WCM-2000

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WELCOME TO THE WCM-2000

Welcome to the Multi-Element Water Content System, Model WCM-2000. Introduction, components, features and operating environment.

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Please E-mail your comments on the documentation to docs@scieng.com.

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WELCOME TO THE WCM-2000

Welcome to the Multi-Element Water Content System, SEA Model WCM-2000 (Multi).

The WCM-2000 multi-element Water content System was designed to provide aircraft and wind tunnel users with a single, rugged sensor to simultaneously measure Liquid Water Content (LWC), Total Water Content (TWC) and Ice Water Content (IWC).

The WCM-2000 is capable of controlling a maximum of four heated elements plus deice. The typical sense head as three heated elements, compensation element and deice. Another typical sense head as one heated element (TWC or LWC) plus the comp element and deice. Other speciality SEA sense heads can also be used with the WCM-2000 system.

The most typical sense head consists of four heated stainless steel elements each with a different shape or size. Each element is directly heated by low voltage DC current flowing through the element. These elements are maintained at a constant temperature, typically 140 °C, by a digital closed loop control system.

Given the dimensions of each element and the speed of the airflow, the power level set by the control system to maintain temperature can be converted directly into the water content of the air stream.

Three of the heated elements are exposed directly to the air stream and incoming cloud water. A fourth element, the reference/compensation (comp) element, is arranged to be exposed to the airflow but not to incoming cloud water. This element is used to establish the "dry power term" that is subtracted from the other three element's power readings to establish the measured water content.

The sense head makes two independent measurements of LWC using two different diameter LWC elements. The small LWC element is the same diameter, 0.5 mm, as the classic JW/CT LWC sensor. The second element is the same size, 2 mm, as the CSIRO (King) LWC sensor. Through wind tunnel testing it has been demonstrated that the ratio of the LWC's measured by the two elements can be used with suitable calibration to indicate the Median Volume Diameter (MVD) of the droplet distribution. This average drop size information can be used directly and also as a correction factor to correct and improve the LWC measurements, particularly in large droplet conditions.

Wind tunnel tests have shown that the two LWC elements have less than 1% false response to Ice Water Content (IWC) in the air stream. This compares favorably to wire wound LWC elements which typically have a false response to IWC of 10 to 20%.

The sense head uses a scoop shaped sensor to collect and measure both liquid water (LWC) and ice crystals (IWC). The combined total of LWC and IWC is referred to as Total Water Content (TWC). By subtracting the LWC measured by the LWC elements from the TWC measured by the scoop element, the IWC can be calculated.

The shape and size of the LWC/TWC elements can be varied to match the LWC/TWC measurement to different ranges of airspeed, altitude, water content, etc. In addition to temperature control for the four heated elements, the deice system is also temperature controlled. During operation the deice power is adjusted to maintain the instrument housing at a constant 50 °C, which is comfortably warm to the touch. Maintaining the instrument housing at a constant temperature provides a stabilized thermal environment around the sensing elements which leads to improved LWC and TWC measurement accuracies.

Temperature control of the heated elements and the deice heaters allows the unit to be operated safely and continuously at zero airspeed.

COMPONENTS

The system consists of three major components, the power box, the sense head and the control system to run SeaWcm application (this can be embedded into the M300 system or a separate control system, QNX 4 based). The sense head is mounted in the air stream. The power box is mounted near the sense head. The control unit is mounted where it is convenient for the user.
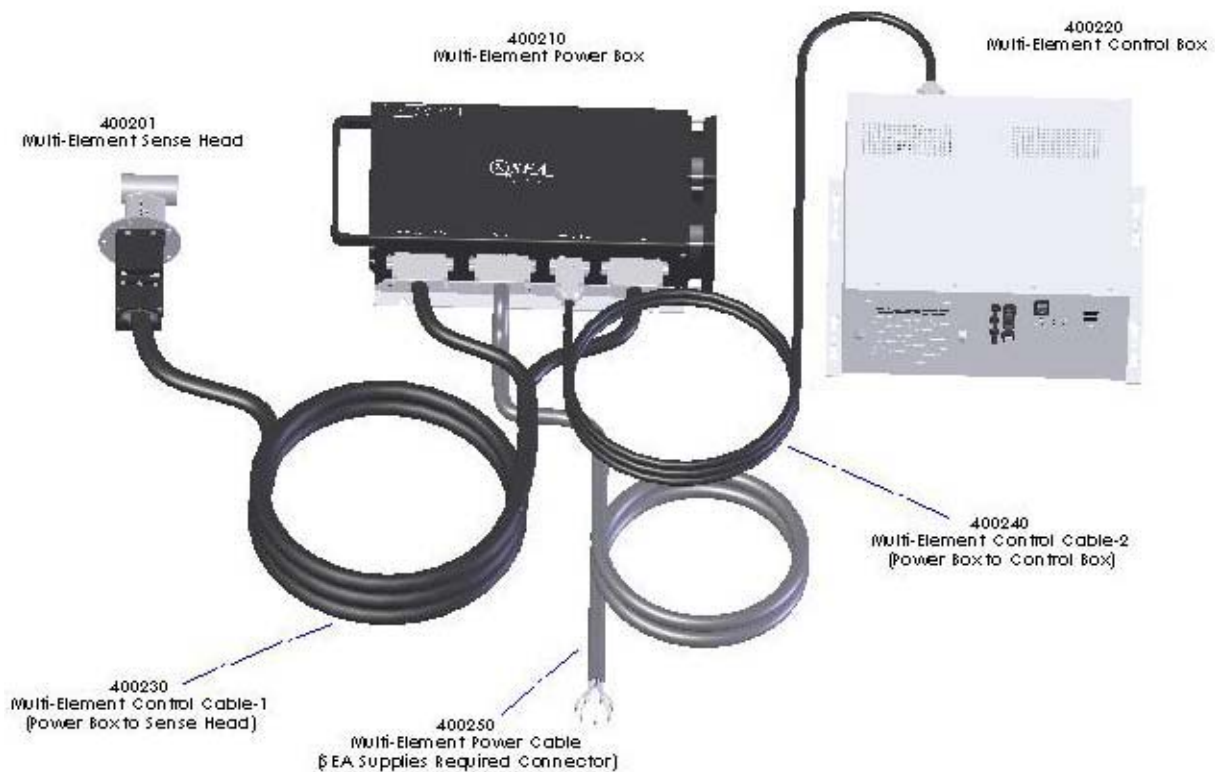
POWER BOX

The power box for WCM-2000 system interfaces with the sense head and the control system.

SENSE HEAD

The WCM-2000 multi-element sense head. The sense head connector can have an alternative orientation. Contact SEA for more information.

CONTROL SYSTEM

The WCM-2000 control system. This can be integrated in the M300 or stand alone.

The following picture shows the WCM-2000 control panel up close. Notice the main power, element power and deice power switches. The LEDs will light up when the button is on and there is power to the system.
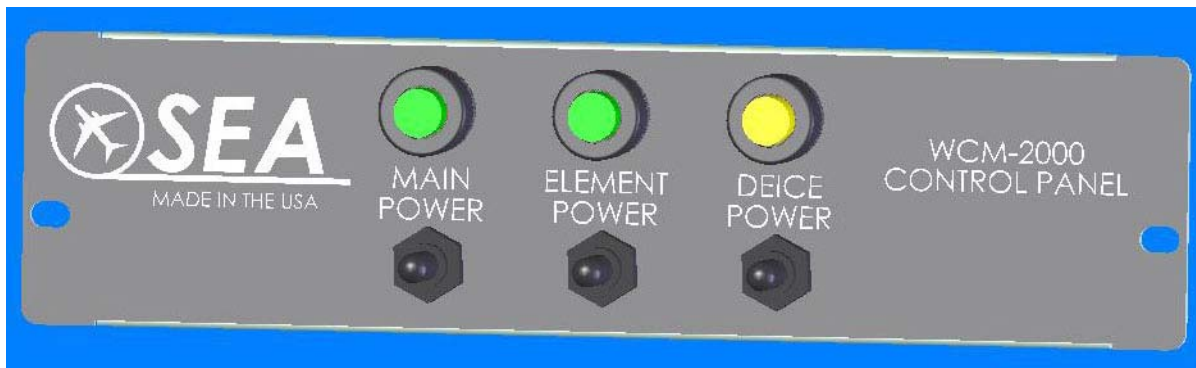
SENSE HEAD CABLE

The WCM-2000 multi-element sense head cable, connects the sense head to the power box. This is the standard 10 ft cable (other cables are possible as an option).

Orientation of the connector at the bottom of the head can be changed to meet different clearances.

COMMUNICATION CABLE

The WCM-2000 multi-element communication cable, connects the power box and the control system together. This is the standard 40 ft cable (other cables are possible as an option).

POWER CABLE

SEA provides the connector for the input power to the power box. The users should make a power cable to the power box.

APPLICATIONS

- Severe Weather Research.

- Cloud Physics Research.

- FAA Aircraft Icing Certification.

- High Altitude, High Speed Ice Crystal Content Measurement.

- Wind Tunnel Spray Measurement.

- Wind Tunnel Reference Instrument.

FEATURES

- Direct Measurement of LWC and TWC.

- Derived Measurement of IWC and MVD.

- Rugged Sensor Designed for High Speed, High Altitude Operation.

- Safe Operation at Zero Airspeed, *see endnote 1*.

- 28 vdc Power, Light Weight.

- High Water Content Capability.

- Self calibration/housekeeping values for power box.

- Self calibration/housekeeping values for sense head (plug and play).

- Self calibration/housekeeping values for cables.

- Ethernet/Network Data Output, UDP/TCP.

- Easy Interface to Aircraft Flight Data Computers.

- Small Size (Control System can be combined with existing M300 Data System).

- Measurement over a Wide MVD Range, Including SLD drop sizes.

- Excellent Deice Performance.

- First Principles Instrument for LWC and IWC.

- Very Low Contamination, < 1%, of LWC Measurement by Ice Crystals.

- Aircraft Icing Severity Indicator.

- Detection and Measurements of Ice Crystals especially at High Altitudes and Airspeeds.

REQUIREMENTS

- Two RS-422 ports (one for 845 controller and one for 1-wire devices).

- SeaWcm software to run the WCM-2000 system (QNX 4 based).

- Ethernet port connection to transmit data.

- Ethernet port connection to receive airspeed, static pressure and temperature.

SPECIFICATIONS

Description	Range
LWC/TWC Range, *see endnote 2*	0-10 gm/m3, TAS < 150 m/s, SL - 45,000 ft 0-6 gm/m3, TAS < 230 m/s, SL - 45,000 ft
Airspeed Range	0–275 m/s, (0–533 kt)
Measurement Range	10–275 m/s, (20–533 kt), *see endnote 1*
Power Supply Range	18–32 vdc, 28 vdc nominal
Power Consumption, *see endnote 3*	3.5 amp minimum 11 amp typical 54 amp maximum
Sensor Head Dimensions	3.25 in x 1.2 in x 2.25 in external 5.65 in x 3.25 in x 3.25 in overall
Power Control Box Dimensions	15.2 in x 7.8 in x 3.5 in
Sensor Head Weight	1.5 lb
Power Control Box Weight	12.0 lb
Data Output	Ethernet Network TCP/UDP
Display Data Rate	1 to 20 Hz, selectable
Data Output Rate	1 to 20 Hz, selectable

WCM-2000 Specifications

1 "Safe Operation" means that the instrument can be left fully powered on continuously at zero airspeed without damage. However as the airspeed is reduced to zero, the effective sample volume decreases to zero and the measurement of LWC is not possible. Depending on the specifics, some minimum airspeed is required to establish a minimum acceptable sample volume. Please contact SEA for details about measurements at very low speeds.

2 Refer to graph for details. Maximum possible LWC/TWC varies slightly with altitude and is about 10% greater at sea level compared to 40,000 ft at the same airspeed.

3   Power supply current varies with airspeed, altitude, ambient temperature and water content. Supply currents include deice power. Minimum current is for zero airspeed at 20 °C. Typical current is for 67 m/s, -9 °C, 1.5 gm/m3. Maximum current is for maximum possible LWC/TWC.

OPERATING ENVIRONMENT

Power Box

Sense Head

Control System

INSTALLATION

On a new installation or modifications to the input power to the system, the user must verify with a multi-meter that the correct power specifications is present for each component.

⚡ *WARNING:* **As a general rule, make sure power is off before installing any of the components and cables. The client's DC breakers must be off.**

POWER BOX INSTALLATION

The power box needs to be installed near the sense head in order to minimize cable loss in distributing power to the sense elements. The standard cable between the sense head and power box is 10 ft. Other lengths possible please contact SEA.

All cables provided are labeled and uniquely keyed so they cannot be inserted in the wrong connector. The lid on the power box has labels for each of the four connecting ports. They are Small LWC/Large TWC, Power In, Communication and TWC/Large LWC.

Make sure you tighten all screws on the mounting cables assemblies, so each cable is secured properly and tight to the appropriate mounting connector on the power box.

The power box must be connected to the sense head with the sense head cable. The sense head cable splits into two sections where it connects to the power box. One connector connects to the Small LWC/Comp/Deice. The other connects to the TWC/Large LWC connector. If you are having trouble getting these pushed in, make sure that you have the right connector to the right port. New cables tend to be harder to push in, after they wear out a bit they are easier to push in.

The power box must be connected to the control system with the communication cable on the communication port.

SEA provides a connector for the input power to the power box (Power In). Make sure the client DC breakers are off before connecting the power cable to the "Power In" connector.

The main power switch in the front of the control box powers up the power box. Before you provide power to the control box it is also a good idea to have that switch in the off position.

SENSE HEAD INSTALLATION

The sense head (probe) will operate in any orientation, including upside down. However, for aircraft operations the sense head should be mounted in a horizontal orientation and in a location of undisturbed airflow. The sense element should be at a right angle to the airflow and parallel with the horizon.
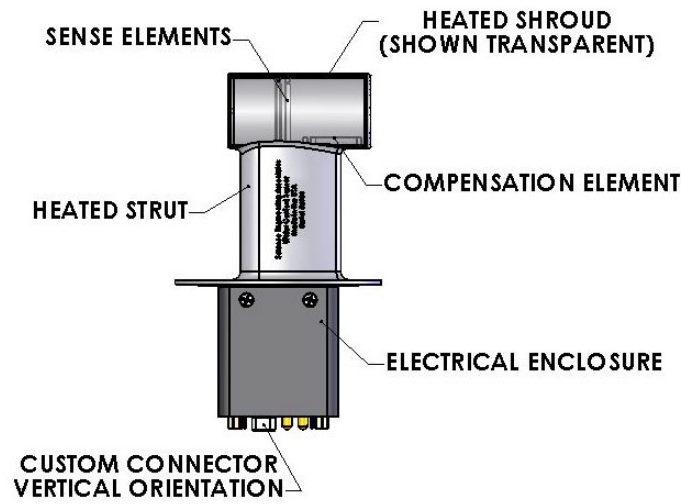
The strut portion of the sense head positions the sense elements away from the disturbed air near the connection point. The circular shroud provides an anchor point for the sense and compensating elements. The cylindrical shape of the shroud directs airflow past the elements and protects them from damage. The support strut and the shroud contain deicing heaters. Additional mechanical details are provided in the schematics, diagrams and mechanical drawings.

