

Edit the CPEC310 CRBasic program to set constant **CPEC310SCRUB** = **True** and recompile.

The CPEC310 program will add the appropriate variables. It will control the temperature of the scrub module whenever it controls the temperature of the valve module. It will turn on the scrub module pump whenever the **Zero Air** valve is selected. The scrub module will push a flow of ambient air that has been scrubbed of CO_2 and water through the valve module to the EC155.

G.4 Maintenance

Once per year, refill the first bottle with fresh molecular sieve (molecular sieve 13X, 1.6 – 2.5 mm beads) according to the following steps:

1. Power down the CPEC310 or unplug the scrub module cable from the CPEC310. This will ensure the scrub module pump does not turn on while you replace the molecular sieve.
2. Open the door of the scrub module enclosure to expose the bottles containing the molecular sieve as shown in FIGURE G-2.

FIGURE G-2. CPEC310 scrub module interior

3. Disconnect the fully exposed black tube (S-shaped and tied to the center of the cover as shown in FIGURE G-2) at both ends. This tube remains captive to the cover plate.

NOTE Disconnecting this tube ensures the bottles are not pressurized when the cover is removed. The scrub module has been designed to require this tube to be disconnected before removing the cover as a safety precaution.

4. Loosen the four thumbscrews (shown in FIGURE G-2) and remove the cover plate to gain access to the bottles (FIGURE G-3). Note that the thumb screws are captive; they remain attached to the cover plate.

FIGURE G-3. Interior of CPEC310 scrub module with tubing and cover removed

5. Disconnect the remaining tubes from the bottles at the Swagelok fittings.

NOTE Caps are spring loaded!

6. Remove the center bottle from the scrub module and set it aside.
7. Remove the left bottle and place it in the center position.
8. Remove the right bottle and place it in the left position.
9. Refill the bottle that was removed by twisting while pulling to remove the top cap. The caps are held in place by friction only and the spring inside the bottle may eject the cap.

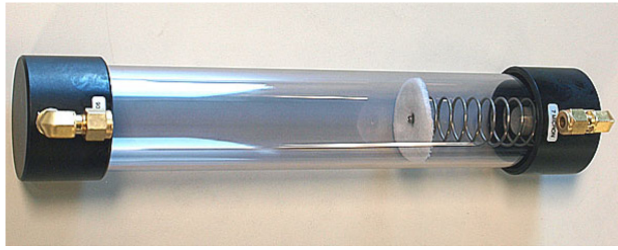


FIGURE G-4. Empty bottle showing the top (on the right with spring) and bottom (left) caps

10. Remove the spent molecular sieve in accordance to local ordinances and the manufacturer's Safety Data Sheet.
11. Refill the bottle with new molecular sieve and replace the top cap (the cap with the spring).
12. Replace freshly filled bottle in the open position on the right side of the enclosure.
13. Reconnect the tubes to the bottles.
14. Replace the cover plate and retighten the thumb screws.
15. Reconnect the black tube in its original location over the cover plate.
16. Close the scrub module enclosure.
17. Reconnect the scrub module cable as in Appendix G.3, *Installation* *(p.G-2)*, and restart the CPEC310.

Appendix H. CPEC300 Series Pump Replacement

H.1 Introduction

A properly maintained CPEC300 system will exceed the lifetime of the system's pump. However, this section provides step-by-step instructions for the user to replace the system pump, rather than needing to return the pump enclosure to Campbell Scientific for replacement.

H.2 Removal

To remove a CPEC300 system pump, carry out the following steps:

1. Place the pump module or system enclosure on a horizontal surface.

NOTE It is very difficult to replace the pump if the module is mounted vertically on a tower.

---

2. Remove the four, #10 self-sealing screws that hold the filter assembly within the CPEC300 pump module or system enclosure (see FIGURE H-1). If these screws become lost or damaged, replace them with pn 26412.

