wilks
simple analytical solutions

InfraCal® Filtometer

Antioxidant in Transformer Oil

User's Guide

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Contents

List of Figures

1. InfraCal Filtometer Overview

1.1. Introduction

InfraCal Filtometers for measuring antioxidant in transformer oil are filter based infrared analyzers, specifically designed to monitor the degradation of 2,6 ditertiary-bytyl paracresol (DBPC) and 2,6-di-tert-Butyl Phenol (DBP) in transformer insulting oil in the laboratory, in the manufacturing plant, or in the field. The basic InfraCal Filtometer utilizes a fixed band pass filter/pyroelectric detector selected for the antioxidant measurement and a transmission sample stage with a 2 mm cuvette. Infrared radiation is passed through a sample using an elliptical source mirror and focused on the detector package that contains filters to isolate an analytical and a reference wavelength. The result is calculated from the difference in the measured light absorbed by the sample at the analytical wavelength(s) and the reference wavelength.

1.2. Basic measurement concept

The InfraCal Filtometer makes use of the fact that many molecules absorb infrared energy at a specific wavelength and the amount of energy absorbed is proportional to the concentration. The energy collected at the analytical wavelength (I_A), is reduced when compared to the energy collected at the reference wavelength (I_R). The sample concentration is determined by a calculation of the logarithm of the ratio of the light transmission at the reference wavelength to the light transmission at the analytical wavelength (Beer-Lambert law). "A" equals the infrared absorbance. The Beer-Lambert law assumes a linear relationship between absorbance and concentration.

Beer-Lambert Law: $\mathbf{A = \log I_R/I_A}$

Deviations from linearity are determined by obtaining absorbance values from known samples and an internal point to point calibration table is prepared (see Section 3) so that concentration in the desired units is directly presented on the display.

1.3. Filtometer description and physical properties

Figure 1: The InfraCal Filtometer: Front View

1.3.1. Front operating panel

The front panel consists of a 4 digit LED display and four labeled, touch-sensitive push button controls as illustrated in Figure 2. The LED display remains illuminated at all times while the analyzer is plugged in (switched on). When the instrument is not in use, and ready for use, the display may either show the result of the last analysis, or it may show ***idLE***.

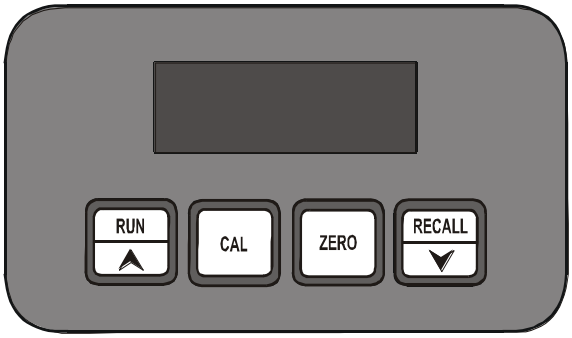

Figure 2: The Display and Control Panel

1.3.2. Back panel

The main power socket for the 12 Volt power supply is located on the back panel. The back panel also provides a standard nine pin, female DB9 connector for serial (RS232-C) data communications with the analyzer. This requires the use of a standard straight through serial data cable. See Section 7 for details of data communications with the Filtometer.

The back panel also contains the CE Mark designation indicating compliance with the codes for operation within the European Community countries, and also the analyzer serial number. The CAL lockout switch deactivates the front panel CAL button to keep the internal calibration table from being inadvertently changed or turned off. For calibration, the switch is ON (I). After calibration the switch may be moved to the locked position (O). Make a permanent note of the serial number, and quote this when contacting Wilks Enterprise with a service or warranty related issue.

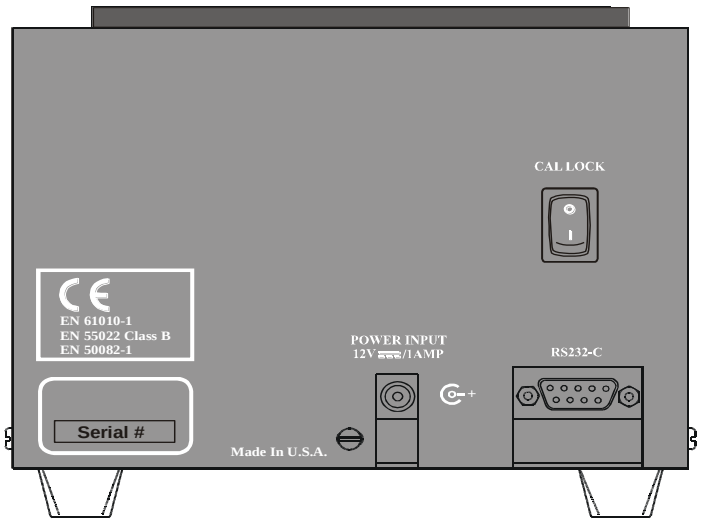

Figure 3: The Filtometer: Rear View

1.3.3. Description of the push button controls

RUN - initiates sample analysis (Section 4). Also used in the calibration mode (***CAL***) to record a calibration sample (Section 3).