If the airflow angle is fixed, such as in a wind tunnel, any orientation is acceptable.

The sense head must be connected to the power box using the sense head cable. Align the pins on the cable with the connector on the sense head. Gently push in until fully inserted. Make sure to tighten screws in cable assembly.

Note: It is safe to remove and change sense heads with power to the power box and control system, as long as the element power and deice power switches are off. If the user is running SeaWcm, it also recommended to click on the stop button, so the SeaWcm stops trying to run and control the WCM-2000 system.

CONTROL SYSTEM INSTALLATION

The control system can be stand alone or integrated into the M300 system. The control system must be connected to the power box. This allows interface with the power box and sense head.

Usually you must provide power to the control system, this can be AC or DC, depending on user specifications. If the control system is in a PC104 enclosure, the power is supplied in the control port from the power box.

Make sure the main power, element power and deice power switches in the front of the control system are in the off position prior to installation of the cables.

The installation of the control system should be pretty straight forward. This usually follows from the type of system being used and the application.

The standard cable between the Control Box and the control system is 40 ft. Other length possible, please contact SEA.

Typically, in the control system there is serial interface which usually supports up to 8 serial ports. There is a fan out cable with eight DB-9 connectors and one large connector. The large connector plugs into the serial card. Some of these are setup for RS-232 and some for RS-422.

Sometimes, depending on which control system is used there might be only a few serial ports labeled in the back of the system (like in the case of PC104 enclosures).

The import thing to keep in mind is that the WCM-2000 needs to use two RS-422 ports. One is the control port. The other is the 1-wire (EPROM) port. These can be in the control system (stand alone or M300) or sometimes in network to serial boxes which are connected to the ethernet port. The SeaWcm application uses these port to control the WCM-2000.

Usually port "/dev/ser8" is the control port to the WCM-2000. You must connect the appropriate port to the control port on the back of the control system. Double check in the SeaWcm application in the "setup" tab to see which port is assigned to the control port.

Usually port "/dev/ser9" is the 1-wire (EPROM) port to the WCM-2000. You must connect the appropriate port to the 1-wire (EPROM) port on the back of the control system. Double check in the SeaWcm application in the "setup" tab to see which port is assigned to the 1-wire (EPROM) port.

In the back of the control system there an ethernet connection port which sometimes also needs to be connected. This can be used to connect to other systems (M300 or user DAS) to transmit/ receive the data. The SeaWcm uses this connection to transmit data to many different systems using UDP (if necessary). The SeaWcm can also use this connection to get static pressure, static temperature and true airspeed from one source (and only one). If the M300 and SeaWcm are running in the same system and there is no other use for the ethernet port, then you don't need to make a connection.

CABLING

The interconnect cables can be purchased with the system or fabricated by the user. If the user does fabricate their own cables, strict adherence to the (required components, wire size, and assembly methods is necessary). Please contact SEA for help with these specifications.

If the user fabricates the cables, he must follow the schematics provided SEA and very each pin with an ohm meter to make sure the wire goes where it's supposed to go.

The most import cable is the input power cable and the user should check that each pin has the correct power source according to the schematic and specifications provided by SEA.

OPERATING INSTRUCTIONS

The WCM-2000 system uses QNX 4 RT OS. If your system is not setup to automatically start the Photon micro GUI, see these instructions.

Note: Whenever we use the word QNX for it refers only to the QNX 4 RT OS system.

It is probably a good idea to look over the SeaWcm application documentation,

LOGIN

In the QNX system there are users assigned to the system. Each user has a login name and password. To login into the QNX system.

1. Enter you username at the login prompt.
2. Enter you password at the password prompt.

Note: If you are going to run the SeaWcm during this session, you should <u>NOT</u> login as root/superuser. Rather, you should set-up a user account (if not already done so) with reasonable access rights and privileges.

Note: If you enter an incorrect or non-existent username/password, for security reasons, QNX will return to the login prompt without providing notification of the error.

For the WCM-2000 system the user name is usually 'operator' and there is no password setup initially.

LOGOUT

To logout from the QNX system.

1. If Photon is running at this point, first.
2. Type 'exit' or 'logout' at the QNX command prompt.

This will not make the system safe for shutdown. For that you need to look at the 'halt' section bellow.
You may see some error messages on the QNX console, there are normal and can be ignored.

HALT

QNX has a shutdown command that can be used. We have made a simple command called 'halt' that performs the QNX shutdown. Make sure you save any changes before using the halt. Power will have to be cycled manually.

1. Type `halt` from any command prompt window.

REBOOT

QNX can also use the shutdown command to perform a system reboot (restart). We have made a simple command called 'reboot' that performs the restart. Make sure you save any changes before using the reboot.

1. Type `reboot` from any command prompt window.

STARTING PHOTON

To start the QNX Photon GUI.

1. Type 'ph' at the QNX command prompt.

☞ *Note: **The system can be configured to start Photon automatically after boot up as opposed to the traditional login through the QNX shell. If you wish to have this, just contact SEA for help on getting it done.***

GETTING FAMILIAR WITH PHOTON

The QNX Photon GUI (Graphical User Interface) has a similar interface much like any GUI you might be familiar with already, with the exception that it is designed for a real-time operating system. It is because of this real-time requirement that some of the special features of modern day GUI are not available in the Photon GUI. With that said, Photon still provides scalable graphics support, multimedia capability, and a fully customized interface. Below is a snapshot of the Photon desktop along with the highlighting of its main features.

QNX Desktop
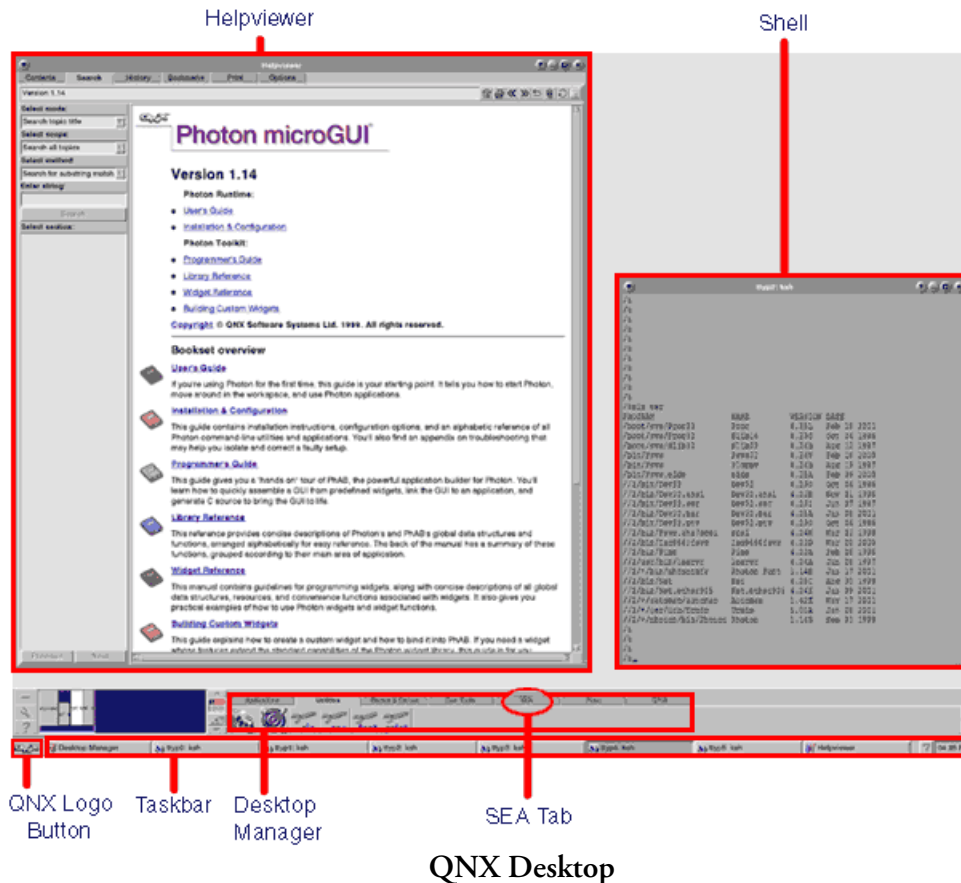
👉 *Note: This section will provide you with an overall description of main Photon GUI features, to get more help on the Photon GUI, please see the Photon documentation in the QNX Helpviewer (See "Getting Help for QNX 4 and Photon" on page 19).*

Helpviewer

This is the application you will use to view any electronic QNX Documentation.

QNX Logo Button

This is similar to the 'start' button on Windows 7. However this button will only give you access to system configuration dialogs and the **shutdown** command.

Desktop Manager

This is where any Photon applications can be launched from. By default, QNX has a handful of different tabs for various applications on this menu bar. This is where you will find the **SEA Tab**.

Task Bar

This is where any running application's buttons will displayed. For SEA applications, each window will have a corresponding button on this taskbar. To bring a particular window into focus, click on its task button.

In the task bar you switch between running applications. In the SEA tab you start the program.

SEA Tab

This is where you will find the program icons for any SEA software you have purchased.

This includes the SeaWcm application, which is responsible for running the WCM-2000 system.

The user clicks here to start a new instance of the Program, such as SeaWcm.

Shell

This is a QNX shell (pterm window, command/terminal window) that will provide you with an interface to enter commands directly into the QNX system. This is useful to type many different commands. SEA provides a detailed list of command from time to time to achieve a range of different purposes.

The QNX terminal window is similar to a LINUX/UNIX terminal window or the Windows 7 command window.

Screen saver

It's not recommend to use a screen saver with the system. You don't want the screen saver to come up while you are passively looking at the data. If you set a screen saver, stay away from the blank screen saver. Many novice users confuse this with a system shutting down or crash (not realizing the screen saver has engaged a blank screen).

EXITING PHOTON

You can exit Photon using a couple of different commands. Before you exit Photon you should terminate any applications you have running first.

Click on the QNX logo in the bottom left corner of the screen, and select **s**h**utdown**.

Don't use the **CTL + ALT + SHIFT + BACKSPACE** key combination to shutdown photon.

Note: We had to disable this option on WCM-2000 installed systems. The key combination exit is not the same as mouse exit on the QNX button. As a result applications don't get shutdown the way they should and cause problems with bad values on files, etc.

Note: Once you exit Photon, you will return to the QNX 4 command prompt or to the Photon login screen if your system is configured to start Photon automatically.

GETTING HELP FOR QNX 4 AND PHOTON

The QNX 4 system does not provide `man` pages like in traditional UNIX systems. To get help on a command, type '`use` *cmd*' where '*cmd*' is the command in question. For example, for help with the '`ls`' command, type '`use ls`' at the command prompt from a 'pterm' window). Help is also

available using the Helpviewer Photon application. To get help on any QNX 4, TCP/IP 5 and Photon 1.14 issues consult the Helpviewer using one of the following methods.

1. In the **Desktop Manager**, select the **Applications** tab in the application groups panel. Click on the **Helpviewer** 📘 icon. Or from a QNX shell, type '`helpviewer &`'.

POWER UP THE **WCM-2000** FOR THE VERY FIRST TIME

The user should be extra cautious when running the SeaWcm for the first time and follow all the required guidelines in the installation section.

If SEA provides the cables for the WCM-2000 system the user should be aware that these cables have been tested and are okay to use.

Any cables or wiring that the user provides should be checked with care to ensure that the pinout for the cable is okay.

POWER UP THE **WCM-2000**

To power up the WCM-2000 system.

⚠️ *WARNING:* **This assumes all components of the WCM-2000 system are connected properly to avoid damage to the sense head or power box.**

1. Turn on the client's DC power supplies (circuit breakers).
2. Turn on the control system or M300. Wait for it to power up. Login and start photon.
3. Turn on the main power to the WCM-2000 system (this provides power to the power box).

STARTING THE **WCM-2000**

To start SeaWcm application.

1. In the **Desktop Manager**, select the **SEA** tab in the application groups panel. Click on the **SeaWcm** 🖧 icon. Or from a QNX shell, type '`SeaWcm &`'.

2. Click on the start button (a window with the loading message should appear for a few seconds). The SeaWcm will load all settings from the EPROMs and start to control the WCM-2000 system. Consequently you should be in the TWC/LWC tab with data updating at 1 hz. To see all the detailed information about the WCM-2000, click on the data tab. You can switch back and forth between the TWC/LWC and the data tabs any time.

⚠️ *WARNING:* **If the SeaWcm doesn't load all the data properly and goes immediately to the TWC/LWC tab when you click on the start button, then you should not proceed to the next step. You should instead troubleshoot your connection cables and make sure that you have actually power to the components in the system.**

3. Turn on the element power (leave your fingers on the switch). Make sure you look at the values on the data tab. The temperature of the elements should increase to the set point (usually 140 °C). Make sure no text values are in red color (indicating warnings or error conditions) in any of the text boxes for the elements. If you suspect a problem you should turn off the element power immediately and troubleshoot this before proceeding any further.

4. Turn on the deice power (leave your fingers on the switch). Again make sure you look at the values for the deice element. The temperature of the deice element should increase until is reaches the set point (usually 50 °C). Make sure no text values are in red color (indicating warnings or error conditions) in any of the text for the deice element. If you suspect a problem, you should turn off the power to the deice element immediately and troubleshoot this.

HOW TO EXIT WCM-2000

Exit the SeaWcm by using one of the following methods.

1. To be extra safe, click on the stop button on the SeaWcm (before exit).
2. It is recommended that you turn off the power to the deice and element power to sense head.
3. From the **File** menu, select **Exit**. (Shortcut: **Alt + F, X**). Or click on the close symbol ("**X**") in the upper right corner of the main interface window.

Note: **If the SeaWcm system freezes for any reason, you can close the program by typing `'slay SeaWcm'` from a QNX shell. However, this will not allow you to save any changes you have made. Use only a last resort to close the program.**

SHUTTING DOWN THE WCM-2000

Shutdown the WCM-2000 system by performing the following.

1. If running the WCM-2000 system it is recommended that you turn off the power to the deice and element power to sense head.
2. Exit all applications, including SeaWcm and Photon if they're running.
3. Turn the main power off to WCM-2000 control box (this powers off the power box).
4. Wait at 3 three seconds before turning power off to the control box or M300 system (this allows the cache to empty to the hard drive). Additionally you can type `'halt'`. This is the preferred way to shutdown QNX 4 and ensures proper and safe termination.
5. Turn off the client's DC power supplies (circuit breakers).

CHANGE SENSE HEAD

To change the Sense Head you can follow the following steps.

1. Turn off the power to the deice and element power to sense head.
2. Exit SeaWcm application. See how to exit WCM-2000 about.
3. Turn the main power off to WCM-2000 control box (this powers off the power box).

