WETView 5.0a

User's Guide

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1. Introduction

WETView is a data acquisition and display program for acquiring and viewing the data produced by WET Labs instruments. It runs on IBM PC compatible computers.

This document describes what is required to run WETView, how to install it and how to use it.

2. System Requirements

It is recommended you have at least a 90 Mhz Pentium with at least 16 Mb of memory. You will need about 3 Mb of disk space for the WETView program and related files. The speed of the processor limits how much real-time graphing can be accomplished without data loss. The size of memory limits the number of data points that can be plotted in one run.

You need to be running either Windows 95 or Windows NT Workstation 4.0 operating systems.

3. Installation

The WETView distribution disks contain three files: `SETUP.EXE, WETVIEW.001`, and `WETVIEW.002`.

Once installed, the WETView directory contains the following files:

- `WETVIEW.EXE` WETView program
- `WETVIEW.UIR` WETView user interface resource file
- `*.DEV` Device configuration files (the actual name(s) of these files depend upon the instrument(s) that you have purchased)
- `README.TXT`Some late-breaking information.

3.1 Installing the Software

Step 1: Insert the floppy disk labeled “WetView Installation Disk 1” in your floppy disk drive.

Step 2: Using the Explorer, open the floppy and double-click on the SETUP.EXE icon. SETUP will guide you through the rest of the installation process.

4. Quick Start

This section gives instructions for you to quickly get a single meter connected and displaying data.

After installing the software:

1. Connect the meter to an appropriate power supply (15 VDC, 5 W).
2. Connect the data line to one of the communication ports on your computer.
3. Turn the meter power supply on.
4. Start the WETView program.
5. Open a device configuration file by pressing the "^O to Open" button at the top of the screen (or by typing control-O). A dialog will appear, allowing you to select a file to open.
6. Select the COM port to which you attached the meter.
7. Press the "F1 to Start" button at the top of the screen.
8. After several seconds, stop the acquisition by pressing the "F2 to Stop" button.
9. Save the newly acquired data to a file. Name the file TMP.DAT.
10. Rescale the graph by selecting the "All channels" button in the lower right corner of the screen. You can zoom in on one channel by press the colored button next to the channel's name on the right-hand side of the screen.
11. Open the data file you have just created by selecting the "Open .DAT file..." item from the "File" menu. Choose the file named TMP.DAT.
12. View the data in the file by pressing the "F1 to Start" button at the top of the screen.

5. Operational Overview

WETView performs two main functions. It acquires data from WET Labs' instruments and it displays data that has been collected. WETView can perform these simultaneously or independently.

5.1 How to Control WETView

You may use a mouse or keyboard commands to control WETView. The assigned function keys are:

F1	Start acquiring data
F2	Stop acquiring data
F3	Bring up Graph Options dialog
F4	Bring up Binning Options dialog
F5	Move data on graph to the left (or down)
F6	Move data on graph to the right (or up)
F7	Zoom graph in
F8	Zoom graph out

^O (control-O) Opens a device for data acquisition.

To operate controls on the screen using the keyboard, select the control by tabbing until the desired control is highlighted, then change its value. The method for changing a control's value depends on the type of control:

- For a text or numeric field, type the desired value.
- For a radio button, type a space to toggle its value.
- For a button, type Return to activate the button.

Most dialogs have an "OK" and a "Cancel" button. The function key F1 will select "OK" and the Escape key will cancel the dialog.

5.2 How Data is Collected

As data is collected, it is averaged into bins. The average of each bin is stored and can be written to a file after the acquisition is complete. The number of samples per bin is set by the user via the "Options | Channels/Binning…" menu item. Once the data has been averaged into bins, those bins can be further averaged into bins of bins for plotting.

Regardless of which channels are being displayed, all data acquired from an instrument is remembered and can be saved to a data file.

5.3 How to Display Data

Data can be read directly from an instrument and displayed in real time, or it can be read from a previously stored data file. You may configure the X and Y ranges for graphs, and select which traces are to be plotted. Data that is collected may be averaged into bins for display. Thus, you can average acquired data into bins of 4 samples each, and then display bins of 12 samples each by selecting a collection bin size of 4 and a display bin size of 3.

5.4 How to Rescale Graphs

When there is data displayed in a graph, you can rescale the graph's bounds to zoom in on a single channel by clicking on the small button associated with the channel's label (on the right side of the screen). Clicking on the "All channels" button will rescale the graph so that all displayed channels will be shown.

In the lower right corner of the screen are four buttons for navigating around a displayed graph. You can zoom in (magnify) a graph, or zoom out.

You can also move the bounds on the graph to shift the viewed data to the right or left on the current graph (for strip charts, these move the graph up and down).

You can change other characteristics of a graph by selecting the "Options | Graph" menu item (or, equivalently, the "Graph | Options" menu item).

6. The Menus

6.1 File menu

New	^N	Clears the current graph and disconnects from the current instrument.
Open Device...	^O	Chooses which type of device to collect data from.
Open .DAT File...		Opens a previously saved data file for display.
Save as...	^S	Saves the most recently acquired data into a data file.
Configure…		Allows you to edit the configuration for an instrument, including the calibration constants.
Quit	^Q	Quits the WETView program.

6.2 Graph menu

Absorption vs. Time		Selects the vertical graph of absorption versus time.
Absorption vs. Temp...		Selects the vertical graph of absorption versus temperature.
Time Strip Chart		Selects the horizontal strip chart for display (absorption vs. time).
Spectrograph (Scatter plot)		Selects the scatter plot of absorption/attenuation vs. wavelength.
Spectrograph (Spectrum)		Selects the spectrum display of absorption/attenuation vs. wavelength.
Open Graph...		Opens a graph file for viewing.
Save Graph...		Saves the current graph to a file.
Print Graph...		Prints the current graph to a printer.
Options...	F3	Allows you to configure the scaling of graphical output.

6.3 Options menu

Graph…	F3	Allows you to configure the scaling of graphical output.
Channels/ Binning...	F4	Allows you to set the bin size for sampling and the traces to display.

Each of these items is discussed in greater detail below.

6.3.1 Opening a device

Select the "Open Device..." item to open an instrument for data collection. (Actually, you are opening a device configuration file that describes the device to be used.)

Once you have selected an instrument, you will be asked to identify the source of the data stream. This can be either a communication port that the device is connected to or a binary file. (A binary file is created by using a communications program to read a device's data from a serial port and write it directly to a file in binary format.) Choose COM1, COM2, or .RAW File.