UP arrow control - used to increase numerical values used in the calibration mode (***CAL***) (Section 3).

CAL – Hold for 2 seconds to select calibration type (***uSEr, Edit*** or ***oFF***). Also used to generate a new user calibration. Quickly press and release to print the last result.

ZERO - Hold for 2 seconds to zero balance the instrument (***bAL*** appears on display during operation (Sections 2). Also used to exit the calibration mode (***CAL***). For printer, quickly press and release to print the current calibration table.

RECALL - Quickly press and release to recall up to the last ten results (recall mode) or to display the average (averaging mode). Hold for 2 seconds to reset the printer sequence number.

DOWN arrow control - used to decrease numerical values used in the calibration mode.

1.4. Filtometer Features

1.4.1. Internal Calibration:

The InfraCal Filtometer reads in relative absorbance units that are proportional to concentration. An internal microprocessor allows the user to enter a calibration in order to read in the desired units. The Filtometer contains three different user selectable calibration modes. These are ***oFF***, ***uSEr*** or ***Edit***. Section 3.4 explains the calibration functions in detail.

1.4.2. External Communication and Calibration:

The InfraCal Filtometer supports communications to a PC, printer or controller via an RS-232C asynchronous serial communications port. This capability allows for collection of sample measurement data and instrument control by a host computer. It also allows for multiple calibration tables if more than one table is being used with a single instrument.

Specification details for communication parameters are in Section 7.

1.4.3. Recall Function/Averaging Results

The Filtometer has the ability to store ten results for use with the averaging function or for local recall and display (see Section 4.2.1). Results may be data logged via the serial communications interface to a serial printer available as an accessory or to an external PC.

1.4.4. Printing the Result

An optional printer can be connected to the analyzer through the RS232C port located on the back. To print the result, momentarily press and release the **CAL** button. The result is printed on one line. The first number printed is a 5-digit sequence number. The sequence number is followed by the result. The remainder of the line contains the date, time and day of the week.

To reset the print sequence number press and hold the **RECALL** button until ***PCLr*** is displayed. The next result will print as sequence number 000001.

2. Getting Started

2.1. Installation

2.1.1. Location

The InfraCal Filtometer may be installed virtually anywhere. It is not affected by vibration and it can operate over a broad range of ambient temperatures (40^{o} F, 4^{o}C to 110^{o}F, 45^{o}C).

2.1.2. Power Requirements

The Filtometer is powered from a 12 volts d.c. power source. A standard 12 volt power supply is provided with the analyzer, and this may be operated from any grounded a.c. outlet (line power requirements: 100 - 250 VAC, 50-60 Hz, 0.5-0.3 amps). When operating, the Filtometer consumes approximately 8 watts (0.67 amps). For field use, the instrument may be connected to other sources of 12 volt d.c. power, such as an external battery pack or the cigarette lighter output of an automobile (contact Wilks Enterprise for details). If the lighter output is used, the vehicle engine should be switched off during operation of the analyzer. Use with the engine running may result in the generation of a ***bAtt*** error code.

Plug in the external 12 volt supply to the power connector at the rear of the instrument. When plugged in, the instrument display will show ***init*** for a short time. Once the power-on initialization is complete, the instrument displays ***idLE***. The Filtometer is now ready for use.

Note: the connector is polarized with the center pole positive. Failure to use the correct power supply or the correct cable can result in permanent damage to the Filtometer and may invalidate the warranty.

2.1.3. Warm up time

For normal operation, it is recommended that the instrument be allowed to warm up for 1 hour prior to use. However, the Filtometer is sufficiently stable after 15 minutes, and meaningful measurements may be obtained at this time. If the analyzer is used under the 1 hour warm-up time, check the zero prior to each run for best results. The longer warm-up time is recommended for critical measurements and for analyzer calibration. The Filtometer draws very little power and, unless operated from an external battery pack, it can be left on.

2.2. Zeroing the InfraCal Filtometer

For initial set-up the Filtometer will need to establish zero using the following procedure. Once a zero has been established, subsequent zero checks should use the zero check procedure described in section 2.2.2.