4. Then it's safe to change the Sense Head. This might be different depending on the user installation. If necessary remove the mounting screws for Sense Head first. Then, remove the four captive screws that hold the cable to the Sense Head.
5. Install new Sense Head. See Installation instructions for Sense Head.
6. Turn the main power on to WCM-2000 control box (this powers on the power box).
7. Then follow instructions for starting the WCM-2000 system.

SEAWCM

DESCRIPTION

The SeaWcm utility is used to control and interface with the Water Content Measurement (WCM-2000) system.

The three main purposes of the WCM-2000 system are configuration of the system, controlling the data from the WCM-2000 system and reading/recording the data from the system.

The SeaWcm can program and change the settings for the 1-wire devices on the WCM-2000 system. The 1-wire devices are programmable EPROMs that keep all the settings for the WCM-2000 system. Each component of the WCM-2000 system has an EPROM identifying it's features/settings.

When the SeaWcm runs to control the WCM-2000 system it loads these settings before it can actually start to control the system. The control of the WCM-2000 system is always being done as long as the SeaWcm is running and the user clicks on the play button.

While the SeaWcm is controlling the system it reads back data from the 845 controller modules inside the power box and display the data from the system. Optionally the user may record this data.

The WCM-2000 system has three modes of operation, safe/auto mode, expert mode and playback mode.

The safe/auto mode is the most common way of operating the WCM-2000 system. In this mode all the settings are read from the EPROMs (1-wire devices) and then these are used to control the WCM-2000 system. This mode allows for recording and transmission of data to another system.

The playback mode allows the user to playback data that was recorded with the SeaWcm. The file must be a raw ASCII with the WCM format. The playback mode will not playback any other types of files, such as an CSV file. In playback mode there is no control of the WCM-2000 system, so playback can be performed while the WCM-2000 is power off. In playback mode there is no transmission of the data to other systems.

Use caution while running in expert mode, invalid parameters used might cause damage to some components.

Don't run SeaWcm in expert mode, unless asked to do so by an SEA Engineer.

The final mode of operation for the WCM-2000 system is expert mode. In this mode the SeaWcm reads the settings from the configuration files and uses these for control of the WCM-2000 system. Additionally the settings read from configuration may be changed before entering the control of the WCM-2000 system. On rare occasions if there is trouble communicating with the EPROM devices on the WCM-2000 system, the user might use expert mode instead. Please contact SEA first before using this mode of operation under these circumstances. This mode allows for recording and transmission of the data to another system.

The SeaWcm can also transmit data to a remote computer system. Usually this is done over UDP/TCP packets (see format bellow).

The SeaWcm can be setup to auto run on system start up. Normally when the utility starts the user must click on play/start to get it going. This gives the user time to interface with the WCM-2000 system before it runs it.

On systems where the SeaWcm and the M300 run simultaneously, it might be necessary to reduce the display frequency to 1 hz, in order to minimize CPU and video display usage. We need real time performance for M300. The data from the WCM-2000 will be transmitted to the M300 and displayed there as well, so it is redundant to have it in two places.

The SeaWcm uses the configuration file under the '.sea' directory, off the user home directory (.sea/SeaWcma.cfg). Like the M300 system we can start multiple sessions of SeaWcm. Each session uses a letter 'a' to 'z' to identify and differentiate different sessions running.

It is possible to run more than one session/instance of the SeaWcm to control multiple WCM-2000 units per QNX 4 system.

The SeaWcm is key part of the WCM-2000 system and any one using the WCM-2000 system should be familiar with this.

The seadrive and cp (copy) utilities run at priority 10. These interfere with the SeaWcm. Please don't run these while SeaWcm is running.

STARTING SeaWcm

1. Click on the **Desktop Manager** button in the task bar.
2. In the **Application Icon** bar, select the **SEA** tab.
3. Click on the **SeaWcm** icon.

In addition you can start SeaWcm from the command line. Here are the steps for that.

1. Select the **Desktop Manager** in the **task bar**.
2. Select the **Applications** tabs.
3. Click on the **Pterm** icon.
4. Click inside the newly created command window.
   Type '**SeaWcm &**'.

SeaWcm Command Line Options

The SeaWcm has a few optional parameters which can be used, if so desired.

x

     Letter indicating session ('a' to 'z' possible values, in sequence). Must be first parameter. Normally the user doesn't need to worry about which session of SeaWcm to start. If more than one session is running this gives the advanced feature of selecting which session to run. It is possible this way to start sessions out of sequence. Use extreme caution when running multiple WCM-2000 system to make sure there is no confusion as to which system is being used.

-auto

     Auto start. When SeaWcm is started it will automatically start running and controlling the WCM-2000 system. This is equivalent to the user clicking on the start button.

-rec

     Automatically record the *.wcm raw ASCII files (when using auto start). This files may be used for play back mode.

-reccsv

     Automatically record the *.csv ASCII files (when using start auto start). This files may not be used for play back mode, they are intended to be used by other software applications for data analyses.

-expert

     Expert mode/manual override of WCM-2000 settings from the 1-wire devices.

     ☞   ***Note: Use this mode with extreme caution. For advanced users only or under the advise of SEA personnel.***

-pb

     When SeaWcm is started it will be in playback mode allowing the user to play back the recorded *.wcm raw ASCII files.

THE SEAWCM WINDOW
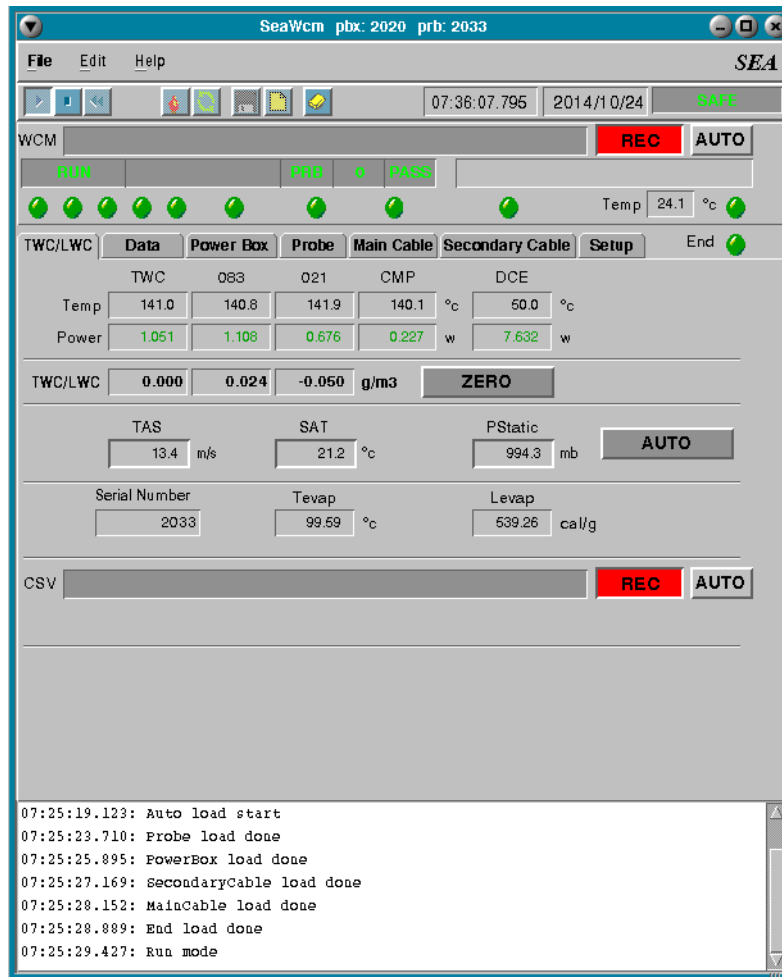
MENUS

File

Open option while in playback mode to open an existing file for playback. Typically the *.wcm raw ASCII files are in the /wc2000/wcm folder.

Close option to close the currently open *.wcm raw ASCII file.

Close CSV option to close the currently open *.csv ASCII file.

File history of the most recently used *.wcm raw ASCII files. If you are in play back mode selecting a file would open it for reading. If you are in normal running mode, selection a file from the list will try to overwrite the file with new data. The user is given an option to prevent overwriting wanted data files.

☞ *Use caution not to overwrite any data files and backup your files as much as possible.*

Exit is the only menu item. Use it to exit.

Edit

Cut, Copy and Paste are menu items. They are disabled.

Help

About SeaWcm is the only menu item. Use it to check the SeaWcm version.

TOOLBAR BUTTONS

start

This is used to start the WCM-2000 system. It goes into run mode and will start reading the settings from the EPROMs prior to entering active control mode.

stop

This stops the WCM-2000 system. This can be done in other to make changes to the settings or prior to exit the SeaWcm application.

rewind

This is available only while the user is in playback mode to rewind the file.

burn to EPROM

This burns data from the display screen to the EPROM (1-wire). This is valid/enabled for power box, probe, main cable and secondary cable.

☞ *Don't change values for the device, unless asked to do so by an SEA Engineer.*

load from EPROM

This loads current data from EPROM (1-wire) to the display tab. This is valid/enabled for power box, probe, main cable and secondary cable.

save to configuration file

This saves the data from current display tab to the configuration file. This is valid/enabled for power box, probe, main cable and secondary cable.

load from configuration file

This loads the configuration file from hard disk file to the current display tab. This is valid for power box, probe, main cable and secondary cable.

The following conventions apply to the configuration file names. All files will be off the SeaWcm directory. This is usually '/wc2000'.

The file names for power box are in the 'pbx' folder. The file name is made up of the serial number and it ends in '.cfg'. For example, '/wc2000/pbx/1010.cfg'.

The file names for probe are in the 'prb' folder. The file name is made up of the serial number and it ends in '.cfg'. For example, '/wc2000/prb/1010.cfg'.

The file names for main cable are in the 'mcb' folder. The file name is made up of the serial number and it ends in '.cfg'. For example, '/wc2000/mcb/1010.cfg'.

The file names for secondary cable are in the 'scb' folder. The file name is made up of the serial number and it ends in '.cfg'. For example, '/wc2000/scb/1010.cfg'.

clear status list
Clears status list at the bottom of the SeaWcm. For example, use this if you are looking to see if any error or status messages show up.

time
This shows the current time from the QNX 4 system. If necessary adjust the time in the QNX 4 system to the correct time.

date
This shows the current date for the QNX4 system. If necessary adjust the date in the QNX 4 system to the correct date.

mode label
Shows "safe" in green color for normal operational mode. This is the normal operational mode for the SeaWcm.
Show "playback" in playback mode. This will alert the user during this mode only playback of recorded data files is possible
Shows "expert" in red color for expert/manual mode. This is to indicate that the SeaWcm and the WCM-2000 system are operating in expert mode manual mode and caution needs to be used.

WCM RECORDING FILE

WCM Recording file name and folder
Following the 'WCM' label you have a text box with the folder and the name of the file for the raw ASCII file. The folder is usually in /wc2000/wcm and the file name is automatically generate from the date and time. For example, '2014-10-24_07_36_23.wcm' would correspond to a file from 2014 year, 10 for October and the 24th day of the month. The time would be 07:36:23 for the start time of the data in the file.

REC
The 'REC' button is used to enable/disable the recording of raw ASCII data to the 'WCM' file.

AUTO
The 'AUTO' button may be pressed automatically create a new raw ASCII data for the 'WCM' file. If there is a file already being used and the user presses the 'AUTO' button again, then the current files is automatically closed and another file is started.

PROGRESS PANE

Operation, Step, Chip, Page and Status

The second line on the progress pane show information relating to the 1-wire operation. Typically this is not important for normal operation of the SeaWcm system. It used mainly for status and debugging any problems with the communication. So if a problem arises with the 1-wire communication you might be asked to provide information from the second line.

File Name

The last field in the progress pane shows the file name. This is valid only for the power box, probe, main cable and secondary cable tabs. The user only sees the name of the file in use. Black color indicates normal. Red indicates the variables where changed for device and might need to be saved.

Element 1, Element 2, Element 3, Comp, Deice Status Indicators

The function of these indicators is to let the know if SeaWcm is communicating and receiving data from the 845 controller modules from the power box.

The first five indicators under the Operation text boxes are used for element 1, element 2, element 3, comp and deice.

The color codes for these are green if the device is working normally and is turned on. Red indicates a problem, such as not communicating with the 845 control, the user should investigate that problem. Gray indicates that the device is communicating but it hasn't been turned on. When the user turns on/off the element power these should go green/gray without a large delay. When the user turns on/off on the deice power switch the delay for the indicator to switch colors is longer.

If an element/comp/deice is disabled under the power box tab configuration then the corresponding indicator will be omitted.

Power Box, Probe, Main Cable and Secondary Cable Burn Indicator

On top of these tabs there is an indicator for each device. A green color indicates normal operational mode. A red color while the SeaWcm is stopped indicates the device might need to be burned (since it was changed). A red color during normal run mode indicates a problem with the device (not connected or trouble or in expert mode).

Temp

Internal temperature on the Power Box. This comes from the 1-wire temperature device installed there.

This is followed by a green or red status button which indicates normal or failure in communication with the temperature device.

End

At the end of the 1-wire communication bus we have placed a device. This can be used to check that all devices on the 1-wire bus are properly connected. A red status button indicates failure; green normal.

STATUS LIST

The status list is located at the bottom of the SeaWcm window. The status list shows a scroll list of any error or status messages seen by the SeaWcm.

These messages are additionally displayed on a PTerm window, if the SeaWcm was started from there. Otherwise the status list is the only place where error or status messages will appear.

The format for these is usually time followed by a text message on the actual error.

For the most part the messages are self explanatory. For any message the user might not understand contact SEA.

At the present there no way too capture these messages to a file.

THE TWC/LWC TAB

The TWC/LWC tab display maim information about the WCM-2000 system, such as TWC/LWC values, temperatures, power, TAS, SAT, Press Static, etc. The user will spend most of the time looking at the TWC/LWC tab or the Data tab while operating the WCM-2000 system.

This pane shows real-time measurements at 1 hz for temperature and power for all the elements.

It also shows TWC/LWC for element 1, element 2 and element 3.

There is zero button in this pane that can be click to zero the TWC/LWC values when necessary.

The true air speed, saturated air temperature, static pressure coming form input port which are necessary for the TWC/LWC calculation.

There is a button that can be toggled between auto and override mode. Auto mode is the default mode. In overwrite mode the user may select a different value for TAS, SAT and PStatic, than the input data being sent to the SeaWcm. If necessary click on the override button to go back to auto mode.

The probe serial number, Tevap and Levap values are also shown.

CSV recording file name and folder

Following the 'CSV' label you have a text box with the folder and the name of the file for the csv ASCII file. The folder is usually in /wc2000/csv and the file name is automatically generate from the date and time. For example, '2014-10-24_07_36_23.csv' would correspond to a file from 2014 year, 10 for October and the 24th day of the month. The time would be 07:36:23 for the start time of the data in the file.

REC

The 'REC' button may be pressed to enable/disable the recording of ASCII data to the 'CSV' file.
From the TWC/LWC tab under playback mode you see the additional control widgets available for the user.

AUTO

The 'AUTO' button may be pressed automatically create a new ASCII data for the 'CSV' file. If there is a file already being used and the user presses the 'AUTO' button again, then the current files is automatically closed and another file is started.