Once you have selected the appropriate port(s), WETView attempts to synchronize with the device on that port. If there is any error in doing this, it will be reported immediately. Possible errors are:

Port timed out	WETView timed out trying to read data from the selected port. Was the correct port selected? Are cables and connections correct?
Bad format from source	WETView did receive data from the selected port, but it did not recognize the data stream. Is the correct device connected to the selected port? Is it turned on?

6.3.2 Serial numbers should match

Once WETView connects to the instrument, it checks to see if the serial number of the instrument matches the serial number given in the configuration file. If it doesn't match, you are warned, but can elect to continue.

Caution

If the serial numbers do not match, the calibration information stored in the configuration file probably will not be correct for the instrument, so collected data is suspect.

Software Error: Current version may always display this warning regardless of matching serial numbers.

6.3.3 Opening a data file

Select the "Open file..." item to open a WETView data file for graphing. You will be presented with a list of file names with .DAT extensions. Choose the file you want to open. Once the file is open, select "Start" from the "Acquire" menu (or type F1). Possible errors in opening the file are:

File not found	The file you named does not exist. Did you type the name

	correctly?
Bad file format	WETView did not recognize the format of the file. Did you select a data file that was created by WETView?
Strange error opening file	WETView ran into an unanticipated error. Did you select a data file that was created by WETView?

6.3.4 Saving data to a file
Select the "Save As ..." item to save the most recently acquired data to a text file. By convention, data files have the extension .DAT, though this is not required.

As WETView collects data, it writes that data to a temporary file called WETVIEW.TMP. When you request to save the data, the file is renamed to the name you specify. (If you quit WETView without saving the data, the WETVIEW.TMP file is not deleted, so you can manually rename it if you wish.)

Note

Because the temporary file, WETVIEW.TMP, is renamed when you save it, the file cannot be saved to a disk other than the one that contains the current directory.

6.3.5 Saving a graph
Select the "Save Graph..." item to save the current graph to a file. The graph may be opened later and viewed, rescaled, and printed.

6.3.6 Opening a graph
Select the "Open Graph..." item to open a previously saved graph file. By convention, WETView expects graph files to have the extension .GPH.

6.3.7 Printing a graph
Select the "Print Graph..." item to print the currently displayed graph.

6.3.8 Changing a device's configuration (calibration)
To change an instrument's calibration, a new device file must be collected. The steps of this process are outlined below.

1. Making sure instrument is properly connected to a power supply and host computer and that WETView is properly loaded and operational, start the program and load an existing device file. Use the *FILE* menu selection and then *Open Device*.

2. Open the Configure dialog box. Use the *FILE* menu selection and then *Configure.*

3. In the lower left-hand corner you will see a sub-dialog box with control buttons for *Zero All* and *Auto Cal.* It is the *Auto Cal* control that collects new offsets for a device file. Note the option for number of samples to average. Select the number of individual samples you wish to average by using this control. The default is 10 samples.

4. Once you have selected the number of samples over which to average, you then can engage the *Auto Cal* control. A temporary pop-up window will notify you as the calibration takes place. After the operation is complete you may exit the Configuration dialog box by pressing *OK* in the lower right hand corner.

5. When you exit you will be prompted as to whether you want to save the new offset values.

Caution

Unless you deliberately save a device file the offsets you have collected will not be permanently stored.

You may write over an older device file if you choose, but the program will ask you if you are sure you want to do this. Otherwise you may write to a new file.

6. Before you can use the new values, reload the newly made device file using *Open Device*.

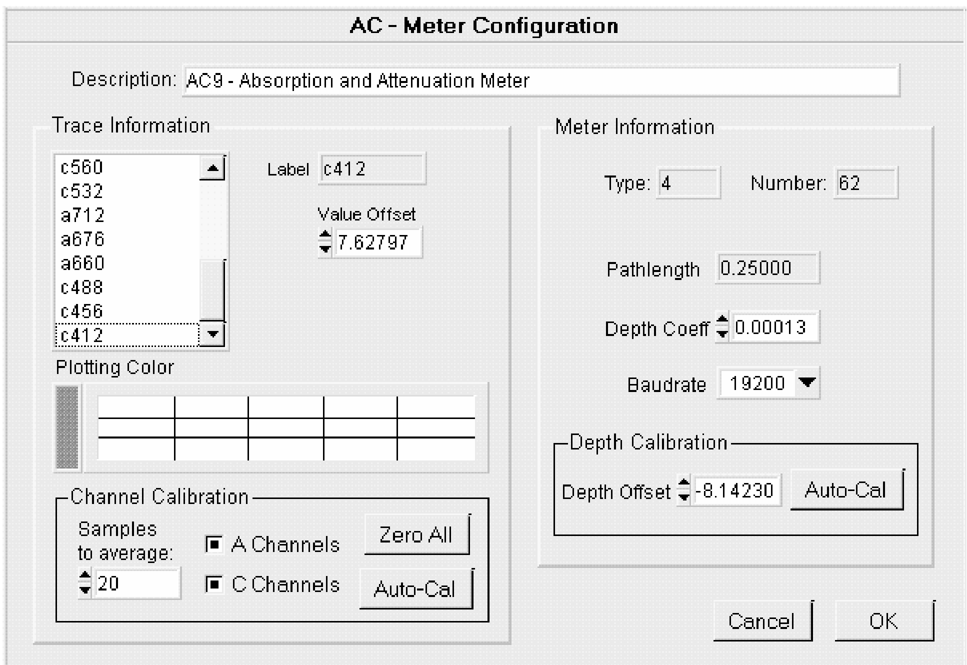
7. Configuration

Configuration is specific to each type of device. The ac-9 and HiStar meters are discussed below.

7.1 Configuring the ac-9

You can change the following settings for the ac-9 meter:

- calibration offsets for absorption measurements
- calibration offset for depth measurement



The ac-9 measures the absorption and attenuation of 9 different wavelengths of light. Each of the measured quantities has a calibration offset added to it so that the resulting number is the difference between a clean water measurement and the measurement in the field. You can manually set the value of this offset for each channel; however, determining the correct value to use is not trivial.

Usually, a “clean water calibration run” is performed. Chemically pure water is run through the instrument and the values for absorption and attenuation are averaged over a number of samples. These values are then used as the calibration offsets.

The “Auto-Cal” button in the “Channel Calibration” area of the dialog does the collecting and averaging for you. You can set the number of samples to collect and average over.