2.2.1. Establishing Zero

- Fill the cell with virgin uninhibited oil by attaching a syringe to the inlet port on the cell. 5ml of sample should be flushed through the cell to ensure the cell contains only the zero oil. Be sure to place a container at the outlet port in order to collect the flushed oil.
- Press the "Run" button to start a 1m30s timer (See section 2.2.3 to set the timer). Once the timer has counted down to zero, "run" will be displayed for approximately 10 seconds. If desired, an external timer can be used to count 1m30s before zeroing the analyzer. The 1m30s delay allows the sample temperature to become stable which improves the analyzer's accuracy.

- After the timer countdown is complete press and hold the **ZERO** button until the display reads ***bAL***. Release the button. A multiplier value to 3 decimal places will be displayed when zero is established. The actual value is only of interest when reporting problems to the factory.
- Press **RUN**. The display should read .00 $\pm$ .07. If not, repeat the zero process.

2.2.2. Zero Check

The zero value is retained in permanent memory and is restored each time the instrument is powered up. It is recommended that the zero be checked and (if necessary) reestablished, on a daily basis.

- To check the zero value, flush the cell with 5ml of uninhibited mineral oil. Press the **RUN** button. After 1m30s the result will be displayed
- If the result is not 0.00 $\pm$ 0.07 flush the cell with uninhibited mineral then press the **RUN** button.
- If the result is not within the acceptable range, reestablish the zero as described in 2.2.1

2.2.3. Setting the timer

Overview

The InfraCal Filtometer contains a built in, user programmable, timer. For the best reproducibility for this application the timer should be set to 1 minute 30 seconds (1.30 on the display).

2.2.4. Timer Programming

The CAL lockout switch must be in the on (I) position to set the timer (see figure 3, section 1.3.2). Press and hold the **RUN** button until the current timer value is displayed. The value is displayed as 1 or 2 digits in minutes and 2 digits in seconds, separated by a period (.). Release the **RUN** button once the current value (initially 0.00) is displayed. Use the up- arrow and down-arrow keys to scroll the timer to the desired value. One minute 30 seconds (1.30) is the recommended setting. To zero the timer during programming, press the **ZERO** button. Once the desired time has been programmed press the **CAL** button. The display will read ***idLE***.

Timer Operation

The timer is disabled when programmed to zero (0.00). When the timer is non-zero, it is invoked during the normal **RUN**, **ZERO** and **CAL** functions.

Press and release **RUN** and the timer value is displayed. The timer will count down one second at a time. The dot separating minutes and seconds flashes to indicate the timer is counting. Once the timer reaches zero the display will read ***run*** during the sample measurement cycle. The result is displayed on completion.

2.2.5. Overriding the Timer

For a zero check or to do a second reading on an evaporated sample, the timer may be overridden. To override the timer, press and release the **RUN** button twice and the analyzer will go directly into the measurement cycle.

3. InfraCal Filtometer Calibration

3.1. Data Presentation

The InfraCal Filtometer should be set to read 2 decimal points (***dEC***). This is the format the analyzer is preset for unless the customer specified otherwise. Other formats are available, and these may be set for specific applications. Details for other formats are in Appendix A – Alternate Data Presentation Modes.

3.2. Calibration

Select a set of carefully prepared samples covering the desired range for the analysis. An ideal calibration set may contain three to five samples. A maximum of 20 samples can be used. Reference samples can either be known samples tested with an alternate method or prepared standards. The calibration is linear therefore, for a range of 0 to 0.60 DBPC or DBP only a zero sample and 4 data points are necessary. The lowest concentration standard should measure at least 10 in the ***oFF*** mode. *Do not use the zero sample used in the zero procedure as the first calibration standard.*

3.2.1. Calibration correlated to an Alternate Method

The InfraCal Filtometer can be calibrated against an alternate method rather than with prepared standards. For calibration against an alternate method obtain duplicate samples or if possible, test the same sample with the InfraCal and the alternate method. Data collected for this purpose should be obtained with the calibration in the ***oFF*** mode (section 3.4.1). With a minimum of 3 data points, make a graph with InfraCal absorbance data vs. the alternate method values. Select 3 to 5 data points within the desired measurement range of operation and enter these calibration points into the InfraCal memory using the **Edit** program that is described in section 3.4.3.

3.2.2. Calibration with Prepared Standards

Prepare 3 to 5 data points within the desired measurement range of operation and enter these calibration points into the InfraCal memory using the ***Edit*** program that is described in section 3.4.3. The following is an example of points that could be used.