Playback Period and Playback Slider Speed

These widgets allow the user to select the speed of the playback. The user can select different values under different conditions to get the optimal speed the desired.

File Location Scroll Bar

This allows the user to position the location on the data file where to go to display the data. The user can go backward and forth in the file location. The percentage text label is only an indicator field, i.e. the user can't enter a percentage value to go to in this field.

The total file size and the current file position are also shown following the percentage text label.

THE DATA TAB

The data tab shows real-time measurements from the elements on the WCM-2000 system.

The user selects the display frequency for this display in the setup tab.

Displayed here are temperature of the elements and power, followed by Resistance, volts and current. The last section shows DAC, P-term, I-term, D-term and spare values.

THE POWER BOX TAB
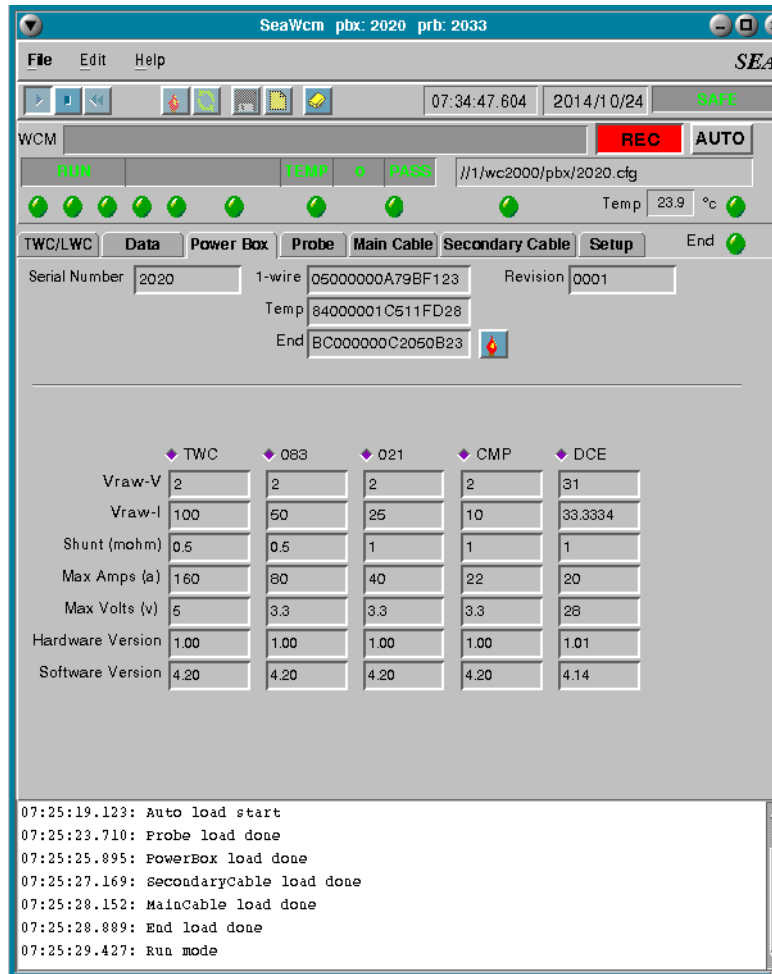
The power box tab is used to inspect and configure the parameters associated with the power box on the WCM-2000 system.

☞ *In order to be able to make changes to any fields here the SeaWcm must be stopped.*

☞ *Note: Don't change values for the power box, unless asked to do so by an SEA Engineer.*

This includes serial number and revision. These can be changed.

The 1-wire (EPROM) serial number, temperature EPROM serial number and end EPROM serial number. These cannot be changed. They merely show what is being used.

A button to configure/burn the end EPROM when it's first blank (only used once by SEA). Not for user.

For all the elements there are values that can be changed for (see immediate list).

Each element/comp/deice has a check box to enable or disabled. For example if you have a TWC only sense head, typically element 1 is the TWC and it's enabled. The element 2 and element 3 are not part of the system and therefore disabled. The comp and deice are necessary and therefore they are also enabled.

When the system is running and you are looking at the indicator leds, any element/comp/deice that are disabled will be omitted.

Shown in the Power Box Tab you will also see Vraw-V, Vraw-I, shunt, max amps, max volts, hardware version and software version.

THE PROBE TAB
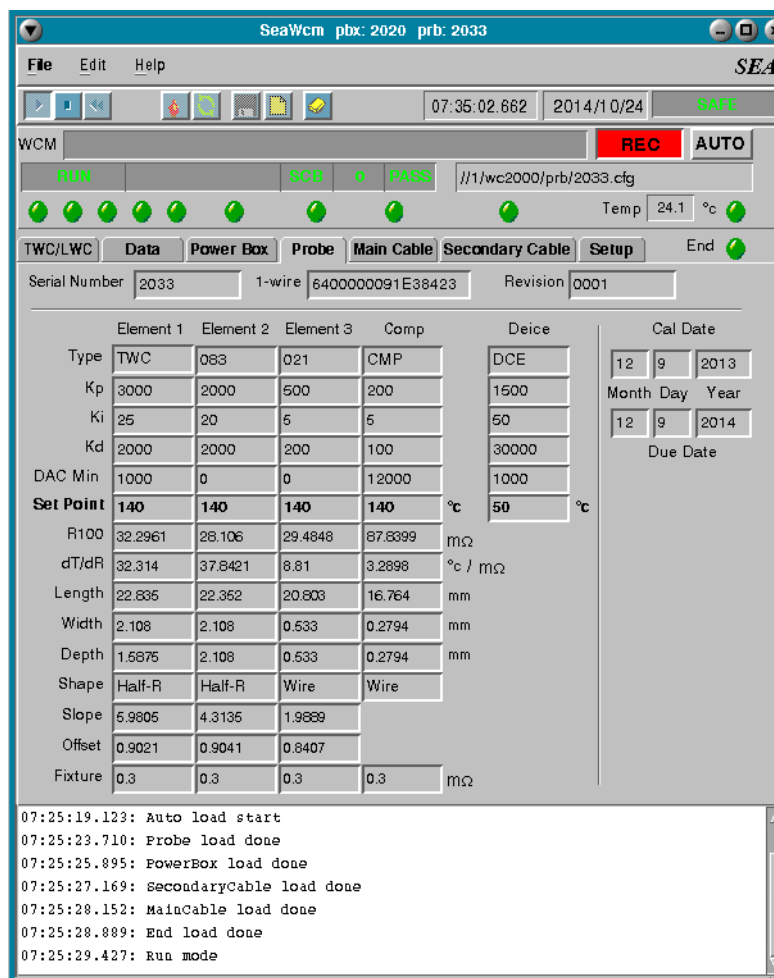
The probe tab is used to inspect and configure the parameters associated with the probe head on the WCM-2000 system. Different probe heads will have different configurations. The WCM-2000 system and the SeaWcm are plug and play aware.

☞ *Note: In order to be able to make changes to any fields here the SeaWcm must be stopped.*

☞ *Note: Don't change values for the probe unless asked to do so by an SEA Engineer.*

This includes serial number and revision. These can be changed.

The 1-wire (EPROM) serial number, temperature EPROM serial number and end EPROM serial number. These cannot be changed. They merely show what is being used.

For all the elements (this includes comp and deice) there are fields for Type, Kp, Ki, Kd, DAC Min and Set Point. These can be changed.

For element1, element2 element3 and comp there are additional fields for R100, dT/dR, Length, Width, Depth, Shape and Fixture. These can be changed.
For element 1, element2 and element3 there are additional fields for Slope and Offset. These can be changed.

Additionally the probe calibration date and due date can be set. These can be changed.

There is also fields to set the probe on and deice on time in hours. These can be changed.

THE MAIN CABLE TAB
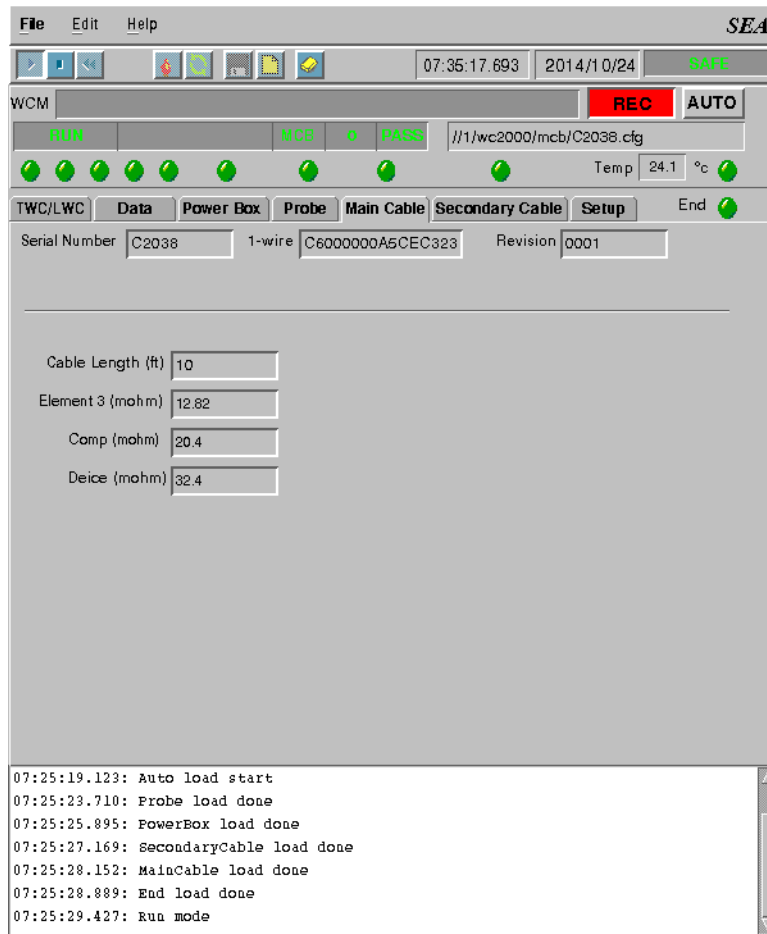
The main cable tab is used to keep settings for the main cable for the WCM-2000 system.

The presence/absence of this EPROM can also indicate that the cable is connected or disconnected or possibly malfunctioning.

☞ *In order to be able to make changes to any fields here the SeaWcm must be stopped.*

☞ *Note: Don't change values for the main cable unless asked to do so by an SEA Engineer.*

Here we keep the serial number for the EPROM in the main cable as well as the revision. These can be changed.

The EPROM serial number. Not a modifiable field.

Cable length, element 3 (mohm), comp (mohm) and deice (mohm).

THE SECONDARY CABLE TAB
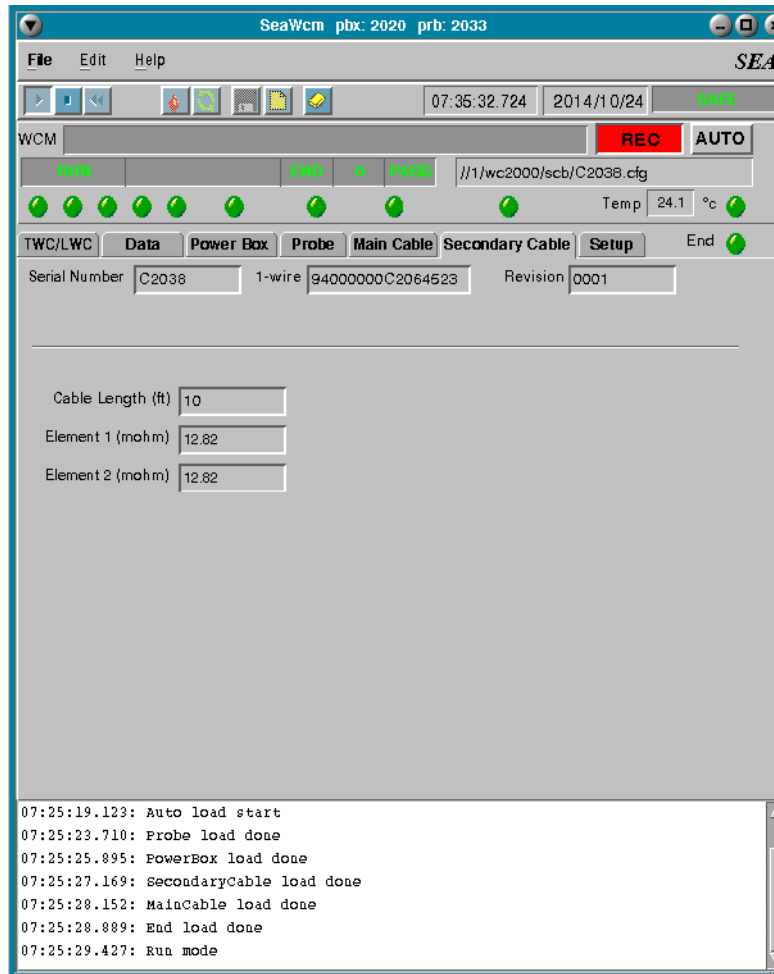
The secondary cable tab is used to keep settings for the secondary cable for the WCM-2000 system.

The presence/absence of this EPROM can also indicate that the cable is connected or disconnected or possibly malfunctioning.

☞ *In order to be able to make changes to any fields here the SeaWcm must be stopped.*

☞ *Note: Don't change values for the secondary cable, unless asked to do so by an SEA Engineer.*

Here we keep the serial number for the EPROM in the secondary cable as well as the revision. These can be changed.

The EPROM serial number. Not a modifiable field.

Cable length, element 1 (mohm) and element 2 (mohm).

THE SETUP TAB
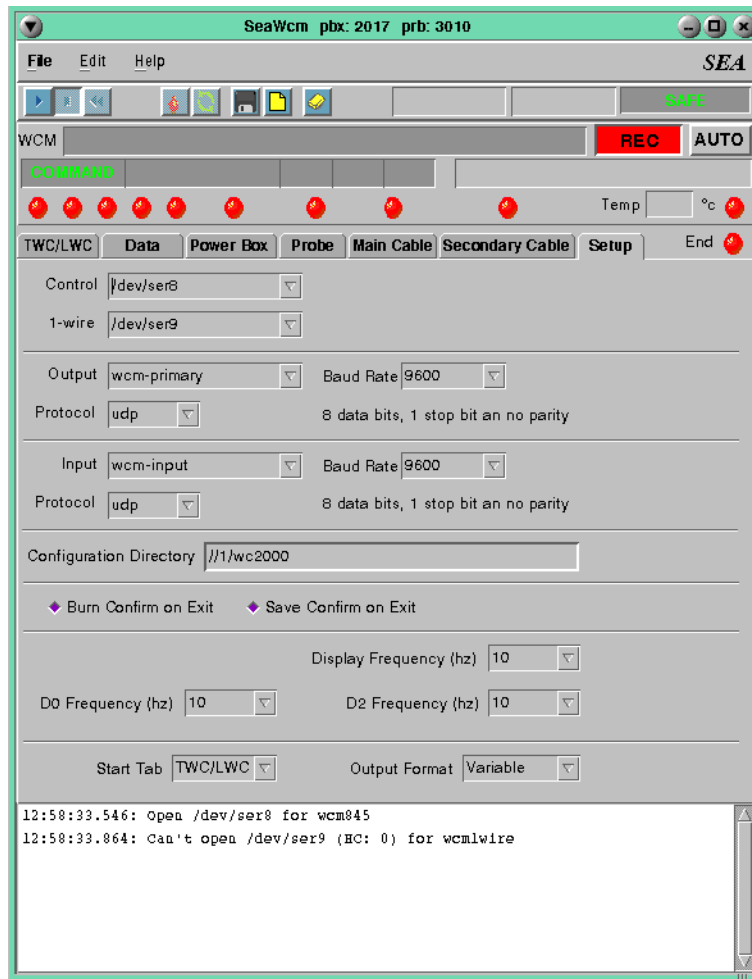
The SeaWcm has several parameters that can be configured as needed.