The “Zero All” button sets all of the calibration offsets to 0.0 so you can collect the raw (uncorrected) values from the meter. Note that these values are always temperature-compensated.

See Appendix B, "Calculations" for a complete description of how these numbers are used.

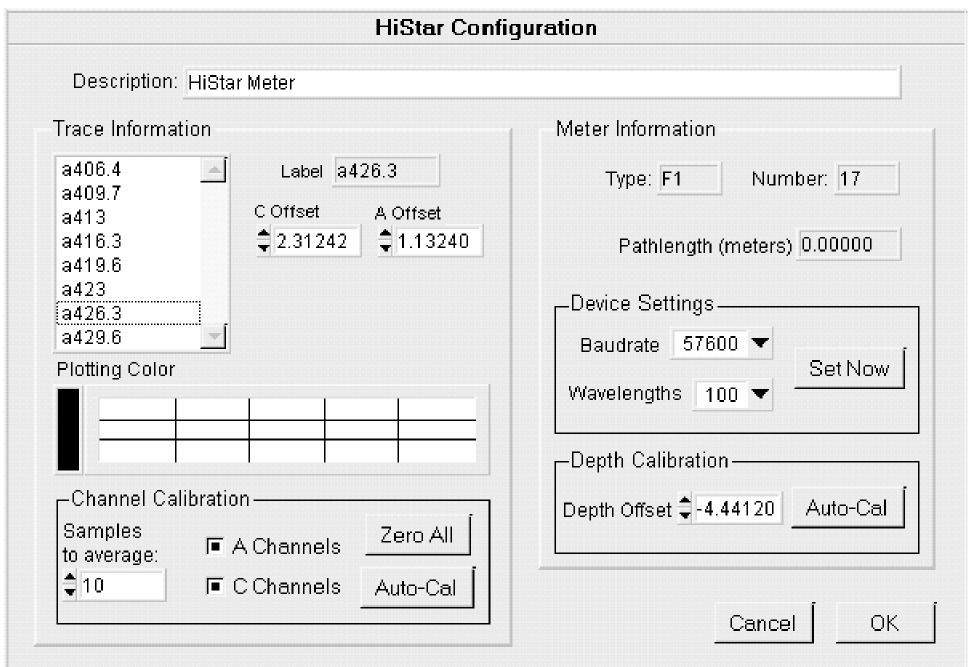
Caution

We recommend you change only the instrument description and the color used for plotting it. Changing the baud rate will most likely cause WETView to be unable to communicate with the ac-9. Changing the calibration constants will affect the accuracy of your results.

7.2 Configuring the HiStar

You can change the following settings for the HiStar Meter:

- calibration offsets for absorption/attenuation measurements
- calibration offset for depth measurement
- communication speed (only for RS-232 connections)
- the number of wavelengths measured



7.2.1 Selecting the graph to display

From the "Graph" menu, choose the graph you want to display.

WETView provides three types of graphs: a vertical X-Y graph of absorption versus time, a horizontal strip chart of absorption versus time, and a graph of absorption versus temperature. There are trade-offs to be considered when choosing which display to use.

The X-Y graph accurately plots both time and absorption, whereas the strip chart accurately plots absorption, but uses a constant time base. However, the strip chart scrolls continuously as data is collected, so you can have detailed view of the most recently received data, whereas the X-Y graph is static. When the data runs off the graph, it is not visible until you stop data acquisition and rescale the graph. In either case, all data acquired is logged to the data file.

The absorption versus temperature graph is used for temperature calibration. The temperature reported is the temperature internal to the instrument, not the ambient temperature. Also, since the temperature is reported once for each set of ten data lines, all ten data lines will be plotted at the same temperature. We recommend setting the collection bin size to a multiple of 10.

7.2.2 Changing the graph options

Select the "Graph | Options..." item to change the appearance of the currently displayed graph. For X-Y graphs, you may set the X and Y ranges and the number of divisions for each axis. For strip charts, you may set the Y range and the speed that the chart scrolls.

7.2.3 Starting an acquisition run

Press the "F1 to Start" button to begin acquiring data from the currently opened device. This item is highlighted only if you have a device open. The function key F1 works as well. As data is acquired, the traces you have selected (via the "Options | Channels/Binning" menu item) are graphed. Graphing the data points uses memory and for long collection runs WETView may exhaust all available memory (this is not true for the Strip Chart graph). If WETView runs out of memory, it erases the graph and begins graphing from where it left off. All collected data is, of course, saved in a file, whether or not it was erased from the graph.

7.2.4 Ending an acquisition run

Once acquisition begins, a "F2 to Stop" button is displayed near the top of the screen. Selecting that button with the mouse, or pressing the F2 key stops data acquisition.

7.2.5 Changing the acquisition options

Select the "Options | Channels/Binning" item to select which traces to display and to set the collection and display bin sizes.

7.2.6 Quitting WETView

Select "Quit" to quit the WETView program.

Appendix A—Absorption Coefficient Computation

The transmittance is computed by taking the ratio of the signal value to the reference value,

$$T_r = \frac{E_{sig}}{E_{ref}}$$

The raw absorption coefficient, a_{raw}, is then computed as,

$$a_{raw} = -\frac{\ln(T_r)}{Z}$$

where Z is the length of the column of water.

The behavior of the electronics circuitry is dependent on temperature. To account for this, the absorption coefficient is corrected by adding a temperature compensation offset, Δ_{Tn}. These offsets are determined for each specific unit in the laboratory by measuring the meter's behavior of over a range of temperatures. The values collected during the temperature calibration run are averaged over two degree intervals. This produces a table of temperature offsets for a wide range of temperatures. WETView uses that table and linear interpolation to compute the temperature compensation offset, Δ_{Tn}, for each wavelength at any given temperature. The temperature-compensated raw absorption, then, is given by:

$$a' = a_{raw} - \Delta_{Tn}$$

Finally, this value is calibrated to subtract out the characteristic absorption of clean water. The calibration constant, C, is calculated in the laboratory using clean water measurements and published values. The final absorption coefficient, *a*, for a measurement in the field, then, is:

$$a = a' + C$$

Each data file contains the calibration constant, *C*, and the table of temperature compensation values used for each channel.

Appendix B—ac-9 Meter

ac-9 Theory of Operation

The WET Labs' ac-9 has a white light source that is directed through a filter that allows a narrow band of wavelengths. The resultant colored light is directed through a beam splitter.