For a range of 0 to 0.60 weight percent DBPC or DBP

0.60 wt% Stock solution: 9.94 grams mineral oil and 0.06 grams DBPC or DBP. Using a hot plate, heat the oil standard to approximately 120 F (48 C) and stir or shake occasionally until antioxidant is dissolved. This could take more than 10 minutes for the antioxidant to dissolve.

Grams stock solution	Grams mineral oil	Wt% DBP or DBPC
1	3	0.15
2	2	0.30
3	1	0.45

3.2.3. Calibration Considerations

1. Allow the Filtometer to warm up at least one hour.

2. Set timer to 1 minute 30 seconds if it is not already set. See Section 2.2.3 *Setting the Timer*

3. Always zero the Filtometer prior to calibration or collecting data for calibration analysis (see Section 2.2).

4. Prepare a set of reference samples covering the desired range for the analysis as described in Section 3.2.2. Ensure that the samples are accurately prepared. When comparing against an alternate method, collect enough data for a good representation of the measurement range.

5. Ensure the calibration is in the ***oFF*** mode by pressing and holding the **Cal** button. Once ***Cal*** is displayed, press the **RECALL** button until the display reads ***oFF***. Press the **ZERO** button to accept the selection.

6. Flush 5ml of the lowest concentration standard through the 2mm cuvette. Be sure to place a container on the outlet port to catch the flushed oil. The timer should count down from 1m30s followed by ***run***.

7. Record the result on the table below (AO1). The values listed in the C01 column is for the standard mixtures from section 3.2.2. Standards may be run several times and an average can be entered in the absorbance value column in the table below.

8. Repeat for the remaining standards.

Note: *The results can plotted graphically as a calibration curve. The resulting plot can be used to prepare a reference chart for users who prefer not to use the analyzer's internal calibration or for data points to be edited into calibration.*

Absorbance Versus Calibration Standard or Alternate Method Table

(Absorbance Value)		(Calibration Standard in Desired Units)	
A01 =		C01=	0.15
A02 =		C02 =	0.30
A03 =		C03 =	0.45
A04 =		C04 =	0.60

N (Number of calibration points or calibration standards) = 4

3.2.4. Entering Calibration Data into Edit program

1. Press the **CAL** button for two seconds, until ***CAL*** appears on the display. Press **RECALL** until ***Edit*** is displayed.

2. Press **CAL**. The display will read ***n*=** for a short time, followed by the number of entries currently in the calibration table. Scroll to the desired number of entries (0 - 20). For the example above ***n*=** 4.

Note: Selecting 0 will erase any existing calibration table.

3. Press **CAL** to proceed. The display will read ***A01*=** for a short time followed by the current absorption value for the first calibration table entry. Using the up and down arrow buttons, set the display to read the desired value from the "Absorbance Versus Calibration Standard" table above.

4. Press **CAL** again and the display will read ***C01*=** followed by the current analyzer concentration value for the entry. Using the up and down arrow buttons, set the display to read the desired concentration corresponding to the previous absorbance value entered in step 3, For the example above ***C01*=** 0.15. Continue to press **CAL** to step through all absorption and concentration values for the table size (***n*=**) entered. Once all absorbance and concentration pairs have been entered, the display will read ***idLE*** and the calibration will be stored in the non volatile memory.

The recommended calibration mode is the Edit Program. For the User Program, see Appendix B

3.2.5. Calibration printing

With the optional printer, the current calibration table can be printed by momentarily pressing and releasing the **ZERO** button when the analyzer is idle. The first line indicates which calibration is active followed by the date and time. The second line gives the headings for the calibration table that follows. **ABS** represents absorption and **CON** represents concentration. The table headings are followed by the balance value. One additional line is printed for each calibration table entry. The absorption and concentration values are given.

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4. Analyzing a Sample

4.1. Samples

Unless the user ordered a factory calibration or has entered in a calibration, the InfraCal Filtometer will readout in relative absorbance units. If the user would like the readout in their desired units directly presented on the display, refer to section 3, analyzer calibration. The InfraCal Filtometer will provide reliable concentration measurements within the range specified for your application. When the maximum value is exceeded, a notr warning code (Section 7) indicates that the light throughput has fallen below an acceptable level, making the results unreliable. The measurement range can often be adjusted by either concentrating or diluting the sample.