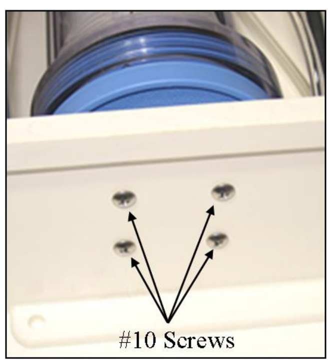


FIGURE H-1. Four screws holding filter assembly inside CPEC300 pump module enclosure

3. Stand the filter up in the enclosure and remove the tubing from the filter inlet by loosening the nut with an 11/16" wrench. Remove the tubing from the outlet of the filter by loosening the nut with a 9/16" wrench (FIGURE H-2).

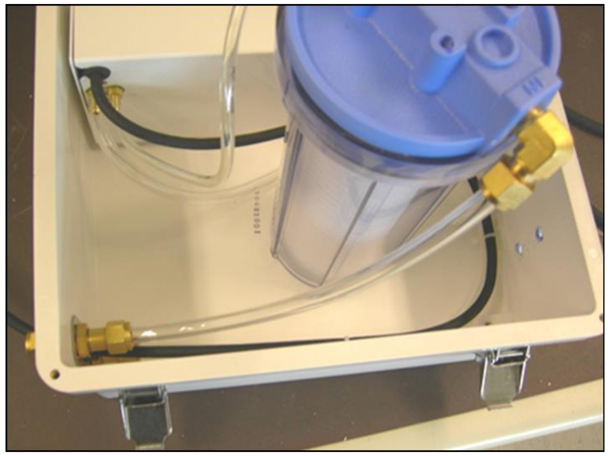


FIGURE H-2. Upright filter unit in enclosure

4. With the filter assembly removed from the CPEC300 system pump module enclosure, remove the six #4 screws (FIGURE H-3) from the pump assembly.