One beam from the splitter is sent through a column of water to a detector at the other end. The voltage from the detector is amplified and converted to a digital value. The transmitted light's energy is measured and that value, called the signal, is sent to the host computer.

The other beam from the splitter is sent directly to a different detector, where it is amplified and converted, giving the reference value for the light source. This reference value is sent to the host as well.

The device has several filters mounted on a rotating wheel. For each different filter, both the signal and reference voltages are measured.

The signal values are sent approximately ten times per second. For each group of ten signal readings, the reference values are averaged and sent approximately once per second.

The reference value line also includes temperature and depth, if they are supported by the instrument.

Temperature

Temperature is calculated from the instrument's raw data by the following equation:

$$T = a + bT_{raw} + cT_{raw}^{-1} + dT_{raw}^{-2} + eT_{raw}^{-3}$$

where:

T = temperature in degrees centigrade
$Traw$ = number of counts sent by the device
a = 10.61831
b = 0.045113
c = -4891.32
d = 208130.2
e = 1171473

Depth

Depth is calculated from the instrument's raw depth data by scaling and offsetting by the depth calibration numbers that are read from the device configuration file.

$D = mD_r + b$

where:

D	=	depth in meters
D_{raw}	=	raw number of counts sent by the device
m	=	multiplier determined in the laboratory for each depth sensor unit and is unique to that unit; stored in the configuration file
b	=	offset determined by calibrating the device at sea level (this can easily be done in the field); stored in the configuration file

ac-9 Configuration File

Configuration files (with file extension .DEV) give calibration and other information specific to a particular unit. These files are tab-delimited text files and have the following format:

Line 1	Device name.
Line 2	Serial number: the serial number of the device that was used to collect the data.
Line 3	Version number of the following structure. This should be “2.”
Line 4	Reserved for future use.
Line 5	Calibrations for depth meter: there are two values, the first is an offset and the second is a multiplier.
Line 6	RS-232 baud rate that the instrument uses
Line 7	Optical path length through water (in meters).
Line 8	Number of temperature compensation bins.
Line 9	Several values (the count is given in the preceding line); each value is the average temperature of the temperature bin.
Line 10–27	Each line describes one channel of the instrument; the first three fields are: label for identifying the channel color for plotting clean water calibration constant (offset) The rest of the line contains temperature compensation values that correspond to the temperature bins given in the previous line.
Line 28	Reserved for future use
Line 29	Extra capabilities mask. This is a list of capabilities that the meter may have in addition to the standard product. Currently, only one such capability exists: an external temperature sensor. If the first number on this line is non-zero, the meter supports such a sensor.

ac-9 Data Files

WETView saves data files in tab-delimited format. The file format of WETView files is described below.

Line 1: Header line. Identifies the version of the program that created the file, and the time and date of creation.
Lines 2–30: Exactly the same format as the configuration file. These lines contain the calibration information that was used while collecting the data.
Line 31: Collection bin size. The number of samples that were averaged into each bin during collection.

Data lines
The rest of the file contains lines of data values. Each line of data starts with a zero-based time stamp. Times are given in milliseconds. The rest of the fields on the line are the data from the device. The data is given as absorption values, after referencing, calibration and temperature correction.

Reference lines
A reference line is a data line that has some extra information appended to it.

1. The first number after the data values is the temperature (deg C).
2. The second number is the sample rate (samples per second).
3. The third number is the depth (in meters, if the meter supports depth).
4. The fourth number is the external temperature, if the meter supports it.
5. The rest of the line contains channel reference values.

A full data line with references then looks like:

Time $Chan_1$ $Chan_2$ ... $Chan_n$ Temp Rate Depth ExtTemp Ref_1 Ref_2 ... Ref_n

The reference values are raw values; no scaling or calibration is applied to them. These are the values that are used in computing the data values for the following set of data lines.

There is a possible ambiguity when the collection bin size is greater than one. Since a bin contains multiple samples, some of the samples in a bin may be computed with one set of reference values and others computed with a different set. The ac-9 uses one set of references for every ten samples. If the collection bin size is six, the first bin (six samples) uses the same reference values, but the second bin uses one set of references for the first four samples and a different set for the last two samples. This makes deconvoluting to the raw data rather complicated.

If you need to deconvolute to raw data, choose a bin size of 1, 2, 5, 10 or an integer multiple of ten. This ensures that the reference values given for a bin apply to all samples in that bin.

Example
For example, given the configuration file:

```
ac9 Absorption and Attenuation Meter
04000103        ; serial number
2               ; structure version number
```

```
Reserved         ; reserved for future
5.41000 0.27000  ; depth calibration
19200            ; baud rate
0.10             ; pathlength = 10 cm
a650 Blue  1.20000 23.00000 2.43000
a560 Green  1.13000 23.00000 2.45000
a532 Brown  1.24000 23.00000 2.65000

c712 Red   1.08000 23.00000 2.31000
c676 Magenta 1.41000 23.00000 2.74000
c660 Gray  1.55000 23.00000 2.56000
a488 LtBlue 1.16000 23.00000 2.44000
a456 LtGreen 1.19000 23.00000 2.52000
a412 Yellow 1.33000 23.00000 2.54000
c650 Blue  0.98000 23.00000 2.47000
c560 Green  1.58000 23.00000 2.36000
c532 Brown  1.94000 23.00000 2.51000
a712 Red   1.32000 23.00000 2.57000
a676 Magenta 1.74000 23.00000 2.46000
a660 Gray  1.83000 23.00000 2.49000
c488 LtBlue 1.35000 23.00000 2.38000
c456 LtGreen 1.50000 23.00000 2.33000
c412 Yellow 1.11000 23.00000 2.39000
0.0035 0.004 0.015 0.02 0.015 0.02 2500 2000 1000 0.01 0.01 …
0            ; auxiliary capabilities
```