4.2. Sample analysis

- Check the zero prior to analysis if it has been more than 1 hour since the previous analysis(see Section 2.2)
- Flush 5ml of the sample to be analyzed through the 2mm cuvette by attaching a syringe to the inlet port. Be sure to place a container at the outlet port to collect the flushed oil.
- Press the **RUN** button. After the 1m30s timer countdown, the sample concentration will appear on the display after the ***run*** cycle. If the unit is calibrated, the analyzer will display the concentration of the sample. If a calibration table has not been entered into the InfraCal Filtometer, the readout will be in relative absorbance units.
- If another sample is to be analyzed, flush 5ml of the new sample through the cell and repeat the above instructions. The cell does not have to be emptied between samples.
- If the instrument is to be unused for more than a day, the sell should be flushed through with hexane or an equivalent solvent to clean the cell. Approximately 10ml of solvent should be used to clean the cell. Ensure the cell is dry after cleaning by pumping a dry syringe attached at the inlet port.

4.2.1. Averaged Results Display

The InfraCal Analyzer can display the average of up to ten sample measurements. To use the averaging mode, use the following procedure:

- Momentarily press the **RECALL** button once and ignore the result displayed.

- Analyze up to ten replicate samples using the measurement procedure described above.
- Momentarily press the **RECALL** button to display the average.

The next sample measurement will then start a new average accumulation.

The Analyzer alternatively can be configured to recall the last 10 measurements (from newest to oldest) in a circular fashion. First the Filtometer must be switched from the average mode (factory default) to the recall mode as described below. Once the recall mode is selected momentarily press the **RECALL** button repeatedly to display the previous results.

The Filtometer recall mode can be switched by pressing the **ZERO** button first, immediately followed by the **RECALL** button and holding both buttons for two seconds. The display will read ***rCL*** when switched to the recall mode. Repeat the procedure to return to average mode. The display will read ***Ag***.

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5. Detailed Sample Stage Description

5.1. Cuvette (CVH) sample stage

5.1.1. Cuvette Sample Stage Description

The InfraCal Filtometer Model CVH-flow through is supplied with an integrated 2mm cuvette and optics sensing system. The sample stage includes the infrared source (modulated) and detector system, positioned such that an elliptical energy beam is transmitted through the sample and focused directly on the detector-sensing window. Inlet and outlet ports allow the cell to be filled with sample. The inlet port uses a standard luer lock connector.

5.1.2. Cuvette (Model CVH) Measurement Concept

With the CVH stage, a sample is placed directly in a quartz cuvette with a known path length. When the cuvette is placed in the sample stage a focused beam is passed through the sample and focused directly on the dual detector package. The energy collected at the analytical wavelength (I_A), is reduced when compared to the energy collected at the reference wavelength (I_R). The sample concentration is determined by a calculation of the logarithm of the ratio of the light transmission at the reference wavelength to the light transmission at the analytical wavelength (Beer-Lambert law) as shown in Figure 6. The Beer-Lambert law assumes a linear relationship between absorbance and concentration. Deviations from linearity are determined by obtaining absorbance values from known samples and an internal calibration table is prepared (Section 3) so that actual concentration is directly presented on the display.

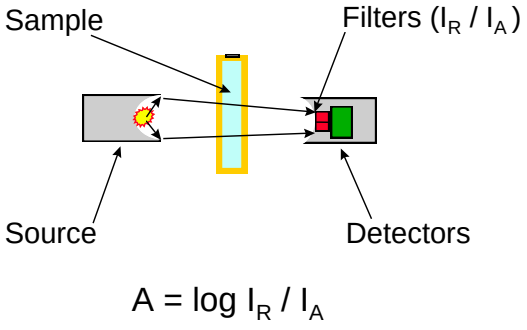

Figure 4: The Measurement of IR Absorption by Transmission

6. InfraCal Filtometer Specifications

6.1. External power requirements

The InfraCal Filtometer operates off external 12-volt power. The power sources can be either regulated DC power supplies or an external battery. This power can be provided by the user or by Wilks Enterprise, Inc. The suggested minimum requirement specifications for the 12 volt power source applied to the analyzer are described below:

Wall Supply Specifications:

Input:	100-250 VAC, 50-60 Hz, 0.5A
Output:	12 VDC, ±1%, 25 Watts

Battery Supply Specifications:

Output:	14 VDC Maximum, 11 VDC Minimum

Load Specifications:

1.5 Amperes Peak

6.2. Physical

Dimensions:		6.5 in. x 6.5 in. x 5 in. (165 mm x 165 mm x 127 mm)
Weight:		4.5 lb. (2.0 kg.)
Control:		Display (output) 4 digit 7 segment red LED, 5/8 in. character height
	User (input)	4 multi-function push-button switches
Connectors:	Power --	Switchcraft Model 760 plug or equivalent
	Communications --	9-pin D-Sub, female