☞ *Note: In order to be able to make changes to any fields here the SeaWcm must be stopped.*

Control

This is the name of the serial port used to talk to the 845 devices on the RS-422 serial bus. This port is passed to the wcm845 worker.

Usually this is "/dev/ser8", but it can change due to the number of ports available in the system.

If using multiple SeaWcm sessions in one system, the control port must be different for each different instance. This setting must also be different from the 1-wire port.

The communication with this port is at 115,200 baud.

1-wire

This is the name of the serial port used to talk to the 1-wire devices (EPROMs) on the RS-422 serial bus. This port is passed to the wcm1wire worker.

Usually this is "/dev/ser9", but it can change due to the number of ports available in the system.

If using multiple SeaWcm sessions in one system, the 1-wire ports must be different for each different instance. This setting must also be different from the control port.

Output

This is a combo box field used to select the name of the network port used to output data to other systems, Usually wcm-primary, wcm-secondary, wcm-tertiary, etc. See Output Data Format. Page 2.46.

Protocol

This is a combo box field with the protocol for the output data. It can be tcp or udp. Usually udp is a better choice if you are going to multiple systems. Use tcp, if you want reliable delivery and can do a one to one connection.

Baud Rate

This is a combo box field with the baud rate for the output data assuming a serial port is selected for the output port. The other serial port protocol parameters are set for 8 data bits, 1 stop bit and no parity.

Input

This is a combo box field used to select the name of the network port used to input data into the SeaWcm system. See Input Data Format. Page 2.50.

If you use multiple sessions of the SeaWcm, you should use the same input port and udp protocol for all. Unless you have a valid reason for implementing different sources for input data.

Protocol

This is a combo box field with the protocol for the input data. It can be tcp or udp. Usually udp is a better choice if you are going to multiple systems. Use tcp, if you want reliable delivery and can do a one to one connection.

Baud Rate

This is a combo box field with the baud rate for the input data assuming a serial port is selected for the input port. The other serial port protocol parameters are set for 8 data bits, 1 stop bit and no parity.

Configuration Directory

The SeaWcm stores the data from power box, probe, main cable, secondary cable into the 1-wire EPROMs. In addition it is possible to save the same information to files. We use this as a backup for the 1-wire settings. This allows use to run in manual or expert mode when using the settings from the files.

The directory is usually //1/wc2000 or /wc2000.

There are directories for power box (pbx), probe (prb), main cable (mcb) and secondary cable (scb). Don't modify files in these directories unless SEA personnel recommends doing so.

The raw 'WCM' ASCII files are in (wcm) folder and 'CSV' ASCII files are in (csv) folder. The user should back these files to another system or another medium.

Burn Confirm on exit

Enable/disable a dialog warning on exit if the user has changed the values and not burned them into the EPROM.

Save Confirm on exit

Enable/disable a dialog warning on exit if the user has changed the values and not saved them to the configuration files.

Display Frequency

Frequency for the SeaWcm data tab. This frequency should be typically 5 to 10 hz. On systems where M300 and SeaWcm are running on the same system, this should be about 1 hz. This allows M300 and SeaWcm to work together.

D0 Frequency

Frequency for the 'd0' type sentences. This allows the user to select different output rates for the different sentence types so as to allow the user better control over the output data flow. See Output Data Format. Page 2.46.

D2 Frequency

Frequency for the 'd2' type sentences. This allows the user to select different output rates for the different sentence types so as to allow the user better control over the output data flow. See Output Data Format. Page 2.46.

Start Tab

The start tab feature allows users to select which tab they want to see when the SeaWcm is when they click on the play button and enter control mode. The user can select between the TWC/LWC tab and the data tabs.

Output Format

The output format can be selected between variable and fixed formats.

In the variable format each data variable is a short as possible and each line of output might have a different number of characters. This is the preferred method since it minimized the data size for recording and transmission to other systems. This is also the traditional way we started for data output.

In the fixed format, each parameter will always be formatted with the same number of characters and thus each line of output also has the constant number of characters. This option was necessary for users whose data systems have limited data parsing or prefer to have the fixed format. This format is not recommend since the data size is larger than it should be with a lot padding characters for the variables.

RECORDING WCM RAW ASCII FILES
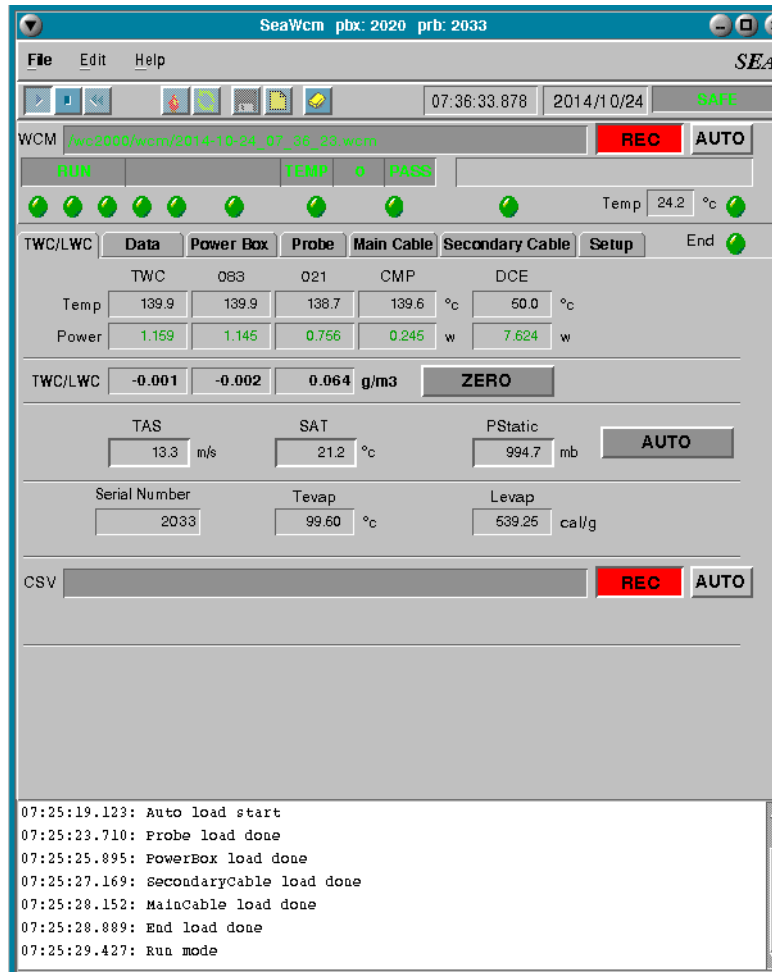
The SeaWcm has the capability of recording all the data sentences that it produces. These sentences can be recorded to a *.wcm file format, which is an ASCII file with all the output data that can later be used for playback purposes.

The location of these files are in the /wc2000/wcm folders. The user may access this files to keep track of the data collected or to playback the necessary data.

RECORDING CSV ASCII FILES
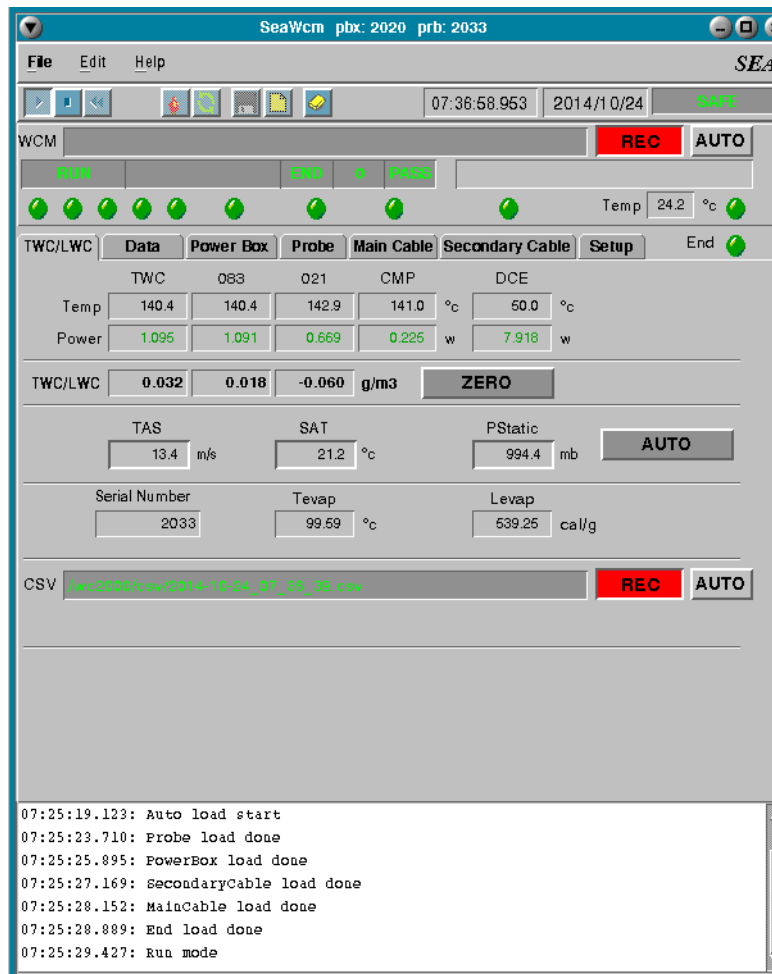
The SeaWcm has the capability of recording some data into CSV ASCII files. The CSV data only goes out to the CSV file and it doesn't go output on the output port to another computer. The CSV files have the basic information that can be imported into other systems.

The location of these files are in the /wc2000/csv folders. The user can't not playback an acquired CSV style file from the SeaWcm application, these files are meant for other systems.

USING SEAWCM TO PLAYBACK DATA FILES

Start the SeaWcm from the command line. Here are the steps for that.

1. Select the **Desktop Manager** in the **task bar.**
2. Select the **Applications** tabs.
3. Click on the **Pterm** icon.
4. Click inside the newly created command window.
   Type '**SeaWcm -pb &**'.

In playback mode generally you might be in the data tab or the TWC/LWC tab as you can see bellow.
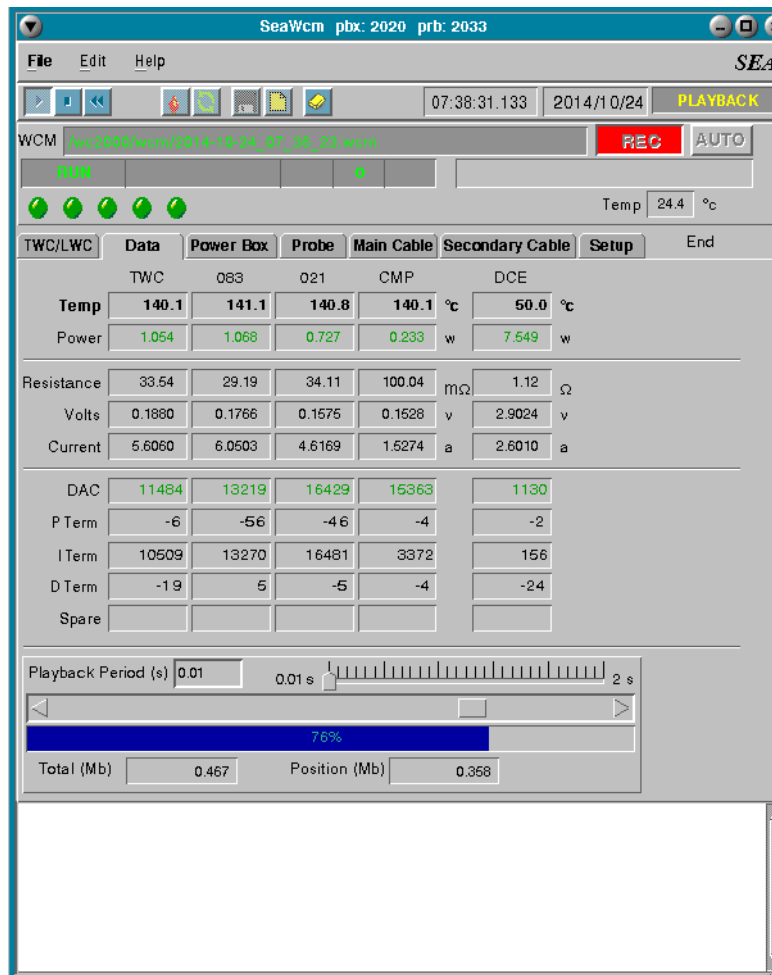
Once the SeaWcm is started, the user can go to the File menu and use the open menu item to select a file for playback. Additionally if the file is in the history the user can click there as a short cut for opening the file.

The current file name that the user is playing back is displayed in the normal field for the file name. The user has several controls mentioned above to select the speed of the playback.

STARTING SEAWCM IN EXPERT MODE
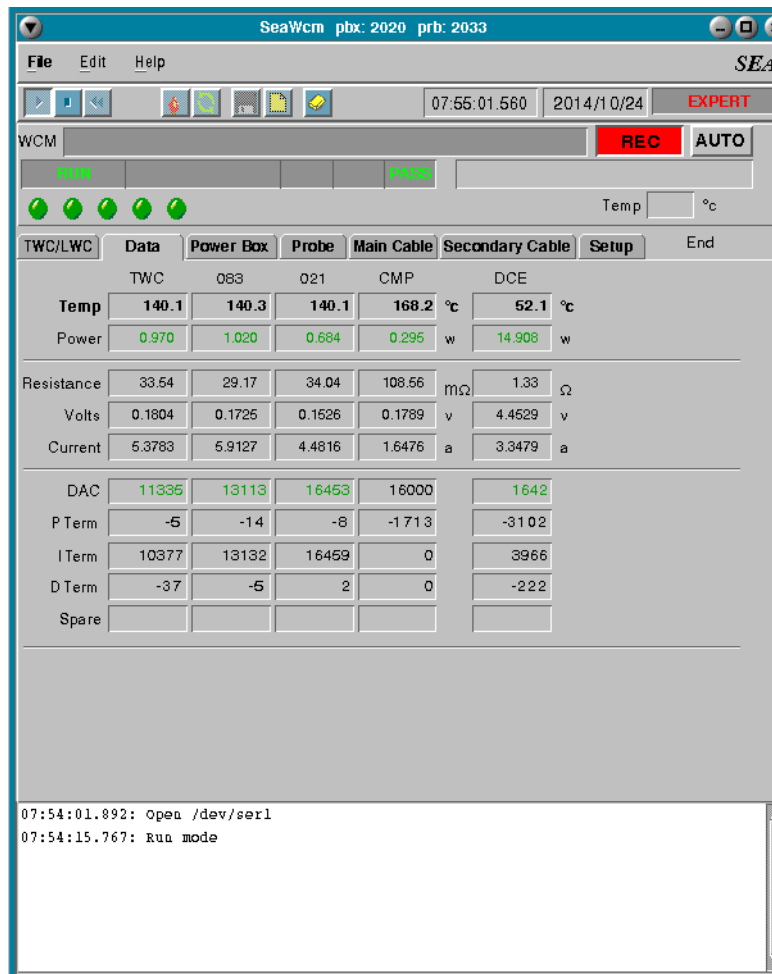
Start the SeaWcm from the command line. Here are the steps for that.