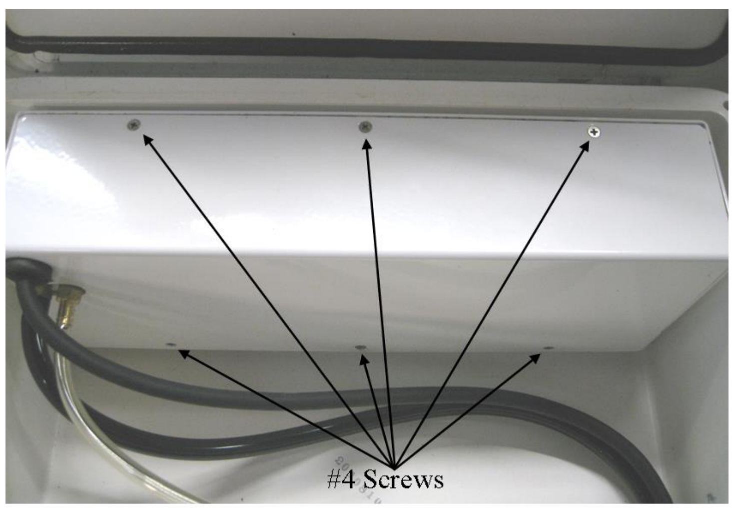


FIGURE H-3. Location of #4 screws of pump assembly

5. Once the screws are removed, fold back the pump assembly from the shell bottom as shown in FIGURE H-4.

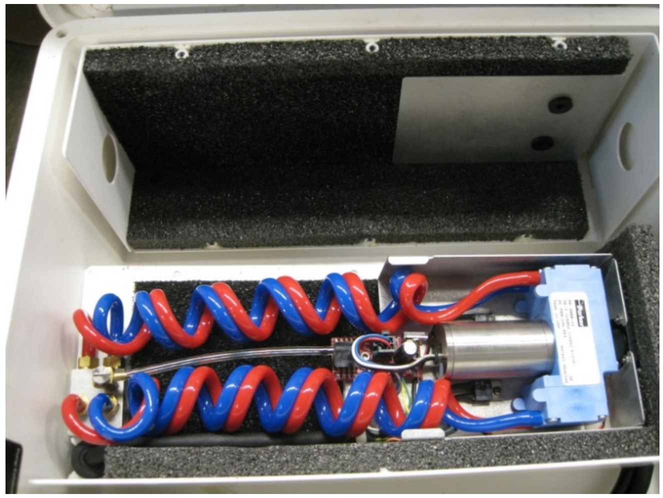


FIGURE H-4. Exposed CPEC300 pump assembly

NOTE As of May 2017, replacement pumps shipping from Campbell Scientific, Inc. have the wire exiting the pump from the top (original pumps had the wire exiting the side of the pump). To account for this change, the original pump module inner plate needs to be replaced with one that includes a large notch to provide clearance for the wire. This replacement inner plate is included in the replacement pump kit.

6. Using the "notched" end of the new inner plate, slowly pry away the original inner plate working around all sides and being careful not to damage the foam backing (FIGURE H-5).

FIGURE H-5. Removal of original pump module inner plate and replacement with new inner plate provided in pump replacement kit

7. Remove the paper from the back of the adhesive tape on the new inner plate (FIGURE H-6) and adhere to the foam in the same location as the original plate paying attention to the direction of the notch (FIGURE H-7).