6.3. Environmental

Temperature:	Non-operating --	0°F (-18°C) to 125°F (52°C)
	Operating --	40°F (4°C) to 110°F (45°C)
Humidity:	Relative --	10% to 60% non-condensing

6.4. Electrical

Noise:	Rejection --	60 dB minimum
Drift:	Short term Ambient --	(< 1 Hr.) ± 0.3% of full scale
	Long term Ambient --	(> 1 Hr.) ± 0.1% of full scale
	Temperature --	± 0.03% of full scale per degree C
	Repeatability --	± 0.1% of full scale

Response:	On Delay --	5, 10, 15 or 20 second factory-set intervals
	Measure Time --	5 seconds
	Modes --	Local control or remote PC control
Resolution:	Conversion --	16 Bits (0.0015%)
Ranging:	Digital Ranging --	256 step automatic ranging
	Analog Range --	0 to 4.096 volts
	Answer Range --	Absolute; 00 to 9999
		Percent; 0.0 to 100.0%
		Decimal; .00 to 99.99
	Measure Range --	Dependant on sample concentration ratio
Measurement Accuracy:		± 1% of full scale
Measurement Repeatability:		± 0.1%, ±1 digit
Memory:	Non-volatile memory for calibration and configuration data	

6.5. Calibration

- Electronic zero balance adjustment
- Up to 20 point curve fitting calibration
- Modes: User Table
  Off
  Factory (special order)

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7. InfraCal Filtometer Communications Interface

The InfraCal Filtometer supports communications to a PC or other host via an RS-232C asynchronous serial communications port. This capability allows for collection of sample measurement data and instrument control by a host computer. The host can also maintain calibration tables and download them to the instrument as required. This is particularly useful when more than one table is being used with a single instrument.

InfraWin, a PC windows software package, developed by Wilks Enterprise, is designed to interface to the analyzer communications port as a host. The host software enhances the value of the analyzer by providing host methods for controlling modes and balances, collecting, labeling and storing data log results with pass/fail limits, calculating and viewing statistical information or presenting data log or calibration information in graphical formats. InfraWin provides enhanced methods for generating, storing and loading multiple calibration tables for Filtometer support. (For more information on InfraWin, contact either your local sales representative or Wilks Enterprise, Inc.)

Specification details for interfacing InfraWin or user customized host software is as follows:

7.1. Physical connection

The InfraCal Filtometer is connected to the external device via the 9-pin female DB9 connector located on the rear panel in the lower left-hand corner. The InfraCal Filtometer operates as a DCE device. To connect to a PC, a standard straight through 9 pin cable can be used, but only 3 wires are required.[1] The required signals are Transmit Data (TXD), Receive Data (RXD) and Ground (GND). The pinout is as follows:

Function	Pin
RXD	3
TXD	2
GND	5

[1] *Systems with serial numbers lower than 10200 require a null modem cable or null modem adapter.*

7.2. Communications port setup parameters

The port setup required by the InfraCal Filtometer is:

- 9600 baud
- 8 data bits, 1 stop bit
- No parity

7.3. Operation

The Filtometer accepts ASCII commands from the host and returns data as a response to certain commands or, in datalogging mode, on completion of a measurement cycle. All commands are two characters in length. Certain commands have parameters that follow the command. Parameters are separated by commas. All commands are terminated by a carriage return character. All data responses are comma separated ASCII fields, terminated by a carriage return character. The first field indicates the result type; the remaining fields are the result. Result types are 'B' for balance results, 'R' for run results or 'C' for calibration data. The result format is determined by the presentation mode and is identical to the LED display data. The Read Display Mode command returns a two character mode code. Alphabetic characters can be sent in upper or lower case. Response data is always upper case.