The data file for an ac-9 begins as:

```
WetView ver 5.0  06/22/93  08:17:44
ac9 Absorption and Attenuation Meter
04000103         ; serial number
2                ; structure version number
Reserved         ; reserved for future
5.41000 0.27000  ; depth calibration
19200            ; baud rate
0.10             ; pathlength = 10 cm
a650 Blue  1.20000 23.00000 2.43000
a560 Green  1.13000 23.00000 2.45000
a532 Brown  1.24000 23.00000 2.65000


c712 Red   1.08000 23.00000 2.31000
c676 Magenta 1.41000 23.00000 2.74000
c660 Gray  1.55000 23.00000 2.56000
a488 LtBlue 1.16000 23.00000 2.44000
a456 LtGreen 1.19000 23.00000 2.52000
a412 Yellow 1.33000 23.00000 2.54000
c650 Blue  0.98000 23.00000 2.47000
c560 Green  1.58000 23.00000 2.36000
c532 Brown  1.94000 23.00000 2.51000
a712 Red   1.32000 23.00000 2.57000
a676 Magenta 1.74000 23.00000 2.46000
a660 Gray 1.83000 23.00000 2.49000
c488 LtBlue 1.35000 23.00000 2.38000
c456 LtGreen 1.50000 23.00000 2.33000
c412 Yellow 1.11000 23.00000 2.39000
0.0035 0.004 0.015 0.02 0.015 0.02 2500 2000 1000 0.01 0.01 …
0         ; auxiliary capabilities
1         ; acquisition binsize
0   1.53275    1.13881    1.31256    0.51315    1.41231    2.51512 ...
160 1.53070    1.13055    1.31583    0.51229    1.41614    2.51415 ...
330 1.53627    1.13536    1.31511    0.51467    1.41151    2.51614 ...
(etc)
```

The fields for the reference line for the ac-9 are:

field #	contents
1	time in milliseconds
2	absorption for 650 nm

3	absorption for 560 nm
4	absorption for 532 nm
5	attenuation for 712 nm
6	attenuation for 676 nm
7	attenuation for 660 nm
8	absorption for 488 nm
9	absorption for 456 nm
10	absorption for 412 nm
11	attenuation for 650 nm
12	attenuation for 560 nm
13	attenuation for 532 nm
14	absorption for 712 nm
15	absorption for 676 nm
16	absorption for 660 nm
17	attenuation for 488 nm
18	attenuation for 456 nm
19	attenuation for 412 nm
20	temperature (^oC)
21	sample rate (samples per second)
22	depth (meters)
23	reserved
24	reference for a650
25	reference for a560
26	reference for a532
27	reference for c712
28	reference for c676
29	reference for c660
30	reference for a488
31	reference for a456
32	reference for a412
33	reference for c650
34	reference for c560
35	reference for c532
36	reference for a712
37	reference for a676
38	reference for a660
39	reference for c488
40	reference for c456
41	reference for c412

The information in a data line is exactly the same as the first 19 fields of the reference line.

ac-9 Complete Example

This section gives a complete example of an ac-9 device configuration file, a raw data record, and the computed results written to a data file.

Configuration file

Below is the configuration file for the ac9 meter used in this example.

```
ac-9 Absorption and Attenuation Meter
00000121                      ; serial number
2                             ; structure version number
Reserved                      ; reserved for future
5.3 0.3                       ; depth calibration
19200                         ; baud rate
```

```
0.25                            ; path length (meters)
15                              ; number of temperature bins
5.5233 8.4553 11.4712 … ; temperature bins
a610  Blue  7.6242 0.1411 0.1028 0.0389 …
a620  Green  7.6819 0.1403 0.1041 0.0393 …
a630  Brown  7.6963 0.1369 0.1034 0.0409 …
c610  Red   6.8377 0.1351 0.1045 0.0427 …
c620  Magenta 6.9157 0.1299 0.1034 0.0423 …
c630  Black  7.0137 0.1203 0.0987 0.0423 …
a640  LtBlue 7.1391 0.1169 0.0980 0.0427 …
a650  LtGreen 7.2244 0.1115 0.0959 0.0436 …
a660  Yellow 7.2360 0.1029 0.0893 0.0411 …
c640  Blue  7.1407 0.1001 0.0901 0.0435 …
c650  Green  6.8605 0.0979 0.0861 0.0429 …
c660  Brown  7.2408 0.0949 0.0851 0.0428 …
a670  Red   7.3416 0.0935 0.0839 0.0417 …
a680  Magenta 7.3578 0.0924 0.0827 0.0431 …
a690  Black  7.3922 0.0911 0.0824 0.0436 …
c670  LtBlue 6.0476 0.0903 0.0815 0.0442 …
c680  LtGreen 6.4225 0.0903 0.0805 0.0431 …
c690  Yellow 6.5098 0.0876 0.0793 0.0405 …
0.0035 0.004  0.015  0.02   …  ; reserved info
0                   ; auxiliary capabilities
```

Raw data

Below is one record of raw data that was captured from the device. It has been converted to hexadecimal, formatted and commented. Note that the two-byte and four-byte values are byte-reversed. That is, the bytes within a word are read from right to left. This reflects the way the Intel 386 and 486 processors store values in memory.

00FF00FF	registration word
7A02	record length, from this word through checksum
21010000	serial number
0000	status
DB13	sample rate
1600	depth
34FF	external temperature
6410 171E 89 2D20 0F 0319 1B …	first sample, time and data
7510 171E CB 2C20 EE 0119 A3 …	second sample, time and data
8510 161E 84 2E20 0A 0119 F2 …	o
9510 131E F1 2920 DE FE18 DF …	o
A510 151E 9B 2B20 BC 0119 51 …	o
B510 151E 7A 2B20 BA 0119 9A …	
C510 161E 5D 2C20 99 0019 49 …	
D510 141E F5 2B20 85 0019 B1 …	
E510 121E 3F 2820 76 FF18 11 …	
F610 141E 05 2A20 5E 0019 35 …	tenth sample, time and data
7804 C8 B604 C0 A603 66 …	3 references and temperature
9701	temperature
65D00000	checksum (FF00FF00 through refs)
00000000	padding (4 null bytes)

Registration word	= 00FF00FF hex
Record length	= 7A02 hex = 634 bytes
Serial number	= 00000121 This is the thirty-third ac-9 meter produced. Production numbers begin with 0100 hex.
Status	= 0000 Zero indicates normal operation.
Sample rate	= 14F9 hex = 5083 This is a count of the time used to take one sample. It is scaled by 0.0000316 to match the hardware's clock rate, then inverted to give samples per second: 1 / (5083 * 0.0000316) = 6.226
Depth	= 0016 hex = 22 This reflects the voltage read from the depth sensor. It is scaled and offset by the values from the configuration file. 22 * 0.3 + 5.3 = 11.9 meters
External Temp	= 34FF hex This word is ignored for this meter because the meter does not have an external temperature probe in it. This is determined by the last line of the configuration file: the value is zero.

For the purpose of this discussion, we skip to the third-from-last line of the data record. This is the reference line, and values here will be used in the computation of the absorption values for each channel.