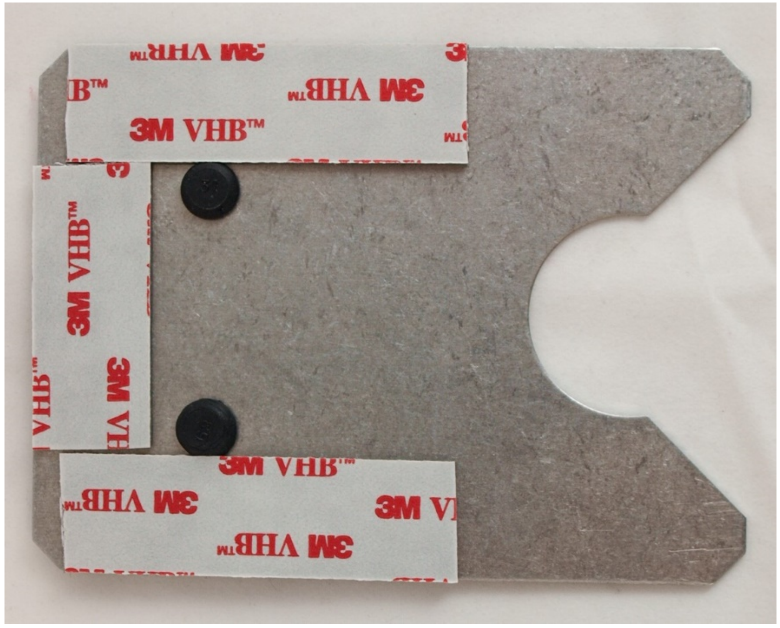


FIGURE H-6. New inner plate with adhesive tape

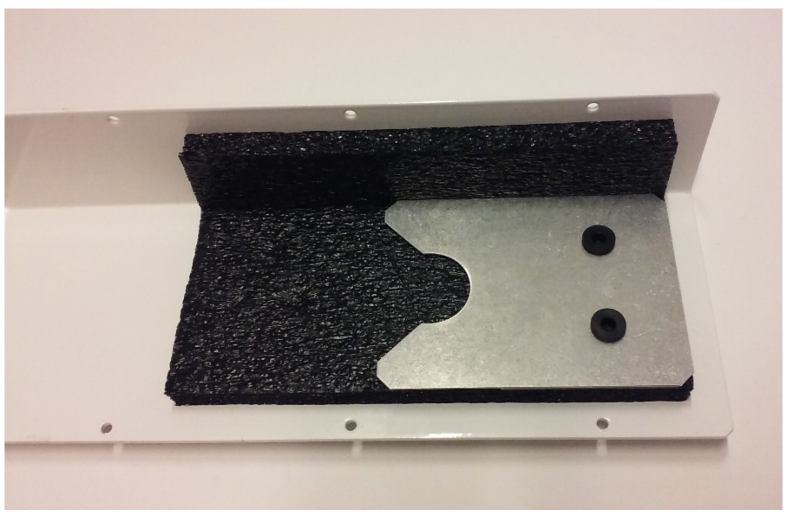


FIGURE H-7. New inner plate placement on pump module cover

8. Remove pump connector from the pump electronics (FIGURE H-8).

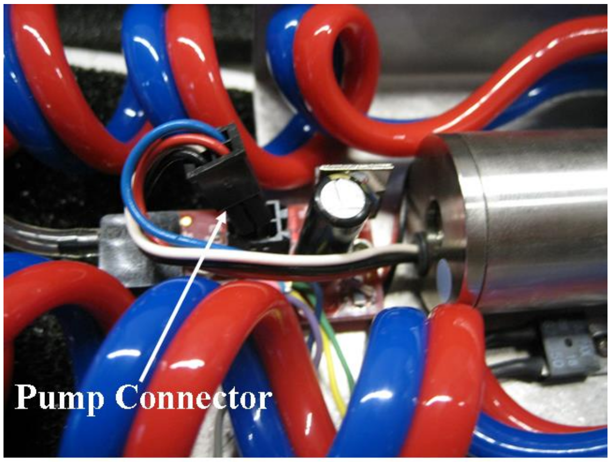


FIGURE H-8. Location of pump connector in CPEC300 pump electronics

9. Gently lift the pump assembly from foam, leaving the tubes attached. Turn it over and remove the two self-tapping #6 screws that attach the pump to the metal box, as shown in FIGURE H-9.

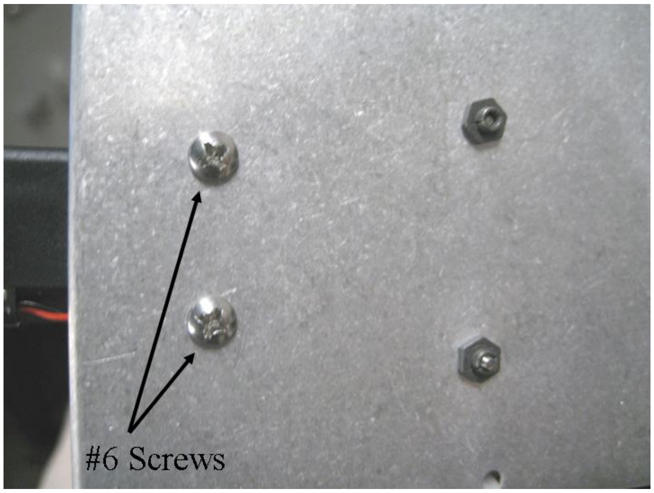


FIGURE H-9. Self-tapping screws attaching pump to metal box

10. Cut the blue (inlet) and red (outlet) tubing on each side of the pump behind the barbed connector as shown in FIGURE H-10.