1. Select the **Desktop Manager** in the **task bar.**
2. Select the **Applications** tabs.
3. Click on the **Pterm** icon.
4. Click inside the newly created command window.
   Type '**SeaWcm -expert &**'.

☞ *Use caution while running in expert mode, invalid parameters used might cause damage to some components.*

☞ *Don't run SeaWcm in expert mode, unless asked to do so by an SEA Engineer.*

OUTPUT DATA FORMAT

The SeaWcm uses network sockets (ports), to establish communication with other systems. The protocol can be TCP (one to one) or UDP (one to many).

Port Name	Port Number
wcm-primary	2100
wcm-secondary	2101
wcm-tertiary	2102

Table 2-1: Output Data Port

Typically the SeaWcm would use the wcm-primary port. If more than one WCM-2000 system is running simultaneously on the same network connection or system, then the wcm-secondary and wcm-tertiary ports should be used.

The SeaWcm can also output data to a serial port.

The SeaWcm sends the following sentences.

The format for the sentences is ASCII data terminated by carriage return (LF or 0x0A).

ele1 represents TWC.

ele2 represents 083.

ele3 represents 021.

cmp represents COMP.

dce represents DEICE.

sn represents serial number.

chipid represent the chip id for the EPROM/1wire devices.

rev represents the revision.

Data 0 Sentence

This sentence sends data for all the elements for volts, current and temperature.

The v represents voltage (volt), a represents current (amp) and t is temperature (deg c).

This sentence starts with 'd0' and ends with carriage return.

The values for v, a, t are floating point numbers.

If an element is disabled, then the system sends a space for the element name and 0, 0, 0 for v, a, t.

The transmit data rate for these sentences (1 to 20 hz).

d0, ele1, v, a, t, ele2, v, a, t, ele3, v, a, t, cmp, v, a, t, dce, v, a, t

Data 1 Sentence

This sentence sends data for all the elements for TWC/LWC.

The twc represents total water content (g/m3) and the lwc represents liquid water content (g/m3).

This sentence starts with 'd1' and ends with carriage return.

The values for TWC/LWC are floating point numbers.

If an element is disabled, then the system sends a space for the element name and 0 for twc/lwc.

The data rate for this sentence is fixed at 1 hz.

d1, ele1, twc, ele2, lwc, ele3, lwc

Data 2 Sentence (added 09/26/2012)

This sentence sends data for all the elements for status, dac, p term, i term and d term. This is additional diagnostic data usually not used for normal operation by the User (unless it is requested by SEA).

The status is used to represent a fault, dac is for digital to analog converter, pt is for the p term, it is for the i term and dt is for the d term.

This sentence starts with 'd2' and ends with carriage return.

If an element is disabled, then the system sends a space for the element name and 0, 0, 0, 0, 0 for status, dac, pt, it, dt.

The transmit data rate for these sentences (1 to 20 hz).

d2, ele1, status, dac, pt, it, dt, ele2, status, dac, pt, it, dt, ele3, status, dac, pt, it, dt, cmp, status, dac, pt, it, dt, dce, status, dac, pt, it, dt

Data 3 Sentence (added 09/26/2012)

This sentence sends date, time true air speed, static air temperature, static pressure, zero state and power box temperature.

The date and time in string format are available, tas is for true air speed (m/s), sat is for static air temperature (deg c), pstatic is for static pressure (mb), zerostate is for the request zero flag and the powerboxtemp is the internal temperature for the power box (deg c).

This sentence starts with 'd3' and ends with carriage return.

The data rate for this sentence is fixed at 1 hz.

d3, date, time, tas, sat, pstatic, zerostate, powerboxtemp

Configuration 0 Sentence

This sentence has the sense head serial number, length, width fixture, slope and offset data for the elements.

The first field is 'sn' and this corresponds to the serial number for the current probe head connected to the system, l is for length (mm), w is for width (mm), f is for fixture (milliohm), s is for slope correction and o is for offset correction. For the cmp only l, w, f are used.

This sentence starts with 'c0' and ends with carriage return.

All data values are floating point.

If an element is disabled the system sends a space for the element name followed by zeros for all the data values.

The data rate for this sentence is fixed at 1 hz.

c0, sn, ele1, l, w, f, s, o, ele2, l, w, f, s, o, ele3, l, w, f, s, o, cmp, l, w, f

Configuration Power Box Sentence (added 09/26/2012)

This sentence has configuration information for the power box. They represent the same values as in the Power Box tab in the SeaWcm.

The sn is for the power box, tid is the temperature EPROM id and endid is the end EPROM id.

For each of the elements (element 1, element 2, element 3, comp and deice) we have state is the state for element, vrawv is for the Vraw-V value, vrawi is for the Vraw-I value, shunt is for the shunt (milliohm), maxamps if for maximum amps (a), maxvolts is for maximum volts (v), hardver is for hardware version and softver is for sotware version.

This sentence starts with 'cpbx' and ends with carriage return.

The data rate for this sentence each time start button clicked.

cpbx, sn, chipid, tid, endid, rev, ele1state, ele1vrawv, ele1vrawi, ele1shunt, ele1maxamps, ele1maxvolts, ele1hardver, ele1softver, ele2state, ele2vrawv, ele2vrawi, ele2shunt, ele2maxamps,

ele2maxvolts, ele2hardver, ele2softver, ele3state, ele3vrawv, ele3vrawi, ele3shunt, ele3maxamps, ele3maxvolts, ele3hardver, ele3softver, cmpstate, cmpvrawv, cmpvrawi, cmpshunt, cmpmaxamps, cmpmaxvolts, cmphardver, cmpsoftver, dcestate, dcevrawv, dcevrawi, dceshunt, dcemaxamps, dcemaxvolts, dcehardver, dcesoftver

Configuration Probe Sentence (added 09/26/2012)

This sentence has configuration information for the probe. They represent the same values as in the Probe tab in the SeaWcm.

The sn is for the sense head.

The following is a description of the data that applied to the elements (element 1, element 2, element 3, comp, deice).

We have type which hold the element name (string), kp is for constant multiplier for p term, ki is for constant multiplier for i term, ki is for constant multiplier for i term, dacmin is for dac minimum value, setpoint is for element temperature, r100 is for calibration parameter (milliohm), dtdr is for calibration parameter (deg c/milliohm), l is for length (mm), w is for width (mm), d is for depth (mm), shape is for the element shape, slope is correction variable, offset is for correction variable, fixture is for correction (milliohm).

The caldatemonth is for the calibration month, caldateday is for calibration day, caldateyear is for calibration year, calduedatemonth is for the calibration due month, calduedateday is for calibration due day and calduedatayear is for calibration due year.

This sentence starts with 'cprb' and ends with carriage return.

The data rate for this sentence each time start button clicked.

cprb, sn, chipid, rev, ele1type, ele1kp, ele1ki, ele1kd, ele1dacmin, ele1setpoint, ele1r100, ele1dtdr, ele1l, ele1w, ele1d, ele1shape, ele1s, ele1o, ele1f, ele2type, ele2kp, ele2ki, ele2kd, ele2dacmin, ele2setpoint, ele2r100, ele2dtdr, ele2l, ele2w, ele2d, ele2shape, ele2s, ele2o, ele2f, ele3type, ele3kp, ele3ki, ele3kd, ele3dacmin, ele3setpoint, ele3r100, ele3dtdr, ele3l, ele3w, ele3d, ele3shape, ele3s, ele3o, ele3f, cmdtype, cmdkp, cmdki, cmdkd, cmddacmin, cmdsetpoint, cmdr100, cmddtdr, cmdl, cmdw, cmdd, cmdshape, cmdf, dcetype, dcekp, dceki, dcekd, dcedacmin, dcesetpoint, caldatemonth, caldateday, caldateyear, calduedatemonth, calduedateday, calduedateyear

Configuration Main Cable Sentence (added 09/26/2012)

This sentence has configuration information for the main cable. They represent the same values as in the Main Cable tab in the SeaWcm.

The sn is for the main cable, cablelen is the cable length (ft), ele3res is for element3 resistance (milliohm), cmpres is for comp resistance (milliohm), dceres is for deice resistance (milliohm).

This sentence starts with 'cmcb' and ends with carriage return.

The data rate for this sentence each time start button clicked.

cmcb, sn, chipid, rev, cablelen, ele3res, cmpres, dceres

Configuration Secondary Cable Sentence (added 09/26/2012)

This sentence has configuration information for the secondary cable. They represent the same values as in the Secondary Cable tab in the SeaWcm.

The sn is for the secondary cable, cablelen is the cable length (ft), ele1res is for element 1 resistance (milliohm), ele2res is for element 2 resistance (milliohm).

This sentence starts with 'cscb' and ends with carriage return.

The data rate for this sentence each time start button clicked.

cscb, sn, chipid, rev, cablelen, ele1res, ele2res

CSV Sentence (added 09/26/2012)

This sentence describes the comma separated values (CSV) sentences, available to record on the CSV type files.

The date and time in string format are available, sn for the sense head, t is for temperature (deg c), p is for power (w), twc is for total water content (g/m3), lwc is for liquid water content (g/m3), tas is for true air speed (m/s), sat is for static air temperature (deg c), pstatic is for static pressure (mb), tevap variable (deg g), levap variable (cal/g), zerostate is for the request zero flag.

The data rate for this sentence is fixed at 1 hz.

date, time, sn, ele1, t, p, twc, ele2, t, p, lwc, ele3, t, p, lwc, cmp, t, p, dce, t, p, tas, sat, pstatic, tevap, levap, zerostate

INPUT DATA FORMAT

The SeaWcm uses network sockets, ports, to input data from other systems. The protocol can be TCP (one to one) or UDP (one to many).

Port Name	Port Number
wcm-input	2110

Table 2-2: Input Data Port

The SeaWcm can also input data from serial port.

The format for the data is ASCII data terminated by carriage return (LF or 0x0A).

A 1 hz data frequency is required.

This data is optional, only used for the real-time LWC calculations.

The SeaWcm expects static pressure (mb), static temperature (°c), TAS in (m/s) and zero state. The first three variables should be floating point values with a space delimiter. The zero state is an integer indicating when to zero TWC/LWC.

StaticPress(mb) StaticTemp(°c) TAS(m/s) ZeroState

The SeaWcm accepts the NOAA AOC aircraft data format. This format is undocumented.

WCM1WIRE

The wcm1wire is a utility used by the SeaWcm program to communicate with the 1-wire devices on the Water Content Measurement (WCM-2000) system. This utility is not used by the user.

SYNTAX

wcm1wire x `[-quiet] [-nolog] [device]`

OPTIONS

x
Letter indicating session ('a' to 'z' possible values, in sequence). Must be first parameter.

-quiet
Be quiet, don't display start message.

-nolog
Don't generate error log.

device
Name of serial port device (default none).

EXAMPLES

No sample given since User doesn't start this utility.

WCM1WIRETEST

The wcm1wiretest is a utility used to test the 1-wire devices present on the Water Content Measurement (WCM-2000) system.

When you first install your WCM-2000 system or make a change, you should use the wcm1wiretest utility to verify that communication with the 1-wire EPROMs are working as it should be before proceeding with running SeaWcm application.

This utility can be used as a debugging tool to determine if the 1-wire devices are functional.

Note: The user should not use this utility to zero the chip type. This is an advanced operation that must only be performed under the supervision or guidance from an SEA engineer. Doing this operation requires the re-programing of the 1-wire chip, using the SeaWcm utility, before the Multi system can be used again for normal operation.

SYNTAX

    wcm1wiretest [-2] [-z sernum] [-quiet] [device]

OPTIONS

-2
    Set the log option to 2 (default, 1).

-z sernum
    Zero chip type with serial number provided, must be 16 hexadecimal digits.

-quiet
    Be quiet, don't display start message.

device
    Name of serial port device (default, /dev/ser9).

EXAMPLES

    wcm1wiretest /dev/ser8

WCM845

The wcm845 is a utility used by the SeaWcm program to communicate with the 845 controllers on the Water Content Measurement (WCM-2000) system. This utility is not used by the user.

SYNTAX

```
wcm845 x [-quiet] [-nolog] [device]
```

OPTIONS

x
Letter indicating session ('a' to 'z' possible values, in sequence). Must be first parameter.

-quiet
Be quiet, don't display start message.

-nolog
Don't generate error log.

device
Name of serial port device (default none).

EXAMPLES

No sample given since User doesn't start this utility.

WCM845TEST

The wcm845test is a utility that can be used by the user to test communication with the 845 controllers on the Water Content Measurement (WCM-2000) system.

When you first install your WCM-2000 system or make a change, you should use the wcm845test utility to verify that communication with the 845 controllers are working as it should be before proceeding with running SeaWcm application.

SYNTAX

```
wcm845test [-quiet] [device]
```

OPTIONS

-quiet
   Be quiet, don't display start message.

device
   Name of serial port device (default /dev/ser8).

EXAMPLES

```
wcm845test /dev/ser6
```

WCMKILL

In rare occasions if the SeaWcm becomes unresponsive, you should use the wcmkill to terminate all the WCM style applications running in the WCM-2000 system.

It would be wise to turn off the element and deice powers when doing do.

This utility terminates SeaWcm, wcm1wire, wcm845, wcmread, wcmrecord and wcmwrite.

SYNTAX

```
wcmkill
```

OPTIONS

EXAMPLES

wcmkill

WCMREAD

The wcmread is a utility used by the SeaWcm program to communicate with all the different possible data formats for input on the Water Content Measurement (WCM-2000) system. This utility is not used by the user.

SYNTAX

```
wcmread x [-quiet] [-nolog] [device]
```

OPTIONS

x
Letter indicating session ('a' to 'z' possible values, in sequence). Must be first parameter.

-quiet
Be quiet, don't display start message.

-nolog
Don't generate error log.

device
Name of serial port device (default none).

EXAMPLES

No sample given since User doesn't start this utility.

WCMRECORD

The wcmrecord is a utility used by the SeaWcm program to record all data from the Water Content Measurement (WCM-2000) system. This utility is not used by the user.

SYNTAX

```
wcmrecord x [-quiet] [-nolog] [device]
```

OPTIONS

x
> Letter indicating session ('a' to 'z' possible values, in sequence). Must be first parameter.