Command Set

Command	Description	Response Examples
RB	Read balance	B,1.025 B,0.865
RR	Read displayed result	R,27.5 R,315 R,1.873
RU	Run (same as RUN button)	None
RA	Run & display uncalibrated result	None
BA	Balance (same as Zero switch)	None
LR	Enable results datalogging	None
DR	Disable results datalogging	None
RM	Read display mode	MA, MP, MD or MR
MA	Set display mode to absolute	None
MP	Set display mode to percent	None
MD	Set display mode to decimal	None
MR	Set display mode to ratio	None
WB,<params.>	Set balance data	None
RC,<params.>	Read calibration table	See detailed description

WC,<params.>	Set calibration table	None
CM	Read Calibration Mode	CD, CE or CF
CD	Disable Calibration	None
CE	Enable User Calibration	None
CF	Enable Factory Calibration	None
ES	Return error status	E,0 E,2
RE	System reset	None
ID	Return firmware ID	2.02.06

7.4. Data logging

Data logging provides results output at the end of each RUN or BALANCE cycle. The results are output when datalogging is enabled both for functions initiated from the instrument control panel and functions initiated by the host. The format of the data returned after a RUN cycle is as shown for the RR command and is determined by the display mode. The format of the data returned after a BALANCE cycle is as shown for the RB command. The RA command allows the host to initiate a run cycle and datalog a result that is not adjusted by the calibration procedure. This can be used by an intelligent host resident calibration table generator.

7.5. Remote zero balance control

The instrument zero balance can be controlled via the communications port. The RB, WB and BA commands provide the necessary controls. This feature can be used to store multiple zero values for different operating conditions. This feature combined with the calibration controls described in the next section can be used to maintain multiple calibration curves when using the instrument for multiple applications.

The RB command will retrieve the current zero balance data. The WB command can then be used to reset the current zero balance to a previously recorded value. The WB data field is identical in format to the data returned in response to the RB command.

The BA command can be used to initiate a zero balance function under remote control. The operation is identical to initiating a zero balance from the instrument control panel. The user must insert the zero sample in the instrument prior to issuing this command. If datalogging is enabled the result will be returned on completion of the function. The data format is identical to the RB command response. The result can optionally be read with the RB command if datalogging mode is not used.

7.6. Remote calibration control

Calibration data can be retrieved or set under remote control. Due to the complexity of the calibration function (and the need to utilize multiple calibration standards) initial calibration can only be performed from the instrument panel. Another approach is to use the host to generate one or more calibration curves from uncorrected datalog results collected with the RA command. This technique is extremely useful if the user desires to generate a calibration curve based on an average result of several measurements from a lot of each calibration standard.

The RC command is used to retrieve the current calibration table. A Calibration table consists of zero to twenty entries. The RC command can take the following forms:

RC	Read entire calibration table
RC,0	Read calibration table size
RC,n	Read a single calibration table entry, where n is the entry number.

The RC,0 command response is C,n where n is the number of calibration table entries from 0 to 20. If 0, the instrument is not calibrated. Otherwise, n is the number of calibration table entries.

The RC,n command response is C,n,x,y where n is the entry number as received, x is the raw measurement data as it appears on the display during calibration and y is the actual value as set by the user during calibration. The format is determined by the display mode (absolute, percent, or decimal). Calibration commands should not be used when in ratio mode since ratio mode does not use a calibration table. An RC command requesting data for a table entry number greater than the current table size returns erroneous data.

The RC command with no arguments returns the complete calibration table, one entry at a time starting with the table size information. The individual entries are then returned in numerical order up to the number of entries.

Read Calibration Table Example

Assume the instrument is calibrated in the absolute mode using three standards. Assume the calibration results were as follows:

Entry	Measured	Actual
1	15	30
2	26	50
3	33	70

The RC command will return the following:

C,0,3
C,1,15,30
C,2,26,50
C,3,33,70

The RC,0 command will return C,0,3

The RC,2 command will return C,2,26,50

The WC command can be used to download calibration table data based on previously uploaded data or as determined by a host program. The command format is WC,n,x,y where the parameters are identical in format to the RC command. The parameters must match the current display mode. When using the WC command the table size and all necessary table entries should always be downloaded. Once all table entries have been downloaded the table size should be set.

Write Calibration Table Example

To download the calibration table described in the previous example, send the following commands:

WC,1, 15,30
WC,2, 26,50
WC,3, 33,70
WC,0,3

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8. Service and Technical Support

Your InfraCal® Filtometer may have been purchased either directly from Wilks Enterprise or from a local dealer or representative. If you have a technical question relative to the operation of the instrument or relative to the analysis, please contact Wilks Enterprise at the contact address provided below:

Customer Services Department
Wilks Enterprise, Inc.
25 Van Zant Street, Suite 8F
East Norwalk, CT 06855
USA
Telephone: **(203) 855-9136**
FAX: **(203) 838-9868**
E-mail: **tech@wilksir.com**

During the warranty period, Wilks Enterprise, Inc. offers free factory service for all failures that occur from normal instrument usage. The user is only required to cover the cost of shipping the instrument to the factory. After the warranty period, the user is required to cover the factory's cost of servicing plus all shipping charges. Normal one week turn around is offered for all InfraCal instruments that are returned to the factory for service. For users requiring faster service times, Wilks Enterprise also offers an advance replacement program that can respond to a user's needs with instrument replacement typically in less than 24 hours. For extended service contracts, advanced replacement programs, factory service charges or sample system installation procedures, please contact Wilks Enterprise, Inc. for details.