Reference a610 = 7804 C8 hex = 13108344

This is the reference value for the first channel (ab610). This is a 24-bit value indicating the output from an analog to digital converter. This represents a fraction of the input voltage. To convert from counts to this fraction, the value is divided by 2^{24} (16777216).

13108344/16777216 = 0.7813

Temperature = 0F01 hex = 271

The temperature is given as a reading from a thermistor. The manufacturer of the thermistor provides a table correlating the reading (counts) to temperature. That table fits the polynomial equation given above. Using 407 counts, we get: 10.61831

+ 0.045113 * 271

+ -4891.32 * 1/271

+ 208130.2 * $1/271^2$

+ 1171473 * $1/271^3$ = 7.69 degrees C

Absorption 610 = 171E 89 hex = 8986135

This is the signal value for the first channel (a610). This 24-bit value is converted to raw voltage in the same manner as for reference values.

8986135 / 16777216 = 0.5356 VDC

Raw absorption is computed from the signal and reference values as described above:

$$a_{raw} = \frac{-\ln\left(\frac{E_{sig}}{E_{ref}}\right)}{Z}$$

The device's optical path length is read from the configuration file.

$$a_{raw} = \frac{-\ln\left(\frac{0.5356}{0.7813}\right)}{0.25}$$

$$= 1.5103 \text{ meter}^{-1}$$

The temperature correction is then applied using the temperature from the reference line and the channel's correction table from the configuration file. The approximate correction value is linearly interpolated from the table. First, the correct temperature bin is determined by finding the two bin temperatures, T_0 and T_1, that bracket the current temperature. Then, using the values, Δ_{Tn} and Δ_{Tn+1}, from the table,

$$\Delta_T = \Delta_{Tn} + \frac{(T - T_0)}{(T_1 - T_0)} * (\Delta_{Tn+1} - \Delta_{Tn})$$

where,

Δ_T=compensation constant

T=current temperature, 7.69

T_0=first bin temperature, 5.5233

T_1=second bin temperature, 8.4553

Δ_{Tn}=first value, 0.1411

Δ_{Tn+1}=second value, 0.1028

Using these values,

$$\Delta_T = 0.1411 + \frac{(7.69 - 5.5233)}{(8.4553 - 5.5233)} * (0.1028 - 0.1411)$$
$$= 0.1127\text{m}^{-1}$$

Subtracting this from the raw absorption,

$$a' = a_{raw} - \Delta_T$$
$$= 1.5103 - 0.1127$$
$$= 1.3976$$

Finally, adding in the calibration offset for a610,

$$a = a' + C$$
$$= 1.3976 + 7.6242$$
$$= 9.0218$$

Checksum = 65D00000 = 53349

The checksum is the sum of all the bytes of the record, beginning with the registration word and ending with the temperature. For this record, the checksum is 53349. This is used to verify that the record was received correctly by WETView.

Padding = 00000000

These four null bytes separate records. They are ignored. The advantage of having them is that if a character is lost in transmission, WETView will read one byte past the end of the corrupted record. If there were no padding bytes, the first byte of the next record would have been read, corrupting that record as well. With the padding bytes, however, if a character is lost in transmission, then WETView will read one byte past the end of the record, which will be a padding byte, and it can be safely discarded. The next record will be read correctly.

Appendix C—HiStar Meter

Theory of Operation

HiStar uses fiber optics and small spectrometers to provide a multi-spectral view of marine optical parameters. Two white tungsten lamps provide the source light for the absorption, attenuation and reference paths. Using bundles of fibers with different packing characteristics, the source light uses a color correction filter and a mixing rod to improve the linearity of the output signal and reference spectrum.

The “a” transmitter is a specially designed termination that provides an isotropic source of light. The “c” transmitter is fed by a separate fiber optic bundle, and uses an achromatic lens to supply a collimated beam of light. Both beams then pass through quartz pressure windows and enter the 250 mm flow cell.

In the “c” side of the flow cell, scattered light that intersects the side wall of the cell is absorbed and “lost” to the system. The “a” tube of the flow cell is lined with an aluminized reflective quartz tube so that light scattered forward of the critical angle (approximately 41 degrees) is reflected back into the path and collected by the detector. Only absorbed light—and the small amount of light scattered backwards—is “lost” to the system. Thus the “c” side measures the attenuation of light due to both scattering and absorption while the “a” side measures absorption only. After applying several corrections to the “a” measurement, the corrected “a” value can be subtracted from the beam transmission, “c” to get a good estimate of “b,” the attenuation due to scattering.

After transiting either the “a” or the “c” flow tube, the remaining light passes through another quartz window and enters the receiver optics. An achromatic lens on the “c” side focuses the beam onto the end of a fiber optic bundle. This bundle is coupled through a chopper to a spectrometer that in turn is connected to the instrument electronics.

Each spectrometer also measures reference. This path is primarily to provide a method of accounting for tiny variations in the source light due to lamp aging, voltage fluctuations and/or temperature variations.

Computations

Instrument Internal Temperature

Temperature is calculated from the instrument's raw data by the following equation:

$$T = a + bT_{raw} + cT_{raw}^{-1} + dT_{raw}^{-2} + eT_{raw}^{-3}$$

where:

T	=	temperature in degrees centigrade
Traw	=	number of counts sent by the device
a	=	10.61831
b	=	0.045113
c	=	-4891.32
d	=	208130.2
e	=	1171473

Depth (Optional Sensor)
Depth is calculated from the instrument's raw depth data by scaling and offsetting the depth calibration numbers which are read from the device configuration file.

$$D = mD_{raw} + b$$

where:

D	=	depth in meters
D_{raw}	=	raw number of counts sent by the device
m	=	multiplier determined in the laboratory for each depth sensor unit and is unique to that unit; stored in the configuration file
b	=	offset determined by calibrating the device at sea level (this can easily be done in the field); stored in the configuration file

HiStar Configuration File

HiStar configuration files (with file extension .DEV) give calibration and other information specific to a particular unit. These files are tab-delimited text files and have the following format:

Line 1	Device name.
Line 2	Serial number. The serial number of the device that was used to collect the data.
Line 3	Version number of the following structure. This should be "2."
Line 4	Reserved for future use.
Line 5	Calibrations for depth meter: there are two values, the first is an offset and the second is a multiplier.
Line 6	RS-232 baud rate that the instrument uses
Line 7	Optical path length through water (in meters).
Line 8	Line 8 Number of pixels to skip in acquisition. The meter can measure up to 100 wavelengths (pixels). A skip value of 1 means that all 100 wavelengths are measured. A skip value of 2 means that every other wavelength is measured. Skip value may be 1, 2, 3, or 4.
Line 9	Number of temperature compensation bins.
Line 10	Several values (the count is given in the preceding line); each value is the average temperature of the temperature bin.