-quiet
> Be quiet, don't display start message.

-nolog
> Don't generate error log.

device
> Name of serial port device (default none).

EXAMPLES

No sample given since User doesn't start this utility.

WCMWRITE

The wcmwrite is a utility used by the SeaWcm program to transfer data from the Water Content Measurement (WCM-2000) system to other computer systems. This data can be using network port or serial ports. This utility is not used by the user.

SYNTAX

```
wcmwrite x [-quiet] [-nolog] [device]
```

OPTIONS

x
Letter indicating session ('a' to 'z' possible values, in sequence). Must be first parameter.

-quiet
Be quiet, don't display start message.

-nolog
Don't generate error log.

device
Name of serial port device (default none).

EXAMPLES

No sample given since User doesn't start this utility.

SERVICE AND TROUBLESHOOTING

TROUBLESHOOTING

The more common technical support questions involves either communication issues with the 845 controllers or the 1-wire EPROMs. For both of these issues the main course of action involves checking for appropriate power into the system as well as correctness of the connection cables.

If the SEA WCM-2000 system becomes unresponsive, then it's suggested to the element and deice power be turned off first and then on a terminal window type 'wcmkill'.

As an alternate solution in some cases the system can be reset or rebooted after the element and deice power are turned off.

On rare occasions it's necessary to terminate all the WCM-2000 applications and then turn off the element, deice and finally the main power switches.

ROUTINE SERVICE

Routine service for the WCM-2000 system is pretty simple and it basically consists of inspecting the sense heads elements for any possible damage. You should contact SEA if you find damage on the sense heads and possible send pictures of the damage so it can be interpreted by SEA personnel.

The best way to clean the elements to tackle tough calcium and lime deposits is with CLR Calcium, Lime & Rust Remover.

SCHEMATICS, DIAGRAMS AND DRAWINGS

For each WCM-2000 system the schematics, diagrams and drawings tend to change and it is therefore recommend that the user checks the drawings that shipped with their system.

The SEA website always has the most up to date information in the products and support sections www.scieng.com.

THEORY OF OPERATION

CALCULATION OF WATER CONTENT

The following section describes the theory of how the LWC/TWC sensor responds to liquid/ice water.

The theory portion provides a basic understanding of the physical process that occurs when liquid/ice water is intercepted by the heated element in the sensor.

The data reduction section gives methods and techniques required to process the data output from the controller into liquid water content. We will describe three basic approaches that have been proven to work well in actual conditions.

Note: For users who are using the companion SEA Model 300 data acquisition system, the data reduction algorithms described in the data reduction portion of this section are already available for your system.

LWC MEASUREMENT THEORY

Note: This section is written primarily for encounters with liquid water. When actual encounters include water in the form of ice and a TWC Sense Element is being used, considerations must be made for the amount of power required to convert the ice to liquid water.

The sense element is exposed to cooling from two sources, airflow and intercepted liquid water. The control system outputs the total amount of power required to maintain the element's temperature in the presence of these two cooling influences.

The total power is made up of two components, dry power and wet power. The dry power is the amount of power required to overcome all cooling influences except the interception and evaporation of water. Wet power is the extra, incremental power required above the dry power requirement to warm and evaporate liquid water intercepted by the heated element. The wet power is directly related to the amount of liquid water present.

Therefore in general.

$$P_{total} = P_{wet} + P_{dry}$$

Or restated in terms of the wet power.

$$P_{wet} = P_{total} - P_{dry}$$

The actual magnitudes of the wet and dry terms depend on airspeed, air density, ambient temperature and sense element geometry.

DATA INTERPRETATION

The first step in measuring the liquid water content is to determine the magnitude of the dry power (P_{dry}) and subtract it from the total power measured by the sense elements. There are several methods to do this.

The primary method used to subtract the dry power is based on the fact that the probe contains two types of heated elements, the sense elements, which is exposed to both liquid water and to the general airflow and the compensation element, which is exposed to only the general airflow. This is accomplished through the mounting arrangement of the two elements. The sense elements are located perpendicular to the airflow and receives the full impact of the impinging water. The compensation element is mounted behind the sense elements and is parallel to the airflow.

Given that the sense elements and compensation element differ in size and location, plus the fact that the compensation element is not sensitive to water content ($P_{comp,wet}$ = 0), we can write the following.

$$P_{sense,wet} = P_{sense,total} - P_{sense,dry}$$
$$P_{comp,total} = P_{comp,dry} = P_{comp}$$

The power measured by the compensation element is highly correlated to the dry power term for the sense elements. Therefore we can write.

$$P_{sense,wet} = P_{sense,total} - (offset + slope \cdot P_{comp})$$

The values for *offset* and *slope* are determined by examination of data at varying airspeeds and altitudes in clear air.

This shows sample data taken with the system over a range of airspeeds. It illustrates one method of determining the correlation between the sense power and the compensation power.

$P_{sense.dry}$ vs $P_{comp.dry}$

$y = 3.969x - 0.373$
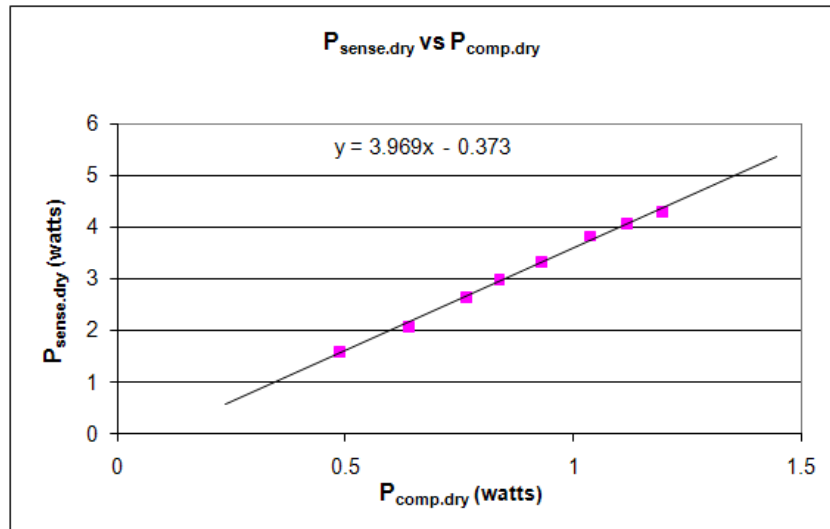
Sense vs. Compensation Power (LWC)

This shows the values of $P_{sense,total}$ and P_{comp} during a typical operational cycle. The upper trace shows the total sense power, $P_{sense,total}$. The lower trace shows the compensation element power, P_{comp}.
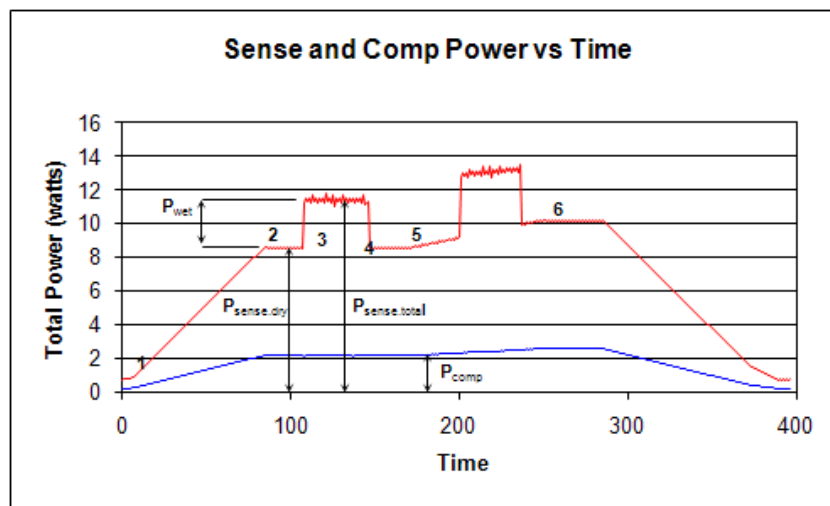
Sense and Compensation Power vs. Time

At point 1, the airspeed is zero and both elements are drawing minimum power. Between points 1 and 2 the airspeed is increasing and both the sense and compensation powers rise in a correlated manner. Between points 2 and 3 the airflow is stable. Points 3 and 4 bracket the first encounter with liquid water. The sense total power is seen to increase by the amount P_{wet}. At point 4, $P_{sense,total}$ returns to its pre-encounter value. This scenario is representative of wind tunnel operation or an

aircraft encounter where the atmosphere is stable and the aircraft does not change altitude, airspeed, attitude, etc.

Points 4, 5 and 6 are a more typical aircraft encounter, where both the dry and wet terms for the sense element and the dry term for the compensation element are changing. In this case the changing ambient conditions are corrected for by changes in the compensation element power.

The first encounter, points 2 to 5, illustrate a situation where a net and tare approach can be used to remove $P_{sense,dry}$ from $P_{sense,total}$. When the ambient conditions are stable before and after encountering liquid water, it is possible to store the value of $P_{sense,total}$, which equals $P_{sense,dry}$ when there is no liquid water present, and subtract it from the value of $P_{sense,total}$ during the encounter. This method has the advantage of not requiring any other data than the value of $P_{sense,total}$. It works particularly well in wind tunnel applications where the pre and post spray conditions are identical.

The net and tare method of dry power removal has the advantage of simplicity but it cannot compensate for any changes in airflow that occur during the encounter.

A third possible method is the direct calculation of $P_{sense,dry}$ from theory. In general a good approximation is:

$$P_{sense,dry} = K_1 \cdot (T_{sense} - T_{ambient}) \cdot (P_{ambient} \cdot TAS)^{K_2}$$

Where:
T_{sense} = Sense element operating temperature (typically 140°C)
$T_{ambient}$ = Ambient temperature of the air stream
$P_{ambient}$ = Ambient (static) air pressure
TAS   = True Air Speed
K_1 = Constant
K_2 = Constant generally in the range of 0.5

The values of K_1 and K_2 can be determined experimentally for a particular installation by recording data in clear air and finding the values for K_1 and K_2 that give the minimum difference between the predicted total sense power and the actual measured sense power.

A more correct approach from a units standpoint is to use ambient air density instead of ambient air pressure in the above equation. However, experience has shown that a more usable prediction is achieved using ambient pressure rather than ambient density, in spite of the mixed units.

The direct calculation method for dry term prediction can be quite accurate, but has the disadvantage of requiring additional information to use in the calculations.

Once the dry power has been removed from the sense element's total power, the next step is to convert the calculated wet power into liquid water content.

When a droplet of liquid water impacts the sense element, two steps are necessary to evaporate the droplet. First the droplet must be heated from its initial temperature to its evaporative temperature at which time it begins to rapidly evaporate. In general it is assumed that the initial temperature of the droplet is the same as the ambient air temperature. By definition it requires one calorie/gm for each degree Celsius rise in temperature.

The temperature at which a droplet begins to rapidly evaporate, T_{evap}, depends on ambient pressure. This shows the dependency of T_{evap} on ambient pressure. A method for calculating the evaporative temperature given the ambient pressure is given later in this section.
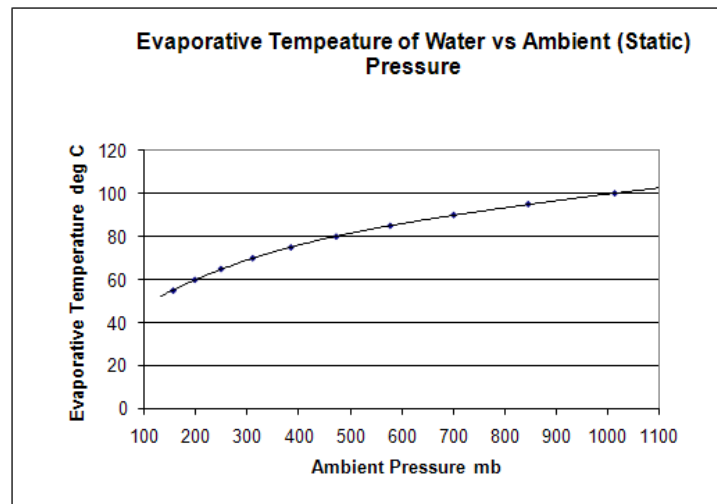
T_{evap} vs. Pressure

Once evaporation begins, it takes an extra quantity of heat, the latent heat of evaporation L_{evap}, to evaporate the droplet. The lower the evaporative temperature, the larger the amount of heat required to evaporate the drop. This shows the relationship between the latent heat of evaporation and the evaporative temperature. A method for calculating the latent heat of evaporation given the evaporative temperature is given later in the data analysis portion of this section.
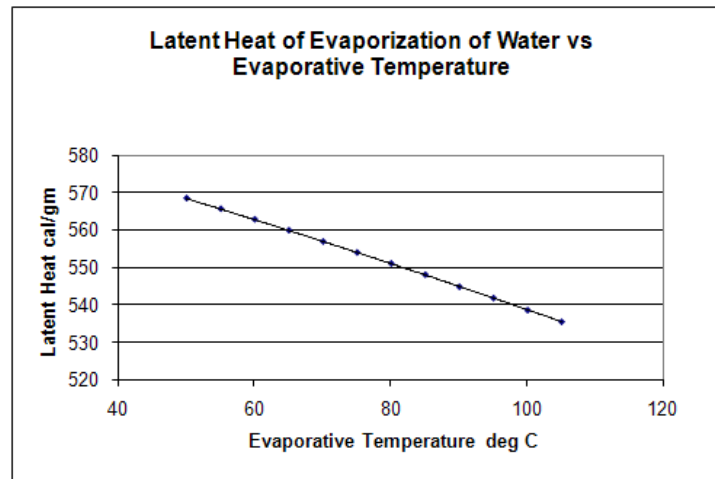
L_{evap} vs. Temperature

The calculation of warming the incoming water to the evaporative temperature plus the latent heat of evaporation allows for the conversion of the wet power in watts to the number of grams of water currently being evaporated per second.

☞ *Note: This section is written primarily for encounters with liquid water. When actual encounters include water in the form of ice and a TWC Sense Element is being used, considerations must be made for the amount of power required to convert the ice to liquid water.*
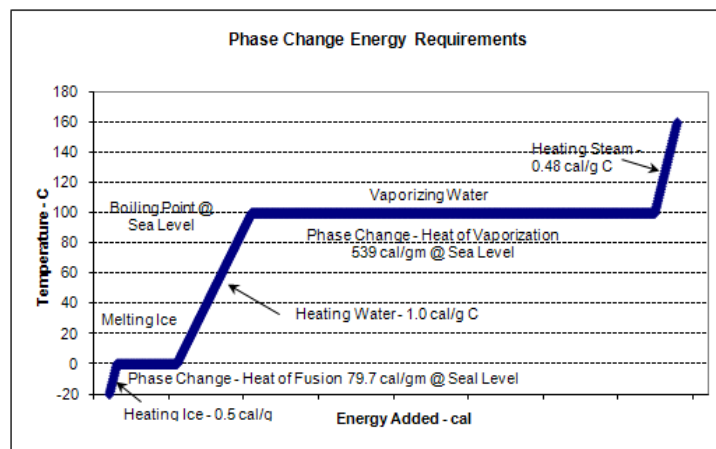
Phase Change Energy Requirements

The second step in the conversion of $P_{sense,wet}$ to LWC is to take the number of grams of water currently being evaporated and convert it to grams per cubic meter. This conversion is done by

calculating the volume of air being sampled by the sense element and then dividing the grams per second by the volume sampled per second. The sample volume is given by.

$$Svol = L_{sense} \cdot W_{sense} \cdot TAS$$

Where:

$Svol$ = Volume of air sampled per unit time
L_{sense} = Length of the sense element
W_{sense} = Width of the sense element
TAS = True Airspeed.