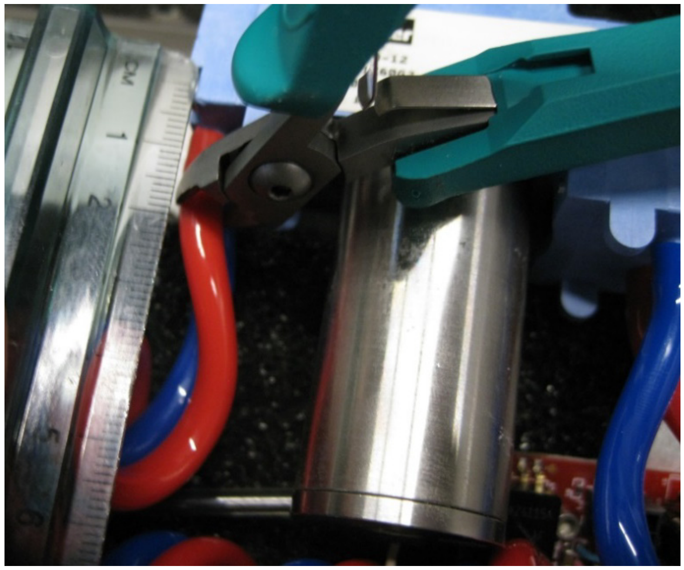


FIGURE H-10. Location of cuts to remove pump assembly from tubing

11. Remove the pump from the assembly.

H.3 Installation

To reinstall a CPEC300 pump, carry out the following steps:

1. Position the pump with the label up and connect the coiled tubing on both sides of the pump (see FIGURE H-11). Blue tubing connects the inlets and red connects the outlets as directional arrows show on the side of the pump (FIGURE H-12).

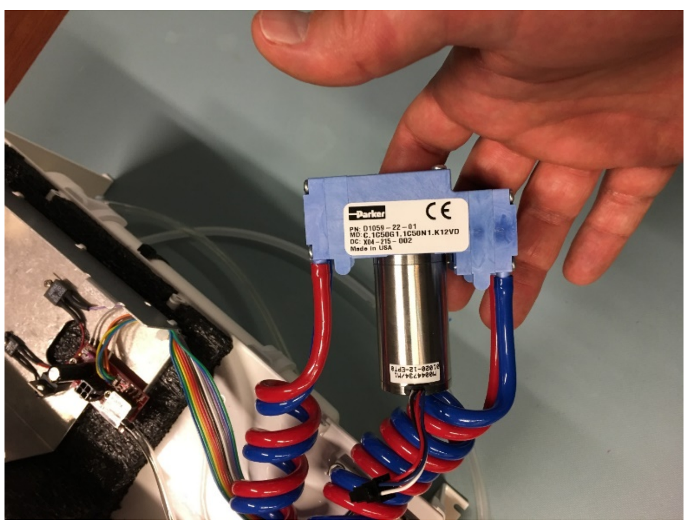


FIGURE H-11. Inlet and outlet tubing reconnected to pump

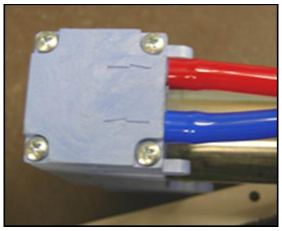


FIGURE H-12. Pump side with inlet and outlet tubing connected

2. Reattach the pump to metal box with two self-tapping #6 screws on the back of the pump module electronics plate (FIGURE H-9).

NOTE Be careful not to pinch the fan wires under the pump and do not overtighten screws.

3. Reattach the pump connector to the pump electronics (FIGURE H-8).

4. Place the pump assembly back into the foam on the shell cover. Make sure the fan is in the hole in the end and the small tab on the metal box is seated in the slit in the foam.

FIGURE H-13. Proper positioning of CPEC300 in shell cover

5. Hold the pump assembly securely to the shell cover while replacing the shell cover to the shell bottom. Make sure the fan does not slide back out of its hole in the foam. Fasten the shell cover in place with the six #4 screws (see FIGURE H-3).

6. Reconnect the tubing to the inlet and outlet of the filter assembly (see step 2 of removal and refer to FIGURE H-3).

NOTE Hold the fitting with a backup wrench to make sure the fitting does not unscrew from the filter holder lid. Be careful to not overtighten the fittings as this could cause damage to the hardware. Finger tighten the fittings first, then snug slightly with a wrench.

7. Rotate the filter holder into position and mount in the enclosure with four #10 screws (FIGURE H-1).

NOTE Do not overtighten screws.

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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.
- 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.

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.

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.

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