Lines 11–110	Each line describes one wavelength of the instrument; the first four fields are: label for identifying the wavelength color for plotting clean water calibration constant for attenuation, c clean water calibration constant for absorption, a The rest of the line contains temperature compensation values that correspond to the temperature bins given in the previous line. The first *n* values are for c, the next *n* values are for a, where *n* is the number of temperature bins.
Line 111	Reserved for future use.

For example:

```
HiStar Meter - skipPixel = 1
F1000007                        ; serial number
2                               ; structure version number
Reserved
    -363.6         1            ; Depth calibration
    38400                       ; Baud rate
      0.25                      ; Path length (meters)
         1                      ; skip value
                                ; number of temperature
        26                      bins
                                                4.904444   5.470667    6.48225  7.474054   8.520571 …
a406.4    LtMagenta     -3.979  1.271513        -0.10979   -0.10665   -0.10019  -0.09359   -0.08665 …
a409.7            1   -3.95405  1.286457        -0.10216   -0.09913   -0.09334  -0.08673    -0.0809 …
a413              2   -3.91322  1.309278          -0.098   -0.09532   -0.09041  -0.08499   -0.07932 …
a416.3            3    -3.8625  1.338559        -0.09317   -0.09196   -0.08846   -0.0832    -0.0765 …
a419.6            5    -3.8105  1.366215         -0.0909   -0.08865   -0.08503  -0.07958   -0.07433 …
a423              6   -3.74401   1.38832        -0.08808   -0.08438   -0.08033  -0.07801   -0.07311 …
a426.3            7   -3.66619  1.415876        -0.08195   -0.08141   -0.07761  -0.07336   -0.06921 …

    o
    o
    o

a716.4            117  2.790931  2.100402          -0.08213  -0.07874    -0.0755    -0.0728  -0.06955 …
a719.7            119  2.749065   1.91727          -0.08037  -0.07621   -0.07138   -0.07033  -0.07255 …
a722.9            120  2.670427  1.687524          -0.08962  -0.08543   -0.08108   -0.07562  -0.06954 …
a726.2            121  2.540299  1.423893          -0.08774  -0.08437   -0.07957   -0.07683  -0.07019 …
a729.5   DkGray        2.356431  1.179627          -0.08659   -0.0844   -0.07951   -0.07743  -0.07197 …
a732.7   LtRed         2.203966  1.026263           -0.0733  -0.07195   -0.06881   -0.06545   -0.0611 …
       0        0         0         0        0         0         0          0          0         0 …
```

HiStar Data Files

WETView saves data files in tab-delimited format. The file format for data files is as follows:

Line 1	Header line. Identifies the version of the program that created the file, and the time and date of creation.
Line 2–11	Exactly the same format as the configuration file. These lines contain the calibration information that was used while collecting the data.
Lines 12–111	Collection bin size. This is the number of samples that were averaged into each bin during collection.
Line 112	Reserved for future use
Line 113	Acquisition bin size
Line 114	WETView label
Lines 115–*n*	Data lines. Each line starts with a zero-based time stamp. Times are in milliseconds from the time the instrument is turned on. Data is given as final values, after referencing, calibration and temperature correction. The first group of values is the “c” values, followed by the “a” values.

After the data, there are four additional columns:
1. instrument temperature (deg C)
2. not used (0)
3. depth (in meters, if the HiStar is equipped with a depth sensor)
4. reserved for future use.

A data line then looks like:

Time $c(\lambda_1)$, $c(\lambda_2)$,… $c(\lambda_n)$, $a(\lambda_1)$, $a(\lambda_2)$, … $a(\lambda_n)$ Temp, 0.0, Depth, 0.0

An example of a data file:

```
WetView
ver 6.0A        5/11/00    9:26:13
HiStar Meter - skipPixel = 1
F100000E                          ; serial number
2                                 ; structure version number
Reserved
-363.6          1                 ; Depth calibration
38400                             ; Baud rate
0.25                              ; Path length (meters)
1                                 ; skip value
0                                 ; number of temperature bins
                                                      0 ; temperature bins
          LtMagent
a406.4    a         -1.32085  3.010416
a409.7           1  -1.41032  3.034271
a413             2  -1.47975  3.047789
a416.3           3  -1.53713  3.071629
a419.6           5  -1.57037  3.088684
a423             6  -1.59529  3.114031
a426.3           7  -1.58554  3.146257
a429.6           8  -1.56934  3.147711
a432.9          10  -1.54645   3.14934
a436.2          11  -1.51666  3.162758
        o
        o
        o
a732.7    LtRed     5.444705  5.247366
         0        0        0        0        0        0        0        0        0
         2                        ; acquisition binsize
          c406.4    c409.7    c413      c416.3    c419.6    c423      c426.3   c429.6
     1560  0.00083  -0.00196  -0.00328   0.00008  -0.00065   0.00325  0.00232  -0.00165 …
     4710 -0.00199  -0.00324    0.0017   0.00008  -0.00065   0.00075  0.00048    0.0008 …
     7860  0.00122  -0.00047  -0.00105  -0.00024  -0.00149  -0.00001  0.00299   0.00019 …
```

HiStar Calculations

The manufacturer of the thermistor provides a table correlating the reading (resistance) to temperature. That table fits the polynomial equation:

$$T = \frac{1}{(a + b\ln R + c(\ln R)^3)} - 273.16$$

where:

$a = 0.00093135$
$b = 0.000221631$
$c = 0.000000125741$

R is the resistance of the thermistor:

$$R = \frac{V * 10{,}000}{2.5 - V}$$

where:

V is the voltage read from the A/D converters:

$$V = 1.27 * \frac{part_2}{part_1}$$

where:

$part_1$ and $part_2$ are raw data sent by the meter. (Refer to the raw data record in the next section.)

HiStar Complete Example

This section gives a complete example of a HiStar device configuration file, a raw data record, and the computed results written to a data file.