Putting all the terms together using metric units, the conversion of wet power to LWC is given by.

$$LWC\left(\frac{g}{m^3}\right) = \frac{P_{sense,wet}(watts) \cdot 2.389 \times 10^5}{\left[L_{evap}\frac{cal}{g} + 1.0\frac{cal}{g \cdot °C}(T_{evap} - T_{ambient})\right] \cdot TAS\frac{m}{s} \cdot L_{sense}mm \cdot W_{sense}mm}$$

Where:

$P_{sense,wet}$ =   Wet power measured by the sense element watts
L_{evap} =   Latent heat of evaporation cal/gm
T_{evap} =   Evaporative temperature in °C
$T_{ambient}$ =   Ambient (SAT) temperature in °C
L_{sense} =   Length of the sense element in mm
W_{sense} =   Width of the sense element in mm
TAS =   True airspeed in m/s

CONVERSION OF OUTPUT DATA

1. Calculation and Subtraction of $P_{sense,dry}$ from $P_{sense,total}$
2. Calculation of T_{evap} and L_{evap}
3. Calculation of LWC

$$P_{sense,total}(watts) = I_{sense} \cdot V_{sense}$$
$$P_{comp}(watts) = I_{comp} \cdot V_{comp}$$
$$P_{deice}(watts) = I_{deice} \cdot V_{deice}$$

If possible, slightly less variability in the power levels for the Sense and Compensation elements can be achieved by multiplying the individual samples of voltage and amperage together and then averaging the resulting power levels to produce a one second average.

It is a good idea, but not necessary to calculate the following resistance values. They can be used to verify correct operation of the system.

$$R_{sense}(m\Omega) = 1\times10^3 \frac{V_{sense}}{I_{sense}}$$

$$R_{comp}(m\Omega) = 1\times10^3 \frac{V_{comp}}{I_{comp}}$$

$$R_{deice}(\Omega) = \frac{V_{deice}}{I_{deice}}$$

Protection in the reduction software should be taken to avoid division by zero when the amperage values are very low or zero.

Once the resistances of the sense and compensation elements are calculated, the sense and compensation element temperatures can be calculated by using the following formula.

$$T_{element}(°C) = 100 + (R_{element} - R_{100}) \cdot \left(\frac{dT}{dR}\right)$$

Where *R100* and *dT/dR* are taken from the calibration data for the Sense Head. During normal operation the calculated element temperature should be close to the set point temperature indicated on the controller.

Continuous operation significantly above or below (±5°C) the set point temperature indicates a problem with either the controller or the data acquisition system. During a encounter, temperature fluctuations are normal due to fluctuations in the amount of water striking the sense element, however the average temperature should not change.

If the element temperature drops and remains below the set point during a encounter, it indicates that the sense element is saturated and the calculated WC values are lower than the actual values.

For the deicing circuit, the calculated resistance should range between 1.3 and 2.2 ohms. The nominal value is 1.7 ohms, but this value depends on the length and size of wire used in the deice supply circuit. Values lower than 1.0 ohms indicate a short in the deicing circuit. Values above 3.0 ohms are indicative of a poor connection or a failed heater element in the probe itself.

CALCULATION AND SUBTRACTION OF $P_{SENSE,DRY}$ FROM $P_{SENSE,TOTAL}$

As mentioned in the previous part of this section, there are several ways to determine $P_{sense,dry}$ and subtract it from $P_{sense,total}$.

Once one method has been chosen, $P_{sense,wet}$ can be determined by subtracting the $P_{sense,dry}$ estimate/measurement/calculation from $P_{sense,total}$.

No method of subtracting the dry term to produce the wet term is completely accurate under all conditions. In general it is advisable to provide the user with some software mechanism to trim calculated LWC to zero.

For example, when using the scaled compensation element power to determine the dry term, slightly adjusting either the slope or offset term will allow the user to perform a final zero adjustment.

CALCULATION OF T_{EVAP} AND L_{EVAP}

The Evaporative Temperature T_{evap} varies with ambient pressure, further, the Latent Heat of Evaporation, L_{evap}, varies with Evaporative Temperature.

For operations at fixed ambient pressures, fixed values for these values can be taken from the following tables.

Evaporative Temp (°C)	Latent Heat (cal/gm)
45	571.3
50	568.4
55	565.6
60	562.8
65	559.9
70	556.9
75	554.0
80	551.1
85	548.1
90	544.9
95	541.9
100	538.7
105	535.6

T_{evap} to L_{evap}

Static Pressure (mb)	Evaporative Temp (°C)
1100	102.56
1000	99.76
900	*96.65*
800	93.35
700	89.84
600	85.97
500	81.50
400	76.04
300	69.07
200	59.96
100	47.95

Static Pressure to T_{evap}

For operations where the ambient pressure varies, the following polynomial functions can be used to calculate T_{evap} and L_{evap}. These equations are of sufficient accuracy over the range of 100 to 1050 mb. Given the ambient pressure in millibars as P_{mb}.

$$T_{evap}(°C) = 32.16 + 0.1801 \cdot P_{mb} - 2.391 \times 10^{-4} \cdot (P_{mb})^2 + 1.785 \times 10^{-7} \cdot (P_{mb})^3 - 5.19 \times 10^{-11} \cdot (P_{mb})^4$$

Once the evaporative temperature has been determined. The latent heat of evaporation can be calculated from.

$$L_{evap}\left(\frac{cal}{gm}\right) = 594.4 - 0.484 \cdot T_{evap} - 7.0 \times 10^{-4} \cdot (T_{evap})^2$$

CALCULATION OF LWC/TWC

The calculation of LWC/TWC is now straight forward. It is important to include software protection if the true airspeed becomes near zero in value. Near zero airspeed, the calculated LWC/TWC becomes very erratic. At zero airspeed the LWC/TWC becomes infinite or undefined.

In addition to $P_{sense,wet}$, T_{evap}, and L_{evap}, the calculation of LWC requires knowledge of the true airspeed and the ambient temperature.

Given that the true airspeed is not zero.

$$LWC\left(\frac{g}{m^3}\right) = \frac{P_{sense,wet}(watts) \cdot 2.389 \times 10^5}{\left[L_{evap}\dfrac{cal}{g} + 1.0\dfrac{cal}{g \cdot °C}(T_{evap} - T_{ambient})\right] \cdot TAS\dfrac{m}{s} \cdot L_{sense}mm \cdot W_{sense}mm}$$

Where:

$P_{sense,wet}$	=	Wet power measured by the sense element in watts
L_{evap}	=	Latent heat of evaporation in cal/gm
T_{evap}	=	Evaporative temperature in °C
$T_{ambient}$	=	Ambient (SAT) temperature in °C
L_{sense}	=	Length of the sense element in mm
W_{sense}	=	Width of the sense element in mm
TAS	=	True airspeed in m/s

P_{SENSE} VS. P_{COMP} CALIBRATION PROCEDURE

The goal is to acquire twelve or more data points covering a range of airspeeds that will be observed during the flight testing. A second way of acquiring this data is to perform the entire test, recording data during dry and wet conditions. After flight in playback the *slope* and *offset* can be generated by using all or some of the dry data.

From the data acquisition system (this could be an M300 or other DAS), at the desired airspeed point, pause the data on the screen and write down the values or capture the data to file. Collect the power for each element including the Compensation element. The following table shows an example of data points for Psense vs. Pcomp.

TWC (w)	083 (w)	021 (w)	COMP (w)
6.665	4.778	2.429	0.895
7.238	5.152	2.613	0.98
7.514	5.345	2.704	1.025
7.769	5.524	2.787	1.068
8.096	5.719	2.879	1.114
8.396	5.914	2.967	1.157
8.68	6.107	3.052	1.201

Psense vs. Pcomp Calibration Data

TWC (w)	083 (w)	021 (w)	COMP (w)
8.94	6.271	3.124	1.243
9.176	6.472	3.213	1.29
9.444	6.645	3.29	1.331
9.67	6.809	3.359	1.364
9.939	6.979	3.43	1.404

Psense vs. Pcomp Calibration Data

Once you have these data points, plot the data into a spreadsheet application. Find the *slope* and *offset* for each element. The following illustrates a chart for the previous data points.

Pcomp vs Psense

$y = 6.3834x + 0.9749$
$R^2 = 0.9994$

$y = 4.3028x + 0.9305$
$R^2 = 0.9999$

$y = 1.9483x + 0.7026$
$R^2 = 0.9994$

◆ Pcomp vs PsenseLWC021   ■ Pcomp vs PsenseLWC083   ▲ Pcomp vs PsenseTWC
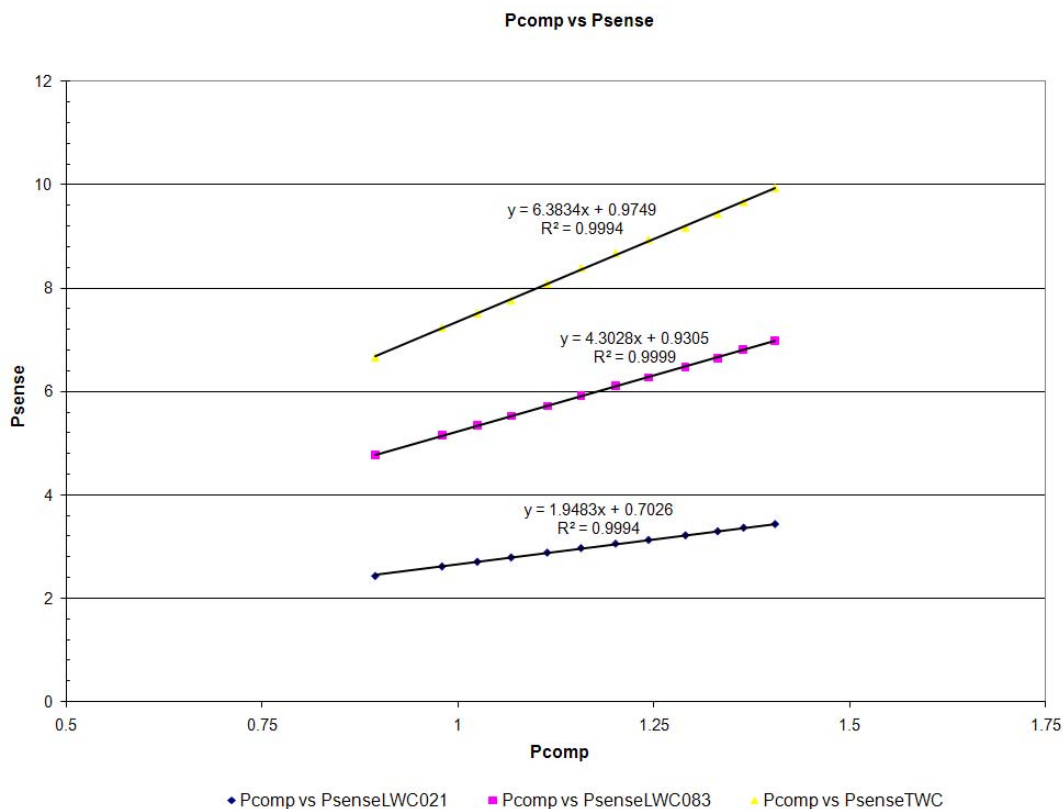
Once you have collected the data and come up with new values for *slope* and *offset* you need to use the SeaWcm application to burn the new values into the sense head EPROM.

Make sure the new values seem reasonable. They should be fairly similar to existing values for *slope* and *offset*. Otherwise there is probably a problem with the data or computation. Double check

your data and computations. If the values seem to be off by quite a bit you might need to contact SEA.

⚠️   **WARNING: Before proceeding to the next steps make sure your are using reasonable values for slope and offset. Use extra caution. If you make a mistake, exit SeaWcm and don't perform the burn operation.**

1. Make sure all cables are connected properly and connect the correct sense head to the WCM-2000 system.
2. Power the WCM-2000 system (main power on only). Element power and deice power switches must be in the off position.
3. Run SeaWcm application.
4. If in play mode, click on the stop button.
5. Click on the probe tab.
6. Click on the read from EPROM button (this loads current values from sense head EPROM). Wait until cycle completes. This might take several seconds.
7. Modify the *slope* and *offset* fields with the appropriate new values. Double check for correctness.
8. Burn the new values by clicking on the burn button. Wait until cycle completes. This might take several seconds.
9. Save new values to configuration file for sense probe by clicking the save button.
10. Press play button to run the WCM-2000 system.
11. Check to make sure new *slope* and *offset* values are correct. Both on the SeaWcm and also on the data acquisition system side (M300 or other DAS).
12. The next step should be to follow normal run procedure for the WCM-2000 system. Make sure to take caution and check all values to be in safe range. The slope and offset will give incorrect results for TWC and LWC, if programmed incorrectly. This will not damage the WCM-2000 system. The fear is making a change on a critical variable, by accident. This is why we advise caution when doing these types of operations with the WCM-2000 system.

CALIBRATION

There is no calibration to be performed by the user for the WCM-2000 system.

CALIBRATION PROCEDURE

The calibration procedure establishes a baseline unique to each sense head. The sense head is suspended in a constant temperature bath. The bath is heated from 85 °C to 145 °C. The resistance for each element is measured at multiple temperatures during the heating. The resistances are plotted verses the temperature and the required calibration constants are computed.

CALIBRATION RESULTS

The calibration procedure results in two constants, two for each of the elements.

- Element resistance at 100°C (R@100)

- Element change in temperature vs. change in resistance (dT/dR)

These values will be unique to an individual sense head. It is desired that each sense head respond identically to any given set of controlled conditions but actual testing indicates that variations do occur. Variations in component dimensions or physical properties combined with manufacturing tolerances can result in variations that may be noticeable in the final calculations. For this reason it is imperative to utilize the calibration constants provided with each sense head.

*Note: **The user should not change any of the values unless advised by an SEA engineer.***

The calibration parameters are programmed in each sense head into the 1-wire EPROMs with the SeaWcm application. Each head is test in the SEA wind tunnel before shipping to the client.

Unused sense heads should theoretically have a very long shelf life.

Sense heads in active service should be re-calibrated on an annual basis.

Sense heads that have been subject to overheating or other physical damage should be re-calibrated before using.

The SeaWcm will display the calibration date and the calibration due date in the probe tab.

Sense heads need to be returned to SEA for calibration due to the specialized equipment required.