Appendix A: Alternate Data Presentation

The standard display format for the InfraCal Analyzer is absorbance (***AbS***) It provides relative absorbance value. Other formats are available, and these may be set for specific applications.

Note: *The InfraCal Analyzer must be calibrated in the selected data presentation mode. Changing the data presentation mode requires re-calibration.*

The following are the different data presentation modes available of the InfraCal analyzer:

The following are the different data presentation modes available of the InfraCal analyzer:

Percent Mode (*PCt*): Calculated values are displayed to a single decimal place (0.0).

Decimal Mode (*dEC*): Calculated values are displayed to two decimal places (.00)

Absorption Mode (*AbS*): An arbitrary scale related to the raw absorption of the sample (00).

Note: *Inserting a decimal point does not change the raw absorbance value displayed for a given sample. ie: an Abs reading of 25 becomes 2.5 (pct) or .25 (dec).*

Note: *Inserting a decimal point does not change the raw absorbance value displayed for a given sample. ie: an Abs reading of 25 becomes 2.5 (dec) or .25 (pct)*

Ratio Mode (*RAt*): A threshold based scale where a value defining an acceptable limit for maximum or minimum acceptable concentration is set to the value of 1.000. All values less than 1.000 indicate that the concentration is less than the threshold, while all values greater than 1.000 indicate that the concentration is greater than the threshold.

The InfraCal Analyzer display format can be switched between modes by pressing and holding both the **CAL** and **ZERO** buttons for two seconds. Each time the **CAL** and **ZERO** buttons are pressed the display mode changes. Release both buttons and repeat until the desired mode is displayed. The display

will read: ***AbS*** for absorption mode, ***PCt*** for percent mode, ***dEC*** for decimal mode, and ***RAt*** for ratio mode. Push **RUN** to exit the display mode.

Appendix B: Calibration with the User Program

1. Insure that the InfraCal Analyzer has been properly cleaned and zeroed (see Section 2.2.2) prior to calibration.

2. Press the **CAL** button for two seconds, until ***CAL*** appears on the display. Press the **RECALL** button to display the active table, either ***uSEr, Edit*** or ***oFF***. Press **RECALL** until ***uSEr*** is displayed.

3. Momentarily press and release the CAL button. The display will read *SA01*.
Caution: Pressing ZERO *at this time will erase any existing calibration table.*

Eject 50 microliters of standard using a pipette or syringe onto the center of the HATR-T2 plate and press **RUN**. For the CH Model remove the sample plate and lay on a flat surface. Eject the standard from the pipette or syringe onto the center of the plate and allow the solvent to evaporate. (The evaporation time can be measured using the programmable timer.) Insert the IR sample plate into sample stage and press run. (Press twice if the timer is preset to override the timer). The display will then show the raw absorption value.

5. Scale the number upward by pressing the **UP** arrow (**RUN)** button or downward by pressing the **DOWN** arrow (**RECALL)** button until the actual standard value is displayed.

6. Momentarily press and release the **CAL** button to advance to the next standard. The display will read ***SA02***. Repeat the above procedure for this sample. Continue to repeat for up to 20 standards. Remember that the standards must be run in increasing concentration order to obtain a valid calibration. If a sample is run that produces a lower absorption value than the previous sample, ***Lo*** will be displayed in place of the absorption value. Press any key to continue once the proper sample has been inserted in the sample holder.

NOTE*: If an error is made during the calibration process you can back up any number of samples to repeat the calibration starting from a given sample. Simply press and release the* ***RECALL*** *button when the sample number is displayed until the desired sample number is displayed. The sample in question plus all higher concentration samples must be run again to complete the calibration procedure*.

9. After the last sample has been run, press the **ZERO** button to exit the calibration mode. The display will read ***idLE.*** The calibration program has been permanently stored in memory.

Calibration printing

With the optional printer, the current calibration table can be printed by momentarily pressing and releasing the **ZERO** button when the analyzer is idle. The first line indicates which calibration is active followed by the date and time. The second line gives the headings for the calibration table that follows. **ABS** represents absorption and **CON** represents concentration. The table headings are followed by the balance value. One additional line is printed for each calibration table entry. The absorption and concentration values are given.