Configuration file

Below is the configuration file for the HiStar meter used in this example.

```
HiStar Meter
F1000004                          ; serial number
2                                 ; structure version number
Reserved                          ; reserved for future
5.3 0.3                           ; depth calibration
57600                             ; baud rate
0.25                              ; path length (meters)
1                                 ; skip value
7                                 ; number of temperature bins
7.2655 12.2142 17.4269 22.4909…   ; temperature bins
w406.4 0 -1.7154 -1.1570 0.1457 0.1038 0.0392 0.0101 …
w409.7 1 -1.6953 -1.1241 0.1411 0.1028 0.0389 0.0112 …
w413.0 2 -1.6779 -1.1429 0.1403 0.1041 0.0409 0.0113 …
w416.3 3 -1.6619 -1.0984 0.1369 0.1034 0.0427 0.0129 …
w419.6 4 -1.6395 -1.0910 0.1351 0.1045 0.0423 0.0119 …
w423.0 5 -1.6217 -1.1006 0.1299 0.1034 0.0423 0.0126 …
 o
 o
 o
w726.2 121 -2.1861 -3.9821 0.0486 0.0442 0.0313 0.0182 …
w729.5 122 -2.2104 -4.0484 0.0487 0.0440 0.0319 0.0198 …
w732.7 123 -2.2311 -4.1049 0.0503 0.0455 0.0341 0.0216 …
0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 …
```

Raw data

Below is one record of raw data that was captured from the device. It has been converted to hexadecimal, formatted and commented. Note that the two-byte and four-byte values are byte-reversed. That is, the bytes within a word are read from right to left. This reflects the way the Intel 386 and 486 processors store values in memory.

```
FF00FF00                  registration word
```

0278	record length, from this word through checksum
01	packet type; reserved for future use
01	pixel skip value
F1000001	serial number
0001	status
0000	reserved for future use
000A	depth
243E	temperature, part 1
3703	temperature, part 2
7FFF0000	reserved for future use
0006DB8C	time
1D	start pixel (used internally only)
64	pixel count (used internally only)
0886 02A4 04D1 2BA0	c reference, a reference, c signal, a signal
094E 02CE 0526 2BA9	c reference, a reference, c signal, a signal
o	o
o	o
o	o
2394 0BE0 1642 2BCC	
233C 0BD6 162A 2BC4	
22FE 0BC7 1618 2BR9	c reference, a reference, c signal, a signal for last wavelength
AF2B	checksum

Registration word	= FF00FF00 hex
Record length	= 0278 hex = 634 bytes
Serial number	= F1000008 This is the eighth HiStar meter produced (production numbers begin with 0000 hex).
Packet type	= 01 Reserved for future use.
Pixel skip value	= 01 This value can be 1, 2, 3, or 4. There are 100 wavelengths at most. The meter can be configured to read every wavelength, every other, every third, or every fourth wavelength. This results in 100, 50, 33, or 25 value reported. This field tells how the meter is configured. In this example, it is set to read out all 100 wavelengths.
Status	= 0001 Reserved for future use.
Reserved	<2 undefined bytes> Reserved for future use.
Depth	= 000A hex = 10 This reflects the voltage read from the depth sensor. It is scaled and offset by the values from the configuration file. 10 * 0.3 + 5.3 = 8.3 meters
Temperature, part 1	= 243E hex = 9278
Temperature, part 2	= 3703 hex = 14083 Using the equation given above, we get:

$$V = 1.27 * \frac{14083}{9278}$$
$$= 1.92772$$

and,

$$R = \frac{1.92772 * 10{,}000}{2.5 - 1.92772}$$
$$= 33685.1$$

and finally,

$$T = \frac{1}{a + b \ln 33685.1 + c(\ln 33685.1)^3} - 273.16$$
$$= 22.325 \text{ degrees C}$$

Reserved	<4 undefined bytes> Reserved for future use.
Data, wavelength 1	= 0886 02A4 04D1 hex = 2182 676 1233

This is the data read for the first wavelength: reference, c, and a channels, respectively. Raw absorption is computed from the signal and reference values as described above:

$$a_{raw} = \frac{-\ln\left(\frac{E_{sig}}{E_{ref}}\right)}{Z}$$

The channel's calibration constant and the device's optical path length are read from the configuration file.

$$a_{raw} = \frac{-\ln\left(\frac{1233}{2182}\right)}{0.25}$$

$$= 2.2832 \text{ meter}^{-1}$$

and,

$$c_{raw} = \frac{-\ln\left(\frac{676}{2182}\right)}{0.25}$$

$$= 4.6872 \text{ meter}^{-1}$$

The temperature correction is then applied using the temperature from the reference line and the channel's correction table from the configuration file. The approximate correction value is linearly interpolated from the table. First, the correct temperature bin is determined by finding the two bin temperatures, T_0 and T_1, that bracket the current temperature. Then, using the values, Δ_{Tn} and Δ_{Tn+1}, from the table,

$$K_T = v_0 + \frac{(T - T_0)}{(T_1 - T_0)} * (v_1 - v_0)$$

where,

Δ_T = compensation constant

T = current temperature, 22.325

T_0 = first bin temperature, 17.4269

T_1 = second bin temperature, 22.4909

Δ_{Tn} = first value, 0.0392

Δ_{Tn+1} = second value, 0.0101

Using these values,

$$\Delta_T = 0.0392 + \frac{(22.325 - 17.4269)}{(22.4909 - 17.4269)} * (0.0101 - 0.0392)$$

$$= 0.0110 \text{ m}^{-1}$$

Subtracting this from the raw absorption,

$$a' = a_{raw} - \Delta_T$$
$$= 2.2832 - 0.0110$$
$$= 2.2722$$

Finally, adding in the calibration offset for a610,

$$a = a' + C$$
$$= 2.2722 + (-1.7154)$$
$$= 0.5568$$

Checksum = AF2B = 44843

The checksum is the sum of all the bytes of the record, beginning with the registration word and ending with the byte just before this checksum. For this record, the checksum is 44843. This is used to verify that the record was received correctly by WETView.

Revision History

Revision	Date	Revision Description	Originator
A	02/08/00	Begin revision control	H. Van Zee
B	04/12/00	Correct calibration offset for ac-9 (DCR 20)	C. de Lespinasse
C	05/23/00	Correct data and device files for HiStar (DCR 31)	D. Hankins, H. Van Zee
D	07/12/00	Correct equation on temperature correction algorithm (DCR 47)	C. de Lespinasse
E	4/12/01	Delete references to three-spectrometer HiStar (DCR 102)	D. Hankins